



Florida Solid Waste Management: State of the State

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ABBREVIATIONS AND ACRONYMS

C&D debris	Construction and demolition debris
EPA	U.S. Environmental Protection Agency
FDEP	Florida Department of Environmental Protection
GHG	Greenhouse gas
LCA	Life-cycle assessment
LCI	Life-cycle impact
MFA	Materials flow analysis
MRF	Material recovery facility
MSW	Municipal solid waste
MWP	Mixed waste processing
SMM	Sustainable materials management
WARM	Waste reduction model
WTE	Waste-to-energy
YT	Yard trash

UNITS OF MEASURE

MJ	Megajoules
mmBTU	Million British thermal units
t	Metric tonnes = 1.1 tons
tCO ₂ eq	Tonnes carbon dioxide equivalence
tons	US short tons = 2,000 pounds

FINAL REPORT

(Dates: 10/01/16 to 09/30/18)

PROJECT TITLE: Florida Solid Waste Management: State of the State

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KEY WORDS: Sustainable materials management (SMM), life-cycle impact (LCI), life-cycle assessment (LCA), Waste Reduction Model (WARM), waste-to-energy (WTE), mixed waste processing (MWP), recycling, Florida, solid waste management.

ABSTRACT:

As new methods for managing solid waste are developed and refined, questions are often posed about the economic and environmental merits of these strategies. To answer these questions as they pertain to Florida, we evaluate the economic and environmental implications of Florida's current solid waste management practices and the potential for implementing sustainable materials management (SMM) principles using alternative recycling metrics. To do that, we used US EPA Waste Reduction Model life-cycle impact assessment factors to quantify greenhouse gas emission and energy use offsets associated with Florida's current practices. We also compiled data on local solid waste non-ad valorem special assessments (and other revenue sources), facility tipping fees, and hauling costs to assess the feasibility of moving to alternative practices in the future.

Alternative solid waste management practices that were evaluated include waste-to-energy, mixed waste processing, construction and demolition debris recycling, curbside recycling, and non-residential food waste recycling. Recycling rates, greenhouse gas emissions, energy use rates, and economic costs associated with the status quo in Florida in 2016 were compared to the alternative approaches. Also, in-depth county case studies were completed for Alachua, Escambia, Sarasota, and Palm Beach counties. We hope our results offer resources and tools that will be helpful to future decision makers in Florida and beyond as they grapple with the complexities associated with solid waste management.

PROJECT WEB SITE: www.essie.ufl.edu/home/townsend/research/florida-solid-waste-issues/hc16/

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3. List research publications resulting from THIS Hinkley Center projects.
 Anshassi, M., Laux, S., Townsend, T.G., 2018. Replacing Recycling Rates with Life-Cycle Metrics as Government Materials Management Targets. *Environ. Sci. Technol.* 52, 6544–6554. <https://doi.org/10.1021/acs.est.7b06007>
4. List research presentations resulting from THIS Hinkley Center projects.
Technical Awareness Group (TAG) I Meeting took place on February 10th, 2017.
Technical Awareness Group (TAG) II Meeting took place on October 5th, 2017.
Technical Awareness Group (TAG) II Meeting took place on June 5th, 2018.
5. List who has referenced or cited your publications from this project?
 No publications to date.
6. How have the research results from THIS Hinkley Center project been leveraged to secure additional research funding?
 Gained interest from other organization to complete similar studies.
7. What new collaborations were initiated based on THIS Hinkley Center project?
 County-based case studies to evaluate the implementation of SMM.
8. How have the results from THIS Hinkley Center funded project been used (not will be used) by FDEP or other stakeholders?
 FDEP and stakeholders can make conclusions regarding Florida’s solid waste statistics and feasibility of implementing SMM.

EXECUTIVE SUMMARY

(Dates: 10/01/16 to 09/30/18)

PROJECT TITLE: Florida Solid Waste Management: State of the State

PRINCIPAL INVESTIGATOR(S): Timothy Townsend

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PROJECT SUMMARY:

Since the passing of the 2008 statute enacting the 75% mass-based recycling rate goal by 2020 Florida has made significant progress toward incorporating sustainable waste practices to achieve the goal. Increasingly, many states and local governments have embraced the idea of sustainable materials management (SMM) whereby materials are managed in a resource-efficient manner across all lifecycle stages: point-of-extraction, refining, manufacturing, assembly, distribution, in-use stages, and end-of-life management. The purpose of this study was to evaluate the application of SMM and this was done by mapping Florida's waste mass flow, assessing alternative waste management approaches, and evaluating the application of life-cycle thinking as an alternative recycling metric.

We mapped Florida's 2016 waste flow using the Florida Department of Environmental Protection (FDEP) 2016 solid waste management annual report. Much of the data needed to map the materials dispositions and management were readily provided in the report, but for some dispositions (e.g., materials landfilled) assumptions were made. We focused on four generator categories (residential, nonresidential, construction & demolition (C&D) debris, and yard trash) and six waste mass flow categories (recycled direct, recycled post-combustion, landfill C&D debris direct, landfill non-C&D debris direct, landfill post-combustion, and combustion). We chose to examine four waste generator categories. These included: residential solid waste, nonresidential solid waste, C&D debris, and yard trash. Treating these generators independent from each other allows local governments to identify areas with the largest recycling potential.

Florida measures recycling with two different metrics: (1) traditional recycling rate, which includes the standard materials recycled directly at a recovery facility and

materials used as alternative landfill cover; and (2) total recycling rate, which includes the traditional recycling rate and renewable energy credits awarded to combusted materials and landfill gas to energy. We determined that the total residential recycling rate (41.0%) was lower than other categories: nonresidential (55.1%); C&D debris (62.6%); and yard trash (78.2%); and the state's total recycling rate (including all generators) was 56%, with a 42% traditional recycling rate. Many of the counties with high total recycling rates - due to FDEP recycling credits - have traditional recycling rates lower or equal to counties that do not receive combustion recycling credits.

We estimated the economic costs and environmental footprint for Florida's 2016 waste management practices. The estimated economic costs were measured using data from financial reports and feasibility studies, local solid waste non-ad valorem special assessments, facility tipping fees, and hauling costs. The environmental footprint was measured using the United States (US) Environmental Protection Agency (EPA) Waste Reduction Model (WARM) life cycle impact (LCI) factors for greenhouse gas (GHG) emissions and energy use. For each of the six disposition categories a cost/ton, GHG emissions/ton, and energy use/ton was approximated and applied to the waste mass flow to generate the costs and environmental footprint for the state and the 67 counties.

Implementing SMM provides decision makers the ability to choose best practices for managing materials based on their social, economic, and environmental impact. Based off observed trends in recycling industry and using insights gained from case studies performed in several Florida counties, we evaluate five prospective alternative waste management approaches in terms of their ability to increase the recycling rate and decrease the environmental footprint. The approaches we evaluated include:

1. Waste-to-energy
2. Mixed waste processing
3. Mandatory construction and demolition debris and yard trash recycling
4. Mandatory residential curbside recycling
5. Mandatory non-residential food waste composting

For each approach the economic costs and environmental footprint were compared with the economic cost and environmental footprint for 2016 waste management practices. When compared to the current results, many approaches had a higher cost, all had a higher recycling rate, and most resulted in a greater reduction of GHG emissions and energy use. A similar analysis was performed for four specific county case studies in Alachua, Escambia, Palm Beach, and Sarasota Counties, however the alternative approaches were chosen specific to each county's interest.

We developed a methodology to generate alternative life-cycle metrics to traditional mass-based metrics, using LCI data for GHG emissions and energy use. The life-cycle metrics are essential environmental footprints transformed to a recycling rate, yielding a LCI-normalized recycling rate. We used Florida's waste management practices in 2008 and 2020 (based on 2015 reported mass per person data) as an example to test the

applicability of the methodology. From the 2008 data we developed two different baselines and compared various 2020 materials management strategies. For most approaches, LCI-normalized recycling rates were greater than mass-based recycling rates. Materials management strategies that included recycling of curbside-collected materials such as metal, paper and plastic resulted in the largest GHG- and energy-normalized recycling rates. Source reduction or increase, determined as the net difference in per-person mass discard rate for individual materials, was a major contributor to the LCI-normalized recycling rates.

This project provides the Florida solid waste community with an understanding of the environmental and economic impacts of the current state of affairs of solid waste management and outlines application of SMM using various approaches. Results show that no single approach leads to successfully meeting the mass-based 75% goal, suggesting that the goal may be met only through a combination of approaches. However, a combination of approaches requires large economic investment and large state regulatory changes, thus achieving the goal by 2020 is unlikely. Also, due to conditions affecting the market price of recyclables, such as China's "Green Fence" which set new standard for trading recyclables, contributes to the challenge faced by Florida to meet the goal. Based on these results there is a clear need for the state to explore a new direction. We demonstrated a prospective new direction that used LCA results to create an alternative metric to the recycling rate. This alternative metric is only one approach to incorporate SMM principles to measure a solid waste system's performance to allow Florida to truly transform to SMM.

1.0 INTRODUCTION

The way our society thinks about natural resources and environmental protection has changed and is continuing to change. Regarding the disposition of solid waste, terminology is shifting along with attitudes. What we were once content to call “solid waste management” has now become sustainable materials management (SMM). US EPA defines SMM as “an approach to serving human needs by using/reusing resources most productively and sustainably throughout their lifecycles, generally minimizing the amount of materials involved and all the associated environmental impacts.” One of the most common manifestations of the SMM approach involves the recycling of municipal solid waste (MSW). Over the past 25 years, popular opinion — and government initiatives at all levels — have led to recycling becoming a routine part of people’s lives both at home and at work.¹

Community recycling is typically accomplished in the US through residential curbside and commercial recycling programs. Materials collected from these programs are sorted at material recovery facilities (MRF) and then sold. To encourage recycling, federal and state regulatory agencies generally require municipal governments to offer recycling services. Agencies often set recycling or landfill diversion targets for MSW; these are typically described as “rates” corresponding to the mass of material recycled (or diverted from a landfill) divided by total generated waste. In Florida, the Energy, Climate Change, and Economic Security Act of 2008 established an ambitious statewide recycling goal of 75% by 2020. In 2016, Florida’s recycling rate was 56%. The purpose of this study is to evaluate how SMM principles are being applied in Florida by mapping the state’s waste mass flow, assessing the environmental footprint and economic costs of current and potential alternative waste management practices, and evaluating the application of life-cycle thinking as an alternative to the current mass-based recycling metric.

2.0 FLORIDA SOLID WASTE MANAGEMENT IN CONTEXT

2.1 LEGISLATIVE HISTORY

The Florida legislature has long played a critical role in increasing Florida's recycling rate. The 1974 Resource Recovery and Management Act (RRMA) established a basis for studying resource recovery and making recommendations to ensure solid waste was "recovered and recycled to the greatest extent practicable for continued use, and for use as a source of energy." It also required counties and municipalities to develop their own solid waste management plans and submit them to the state for approval, exempting communities from recycling only when they were located in regions "where sufficient solid waste is not generated to make it economically practical."²

In 1976 the state published the *Solid Waste Management and Resource Recovery Technical Assistance Handbook* to assist counties and municipalities in implementing the RRMA. By 1985, urban counties, which together produced more than 90% of the state's waste, were expected to achieve a recycling rate of 18% and an energy recovery rate of 50%. Rural counties were expected to achieve a recycling rate of 1%.³

Progress continued with the 1988 passage of the Solid Waste Management Act (SWMA), which established a 30% recycling goal to be achieved by 1995. The act required that no more than half of that goal could be met by recycling yard trash, white goods, and construction and demolition (C&D) debris — programs for recycling aluminum cans, glass, newspaper, and plastic bottles had to account for the other half.⁴ A 1993 amendment to the SWMA then mandated the inclusion of steel cans in recycling programs.⁵

Meanwhile, as Florida's population exploded in the 1990s and 2000s, momentum was building for further legislative action. In 2008, the Energy, Climate Change, and Economic Security Act established an ambitious statewide solid waste disposal reduction goal of 75% by 2020. Solid waste used in the production of renewable energy counted toward the goal, and each county was to develop and implement a composting plan accounting for up to 10% of organic material generated in the county.⁶

The Energy Act also directed the Florida Department of Environmental Protection (FDEP) to submit a plan for achieving the 75% recycling rate, which it did in 2010.⁷ That same year, House Bill 7243 changed the "solid waste disposal reduction goal" to a "recycling goal" and added milestone goals: 40% by the end of 2010, 50% by the end of 2014, 60% by the end of 2016, 70% by the end of 2018, and 75% by the end of 2020.⁸

Later legislation required counties to implement C&D debris recycling programs and directed FDEP to award renewable energy recycling credits to counties contributing solid waste and landfill gas to energy production, where each MW-hr produced was equivalent to 1 ton of recycled material. If counties had a 50% recycling rate or higher, then each MW-hr was equivalent to 2 tons of recycled material.⁷⁻⁹ Additionally, WTE ash did not count as a solid waste, and a county was eligible to receive half of the recycling goal through the use of yard trash or other clean wood or paper waste through innovative

programs.⁸ In 2012, the legislature enacted House Bill 503, which revised the criteria for renewable energy credits. For each MW-hr produced, counties with a 50% or greater recycling rate would receive credit equivalent to 1.25 tons of recycled material, and WTE ash could count toward recycling goals if it was used as alternative landfill cover.⁹

Through public education, advertising, financial incentives and disincentives, and providing expert assistance to recycling businesses, FDEP continues to assist counties and municipalities in enhancing their recycling programs as C&D debris has been incorporated. Figure 2.1.1 shows that, from 1997 to 1998, a sharp decrease in the recycling rate (38% to 28%) resulted from an FDEP methodology change in how C&D debris was counted toward recycling, and then from 2009 to 2010 a sharp increase occurred due to the implementation of renewable energy recycling credits. Meanwhile, as waste generation has increased (Figure 2.1.2), so has the amount of recycled materials (Figure 2.1.3).

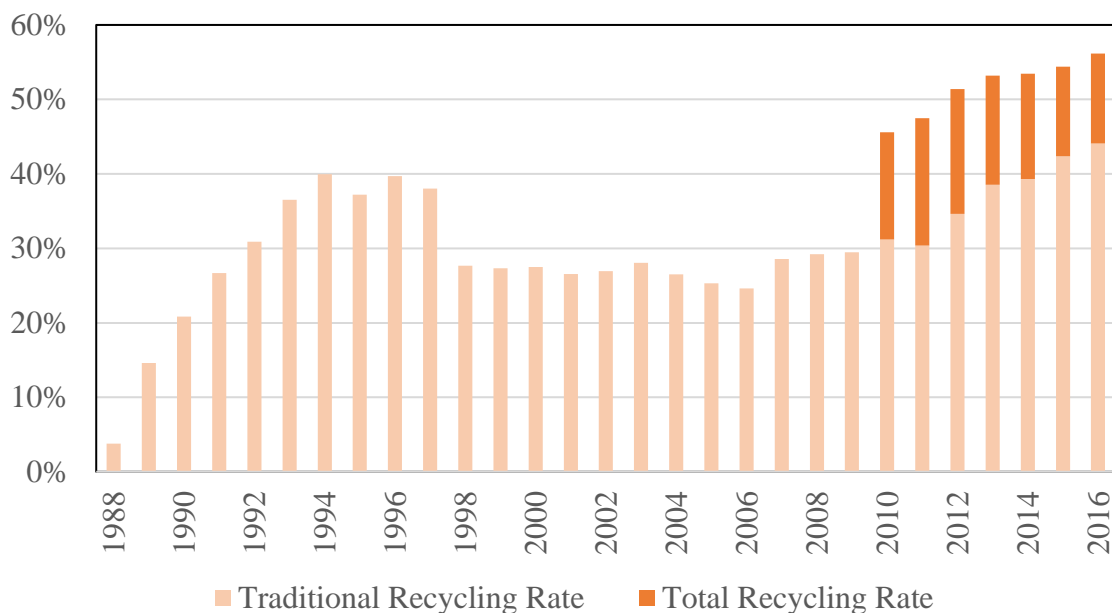


Figure 2.1.1: Traditional and total recycling rates in Florida, 1988-2016. Unless otherwise indicated, data in all figures and tables is based on FDEP solid waste management annual reports.

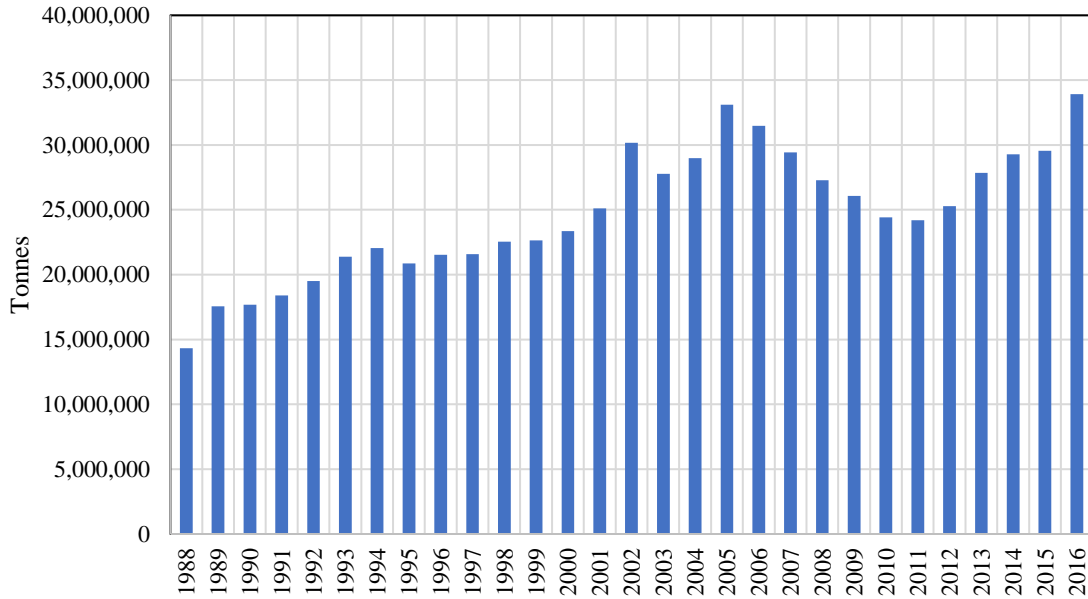


Figure 2.1.2: Solid waste generation in Florida, 1988-2016.

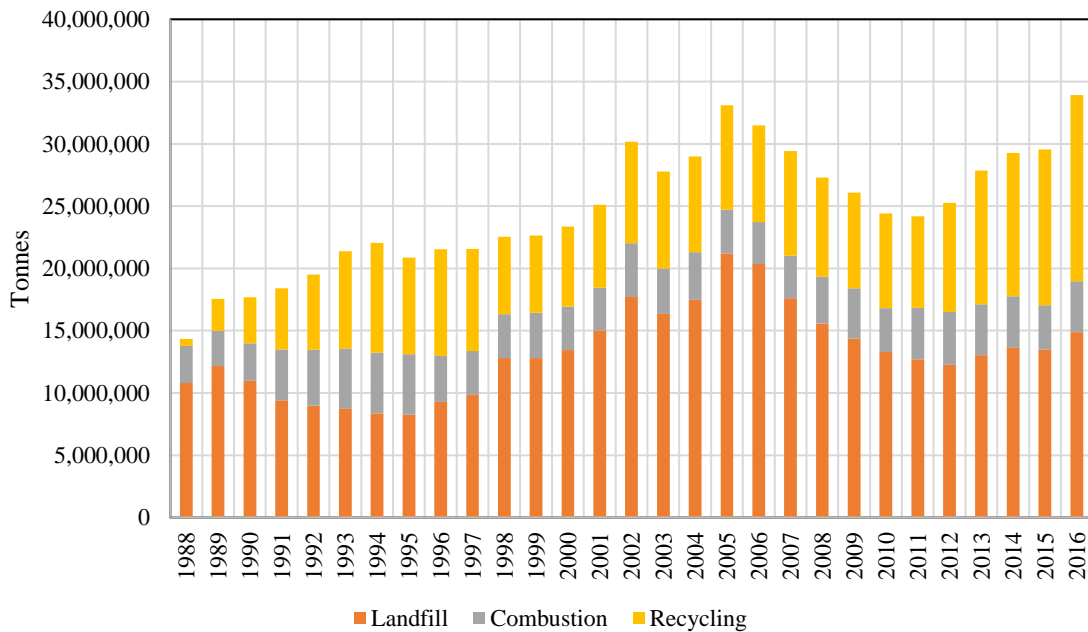


Figure 2.1.3: Waste disposition in Florida, 1988-2016.

2.2 FROM SOLID WASTE MANAGEMENT TO SUSTAINABLE MATERIALS MANAGEMENT

The concept of SMM originated in a 2002 EPA publication entitled “Beyond RCRA: Waste and Materials Management in the Year 2020.” In 2009, EPA further developed the idea in “Sustainable Materials Management: The Road Ahead,” which presented a roadmap for moving toward SMM. In these and other documents, SMM is characterized

as a varying set of resource-efficient actions to be taken across the entire lifecycle of a material or product — from extraction through refinement, manufacturing, assembly, distribution, use, and end-of-life management (Figure 2.2.1).¹⁰⁻¹² In contrast to traditional conceptions of waste management, SMM seeks to establish policies that encourage the most productive uses for all resources while minimizing the impact of waste and pollutants at all stages. From the policy standpoint, SMM is meant to produce a long-term systemic solution to the problem of waste management that takes into account the interests of all public and private stakeholders.¹²

As policymakers incorporate SMM principles into the regulatory framework, they look to promote sustainable production and use practices and to transform end-of-life management into a source of additional sustainability and productivity.^{11,13} To account for their decision making, they use lifecycle assessment (LCA) models, which quantify material flows throughout all lifecycle stages in terms of environmental, economic, and social impact. In addition to tracking material flow paths, LCA models identify which economic sectors generate the most waste and assess the environmental and economic effectiveness of various waste management strategies.^{10,14}



Figure 2.2.1: The five lifecycle stages.

2.3 THE WASTE REDUCTION MODEL (WARM)

2.3.1 Lifecycle Assessment Models

SMM, then, focuses on identifying best material management practices based on environmental, economic, and social impacts. LCA models measure those impacts, and policymakers use LCA results to make SMM-informed decisions.

An LCA has four components. First, the goal of the assessment is defined in terms of the purpose and extent of the study, the intended audience, and the scope or system boundary of the study. The second component consists of inventory analysis, which means creating

an inventory of flows to and from nature for a particular product system. The third stage, lifecycle impact (LCI) assessment, involves arranging this input and output data into impact categories that contribute to aggregated indicators, which are measures of impact. Impact categories include global warming potential and acidification potential; they're selected according to their relevance to the product system being studied. Finally, the data is interpreted and potentially associated with policy alternatives.¹⁵⁻¹⁶

2.3.2 LCA Models Used in Solid Waste Management

Notable LCA models used in various countries around the world include the Municipal Solid Waste Decision Support Tool (MSW-DST), which is used by US EPA. Other LCAs include the Solid Waste Optimization Lifecycle Framework (SWOLF), the Environmental Assessment System for Environmental Technologies (EASETECH), and the Waste Resources Assessment Tool (WRATE).

Another LCA used by US EPA is the Waste Reduction Model (WARM). Of all the tools listed here, only WARM can assess source reduction.¹⁷ Source reduction is defined in this study as any manufacturer or consumer action that results in a decrease in waste generated in a future year compared to a previous year. WARM was chosen for this study because of its ability to quantify these environmental impacts.

In the WARM model, greenhouse gas (GHG) emissions and energy use are quantified for 54 types of waste in terms of six waste management categories: source reduction, recycling, landfill, combustion, composting, and anaerobic digestion. WARM LCI factors are used to compare a baseline approach to an alternative approach to assess the energy and GHG impacts that would occur throughout the material's lifecycle.¹⁸ However, in this study, LCI factors are used in their absolute form. This is possible because LCI factors depict GHG emissions and energy use as an absolute calculation, independent of comparisons to alternate approaches.

Input data in this study is based on state and county waste disposition and composition as reported in 2016; this sets the mass balance in accordance with a static modeling approach based on a single year's data.

The WARM model calculates impacts from a waste generation reference point and captures upstream emissions and sinks when materials are recycled or source-reduced (Figure 2.3.1). GHG emissions and energy use are evaluated based on three factors: GHG emissions and energy use throughout the lifecycle of the material (including end-of-life management); the extent to which carbon sinks are affected by the manufacture, recycling, and disposal of a material; and the extent to which the management option recovers energy that can be used to replace electric utility energy, thus reducing electric utility emissions.

The lifecycle stages included in WARM are: (1) extraction and processing of raw materials; (2) manufacture of products; (3) transportation of materials and products to markets; (4) use by consumers; and (5) end-of-life management. Emissions and energy

use originate in the pre-consumer stages of raw materials acquisition and manufacturing and the post-consumer stage of end-of-life management.

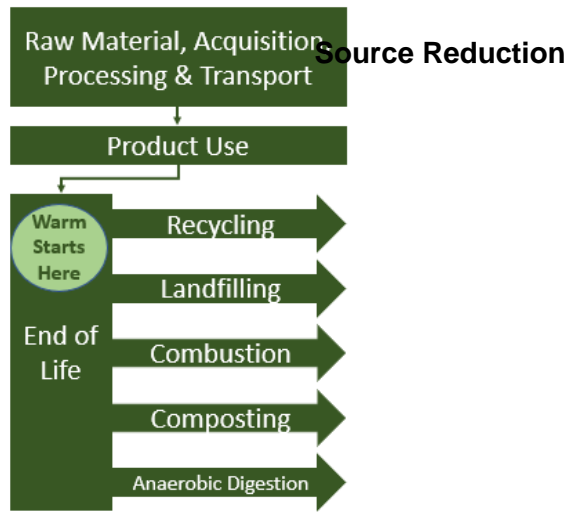


Figure 2.3.1: WARM system boundaries for typical waste products.

In the WARM model, LCIs are given as conversion factors, which quantify the environmental impact of a material’s end-of-life management and the interactions within each management stage. For example, materials recycled include upstream emissions and energy use, and materials landfilled include landfill emissions and energy use. In this study, we quantify Florida state and county solid waste management environmental footprints by evaluating 18 materials using LCI conversion factors. These factors are presented in Table 2.3.1 for GHG emissions and in Table 2.3.2 for energy use. LCI conversion factors for recycled, landfilled, combusted, and source reduction are provided directly from WARM; LCI conversion factors for recycled and landfilled post-combustion were derived by adding the combustion factors to the recycled factors, with the landfilled post-combustion factors assumed to be equivalent to the combustion factors. For some LCI conversion factors, the value is negative. In WARM, a negative value is defined as a reduction or offset in GHG emissions and energy use, while a positive value is associated with an emission of GHG and a usage of energy.

As shown in Figure 2.3.1, WARM estimates LCI factors for six management approaches. The following paragraphs discuss the recycling, source reduction, landfilling, and combustion management approaches.

WARM assumes that in a recycling process, materials transform at the end of their life either into the same product (known as closed-loop recycling) or into a secondary product (known as open-loop recycling). Materials modeled as open-loop in WARM are mixed paper, corrugated containers, copper wire, carpet, personal computers, concrete, tires, fly ash, asphalt shingles, and drywall. Recycled materials replace virgin inputs in the manufacturing process, thus reducing GHG emissions and energy use. Reductions in

GHG emissions and energy use occur when a material is recycled and it offsets a portion of “upstream” GHG emissions and energy use associated with raw material acquisition, manufacture, and transport of virgin inputs, and when the amount of carbon stored in forests increases because of wood and paper product recycling, which offsets harvesting trees.¹⁹ With source reduction, WARM assumes that materials not generated offset all upstream GHG emissions and energy use.

We used the WARM default value of 20 miles for landfill transportation distance and assumed that the landfill generated landfill gas at the national average. GHG emissions and energy use impacts for landfilling are due to: (1) CH₄ emissions from the anaerobic decomposition of biogenic carbon compounds (such as food waste, yard trimmings, and paper-based materials); (2) CO₂ emissions and energy use emanating from landfilling equipment; (3) biogenic carbon stored in the landfill; and (4) CO₂ emissions and energy use avoided through landfill gas-to-energy projects. WARM assumes that plastic-based materials do not contribute to the release of CH₄ in the landfill end-of-life management emissions balance and that some materials (such as newspaper) have a carbon storage capacity that exceeds the emissions related to transportation and CH₄ generation.¹⁸

With WARM materials, combustion occurs in a WTE facility that generates electricity that can be used similar to a utility generating electricity from fossil fuels. As materials combust, GHG emissions in the form of CO₂ and N₂O are emitted. However, for paper-based materials, those emissions are assumed to be biogenic and are not counted in the emissions balance, whereas plastic-based materials are non-biogenic and contribute emissions that are counted toward the combustion end-of-life management emissions balance. The electricity generated by the WTE is assumed to offset the use of utility-generated electricity, which uses non-renewable fossil fuels as energy sources. This allows net GHG emissions and energy use to be calculated by subtracting electric utility GHG emissions and energy use avoided from gross GHG emissions and energy use. Furthermore, WARM assumes steel recovery of the that ash generated at the WTE is recovered for use in steel production; it is treated as a recycled material that offsets virgin steel.¹⁸

Table 2.3.1: WARM emission factors for MSW materials, based on EPA WARM v14 and converted from WARM default units (tCO₂eq/ton to tCO₂eq/t).

MSW material	Recycled (tCO ₂ eq./t)	Recycled post-combustion (tCO ₂ eq/t) ^a	Landfilled direct C&D debris (tCO ₂ eq/t)	Landfilled direct non-C&D debris (tCO ₂ eq/t)	Landfilled post-combustion (tCO ₂ eq/t) ^b	Combusted (tCO ₂ eq/t) ^c	Source reduction (tCO ₂ eq/t)
Newspaper	-3.03	—	—	-0.902	—	-0.639	-5.26
Glass	-0.309	—	—	0.022	0.033	0.033	-0.584
Aluminum cans	-10.0	-10.0	—	0.022	0.044	0.044	-5.41
Plastic bottles ^d	-1.10	—	—	0.022	—	1.36	-2.02
Steel cans	-2.00	-1.96	—	0.022	0.033	0.033	-3.37
Corrugated paper	-3.44	—	—	0.254	—	-0.562	-6.17
Office paper	-3.15	—	—	1.34	—	-0.540	-8.79
Yard trash ^e	-0.165	—	—	-0.198	—	-0.198	—
Other plastic ^f	-1.12	—	—	0.022	—	1.35	-2.12
Ferrous metals ^g	-4.78	-4.75	—	0.022	0.033	0.033	-4.08
White goods ^g	-4.78	-4.75	—	0.022	0.033	0.033	-4.08
Non-ferrous metal ^g	-4.78	-4.75	—	0.022	0.033	0.033	-4.08
Other paper ^h	-3.89	—	—	0.143	—	-0.562	-7.44
Textiles ⁱ	-2.60	—	—	0.022	—	1.19	-4.21
C&D debris ^j	-0.688	—	-0.275	—	—	—	-0.615
Food ^e	-0.198	—	—	0.595	—	-0.154	-4.04
Miscellaneous ^k	—	—	—	0.386	—	0.320	—
Tires	-0.419	—	—	0.022	—	0.706	-4.72
Process fuel ^l	—	—	—	—	—	—	—

- a. Emission factors do not exist for recycled post-combustion; recycling emission factors were used, but the emissions generated during combustion were deducted from the recycling emission factors.
- b. Emission factors do not exist for landfilled post-combustion; emissions generated during combustion were used as a proxy.
- c. Combustion emission factors do not include any steel recovery emission factors.
- d. Emission factors do not exist for plastic bottles in WARM; an average of the WARM categories for HDPE and PET was used as a proxy.
- e. Recycling emission factors do not exist for organic materials in WARM; composted emission factors were used as a proxy.
- f. Emission factors do not exist for other plastics in WARM; the WARM category for mixed plastic was used as a proxy.
- g. Emission factors do not exist for ferrous and non-ferrous metals and white goods in WARM; emission factors for mixed metals were used as a proxy.
- h. Emission factors do not exist for other paper in WARM; the WARM category for mixed paper was used as a proxy.
- i. Emission factors do not exist for textiles in WARM; the WARM category for carpet was used as a proxy.
- j. Emission factors do not exist for C&D debris in WARM; composition using WARM material categories was assumed to be 50% concrete, 25% dimensional lumber, 15% drywall, and 10% asphalt shingles.
- k. Emission factors do not exist for miscellaneous materials in WARM; the mixed MSW WARM category was used as a proxy.
- l. Emissions factors do not exist for process fuels; no proxy was used.

Table 2.3.2: WARM emission factors for MSW materials, based on EPA WARM v14 and converted from WARM default units (mmBTU/ton to MJ/t).

MSW material	Recycled (MJ/t)	Recycled post-combustion (MJ/t) ^a	Landfilled direct C&D debris (MJ/t)	Landfilled direct non-C&D debris (MJ/t)	Landfilled post-combustion (MJ/t) ^b	Combusted (MJ/t) ^c	Source reduction (MJ/t)
Newspaper	-19,177.9	—	—	58.1500	—	-8,757.39	-42,403.0
Glass	-2,477.19	—	—	314.010	581.500	581.500	-8,024.70
Aluminum cans	-177,659	-176,962	—	314.010	697.800	697.800	-104,309
Plastic bottles ^d	-47,723.7	—	—	314.010	—	-17,136.8	-64,819.8
Steel cans	-23,225.1	-22,678.5	—	314.010	546.610	546.610	-34,750.4
Corrugated paper	-17,526.4	—	—	-290.750	—	-7,722.32	-25,958.2
Office paper	-11,723.0	—	—	-616.390	—	-7,443.20	-42,565.8
Yard trash ^e	674.540	—	—	162.820	—	-2,884.24	—
Other plastic ^f	-45,170.9	—	—	314.010	—	-15,851.7	-63,290.4
Ferrous metals ^g	-76,746.3	-76,142.5	—	314.010	603.834	603.834	-58,859.4
White goods ^g	-76,746.3	-76,142.5	—	314.010	603.834	603.834	-58,859.4
Non-ferrous metal ^g	-76,746.3	-76,142.5	—	314.010	603.834	603.834	-58,859.4
Other paper ^h	-23,783.3	—	—	-244.230	—	-7,757.21	-34,238.7
Textiles ⁱ	-24,969.6	—	—	314.010	—	-8,361.97	-105,902
C&D debris ^j	-632.090	—	302.380	—	—	—	-2,052.11
Food ^e	674.540	—	—	-23.2600	—	-2,395.78	-16,933.3
Miscellaneous ^k	—	—	—	-81.4100	—	-5,396.32	—
Tires	-4,140.28	—	—	314.010	—	-31,994.1	-83,398.7
Process fuel ^l	—	—	—	—	—	—	—

- a. Emission factors do not exist for recycled post-combustion; recycling emission factors were used, but the emissions generated during combustion were deducted from the recycling emission factors.
- b. Emission factors do not exist for landfilled post-combustion; emissions generated during combustion were used as a proxy.
- c. Combustion emission factors do not include any steel recovery emission factors.
- d. Emission factors do not exist for plastic bottles in WARM; an average of the WARM categories for HDPE and PET was used as a proxy.
- e. Recycling emission factors do not exist for organic materials in WARM; composted emission factors were used as a proxy.
- f. Emission factors do not exist for other plastics in WARM; the WARM category for mixed plastic was used as a proxy.
- g. Emission factors do not exist for ferrous and non-ferrous metals and white goods in WARM; emission factors for mixed metals were used as a proxy.
- h. Emission factors do not exist for other paper in WARM; the WARM category for mixed paper was used as a proxy.
- i. Emission factors do not exist for textiles in WARM; the WARM category for carpet was used as a proxy.
- j. Emission factors do not exist for C&D debris in WARM; composition using WARM material categories was assumed to be 50% concrete, 25% dimensional lumber, 15% drywall, and 10% asphalt shingles.
- k. Emission factors do not exist for miscellaneous materials in WARM; the mixed MSW WARM category was used as a proxy.
- l. Emission factors do not exist for process fuels; no proxy was used.

2.4 RESEARCH APPROACH

Task 1: Establish stakeholder working group. Members of the Florida solid waste community were invited to participate in a working group to discuss the state of solid waste management in Florida. Representatives from the public sector (municipal governments, regulatory agencies, and environmental groups) and the private sector (facility owner/operators, haulers, technology representatives, end-users) were included.

Task 2: Compile available data on Florida solid waste management disposition and economics. Information was collected from counties and from FDEP-reported data. Other data was collected directly from solid waste directors and representatives. Information on anaerobic digestion, composting, and source-segregated organics collection was not available on a Florida-specific basis; in those cases, data from other US municipalities, along with data from international sources, was collected as needed.

Task 3: Develop alternative waste management economic and environmental approaches. Using the working group's feedback, the research team identified five specific waste management alternative approaches: the WTE approach, the mixed waste processing (MWP) approach, the C&D and yard trash recycling approach, the residential curbside recycling approach, and the non-residential food waste composting approach.

Task 4: Evaluate waste management economic and environmental approaches. Using WARM, Florida solid waste management data from 2016 was compared to alternative approaches in terms of economic costs, social impacts, and environmental impacts.

2.5 REPORT ORGANIZATION

This report is organized into five sections. Section 2 (this section) accounts for the history of Florida waste management regulation, describes SMM, and defines the LCA model used in this study. Section 3 presents 2016 Florida solid waste management data including mass flow for the Florida waste stream, solid waste management practices, and waste disposition calculated for the state as a whole and for each county. Section 4 summarizes SMM implementation findings in case studies conducted in Alachua, Palm Beach, and Sarasota counties. Section 5 discusses the five alternative solid waste management approaches chosen and presents the results of the LCA comparison of Florida's 2016 solid waste management data with the alternative approaches. Section 6 proposes a lifecycle-thinking-based alternative to the mass-based recycling rate currently in use. A Conclusion is also provided.

3.0 2016 FLORIDA WASTE MANAGEMENT DATA

3.1 WASTE DISPOSITION AND COMPOSITION

3.1.1 Overview

The data used in this study to characterize Florida's material stream and solid waste management practices originated in FDEP's 2016 solid waste management annual report.²⁰ These data, collected by county, include the quantities collected, recycled, landfilled, and combusted for each material stream along with traditional and total recycling rates (including recycling credits). The data was compiled by FDEP in an online database known as Re-TRAC Connect.

Every year, certified recyclers (Florida businesses that manage more than 600 tons of recovered material per year) and Florida county recycling programs submit, through Re-TRAC, quantities for the materials they manage. County recycling programs also obtain quantities from non-certified recyclers (Florida businesses that manage fewer than 600 tons of recovered material per year) that they report to FDEP through Re-TRAC. Quantities for recycled materials are typically recorded by material type (e.g., aluminum cans, glass containers, and so on). Quantities for collected and disposed non-recycled MSW are not tracked by material type; Re-TRAC estimates quantities for those materials using FDEP's Waste Composition Calculation Model (WasteCalc). WasteCalc was developed using national and statewide waste composition data and individual county demographic and socioeconomic information. Every county is given the option to use its own solid waste composition model in lieu of WasteCalc. FDEP requires that any recycling credit awarded to a county be based on material originating in that county. It also allows counties to receive recycling credits for combusting their waste in a WTE facility in another county.

We compiled waste generation data into four broad categories: residential solid waste, non-residential solid waste, C&D debris, and yard trash. The mass flow associated with transfer stations in the state was also estimated. The residential and non-residential categories do not include yard trash or C&D debris. Yard trash and C&D debris were estimated independently of residential and non-residential generators because they are the two largest components of Florida's waste stream and their management is often distinct from the rest of the waste stream. This approach provides policymakers with information related to each generator's waste management and recycling progress that they can use to identify areas with the most potential for investing in recycling programs.

The residential solid waste category was estimated by combining reported data for single-family and multi-family units, and the non-residential category was assumed to be equivalent to the commercial data found in the 2016 FDEP annual report. In 2016, Florida recycled 44% of its waste, landfilled 44%, and combusted 12% (Figure 3.1.1). Of the 18 categories of materials collected, the largest were C&D debris (30%), miscellaneous (12%), and yard trash (11%) (Figure 3.1.2). Of the materials recycled, the largest categories were C&D debris (40%), yard trash (17%), and ferrous metals (14%)

(Figure 3.1.3). And of the largest collected materials, food waste and miscellaneous both had a small recycling rate of 8% and 16%, respectively.²⁰

We used three recycling rates to assess residential solid waste, non-residential solid waste, C&D debris, and yard trash. The first of these, known as the standard recycling rate, as defined by this study awards recycling credits only for materials that are recycled through an MRF or a composting facility; this is what people generally think of when they think of recycling. The second rate, known as the traditional recycling rate, as defined by FDEP encompasses includes not only materials that are recycled through an MRF or a composting facility but also encompasses recycling credits for yard trash used as landfill cover, other MSW used as landfill cover (such as crushed glass and processed concrete), treated contaminated soil used as landfill cover, and process fuel and fuel substitutes. The third rate, known as the total recycling rate, also includes renewable energy credits, including landfill gas-to-energy from MSW, landfill gas-to-energy from yard trash, waste-to-energy, renewable energy other than WTE, and yard trash generating landfill gas (generating something other than electricity).

In 2016, Florida's standard recycling rate was 40.6%, its traditional recycling rate was 44.7%, and its total recycling rate was 55.8% (Figure 3.1.4), with the total recycling rate falling short of the state's 2016 interim recycling goal of 60%. Meanwhile, the state's residential and non-residential standard recycling rates differed significantly (21.7% and 35.4%, respectively); this is because the non-residential rate incorporates commercial establishments that contract with haulers to collect their recyclables. High yard trash and C&D rates (50.0% and 59.9%, respectively) are due largely to the requirement that recycling facilities report to FDEP as certified recyclers. Rates by county are shown in Tables 3.1.4 and 3.1.5.

We probed Florida's solid waste management practices by assessing the following six MSW categories:

1. Recycled direct: Materials sent directly to an MRF
2. Recycled post-combustion: Materials recycled after combustion at a WTE facility
3. Landfill direct C&D debris: C&D debris sent directly to a Class III landfill
4. Landfill direct non-C&D debris: All materials other than C&D debris sent to a Class I landfill
5. Landfill post-combustion: Residual materials after combustion at a WTE facility (essentially bottom ash and fly ash)
6. Combustion: Materials combusted fully that do not produce ash

Tonnage estimates for each category are based on the 2016 FDEP annual report. Each category's tonnage was estimated according to the following steps and assumptions used to further refine the FDEP data, as seen in Tables 3.1.1, 3.1.2, and 3.1.3:

Step 1: Remove the process fuel from office paper, other paper, yard trash, and miscellaneous.

- **Assumption 1:** Process fuel mass was removed from collected office paper, other paper, and yard trash mass based on each material's unadjusted collected mass for all counties that report process fuel except for Brevard and St. Lucie counties. The removed process fuel was treated as collected mass.
- **Assumption 2:** For Brevard County, process fuel mass was removed from office paper, other paper, yard trash, and miscellaneous mass based on each material's unadjusted collected mass.
- **Assumption 3:** For St. Lucie County, process fuel mass was removed from office paper and yard trash mass based on each material's unadjusted collected mass.

Step 2: Use FDEP data to identify total county mass disposition for each of the six categories (recycled direct, recycled post-combustion, landfill direct C&D debris, landfill direct non-C&D debris, landfill post-combustion, and combusted).

- **Assumption 1:** Recycled direct mass was estimated by subtracting recycled post-combustion mass (reported in the FDEP 2016 annual report as combustor ash recycled) from total recycled material mass for all counties.
- **Assumption 2:** Landfill direct C&D debris mass was calculated by subtracting recycled C&D debris mass from total collected C&D debris mass for all counties.
- **Assumption 3:** Landfill direct non-C&D debris mass was estimated by subtracting landfill C&D debris mass and landfill post-combustion mass (reported in the FDEP 2016 annual report as combustor ash landfilled) from total landfill mass for all counties except Lee, Pasco, and Hendry.
- **Assumption 4:** For Lee, Pasco, and Hendry counties, there was no landfill direct non-C&D debris tonnage, and landfill direct C&D debris was calculated as the difference between total collected mass and recycled direct, recycled post-combustion, landfill post-combustion, and combusted mass.
- **Assumption 5:** Combusted mass was equivalent to reported net combusted mass.

Step 3: Use FDEP data to estimate mass disposition for the six categories for each of the 18 categories of materials.

- **Assumption 1:** Recycled direct mass was equivalent to reported recycled mass.
- **Assumption 2:** Recycled post-combustion mass applied only to aluminum and steel cans, ferrous and non-ferrous metals, and white goods. Recycled post-combusted mass for those materials was calculated by proportionally distributing the county's total recycled post-combusted mass based on the Excel's Solver function.
- **Assumption 3:** Landfill direct non-C&D debris was calculated by proportionally distributing the remainder mass (collected mass minus the summation of recycled direct and recycled post-combustion mass) based on the county's total landfill direct non-C&D debris and gross combusted mass (the summation of recycled post-combustion, landfilled post-combustion, and combusted mass).

