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

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ABSTRACT

The way in which many think about solid waste in the US is shifting[1]. The US Environmental Protection Agency (EPA), for example, has adopted the approach of sustainable materials management (SMM) instead of solid waste management (both in spirit and literally in terms of a name change). This evolution is being embraced by the EPA, states such as Oregon, and private industry[1]. In Florida, thanks to funding from the Hinkley Center and several municipalities, the University of Florida has begun to evaluate SMM as an approach as well. The project, *Florida Solid Waste Management: State of the State*, involved looking at Florida's solid waste stream with respect to generation, composition, and disposition (the more traditional ways of tracking solid waste), but also included an assessment whereby SMM principles were used to evaluate the implications of how we manage our wastes. For example, the research team used life cycle assessment (LCA) models to estimate greenhouse gas (GHG) emission and energy use avoidance from current and proposed materials management approaches in selected Florida counties and on a statewide level[2]. The team also estimated the cost of solid waste management and the financial impact of various scenarios at the county and statewide levels.

One additional outcome from this work was the development of an alternative recycling rate measurement methodology that relied on more than simply mass. The alternative method allows highly effective materials management strategies such as source reduction, which is not accounted for in the current recycling goal, to be considered in future programs. With this approach, the research team estimated that a combustion dominated waste management strategy that has a traditional mass-based recycling rate of 42.9%[3] would result in a 76.9% GHG-normalized recycling rate (based on GHG emission comparisons over 2008 levels). This idea has been presented around the state and to our working group, with positive reception, and has even caught the attention of EPA, other states, and the private waste services industry.

In this proposal, we propose to continue the development and refinement of this approach. One tangible outcome of this research will be the development of a tool that can be used by local governments and the Florida Department of Environmental Protection (FDEP) to estimate and compare alternative recycling rates based on specific waste streams, composition, disposition, and life cycle assessment impact (LCIA) factors (e.g., GHG emissions and energy use). A major comment received during our early rollout of this approach is that additional factors should be considered. These would include other environmental factors normally used in LCA models (e.g., water consumption, toxicity), as well as factors that would be of specific interest to the solid waste industry (e.g., landfill disposal capacity, recycled material marketability, jobs). Thus, our second major outcome (which will be incorporated into our first major outcome -- the tool) will be the development of new LCIA factors beyond what is currently available.

PRINCIPAL INVESTIGATOR

The investigator for the proposed research is Timothy Townsend, a Professor in the Department of Environmental Engineering at the University of Florida.

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Dr. Townsend's area of specialization is solid and hazardous waste management and engineering. Dr. Townsend has been researching and teaching in the discipline of solid and hazardous waste management since 1990. He teaches engineering courses on solid and hazardous waste management, landfill design, recycling and beneficial use of waste materials to both undergraduate and graduate students. His research areas include sustainable landfill design and operation, landfill leachate and gas management, construction and demolition debris, electronic waste, waste leaching, recycling of waste materials, and waste management in developing countries.

BACKGROUND

The Hinkley Center's 2018 research agenda expresses a desire to think beyond Florida's current 75% recycling by 2020 goal. The University of Florida has been helping the FDEP and the solid waste industry do this through a FY16/17 Hinkley Center-funded project entitled *Florida Solid Waste Management: State of the State*. The University proposes to expand upon this research to develop a Florida-specific LCA tool and additional LCIA factors that will enable planners and decision makers to evaluate the environmental and economic impact of various solid waste management scenarios and further support SMM[4].

The FY16/17 project involved looking at Florida's solid waste stream with respect to generation, composition, and disposition (the more traditional ways of tracking solid waste), but also included an assessment whereby SMM principles were used to evaluate the implications of how we manage our wastes[4]. The research team used the EPA's Waste Reduction Model (WARM)[5] to estimate GHG emissions and energy use avoidance from current and proposed materials management approaches in selected Florida counties and on a statewide level.

