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Opportunity Analysis for Advancing Diversion and the Circular Economy in the Cincinnati Region

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Abbreviations

ATL	Hartsfield-Jackson Atlanta International Airport
BME	Brightmark Energy
BMP	Best Management Practices
CAPEX	Capital expenses
CBSM	Community-based social marketing
CGF	Consumer Goods Forum
CVG	Cincinnati/Northern Kentucky International Airport
DEACS	North Carolina Department of Environmental Quality Division of Environmental Assistance and Customer Service
EPS	Expanded polystyrene
FAA	Federal Aviation Administration
HCRSWD	Hamilton County Recycling and Solid Waste District
GCP	Green Cincinnati Plan
GHG	Greenhouse gas
HDPE	High-density polyethylene
IRV	Incentivized Reverse Vending
LDPE	Low-density polyethylene
MRF	Materials recovery facility
MSW	Municipal solid waste
OBRC	Oregon Beverage Recycling Cooperative
OPEX	Operating expenses
PAYT	Pay-as-you-throw
PDX	Portland International Airport
PP	Polypropylene
PET	Polyethylene terephthalate
RRI	Residential Recycling Initiative
SORTA	Southwest Ohio Regional Transit Authority
TRP	The Recycling Partnership
WMT	Waste Minimization Team
ZWED	Zero Waste Energy Development Company

Executive Summary

The Opportunity Analysis identifies potential solutions to improve the diversion rate of municipal waste in Cincinnati, Ohio. This analysis is the second phase in the Beyond 34 three-phased model that supports the efforts of municipalities and communities to increase the diversion of valuable resources from landfills and accelerate the shift to a circular economy. The Opportunity Analysis informs the Roadmap to Implementation in phase three of the Beyond 34 model.

This report identifies ten potential projects based on the analysis done in the Current State Assessment and feedback from workgroups of local stakeholders. The Current State Assessment provides an assessment of Cincinnati's waste and recycling system, including its infrastructure, material flows, historical efforts, and key stakeholders. The Opportunity Analysis evaluates projects based on their ability to increase diversion, advance efforts to transition the region to a more circular economy, and viability in the greater Cincinnati/Hamilton County region. Additionally, each of the projects has been evaluated based on long-term benefits such as education, infrastructure creation, and integration of relevant best practices from cities around the world that can be adapted to meet Cincinnati's unique needs.

Implementing these ten solutions, see Table-ES 1, could transform Cincinnati's waste and recycling system in both traditional and innovative ways. State of the art technologies, education, and social and economic leverage points relating to citizens and businesses are key factors for enabling these project options and driving the development of a circular economy in Cincinnati.

Table-ES 1: Opportunity Analysis' projects

Opportunity Analysis Project Solutions	
Centralized Compost	Disruptive Reusable Technologies
Plastic to Fuel	Municipal Diversion Education Strategies
Municipal Cardboard Diversion Best Practices	Household Food Waste Prevention Strategies
Incentivized Reverse Vending	Commercial Diversion Strategies
Decentralized Compost	Municipal Systems Optimization

Based on this assessment, the implementation of all proposed projects would increase the current diversion of 23.06% to an estimated 34.60% to 47.22% based on a 30% or 60% increase in the landfill capture rate for each material category. Each of the projects identifies possible assets and barriers for each project. Where applicable and where data permits, financial performance estimates are provided.

1. Introduction

The Opportunity Analysis (OA) identifies potential solutions to improve the rate of municipal solid waste (MSW) diversion in Cincinnati, Ohio. This analysis is the second phase in the Beyond 34 three-phased model and is guided by the Current State Assessment, developed in Phase 1 in conjunction with the USCCF and the City of Cincinnati. The Current State Assessment assessed Cincinnati's waste and recycling systems including its infrastructure, material flows, and historical efforts while identifying key stakeholders. The stakeholders identified in the Current State Assessment help to drive the Opportunity Analysis and will be critical in further developing the Roadmap to Implementation, which is the culminating guidance document in the final phase of the Beyond 34 model. The City of Cincinnati's Green Cincinnati Plan (GCP), which presents a comprehensive set of recommendations to advance sustainability, equity, and resilience, was also used as a resource. The goals in the GCP specifically relating to waste and guided opportunity development are listed below:

- Zero waste by 2035
    - Reduce food waste by 20% by 2025
- Decrease residential tonnage of waste transferred to landfills by 20%
- Increase participation in city curbside recycling programs by 5% for residential areas and by 20% for commercial areas.
- Increase by 10% the number of city residents that can name at least 3 actions they are doing to be green/promote sustainability

This report identifies ten potential projects that will have a positive impact on the diversion rate and analyzes their potential impact in terms of material diverted and long-term benefits such as education, infrastructure creation, and integration of relevant best practices from cities around the world. The ten project solutions are listed below in Table 1 in order of their estimated impact on diversion rates. Calculations for their impact on diversion rates are based on a 30% or 60% increased capture rate from current landfilled material specific to each solution.

A holistic analysis of the projects' interactions reveals synergy between the following four proposed projects and the other six proposed projects.

- Household Food Waste Prevention Strategies
- Municipal Diversion Education Strategies
- Commercial Diversion Strategies
- Municipal System Optimization

This is an important distinction because while these four projects do not have a projected impact on diversion rates directly, they have the potential to be highly impactful on the overall waste system in Cincinnati.

Table 1: Opportunity analysis's potential projects

Solution Name	Increased Landfill Capture: 30%		Increased Landfill Capture: 60%	
	% Impact on Diversion Rate	Potential Amount Captured (Tons)	% Impact on Diversion Rate	Potential Amount Captured (Tons)
**Centralized Compost	5.57 %	4,778	11.15%	9,555
Plastic to Fuel	2.61%	2,245	5.23%	4,491
**Municipal Cardboard Diversion Best Practices	1.79%	1,533	3.58%	3,066
Incentivized Reverse Vending	1.22%	1,049	2.44%	2,097
**Decentralized Compost	0.35%	300	1.75%	1,500
Disruptive Reusable Technologies	0.0045% - 0.0103%	21 - 43	0.0132% - 0.0276%	54 – 107
Additional Diversion	11.54%	9,904 tons	24.16%	20,709
Total Diversion	34.60%		47.22%	

Non-Material Stream Based Solutions:

The following solutions focus on increasing diversion across all material streams by addressing inefficiencies in the system, introducing best practices, and expanding collaboration among stakeholders across the recycling value chain. These projects do not support metrics for calculating the impact of diversion for specific streams or the overall diversion rate. However, each of these solutions has the opportunity to support increased diversion by shifting cultural behavior and values both within the residential sector and among the stakeholders across the recycling value chain.

- **Household Food Waste Prevention Strategies
- **Municipal Diversion Education Strategies
- **Commercial Diversion Strategies
- **Municipal Systems Optimization

**These interventions were prioritized through Beyond 34 Cincinnati community network engagement in 2020, and were refined and consolidated into the Beyond 34 Roadmap to Implementation for the Cincinnati region.

This report estimates that if the City of Cincinnati was to implement all possible projects with a direct impact on diversion rate at a 30% increase capture rate of landfilled material, the city is predicted to see a roughly 11.54% increase in its total diversion rate while a 60% increase in the capture rate of landfilled material is predicted to yield a 24.16% increase in its total diversion rate.

Current material flow maps and potential material flow maps at a 30% increase in landfill capture were created, see Figure 1 and Figure 2, representing both the overall impact and the impact on specific material flows if all projects were implemented. This report introduces the ten potential project-based solutions, including a narrative to each solution, a description of the targeted material flow, relevant case studies, and, where applicable, other related research such as the source of feedstocks, the process flows, and technologies necessary to successfully implement solutions. The possible barriers section for each project analyzes both historical efforts and feedback from stakeholders within the municipality. Each project description also offers financial performance estimates, where applicable, and where data permits. Lastly, project descriptions provide projected outcomes for each solution.

2. Methodology

2.1 Overview

Data for this study was provided by the City of Cincinnati's Office of Environmental Sustainability, Hamilton County Recycling and Solid Waste District (HCRSWD), and Rumpke Waste and Recycling. Table 2 displays a summary of the data that was used for this Opportunity Analysis. The details of the tonnage of landfilled and diverted material can be found in the tables in Appendix A. The current diversion rate was calculated using the following equation:

$$\frac{Total\ amount\ of\ material\ Diverted}{Total\ amount\ of\ material\ Generated} = \frac{19{,}763\ tons}{85{,}709\ tons} = 23.06\%$$

The diversion potential for each solution was estimated using a 30% and 60% increase in landfill capture rate as compared to current diversion of the specific material category.

