



# The Evolution of Mixed Waste Processing Facilities 1970-Today

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**Cover Image Sources (Top to Bottom)**

- GBB Pictures taken in 2007 of the City of Chicago Northwest Materials Recycling & Recovery Facility
- BHS (Greenwaste Recycling, San Jose, CA)
- Machinex
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## 1 Executive Summary

Mixed waste processing (MWP) is a mechanical system that separates recyclable commodities from Municipal Solid Waste (MSW). Mixed waste processing facilities (MWPF) use a variety of new and existing technologies to sort recyclables from a stream of mixed trash. Sometimes MWPFs are combined with source-separated collection of recyclables and a Materials Recovery Facility (MRF). Or a MWPF can be found as a stand-alone facility processing the entire waste stream.

MWPFs, in their earliest of designs, were first introduced in the 1970s<sup>1</sup> as a way to capture high BTU elements of MSW for combustion-based energy recovery. Today, MWP is attracting renewed interest across the country as a way to address low participation rates for source-separated recycling collection systems and prepare feedstocks for conversion technologies and/or fuel products. In theory, these facilities can give communities the opportunity to recycle at much higher rates than has been demonstrated by curbside or other collection systems. Advances in technology make today's mixed waste processing facilities different and in many respects better than older versions. Yet legitimate questions remain regarding recovery rates, quality and contamination of recovered materials, and the commercial readiness of the technologies compared to existing systems.<sup>2</sup>

There are three questions regarding MWPF that proponents need to address with performance data and a coherent public policy argument:

- Will increased volumes of recyclables from MWPFs be contaminated? And would the increased volumes offset discounted prices for contaminated materials?
- Are MWPFs inconsistent with the conventional wisdom that the act of source separating one's recyclables is by itself important?
- Is the belief correct in suspecting that energy recovery, not recycling, is still the main driver behind these facilities?

Interest in these facilities is high. Several communities across the country are evaluating mixed waste processing systems as a way to reduce collection costs while also increasing the recovery of recyclable materials in the waste stream.

The key findings of this Report are:

- Sortation technology continues to evolve and improve. This has enabled significantly higher diversion rates and more recoverable streams. For example, optical near infrared (NIR) light and sensors that recognize different types of plastics are being utilized in modern MWPFs. These systems accurately separate plastics by resin type. This dramatically increases the potential overall recovery of plastics for both recycling and energy recovery.
- Recovery of high value materials, such as plastics and metals, has the potential to increase significantly via modern MWPFs. Recovery rates for lower value materials, such as fiber/paper and glass, are likely to be reduced.

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<sup>1</sup> Robert H. Brickner, Gershman, Brickner & Bratton, Inc., Paper titled: Solid Waste Processing Industry: Technology, Vendors, Developers & Operators. Conference: Municipal Solid Waste Symposium, Washington D.C. December 1986

<sup>2</sup> The findings presented in this Report are based on publicly available information and present the background and design concepts of the original facilities in the context of today's technological advancements through March 2015. This Report also presents historical data on the number of existing MWPFs and their type, as the industry has adjusted to market demands with advanced higher performance equipment.



- Even in communities with single-stream residential recycling, many valuable recyclables remain mixed in MSW and are not recovered. Combining MWP with an existing single-stream system could greatly improve diversion rates.
- Stakeholders need good data and case studies. There is interest in analyzing and evaluating the MWP experience. The technology has evolved and appears to address historical issues, but realistic recovery numbers are still in question.
- The economic value of sourcing additional recyclables from the waste stream now drives much of the expansion and automation of MWP. The value of the energy rich residue from MSW processing has always been apparent. In the early days of MWP when recyclables had less value, energy recovery was the primary driver. Thus, the perception remains that energy recovery, not recycling, is still the principle motivation for MWP.
- The original Refuse Derived Fuel (RDF) facilities that were built to produce a supplemental fuel for coal-fired electricity-generating utility boilers have contributed to long-standing public perceptions about problems with MWPFs. The original RDF output from the 1960s and 1970s was not of a suitable quality to sustain use. Inorganics caused erosion and slagging of the equipment. Current technologies have resolved these issues, but the performance problems of first generation MWPFs continue to color perceptions of MWP today.
- State and municipal recycling goals have driven the development of extensive collection and processing infrastructure that is evolving toward large, centralized MRFs. These MRFs are potentially complementary to MWPFs for maximizing diversion and managing costs.
- MWP is financially attractive for communities that do not have existing single-stream recycling programs. This is because of lower anticipated hauling costs compared to source-separated collection systems. The key question is whether overall recycling performance and service fees for MWPFs are better than the recycling performance and costs for separate collection and MRF processing of source-separated recyclables.
- MWP is an option communities are considering to address the persistent challenge of increasing recycling rates from multi-family units and commercial businesses.
- Communities combining single-stream recycling, mixed waste processing, composting or anaerobic digestion, and energy recovery for the non-recycled plastics and paper residue could achieve extremely high total landfill diversion rates.

This report highlights a series of three hypothetical recovery scenarios based on a material composition study GBB completed for the City of Fort Worth, TX that evaluated the materials found in both their curbside recycling bins and waste bins. One scenario includes the recycle bin only being processed at a traditional MRF. Another scenario assumes all the materials are combined, meaning curbside collection is in one bin or cart, and processed at a MWPF. Another scenario considers a tandem recovery system with the recycling bin materials being processed by a MRF and the waste bin material being processed by a modern MWPF. In the last scenario, the small amount of MRF residue is reprocessed at the MWPF to generate even more recyclables.

Based on the waste composition in the Fort Worth study, the recycling bin material processed at the MRF turned out to provide a 19 percent diversion rate of the total waste stream. From the same overall waste stream, the one bin MWPF system was projected to have a total diversion of 46 percent, over 140 percent more than the MRF alone. Finally, with two independent processing systems consisting of a MRF for the recyclables and a MWPF system for the waste bin material, the total diversion rate increased to 54 percent. It is important to point out that because the MWPF can also potentially process and recover the food waste and organics waste fraction, these diversion numbers also assume that organic material is recovered at the MWPF for composting or as feedstock for Anaerobic Digestion.



There are key tradeoffs that need to be analyzed as part of assessing MWP. The technology promises to deliver more volume of recycled materials but potentially with a lower unit value for some materials because of contamination. Advocates for MWP expect facilities will deliver a higher net value because they will capture materials for recycling that are currently either landfilled or processed by Waste to Energy (WTE) facilities. In fact, GBB finds that combined MRF and MWP systems have the potential to significantly increase both the volume and total revenue from recycling materials. The potential exists to divert 180 percent more high value metals and plastics from landfill than are diverted today (See Section 5 of this report for methodology).

## 2 Overview of MSW Industry History and Trends

In 2014, the collection, processing, recycling, and disposal of MSW was a \$55 billion industry<sup>3</sup> in the United States. Two companies dominate the market, Waste Management, headquartered in Houston, Texas, and Republic Services, headquartered in Phoenix, Arizona. However, many smaller, regional companies are also flourishing.

Until the early 1970s, most municipalities chose the least costly disposal option. However, several factors changed how municipalities managed their waste.

- The recycling business grew beyond junk yard processing of metal and paper scraps as a result of growing environmental awareness.
- The waste business began to consolidate under more professional, national, publicly traded companies.
- The Resource Conservation and Recovery Act (RCRA) was passed by Congress in 1976.
- New air pollution regulations under the Clean Air Act were instituted in 1990. This forced the closure of older, smaller waste-to-energy facilities that were essentially just incinerators.

One of U.S. Environmental Protection Agency's (EPA) first programs was to partner with municipal sanitation departments to search for more environmentally friendly methods for handling MSW. A plethora of innovative start-up technologies appeared from the late 1960s to early 1980s to address the rapidly increasing amount of waste Americans were generating.

Many European-based companies developed WTE components and energy generating systems in the post-World War II era.<sup>4</sup> In the late 1960s and into the 1970s, many of these companies began to investigate the U.S. market. While metal and paper industries employed shredders, magnetic recovery and baling systems, there was little processing of MSW for some value-added end products. The plastics portion of the waste stream was still very small at this time. This historical context helps to frame some of the current trends and renewed interest in mixed waste processing facilities.

### 2.1 Changes to the Curbside Volume and Mix of Garbage and Recyclables

In order to understand the current perceptions of MWP, it is important to place it in the context of MSW and the history of management options available to communities.

MSW is defined by the EPA as the disposal output from homes, schools, hospitals and businesses.<sup>5</sup> MSW includes waste that is recycled, composted, combusted for energy, or landfilled. Since 1960, EPA has tracked the generation of MSW and estimated the disposal and recovery of various components within the waste stream. Figure 2-1 shows the overall generation of MSW material and where it goes. The total amount of material that ends up in a landfill or combusted for energy recovery has been fairly steady since 1990, while the amount of materials recycled or composted has been increasing since that time.

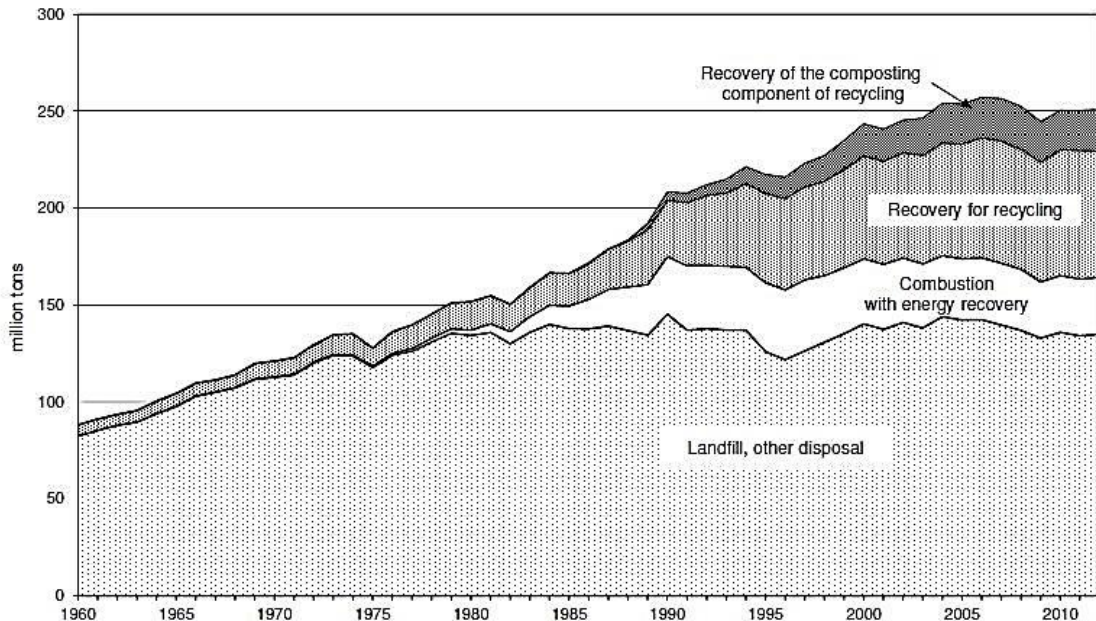
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<sup>3</sup> WasteBusinessJournal.com, Waste Market Overview and Outlook, 2012, p.13.

<sup>4</sup> Robert H. Brickner, Gershman, Brickner & Bratton, Inc., paper: Resource Recovery Vendors presented at U.S. Conference of Mayors Leadership Institute, Nashville TN, October 1983

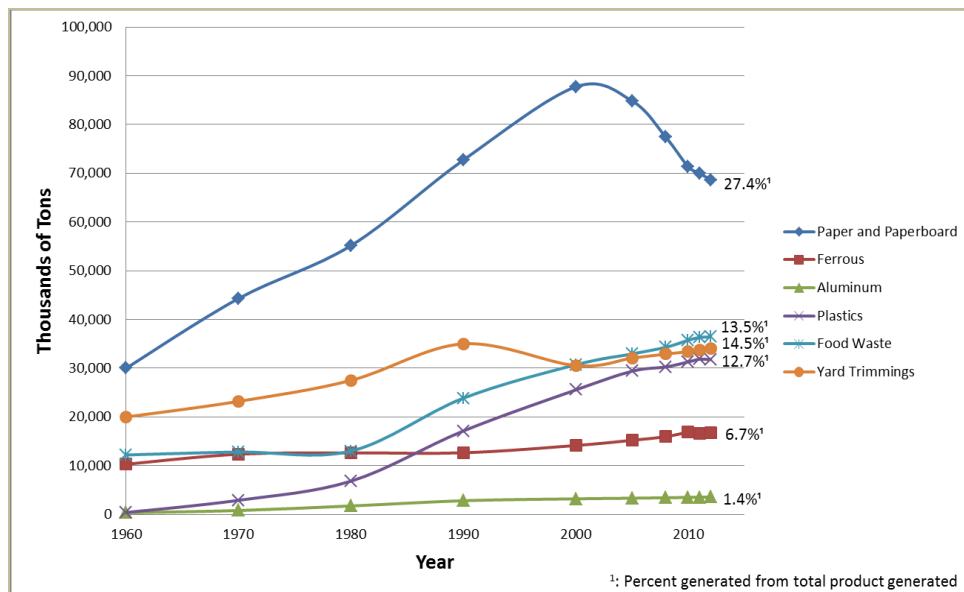
<sup>5</sup> EPA Website – Municipal Solid Waste Home Page -<http://www.epa.gov/epawaste/nonhaz/municipal/>

**Figure 2-1**  
**MSW Production and Management: 1960-2012<sup>6</sup>**



EPA bases much of its data on assumptions about the total materials generated and the amounts of recyclables recovered, with the rest assumed to be used in energy recovery or landfilled.<sup>7</sup> Figure 2-2 shows the total tonnage of MSW generated, before removal of recyclables, over the last 50 years. The most noteworthy trend is the steep decline in the quantity of paper and paperboard since it peaked in 2000.

**Figure 2-2**  
**Total Generated Amounts for Select Materials<sup>8</sup>**



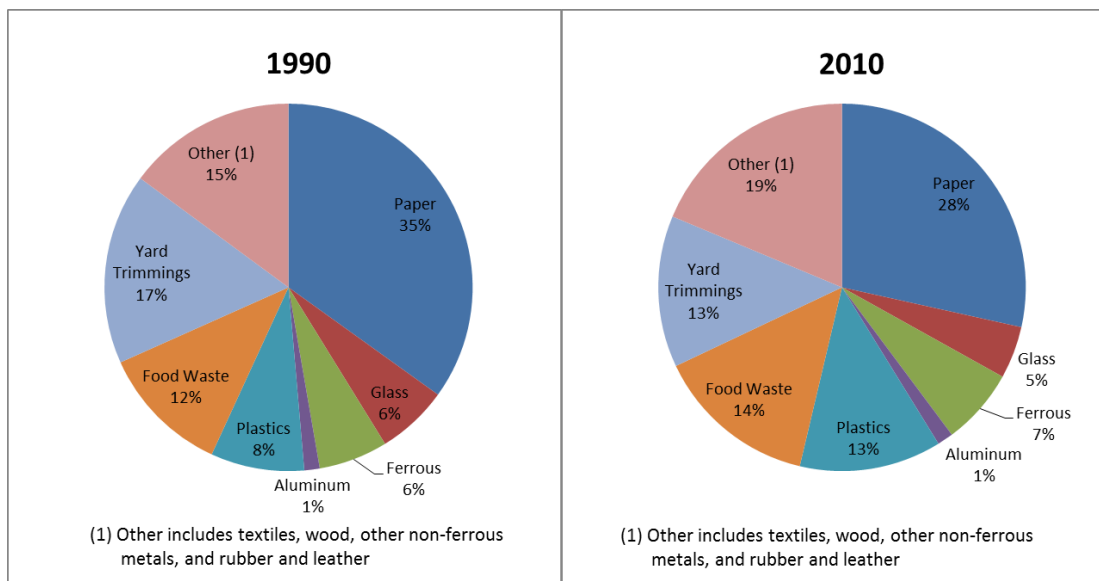
<sup>6</sup> EPA Office of Resource and Recovery – Municipal Solid Waste Generation, Recycling, and Disposal in the United States, February 2014 (February 2014 Report), p.59

<sup>7</sup> Actual reported landfilled weights from municipalities and states are not included in EPA’s report.

<sup>8</sup> Developed by Gershman, Brickner & Bratton, Inc. from EPA information, February 2014 Report

Figure 2-3 shows the comparative difference in EPA's estimate of material composition and change between 1990 and 2010. It should be noted that the percentage of waste generation of the primary recyclable materials has increased in the last 20 years except for paper and paperboard, which has decreased significantly because of market and consumption factors.

**Figure 2-3**  
**Material Composition of Generated MSW<sup>9</sup>**



The growth of recycling, and to a lesser degree composting, played a significant role in the reduction of material bound for disposal or recovery through WTE in the 1990s. Figure 2-4 shows the total tons of certain recycled materials and the 2012 percentage of these selected materials as a percentage of the total recycled material stream. The inclusion of yard trimmings is a significant contributor to the total volume of recyclables. Legislation banning yard trimmings from landfills has contributed to the recycling of this stream in some communities through composting. Yard trimmings are not typically accepted in recycling carts and bins. Many communities provide separate collection of yard trimmings (and sometimes food scrap as well) in carts, bags, or separate bundles.

<sup>9</sup> GBB developed from EPA information, February 2014 Report

**Figure 2-4**  
**Recycled Amounts of Select Key Materials<sup>10</sup>**

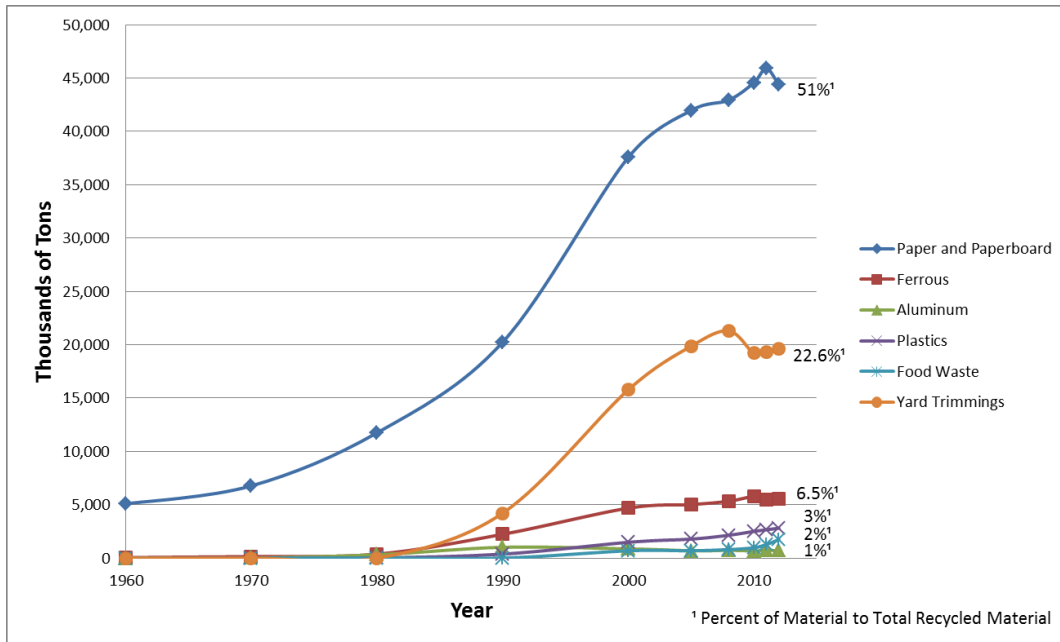
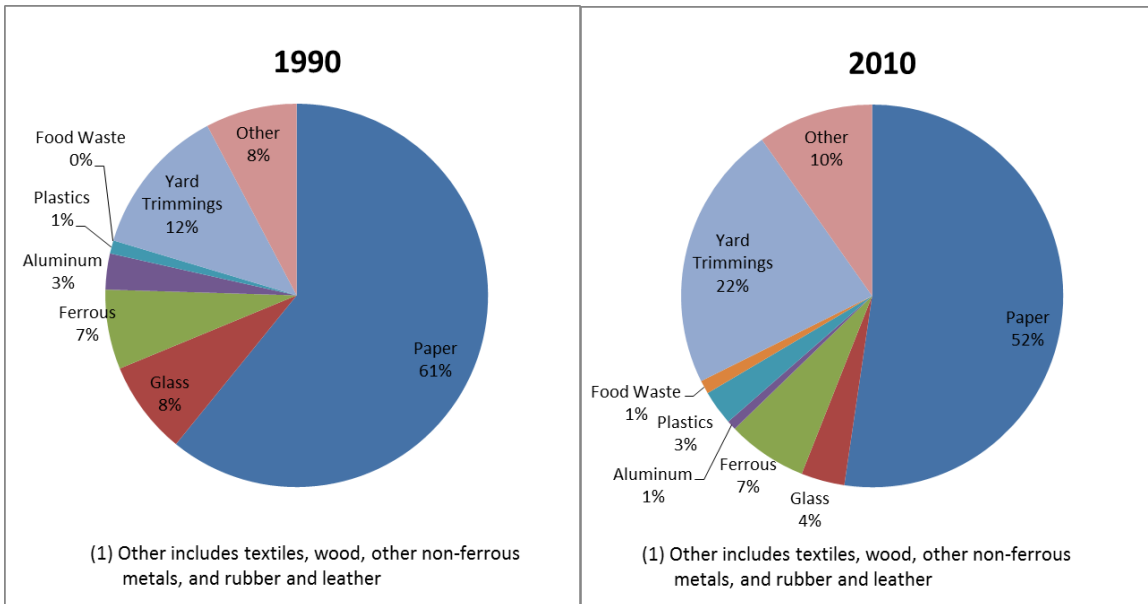


Figure 2-5 shows the primary materials recycled and their proportional weight compared to other recycled materials. Some materials are easier to segregate for recycling than others.