In the previous project we characterized Florida's waste stream into four waste generator categories (i.e., residential solid waste, non-residential solid waste, construction and demolition debris (C&D), and yard trash (YT)) and evaluated three recycling rates (i.e., standard, traditional, and total recycling rates). Of the three recycling rates, the study developed the 'standard' recycling rate which consists of only materials recycled at a materials recovery facility (MRF). The standard recycling rate was developed because the traditional and total recycling rates (as defined by FDEP) include other materials and solid waste management practices (e.g., combustion of waste, landfill gas-to-energy) not typically included in the recycling rate calculation across the US. We evaluated the residential and non-residential solid waste streams independent from C&D and yard trash because they are the two largest components of the waste stream and we wanted to estimate the residential curbside residential recycling rate. Figure 1 shows that all the generators standard and traditional 2016 recycling rates are below the 75%, and only the YT total recycling rate achieved the 75%. This highlights the challenges of each generator to reach the 75% recycling rate and provides decision makers with insight on which generators to invest recycling programs in.

After estimating the generator recycling rates, the study used these findings along with discussions from the solid waste industry to identify five alternative waste management approaches rate (i.e., waste-to-energy (WTE), mixed waste processing facility (MWPF), residential curbside recycling, C&D and YT recycling, and non-residential food waste compositing) that have the potential to achieve the 75% recycling. Because SMM focuses on resource efficient practices, decision makers can use the approaches' environmental footprint and economic cost to compare to the 2016 Florida waste management's environmental and economic costs to make decisions to best manage materials. In this study, we evaluated how each approach compares to the 2016 management by calculating the GHG emissions, energy use, and costs associated with the total recycling rate percentage point increase (Table 1) from the initial 56% 2016 total recycling rate (see Figure 2). Results of this strategy show that on a percentage point increase the non-residential food waste approach may generate the largest avoidance of GHG emissions (negative value represents an avoidance) but it has the largest costs. Whereas, residential curbside recycling approach has the second largest GHG emissions avoidance, the largest energy use avoidance, and the only reduction in costs (because of less materials disposed of). Each approach has varying environmental and economic results; this further supporting the need to develop additional LCIA factors to provide decision-makers a suite of environmental, social, and economic impact results that can be used to make decisions.