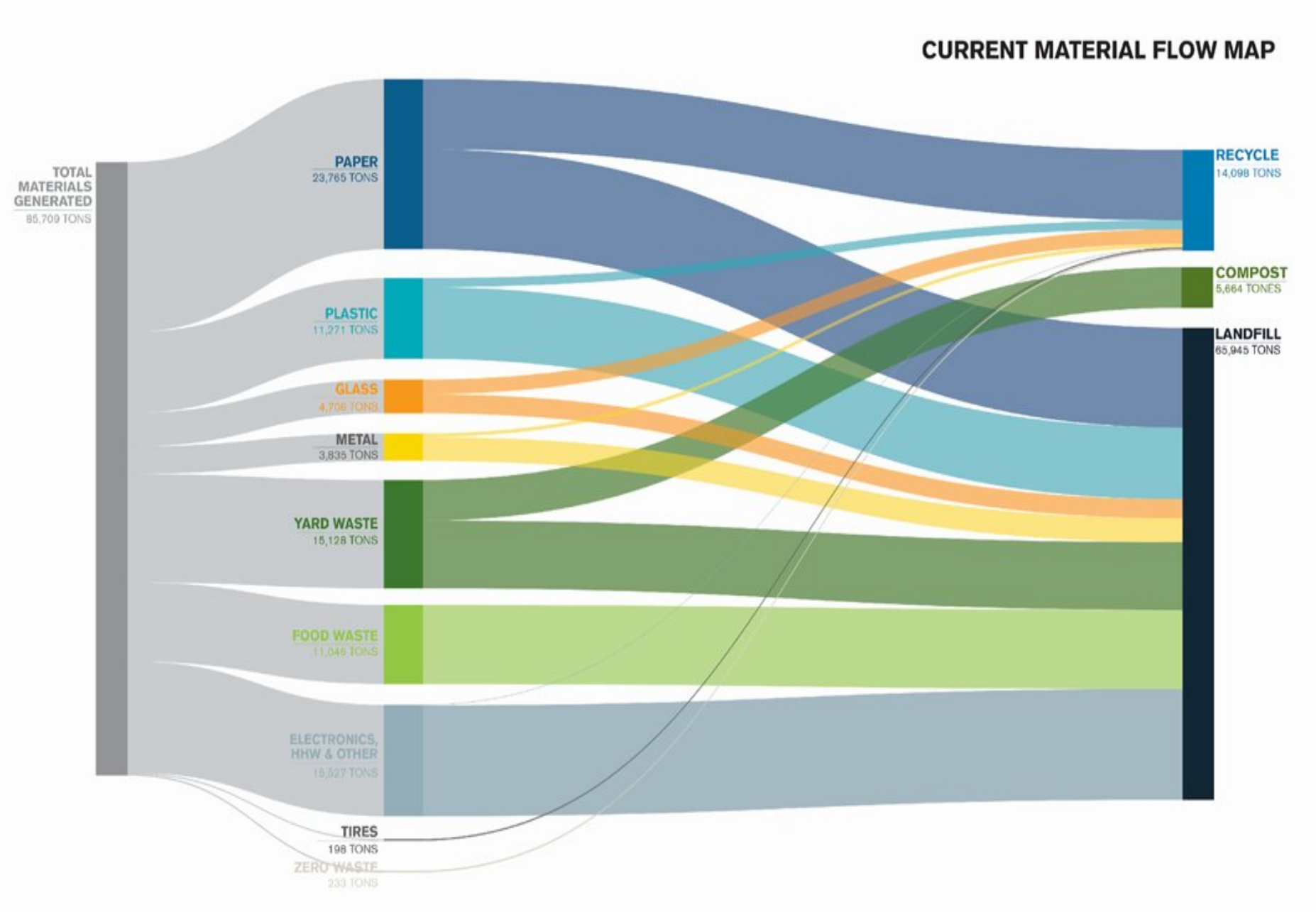

Figure 1: Current material flow map for Cincinnati

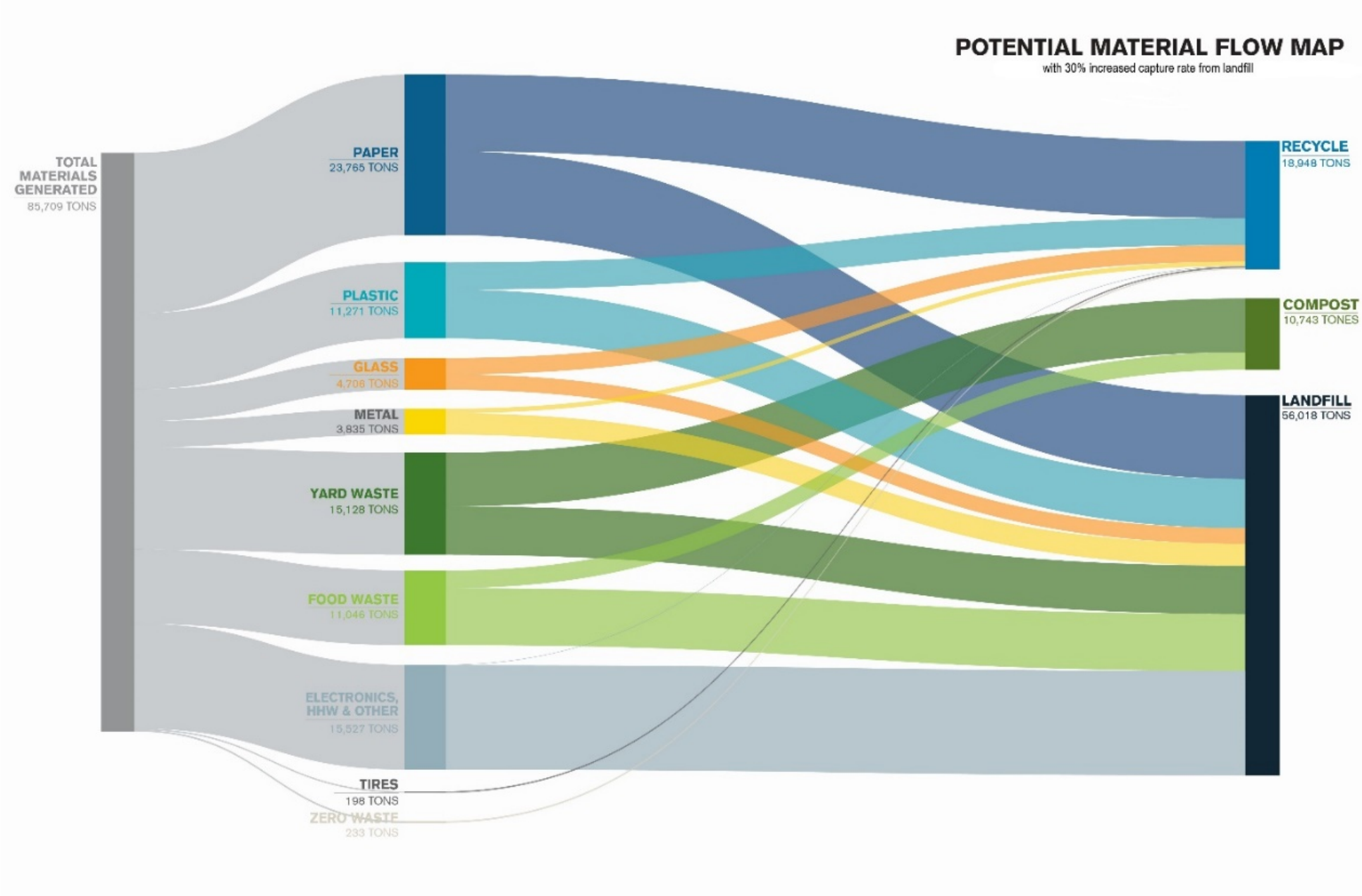

Figure 2: Potential material flow map at 30% increase capture from landfill

Table 2: Summary of waste and recycling data

Data Description	Data Value
Total Amount of Material Generated by Cincinnati	85,709 tons
Total Amount of Material Landfilled by Cincinnati	65,945 tons
Total Amounts of Material Diverted by Cincinnati	19,763 tons[1]
Increased Landfill Capture Rate	30% or 60%
Current Diversion Rate for Cincinnati	23.06%
% of Specific Material in the landfill stream	Table-A 2 in Appendix A
Tonnage Amount of each Specific Material Diverted	Table-A 3 in Appendix A

3. Centralized Class II Compost Facility in Cincinnati

The most impactful solution in terms of diversion is the creation of a Class II composting facility within the City of Cincinnati. As defined by the Ohio EPA, a Class II compost facility can collect yard waste, agricultural plant materials, animal waste, dead animals, raw rendering material, and food scraps.[2] In 2018, approximately 15,926 tons, or 24.15% of the waste stream, of compostable material that could have been diverted to a composting facility was landfilled, see Table 3.

Table 3: Materials that are compostable

Material Category	Description	% of Waste Stream	Tonnage of Material Available
Grass	lawn clippings	3.25%	2,143
Leaves	leaves, pine needles	3.20%	2,110
Brush	shrubs, bushes, small twigs	0.95%	626
Vegetative Food	plant-based foods	11.15%	7,352
Non-vegetative Food	non-plant-based foods	5.60%	3,692
	Totals	24.15%	15,926

[1] This includes 19,333 tons of material diverted from the waste stream without the use of a program or event, 197.82 tons of tires collected and diverted, and 232.84 tons of material collected from one-off programs.

[2] Class II Composting Facility Requirements - Ohio EPA: https://epa.ohio.gov/portals/34/document/guidance/gd_667.pdf

Figure 3 shows the percentage of all compostable material within the waste stream in comparison to all non-compostable material.

Locally developed compost could be used by the city in specialized projects and city parks or for purchase by citizens and businesses for use in gardening, urban farming, and landscaping. A centralized composting facility can help to reduce landfill greenhouse gas (GHG) emissions. Landfills produce an estimated 0.76 metric tons of CO_2 equivalent per ton of organic waste, whereas composting creates 0.09 metric tons of CO_2 equivalent per ton of organic waste. In addition, when factoring in both methane and nitrous oxide, composting releases less than 10% of the GHG produced in comparison to landfill GHG production[3].

Vision Statement

The vision of the centralized Class II compost facility is to facilitate the deployment of critical infrastructure to provide organic waste recovery and composting to the citizens and businesses of Cincinnati.

3.2 Project Options

The development of a composting facility could draw upon services already available to the City of Cincinnati, along with enhanced collection practices and education and outreach efforts. The Department of Public Services currently provides yard waste collection every other week from April through the second week of January. Another relevant asset is the GCP, which articulates goals to reduce food waste diverted to landfill, decrease residential tonnage to landfill, and reduce GHG emissions. The creation of a centralized compost facility would synergistically address each of these goals.

Municipalities often use “third bin” programs to collect yard waste, with some including food waste and compostable paper products in their organics collections. Cincinnati could adopt these collection options along with a drop-off option for commercial landscaping businesses to encourage their participation.

The Econservation Institute’s report, “Best Management Practices in Food Scraps Programs“, offers information that may be relevant to efforts to implement organics recycling in Cincinnati. The most important among these, arguably, is education. The report recommends quarterly outreach through print media, direct mail, social media, and emailing residents to facilitate interest in the compost programs.

[3] Comparing greenhouse gases from composting and landfilling. B. Deesing

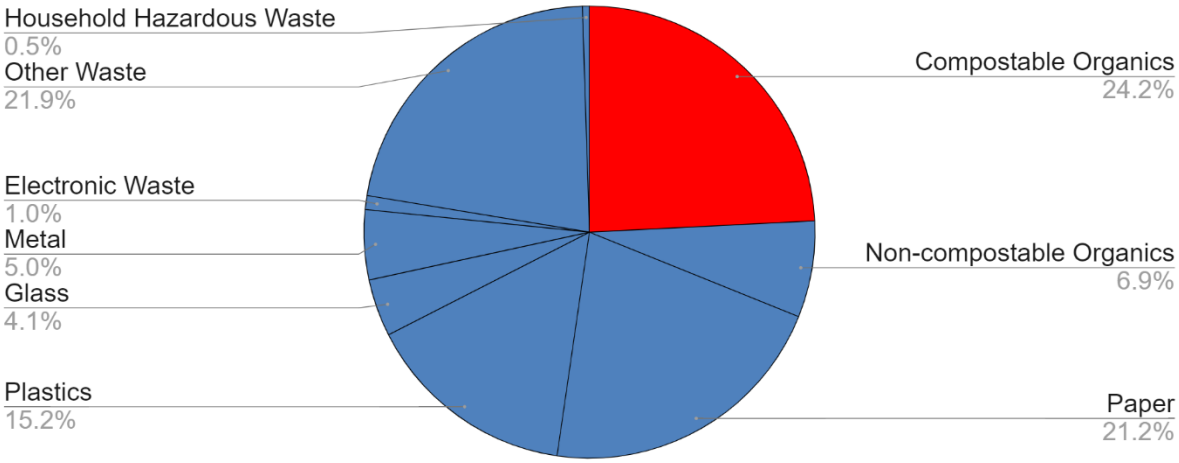

Figure 3: Compostable Organics in 2018 Cincinnati Municipal Landfilled Material

3.3 Possible Barriers

Synergistic policies in Cincinnati that support the economic and logistical development of organics composting are important to increasing waste diversion. Cincinnati's city charter holds it responsible for providing weekly garbage collection to the residents at no cost. Costs for waste collection services are covered by the general fund tax revenue. However, based on a 2014 MIT report on municipal organics curbside collection, nearly 80% of all cities with organics curbside collection use Pay-as-you-throw (PAYT) models[4] under which residents are charged for collection based on the size of their waste, recycling, and organics containers. The most successful curbside collection programs all followed a similar PAYT model with an embedded base fee. In each of these programs, the landfill-bound waste container is the more expensive container for collection compared to the recycling or organics containers, encouraging citizens to divert material away from the waste bin into bins that support diversion. Cincinnati's current city charter requiring the free collection of waste restricts its ability to take advantage of a PAYT model to incentivize its residents.

A significant concern regarding composting is the contamination of feedstock with waste and other non-compostable materials. Education, engagement, and communication of successes and challenges can play a role in mitigating this barrier. Further clarification can be found in the Municipal Diversion Education Strategies in Section 10.

Another possible barrier lies in the history of composting within Cincinnati. Compost Cincy, a commercial food waste composting facility that operated near the Center Hill

[4] Municipal Curbside Compostable Collection: A. Schulman https://dusp.mit.edu/sites/dusp.mit.edu/files/attachments/project/Municipal%20Curbside%20Compostables%20Collection%20%20What%20Works%20and%20Why.pdf

Landfill in 2012 and 2013, was closed due to complaints about odors, birds, insects, and other vermin. As such, management at these facilities will need to be sensitive to potential for odor and vector challenges. Proper material mix and management strategies can be employed to reduce or eliminate potential odors.

3.4 Financial Performance

Cincinnati's existing yard waste diversion program has a residential participation rate of 75% and captures approximately 50% of the yard waste material generated by participating residents. This results in an overall residential yard waste diversion rate of 37.45%, with each household generating approximately 0.17 tons of yard waste annually. Opportunities for increased diversion include increasing residential participation and capturing more of the yard waste generated by residents who are already participating. Table 4 lists a variety of alternatives for achieving a 30% or a 60% increased landfill capture rate based on a mix of increased participation and/or increased capture rate.

Table 4: Participation and capture rates required to achieve a 30% and 60% increase in yard waste capture rate

Yard Waste Diversion Rate Increase	**Increased Landfill Capture: 30%**		
Participation Rate	75%	85%	95%
Capture rate	90%	80%	70%
Yard Waste Diversion Rate Increase	**Increased Landfill Capture: 60%**		
Participation Rate	85%	90%	95%
Capture rate	95%	90%	85%

A 30% increase in capture rate of the amount of yard waste currently going to the landfill would result in the diversion of an additional 1,464 tons, for a total yard waste diversion rate of 67.60%, and an increase of 5.06% in the overall diversion rate. A 60% increase in capture rate of yard waste would result in the diversion of an additional 2,928 tons, a total yard waste diversion rate of 81.49%, and a 6.69% increase in the overall diversion rate, see Table 5.

Increasing the overall diversion rate by decreasing the amount of yard and food waste currently being landfilled would also increase the Residential Recycling Incentive (RRI) Rebate that is issued by HCRSWD. HCRSWD provides RRI funds to Hamilton County communities as a tiered incentive to increase recycling and organics diversion. Municipalities in Hamilton County receive RRI funds as a per ton rebate for the diverting of recycling material from the landfill. As their diversion rate increases, the per ton rebate amount also increases, see Table 6. Communities with recycling rates lower than 20% are encouraged to use these funds to increase their recycling rate and finance

their recycling and diversion programs. Communities with recycling rates over 20% can spend RRI funding on expanding recycling and diversion programs, but they are also able to spend funds on shifting procurement practices to include purchasing items with recycled content, such as recycled plastic playground equipment or office paper.

Table 5: Impact of 30% and 60% increase in the capture of yard waste going to the landfill on the diversion rate

Diversion	Yard Waste		Total	Overall Diversion Rate
	Landfilled	Diverted		
Current	4,880	5,665	10,545	23.06%
	46.28%	53.72%		
30% increase	3,416	7,129	10,545	28.12% (+5.06%)
	32.39%	67.61%		
60% increase	1,952	8,593	10,545	29.75% (+6.69%)
	18.51%	81.49%		

The diversion of yard and food waste is eligible to be included in the RRI diversion rate calculation, but the organic waste tonnage is not eligible for the actual rebate amount, which is only applied to the diversion of recycling material. Therefore, although the increased tonnage of yard waste would not be eligible for the RRI rebate, a 30% or 60% increase in the landfill capture rate of yard waste would increase the RRI amount received for the recycled tons from the current rate of $24.61 per ton to $28.61 per ton.

Table 6: Hamilton County Recycling and Solid Waste District Residential Recycling Incentive rebate amounts

Residential Recycling Incentive (RRI) Rebate		
Diversion Rate		$/ton
30%	100%	$32.61
25%	29.99%	$28.61
20%	24.99%	$24.61
15%	19.99%	$20.61
10%	14.99%	$16.61
5%	9.99%	$12.61
0%	4.99%	$8.61

This study evaluated the viability of a windrow composting facility to support a 30% and a 60% increase in the capture rate of residential yard waste. The 30% or 60% increase could support a 10,000-ton composting facility with the excess going to Rumpke to support its operations (alternative daily cover, compost, and mulch). Alternatively, a 30% increase could support a 12,000-ton facility, and a 60% increase could support a 14,000-ton facility.

Each facility capacity was evaluated under the assumptions that: all yard waste material will be collected via the city trucks at a tipping fee of $134.58 per truck ($18.69 per ton); all food waste will be dropped off at the facility at $20 per ton by industrial sources of food waste; and all finished compost will be sold in bulk at $10 per ton. Table 7 shows the capital expenditure (CAPEX) and operational expenditure (OPEX) investments that would be required to achieve a 20-year return on investment at 8% for each of the facilities evaluated.

Due to the lack of available data, this financial model does not include residential food waste collection and only includes residential drop-off; however, residential collection can be an important factor influencing financial performance.