**Figure 2-5**  
**Material Composition of Recycled Materials<sup>11</sup>**

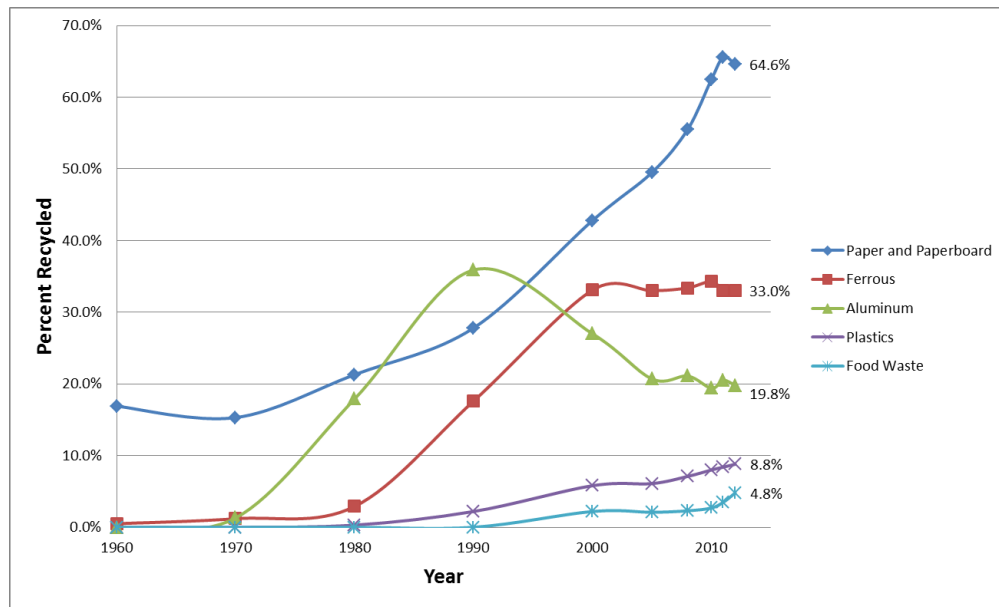


<sup>10</sup> GBB developed from EPA information, February 2014 Report

<sup>11</sup> EPA, op.cit. p.4.

Figure 2-6 presents the major constituents of MSW that are recycled. EPA data shows paper has the highest recycled rate. The percentages for aluminum and ferrous are in relation to the total of these metals generated, while the recovery numbers for aluminum and steel containers exclusively are much higher.

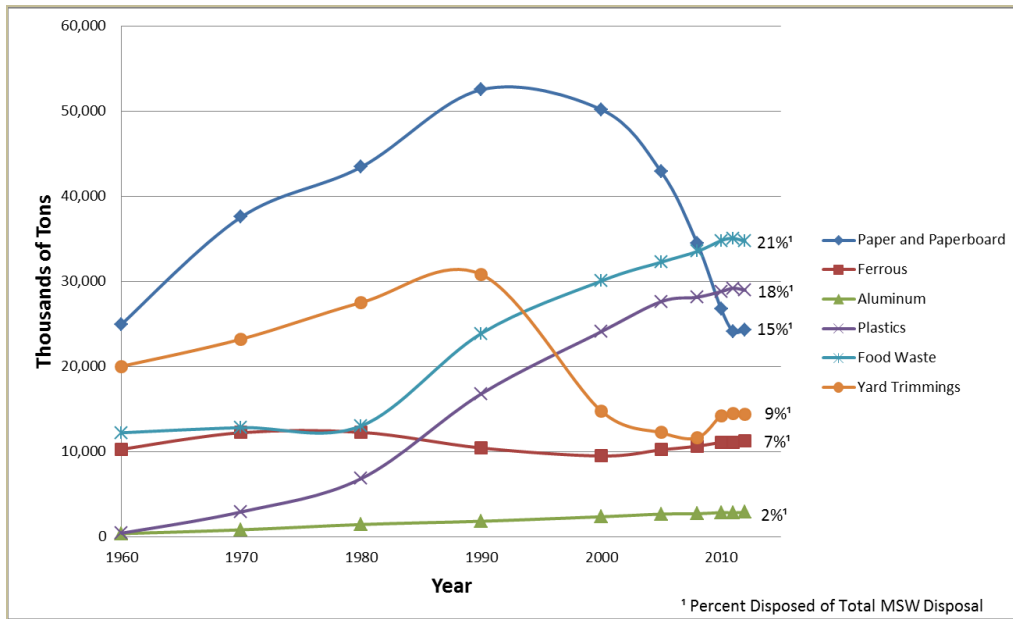
**Figure 2-6**  
**Percentage of Material Recycled with Respect to Total Individual Material Generated<sup>12</sup>**



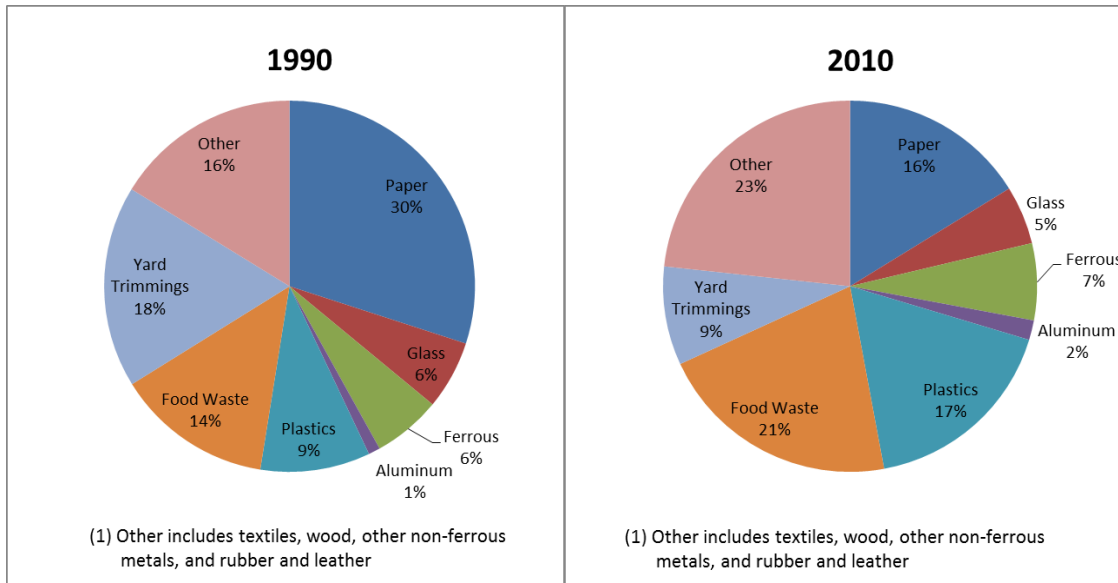
The waste-generation methodology assumes that if it was generated and not recycled, it must have been processed for energy recovery or disposed at a landfill. Based on this method, Figure 2-7 shows the estimated annual tonnage of select materials combusted for energy or disposed. Figure 2-8 presents the composition of the non-recycled MSW as published by EPA for 1990 through 2010.

<sup>12</sup> GBB developed from EPA information, February 2014 Report

**Figure 2-7  
Total Disposal Amounts for Select Materials<sup>13</sup>**



**Figure 2-8  
Estimated Composition of Non-Recycled Material<sup>14</sup>**



The actual percentages of materials in the MSW stream after source separation of recyclables can vary significantly from state to state. Factors include population density, demographics, and level of recycling availability and participation. Many states track the material and the source of material that ends up in the landfill. Table 2-1 shows the percentages of select materials from several states in comparison to the national EPA estimates of composition. The material composition is important when estimating the percentages of recovery that are possible from the various disposal streams.

<sup>13</sup> EPA, op.cit., p 4

<sup>14</sup> EPA, op. cit., p. 4



**Table 2-1  
Examples of Non-Recycled Waste Percentages**

<b>Material</b>	<b>National (2008) (1)</b>	<b>Oregon (2009) (2)</b>	<b>New York (2008) (3)</b>	<b>Mississippi (2009) (4)</b>	<b>Indiana (2012) (5)</b>
Paper	20.5%	17.0%	27.1%	32.2%	29.1%
Glass	5.5%	2.0%	3.3%	3.8%	2.9%
Metals	8.8%	7.0%	5.7%	4.0%	5.8%
Plastics	16.7%	11.6%	16.6%	17.4%	16.7%
Food/Yard	26.8%	21.5%	24.0%	29.6%	17.0%
Other	22.7%	41.0%	23.4%	13.9%	28.5%

(1) EPA Office of Resource and Recovery - Municipal Solid Waste Generation, Recycling, and Disposal in the United States Tables and Figures for 2012 – February 2014 – Table 3 Page 4

(2) Derived from Oregon Department of Environmental Quality - Oregon Statewide Waste Composition 2009 – Table A2

(3) Derived by GBB from data published by the State of New York DEC – Beyond Waste-A Sustainable Materials Management Strategy for New York State -December 2010 - Appendix H, Table H-1

(4) Gershman, Brickner & Bratton, Inc. - Two Season Waste Characterization Final Report – June 8th, 2011

(5) Derived by GBB from data published by Harvey Abramowitz and Yu Sun – Municipal Solid Waste Characterization Study for Indiana – May 25, 2012 – Table 3-11 pages 44-45

## **2.2 Organics Recovery and Composting**

Figures 2-7 and 2-8 demonstrate the increase of both the volume and share of food waste in the disposed stream over the past 20 years. Food waste, along with some yard debris, constitutes much of the organic portion of MSW and represents a significant percentage of the total tonnage disposed in landfills. Once landfilled, organic material decomposes and produces methane, a powerful greenhouse gas. The environmental implications of food waste disposal have driven some local, state, and national interests to explore alternative diversion methods.<sup>15</sup> Organic waste is high in moisture content and is therefore not easily combusted for energy. An alternative process to convert the food waste to energy is called anaerobic digestion (AD). AD is a controlled process that allows microbes to break down organics in an environment devoid of oxygen. The process produces a biogas that can be used for electricity production or processed into compressed natural gas (CNG).

AD technology has been around for decades and is prevalent in Europe. In the U.S., most AD systems are utilized at wastewater treatment plants (WWTPs). AD enhances the wastewater treatment process by breaking down sewage sludge. Only recently has it begun to gain traction in the United States for MSW-related organics like food waste. While typical yard waste can technically be digested, it is more suitable for composting because of its low biogas yield.

For MSW, AD facilities are being explored for processing mixed organics generated from processing MSW or from source-separated organics. Content with low solids (less than 15 percent total solids) is sometimes referred to as “wet” digestion. Content with higher solids (25-30 percent) is referred to as “dry” digestion. Other differences between wet and dry digestion can include temperature of reactions, number of reactor vessels, and either continuous or batch feeds.

Pre-processing of the MSW stream is required to remove most of the organics from the material and, in addition to the biogas, AD facilities produce “digestate.” The digestate product can be further co-composted with yard waste to final compost/soil amendment product. If the original feedstock was co-

<sup>15</sup> The President’s Climate Action Plan- Executive Office of the President, June 2013

mingled with other waste, additional processing is required to remove inert materials such as glass, plastics, and metals before it can be used as compost. Anaerobic digestion and composting of food waste is a novel approach in the U.S. and organizations like American Biogas Council and the U.S. Composting Council are working to get it recognized by the legislation.<sup>16,17</sup>

More than 20 states have instituted laws that ban landfill disposal of yard waste materials.<sup>18</sup> These laws date back to the 1990s. Four states have passed laws since 2011 banning food waste from landfills (Vermont, Massachusetts, Connecticut,<sup>19</sup> and California<sup>20</sup>). However, banning disposal of both residential and commercial generators of food waste is a relatively new approach.

**Figure 2-9**  
**Trommel Screen Processing MSW**



Source: Machinex

### **2.3 Collection Costs**

Costs for recycling and waste management services differ depending on the region of the country. A “subscription service” is when the resident deals directly with a collector and pays for their services. The most common approach is for municipalities to perform the service directly or contract with a private hauler. Homeowners are then charged via taxes or a municipal services bill.

The introduction of curbside recycling required adding an additional collection vehicle to the existing vehicle collecting garbage. Initially homeowners separated their recyclables into multiple smaller bins. In recent years, the trend went toward “single-stream recycling.” In a “single-stream” system, homeowners co-mingle all their recyclables in one larger wheeled cart. Now some communities are adding a third service for yard waste. Also around 200 communities offer curbside collection of food

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<sup>16</sup> American Biogas Council – 2014 Overall ABC Priorities, PDF File -

<https://www.americanbiogascouncil.org/pdf/ABC2014priorities.pdf>

<sup>17</sup> US Composting Council – Landfill Bans on Organics Webpage - <http://compostingcouncil.org/landfill-bans-on-organics/>

<sup>18</sup> State of Composting in the U.S.- Brenda Platt and Nora Goldstein BioCycle July 2014, Vol. 55, No. 6, p. 19

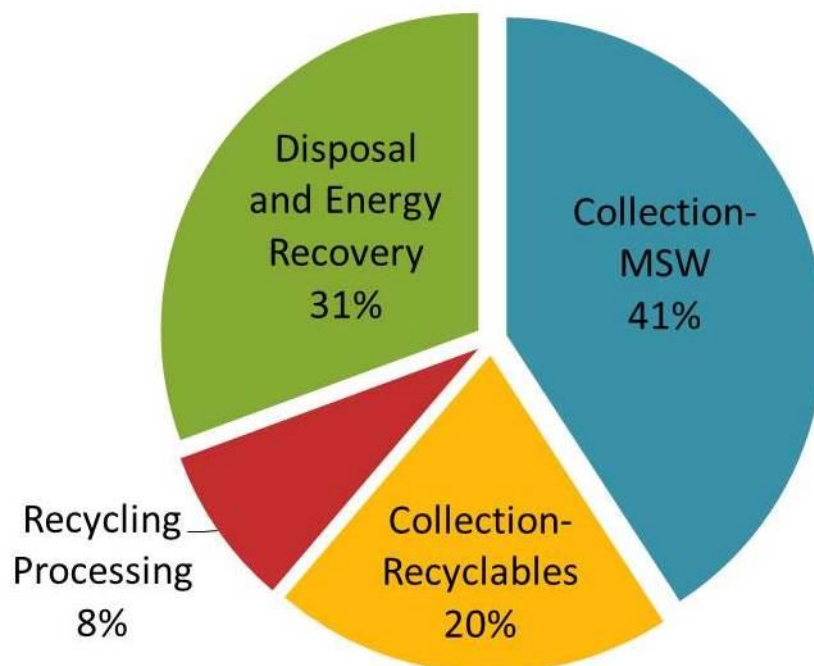
<sup>19</sup> More States Ban Organic Waste in Landfills-by Mark Henricks, January 2014, American Recycler News, Inc.

<sup>20</sup> Governor Signs Historic Organic Waste Legislation (Press Release), September 2014- Californians Against Waste

waste as added to yard waste container or as a separate fraction.<sup>21</sup> Regardless of where one lives, basic service remains relatively consistent across the country. If there is a bin or cart, a service is required for collection and transfer of the material to the intended facility.

GBB has found that collection costs represent about two-thirds of waste management costs, while disposal and energy recovery-related costs (including transfer stations, materials recovery facilities, WTE facilities, and eventually landfills), represent only about one-third of the total costs. GBB's finding of the cost break down is represented in Figure 2-10.

**Figure 2-10**  
**Sharing of Solid Waste Costs, Collection versus Disposal**



The average cost at U.S. WTE plants was \$68 per ton in 2010, and average U.S. landfill costs were estimated at \$45 per ton in 2009.<sup>22</sup> Conversely, depending on the region, requirements, and scope of waste-related services, combined costs for all collection, disposal and energy recovery activities can range from \$100 per ton up to \$450 per ton in a municipality such as San Francisco.

## 2.4 Additional Trends

Alternative methods of handling, sorting and recovering MSW are being implemented in a number of locations. These strategies are seeking to address high costs and stalled recycling rates. A summary of these methods are below.

### 2.4.1 Single Bin Collection

<sup>21</sup> Residential Food Waste Collection In The U.S. BioCycle Nationwide Survey- Rhodes Yepsen, BioCycle March 2013, Vol. 54, No. 3, p. 23

<sup>22</sup> Van Haaren, R., Themilis, N. and Goldstein, N. "The State of Garbage in America [17<sup>th</sup> Nationwide Survey of MSW Management in the U.S.]", *Biocycle*, October 2010

Because collection costs can represent nearly two thirds of waste management expenditures, municipalities and private haulers are looking to reduce costs. One evolution from single-stream recycling has been to combine all trash and recyclables in a single bin. Then processing equipment, similar to what is used at single-stream MRFs, is used to recover recyclables. The food waste organics can go to an AD system and the non-recycled plastics and paper are used for energy recovery such as solid engineered fuel. The economics of this type of one-bin system are attractive. Yet, this concept has proven controversial. Contamination of recyclables processed at single-stream MRFs is already a challenge for recyclers, and there is a greater possibility of contamination when all materials are co-mingled with the rest of the garbage in a single bin.

There are several large communities in the United States that have already implemented single-bin systems, or are considering opening a MWPF. Most of these communities have kept, or will keep, their existing separate collection for yard waste. As examples, the Infinitus facility has recently begun operating in Montgomery, Alabama. The City of Indianapolis, Indiana, recently approved a contract with Covanta to build a MWPF to recover recyclables before sending the waste to Covanta's existing WTE facility. Indianapolis has an existing subscription curbside recycling program that is estimated to serve just 10 percent of the City's households.<sup>23</sup> The subscription recycling service will remain available when the MWPF opens. The City of Houston, Texas has been evaluating proposals for what they are calling "one-bin-for-all." The common link between the Montgomery, Indianapolis, and Houston programs is that none of these cities has had an extensive curbside recycling collection program, which means there are many recyclables in the MSW that could be recovered, but are currently being sent to landfill or a WTE plant.