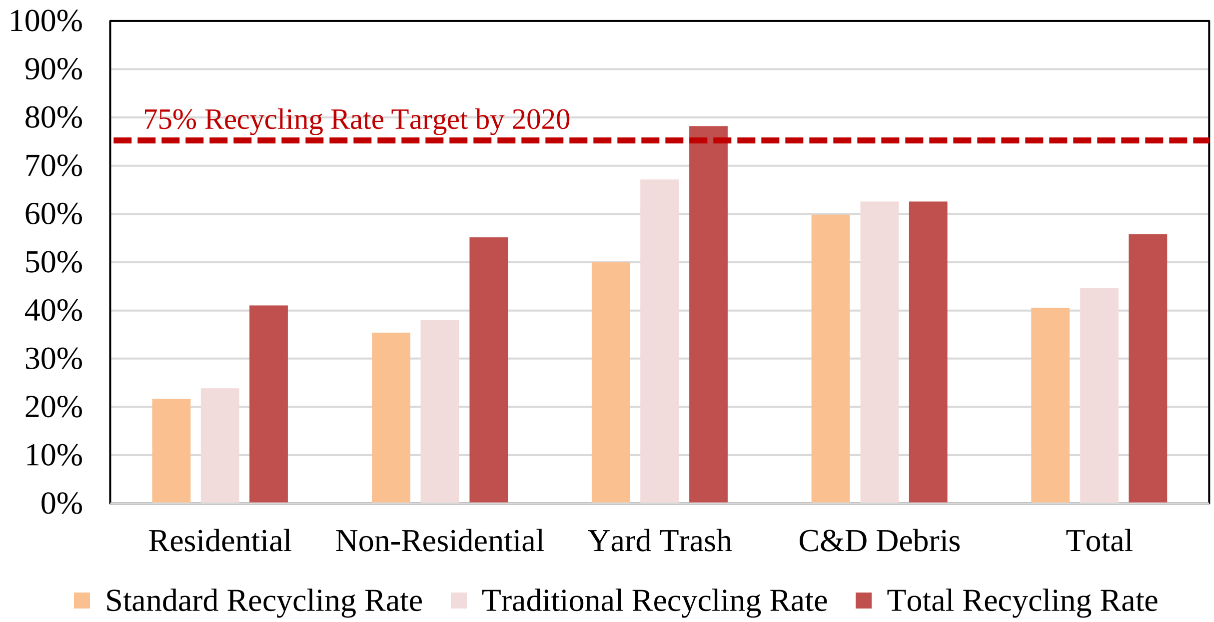

Figure 1: Standard, traditional, and total 2016 recycling rates for the four waste generator categories (residential solid waste, non-residential solid waste, yard trash, and C&D debris).

Table 1. The total recycling rate percentage point difference between the approaches and the 2016 baseline.

Approach	Total Recycling Rate Percentage Point Increase
WTE Approach	12.9%
MWPF Approach	10.4%
Residential Curbside Recycling Approach	8.14%
C&D and YT Recycling Approach	6.52%
Non-Residential Food Waste Composting Approach	0.042%

