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POWERING THE NEW ENGINEER TO TRANSFORM THE FUTURE

An Integrated Tool for Local Government to Track Materials Management and Progress toward Sustainability Goals

October 13th, 2020

University of Florida

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University of Florida, USA

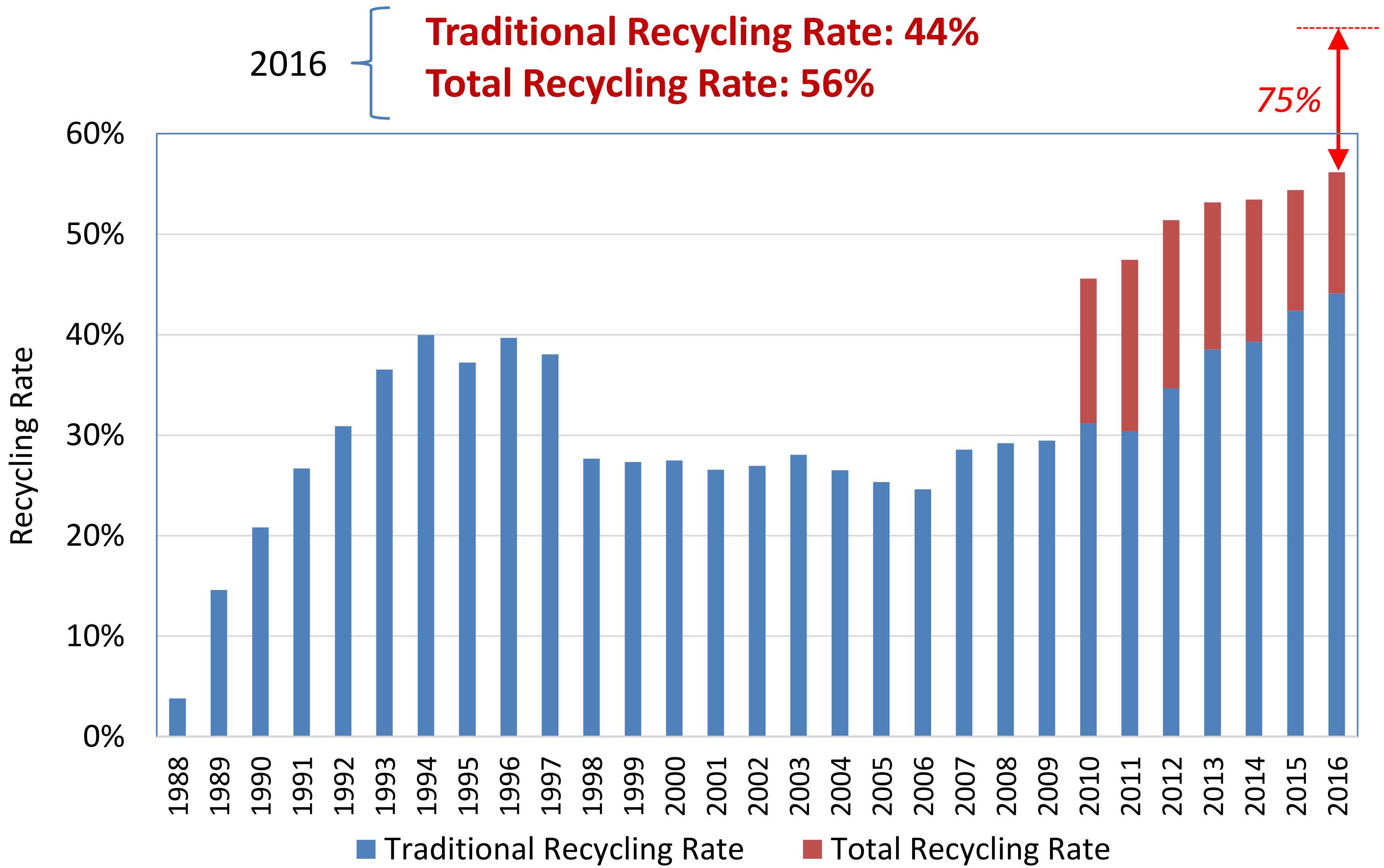
Projects History

2016

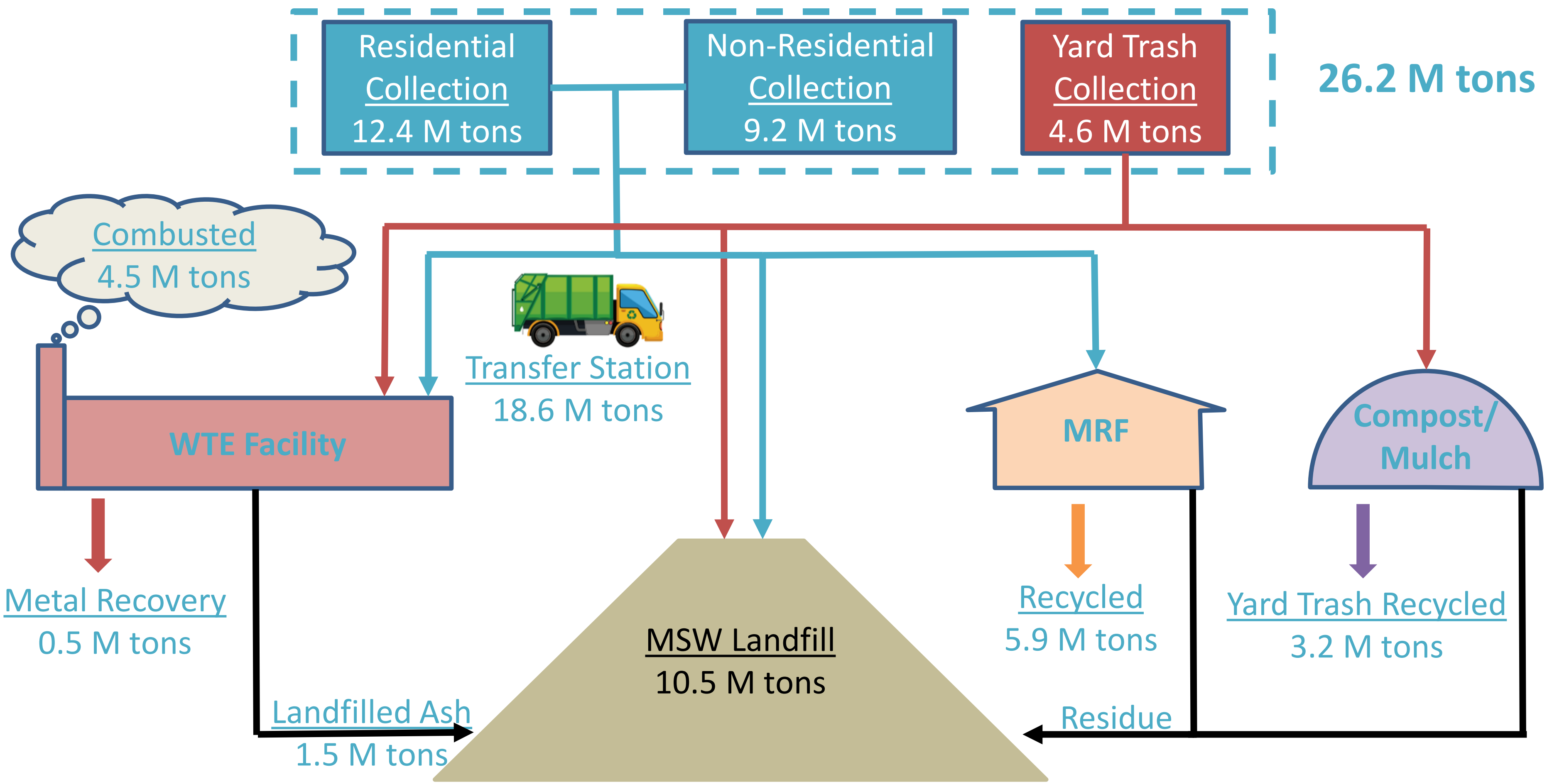
Hinkley Center Florida Solid Waste Management: State of the State

(HC16/17 Project)

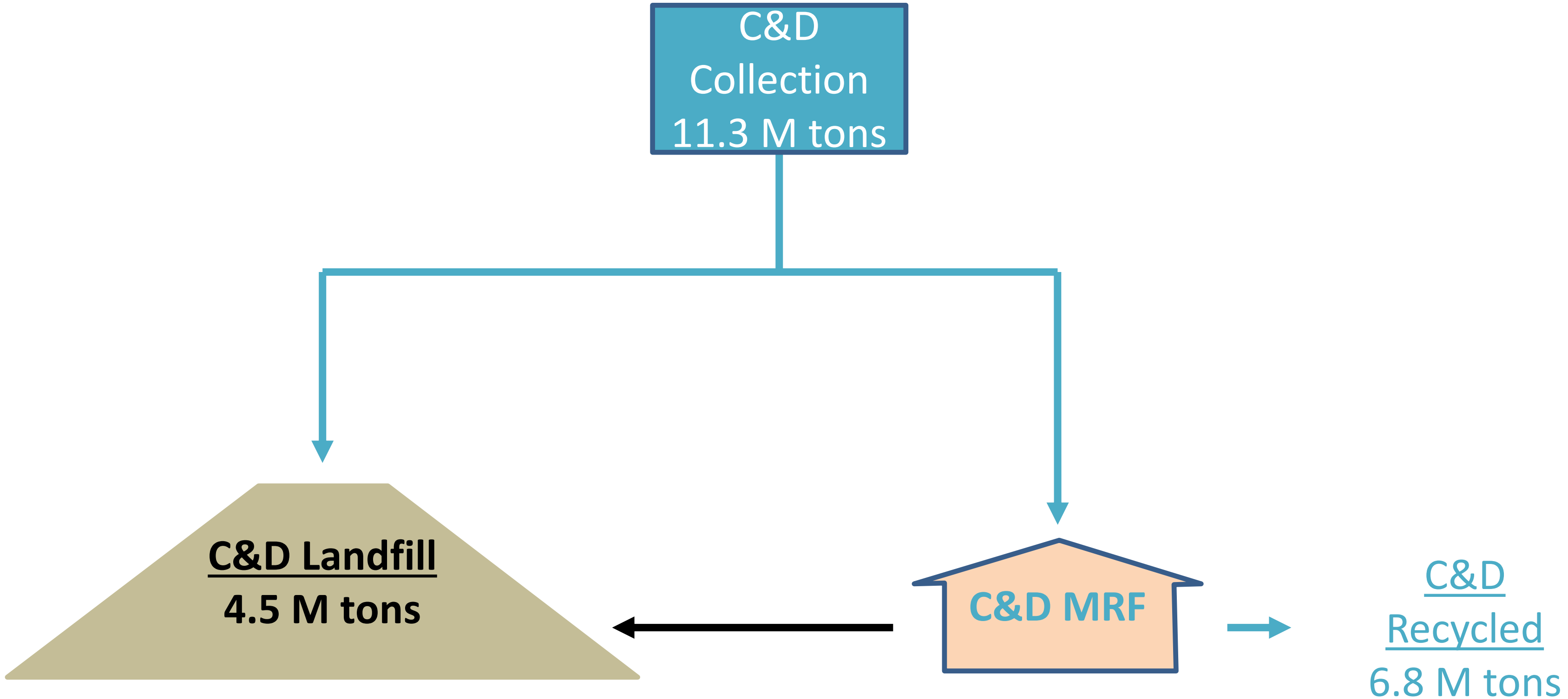
Florida's Recycling Rate



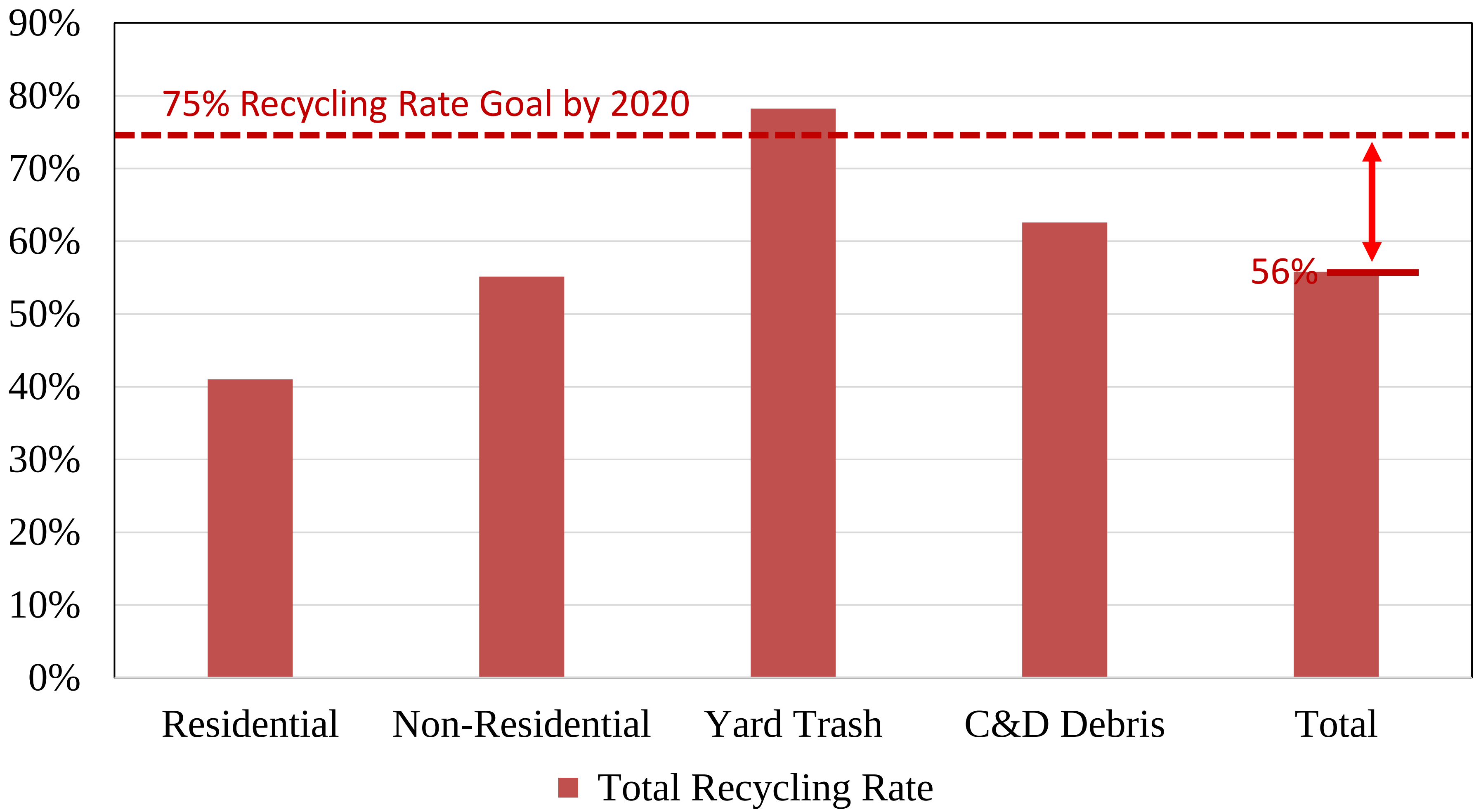
Florida Material Mass Flow (2016)



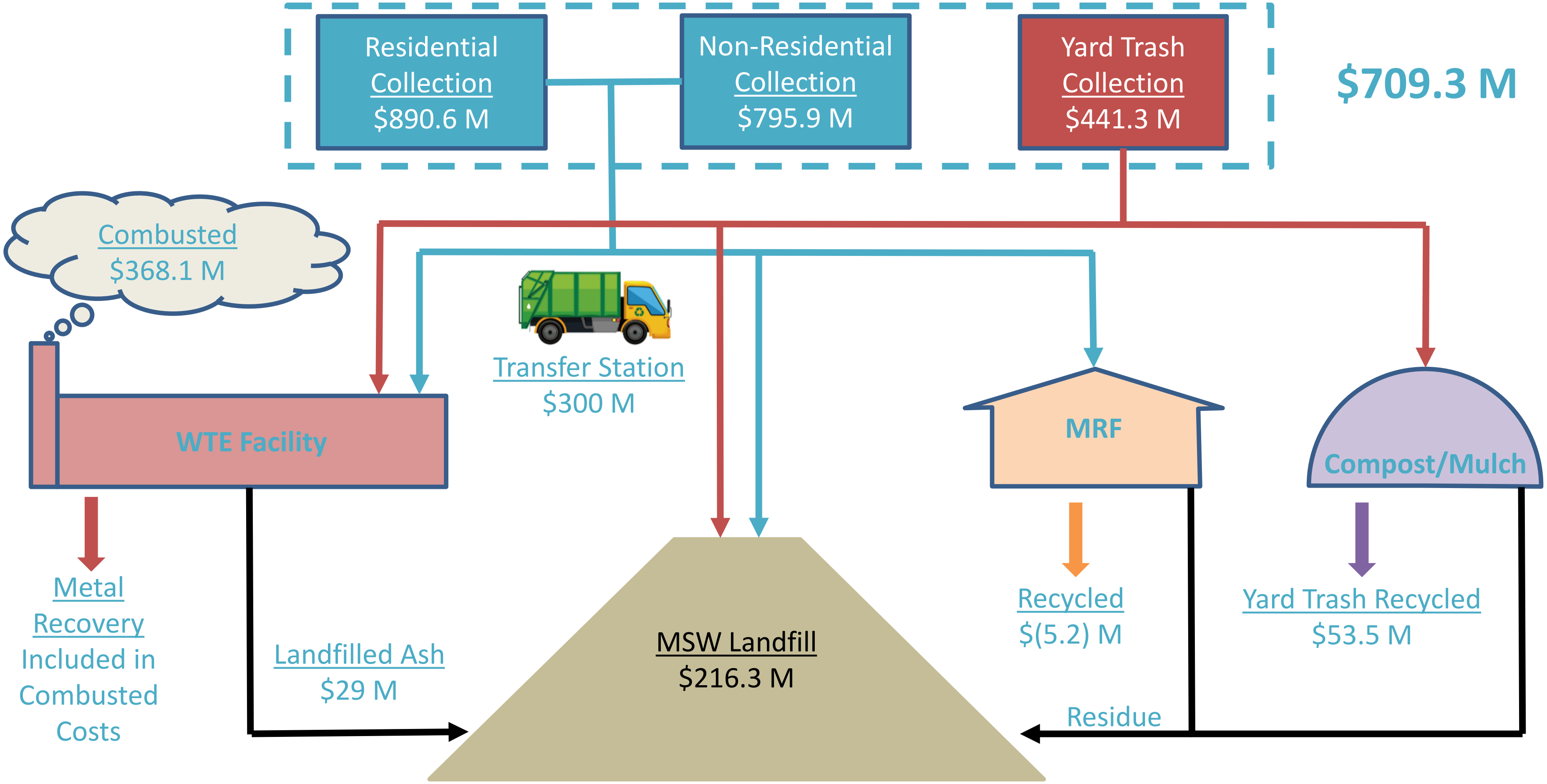
Florida Material Mass Flow (2016)