- **Assumption 4:** Landfilled post-combustion mass applied only to glass, aluminum and steel cans, ferrous and non-ferrous metals, white goods, and miscellaneous. Landfilled post-combusted mass for those materials was calculated as the difference between gross combusted mass and landfill direct non-C&D debris mass minus recycled post-combusted mass, with the exception that miscellaneous mass was calculated by also subtracting combusted mass. This assumption applied for all counties reporting combustor ash landfilled except Miami-Dade, Pinellas, Lee, Pasco, Hendry, Leon, and Alachua.
- **Assumption 5:** For Miami-Dade County, no steel, ferrous metals, or white goods contributed to landfill post-combustion mass. In Pinellas County, no ferrous metals contributed to landfill post-combustion mass. C&D debris contributed to landfill post-combustion mass in Lee, Pasco, and Hendry counties, while in Leon County only miscellaneous contributed to landfill post-combustion mass and in Alachua only yard trash and miscellaneous contributed.
- **Assumption 6:** Combusted mass applied only to newspaper, plastic bottles, corrugated and office paper, yard trash, other plastics and paper, textiles, food, miscellaneous, and tires. Combusted mass for those materials was calculated as the difference between gross combusted mass minus landfill direct non-C&D debris mass with the exception that miscellaneous combusted mass was calculated using Excel's Solver function to ensure that the summation of the calculated material's combusted mass equaled reported net combusted mass. This assumption applied to all counties reporting net combusted mass except Duval, Brevard, Manatee, Alachua, Indian River, and Columbia.
- **Assumption 7:** For Duval, Brevard, Manatee, Indian River, and Columbia counties, only yard trash was combusted, but in Alachua County yard trash and miscellaneous were combusted. The following assumptions related to combustion mass were used:
 - Counties that combusted MSW at a WTE facility: Miami-Dade, Broward, Palm Beach, Hillsborough, Pinellas, Lee, Pasco, Lake, Leon, Bay, Martin, Citrus, Monroe, Putnam, Walton, Jackson, Hendry, Washington, Holmes, Gulf, Calhoun.
 - Counties that combusted yard trash at a renewable energy facility: Duval, Brevard, Manatee, Alachua, Indian River, Columbia.
 - Counties that combusted MSW at a WTE facility and combusted yard trash at a renewable energy facility: Marion.

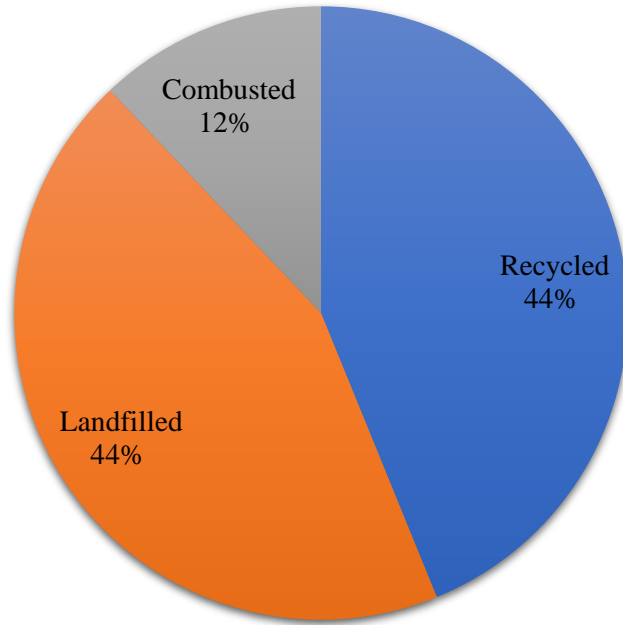


Figure 3.1.1: Landfilled, combusted, and recycled waste collected in Florida.

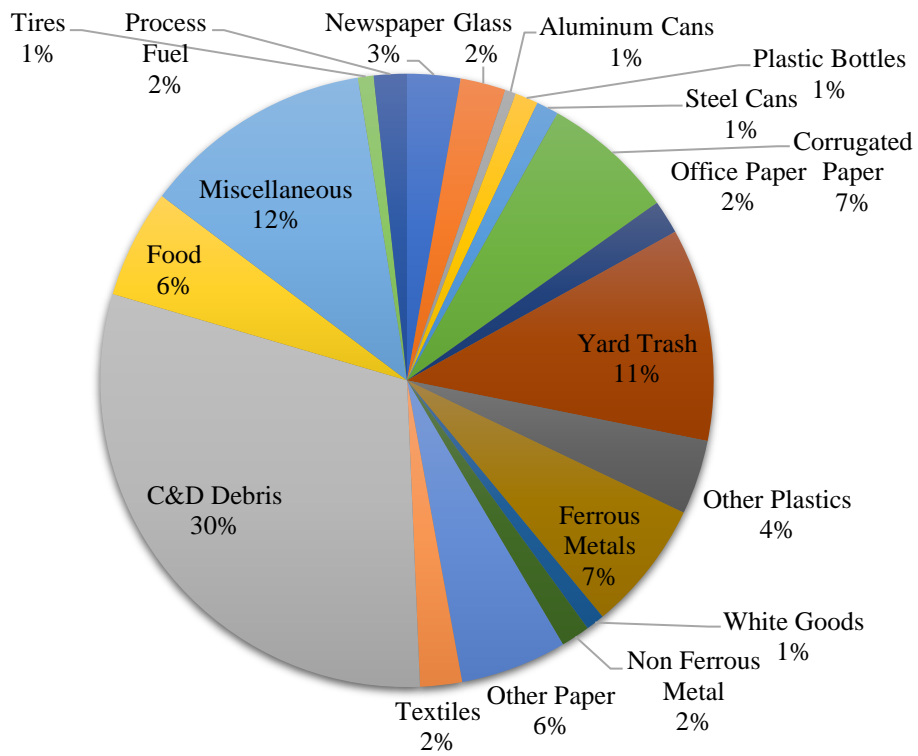


Figure 3.1.2: Materials collected in the Florida waste stream.

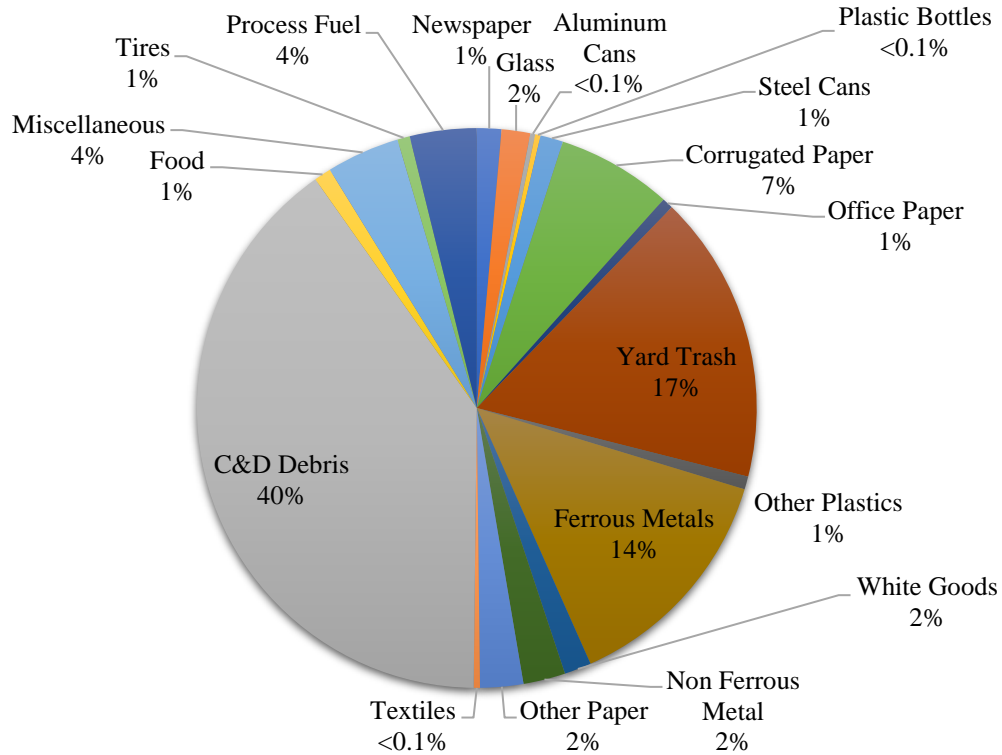


Figure 3.1.3: Materials recycled in Florida.

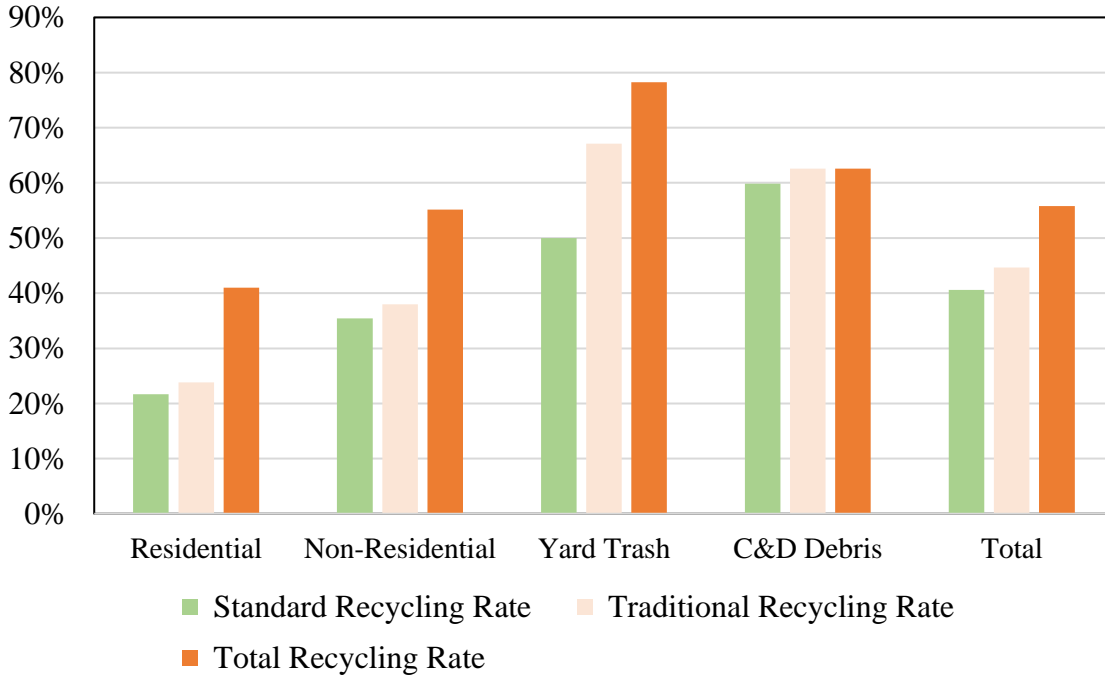


Figure 3.1.4: Standard, traditional, and total recycling rates for the four waste generator categories.

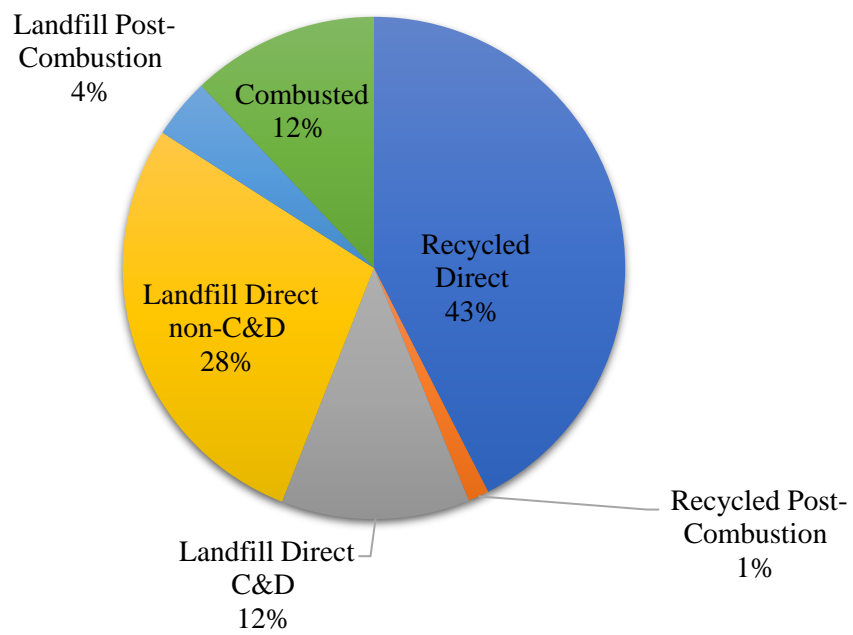


Figure 3.1.5: Mass disposition in detail.

Table 3.1.1: Mass disposition for Florida counties with populations greater than 150,000.

County	Collected (tonnes)	Recycled direct (tonnes)	Recycled post-combustion (tonnes)	Landfill direct C&D debris (tonnes)	Landfill direct non-C&D debris (tonnes)	Landfill post-combustion (tonnes)	Combusted (tonnes)
Miami-Dade	3,982,274	1,115,434	216,246	467,072	1,462,975	135,459	585,088
Broward	3,264,679	1,081,111	13,802	44,561	1,356,264	200,450	568,492
Palm Beach	2,813,240	1,167,666	98,167	170,838	62,336	309,141	1,005,090
Hillsborough	2,158,961	1,146,891	32,631	185,882	21,321	179,431	592,805
Orange	1,963,542	1,179,426	—	206,554	577,562	—	—
Pinellas	1,828,321	935,000	59,068	25,530	167,697	190,925	450,101
Duval	1,943,647	963,180	—	407,641	571,522	—	1,305
Lee	1,263,002	561,908	22,470	150,168	—	139,154	389,302
Polk	1,056,537	345,273	—	158,416	552,848	—	—
Brevard	1,367,789	758,617	—	162,800	431,591	—	14,781
Volusia	963,326	402,925	—	201,885	358,516	—	—
Pasco	748,837	279,208	10,837	160,944	—	72,730	225,118
Seminole	498,468	148,468	—	23,072	326,928	—	—
Sarasota	796,234	480,561	—	73,412	242,260	—	—
Manatee	724,276	359,061	—	119,388	229,334	—	16,493
Collier	840,268	491,780	—	139,118	209,370	—	—
Marion	374,881	179,861	—	20,306	160,079	1,463	13,171
Lake	338,261	57,512	—	153,345	97,450	—	29,954
Osceola	151,435	42,135	—	25,401	83,898	—	—
Escambia	514,316	222,536	—	28,956	262,823	—	—
St. Lucie	409,393	227,377	—	70,824	111,192	—	—
Leon	419,075	219,837	—	36,630	162,474	51	83
Alachua	513,367	271,134	—	80,287	152,809	943	8,194
St. Johns	382,918	81,058	—	185,095	116,766	—	—
Clay	188,436	47,026	—	37,730	103,680	—	—
Okaloosa	192,694	42,126	—	57,601	92,967	—	—
Hernando	175,074	50,879	—	14,851	109,344	—	—
Bay	357,298	100,375	—	81,623	36,695	50,863	87,742
Charlotte	545,241	375,057	—	72,082	98,102	—	—
Santa Rosa	240,161	35,697	—	48,295	156,169	—	—
Martin	298,386	165,566	—	19,827	112,901	—	92
State	33,929,982	14,418,493	456,072	4,115,872	9,530,393	1,314,482	4,094,670

Table 3.1.2: Mass disposition for Florida counties with populations less than 150,000.

County	Collected (tonnes)	Recycled direct (tonnes)	Recycled post-combustion (tonnes)	Landfill direct C&D debris (tonnes)	Landfill direct non-C&D debris (tonnes)	Landfill post-combustion (tonnes)	Combusted (tonnes)
Indian River	338,261	57,512	—	153,345	97,450	—	29,954
Citrus	151,435	42,135	—	25,401	83,898	—	—
Sumter	514,316	222,536	—	28,956	262,823	—	—
Flagler	409,393	227,377	—	70,824	111,192	—	—
Highlands	419,075	219,837	—	36,630	162,474	51	83
Nassau	513,367	271,134	—	80,287	152,809	943	8,194
Monroe	382,918	81,058	—	185,095	116,766	—	—
Putnam	188,436	47,026	—	37,730	103,680	—	—
Columbia	192,694	42,126	—	57,601	92,967	—	—
Walton	175,074	50,879	—	14,851	109,344	—	—
Jackson	357,298	100,375	—	81,623	36,695	50,863	87,742
Gadsden	545,241	375,057	—	72,082	98,102	—	—
Suwannee	240,161	35,697	—	48,295	156,169	—	—
Okeechobee	298,386	165,566	—	19,827	112,901	—	92
Levy	380,916	192,839	—	57,421	123,496	—	7,160
Hendry	119,669	60,435	—	19,974	38,775	—	485
Desoto	230,318	145,884	—	38,363	46,071	—	—
Wakulla	146,060	16,935	—	17,346	111,778	—	—
Hardee	112,330	19,336	—	6,791	86,203	—	—
Bradford	157,212	34,235	—	65,505	57,471	—	—
Baker	320,833	179,352	2,851	39,989	2,453	25,409	70,779
Washington	131,525	74,972	—	10,823	45,107	—	624
Taylor	83,763	22,216	—	13,644	47,279	—	624
Holmes County RC	103,121	10,705	—	71,142	20,620	218	435
Madison	56,770	5,128	—	6,935	44,367	130	210
Gilchrist	42,578	8,538	—	12,313	21,726	—	—
Dixie	128,272	15,451	—	16,420	96,401	—	—
Gulf	178,914	10,909	—	28,101	139,904	—	—
Union	30,060	3,058	—	2,946	24,056	—	—
Hamilton	54,112	15,973	—	5,813	—	7,234	25,092
Calhoun	59,823	22,647	—	12,604	24,572	—	—
Jefferson	29,136	10,088	—	2,477	16,572	—	—
Glades	19,176	1,440	—	1,563	16,173	—	—
Franklin	23,357	7,433	—	1,259	14,666	—	—
Liberty	18,842	2,590	—	940	15,312	—	—
Lafayette	20,115	1,934	—	6,172	12,004	—	5
State	33,929,982	14,418,493	456,072	4,115,872	9,530,393	1,314,482	4,094,670

Table 3.1.3: Solid waste composition and disposition in Florida.

MSW material	Mass generated (tonne/person)	Mass recycled directly (tonne/person)	Mass recycled post-combustion (tonne/person)	Mass landfilled directly C&D (tonne/person)	Mass landfilled directly non-C&D (tonne/person)	Mass landfilled post-combustion (tonne/person)	Mass combusted (tonne/person)
Newspaper	0.0472	0.0108	—	—	0.0226	—	0.0139
Glass	0.0404	0.0126	—	—	0.0172	0.0106	—
Aluminum cans	0.0096	0.0015	0.0003	—	0.0050	0.0028	—
Plastic bottles	0.0206	0.0024	—	—	0.0113	—	0.0069
Steel cans	0.0199	0.0069	0.0016	—	0.0080	0.0034	—
Corrugated paper	0.1178	0.0506	—	—	0.0416	—	0.0256
Office paper	0.0299	0.0048	—	—	0.0155	—	0.0096
Yard trash	0.1890	0.1269	—	—	0.0385	—	0.0237
Other plastics	0.0662	0.0057	—	—	0.0374	—	0.0230
Ferrous metals	0.1162	0.0717	0.0161	—	0.0275	0.0009	—
White goods	0.0165	0.0082	0.0018	—	0.0052	0.0013	—
Non-ferrous metal	0.0257	0.0128	0.0029	—	0.0080	0.0021	—
Other paper	0.0945	0.0189	—	—	0.0468	—	0.0288
Textiles	0.0372	0.0028	—	—	0.0213	—	0.0131
C&D debris	0.5089	0.3046	—	0.2043	—	—	—
Food	0.0963	0.0075	—	—	0.0550	—	0.0338
Miscellaneous	0.2050	0.0321	—	—	0.1070	0.0442	0.0216
Tires	0.0139	0.0055	—	—	0.0052	—	0.0032
Process fuel	0.0293	0.0293	—	—	—	—	—
Total	1.684	0.7156	0.0226	0.2043	0.4730	0.0652	0.2032

Table 3.1.4: Total collected mass and standard, traditional, and total recycling rates for Florida counties with populations greater than 150,000.

County	Collected (tonnes)	Standard recycling rate	Traditional recycling rate	Total recycling rate
Miami-Dade	3,982,274	25.8%	33.4%	45.2%
Broward	3,264,679	33.1%	33.5%	48.4%
Palm Beach	2,813,240	41.5%	45.0%	73.6%
Hillsborough	2,158,961	52.8%	58.0%	79.9%
Orange	1,963,542	60.1%	60.1%	69.7%
Pinellas	1,828,321	49.1%	54.4%	74.1%
Duval	1,943,647	46.8%	50.5%	52.2%
Lee	1,263,002	44.5%	46.7%	71.4%
Polk	1,056,537	32.7%	32.7%	32.7%
Brevard	1,367,789	44.9%	55.5%	60.1%
Volusia	963,326	33.6%	42.2%	42.2%
Pasco	748,837	37.3%	38.7%	62.8%
Seminole	498,468	25.4%	29.8%	33.8%
Sarasota	796,234	58.7%	60.4%	64.5%
Manatee	724,276	49.6%	55.8%	59.6%
Collier	840,268	52.5%	58.5%	64.1%
Marion	374,881	48.0%	48.0%	51.2%
Lake	338,261	15.4%	17.0%	24.1%
Osceola	151,435	27.8%	27.8%	27.8%
Escambia	514,316	38.3%	47.9%	52.4%
St. Lucie	409,393	52.7%	59.1%	61.3%
Leon	419,075	51.8%	52.5%	54.7%
Alachua	513,367	52.8%	52.8%	54.2%
St. Johns	382,918	12.5%	21.2%	21.2%
Clay	188,436	12.9%	25.0%	25.0%
Okaloosa	192,694	14.1%	21.9%	24.4%
Hernando	175,074	29.1%	29.1%	35.5%
Bay	357,298	27.0%	41.8%	61.5%
Charlotte	545,241	63.7%	68.8%	71.2%
Santa Rosa	240,161	11.8%	15.2%	15.2%
Martin	298,386	55.5%	58.0%	58.0%
State	33,929,982	40.6%	44.7%	55.8%

Table 3.1.5: Total collected mass and standard, traditional, and total recycling rates for Florida counties with populations less than 150,000.

County	Collected (tonnes)	Standard recycling rate	Traditional recycling rate	Total recycling rate
Indian River	380,916	46.7%	50.6%	52.5%
Citrus	119,669	49.6%	50.5%	50.8%
Sumter	230,318	63.3%	63.3%	63.3%
Flagler	146,060	11.6%	11.6%	11.6%
Highlands	112,330	12.6%	17.2%	17.2%
Nassau	157,212	21.8%	21.8%	21.8%
Monroe	320,833	55.3%	56.8%	74.4%
Putnam	131,525	52.9%	57.0%	57.4%
Columbia	83,763	26.5%	26.5%	27.2%
Walton	103,121	4.66%	10.6%	13.8%
Jackson	56,770	9.03%	9.26%	13.8%
Gadsden	42,578	20.1%	20.1%	20.1%
Suwannee	128,272	12.0%	12.0%	12.0%
Okeechobee	178,914	6.10%	6.10%	6.10%
Levy	30,060	10.2%	10.2%	10.2%
Hendry	54,112	29.5%	43.4%	80.5%
Desoto	59,823	37.9%	37.9%	37.9%
Wakulla	29,136	34.6%	34.6%	36.3%
Hardee	19,176	7.51%	7.51%	7.51%
Bradford	23,357	25.7%	31.8%	31.8%
Baker	18,842	13.6%	13.7%	13.7%
Washington	20,115	9.62%	9.62%	12.4%
Taylor	19,846	16.8%	16.8%	16.8%
Holmes County RC	5,015	18.8%	18.8%	22.3%
Madison	12,069	36.9%	36.9%	36.9%
Gilchrist	8,652	11.6%	11.6%	11.6%
Dixie	9,492	2.30%	2.30%	2.30%
Gulf	11,985	5.98%	7.39%	16.3%
Union	8,415	1.91%	9.00%	9.00%
Hamilton	12,631	14.8%	14.8%	14.8%
Calhoun	21,479	4.74%	8.04%	13.2%
Jefferson	10,962	5.96%	5.96%	5.96%
Glades	16,601	3.68%	3.68%	3.68%
Franklin	22,514	3.92%	24.1%	24.1%
Liberty	6,042	7.66%	7.66%	7.66%
Lafayette	3,282	7.55%	7.55%	7.55%
State	33,929,982	40.6%	44.7%	55.8%

3.1.2 Residential and Non-residential Waste Disposition and Composition

The residential and non-residential categories required additional refinements in order to estimate the tonnages associated with each of the six waste management categories. Because yard trash and C&D debris tonnages were embedded in residential and non-residential collected and recycled tonnages, the following steps and assumptions were required in order to achieve separation:

Step: Remove yard trash and C&D debris from the residential and non-residential categories. The following assumptions are shown for residential and non-residential collected and recycled masses:

- **Assumption 1:** Collected yard trash was removed from collected residential mass, and collected C&D debris was removed from collected non-residential mass for all the counties except Palm Beach, Hillsborough, Lee, Collier, Lake, Escambia, Alachua, St. Johns, Clay, Charlotte, Sumter, Nassau, Desoto, Union, Franklin, and Lafayette.
- **Assumption 2:** For Palm Beach, Lee, Lake, St. Johns, Clay, Sumter, Desoto, and Union counties, collected yard trash and C&D debris were proportionally removed from collected residential and non-residential mass based on their unadjusted collected residential and non-residential mass.
- **Assumption 3:** For Hillsborough, Collier, Escambia, and Alachua counties, collected yard trash and C&D debris were removed only from the non-residential mass.
- **Assumption 4:** For Charlotte County, 55% of collected yard trash and 25% of collected C&D debris were removed from collected residential mass, and 45% of collected yard trash and 75% of collected C&D debris were removed from collected non-residential mass.
- **Assumption 5:** For Nassau County, 50% of collected yard trash and 33% of collected C&D debris were removed from collected residential mass, and 40% of collected yard trash and 67% of collected C&D debris were removed from collected non-residential mass.
- **Assumption 6:** For Franklin County, 75% of collected yard trash was removed from collected residential mass, and 25% of collected yard trash and all C&D debris were removed from collected non-residential mass.
- **Assumption 7:** For Lafayette County, all collected yard trash and 25% of collected C&D debris were removed from collected residential mass, and 75% of collected C&D debris was removed from collected non-residential mass.

Adjusted residential and non-residential collected mass (not including yard trash or C&D debris) were used to proportionally distribute total collected, landfill post-combustion, and combusted mass into residential and non-residential for each of the 18 materials. For some materials, the resultant recycled direct mass was greater than the collected mass. In those cases, recycled direct mass was distributed into residential and non-residential categories based on reasonable assumptions. To maintain the mass balance for each of the materials' residential and non-residential categories, landfill non-C&D debris material was calculated as the difference between the collected and all the other management categories (recycled direct, recycled post-

combustion, landfill post-combustion, landfilled non-C&D, and combustion). For counties that reported MSW landfill gas-to-energy recycling credits, adjusted collected mass was used to distribute into residential and non-residential total mass and then removed from total landfill non-C&D debris mass. In Marion County, recycling credits for renewable energy other than WTE were proportionally distributed based on adjusted collected mass and then removed from total combusted mass. In Hendry County, other MSW used as landfill cover recycling credits was proportionally distributed based on adjusted collected mass and then removed from total landfill direct non-C&D debris. Residential estimated collected mass and associated standard, traditional, and total recycling rates are shown in Tables 3.1.6 and 3.1.7; non-residential estimates are shown in Tables 3.1.8 and 3.1.9.

The three recycling rates awarded credit only to the materials recycled at an MRF for the standard recycling rate. The traditional recycling rate awarded credit to recycled direct, recycled post-combustion, and other MSW used as landfill cover for traditional recycling. The total recycling rate consisted of traditional recycling credits, combusted, MSW landfill gas, and renewable energy other than WTE. Many counties' residential recycling rates are much lower than their non-residential rates; these include Volusia County, which has a total residential recycling rate of 18.2%, which increases to 46.8% for non-residential (Tables 3.1.6 and 3.1.8). Florida's standard residential recycling rate — assumed to represent the curbside recycling rate — is much lower (21.7%) than the non-residential recycling rate (35.4%). Although both recycling rates are lower than the state's overall standard recycling rate of 40.6%, the residential standard recycling rate has the potential to increase greatly. Of the counties with populations less than 150,000, Citrus County has the highest residential standard recycling rate (48.1%) — a rate that is higher than the five most populated counties in the state. All of the five largest counties except for Orange County have WTE facilities that provide recycling credits that count toward their total recycling rate. For some counties, residential and non-residential recycling rates are similar or identical, because collected residential and non-residential tonnages are similar or because the proportions of yard trash and C&D debris removed from the residential and non-residential categories are the same. In some counties, such as Palm Beach, both of these cases exist.

Table 3.1.6: Total collected mass for the residential category and standard, traditional, and total recycling rates for Florida counties with populations greater than 150,000.

County	Collected (tonnes)	Standard recycling rate	Traditional recycling rate	Total recycling rate
Miami-Dade	2,072,278	15.6%	21.9%	38.2%
Broward	590,265	13.0%	13.5%	30.5%
Palm Beach	823,546	14.2%	20.0%	66.5%
Hillsborough	647,690	36.8%	39.0%	77.3%
Orange	731,604	36.2%	36.2%	59.5%
Pinellas	657,908	18.0%	23.4%	56.2%
Duval	205,969	36.6%	36.6%	40.2%
Lee	246,743	18.4%	21.5%	67.3%
Polk	392,787	20.9%	20.9%	20.9%
Brevard	374,092	39.3%	39.3%	46.4%
Volusia	390,681	18.2%	18.2%	18.2%
Pasco	241,204	23.2%	25.6%	74.5%
Seminole	248,997	26.7%	26.7%	31.8%
Sarasota	269,071	43.2%	43.2%	51.8%
Manatee	164,156	51.7%	51.7%	54.6%
Collier	167,440	44.4%	44.4%	59.1%
Marion	157,599	40.1%	40.1%	44.6%
Lake	158,834	25.2%	25.2%	39.3%
Osceola	84,368	30.3%	30.3%	30.3%
Escambia	246,872	13.5%	13.5%	20.4%
St. Lucie	224,350	54.6%	54.6%	58.5%
Leon	198,157	40.3%	40.3%	44.2%
Alachua	83,877	32.5%	32.5%	34.7%
St. Johns	48,420	45.0%	45.0%	45.0%
Clay	61,901	7.65%	7.65%	7.65%
Okaloosa	54,466	19.7%	19.7%	24.2%
Hernando	83,019	22.9%	22.9%	31.3%
Bay	120,767	30.7%	30.7%	54.7%
Charlotte	102,094	20.1%	20.1%	30.1%
Santa Rosa	91,104	19.1%	19.1%	19.1%
Martin	86,042	27.8%	27.8%	27.9%
State	11,205,918	21.7%	23.8%	41.0%

Table 3.1.7: Total collected mass for the residential category and standard, traditional, and total recycling rates for Florida counties with populations less than 150,000.

County	Collected (tonnes)	Standard recycling rate	Traditional recycling rate	Total recycling rate
Indian River	82,002	40.6%	40.6%	40.6%
Citrus	64,412	48.1%	48.1%	48.6%
Sumter	25,910	29.4%	29.4%	29.4%
Flagler	62,832	16.2%	16.2%	16.2%
Highlands	51,709	12.0%	12.0%	12.0%
Nassau	45,894	1.32%	1.32%	1.37%
Monroe	52,225	16.9%	19.3%	65.0%
Putnam	40,707	45.4%	45.4%	46.0%
Columbia	44,210	36.2%	36.2%	36.2%
Walton	20,255	16.4%	16.4%	29.5%
Jackson	29,604	5.36%	5.36%	11.06%
Gadsden	12,445	30.7%	30.7%	30.7%
Suwannee	68,484	13.3%	13.3%	13.3%
Okeechobee	82,692	9.87%	9.87%	9.87%
Levy	23,089	12.6%	12.6%	12.6%
Hendry	31,043	33.6%	37.5%	76.6%
Desoto	14,463	14.7%	14.7%	14.7%
Wakulla	17,422	31.1%	31.1%	33.4%
Hardee	9,104	9.74%	9.74%	9.74%
Bradford	15,066	30.1%	30.1%	30.1%
Baker	10,600	17.6%	17.6%	17.6%
Washington	11,973	15.4%	15.4%	20.0%
Taylor	10,024	10.0%	10.0%	10.0%
Holmes County RC	2,659	20.4%	20.4%	24.5%
Madison	6,423	40.2%	40.2%	40.2%
Gilchrist	6,811	13.6%	13.6%	13.6%
Dixie	6,510	2.79%	2.79%	2.79%
Gulf	8,119	5.62%	5.62%	17.1%
Union	4,354	1.48%	1.48%	1.48%
Hamilton	5,262	21.0%	21.0%	21.0%
Calhoun	9,611	3.27%	3.27%	9.92%
Jefferson	7,631	6.37%	6.37%	6.37%
Glades	9,607	0.68%	0.68%	0.68%
Franklin	8,879	5.86%	5.86%	5.86%
Liberty	2,867	9.81%	9.81%	9.81%
Lafayette	2,126	2.76%	2.76%	2.76%
State	11,205,918	21.7%	23.8%	41.0%

Table 3.1.8: Total collected mass for the non-residential category and standard, traditional, and total recycling rates for Florida counties with populations greater than 150,000.

County	Collected (tonnes)	Standard recycling rate	Traditional recycling rate	Total recycling rate
Miami-Dade	810,849	37.6%	48.1%	64.3%
Broward	1,655,835	16.8%	17.4%	34.4%
Palm Beach	868,916	14.2%	20.0%	66.5%
Hillsborough	558,882	35.3%	38.5%	76.9%
Orange	236,084	86.2%	86.2%	94.2%
Pinellas	392,070	22.3%	28.3%	61.2%
Duval	659,731	62.9%	62.9%	66.5%
Lee	429,265	36.1%	39.6%	75.6%
Polk	327,560	38.8%	38.8%	38.8%
Brevard	327,995	49.9%	49.9%	56.9%
Volusia	51,791	46.8%	46.8%	46.8%
Pasco	134,359	31.1%	34.9%	77.5%
Seminole	138,854	21.4%	21.4%	26.5%
Sarasota	84,556	12.7%	12.7%	21.3%
Manatee	247,416	47.9%	47.9%	50.7%
Collier	152,166	23.8%	23.8%	38.5%
Marion	88,803	20.7%	20.7%	25.5%
Lake	0	37.2%	37.2%	51.2%
Osceola	29,872	55.5%	55.5%	55.5%
Escambia	87,433	54.5%	54.5%	61.4%
St. Lucie	5,732	28.6%	28.6%	32.5%
Leon	43,243	40.4%	40.4%	44.3%
Alachua	138,311	26.7%	26.7%	28.9%
St. Johns	100,616	25.6%	25.6%	25.6%
Clay	64,795	28.2%	28.2%	28.2%
Okaloosa	53,526	30.2%	30.2%	34.7%
Hernando	50,445	37.8%	37.8%	46.3%
Bay	132,379	42.2%	42.2%	66.2%
Charlotte	30,052	49.6%	49.6%	59.5%
Santa Rosa	86,512	12.5%	12.5%	12.5%
Martin	80,820	43.8%	43.8%	43.8%
State	8,175,038	35.4%	38.0%	55.1%

Table 3.1.9: Total collected mass for the non-residential category and standard, traditional, and total recycling rates for Florida counties with populations less than 150,000.

County	Collected (tonnes)	Standard recycling rate	Traditional recycling rate	Total recycling rate
Indian River	43,140	14.2%	14.2%	14.2%
Citrus	7,670	38.4%	38.4%	39.0%
Sumter	31,667	29.4%	29.4%	29.4%
Flagler	51,386	13.1%	13.1%	13.1%
Highlands	40,927	9.80%	9.80%	9.80%
Nassau	6,881	2.25%	2.25%	2.31%
Monroe	62,979	15.9%	18.4%	64.0%
Putnam	38,176	43.8%	43.8%	44.4%
Columbia	20,013	31.1%	31.1%	31.1%
Walton	5,192	28.7%	28.7%	41.9%
Jackson	15,067	23.5%	23.5%	29.2%
Gadsden	12,584	35.8%	35.8%	35.8%
Suwannee	40,128	15.8%	15.8%	15.8%
Okeechobee	51,023	5.38%	5.38%	5.38%
Levy	3,094	4.96%	4.96%	4.96%
Hendry	13,402	41.4%	46.4%	84.3%
Desoto	13,002	17.8%	17.8%	17.8%
Wakulla	4,405	16.9%	16.9%	19.2%
Hardee	6,574	7.16%	7.16%	7.16%
Bradford	4,462	30.0%	30.0%	30.0%
Baker	4,801	12.9%	12.9%	12.9%
Washington	291	30.8%	30.8%	35.4%
Taylor	5,554	25.6%	25.6%	25.6%
Holmes County RC	1,644	18.0%	18.0%	22.1%
Madison	3,673	39.7%	39.7%	39.7%
Gilchrist	576	13.2%	13.2%	13.2%
Dixie	798	4.66%	4.66%	4.66%
Gulf	1,012	25.7%	25.7%	37.2%
Union	1,866	1.51%	1.51%	1.51%
Hamilton	4,171	17.4%	17.4%	17.4%
Calhoun	4,501	15.7%	15.7%	22.3%
Jefferson	2,368	6.28%	6.28%	6.28%
Glades	1,973	3.96%	3.96%	3.96%
Franklin	2,617	11.5%	11.5%	11.5%
Liberty	1,860	9.76%	9.76%	9.76%
Lafayette	714	1.43%	1.43%	1.43%
State	8,306,224	35.4%	38.0%	55.1%

3.1.3 Yard Trash Waste Disposition and Composition

Typically, yard trash is picked up as a part of residential curbside service or it is collected by independent businesses. Both collection cases send the yard trash to a landfill, compost facility, C&D debris recycling facility, or renewable energy facility. Florida permits disposal of yard waste in a Class I landfill only if the landfill “uses an active gas collection system to collect landfill gas generated at the disposal facility and provides or arranges for beneficial use of the gas,” or if yard trash is mulched to be used to provide landfill cover.²¹ Estimates for recycled direct, landfill direct non-C&D debris, landfill post-combustion, and combusted follow the steps described in Section 3.1.1. Some modifications were made to the material management category estimates to account for recycling credits awarded to yard trash used as landfill cover, renewable energy, landfill gas-to-energy from yard trash only, and yard trash receiving landfill gas (generating something other than electricity). It was assumed that yard trash used as landfill cover was removed from total recycled direct, that renewable energy was removed from total combusted mass, and that landfill gas-to-energy from yard trash only and yard trash receiving landfill gas were removed from total landfill direct non-C&D debris.

A sizable portion of the yard trash in Florida is used as landfill cover. This is evident when observing the large differences between standard and traditional recycling rates, such as in Brevard County (38.2% versus 83.0%) and Putnam County (13.0% versus 75.9%) (Tables 3.1.10 and 3.1.11). Yard trash is one of the major materials FDEP encourages counties to recycle. FDEP’s encouragement resulted in yard trash being one of the largest components of the total recycled stream (Figure 3.1.3) with a high standard (50.0%), traditional (67.1%), and total recycling rates (78.2%). Collected mass and recycling rates for yard trash are shown in Tables 3.1.10 and 3.1.11.

Table 3.1.10: Total collected mass for the yard trash category and standard, traditional, and total recycling rates for Florida counties with populations greater than 150,000.

County	Collected (tonnes)	Standard recycling rate	Traditional recycling rate	Total recycling rate
Miami-Dade	517,760	50.7%	69.1%	69.1%
Broward	258,072	4.29%	4.29%	43.6%
Palm Beach	228,860	89.8%	89.8%	97.6%
Hillsborough	254,528	75.8%	78.4%	83.1%
Orange	167,543	53.4%	53.4%	53.4%
Pinellas	235,868	90.0%	90.0%	96.5%
Duval	307,804	5.29%	25.3%	26.3%
Lee	222,249	75.4%	75.4%	95.1%
Polk	87,536	50.6%	50.6%	50.6%
Brevard	323,480	38.2%	83.0%	85.8%
Volusia	176,562	48.9%	93.6%	93.6%
Pasco	55,526	50.7%	50.7%	59.4%
Seminole	56,968	0.0%	37.9%	37.9%
Sarasota	75,614	61.7%	79.5%	82.7%
Manatee	143,386	53.1%	53.1%	68.0%
Collier	212,981	76.0%	99.8%	99.8%
Marion	40,995	75.8%	75.8%	77.8%
Lake	23,387	40.3%	63.3%	70.2%
Osceola	11,793	0.0%	0.0%	0.0%
Escambia	51,432	31.6%	81.6%	81.6%
St. Lucie	58,132	0.0%	69.2%	69.2%
Leon	48,397	5.46%	18.1%	18.1%
Alachua	45,571	91.4%	91.4%	95.7%
St. Johns	48,599	0.0%	68.6%	68.6%
Clay	22,696	0.0%	100.0%	100.0%
Okaloosa	27,085	1.2%	56.1%	56.1%
Hernando	26,670	47.8%	47.8%	47.8%
Bay	22,509	14.7%	32.6%	75.2%
Charlotte	57,796	49.4%	97.6%	97.6%
Santa Rosa	14,205	0.0%	51.9%	51.9%
Martin	69,148	87.0%	87.0%	87.0%
State	4,164,220	50.0%	67.1%	78.2%

Table 3.1.11: Total collected mass for the yard trash category and standard, traditional, and total recycling rates for Florida counties with populations less than 150,000.

County	Collected (tonnes)	Standard recycling rate	Traditional recycling rate	Total recycling rate
Indian River	97,029	21.1%	40.9%	50.3%
Citrus	11,301	80.4%	90.2%	90.2%
Sumter	5,412	0.0%	0.0%	0.0%
Flagler	14,448	0.0%	0.0%	0.0%
Highlands	8,996	0.0%	57.9%	57.9%
Nassau	5,457	0.0%	0.0%	0.0%
Monroe	37,901	81.3%	86.6%	97.1%
Putnam	8,563	13.0%	75.9%	76.1%
Columbia	5,897	0.0%	0.0%	3.70%
Walton	6,532	0.0%	90.3%	90.3%
Jackson	5,164	0.0%	0.0%	0.609%
Gadsden	5,014	0.0%	0.0%	0.0%
Suwannee	3,230	0.0%	0.0%	0.0%
Okeechobee	17,099	0.0%	0.0%	0.0%
Levy	932	0.0%	0.0%	0.0%
Hendry	3,571	0.0%	0.0%	80.0%
Desoto	1,572	1.44%	1.44%	1.44%
Wakulla	3,262	72.2%	72.2%	72.2%
Hardee	1,852	0.0%	0.0%	0.0%
Bradford	2,452	0.0%	58.5%	58.5%
Baker	2,418	0.0%	0.863%	0.863%
Washington	1,678	0.0%	0.0%	0.0%
Taylor	2,676	33.9%	33.9%	33.9%
Holmes County RC	480	0.0%	0.0%	0.147%
Madison	857	12.0%	12.0%	12.0%
Gilchrist	787	0.0%	0.0%	0.0%
Dixie	748	0.0%	0.0%	0.0%
Gulf	680	0.0%	0.0%	3.89%
Union	1,069	0.0%	55.9%	55.9%
Hamilton	1,588	0.0%	0.0%	0.0%
Calhoun	1,549	0.0%	0.0%	10.3%
Jefferson	554	0.0%	0.0%	0.0%
Glades	1,438	32.5%	32.5%	32.5%
Franklin	8,165	0.0%	55.6%	55.6%
Liberty	544	0.0%	0.0%	0.0%
Lafayette	154	0.0%	0.0%	0.0%
State	4,164,220	50.0%	67.1%	78.2%

3.1.4 C&D Debris Waste Disposition and Composition

Unlike yard trash, C&D debris is typically not managed by a local government but is instead contracted with private haulers. Collected C&D debris is either sent to a C&D debris MRF, which processes and separates materials to send to remanufacture facilities; processed and used as alternative landfill cover; or disposed of in a Class III landfill. Like with yard trash, FDEP encourages recycling of C&D debris. County recycling coordinators are responsible for collecting data from uncertified recyclers; materials they collect information on include recycled concrete and reclaimed asphalt pavement. Because these materials are large in mass, recycling them increases a county's overall recycling rate. C&D debris represents the largest component of collected and recycled (40%) streams in the state (Figures 3.1.2 and 3.1.3) with a standard (59.9%), traditional (62.6%), and total (62.6%) recycling rate; among the highest in comparison to other materials. Many counties with populations greater than 150,000 have high C&D debris recycling rates, while smaller counties (with populations less than 150,000) have very low recycling rates (Tables 3.1.12 and 3.1.13).

Estimates for recycled direct, landfill direct C&D debris, and landfill post-combustion followed the steps described in Section 3.1.1. Similar to yard trash, some modifications were made to material management category estimates to account for recycling credits awarded to treated contaminated soil used as landfill cover and other MSW used as landfill cover. It was assumed that both of those recycling credits were removed from total landfill direct C&D debris for all counties except Pinellas, where other MSW used as landfill cover was removed from recycled direct mass. For all but one county, other MSW used as landfill cover was assumed to be associated with C&D debris. The exception is Hendry County, where only 75% was associated and the remaining 25% came from the residential and non-residential categories.

Table 3.1.12: Total collected mass for the C&D debris category and standard, traditional, and total recycling rates for Florida counties with populations greater than 150,000.