Table 7: CAPEX and OPEX requirements for siting a composting facility

Capacity (tons)	Yard Waste (tons)	Food Waste (tons)	CAPEX	OPEX
10,000	6,000	4,000	$1,400,000	$154,000
12,000	7,200	4,800	$1,680,000	$185,040
14,000	8,400	5,600	$1,960,000	$216,000

3.5 Outcomes

Analyzing the current waste stream at an increased landfill capture rate of 30% or 60% of yard waste enabled this study's projection that the creation of a 10,000-ton composting facility will have the potential to increase the current 23.06% diversion to the range of 28.12% - 29.75%, see Table 8.

Table 8: Diversion outcomes from 30% and 60% increase in capture rate of organics

Solution Name	Increased Landfill Capture: 30%		Increased Landfill Capture: 60%	
	% Impact on Diversion Rate	Potential Amount Captured (Tons)	% Impact on Diversion Rate	Potential Amount Captured (Tons)
Class II Compost Facility	5.06%	5,464 (YW – 1,464 FW – 4000)	6.69%	6,928 (YW – 2,928 FW – 4000)

NOTE: This intervention was prioritized through Beyond 34 Cincinnati community network engagement in 2020 and was refined and consolidated into the Beyond 34 Roadmap to Implementation for the Cincinnati region.

4. Plastic to Fuel

In the 2018 Cincinnati waste stream, 7.73% of all material generated and 11.4% of all material landfilled, see Figure 4, is plastic that could be diverted through a plastic to fuel project option. Per the defined material types in the Hamilton County Waste Characterization Report, the type of plastics included in the calculation include “other bottles/jugs, trays, and tubs, rigid plastics other plastics and films”.

When looking only at the materials streams stated above, 92.11% of the material generated was landfilled, and approximately 7.89% was diverted, see Table 9.

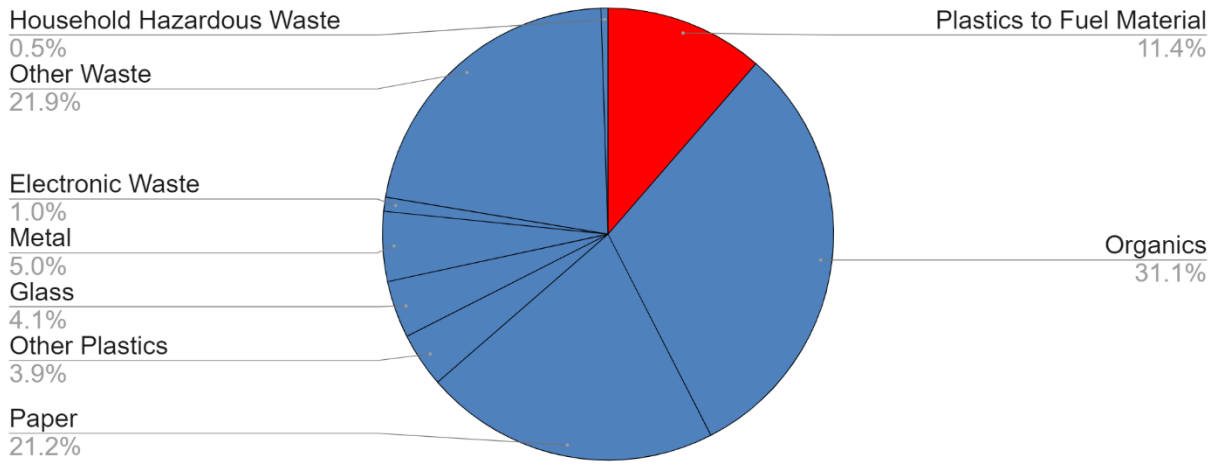

Figure 4: Plastic to Fuel in 2018 Cincinnati Municipal Landfilled Material

Vision Statement

The vision for the plastic to fuel project option is to use the non-recyclable waste plastics currently being landfilled, which contribute an estimated 11.4% of total landfilled material, to be repurposed as feedstock for a viable plastic-to-fuel facility.

4.1 Case Studies

Argonne National Laboratory

In 2017, Argonne National Laboratory published an article analyzing the life cycle of fuels produced from non-recycled plastics. The study found that fuel produced from non-recycled plastic results in a 1%-14% GHG emission reduction, an 83% reduction in fossil fuel energy consumption, and a 58% reduction in water consumption.[5] The final study findings indicated that ultra-low sulfur diesel fuel produced from traditional, non-

[5] Life-cycle analysis of fuels from post-use non-recycled plastics: P. T. Benavides et al., https://www.osti.gov/servlets/purl/1353191

recycled plastic can be considered a carbon-neutral fuel and that the use of this fuel can reduce the overall environmental impacts when compared to petroleum produced fuel.

Table 9: Plastic-to-Fuel materials - generated, landfilled, and recycled

Specific Material Type	Description	Amount Landfilled (Tons)	Amount Recycled (Tons)	Total Generated (Tons)
Other bottle/jugs	#3-#7 bottles	33	226	259
Trays and Tubs	PET and HDPE trays/tubes	989	0	989
Rigid Plastics	plastic toys, items without a #	1,088	0	1,088
Other Plastics	Polystyrene, #6 trays, solo cups	989	0	989
Films	Garbage bags, chip bags, misc. films	4,385	0	4,385
	Total	7,485 (92.11%)	226 (7.89%)	7,711

New York

In 2010, New York City generated an estimated 750,000 tons of waste, including approximately 61,500 tons of plastic waste.[6] For the residential and commercial sectors, the New York Department of Sanitation defined only 14.2% of PET bottles and 7.5% of HDPE bottles as recyclable material. The city conducted a study in 2013 to evaluate viable processes to turn non-recycled plastic into synthetic oil.

The city's report proposed a pyrolysis process to transform waste plastics into high-value diesel fuel through proper collection and processing. The major advantage of this process, according to the study, is that it can process mixed plastic waste and produce marketable end products with minimal excess waste. The study recommended that New York City could utilize JBI Inc.'s Plastic to Oil process, which can generate 4.4 barrels of oil per ton of plastic waste and create a net revenue of $280 per ton of collected plastic waste.[6] New York City is using the findings of this report to inform efforts to reinvent its plastic recycling process.

[6] Transforming the Non-Recycled Plastics of New York City to Synthetic Oil: D. Tsiamis http://www.seas.columbia.edu/earth/wtert/newwtert/Research/sofos/ms_thesis/Demetra%20T_Thesis%20Final%20Rev%20for%20publication_April%2018.pdf

4.2 Technologies

Renewlogy

Renewlogy has developed a system that can convert non-recyclable plastic waste into high-value fuels like diesel.[7] Renewlogy management has expressed interest in working in the Cincinnati area.

One of Renewlogy's key innovations is the company's use of a continuous system of plastics to save energy by eliminating the reheat system that is needed to convert the plastic to a liquid output. This complex system can process 10 tons of plastic per day into 60 barrels of diesel fuel with zero toxic emissions. The Renewlogy facility's small footprint (approximately 3,000 sq. ft.) makes it an attractive solution for communities all over the country.[8]

In 2018, Renewlogy partnered with Dow's EnergyBag program and a Canadian-based cleantech innovator, Sustain Technologies, to build a large-scale plastic conversion system in Chester, Nova Scotia.[9] The plastic conversion system is projected to produce both synthetic kerosene and 9,000 liters of high-value diesel per day.[10] The feedstock for the Nova Scotia facility includes common packaging materials (polyethylene, polypropylene, and polystyrene).[11]

In 2019, the Renew Phoenix project was awarded to Renewlogy and its local partner GMR to divert plastics #3, #6 and #7. The Renew Phoenix project is estimated to cost $5.5 million for a 30,000 sq. ft. facility and create 15 full-time jobs.[12] The City of Phoenix is now partnering with local utilities and businesses to acquire more material for this diversion solution.

Brightmark Energy

Brightmark Energy (BME) is a San Francisco-based waste and energy development company that aims to create significant long-term value and a positive impact on global

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[7] Renewlogy Home Page: http://renewlogy.com/

[8] Renewlogy Converting Landfill-Bound Plastics to Fuel: https://www.ptonline.com/blog/post/renewlogy-converting-landfill-bound-plastics-to-fuel-

[9] Renewlogy: Nova Scotia https://renewlogy.com/project/nova-scotia-canada/

[10] Province Gives Environmental Stamp of Approval for Plastics-to-Fuel Plant: F. Willick https://www.cbc.ca/news/canada/nova-scotia/sustane-technologies-plastic-plant-chester-fuel-pyrolysis-1.4798034

[11] Plastic Recycling to Hit Oil Producers: B. Barnes https://www.petroleum-economist.com/articles/midstream-downstream/refining-marketing/2019/plastic-recycling-to-hit-oil-producers,

[12] Phoenix Awards Contract to Renewlogy for Chemical Recycling Project: K. Pyzyk https://www.wastedive.com/news/phoenix-awards-contract-to-renewlogy-for-chemical-recycling-project/552055/

waste value chains by delivering waste and energy solutions.[13] In 2018, BME began the process of opening a plastics renewal facility in Ashley, Indiana, which will be the first commercial-scale plastic to fuel facility in the U.S.

In Ashley, Indiana, BME is opening an advanced plastic renewal facility that is projected to divert 100,000 tons of plastic waste each year from landfills and incinerators.[14] During phase one of the construction, BME has invested $138.3 million in Steuben County, Indiana. Once this 112,000 sq. ft. facility is constructed, BME will partner with RecycleForce[15] to create 136 full-time jobs for those who were formerly incarcerated. From a waste and energy perspective, the facility is projected to annually produce over 18 million gallons of ultra-low sulfur diesel fuel, reduce GHG emissions by 152 million metric tons, and achieve approximately 93% energy efficiency in its degradation process.[16] BME will process all plastics, including PET thermoforms, plastics labeled #3-#7 and plastic films. BME aims to source more plastic material and has expressed interest in helping Cincinnati divert non-recyclable plastic #3-#7s and films. PVC and plastic material that has been treated with flame-retardant are not accepted in the BME process due to previously discussed potential for toxic emissions. Notably, Brightmark is not looking to compete for PET bottles since they have such high recycling potential.

4.3 Project Options

One option would be to engage with a private company to build a facility in Cincinnati. Overall, Cincinnati landfills approximately 7,485 tons of plastic-to-fuel material annually, with approximately 226 tons currently being recycled, see Table 10. Another option is the utilization of the BME facility in Ashley, Indiana. This facility is 215 miles from Cincinnati (about 3.75 hours driving time). As determined in the Current State Assessment for Cincinnati, anything less than six hours is deemed logistically feasible. Currently, the BME facility is collecting material from Indiana and Chicago, which are 156 and 177 miles from the facility, and is seeking additional partners and collection areas.

4.4 Possible Barriers

One potential barrier pertains to the amount of material that can be diverted to a plastics-to-fuel facility. These plastics currently do not have an established collection

[13] Plastics Renewal: Brightmark Energy https://www.brightmark.com/our-work/plastics-renewal/

[14] Brightmark: Ashley Sustainability Program https://www.brightmark.com/engage/ashley-sustainability-program/

[15] Recycle Force: Innovative Electronics Recycling https://recycleforce.org/

[16] Brightmark Energy Closes $260M in Financing for Nation's First Commercial-Scale Plastics-to-Fuel Plant: J. Nolan https://www.businesswire.com/news/home/20190411005170/en/Brightmark-Energy-Closes-260M-Financing-Nation%E2%80%99s-Commercial-Scale

and source separation stream. Including these plastics in the existing blue bin recycling program will require working with the Rumpke-owned materials recovery facility (MRF) to ensure appropriate technologies for source separation are in place.

Like the siting of landfills, the siting of plastics to fuel or other waste-to-energy plants is difficult. Residents do not want these types of plants that involve many trash-filled trucks driving every day through or near their neighborhoods. Unfortunately, these plants often end up being located near low-income communities. Additionally, these plants have the potential to emit low levels of toxic pollutants such as dioxins, acid gases, and heavy metals, and studies have shown that recycling plastic waste saves more energy—by reducing the need to extract fossil fuel and process it into new plastic—than converting it to fuel to be burned for energy.[17]

4.5 Outcomes

Assuming an increased landfill capture rate of 30% or 60%, a partnership with a plastics-to-fuel facility has the potential to increase the current 23.06% diversion rate to the 25.47% - 28.29%, see Table 10.

NOTE: This project was not initially prioritized by the Beyond 34 Cincinnati community in 2020, but it can be revisited as an additional solution in the future.

Table 10: Diversion outcomes from 30% and 60% increase in capture rate of plastics

Solution Name	Increased Landfill Capture: 30%		Increased Landfill Capture: 60%	
	% Impact on Diversion Rate	Potential Amount Captured (Tons)	% Impact on Diversion Rate	Potential Amount Captured (Tons)
Plastic-to-Fuel	2.61%	2,245	5.23%	4,491

5. Municipal Cardboard Diversion Best Practices

In the 2018 Cincinnati municipal solid waste material stream, there were 7,603 tons of corrugated cardboard generated, of which 67.22% was landfilled, and 32.78% was diverted. Cardboard makes up 7.75% of the total landfilled material and is the third-largest material category, as shown in Figure 5.

[17] Is burning plastic waste a good idea?: https://www.nationalgeographic.com/environment/2019/03/should-we-burn-plastic-waste/#close

Corrugated cardboard disposal bans have been implemented in several municipalities and counties across the nation to divert waste from regional landfills and increase the percentage of recycled material. This analysis examined the implementation, regulation, and effectiveness of cardboard disposal bans in Lincoln, Nebraska, Linn County, Iowa, and Fort Collins, Colorado. All cases share similarities in reasoning, approach, and effectiveness of the implementation of cardboard disposal bans.