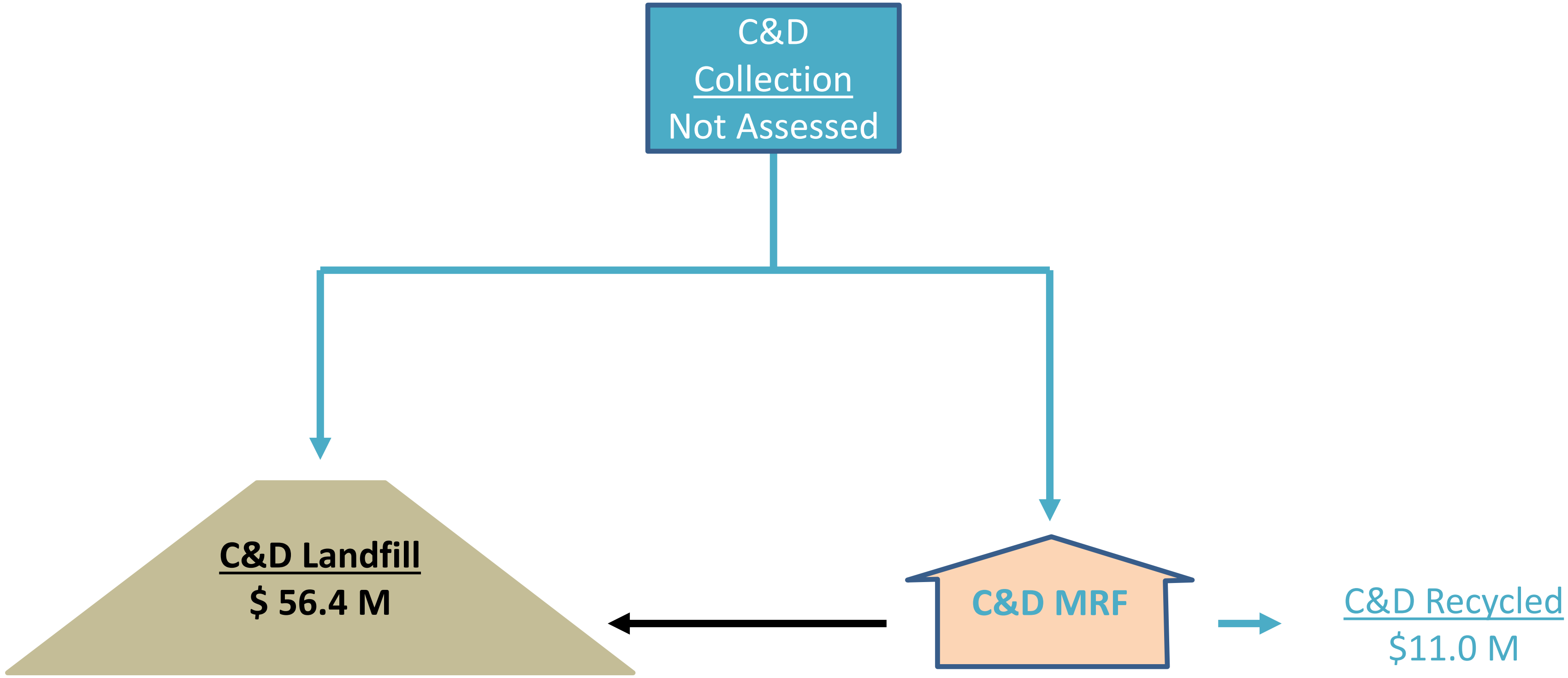
Generator Recycling Rates (2016)



Florida Material Cost Flow (2016)



Florida Material Cost Flow (2016)



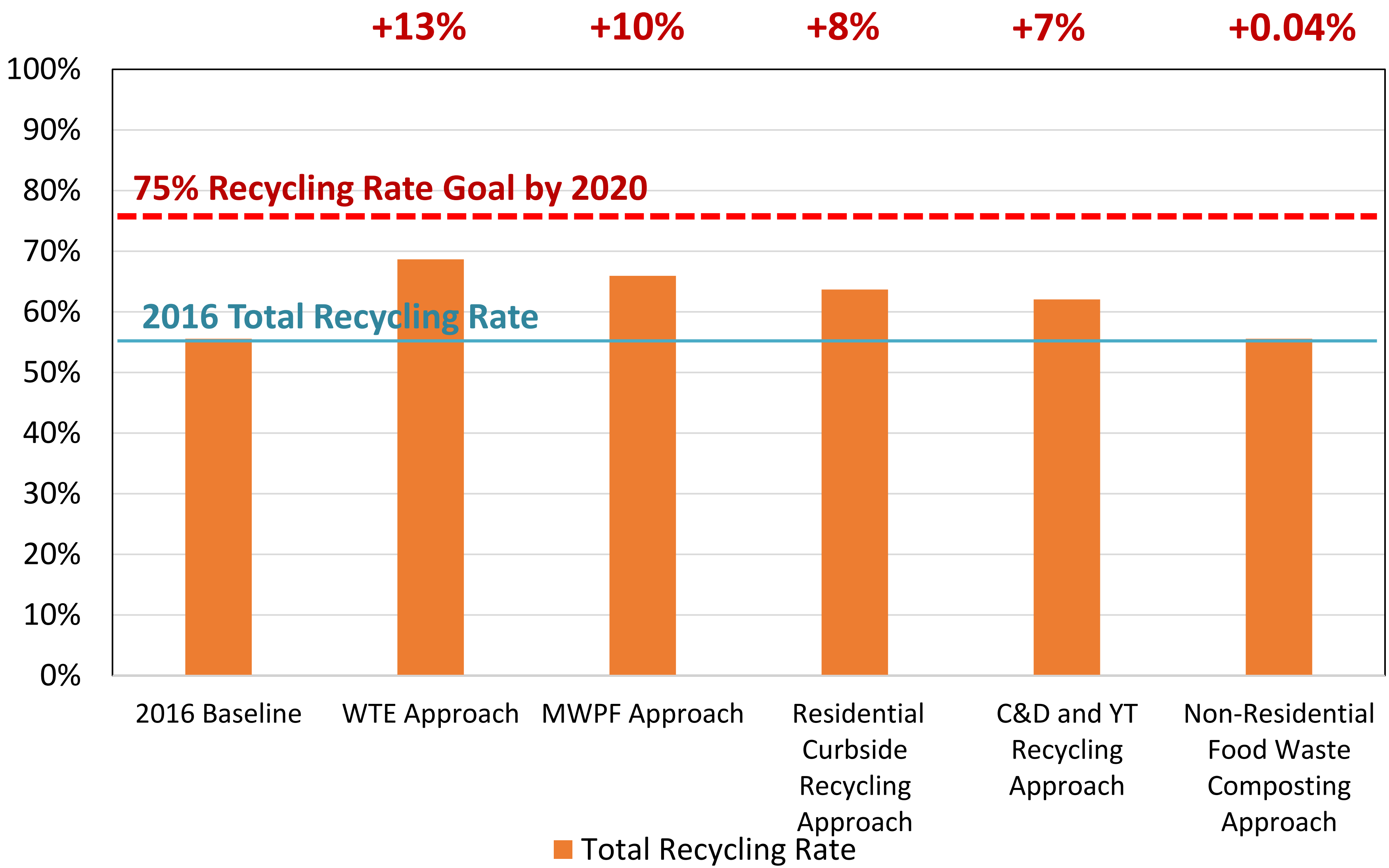
Total Costs (not including Transfer Station): $2.9 Billion
Total Costs (including Transfer Station): $3.2 Billion

Evaluating Reaching 75% Using Different Approaches

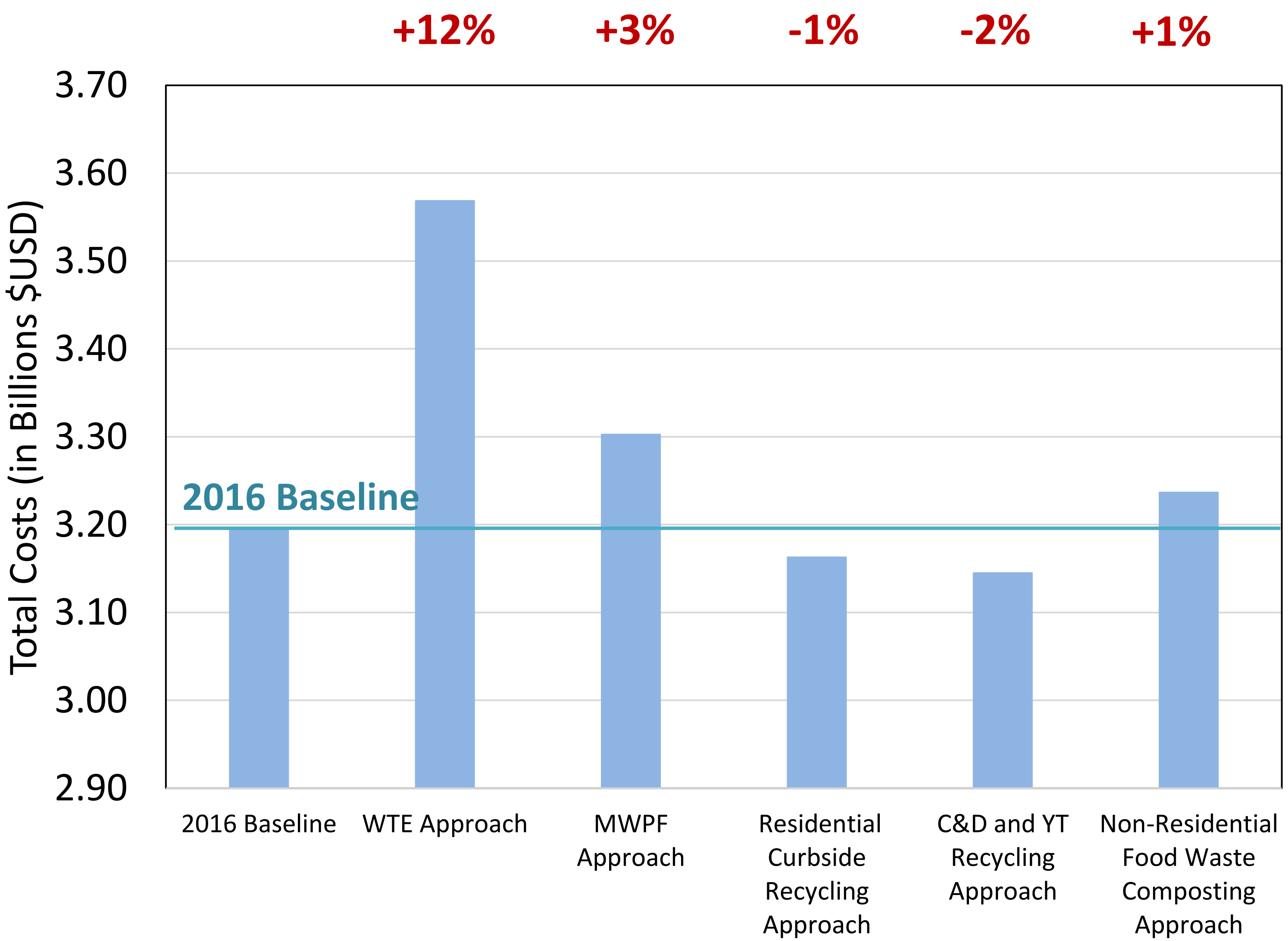
1. Waste-to-Energy (WTE) Approach
2. Mixed Waste Processing (MWP) Approach
3. Mandatory Residential Curbside Recycling Approach
4. Mandatory Construction & Demolition Debris (C&D) and Yard Trash (YT) Recycling Approach
5. Mandatory Non-Residential Food Waste Composting Approach

NOTE: Applied only to counties with populations of 150,000+

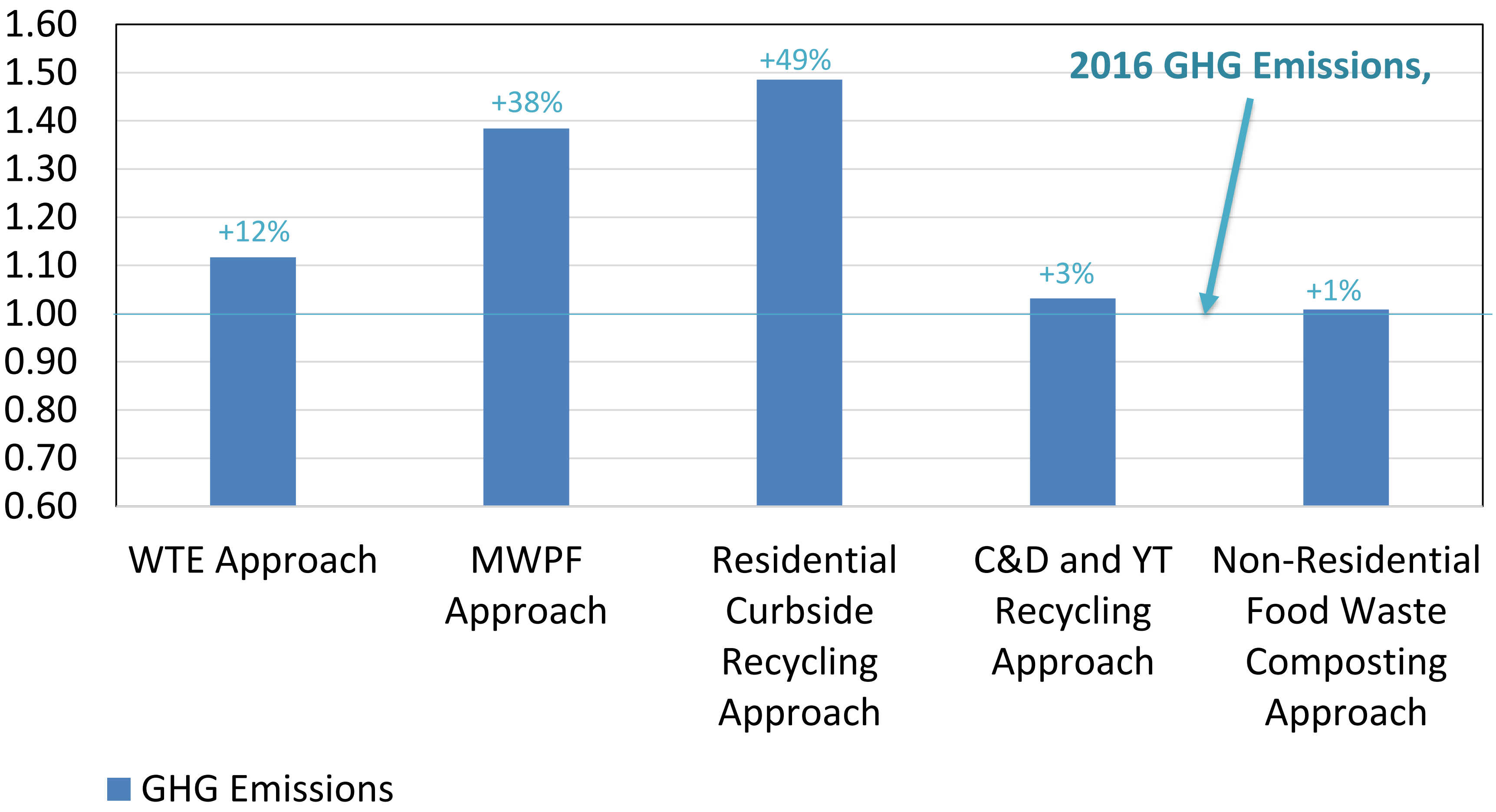
Impact on Recycling Rates (Percentage Points)



Impact on Costs (2016)

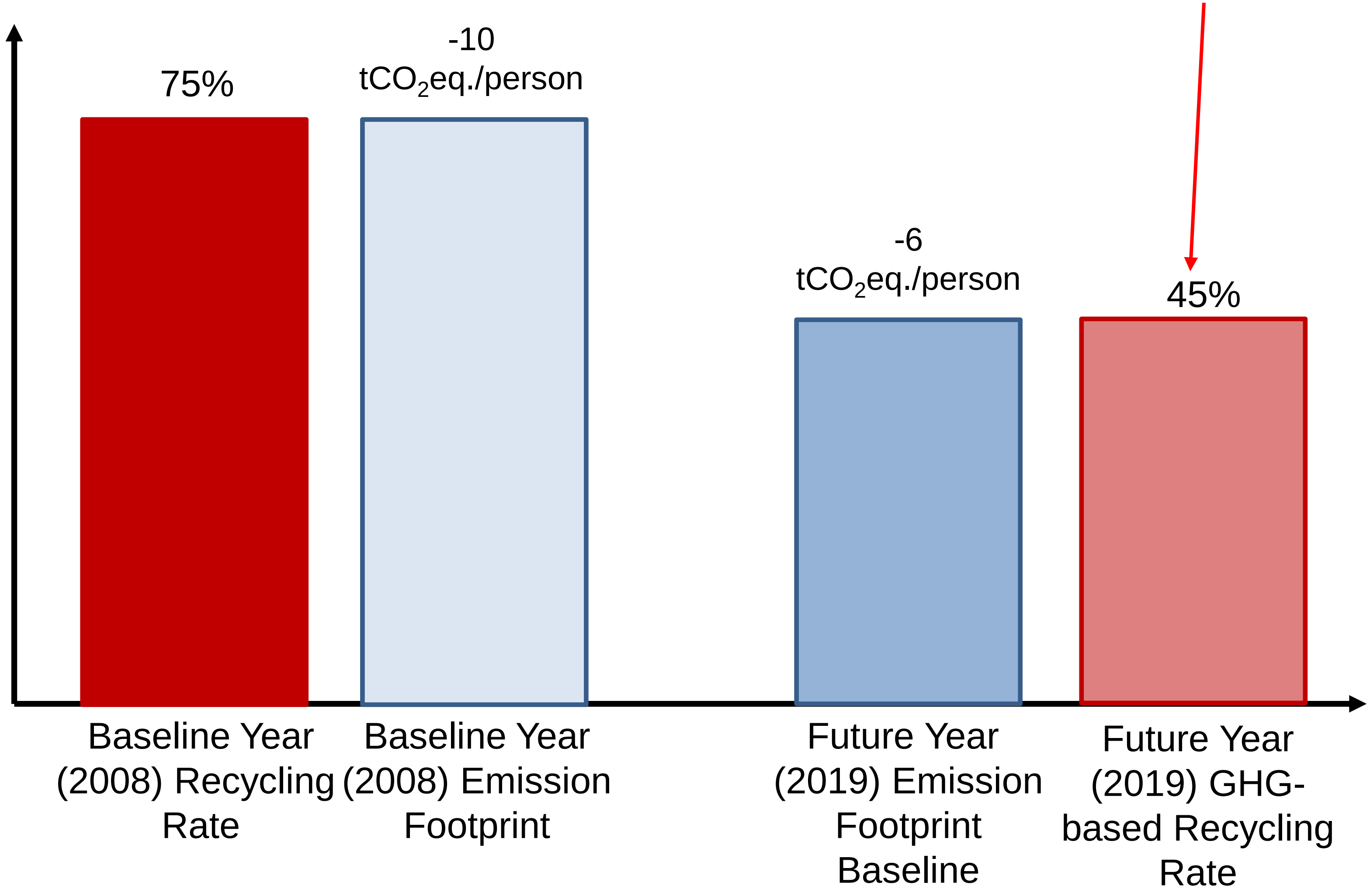


Impact on GHG Emissions (2016)