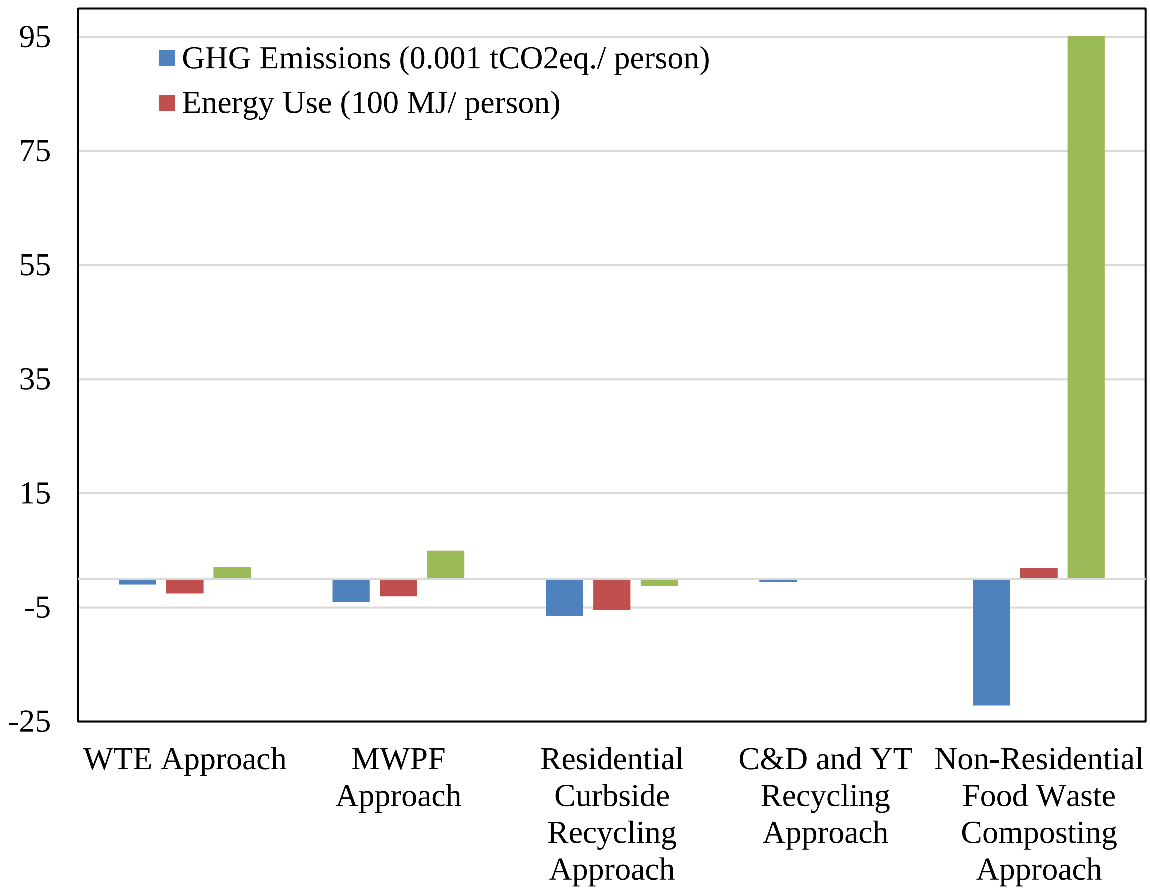

Figure 2. The GHG emissions (0.001 tCO_2eq./person), energy use (100 MJ/person), and cost (10,000,000 $USD) associated with each approachs' incremental total recycling rate percentage point increase.

One of the key findings of the FY16/17 project was that recycling certain materials generated a greater environmental benefit than recycling the same percentages of other materials[3]. For example, recycling 75% of Florida's mixed paper is expected to result in a larger greenhouse gas emission and energy-use avoidance than recycling 75% of mixed metals generated in Florida[3]. While recycling a ton of mixed paper results in less greenhouse gas and energy-use avoidance than recycling a ton of mixed metals, the much larger mass of mixed paper in Florida makes recycling a larger percentage of this material a greater environmental benefit (Figure 1). Once this concept is understood, the need for a Florida-specific LCA tool becomes apparent.

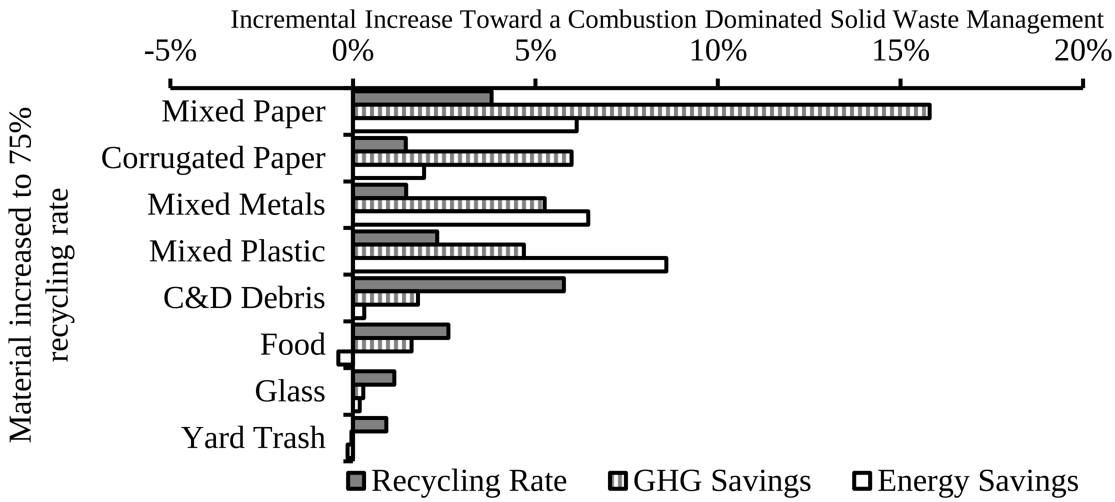

Figure 3: The incremental increase of the recycling rate, GHG and energy avoidance toward a combustion dominated waste management when the recycling rate for each material in 2020 was set to 75%. This was calculated as the ratio of the results of the recycling rate, GHG and energy use avoidance when the materials recycling rate was increased to 75% in 2020 to the recycling rate, GHG emissions and energy use avoidance of the combustion dominated waste management in 2008.