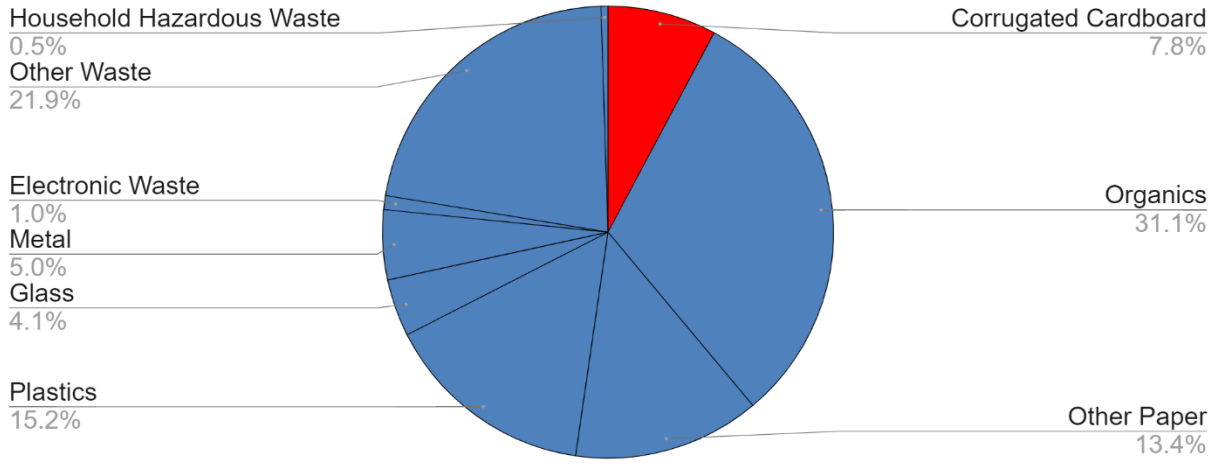

Figure 5: Corrugated Cardboard in 2018 Cincinnati Municipal Landfilled Material

Vision Statement

The vision of municipal cardboard diversion best practices project option is to adopt and adapt successful strategies that other cities have taken in diverting cardboard from the landfill across both the residential and commercial sectors.

5.1 Case Studies

Lincoln, Nebraska Cardboard Ban

In April of 2018, the City of Lincoln, Nebraska, implemented a corrugated cardboard disposal ban that prohibited clean and dry corrugated cardboard from entering the landfill. Because the landfill is used by the City of Lincoln as well as the entire county, the City first gained approval from Lancaster County before moving forward and implementing the ban in Lincoln. Once the City gained the approval, the City and the County worked together to draft a specific city code.[18]

[18] Recycle Lincoln – Corrugated Cardboard Disposal Ban: https://www.lincoln.ne.gov/city/ltu/solid-waste/recycle/pdf/corrugated-cardboard-faq.pdf?2019

*Lincoln Municipal Code 8.32.040, Section C / Recyclable cardboard** shall not be accepted for disposal in the City's public sanitary landfills effective April 1, 2018. (**Clean and dry corrugated cardboard.)*

Contaminated corrugated cardboard is considered non-divertible. The City has accommodated this fact by exempting corrugated cardboard that is contaminated with solid food residue, or that is completely wet. The landfill will not accept clean and dry cardboard. For example, pizza boxes that have grease stains, but no solid food residue, are considered recyclable. This ban has had a positive outcome in Lincoln as well as in Lancaster County.

Enforcement Structure

1. Waste haulers are prohibited from placing recyclable corrugated cardboard in the trucks being sent to the landfill
2. Landfill staff monitor the waste in vehicles and require any recyclable corrugated cardboard to be removed
3. Residents and businesses must ensure that clean, dry corrugated cardboard is not placed in trash containers

This structure is designed to monitor and regulate the amount of cardboard entering the landfill waste stream. The City has not specified penalties for residents or businesses that place clean, dry corrugated cardboard in the garbage. However, haulers can enforce their own penalty fees if recyclable corrugated cardboard is found in the trash.

In addition to the enforcement mechanisms mentioned above, the City of Lincoln created educational posters for their drop-off sites to inform residents and businesses of the newly enforced ban. These drop-off sites are open to Lincoln and Lancaster County residents and businesses and require no fee.

Education and Marketing

The City of Lincoln teamed up with the Verdis Group and Carson+Co Global marketing firms for the "Take it to the Bin" campaign. This campaign mainly used Community-Based Social Marketing (CBSM) to encourage people to adapt to the cardboard disposal ban. This marketing technique used TV advertisements that portrayed residents recycling cardboard and home improvement retailers installing cardboard recycling bins in optimal locations; and business recognition programs that identified key businesses that supported the cardboard disposal ban, as well as other marketing techniques. Overall, this marketing strategy has had positive results in the education of residents and the promotion of the cardboard disposal ban.[19]

[19] Using Behavior Change Strategies to Encourage Cardboard Recycling in Lincoln: K. Morrow http://verdisgroup.com/using-behavior-change-strategies-to-encourage-cardboard-recycling-in-lincoln/

Results and Outcomes

In 2017, Lincoln landfilled 18,478 tons of corrugated cardboard, which comprised 9.4% of the landfilled waste. Once the ban was implemented, the amount of cardboard landfilled was reduced to 4,398 tons, comprising only 2.4% of the landfilled waste. This represents a 76.19% reduction in tonnage and a 7% increase in waste diverted from the landfill. Local recycling processors reported a 52% increase in cardboard material received after the cardboard ban was enacted. At the residential level, the amount of corrugated cardboard deposited at drop-off locations more than doubled in tonnage after the ban was implemented.[20]

Linn County, Iowa Cardboard Ban

In 1999, Linn County, Iowa (population: 216,000), required all cardboard to be separated for recycling by implementing and enforcing a cardboard disposal ban. The cardboard disposal ban was initially used as a viable solution to remove easily identifiable material to preserve the limited capacity of the Cedar Rapids Linn County Solid Waste Agency, which serves 17 different communities with only two locations for disposal within Linn County through one landfill/MRF location and one compost and yard waste location.[21,22]

Linn County Corrugated Cardboard Recycling Ordinance Section 35.3 / “all Recyclable Corrugated Cardboard shall be separated by the Generator from all other garbage, refuse and rubbish for the purpose of Recycling. Recyclable Corrugated Cardboard may be mixed with other approved Recyclable Materials for Recycling.”

Enforcement Structure

Like the Lincoln cardboard disposal ban enforcement structure, Linn County uses landfill employees as “spotters” to identify when residents or businesses have violated the disposal ban. However, the structure of this corrugated cardboard ban is much stricter than the Lincoln cardboard disposal ban. Once landfill employees have identified banned material, they take pictures of the load and the truck that brought the load into the landfill. A ticket is issued by the spotter and the ticket is paid at the scale house upon departure.[23] The ticket penalty for each violation of the landfill disposal ban is $76 per ton, effectively double the landfill fee of $38 per ton.

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[20] City of Lincoln – Corrugated Cardboard Ban Success: City of Lincoln https://lincoln.ne.gov/city/ltu/solid-waste/recycle/pdf/corrugated-cardboard-success.pdf

[21] Disposal Ban - Linn County, Iowa: Eco-Cycle Solutions https://www.ecocyclesolutionshub.org/location/disposal-ban-linn-county-iowa-usa/

[22] Cedar Rapids Solid Waste Agency: https://www.solidwasteagency.org/garbage

[23] Scale House in this context refers to the building that is used to measure and track material weights that enter the landfill.

Linn County Corrugated Cardboard Recycling Ordinance Section 35.4 / "Any Person, firm, or corporation who violates this Ordinance shall commit a County infraction and shall be subject to a penalty in accordance with Chapter 19 of the Linn County Code of Ordinances. Each day that a violation is permitted to exist shall constitute a separate offense."

Results and Outcomes

The implementation of the cardboard disposal ban has enabled the county to reduce the amount of corrugated cardboard being landfilled from 9% to 2% of the waste stream.[24]

Fort Collins, Colorado Cardboard Disposal Ban

In 2012, the City Council of Fort Collins created a cardboard disposal ordinance to meet the City's goal of diverting 50% of waste that enters the waste stream and to prevent "approximately 42,000 tons of carbon dioxide equivalents from being released."[25] In 2013, this ordinance was passed and enforced in the community. The ban prohibits the deposit of clean and dry corrugated cardboard in landfills, while cardboard with food residue and wet cardboard is accepted. In order to increase public participation, the staff in the City's Environmental Services Department began outreach programs to educate the public about the "three R's," reduction, re-use, and recycling,[26] by providing clear, informative guidelines and offering financial incentives.

Enforcement Structure

1. Warnings
    a. When a member of the public has a trash receptacle that contains more than 25% cardboard by volume, a warning will be placed at the site as a friendly reminder of the corrugated cardboard disposal ban. These warnings are then filed into a database maintained by the City.
    b. Once a site has received two notifications, the Environmental Services Department attempts to directly contact the entity[27] generating the material, while the Code Enforcement Department prepares a violation notice.
2. Violations
    a. The notice of violation sent to the entity describes the offense and explains fines and any other penalties incurred if there is a repeat offense.

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[24] Disposal Ban - Linn County, Iowa: Eco-Cycle Solutions https://www.ecocyclesolutionshub.org/location/disposal-ban-linn-county-iowa-usa/

[25] Cardboard Disposal Ban for Fort Collins: A. Arias https://www.fcgov.com/recycling/pdf/cardboard-disposal-ban.pdf?1366663321

[26] Implementation & Enforcement Response Plan: City of Fort Collins https://www.fcgov.com/recycling/pdf/cardboard-enforcement-report.pdf?1384553584

[27] Entity in this context refers to a resident, business, etc. who generate waste at a specific site.

Results and Outcomes

Through the cardboard disposal ban, the City sought to help residents and businesses reuse cardboard, including moving, storage, and shipping boxes. The City developed the Cardboard Box Exchange, a website where community members can connect with each other to provide or receive usable, clean cardboard. Additionally, the City was able to reuse cardboard as weed barriers for landscaping projects and created guides for residents to use cardboard as an organic landscaping tool. Finally, the City provided residents with contacts to organizations like Freecycle.org that can further facilitate the reuse of cardboard boxes. No diversion rate changes were clearly listed; however, the City claims this band has contributed to a 28.4% increase in the diversion rate, from 29% in 2017 to 57.4% in 2018.

5.2 Project Options

The municipality in each of these case studies reported positive results as measured by multiple performance indicators including diversion rates, waste reduction in landfills, and an increase in cardboard material received by recycling processors, see Table 11.

Table 11: Results of cardboard diversion bans from case studies

Lincoln, Nebraska

Year Implemented	Population	Reduction in Landfilled Cardboard Tonnage	Percent of Overall Waste Diverted from Landfill	Increase in Cardboard Received by Recycling Processors
2018	287,401[28]	76.19%	7%	52%

Linn County, Iowa

Year Implemented	Population	Decrease in Landfilled Corrugated Cardboard
1999	216,000	Cardboard currently makes up only 2% of the county's waste stream, as compared to the state average of 9.4%

Fort Collins, Colorado

Year Implemented	Population	Increase in Diversion Rate
2012	167,830[29]	28.4% increase (29% in 2017 to 57.4% in 2018)

[28] United States Census Bureau – Lincoln City, Nebraska: https://www.census.gov/quickfacts/lincolncitynebraska

[29] United States Census Bureau – Fort Collins, Colorado: https://www.census.gov/quickfacts/fortcollinscitycolorado

Using these case studies as a guide, Cincinnati could establish a marketing and education campaign that promotes the "three R's," Reduction, Re-use, and Recycling, as well as a campaign that provides education about the cardboard policy and related programs, see Figure 6 and Figure 7. Specifics of the ban can be included on the municipality's websites along with a suite of educational materials such as videos, brochures, and infographics pertaining both to residents and businesses.

Figure 6: Lynn County

Figure 7: Cardboard Diversion - Fort Collins

This campaign could assist businesses and residents in the adoption of the policy, secure public support, and encourage greater participation. In addition, as seen in the Fort Collins example, Cincinnati could promote the residential use of the Freecycle Network and the commercial/industrial use of the Ohio Materials Marketplace in order to keep clean cardboard in use for as long as possible.

Education regarding the environmental benefits of cardboard recycling could address the benefits of reduction of waste to landfill, reduction in GHG emissions, and increasing the number of trees saved. Finally, a policy that increases cardboard recycling would bring economic benefits. Highlighting how stakeholders benefit financially would also increase the social and political will to begin implementation of a cardboard policy.

5.3 Possible Barriers

In the case studies discussed, all landfills were publicly owned facilities and cardboard diversion practices were enforced by the public authority responsible for the landfill. Hamilton County residential, commercial, and industrial waste goes to the Rumpke landfill, a privately-owned facility. Therefore, having an enforcement strategy managed at the landfill level is not viable for Cincinnati. However, policy-based enforcement options could still be a viable solution. As indicated in the Lincoln, NE case study, enforcement can take place not only at the landfill but also during collection. Cincinnati could implement a policy that would prohibit residents and businesses from placing clean, dry cardboard in trash cans. The business franchise agreements with private haulers could also be used to have them enforce the ban for the commercial and industrial sectors. Additionally, policy strategies, such as bans, although politically sensitive, have proven to be effective leverage points in driving behavioral change. It is well established that attempts to implement a policy-based ban can generate social and political concerns, which may lead to pushback.[30] Strategies to address political concerns and begin implementation of a cardboard disposal policy strategy should aim to establish positive relationships between cardboard recyclers and citizens of Cincinnati through education regarding its environmental, social, and economic benefits.

5.4 Financial Performance

Decreasing the amount of cardboard currently going to the landfill will increase the RRI Rebate incentive is issued by HCRSWD, see Table 6 on page 10. This analysis presents the potential increased revenue from RRI based on an increase in the landfill capture rate of cardboard at 30% and 60%.

The current cardboard diversion rate is 32.78%. A 30% increase in the capture rate of the amount of cardboard currently going to the landfill would result in the diversion of an additional 1,533 tons, a total cardboard diversion rate of 52.95%, and an increase of 1.79% in the overall diversion rate. A 60% increase in the capture rate of the amount of cardboard currently going to the landfill would result in the diversion of an additional 3,066 tons, a total cardboard diversion rate of 73.11%, and an increase in the overall diversion rate of 3.58%, see Table 12.