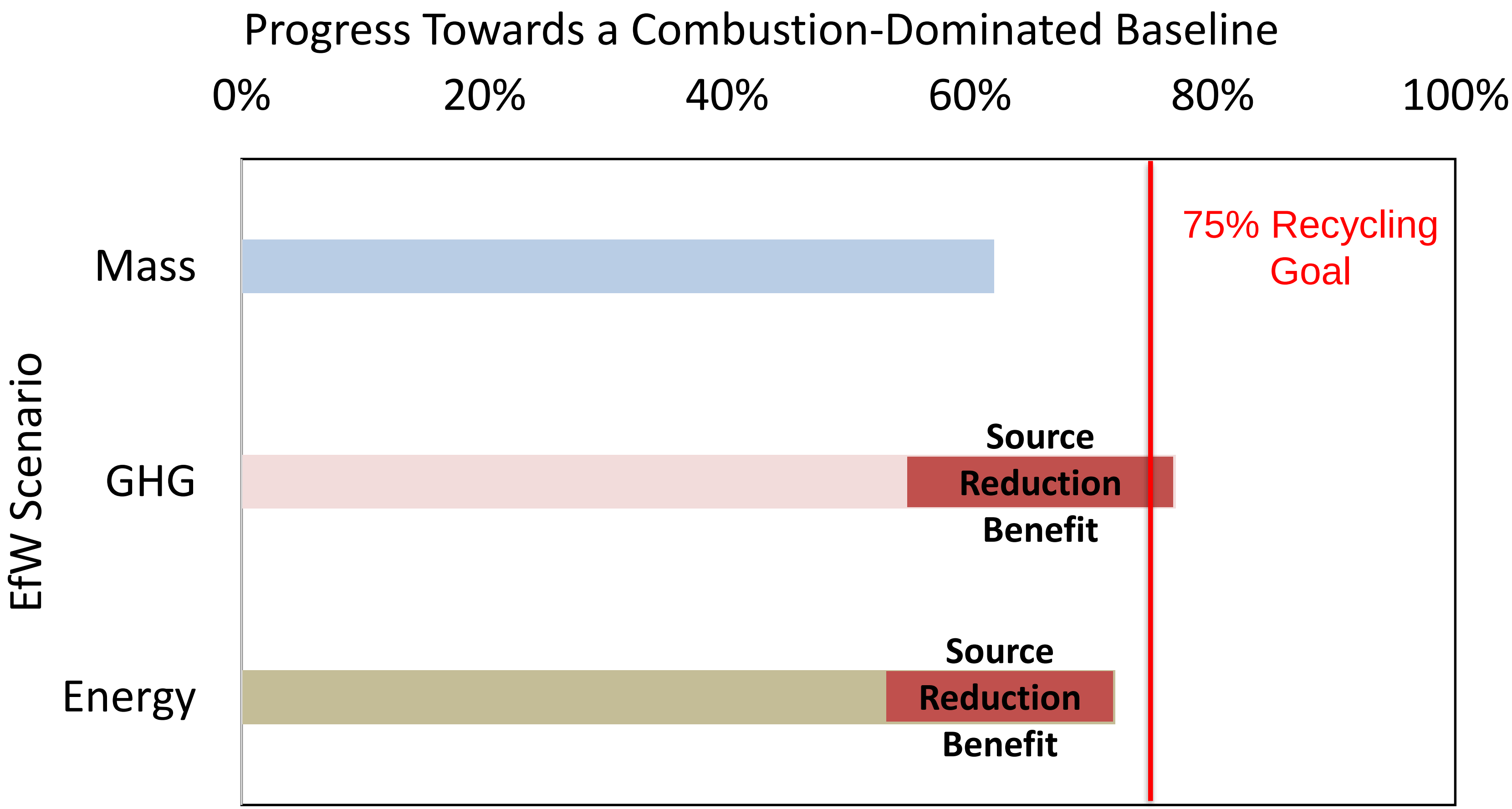


Using environmental impacts in goal setting

$$\text{GHG-Based Recycling Rate} = \frac{\textit{Future Year GHG footprint}}{\textit{Baseline Year GHG footprint}} (\textbf{Target Recycling Rate}) = X\%$$



Importance of Source Reduction



Source: "Replacing Recycling Rates with Life-Cycle Metrics as Government Materials Management Targets" (Anshassi et al., 2018)

Historic Source Reduced Materials

MSW Material	2008 Generation Rate (Tons/Person)	2015 Generation Rate (Tons/Person)	Source reduced or generated since 2008?
Newspaper	0.0768	0.0508	Source Reduced
Glass	0.0423	0.0433	Source Generated
Aluminum Cans	0.0120	0.0097	Source Reduced
Plastic Bottles	0.0238	0.0230	Source Reduced
Steel Cans	0.0172	0.0154	Source Reduced
Corrugated Paper	0.1369	0.1276	Source Reduced
Office Paper	0.0433	0.0309	Source Reduced
Other Plastics	0.0610	0.0725	Source Generated
Other Paper	0.1091	0.1101	Source Generated
Textiles	0.0480	0.0379	Source Reduced
C&D Debris	0.3999	0.4867	Source Generated
Tires	0.0198	0.0120	Source Reduced

Environmental Science & Technology
Article
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pubs.acs.org/est

Replacing Recycling Rates with Life-Cycle Metrics as Government Materials Management Targets

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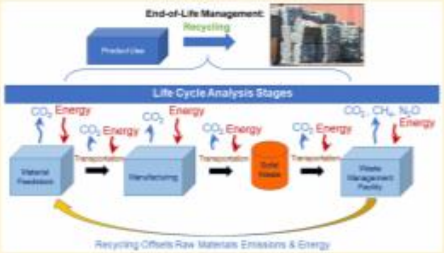
Supporting Information

ABSTRACT: In Florida, the passing of the Energy, Climate Change, and Economic Security Act of 2008 established a statewide mass-based municipal solid waste recycling rate goal of 75% by 2020. In this study, we describe an alternative approach to tracking performance of materials management systems that incorporates life-cycle thinking. Using both greenhouse gas (GHG) emissions and energy use as life-cycle indicators, we create two different materials management baselines based on a hypothetical 75% recycling rate in Florida in 2008. GHG emission and energy use footprints resulting from various 2020 materials management strategies are compared to these baselines, with the results normalized to the same mass-based 75% recycling rate. For most scenarios, LCI-normalized recycling rates are greater than mass-based recycling rates. Materials management strategies that include recycling of curbside-collected materials such as metal, paper, and plastic result in the largest GHG- and energy-normalized recycling rates. Waste prevention or increase, determined as the net difference in per-person mass discard rate for individual materials, is a major contributor to the life-cycle-normalized recycling rates. The methodology outlined here provides policy makers with one means of transitioning to life-cycle thinking in state and local waste management goal setting and planning.



INTRODUCTION

State and local governments in the United States (US) commonly rely on mass-based municipal solid waste (MSW) recycling rate goals or targets to promote sustainable materials management (SMM) and landfill diversion. These goals are typically established by state legislatures or local governments and apply to waste materials generated by households, institutions, and businesses. Examples of these goals include South Carolina (40% recycling),[1] Maryland (55% recycling),[2] Florida (75% recycling),[3] and San Francisco (zero waste),[4] all 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. While providing a tangible target that can be tracked over time to quantify progress, the recycling rate metric suffers from several inherent problems.[5−7] First, a reduction in the overall mass of materials discarded, referred to in this paper as waste prevention (commonly called source reduction by the waste management community) and the most desired step in the waste management hierarchy,[6,8−10] is not appropriately

A second problem with mass-based recycling goals is that they favor heavier materials without considering the environmental benefits gained through recycling. In reality, the recycling of some waste components produces much greater environmental benefits (e.g., avoidance of greenhouse gas (GHG) emissions and energy use) than others.[11−13] For example, recycling aluminum cans and office paper provides a considerably greater GHG emission and energy use avoidance than recycling (in some cases through composting) equivalent masses of glass, yard trash (YT), or food waste.[14] Also, a singular reliance on recycling rates neglects the positive contributions from other SMM approaches, including changes in product and packaging design, the recovery of energy from waste (EfW), and the implementation of more sustainable landfill practices.[13]

This study examines a different approach to mass-based recycling rates for quantifying and tracking progress toward SMM. One potential alternative is to measure materials management progress relative to the mass of material recycled or landfilled at an initial point in time. For example, California has established a statewide recycling goal corresponding to 75%

Projects History

2016

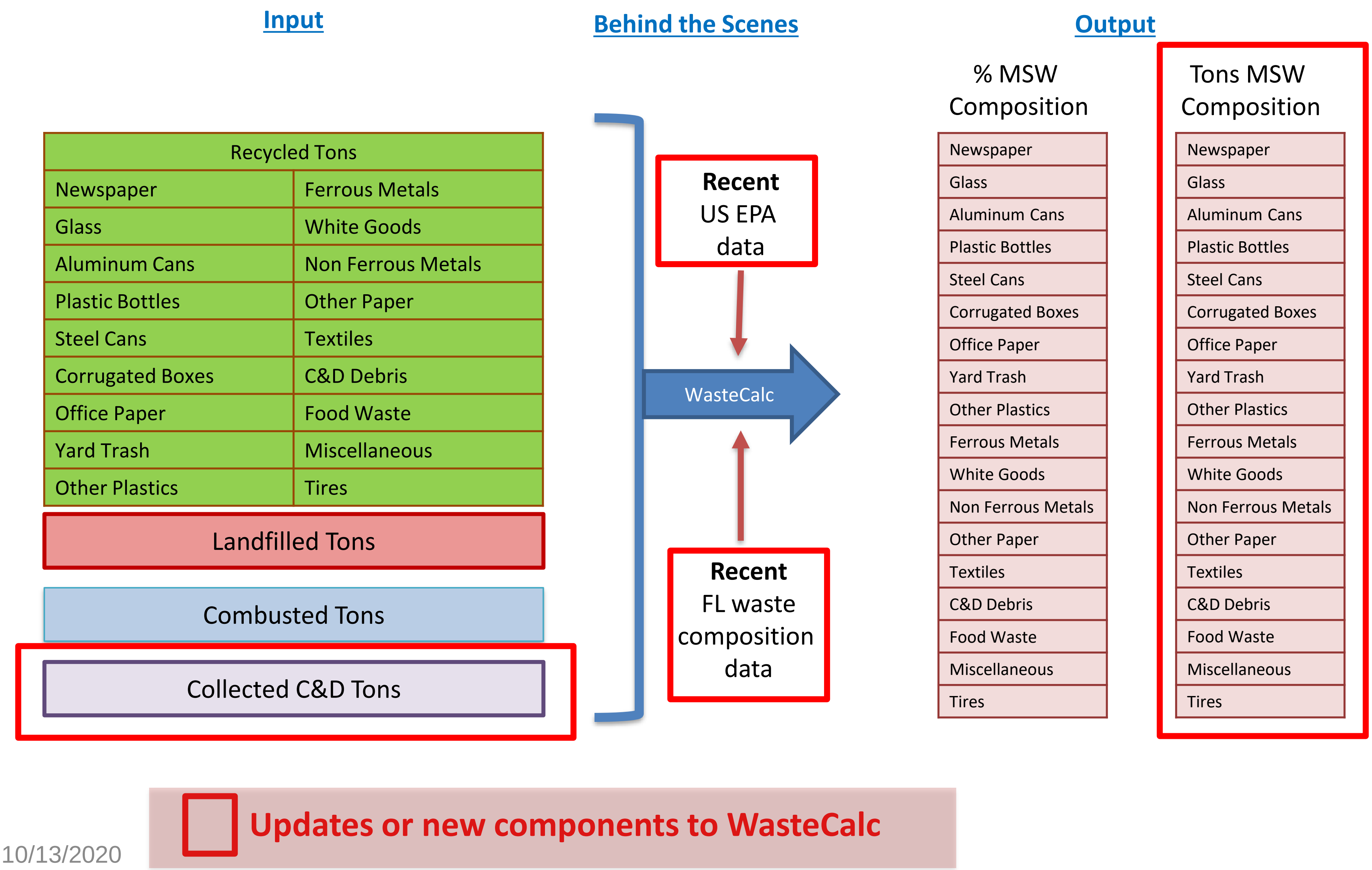
Hinkley Center Florida Solid Waste Management: State of the State

(HC16/17 Project)

2018

FDEP WasteCalc Upate

Updated WasteCalc Functionality



Projects History

2016

Hinkley Center Florida Solid Waste Management: State of the State

(HC16/17 Project)

2018

FDEP WasteCalc Upate

2019

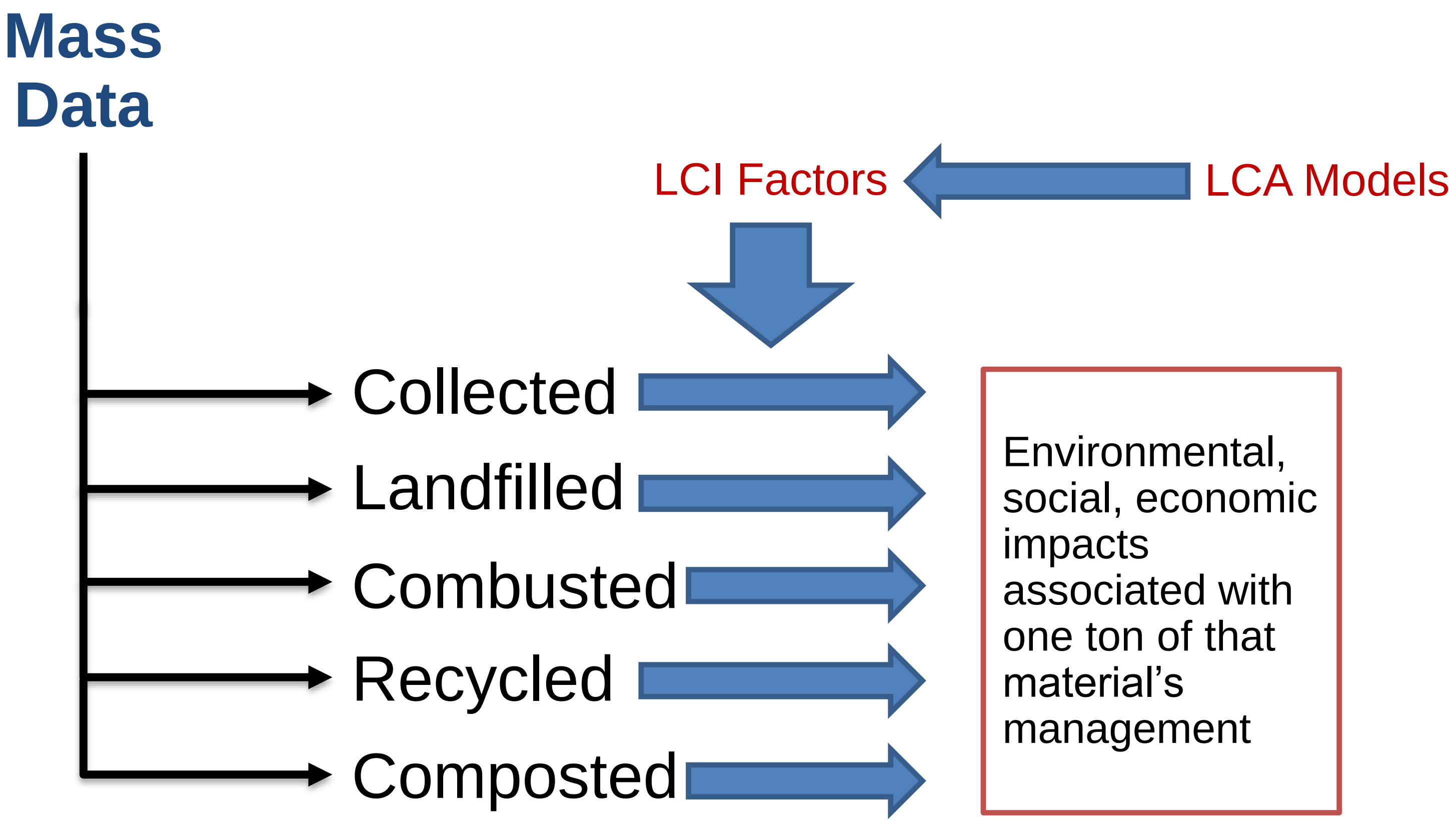
Hinkley Center Looking beyond Florida's 75% Recycling Goal: Development of a Methodology and Tool for Assessing Sustainable Materials Management Recycling Rates in Florida

(HC17/18 Project)

HC 18/19 Project Objectives

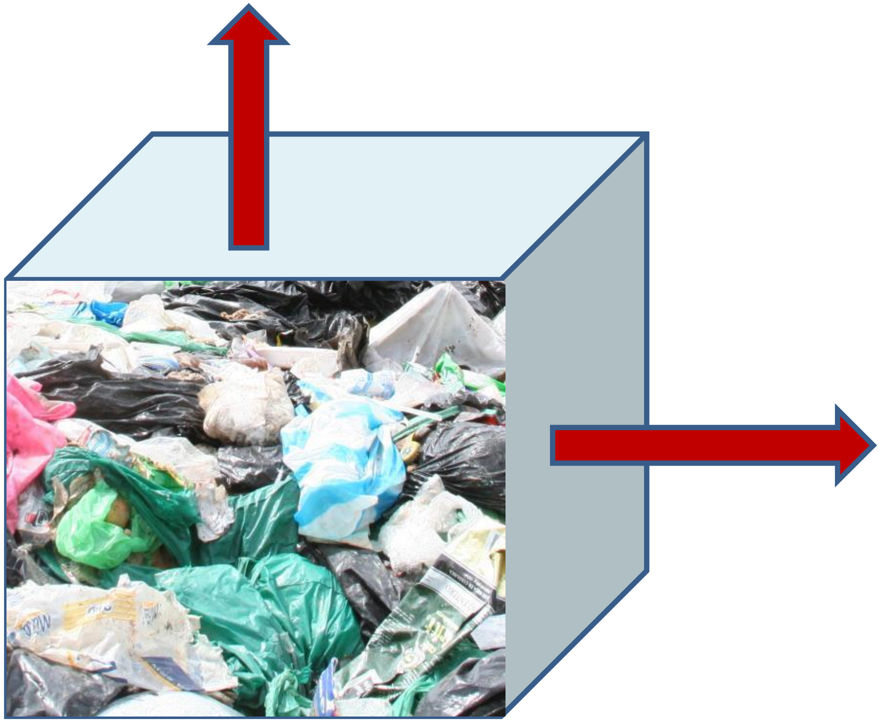
- **Develop a publicly available LCA tool** used to measure and compare social, economic, and environmental impacts for various Florida solid waste management approaches.
- **Develop additional lifecycle impact (LCI) factors** (e.g., energy use, emissions, etc.) that will allow users to consider a wider variety of impacts associated with various materials management approaches.