#### **2.4.2 Separation of Wet and Dry**

Another concept to maximize diversion that is drawing increasing interest is the separation of wet organic trash, such as food waste, from the remainder of the "dry" waste stream. The wet residue is converted to energy through AD or it can be composted with yard waste. In theory, recyclables that are separated from the dry waste will have less contamination. Some municipalities use two bins for this system. Others may use a single bin with different colored bags to indicate the type of material.

Guelph, Ontario, Canada, was one of the first regions to implement a two bin wet/dry system in the mid-1990s.<sup>24</sup> Participation was high, but over time the facility that handled the material fell into disrepair with structural problems and odor complaints, and was closed in 2006.<sup>25,26</sup> A newly designed replacement facility was opened in September 2011.<sup>27</sup>

The wet/dry system for commercial waste at Newby Island in Milpitas, California, is also accepting two unique streams from the City of San Jose. The results have been mixed. The unique streams are sometimes difficult to tell apart and wet and dry can end up co-mingled in both processing lines. The quality of the wet stream is best when collected from restaurants and food markets. Dry collections are best from other businesses and office spaces. After processing, the wet organic waste is diverted to the Zero Waste San Jose AD facility. The dry waste is sorted for recyclable paper and plastic containers.

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<sup>23</sup> Article: City Board Approves Recycling Deal with Covanta by Kathleen McLaughlin, Indianapolis Business Journal, August 6, 2014.

<sup>24</sup> Alexander N. Themelis, Research Associate, Earth Engineering Center, Columbia University, The City of Guelph Wet-Dry Recycling Center – 2000

<sup>25</sup> Article: East-end Residents Hold Their Noses over Organics Plan, Guelph Mercury News, Nov. 25, 2011

<sup>26</sup> Article: Something Rotten in the Green Bin, by Magda Konieczna, Maclean's, December 11, 2006

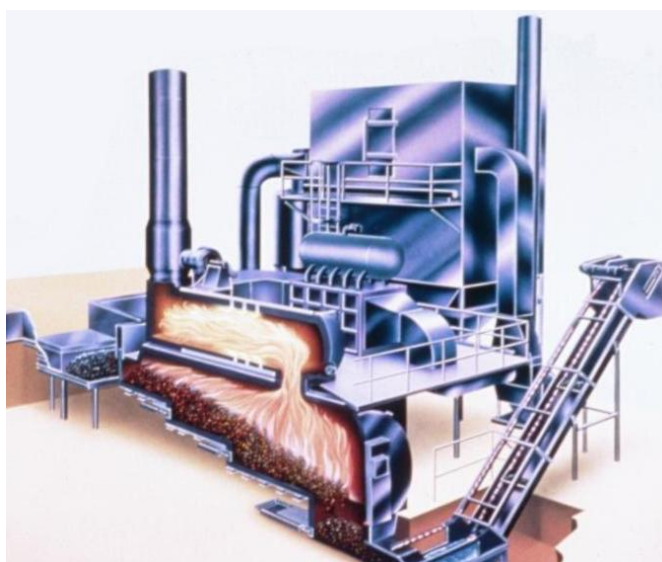
<sup>27</sup> Article: New organic waste facility opens in Guelph, Ontario Daily News, Oct 3, 2011.

The City of Louisville, Kentucky, has a new one-bin system for downtown that started in the summer of 2014. All trash and recyclables are placed in one orange bin, with black bags used exclusively for wet trash and clear bags for dry.<sup>28</sup> The success of the Louisville program has not yet been determined.

### 2.4.3 Energy Recovery/Gasification

Gasification of MSW with modular controlled air systems began in the early 1960s. The “controlled air” incinerators were typically installed as waste volume reduction units without energy generation. The combustion off-gases that were generated in the main chamber were consumed in a secondary chamber. The secondary chamber contained an additional chamber burner that combusted the gas prior to release in the atmosphere. An example of the early two-chamber gasifier is shown in Figure 2-11.

**Figure 2-11**  
**Example of Controlled Air Gasifier-Type System**



Source: Consutech Systems LLC

With increased energy costs in the late 1970s, these units were integrated with waste-heat boilers and converted from incineration units into modular WTE units. Many of these early gasification units are still functioning today. Gasification to chemicals and fuels is being explored today as an alternative to combustion or landfilling. Most of the large gasification plants being built or operating require the MSW to be pre-processed into RDF with low moisture content and with inerts such as glass, metals, and ceramics removed.

GBB has documented more than 100 companies from around the world that are active in the marketing and/or manufacturing of gasification technologies. A report prepared for the American Chemistry Council was released in 2013. The report provides a specific review of the current state of the gasification technologies for MSW and non-recycled plastics.<sup>29</sup>

### 2.4.4 Evolution of MRFs

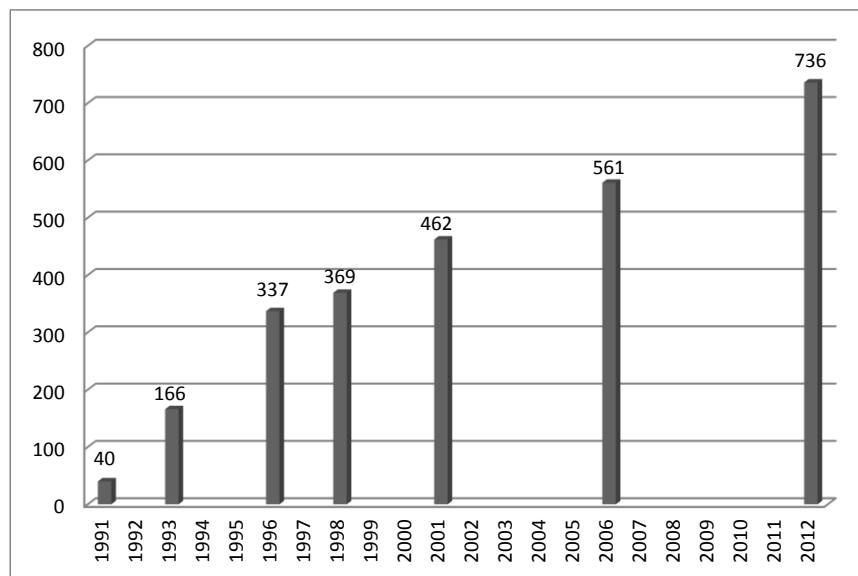
<sup>28</sup> Article: Louisville Introduces “Wet-Dry Recycling” Program, by Kelsey Pekare, The Trash Times, October 14, 2014

<sup>29</sup> Gershman, Brickner & Bratton, Inc. Report for The American Chemistry Council, Gasification of Non-Recycled Plastics From Municipal Solid Waste In the United States, September, 2013

A major trend over the last 20 years has been the evolution of recycling facilities from small scale drop-off centers to large regional MRFs. Initially, Intermediate Processing Facilities (IPFs) replaced drop-off centers and dual-stream MRFs complemented the IPFs. Eventually, many older, less sophisticated, dual-stream MRFs yielded to larger, regional single-stream MRFs. This is the system the U.S. mainly has today. Together, Waste Management Inc. and ReCommunity operate more than 72 large, single stream MRFs. On average, these MRFs operate 16 to 20 hours per day, and larger MRFs can process up to 15,000 tons per month.

In 1991, Governmental Advisory Associates, Inc. (GAA) identified 40 MRFs in the United States<sup>30</sup> including two MRFs that were constructed in 1975. In 2006, the number of MRFs operating was estimated to be 552.<sup>31</sup> In 2012, the number was estimated to be 736.<sup>32</sup> GAA's estimates of the operating MRFs, by year, from 1991 to 2012 are shown in Figure 2-12.

**Figure 2-12**  
**Operating MRFs in the US, by Year (1991-2012)<sup>33</sup>**



Due to the nature of the residential separation activities, and much cleaner waste constituents than “trash,” these early MRFs were labor intensive, with human sorters pulling designated materials off conveyor belts as the commodities sped past their sorting stations. Different classifications of paper, such as Old Newspaper (ONP), Old Corrugated Containers (OCC) and Office Paper (OP), were each sorted at the majority of sites. Glass was color sorted by hand, into clear, brown, and green. Hand-sorters were used to recover combined high density polyethylene (HPDE) and polyethylene terephthalate (PET). Magnets usually pulled out the ferrous metals. Aluminum cans were hand sorted.

Concerns about the quality of recyclables that were derived from single-stream systems were prevalent 20 years ago and continue to this day. However, the initial skepticism of quality eventually gave way to many conversions to single-stream systems. The earliest MRFs were mainly manual sorting systems

<sup>30</sup> Governmental Advisory Associates, Inc. Article: Up with MRF's, Resource Recycling Magazine, July 2013

<sup>31</sup> Ibid p.16

<sup>32</sup> Ibid p.16

<sup>33</sup> Ibid p.16



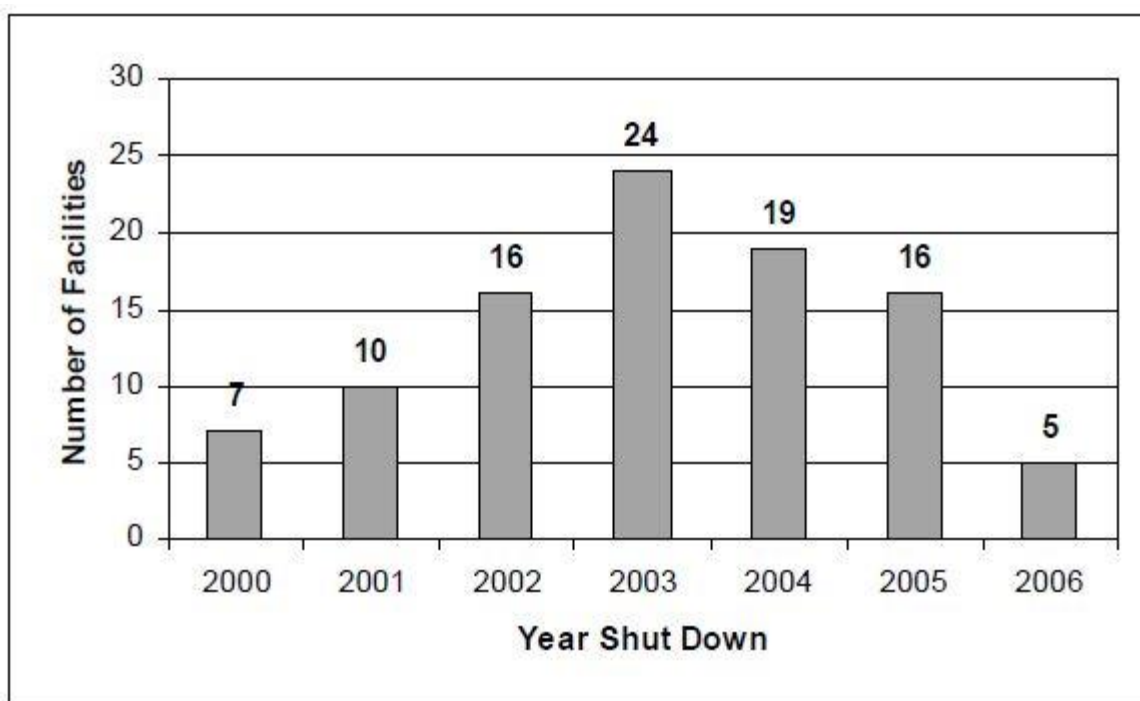
alongside numerous picking belt conveyors. A few vibrating feeders and magnets for ferrous removal were common. PET and HDPE sortation increased as new technologies for screening, air separation, magnetic and optical sorting was developed and commercialized.

The success of statewide recycling goals and other administrative regulations to encourage recycling has continued to drive MRF implementations. Many developers and equipment companies started to promote newer, larger, and more cost-effective MRFs. As consumers demanded more recycled content in their packaging and products, municipalities, MRFs and others expanded their programs to accept more types of materials.

The scale of single-stream MRFs has also increased. GAA reports the average MRF throughput in 2001 was 129 tons per day (TPD), whereas MRFs built after 2007 (mainly single stream), average a throughput of 214 TPD.<sup>34</sup>

In 2006, there were 561 MRFs operating.<sup>35</sup> However, from 2000 through 2006 approximately 100 MRFs were shut down.<sup>36</sup> Figure 2-13 shows the number of MRFs that were shut down each year.

**Figure 2-13**  
**MRFs that Ceased Operations, by Year<sup>37</sup>**



Many of these early MRFs ceased operating because the plants were upgraded or even replaced, or because larger plants replaced the smaller ones.<sup>38</sup> However, there was not a net reduction in throughput capacity as a result of these shutdowns. Even today, the MRF industry continues to see a certain level of consolidation. Centrally located, large, single-stream MRFs replace the older and smaller MRFs.

<sup>34</sup> Governmental Advisory Associates, Inc., Article: Up with MRF's, Resource Recycling Magazine, July 2013

<sup>35</sup> Ibid, p. 16

<sup>36</sup> Berenyi 2007-2008, op. cit., p. 6

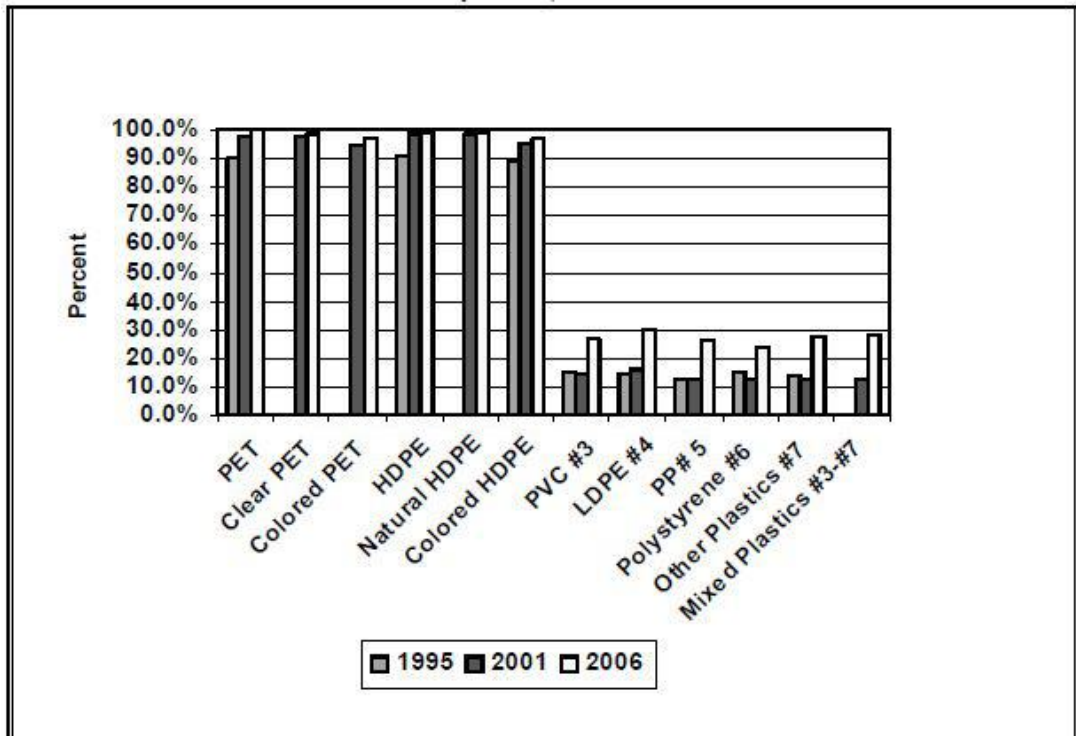
<sup>37</sup> Ibid.

<sup>38</sup> Berenyi 2007-2008, op. cit., p. 6.



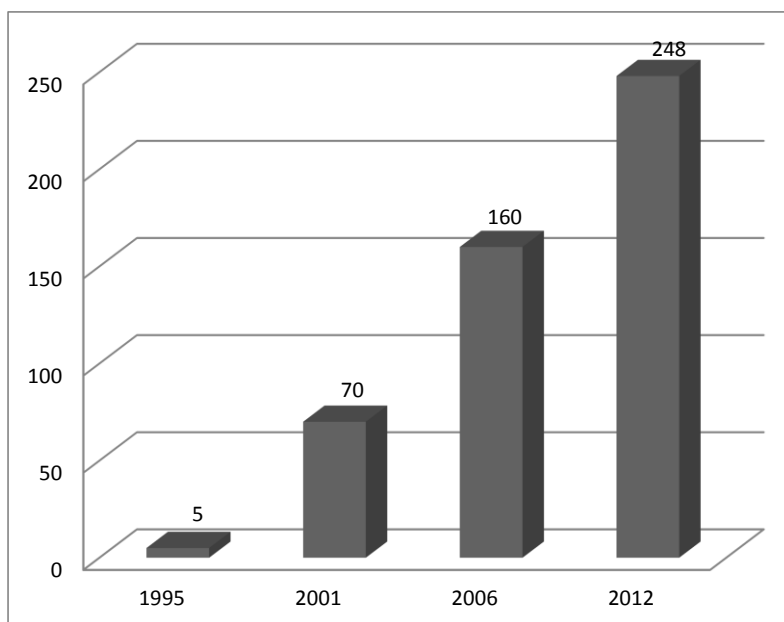
As a result of strong and growing markets for HDPE and PET plastics, MRFs in the early 1990s began to extract plastics from mixed recyclable streams. Figure 2-14 depicts the expansion of MRFs to include other types of plastics beyond PET and HDPE over this 10 year expansion period from 1995 through 2006.

**Figure 2-14**  
**Percentage of MRF Facilities Incorporating Plastics Recovery<sup>39</sup>**



<sup>39</sup> Berenyi 2007-2008, op. cit., p. 24

**Figure 2-15**  
**Number of Single Stream MRFs by Year, 1995-2012<sup>40</sup>**



It is important to note that concerns about material quality are real and continue to challenge the recycling industry. Waste Management Inc. and ReCommunity Recycling through an “Inbound Quality Alert” memo<sup>41</sup> in 2014 publicly voiced their concerns about the deteriorating quality of MRF feedstock. The CEO of Waste Management has noted that some of its facilities have seen MRF residue rates as high as 40 percent, and in its second quarter earnings report of 2014 specifically noted that the company is trying to improve its enforcement of restrictions on contaminated loads of delivered recyclables because of the significant difference in value for contaminated and uncontaminated materials.<sup>42</sup>

Single stream recycling has been successful, but rates have recently plateaued, penetration to multi-family residences and businesses continues to be poor, and contamination rates overall continue to be high. Adding MWPF to a community with an existing single stream system could significantly increase the recycling rate as multi-family, business, and household waste is sorted for recyclables. The opportunity to increase recycling rates is explored in Section 5.

If the contract with the city is structured to allow it, routing MRF residue to the MWPF would allow for the reprocessing and potential recovery of more recyclables. The MWPF could also be the consolidation point for all the non-recovered material output streams which improves efficiency. This way the MRF can still recover high quality recyclables while the MWPF would recover additional recyclables of an adequate quality. This integration would provide additional recovery and additional revenues, and would also increase diversion rates from landfills.

<sup>40</sup> Government Advisory Associates, Inc. Article: Up with MRF’s, *Resource Recycling Magazine*, July 2013

<sup>41</sup> Bobby Elliott, ReCommunity Says Recycling Quality Must Improve, *Resource Recycling Magazine*, Aug. 27, 2014

<sup>42</sup> Waste Management Announces Second Quarter Earnings, Press Release of July 29, 2014, p. 1.