[30] Trapped in trash: “Modes of governing” and barriers to transitioning to sustainable waste management: L. Pollans https://journals.sagepub.com/doi/pdf/10.1177/0308518X17719461

Table 12: Diversion impact of increase of cardboard diverted from landfill

Capture Rate	Cardboard		Total	Overall Diversion Rate
	Landfilled	Diverted		
Current	5,110	2,492	7,603	23.06%
	67.22%	32.78%		
30% increase (1,533 tons)	3,577	4,025	7,603	24.85% (+1.79%)
	47.05%	52.95%		
60% increase (3,066 tons)	2,044	5,558	7,603	26.64% (+3.58%)
	26.89%	73.11%		

An increase in cardboard diverted from landfill by 30% will increase the RRI rebate amount by $37,727 annually. An increase in cardboard diverted from the landfill by 60% increase the RRI rebate amount by $87,718 annually, see Table 13. Calculations for the 30% increase in the capture rate assume an RRI rebate amount of $24.61 per ton, and calculations for the 60% increase in the capture rate assume an RRI rebate amount of $28.61.

Table 13: RRI rebate based on increase in cardboard diverted from landfill

Diversion	Increase Tonnage	Increase RRI Rebate
30% increase	1,533	$37,727
60% increase	3,066	$87,718

5.5 Outcomes

When analyzing this solution's effects on diversion at an increase in cardboard capture from the landfill at a rate of 30% and 60%, diversion of household MSW would increase from the current 23.06% to 24.85% and 26.64%, respectively.

A policy-based strategy could also have an impact on the diversion of commercial waste streams. Although the potential impact on diversion of the industrial waste stream cannot be directly calculated due to a lack of available data, an estimated diversion percentage and tonnage range can be calculated from the commercial waste stream using Hamilton County's 2017 total amount of landfilled waste (649,445 tons) and assuming that the commercial waste stream composition mirrors the residential waste

stream composition of Cincinnati from the Hamilton County 2018 Waste Characterization report[31], see Figure 5 on page 17.

Implementing the same statistical methods that were used to project monthly cardboard diversion rates in the residential stream for the increased landfill capture rates of 30% and 60% applied to the commercial sector, the percentage impact on the commercial waste stream would increase total diversion by 1.32% to 3.33% and 2.64% to 6.66%, respectively. Combining the impact of a 30% and 60% increase in both the residential and commercial cardboard capture could increase the overall diversion by 3.11% - 10.24%, see Table 14.

Table 14: Diversion outcomes from 30% and 60% increase in capture rate cardboard

Solution Name	Increased Landfill Capture: 30%		Increased Landfill Capture: 60%	
	% Impact on Diversion Rate	Potential Amount Captured (Tons)	% Impact on Diversion Rate	Potential Amount Captured (Tons)
Cardboard Policy Residential Sector	1.79%	1,533	3.58%	3,066
Cardboard Policy Commercial Sector	0.04% - 0.23%	377 – 2,401	0.07% - 0.46%	754 – 4,801
Total	1.83% - 2.02%	1,910 – 3,934	3.65% - 4.04%	3,820 – 7,867

NOTE: This intervention was prioritized through Beyond 34 Cincinnati community network engagement in 2020 and was refined and consolidated into the Beyond 34 Roadmap to Implementation for the Cincinnati region.

6. Incentivized Reverse Vending System

In the 2018 Cincinnati MSW stream, there were 1,834 tons of PET bottles or jugs generated, 1,682 tons of glass bottles generated, and 866 tons of aluminum cans generated, equating to an overall total of 4,382 tons. Of that total, 3,495 tons (79.75%) were landfilled, and 887 tons (20.25%) of the material were diverted. For 2018, the

[31] This assumption is based on 2017 data sent to the ASU research team on 06/10/2019 from Hamilton County representative Michelle Balz.

combination of PET bottles or jugs, glass bottles, and aluminum cans made up about 5.30% of the total landfilled material in Cincinnati, see Figure 8.

Vision Statement

To provide residents with an additional outlet to recycle PET, glass bottles, and aluminum cans, which also provides an immediate positive reinforcement mechanism, resulting in changed resident perceptions about “waste”.

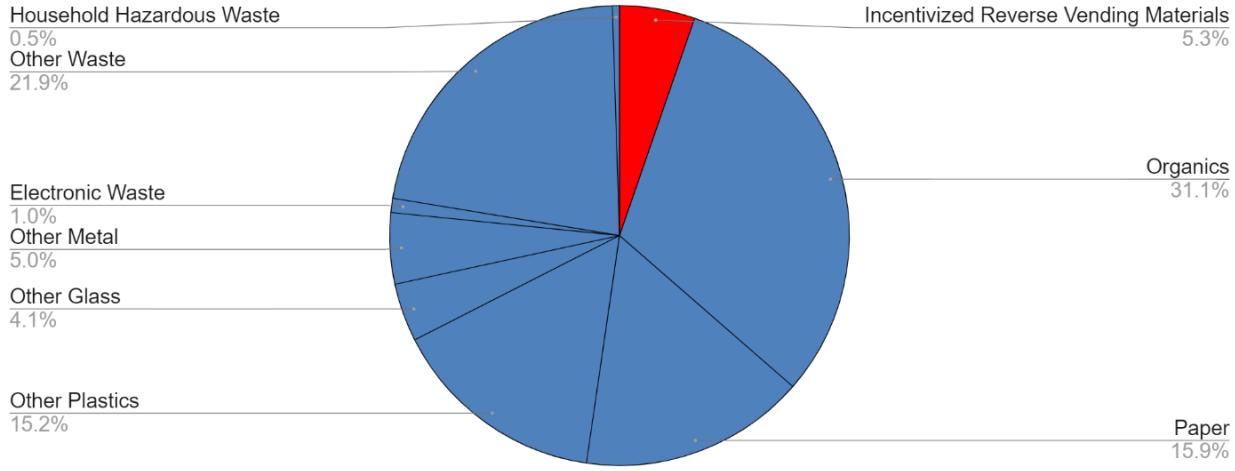

Figure 8: Incentivized Reverse Vending Materials in 2018 Cincinnati Municipal Landfilled Material

6.1 Case Studies

Overview

In the United States in 2015, only 9.2% of all plastics were sent to recycling centers.[32] More recently, the EPA calculated that in 2017 the recycling rate for all plastic was approximately 3.1%, which represents a 6.1% decrease in the recycling percentage.[33] Incentivized Reverse Vending (IRV) offers consumers an attractive reason to return empty bottles for recycling. IRV platforms have been used throughout the world, see Figure 9, and have been able to achieve high capture rates and low contamination rates for food-grade PET bottles. [34]

[32] How to Close the Loop on Quarter-trillion Plastic Bottles a Year: J. Dell and M. Eriksen https://www.greenbiz.com/article/how-close-loop-quarter-trillion-plastic-bottles-year

[33] EPA: U.S. Recycled Less in 2017: J. Paben https://resource-recycling.com/plastics/2019/11/21/epa-us-recycled-less-plastic-in-2017/

[34] How to Close the Loop on Quarter-trillion Plastic Bottles a Year: J. Dell and M. Eriksen https://www.greenbiz.com/article/how-close-loop-quarter-trillion-plastic-bottles-year

Reverse Vending & Plastic Pollution Rates by Country

Figure 9: Map of IRV Program Locations

TOMRA

Over the course of two decades, TOMRA, a leader in sensor-based technology, launched IRV programs in Michigan at grocer Central ShopRite.[35] In 2016, TOMRA expanded the program to 35 Meijer stores[36] through its TOMRA Makes Change loyalty program, which allows recyclers to earn points toward prizes such as earbuds, fitness trackers, and gift cards or to donate points to charitable causes.[37] TOMRA also helps other retailers launch the program and set up fundraising efforts for local organizations. Central ShopRite has seen grocery sales increase as IRV users have also become shoppers. TOMRA has installed IRV machines at multiple universities, including Harvard University, Northeastern University, and the University of Southern Indiana.[38]

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[35]Central ShopRite Reports Reverse Vending Benefits: Recycling Today Staff https://www.recyclingtoday.com/article/tomra-reverse-vending-michigan-central-shoprite-recycling/

[36]TOMRA Launching Reverse-vending Program at Meijer: https://progressivegrocer.com/tomra-launching-reverse-vending-program-meijer

[37] TOMRA Launches Reverse Vending Machine Program in Michigan: Editorial Team https://pointofsale.com/tomra-launches-reverse-vending-machine-program-in-michigan/

[38] Tomra Expands Reverse Vending Machine Recycling Program: L. Tufano https://www.wastedive.com/news/tomra-expands-reverse-vending-machine-recycling-program/407021/

A 2010 study estimated that TOMRA machines installed worldwide annually collect approximately 30 billion used beverage containers, representing about 3% of the world's annual consumption.[39] In 2018, TOMRA's approach helped U.S. consumers to redeem 2 billion beverage containers in the Northeast alone. Globally, the company collected 40 billion cans and bottles—an increase over 2017 levels by 5 billion bottles.[40]

The T-90 TOMRA RVM, see Figure 10, is a large-sized model that integrates compaction technology and front or rear unloading capabilities. It can process up to 45 containers per minute and has the capacity to store 3,000 compacted PET bottles, 300 glass bottles, and 12,000 compacted aluminum cans.

Figure 10: TOMRA T-90 Incentivized Reverse Vending Machine

Envipco

Envipco, a Norwegian firm, manufactures IRV machines that collect plastic, glass, and metal bottles and cans and currently has four U.S. locations in Oregon, Iowa, Michigan, and Connecticut. Envipco's IRV machines allow customers to deposit bags full of collected material in bulk without requiring sorting and come in four different categories of machines:

1. Flex, see Figure 11, is a small-sized model that is mainly used in schools and pharmacies. It can process up to 40 containers per minute and store 935 aluminum

[39] Recycling for the Future: WIPO https://www.wipo.int/ipadvantage/en/details.jsp?id=2589

[40] U.S. Consumers Redeemed Billions of UBCs Through TOMRA Reverse Vending Machines in 2018: https://www.recyclingproductnews.com/article/30901/us-consumers-redeemed-billions-of-ubcs-through-tomra-reverse-vending-machines-in-2018

cans and 282 plastic bottles. Glass containers require an increase in the unit's footprint.

Figure 11: Envipco Flex machine

2. Ultra, see Figure 12, is a medium-sized model that has integrated compaction technology and front or rear unloading capabilities. It can process up to 42 containers per minute and store 2,050 aluminum cans, 765 plastic bottles, 200 soft glass bottles, and 970 crushed glass bottles.
3. HDS, see Figure 13, is a large-sized model, predominately used in supermarkets due to its larger storage capacity. It can process up to 42 containers per minute and store 7,100 aluminum cans, 2,500 plastic bottles, and soft drop 1,120 glass bottles.

Figure 12: Envipco Ultra machine

Figure 13: Envipco HDS machine

4. Quantum, see Figure 14 and Figure 15, is a larger model, mainly used in return centers, because it can break through bulk feeds. It can process up to 100 containers per minute and store 5,000 aluminum cans and 1,750 plastic bottles.

Figure 14: Envipco Quantum INDOOR machine

Figure 15: Envipco Quantum OUTDOOR machine

Oregon

In 2009, the Oregon Beverage Recycling Cooperative (OBRC) was created to standardize the beverage container deposit program within Oregon.[41] While Oregon is a beverage container deposit state, the OBRC program operates entirely without public funding. For the residential waste sector, OBRC provides the BottleDrop, a bottle and can collection program that also allows customers to donate to local non-profit organizations after each bottle or can deposited.[42] For the commercial and industrial waste sectors, OBRC offers a container pick-up service that currently services 2,500 local retailers within Oregon.[43] OBRC is able to process approximately 25,000 truckloads of containers each year from residential, commercial, and industrial bottle/can collection. After processing collected materials at the processing warehouse, aluminum cans are crushed, and transported to a local recycling smelter; plastic bottles are perforated, crushed and transported to ORPET, LLC;[44] and glass bottles are crushed and transported to a local glass recycler.

As a result of its partnership with local retailers and ORPET and the BottleDrop program, the OBRC has been able to collect more than 138 million pounds of beverage containers and process 545,454 tons of recycled bottles and cans each operating day.[45] In 2018, Oregon recycled 90% of beverage containers (compared with just 64% two years prior) using the bottle deposit system, resulting in two billion bottles recycled. The BottleDrop service also saw a 50% increase in sign-ups for a total of 300,000

[41] Oregon Beverage Recycling Cooperative: What we do: https://www.obrc.com/About/WhatWeDo

[42] Oregon Beverage Recycling Cooperative: BottleDrop: https://www.obrc.com/Partners/BottleDrop

[43] About: Oregon Beverage Recycling Cooperative https://www.obrc.com/About

[44] ORPET, LLC is a post-consumer PET bottle recycling facility. The ORPET recycling processes sorts, granulates and washes the PET material for re-use by a wide variety of end-users.

[45] Operating day refers to the Monday through Friday, average workdays, averaged to be 253 days in a year.

Oregonians with BottleDrop accounts. Compared to curbside service, the redemption centers decrease contamination. OBRC plays a vital role in the performance of the recycling system, and its success proves how incentivized recycling can motivate individuals to recycle. While this case study does not utilize IRV, the model can be used with IRV machines to improve collections and processing.

6.2 Possible Barriers

Ohio does not have a beverage container deposit collection system. The State of Ohio General Assembly currently prohibits counties and municipalities from enacting ordinances on placing fees and deposits on the collection of beverage containers.

6.3 Outcomes

Assuming an increased landfill capture rate of 30% or 60%, the installation of IRV machines throughout the City of Cincinnati has the potential to increase the current 23.06% diversion rate to 24.28% and 25.50%, respectively, see Table 15. Note: This project was not initially prioritized by the Beyond 34 Cincinnati community in 2020, but it can be revisited as an additional solution in the future.