Workbook-Based LCA Tool



LCI Factors

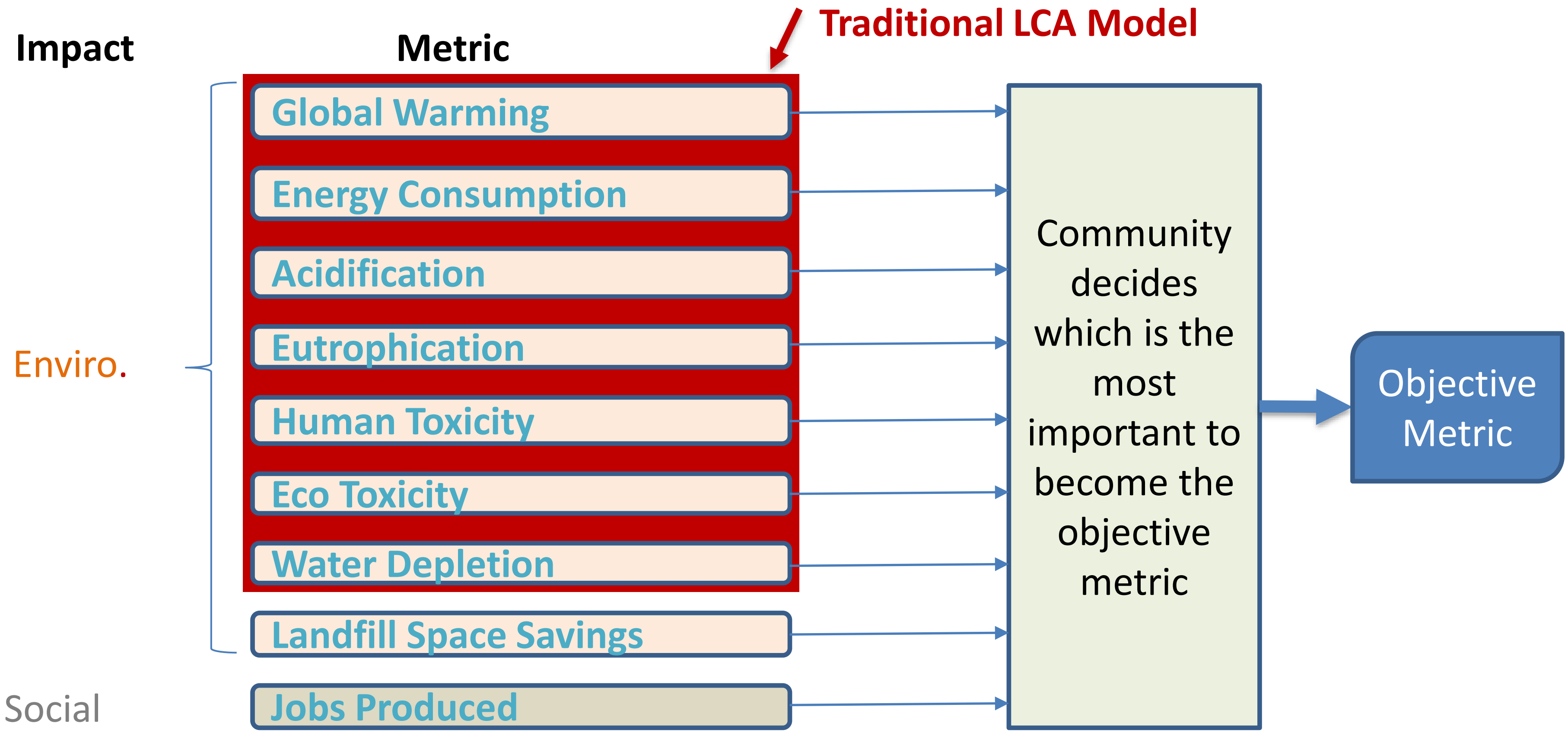
Metric Tons of CO_2 Equivalents (tCO2eq.)



Mass of Waste

$$\frac{tCO_2eq.}{Ton\ Waste}$$

Methods of Obtaining Environmental-Based LCI Factors



Traditional LCA Models

Version 15

Waste Reduction Model (WARM) -- Inputs

Use this worksheet to describe the baseline and alternative waste management scenarios that you want to compare. The blue shaded areas indicate where you need to enter information.
Please enter data in short tons (1 short ton = 2,000 lbs.)

1. Describe the baseline generation and management for the waste materials listed below.
If the material is not generated in your community or you do not want to analyze it, leave it blank or enter 0. Make sure that the total quantity generated equals the total quantity managed.

2. Describe the alternative management scenario for the waste materials generated in the baseline.
Any decrease in generation should be entered in the Source Reduction column.
Any increase in generation should be entered in the Source Reduction column as a negative value.
Make sure that the total quantity generated equals the total quantity managed.

Material Type	Material	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Tons Generated	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested

3. In order to account for the avoided electricity-related emissions in the landfilling and combustion pathways, EPA assigns the appropriate regional "marginal" electricity grid mix emission factor based on your location.
Select state for which you are conducting this analysis.

Please select state or select national average: National Average

Region Location: National Average

4. To estimate the benefits from source reduction, EPA usually assumes that the material that is source reduced would have been manufactured from the current mix of virgin and recycled inputs.
However, you may choose to estimate the emission reductions from source reduction under the assumption that the material would have been manufactured from 100% virgin inputs in order to obtain an upper bound estimate of the benefits from source reduction. Select which assumption you want to use in the analysis. Note that for materials for which information on the share of recycled inputs used in production is unavailable or is not a common practice; EPA assumes that the current mix is comprised of 100% virgin inputs. Consequently, the source reduction benefits of both the "Current mix" and "100% virgin" inputs are the same.

- (●) Current Mix
- ( ) 100% Virgin

5. The emissions from landfilling depends on whether the landfill where your waste is disposed has a landfill gas (LFG) control system. If you do not know whether your landfill has LFG control, select "National Average" to calculate emissions based on the estimated proportions of landfills with LFG control in 2012 and proceed to question 7. If your landfill does not have a LFG system, select "No LFG Recovery" and proceed to question 8. If a LFG system is in place at your landfill, select "LFG Recovery" and click one of the options in 6a to indicate whether LFG is recovered for energy or flared.

- (●) National Average
- ( ) LFG Recovery
- ( ) No LFG Recovery

6a. If your landfill has gas recovery, does it recover the methane for energy or flare it?

- (●) Recover for energy
- ( ) Flare

EPA Waste Reduction Model (WARM) User Input

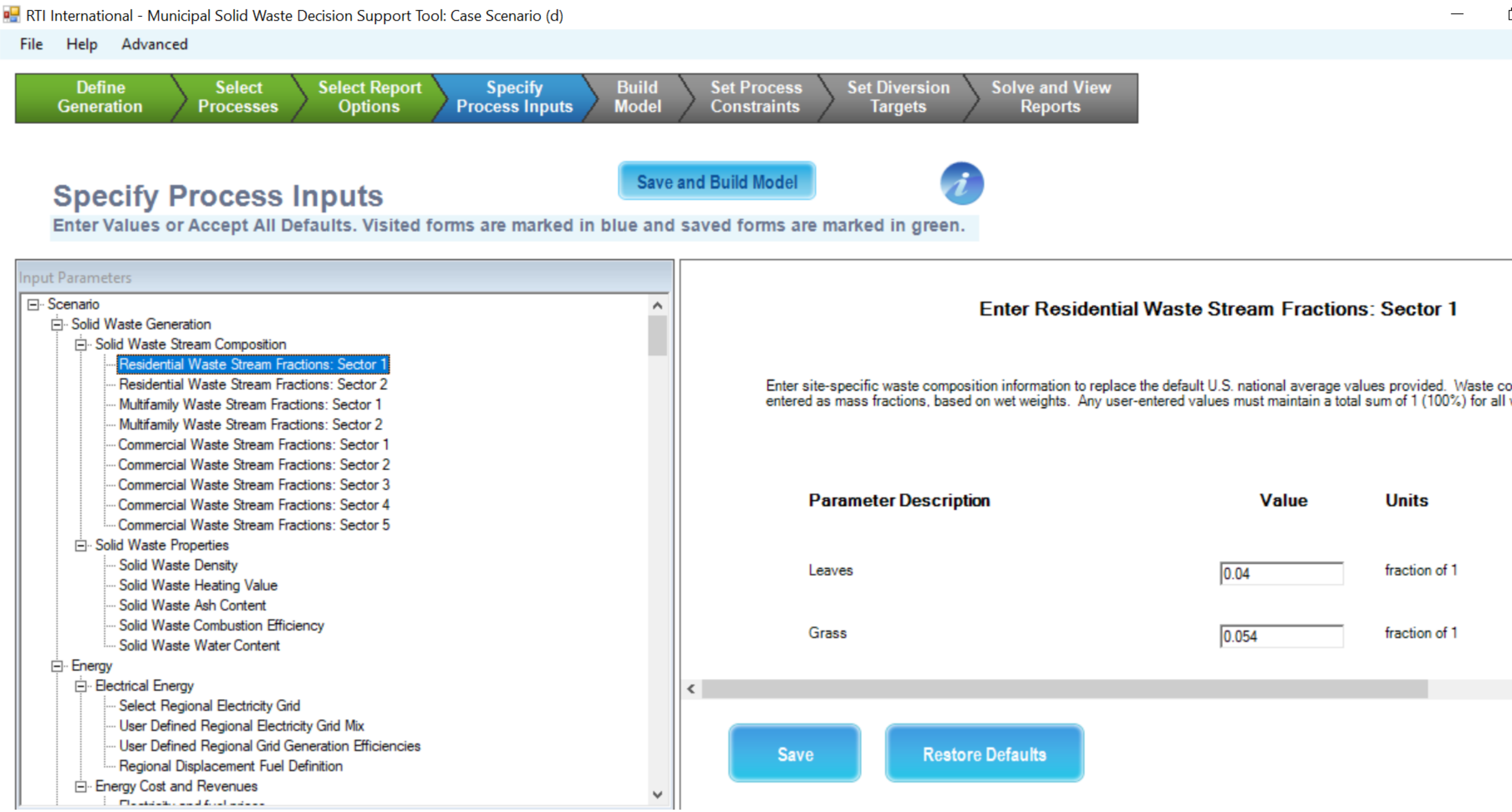
Traditional LCA Models

Per Ton Estimates of GHG Emissions for Baseline and Alternative Management Scenarios

Material	GHG Emissions per Ton of Material Source Reduced ($MTCO_2E$)	GHG Emissions per Ton of Material Recycled ($MTCO_2E$)	GHG Emissions per Ton of Material Landfilled ($MTCO_2E$)	GHG Emissions per Ton of Material Combusted ($MTCO_2E$)	GHG Emissions per Ton of Material Composted ($MTCO_2E$)	GHG Emission per Ton of Material Anaerobically Digested ($MTCO_2E$)
Corrugated Containers	(5.58)	(3.14)	0.25	(0.49)	NA	NA
Magazines/third-class mail	(8.57)	(3.07)	(0.40)	(0.36)	NA	NA
Newspaper	(4.68)	(2.71)	(0.82)	(0.56)	NA	NA
Office Paper	(7.95)	(2.87)	1.24	(0.47)	NA	NA
Phonebooks	(6.17)	(2.63)	(0.82)	(0.56)	NA	NA
Textbooks	(9.02)	(3.11)	1.24	(0.47)	NA	NA
Mixed Paper (general)	(6.07)	(3.55)	0.14	(0.49)	NA	NA
Mixed Paper (primarily residential)	(6.00)	(3.55)	0.08	(0.49)	NA	NA
Mixed Paper (primarily from offices)	(7.37)	(3.58)	0.18	(0.45)	NA	NA
Food Waste	(3.66)	NA	0.54	(0.14)	(0.18)	(0.04)
Food Waste (non-meat)	(0.76)	NA	0.54	(0.14)	(0.18)	(0.04)
Food Waste (meat only)	(15.10)	NA	0.54	(0.14)	(0.18)	(0.04)
Beef	(30.09)	NA	0.54	(0.14)	(0.18)	(0.04)
Poultry	(2.45)	NA	0.54	(0.14)	(0.18)	(0.04)
Grains	(0.62)	NA	0.54	(0.14)	(0.18)	(0.04)
Bread	(0.66)	NA	0.54	(0.14)	(0.18)	(0.04)
Fruits and Vegetables	(0.44)	NA	0.54	(0.14)	(0.18)	(0.04)
Dairy Products	(1.75)	NA	0.54	(0.14)	(0.18)	(0.04)
Yard Trimmings	NA	NA	(0.18)	(0.17)	(0.15)	(0.09)
Grass	NA	NA	0.13	(0.17)	(0.15)	0.00
Leaves	NA	NA	(0.52)	(0.17)	(0.15)	(0.15)
Branches	NA	NA	(0.50)	(0.17)	(0.15)	(0.23)
HDPE	(1.42)	(0.86)	0.02	1.28	NA	NA
LDPE	(1.80)	NA	0.02	1.29	NA	NA
PET	(2.17)	(1.15)	0.02	1.24	NA	NA

EPA Waste Reduction Model (WARM) Results Output

Traditional LCA Models

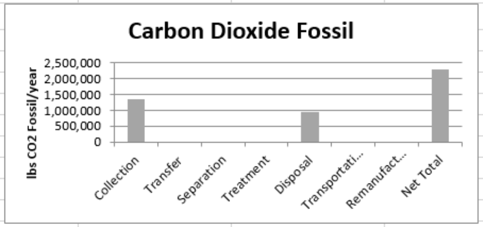


EPA/RTI Municipal Solid Waste Decision Support Tool (MSW-DST) User Input

Traditional LCA Models

Cost/LCI Report for All Unit Processes by Specific Sector

	Carbon Dioxide Fossil
Collection	1,360,000
Transfer	0
Separation	0
Treatment	0
Disposal	941,000
Transportation	0
Remanufacturing	0
Net Total	2,300,000



Name		Mixed MSW	Landfill			
Node Type		Collection	Disposal	Transportation	Remanufacturing	Total
Sector Name		Residential Sector 1				
Cost	$/year	6,670,000	3,820,000	0	0	10,500,000
Energy Consumption	MMBTU/year	33,500	57,500	0	0	91,000
Total Particulate Matter	lbs Total PM/year	325	1,150	0	0	1,480
Nitrogen Oxides	lbs NOx/year	21,000	13,200	0	0	34,200
Hydrocarbons (non CH4)	lbs HC/year	5,640	3,200	0	0	8,840
Sulfur Oxides	lbs SOx/year	2,740	2,370	0	0	5,110
Carbon Monoxide	lbs CO/year	9,530	4,880	0	0	14,400
Carbon Dioxide Biogenic	lbs CO2 Bio/year	643	232	0	0	875
Carbon Dioxide Fossil	lbs CO2 Fossil/year	1,360,000	941,000	0	0	2,300,000
Ammonia (Air)	lbs NH4 (Air)/year	0	2	0	0	2
Lead (Air)	lbs Pb (Air)/year	0	0	0	0	0
Methane (CH4)	lbs CH4/year	430	186	0	0	616
Hydrochloric Acid	lbs HCl/year	3	2	0	0	5
Carbon Equivalents	tons C-eq/year	187	129	0	0	316
Solid Waste 1	lbs SW1/year	n/a	n/a	n/a	n/a	0
Solid Waste 2	lbs SW2/year	n/a	n/a	n/a	n/a	0
Solid Waste 3	lbs SW3/year	n/a	n/a	n/a	n/a	0
Solid Waste 4	lbs SW4/year	n/a	n/a	n/a	n/a	0
Solid Waste 5	lbs SW5/year	n/a	n/a	n/a	n/a	0
Total Solid Waste	lbs SWTotal/year	14,400	5,160	0	0	19,600
Dissolved Solids	lbs DS/year	3,680	1,320	0	0	5,000
Suspended Solids	lbs SS/year	84	69	0	0	154
BOD	lbs BOD/year	14	13	0	0	27
COD	lbs COD/year	92	103	0	0	195
Oil	lbs Oil/year	85	22,100	0	0	22,200

MassFlows | Recycling | Cost_LCI | TRACI

EPA/RTI Municipal Solid Waste Decision Support Tool (MSW-DST) Results Output

Traditional LCA Models

Solid Waste Optimization Life-cycle Framework

Accounting Mode Tool

Developed at North Carolina State University

System Inputs

Scenario name: Landfill

Starting Process: Landfill

New Scenario — Clears all data and starts from the beginning

Continue Scenario — Continues from save point

Additional resources

Additional model documentation and publications can be found at the SWOLF website

go.ncsu.edu/SWOLF

Change log and version

Date	Changes	Version #
August 11, 2016	Initial release of evaluation version.	0.9
November 30, 2016	Updated collection models and calculations.	0.9.1
December 13, 2016	Updated calculations for other modes of internodal transportation	0.9.2
February 10, 2017	Added Continue Scenario option	0.9.3
March 26, 2018	Added additional error checking and removed mixed waste collection.	0.9.4
April 3, 2019	Made additional to models and calculations.	0.9.5

NCSU Solid Waste Optimization Framework (SWOLF) User Input

Traditional LCA Models

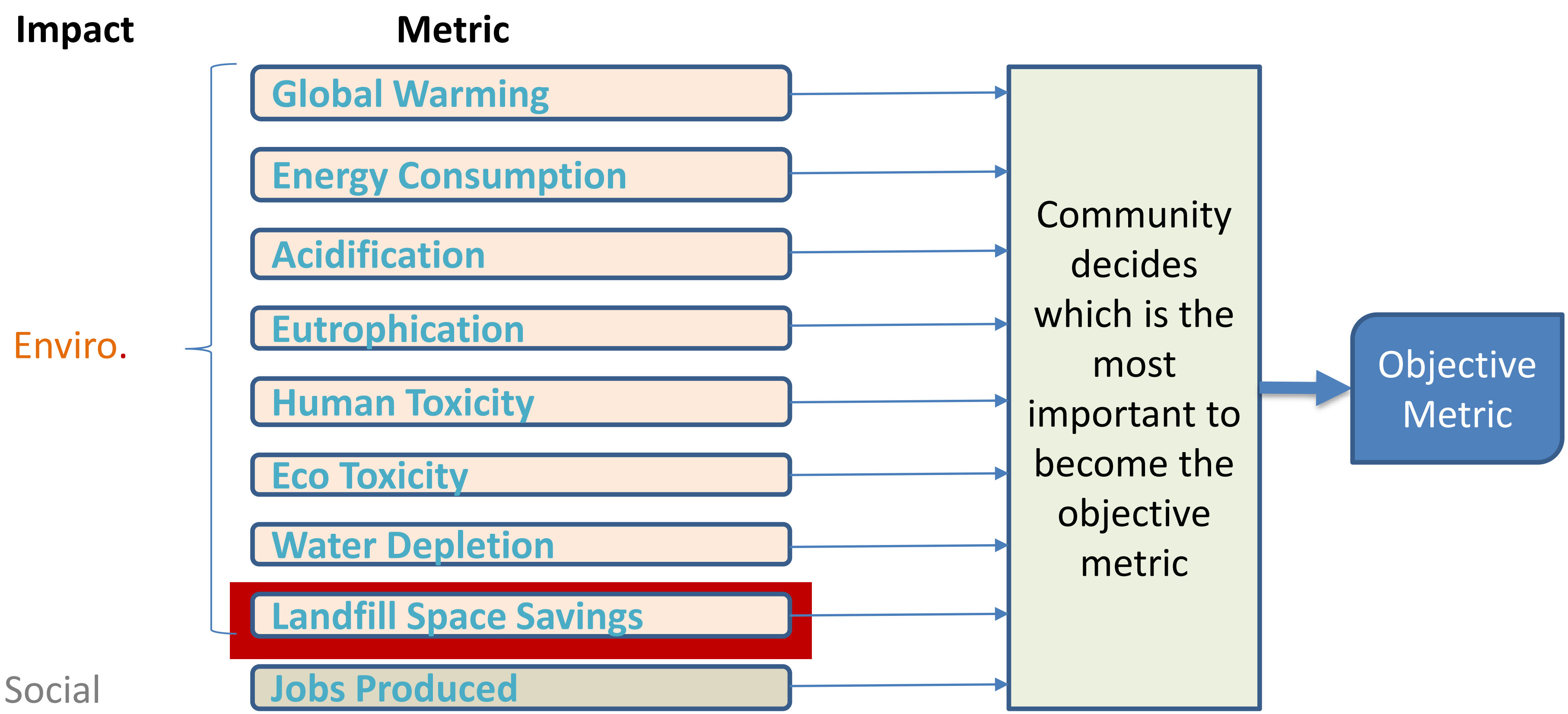
LCIA Outputs

Impacts	Total	Collection	Transportation	Separation	AD	Composting	WTE	Landfill	Reprocessing	Landfill LF1
IPCC 2007 climate change GWP 100a	40,314,742	0	0	0	0	0	0	40,314,742	0	40,314,742
cumulative energy demand fossil non-renewable energy resources, fossil	152,967,548	0	0	0	0	0	0	152,967,548	0	152,967,548
TRACI environmental impact acidification	1,179,201	0	0	0	0	0	0	1,179,201	0	1,179,201
TRACI environmental impact eutrophication	6,180	0	0	0	0	0	0	6,180	0	6,180
TRACI environmental impact photochemical oxidation	57,144	0	0	0	0	0	0	57,144	0	57,144
USEtox ecotoxicity total	9,665,260	0	0	0	0	0	0	9,665,260	0	9,665,260
USEtox human toxicity total	1	0	0	0	0	0	0	1	0	1
Cost ($)	1731000.606	0	0	0	0	0	0	1731000.606	0	1731000.606