County	Collected (tonnes)	Standard recycling rate	Traditional recycling rate	Total recycling rate
Miami-Dade	581,387	19.7%	19.7%	19.7%
Broward	760,507	94.1%	94.1%	94.1%
Palm Beach	891,917	80.8%	80.8%	80.8%
Hillsborough	697,860	73.4%	83.7%	83.7%
Orange	828,312	75.1%	75.1%	75.1%
Pinellas	542,475	88.3%	95.3%	95.3%
Duval	770,143	47.1%	49.3%	49.3%
Lee	364,746	53.2%	54.8%	54.8%
Polk	248,654	36.3%	36.3%	36.3%
Brevard	342,221	52.4%	52.4%	52.4%
Volusia	344,292	41.4%	42.4%	42.4%
Pasco	317,748	48.2%	48.2%	48.2%
Seminole	53,649	57.0%	57.0%	57.0%
Sarasota	366,993	80.0%	80.0%	80.0%
Manatee	169,318	29.5%	56.1%	56.1%
Collier	307,682	54.8%	54.8%	54.8%
Marion	87,483	76.8%	76.8%	76.8%
Lake	156,039	1.73%	1.73%	1.73%
Osceola	25,401	0.0%	0.0%	0.0%
Escambia	128,579	77.5%	96.1%	96.1%
St. Lucie	121,180	41.6%	53.5%	53.5%
Leon	129,277	71.7%	71.7%	71.7%
Alachua	245,608	67.3%	67.3%	67.3%
St. Johns	185,283	0.1%	0.1%	0.1%
Clay	39,043	3.4%	3.4%	3.4%
Okaloosa	57,617	0.0%	0.0%	0.0%
Hernando	14,940	0.6%	0.6%	0.6%
Bay	81,642	0.0%	60.0%	60.0%
Charlotte	355,299	79.7%	79.7%	79.7%
Santa Rosa	48,340	0.1%	2.0%	2.0%
Martin	62,375	68.2%	68.2%	68.2%
State	10,253,620	59.9%	62.6%	62.6%

Table 3.1.13: Total collected mass for the C&D debris category and standard, traditional, and total recycling rates for Florida counties with populations less than 150,000.

County	Collected (tonnes)	Standard recycling rate	Traditional recycling rate	Total recycling rate
Indian River	158,745	63.8%	63.8%	63.8%
Citrus	36,287	45.0%	45.0%	45.0%
Sumter	167,328	77.1%	77.1%	77.1%
Flagler	17,394	0.3%	0.3%	0.3%
Highlands	10,699	36.5%	36.5%	36.5%
Nassau	98,980	33.8%	33.8%	33.8%
Monroe	167,729	76.2%	76.2%	76.2%
Putnam	44,079	75.4%	75.4%	75.4%
Columbia	13,644	0.0%	0.0%	0.0%
Walton	71,142	0.0%	0.3%	0.3%
Jackson	6,935	0.0%	1.9%	1.9%
Gadsden	12,535	1.8%	1.8%	1.8%
Suwannee	16,430	0.1%	0.1%	0.1%
Okeechobee	28,101	0.0%	0.0%	0.0%
Levy	2,946	0.0%	0.0%	0.0%
Hendry	6,096	0.0%	92.7%	92.7%
Desoto	30,786	59.1%	59.1%	59.1%
Wakulla	4,046	38.8%	38.8%	38.8%
Hardee	1,646	5.0%	5.0%	5.0%
Bradford	1,378	8.6%	8.6%	8.6%
Baker	1,023	8.2%	8.2%	8.2%
Washington	6,172	0.0%	0.0%	0.0%
Taylor	1,591	0.2%	0.2%	0.2%
Holmes County RC	232	44.1%	45.3%	45.3%
Madison	1,116	28.1%	28.1%	28.1%
Gilchrist	477	0.0%	0.0%	0.0%
Dixie	1,436	0.0%	0.0%	0.0%
Gulf	2,173	0.0%	7.8%	7.8%
Union	1,127	6.0%	6.0%	6.0%
Hamilton	1,610	2.8%	2.8%	2.8%
Calhoun	5,819	0.0%	12.2%	12.2%
Jefferson	409	4.4%	4.4%	4.4%
Glades	3,583	0.0%	0.0%	0.0%
Franklin	2,853	2.2%	2.2%	2.2%
Liberty	771	0.0%	0.0%	0.0%
Lafayette	288	61.9%	61.9%	61.9%
State	10,253,620	59.9%	62.6%	62.6%

3.1.5 Transfer Station Waste Mass Flow

The mass associated with transfer stations and long-distance waste hauling provides a more complete accounting of solid waste mass flow in Florida. Transfer stations are typically constructed near population centers to provide a convenient location for collection vehicles (with capacities up to about 9 tons) to deposit MSW instead of having to transport the waste longer distances to remote disposal facilities. MSW deposited at these transfer stations is then loaded into larger tractor-trailers (with capacities of up to 26 tons), which can more efficiently transport the material to remote disposal locations. In 2016, a total of 99 transfer stations were used in Florida to aggregate and transport an estimated 16.9 million tonnes of MSW. For the purposes of this study, data related to all active transfer stations was retrieved from the FDEP Facility Reports Search website, and the tonnage associated with each transfer station was estimated using an average tonnage (170,382 tonnes) based on facilities that report tonnages. Facility-reported tonnages are used directly, and average tonnage is used in cases where facilities do not report tonnages (Table 3.1.5). Mass managed by the state in transfer stations is a rough estimate based on averaging reported mass processed at nine of the 99 facilities. To determine a more accurate representation of the mass managed in the state, a future analysis should compile mass data from all the facilities.

Table 3.1.14: Active transfer stations and mass processed.

Number	Transfer station name	City	County	Year	Tonnes
1	GAINESVILLE SOLID WASTE MANAGEMENT FACILITY (FKA WCA OF FL)	GAINESVILLE	ALACHUA		161,479
2	ALACHUA COUNTY SOLID WASTE TRANSFER STATION AND WTCC	GAINESVILLE	ALACHUA	2014	170,382
3	SARNO ROAD LANDFILL	MELBOURNE	BREVARD		170,382
4	TITUSVILLE (NORTH) TRANSFER STATION	TITUSVILLE	BREVARD		170,382
5	CITY OF HALLANDALE TRANSFER STATION	HALLANDALE	BROWARD		170,382
6	CORAL SPRINGS TRANSFER STATION SAWGRASS	CORAL SPRINGS	BROWARD		170,382
7	BROWARD COUNTY CENTRAL RESIDENTIAL TRANSFER STATION	DAVIE	BROWARD		170,382
8	REUTER RECYCLING OF FLORIDA INC.	PEMBROKE PINES	BROWARD		170,382

9	SNYDER PARK TRANSFER STATION	FORT LAUDERDALE	BROWARD		170,382
10	WM RECYCLING SUN 11	DEERFIELD BEACH	BROWARD		170,382
11	WEST CHARLOTTE TRANSFER STATION AKA ENGLEWOOD	ROTONDA WEST	CHARLOTTE		170,382
12	ROSEMARY HILL WASTE PROCESSING FACILITY (WASTE MANAGEMENT)	GREEN COVE SPRINGS	CLAY		170,382
13	CLAY COUNTY C&D TRANSFER STATION ROSEMARY HILL	GREEN COVE SPRINGS	CLAY		170,382
14	IMMOKALEE SLF AND TRANSFER STATION (STOCKADE)	IMMOKALEE	COLLIER		170,382
15	PWSFL - NAPLES MATERIALS TRANSFER STATION	NAPLES	COLLIER		170,382
16	DIXIE COUNTY SOLID WASTE MANAGEMENT FACILITY	CROSS CITY	DIXIE		170,382
17	MAYPORT SOLID WASTE TRANSFER STATION	MAYPORT	DUVAL		170,382
18	PENSACOLA TRANSFER STATION	PENSACOLA	ESCAMBIA		170,382
19	ESCAMBIA COUNTY PALAFOX TRANSFER STATION	PENSACOLA	ESCAMBIA		170,382
20	ENVIRONMENTAL LAND SERVICES	BUNNELL	FLAGLER		170,382
21	FRANKLIN COUNTY TRANSFER STATION	EASTPOINT	FRANKLIN		170,382
22	QUINCY TRANSFER STATION	QUINCY	GADSDEN		170,382
23	GILCHRIST COUNTY CENTRAL WASTE MANAGEMENT FACILITY	BELL	GILCHRIST		170,382
24	GLADES COUNTY SLF AND TRANSFER STATION	MOORE HAVEN	GLADES		170,382
25	INDUSTRIAL ROAD TRANSFER STATION	PORT ST JOE	GULF		170,382
26	FIVE POINTS TRANSFER STATION	PORT ST JOE	GULF		170,382
27	LABELLE TRANSFER STATION	LABELLE	HENDRY		170,382
28	CLEWISTON TRANSFER STATION	CLEWISTON	HENDRY		170,382

29	NORTHWEST HILLSBOROUGH SLF	TAMPA	HILLSBOROUGH		170,382
30	SOUTH COUNTY TRANSFER STATION	GIBSONTON	HILLSBOROUGH		170,382
31	MCKAY BAY REFUSE-TO-ENERGY PROJECT	TAMPA	HILLSBOROUGH		170,382
32	ANGELO'S RECYCLED MATERIALS - LUTZ TS	TAMPA	HILLSBOROUGH		170,382
33	ANGELO'S RECYCLED MATERIALS - BRANDON TS	TAMPA	HILLSBOROUGH		170,382
34	GROVELAND TRANSFER AND RECYCLING FACILITY	GROVELAND	LAKE		170,382
35	PWSFL-GATOR RD. C&D TRANSFER STATION	FORT MYERS	LEE		170,382
36	PWSFL, INC- FORT MYERS MATERIALS TRANSFER STATION	FORT MYERS	LEE		170,382
37	MAINLINE	FORT MYERS	LEE		170,382
38	VISION TRANSFER STATION	BONITA SPRINGS	LEE		170,382
39	SOUTHWEST DISPOSAL	FORT MYERS	LEE		170,382
40	LEON COUNTY SOLID WASTE TRANSFER STATION	TALLAHASSEE	LEON		170,382
41	LEVY COUNTY SOLID WASTE MANAGEMENT FACILITY	WILLISTON	LEVY		170,382
42	LIBERTY COUNTY LANDFILL - CLASS III - CLOSED CLASS II	BRISTOL	LIBERTY		170,382
43	OCALA TRANSFER STATION	OCALA	MARION		170,382
44	MARTIN COUNTY (PALM CITY II) SLF	PALM CITY	MARTIN		170,382
45	WASTE MANAGEMENT OF PALM CITY	PALM CITY	MARTIN		170,382
46	CENTRAL TRANSFER STATION	MIAMI	MIAMI-DADE	2016	138,761
47	NORTHEAST DADE TRANSFER STATION	N MIAMI BEACH	MIAMI-DADE	2016	174,511
48	WEST DADE TRANSFER STATION	MIAMI	MIAMI-DADE	2016	219,318

49	P.H. WASTE COLLECTION SERVICE, INC.	MIAMI	MIAMI-DADE		170,382
50	MIAMI TRANSFER STATION	MIAMI	MIAMI-DADE		170,382
51	MIA INTERNATIONAL WASTE TRANSFER STATION	MIAMI	MIAMI-DADE		170,382
52	WASTE MANAGEMENT INC. OF FLORIDA DBA WM TRANSFER MIAMI	MIAMI	MIAMI-DADE		170,382
53	CUDJOE KEY LANDFILL	SUMMERLAND KEY	MONROE		170,382
54	KEY LARGO TRANSFER STATION AND CLOSED LANDFILL	KEY LARGO	MONROE		170,382
55	KEY WEST TRANSFER STATION AND HAULING SERVICE INC	KEY WEST	MONROE		44,264
56	LONG KEY TRANSFER STATION	LONG KEY	MONROE		170,382
57	CITY OF KEY WEST SOLID WASTE TRANSFER STATION	KEY WEST	MONROE		170,382
58	ATLANTIC TRASH AND TRANSFER	KEY LARGO	MONROE		170,382
59	NEW ROCKLAND RECYCLING CENTER	KEY WEST	MONROE		170,382
60	MARATHON TRANSFER STATION	MARATHON	MONROE		170,382
61	BAKER LANDFILL	BAKER	OKALOOSA		170,382
62	OKALOOSA COUNTY TRANSFER STATION	FORT WALTON BEACH	OKALOOSA		170,382
63	ALLIED SERVICES, LLC FT. WALTON TRANSFER STATION	FORT WALTON BEACH	OKALOOSA		170,382
64	PORTER TRANSFER STATION	ORLANDO	ORANGE		170,382
65	MCLEOD ROAD TRANSFER STATION	ORLANDO	ORANGE		170,382
66	CRS CENTRAL ROCK & SUPPLY, INC.	ORLANDO	ORANGE		170,382
67	ORLANDO TRANSFER STATION-WPF	ORLANDO	ORANGE		170,382
68	TAFT RECYCLING, INC.	ORLANDO	ORANGE		170,382
69	TRIUMVIRATE ENVIRONMENTAL (FLORIDA), INC.	ORLANDO	ORANGE		170,382

70	REEDY CREEK TRANSFER STATION	LAKE BUENA VISTA	ORANGE		170,382
71	ST. CLOUD LANDFILL, CLASS I	SAINT CLOUD	OSCEOLA		170,382
72	SWA CENTRAL COUNTY TRANSFER STATION	LANTANA	PALM BEACH	2014	340,023
73	NORTH COUNTY TRANS STA (JUPITER)	JUPITER	PALM BEACH	2014	190,532
74	SWA WEST CENTRAL TRANSFER STATION	ROYAL PALM BEACH	PALM BEACH	2014	247,407
75	SWA WEST COUNTY TRANSFER STATION	BELLE GLADE	PALM BEACH	2014	28,273
76	TOWN OF PALM BEACH -- PINEWALK TRANSFER STATION	PALM BEACH	PALM BEACH		170,382
77	SWA SOUTH COUNTY TRANS STA (DELRAY BCH)	DELRAY BEACH	PALM BEACH	2014	172,343
78	SWA SOUTHWEST COUNTY TRANSFER STATION (TS)	DELRAY BEACH	PALM BEACH	2014	157,284
79	EAST PASCO TRANSFER STATION	DADE CITY	PASCO		170,382
80	NWMS TRANSFER STATION & YTPF	PORT RICHEY	PASCO		170,382
81	CITY OF CLEARWATER TRANSFER STATION	CLEARWATER	PINELLAS		170,382
82	CLEARWATER MATERIALS TRANSFER FACILITY	CLEARWATER	PINELLAS		170,382
83	BOB WALKER HAULING & TRANSFER POINT	CLEARWATER	PINELLAS		170,382
84	CHASE N' GREEN RECYCLING	TARPON SPRINGS	PINELLAS		170,382
85	ANGELO'S RECYCLED MATERIALS - LAKELAND TS	LAKELAND	POLK		170,382
86	CITY OF SARASOTA TRANSFER STATION	SARASOTA	SARASOTA		170,382
87	RECYCLE AMERICA OF SARASOTA	SARASOTA	SARASOTA		170,382
88	SEMINOLE COUNTY CENTRAL TRANS STATION	LONGWOOD	SEMINOLE		170,382
89	SANFORD RECYCLING & TRANSFER STATION	SANFORD	SEMINOLE		170,382
90	TILLMAN RIDGE WASTE	ELKTON	ST. JOHNS		170,382

	MANAGEMENT FACILITY				
91	THE OLD CITY TRANSFER STATION	ELKTON	ST. JOHNS		170,382
92	STRATTON ROAD CLASS I TRANSFER STATION	ST AUGUSTINE	ST. JOHNS		170,382
93	WMIF FORT PIERCE TRANSFER & RECYCLING FACILITY	FORT PIERCE	ST. LUCIE		170,382
94	WILDWOOD TRANSFER STATION	WILDWOOD	SUTER		170,382
95	SUWANNEE COUNTY CENTRAL LANDFILL WASTE DISPOSAL FACILITY	LIVE OAK	SUWANNEE		170,382
96	WEST VOLUSIA TRANSFER STATION	DELAND	VOLUSIA		170,382
97	CITY OF EDGEWATER SOLID WASTE TRANSFER STATION	EDGEWATER	VOLUSIA		170,382
98	ORMOND BEACH TRANSFER STATION	ORMOND BEACH	VOLUSIA		170,382
99	WALTON COUNTY CENTRAL LANDFILL	DEFUNIAK SPRINGS	WALTON		170,382

Note: Data retrieved from the FDEP Facility Report Search website in January 2018 and directly from county reports. Only transfer stations that reported mass have a corresponding year.

3.2 ENVIRONMENTAL FOOTPRINT

We used the EPA WARM LCI factors shown in Tables 2.3.1 and 2.3.2 to estimate GHG emissions and energy use associated with net 2016 waste management practices. The factors correspond to the six waste disposition categories and all include an associated default transportation GHG emission and energy use with each management practice. GHG emissions and energy use associated with the mass processed at a transfer station are not included in this study. Using the waste composition and disposition estimates shown in Table 3.1.3 as input data and multiplying each disposition mass (tonne/person) by its associated LCI factors (tCO₂eq/person and MJ/person), the 2016 environmental footprint for state was -1.08 tCO₂eq/person and -12,900 MJ/person (negative values signify GHG emissions and energy offset). The total tCO₂eq for the whole state's population is equivalent to 4.7 million passenger vehicles driven for one year, yearly electricity use in 3.3 million homes, 730.8 million incandescent lamps switched to LEDs, or 1.1 million garbage trucks of waste recycled instead of landfilled. These significant GHG emissions and energy offsets are due primarily to the large quantity of recycled materials offsetting GHG emissions and energy use associated with material extraction, manufacture, and transportation of virgin materials, as described in Section 2.3.2.

Environmental footprint measurements revealed that ferrous metals, C&D debris, and corrugated paper were associated with the largest GHG emission offset, and other plastics, food, and miscellaneous emitted the most GHG emissions (Figure 3.2.1). The materials management net energy use footprint for ferrous metals, non-ferrous metals, and corrugated paper offset the most energy, while food, glass, and yard trash required the most energy use (Figure 3.2.2).

Although the recycling mass associated with ferrous and non-ferrous materials is smaller than other material stream recycling masses (e.g., yard trash and C&D debris), the WARM LCI factor for recycling metals has a larger environmental offset than many others. This is because recycled ferrous metals, in replacing virgin metals, offset the need to use metal ingots to produce virgin products, which reduces GHG and energy required for extraction, manufacture, and transport. This is also true for C&D debris because the large mass recycled outweighs the environmental impact of landfilling C&D debris. For corrugated paper, the LCI factor for recycled paper products assumes an offset due to a reduction in wood harvesting and virgin paper manufacturing and a corresponding large reduction in methane emissions, which have 25 times the GHG potential of CO₂.

In WARM, materials contributing the most GHG emissions and energy use have a low environmental benefit associated with their net waste management. Glass is made up of 73% sand. WARM-reported process energy needed to manufacture glass using virgin inputs generates 0.37 tCO₂eq/ ton, while process energy associated with using recycled glass is 0.23 tCO₂eq/ ton. That small difference is due to the abundance and easy extractability of sand. The combustion GHG emission factor for glass is a positive 0.03 tCO₂eq/ ton. This means that glass is contributing to emissions because glass absorbs heat that would have been used to generate electricity at WTE facilities.

WARM does not consider yard trash and food waste recycling. In this study, composting LCI factors were used as a proxy. When yard trash is composted, it generates non-biogenic CO₂ emissions because operating the equipment needed to mechanically turn the compost is energy-intensive. However, because compost stores carbon, it generates a GHG emission offset.

Net waste management associated with combusting, landfilling, and recycling other plastics results in one of the largest GHG emissions because of the small mass recycled and the larger mass combusted. In WARM, when plastics are combusted, they contribute to energy generation that offsets nonrenewable fuel sources, but because combustion releases non-biogenic CO₂, it outweighs the previous environmental benefit because non-biogenic CO₂ would not have been released originally if the plastic had not been extracted from the earth.

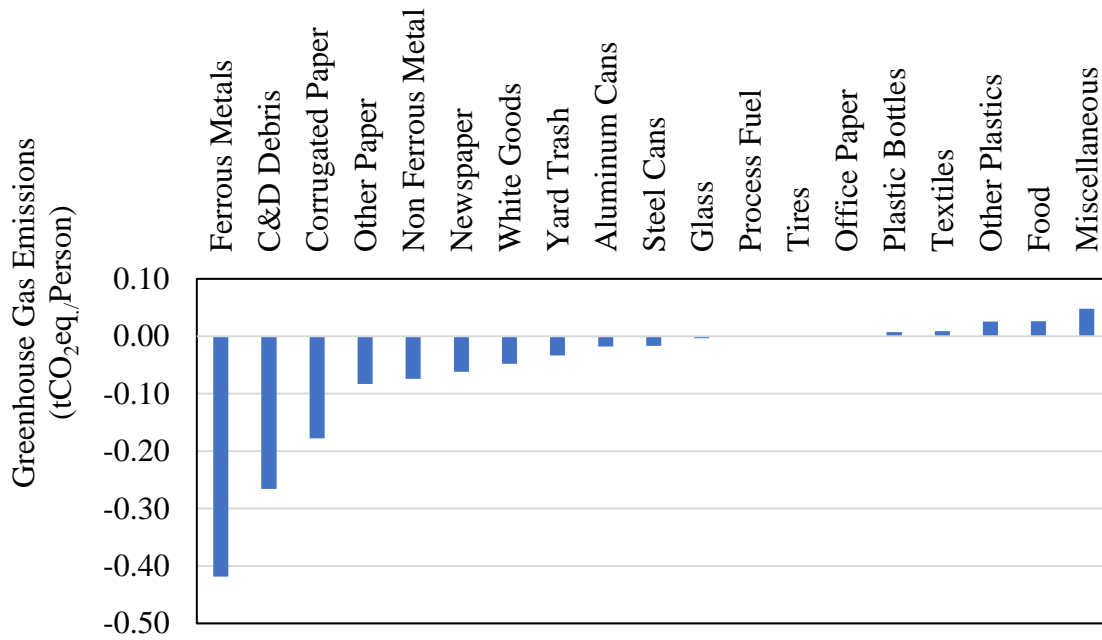


Figure 3.2.1: Net greenhouse gas emissions in Florida.

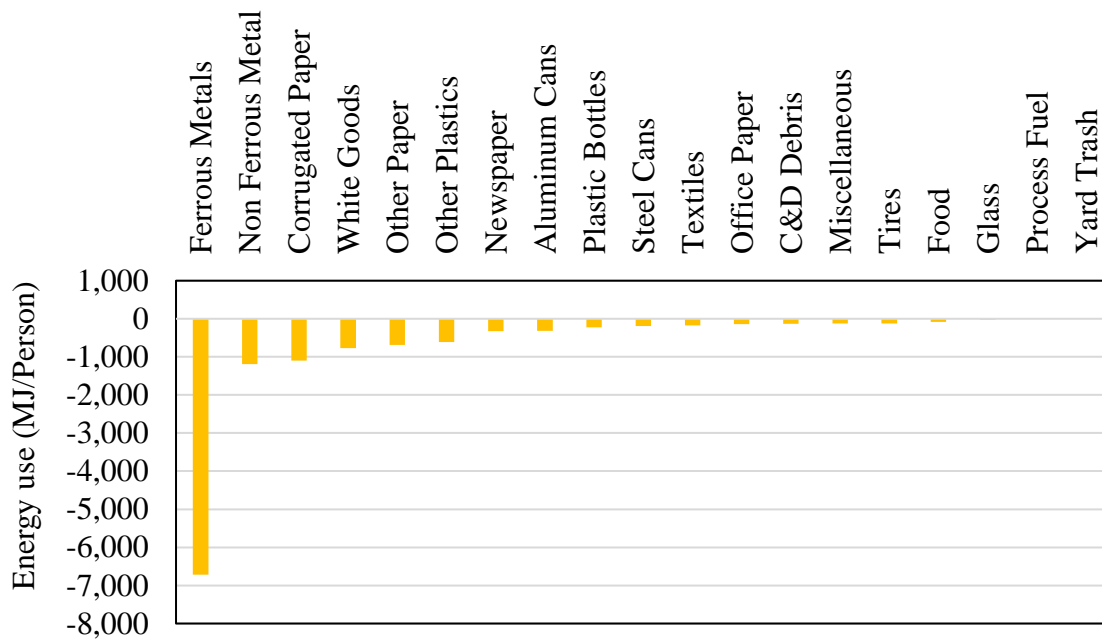


Figure 3.2.2: Net energy use in Florida.

3.3 ECONOMIC COSTS

From 1988 to 2012, FAC Rule 62-708 required Florida counties and municipalities to report to FDEP full-cost accounting (FCA) for their solid waste management by completing a standardized FDEP-provided spreadsheet. The rule defined full-cost accounting as accounting for the rate charged to the end user for services, outside contractors, and direct and indirect costs. It also instructed counties and municipalities to publicly disclose the information, divide it into residential and non-residential user categories, and include costs associated with MSW collection, disposal, and recycling for each category. Today (2018), counties and municipalities are not required to submit this data to FDEP, but they must still comply with the ruling. We participated in exhaustive efforts to collect FCA information for each county and municipality from 1988-2016 in hopes of using this data to estimate the total costs associated with Florida's solid waste management. In collecting the data, we identified many issues with the FCA information. Some of these issues are listed below.

1. Although the rule requires counties and municipalities to submit data to FDEP from 1988-2012, many of the counties and municipalities did not report to FDEP for each year, resulting in many data gaps.
2. The rule requires the data to be separated into the residential and non-residential categories and for costs to be tracked for collection, disposal, and recycling. But because the rule does not describe specific units for costs, the data was reported in various incomparable units such as \$/ton, \$/ft³, \$/yd³, \$/unit, \$/household, etc.
3. Although counties and municipalities were required to complete the standardized spreadsheet after talking with county solid waste directors and recycling coordinators, we established that data reported for each year sometimes differs greatly because of changes in leadership and in what is accounted for each year.

Because of the incomplete FCA data sets and the low quality of the data, we took another approach to estimating total costs, using financial data from Florida counties and municipalities, feasibility studies, and other research. For each mass flow disposition, an associated cost per metric ton was developed and applied to each county's mass flow in order to generate a county-based total economic cost. Those costs included both the costs and revenues associated with each mass flow, which generated a net cost for the state. Total statewide net cost resulted from summing the county-based total costs, indirect costs, and transfer station costs. Indirect costs include any costs not accounted for in the conversion factors. Transfer station and hauling costs relate only to the MSW managed by transfer stations (as discussed in Section 3.1.5). Total statewide costs associated with Florida solid waste management in 2016 were \$3.20 billion (Table A1). No indirect costs were included in these values.

The mass categories and their associated economic cost category used to generate the economic cost are shown in Table A2. For each mass category, a conversion factor (in \$USD/tonne) was developed that included all the costs associated with the mass category. The conversion factor accounts for amortized capital costs, operating and maintenance costs, transportation costs, and revenue. For the 2016 current state of affairs costs, the mass categories evaluated included:

1. Residential collection^a
2. Non-residential collection^b
3. YT collection^c
4. C&D collection
5. Recycled direct residential & non-residential
6. Recycled direct yard trash^d
7. Recycled yard trash used as landfill cover^e
8. Recycled direct C&D
9. Recycled post-combustion
10. Landfilled direct C&D
11. Landfill direct non-C&D
12. Landfill post-combustion
13. Combustion
14. Transfer station and hauling

The mass for each mass category can be found in Section 3.1 and the cost conversion factors (\$USD/tonne) are found in Table A3. A detailed description of how each cost conversion factor was developed is found in Appendix A.

^a **The mass of residential collected tons was multiplied by 75% because 25% of the collected mass was assumed to be serviced by drop-off centers.**

^b **No percentage of the total commercial collected tons were attributed to self-haul, although we recognize that a certain number of commercial establishments will chose to self-haul rather than be serviced by a subscription service.**

^c **The mass of yard trash collected only included the mass of yard trash attributed to be residential.**

^d **The mass of recycled direct yard trash refers to yard trash recycled by mulching.**

^e **The mass of recycled yard trash used as landfill cover refers to yard trash recycled by mulching and transported to a landfill to be used as landfill cover.**

4.0 COUNTY CASE STUDIES

4.1 OVERVIEW

As part of this study, several counties provided detailed information concerning their waste management and disposition that provided overall project insight that was used in identifying Florida's waste mass flows and associated costs. We also analyzed the impact of implementing SMM by identifying the current state of affairs and comparing it to alternative waste management approaches. This provided valuable quantified environmental impacts and economic costs to the counties. Five counties took part in this study: Alachua, Escambia, Palm Beach, Polk, and Sarasota. This section provides detailed information on waste management and disposition, environmental footprints, and economic costs for Alachua, Palm Beach, and Sarasota counties. Alternative approaches were chosen based on the counties' interests in prospective new waste management approaches.

Data describing each county's waste stream was gathered from FDEP's 2016 solid waste management annual report and from county-provided documents. The data from the FDEP report is summarized on Re-TRAC, the online database where Florida counties submit solid waste management and disposition data. This information was used to create a mass flow to track each waste material in the following four categories: (1) residential; (2) non-residential; (3) yard trash; and (4) C&D debris. The residential and non-residential categories do not include yard trash or C&D debris. Instead, those two categories were treated separately because yard trash and C&D debris are collected separately from residential and non-residential MSW and they represent the two largest waste components of the Florida waste stream.

To compare the environmental footprint of the current state of affairs to the set of alternative waste management approaches, LCA tools were used to quantify environmental impacts. We used EPA WARM LCI factors to quantify GHG emissions and energy consumption per ton of each waste material managed in each county. Budget documents were obtained describing the current and projected economics in each county. That method offers an estimate of the relative increase or decrease in environmental impact and economic cost for each alternative approach.

4.2 ALACHUA COUNTY

4.2.1 Waste Management and Disposition

4.2.1.1 Current State of Affairs

Alachua County is responsible for collecting residential waste from its unincorporated areas. The county also operates five rural collection centers and the Leveda Brown Environmental Park and Transfer Station, which houses a dual-stream MRF along with a transfer station. All MSW generated in Alachua County is sent to the transfer station and then to the New River Regional Landfill (located approximately one hour north of Alachua County) for disposal. Most residential and non-residential recyclables are sent to the MRF to be separated and transported to remanufacturing facilities. The residential mass flow incorporates the tonnages contributed by single-family and multi-family generators but excludes all yard trash and C&D debris. This waste stream collected 82,553 tonnes of MSW and recycled 27,754 tonnes of that material. The collection methods for residential MSW are unique to Alachua County.

Municipalities such as the City of Gainesville, the City of Alachua, and Newberry have county-contracted hauling services. Other municipalities and unincorporated areas rely on the five rural collection centers. These facilities collect residential waste, paper, commingled recyclables, and yard trash that is hauled directly by residents. In the past, some of the rural collection centers used as landfills. Due to population increase, those landfill locations became controversial. During the late 1990s, they were closed, and Alachua County entered into an interlocal agreement with the New River Solid Waste Authority to use their landfill in Union County.

At present, the New River Regional Landfill is the only active Class I landfill that Alachua County and five other counties use. Alachua County provides yard trash collection services with its contracted haulers, and separation of yard trash from general MSW is required by county law. Ordinances restricting yard trash that is disposed of in Alachua County encourage more recycling. Recycled yard trash is mostly kept within the county, either going to the Watson C&D (mostly residential), the Wood Resource Recovery (mostly commercial), or the Gainesville Renewable Energy Center (land-clearing yard waste from various companies) to be combusted. Based on 2016 FDEP data, the traditional recycling rate in Alachua County is 52%. About 8,064 tonnes of recycling credits were earned from combusting 8,993 tonnes of land-clearing debris and commercial yard waste, giving the county a total recycling rate of 54%. The 2016 solid waste management and disposition of county waste that is landfilled, incinerated, and recycled is shown in Figures 4.2.1 and 4.2.2.

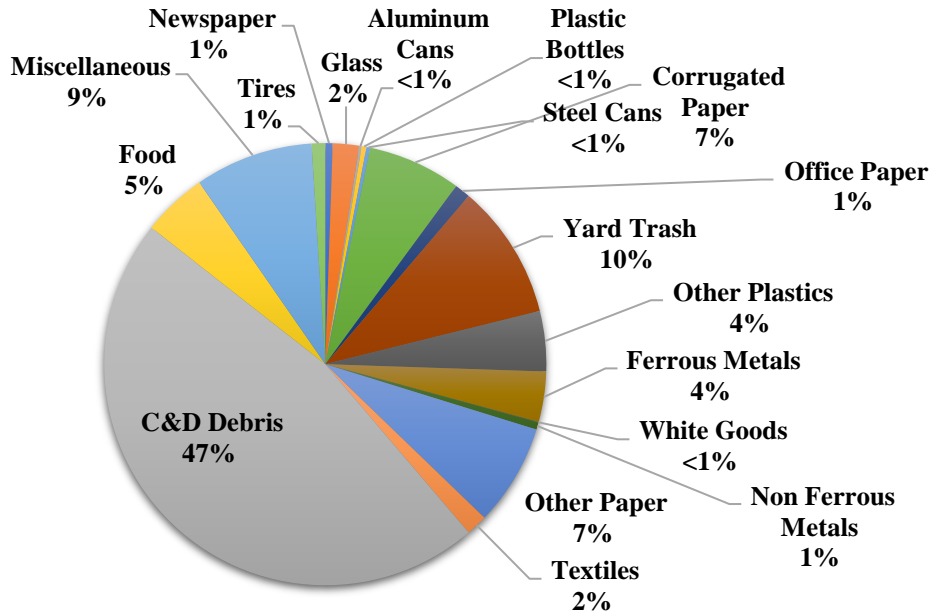


Figure 4.2.1: Waste component percentages in the Alachua County waste stream.

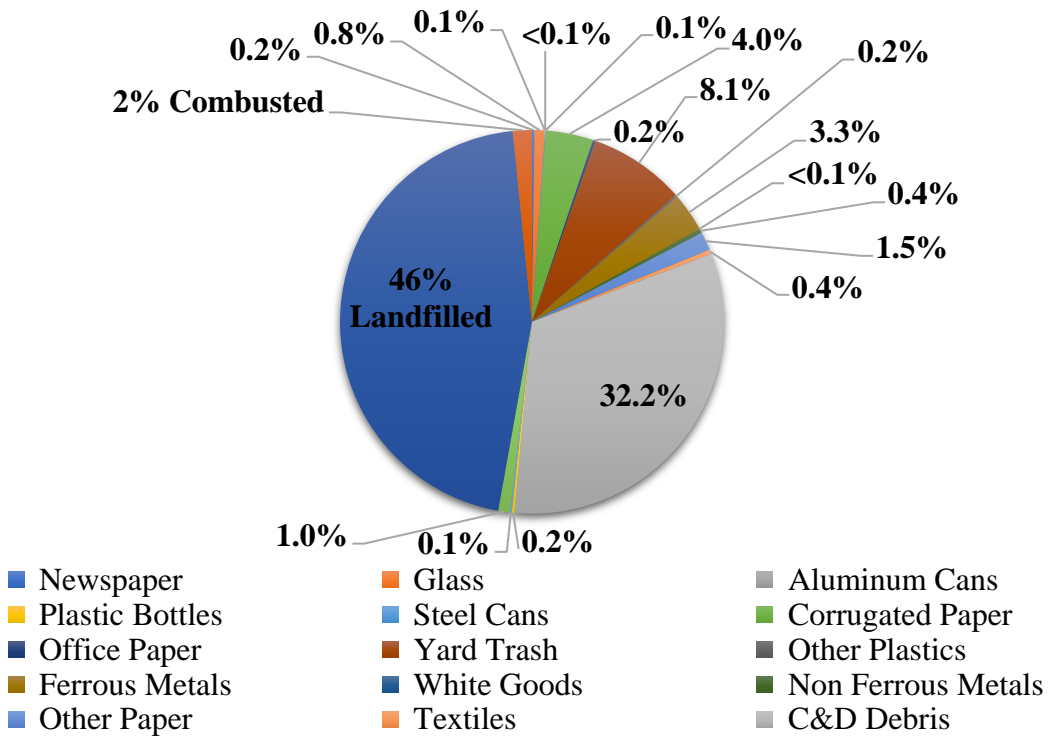


Figure 4.2.2: Alachua County 2016 solid waste dispositions with recycled composition separately shown.

4.2.1.2 Prospective Alternative Approach: Mandatory C&D Recycling

C&D debris is one of the largest waste streams in Alachua County. It consists mostly of concrete, building wood, steel, and plastics. In Florida, many of the more populated counties report a recycling rate for C&D debris in excess of 50%. Some local governments require C&D debris recycling because of its environmental and economic benefits, which include minimizing landfill space consumption. For that reason, Alachua County is evaluating the construction of a C&D debris MRF.

By operating a C&D MRF, Alachua County could increase its recycling rate. This would divert a significant fraction of the C&D waste stream from private C&D businesses and into the county MRF. Certain issues would have to be resolved to create such a facility. Alachua County would have to establish new ordinances for mandatory C&D recycling. Because there are two private C&D debris landfill sites in the county, the county would need to consider how those businesses could benefit from a C&D MRF. The facility could be run publicly or in partnership with a private company. Either way, Alachua County could recover 179,817 tonnes of C&D debris, assuming that the recycling rate for C&D debris increases to 76%, based upon the C&D diversion rate in Los Angeles.²² This alternative approach would increase traditional and total county recycling rates to 56% and 58%. Waste disposition in the county with mandatory C&D debris recycling is shown in Figure 4.2.3, and a comparison of baseline and alternative traditional and total recycling rates is shown in Figure 4.2.4.

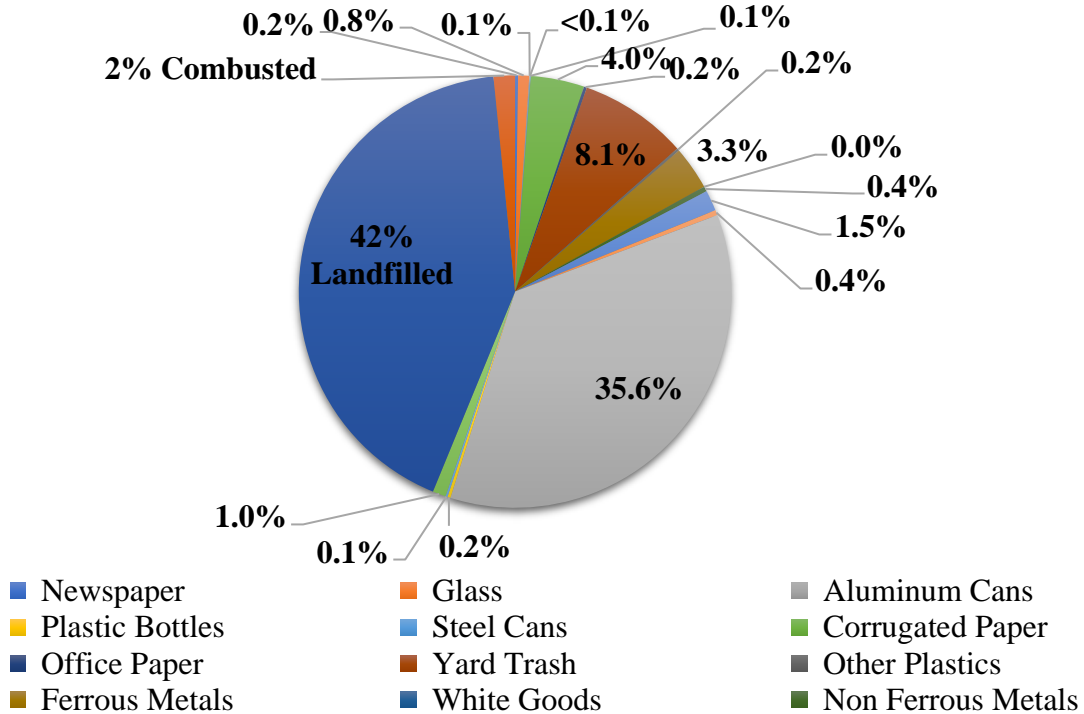


Figure 4.2.3: Solid waste disposition in Alachua County with mandatory C&D debris recycling with recycled composition separately shown.

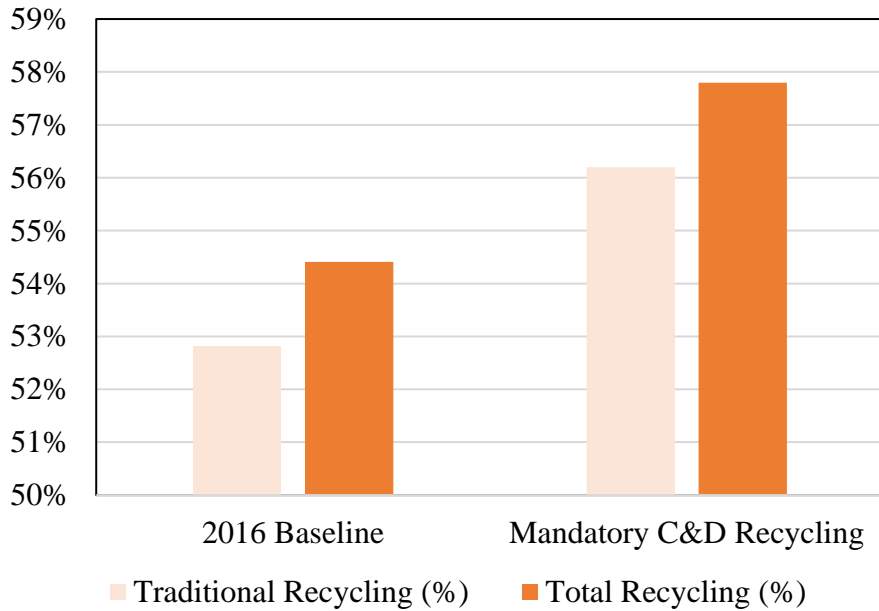


Figure 4.2.4: Alachua County traditional and total recycling, comparing 2016 baseline results to prospective results obtained through mandatory C&D debris recycling.

4.2.2 Environmental Footprint

4.2.2.1 Current State of Affairs

Alachua County has done an excellent job in managing its environmental footprint. Not only does the county have one of the highest recycling rates in Florida (even before considering renewable energy credits), WARM-based analysis shows that the county’s current solid waste management practices result in relatively low GHG emissions as well as relatively low net energy consumption. Based on 2016 baseline data, the WARM-based total GHG emission value was -309 thousand tCO₂eq; WARM-based total energy savings were -2,274 thousand MJ. The environmental footprint for Alachua County is shown in Figures 4.2.5 and 4.2.6. These savings are tremendously high relative to other counties in Florida because of the county’s emphasis on recycling materials that contribute to GHG emissions and energy use offsets. This GHG emissions value is equivalent to 66,208 passenger vehicles taken off the road for one year, yearly electricity use in 46,341 homes, or 15,406 garbage trucks of waste recycled instead of landfilled.

Total GHG and energy savings are the sum of GHG emissions and energy savings calculated for each individual waste component. A waste component’s GHG emissions and energy savings is estimated by multiplying the mass recycled, landfilled, and incinerated by the respective WARM emission factor for each waste management process and summing the resultant values.

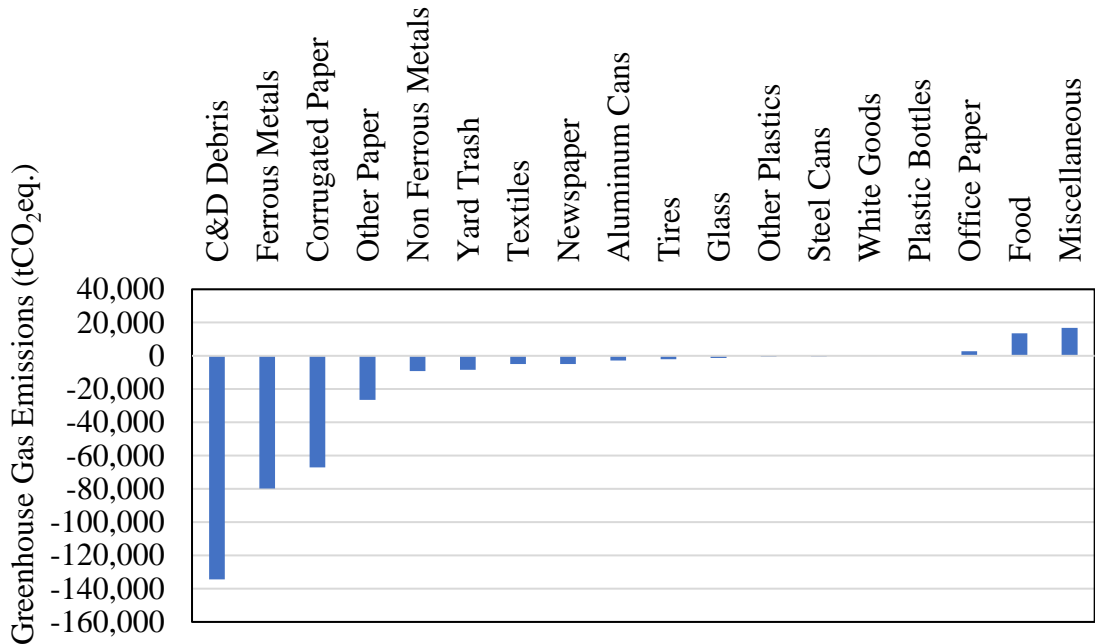


Figure 4.2.5: Net greenhouse gas emissions associated with Alachua County’s solid waste management in 2016, categorized by material.