Table 15: Diversion outcomes from 30% and 60% increase in capture rate using reverse vending machines

Solution Name	Increase in Capture Rate: 30%		Increase in Capture Rate: 60%	
	% Impact on Diversion Rate	Potential Amount Captured (Tons)	% Impact on Diversion Rate	Potential Amount Captured (Tons)
Reverse Vending	1.22%	1,049	2.44%	2,097

NOTE: This project was not initially prioritized by the Beyond 34 Cincinnati community in 2020, but it can be revisited as an additional solution in the future.

7. Decentralized Compost Facility

A decentralized compost facility in Cincinnati addresses the processing of organics waste stream with a small footprint and low start-up requirements for each facility. Decentralized facilities, as analyzed in this solution use food waste collection schemes from residential single-family and multi-family households as well as drop-off availability for residents and commercial businesses.

Analysis of existing local decentralized composting facilities in Ohio indicates that one 500 sq. ft. decentralized composting facility can process 300 tons of organic material

per year. A list of compostable material that could be diverted to a composting facility is shown in Table 16.

Table 16: Materials in the waste stream that are compostable

Specific Material	Description	% of Waste Stream	Tonnage of Material Available
Grass	lawn clippings	3.25%	2,143
Leaves	leaves, pine needles	3.20%	2,110
Brush	shrubs, bushes, small twigs	0.95%	626
Vegetative Food	plant-based foods	11.15%	7,352
Non-vegetative Food	non-plant-based foods	5.60%	3,692
Total		24.15%	15,926

Figure 16 below shows the percentage of all compostable material within the waste stream in comparison to all non-compostable material.

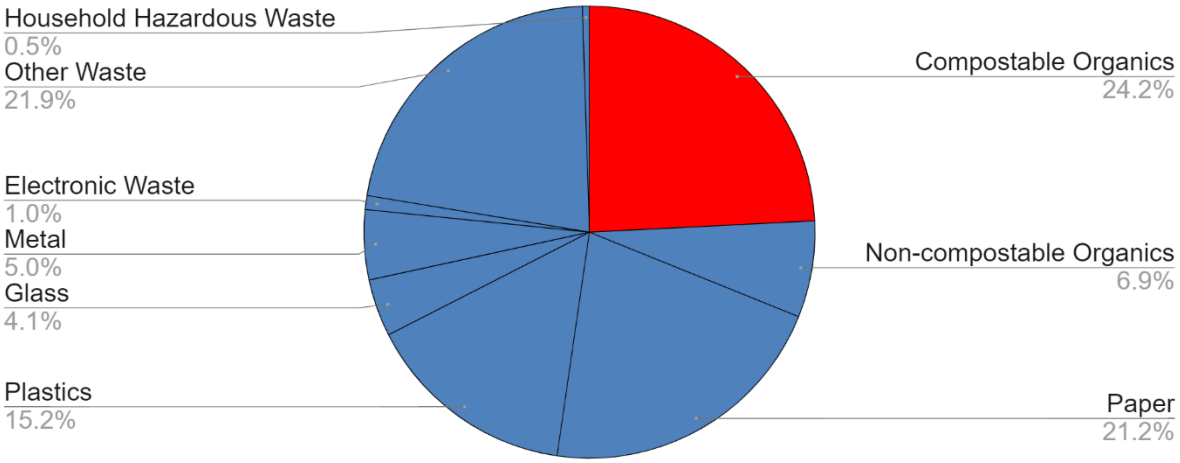

Figure 16: Compostable Organics in 2018 Cincinnati Municipal Landfilled Material

In Cincinnati's current residential MSW stream, 0.00% of the potential 11,046 tons of food waste is diverted from the landfill, and 37.45% or 5,665 tons of the 15,128 tons of yard waste is diverted from the landfill.

Estimates of decentralized composting assume a ratio of 40% food waste and 60% yard waste, which would be primarily wood chips, and would allow each decentralized compost facility to process 120 tons of food waste per year.

Vision Statement

The vision of the decentralized compost facility is to provide citizens with distributed composting infrastructure that can be deployed quickly and at a low cost.

7.1 Project Options

Better Bin Compost, a food waste collection service that currently provides a weekly collection of food waste through a subscriber-based business model in Cincinnati, has indicated an interest in supporting and potentially operating a decentralized composting facility.

Important factors to note are listed below:

- Residential household collection service through Better Bin Compost costs approximately $30 per month, which provides residents with a 4- or 5-gallon bucket with a compostable liner for their food waste and weekly collection.
- Currently, there are no food waste composting facilities in southern Ohio. Food waste collected is given to a food waste courier, GoZero Services, and then is taken to northern Ohio composting facilities.
- Four of the five most populated urban neighborhoods (Westwood, West Price Hill, CUF, and East Price Hill) are all on the western and southwestern sides of Cincinnati, which could be possible starting locations for decentralized compost facilities.
- Based on the success of other decentralized compost facilities in Ohio, wood and wood chips are the best option for this solution. As such, these local producers of wooden yard waste could partner with and bring their wood chips directly to the decentralized compost facilities. ChipDrop, a service that has facilitated over 80,000 deliveries between local tree companies and gardeners who want free wood chips and logs, could provide logistical capacity for coordinating these stakeholders. ChipDrop works with companies in every major city in the U.S., Canada, and the U.K.
- Rumpke currently ships ground yard waste to Paygro, a composting facility, which requires a 70-mile round trip. Local decentralized composting facilities could provide Rumpke with a closer and more cost-effective offtake for this material.

7.2 Possible Barriers

One potential barrier would be a lack of awareness for the decentralized compost facility and its collection mechanisms, which could lead to resistance from neighbors for siting a facility. Currently, it is estimated that food waste feedstock from 572 households would be needed to create a 500 sq. ft. compost facility. One option to address this

barrier could be to use the Cincinnati municipal website, which contains information about food waste reduction under the “Food Waste” section, to encourage increased food waste diversion and provide additional information about composting. A similar approach could be taken to source woodchips from residents and businesses alike.

7.3 Outcomes

A single 500 sq. ft. composting facility could divert 300 tons of organic material, 120 tons of food waste, and 180 tons of yard waste. Expanding to five decentralized composting facilities could divert 1,500 tons of organic material, 600 tons of food waste, and 900 tons of yard waste. Scaling to additional sites would be less cost intensive as these facilities become more common, and the availability of food waste diversion increases residential participation. Table 17 shows the impact on the diversion rate for one and five decentralized compost facilities.

Table 17: Decentralized composting impact on diversion rate

Solution Name	One Decentralized Compost Facility		Five Decentralized Compost Facilities	
	% Impact on Diversion Rate	Potential Amount Captured (Tons)	% Impact on Diversion Rate	Potential Amount Captured (Tons)
Decentralized Compost Facility	0.35%	300	1.75%	1,500

NOTE: This intervention was prioritized through Beyond 34 Cincinnati community network engagement in 2020 and was refined and consolidated into the Beyond 34 Roadmap to Implementation for the Cincinnati region.

8. Disruptive Disposable Technologies

According to the Clean Water Action and Clean Water Fund, Americans use 118 billion[46] disposable single-use cups every year, of which 46% are paper, 32% plastic, and 22% foam or expanded polystyrene (EPS). Using this as a per-capita metric, based on the population of Cincinnati (302,605), the total number of cups used in Cincinnati is 109.12 million.

[46] Clean Water Action/Clean Water Fund https://www.cityofberkeley.info/uploadedFiles/Public_Works/Level_3_-_Solid_Waste/CA_ReTh_Infographic_Cups_06.22.16b-1FINAL.pdf

Using the following average weights[47,48] for each cup type allows calculations of an annual estimated count and tonnage per cup type, see Table 18.

- Weight of a paper cup: 10.1 g
- Weight of plastic cup: 3 g
- Weight of foam cup: 1.5 g

Table 18: Estimate total number and total weight of disposable cups in Cincinnati by cup material

Disposable Cup Type	Estimated Millions of Cups Used Annually	Estimated Tons of Material Landfilled
Paper	50.20	558.89
Plastic	34.92	115.48
Foam	24.00	39.68
Totals	109.12	714.05

The total tonnage of disposable cups generated by Cincinnati residents, according to these calculations, amounts to 714.05 tons per year. This represents 0.83% of the total materials generated in 2018 and makes up 1.08% of the portion of waste going to landfill. See Figure 17. This does not include takeout containers or other disposable food service ware.

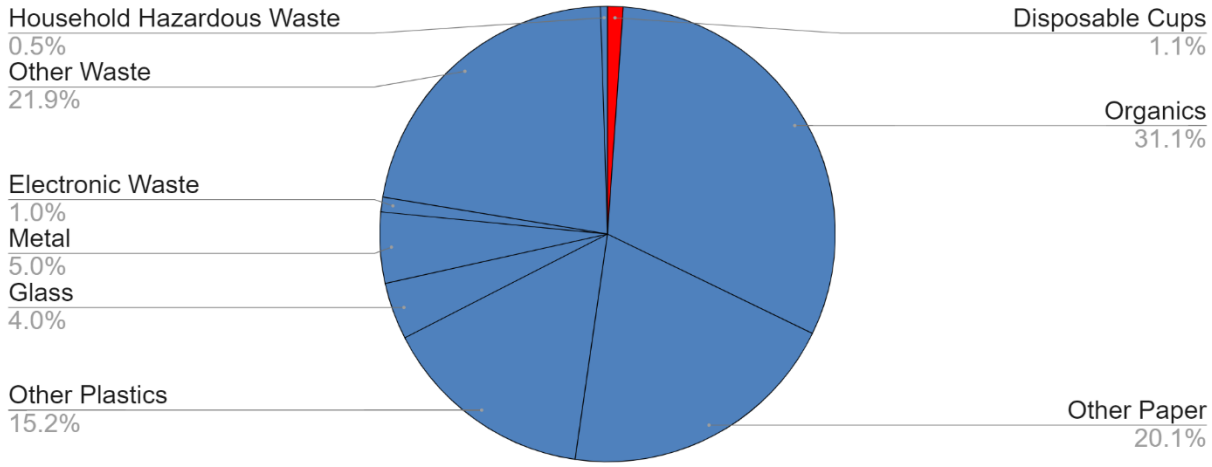

Figure 17: Disposable Cups in 2018 Cincinnati Municipal Landfilled Material

[47] The Cup that Cheers Environmentalists: New Scientist https://www.newscientist.com/article/mg12917562-700-the-cup-that-cheers-environmentalists/

[48] Disposable Plastic Cup Specifications: Global Sources https://www.globalsources.com/si/AS/Guangzhou-Huaming/6008813038091/pdtl/disposable-plastic-cup-200ml-Material/1117444438.htm

Vision Statement

The vision for disruptive reusable technologies is to replace disposable food service ware through rental and/or reusable food service ware programs that benefit local food and beverage businesses.

8.1 Case Studies

GO Box

Launched in Portland, Oregon, in 2011, GO Box is a reusable takeout container subscription-based service model that eliminates the need for single-use disposable food containers and cups. At its launch, the program was the first public takeout container reuse system in North America. GO Box partners with local vendors across Portland to offer reusable containers that subscribers can rent using the GO Box mobile application. After the meal or beverage is completed, subscribers return the reusable containers to designated drop sites, see Figure 18. The GO Box team collects the used containers and professionally cleans and sanitizes them before redistributing to local vendors that subscribe to the service.

The program was a success in Portland and has since expanded to the San Francisco area in California. To date, there are over 4,000 subscribers and 140 vendors across the two regions, and over 226,000 single-use containers and cups have been eliminated through the utilization of the GO Box system.

GO Box has annual and monthly subscription options for users. Users are offered credits representing the total number of reusable containers that can be checked out at once. GO Box provides a turnkey digital ecosystem of mobile applications and administration websites, resources, branding materials, and marketing collateral to utilize for program launch, as well as strategies to grow and manage the program.

Figure 18: GO Box Reusable Container and Cup

GreenToGo

GreenToGo is a reusable take-out container service that aims to reduce the landfilling of trash and improve the quality of life for citizens in Durham, North Carolina. Like GO Box, GreenToGo uses a check-in and check-out system for containers. Every time a participating restaurant is visited, subscribers can use the GreenToGo mobile application to check out a clean take-out container, see Figure 19, and return empties to GreenToGo drop-off bins at participating restaurants, where they are washed and sanitized. Membership fees support the cost of the containers and building of return stations for each restaurant, as well as publicity, operations, and management of the service in the community.

Figure 19: GreenToGo Reusable Container

CupClub

CupClub is a London-based reusable packaging service managed by an Internet-of-Things- and cloud-based software for both hot and cold drinks. The service partners with coffee retailers and shops to provide reusable to-go cups, see Figure 20.[49] Customers sign up for the service through the online CupClub app to use the cups, which are tracked by embedded RFID chips. Collection bins where

[49]This Coffee Cup Can be Reused 132 Times. Here's How to Try One: E. Segran
https://www.fastcompany.com/90399753/this-coffee-cup-can-be-reused-132-times-heres-how-to-try-one

customers can drop off their used cups are located near the participating coffee shops throughout London. The cups are collected by CupClub, washed using an industrial washer, and redistributed to the coffee shops for reuse. If the cup is not returned after several days, a fee of $3 is charged to the customer via the app. Each cup can be used 132 times before being recycled.

CupClub has recently piloted its services at the Google Campus in San Francisco, where it was able to sign up more than 50% of the campus population and had a 97.3% return rate of the scanned-out items.[50]

Figure 20: CupClub Reusable Cup and Distribution

8.2 Project Options

A strategy focused on decreasing the use of disposable food service ware through rental and/or reusable programs while benefitting local food and beverage businesses has the potential to increase waste aversion, as Cincinnati is a major hub of food retail outlets in the U.S., with approximately 400 restaurants.[51]

This option could be a good platform to promote a circular economy by decreasing the amount of waste generated by using single-use disposable service ware. The city could educate the citizens about the environmental, social, and economic benefits of using the rental cup services to encourage participation.