Mass Flows | Costs | LCI Outputs | **LCIA Outputs**

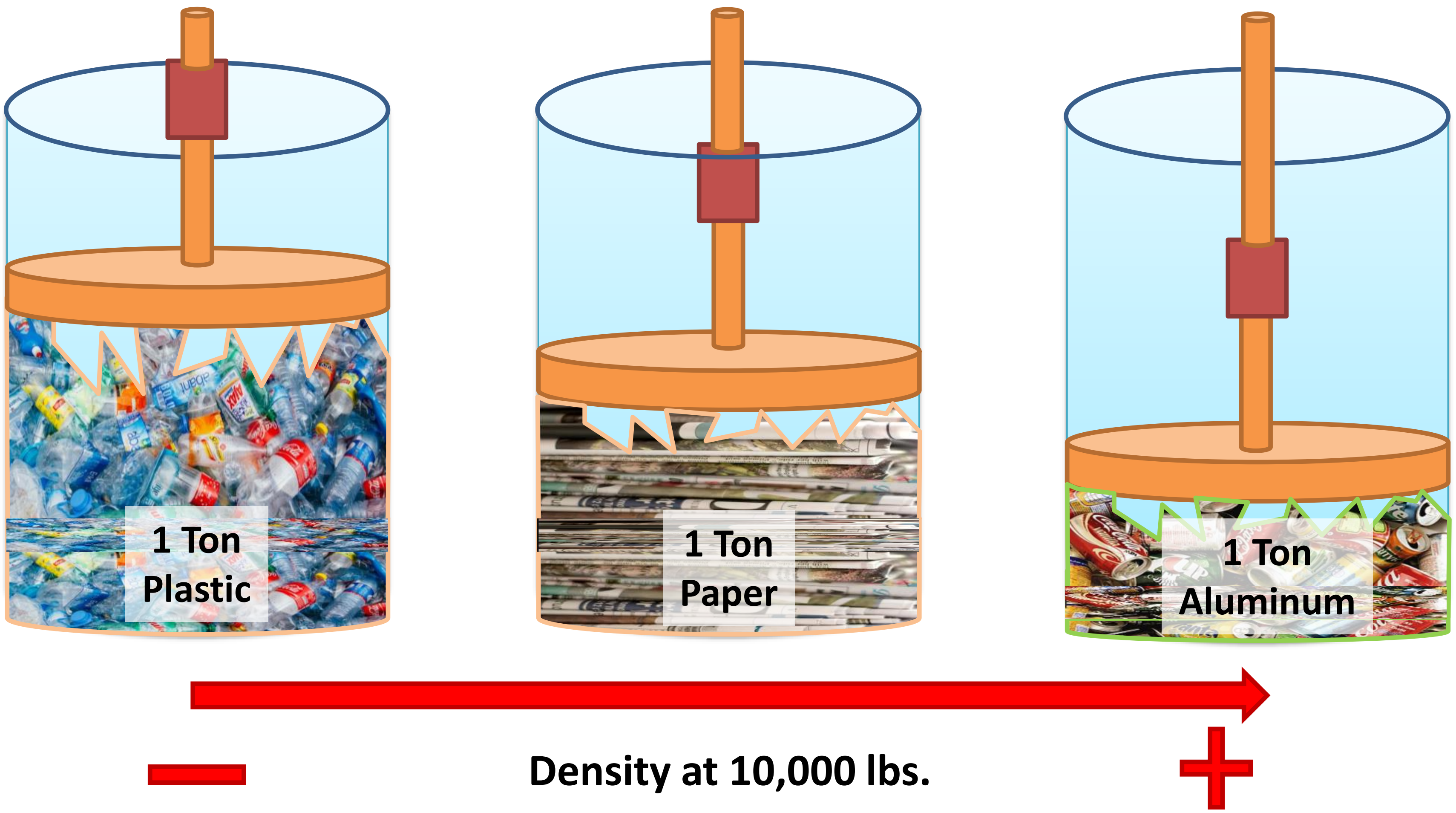
NCSU Solid Waste Optimization Framework (SWOLF) Results Output

Methods of Obtaining Environmental-Based LCI Factors

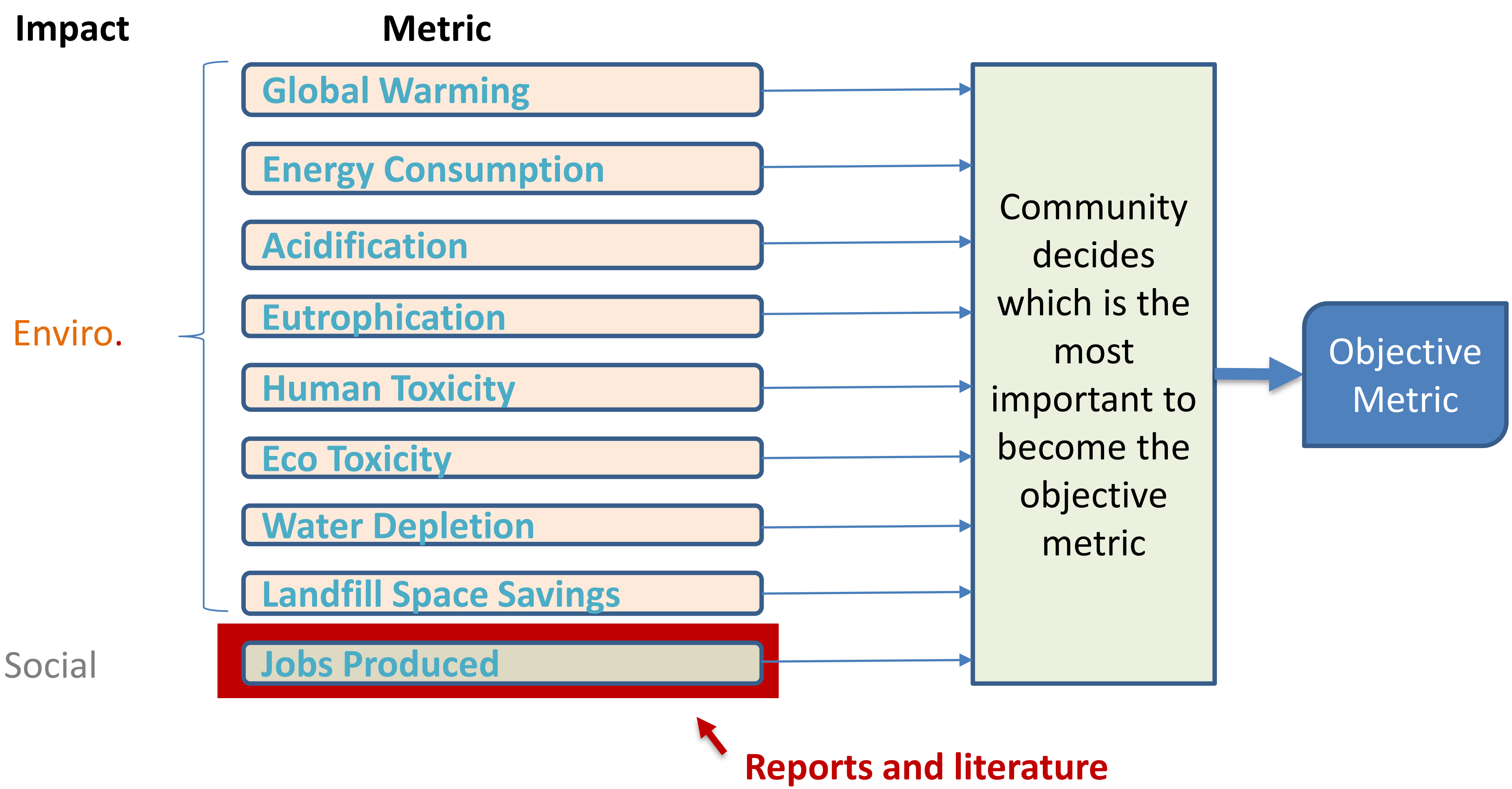


Landfill Space Savings

Landfill Space Savings



Methods of Obtaining Environmental-Based LCI Factors



HC18/19 Workbook Tool

Workbook Tool Introduction Screen for Users

…lorida's 75% Recycling Goal: Development of a Methodology and Tool for Assessing Sustainable Materials Management Recycling Rates in Florida

Welcome to the Hinkley Center for Solid and Hazardous Waste Management Funded SMM Workbook Tool!

This tool is an outcome of the Hinkley Center funded project titled, "Looking beyond Florida's 75% Recycling Goal: Development of a Methodology and Tool for Assessing Sustainable Materials Management Recycling Rates in Florida". In a previous Hinkley Center project titled, "Florida Solid Waste Management: State of the State", researchers from the University of Florida estimated the material mass flow for the Florida solid wase stream and conducted a comprehensive analysis on the economic costs and environmental footprints associated with the 2016 waste stream. The researchers also conducted an evaluation of alternative waste management strategies upon the recycling rate, economic costs, and environmental footprint. The alternative waste management strategies were based on the concept of sustainable materials management (SMM). 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. SMM, then, focuses on identifying best material management practices based on environmental, economic, and social impacts. Lifecycle assessment (LCA) models are tools that measure those impacts, and policymakers use LCA results to make SMM-informed decisions. In effort to continue this research, University of Florida researchers evaluated various US-developed LCA models and literature to create lifecycle impact (LCI) factors that can be used to measure the impacts of a community's waste management practices as part of the "Looking beyond Florida's 75% Recycling Goal: Development of a Methodology and Tool for Assessing Sustainable Materials Management Recycling Rates in Florida" project.

To read more on the scope of this project and documentation of this tool please visit:
https://www.essie.ufl.edu/home/townsend/research/florida-solid-waste-issues/hc18/

To read more about the previous project please visit:
https://www.essie.ufl.edu/home/townsend/research/florida-solid-waste-issues/hc16/

This workbook tool provides local government and other users the opportunity to measure the impacts of their solid waste management practices. Below is a description of the components of this workbook tool.

Tab No.	Tab Title	Tab Description
1	User Input	User must complete Steps 1 and 2. Step 1 permits the user to select from seven models, which are used to estimate LCI factors. The LCI factors are specifically associated with each model. In Step 2 the user must enter the

Introduction | 1-User Input | 2-Summary LCA Output | 3-Clim. Chan. (tCO2eq per Ton) | 4-Energy …

HC18/19 Workbook Tool

User Input Page to Select LCA Model and Input Mass Data

User Directions:

Step 1:

From the drop-down window to the right please select the model preference. SWOLF (US)

Note: See below for a description of each model. All models are US-based LCA models specifcally created for US LCA study use.

Model	Description of LCI Factors That Can be Estimated When Selecting Model
MSWDST (FL)	5 LCI factors: climate change, human toxicity, marine ecotoxicity, acidification potential, eutrophication potential. Factors were created using Florida-specific electricity grid.
SWOLF (FL)	7 LCI factors: climate change, energy use, water use, human toxicity, marine ecotoxicity, acidification potential, eutrophication potential. Factors were created using Florida-specific electricity grid.
SWOLF (US)	7 LCI factors: climate change, energy use, water use, human toxicity, marine ecotoxicity, acidification potential, eutrophication potential. Factors were created using US national average-specific electricity grid.
WARM (FL)	2 LCI factors: climate change and energy use. Factors were created using Florida-specific electricty grid.
WARM (US)	2 LCI factors: climate change and energy use. Factors were created using US national average-specific electricity grid.
Literature	Uses data from peer-reviewed published studies and LCA study reports. The LCI factors vary depending upon the material. *Note: For the two LCI factors, Jobs Produced and Landfill Space Use, the user must select this model to receive the outputs.*

Step 2:

Input mass data in US short tons in for each material category and its corresponding management approach. For example, if 20 tons of newspaper were collected, 5 of those tons were recycled landfilled then type "20" into cell E20, "10" into cell F20, and "15" into cell I20.

Input data:

Table 1. Mass estimates (tons)

Material Category	Item No.	Material Type	Collection	Recycling	Composting	Anaerobic Digestion	Landfill	Combustion	Check mass
MSW	1	Mixed MSW							
Paper	2	Newspaper							
	3	Corrugated Cardboard (OCC)							
	4	High Grade Paper (Office Type Paper)							
	5	Magazines/third-class mail							
	6	Mixed Paper							
Plastic	7	HDPE							
	8	PET							
	9	Mixed Plastic							
Glass	10	Glass							
	11	Aluminum Cans							

Introduction | 1-User Input | 2-Summary LCA Output | 3-Clim. Chan. (tCO2eq per Ton) | 4-Energy ...

HC18/19 Workbook Tool

All Units (Gal./ Short Ton)

Water Use (Gallons): Freshwater from lakes, rivers, and wells are consumed by different processes. The units are expressed as units of gallons. This a measure of the water used in such way that the water is evaporated, incorporated into products, transferred to other watersheds, or disposed into the sea.

Material Category	Item No.	Material Type	Collection	Recycling	Composting	Anaerobic Digestion	Landfill	Combustion
MSW	1	Mixed MSW	26.20	NA	NA	NA	(16.88)	(141.69)
Paper	2	Newspaper	26.20	(542.48)	(10.80)	4.81	(21.40)	(434.87)
	3	Corrugated Cardboard (OCC)	26.20	91.54	(7.46)	(85.86)	(72.62)	(363.42)
	4	High Grade Paper (Office Type Paper)	26.20	94.33	(5.84)	(152.76)	(155.33)	(333.90)
	5	Magazines/third-class mail	26.20	(272.97)	(19.18)	(74.60)	(19.36)	(331.20)
	6	Mixed Paper	26.20	(542.48)	(19.06)	(50.60)	(67.40)	(368.47)
Plastic	7	HDPE	26.20	113.32	NA	NA	30.62	(977.29)
	8	PET	26.20	(381.55)	NA	NA	30.65	(977.29)
	9	Mixed Plastic	26.20	NA	NA	NA	30.65	(1,027.86)
Glass	10	Glass	26.20	(46.66)	NA	NA	30.65	14.67
Metals	11	Aluminum Cans	26.20	(7,964.58)	NA	NA	30.65	(3,939.95)
	12	Steel/Tin Cans	26.20	(536.23)	NA	NA	30.65	(451.44)
	13	Mixed Metals	26.20	(4,250.36)	NA	NA	30.65	(4,116.48)
Organic	14	Yard Waste	26.20	NA	(138.54)	(19.87)	15.88	(173.96)
	15	Food Waste	26.20	NA	(73.28)	(191.40)	(45.35)	(169.79)
Other	16	Tires	26.20	NA	NA	NA	30.65	[illegible]
	17	Clothing and Footwear	26.20	NA	(292.15)	[illegible]		
	18	Electronics	26.20	NA	NA			
C&D Debris	19	Dimensional Lumber	26.20	NA	(84.81)	[illegible]		
	20	Asphalt Shingles	26.20	NA	NA			
	21	Gypsum Drywall	26.20	NA	NA			
	22	Concrete	26.20	NA	NA			
	23	Reclaimed Asphalt Pavement	26.20	NA	NA			

Impact Factor Page for Water Use (Gal/Ton) for Selected LCA

3-Clim. Chan. (tCO2eq per Ton) | 4-Energy Use (MJ per Ton) | 5-Water Use (Gal per Ton) | 6-Hum...

HC18/19 Workbook Tool

Summary LCA Output for Selected LCA and Impact Categories Based on User Mass Data

Summary Output: All output units are in parenthesis next to the table label and LCI factor category name. A negative value

Output data:

Table 1.

Climate Change ($tCO_2eq.$): Greenhouse gases (GHG) absorb energy and slow energy from escaping into space which causes the Earth to expressed as units of $tCO_2eq.$ of material to allow for comparison of global warming impacts of different gases relative to CO_2. This is a m energy the emission of 1 ton of gas will absorb over a given period of time, relative to the emissions of 1 ton of CO_2.

Material Category	Item No.	Material Type	Collection	Recycling	Composting	Anaerobic Digestion	Landf		
MSW	1	Mixed MSW	3.6	-	-	-			
Paper	2	Newspaper	-	-	-	-			
	3	Corrugated Cardboard (OCC)	3.6	2.3	-	-			
	4	High Grade Paper (Office Type Paper)	3.6	18.5	-	-			
	5	Magazines/third-class mail	3.6	(20.4)	-	-	(5.3)	-	(22.0)
	6	Mixed Paper	-	-	-	-	-	-	-
Plastic	7	HDPE	3.6	1.1	-	-	0.9	-	5.6
	8	PET	3.6	(77.6)	-	-	0.9	-	(73.1)
	9	Mixed Plastic	-	-	-	-	-	-	-
Glass	10	Glass	3.6	(11.1)	-	-	0.9	-	(6.6)
Metals	11	Aluminum Cans	-	-	-	-	-	-	-
	12	Steel/Tin Cans	-	-	-	-	-	-	-
	13	Mixed Metals	-	-	-	-	-	-	-
Organic	14	Yard Waste	-	-	-	-	-	-	-
	15	Food Waste	-	-	-	-	-	-	-
Other	16	Tires	-	-	-	-	-	-	-
	17	Clothing and Footwear	-	-	-	-	-	-	-
	18	Electronics	-	-	-	-	-	-	-
C&D Debris	19	Dimensional Lumber	-	-	-	-	-	-	-
	20	Asphalt Shingles	-	-	-	-	-	-	-
	21	Gypsum Drywall	-	-	-	-	-	-	-
	22	Concrete	-	-	-	-	-	-	-
	23	Reclaimed Asphalt Pavement	-	-	-	-	-	-	-
Total			25.5	(87.2)	-	-	5.8	-	(55.9)

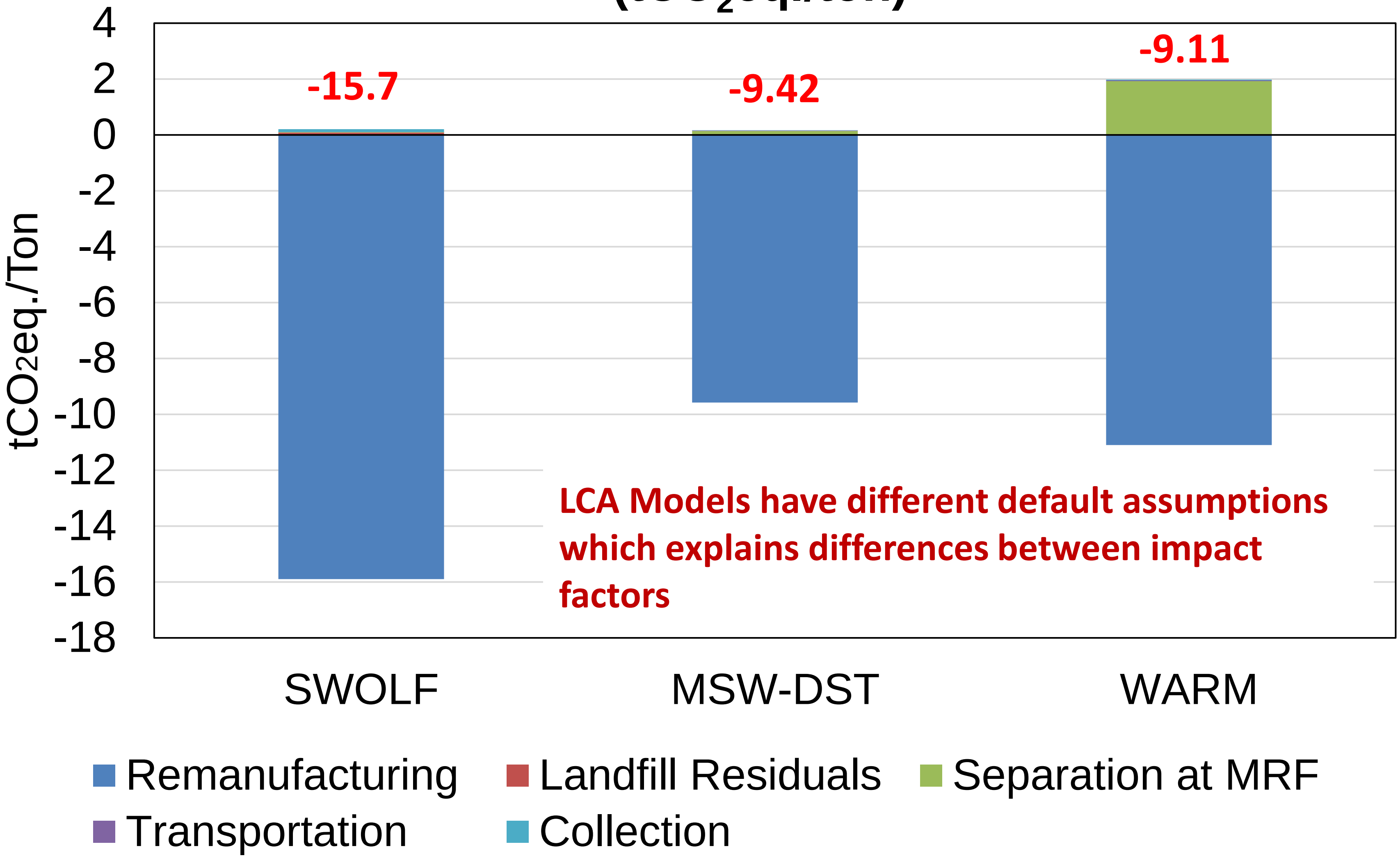
Table 2.