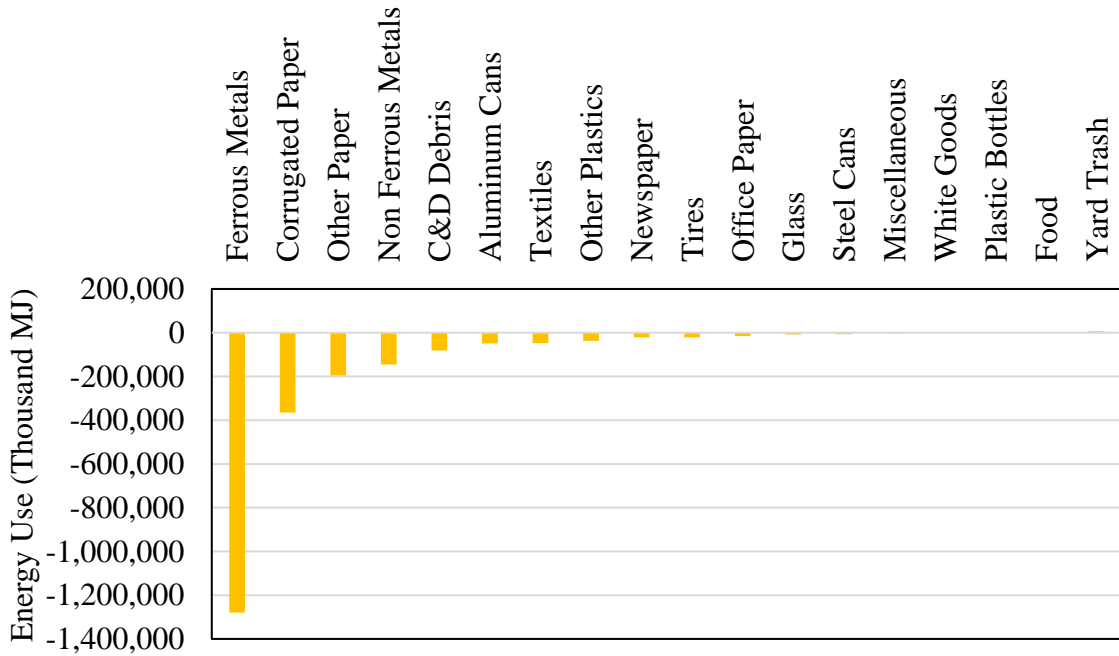


Figure 4.2.6: Energy use associated with Alachua County solid waste management in 2016, categorized by material.

4.2.2.2 Prospective Alternative Approach: Mandatory C&D Recycling

Results of this approach shows that recycling 76% of Alachua County’s C&D debris results in a decrease in GHG emissions and energy usage. Figures 4.2.9 and 4.2.10 show that recycling C&D reduces GHG emissions by 141,000 tCO₂eq and contributes to saving 90,700 MJ. Individual material contributions to overall net GHG emissions and energy use are illustrated in Figures 4.2.7 and 4.2.8. These savings represent 1,539 fewer passenger vehicles driven in a year, yearly electricity usage in 1,077 fewer homes, 240,297 more incandescent lamps switched to LEDs, or 358 more garbage trucks of waste recycled instead of landfilled.

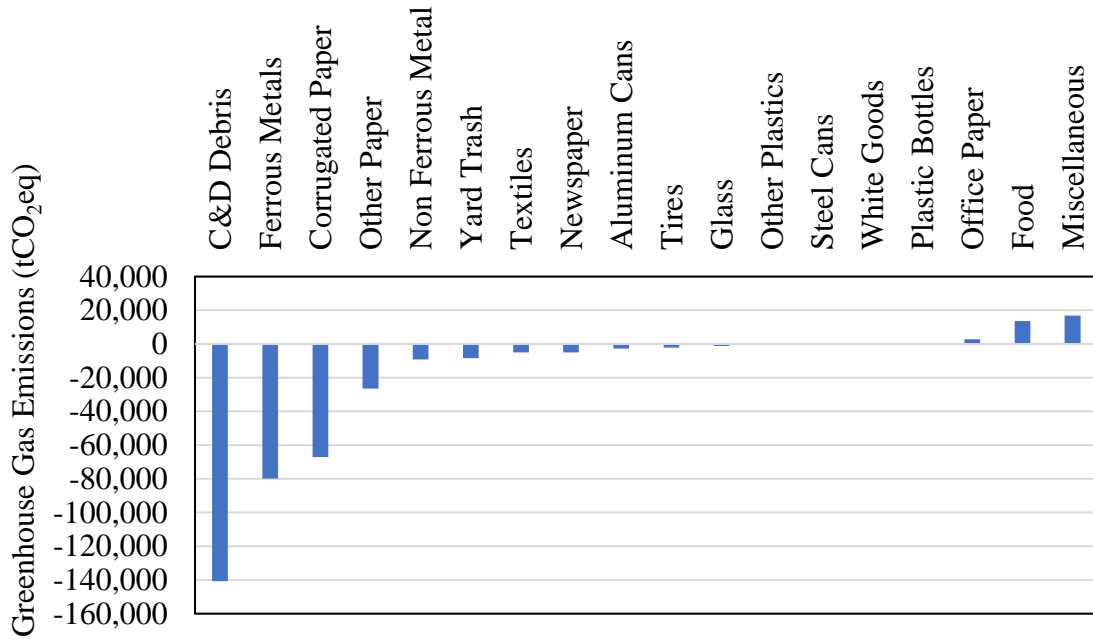


Figure 4.2.7: Net greenhouse gas emissions in Alachua County resulting from mandatory C&D debris recycling, categorized by material.

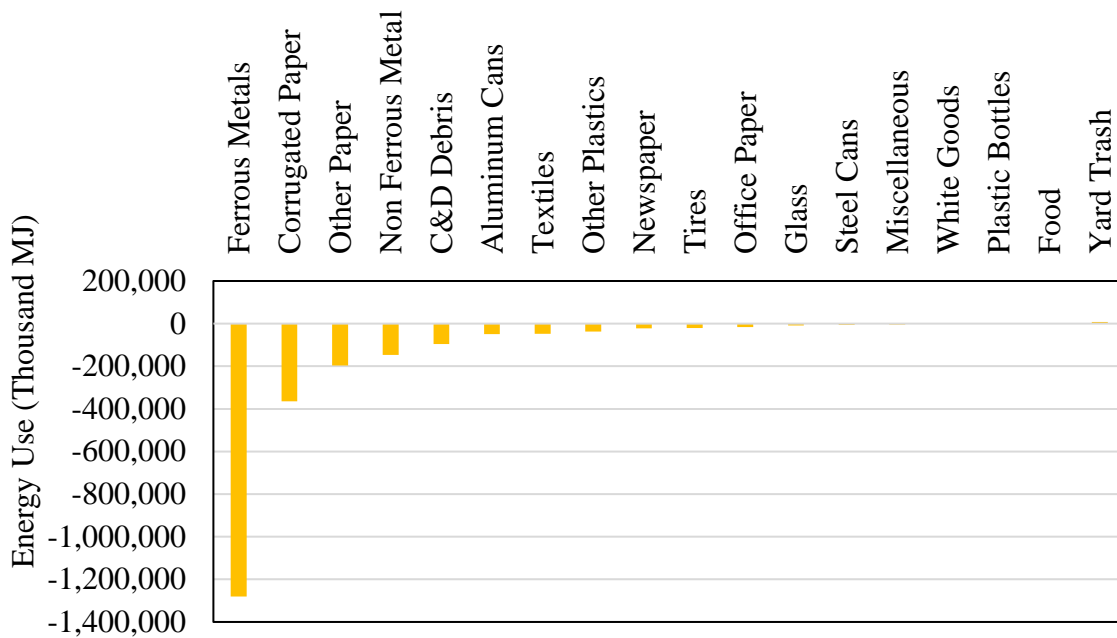


Figure 4.2.8: Energy use in Alachua County resulting from mandatory C&D debris recycling, categorized by material.

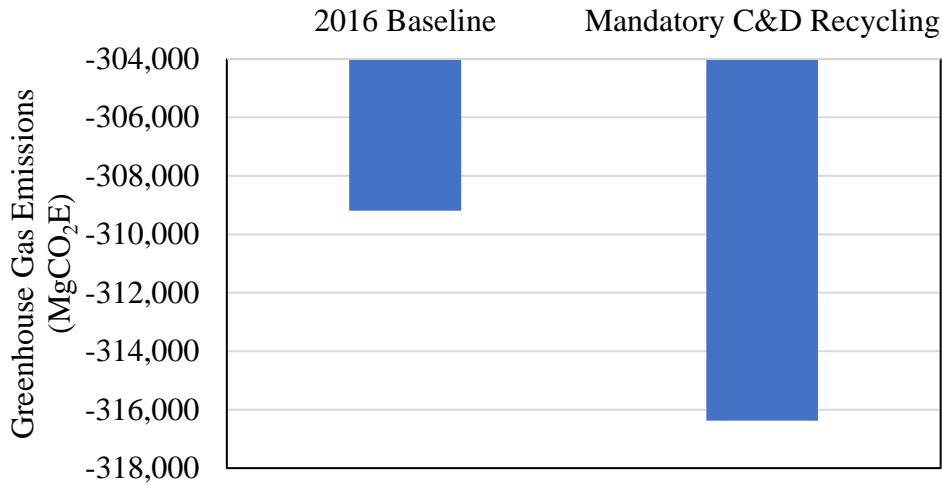


Figure 4.2.9: Comparison of 2016 baseline net greenhouse gas emissions data in Alachua County with prospective data for mandatory C&D debris recycling.

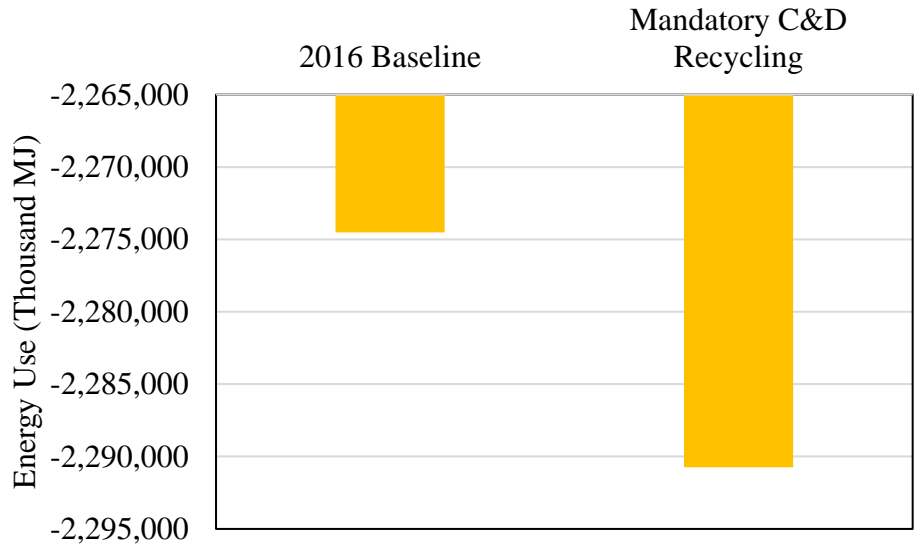


Figure 4.2.10: Comparison of 2016 baseline net energy use data in Alachua County with prospective data for mandatory C&D debris recycling.

4.2.3 Economic Costs

4.2.3.1 Current State of Affairs

We examined the cost of operating each individual MSW facility using actual audited costs for fiscal year 2016 (Table 4.2.1). Total collection costs included personal services, operating expenditures (curbside contract fees for refuse disposal), and capital outlay. MSW management was broken into three categories: (1) transfer station; (2) hauling; and (3) disposal. The total cost of MSW management was \$9,511,340. Other service costs were broken into three categories: (1) rural collection centers; (2) waste alternatives; and (3) closed landfill. Total solid waste management cost for Alachua County in 2016 was \$18,344,509.

The mass of waste collected was provided by Alachua County and associated with the residential unincorporated mass that Alachua County handles. The mass of waste recycled at the MRF was calculated by subtracting C&D debris and yard trash. Rural collection centers' collected mass was calculated by summing total mass collected as reported by each collection center to the transfer station. Out of these costs, MSW management is associated with 52% of the total costs to the county, followed by collection (24%), other solid waste services (13%), and materials recovery facility (11%) (Figure 4.2.11).

Table 4.2.1: 2016 baseline economic costs based on budgets and reports.

Service	Total costs	Tonnes	Cost per tonne
Collection	\$4,437,163	17,591	\$252.24
MSW management			
Transfer station	\$1,816,403	162,148	\$11.20
Hauling	\$1,603,864	162,148	\$9.89
Disposal	\$6,091,073	162,148	\$37.56
Total costs	\$9,511,340	162,148	\$58.65
Materials recovery facility	\$2,016,504	63,156	\$31.93
Other solid waste services			
Rural collection centers	\$1,030,904	8,871	\$116.19
Waste alternatives	\$770,206	63,156	\$12.20
Closed landfill	\$578,392	—	—
Total costs	\$2,379,502	72,029	\$33.04
TOTAL solid waste management costs	\$18,344,509		

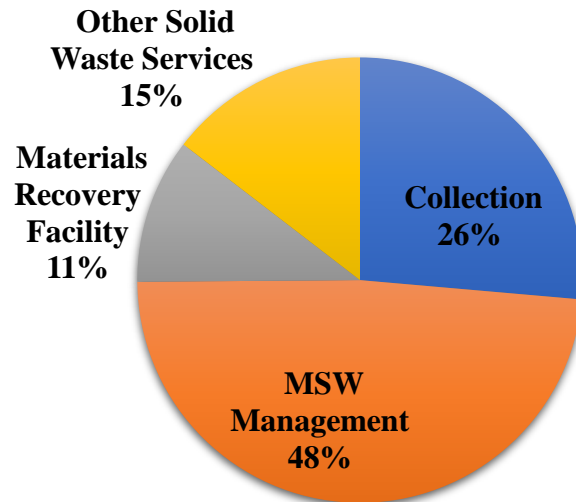


Figure 4.2.11: Total cost composition of solid waste services funded by the Alachua County Solid Waste and Resource Recovery Department.

4.2.3.2 Prospective Alternative Approach: Mandatory C&D Debris Recycling

Overall costs for the mandatory C&D recycling approach are estimated to be 58% higher than costs for the 2016 baseline approach. This increase is due to the increased capital and operational expenses involved in managing a C&D MRF. The burden for recycling this material would be shifted from private companies to the county (along with the facilities' potential profits). A large-scale C&D facility, including operation and maintenance expenses, is estimated to cost between \$3.6 million and \$10.6 million, based on scaling the C&D MRF operation in Sarasota County, which costs that county

\$45.01/tonne. Costs associated with operating a prospective C&D MRF in Alachua County for 20 years are presented in Table 4.2.2. The facility would require a scale, a building, a tip area, and an excavator as well as magnets and picking lines for operation. The proposed C&D MRF has the potential to generate revenue for the county based on the sale of recycled C&D debris to remanufacturers. It is estimated that the revenue generated could range from \$12.56/tonne to \$18.08/tonne based on the estimated mass of C&D debris recycled via this approach.

Table 4.2.2: Costs associated with the prospective mandatory C&D recycling approach in Alachua County.

Service	Total Costs	Tonnes	Cost per Tonne
Collection	<i>\$4,437,163</i>	<i>17,591</i>	<i>\$252.24</i>
MSW management			
Transfer station	\$1,816,403	162,148	\$11.20
Hauling	\$1,603,864	162,148	\$9.89
Disposal	\$6,091,073	162,148	\$37.56
<i>Total costs</i>	<i>\$9,511,340</i>	<i>162,148</i>	<i>\$58.65</i>
Materials recovery facility	<i>\$2,016,504</i>	<i>63,156</i>	<i>\$31.93</i>
Other solid waste services			
Rural collection centers	\$1,030,904	8,872	\$116.19
Waste alternatives	\$770,206	63,156	\$12.20
Closed landfill	\$578,392	—	\$0.00
<i>Total costs</i>	<i>\$2,379,502</i>	<i>72,029</i>	<i>\$33.04</i>
C&D debris materials recovery facility			
Sarasota scaled-up	\$10,649,917	236,601	\$45.01
R.W. Beck (upper)	\$4,972,181	236,601	\$21.01
R.W. Beck (lower)	\$3,655,066	236,601	\$15.44
TOTAL solid waste management costs			
With Sarasota scaled-up	<i>\$28,994,427</i>	<i>236,601</i>	<i>\$45.01</i>
With R.W. Beck (upper)	<i>\$23,316,690</i>	<i>236,601</i>	<i>\$21.01</i>
With R.W. Beck (lower)	<i>\$21,999,575</i>	<i>236,601</i>	<i>\$15.44</i>

Note: Economic costs associated with mandatory C&D recycling in Alachua County assume a C&D MRF is constructed and operated. These costs reference reported Sarasota County C&D MRF costs and costs reported in R.W. Beck (2007).

4.3 PALM BEACH COUNTY

4.3.1 Waste Management and Disposition

4.3.1.1 Current State of Affairs

The Solid Waste Authority of Palm Beach County is the agency responsible for waste collection, disposal, and recycling services in Palm Beach County. The Authority operates six transfer stations, a landfill, two WTE facilities (referred to here as REF #1 and REF #2), a MRF, and a biosolids pelletizer. Since 2008, the county has increased its traditional recycling rate from 31% to 45%. The county's total recycling rate of 72% in 2016 was due in large part to REF #2 coming online in mid-2015; it is one of the highest rates in Florida, and it meets the legislature's benchmarks of 60% for 2016 and 70% for 2018.

Based on 2016 data provided in FDEP's annual report, the traditional recycling rate in Palm Beach County is 45%. The Authority uses ash generated from REF #1 and REF #2 as landfill cover, and these credits are part of the total amount of miscellaneous material recycled. In addition, 739,625 tonnes of WTE renewable energy credits were reported for 2016. WasteCalc waste composition and yard trash results were modified to include additional tonnage corresponding to the reported landfilled mass of yard trash (Figure 4.3.1). Baseline data for 2016 is shown in Figure 4.3.2.

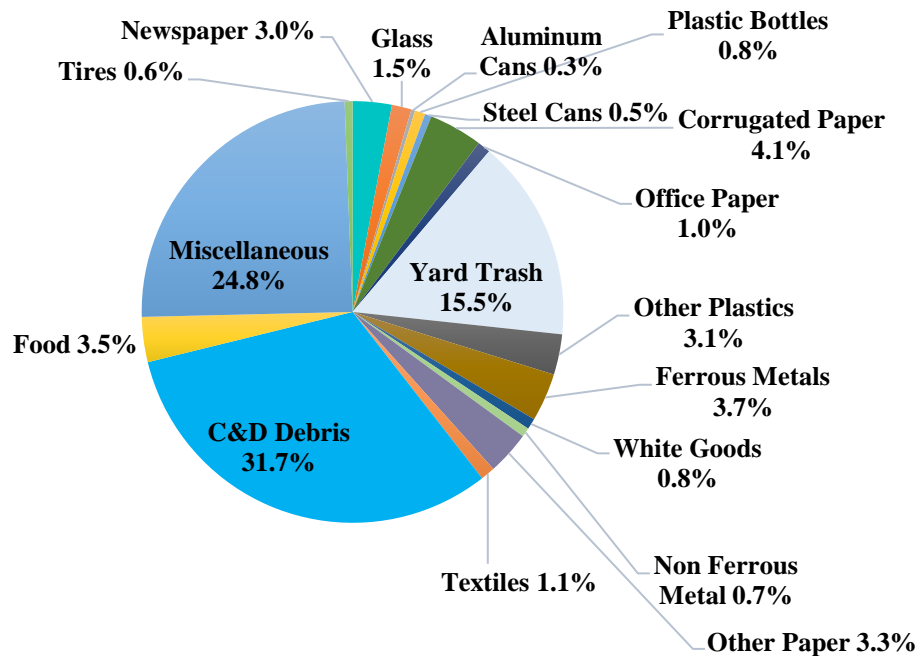


Figure 4.3.1: 2016 Palm Beach County waste composition as estimated by WasteCalc.

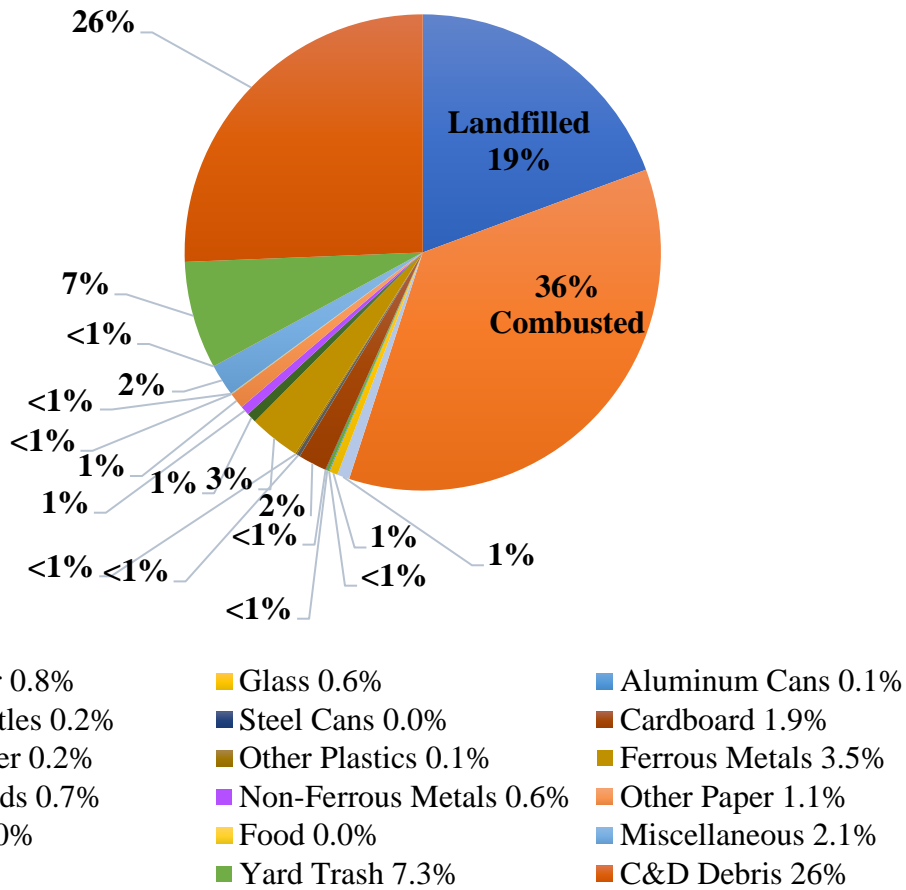


Figure 4.3.2: Palm Beach County 2016 solid waste dispositions with recycled composition separately shown.

4.3.1.2 Prospective Alternative Approach: WTE Ash Recycling and Glass Pozzolan Processing

The use of municipal solid waste incinerator bottom ash (MSWI-BA, or BA) in road base and cement products is a common practice in European countries because it offsets the need to use virgin materials in these products. Removing metals from the ash saves valuable resources and creates a marketable ash product. The current market for recycled glass is poor, and counties across Florida are considering different options for the disposal of recycled glass. Recent studies have evaluated whether recycled glass can be used in concrete by crushing it into a fine pozzolanic material that can be used as a substitute for Portland cement. If the Authority builds an advanced metal recovery facility and a glass pozzolan (GP) processing facility, it may see an increase in the recycling rate, a reduction in landfill operation costs due to the reduction in landfill tonnage, and additional revenue streams from recovered additional metal, BA aggregate products, and glass pozzolan.

The success of BA recycling seen in Europe is a result of governmental policies requiring it. The regulatory landscape is vastly different in the US as a whole and in Florida in particular. As a result, market conditions for BA aggregate use are less favorable in the US than in Europe. In order for this approach to become feasible, FDEP and the Florida Department of Transportation (FDOT) would need to promote greater acceptance of BA application in road base and other materials, and policy changes would have to occur.

Currently, BA is taken in Palm Beach County from REF #1 and REF #2, metal recovery is performed, the processed BA is mixed with fly ash, and the mixed ash is landfilled. The majority of the metal from REF #1 is recovered during the creation of refuse-derived fuel, and remaining recoverable metal is recovered from the ash. Because REF #2 is a mass-burn facility (meaning that waste is fed directly into the incinerator with minimal processing), metal recovery is performed on the BA leaving REF #2 before it is mixed with fly ash and landfilled.

The proposed alternate flow requires diverting processed BA and all collected glass. The processed BA exiting from REF #1 and REF #2's metal recovery facility would be transported to a privately operated advanced metal recovery plant located on land at the Authority's Renewable Energy Park. There, additional ferrous and non-ferrous metals would be recovered from the ash by metal type and size fraction, and then the recovered material would be refined by a metal recycler. Metal recovery rates from an advanced metal recovery operation are estimated to be 0.1-0.3% ferrous and 0.8-1.33% non-ferrous based on estimates from an ash processing facility operator (the Operator) that recovers metals from WTE ash in Florida, and variances used in other metal recovery operations.²³ All the collected glass processed by the recycled material processing facility (RMPF) would be ground to create GP as a replacement for Portland cement.

In 2016, 15,664 tonnes of glass were reported to have been recycled in the county, and 14,646 tons were marketed at the RMPF by the Authority. In the proposed flow, it is assumed that the 14,646 tons of processed glass would be recycled into GP and the remaining 1,141 tons recycled by standard recycling measures, not through the Authority. The composition of GP in concrete presented in this approach is based on a study by Schafer et al. (2018). The composition consists of a 20% replacement of Portland cement with GP and a 30% replacement of concrete aggregate with BA.

Based on these recovery rates, ash processed at the advanced metal recovery facility is estimated to yield an additional mass of recovered ferrous and non-ferrous metals. Of the resulting mass of non-ferrous metal, 78.6-79.4% is estimated to be aluminum and the remaining 20.6-21.4% is assumed to be non-ferrous, based on recovery and yield rate estimates provided by the Operator. This percentage refers to non-ferrous metal yielded from a metal recycler and does not include inherent waste material in the recovered material from an advanced metal recovery facility.

Because these metal recovery rates are for ash that is mixed BA and fly ash, the Authority's reported tonnage of landfilled ash (i.e., mixed ash) for 2016 is used to

calculate the amount of metals recovered and recycled. Because the Authority does not measure the amount of BA coming into its ash processing facility, 80% of the total ash (ash reported as landfilled plus metals reported to be recovered from ash) generated by REF #1 and REF #2 is assumed to be BA and the remainder is assumed to be fly ash. The mass of material recovered is subtracted from the estimated amount of BA generated to find the amount of BA that remains after processing.

Of the BA that remains, 40% would be mixed with fly ash and landfilled and 60% would be processed into a marketable road base substitute. The amount of BA diverted from the landfill and the amount of metals recovered from the advanced metal recovery process is subtracted from the total amount landfilled in 2016. This reduction in landfilled ash results in an estimated 27.3-27.5% potential reduction in the amount of total material landfilled in 2016. Tables 4.3.1 and 4.3.2 provide details as to the mass balance and environmental impact of the ash. Figure 4.3.3 illustrates the flow of ash and other materials.

Implementing WTE ash recycling and glass pozzolan processing in Palm Beach County would result in the total recycling rate increasing from 72% to 76.9% (Figure 4.3.4) due to the additional metals and BA aggregate recycled that would be attributed to the county. By diverting BA from the landfill, a volume of 149,800-151,000 cubic yards would be saved annually, extending the life of the landfill.

Table 4.3.1: BA recycling mass balance for economic values in Palm Beach County.

Step 1. Mass balance for ash currently processed by the Authority

	Ash landfilled	Ferrous from ash by Authority	Non-ferrous from ash by Authority	Total metal (Fe + non-Fe)	Total ash (ash landfilled + total metal)
REF 1	120,413	3,736	3,416	7,153	127,566
REF 2	272,113	23,284	894	24,178	296,290
Total	392,526	27,020	4,310	31,330	423,856

Step 2. Estimated mass balance of authority's BA (80% of total ash)

	Bottom ash	Metal recovered by Authority	Actual BA sent to Operator
REF 1	102,053	7,153	94,900
REF 2	237,032	24,178	212,855
Total	339,085	31,330	307,755

Step 3. Estimated advanced metal recovery and recycling mass balance (estimated recovery is based on mixed ash tonnage)^a

	Total mixed ash for estimating material recovery	Ferrous material recovered	Non-ferrous material recovered	Total material recovered
Total	392,526	1,963	6,476	8,439

	Material sent to metal recycler	Ferrous recycled	Non-ferrous recycled	Total metal recycled
Total	8,439	785	4,307	5,092

Step 4. Estimated mass balance of BA remaining after advanced metal recovery^b

	Bottom ash actually inputted	Material recovered	Bottom ash remaining
Total	307,755	8,439	299,315

Step 5. Estimated mass balance for final disposition of remaining BA and fly ash

	BA aggregate (60% of remaining BA)	Landfilled BA (40% of remaining BA)	Fly ash landfilled (20% of total ash)
Total	179,589	119,726	84,771

- a. Ferrous material recovered per ton of mixed ash: 0.50% (recycled metal yield of 40%); non-ferrous material recovered per ton of mixed ash: 1.65% (recycled metal yield of 66.5%).
- b. Values from section 2 and 3 are used to calculate estimated BA leaving the operator. Total mixed ash is needed to estimate material recovery only; in reality, only BA will be processed by the operator and recycled.

Table 4.3.2: BA recycling mass balance for environmental impact in Palm Beach County.

Step 1. Mass balance for ash currently processed by the Authority

	Ash landfilled	Ferrous from ash by Authority	Non-ferrous from ash by Authority	Total metal (Fe + non-FE)	Total ash (ash landfilled + total metal)
REF 1	120,413	3,736	3,416	7,153	127,566
REF 2	222,071	19,002	729	19,731	241,803
Total	342,484	22,738	4,146	26,884	369,368

Step 2. Estimated mass balance of authority's BA (80% of total ash)

	Bottom ash	Metal recovered by Authority	Actual BA sent to Operator
REF 1	102,053	7,153	94,900
REF 2	193,442	19,731	173,711
Total	295,495	26,884	268,611

Step 3. Estimated advanced metal recovery and recycling mass balance (estimated recovery is based on mixed ash tonnage)^a

	Total mixed ash for estimating material recovery	Ferrous material recovered	Non-ferrous material recovered	Total material recovered
Total	342,484	1,712	5,651	7,363

	Material sent to metal recycler	Ferrous recycled	Non-ferrous recycled	Total metal recycled
Total	7,363	685	3,758	4,443

Step 4. Estimated mass balance of BA remaining after advanced metal recovery^b

	Bottom ash actually inputted	Material recovered	Bottom ash remaining
Total	268,611	7,363	261,248

Step 5. Estimated mass balance for final disposition of remaining BA and fly ash

	BA aggregate (60% of remaining BA)	Landfilled BA (40% of remaining BA)	Fly ash landfilled (20% of total ash)
Total	156,749	104,499	73,873

- a. Ferrous material recovered per ton of mixed ash: 0.50% (recycled metal yield of 40%); non-ferrous material recovered per ton of mixed ash: 1.65% (recycled metal yield of 66.5%).
- b. Values from section 2 and 3 are used to calculate estimated BA leaving the operator. Total mixed ash is needed to estimate material recovery only; in reality, only BA will be processed by the operator and recycled.

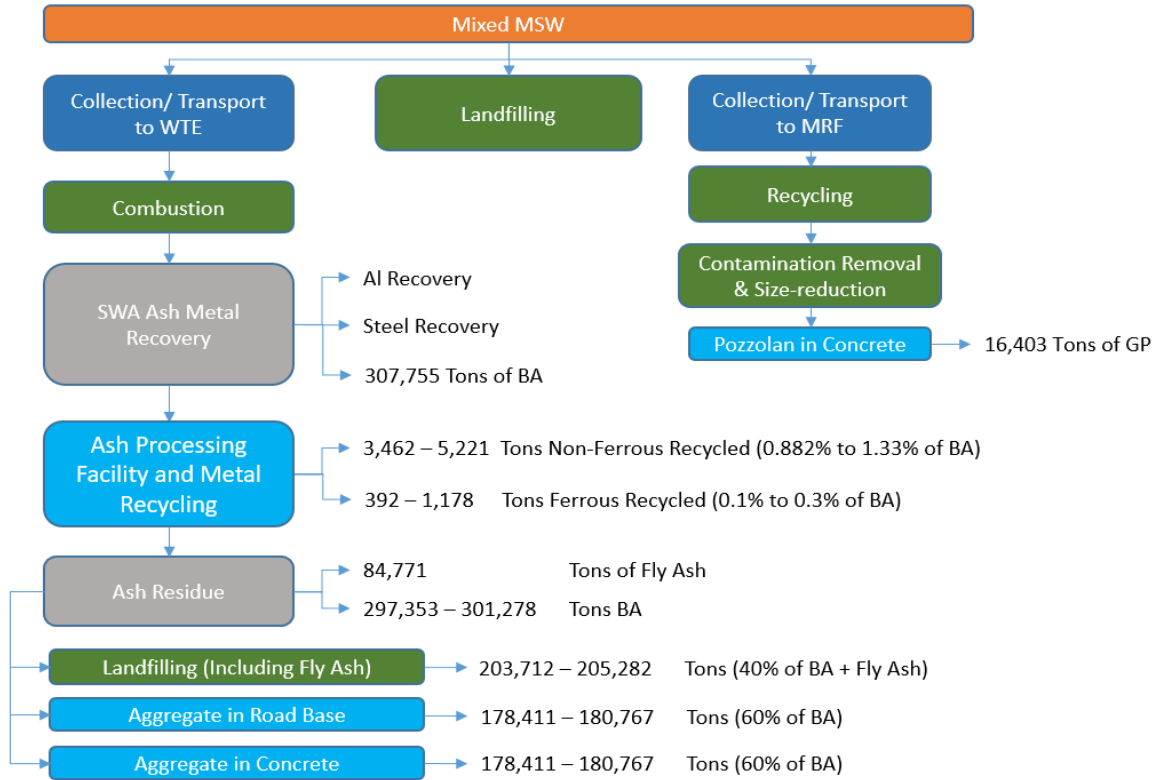


Figure 4.3.3: Illustrated mass flow for BA recycling and glass pozzolan production in Palm Beach County.

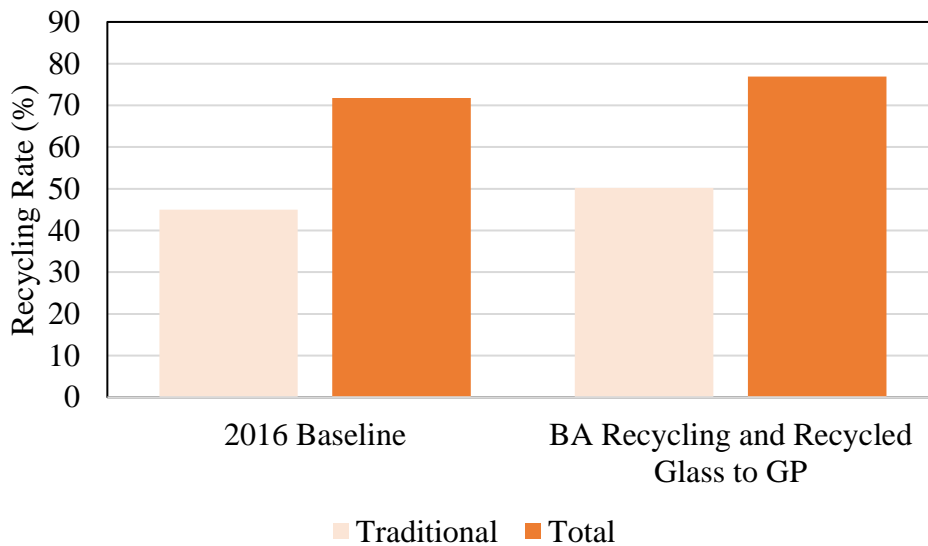


Figure 4.3.4: Comparing 2016 baseline data for traditional and total recycling in Palm Beach County with the prospective BA recycling alternative.

4.3.2 Environmental Footprint

4.3.2.1 Current State of Affairs

Different waste management practices (e.g., landfills, recycling, combustion, etc.) can increase or decrease the amount of GHGs emitted into the atmosphere, and these practices consume or produce different amounts of energy. Palm Beach County has one of the highest traditional recycling rates in Florida and one of the highest total recycling rates attributed to its two WTE facilities. The environmental footprint for the county represents GHG emissions and energy consumption associated with 2016 waste management practices. In 2016, the WARM-based total GHG emission savings value was 1,498,848 tCO₂eq and the total energy savings was 20,200,097 MJ. The tCO₂eq value is equivalent to 320,953 passenger vehicles taken off the road for one year, yearly electricity use in 224,648 homes, or 74,681 garbage trucks of waste recycled instead of landfilled. Figures 4.3.5 and 4.3.6 show GHG emissions and energy use associated with our 18 material components based on 2016 FDEP data.

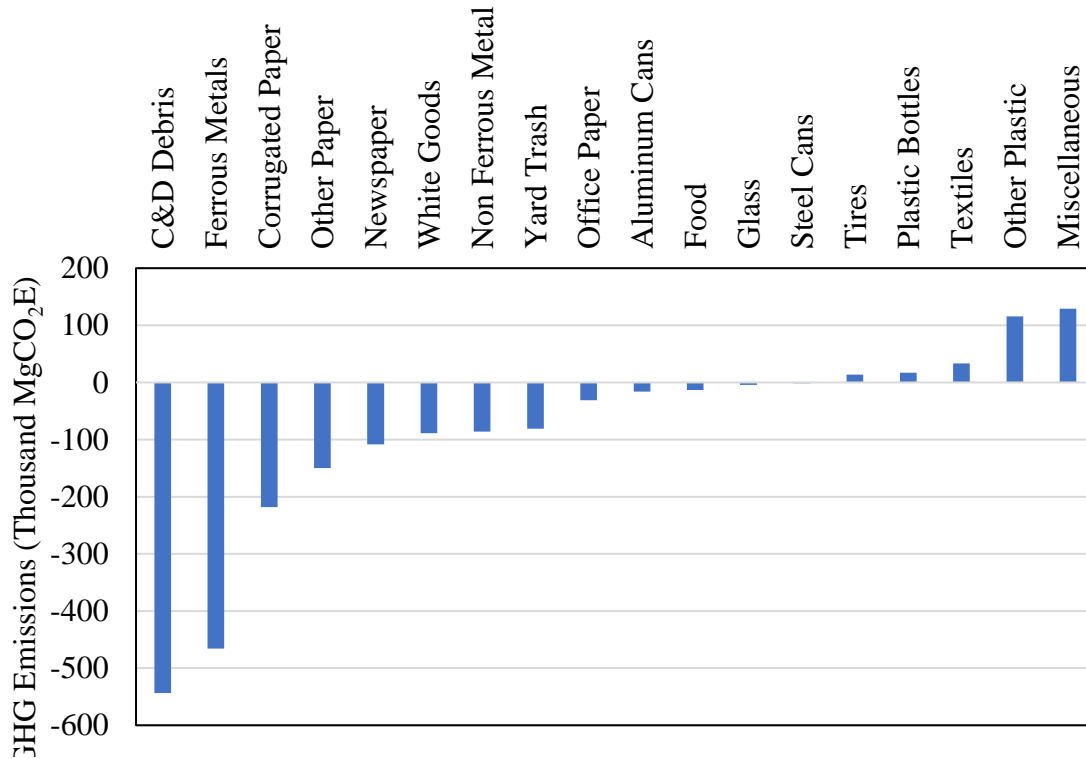


Figure 4.3.5: Net greenhouse gas emissions in Palm Beach County in 2016, categorized by material.

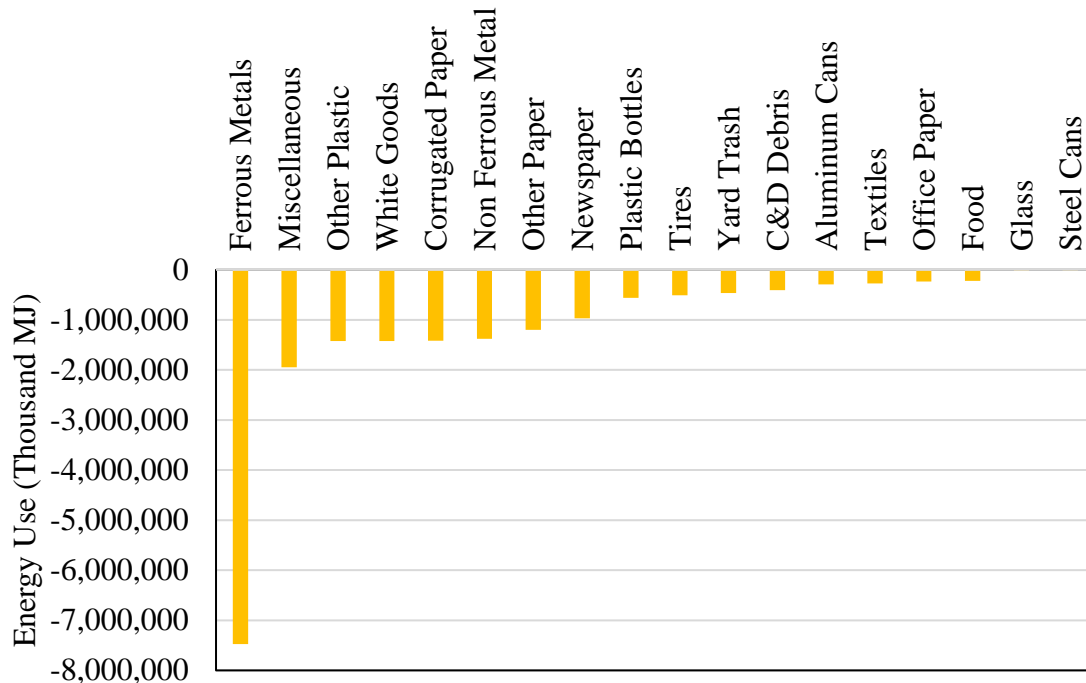


Figure 4.3.6: Net energy use in Palm Beach County in 2016, categorized by material.

4.3.2.2 Prospective Alternative Approach: WTE Ash Recycling and Glass Pozzolan Processing

Implementing WTE ash recycling and glass pozzolan processing in Palm Beach County would increase the total recycling rate from 72% to 76.9%. By diverting BA from the landfill, a volume of 149,800-151,000 cubic yards would be saved, extending the life of the landfill.

Environmental impacts due to the transportation of ash to the metal recovery facility are assumed to be minimal due to the proximity of REF #1 and REF #2 to the processing site. Impacts associated with recovering additional metal from the ash are estimated to be 0.01 tCO₂eq per ton of ash processed, based on monthly fuel requirements from the Operator to process incoming ash. Fuel requirements are derived from the excavating and hauling equipment used to transport the ash on site as well as the fuel consumed by the generators used to power the metal recovery equipment (ferrous magnets, eddy current separators, trommel, and flip flop screens), metal processing equipment (washing facility with screen), and an onsite office space.

The impact associated with processing the BA can be offset by the emissions and energy saved from recycling the recovered metal and using the BA in road base. The environmental impact of the recycled ferrous and non-ferrous metals recovered from BA by the Authority at its current ash processing facility is included in the baseline. Assuming that all additional metal recovered is recycled, an additional 25,912-41,113 tCO₂eq would be saved based on WARM emission factors for metal recycling. As stated previously, because WARM does not model a general ferrous or non-ferrous material

type, emission factors for the WARM material type mixed metals are used to calculate the environmental impact of recycling those recovered metals. The aluminum can WARM recycling emission factor is used to calculate savings generated from recycling the recovered aluminum metal.

Recycling 60% of the BA leaving the advanced metal recovery facility would generate a GHG savings of 1,557-1,578 tCO₂eq. This is based on the tons recycled attributed to the county and the assumption that the BA would offset the mining of virgin aggregate material, a process that emits 0.01 tCO₂eq per ton mined. GHG emissions associated with transporting the material to a construction site are assumed to result in 0.01 tCO₂eq per ton transported. The combination of offsets and emissions results in a net neutral impact.

Overall, the metal recovery and BA recycling would result in an additional 23,375-38,654 tCO₂eq and 435,097-698,017 thousand MJ being saved. The large range in energy savings can be attributed to the large impact a small amount of aluminum recycling can make. Figures 4.3.7 and 4.3.8 present the environmental impact associated with additional processing or handling of materials.

The average of the range of the alternative approach's WARM-based tCO₂eq value is -1,530 thousand tCO₂eq. This is equivalent to 327,594 vehicles taken off the road for one year, 38.4 million tree seedlings grown for 10 years, 229,296 homes powered for one year, or 76,227 garbage trucks of waste recycled instead of landfilled. The alternative approach represents 5,754 fewer passenger vehicles driven for one year, 795,000 more tree seedlings planted, 4,648 more homes powered for a year, or 1,546 more garbage trucks of waste recycled instead of landfilled.