### 3 History of Mixed Waste Processing Facilities and Processing

#### 3.1 The Development and Definition of “Mixed Waste Processing Facilities”

The Solid Waste Disposal Act of 1965 offered financial and technical assistance to state and local governments for solid waste management research and planning. The assistance contributed to the construction of several MWPFs. A continuum of options was considered, with separation of recyclables from waste by consumers and households at one end, and commingling of waste and separation at a centralized facility at the other end. The early MWPFs represented the first attempt at centralized recyclable extraction. An example of technology still in use today was described at the 1970 National Waste Utilization Symposium. It explored the use of air to recover waste paper from MSW.<sup>43</sup>

The National Center for Resource Recovery (NCRR) was founded in the early 1970s. Its services included research, development, and evaluation of existing and emerging technology and technical assistance programs.<sup>44</sup> One concentration included strategies to recover and reuse materials within household refuse. Figure 3-1 is a schematic of the NCRR Recovery 1 full scale demonstration facility built in the 1970s. It was located in New Orleans, Louisiana. This early version of a MWPF included a full array of processing equipment including grinders, a trommel screen, air classifiers, and ferrous and aluminum separation. It also produced RDF. However the RDF was landfilled because there were no customers for the fuel. After three years of operation, Recovery 1 was closed.

One of the first MSW processing plants was built and operated by The Black Clawson Company in Franklin, Ohio. They started researching how to integrate their pulp and paper technology to the processing of solid waste in 1967.<sup>45</sup> Ultimately, they constructed a 150 TPD MWPF that operated 24 hours per day to recover ferrous, glass, aluminum, and all fibers. A flow sheet of that plant is provided as Figure 3-2. This facility became the prototype for several larger proposed systems.

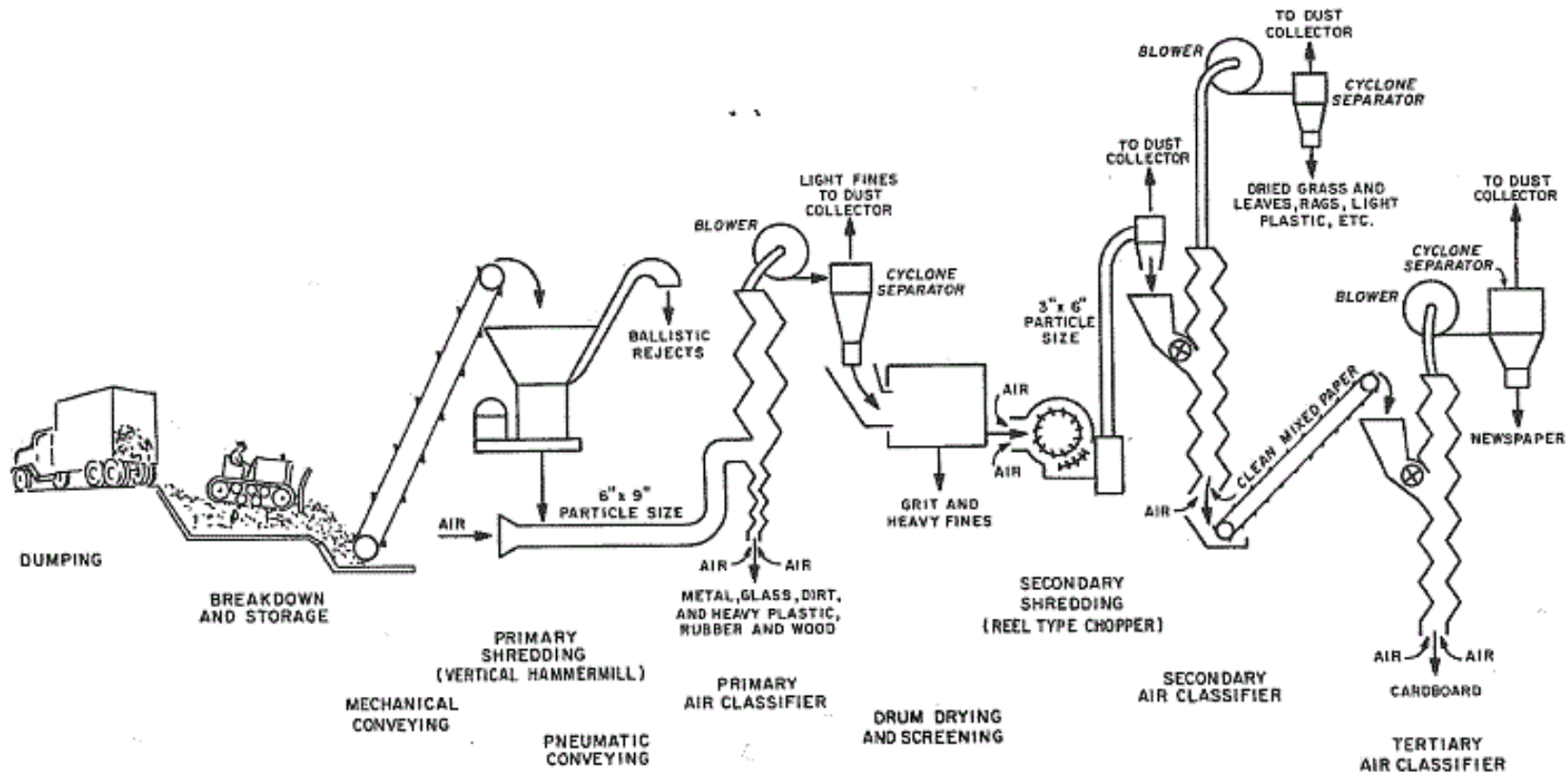
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<sup>43</sup> Richard Boettcher, Program Manager for Solid Waste Technology, Air Classification for Reclamation of Solid Waste, March 1970

<sup>44</sup> Dr. Richard Leshner, NCRR, Washington D.C. Waste Utilization Symposium in Chicago, March 1972

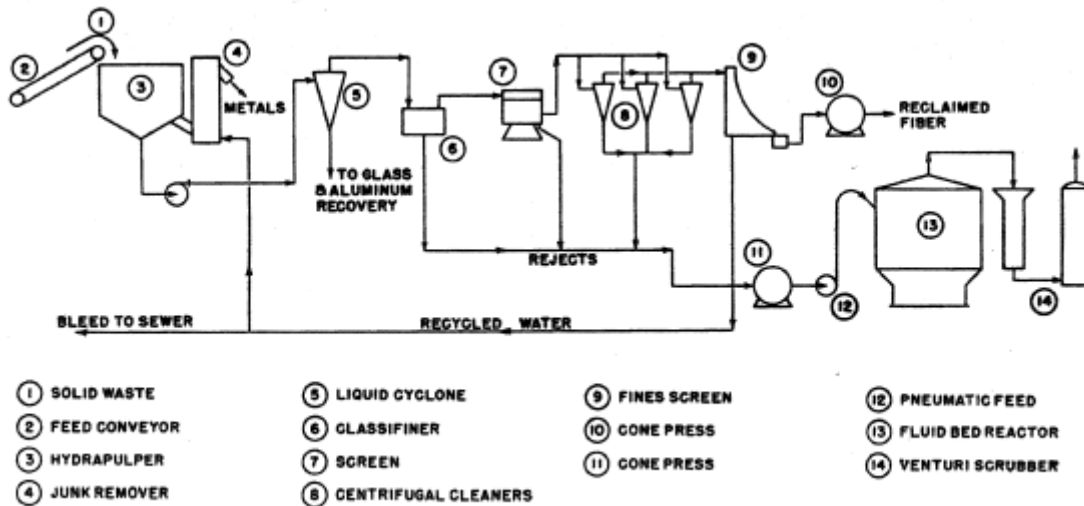
<sup>45</sup> William Herbert of Black Clawson Company Middletown Ohio, Waste Utilization Symposium in Chicago, March 1972.

Figure 3-1  
Schematic Flow Diagram of Air-Classification Process for Wastepaper Recovery from Municipal Refuse<sup>46</sup>



<sup>46</sup> Richard A. Boettcher, Air Classification for Reclamation of Solid Waste, Proceedings of the Second Mineral Waste Utilization Symposium, Chicago, March 1970, p.273.

Figure 3-2  
Flow Sheet – Solid Waste Plant – Franklin, Ohio<sup>47</sup>



The aluminum can industry was also active in the early 1970s.<sup>48</sup> The first aluminum can reclamation program was conducted in Miami, Florida in 1957. However, the initial processing for aluminum recovery from MSW wasn't done until 1971.<sup>49</sup> This process used a liquid-based heavy media separation system to float off the lighter aluminum fraction from the concentrated heavies after the MSW was shredded, air classified and magnetically separated.

The need for energy recovery outlets for the energy rich residue from MSW processing was apparent from the early days of MWP development. In the early days of MWP technology, recyclables had less value, so energy recovery was actually the primary driver. In the early 1970s, the EPA explored the potential for co-combusting processed municipal refuse with coal in utility boilers and partially funded a MWP facility in St. Louis.<sup>50</sup> The dual benefits of waste disposal and energy generation were attractive. St. Louis, Missouri, was selected as the site for the demonstration plant. It was named the St. Louis-Union Electric Refuse Fuel Project. This 300-TPD facility began producing RDF in April 1972.<sup>51</sup> Figure 3-3 provides a flow diagram of the process. Co-combusting RDF with coal was expected to yield emissions benefits because the RDF contained 10 percent of the sulfur and 40 percent of the nitrogen content of coal.

<sup>47</sup> Ibid. p. 309

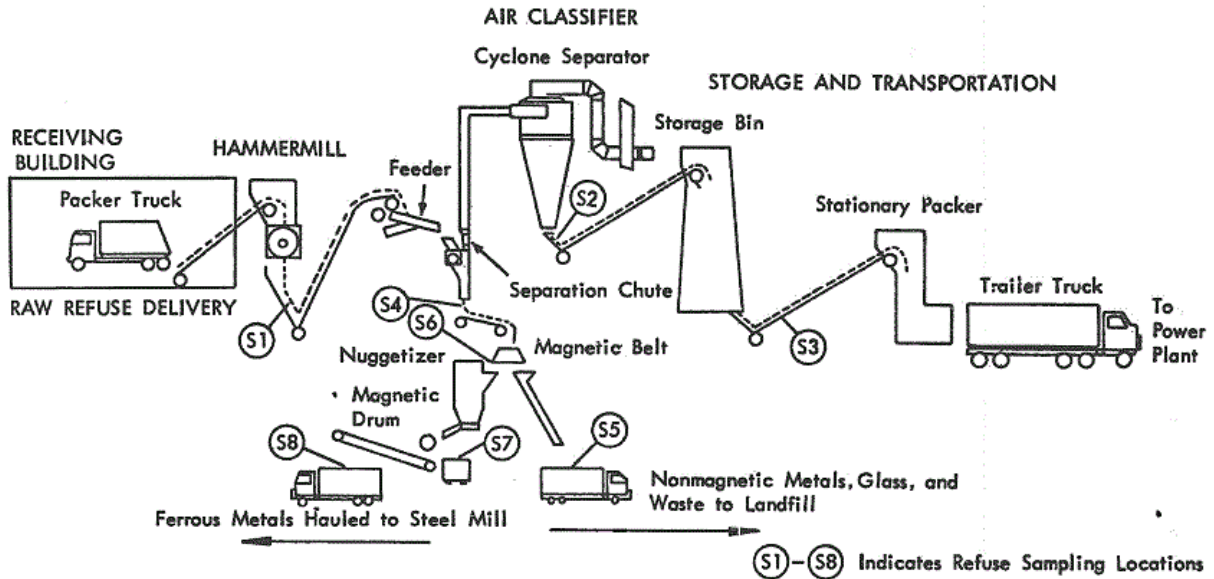
<sup>48</sup> G.F Bourcier, K.H.Dale, and R.F.Testin of Reynolds Metal Company Richmond VA, Recovery of Aluminum from Solid Waste, Waste Utilization Symposium in Chicago, March 1972, p. 346.

<sup>49</sup> Ibid

<sup>50</sup> Stuart H. Russell, Thermo Electron Energy Systems, Solid Waste Preprocessing: The Return of an Alternative to Mass Burn. National Waste Processing Conference, 1988, p. 73.

<sup>51</sup> Douglas Fiscus and Paul Gorman Midwest Research Institute and James D. Kilgore, EPA, Refuse Processing Plant Equipment, Facilities, and Environmental Considerations at the St. Louis-Union Electric Refuse Fuel Project, Research Triangle Park, NC, Proceedings of the 1976 National Waste Processing Conference Boston, 1976,P. 373.

**Figure 3-3**  
**Flow Diagram of Processing Plant and Refuse Sampling Locations**<sup>52</sup>

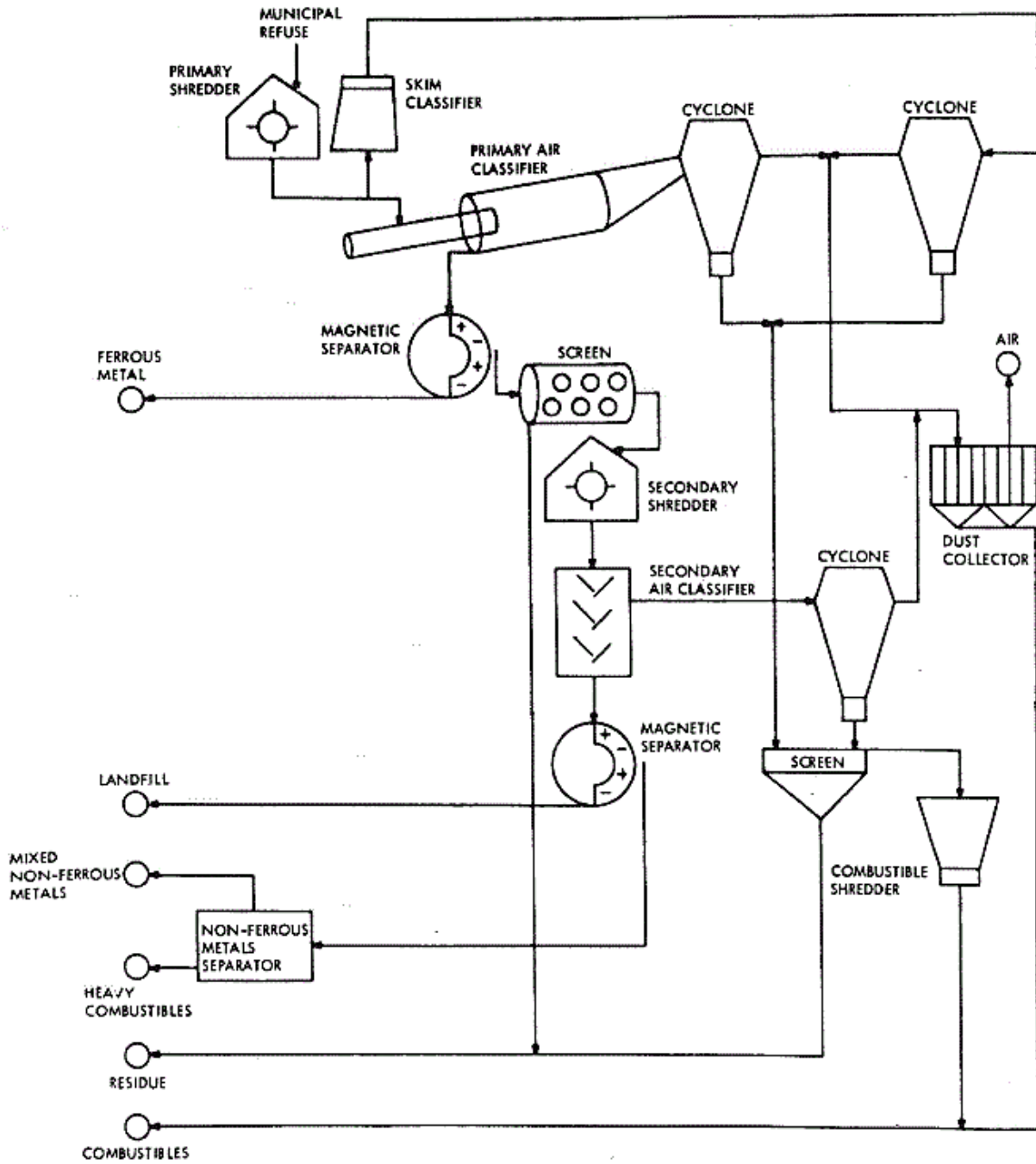


This system operated for about three years and served as the first performance benchmark for processing MSW to recover recyclable metals. Ultimately, the RDF was not clean enough for the utility boilers and the demonstration facility was abandoned. Many of the ensuing RDF production systems in the mid-to-late 1970s applied the lessons published from the St. Louis project. Design improvements included generating a higher quality RDF and recovering additional recyclable materials. The Monroe County facility in Rochester, New York, was one of the most comprehensive systems built in the mid-1970s. It was designed to process 2,000 TPD and convert roughly 60 percent of the incoming MSW into RDF. The RDF would be used at Rochester Gas and Electric's (RG&E) coal fired boilers.<sup>53</sup> As can be seen in Figures 3-4 and 3-5, this particular MWPF included additional light and heavy ferrous and non-ferrous metals along with glass and a sand-like fraction.

<sup>52</sup> Ibid., p. 375.

<sup>53</sup> David B. Spencer, Raytheon Service Company, Burlington, MA, Solid Waste Resource Recovery Facility Monroe County New York, Proceedings of the May 1976 National Waste Processing Conference, Boston, p.409.

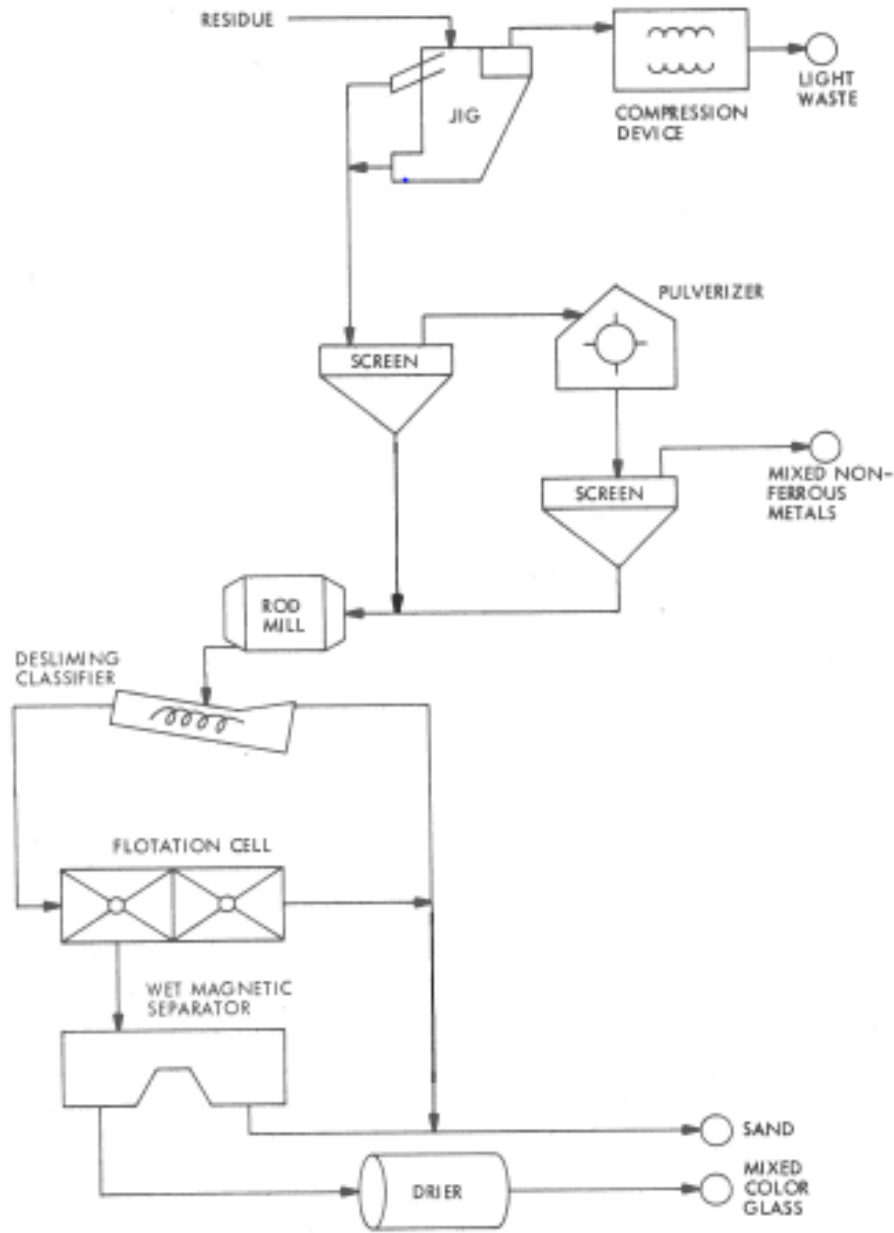
Figure 3-4  
 Monroe County (New York) Facility Baseline Waste Process Flow<sup>54</sup>



<sup>54</sup> Ibid, p. 418



Figure 3-5  
Monroe County, NY Residue Recovery System<sup>55</sup>



<sup>55</sup> Ibid, p. 420

This facility ultimately closed as a long-term market agreement for the RDF could not be finalized. While the energy content and pricing of the RDF was attractive, its usage created erosion and corrosion issues for the boilers.