Energy Use (MJ): Energy is consumed by different processes, the units are expressed as MJ. This is a measure of the direct and indirect energy use throughout the life cycle and can include both renewable and non-renewable energy source.

Material Category	Item No.	Material Type	Collection	Recycling	Composting	Anaerobic Digestion	Landfill	Combustion	Total
MSW	1	Mixed MSW	225,905	-	-	-	13,699	-	239,604
Paper	2	Newspaper	-	-	-	-	-	-	-
	3	Corrugated Cardboard (OCC)	225,905	19,720	-	-	4,088	-	249,713
	4	High Grade Paper (Office Type Paper)	225,905	119,282	-	-	(10,173)	-	335,014
	5	Magazines/third-class mail	225,905	(270,019)	-	-	13,270	-	(30,844)
	6	Mixed Paper	-	-	-	-	-	-	-
Plastic	7	HDPE	225,905	105,183	-	-	21,888	-	352,976
	8	PET	225,905	(988,332)	-	-	21,887	-	(740,540)
	9	Mixed Plastic	-	-	-	-	-	-	-
Glass	10	Glass	225,905	(73,435)	-	-	21,887	-	174,356
	11	Aluminum Cans	-	-	-	-	-	-	-

Introduction | 1-User Input | 2-Summary LCA Output | 3-Clim. Chan. (tCO2eq per Ton) | 4-Energy ...

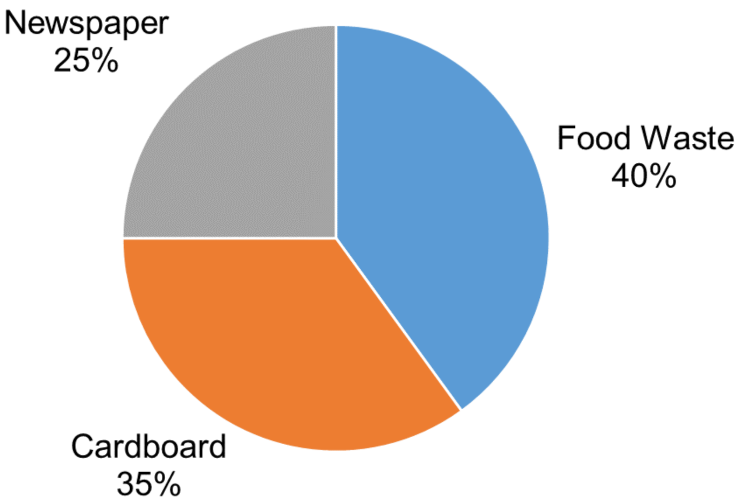
Recycling Aluminum Cans GHG Emission Factor (tCO_2eq./ton)



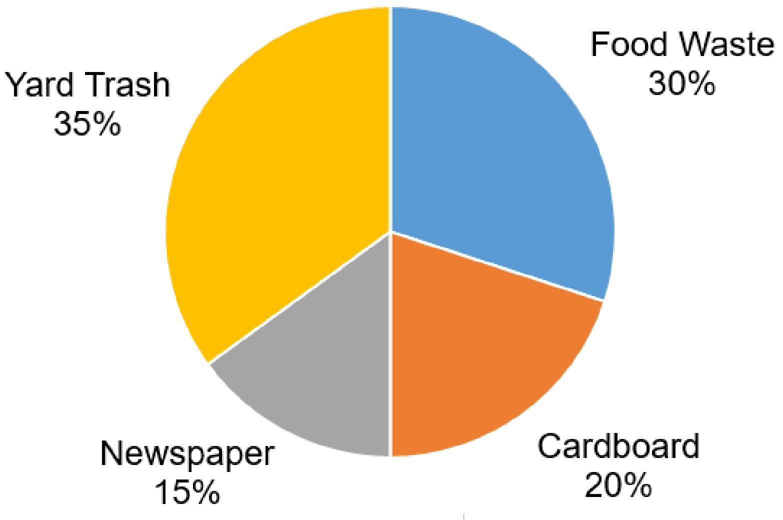
Use the tool to evaluate best materials management approaches in Florida

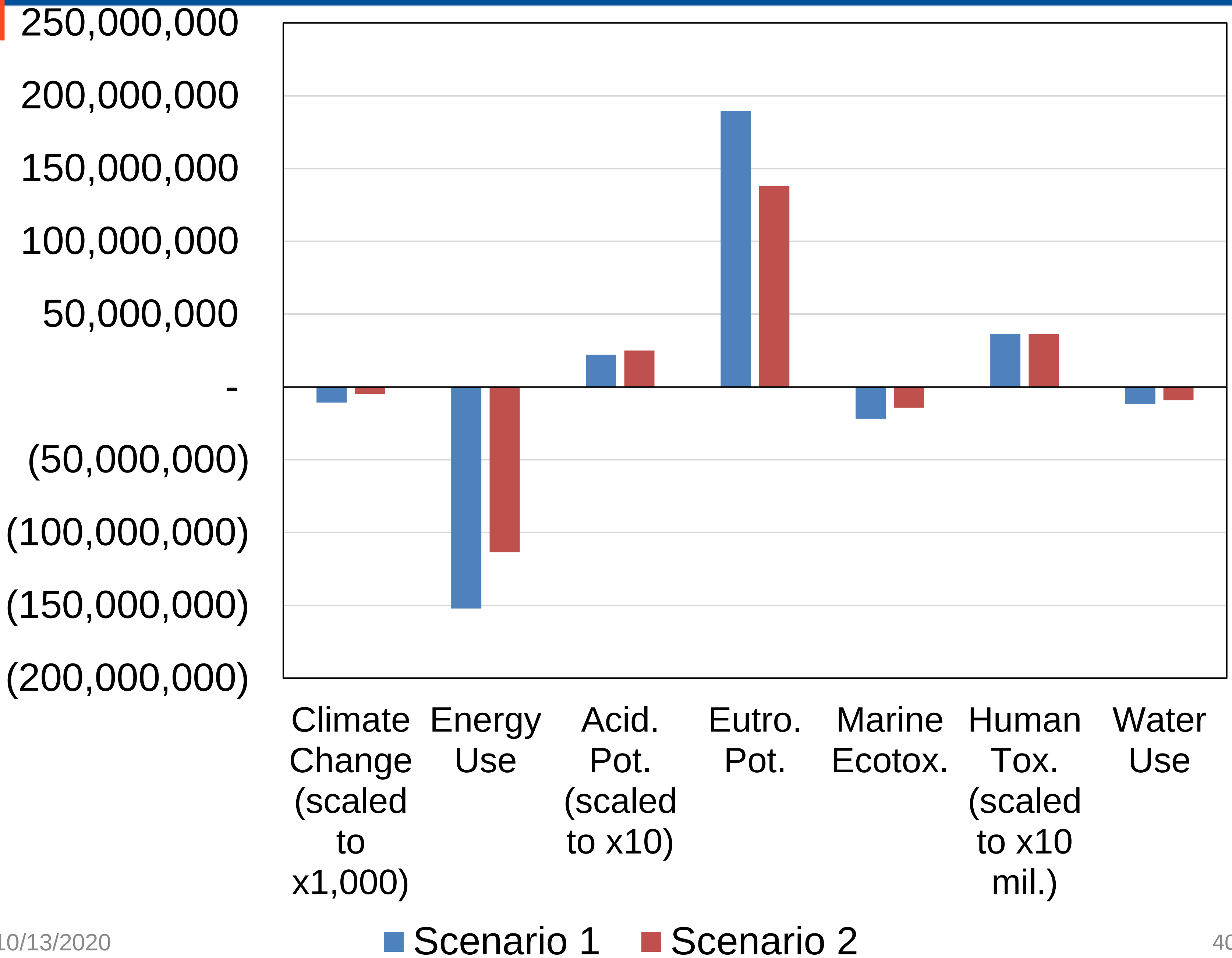
Hypothetical: 100,000 Tons with two varying compositions and desired to be anaerobically digested

Scenario 1



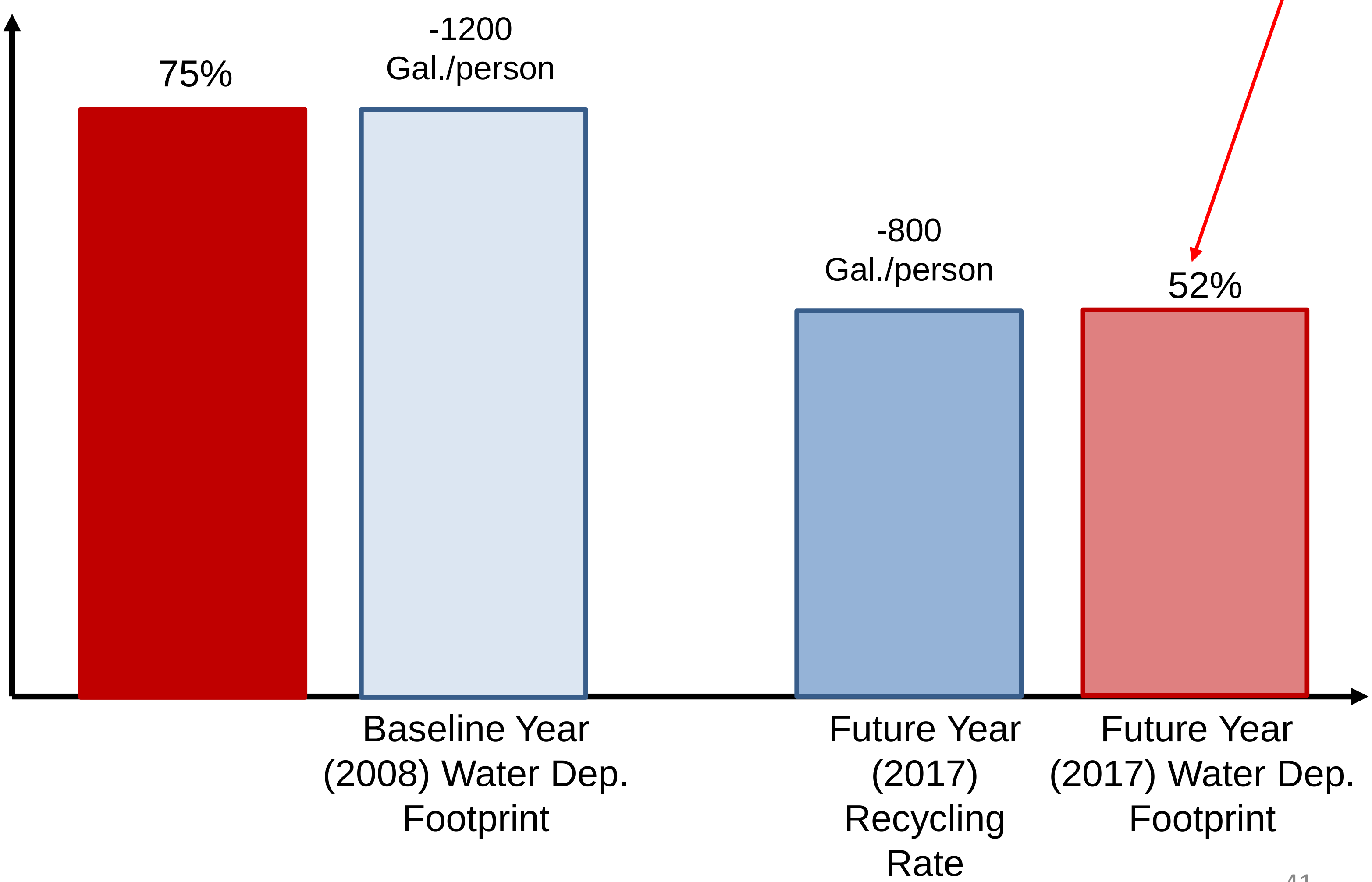
Scenario 2




250,000,000
200,000,000
150,000,000
100,000,000
50,000,000
-
(50,000,000)
(100,000,000)
(150,000,000)
(200,000,000)
Climate Change (scaled to x1,000)
Energy Use
Acid. Pot. (scaled to x10)
Eutro. Pot.
Marine Ecotox.
Human Tox. (scaled to x10 mil.)
Water Use
Scenario 1
Scenario 2

Use the tool to evaluate other metrics for using environmental impacts in goal setting

Water Dep.-Based Recycling Rate $= \frac{\textit{Future Year Water Dep. footprint}}{\textit{Baseline Year Water Dep. footprint}} \left(\textbf{Target Recycling Rate}\right) =$



Use the tool to measure waste management system footprints

For Florida 2018 Solid Waste Management System:

- GHG Emissions Footprint: **-0.91 to -1.3 tCO_2eq./person**
- Energy Use Footprint: **-800 gal/person**
- Water Use Footprint : **-7,700 to -18,050 MJ/person**
- Human Toxicity Footprint: **-0.00021 to -0.00029 CTUh/person**
- Ecotoxicity Footprint: **-33 to -6,200 CTUe/person**
- Eutrophication Footprint: **-0.23 to 0.21 kgNeq./person**
- Acidification Footprint: -**7 to -10 $kgSO_2$eq./person**

Note: Range is because we used SWOLF, WARM, and MSW-DST impact factors

Projects History

2016

Hinkley Center Florida Solid Waste Management: State of the State

(HC16/17 Project)

2018

FDEP WasteCalc Upate

2019

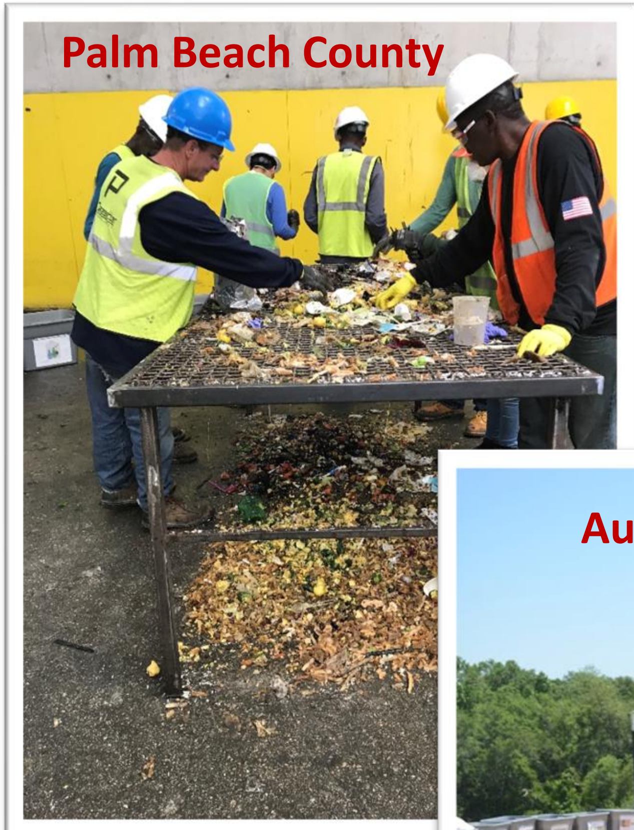
Hinkley Center Looking beyond Florida's 75% Recycling Goal: Development of a Methodology and Tool for Assessing Sustainable Materials Management Recycling Rates in Florida

(HC17/18 Project)

2019

FDEP WasteCalc & Waste Compositions

Composition Studies



Updated WasteCalc Composition Studies

Input

Recycled Tons	
Newspaper	Ferrous Metals
Glass	White Goods
Aluminum Cans	Non Ferrous Metals
Plastic Bottles	Other Paper
Steel Cans	Textiles
Corrugated Boxes	C&D Debris
Office Paper	Food Waste
Yard Trash	Miscellaneous
Other Plastics	Tires

Landfilled Tons

Combusted Tons

Collected C&D Tons

Behind the Scenes

Recent US EPA data

WasteCalc

Recent FL waste composition data

Output

% MSW Composition
Newspaper
Glass
Aluminum Cans
Plastic Bottles
Steel Cans
Corrugated Boxes
Office Paper
Yard Trash
Other Plastics
Ferrous Metals
White Goods
Non Ferrous Metals
Other Paper
Textiles
C&D Debris
Food Waste
Miscellaneous
Tires

Tons MSW Composition
Newspaper
Glass
Aluminum Cans
Plastic Bottles
Steel Cans
Corrugated Boxes
Office Paper
Yard Trash
Other Plastics
Ferrous Metals
White Goods
Non Ferrous Metals
Other Paper
Textiles
C&D Debris
Food Waste
Miscellaneous
Tires

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2018

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(HC17/18 Project)

2019

FDEP WasteCalc & Waste Compositions

2020

Hinkley Center An Integrated Tool for Local Government to Track Materials Management and Progress toward Sustainability Goals
(HC19/20 Project)

HC 19/20 Objectives

- **Refinements to the WasteCalc model** in a manner that retains its existing functionality
- **Incorporate SMM using metrics to measure** environmental, social, and economic **impacts** developed from the FY18/19 project, include new waste categories, and provide a **means to better integrate source reduction activities**
- **Develop necessary support materials** for future users and developers

Refinements to the WasteCalc model

Input

Recycled Tons	
Newspaper	Ferrous Metals
Glass	White Goods
Aluminum Cans	Non Ferrous Metals
Plastic Bottles	Other Paper
Steel Cans	Textiles
Corrugated Boxes	C&D Debris
Office Paper	Food Waste
Yard Trash	Miscellaneous
Other Plastics	Tires