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[50] CupClub is Rolling Out a daily Reusable Packaging Service for Drinks Across London Offices: European Circular Economy Stakeholder Platform https://circulareconomy.europa.eu/platform/en/good-practices/cupclub-rolling-out-daily-reusable-packaging-service-drinks-across-london-offices

[51] Orlando, Cincinnati and the Fast Food Capitals of the U.S.: Forbes https://www.forbes.com/sites/priceonomics/2018/03/22/where-is-the-fast-food-capital-of-the-united-states/#12df678a70a9

8.3 Possible Barriers

The scaling of this solution presents one potential challenge. Success would necessitate significant uptake by cafes, restaurants, businesses, and college campuses that would partner with the program. Drop-off locations would also need to be convenient, and the cost of entry for the subscriptions could also be a barrier to some organizations. The City of Cincinnati could promote initiatives to work with businesses and organizations to implement a scalable model that addresses these barriers and encourages widespread participation.

8.4 Outcomes

Assuming landfill aversion of disposable food ware increases by 10% and 25% through a reusable to-go platform, the percentage impact on household solid waste would decrease approximately 0.032% and 0.081%, respectively, see Table 19. This intervention could play a role in cognitively changing consumer behavior. Based on previous research, the optimum tipping point for social norms to change is a 25% adoption of a new practice.[52] Setting this as the upper bound target could support a reusable food service ware platform to become more available across the city. Additionally, research and modeling completed have suggested that social norms can be adjusted by as low as a 10% adoption rate, which is used for the lower bound target.[53]

Although this intervention initially has a low impact on diversion, a transition to reusable food service ware across Cincinnati would create jobs, reduce the landfilling of waste, and provide an important service for restaurants and coffee shops that might not have space, infrastructure, or labor resources to implement self-dishwashing. Additionally, changing consumer behavior can help to eliminate the take-make-waste consumer perception and advance an understanding and transition to a more circular economy.

NOTE: This project was not initially prioritized by the Beyond 34 Cincinnati community in 2020, but it can be revisited as an additional solution in the future.

[52] Experimental Evidence for Tipping Points in Social Convention: D. Centola et al., https://science.sciencemag.org/content/sci/360/6393/1116.full.pdf

[53] Social consensus through the influence of committed minorities: J. Xie et al., eISSN: 1550-2376

9. Residential Food Waste Prevention Strategies

Significant environmental, financial, and food security benefits occur thru the reduction and prevention of food waste. It is estimated that one-third of all food produced for human consumption is lost or wasted, equivalent to 1.32 billion tons per year globally.[54] ReFED estimated in its 2016 Roadmap to Reduce Food Waste by 20 Percent report that 43% of all food waste generated was from the household level, which is the highest percentage ahead of consumer-facing businesses, manufacturers, and farms. The 43% reported by ReFED accounts for 567.60 million tons of food waste. Additionally, ReFED estimates that 21% of all freshwater and 18% of cropland is used to produce food that is ultimately wasted.[55] Reducing food waste is the most effective way to address the environmental concerns of food production when compared to repurposing food such as using it in composting or as animal feed.

Vision Statement

The vision of residential food waste prevention strategies is to create custom education materials and behavior change practices that can be used to engage residents to reduce food waste at the household level.

Table 19: Total impact of disruptive reusable technologies at a 10% and 25% adoption rate

Solution Name	Adoption Rate: 10%		Adoption Rate: 25%	
	% Impact on Household MSW	Potential Amount Averted (Tons)	% Impact on Household MSW	Potential Amount Averted (Tons)
Disruptive Disposable Technologies - Reusable Cup Service	0.032%	21.42	0.081%	53.55

[54] Global Food Losses and Food Waste. J. Gustavsson: https://www.madr.ro/docs/ind-alimentara/risipa_alimentara/presentation_food_waste.pdf

[55] Roadmap to Reduce Food Waste by 20 Percent: ReFED https://www.refed.com/downloads/Foundation_Action_Paper_Web.pdf

9.1 Case Studies

Food Waste Reduction Intervention Study

In 2019, the City of Phoenix commissioned ASU to carry out a study on household food waste reduction education.[56] The project utilized a values-based approach with multimedia delivery to provide relevant and easily accessible information to participants. Throughout the project, participants were asked to measure their food waste and answer surveys relevant to food waste knowledge and were provided with website educational content.

Both the qualitative and quantitative results from the project showed that awareness of food waste reduction practices increased and that the quantity of food waste was reduced through the intervention. Additionally, five forms of content delivery were measured to determine their effectiveness in food waste prevention, with residents reporting videos and podcasts being the most impactful. Interestingly, however, podcasts and videos were the second and third most viewed forms of content behind infographics, which were rated by the residents as the least effective in reducing food waste. A total of 53 households participated in the study, with a median reduction of 8.83 pounds of food waste reduction throughout the five-week project, which equated to a 46% reduction in household food waste.

Additionally, ASU and the City of Phoenix created a Waste Watchers website that hosts the educational resources used in the study. The resources include podcasts and videos that educate listeners on specific facets of food consumption, such as proper shopping habits, how to safely store food, and misperceptions about expiration dates. The website is still active and hosted on the ASU website.

Los Angeles Food Waste Grant Challenge

In 2017, Los Angeles, California, developed a grant call to 1) “increase public awareness on food waste prevention and recovery” and 2) “catalyze innovation and community resources to help Angelinos reduce food waste, recover surplus food and turn waste into a resource.” In total, Los Angeles had 27 submissions detailing a variety of food waste prevention strategies, including food waste education to businesses, drop-off sites, and composting education to residents.[57] Los Angeles separated the applications into administrative grants and project grants. The purpose of the

[56] Waste Watchers: A Values-based Intervention to Reduce Household Food Waste in Phoenix: Arizona State University https://sustainability.asu.edu/research/project/waste-watchers-a-values-based-intervention-to-reduce-household-food-waste-in-phoenix/

[57] L.A. Hosts First-ever Food Waste Grant Challenge: Waste 360 https://www.waste360.com/food-waste/la-hosts-first-ever-food-waste-grant-challenge

administrative grants was to serve as technical assistants and facilitators for the project grantees. This included helping to train project grantee applicants in collecting baseline data and engaging the broader community in their efforts. In order to receive an administrative grant, applicants were required to show expertise in one or more of the four food waste challenge categories: food waste prevention, food donation, upcycled use (e.g., animal feed), and composting with a strong network. The purpose of project grants was to demonstrate ways to keep food from the landfill through one of the four food waste challenge categories. Project grants were available to any organization that could measure the impact in both pounds of food diverted and the number of residents who participated in the project. In total, approximately $100,000 was awarded to 10 projects.

The 10 winners of the grant included three $15,000 administrative grants and seven $7,500 project grants, all of which were active as of March 2018. Examples of the project grants include an organization called Netiya, which aims to "educate and mobilize the student population at the Toledo High School" through the creation of a comprehensive program that incorporates food donation, food waste diversion, and composting education. Similarly, the Japanese American Cultural and Community Center's Sustainable Little Tokyo organization project was designed to educate Little Tokyo's residents and food businesses about the impacts of food waste through community gatherings and experiential education.[58]

9.2 Project Options

Building off the Phoenix Food Waste Reduction Intervention Study, Cincinnati could implement a similar food waste challenge that would engage residents and households to track their food purchase/consumption and waste reduction over a specified time period and expand food waste reduction education and outreach based on local results

A food waste challenge similar to the Los Angeles initiative could provide an opportunity to engage Cincinnati businesses, communities, and local organizations interested in creating greater food waste prevention and diversion.

9.3 Possible Barriers

One set of barriers to the food waste reduction intervention study pertains to recruitment and attrition, e.g., difficulty in finding enough willing participants to engage with the study or not having enough participants that finish the study. These challenges are common in public engagement projects. Another barrier may be a lack of resources or

[58] News Release - City of Los Angeles Announces Winners of Food Waste Grant Challenge: City of Los Angeles https://dpw.lacity.org/blog/news-release-city-los-angeles-announces-winners-food-waste-grant-challenge

funding to engage residents by hosting new educational resources on the city's website with new educational tools. Similar resource-related challenges would apply to efforts to engage residents directly.

9.4 Outcomes

Upon completion of the project, the City of Cincinnati would have detailed residential data identifying the most effective and translatable interventions for changing residents' behaviors to decrease food waste. Additional data and successful community-specific interventions may need to be identified. However, it is also possible that a portion of these projects could continue beyond the duration of the food waste challenge. Finally, a Cincinnati website where all the resources created as well as the details of the city-wide food waste challenge, could provide guidance to help website visitors learn to reduce food waste by addressing key areas that would be most effective in Cincinnati.

NOTE: This intervention was prioritized through Beyond 34 Cincinnati community network engagement in 2020 and was refined and consolidated into the Beyond 34 Roadmap to Implementation for the Cincinnati region.

10. Municipal Diversion Education Strategies

A necessary component for Cincinnati to achieve its zero waste goals is the creation and implementation of education strategies to increase recycling participation. Focus on the "three R's"—Reduce, Reuse, Recycle, in that order—is a core maxim of sustainability. However, basic knowledge gaps contribute to a lack of adherence to optimal material management practices. A 2018 study that addressed the reasons why people do not recycle identified three factors: inconvenience, lack of knowledge, and lack of personal responsibility.[59]

Human behavior plays a critical role in the success of municipal waste reduction and recycling initiatives. Municipalities can close the knowledge gap and lead the way to increased recycling participation rates and a reduction in contamination rates through targeted, multi-faceted educational programs. These programs could focus on improving recycling rates and quality while reducing solid waste generation. Strategies that support this include:

- enabling residents to reduce their waste thru aversion and discontinuing the use of common single-use items
- encouraging reuse materials where possible

[59] Barriers to household waste recycling: W. Strydom Barriers to Household Waste Recycling: Empirical Evidence from South Africa

- clarify what materials are and are not recyclable
- focusing on the need for clean contamination free recycling
- providing guidance on the proper disposal of questionable materials

Vision Statement

The vision for the municipal diversion education strategies is to develop an integrated circular economy or zero waste education strategy for Cincinnati. This intervention would leverage best practices from high-diversion cities, including a review of effective education strategies for multi-family recycling and single-family households and strategies for various demographic groups.

10.1 Case Studies

The District of Columbia Department of Public Works

The District of Columbia established the goal of achieving zero waste (defined as a diversion rate of at least 80%) by 2032.[60] It set specific recycling targets to achieve this goal, such as reducing contamination by 12%,[61] and adopted a multi-tiered approach to education. In 2018, the Washington, D.C. Department of Public Works rolled out a multi-media outreach campaign called "Waste Less, Recycle More" that includes a suite of resources housed on a webpage created specifically for the zero-waste initiative. The resources include fact sheets (printed in several languages), signage, videos, and a "what goes where?" desktop app, which allows residents to search questionable material to determine if an item is recyclable or not.

The "Waste Less, Recycle More" campaign included a short-term "Feet on the Street" educational component to help reduce contamination rates in the residential curbside collection. As high contamination collection routes appeared, inspectors would flag bins with "Oops" tags, see Figure 21, to point out non-recyclable items.

Figure 21: "Oops" tags applied to contaminated curbside bins

Additional components of the campaign have included household mailers, advertisements on public transport infrastructure, and messaging on collection trucks. The outreach campaign resulted in a

[60] Success Stories in Recycling: EPA https://www.epa.gov/sites/production/files/2019-11/documents/americarecyclessuccess_2019.pdf

[61] About Zero Waste DC: Zero Waste DC https://zerowaste.dc.gov/about-zero-waste-dc

9.5% increase in collection volume and a decrease in contamination by 8%.

Recycle Right NC

In 2019, led by the North Carolina Department of Environmental Quality's Division of Environmental Assistance and Customer Service (DEACS), 215 local governments in North Carolina came together to launch a 10-week educational campaign called Recycle Right NC.[62] The campaign educated residents on what items are recyclable in the state and encouraged increased recycling, with the goal of increasing the recovery of valuable recyclable materials while reducing contamination rates.

The campaign used social media to increase knowledge about proper recycling methods, see Figure 22. The Recycle More NC webpage, which contains information regarding the Recycle Right NC campaign, contains a suite of resources for residents and local governments to provide outreach. Recycle More NC includes information regarding recycling, including a ready-to-use social media toolkit on how to reduce contamination. DEACS encourages stakeholders to share these resources to educate the public.

Since its launch, the Recycle More NC Facebook page has reached over 600,000 users and received nearly 20,000 responses, likes, and shares.

Figure 22: Examples of material available in social media toolkit

[62] Success Stories in Recycling: EPA https://www.epa.gov/sites/production/files/2019-11/documents/americarecyclessuccess_2019.pdf

10.2 Project Options

Single Family Considerations

Educational programs must be multi-faceted and tailored to different living situations within Cincinnati. Effective single-family outreach programs take a community-based approach. Having dedicated city staff that can provide outreach and education on how-to and the importance of recycling is essential. Furthermore, dedicated staff members can share information on how residents can participate in responsible recycling at community events, festivals, farmers' markets, and schools, which is a common practice in most high diversion cities. Partnering with schools to promote recycling education for students can play a significant role in reaching families. Education and outreach should include information on the types of recyclables and ways to recycle them. Signage should accompany each bin and have multi-lingual printing to reach diverse populations. Basic signage on curbside bins detailing accepted items and common contaminants can assist in residents' decision making, see Figure 23.

The city website could serve as the main source of recycling information for residents with clear information on the available recycling programs offered in Cincinnati, including a curbside pick-up schedule and recycling drop-off locations. Additionally, the city could provide resources such as flyers with recycling best practices, recycling guidelines, and infographics that can easily be shared. To minimize confusion and hazardous waste contamination, the city could also provide residents with educational resources on proper disposal of hazardous waste.