Furthermore, the county would see an increase in savings for GHG emission and energy use. Based on a study by Tucker et. al. (2018),²⁴ use of GP in concrete is estimated to save -0.44 tCO₂eq and -2,933 MJ per ton of GP. These factors are calculated based on the assumption that the GP is used to replace 20% of the Portland cement in a concrete mixture, based on a study by Schafer et al. (2018).²⁵ In that research, the difference in global warming impact between one cubic meter of 30MPa conventional concrete and one cubic meter of 30MPa GP concrete is found. This difference is then divided by the total amount of glass assumed to be used in one cubic meter of GP concrete to calculate the emission factor (-0.44 tCO₂eq/ton GP), as shown above. A similar procedure is performed to find the energy saving factor. Net savings for both factors can likely be attributed to the savings generated from reduced Portland cement production.

The BA recycling and glass to GP approach's average WARM-based tCO₂eq value is -1,532 thousand tCO₂eq. This is equivalent to 328,140 vehicles taken off the road for one year or 229,679 homes powered for one year. Total emissions and energy saved are presented in Figures 4.3.9 and 4.3.10.

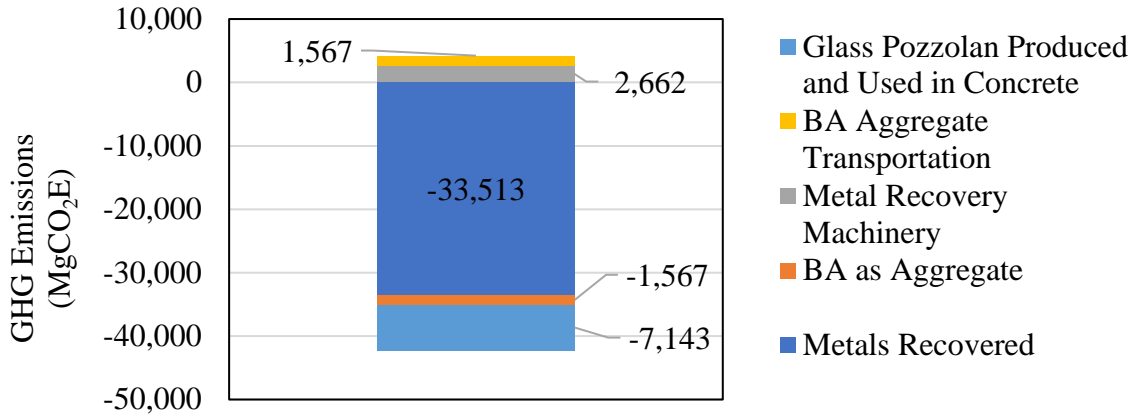


Figure 4.3.7: WARM-based GHG emissions values for the BA recycling and glass pozzolan production approach.

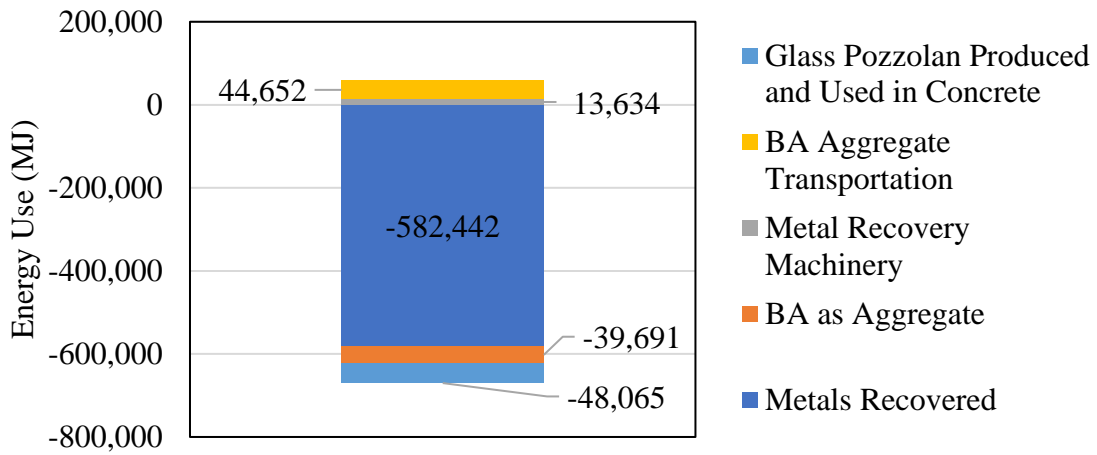


Figure 4.3.8: WARM-based energy saving values for the BA recycling and glass pozzolan production approach.

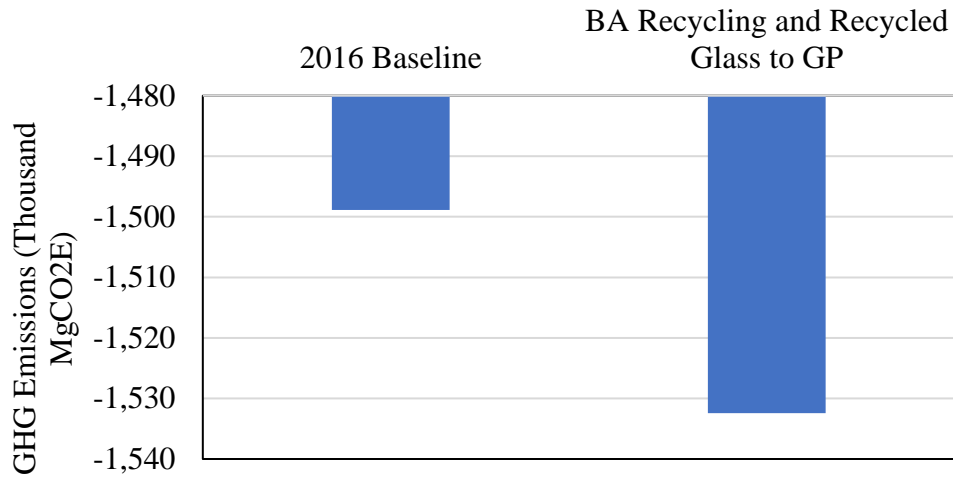


Figure 4.3.9: Net GHG emissions in Palm Beach County in 2016 compared to the prospective alternative results.

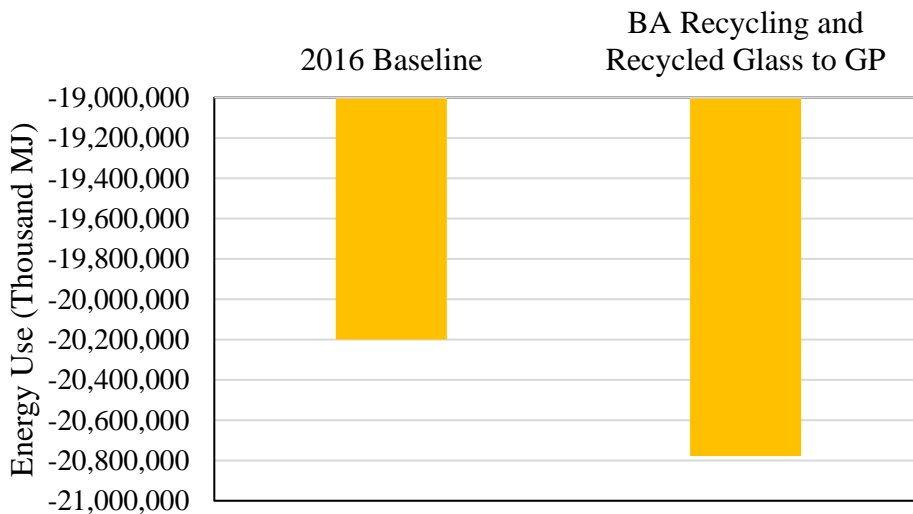


Figure 4.3.10: Net energy use in Palm Beach County in 2016 compared to the prospective alternative results.

4.3.3 Economic Costs

4.3.3.1 Current State of Affairs

The Authority provides an extensive breakdown of its finances in annual budgets and component cost summaries. In the FY 2016 budget, total revenue (including sources such as special assessments to residential and commercial units, tipping fees, and sales from electricity generated in REF #1 and REF #2) is budgeted as \$292 million. Total operating expenses (including operation of the landfill, REF #1 and REF #2, the RMPF, and unincorporated county collection by Authority franchisees) is budgeted as \$187 million.

Non-operating expenses (including annual debt service expenses and capital improvement) is budgeted as \$112.5 million, and due to the difference between budgeted revenue and costs, the net change in reserve is \$7.7 million.

The Authority’s full cost accounting data provides a breakdown of the cost of collection and disposal for residents and businesses in the county. Table 4.3.3 provides a breakdown of the reported cost of solid waste collection and recycling for both curbside and container units in the unincorporated area of the county for residential service. Based on the number of curbside and container units listed in the FY 2016 budget, a total cost for each component is calculated, resulting in a total cost of \$37.6 million for residential collection in the county’s unincorporated areas.

The Authority’s FY 2016 budget includes residential disposal assessment revenue of \$93.13 million, commercial disposal assessment revenue of \$59.6 million, and revenue from tipping fees of \$24.7 million. Table 4.3.4 provides a breakdown of reported residential and non-residential disposal revenue as well as an estimated cost per ton based on the estimated total tons for both sources.

Table 4.3.3: 2016 baseline economic costs for residential collection in unincorporated Palm Beach County.

Appropriations			
Hauler payments			
Collection service	Cost	Collection units	Cost per collection unit
Curbside service	\$25,193,619	196,682	\$128.09
Containerized service	\$9,941,772	87,056	\$114.20
Certificate of occupancy units	90,000	N/A	N/A
Total hauler payments	\$35,225,391	283,738	N/A
Other expenses			
Administrative cost	\$2,383,399		
Total other expenses	\$2,383,399		
Total appropriations	\$37,608,790		

Table 4.3.4: 2016 baseline economic costs for county disposal in Palm Beach County.

Disposal (county)	Tonnes	Cost	Cost/tonne
Residential/government	538,750	\$93,129,856.00	\$172.86
Commercial	524,589	\$84,291,924.00	\$160.69

4.3.2.2 Alternative Approach: WTE Ash Recycling and Glass Pozzolan Processing

Based on financial data gathered from the Operator, the additional processing of the BA and glass would create additional expenses for the Authority. For BA recycling, if the Authority shares in the risk of operation with an operator, the cost is estimated to be \$3-5 per ton of BA processed, and if an operator assumes the majority of the risk, the cost is estimated to be \$8-12 per ton of BA. This cost is offset by the revenue generated from the metals recovered and recycled.

The revenue received from metal recovery and recycling can vary from month to month based on markets for the metals. The difference between the Authority's FY 2016 and FY 2017 budgets reflects an expected decrease in per-ton ferrous and non-ferrous metal revenue. Data provided for recycled metals sold in FY 2016 to Covanta generates an average revenue of \$73 per ton for ferrous and \$1,038 per ton for non-ferrous. The range of revenue is \$25-\$135 per ton for ferrous and \$635-\$1,450 per ton for non-ferrous.

Size sorting is a key component of advanced metal recovery, as is aggregate production. The resulting size-sorted BA material, after metal recovery, is considered finished and can be sold as an aggregate material. Only the cost of processing up to size sorting is accounted for, and further processing costs associated with shipping and marketing the aggregate (stockpiling, loading trucks, fuel, management, etc.) are not included in this study. Selling this aggregate would generate a maximum potential revenue of \$9-\$18 per ton based on current market prices. It is assumed that the BA material will sell at 50% of the price of limerock, generating a potential revenue of \$4.60-\$8.75 per ton. All told, recycling recovered metals and selling 178,412 to 180,767 tons of BA aggregate would result in an additional net revenue of \$582,000 to \$5.6 million.

In addition to the revenue generated by ash aggregate sales, the diversion of ash from the landfill would reduce landfill expenses. A 27.3-27.5% reduction in material landfilled would result in a 27.3-27.5% reduction in the annualized and total costs associated with the depreciation, cell construction, and closure of the landfill listed in the Authority's FY 2015 cost component summary. A 10% reduction in the cost of operating the landfill is assumed because a reduction in ash input would not greatly affect daily operation, and the Authority would likely continue to offer 24/6 operation at the landfill. The reduction in landfill costs and operations would result in a savings of \$2.90-\$2.91 million.

Estimated landfill cost savings in addition to the revenue generated from the recycling of BA and metals are normalized to tons of BA processed. The sum of revenues and costs of processing would result in a net revenue of \$11.35-\$27.68 per ton of BA processed. Overall net revenue would be \$3.5-\$8.5 million for the Authority when compared to the

baseline. Net revenue is a function of operating cost minus landfill savings, BA aggregate sales, and metal revenue. Estimated net revenue is available for savings and profit sharing between the Authority, the metal recovery operator, and the metal recycler. The sharing would be contracted such that all parties would be incentivized to maximize performance and revenue and minimize cost. An estimated revenue sharing amount is not considered in this study. Table 4.3.5 shows the breakdown of estimated costs and revenues.

The cost of processing recycled glass into a 10 micrometer GP material is calculated based on values from the previously mentioned UF study by Tucker et. al. (2017). In this approach, it is assumed that a GP processing facility would be built and operated by the Authority with an estimated annualized capital cost of \$373,340. Table 4.3.6 illustrates the range of values for the total capital, operating, and maintenance costs, which are based on material throughput as well as on assumptions regarding labor costs used in the Tucker study. From these estimates, a relationship between total annual processing cost and the annual throughput of the recycling facility is derived. Assuming that all of the processed glass at the RMPF in 2016 would be processed at the new facility, processing recycled glass into GP would cost the Authority \$1.84 million more than the current operation. Due to the fine size of the glass, air pollution control technology might be necessary to reduce particulate matter in the air. The additional cost of this technology is not considered in the cost.

The cost of processing the glass is offset by the revenue generated from marketing it. In order for the cost of processing and revenue to balance evenly, the Authority would need to market the material at \$112 per ton. Comparable materials such as Portland cement and Class F coal fly ash are currently sold for \$109 per ton and \$36 per ton, respectively. The price of coal fly ash in South Florida is about \$60 per ton, based on an industry estimate. In order for the cost of processing the glass compare to the current price of Class F coal fly ash, the amount of glass recycled would need to increase to 55,000 tons per year, which would increase the annualized capital cost to \$379,255. The cost per ton of glass processed would be equal to the cost per ton of fly ash (\$36). Achieving this processing rate based on the county's glass generation alone is not feasible at present because 55,000 tons of glass exceeds the amount of glass estimated to have been collected in the county in 2016.

Assuming that the mass of recycled glass remains the same, the Authority could market the recycled glass at the current rate of Class F coal fly ash, resulting in a revenue of \$595,000. The economic impact of diverting the recycled glass from the landfill is not evaluated in this study due to the uncertainty of economic benefits gained from beneficially using the glass in the landfill. If the GP is sold at the price of class F coal fly ash listed in this study, recycling the glass would cost the Authority \$1.25 million annually in addition to its current operating expenses. If it is sold at the estimated cost of coal fly ash in South Florida, it would cost the Authority \$859,500 compared to the current operation. If it is sold at the cost of Portland cement, it would cost the Authority \$58,000, but it would be highly unlikely for GP to sell at that price. Figure 4.3.11 shows

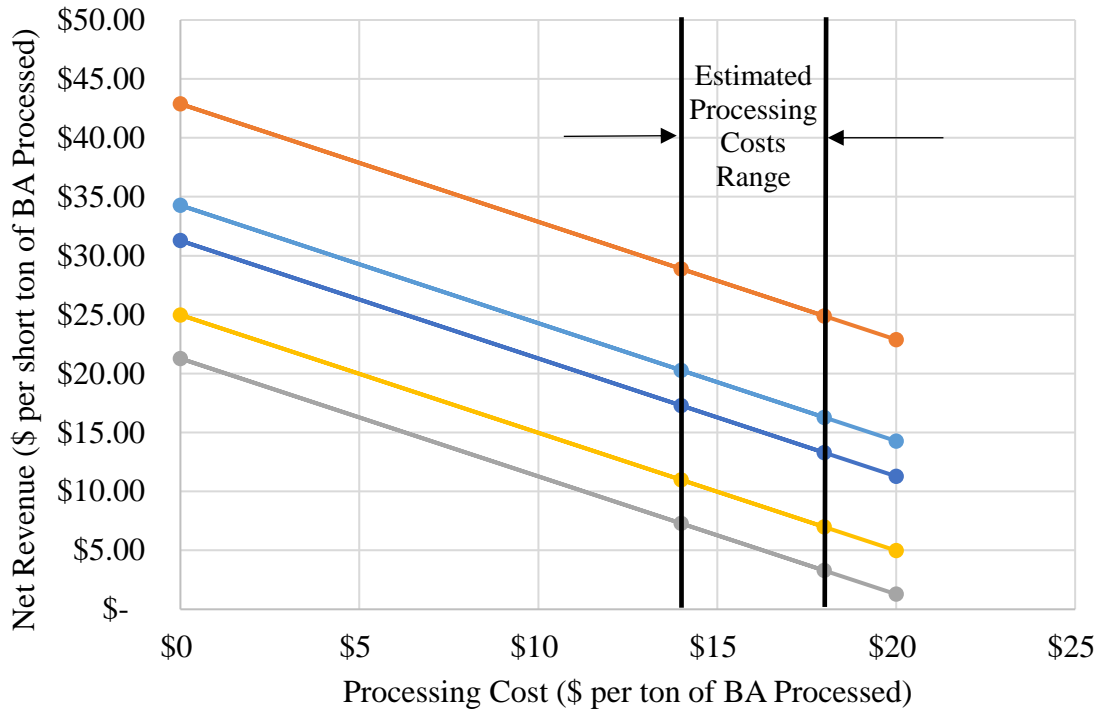
the estimated selling price of GP and net revenue and processing costs normalized to dollars per ton of BA processed for various recycling scenarios.

Table 4.3.5: BA recycling and glass pozzolan approach economic costs in Palm Beach County.

Program area	Lower			Upper		
	Total tons	Cost per ton	Total cost	Total tons	Cost per ton	Total cost
Advanced BA metal recovery	307,755	\$8.00	\$2,462,037	307,755	\$12.00	\$3,693,056
Glass-to-glass pozzolan processing	16,403	\$112.40	\$1,843,705	16,403	\$112.40	\$1,843,705
Total cost			\$4,305,742			\$5,536,761
Program area	Lower			Upper		
	Total tons	Savings per ton	Total savings	Total tons	Savings per ton	Total savings
Recycled non-ferrous	3,462	\$635.00	\$2,198,420	5,221	\$1,450.00	\$7,569,861
Recycled ferrous	393	\$25.00	\$9,813	1,178	\$134.62	\$158,520
Landfilling tonnage reduction	187,243	\$15.54	\$2,909,402	188,814	\$15.48	\$2,922,239
BA aggregate sales	180,767	\$4.63	\$836,046	178,412	\$8.75	\$1,561,102
GP sales	16,403	\$36.28	\$595,111	16,403	\$60.00	\$984,197
Total savings			\$6,548,792			\$13,195,919
Net revenue			\$2,243,049			\$7,659,158

Table 4.3.6: Glass crushing operation assumptions made by Tucker et al. (2017) applied to glass pozzolan processing.

Category	Annual cost
Total annual fixed capital costs	\$345,000-\$550,000
Total annual operating costs	\$185,000-\$360,000
Total annual maintenance costs	\$35,000-\$315,000
Total annual labor costs	\$1,250,00
Operating labor	\$600,000
Supervision, 15% operating labor	\$90,000
Plant overhead, 60% operating labor + supervision + equipment maintenance	Approx. \$400,000
General administration, 25% operating labor	\$150,000
Total annual costs	\$1,815,000-2,475,000



- Scenario 1. Given Recovery and Recycling Rate (1.1% Non-Fe and 0.2% Fe), SWA Metal Revenue CY 2016 (\$1,038 Non-Fe and \$72.59 Fe), Average BA Aggregate Sale Price (\$6.69), Industry GP Revenue (\$60)
- Scenario 2. High Metal Revenue (\$1,450 Non-Fe and \$135 Fe), High Recovery and Recycling Rate (1.33% Non-Fe and 0.3% Fe), High BA Aggregate Sale Price (\$8.75), High GP Revenue (\$60)
- Scenario 3. Low Metal Revenue (\$635 Non-Fe and \$25 FE), Low Metal Recovery and Recycling Rate (0.88% Non-Fe and 0.1% FE), Low BA Aggregate Sale Price (\$4.63), Low GP Revenue (\$36.28)
- Scenario 4. Low Metal Revenue, High Metal Recovery, Low BA Aggregate Sale Price, Low GP Revenue
- Scenario 5. High Metal Revenue, Low Metal Recovery, High BA Aggregate Sale Price, High GP Revenue

Figure 4.3.11: Net revenue and processing costs normalized to dollars per ton of BA processed for the BA recycling and GP processing approach.

4.4 SARASOTA COUNTY

4.4.1 Waste Management and Disposition

4.4.1.1 Current State of Affairs

Sarasota County operates a transfer station and the Central County Solid Waste Disposal Complex, which accepts both residential and non-residential solid waste from the county's unincorporated areas and three municipalities and processes C&D debris for recycling. For 2016, WasteCalc provided the composition estimate for Sarasota County shown in Figures 4.4.1 and 4.4.2. For most of these materials, the WasteCalc estimate was relatively close. However, for the C&D debris waste stream, there was a large difference between FDEP (46%) and WasteCalc (37%).

In the residential category, the traditional recycling rate is 32% because all landfill cover in the county comes from yard trash, which is separated from the residential category. The total recycling rate is higher due to landfill gas-to-energy, a fraction of which originates from landfilled residential waste. Likewise, in the non-residential category, the traditional recycling rates is 39% because yard trash for landfill cover has been extracted from the non-residential category. As in the residential category, the non-residential total recycling rate is higher due to landfill gas-to-energy credits that originate from non-residential solid waste. In the 2016 yard trash category, including the recycling credits from landfill cover, the yard trash traditional rate is 80%. A small amount of yard trash is counted as contributing to the landfill gas-to-energy, so the total recycling rate is slightly higher at 83%. In the 2016 C&D debris category, the two recycling rates are the same (80%). C&D debris is not used for landfill cover, so the traditional rate does not change, and no landfill gas-to-energy credits are assumed to originate from C&D debris.

Sarasota County has long had one of the highest recycling rates in Florida, and until only recently these rates were achieved without renewable energy credits. The recycling rate has generally increased during the past two decades, from 32% in 1996 to 36% in 2008 and 53% in 2014. In 2015, a landfill-gas-to-energy facility began generating electricity from methane collected from the landfill, increasing the total recycling rate to 64% in 2016. The county also uses RSM from its C&D debris station as landfill cover, which counts as recycled material. Almost all yard trash is now sent out of the county to be composted, which also increases the recycling rate. The county has been active in educating residents and businesses about the importance of recycling, including encouraging C&D debris businesses to recycle their material. These efforts appear to have been beneficial, especially in light of the county's C&D debris recycling rate of 80% in 2016.

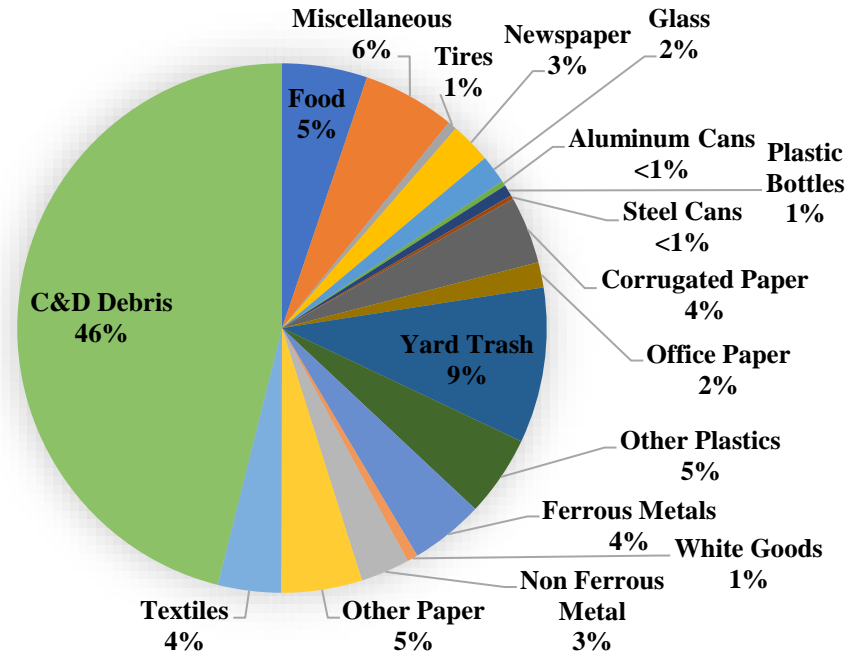


Figure 4.4.1: 2016 waste composition in Sarasota County.

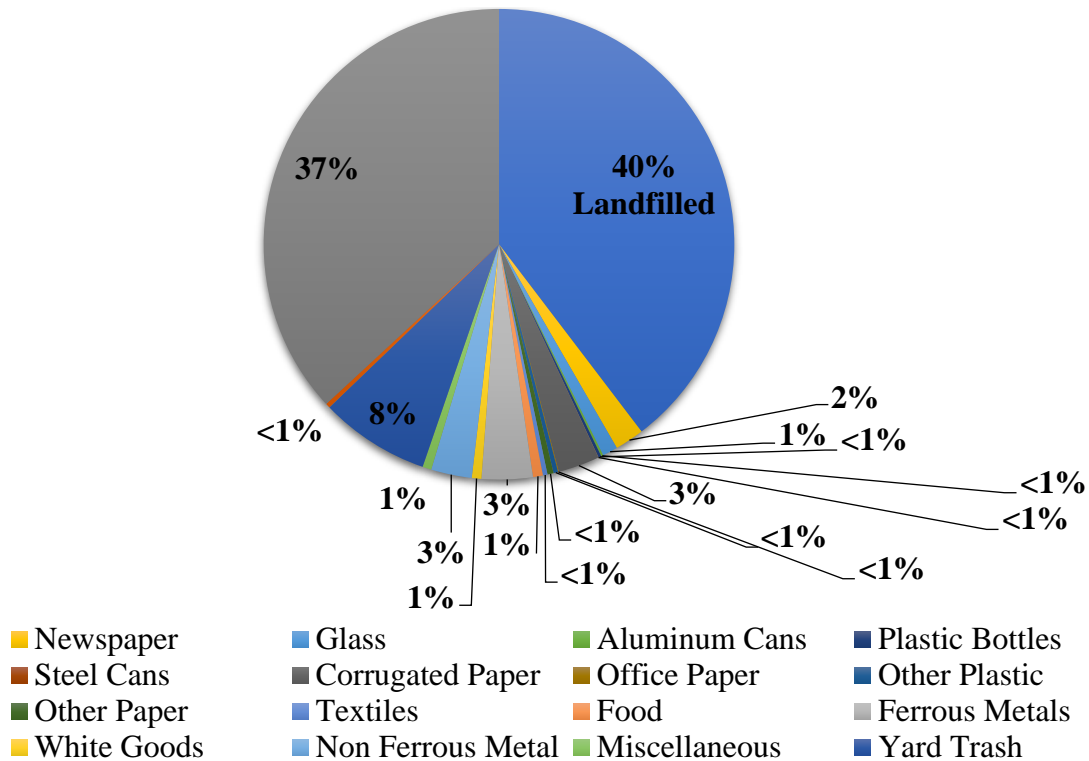


Figure 4.4.2: Sarasota County 2016 solid waste dispositions with recycled composition separately shown.

4.4.1.2 Prospective Alternative Approach: Food Waste Anaerobic Digestion

Anaerobic digestion (AD) is a treatment technology primarily used for food waste, manure, and biosolids. AD involves digesting organic matter in a large tank using microorganisms to produce methane that can be burned for energy and leftover solids that can be used as fertilizer. AD is most commonly used to treat wastewater treatment plant biosolids, but in recent years it has been increasingly used to manage food waste. Sarasota County recognizes that food waste is one of the largest materials collected and landfilled, and for this reason the construction and operation of an AD facility to treat food waste is being evaluated.

Sarasota County's food waste anaerobic digestion approach assumes that 65% of all food waste (residential and non-residential) would be digested and therefore diverted from the landfill. This is a reasonable estimate based on the organics recovery rate in Portland, Oregon.²⁶ For non-residential waste, this may be achieved by mandating that businesses and institutions contract with the franchised hauler to collect their food waste if they generate more than a predetermined tonnage of per year. For residential waste, the county would need to consider adding an extra collection truck to transport source-separated food waste from residences. An AD facility would likely be located at the central landfill. Diverting 65% of collected food waste toward AD instead of landfilling modestly increases the total recycling rate from 64% to 67%, as seen in Figure 4.4.3.

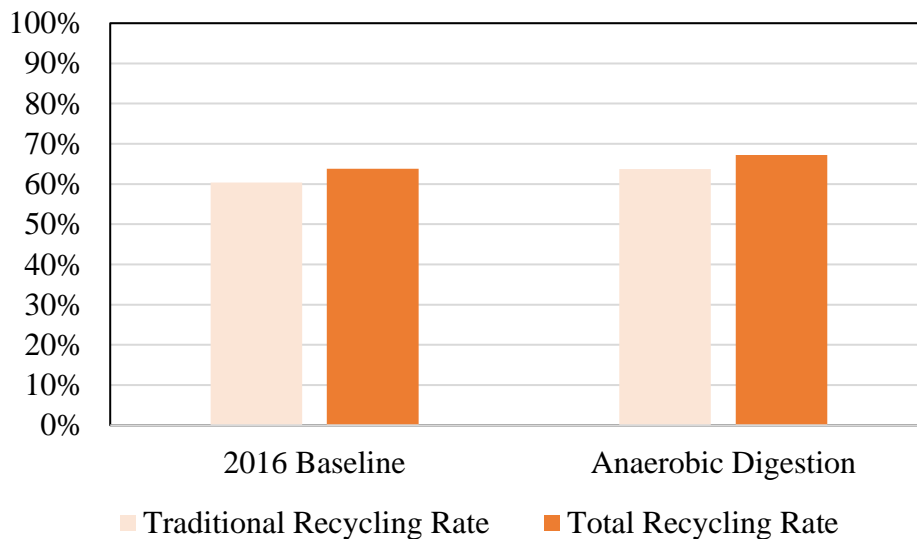


Figure 4.4.3: Estimated traditional and total Sarasota County recycling rates for 2016 based on the estimated increase in recycled material.

4.4.2 Environmental Footprint

4.4.2.1 Current State of Affairs

Sarasota County has one of the highest recycling rates in Florida even without considering renewable energy credits. WARM-based analysis shows that the county's current solid waste management practices are estimated to result in relatively low GHG emissions and relatively low net energy consumption. For 2016 waste management practices, the WARM-based total GHG emission value was -673 thousand tCO₂eq and the total energy savings was -5,771 thousand MJ. These savings are tremendous because of Sarasota's emphasis on recycling materials that contribute to GHGs and energy savings. The tCO₂eq value is equivalent to 144,017 passenger vehicles driven for one year, yearly electricity use in 100,804 homes, 22,493,682 incandescent lamps switched to LEDs, and 33,511 garbage trucks of waste recycled instead of landfilled. The baseline environmental footprint is shown in Figures 4.4.4 and 4.4.5.

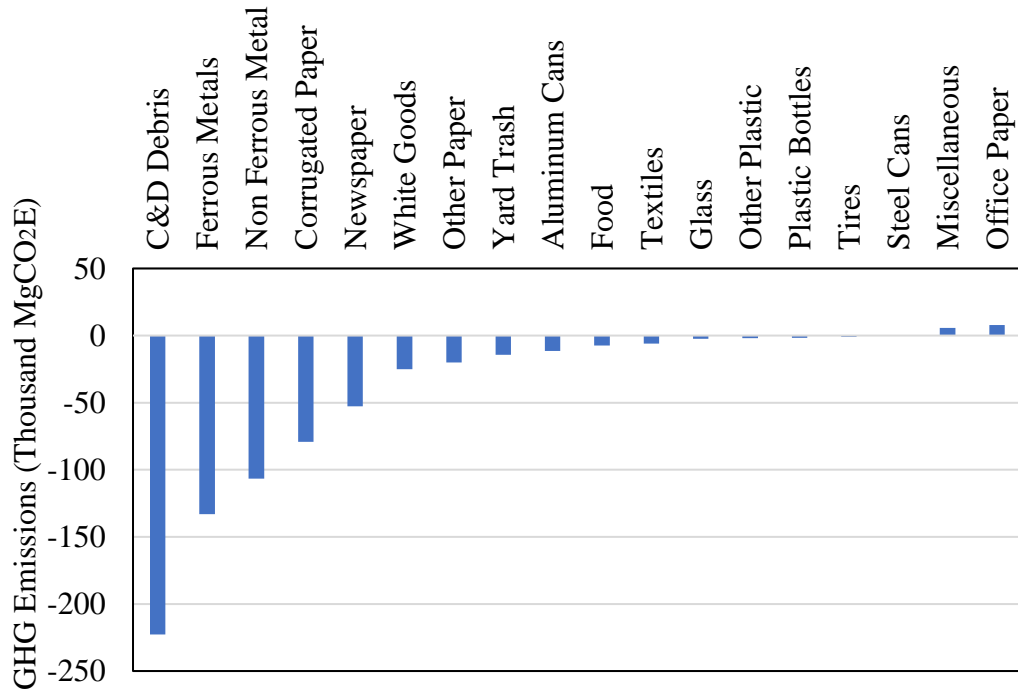


Figure 4.4.4: Net greenhouse gas emissions in Sarasota County in 2016, categorized by material.

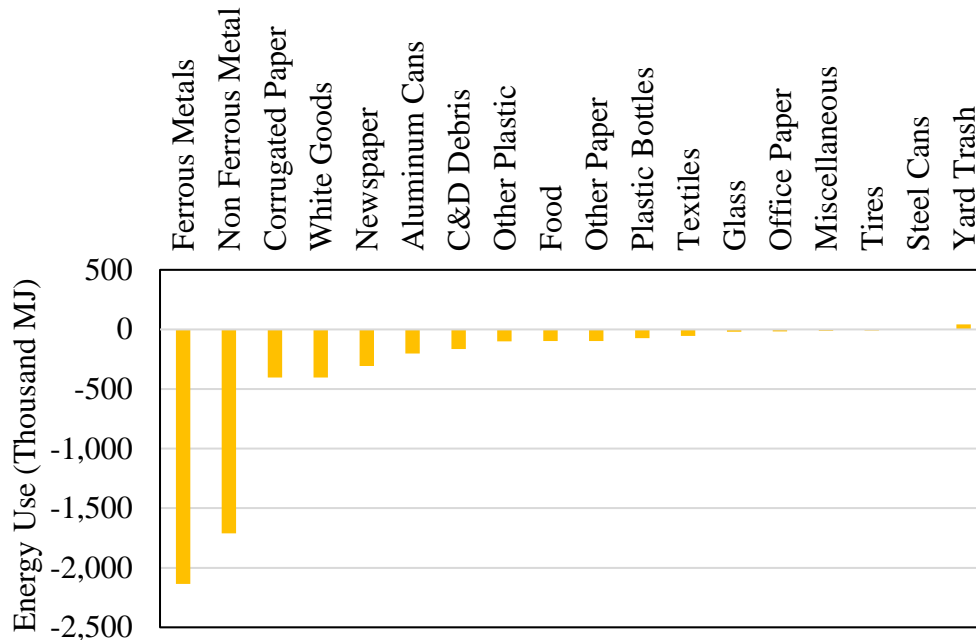


Figure 4.4.5: Net energy use in Sarasota County in 2016, categorized by material.

4.4.2.2 Prospective Alternative Approach: Food Waste Anaerobic Digestion

Under the AD approach, greenhouse gas emissions would decrease 12.5 thousand tCO₂eq less than the baseline approach, and energy consumption would decrease by 38.5 thousand MJ less than the baseline approach. Figures 4.4.6 and 4.4.7 present WARM-based GHG and energy results for each component. The AD approach’s WARM-based tCO₂eq value is -685 thousand tCO₂eq, equivalent to 146,687 passenger vehicles driven for one year, yearly electricity use in 102,672 homes, 22,910,714 incandescent lamps switched to LEDs, or 34,132 garbage trucks of waste recycled instead of landfilled. The AD approach represents 2,670 fewer passenger vehicles driven for one year, yearly electricity use in 1,869 fewer homes, 417,033 more incandescent lamps switched to LEDs, and 621 more garbage trucks full of waste that is recycled instead of landfilled, a net greenhouse gas benefit relative to the baseline (Figures 4.4.8 and 4.4.9).

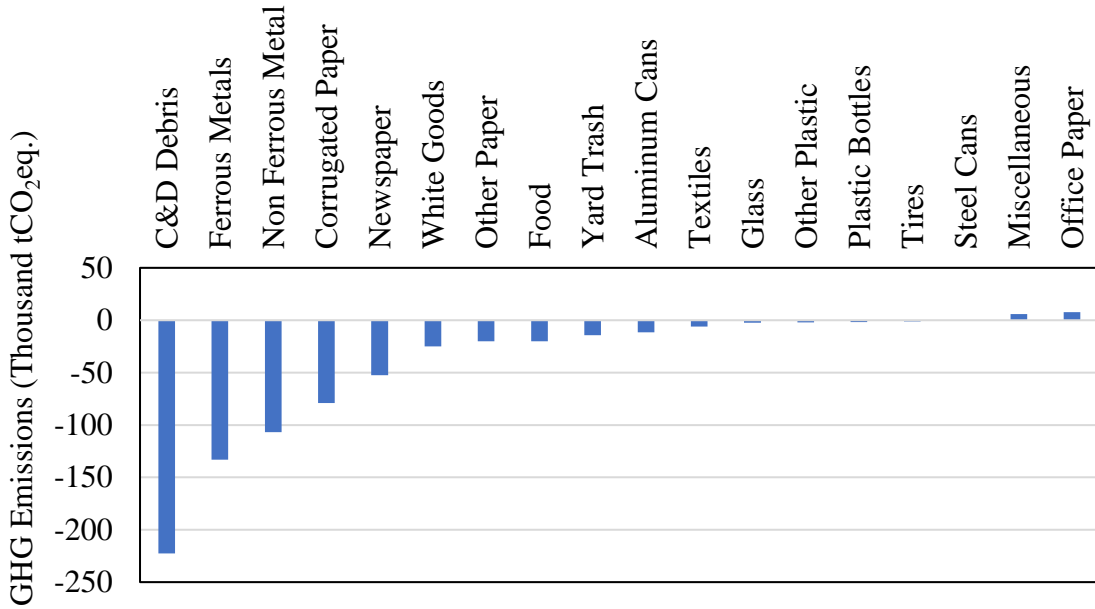


Figure 4.4.6: Net GHG emissions associated with implementing the AD approach in Sarasota County, categorized by material.

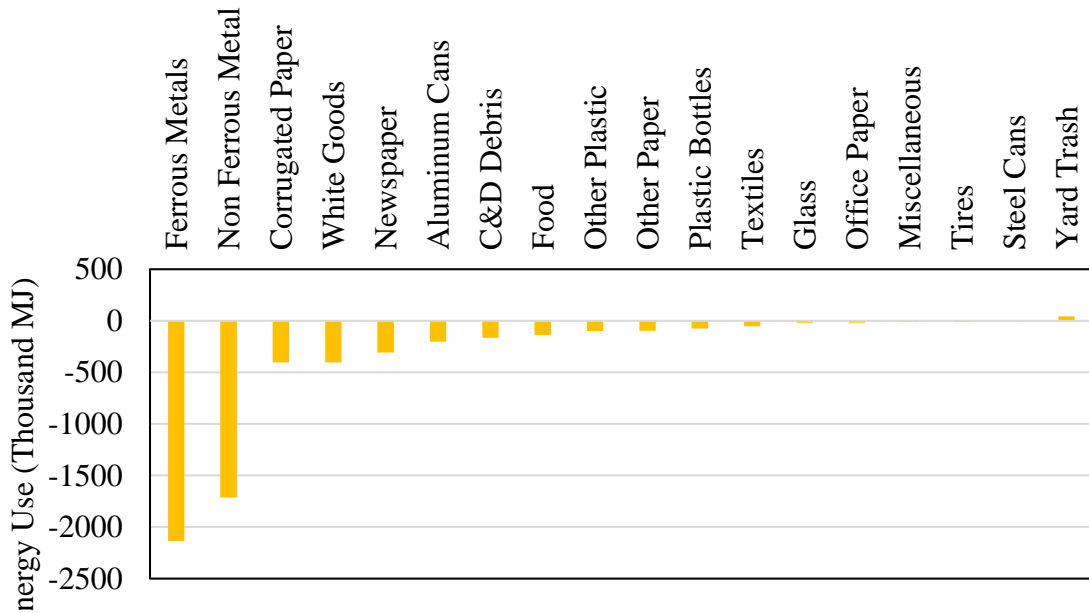


Figure 4.4.7: Net energy use associated with implementing the AD approach in Sarasota County, categorized by material.

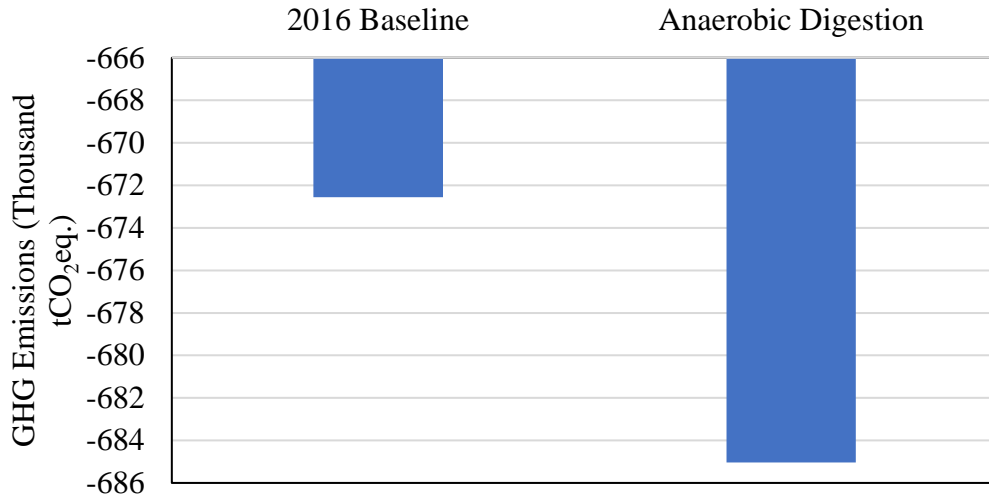


Figure 4.4.8: Net GHG emissions in Sarasota County in 2016 compared to the prospective alternative.

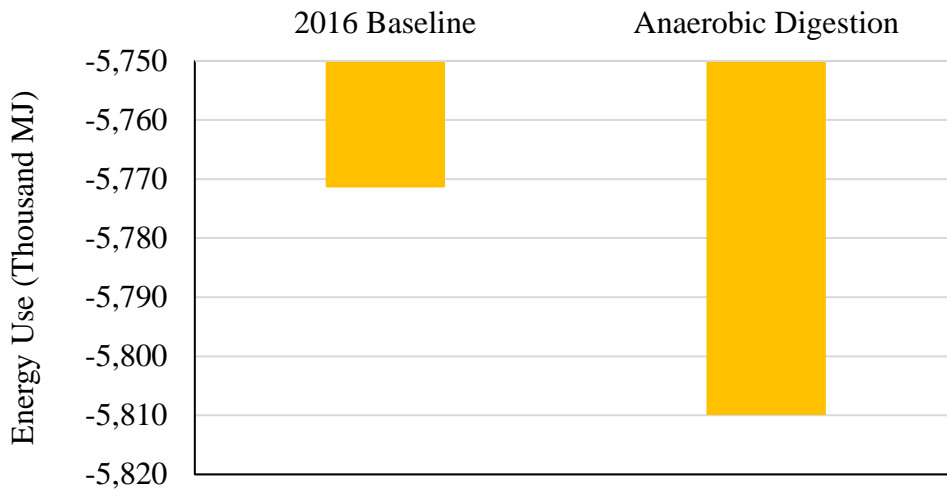


Figure 4.4.9: Net energy use in Sarasota County in 2016 compared to the prospective alternative.

4.4.3 Economic Costs

4.4.3.1 Current State of Affairs

Table 4.1.1 summarizes 2016 costs for key program areas. The overall collection cost is \$83.18 per ton, the disposal cost is \$47.06 per ton, and the overall cost is \$77.60 per ton. Note that the costs per ton do not add; different tonnages are associated with each program area, so the overall cost is the total cost required to manage all of these programs divided by the total mass managed. The collection cost of recycling (\$153.88 per ton) is the greatest of any program area, though this cost is offset by the \$509,462 the county earned in revenue from the sale of recyclables. The total mass (419,535 tons) includes the waste buried in the landfill, the C&D debris that was processed at the landfill complex,

the yard trash that was transported to and processed at the landfill complex, and the recycled materials sent through the MRF. This represents the total tonnage of material the county paid to manage in 2016, which is less than half the total waste tonnage reported in the county. The other mass (such as the C&D debris that is collected by other recycling or disposal businesses) does not directly incur a cost to the county. The disposal cost is 57% of the total cost, while the total collection cost represents 43% of the total, and it is shown broken down into the three major collection areas (solid waste or household garbage, yard trash, and recycling). This breakdown is based on the county's assumption that solid waste represents 47% of the collection costs, yard trash represents 20%, and recycling represents 33%.

The standard MSW tipping fee is \$57.56 per ton, as it has been since 2013. The 2016 tipping fees resulted in a budget surplus, but if the current tipping fee is not adjusted by 2021, a budget deficit will develop. The tipping fee pays for a number of expenses related to solid waste management, including disposal, the hazardous waste program, debt services, and other programs, resulting in a 2016 net revenue requirement of \$18.4 million. The disposal costs (Central County Complex, \$5 million) are the greatest fraction of the 2016 expenses, although the debt service required to pay off capital costs is also significant at \$3 million.