Landfilled Tons

Combusted Tons

Collected C&D Tons

Behind the Scenes

Recent US EPA data

WasteCalc

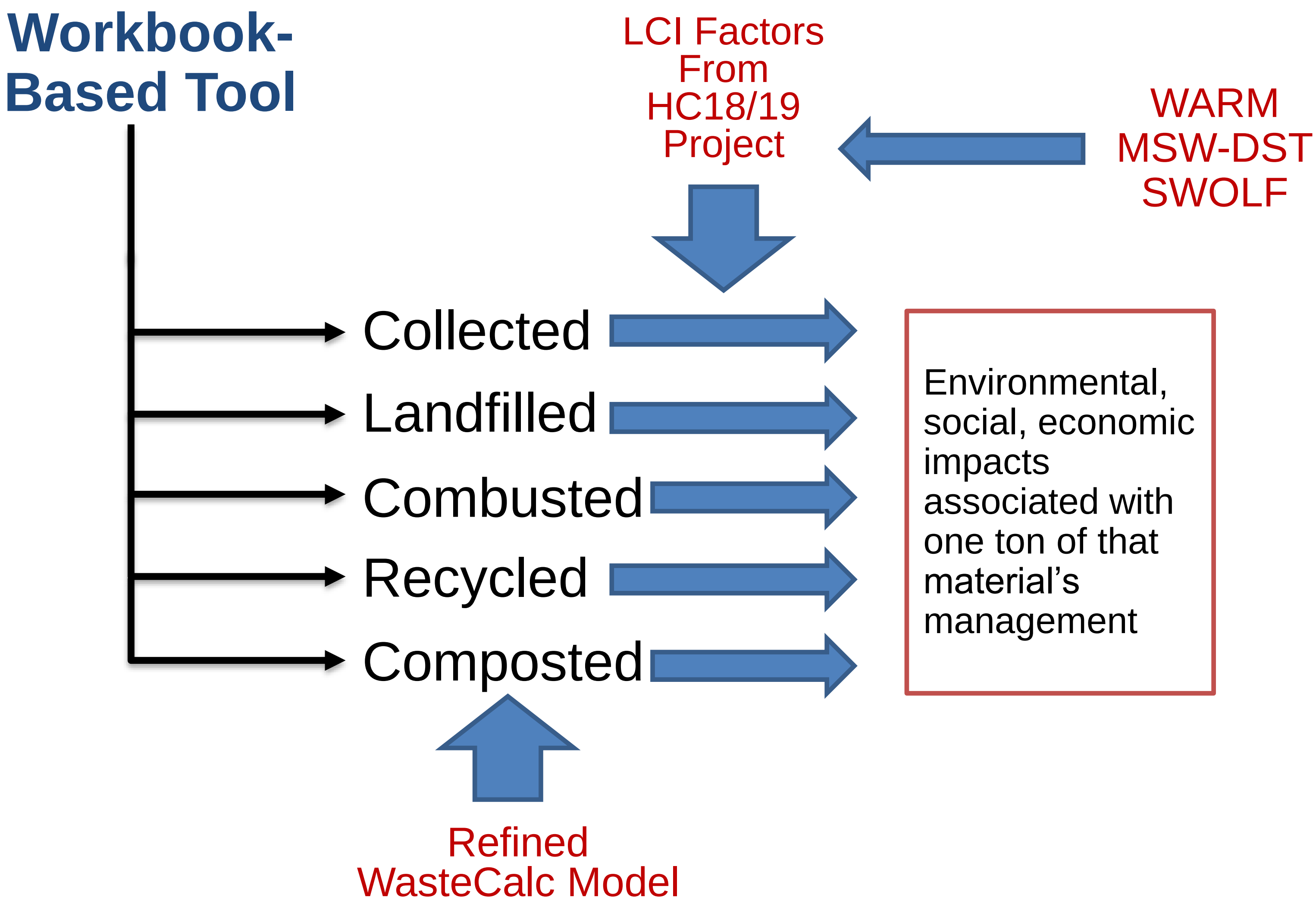
Recent FL waste composition data

Output

% MSW Composition	Tons MSW Composition
Newspaper	Newspaper
Glass	Glass
Aluminum Cans	Aluminum Cans
Plastic Bottles	Plastic Bottles
Steel Cans	Steel Cans
Corrugated Boxes	Corrugated Boxes
Office Paper	Office Paper
Yard Trash	Yard Trash
Other Plastics	Other Plastics
Ferrous Metals	Ferrous Metals
White Goods	White Goods
Non Ferrous Metals	Non Ferrous Metals
Other Paper	Other Paper
Textiles	Textiles
C&D Debris	C&D Debris
Food Waste	Food Waste
Miscellaneous	Miscellaneous
Tires	Tires

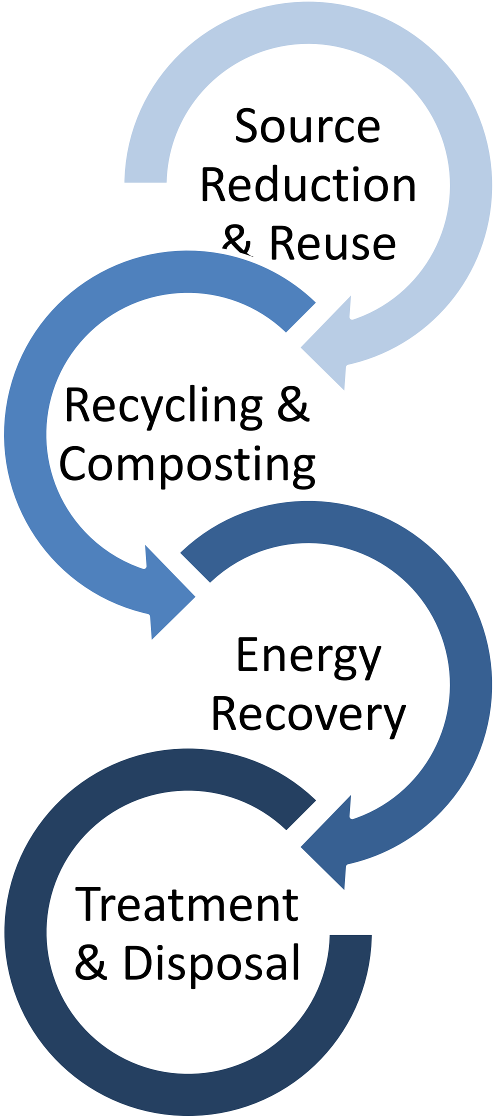
Output the Tons of MSW Collected, Recycled, Landfilled, Composted, Combusted

Incorporate SMM Using Metrics



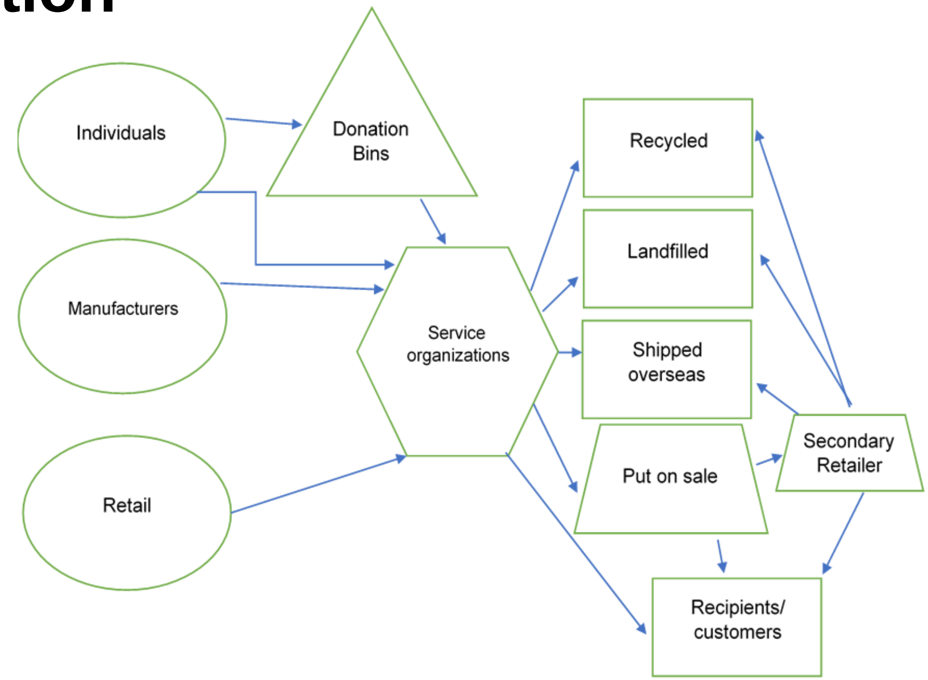
Integrate Source Reduction Activities

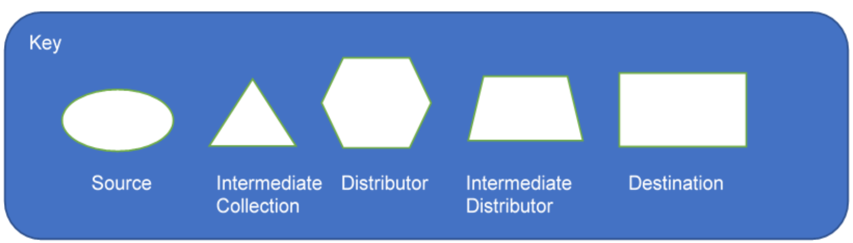
- Measure the mass of materials consumed for in previous years and compare to recent years
- Donation is a form of source reduction since materials are directly reused
  - Map the donation flow of materials



Integrate Source Reduction Activities: Textiles Donation

- Year-end reports from donation services (e.g., Goodwill, ESOL Closet)
- Services will either put the item so sale, ship them overseas for resale, or dispose of them
- Data from Goodwill collected for Florida Total



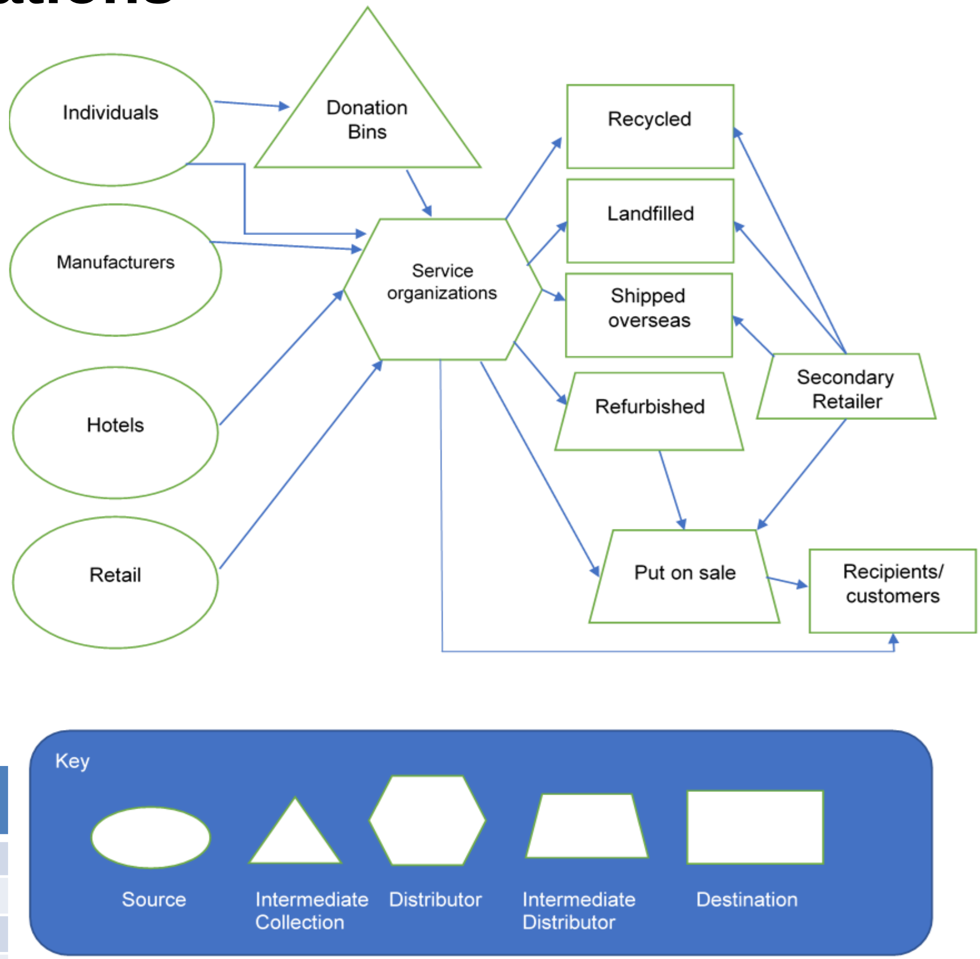


2020	Apparel (lbs.)	Linens (lbs.)	Total (lbs.)
Jan	431852	115628	547480
Feb	367108	91557	458665
Mar	470895	80836	551731
Apr	366281	56776	423057
May	386510	74567	461077
Jun	403259	96312	499571
Jul	452794	124510	577304
		Total	3518885

Total Textiles Donated at Goodwill = ~3,000 Tons / Yr

Integrate Source Reduction Activities: Furniture Donations

- Year-end reports from donation services (e.g., Goodwill, Habitat for Humanity ReStore)
- Most services do not measure mass sold or received of furniture
- Data from Goodwill collected for Florida Total

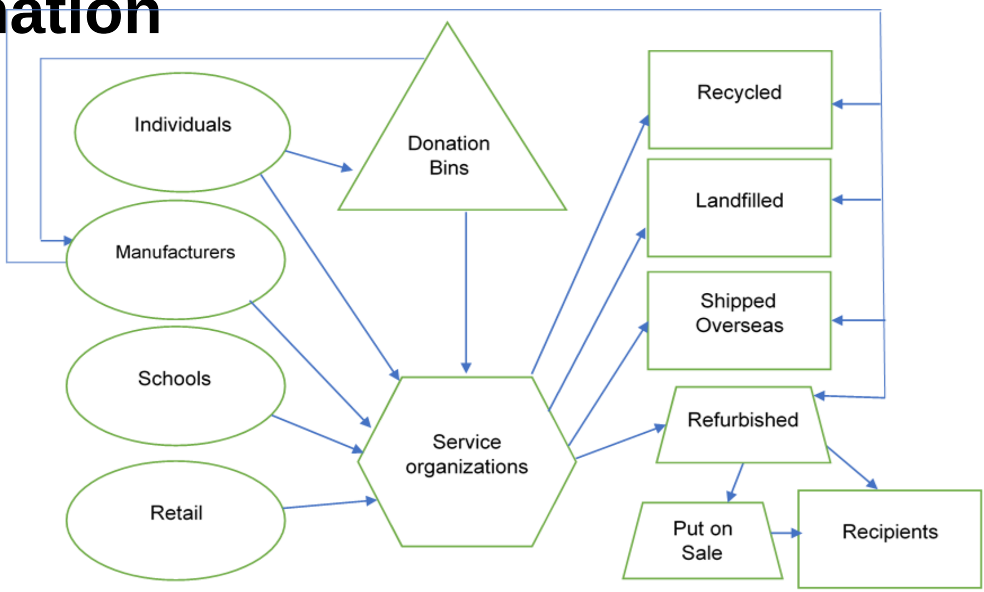


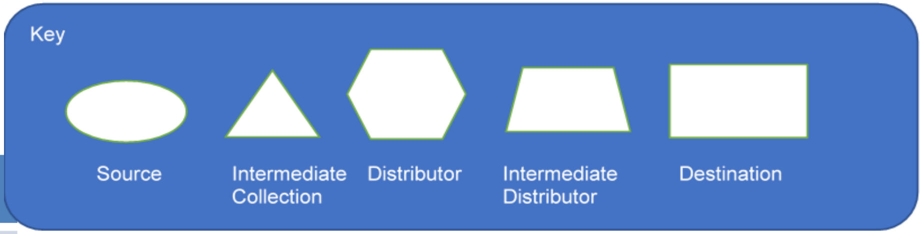
2020	Bric Brac/Wares (lbs.)	Metal (lbs.)	Kitchen Wares (lbs.)	Total (lbs)
Jan	41256	127718	12340	181314
Feb	41297	95526	10335	147158
Mar	25794	101646	10069	137509
Apr	1743	159760	8636	170139
May	4802	105783	8862	119447
Jun	9332	104583	9679	123594
Jul	14606	106342	13743	134691
			Total	1013852

Total Furniture Donated at Goodwill = ~870,000 Tons / Yr

Integrate Source Reduction Activities: Electronics Donation

- Year-end reports from manufactures and donation services
- Many manufactures recycle the donated electronics and do not refurbish for resale
- Data from Goodwill collected for Florida Total



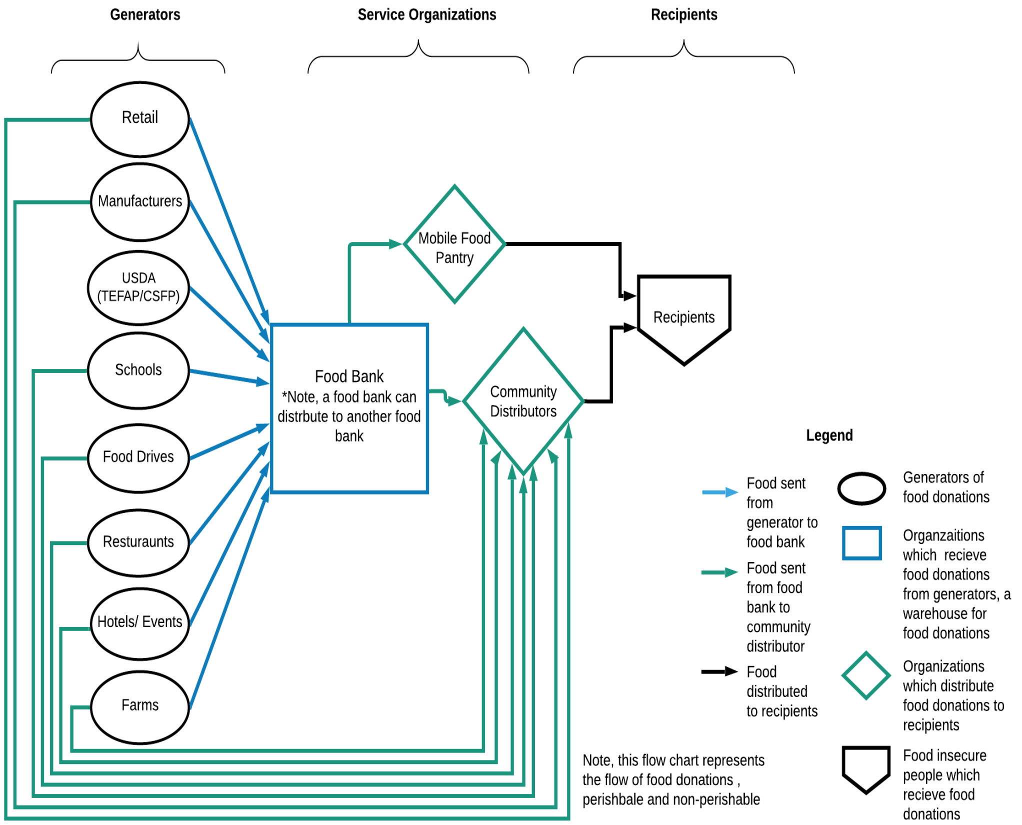


2020	Computers (lbs.)	Electrical (lbs.)	Phones (lbs.)	Total (lbs)
Jan	19223	22125	0	41348
Feb	30183	29797	0	59980
Mar	7603	9935	0	17538
Apr	19655	19843	0	39498
May	9123	9649	0	18772
Jun	8124	9803	0	17927
Jul	21880	21945	339	44164
			Total	239227

Total Electronics Donated at Goodwill = ~200 Tons / Yr

Integrate Source Reduction Activities: Food Donations

- Year-end reports from donation services (e.g., Feeding Florida Food Banks, local food pantries)
- Many manufactures recycle the donated electronics and do not refurbish for resale
- Data from mostly Feeding Florida Food Banks and Heartland Farm Gleaner