The research team proposes to develop an LCA tool that includes many LCIA factors and calculates LCIA-normalized recycling rates that can be used by local government to identify ideal management practices for each material within Florida's waste stream. Additional LCIA factors that could be developed for the project include economic costs, jobs produced, water consumption and toxicity. Actual LCIA factors to be developed in this project will be determined after consulting with key stakeholders, such as the FDEP. Existing LCA models, like US EPA's WARM model or MSW-DST provide LCA inventories that will be used to determine the LCIA conversion factors for traditionally used LCA criteria. However, for LCIA factors not traditionally documented- such as jobs produced per mass of material recycled- additional data will need to be collected.

The goal of this study is to provide a comprehensive and publicly available tool that can be used by planners and decision makers to measure and compare the environmental and economic benefits of various recycling and beneficial use scenarios through LCI-normalized recycling rates. It is anticipated that this tool will result in decisions that are more informed and the implementation of more cost-effective and environmentally beneficial recycling programs.

OBJECTIVES

The specific objectives of this research project are as follows:

- Develop a publicly available LCA tool that that can be used to measure and compare social, economic, and environmental impacts for various Florida solid waste management approaches.
- Develop additional LCIA factors that will allow users to consider a wider variety of impacts associated with various materials management scenarios.

METHODOLOGY

Task 1. Compile Available Data on The LCIA Criteria. The research team will compile the following data to be used in Task 2:

- Traditional LCIA Criteria will be collected from the following sources:
    - **A.** Developed LCA model's inventory and background documents such as WARM, MSW-DST, and OpenLCA document their databases.
    - **B.** Reported LCA related literature and reports on the social, economic, and environmental impacts attributed to the product, material, or process life cycle.
- Nontraditional LCIA Criteria will be collected from the following sources:
    - **A.** Solid waste industry data on the energy use, jobs produced, landfill capacity, etc. associated with a solid waste management facility such as a mixed waste processing facility, materials recovery facility, composting facility, etc.

Task 2. Develop LCIA Factors. Using the data collected as part of Task 1, the research team will identify the LCIA criteria of interest by discussing with the working group members and then coming to a consensus on which factors to develop; the potential LCIA factors will be developed for the project may include:

- Energy Use
- Greenhous Gas Emissions
- Economic Costs
- Landfill Disposal Capacity
- Recycled Material Marketability
- Jobs Produced
- Water Consumption
- Toxicity

The LCIA factors will incorporate the associated impacts of each life-cycle stage (raw materials extraction, transportation, manufacture, use, and end-of-life treatment) of a material's management approach; these will potentially include:

- Landfilling
- Combustion
- Recycling
- Source Reduction
- Composting
- Anaerobic Digestion
- Mixed Waste Processing

The LCIA factors will measure the environmental or economic impact associated with a mass of material's management approach (e.g., 1 ton newspaper recycled generates X jobs produced) for various materials. The materials of interest are the 18 types reported by the FDEP in the Solid Waste Management Annual Report.

Task 3. Create an LCA Model. The research team will use the refined Florida waste management data collected in Task 1 and the LCIA factors developed in Task 2 to create an LCA model in the form of a spreadsheet that quantifies the social, economic, and environmental impacts of different materials management options.

The model will consist of an input-output analysis structure, where the inputs are the Florida waste management disposition and composition and the LCIA factors, and the outputs are the associated impacts of a management approach. The function of the model will be similar to other LCA models where users input site specific data and output data exports; however, unlike many LCA models the proposed model will have a simple user interface and the output data will be easily understood.

Task 4. Use the LCA Tool to Evaluate Best Material Management Approaches in Florida. The research team will use the LCA tool to quantify the social, economic, and environmental impact of each of the materials in Florida's waste stream to identify the best material management approach and conduct similar efforts in county oriented case studies.