The 2016 residential assessment charge was \$159.48 per year for single-family households and \$134.94 per year for multi-family households. This includes the costs of collecting household garbage, yard trash, and recyclables; the cost of disposal; and district operational expenses. Collection costs are paid to the franchised hauler of residential waste (in 2016 this was Waste Management, Inc., of Florida). The assessment's allocated disposal cost is calculated by multiplying the tipping fee by the average yearly tonnage generated by county residents.

Commercial entities do not pay the county directly for disposal of their waste; rather, businesses contract individually with the franchised hauler for solid waste and yard trash collection. The franchised hauler then pays the tipping fee for disposal of the waste at the Central County Complex. For recycling, businesses have their choice of contracting with any authorized recycling dealer (including Republic Services, Waste Connection, WastePro, and Waste Management). Because commercial entities do not directly incur a cost to the county government, these costs are not reflected in this analysis.

Table 4.4.1: 2016 Sarasota County baseline economic costs.

Program area	Total tons	Total cost	Cost per ton
Collection			
MSW	103,711	\$6,881,989	\$66.36
Yard trash	38,101	\$2,928,506	\$76.86
Recycling	28,091	\$4,322,573	\$153.88
<i>Total collection</i>	<i>169,903</i>	<i>\$14,133,068</i>	<i>\$83.18</i>
Disposal			
MSW	289,884	\$11,843,495	\$40.86
Yard trash	55,869	\$3,401,172	\$60.88
C&D debris	45,690	\$3,178,599	\$69.57
<i>Total disposal</i>	<i>391,444</i>	<i>\$18,423,267</i>	<i>\$47.06</i>
Total waste management	419,535	\$32,556,336	\$77.60

Note: The row “total waste management” refers to all mass managed at the landfill or recycled.

4.4.3.2 Prospective Alternative Approach: Food Waste Anaerobic Digestion

Table 4.4.2 summarizes the cost implications of the AD approach. The AD approach would result in an increase of 20% to 24% in cost per ton compared to the 2016 baseline approach. This increase is due to the high capital and operational costs associated with managing an AD facility. The costs associated with operating an AD facility were adapted from R.W. Beck (2010) and NREL (2013). The recycling cost would remain unchanged, but the collection cost would likely change. Food waste diversion would likely require separate collection of those organics, increasing overall collection costs. Total disposal cost would not be expected to change because food waste represents only a small fraction of the total waste stream and its decrease would not significantly affect disposal costs. Some revenue would be expected from an AD facility due to the sale of electricity generated from methane gas produced in the digestion process.

Table 4.4.2: AD approach economic costs.

Program area	Total tons	Lower cost range		Upper cost range	
		Total cost	Cost per ton	Total cost	Cost per ton
Collection	169,903	\$14,133,068	\$83.18	\$14,133,068	\$83.18
Disposal	361,756	\$18,423,267	\$50.93	\$18,423,267	\$50.93
Curbside recycling	28,091	\$4,322,573	\$153.88	\$4,322,573	\$153.88
Residential food waste collection	14,893	\$2,928,506	\$196.64	\$2,928,506	\$196.64
AD	29,689	\$3,635,426	\$122.45	\$4,952,835	\$166.83
Total waste management	419,535	\$39,120,268	\$93.25	\$40,437,678	\$96.39

Note: The row “total waste management” refers to all tons that are managed at the landfill, recycled, or anaerobically digested.

5.0 PROSPECTIVE ALTERNATIVE WASTE MANAGEMENT APPROACHES

5.1 OVERVIEW

A major aim of this study was to identify and evaluate prospective alternative approaches to the management of solid waste that follow concepts of SMM, such as investing in technology or policy that result in a reduction in resource consumption and adverse environmental impacts. Discussions with stakeholder working group members as to trends in the solid waste management industry resulted in the research group choosing five prospective alternative approaches for evaluation (Table 5.1.1):

1. Waste-to-energy (WTE) approach
2. Mixed waste processing (MWP) approach
3. Mandatory curbside recycling approach
4. Mandatory C&D debris and yard trash recycling approach
5. Mandatory non-residential food waste composting approach

Our task was to analyze and modify the baseline solid waste management and disposition data based on the FDEP 2016 solid waste management annual report (presented in Section 3) in order to investigate the feasibility of implementing SMM-based approaches. We did this by comparing the waste management and disposition, economic, and environmental impact results associated with each approach to the baseline.

Table 5.1.1: Alternative approaches evaluated in this study.

Approach	Description
2016 baseline	2016 Florida solid waste management and disposition as calculated in Section 3 of this report using data from FDEP’s 2016 annual report.
WTE approach	The focus of this approach is to divert all materials (other than C&D debris and process fuel) originally landfilled to be combusted at a WTE facility so that the landfill rate for the total potential combustible waste (any mass other than recycled direct) is 2.6% based on Hillsborough County’s 2016 rate. The incoming additional waste sent to a WTE facility is assumed to be combusted at 70% efficiency.
MWP approach	Newspaper, glass, aluminum and steel cans, plastic bottles, corrugated paper, office paper, other paper and plastics, textiles, food, and miscellaneous mass not recycled directly are first sent to a MWP facility and then sent to be combusted or landfilled. To account for the MWP facility’s additional recycled mass, standard residential and non-residential recycling rates increased to 55.7% and 47.6%, respectively, based on Burns & McDonnell (2015).
Mandatory residential curbside recycling approach	This approach impacts residential curbside recycling, including newspaper, glass, aluminum and steel cans, plastic bottles, corrugated paper, office paper, and other paper and plastics. The approach increased the residential standard recycling rate to 64% based on Seattle’s reported residential rate.
Mandatory C&D debris and yard trash recycling approach	Mandatory C&D debris and yard trash recycling rates are modeled after Los Angeles and San Jose, California, resulting in increasing the standard recycling rates to 76.5% and 97%, respectively.
Mandatory non-residential food waste composting approach	The mandatory non-residential food waste standard recycling rate was modeled after Portland’s 58% non-residential food waste recycling rate.

Note: The alternative approaches impacted waste management only in counties with populations greater than 150,000.

5.2 WASTE MANAGEMENT AND DISPOSITION

5.2.1 Waste-to-Energy Approach

Because Florida awards renewable energy recycling credits to counties that combust MSW in WTE facilities, we chose to evaluate the impact of a transition to a WTE approach statewide. Currently, 11 WTE facilities operate in the state — in Miami-Dade, Broward, Palm Beach, Hillsborough, Pinellas, Lee, Pasco, Lake, and Bay counties. We assumed at the outset that moving to a WTE approach would be feasible only in counties with populations greater than 150,000 because WTE facilities require large MSW feedstocks that would not be generated in smaller counties. For that reason, our approach involves constructing new WTE facilities only in larger counties that do not have existing ones — namely, Orange, Duval, Polk, Brevard, and Volusia. Smaller counties would transport their MSW to WTE facilities located in larger counties.

We also assumed a landfill direct non-C&D debris rate of 2.6% (computed by dividing landfill direct non-C&D debris mass by total available combustible materials mass). We based that figure on the 2016 rate in Hillsborough County, which was the lowest reported by FDEP that year (other than Lee, Pasco, and Hendry County because we assumed the landfill direct non-C&D debris mass was zero; see Section 3.1 for further details). We then assumed that 70% of all other MSW (all materials except for C&D debris and process fuel), would be combusted at a WTE facility, with the remaining 30% becoming ash. Although Florida calculates renewable energy credits for combusted waste on a 1 MWh = 1 recycled ton basis, we calculated the credit by assuming that for each 0.78 ton combusted = 1 recycled ton. The value 0.78 was used because it corresponds to the ratio of state's total recycling credits for WTE and renewable energy (other than WTE) to the net combusted mass for 2016. Mass disposition for the WTE approach is shown in Table 5.2.1, and the impact of moving to WTE on material composition and disposition is shown in Table 5.2.2.

Under a statewide WTE regime, Florida's mass disposition for combusted and recycled materials would increase by 17% and 1%, respectively; landfill disposition would decrease from 44% to 26% (Figures 5.2.1 and 5.2.2). Moreover, the state's total recycling rate would increase from 55.8% to 68.3%, with total residential, non-residential, and yard trash rates also increasing dramatically. Because the total recycling rate is the only rate impacted by renewable energy recycling credits, total standard and standard residential, non-residential, yard trash, and C&D debris rates would be unaffected. Due to the increase in recycled post-combustion mass, however, total traditional and traditional residential and non-residential rates would increase slightly (Figure 5.2.3).

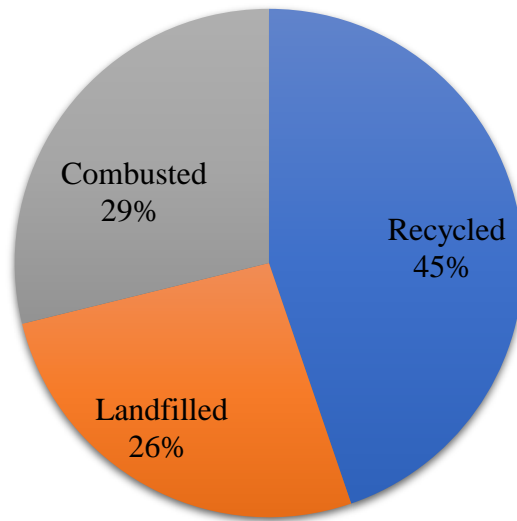


Figure 5.2.1: Mass disposition for the waste-to-energy approach.

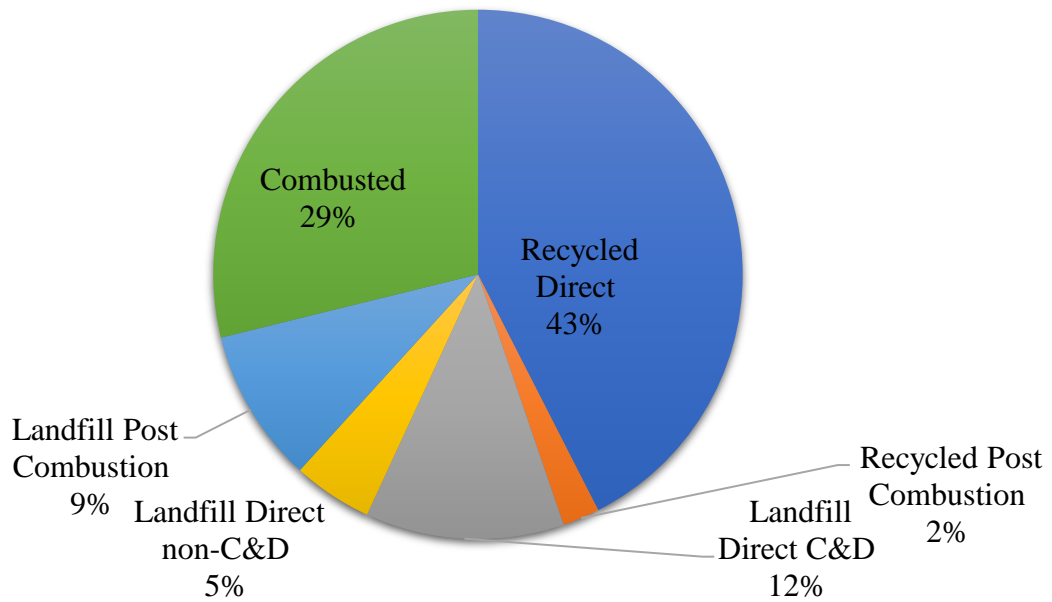


Figure 5.2.2: Detailed mass disposition for the waste-to-energy approach.

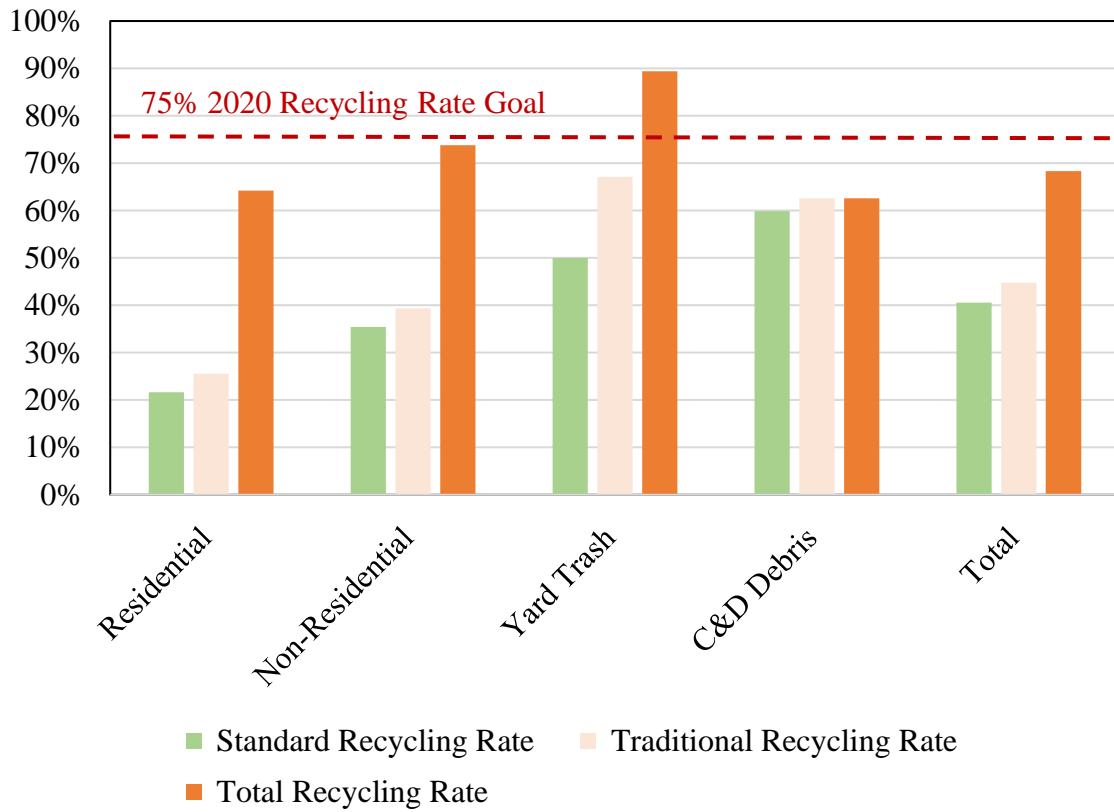


Figure 5.2.3: Recycling rates for the waste-to-energy approach’s four waste generator categories.

Table 5.2.1: Mass disposition for the waste-to-energy approach for Florida counties with populations greater than 150,000. For counties with populations less than 150,000 see Table 3.1.2.

County	Collected (tonnes)	Recycled direct (tonnes)	Recycled post-combustion (tonnes)	Landfill direct C&D debris (tonnes)	Landfill direct non-C&D debris (tonnes)	Landfill post-combustion (tonnes)	Combusted (tonnes)
Miami-Dade	3,982,274	1,115,434	272,334	467,072	61,929	474,304	1,591,201
Broward	3,264,679	1,081,111	62,833	44,561	55,199	496,664	1,524,312
Palm Beach	2,813,240	1,167,666	99,185	170,838	38,057	315,292	1,022,201
Hillsborough	2,158,961	1,146,891	32,631	185,882	21,321	179,431	592,805
Orange	1,963,542	1,179,426	20,730	206,554	14,905	125,236	416,692
Pinellas	1,828,321	935,000	65,090	25,530	22,394	227,311	552,995
Duval	1,943,647	963,180	15,580	407,641	14,782	94,124	448,340
Lee	1,263,002	561,908	22,470	170,873	(0)	118,449	389,302
Polk	1,056,537	345,273	21,223	158,416	14,267	128,217	389,140
Brevard	1,367,789	758,617	16,240	162,800	11,519	98,113	320,500
Volusia	963,326	402,925	14,415	201,885	9,252	87,085	247,764
Pasco	748,837	279,209	10,837	164,455	(0)	69,218	225,118
Seminole	498,468	148,468	12,102	23,072	8,437	73,111	233,278
Sarasota	796,234	480,561	9,412	73,412	6,252	56,863	169,733
Manatee	724,276	359,061	8,642	119,388	6,226	52,211	178,747
Collier	840,268	491,780	8,676	139,118	5,403	52,412	142,879
Marion	374,881	179,861	6,252	20,306	4,509	39,232	124,720
Lake	338,261	57,512	3,742	153,345	3,288	22,604	97,771
Osceola	151,435	42,135	2,993	25,401	2,165	18,080	60,660
Escambia	514,316	222,536	10,516	28,956	6,782	63,532	181,993
St. Lucie	409,393	227,377	4,398	70,824	2,869	26,567	77,358
Leon	419,075	219,837	5,978	36,630	4,196	36,163	116,270
Alachua	513,367	271,134	6,267	80,287	4,179	38,803	112,697
St. Johns	382,918	81,058	4,213	185,095	3,013	25,455	84,084
Clay	188,436	47,026	4,303	37,730	2,676	25,998	70,703
Okaloosa	192,694	42,126	3,365	57,601	2,399	20,328	66,875
Hernando	175,074	50,879	3,961	14,851	2,822	23,929	78,632
Bay	357,298	100,375	1,252	81,623	4,524	58,428	111,096
Charlotte	545,241	375,057	4,013	72,082	2,532	24,246	67,311
Santa Rosa	240,161	35,697	6,199	48,295	4,030	37,447	108,493
Martin	298,386	165,566	4,459	19,827	2,916	26,941	78,676
State	33,929,982	14,418,493	767,163	4,115,872	1,648,658	3,193,882	9,785,914

Table 5.2.2: Waste-to-energy approach composition and disposition calculated using Table 5.2.1 state data.

MSW material	Mass generated (tonnes/person)	Mass recycled directly (tonnes/person)	Mass recycled post-combustion (tonnes/person)	Mass landfilled directly C&D (tonnes/person)	Mass landfilled directly non-C&D (tonnes/person)	Mass landfilled post-combustion (tonnes/person)	Mass combusted (tonnes/person)
Newspaper	0.0472	0.0108	—	—	0.0039	—	0.0325
Glass	0.0404	0.0126	—	—	0.0030	0.0248	—
Aluminum cans	0.0096	0.0019	0.0007	—	0.0008	0.0062	—
Plastic bottles	0.0206	0.0024	—	—	0.0020	—	0.0163
Steel cans	0.0199	0.0074	0.0028	—	0.0013	0.0084	—
Corrugated paper	0.1178	0.0506	—	—	0.0072	—	0.0600
Office paper	0.0299	0.0048	—	—	0.0027	—	0.0224
Yard trash	0.1890	0.1269	—	—	0.0067	—	0.0555
Other plastics	0.0662	0.0057	—	—	0.0065	—	0.0540
Ferrous metals	0.1162	0.0707	0.0266	—	0.0049	0.0140	—
White goods	0.0165	0.0083	0.0031	—	0.0009	0.0042	—
Non-ferrous metal	0.0257	0.0129	0.0048	—	0.0014	0.0066	—
Other paper	0.0945	0.0189	—	—	0.0081	—	0.0674
Textiles	0.0372	0.0028	—	—	0.0037	—	0.0307
C&D debris	0.5089	0.3046	—	0.2043	—	—	—
Food	0.0963	0.0075	—	—	0.0095	—	0.0793
Miscellaneous	0.2050	0.0321	—	—	0.0185	0.0943	0.0601
Tires	0.0139	0.0055	—	—	0.0009	—	0.0075
Process fuel	0.0293	0.0293	—	—	—	—	—
Total	1.684	0.7156	0.0381	0.2043	0.0818	0.1585	0.4857

5.2.2 Mixed Waste Processing Approach

Another prospective alternative approach is mixed waste processing. Mixed waste processing (MWP) facilities work like single-stream material recovery facilities (MRF) except incoming materials are not source-segregated. Rather, MWP facilities sort comingled MSW and recyclables, including paper, plastics, aluminum and steel cans, glass, and compostable organics like food waste.²⁷ Counties and municipalities invest in MWP facilities because they help them achieve their recycling rate goals. Sometimes MWP facilities operate alongside existing recycling programs, but they can also completely replace an existing program.

We assumed that, for counties with populations greater than 150,000 incorporating MWP, standard residential and non-residential recycling rates would increase to 55.7% and 47.6%, respectively. Our computations are based on research presented in Burns & McDonnell (2015), which computed residential and non-residential standard recycling rates under MWP rates by summing the recycled and composted recycling rates reported in an MWP feasibility study. In that research, the MWP facility operates concurrently with the current MRFs for the residential waste stream, generating a recycling rate of 32.9% and a composting rate of 22.8%. Non-residential generators send their waste directly to an MWP facility, which recycles at 18.9% and composts at 28.7%.²⁷

In this approach, residential and non-residential mass that would have been combusted or sent to a landfill is instead processed in an MWP facility before being sent to disposal sites. Materials contributing to the standard recycling rate increase are newspaper, glass, aluminum and steel cans, corrugated paper, office paper, other plastics and paper, textiles, food, and miscellaneous materials. Burns & McDonnell determined that a relatively small MWP facility, with a capacity of 217,634 tonnes/year, would provide suitable service in a combined residential program, and a relatively large facility, with a capacity of 290,179 tonnes/year, would be needed to service non-residential processed mass. Applying those capacity assumptions to our own research resulted in a need for the construction of 34 smaller and 18 larger MWP facilities in Florida.

Accompanying the increase in standard residential and non-residential recycling rates would be an increase in the state's total standard recycling rate to 53.8% and an increase in the total recycling rate to 65.8%. Additional recycled mass processed at MWP facilities would decrease the mass that would need to be landfilled or combusted at WTE facilities, which would in turn reduce renewable energy recycling credits. Mass disposition under the MWP approach is shown in Table 5.2.2 and Section 5.2.1, and the impact of moving to MWP on material composition and disposition is shown in Table 5.2.3. Mass disposition for combustion and landfill would decrease by 2% and 11%, respectively, with recycled disposition increasing from 44% to 57% (Figures 5.2.4 and 5.2.5). Figure 5.2.6 shows the increased recycling rates. In MWP facilities, yard trash and C&D debris are not processed, so rates in those categories would not differ from 2016 baseline data.

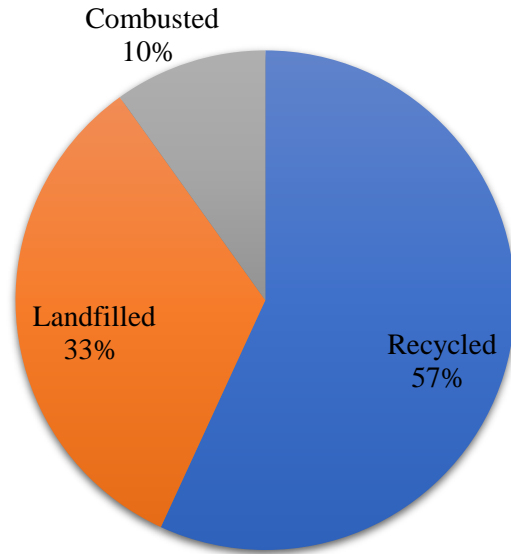


Figure 5.2.4: Mass disposition for the mixed waste processing approach.

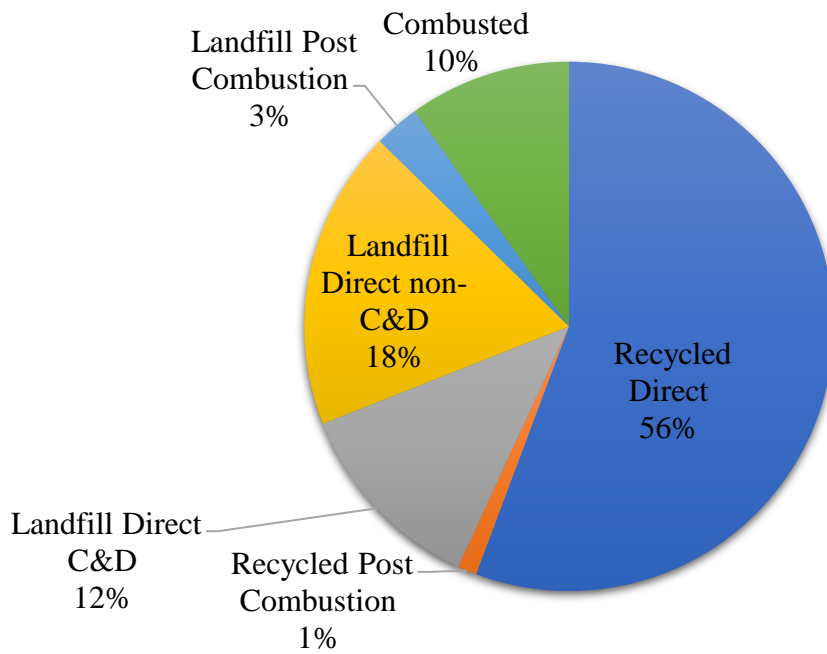


Figure 5.2.5: Detailed mass disposition for the mixed waste processing approach.

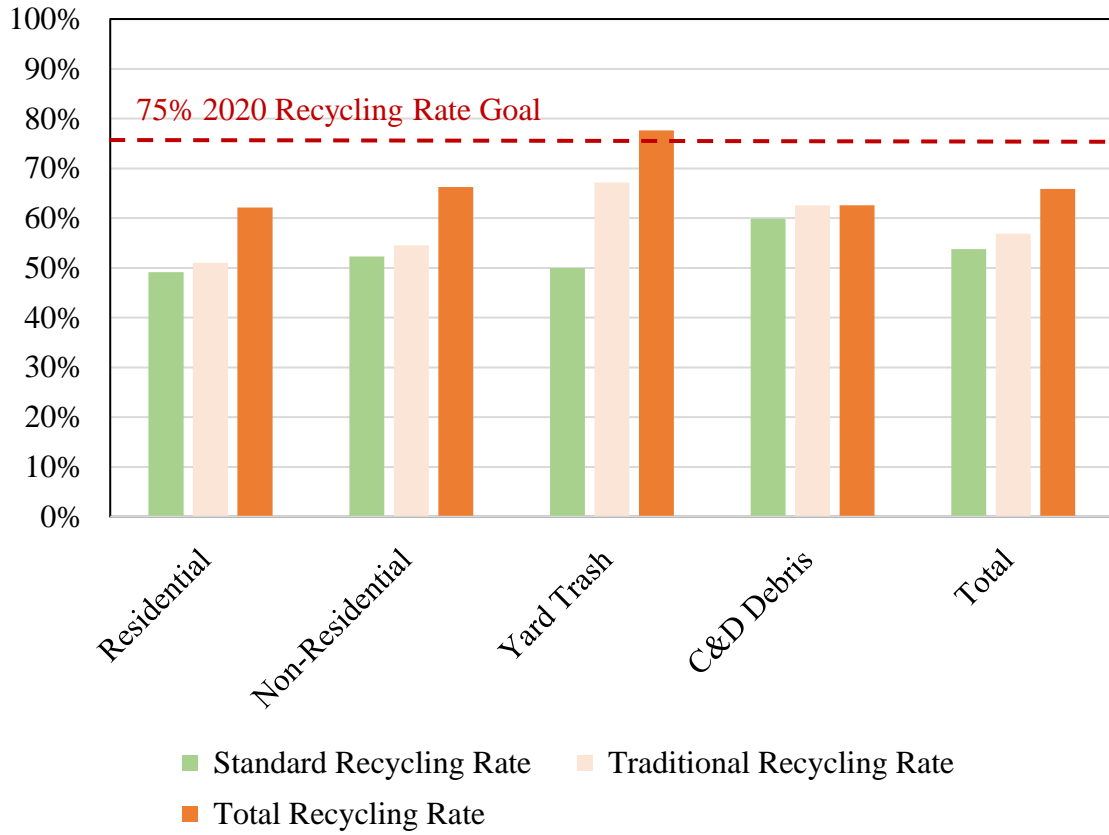


Figure 5.2.6: Recycling rates for the mixed waste processing approach’s four waste generator categories.

Table 5.2.3: Mass disposition for the mixed waste processing approach for Florida counties with populations greater than 150,000. For counties with populations less than 150,000, see Table 3.1.2.

County	Collected (tonnes)	Recycled direct (tonnes)	Recycled post combustion (tonnes)	Landfill direct C&D debris (tonnes)	Landfill direct non-C&D debris (tonnes)	Landfill post combustion (tonnes)	Combusted (tonnes)
Miami-Dade	3,982,274	2,028,530	216,246	467,072	549,878	135,458	585,089
Broward	3,264,679	1,844,654	13,802	44,561	592,721	200,450	568,492
Palm Beach	2,813,240	1,799,436	67,235	170,838	990	127,031	647,710
Hillsborough	2,158,961	1,338,739	23,306	185,882	1,419	124,537	485,077
Orange	1,963,542	1,322,454	—	206,554	434,534	—	—
Pinellas	1,828,321	1,282,747	49,057	25,530	4,550	131,991	334,446
Duval	1,943,647	1,002,530	—	407,641	532,172	—	1,305
Lee	1,263,002	703,409	14,796	150,168	—	93,979	300,649
Polk	1,056,537	511,219	—	158,416	386,901	—	—
Brevard	1,367,789	819,962	—	162,800	370,246	—	14,781
Volusia	963,326	550,198	—	201,885	211,243	—	—
Pasco	748,837	379,918	5,375	160,944	—	40,578	162,022
Seminole	498,468	257,118	—	23,072	218,277	—	—
Sarasota	796,234	543,969	—	73,412	178,852	—	—
Manatee	724,276	365,654	—	119,388	222,741	—	16,493
Collier	840,268	547,005	—	139,118	154,146	—	—
Marion	374,881	228,396	—	20,306	111,545	1,463	13,170
Lake	338,261	106,041	—	153,345	48,921	—	29,955
Osceola	151,435	63,617	—	25,401	62,417	—	—
Escambia	514,316	326,868	—	28,956	158,491	—	—
St. Lucie	409,393	231,039	—	70,824	107,530	—	—
Leon	419,075	253,648	—	36,630	128,663	51	83
Alachua	513,367	319,594	—	80,287	104,349	943	8,194
St. Johns	382,918	108,446	—	185,095	89,378	—	—
Clay	188,436	89,376	—	37,730	61,330	—	—
Okaloosa	192,694	71,058	—	57,601	64,036	—	—
Hernando	175,074	83,148	—	14,851	77,076	—	—
Bay	357,298	137,736	—	81,623	6,293	48,641	80,783
Charlotte	545,241	411,421	—	72,082	61,738	—	—
Santa Rosa	240,161	99,409	—	48,295	92,457	—	—
Martin	298,386	192,689	—	19,827	85,778	—	92
State	33,929,982	18,903,832	392,293	4,115,872	6,221,192	938,994	3,357,798

Table 5.2.4: Mixed waste processing approach composition and disposition calculated using Table 5.2.3 state data.

MSW material	Mass generated (tonnes/person)	Mass recycled directly (tonnes/person)	Mass recycled post-combustion (tonnes/person)	Mass landfilled directly C&D (tonnes/person)	Mass landfilled directly non-C&D (tonnes/person)	Mass landfilled post-combustion (tonnes/person)	Mass combusted (tonnes/person)
Newspaper	0.0472	0.0238	—	—	0.0134	—	0.0101
Glass	0.0404	0.0237	—	—	0.0095	0.0071	—
Aluminum cans	0.0096	0.0038	0.0007	—	0.0033	0.0018	—
Plastic bottles	0.0206	0.0080	—	—	0.0072	—	0.0054
Steel cans	0.0199	0.0119	0.0021	—	0.0045	0.0014	—
Corrugated paper	0.1178	0.0831	—	—	0.0198	—	0.0149
Office paper	0.0299	0.0139	—	—	0.0092	—	0.0069
Yard trash	0.1890	0.1269	—	—	0.0354	—	0.0267
Other plastics	0.0662	0.0239	—	—	0.0241	—	0.0181
Ferrous metals	0.1162	0.0748	0.0130	—	0.0236	0.0048	—
White goods	0.0165	0.0086	0.0015	—	0.0045	0.0019	—
Non—ferrous metal	0.0257	0.0133	0.0023	—	0.0071	0.0030	—
Other paper	0.0945	0.0474	—	—	0.0268	—	0.0202
Textiles	0.0372	0.0130	—	—	0.0138	—	0.0104
C&D debris	0.5089	0.3046	—	0.2043	—	—	—
Food	0.0963	0.0341	—	—	0.0355	—	0.0267
Miscellaneous	0.2050	0.0886	—	—	0.0663	0.0265	0.0235
Tires	0.0139	0.0055	—	—	0.0048	—	0.0036
Process fuel	0.0293	0.0293	—	—	—	—	—
Total	1.684	0.9382	0.0195	0.2043	0.3088	0.0466	0.1667

5.2.3 Mandatory C&D Debris and Yard Trash Recycling Approach

FDEP's 2010 plan for achieving the 75% statewide recycling goal by 2020 recognized that approximately 12% of the 75% goal could be achieved by recycling C&D debris that would have been disposed of before the Energy Act went into effect. FDEP recommended that mixed loads of C&D debris be processed at MRFs prior to disposal through sorting operations added at the front end of existing C&D debris disposal facilities. Another material FDEP has promoted recycling of is yard trash because it also contributes a large majority of the waste stream. Although not all Florida counties have adopted those recommendations, by 2016 C&D debris and yard trash recycling rates increased to 63% and 67%, respectively.

Based on the results obtained in cities outside Florida, our research establishes that mandatory C&D debris and yard trash recycling in counties with populations greater than 150,000 would further increase the state's recycling rates. Los Angeles, for example, has achieved a C&D debris recycling rate of 76.5%,²² while San Jose has achieved a yard trash rate of 97%.²⁸ The C&D debris recycling ordinance in Los Angeles requires all mixed C&D debris generated within city limits be transported to a city-certified C&D waste processor, and all haulers and contractors responsible for handling C&D debris waste must obtain a private waste hauler permit prior to collecting and hauling the waste.²⁹ Meanwhile, San Jose diverts its residential and commercial yard trash to a private company, GreenWaste Recovery, which composts it.³⁰ The city has invested in a "green vision" that includes programs for educating residents about their participation in the yard trash program.³¹

In our approach, incoming C&D debris MRF material consists of all C&D debris and yard trash not recycled directly. The MRF would function like an MWP facility, where materials would be sent to be landfilled or combusted after processing. Recycling more yard trash would reduce the amount of yard trash that would need to be combusted, which would therefore reduce renewable energy recycling credits. Mass disposition under mandatory C&D debris and yard trash recycling is shown in Table 5.2.5, and the impact of moving to this regime on material composition and disposition is shown in Table 5.2.6. Mass disposition for combustion and landfill would decrease by 1% and 7%, respectively, while recycled disposition would increase from 44% to 52% (Figures 5.2.7 and 5.2.8). Figure 5.2.9 shows an increased statewide total recycling rate of 61.9% and dramatic increases in standard, traditional, and total yard trash and C&D debris rates. Mandatory C&D debris and yard trash recycling would not affect residential and non-residential waste management or recycling rates.

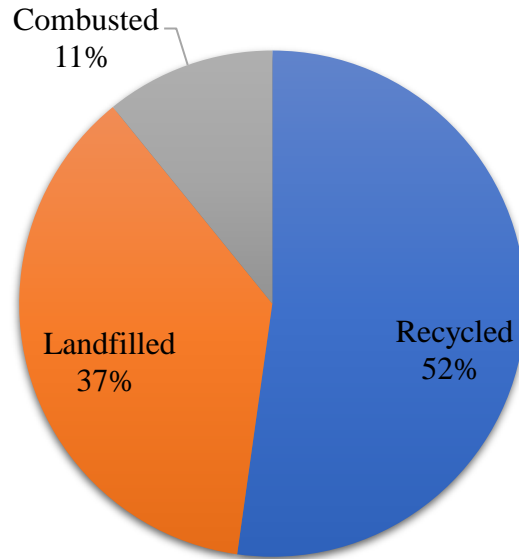


Figure 5.2.7: Mass disposition for the mandatory C&D debris and yard trash recycling approach.

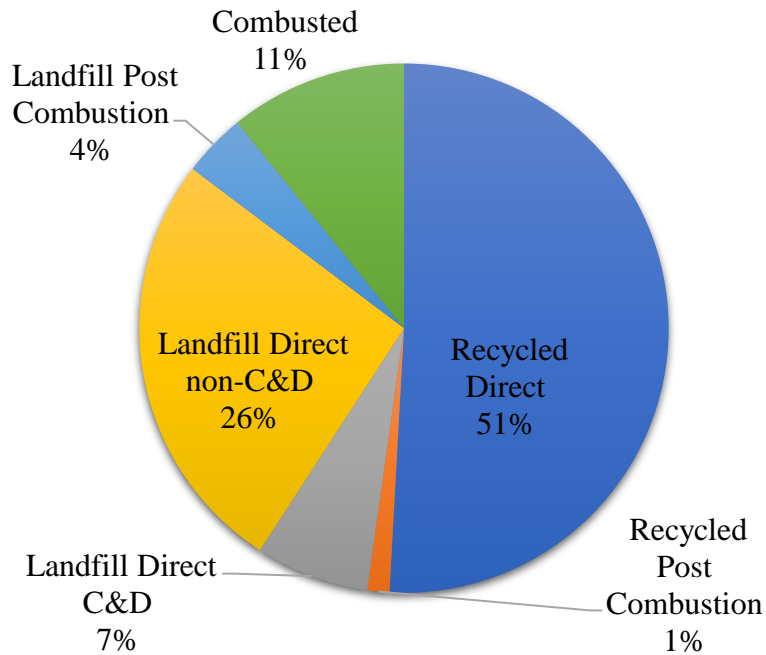


Figure 5.2.8: Detailed mass disposition for the mandatory C&D debris and yard trash recycling approach.

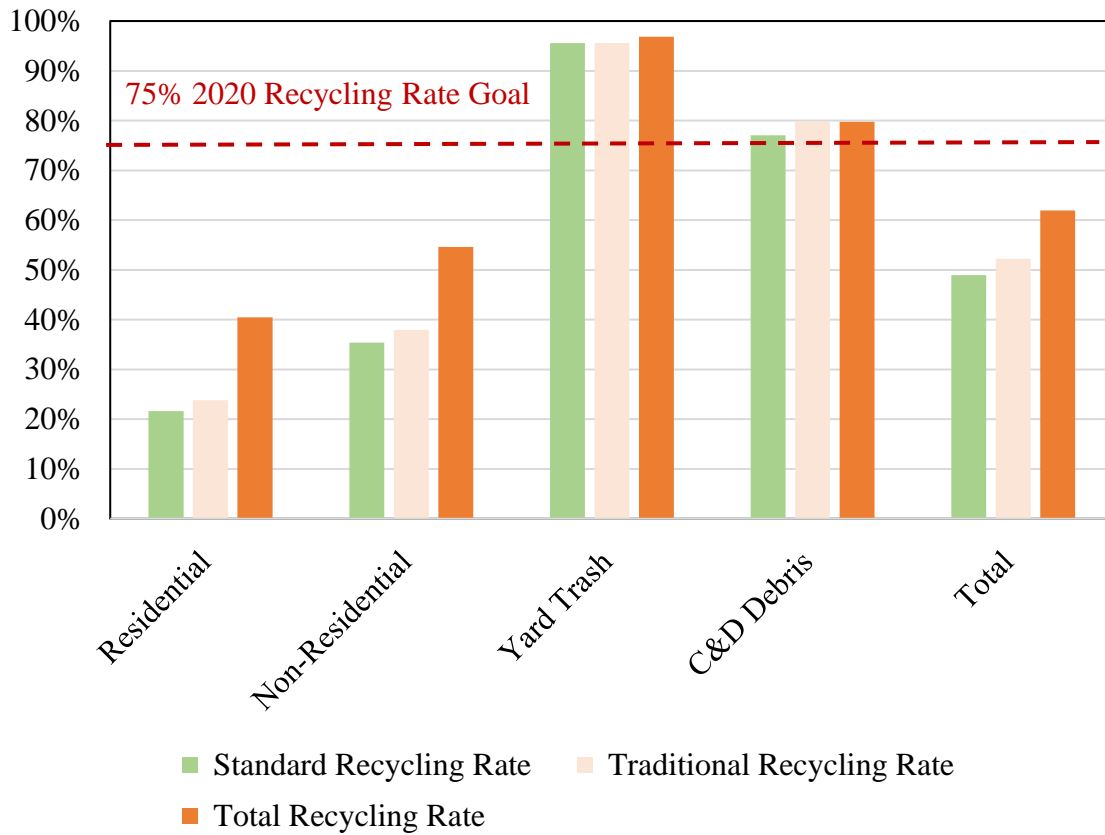


Figure 5.2.9: Recycling rates for the mandatory C&D debris and yard trash recycling approach’s four waste generator categories.

Table 5.2.5: Mass disposition for the mandatory C&D debris and yard trash recycling approach for Florida counties with populations greater than 150,000. For counties with populations less than 150,000, see Table 3.1.2.

County	Collected (tonnes)	Recycled direct (tonnes)	Recycled post-combustion (tonnes)	Landfill direct C&D debris (tonnes)	Landfill direct non-C&D debris (tonnes)	Landfill post-combustion (tonnes)	Combusted (tonnes)
Miami-Dade	3,982,274	2,118,292	107,966	467,072	490,841	213,013	585,089
Broward	3,264,679	1,382,210	17,627	44,561	1,063,905	187,885	568,492
Palm Beach	2,813,240	1,577,394	57,490	170,838	149,356	200,463	657,698
Hillsborough	2,158,961	1,323,381	26,417	185,882	32,251	153,393	437,635
Orange	1,963,542	1,382,849	—	206,554	374,139	—	—
Pinellas	1,828,321	1,237,620	31,019	25,530	104,516	114,458	315,177
Duval	1,943,647	1,019,533	—	407,641	515,169	—	1,305
Lee	1,263,002	674,423	16,473	150,168	49,158	95,991	276,787
Polk	1,056,537	514,594	—	158,416	383,526	—	—
Brevard	1,367,789	850,844	—	162,800	339,365	—	14,781
Volusia	963,326	581,997	—	201,885	179,444	—	—
Pasco	748,837	377,577	7,753	160,944	19,356	56,457	126,750
Seminole	498,468	241,245	—	23,072	234,151	—	—
Sarasota	796,234	536,629	—	73,412	186,192	—	—
Manatee	724,276	379,205	—	119,388	209,190	—	16,493
Collier	840,268	524,537	—	139,118	176,614	—	—
Marion	374,881	217,493	—	20,306	120,864	3,047	13,170
Lake	338,261	119,153	—	153,345	35,809	—	29,955
Osceola	151,435	70,581	—	25,401	55,452	—	—
Escambia	514,316	347,248	—	28,956	138,112	—	—
St. Lucie	409,393	248,469	—	70,824	90,100	—	—
Leon	419,075	266,871	—	36,630	115,461	31	83
Alachua	513,367	297,589	—	80,287	125,881	1,417	8,194
St. Johns	382,918	90,236	—	185,095	107,588	—	—
Clay	188,436	81,906	—	37,730	68,800	—	—
Okaloosa	192,694	66,248	—	57,601	68,846	—	—
Hernando	175,074	85,041	—	14,851	75,183	—	—
Bay	357,298	140,555	—	81,623	13,840	37,023	84,256
Charlotte	545,241	419,849	—	72,082	53,310	—	—
Santa Rosa	240,161	76,564	—	48,295	115,302	—	—
Martin	298,386	196,671	—	19,827	81,796	-	92
State	33,929,982	18,330,609	277,228	4,115,872	7,012,511	950,945	3,242,816

Table 5.2.6: Mandatory C&D debris and yard trash recycling approach composition and disposition calculated using Table 5.2.5 state data.

MSW material	Mass generated (tonnes/person)	Mass recycled directly (tonnes/person)	Mass recycled post-combustion (tonnes/person)	Mass landfilled directly C&D (tonnes/person))	Mass landfilled directly non-C&D (tonnes/person)	Mass landfilled post-combustion (tonnes/person)	Mass combusted (tonnes/person)
Newspaper	0.0472	0.0299	—	—	0.0106	—	0.0067
Glass	0.0404	0.0290	—	—	0.0070	0.0044	—
Aluminum cans	0.0096	0.0051	0.0006	—	0.0028	0.0012	—
Plastic bottles	0.0206	0.0107	—	—	0.0060	—	0.0038
Steel cans	0.0199	0.0149	0.0017	—	0.0031	0.0003	—
Corrugated paper	0.1178	0.0983	—	—	0.0119	—	0.0076
Office paper	0.0299	0.0181	—	—	0.0072	—	0.0046
Yard trash	0.1890	0.1269	—	—	0.0379	—	0.0242
Other plastics	0.0662	0.0325	—	—	0.0206	—	0.0131
Ferrous metals	0.1162	0.0789	0.0089	—	0.0228	0.0056	—
White goods	0.0165	0.0090	0.0010	—	0.0046	0.0019	—
Non—ferrous metal	0.0257	0.0140	0.0016	—	0.0071	0.0030	—
Other paper	0.0945	0.0608	—	—	0.0206	—	0.0131
Textiles	0.0372	0.0028	—	—	0.0210	—	0.0134
C&D debris	0.5089	0.3046	—	0.2043	—	—	—
food	0.0963	0.0075	—	—	0.0542	—	0.0346
Miscellaneous	0.2050	0.0321	—	—	0.1055	0.0308	0.0365
Tires	0.0139	0.0055	—	—	0.0051	—	0.0033
Process fuel	0.0293	0.0293	—	—	—	—	-
Total	1.684	0.9098	0.0138	0.2043	0.3480	0.0472	0.1609

5.2.4 Mandatory Curbside Recycling Approach

The fact that Florida’s statewide standard residential recycling rate as reported in FDEP’s 2016 baseline data is only 21.7% (Table 3.1.6) points to the necessity to increase residential recycling. Looking to Seattle, we assume that Florida counties with populations larger than 150,000 adopt mandatory curbside recycling and achieve a total residential recycling rate of 64% — attributable to increases in typically recycled curbside materials, including newspaper, glass, aluminum and steel cans, corrugated paper, office paper, and other plastics and paper.