Based on these learning experiences and specifications of the RDF that was produced from the MSW processing system, boiler manufacturers built dedicated boilers that could use RDF consistently. Some of these RDF-dedicated boiler systems have operated successfully for more than 20 years. Table 3-1 contains a list of currently operating facilities that use RDF.

**Table 3-1  
Representative Operational MWPF Locations -- Mainly Producing an RDF Product**

Location of Facility	Owner of MWPF	Year of Startup	Nominal Capacity,MSW	
			TPD	TPY
Detroit, MI	Detroit Edison Corporation	1991	4,000	850,000
Honolulu, HI	City & Co. of Honolulu	1990	2,000	610,000
Hartford, CT	CRRA	1988	2,850	725,000
Palm Beach County, FL	Palm Beach SWA	1989	2,000	624,000
Elk River, MN	Great River Energy	1991	1,500	300,000
LaCrosse County, WI	Excel Energy	1987	300	73,000
Newport, MN	RRT	1987	1,500	400,000
Portsmouth, VA	Wheelabrator	1987	2,000	600,000
Rochester, MA	SEMASS Partnership	1988	3,000	1,100,000
Niagara Falls, NY	Covanta	1980	2,250	800,000
Ames, IA	City of Ames	1975	200	50,000

Source: Gershman, Brickner & Bratton, Inc.

The primary purpose of these first generation MWPFs was to produce RDF. Many recyclables had low value at the time so recycling was an ancillary benefit. Some facilities later added upgrades to increase the recovery of certain recyclables. These early facilities were also built to reduce the demand for landfilling solid waste. In this period, landfilling was still very much a local function. The development of very large, regional landfills came in the late 1980s. The local “open dump” was under regulatory pressure to change or close and new sites were being sought with great difficulty. There was interest in developing alternatives that would divert significant amounts of MSW from land disposal. The idea to use RDF at existing utility plants was attractive since some regions also had coal-fired boilers near the same collections area as the landfills.

For example, the Solid Waste Authority of Palm Beach County in Florida adopted a regional landfill and closed multiple smaller landfills in the 1970s. Due to state legislation in the late 1980s, the Authority began a dual-stream collection and processing system and it also developed a new WTE facility that began operating in 1989.<sup>56</sup> The Authority operated separate residential and commercial MRFs that were

<sup>56</sup> Successful Modernization of the Solid Waste Authority’s (SWA) Palm Beach Waste to Energy Facility (PBREF 1), Bob Worobel, Project Manager of Solid Waste Authority of Palm Beach County, et. al., December 14, 2011, page 5.

consolidated to a single MRF in 2009. Construction on a new WTE facility began in 2012,<sup>57</sup> and the Authority continues to also process construction and demolition (C&D), yard waste, and biosolids to recover materials before landfilling.

In contrast to the facilities cited in Table 3-1, there were earlier MWPFs that were designed primarily to recover additional recyclables.

In the early 1990s, Government Advisory Associates, Inc. (GAA) published data identifying 35 MWPFs,<sup>58</sup> with 13 in operation, 3 under construction, several in shakedown, and the remainder closed. The GAA document noted that these plants were often referred to as “dirty MRFs,” however the origination of this phrase is not known. Table 3-2 presents a review of several MWPFs. This demonstrates that municipalities with and without curbside recycling programs constructed MWPFs to recover additional recyclables from their MSW. One of the largest systems was built by the City of Chicago and is privately operated. Medina County, Ohio’s MWPF began operating in 1993 and only recently in early 2015 suspended operation. Some of these original facilities recently have been upgraded with modern technology and equipment in order to source additional recyclables.

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<sup>57</sup> Solid Waste Authority of Palm Beach County Waste-to-Energy Project website accessed 03/23/2015-  
<http://www.swa-wteproject.com/about/>

<sup>58</sup> Berenyi 1992-1993, op. cit., p. 63.

**Table 3-2  
Representative MWPF Locations - Mainly Producing Recyclable Materials as Products**

Location of Facility	Owner of MWPF	Year of Startup	Current Status	Nominal Capacity,MSW		
				TPH	TPD	TPY
Chicago, IL (3 plants locations/2 lines per plant)	City of Chicago	1992	Operational	50 MSW per line (100 total)	1250-1500 each location	NA
Medina County, OH	Medina County	1993	Inactive	NA	400	125,000
City of Sunnyvale, CA (2 lines, w/one for MSW)	Waste Management	1994; upgraded in 2008	Operational	50 MSW	800	NA
City of Industry, CA (3 MSW lines)	Athens Disposal Co.	2002; upgraded in 2007	Operational	50 ea.	2,400	NA
Roseville, CA (2 infeed lines to 8 sort lines)	Western Placer Waste Management Authority	1995, upgraded in 2007	Operational	NA	2,000	NA
San Jose, CA (2 lines, w/one for MSW)	Green Waste Recovery/Zanker Road Resource Management Ltd.	2008	Operational	35-40 of MSW	1,400	up to 500,000
Milpitas, CA (4 lines: Organics, Wet & Dry Commercial, SS Commercial)	Republic Services	2012	Operational	110 Total	1,500 Est.	NA
Montgomery, AL	Infinitus (IREP)	May, 2014	Operational	30-35	300	up to 225,000
Hesperia, CA	Advance Disposal	May, 2014	Operational	50	Up to 1,500	NA
Glendale, AR	Vieste	Summer, 2014	Operational	40	NA	NA
Sun Valley, CA	Athens Disposal Co.	Fall, 2014	Operational	70	1,500	NA
Troy, VA	Van der Linde Recycling	2009, upgrade late 2014	Retrofit Under Construction	NA	NA	NA

NA - Not Available

Source: Gershman, Brickner & Bratton, Inc.

Several of the MWPFs listed in Table 3-2 were originally built as MRFs. Other sites were expanded or modified with the addition of a new processing line or equipment to accommodate the processing of MSW. Additionally, over a dozen large waste handling sites in California have integrated several different material receiving buildings onto one site, each with unique processing systems. For example, one site could include: (1) a conventional MRF, (2) a C&D processing/recovery system, (3) a yard waste receiving/processing area, and (4) a MWPF to process and sort out the additional MSW-based recyclables. In 2012, there were 60 plants around the U.S. that were listed as “hybrid facilities” with sorting from both MSW and a presorted recyclables stream.<sup>59</sup>

MWPFs are integrating many of the same types of automated equipment that have been used at MRFs. Along with savings on collection, these attractive cost attributes have heightened interest among cost-conscious municipalities, haulers, and the waste and recycling industry. The facilities in San Jose, California, and Montgomery, Alabama, best represent how MWPFs have evolved since the 1970s-era St. Louis and Monroe County facilities.

<sup>59</sup> Eileen Brettler Berenyi, What’s up with MRF’s, Resource Recycling Magazine, July 2013, p.19.

In 1989, the California legislature mandated a state recycling goal of 50 percent by the year 2000, and recently it voted to increase that mandate to 75 percent by the year 2020.<sup>60</sup> The City of San Jose had an existing single stream collection program and a MRF, yet it elected to build a MWPF to recover additional recyclables from the remaining MSW waste. The San Jose MWPF does not generate a fuel product. The facility in Milpitas, California (Newby Island) is specifically designed for commercial sector waste, while the Greenwaste facility in nearby San Jose is designed for processing residential waste.

A few other modern MWPFs are serving as secondary recyclable processing facilities, but the primary objective is to manufacture an engineered fuel. These systems in San Antonio, Philadelphia, and Edmonton are integrated with existing single stream processing and are shown in Table 3-3.

**Table 3-3  
Representative MWPF Locations – Currently Producing Both Recyclable Materials and Fuel Products**

<b>Location of Facility</b>	<b>Owner of MWPF</b>	<b>Year of Startup</b>	<b>Current Status</b>
Region of York, Ontario, Canada	Lakeside/Borealis Infrastructure (Dongara)	2009	Operational
San Antonio, TX	Waste Management	2012	Operational
Philadelphia, PA	Waste Management	2014	Operational
Edmonton, Alberta Canada	City of Edmonton	2014	Operational

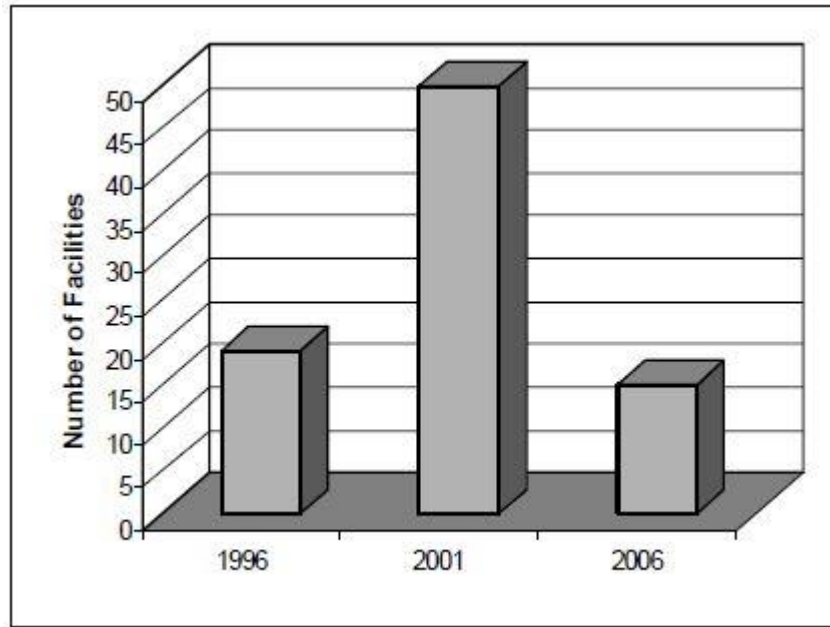
Source: Gershman, Brickner & Bratton, Inc.

### **3.3.1 Expansion of MRF Applications and Evolution to MSW Opportunities**

In the mid-1990s, a few local governments such as the City of Chicago and Waukesha, WI introduced the collection of mixed recyclables through blue bags. The blue bags system enabled a single truck to collect both trash bags and blue bags for separation and processing of mixed recyclables at MWPFs. As indicated in Figure 3-6, the number of facilities employing blue-bag collection rose and then fell from the mid-1990s through the mid-2000s. Recovery rates proved to be low and the cost to separate the bags from the trash proved to be prohibitive.

<sup>60</sup> California Bill AB 939, 1989, Author: Sher – Subject: The California Integrated Waste Management Act of 1989 (IWMA)

**Figure 3-6**  
**Number of Facilities Processing Blue Bag Recyclables<sup>61</sup>**

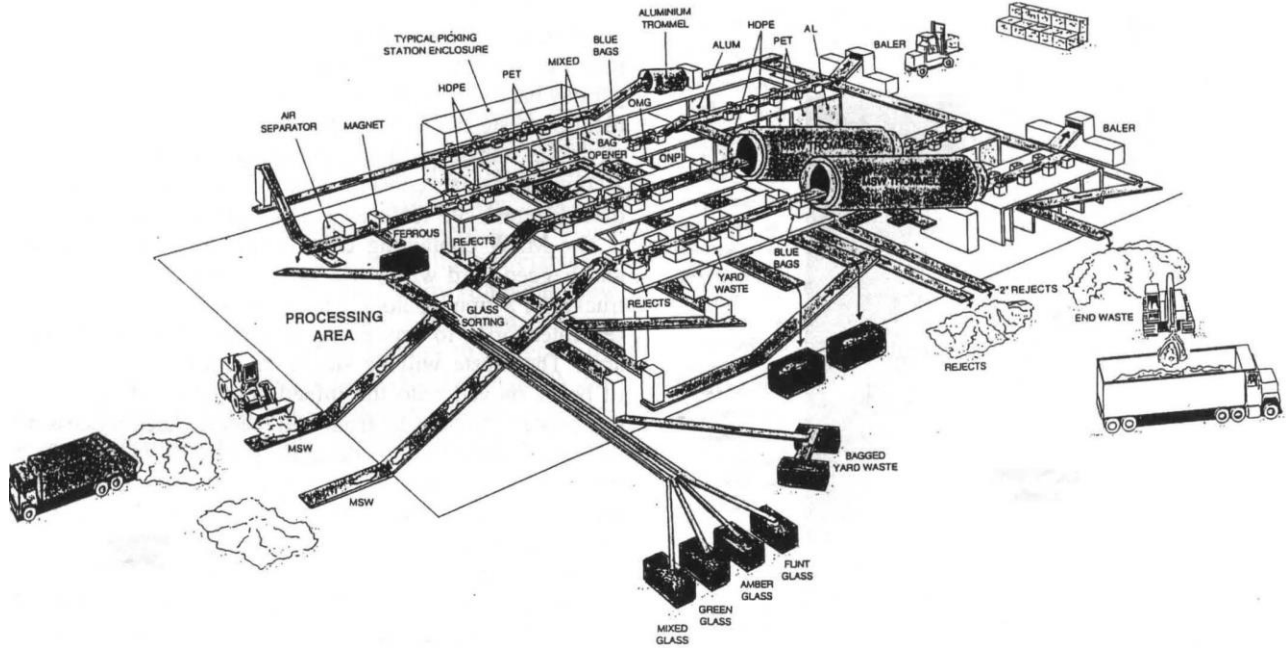


The largest blue-bag program was the City of Chicago’s three-facility system noted in Table 3-2. At each of these 1,000-plus TPD plants, blue bags were pulled out of the trash and separately processed for marketable recyclables. The remainder was transferred to landfills for disposal. The impetus for this concept was to save on the costs of a separate curbside recycling collection program. As noted in Figure 3-7, almost 50 facilities were processing blue bags at their peak in 2001. However, because recovery rates were low, only 13 plants remained by 2006 as most communities preferred using a separate collection system for recyclables and hauling to a MRF to process the source-separated recyclables.

The steady growth of single stream MRFs and the rising value of recycled plastics contributed to the growing sophistication of processing equipment. The use of front-end processing equipment has roots dating back to the 1980s. The Monroe County, New York, facility split the MSW into various light and heavy fraction streams using both screens and air systems. One of the early 1990s Chicago MWPFs is illustrated in Figure 3-7. This Figure depicts the different processing equipment used and materials that were targeted by the facility and illustrates the complexity of the system. This concept is similar to many modern MWPF front-end lines and is fully integrated with the downstream technology and sorters. This setup is very similar to the equipment found at modern MRFs.

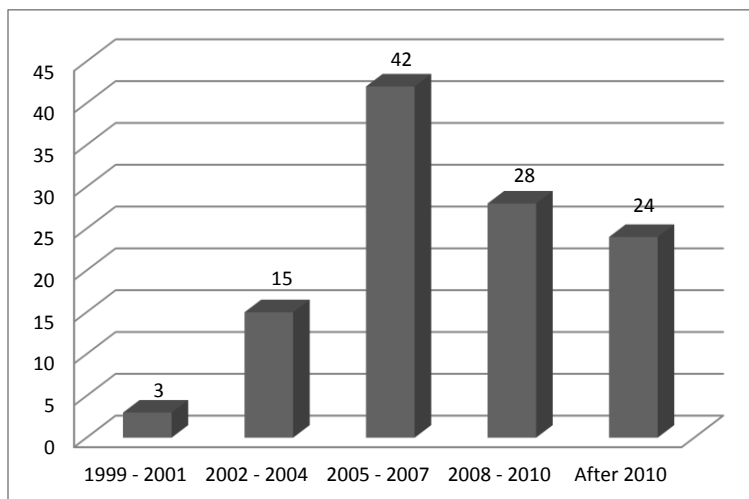
<sup>61</sup> Berenyi 2007-2008, op. cit., p. 29.

**Figure 3-7**  
**Conceptual Layout for MWPF (Medill Ave, Chicago), 1994<sup>62</sup>**



One of the most sophisticated equipment components of the modern MRF and MWPF systems are the optical sorter units. These units use light or near infrared (NIR) light to detect certain types of constituents in the material stream. NIR optical units are able to detect and distinguish #1 through #7 plastic with a high degree of accuracy. Figure 3-8 demonstrates the penetration of optical sorters in single stream MRFs. This accuracy and ability to quickly sort containers means a single optical unit can replace multiple manual sorters. Sophisticated optical sortation at large throughput facilities is indispensable for sorting plastic containers found in single stream material.