TIMELINE

A 12-month project is proposed with the following timeline:

Task/ Milestone	Description	1	2	3	4	5	6	7	8	9	10	11	12
Milestone 1	Meet with TAG members to seek consensus on which LCIA factors and tool features to develop	X											
Task 1	Compile available data to develop the LCIA factors	X	X	X	X	X	X	X					
Task 2	Develop the LCIA factors			X	X	X	X	X					
Milestone 2	Meet and receive feedback from TAG members on current progress in developing the LCIA factors and potential best management approaches to be studied						X						
Task 3	Create an LCA tool						X	X	X	X	X		
Task 4	Use the LCA tool to evaluate best material management approaches in Florida									X	X	X	X
Milestone 3	Present to TAG members final tool and results from evaluating best management approaches											X	
Milestone 4	Incorporate comments from TAG members and finalize the LCA tool												X
-	**TAG Meeting**	X					X					X	

COMMUNICATION PLAN

Through planned stakeholder working group meetings the study's objectives, progress, and deliverables will be communicated. We expect that through the TAG members we will satisfactorily meet each milestone and receive well-rounded feedback from federal and state regulatory agencies, local government, non-governmental organizations, solid waste consultants, and the waste management and recycling industry.

PERTINENT LITERATURE

1) Silva, A.; Rosano, M.; Stocker, L.; Gorissen, L. From waste to sustainable materials management: Three case studies of the transition journey. *Waste Management* **2017**, *61* (Supplement C), 547–557.
2) Greene, K. L.; Tonjes, D. J. Quantitative assessments of municipal waste management systems: Using different indicators to compare and rank programs in New York State. *Waste Manag.* **2014**, *34* (4), 825–836.
3) Malak Anshassi; Timothy Townsend; Steven Laux. Should Life Cycle Metrics Replace Recycling Rates as Government Materials Management Targets? *Submitted To Environmental Science & Technology* **2017**.
4) Chen, P.-C.; Liu, K.-H.; Ma, H. Resource and waste-stream modeling and visualization as decision support tools for sustainable materials management. *Journal of Cleaner Production* **2017**, *150* (Supplement C), 16–25.
5) ICF International. Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM): Management Practices Chapters. U.S. Environmental Protection Agency February 2016.

DELIVERABLES

Deliverables for the proposed work include progress reports to the Center, the developed LCIA factors and the LCA tool, and any manuscripts or thesis chapters completed by students working on this project as part of their degree requirements. All other deliverables required by the Center will be met. A project website will be maintained, an information dissemination plan will be developed, and other necessary deliverables will be completed.

BUDGET

A breakdown of the proposed project budget is provided in Table 2. This includes three weeks of Dr. Townsends time (Salary + Fringe), One 12-month 0.5 FTE graduate student (Salary + Fringe + Tuition). 500 hours of OPS student assistance, $2,000 for project supplies (modeling software and meeting costs) and $1,000 for project travel.

Table 2. Proposed Project Budget

Category	Amount
PI (Townsend) @ 3 week [Salary + Fringe]	$21,159
Grad Student 1 0.5 FTE [Salary/Fringe/Tuition]	$38,857
OPS Student Assistant	$5,300
Expenses (Lab - $10K; Travel = $1,000)	$2,000
Total Indirect	$67,316
Indirect (0%)	--
Total Project Budget	$67,316

BENEFITS

The solid waste community in Florida will benefit from having a Florida-specific LCA model. This information will allow solid waste practitioners, planners, and policy makers to quantify and compare the environmental and economic impacts of various solid waste management alternatives. A tool such as this will provide a uniform platform for comparison that includes existing and future LCIA factors that will enable more rational and cost-effective material management decisions that go beyond mass-based recycling goals.

PLAN FOR SEEKING OTHER SOURCES OF FUNDING

The previous study successfully obtained additional local-government funding by conducting county-based case studies that followed the same methodology, tasks, and objectives of the overall study for five counties in the state. The case studies enhanced the statewide study providing the county more specific and detailed information regarding their material management programs. Similar efforts to seek other sources of funding will be completed, however the case studies will focus on using the LCA tool to evaluate each county's best material management approaches.