Seattle reports single-family and multi-family residential recycling rates of 74% and 38.4%, respectively, resulting in a total residential recycling rate of 64%.³² Furthermore, the city has a goal of achieving a rate of 75% by 2022. Seattle has achieved its success by prohibiting recyclables and compostables in garbage. The city’s ordinance prohibits residents and businesses from placing food scraps, compostable paper, yard waste, and recyclables in their garbage.³³ Recyclables include glass bottles and jars, plastic cups, and aluminum and steel cans, and businesses are required to provide convenient food, yard waste, and recycling services at their properties. The Seattle Public Utilities, issues warning notices for when garbage containers contain recyclables or compostables. After two warnings, a \$50 fee is assessed.³³

When recycling increases, landfilled and combusted material mass decreases, along with renewable energy recycling credits. Mass disposition for mandatory curbside recycling is shown in Table 5.2.7, and its impact on material composition and disposition is shown in Table 5.2.8. Florida’s mass disposition for combustion and landfill would decrease by 3% and 8%, respectively; recycled disposition would increase from 44% to 55% (Figures 5.2.10 and 5.2.11). In Figure 5.2.12, Florida’s total recycling rate is shown as increasing to 63.6%, and standard, traditional, and total residential recycling rates are shown as increasing to 56.6%, 57.2%, and 67.9%, respectively. Non-residential, yard trash, and C&D debris recycling rates and masses are not impacted.

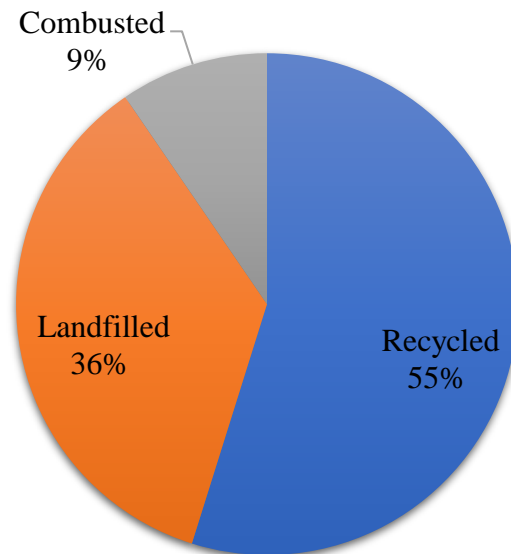


Figure 5.2.10: Mass disposition for the mandatory curbside recycling approach.

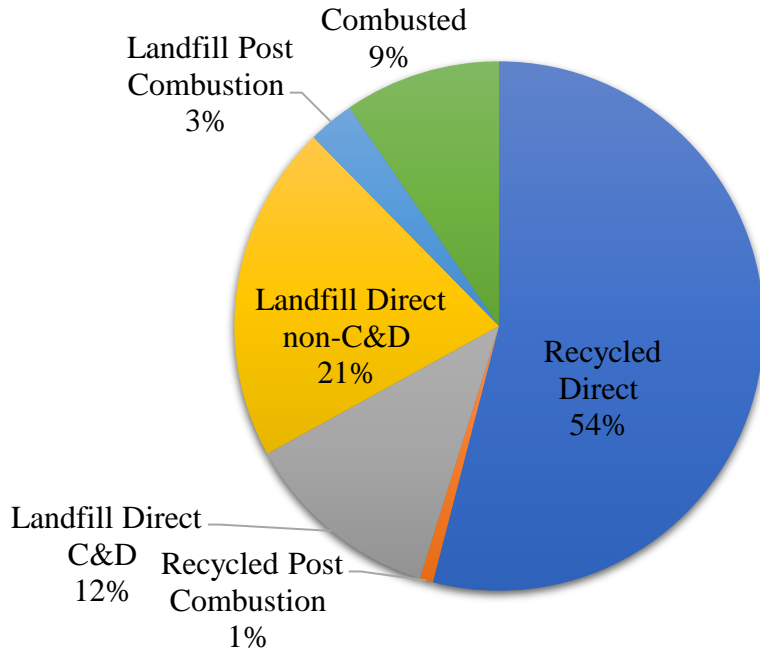


Figure 5.2.11: Detailed mass disposition for the mandatory curbside recycling approach.

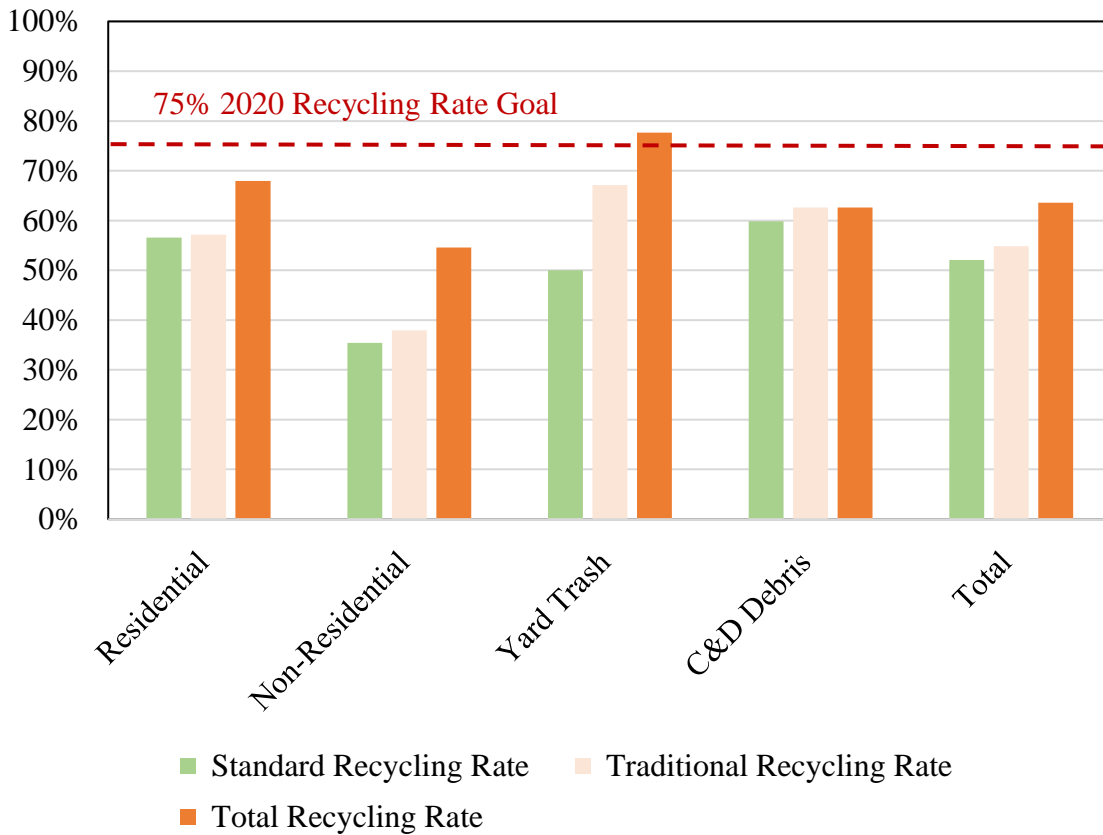


Figure 5.2.12: Recycling rates for the mandatory curbside recycling approach’s four waste generator categories.

Table 5.2.7: Mass disposition for the mandatory curbside recycling approach for Florida counties with populations greater than 150,000. For counties with populations less than 150,000, see Table 3.1.2.

County	Collected (tonnes)	Recycled direct (tonnes)	Recycled post-combustion (tonnes)	Landfill direct C&D debris (tonnes)	Landfill direct non-C&D debris (tonnes)	Landfill post-combustion (tonnes)	Combusted (tonnes)
Miami-Dade	3,982,274	1,576,495	216,246	136,844	1,374,635	92,966	585,089
Broward	3,264,679	1,320,381	13,802	44,561	1,199,643	200,450	485,843
Palm Beach	2,813,240	1,184,217	98,167	170,838	61,346	309,141	989,529
Hillsborough	2,158,961	1,215,872	32,631	164,259	19,901	140,729	585,569
Orange	1,963,542	1,264,112	—	194,964	504,466	—	—
Pinellas	1,828,321	951,467	59,068	25,530	163,147	190,925	438,183
Duval	1,943,647	1,379,082	—	181,272	381,989	—	1,305
Lee	1,263,002	694,962	22,470	65,147	—	139,154	341,269
Polk	1,056,537	484,159	—	58,527	513,851	—	—
Brevard	1,367,789	886,261	—	80,550	391,273	—	9,704
Volusia	963,326	529,698	—	81,038	352,591	—	—
Pasco	748,837	394,557	10,837	71,278	—	51,390	220,775
Seminole	498,468	192,564	—	12,628	293,276	—	—
Sarasota	796,234	493,782	—	73,412	229,039	—	—
Manatee	724,276	473,798	—	39,853	208,219	—	2,405
Collier	840,268	558,478	—	72,421	209,370	—	—
Marion	374,881	188,554	—	20,306	151,387	1,463	13,170
Lake	338,261	182,010	—	36,728	90,885	—	28,638
Osceola	151,435	72,997	—	5,979	72,459	—	—
Escambia	514,316	230,451	—	28,956	254,909	—	—
St. Lucie	409,393	274,410	—	28,523	106,460	—	—
Leon	419,075	243,817	—	30,429	144,696	51	83
Alachua	513,367	296,171	—	57,810	151,166	708	7,512
St. Johns	382,918	236,336	—	43,611	102,971	—	—
Clay	188,436	75,566	—	9,190	103,680	—	—
Okaloosa	192,694	97,250	—	13,562	81,882	—	—
Hernando	175,074	75,329	—	3,516	96,229	—	—
Bay	357,298	177,267	—	19,217	33,521	50,863	76,430
Charlotte	545,241	375,057	—	72,082	98,102	—	—
Santa Rosa	240,161	79,017	—	11,378	149,766	—	—
Martin	298,386	174,918	—	14,682	108,695	-	92
State	33,929,982	17,262,842	456,072	2,354,826	8,861,984	1,314,482	3,679,776

Table 5.2.8: Mandatory curbside recycling approach composition and disposition calculated using Table 5.2.7 state data.

MSW material	Mass generated (tonnes/person)	Mass recycled directly (tonnes/person)	Mass recycled post-combustion (tonnes/person)	Mass landfilled directly C&D (tonnes/person)	Mass landfilled directly non-C&D (tonnes/person)	Mass landfilled post-combustion (tonnes/person)	Mass combusted (tonnes/person)
Newspaper	0.0472	0.0108	—	—	0.0226	—	0.0139
Glass	0.0404	0.0126	—	—	0.0172	0.0106	—
Aluminum cans	0.0096	0.0015	0.0003	—	0.0051	0.0028	—
Plastic bottles	0.0206	0.0024	—	—	0.0113	—	0.0069
Steel cans	0.0199	0.0069	0.0016	—	0.0080	0.0034	—
Corrugated paper	0.1178	0.0506	—	—	0.0416	—	0.0256
Office paper	0.0299	0.0048	—	—	0.0155	—	0.0095
Yard trash	0.1890	0.1807	—	—	0.0052	—	0.0032
Other plastics	0.0662	0.0057	—	—	0.0374	—	0.0230
Ferrous metals	0.1162	0.0717	0.0161	—	0.0275	0.0009	—
White goods	0.0165	0.0082	0.0018	—	0.0052	0.0013	—
Non—ferrous metal	0.0257	0.0128	0.0029	—	0.0080	0.0021	—
Other paper	0.0945	0.0189	—	—	0.0468	—	0.0288
Textiles	0.0372	0.0028	—	—	0.0213	—	0.0131
C&D debris	0.5089	0.3920	—	0.1169	—	—	—
Food	0.0963	0.0075	—	—	0.0550	—	0.0338
Miscellaneous	0.2050	0.0321	—	—	0.1070	0.0442	0.0216
Tires	0.0139	0.0055	—	—	0.0052	—	0.0032
Process fuel	0.0293	0.0293	—	—	—	—	—
Total	1.684	0.8568	0.0226	0.1169	0.4398	0.0652	0.1826

5.2.5 Mandatory Non-residential Food Waste Composting Approach

The 2010 FDEP plan for achieving the 75% recycling goal also highlighted the potential positive impact of increasing organic waste composting. In 2010, the recycling rate for food waste was 1.4%⁷; by 2016 the rate had increased to 7.8%.²⁰ Although FDEP has encouraged counties and municipalities to recycle food waste, it is evident that the material's recycling potential is still high — 1.9 million tonnes were generated in 2016 — and approaches to achieve the 75% goal vary. We considered an approach where counties with populations greater than 150,000 increase their standard non-residential food waste recycling rate to 58% — modeled after Portland's rate — through mandatory non-residential food waste recycling.²⁶

Like Los Angeles, San Jose, and Seattle, Portland is a city with one of the highest total recycling rates in the nation and one of highest food waste recycling rates. Portland has achieved this recycling rate due to its Portland Composts! Program, which began in 2005 and which requires every waste collection company to offer commercial composting services to collect food waste. In 2011, the city began a curbside food collection service that allowed residents to include food scraps with yard debris. The city's Bureau of Planning and Sustainability is responsible for implementing policies to reduce waste and increase recycling and organic waste recovery rates. The Bureau first chose to focus on a voluntary commercial food collection program and only after on the residential curbside program in order to increase the commercial food waste recycling rate and reduce the city's landfilled mass.

In Florida, incoming non-residential food waste would be removed from original landfilled and combusted masses, resulting in a reduction in renewable energy recycling credits. Mass disposition for mandatory non-residential food waste composting is shown in Table 5.2.9, and its impact on material composition and disposition is shown in Table 5.2.10. Recycling an additional 378,965 tonnes of food waste would have a minimal impact on the state's mass disposition by percentage for combustion, landfilling, and recycling (Figures 5.2.13 and 5.2.14). In Figure 5.2.15, the state's total recycling rate is shown as increasing to 55.5%, with total non-residential standard, traditional, and total recycling rates increasing to 40.1%, 42.6%, and 58.5%, respectively. Residential MSW, yard trash, and C&D debris recycling rates and masses are not impacted.

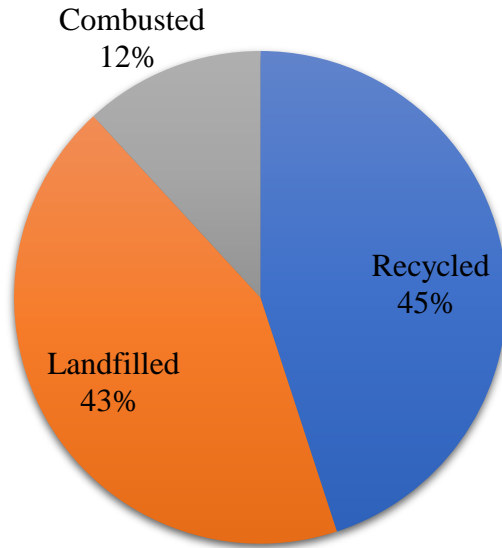


Figure 5.2.13: Mass disposition for the mandatory non-residential food waste composting approach.

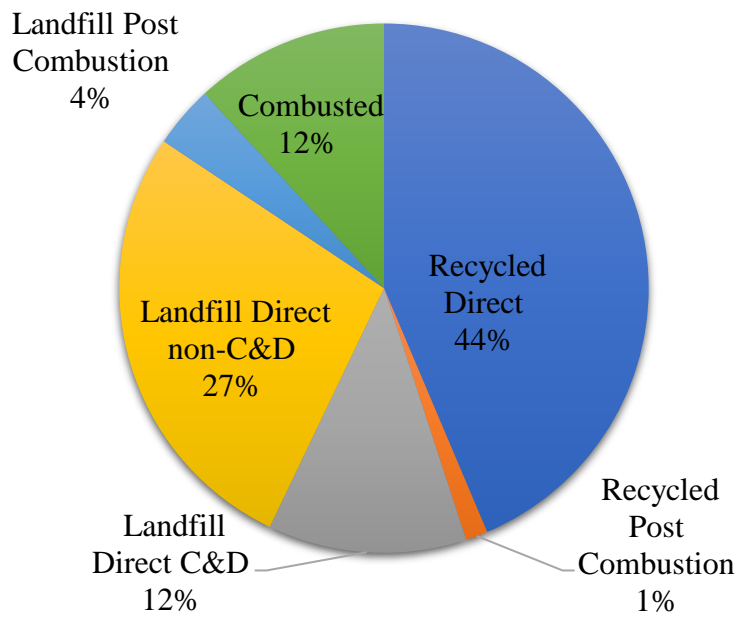


Figure 5.2.14: Detailed mass disposition for the mandatory non-residential food waste composting approach.

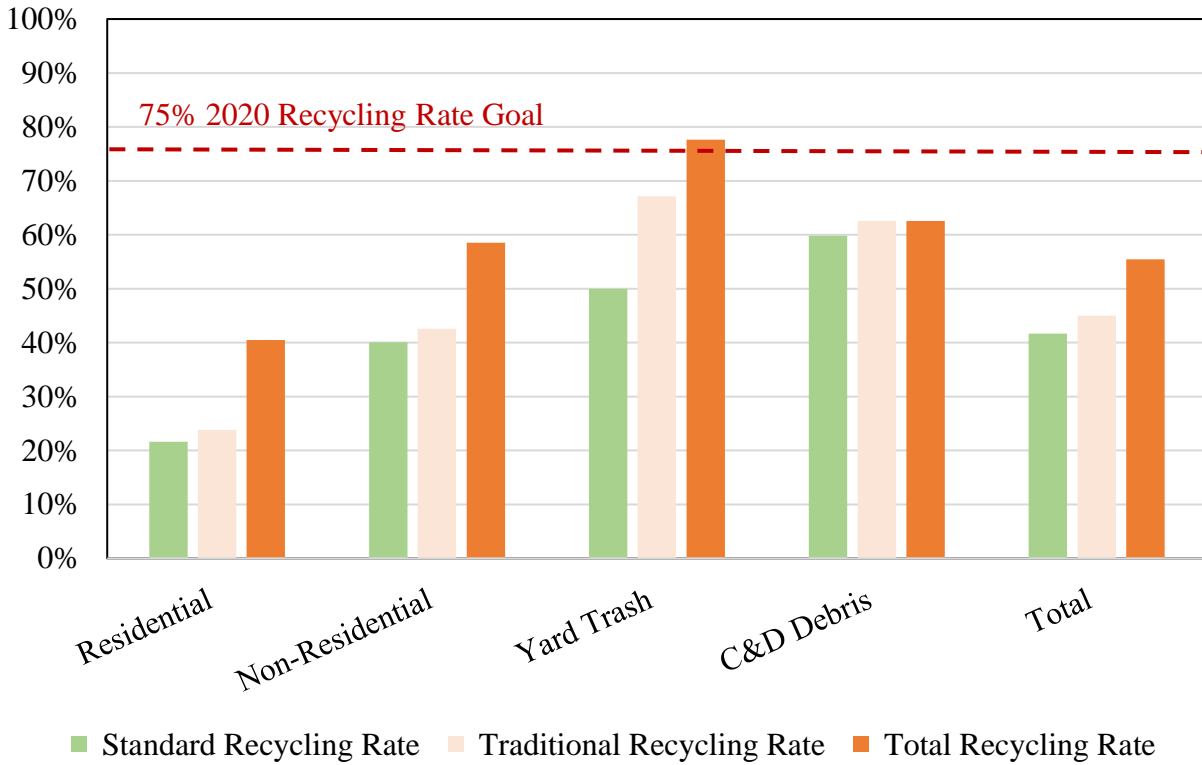


Figure 5.2.15: Recycling rates for the mandatory non-residential food waste composting approach’s four waste generator categories.

Table 5.2.9: Mass disposition for the mandatory non-residential food waste composting approach for Florida counties with populations greater than 150,000. For counties with populations less than 150,000, see Table 3.1.2.

County	Collected (tonnes)	Recycled direct (tonnes)	Recycled post-combustion (tonnes)	Landfill direct C&D debris (tonnes)	Landfill direct non-C&D debris (tonnes)	Landfill post-combustion (tonnes)	Combusted (tonnes)
Miami-Dade	3,982,274	1,137,378	216,246	467,072	1,441,031	135,458	585,089
Broward	3,264,679	1,158,826	13,802	44,561	1,278,549	200,450	568,492
Palm Beach	2,813,240	1,196,157	98,167	170,838	33,846	309,141	1,005,090
Hillsborough	2,158,961	1,176,434	32,631	185,882	17,735	172,373	573,906
Orange	1,963,542	1,179,426	—	206,554	577,562	—	—
Pinellas	1,828,321	923,730	59,068	63,715	140,781	190,925	450,101
Duval	1,943,647	996,008	—	407,641	538,694	—	1,305
Lee	1,263,002	611,798	22,470	150,168	—	139,154	339,412
Polk	1,056,537	358,471	—	158,416	539,650	—	—
Brevard	1,367,789	768,655	—	162,800	421,554	—	14,781
Volusia	963,326	408,313	—	201,885	353,128	—	—
Pasco	748,837	285,572	10,837	160,944	—	72,730	218,754
Seminole	498,468	157,209	—	23,072	318,187	—	—
Sarasota	796,234	486,087	—	73,412	236,734	—	—
Manatee	724,276	359,502	—	119,388	228,892	—	16,493
Collier	840,268	500,952	—	139,118	200,199	—	—
Marion	374,881	185,773	—	20,306	154,168	1,463	13,170
Lake	338,261	57,512	—	153,345	97,450	—	29,955
Osceola	151,435	43,902	—	25,401	82,132	—	—
Escambia	514,316	226,796	—	28,956	258,564	—	—
St. Lucie	409,393	227,684	—	70,824	110,885	—	—
Leon	419,075	221,768	—	36,630	160,543	51	83
Alachua	513,367	279,291	—	80,287	144,652	943	8,194
St. Johns	382,918	86,815	—	185,095	111,009	—	—
Clay	188,436	54,845	—	37,730	95,861	—	—
Okaloosa	192,694	46,648	—	57,601	88,445	—	—
Hernando	175,074	53,362	—	14,851	106,862	—	—
Bay	357,298	104,241	—	81,623	32,828	50,863	87,742
Charlotte	545,241	376,702	—	72,082	96,456	—	—
Santa Rosa	240,161	40,679	—	48,295	151,187	—	—
Martin	298,386	171,012	—	19,827	107,454	—	92
State	33,929,982	14,803,539	456,072	4,115,872	9,248,568	1,286,414	4,019,517

Table 5.2.10: Mandatory non-residential food waste composting approach composition and disposition calculated using Table 5.2.9 state data.

MSW material	Mass generated (tonnes/person)	Mass recycled directly (tonnes/person)	Mass recycled post-combustion (tonnes/person)	Mass landfilled directly C&D (tonnes/person)	Mass landfilled directly non-C&D (tonnes/person)	Mass landfilled post-combustion (tonnes/person)	Mass combusted (tonnes/person)
Newspaper	0.0472	0.0108	—	—	0.0224	—	0.0140
Glass	0.0404	0.0126	—	—	0.0171	0.0106	—
Aluminum cans	0.0096	0.0015	0.0003	—	0.0050	0.0028	—
Plastic bottles	0.0206	0.0024	—	—	0.0112	—	0.0070
Steel cans	0.0199	0.0069	0.0016	—	0.0080	0.0034	—
Corrugated paper	0.1178	0.0506	—	—	0.0414	—	0.0258
Office paper	0.0299	0.0048	—	—	0.0155	—	0.0096
Yard trash	0.1890	0.1269	—	—	0.0383	—	0.0238
Other plastics	0.0662	0.0057	—	—	0.0373	—	0.0232
Ferrous metals	0.1162	0.0717	0.0161	—	0.0274	0.0010	—
White goods	0.0165	0.0082	0.0018	—	0.0051	0.0014	—
Non—ferrous metal	0.0257	0.0128	0.0029	—	0.0080	0.0021	—
Other paper	0.0945	0.0189	—	—	0.0465	—	0.0290
Textiles	0.0372	0.0028	—	—	0.0212	—	0.0132
C&D debris	0.5089	0.3046	—	0.2043	—	—	—
Food	0.0963	0.0266	—	—	0.0429	—	0.0267
Miscellaneous	0.2050	0.0321	—	—	0.1065	0.0425	0.0239
Tires	0.0139	0.0055	—	—	0.0052	—	0.0032
Process fuel	0.0293	0.0293	—	—	—	—	—
Total	1.684	0.7347	0.0226	0.2043	0.4590	0.0638	0.1995

5.3 ENVIRONMENTAL FOOTPRINT

In Section 3.2, we estimated Florida's environmental footprint in 2016 to have been -1.08 tCO₂eq/person and -12,900 MJ/person. Comparing the 2016 baseline data with the prospective alternative approaches required multiplying waste composition and disposition estimates by their associated LCI factors, as shown in Tables 2.3.1 and 2.3.2. Waste composition and disposition estimates for 2016 baseline data and the alternative approaches are shown in Tables 3.1.3, 5.2.2, 5.2.3, 5.2.6, 5.2.8, and 5.2.10.

Among the prospective alternative approaches, residential curbside recycling has the highest GHG emissions offset (-1.61 tCO₂eq/person) and energy use offset (-17,300 MJ/person) (Figures 5.3.1 and 5.3.2). The MWP approach has the second highest GHG emissions offset, followed by the WTE approach, C&D debris and yard trash recycling, and non-residential food waste composting (Figure 5.3.1). The second-highest energy use offset is the WTE approach, which is followed by the MWP approach, non-residential food waste composting, and C&D debris and yard trash recycling (Figure 5.3.2). The equivalent tCO₂eq offsets in passenger vehicles driven for one year, home electricity use for one year, incandescent lamps switched to LEDs, and garbage trucks of waste recycled instead of landfilled are presented for the baseline data and each prospective alternative approach in Table 5.3.1, and the comparisons are shown in Table 5.3.2.

GHG emissions and energy use offsets are greatest when a material is recycled because recycling a material reduces the need for virgin materials. For this reason, residential curbside recycling and the MWP approaches have the highest GHG emissions offset. The WTE approach generates a high GHG emissions and energy use offset because combusting materials generates electricity, which offsets the use of nonrenewable resources. The WTE approach has a lower GHG emissions offset than the approaches with high amounts of recycling, because materials such as plastics release CO₂ when combusted that would not have originally been released.

The MWP approach has a lower energy use offset than the WTE facility approach because we assumed that all waste other than residential and non-residential recycled direct mass would first be processed in an MWP facility before being combusted or landfilled. To account for this, LCI factors for recycled post-combustion, landfill direct non-C&D debris, landfill post-combustion, and combustion were modified to include GHG emissions and energy use associated with an MWP facility, as taken from Combs (2012)³⁴ and Pressley (2015).⁴⁶ MWP facility GHG emissions and energy use reported in those studies was converted, averaged, and aggregated into LCI factors. The C&D debris and yard trash recycling and non-residential food waste composting approaches had the lowest GHG emissions and energy offsets because their WARM environmental benefits are low. The net environmental impact of managing yard trash and food waste is low because of the energy-intensive process of operating compost machinery and the potential of organic materials to generate methane.

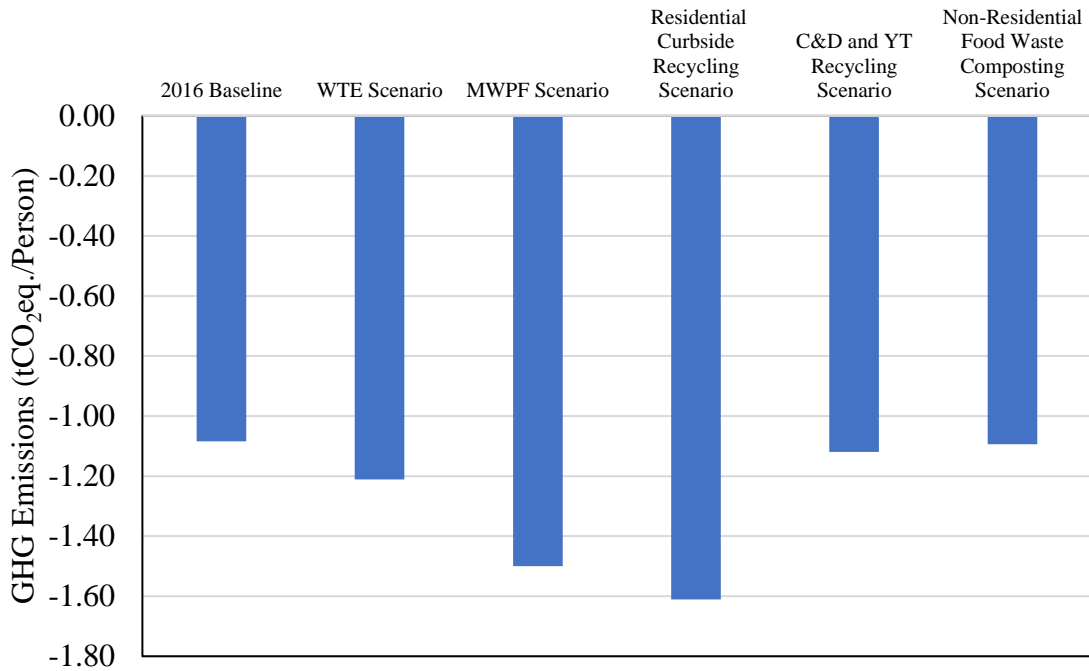


Figure 5.3.1: Net GHG emissions (tCO₂eq/person) associated with Florida’s solid waste management in 2016 compared to the alternative results.

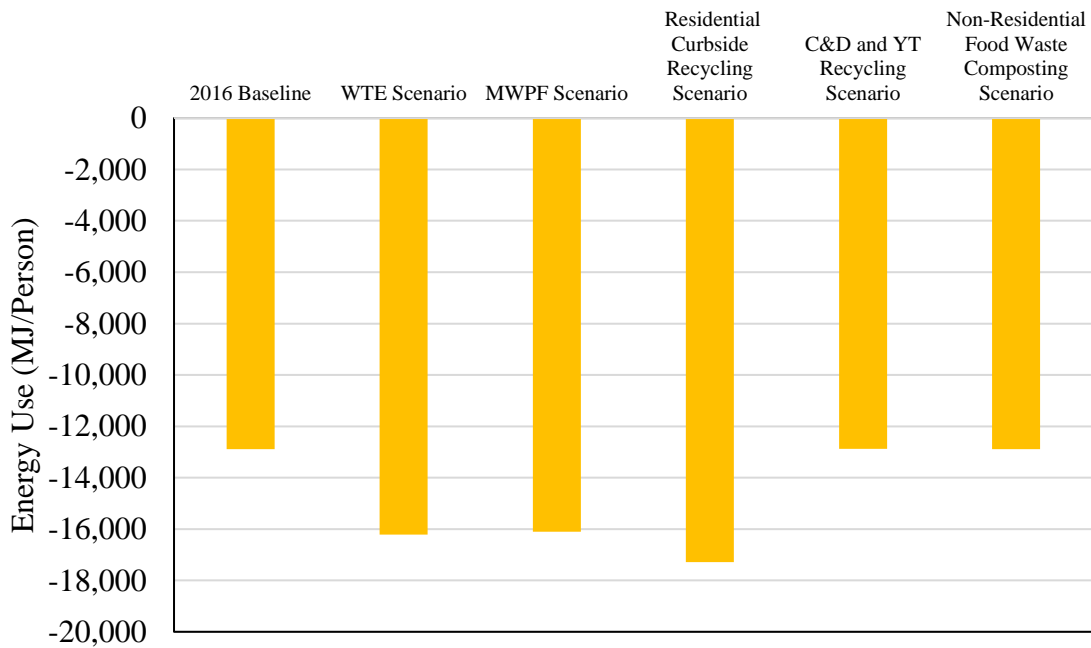


Figure 5.3.2: Net energy use (MJ/person) associated with Florida’s solid waste management in 2016 compared to the alternative results.

Table 5.3.1: Equivalent tCO₂eq for the whole state’s population offset for the 2016 baseline and each alternative approach based on WARM tCO₂eq equivalency estimates.

Approach	Reduction in number of passenger vehicles driven for one year	Reduction in number of homes' electricity use for one year	Reduction in number of incandescent lamps switched to LEDs	Reduction in number of garbage trucks of waste recycled instead of landfilled
2016 baseline	4,679,237	3,275,186	730,837,400	1,088,791
WTE approach	5,225,079	3,657,242	816,090,907	1,215,801
MWP approach	6,468,746	4,527,734	1,010,335,928	1,505,184
Residential curbside recycling approach	6,950,423	4,864,879	1,085,567,709	1,617,263
C&D and YT recycling approach	4,827,422	3,378,906	753,981,986	1,123,272
Non-residential food waste composting approach	4,719,477	3,303,351	737,122,296	1,098,154

Table 5.3.2: The difference in net equivalent tCO₂eq for the whole state’s population offset for the 2016 baseline and each alternative approach based on WARM tCO₂eq equivalency estimates.

Approach	Reduction in number of passenger vehicles driven for one year	Reduction in number of homes' electricity use for one year	Reduction in number of incandescent lamps switched to LEDs	Reduction in number of garbage trucks of waste recycled instead of landfilled
WTE approach	545,842	382,056	85,253,507	127,009
MWP approach	1,789,509	1,252,549	279,498,529	416,393
Residential curbside recycling approach	2,271,185	1,589,694	354,730,309	528,472
C&D and YT recycling approach	148,185	103,720	23,144,587	34,480
Non-residential food waste composting approach	40,239	28,165	6,284,897	9,363

5.4 ECONOMIC COSTS

We estimated Florida's 2016 solid waste management costs (see Section 3) using an economic cost conversion factor for each mass flow disposition (see the Appendix for detailed methodology descriptions for each conversion factor.) The conversion factors account for amortized capital costs, operating and maintenance costs, transportation costs, and revenue. Estimating the net economic cost for each approach accounts for mass flow changes such a decrease in mass landfilled. Only the residential curbside recycling approach included indirect costs, which are attributed to the cost of employing code enforcement officers. Total statewide costs associated with Florida solid waste management in 2016 and for each alternative approach are shown in Table 5.4.1. Table A1 depicts the mass category and its associated economic costs category. Table A2 provides the net economic cost in (\$USD/tonne), which includes the costs and revenues associated with each category. Further details as to how each of the economic categories were calculated are shown in Tables A3-A12.

For WTE, residential curbside recycling, and C&D and YT, mass categories followed the current state of affairs. They included:

1. Residential collection
2. Non-residential collection
3. YT collection
4. C&D collection
5. Recycled direct residential and non-residential
6. Recycled direct yard trash
7. Recycled yard trash used as landfill cover
8. Recycled direct C&D
9. Recycled post-combustion
10. Landfilled direct C&D
11. Landfill direct non-C&D
12. Landfill post-combustion
13. Combustion
14. Transfer station and hauling

For the MWP approach, mass categories included:

1. Residential collection
2. Non-residential collection
3. YT collection
4. C&D collection
5. Mixed waste processed mass
6. Recycled direct residential and non-residential
7. Recycled direct yard trash
8. Recycled yard trash used as landfill cover
9. Recycled direct C&D
10. Recycled post-combustion
11. Landfilled direct C&D

12. Landfill direct non-C&D
13. Landfill post-combustion
14. Combustion
15. Transfer station and hauling

For the non-residential food-waste composting approach, the mass categories included:

1. Residential collection
2. Non-residential collection
3. YT collection
4. C&D collection
5. Food waste composting mass
6. Recycled direct residential and non-residential
7. Recycled direct yard trash
8. Recycled yard trash used as landfill cover
9. Recycled direct C&D
10. Recycled post-combustion
11. Landfilled direct C&D
12. Landfill direct non-C&D
13. Landfill post-combustion
14. Combustion
15. Transfer station and hauling

The WTE approach had the highest net annual economic cost, exceeding the 2016 baseline cost by \$376 million. WTE assumes that only the larger counties would construct a WTE facility, and smaller counties (with populations lower than 150,000) would transport their waste to those facilities. Note that the cost of transporting waste from smaller to larger counties is not included. The WTE facility net economic conversion factor (\$90.63/tonne, Table A2; see the Appendix for methodology) was applied to the combustion mass flow. The conversion factor was calculated by averaging annual costs per tonne for Palm Beach County, Miami-Dade County, and Lee County. Annual costs per tonne include amortized capital costs, operation and maintenance costs, and revenue from recovery of metals divided by the total mass managed by the county's WTE facility (see Tables A5 and A11 for additional details).

The residential curbside and C&D and YT recycling approaches resulted in a decrease in cost compared to the 2016 baseline. This is due to the revenue associated with recycling materials because of the increased recycled mass and a reduction in the mass of materials disposed and combusted. The non-residential food-waste composting approach costs (see Tables A2 and A7) do include the costs associated with additional food waste collection, because the food waste would need to be collected in a separate dumpster and collection vehicle. The mass managed or costs associated with a transfer station did not change for any of the approaches, although the WTE approach assumes that the smaller counties would need to transport their wastes to a WTE located in a larger county.

Table 5.4.1: Economic net cost in total cost for the baseline and alternative approaches.

Approach	Economic net cost (total cost in \$USD)	Economic cost variation (total cost in \$USD)
2016 baseline	\$3,196,133,190	-
WTE approach	\$3,568,278,784	\$372,145,595
MWP approach	\$3,302,449,538	\$106,316,348
Residential curbside recycling approach	\$3,162,714,786	-\$33,418,404
C&D and YT recycling approach	\$3,144,865,332	-\$51,267,857
Non-residential food waste composting approach	\$3,236,699,738	\$40,566,548

5.5 PROSPECTIVE ALTERNATIVE APPROACHES COMPARISON

As described throughout this report, an objective of this study was to evaluate the application of SMM. One way of doing this is to compare the environmental footprint and economic costs of prospective alternative waste management approaches. Decision makers can use the environmental and economic results to identify the most environmental and economically advantageous alternatives.

In this section, the five alternative approaches have been discussed in detail and their environmental footprints and economic costs are described. A concept of SMM is to base decisions using lifecycle thinking, where more than one impact indicator (e.g., GHG emissions, costs, etc.) is used. For example, a solid waste decision maker would choose a management approach based on that approach's environmental, economic, and social impact. We chose to evaluate the environmental and economic impact of the current and alternative approaches, but future studies can also incorporate an approach's social impact.

The use of more than one indicator to base decisions upon provides a holistic perspective in understanding the impact of a management strategy. We used direct environmental and economic results to create a metric for comparing the environmental and economic impact of each alternative approach. The metric estimated GHG emissions (in modified units of 0.001 tCO₂eq./person), energy use (in modified units of 100 MJ/person), and costs (in modified units 10,000,000 \$USD) associated with additional total recycling rate percentage points in the 2016 baseline data and the approaches (Figure 5.5.1). This was done by first calculating the differences in per capita GHG emissions, per capita energy use, and total costs between the approaches and the baseline and then dividing those differences by the percentage point increase of each approach, as shown in Table 5.5.1.

Standardizing baseline and alternative environmental and economic costs to the benefit associated with increasing total recycling rate percentage points shows that the residential curbside recycling approach generated the largest energy use reduction (Figure 5.5.1), and when comparing the results to the 2016 baseline, there was a cost reduction (Section 5.4). This large environmental reduction was due to recycling materials that WARM assumes offset the need and

use of virgin materials and because the materials recycled in that approach (e.g., aluminum cans, cardboard) have a larger environmental impact than other materials.¹⁹ In fact, the MWP approach generated the second-largest energy use reductions due to recycling.

The WTE approach generated the greatest total recycling rate percentage point difference compared to the baseline (13.1%, Table 5.5.1) and one of the least GHG emissions reductions (Figure 5.5.1). This is because although WARM assumes that materials combusted at a WTE facility generate energy that offsets the use of non-renewable resources (which explains why the WTE approach has the third-highest energy use reduction), the combustion of plastics releases non-biogenic CO₂ that would have not been released if raw materials used in the manufacturing of plastics were not extracted from the earth.¹⁹

The C&D and YT approach had a GHG emissions and energy usage reduction slightly less than the baseline because composting yard trash releases methane and is energy intensive (Figure 5.5.1). Although Figure 5.5.1 shows that the non-residential food waste composting approach has the largest GHG emissions reduction, this is because the associated percentage point increase is the lowest (0.040%) of all the approaches. Dividing the additional GHG emissions reductions by a small percentage point results in a large GHG emissions reduction per percentage point but also results in a high cost per percentage point, as seen in Figure 5.5.1. Notably, WARM composting GHG emissions and energy factors do not include offsetting the manufacture of fertilizers, which are energy and emission intensive processes due to the mining of nitrogen and phosphorous. There is potential to expand WARM's system boundary and include offsetting fertilizer manufacture in the composting factors.

Other metrics not evaluated included politics and marketability of recyclables. Many of the approaches include mandates from the state (e.g., mandatory residential recycling, mandatory C&D and YT recycling, etc.). In Florida implementing such mandates would be challenging. With recycling, many recycling commodity's marketability experience fluctuations due to challenges in the global markets. The current 2016 baseline and alternative approaches rely on a 2016 inflated revenue per tonne (see Tables A2, A6, and A8), which is based on referenced feasibility studies and local government financial reports from various past years that provide revenue based on that year's marketability. However, it should be noted that in the future, decision makers need to base decisions on that year's current marketability realities in order to make the best decisions.

Using the current metric of comparing GHG emissions, energy use, and costs with the incremental total recycling rate percentage point increase shows the associated environmental and economic impact of each approach. It is important for decision makers to evaluate materials management approaches using SMM and lifecycle thinking because it provides them with a holistic strategy that incorporates impacts beyond one area of concern.

Table 5.5.1: Total recycling rate percentage point differenced between the approaches and the 2016 baseline.

Approach	Total recycling rate percentage point increase
WTE approach	13.1%
MWPF approach	10.4%
Residential curbside recycling approach	8.12%
C&D and YT recycling approach	6.51%
Non-residential food waste composting approach	0.040%

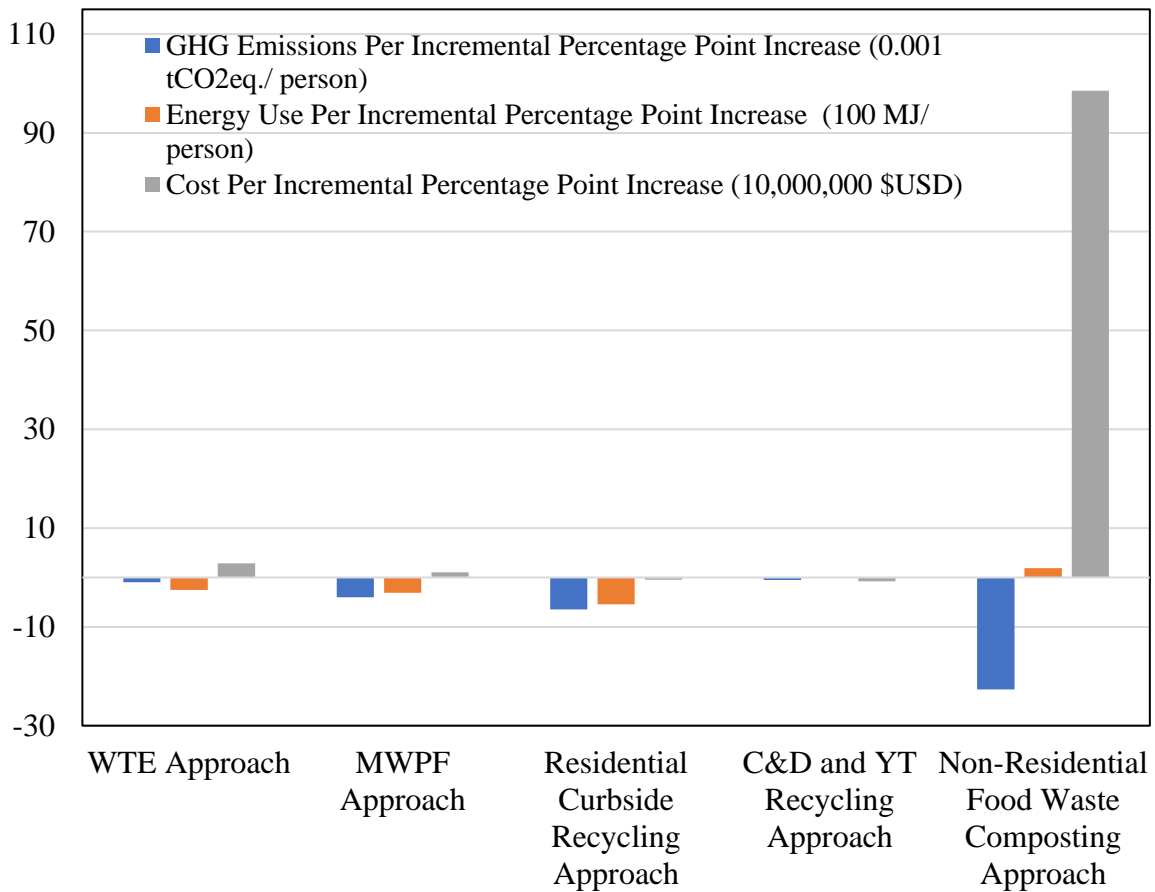


Figure 5.5.1: GHG emissions, energy use, and cost associated with each approaches' incremental total recycling rate percentage point increase.