**Figure 3-8**  
**MRF Installations with Optical Sorters, by Year Installed<sup>63</sup>**



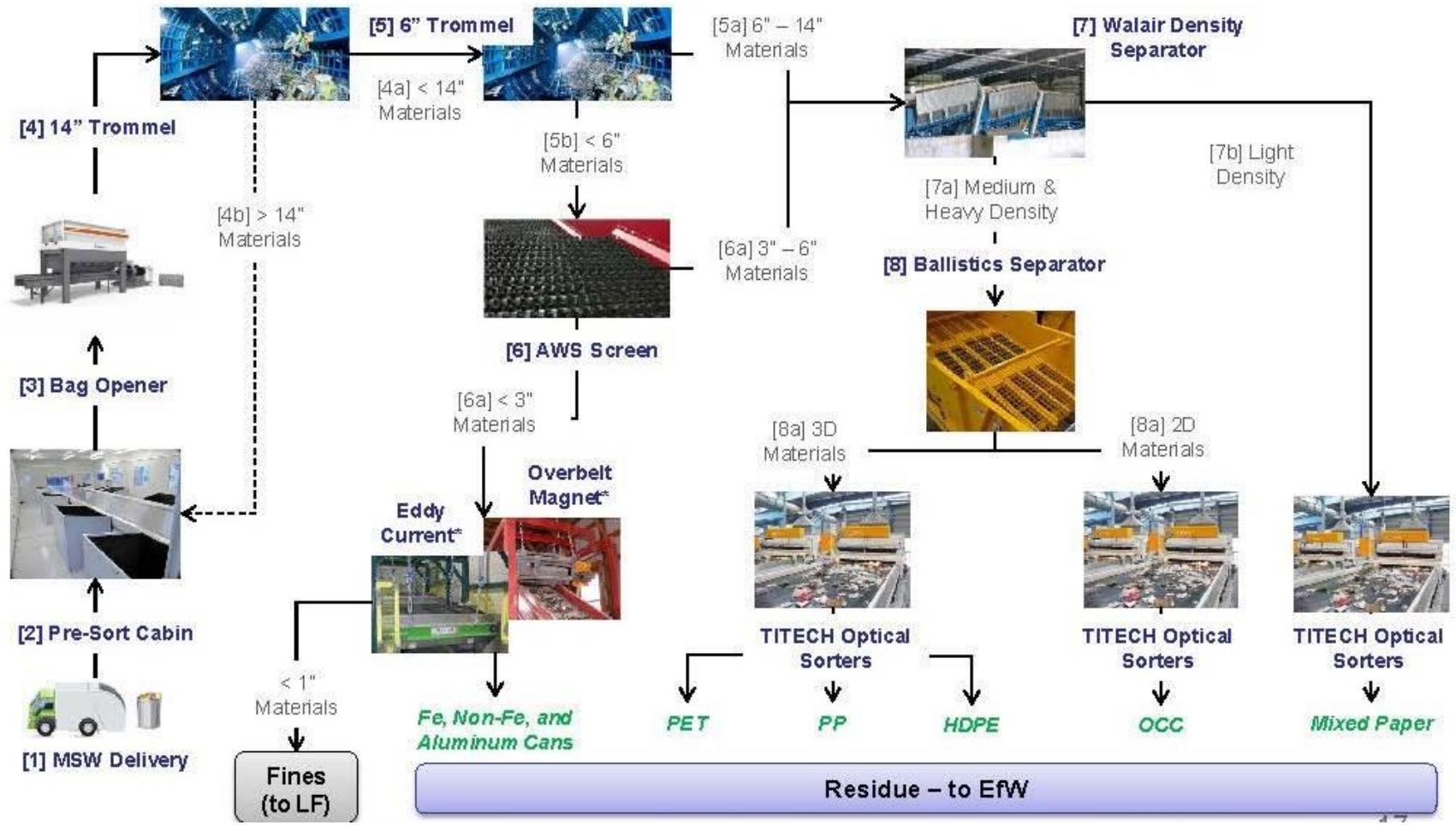
<sup>62</sup> Stuart H. Russell, Integrating Recycling with MSW Processing and Transfer in a Large Urban Area, National Waste Processing Conference Proceedings, ASME, 1994

<sup>63</sup> Government Advisory Associates, Inc. Article: Up with MRF's, Resource Recycling Magazine, July 2013, p.20.



Modern MWPFs incorporate different equipment and technology to sort and separate the materials, although most have similar objectives in handling the MSW stream. Nearly all modern designs have a pre-sort to eliminate bulky or prohibitive materials, a method to open bags, and screens to remove fine materials. Nearly all incorporate Eddy Current Separators (ECS) and magnets to recover metals. More automated facilities also have a density separator to remove heavy objects, and a 2D/3D separator to split flat items, such as paper, from those with shape, such as containers. The most sophisticated plants then incorporate NIR optical units to recover recyclables from these split streams. Figure 3-9 is a representative flow diagram of a typical modern MWPF and some of the equipment that is used to recover the materials.

**Figure 3-9**  
**Process Flow Diagram and Equipment for MWPF<sup>64</sup>**



<sup>64</sup> Scott Holkeboer, Covanta Energy, Inc. - Presentation to Recycling Committee, Metropolitan Washington Council of Governments, December 4, 2014.

## 4 Materials Recovery at Today's MWPF

### 4.1 Recovery of Materials: Dirty MRF to MWPF

The terms “dirty MRF” and “mixed waste processing facility” are still being used interchangeably. Historically, the phrase “dirty MRF” had been used to emphasize the contamination inherent in MSW feedstock. However, the processing or pulling of materials from trash has also created the image of a “dirty” work environment. The phrase is now used as a pejorative.

The phrase “mixed waste processing facility” is a better description of the evolution of these facilities. A MWPF can be designed to accept and process co-mingled recyclables (if a single-stream collection system exists and the MSW stream itself). Many national manufacturers of separation equipment are recognizing the potential opportunities of MWPF systems and tout their MSW experience in their marketing materials.

**Figure 4-1**  
Newby Island Resource Recovery Park in Milpitas, California



Source: Bulk Handling Systems

### 4.2 Outlook for Plastics Recovery at MWPFs

For areas with curbside recycling processed at a MRF, the assumption may be only mixed waste remains as many recyclables have been pre-sorted. Thanks, in part, to light weighting, recycling rates for certain plastics have seemingly plateaued. Two examples are PET and HDPE containers, which are easily recyclable and both have high value. Yet nationally, while more bottles and containers are being

collected, HDPE and PET recycling rates have been at roughly 30 percent for several years now.<sup>65</sup> This is despite high investment in efforts to incentivize more collection. As a result, up to 70 percent of a valuable recyclable commodity is being landfilled or processed through traditional mass burn waste-to-energy.

Table 4-1 shows the EPA estimates of the top four plastic resins made into bottles and containers and the estimated level of recovery for those individual resins. In 2012, approximately 30 percent of all the PET and natural HDPE containers were recycled. The last column of Table 4-1 shows the estimated weight of bottles that are discarded and not recycled each year.

**Table 4-1  
2012 EPA Estimates of Plastic Bottle Recovery, by Resin Type<sup>66</sup>**

<b>Material</b>	<b>Generated (Millions of Tons)</b>	<b>Recovery (Millions of Tons)</b>	<b>Percent of Recovery</b>	<b>Discards (Millions of Tons)</b>
PET	2.79	0.86	30.8%	1.93
HDPE- Natural	0.78	0.22	28.2%	0.56
HDPE-Colored	1.41	0.29	20.6%	1.12
PP	0.28	0.02	7.1%	0.26
<b>Totals</b>	<b>5.26</b>	<b>1.39</b>	<b>26%</b>	<b>3.87</b>

However, challenges and tradeoffs remain in recovering the other 70 percent. For plastics recovery, mixed waste processing offers an opportunity to achieve higher recycling rates, but with possible tradeoffs in material quality and value. Potential impact on public perception is another potential trade-off. Individual operators need to determine their breakeven point where the incremental cost of handling additional volume and potentially lower value from contamination would be adequately offset by higher revenues from greater volumes of high value materials. Both the recycling industry and policy makers will need to assess the perceptions of the public and whether people are satisfied that MWP satisfies the environmental drivers that are the foundations of public support for recycling.

One challenge to recycling more plastics containers at a MWPF is many still contain liquid. Most of these end up with the heavy stream from air classification or in the default residue because they were not ejected. Optical units have difficulty identifying containers with liquid as the infrared light is absorbed without reflecting. Even if identified, the air blast may not be strong enough to eject the heavier liquid-filled container. When MWPF equipment vendors tout plastic container recovery rates that are frequently higher than 80 percent,<sup>67</sup> they may be referring to the percentage of “recoverable” containers. This is especially true when referring to performance testing recovery numbers. Recoverable plastics exclude containers with too much liquid, covered in a label, all black, or are not a container. Therefore the actual total recovery percentage may be lower than advertised, and is dependent on the quality of the containers in the stream.

<sup>65</sup> EPA – Economic Data and Indicators Scoping Analysis - Office of Resource Conservation and Recovery, Page 14 Figure 11, December 2013

<sup>66</sup> EPA 2012 MSW Tables, Table 7, pages 8-9.

<sup>67</sup> SWANA webinar, July 23, 2014. Title: Mixed Waste Processing: What Does It Offer? Presenters: Karl Hufnagel, PE, Civil Engr. – Brown and Caldwell; Eric Winkler, Sales – Bulk Handling Systems

Hypothetically, if all of the MSW material that is currently being directly discarded could be processed at highly automated MWPFs with optical units, greater amounts of containers could be recovered. As stated before, many of the current MWPFs with optical units are touting recovery rates above 80 percent. However, there is little to no public data to confirm or verify these claims. Most are also claiming that they get “hi-side” or normal pricing for containers. Therefore, taking into account the excluded containers and recovered containers that are sold at a lower price point, a more conservative assumption of total container recovery could be in the 50 to 60 percent range. This would still be a significant recovery number in terms of value and total recovery percentage.

As an example, noted in Table 4-1, 0.86 million tons of PET containers were recycled in 2012. However 1.93 million tons were discarded. If the material streams that contained that 1.93 million tons of PET were processed at highly automated MWPFs, and achieved an estimated 60 percent recovery of those discarded containers, over one million tons of additional PET (1.16 million tons) could be recovered. Add this to the already recovered 0.86 tons of PET, and the overall percentage of recovered PET could be 72 percent. Using historical pricing, Table 4-2 takes the total tonnages of discarded containers from Table 4-1 and shows the value of the recyclables that could potentially be recovered.

**Table 4-2  
Estimated Value if 60 Percent of Certain Containers Currently Discarded were Instead Recovered**

<b>Material Types</b>	<b>Estimated Annual Disposed (1) (million tons)</b>	<b>Estimated Recovery %</b>	<b>Estimated Recovery (million tons)</b>	<b>Sale Price (\$ per ton) (2)</b>	<b>Estimated Commodity Value (\$millions)</b>
PET Containers	1.93	60%	1.16	\$403	\$466
HDPE Natural Containers	0.56	60%	0.34	\$646	\$217
HDPE Color Containers	1.12	60%	0.67	\$433	\$291
Polypropylene Containers	0.26	60%	0.16	\$197	\$31
<b>Estimated Totals</b>	<b>3.87</b>		<b>2.32</b>		<b>\$1,005</b>

(1) From Table 4-1

(2) Price assumes material sorted and baled, based on RecyclingMarkets.net average price from May 2012-May 2014

Source: Gershman, Brickner & Bratton, Inc.

This model assumes that all the remaining MSW that contains these discarded containers is processed at highly automated MWPFs. This also assumes these MWPFs achieve a recovery rate of 60 percent of each of the four container materials listed. Based on the historic value of these commodities, Table 4-2 also shows the total amount of revenue that could be achieved by recovering these containers. The potential market value for these additionally recovered recyclables is approximately one billion dollars. The additional recovery of 2.32 million tons of containers would increase the total recovery rate for all plastics by more than seven percent. It is also likely even more containers are recovered, but sold at a lower price. Using EPA’s 2012 estimate of over 164 million tons of MSW being discarded, the recovered value of just these four commodities represents \$6.12 per ton.

Roughly one third of plastics in the waste stream represent packaging and containers, and another third consists of durable goods, such as the plastics found in electronics and appliances. Nondurable goods, such plastic utensils, cups, and diapers compose the remaining third of plastics in MSW. Some of this material is difficult to separate into different resin components. Certain composite materials, such as electronics, are accepted back by manufacturers. Additionally, the recycling of non-bottle rigid plastics made from HDPE and polypropylene (PP) has grown in recent years. These include containers such as



yogurt and butter tubs, as well as bulky plastics, such as laundry baskets, kiddie pools, crates, and buckets.

Other plastic items can be targeted for recovery from the MSW stream. Mixed Rigid Plastics (MRP) include items such as baskets, totes, and lawn furniture, and they are frequently picked by hand at a pre-sort station. The value of bulky MRP is lower than other plastics and is frequently pre-sorted to protect the downstream processing equipment. Sorting MRP is much less common in systems with a primary shredder as the bulky items are sized for processing by the shredder.

Most optical units in modern MRFs are used to recover PET and HDPE. However, optical units can also be used to recover other recyclable mixed plastics, frequently referred to as #3 through #7 plastics. Currently, the value of mixed plastics is relatively low compared to PET and HDPE, but an advantage of having an additional optical unit for mixed plastics is that it can easily be reprogrammed to target another specific plastic. For example, PP has recently been increasing in value<sup>68</sup> compared to its historic price. Thus the mixed plastics optical unit could be reprogrammed to specifically recover PP. An alternative would be to consider selling the #3 - #7 plastics to a plastics recovery facility (PRF) for additional sortation and recovery.

Low density polyethylene (LDPE) and HDPE films have mostly been recovered by hand sorting as a specific commodity or as secondary recovery (instead of residue) from single stream MRFs. However, once these LDPE and HDPE films are contaminated via co-mingling with other recyclables or MSW, their value can greatly decrease. An existing challenge for recovering film at MRFs is that it tends to get wrapped around machinery if not pulled out early in the process. This challenge would seemingly extend to MWPFs where much of the same equipment is used. However, optical units that eject LDPE film for recovery have shown to be technically successful in Europe (Helector, Cyprus)<sup>69</sup> and at the Montgomery, Alabama, MWPF.<sup>70</sup> Film that is recovered using an optical unit may produce a lower quality bale, although likely in much greater quantities. Unfortunately, the market for different grades of LDPE can be variable, and finding a buyer, especially locally, may be difficult. However, there may be other viable outlets for these lower value recoverables.

Besides being recovered for the secondary scrap market, there is also tremendous potential for using the residue plastics in the MSW stream as feedstock to produce synthetic oil that can be converted to fuels. This is discussed more in depth in the 2014 report from the Columbia University Earth Engineering Center, which reports if all non-recycled plastics (NRP) were converted to synthetic oil, 5.7 billion gallons of gasoline could be produced.<sup>71</sup> The potential revenues from producing this high-value fuel may outweigh the costs of instead recovering some of the lower-value plastics for resale. The versatility to choose the types of recovery in a MWPF is advantageous for adapting to changing markets.

### 4.3 Generation of Desirable Recyclables

The Association of Postconsumer Plastics Recyclers (APR) publishes guidelines for PET and HDPE bales as a “benchmark to suppliers” and states that the model “is not meant to replace the specifications of the

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<sup>68</sup> RecyclingMarkets.net Secondary Materials Pricing – August 2014

<sup>69</sup> TiTech Recycling YouTube Video “Mixed Municipal Solid Waste sorting, Larnaca, Cyprus” May 22, 2012

<sup>70</sup> REW Conference, San Jose, CA – talk by Kyle Mowitz, Infinitus Energy, November 2014

<sup>71</sup> Nickolas J. Themelis and Charles Mussche, Earth Engineering Center, Columbia University, 2014 Energy and Economic Value of Municipal Solid Waste (MSW), Including Non-Recycled Plastics (NPR), Currently Landfilled in the Fifty States, July 2014, p. 3

buyer.”<sup>72</sup> The report indicates that the bale should have no more than four percent of contaminants, by weight, no more than two percent of another type of plastic, and no more than two percent of liquid. For HDPE natural bales, the conditions are similar to that of PET bottles except that the allowance of total contaminants is not to exceed 10 percent, by weight, and not more than two percent total by weight of pigmented HDPE, injection molded HDPE, and other containers.<sup>73</sup>

Plastics reclaimers measure the “yield loss” as the difference between the weight of an incoming bale and the actual weight of clean, processed flake derived from that bale. Yield loss for bottles includes labels, caps, and adhesives. For PET bottles, the inherent yield loss averages about 13 percent,<sup>74</sup> meaning for a clean PET bale with 96 percent purity, the bale would yield approximately 83 percent PET after processing at a plastics recovery facility. However, in 2012, average yields for PET bales were 65-75 percent<sup>75</sup> with some yields much lower. Most of these bales were still purchased due to the high demand for post-consumer PET material. The market has recently demanded that bale quality improve and higher quality bales command higher prices.

**Figure 4-2**  
**A Typical Bale of PET**



Source: MaterialMix.com

The majority of these container bales come from curbside collection and single-stream MRFs,<sup>76</sup> with very few originating from MWPFs. With newer, highly automated facilities for single stream, manufacturers

<sup>72</sup> APR – Model Bale Specification: PET Bottles, June 2013

<sup>73</sup> APR – Model Bale Specifications: Unpigmented (“Natural”) HDPE Bottles

<sup>74</sup> Susan Collins, A Common Theme, Resource Recycling Magazine, Feb 2012, p.14

<sup>75</sup> Plastics News – Mike Verespej Recycling Challenges including Container Lightweighting, Bale Contamination, Oct 2012

<sup>76</sup> Collins, op.cit., p. 14



are touting 95 percent purity.<sup>77</sup> At most of these facilities, a quality control (QC) sorter is generally located at the recovery conveyor from an optical unit output to remove such things as thermoformed clamshells and possible collateral such as other types of containers or wayward film or fiber. The source of the containers, either from single stream or MSW, doesn't seem to make much difference in the quality of the bales.

Greenwaste Recycling in San Jose combines the container streams from both a MWP line and a single-stream line into one container stream that uses an optical unit for PET, manual sort for HDPE, and another optical unit for mixed plastics. The Greenwaste facility touts a recovery rate of 98 percent from single stream. With a 75 percent recovery rate from MSW, a total facility diversion is noted as 88 percent, which includes recovery of organics.<sup>78</sup> The large Newby Island facility in Milpitas, California, combines the container streams off of 2D/3D sorters from single stream and commercial waste into one highly automated optical sorting line.<sup>79</sup> Many of the new facilities, both single stream and MWPFs, will have guarantees, with certain exclusions, for both recovery rates and purity rates of the recyclables.

The SWANA Applied Research Foundation (ARF) did a preliminary study of recyclable and organics recovery from multifamily housing in Seattle. Recyclables, trash, and organics at their multi-facility housing units have separate bins for collection. This data was compared to information from San Jose where a MWPF processes the MSW recovered from multifamily housing. While the quality of the recyclables from the source separated bins in Seattle was labeled as "high," the quality of recyclables from San Jose was labeled as "acceptable."<sup>80</sup> This is one of the few published sources verifying that the recovered materials from MWPFs are of adequate standard for the commodities market.

The collection of film as a recyclable commodity is not as common as for containers. However, there exists a nationwide system of retail take back of polyethylene film. In 2013, the US collected for recycling 1.14 billion pounds of postconsumer plastic product wraps, commercial shrink wrap, and plastic bags.<sup>81</sup> Unlike most container bales, there are also a number of different classifications of bales for film, including grades of clear film, agricultural film, and even furniture wrap. Each has differing values and marketability, which can greatly impact the economics of whether or not to recover the film. The most common bale grades from a MWPF would be MRF mix film and PE retail mix film. The APR publishes guidelines on film bale content for different grades, but notes that the model is "not meant to replace the specifications of individual buyers."<sup>82</sup> The guidelines state that total contaminants should not exceed five percent by weight and one percent liquid residue, with contaminants of wood, glass, oils and grease, and certain types of film not allowed at all. If film is hand pulled, this specification should be easy to attain, although the quantity recovered is generally much less than what can be recovered by an optical unit.

Concern for the ability of MWPFs to procure clean, useful commodities for users of these materials is the biggest issue of concern for opponents to these systems. Clearly more data and testimonials from

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<sup>77</sup> Alex Wolf, sales engineer for TiTech, Article: Eye on Quality by DeAnne Toto, *Recycling Today Magazine*, March 2009

<sup>78</sup> Website at Greenwaste.com – About Us; as of August 25 2014

<sup>79</sup> REW 2014 Conference – Newby Island Site Tour given by Michael Geiss, Sales Supervisor, November 2014 – attended by Bradley Kelley – Gershman, Brickner & Bratton

<sup>80</sup> MSW Management Magazine - Jeremy K. O'Brien - *Source-Separation and Mixed Waste Recycling Systems for Multifamily Buildings: A Comparative Analysis* – March-April 2014

<sup>81</sup> Moore Recycling Associates prepared for American Chemistry Council – *2013 National Postconsumer Plastic Bag and Film Recycling Report* – February 2015

<sup>82</sup> APR – Post Consumer Bale Specification: *MRF Mix Film* – November, 2013

actual buyers of these materials are needed to alleviate concerns. The facilities at Newby Island, Greenwaste, and Montgomery have been selling their recovered recyclables, including fiber, and it was indicated by Infinitus that the price was “hi-side,” especially for containers and metal.<sup>83</sup> On the other hand, the Medina County MWPF has recently been idled and come under scrutiny because of the county’s low recycling rate.<sup>84</sup> However, the fiber, plastics and metals recovered from the Medina County MWPF have been able to be marketed by their facility operator over the past 20 years. It is an older facility but the operator and paper market both indicated to GBB that the fiber recovered from their manual sort lines had always been marketable. It is important to understand that the Medina system is old and has none of the design features or unique specialty equipment that is being installed in modern MRFs and MWPFs.