Total Food Donated = ~149,000 Tons / Yr

Challenges with Donation Data

- This research was conducted during the COVID-19 pandemic, impact on donation flow quantities
- Many locations could not accurately quantify mass or volume of donations received
- Many service organizations contacted could not (because of COVID or proprietary data) provide the information needed for this research

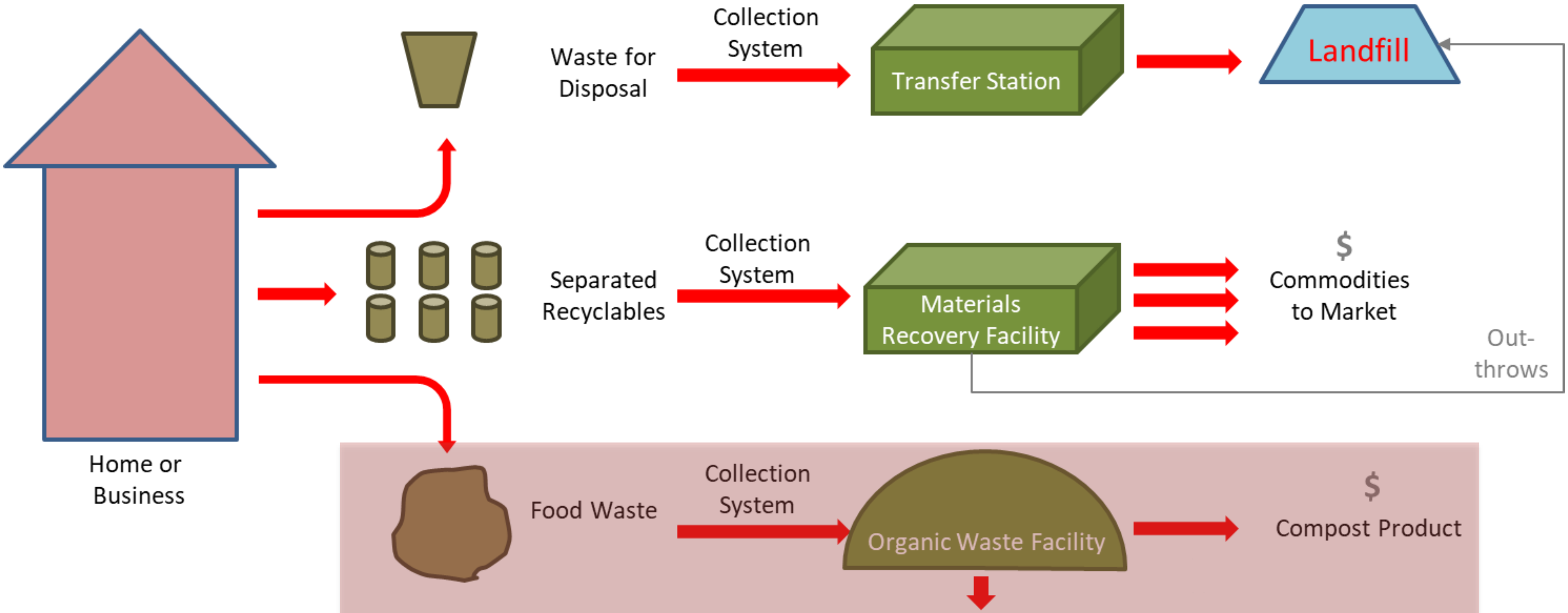
Develop Necessary Support Materials

- Training materials for the refined model will be developed
- We will work with FDEP, local governments and the working group to test these training materials
- A series of case studies for several counties will be integrated into this exercise
- Work with FDEP to provide training statewide through a webinar or conference presentations.
- Following each training event we expect to receive feedback or comments that will be used in potential model refinement.

Bulky Waste Reuse

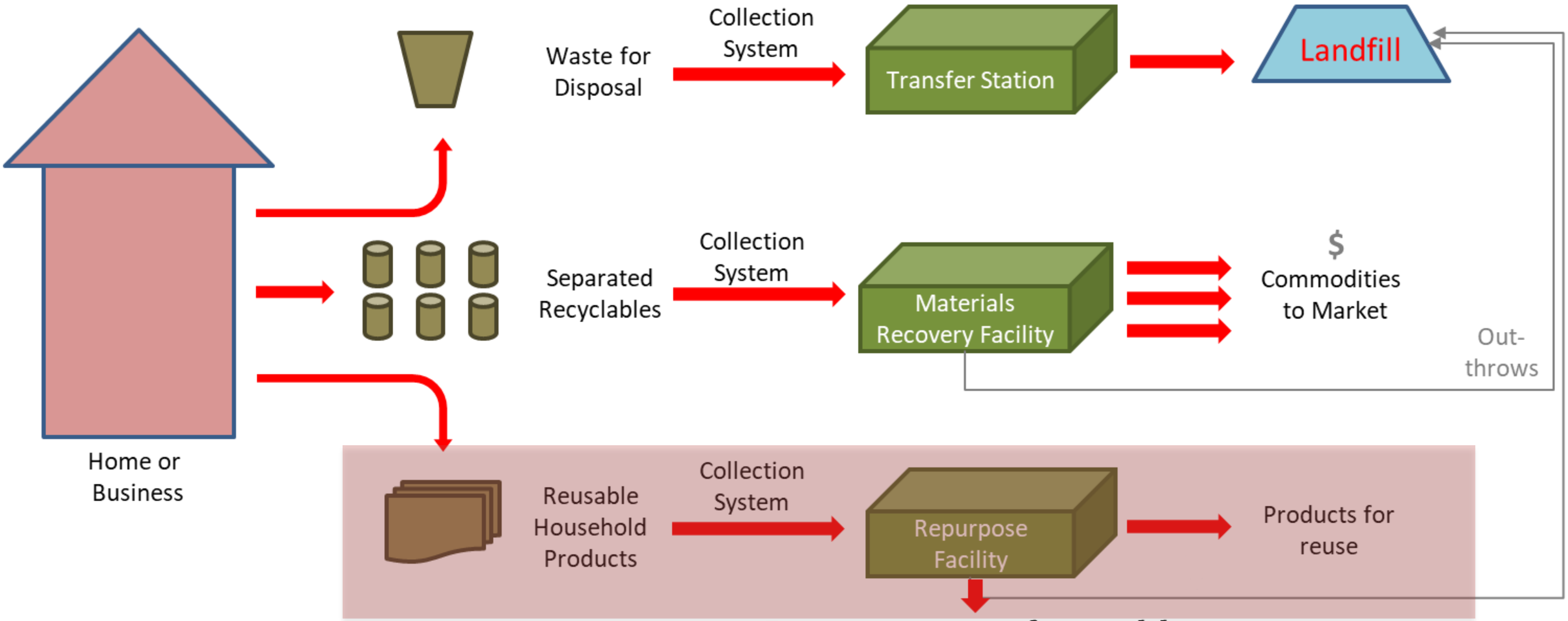
- Let's say we want to incorporate better collection services to encourage source reduction.
  - We looked at two alternative systems:
    1) Separate food collection for composting
    2) Separate bulky waste collection for refurbishment

Bulky Waste Reuse



Recovery rate of food waste: **35%**

Bulky Waste Reuse

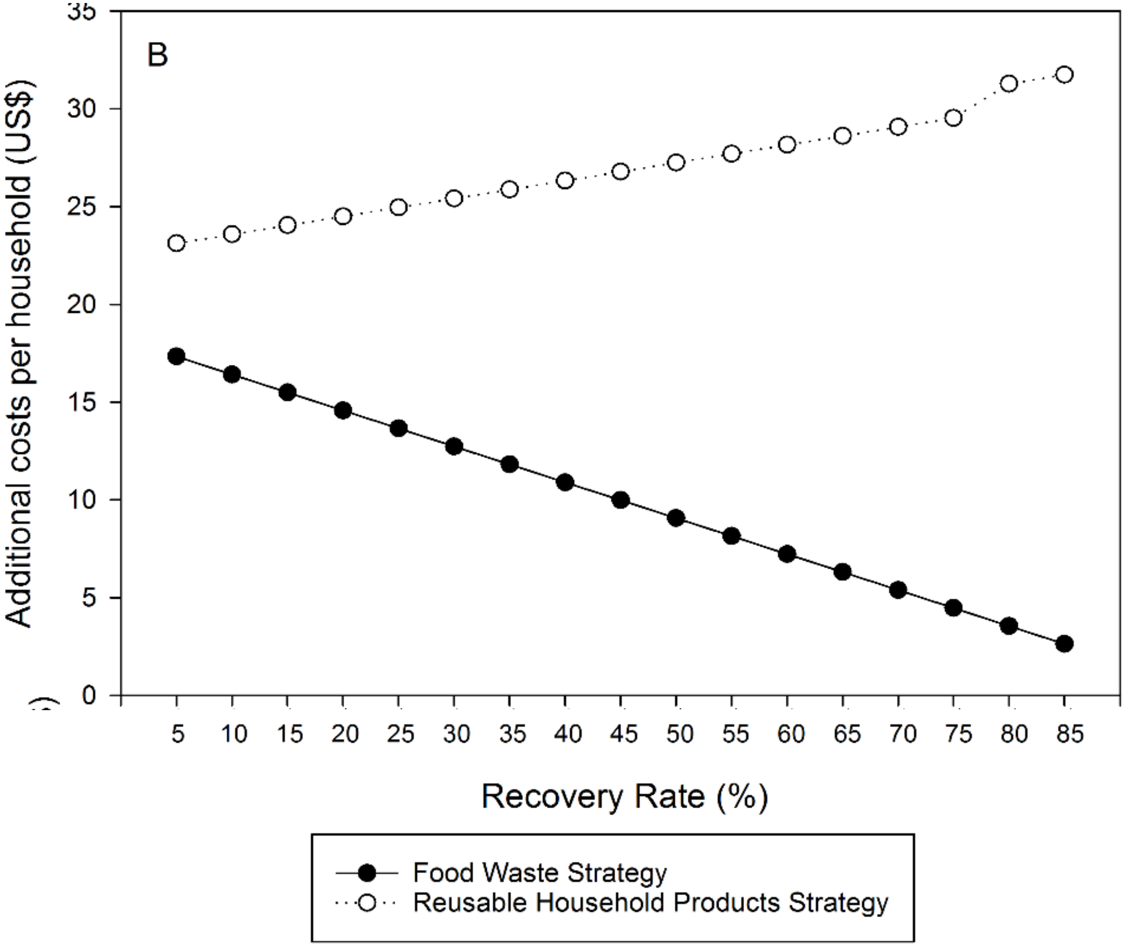


Recovery rate of reusable products: **9.5%**

- Major appliances
- Small appliances
- Furniture
- Electronics
- Textiles

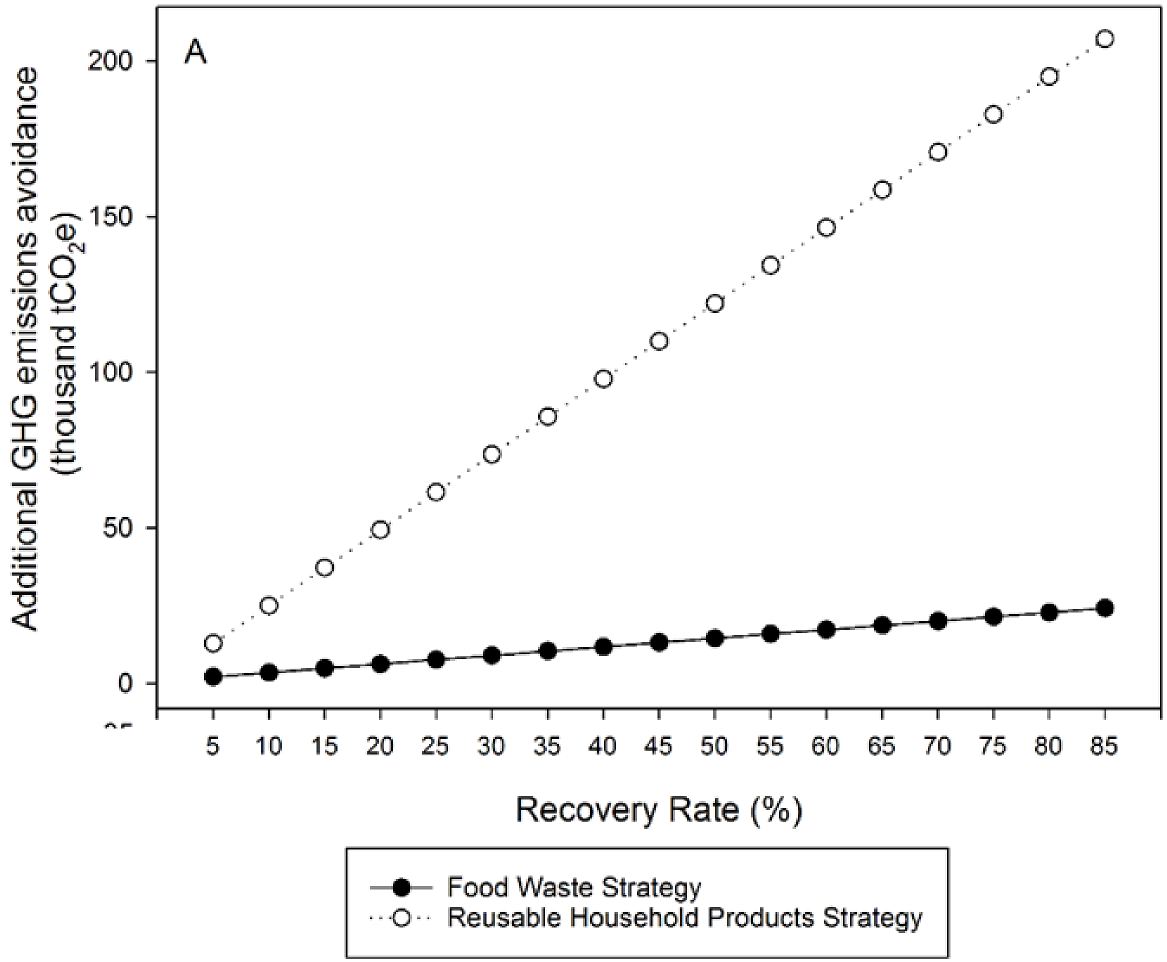
Bulky Waste Reuse

What is the additional cost to the household?



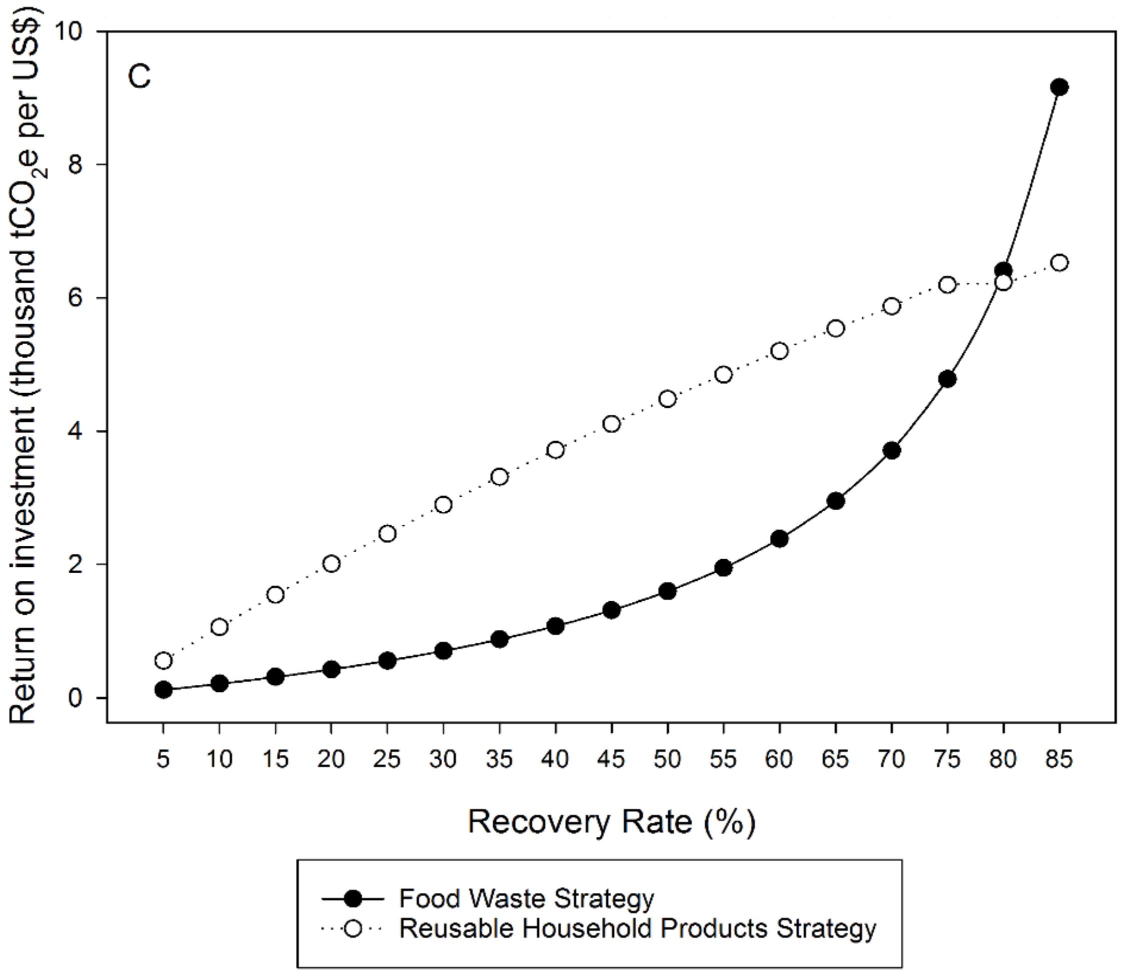
Bulky Waste Reuse

What is the additional GHG savings?



Bulky Waste Reuse

What is the "return-on-investment"?



https://faculty.eng.ufl.edu/timothy-townsend/research/florida-solid-waste-issues/florida-solid-waste-management/

UF Dr. Timothy G. Townsend
Sustainable Materials Management Research Laboratory

RESEARCH COURSES PUBLICATIONS TEAM CONTACT MY DEPT

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FLORIDA SOLID WASTE MANAGEMENT

SUSTAINABLE LANDFILL PRACTICES

CONSTRUCTION AND DEMOLITION DEBRIS

BENEFICIAL USE OF WASTE MATERIALS

Florida Solid Waste Management: State of the State

As new methods for the management of solid wastes are developed and refined,

Progress Reports

Progress Report 1: HC16PR01

Progress Report 2: HC16PR02

Progress Report 3: HC16PR03

Herbert Wertheim College of Engineering

POWERING THE NEW ENGINEER TO TRANSFORM THE FUTURE

https://faculty.eng.ufl.edu/timothy-townsend/research/florida-solid-waste-issues/looking-beyond-floridas-75-recycling-goal/

Dr. Timothy G. Townsend

Sustainable Materials Management Research Laboratory

RESEARCH   COURSES   PUBLICATIONS   TEAM   CONTACT   MY DEPT

Home • Research • Florida Solid Waste Issues • Looking Beyond Florida's 75% Recycling Goal

LOOKING BEYOND FLORIDA'S 75% RECYCLING GOAL

SUSTAINABLE LANDFILL PRACTICES

CONSTRUCTION AND DEMOLITION DEBRIS

BENEFICIAL USE OF WASTE MATERIALS

Looking Beyond Florida's 75% Recycling Goal: Development of a Methodology and Tool for Assessing Sustainable

Progress Reports

Progress Report 1: HC18PR01

Progress Report 2: HC18PR02

Progress Report 3: HC18PR03

https://faculty.eng.ufl.edu/timothy-townsend/research/florida-solid-waste-issues/tool-to-track-progress-toward-smm-goals/

Thank You for Your Time!

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