6.0 LIFECYCLE-THINKING-BASED ALTERNATIVE METRICS

Across the US, local governments rely on specific indicators to evaluate their performance and progress toward sustainably managing materials. In many states, the recycling rate is a popular metric used to establish goals to be achieved by a deadline; such is the case in Maryland and Florida, which set recycling rate goals of 55% and 75%, respectively, to be reached by 2020. These recycling rates correspond to the mass of material recycled (or diverted from landfill disposal in some cases) divided by the total mass generated. Although the mass-based metric is a tangible target, it suffers from numerous integral problems.³⁵⁻³⁷ The fundamental issues are that (a) source reduction efforts and impacts are not reflected in the rate and (b) environmental benefits associated with recycling a material are treated equally among all materials. In reality, the recycling of some materials produces much greater environmental savings (e.g., GHG emissions reduction and energy use savings) than others.³⁸⁻⁴⁰

The aim of this section is to examine alternative approaches to mass-based recycling rates for quantifying and tracking progress toward SMM. The evaluation uses existing LCI conversion factors and mass data on materials generation and disposition to demonstrate an approach whereby the lifecycle outcomes related to changes in materials management (e.g., energy use savings through an increase in source reduction) are expressed in units equivalent to mass-based recycling rates. We illustrated this approach for Florida by connecting the state's statutory recycling goal of 75% with a set of GHG emissions and energy use savings metrics corresponding to the year the Legislature enacted the goal (2008). The aim of this evaluation is to present an example of utilizing lifecycle data in SMM goal setting to provide a platform for policy makers to explore future alternatives to traditional mass-based recycling rates.

Setting 2008 as the baseline year, the examination used state-reported, per-capita materials flow data to develop two different materials management baselines (Table 6.1), each representing materials management approaches corresponding to a 75% recycling rate in that year. The WARM LCI factors for individual waste components were applied to the materials flow and disposition for each baseline, yielding a total GHG emissions and energy use footprint corresponding to a 75% recycling rate. The examination used per capita generation rates of individual waste components from 2008 and 2020 (projected using 2015 data) and utilized the differences between the two years to account for source reduction. To illustrate the application of this method, several different 2020 SMM approaches were developed and compared to examine the progress each strategy makes toward the conventional and LCI-normalized recycling rate aims. The approaches includes expanded use of EfW, enhanced recycling of curbside recyclables (e.g., bottles, cans, and paper products), organics (e.g., food waste) and a combination of C&D and YT (Table 6.2). The fifth approach integrates recycling of curbside materials, organics, C&D and YT. GHG emissions and energy use footprints in future years were similarly calculated and compared to each baseline. The results were normalized to the 75% mass-based recycling rate to express the environmental footprint results in similar units.

The recycling-dominated baseline resulted in a greater GHG emissions and energy use avoidance (-1.87 tCO₂eq/capita and -20,600 MJ/person, respectively). The negative value indicates a GHG emissions or energy use avoidance compared to the combustion-dominated baseline (-1.49

tCO₂eq/capita and -19,500 MJ/person, respectively). GHG emissions and energy use avoidance occurs when recycled materials offset the use of virgin materials because of the large savings associated with recycling waste components.⁴¹⁻⁴³ The net results, even when a relatively large fraction of the waste is landfilled, remain negative (i.e., the overall waste management footprint results in energy offset and GHG emissions reduction). Both the GHG emissions and energy use footprints represent the net MJ and tCO₂eq emissions based on end-of-life management (emissions associated with materials collection, transport, recycling, and disposal). WARM energy use factors for some recycled materials provide greater GHG emissions and energy savings relative to combustion; thus, the recycling-dominated baseline is more negative (greater savings) compared to the combustion-dominated baseline.

The mass-based recycling rates for each approach are the same in both Figures 6.1 and 6.2 (mass-based rates are independent of baseline). Without the inclusion of EfW as recycling credit (labeled as traditional), the greatest recycling rate reached among the approaches is 60.7%, corresponding to an approach where the recycling rates of dominant curbside recyclables (see Table 6.2), food waste, yard trash, and C&D are all increased to 75%. This highlights the challenges faced by state and local governments in meeting aggressive recycling rate goals. Even if these materials were recycled at 75% (which would be challenging), much of the waste stream is composed of other types of paper, plastic, and miscellaneous materials. When EfW is included as recycling, following the current Florida model, the highest rate achieved (68.8%) still falls short of Florida's 75% recycling goal.

Figures 6.1 and 6.2 also present the LCI-normalized recycling rates for both the GHG emissions and energy use footprint categories. The contribution of waste prevention (or increase) are separately noted. A comparison of both figures reveals that LCI-normalized recycling rates are notably greater when progress is compared to the combustion-dominated baseline rather than the recycling-dominated baseline. As previously discussed, WARM LCI factors for the recycling of many materials are greater than the LCI factors associated with combustion. When a benchmark baseline incorporates a large amount of EfW, SMM methods with large recycling (especially of materials with highly negative emission factors) result in much greater LCI-normalized recycling rates. On the other hand, baselines derived from approaches with large amounts of recycling result in LCI-normalized recycling rates that are more challenging to meet through EfW. Another shared observation from both Figures 6.1 and 6.2 is the relatively large contribution of source reduction to LCI-normalized recycling rates. In most cases, LCI-normalized recycling rates exceeding 75% would not be observed without the inclusion of source reduction.

Figure 6.3 further illustrates the relative difference among materials with respect to GHG emissions and energy use. Shown are the increases in mass-based and LCI-normalized recycling rates that would result from an increase in the recycling rates of individual waste components to 75% by 2020 (increased from the projected values based on 2015 measured recycling rates). The two material categories that result in the largest incremental increase in mass-based recycling rates are mixed paper (3.8%) and C&D (5.8%). These components are among the largest in the waste stream. When the GHG-normalized recycling rates for these two materials are compared, the results are dramatically different. An increase in mixed paper recycling would result in a

much-enhanced incremental GHG-normalized recycling rate of 15.8%, while C&D would only produce a 1.8% increase. If a lifecycle-based LCI-normalized recycling rate system were employed using only GHG emissions and energy use as environmental footprints, some materials would result in LCI-normalized recycling rates greater than mass-based rates (paper, metals, plastic), while others would be less (food waste, C&D, glass, yard trash).

Government agencies at the local, state and federal levels as well as larger corporate and institutional entities are more commonly embracing concepts such as SMM and the circular economy. States such as Oregon are beginning to integrate SMM principles into their waste (materials) management plans using LCI metrics on environmental footprint categories such as GHG emissions for goal setting and resource allocation.⁴⁴ Here, the approach provides two environmental footprint categories (GHG emissions and energy use) and measures materials management program progress in a form analogous to the commonly used mass-based recycling rate. This approach may, in some cases, make the transition from mass-based to LCI-normalized targets more feasible to policymakers and the public, as the resulting metric is less abstract.

Table 6.1: Combustion-dominated and recycled-dominated baselines.

Baseline	Description
Combustion-dominated baseline	Achieved by a mixture of increasing the reported 2008 material's recycling rates and portioned the rest (collected-recycling) more towards combustion than landfilling.
Recycled-dominated baseline	The reported combustion materials were unmodified, but all MSW material's recycling rates were increased to 65%, except ferrous metals (75%).

Note: Created using FDEP 2008 SWM annual reports to hypothetically achieve the 75% recycling rate in that year by increasing the materials that were otherwise landfilled to either be combusted or recycled. Both baselines include recycling credits from Florida's 2008 EfW facilities.

Table 6.2: The five approaches.

Approach	Description
EfW approach	Expands on Florida's EfW recycling credits, by diverting a third of the total collected MSW of the five most populated counties (Duval, Brevard, Polk, Volusia, and Orange county) to a WTE facility to recover EfW recycling credits.
Curbside approach	The major residential curbside materials (newspaper, glass, aluminum and steel cans, plastic bottles, corrugated and office paper) are recycled in the state at 75%.
Organics approach	The state's food waste is recycled at 75%.
C&D and YT approach	The state's C&D and YT are recycled at 75%.
Combination approach	Combines the curbside, organics, and C&D and YT approaches.

Note: Created using FDEP 2015 SWM annual reports and projections for Florida's population in 2020. The five approaches correspond to aggressive approaches in increasing either the recycling or combustion rates of materials that otherwise would be landfilled in Florida in 2020 to increase the state's total recycling rate.

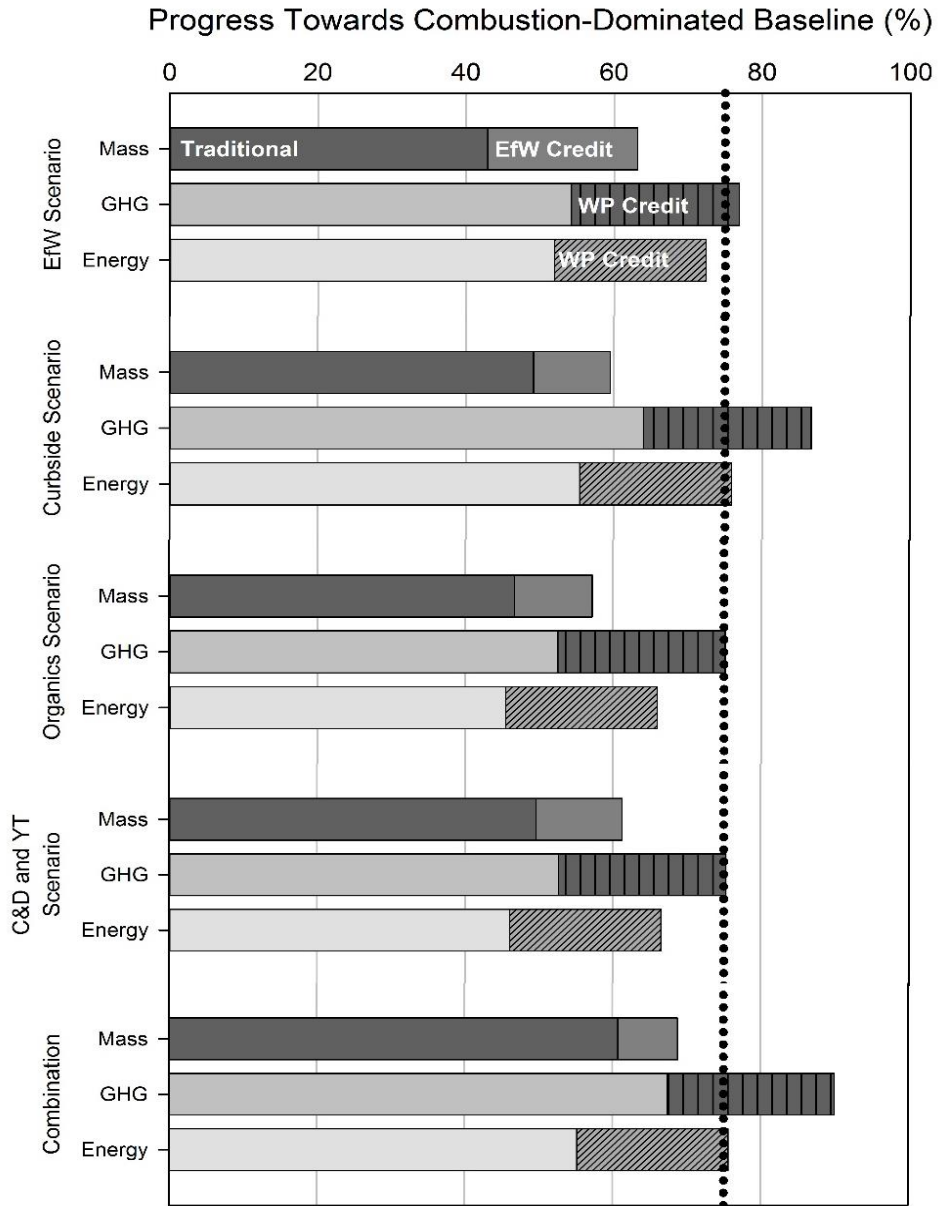


Figure 6.1: Comparison of the progress of the five scenarios toward the combustion-dominated baseline.

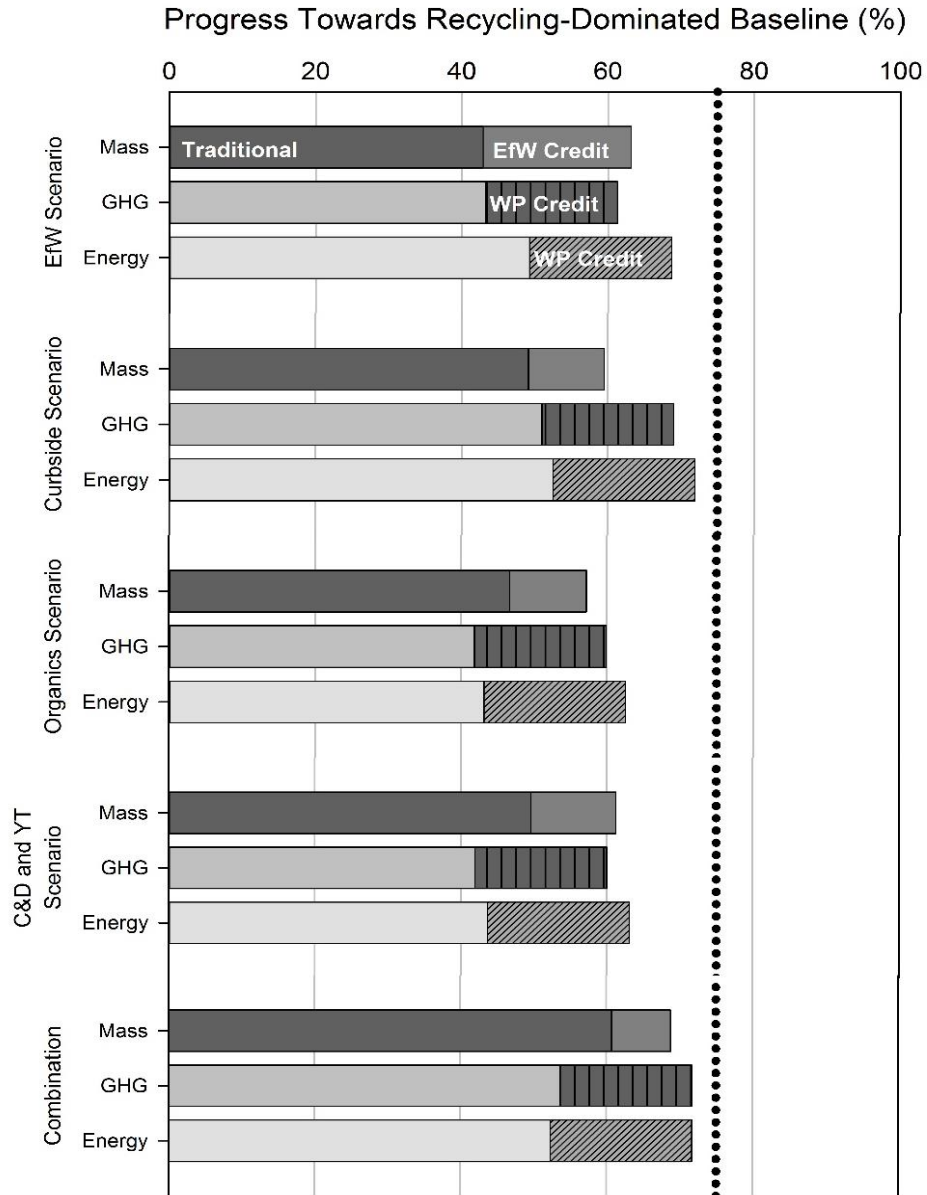


Figure 6.2: Comparison of the progress of the five scenarios toward the recycling-dominated baseline.

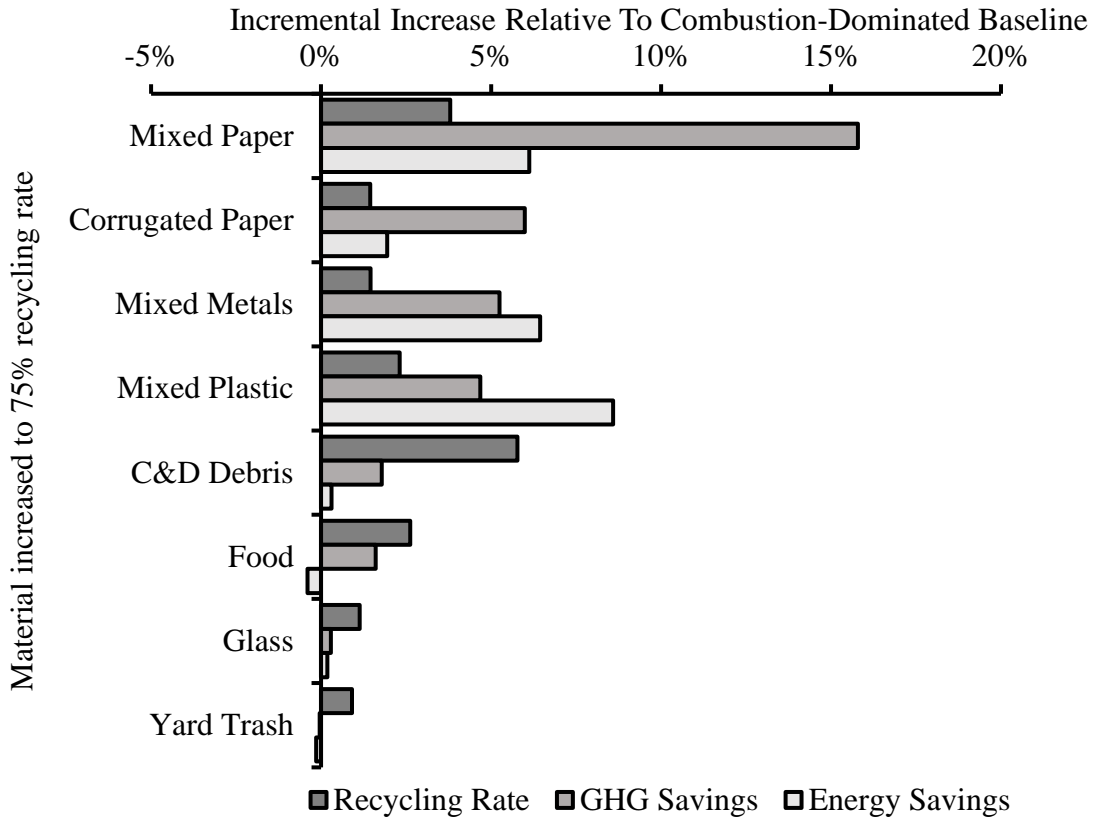


Figure 6.3: Incremental increase in progress toward the combustion-dominated baseline LCI results when the recycling rate for each material in 2020 is set to 75%, not including source reduction.

7.0 CONCLUSION

We mapped Florida's solid waste management and disposition, used WARM LCI factors to measure the associated environmental footprint, conducted an associated economic assessment, and assessed the implications of implementing SMM principles through alternative management approaches and potential alternative recycling metrics.

The mapped solid waste management and disposition refined the reported 2016 estimates into four overall generator categories: residential, non-residential, construction and demolition (C&D) debris, and yard trash. It also refined the overall mass dispositions into five categories: recycled direct, recycled post-combustion, landfill C&D debris direct, landfill non-C&D debris direct, landfill post-combustion, and combustion. The estimates provided valuable recycling rate data in terms of standard, traditional, and total recycling rates. The total residential recycling rate (41.0%) had the lowest rate compared to the other categories: non-residential (55.1%), C&D debris (62.6%), and yard trash (78.2%). The state's total recycling rate was 56%, with 42% attributed to traditional recycling and 12% to combustion of waste. Many of the counties with the highest reported total residential recycling rates have standard and traditional recycling rates that fall within the range of many counties in Florida that do not receive any recycling credits due to combustion.

The implications of implementing SMM were analyzed by comparing the 2016 environmental and economic baseline to alternative approaches that used SMM principles. The alternative approaches included waste-to-energy, mixed waste processing, mandatory C&D debris and yard trash recycling, mandatory residential curbside recycling, and mandatory non-residential food waste composting. When each approach was compared to the baseline 2016 results, many approaches had a higher economic cost, all had a higher recycling rate, and most resulted in a greater savings of GHG emissions and energy use. However, none of the approaches achieved the 75% recycling rate goal by 2020. Furthermore, this analysis was completed for case studies in Alachua, Escambia, Palm Beach, and Sarasota County (using different alternative approaches for each).

We examined other metrics (other than the traditional mass-based recycling rate) that included a GHG emissions and energy use normalized recycling rate. Florida's body of solid waste management data served as a case study to examine the applicability of alternative metrics. Steps to calculate the alternative metric included developing a baseline set of LCA output results for the 2008 waste composition and disposition using WARM, then comparing those results with LCA output results for five prospective 2020 alternative waste composition and disposition approaches. The metric developed was related to Florida's 75% recycling goal by 2020 by normalizing the initial LCA output rate, which was calculated as the ratio of the outputs for each 2020 approach to the LCA output results for 2008. The overall results signify that none of the 2020 approaches for mass-based rates were able to achieve the 75% recycling goal, however, in some cases the LCA-based rate achieved the goal.

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APPENDIX: ECONOMIC COSTS

Table A1: Mass categories and corresponding economic cost categories examined in this study.

Mass category	Associated economic cost category
Collected residential	Residential collection
Collected non-residential	Non-residential collection
Collected yard trash	Residential collection
Collected C&D debris	N/A
MWP	MWP facility
Windrow composting	Windrow composting facility
Aerated static pile composting	Aerated static pile composting facility
In-vessel composting	In-vessel composting facility
Recycled direct residential and non-residential	Single- and dual-stream MRF
Recycled direct yard trash	Yard trash windrowing
Recycled yard trash used as landfill cover	Yard trash mulching
Recycled direct C&D debris	C&D debris MRF
Recycled post-combustion	WTE facility
Landfill direct C&D debris	C&D debris landfill
Landfill direct non-C&D debris	MSW landfill
Landfill post-combustion	MSW landfill
Combusted	WTE facility
Transfer station and hauling	Transfer station facility

Note: Used to estimate Florida 2016 baseline and alternative-approach solid waste management costs. Economic cost category values are presented in Table A2.

Table A2: Economic cost categories evaluated in this study and their economic costs, revenue, and net costs.

Economic cost category	Economic cost (cost per tonne in \$USD/tonne)	Economic revenue (cost per tonne in \$USD/tonne)	Net economic cost (cost per tonne in \$USD/tonne)
Residential collection^a	\$105.97	—	\$105.97
Non-residential collection	\$95.82	—	\$95.82
C&D Debris collection^b	—	—	—
MWP facility	\$51.05	\$90.24	-\$39.19
Yard trash windrowing	\$23.58	—	\$23.58
Yard trash mulching	\$13.23	—	\$13.23
Windrow composting facility	\$47.79	\$17.63	\$30.16
Aerated static pile composting facility	\$54.02	\$22.60	\$31.43
In-vessel food waste composting facility	\$168.43	\$22.60	\$145.83
Single-stream MRF	\$81.49	\$90.24	-\$8.75
Dual-stream MRF	\$107.43	\$90.24	\$17.19
C&D debris MRF	\$80.29	\$78.49	\$1.79
C&D debris Landfill	\$14.70	—	\$14.70
MSW landfill	\$22.05	—	\$22.05
WTE facility^c	\$89.90	\$0.00	\$89.90
Transfer station facility	\$20.11	—	\$20.11

Note: Net cost for each category was used as a conversion factor to convert the mass (in tonnes) for each mass flow to a cost (in \$USD). Net costs are specific to each cost category; methods for estimating each category are shown in Tables A3-A12.

- a. Includes costs associated with yard trash and recycling collection.*
- b. Not evaluated.*
- c. Includes costs and revenues associated with recovery of ferrous and non-ferrous metals in combustor ash.*

Table A3: Average cost of residential collection.

Municipality/county	Cost per tonne (\$USD/tonne-year)
City of Sanibel	\$133.87
City of Eustis	\$91.22
Indian River County	\$98.64
City of Key West	\$209.22
Solid Waste Authority of Palm Beach County	\$133.87
Charlotte County	\$75.25
Collier County	\$68.97
Hernando County	\$59.89
Pasco County	\$100.34
Polk County	\$73.80
Sarasota County	\$123.74
Martin County	\$138.41
Hillsborough County	\$56.42
Volusia County	\$123.74
Average cost of residential collection	\$105.97

Note: Calculated by averaging each cost from Florida municipalities and counties. Each jurisdiction publishes rate study reports that include residential collection costs broken into separate categories (e.g., collection, disposal, administrative charge). The cost per tonne for each jurisdiction includes only collection-related costs and does not include disposal costs. The collection cost per household-year was converted to a cost per tonnes-year by assuming that a household generates 1.64 tons/year (based on the City of Sanibel rate study); then, that value for cost per ton was converted to a cost per tonne.

Table A4: Average cost of non-residential collection.

Municipality/county	Cost per tonne (\$USD/tonne-year)
City of Sanibel ^a	\$134.90
City of Key West ^b	\$108.56
City of Coconut Creek ^b	\$61.13
City of Lauderdale Lakes ^b	\$109.06
Manatee County (average area 1-2) ^b	\$82.55
Monroe County (average area 1-4) ^b	\$98.38
Solid Waste Authority of Palm Beach County ^c	\$64.83
Average cost non-residential collection	\$95.82

Note: Calculated similarly to Table A3. Costs include only costs related to collection and container rental/maintenance, not disposal. Costs shown are an average of the cost per ton associated with varied container sizes (2, 4, 6, and 8 yd³) and varied collection rates (e.g., once a week, twice a week). After disposal costs were removed, costs associated with each cubic yard were converted to tons using an assumed container density (lbs/yd³); then, that value was converted from cost per ton to cost per tonne.

- a. The City of Sanibel rate study reports that the density of a container is (153 lbs/yd³); this value was used to convert from cost per yd³ to cost per ton and then to cost per tonne.*
- b. The City of Key West rate study reports that the density of a container is (163 lbs/yd³); this value was used to convert from cost per yd³ to cost per ton and then to cost per tonne.*
- c. The Solid Waste Authority of Palm Beach County rate study reports that the density of a container is (134 lbs/yd³); this value was used to convert from cost per yd³ to cost per ton and then to cost per tonne.*

Table A5: Average cost of a WTE facility.

Municipality/county	Cost per tonne (including revenue) (\$USD/tonne)	Cost per tonne (not including revenue) (\$USD/tonne)
Solid Waste Authority of Palm Beach County (REF #1)	\$110.03	\$108.92
Solid Waste Authority of Palm Beach County (REF #2)	\$113.90	\$115.95
Lee County	\$47.98	\$53.64
Miami-Dade County	—	\$79.26
Average cost of a WTE facility	\$90.63	\$89.44

Note: Based on county financial reports that provide the throughput tonnage processed by each county's WTE facility and its associated WTE costs (including depreciation, operation, maintenance, and revenue from metals recovery). WTE costs were divided by the throughput tonnage to generate a cost per ton and then converted to a cost per tonne. Table A11 provides greater detail on how the average cost of WTE facilities was derived.

Table A6: MWP facility cost.

Facility type	Reference capacity (tons/year)	Original capital cost	Inflated to 2016 capital cost	Original operating life (years)	Amortized capital cost	Capital cost (\$USD/tonnes)		
MWP	243,750	\$45,181,000	\$45,510,821	59	\$3,502,970	\$15.84		
	325,000	\$61,111,000	\$61,575,444	78	\$4,356,442	\$14.78		
Average cost MWP						\$15.31		
Facility type	Original O&M cost	Inflated 2016 O&M cost	O&M cost (\$USD/tonnes)	Reference recycled tons	Revenue (\$USD/tonnes)	Total cost (\$USD/tonnes-year)	Net cost (\$USD/tonnes-year)	Source
MWP	\$8,351,194	\$8,412,157	\$38.04	—	—	—	—	Burns & McDonnell, 2015
	\$9,786,133	\$9,857,572	\$33.43	—	—	—	—	Burns & McDonnell, 2015
Average cost MWP			\$35.74		\$90.24^a	\$51.05	-\$171.25	

Note: MWP facility cost is an average of the estimated costs from reported MWP facility feasibility studies. The studies provide data related to throughput tonnage, capital costs, operating life, operation and maintenance (O&M) costs, and revenue from recycling. Capital and O&M costs were inflated from the feasibility study publication year to 2016, and the capital costs were amortized over 20 years using a 2016 federal funds discount rate of 1.02%.

- a. We assumed that the MWP revenue was equal to the single and dual stream MRF revenue obtained from the 2016 Solid Waste Authority of Palm Beach County financial report (see Table A8).*

Table A7: Composting costs.

Facility type	Reference capacity (tons/year)	Original capital cost	Inflated to 2016 capital cost	Original operating life (years)	Amortized capital cost	Capital cost (\$USD/tonnes)	Collection cost (\$USD/tonnes) ^a	
Windrow	40,150	\$3,492,500	\$4,719,067	20	\$262,057	\$7.19	\$11.02	
Aerated static pile	40,000	\$7,350,000	\$8,868,954	20	\$492,507	\$13.57	\$11.02	
In-vessel	40,000	\$6,272,000	\$9,217,041	20	\$511,837	\$14.11	\$11.02	
Windrow	50,000	\$2,500,000	\$2,733,608	20	\$151,802	\$3.04	\$11.02	
Windrow	1.12	\$49.75	\$51.33	20	\$2.85	\$2.85	\$11.02	
Average cost windrow						\$4.36	\$11.02	
Average cost aerated static pile						\$13.57	\$11.02	
Average cost in-vessel						\$14.11	\$11.02	
Facility type	Original O&M cost	Inflated 2016 O&M cost	O&M cost (\$USD/tonnes)	Lower bound revenue (\$USD/tonnes)	Upper bound revenue (\$USD/tonnes)	Total cost (\$USD/tonnes-year)	Net cost (\$USD/tonnes-year)	Source
Windrow	\$473,000	\$639,118	\$17.55	\$11.02	\$34.17	—	—	Haaren,2009
Aerated static pile	\$885,000	\$1,067,894	\$29.43	\$11.02	\$34.17	—	—	Haaren,2009
In-vessel	—	—	\$143.30	\$11.02	\$34.17	—	—	Haaren,2009
Windrow	\$48.69	\$53.24	\$53.24	—	—	—	—	Pisarek, 2012
Windrow	\$25.63	\$26.45	\$26.45	\$7.71	—	—	—	Levis, 2013
Average cost windrow			\$32.41	\$17.63		\$47.79	\$30.16	
Average cost aerated static pile			\$29.43	\$22.60		\$54.02	\$31.43	
Average cost in-vessel			\$143.30	\$22.60		\$168.43	\$145.83	

Note: Composting costs are an average of the estimated costs from reported composting facility feasibility studies. The studies provide data related to throughput tonnage, capital costs, operating life, operation and maintenance (O&M) costs, and revenue from recycling. Capital and O&M costs were inflated from the feasibility study publication year to 2016, and capital costs were amortized over 20 years using a 2016 federal funds discount rate of 1.02%.

a. Based on discussion with Waste Management contact.

Table A8: Single- and dual-stream MRF costs.

Facility type	Reference capacity (tons/year)	Original capital cost	Inflated to 2016 capital cost	Original operating life (years)	Amortized capital cost	Capital cost (\$USD/tonnes)		
Single-stream MRF	1.12	—	—	10	—	—		
Dual-stream MRF	1.12	—	—	10	—	—		
Single-stream MRF	65,000	\$25,993,591	\$26,181,335	10	\$2,767,370	\$46.93		
Single-stream MRF	1.12	\$18.10	\$18.23	10	\$18.23	\$18.23		
Dual-stream MRF	1.00	\$17.60	\$17.73	10	\$17.73	\$17.73		
Single-stream MRF	10,210	\$604,125	\$728,974	10	\$77,053	\$8.32		
Dual-stream MRF	8,439	\$517,417	\$624,347	10	\$65,994	\$8.62		
Dual-stream MRF ^a	98,142	—	—	—	—	—		
Average cost single-stream MRF						\$24.49		
Average cost dual stream MRF						—		
Facility type	Original O&M cost	Inflated 2016 O&M cost	O&M cost (\$USD/tonnes)	Original revenue (\$/tonnes)	Revenue (\$USD/tonnes)	Total cost (\$USD/tonnes-year)	Net cost (\$USD/tonnes-year)	Source
Single-stream MRF	\$15.16	\$16.24	\$16.24	—	—	—	—	Combs, 2012
Dual-stream MRF	\$9.72	\$10.41	\$10.41	—	—	—	—	Combs, 2012
Single-stream MRF	\$60.83	\$61.27	\$67.54	—	—	—	—	Gershman, Brickner & Bratton, Inc., 2008
Single-stream MRF	\$6.90	\$6.95	\$6.95	—	—	—	—	Pressley, 2015
Dual-stream MRF	\$5.80	\$5.84	\$5.84	—	—	—	—	Pressley, 2015
Single-stream MRF	\$1,053,634	\$1,271,378	\$137.26	—	—	—	—	R. W. Beck, 2009
Dual-stream MRF	\$1,015,846	\$1,022,263	\$133.53	—	—	—	—	R. W. Beck, 2009
Dual-stream MRF	—	—	—	—	\$90.24^a	\$151.75	—	SWA 2017 Component Cost Summary
Average cost single-stream MRF			\$57.00		\$90.24^a	\$81.49	-\$8.75	
Average cost dual-stream MRF			—		\$90.24^a	\$107.43	\$17.19	

Note: Single- and dual-stream MRF costs are an average of the estimated costs from reported single-stream and dual-stream facility feasibility studies and county financial reports. The studies provide data related to throughput tonnage, capital costs, operating life, operation and maintenance (O&M) costs, and revenue from recycling. Capital and O&M costs were inflated from the feasibility study publication year to 2016, and capital costs were amortized over 20 years using a 2016 federal funds discount rate of 1.02%. Capital cost per tonne is the amortized capital cost divided by the reference capacity. O&M costs per tonne is the inflated O&M cost divided by the reference capacity.

- a. SWA of Palm Beach County financial reports publish only the dual-stream total cost (depreciation and O&M costs combined) and throughput tonnage. We calculated a total cost per tonne of \$151.75. To find average dual-stream MRF costs, amortized and O&M costs for each source were summed, then the summed values and \$151.75 were averaged. We assumed that single- and dual-stream MRF revenue were equal to SWA of Palm Beach County reported revenue for 2016.

Table A9: C&D debris MRF costs.

Facility type	Reference capacity (tons/year)	Original capital cost	Inflated to 2016 capital cost	Original operating life (years)	Amortized capital cost	Capital cost (\$USD/tonnes)		
C&D debris MRF	126,541	\$1,204,498	\$1,726,282	20	\$95,863	\$0.84		
	126,541	\$1,583,105	\$2,268,900	20	\$125,996	\$1.10		
	4,113	\$74,711	\$90,151	20	\$5,006	\$1.34		
	68,528	—	—	20	\$235,500	\$3.79		
Average cost C&D debris MRF						\$1.77		
Facility type	Original O&M cost	Inflated 2016 O&M cost	O&M cost (\$USD/tonnes)	Lower bound revenue (\$USD/tonnes)	Upper bound revenue (\$USD/tonnes)	Total cost (\$USD/tonnes-year)	Net cost (\$USD/tonnes-year)	Source
C&D debris MRF	\$2,450,566	\$3,512,141	\$30.59	\$31.33^a	\$45.11^a	—	—	R. W. Beck, 2007
	\$3,389,075	\$4,857,208	\$42.31	\$31.33^a	\$45.11^a	—	—	R. W. Beck, 2007
	\$521,225	\$628,942	\$168.56	\$44.32		—	—	R. W. Beck, 2009
	\$4,514,098	—	\$72.61	\$193.19		—	—	Florida C&D MRF
Average cost C&D debris MRF			\$78.52	\$78.49		\$80.29	\$1.79	

Note: C&D debris MRF costs are an average of estimated costs from reported C&D debris MRF feasibility studies. The studies provide data related to throughput tonnage, capital costs, operating life, operation and maintenance (O&M) costs, and revenue from recycling. Capital and O&M costs were inflated from the feasibility study publication year to 2016, and capital costs were amortized over 20 years using a 2016 federal funds discount rate of 1.02%. Capital cost per tonne is the amortized capital cost divided by the reference capacity. O&M cost per tonne is the inflated O&M cost divided by the reference capacity.

a. Based on assuming that the mass recycled is 35% of the total collected mass (reference capacity).

Table A10: Average cost associated with MSW and C&D debris landfills.

Facility/region	Annual throughput (tonnes/year)	Net cost (\$USD/tonne)
<i>Privately owned MSW landfills</i>		
Clay County	118,841	\$18.49
Alachua County Disposal Bids		
ACMS-Heart of Florida, Sumter County, FL	163,293	\$18.19
Waste Management, Chesser Island Road, GA	163,293	\$15.38
<i>Publicly owned MSW landfills</i>		
Solid Waste Authority of Palm Beach County	721,212	\$26.84
Average private MSW landfill cost		\$14.22
Average public MSW landfill cost		\$26.84
Average cost MSW landfill		\$22.05
C&D debris landfills		
Orange Blossom and Orange County disposal cost estimate		\$14.70
Average cost C&D debris landfill		\$14.70

Note: Costs were estimated based on county financial reports and direct discussions with landfill operators. Net costs were calculated by dividing the annual throughput by total costs for each source.

Table A11: Average WTE facility costs.

Facility	Annual throughput (tonnes/year)	Net economic cost (\$USD)	Combustion cost (\$USD/tonne)
<i>Combustion Cost (not including metals recovery revenue)</i>			
Miami-Dade County	740,293	\$58,674,000	\$79.26
Lee County	557,919	\$29,926,035	\$53.64
Solid Waste Authority of Palm Beach County	392,716	\$42,781,156	\$108.94
Solid Waste Authority of Palm Beach County	596,419	\$67,260,265	\$112.77
<i>Combustion Cost (including metals recovery revenue)</i>			
Miami-Dade County	740,293	—	—
Lee County	557,919	\$26,766,628	\$47.98
Solid Waste Authority of Palm Beach County	392,716	\$42,781,156	\$108.94
Solid Waste Authority of Palm Beach County	596,419	\$67,260,265	\$112.77
Average waste-to-energy facility cost (not including metal recovery revenue)			\$88.65
Average waste-to-energy facility cost (including metal recovery revenue)			\$89.90

Note: Average WTE facility costs are based on county financial reports that provide throughput tonnage processed by each county's WTE facility and associated WTE costs (including depreciation, operation, maintenance, and revenue from metals recovery). WTE costs were divided by throughput tonnage to generate a cost per ton and then converted to a cost per tonne.

Table A12: Transfer station and hauling costs.

Facility type	Reference capacity (tons/year)	Original capital cost	Inflated to 2016 capital cost	Original operating life (years)	Amortized capital cost	Capital cost (\$USD/MT)					
Transfer station	260,000	\$7,300,000	\$8,446,281	25	\$384,506	\$1.63					
	390,130	\$10,503,500	\$12,152,810	25	\$553,242	\$1.56					
	552,630	\$14,453,400	\$16,722,942	25	\$761,291	\$1.52					
	51,508	\$4,116,000	\$4,146,047	25	\$188,744	\$4.04					
	136,512	\$5,496,000	\$5,536,121	25	\$252,025	\$2.04					
	520,000	\$13,292,000	\$15,379,174	25	\$700,118	\$1.48					
	181,606	—	—	—	—	—					
	131,000	—	—	—	—	—					
Average cost transfer station						\$2.05					
Facility type	Original O&M cost	Inflated 2016 O&M cost	O&M cost (\$USD/MT)	Transfer station amortized capital cost + O&M costs	Transfer station amortized capital cost + O&M costs (\$/ton)	Hauling costs	Hauling costs (\$USD/MT)	Total cost (\$USD/MT-year)	Net cost (\$USD/MT-year)	Source	
Transfer station	\$3.10	\$3.59	\$3.95	—	—	—	—	—	—	Kessler Consulting, Inc., 2011	
	\$3.10	\$3.59	\$3.95	—	—	—	—	—	—	Kessler Consulting, Inc., 2011	
	\$3.10	\$3.59	\$3.95	—	—	—	—	—	—	Kessler Consulting, Inc., 2011	
	\$474,000	\$477,460	\$10.22	—	—	—	—	—	—	GT Environmental, Inc., 2016	
	\$785,000	\$790,966	\$6.39	—	—	—	—	—	—	GT Environmental, Inc., 2016	
	\$2,630,000	\$3,042,975	\$6.45	—	—	—	—	—	—	J. R. Miller & Associates, 2014	
	—	—	—	\$1,816,403	\$11.03	\$1,603,864	\$9.74	—	—	Alachua County, 2016	
	—	—	—	\$2,196,870	\$18.49	—	—	—	—	Clay County, 2016	
Average cost transfer station			\$5.82	—	—	\$111 ^b	\$5.58^b	—	—	EPA, 2000, and ATRI, 2016	
Average cost transfer station							\$7.66	\$20.11^a	\$20.11		

Note: Transfer station and hauling costs are an average of estimated costs from reported transfer station feasibility studies. The studies provide data related to throughput tonnage, capital costs, operating life, operation and maintenance (O&M) costs, and revenue from recycling. Capital and O&M costs were inflated from the feasibility study publication year to 2016, and capital costs were amortized over 20 years using a 2016 federal funds discount rate of 1.02%. Capital cost per tonne is the amortized capital cost divided by the reference capacity. O&M cost per tonne is the inflated O&M cost divided by the reference capacity.

- a. Total cost is calculated by taking the average of (1) the value after averaging \$2.05 (average capital cost per tonne) and \$5.82 (average O&M cost per tonne); (2) Alachua County transfer station amortized capital + O&M costs (\$11.03); and (3) Clay

County transfer station amortized capital + O&M costs (\$18.49). Then, average hauling costs of \$7.66 are added to total \$20.11.

- b. Hauling cost was calculated by assuming that the cost of a tractor trailer truck is \$1.59/mile; this value includes vehicle- and driver-based costs and was extracted from the American Transportation Research Institute 2016 report. Then, using the EPA Waste Transfer Station document, we assumed that the average round-trip distance between a transfer station and a landfill is 70 miles/load and that for each load a transfer station tractor trailer can dispose of 22 tons. Multiplying \$1.59/miles by 70 miles/load results in \$111 total hauling costs. Then, dividing by 22 tons/load and converting to cost per tonne, we estimate hauling costs were \$5.58/tonne.*

Table A13: Amortized capital, O&M, and transportation costs, revenue, and operating life for each facility type.

Facility type	Operating life (years)	Amortized capital cost (\$USD/tonne)	O&M cost (\$USD/tonne)	Transportation costs (\$USD/tonne)	Revenue (\$USD/tonne)	Total cost (\$USD/tonne)	Net cost (\$USD/tonne)
MWP	20	\$15.31	\$35.74		\$90.24	\$51.05	-\$39.19
Windrow composting	20	\$4.36	\$32.41	\$11.02	\$17.63	\$47.79	\$30.16
Aerated static pile composting	20	\$13.57	\$29.43	\$11.02	\$22.60	\$54.02	\$31.43
In-vessel composting	20	\$14.11	\$143.30	\$11.02	\$22.60	\$168.43	\$145.83
Single-stream MRF	10	\$24.49	\$57.00		\$90.24	\$81.49	-\$8.75
Dual-stream MRF	10	\$13.17	\$49.93		\$90.24	\$107.43	\$17.19
C&D debris MRF	20	\$1.77	\$78.52		\$78.49	\$80.29	\$1.79
C&D debris Landfill	—						
MSW landfill	—						
Transfer station facility	25	\$2.05	\$5.82	\$7.66	\$0.00	\$20.11	\$20.11

Table A14: Methodology used to estimate the cost of a new compliance officer.

Household waste generates (tons/household-year)	3.29
Total recycled curbside materials (tons/year)	4,312,369
Total of number of households	1,312,746
Number of households serviced by officer (household/officer-year)	1,000
Number of officers needed	1,313
Compliance officer annual salary + 40% fringe	\$85,722
Total cost of new compliance officers	\$112,531,177

Note: This cost was incorporated only in the residential curbside recycling approach as an indirect cost. To estimate the cost, we assumed a household will generate 3.29 tons/household-year (derived from the EPA-reported 4.5 lbs waste/person-year). Then, based on the additional 4.31 million tons recycled in the residential curbside recycling approach, this results in a total of 1.31 million households. We assumed that one compliance officer is responsible for 1,000 households (1,000 households managed/officer-year), which results in a total of 1,313 officers needed to manage the additional recycled curbside mass. The US Department of Labor Bureau of Labor Statistics reports that a compliance officer in Florida in 2016 earned a salary of \$61,230, and we assumed that an officer will receive a 40% fringe benefit. Total indirect cost added to the final residential curbside recycling approach was \$112.5 million.