In dealing with commodity contracts, the specifications, quantity, and delivery points are relevant to the value received. Similar to MRFs, the economics of an entire MWPF do not revolve around one commodity or singular price assumption. Developers of MWPFs understand that market pricing is a risk that they typically bear in their contracts with the MSW suppliers, and they know that they may not obtain a community guarantee of the MSW composition.

## **5 Potential Recovery of Recyclables from MWP, MRF, and a MRF-MWP Combination**

Unfortunately, a lot of valuable materials still end up in landfills, despite the growth in single-stream recycling and the development of innovative sortation technology. However not all of the recyclables are recoverable. The percentages of commodities that can be recovered at a MWPF are variable, depending on the material, the type of equipment, and the level of automation. Recent publicly available information has indicated promising numbers for recovery at highly automated MWPFs. These potential rates of recovery are shown in Table 5-1. It should be noted that these numbers are from an equipment manufacturer with recent experience with these modern MWP facilities. These numbers also exclude certain items such as liquid filled containers that end up as residue. Other manufacturers are also indicating similar recovery numbers although hard data are not available to confirm.

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<sup>83</sup> Mowitz, REW Conference, op. cit.

<sup>84</sup> Andrew Davis, *The Medina-Gazette, Ex-operator of Recycling Center Cries Foul Against Medina County Officials*, April 22, 2015

**Table 5-1  
Projected MWPF Recovery Rates, by Commodity<sup>85</sup>**

<b>Material</b>	<b>Highly Automated Sorting System, %</b>
Fiber	
Mixed Fiber	50-70
Cardboard (OCC)	65-75
Plastics	
PET	85-90
HDPE	85-90
Plastics #3-#7	75-80
Film	25-40
Metals	
Ferrous	90-95
Aluminum	90-95
Organics Foodwaste, Yardwaste	80-90

Even in communities with high levels of participation, there is still a significant amount of recyclables in the waste stream. A recent MSW composition study<sup>86</sup> was completed by GBB for the City of Fort Worth, Texas, to measure the specific composition of residential-generated materials in their waste bins versus the materials separated and placed in recycling bins by city residents. During a week-long study, GBB staff collected individual waste and recycling bins from around the city and cataloged the contents.

As detailed in Table 5-2, the data indicates that during the study, Fort Worth had 72 percent (by weight of the total material generated) set out in the waste container and 28 percent placed in the recycle cart. Fort Worth has a third collection bin for yard waste that was not considered in this report. However, some yard waste still ended up in the waste container and was included in the organics commodity amounts.

<sup>85</sup> Kufnagel and Winkler, op.cit.

<sup>86</sup> Gershman, Brickner & Bratton, Inc. - Data from Waste Characterization Study Performed for the City of Fort Worth, TX – April, 2014. Data released with permission from City of Fort Worth, TX

**Table 5-2  
City of Fort Worth (Texas) Material Composition Study Summary Results<sup>87</sup>**

Commodity	Trash Cart			Recyclables Cart		
	Garbage Weight (lbs)	As a % of Garbage	As a % of Overall	Recyclables Weight (lbs)	As a % of Recyclables	As a % of Overall
Organics <sup>(1)</sup>	5,078	38.8%	27.8%	272	5.2%	1.5%
OCC	139	1.1%	0.8%	482	9.3%	2.6%
Other Fibers	1,522	11.6%	8.3%	1,901	36.7%	10.4%
Glass	451	3.4%	2.5%	961	18.5%	5.3%
PET	295	2.3%	1.6%	280	5.4%	1.5%
HDPE-(Natural)	49	0.4%	0.3%	125	2.4%	0.7%
HDPE-(Colored)	117	0.9%	0.6%	161	3.1%	0.9%
Mixed Plastic	487	3.7%	2.7%	216	4.2%	1.2%
Bags and Film	550	4.2%	3.0%	137	2.6%	0.7%
Aluminum	167	1.3%	0.9%	133	2.6%	0.7%
Ferrous	380	2.9%	2.1%	171	3.3%	0.9%
Other Residue <sup>(2)</sup>	3,849	29.4%	21.1%	344	6.6%	1.9%
<b>Totals</b>	<b>13,084</b>	<b>100.0%</b>	<b>72%</b>	<b>5,183</b>	<b>100.0%</b>	<b>28%</b>

(1) Contains Food Waste, Soiled Paper, and Yard Trimmings

(2) Includes C&D, Diapers, Textiles, Electronics and Other Residue

Based on the composition data presented in Table 5-2, the recycling cart included 12 percent non-recyclable materials, while the waste bin contained a number of recyclables. In fact, except for some fiber, glass and HDPE, greater than half of the total recyclables cataloged were in the waste bin. Table 5-3 shows the percentage of the individual commodities that were in each container, and the percentage of that commodity in the total materials, as set out at the curb and collected. This indicates that recyclable fiber, glass, and HDPE natural were well represented, with over two thirds of each commodity in the recycling bin. However, other containers, fibers, and metals are more evenly split between the two streams.

<sup>87</sup> Ibid.

**Table 5-3  
City of Fort Worth, TX Material Composition Study, Comparison of Recycling and Garbage Set-outs<sup>88</sup>**

<b>Summary Information - All Materials As Setout by Residents</b>				
<b>Commodity</b>	<b>Total Weight of Commodity (Both Carts)(lbs)</b>	<b>% of Commodity located in Garbage Bin</b>	<b>% of Commodity located in Recycling Bin</b>	<b>Commodity as % of Overall Collection Stream</b>
Organics	5,350	95%	5%	29%
OCC	621	22%	78%	3%
Other Fibers	3,423	44%	56%	19%
Glass	1,412	32%	68%	8%
PET	575	51%	49%	3%
HDPE-(Natural)	174	28%	72%	1%
HDPE-(Colored)	279	42%	58%	2%
Mixed Plastic	703	69%	31%	4%
Bags and Film	686	80%	20%	4%
Aluminum	300	56%	44%	2%
Ferrous	551	69%	31%	3%
Other Residue	4,194	92%	8%	23%
<b>Totals</b>	<b>18,267</b>	<b>72%</b>	<b>28%</b>	<b>100%</b>

Based on the individual setouts, GBB conducted a more critical review of recovery opportunities. All MRFs and MWPFs have an inherent efficiency of recovery, thus not all the recyclable material is actually recovered. The modern automated systems generally have a very high efficiency, and many equipment vendors are guaranteeing these recovery percentages. These percentages are commonly not published due to competition in the marketplace.

In general, a highly automated single-stream MRF will have a higher efficiency than a modern MWPF. This is due to the high quality and concentration of the recyclable commodities. For illustrative purposes, the higher recovery efficiencies stated earlier in Table 5-1 are used to estimate the recovery from a MRF. In actuality, modern MRFs may achieve slightly higher efficiencies, especially for fiber, but these assumptions provide a reasonable estimate for comparison in this Report.

Table 5-4 shows the estimated recovery rates from the recycling bin only as if it were to be processed at a modern MRF with these assumed recovery efficiencies. (This is not indicative of the actual recovery at Fort Worth, which was not part of the Composition Report). The last column shows the potential individual recovery of each commodity, meaning the total commodity recovered at the MRF with respect to the total of that commodity in both collection streams. The total diversion rate, which is the percentage of the total recovered recyclables divided by all the material collected in both bins, is 19 percent.

<sup>88</sup> Ibid.

**Table 5-4  
Estimate of MRF Recovery Based on City of Fort Worth, TX Material Composition Data**

Commodity	Est. of MRF Processing & Recovery			
	Recyclables Weight (lbs)	Est. of % Recyclables Recovered at a MRF	Est. Weight Recovered at MRF (lbs)	Individual Total Recovery Rate, MRF Recyclable Materials
Organics	272	0%	0	0%
OCC	482	75%	362	58%
Other Fibers	1,901	70%	1,331	39%
Glass	961	80%	769	54%
PET	280	90%	252	44%
HDPE-(Natural)	125	90%	112	64%
HDPE-(Colored)	161	90%	145	52%
Mixed Plastic	216	80%	173	25%
Bags and Film	137	40%	55	8%
Aluminum	133	95%	127	42%
Ferrous	171	95%	162	29%
Other Residue	344	0%	0	0%
<b>Totals</b>	<b>5,183</b>	<b>67%</b>	<b>3,487</b>	
<b>Total Diversion Rate</b>				<b>19%</b>

Source: Gershman, Brickner & Bratton, Inc.

Table 5-4 indicates that that approximately half of the fiber and plastic containers would be recovered for recycling from the entire waste stream. This also indicates that there are still more materials that can be recovered, especially metals and mixed plastics, in the waste container. If all of the material from the waste container along with the residue from the MRF were assumed to be processed through a separate MWPF, Table 5-5 provides the estimates for such a co-located materials recovery system.

**Table 5-5  
Estimate of Processing Waste and MRF Residue through a MWPF Plus MRF Recovery of Recyclables  
Based on City of Fort Worth, TX Material Composition**

Commodity	Recovery Rate for MRF and MWPF				
	MRF Residue and Garbage Total into MWPF (lbs)	% Recovered at MWPF	Additional Weight Recovered (lbs)	Net Weight to Landfill for Disposal (lbs)	Individual Total Recovery Rate with MRF + MWPF
Organics <sup>(1)</sup>	5,350	70%	3,745	1,605	70%
OCC	259	55%	142	117	81%
Other Fibers	2,092	40%	837	1,255	63%
Glass (1)	643	65%	418	225	84%
PET	323	75%	242	81	86%
HDPE-(Natural)	62	75%	46	15	91%
HDPE-(Colored)	133	75%	100	33	88%
Mixed Plastic	530	65%	345	186	74%
Bags and Film	631	15%	95	537	22%
Aluminum	173	80%	139	35	88%
Ferrous	389	80%	311	78	86%
Other Residue	4,194	0%	0	4,194	0%
<b>Totals</b>	<b>14,780</b>		<b>6,420</b>	<b>8,360</b>	
			<b>Total Diversion Rate W/O Organics</b>		<b>34%</b>
			<b>Total Diversion Rate W/ Organics</b>		<b>54%</b>

(1) Organics and Glass recovery will require additional processing and facilities

Source: Gershman, Brickner & Bratton, Inc.

In Table 5-5, it is assumed this MWPF receives a combined feedstock of the residential trash plus the MRF residue. Using the lower baseline recovery rates noted earlier in Table 5-1 and an additional 10 percent loss due to excluded recyclable material, each commodity is shown with a projected recovery rate within the MWPF. Therefore, in conjunction with a MRF, a MWPF could recover an additional 35 percent of material from the overall residential waste stream. The analysis includes commodities and an organic fraction. In this analysis, and based on the assumptions noted, the overall recovery rate would increase from 19 percent with a MRF only, to 54 percent with a MRF and MWPF tandem. The far right column in Table 4-5 indicates the combined recovery rates for the individual materials, with the overall recovery rate of some commodities reaching close to 90 percent.

In addition, the food waste organics, which are prevalent in the mixed waste container, are assumed to be separated at the MWPF. This organics-rich stream could enter into an anaerobic digestion process or go to a composting facility. This and the recovery of glass would require additional processing and facilities to recover as a recyclable commodity. If the organics are not included in the recovery, the overall diversion drops to 34 percent. Alternatively, if organics were recovered and 75 percent of the remaining residue was utilized as an engineered fuel, the total diversion rate would be approximately 89 percent.

While many communities may have good residential recycling programs with significant participation and high diversion rates, others do not. Table 5-6 uses the same data, in a combined mode, to illustrate a scenario where there is no significant residential participation in a local curbside program, and the



community wants to consider only a MWPF for all of their residential waste materials. In this case, and assuming the same recovery efficiencies for the MWPF as assumed in Table 5-5, the total recovery rate for an MWPF alone is calculated to be 46 percent. This recovery is lower than the previous two-facility example due mainly to the lower efficiencies of commodity recovery assumed for the fiber fraction processed at the MWPF. If organics are not recovered by the MWPF, the overall diversion rate would drop to 25 percent.

**Table 5-6  
Estimate of One Bin Only MWPF Recovery Based on City of Fort Worth Material Composition**

Commodity	MWPF Only For All MSW - One Bin				
	Total weight of Commodity (lbs)	% Recovered at MWPF	Weight Recovered (lbs)	Net Weight to Landfill for Disposal	Overall Recovery Rate MWPF only
Organics <sup>(1)</sup>	5,350	70%	3,745	1,605	70%
OCC	621	55%	341	279	55%
Other Fibers	3,423	40%	1,369	2,054	40%
Glass <sup>(1)</sup>	1,412	65%	918	494	65%
PET	575	75%	431	144	75%
HDPE-(Natural)	174	75%	131	44	75%
HDPE-(Colored)	279	75%	209	70	75%
Mixed Plastic	703	65%	457	246	65%
Bags and Film	686	15%	103	583	15%
Aluminum	300	80%	240	60	80%
Ferrous	551	80%	441	110	80%
Other Residue	4,194	0%	0	4,194	0%
<b>Totals</b>	<b>18,267</b>		<b>8,385</b>	<b>9,882</b>	
<b>Total Diversion Rate W/O Organics</b>					<b>46%</b>
<b>Total Diversion Rate W/ Organics</b>					<b>25%</b>

(1) Organics and Glass recovery will require additional processing and facilities

Source: Gershman, Brickner & Bratton, Inc.

Based on the composition of the waste from the detailed field sort, and equipment/system efficiencies of recovery at both a MRF and a new technology MWPF versus a MRF alone, the projected impact on total quantities recovered are:

- 58% more OCC, Mixed Paper and ONP;
- 107% more PET, HDPE, and Mixed Plastics; and
- 156% more metals.

Note that this is a hypothetical exercise and the MWPF extraction rate is based on the new generation of MWPF which is still being commercialized. True recovery numbers are still unknown and GBB did not do a cost estimate for a MRF/MWPF combination.

Additional review concluded that because 25 percent of the source-separated material in the recycling cart is residue, the MRF would divert a total of 19 percent of the total waste stream from landfill. Alternatively, in the model, the addition of a MWPF showed a 54 percent overall waste diversion rate, which includes certain organics recovery opportunities that are not provided at a MRF. This diversion

rate represents the potential for over 180 percent more overall MSW materials being diverted from a landfill by using a MWPF in tandem with a MRF.

In evaluating a MRF versus MWPF, the reduced efficiencies of the MWPF fiber sort recovery were considered as fiber quality (but not necessarily marketability) suffers in the MWPF process and calculated quantity of total fiber recovered was similar. While it is not an ideal feedstock, the other non-recovered fiber could possibly be integrated into an anaerobic digestion system. However, this alternative process to further increase diversion is not considered in the above analysis. Additionally, the revenue value of increased plastics and metals recovery using a modern technology could potentially overcome lower prices due to heavier contamination. These hypothetical scenarios do not take into account the costs associated with the facilities, their equipment, or material collection. Assessing these factors would require further study and analysis.

Because plastics are derived from natural gas and crude oil, the inherent energy value of plastics make them a potentially valuable feedstock for engineered fuels, for plastics to oil conversion, or for gasification to chemical feedstocks systems. Technology is being developed to increase plastics recovery at each step in the waste management chain because of the high economic value of plastics for recycling and high energy value. The lower heating values for some common resins are shown in Table 5-7. Some plastics applications are not suited for recycling but are excellent feedstock for either RDF or pyrolysis processes. This study shows that an integrated system using the projected recovery rates for new MWPF, in lieu of a MRF, and pyrolysis technologies has the potential to increase the quantity of plastics recycled and recovered by as much as 80 percent. If only the marginal mixed plastics were used in a pyrolysis system, the plastics captured for energy recovery could increase by as much as 160 percent.

**Table 5-7  
Estimated Lower Heating Value (LHV) of MSW Constituents**

<b>Material</b>	<b>MJ/kg<sup>89</sup></b>	<b>BTU/pound</b>
PET	23.9	10,275
HDPE	44.3	19,045
LDPE/LLDPE	44.3	19,045
PP	44.3	19,045
PS	41.5	17,840

As is shown earlier in section 4.2, the secondary market for such plastics as PET and HDPE make them attractive for recyclable recovery, while some of the other types of plastics may not be as economically viable to singularly separate for resale. The use of these other plastics, either as a direct fuel or a feedstock for producing synthetic oil or other chemicals could potentially yield greater revenue than scrap recycling. Energy recovery would still divert these plastics from landfills. However, the technology of producing synthetic oils from NRP is still in the commercialization stage, and consequently the demand for such feedstock is currently low.<sup>90</sup> A versatile MWPF that can recover high value recyclables and also produce materials for fuel would create greater total diversion of plastics from landfill, and would potentially be more economically viable in the long run.

<sup>89</sup> Themelis and Mussche, op cit, p. 24

<sup>90</sup> Themelis and Mussche, op cit, p. 23

## 6 Communities Currently Using or Exploring the Idea of Using MWP Facilities

The wide disparity in function, incoming material, and equipment makes it difficult to compare MWPFs across the country in terms of throughput, recovery, and cost. Table 6-1 is a partial list of facilities in the U.S. and Canada that are either dedicated MWPFs or are MRFs that also have MWP lines to recover more recyclables from MSW. It highlights facilities that have a high throughput, generally 100 TPD or more, and are more automated in design. Included in the list are several high-profile communities that are either constructing or exploring the construction of an advanced MWPF at the time of this report. There are a number of other facilities that are collecting recyclables from MSW, with a majority of them in California. These smaller facilities are generally not as automated, and typically use a manual sort line to recover recyclables. Some even smaller communities, such as Newport Beach and Lynnwood, California, are using a one-bin system, where recyclables are processed and recovered at local MWPFs. It should be noted that Lynnwood does have a separate bin for yard waste collection, so its not a true “one-bin” approach.

**Table 6-1**  
**Operating or Planned MWPFs or MRFs with MWP Lines at Larger Recycling Plants<sup>91</sup>**

Location of Facility	Owner of Facility, Incl. MWP Line(s)	Year of Startup (1)	Current Status	Est. Total of All Incoming Waste, TPD
Anaheim, CA	Republic Recycling Complex (Taormina Regional MRF)	1991	Operational	4800
Irvine, CA	Sunset Environmental-WMI	1992	Operational	2000
Hesperia, CA	Advance Disposal (updated 2014)	1992	Operational	600-1500
Sunnyvale, CA	Sunnyvale Material Recovery & Transfer Station (SMART) (updated 2008)	1993	Operational	1100
Medina Co., OH	Medina County	1993	Inactive	1200
South Lake Tahoe, CA	South Tahoe Refuse MRF	1995	Operational	270
Lincoln, CA	Placer County/Western Regional Material Recovery Facility (updated 2007)	1996	Operational	2000
Perris, CA	CR & R Inc.	1996	Operational	900
Fontana, CA	West Valley MRF and Transfer Station	1997	Operational	5000
South San Francisco, CA	South San Francisco MRF	2001	Operational	1000
City of Industry, CA	Athens Disposal Company MRF	2002	Operational	2400
Colton, CA	Inland Regional MRF and Transfer Station.	2004	Operational	1950
Rubidoux, CA	Robert A. Nelson TS/MRF (RANT)	2004	Operational	2700
San Jose, CA	GreenWaste Recovery Inc.	2008	Operational	1500
Willimantic, CT	Willimantic Waste Reduction and Processing Facility	2008	Operational	300
Sun Valley, CA	Sun Valley Recycling Park (Bradley West Transfer Station and MRF)	2009	Operational	1500
Troy, VA	Van der Linde Recycling (updated 2014)	2009	Retrofit Const.	Not Available
Waterloo, IN	Waterloo Recycling Center	2010	Operational	350
Milpitas, CA	Republic Services, Newby Island Resource Recovery Park	2012	Operational	1,500 (Est.)
Glendale AR	Vieste	2014	Operational	Not Available
Montgomery, AL	Infinitus (IREP)	2014	Operational	300
Indianapolis, IN	City Approved Covanta to Develop MWPF adjacent to their WTE Facility	2016 Est	Development	1,000 (Est.)
Marion, IA	Fiberight, LLC	2015 Est	Under Construction	250
Cleveland, OH	Received Proposals for MWPF and RDF Generation, No Decision	NA	Evaluation	Not Available
Houston, TX	Received Proposals for MWPF and RDF Generation, No Decision	NA	Evaluation	Not Available

(1) Year of startup could have been for a MRF only that later got expanded and/or permitted to allow for the addition of a MWP line at the Facility.

### 6.1 Successes and Failures

Until there is better publicly available data or testimonials from buyers of the materials, it will remain a challenge to evaluate newer MWPFs. Additionally, it is challenging to compare today’s technologies and current expectations for mechanical recycling with a MWPF built a generation ago to produce RDF.

<sup>91</sup> GBB information & Berenyi information provided to GBB

Tables 3-1 and 3-2 noted that many early MWPFs are more than 20 years old, yet these facilities are still providing a similar service that they delivered in the 1980s and early 1990s. Communities exploring MWPF have an expectation that these facilities will recover saleable recyclable materials at a rate approaching or equal to an existing single-stream system.

As discussed in Section 3, early MWPFs failed because either their RDF lacked quality or there were no sustainable markets for the RDF. The MWPFs in Chicago, Rochester, and Milwaukee closed in the 1980s for these reasons.<sup>92</sup> However, projects built by companies like Combustion Engineering Inc., including three facilities with new dedicated boilers, are all included in the survivor projects of the last two decades.

## 6.2 Current Stages of Implementation

The previous two years have been active with construction and operations of several new MWPFs. Montgomery's MWPF, built by Infinitus, is designed to recover recyclables from MSW. The facility has the current, sophisticated technology for sort stations, disc screens, air classification, an ECS unit and magnets, and multiple optical units to separate various recyclables, including plastic containers and film. There are plans to eventually add an AD facility to generate compressed natural gas (CNG) from the organics.<sup>93</sup> The residue that remains is sent to landfill. The system has been operational since June 2014. Naturally, there is a great deal of interest in this facility. Robust data and testimonials from buyers of its recovered materials would add greatly needed information to the current debate regarding these types of facilities.

Several large cities have recently begun processing MSW, however it must be noted that the main purpose is to produce an RDF. Edmonton, Alberta, Canada already has separate yard waste collection for composting and a robust single-stream recycling program. Their MWPF is designed to process the remaining MSW to recover some additional recyclables, remove the organics to be sent to the existing composting facility, and then use secondary shredders to produce an RDF feedstock for Enerkem's waste-to-biofuels system. Enerkem has begun producing methanol from this system in 2015. Waste Management's recent SpecFuel™ facility in Philadelphia is similar to Edmonton's system in that both systems complement existing single-stream recycling programs. Additionally, the MRF residue that is left after the single-stream recyclables are sorted is added to the feedstock of the SpecFUEL™ facility for fuel production. SpecFuel™ is intended to be sold as an alternative solid fuel for use at cement kilns and boilers, whereas Edmonton's RDF is feedstock for Enerkem's gasification system. It should also be noted that the primary purpose of these facilities are for energy recovery, not recycling, and neither system impacts the existing upstream collection system in their cities.

Two other large MWPFs began operations in 2014. The City of Glendale, Arizona, with Vieste, are processing up to 180,000 TPY of MSW to recover additional recyclables including ferrous and aluminum along with the capability to recover fiber and high-value plastic containers<sup>94</sup>. This system complements Glendale's existing single-stream recycling system. The residue will not be processed into engineered

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<sup>92</sup> Personal Communication with Robert H. Brickner, Gershman, Brickner & Bratton, Inc., March 17, 2015

<sup>93</sup> Mowitz, REW 2014 Conference, op. cit.

<sup>94</sup> The Glendale Star, Energy Boost: New Recycling Plant at City Landfill Given a Mega-Watt Welcome, February 21, 2014

fuel but will be landfilled for now.<sup>95</sup> Advance Recycling in Hesperia, California, also has added an automated MWPF<sup>96</sup> that is similar to the system at Glendale.

Covanta's proposed MWPF in Indianapolis was recently approved by the City of Indianapolis's Board of Public Works. This facility will be similar in technological scope to the facility in Montgomery. Neither Montgomery nor Indianapolis had an existing city-wide residential curbside recycling program. According to Covanta, it will recover metals, plastics and fiber with the remaining residue used as fuel for Covanta's existing 2,000 TPD WTE facility.

There are other facilities that have recently begun operations, or will soon, that are processing MSW with a high level of automations such as Van der Linde Recycling in Troy, Virginia, which has undergone a complete renovation including screens and optical units.<sup>97</sup>

## 7 Potential Barriers to Adoption of MWP Technologies

### 7.1 Federal or State Regulations and Policies

There are no federal regulations barring the adoption of a MWPF as a stand-alone recycling solution. However, the EPA prefers that MWPFs with energy recovery or gasification-based technologies include materials recovery equipment to increase the generation of recyclable materials and organics prior to the energy recovery module. The Montgomery MWPF did not require any Federal permits.<sup>98</sup>

In the State of California there have been a number of MWPFs for years. These facilities are currently defined as permitted solid waste facilities. Solid wastes that did not have recyclables separated at the source are sorted or separated by hand or by machinery. However, CalRecycle is tackling the issues of MRFs versus MWPFs. In July 2013, CalRecycle proposed a process for public review that included a new definition.<sup>99</sup> "High performance mixed waste processing facility" or "HP-MWPF" was defined by CalRecycle<sup>100</sup> as a MWPF that:

- Meets the numerical standards;
- Is evaluated and becomes certified;
- Is annually evaluated and stays certified;
- Is deemed comparable to source separation; and
- Can offer Mandatory Commercial Recycling compliant services to businesses.

The dilemma facing California is how to review and specifically evaluate MWPFs versus single stream MRFs. This is critical since municipalities need to increase recycling to meet the statutory requirements (75% recycling rate) of AB 341.<sup>101</sup> Some newly designed MWPFs have the specific purpose of processing

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<sup>95</sup> Caitlin McGlade - Glendale Landfill will turn Garbage into Energy The Republic, January 1, 2014

<sup>96</sup> Staff – Advance Disposal Reopens MSW MRF in California, Recycling Today, August 27, 2014

<sup>97</sup> Van der Linde Recycling – Construction Update web page -

<http://www.vanderlinderecycling.com/facility/facility-news/construction-update/>

<sup>98</sup> The Alabama Capital Region Solid Waste Disposal Authority Bond Issue June 26, 2013

<sup>99</sup> CalRecycle Workshops, Comparable to Source Separation-MRF Performance Standards July 16<sup>th</sup> and 18<sup>th</sup>, 2013

<sup>100</sup> Ibid.

<sup>101</sup> AB 341 – Requires that all commercial and business entities, including schools and multi-family dwellings, that generate more than 4 cubic yards of MSW each week shall arrange for recycling services. Participation can include self-haul or source separation of recyclables or subscription to a service or haulers that may include MWP. Local

MSW and recovering recyclable materials. However, the majority of the current new initiatives in the state are considering not only the recovery of traditional recyclables, but also, using a MWPF to recover more recyclables. This would also allow the integration of an organics processing line to recover and concentrate the organic streams for eventual AD or composting.

The State of Nevada's regulations governing MRFs, which were adopted pursuant to the authority of Nevada Revised Statutes (NRS) 444.580, notes that "Materials Recovery Facility" means "a solid waste management facility that provides for the extraction from solid waste of recyclable materials, materials suitable for use as a fuel or soil amendment, or any combination of those materials."<sup>102</sup> The term does not include a facility that receives only recyclable materials that have been separated at the source of waste generation. Therefore, regardless of the design and intended recovery rates, a MWPF is subject to a solid waste permit process and their extensive requirements.

## 7.2 Controversy over Proposed Facilities

It is important to note that the Montgomery and Indianapolis facilities are controversial precisely because these cities do not have an existing city-wide curbside recycling program. Houston is controversial because its "one bin for all" program would potentially replace its existing, but limited, single stream collection system. This is in contrast to the plants in Philadelphia, Glendale, and Edmonton. Those facilities were built to complement existing single-stream recycling programs.

Detractors of MWPFs have cited at least four main concerns with these systems: (1) recyclables will be more heavily contaminated than single or dual-stream processing; (2) fewer recyclables will be recovered compared to single or dual stream systems; (3) energy recovery, not recycling, is the main focus for these systems; and (4) these systems will devalue our culture of recycling and encourage more waste as residents will not participate in the act of recycling.

The response from MWPF advocates to these four concerns can be summarized by the following:

1. Contamination – the industry agrees that some of the output materials will be further contaminated, particularly paper and fibers which already suffer from lower value. Washable materials such as metals and plastics will experience less degradation.
2. Recovery/diversion – GBB's Fort Worth study indicates that MWPFs employing new technologies, working in tandem with a MRF, have the potential to increase landfill diversion from about 21 to 55 percent.
3. Energy recovery focus – the industry describes MWPF as complementary to traditional source-separated collection and recycling, with energy recovery as the next logical step in the waste management hierarchy, not a higher priority.
4. Recycling culture – MWPF advocates indicate that the facilities will allow 100 percent participation in recycling through the use of mechanized systems and not require individualized participation.

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governments are required to implement a recycling program that includes education, outreach, and monitoring. The law sets a goal of a diversion rate of 75% by the year 2020.

<sup>102</sup> Nevada Revised Statutes (NRS) 444.580

Recently, the City of Indianapolis received a proposal from Covanta to build a \$45 million MWPF on the front end of its existing WTE facility. Covanta's MWPF will be designed to process and recover recyclables contained in the MSW that currently go directly to its WTE facility. On August 6, 2014, the city's Board of Public Works voted to approve an agreement to provide recycling for all single-family residences in Indianapolis with no government mandate and no tax or rate increase.<sup>103</sup> The contract runs through 2028. Local and statewide NGOs that oppose it, including the Indiana Recycling Coalition (IRC), were vocal at the public hearings. Critics said Covanta's facility would not produce enough high quality recovered materials. In recent months, the IRC, alongside Alcoa, Pratt Industries, and other consumers of recyclable materials, asked Indianapolis decision-makers to consider other recycling options.<sup>104</sup> The Institute of Scrap Recycling Industries (ISRI) also recently stated its opposition to all-in-one-bin collection.<sup>105</sup>

Much of the non-public sector opposition to MWPFs seems to be coming from commodity buyers that require high quality feedstock due to the nature of their manufactured end products.<sup>106</sup> For example, Pratt Industries recently gave a presentation regarding their unwillingness to accept fiber from MWPFs.<sup>107</sup> The premise of the presentation was that Pratt manufactures items for the food industry and that they can't undo the contamination of fiber from such things as diapers or kitty litter. Pratt manufactures 100 percent recycled content corrugated containers for companies. They operate three mills in the US as well as 16 recycling MRFs, with much of their fiber feedstock coming from dual and single stream recycling streams.

As with all new technologies, or new applications of existing technologies, there is a lack of good publicly available performance data. This is one reason the Montgomery facility is under so much scrutiny. The facility has yet to publish any performance numbers, but public information from within the industry indicates that they are selling all of the materials recovered.<sup>108</sup>

Many recycling commodity producers and market brokers are not revealing their distribution networks and sales prices. Also, whether materials are accepted or rejected can tend to depend more on where the material came from than actual, quantifiable measures. There seems to be limited real data on the level of allowable contamination, other than the existing bale specifications. It is difficult to ascertain without additional study whether the refusal of materials from MWPFs is more due to perception of contamination rather than the reality of the material quality.

However, the absence of quality contemporary data has led opponents of MWPF to cite information from older facilities. For example, the Medina County's facility has been cited in opposition arguments because its recycling rate historically was low.<sup>109</sup> This facility does not reflect the current state of MWP technology because it began operations in 1993 and has made no significant permanent equipment upgrades in over 20 years.

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<sup>103</sup> Mayor's Office, City of Indianapolis, Indiana, Press Release titled: Board Approves Plan to Bring Recycling to All Single Family Homes at No Cost to Indy Residents, August 6, 2014

<sup>104</sup> Dan Leif, Resource Recycling Magazine, August 13, 2014

<sup>105</sup> Mark Carpenter, Recyclers Announce Policy Opposing One-Bin Collection, Institute of Scrap Recycling Industries (ISRI), Summer Board of Directors Meeting Aug 07, 2014

<sup>106</sup> <http://indianapolis.granicus.com/> - Broadcast of Indianapolis Board of Public Works meeting – July 23, 2014

<sup>107</sup> Presentation by Shawn State - Pratt Industries Paper Recycling Perspective, Metropolitan Washington Council of Governments, December 4<sup>th</sup>, 2014

<sup>108</sup> Karl Hufnagel, PE Brown and Caldwell and Eric Winkler Bulk Handling Systems SWANA Webinar, July 23, 2014, op.cit.

<sup>109</sup> Andrew Davis, op.cit.



There also seems to be a correlation between opposition to new projects and whether the project will be using residue for energy recovery. The Glendale and Montgomery MWWFs are removing recyclables before landfilling and received almost no opposition. The Indianapolis project that will send the waste to a WTE facility after removing recyclables has received extensive public opposition and a lawsuit. The City of Houston, Texas, had a provision allowing for the use of the light residue from the proposed MWWF as RDF. In the Texas Campaign for the Environment's 27-page document outlining their opposition to Houston's "one-bin for all" system, a third of the document was dedicated to their opposition to gasification, incineration, and ash generation.<sup>110</sup>

## 8 Conclusions

Even after residents have separated out their recycled commodities, the average MSW stream may contain up to half of the total volume of recyclables, and in many cases more than half. Those recyclables are currently either going to landfill or to energy recovery. Mixed waste processing offers a potential solution. Originally the technology focused on the production of refuse derived fuel and was considered a "dirty" process. However modern MWWFs are an evolutionary step from single stream processing, technically mature, and employ demonstrated technology for processing MSW and capturing recyclables. The non-recycled residue could go to energy recovery. MWWF technology developers are now attempting to build commercial-scale facilities for processing both (a) MSW that has not had any source separation prior to collection and (b) mixed wastes remaining after source-separation programs.

These combined MRF and/or MWWF systems have the potential to significantly increase the volume and total revenue from recycling materials, particularly high value metals and plastics, and to divert up to 156 percent more of certain materials from landfill. The erosion of the quality of recycled materials because of contamination is expected to have a negative impact on pricing, particularly for glass and paper. These materials are already suffering from weaker markets and lower valuations. However, the cost of operating a combined system or a stand-alone MWWF would need to be more fully analyzed against the additional materials recovered and diverted from landfills.

Based on its roots in single-stream sortation, today's MWP technology appears promising. The results in terms of outputs, net revenue, and reduced collection costs could be attractive for some communities. The combination of recycling with energy recovery for non-recycled materials is an excellent approach to managing post-use materials more sustainably. Despite MWP's positive attributes, some very important questions remain, including costs, recovery capabilities, and the potential lack of markets and value for recovered materials. New projects coming online can provide important data, case studies, and learnings that will help determine a path forward for these technologies and help individual municipalities to decide if these technologies are a good fit for their specific communities.

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<sup>110</sup> Texas Campaign for the Environment – Zero Waste Houston Coalition – Its Smarter to Separate: Why Houston's Trash Proposal Would Waste Our Resources, Pollute Our Air, and Harm Our Community's Health – July 2011

## **Disclaimer**

This Report, titled, *The Evolution of Mixed Waste Processing Facilities, 1970 - Today* has been prepared to provide information to parties interested in the recycling and recovery of plastics and other materials. Mixed waste processing facilities may vary their approach with respect to particular operations, products, or locations based on specific factual circumstances, the practicality and effectiveness of particular actions and economic and technological feasibilities. This report is not designed or intended to define or create legal rights or obligations. ACC does not make any warranty or representation, either express or implied, with respect to the accuracy or completeness of the information contained in this report; nor does ACC assume any liability of any kind whatsoever resulting from the use of or reliance upon any information, conclusion, or options contained herein. The American Chemistry Council sponsored this report. This work is protected by copyright. The American Chemistry Council, which is the owner of the copyright, hereby grants a nonexclusive royalty-free license to reproduce and distribute this work, subject to the following limitations: (1) the work must be reproduced in its entirety, without alterations; and (2) copies of the work may not be sold.

## List of Report Acronyms

ACT – Alternative Conversion Technology	NCRR – National Center for Resource Recovery
AD – Anaerobic Digestion	NGO – Non-Government Organization
ADS – Air Drum Separator	NIR – Near Infrared
APR – Association of Postconsumer Plastic Recyclers	OCC – Old Corrugated Containers (Cardboard)
ARF – Applied Research Foundation	ONP – Old News Print – Newspaper
BTU – British Thermal Unit	PET – Polyethylene Terephthalate
C&D – Construction and Demolition	PP – Polypropylene
CEC – County Environmental Charge	PVC – Polyvinyl Chloride
CEO – Chief Executive Officer	QC – Quality Control
CNG – Compressed Natural Gas	R&D – Research and Development
DEQ – Department of Environmental Quality	RAS – Rotary Air Separator
ECS – Eddy Current Separator	RCRA – Resource Conservation and Recovery Act
EPA – United States Environmental Protection Agency	RDF – Refuse Derived Fuel
ECUA – Emerald Coast Utilities Authority	REW – Renewable Energy from Waste
GAA – Governmental Advisory Associates	RG&E – Rochester Gas and Electric
GBB – Gershman, Brickner & Bratton, Inc.	RIC – Resin Identification Coding
HDPE – High Density Polyethylene	RPM – Revolutions per Minute
IPF – Intermediate Processing Facility	SWANA – Solid Waste Association of North America
ISRI – Institute for Scrap Recycling Industries	TPD – Tons per Day
LDPE – Low Density Polyethylene	TPH – Tons per Hour
MCR – Mandatory Commercial Recycling	TPY – Tons per Year
MRP – Mixed Rigid Plastics	WTE – Waste to Energy
MRF – Materials Recovery Facility	WWTP – Wastewater Treatment Plants
MSW – Municipal Solid Waste	2D – Two Dimensional
MWP – Mixed Waste Processing	3D – Three Dimensional
MWPF – Mixed Waste Processing Facility	

## Glossary of Terms

Biosolids: Nutrient rich sludge from Wastewater Treatment Plants or from other organic processing.

Dual Stream: Recyclables that are source-separated into two bins, with one bin generally consisting of fiber with the other generally consisting of containers, metals, and usually glass.

Fines: Fine material, generally meaning less than 2" in size, but can also be somewhat smaller or larger.

Hi-Side: Reference to the higher end of pricing ranges for a given commodity.

Hybrid Facility: A facility that processes both single stream and MSW, either on separate lines or individually on the same line.

Inerts: Materials that will not release energy for combustion or digestion.

Gasifier: Specialized combustion to produce a carbon rich gas that can be utilized for further combustion or other chemical uses.

Non-recycled Plastics: Post-use plastics that, for whatever reason, is not recycled in commercial markets.

Overs: Material that travels on-top-of or over a screen, so is larger than the screening size.

Reclaimers: Manufacturers or other industries that use recycled material for re-use.

Single Stream: Commingled recyclables that generally includes fiber, metals, and plastic containers. Some include glass and others do not.

Throughput: The amount of material (stream) that is processed by a system in a given amount of time. For example, the systems average throughput is 35 tons per hour (TPH).

Yield Loss: The difference in weight between the initial weight of a commodity bale and the actual usable recovered commodity from that bale.

Unders: Material that falls through a screen, so is smaller than the screening size.

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