Figure 23: Example of basic signage on curbside bins

Multi-family Considerations

Education campaigns for multi-family housing residents require different strategies than those used for single-family residents. One important difference with multi-family recycling is that property owners and landlords have primary control over access to and availability of recycling. Engaging with these stakeholders is necessary to increase the availability of recycling infrastructure to multi-family residents. One typical source of motivation for property owners is cost savings. Providing recycling can reduce a

building's trash stream, decreasing the frequency that dumpsters need to be tipped, potentially reducing fees associated with waste collection.[63]

A successful multi-family recycling program relies on property owners sharing guidelines for recycling practices with property tenants. Cincinnati can assist in the education process by providing a guide (example guide) for how property owners can effectively communicate recycling programs to their tenants. The information that property owners could provide includes:

- Types of materials to be recycled
- Preparation and sorting of materials
- Locations to drop recyclables
- Schedules for recycling collection
- Contact information for questions

Property owners can adopt various methods of education. Proven methods include:

- Additional document in lease
- Move-in packets
- A recycling “how-to” guide
- Websites
- Social Media
- Signage around properties
- Newsletters

As an added value, the availability of recycling in multi-family properties may attract environmentally conscious tenants. Providing evidence that Cincinnati renters demand recycling could serve as added motivation for property owners to offer and promote recycling. Additionally, Hamilton County offers property managers of apartments and other multi-family dwellings free assistance to reduce waste and start a recycling program.

Like the single-family education approach, all information on the city website should be clear and accessible to residents. Furthermore, multi-family residents who do not have access to recycling on their property need to know their options. Providing links to the location of community recycling centers, see Figure 24, will ensure that residents are aware of their ability to recycle.

[63] Engaging Multi-family Homes to Recycle Better: K. Millman https://recollect.net/blog/engaging-multi-family-homes-to-recycle-better/

Figure 24: Common recycling collection bin located near multi-family housing

Options in Cincinnati

Potential near-term actions Cincinnati can take to improve recycling education efforts include:

- Outreach
  - Create a dedicated zero waste team to engage residents and monitor recycling progress in Cincinnati. The team can also identify grants offered by the EPA and other sources to secure funding for further environmental education programs
  - Additional outreach opportunities could include partnering with neighborhood organizations and homeowners' associations; providing support for communities initiating recycling programs; celebrating the communities' achievements and dedication to recycling efforts; and door-to-door sharing of flyers and information to promote recycling efforts
  - Public bins could include signage and visual aids as a strategy to provide awareness and minimize contamination rates, see Figure 25

Figure 25: Examples of effective recycling signage

- Media
  - Provide a social media toolkit on the Cincinnati recycling webpage that residents can easily download and share through their social media networks
  - Showcase innovative and engaging arts centered on recycling and the repurposing of materials
  - Partner with local radio stations for advertisements
  - Create ads centered on growing job opportunities that result from the local recycling industry
- Partner with local institutions
  - Utilize partnerships with institutions such as schools, universities, the Cincinnati/Northern Kentucky Airport (CVG), and the Cincinnati Zoo, which has implemented a robust "Green Initiative" plan
- Promote Repair Café
  - Repair Cafés are informal meetups for residents who share knowledge and assist each other in repairing items to extend their useful life. Repair Café events are already taking place in Cincinnati. Promoting and advertising future events could create an additional pathway for education, see Figure 26

Figure 26: Repair Café Cincinnati advertisement

- Target Age Groups
  - Children (Age 4-15): Instilling the importance of recycling into children at an early age establishes an innate habit and provides the knowledge to become sustainability-conscious citizens [64,65]
    - Work with local schools to build Environmental Literacy education into the curriculum.
    - Teach recycling at school: create opportunities for students to manage classroom recycling[66]
    - Encourage schools to reuse materials: sponsor school projects that focus on creating something new out of waste
    - Provide resources for children to learn at home: examples include recycling coloring books and interactive online or mobile games
    - Sponsor and promote student tours of the landfill and MRF to educate children on local waste management practices
  - Young Adults (Age 15-28): This age range most effectively communicates and absorbs information through social media platforms. Influencers and content creators hold considerable leverage, and their techniques can be

[64] How Can Education Improve the Recycling Behaviors and Attitudes of Middle School Students?: S. Flanagan https://digitalcommons.hamline.edu/cgi/viewcontent.cgi?article=5326&context=hse_all

[65] 14 Ways to Improve Community Recycling: L. Dillon http://blog.bigbelly.com/14-ways-to-improve-community-recycling-rates

[66] The Game of Recycling or How to Make Children Aware: Iberdrola https://www.iberdrola.com/environment/recycling-for-kids

applied to educational campaigns. For example, the #byebuychallenge hashtag that trended on Instagram in 2019 encouraged users to buy less and reuse or purchase second-hand[67]

- Partner with local environmental groups to create awareness in the community about recycling and the associated environmental and economic benefits
- Create a social media team that focuses on recycling education campaigns

- Adults (Age 28 and older): Multifaceted public engagement encouraging correct recycling practices and participation
  - Engage via online, social media, infographics, public advertising, news articles, printed material, and radio mentions

- Inclusive Messaging
  - Although visual aids should maintain priority, the information should be made available in commonly spoken languages in Cincinnati, see Figure 27. Based on Census data from 2013, Cincinnati's metropolitan area had a foreign-born population of 93,700. Of these, 42% arrived from Asia, 24% from Latin America, and 17% from Europe[68]

Resources

"Where does it go?" Tool

- Seattle, Phoenix (Recycling Assistant), and Washington D.C. provide access to an app for the public to research what materials can go in the curbside recycling containers. If not accepted in curbside recycling, the app provides options for proper disposal of an item, such as recycling centers or hazardous waste collection sites

Anti-Contamination Recycling Kit

- Anti-Contamination Recycling Kit created by The Recycling Partnership to assist municipalities and waste haulers in "cleaning up" residential recycling streams. Included in the kit are proven strategies and tools (such as signage and "Oops tags")

[67] Teaching the New Generation About Recycling: C. Madison https://www.voicesofyouth.org/blog/teaching-new-generation-about-recycling-green-initiatives-youth-tomorrow

[68] Asians Largest Group of New Arrivals among Cincinnati's Foreign-Born Population: J. Harrah https://crcblog.typepad.com/crcblog/asians-largest-group-of-new-arrivals-among-cincinnatis-foreign-born-population-.html#:~:text=

Figure 27: Recycling infographic printed in Spanish

Sustainable Jersey – Recycling and Waste Reduction Education and Compliance

- A "how-to" guide for developing and implementing a residential recycling education outreach strategy that describes the necessary resources and what a successful education plan would include

NOTE: This intervention was prioritized through Beyond 34 Cincinnati community network engagement in 2020 and was refined and consolidated into the Beyond 34 Roadmap to Implementation for the Cincinnati region.

11. Commercial Diversion Strategies: Grocery Retail and Airports

In 2017, Hamilton County generated over 2 million tons of waste and recycling material across the residential, commercial, and industrial sectors. Of this amount, the commercial sector was responsible for about 57%. The commercial sector landfilled roughly 649,445 tons of material and diverted 401,262 tons for a diversion rate of 38.19%. The commercial diversion strategy solutions described in this report focuses on grocery retail and airport diversion best practices. This project option description is divided into two sections: best practices in grocery retail and best practices in airport waste diversion.

Vision Statement

The vision for commercial diversion strategies is to provide best practices and innovative ideas to increase waste diversion in highly trafficked and large employment commercial entities such as grocery retail and the CVG airport. This can help to increase diversion across Cincinnati as well as engage customers and workers to help these practices to be adopted at home as well.

11.1a Grocery Retail Diversion Best Practices

Food Waste Worldwide

It is estimated that between 33% and 50% of all food produced worldwide is wasted each year.[69,70] The estimates are broken down by types of food being wasted, see Table 20.[71]

Table 20: Percentage breakdown of food waste

Material Type	Percentage of Food Waste
Fruits and Vegetables	45%
Fish and Seafood	35%
Cereals	30%
Meat and Dairy Products	20%

Grocery retailers are in a unique situation to help prevent further increase in food waste due to their connections with farmers, processors, and consumers through the supply chain. Although not all surplus food from retailers, farmers, and manufacturers is fit for consumption, these sectors are able to implement efforts for diverting food waste through donation, animal feed, composting,[72] and other technologies.

[69] Sustainable Management of Food Basics - EPA https://www.epa.gov/sustainable-management-food/sustainable-management-food-basics#what

[70] Extent of food losses and waste – FAO: http://www.fao.org/3/mb060e/mb060e02.pdf

[71] How Large Food Retailers Can Help Solve the Food Crisis: Y. Kor, J. Prabhu, and M. Esposito https://hbr.org/2017/12/how-large-food-retailers-can-help-solve-the-food-waste-crisis

[72] Farm, Fork, and Food Waste: National Conference of State Legislatures https://www.ncsl.org/research/immigration/farm-fork-and-food-wast.aspx

11.1b Case Studies

Target

The Consumer Goods Forum (CGF) is a global industry network that brings together CEOs and management of over 400 retailers, manufacturers, and service providers.[73] In 2017, the CGF published a report showcasing the food waste programs that are being implemented across various retailers, manufacturers, and service providers.[74]

The board chairman and chief executive officer of Target, Brian Cornell, stated that as a part of the CGF, the sustainability program at Target is focused on leveraging the size of its facilities to positively impact the communities they serve. In 2015, Target publicly committed to diverting 70% of retail waste from landfills by 2020. In 2016, the company surpassed this goal by diverting 72.3% of retail waste. Strategies it used include:

- Expanding recycling programs in its stores
- Donating approximately 30,900 tons of food to Feeding America
- A store-level reporting system that tracks, reports, and analyzes inventory, waste levels, and impact levels
- Waste innovation monitoring through a store-level compactor monitoring system to support continuous improvement[75]

Flashfood and Meijer

Flashfood is an e-commerce application that allows grocers to list their nearly perishing items for up to 50% off. Through the application, customers can buy food and collect it at a designated location in-store. The Flashfood application is free to all users, but when consumers use the application and purchase food products, revenue from the price of each product is split between retailers (75%) and Flashfood (25%).[76]

In November of 2019, Meijer ran a pilot program for the Flashflood mobile app in four stores within metropolitan Detroit, including Brighton, Waterford, Commerce, and Howell.[77] During the 2019 pilot program, more than 1,000 customers within the Detroit metropolitan area were estimated to have used the application, resulting in a decrease

[73] The Consumer Goods Forum: https://www.theconsumergoodsforum.com/

[74] Sustainable Retail Summit, Executive Summary: The Consumer Goods Forum https://www.theconsumergoodsforum.com/wp-content/uploads/2017/09/SRS_2017_Executive_Summary_web.pdf

[75] Sustainable Retail Summit Food Waste Booklet: The Consumer Goods Forum https://www.theconsumergoodsforum.com/wp-content/uploads/2017/10/Environmental-Sustainability-Food-Waste-Booklet-2018.pdf

[76] Flashfood is a new app that is helping to eliminiate food waste: L. Lou https://www.pastemagazine.com/articles/2016/06/flashfood-is-a-new-app-that-helps-eliminate-food-w.html

[77] Meijer goes chain wide with Flashfood: R. Redman https://www.supermarketnews.com/sustainability/meijer-goes-chainwide-flashfood

in food waste by approximately 10%. By 2020, the pilot was so successful that Meijer rolled out the Flashflood mobile app in all 246 stores.

11.1c Project Options

In order to improve the diversion rate for the commercial sector among grocery retailers, the City of Cincinnati may consider the four-step approach described above and in greater depth here:

1) Modifying or eliminating traditional store practices (i.e., not selling imperfect perishables):
   a) Encourage grocery retailers to create a food donation program. The program could partner with a local non-profit organization, such as La Soupe.
   b) Encourage grocery retailers to create an organics recycling program that could partner with a local compost facility to ensure that food waste is sent to the composting process rather than the landfill.
2) Teaming up with grocery retailers to create a "waste less" campaign:
   a) Implement a Flashfood-type application for grocery retailers across Cincinnati that would function as a buy-sell platform as well as serve as an educational resource with food waste-related content, including recipes, storage tips, etc.

11.2a Airport Diversion Best Practices

Background

The CVG Airport is one of the largest employers in Cincinnati, with over 14,500 badged employees, and is North America's 8th largest cargo airport.[78] In 2018, CVG served 8.9 million passengers, which is its largest volume of passengers since 2010.

Airports are an ideal location for high-volume recycling programs because airlines have high foot traffic and can influence passengers to recycle if the correct infrastructure is in place. A 2006 report stated that airports should focus on plastic bottles, aluminum cans, and paper recovery and should target the retail and restaurant tenants within the terminals in order to maximize the impact of their recycling programs.[79] A 2013 Federal Aviation Administration (FAA) report analyzed seven different waste streams that airports typically generate through their operations and offered recommendations for recycling programs to address them, see Table 21. The FAA report also provides best practices examples from around the U.S., as well as a list of resources for users to examine the market for recyclables. These insights indicate not only where more

[78] CVG facts: https://www.cvgairport.com/docs/default-source/stats/cvg-facts---january-2020.pdf

[79] Trash landings – How Airlines and Airports Can Clean up Their Recycling Programs: A. Hershkowitz, D. Hoover https://www.nrdc.org/sites/default/files/airline.pdf

recyclable material can be removed from the waste stream, but also how to minimize the overall waste stream throughout the value chain and increase the amount of reuse that occurs.

In addition, the FAA report articulates the ten main pillars of an effective airport recycling program:

1. Commitment from management to display and enforce a top-down structure that forces continuous improvement
2. Program leadership, including an overall program coordinator that interacts with all the waste streams
3. Waste identification to examine the waste materials both through qualitative and quantitative data
4. Work with waste collection haulers to gauge potential markets for the collected material
5. Waste management plan development to identify stakeholders, conduct a waste characterization, and develop waste reduction strategies
6. Education and outreach to passengers, airport tenants, and administration about what materials can be recycled and where they can be recycled
7. Monitoring and refining approaches to ensure recycling is encouraged across all airport infrastructure
8. Performance monitoring to track the program's impact and collection capacities
9. Promote success to ensure public support for the program
10. Continuous improvement to ensure that the program is successful and developing consistently

CVG Waste Program

The CVG airport currently has a recycling program focused on aluminum cans, paper products, plastic bottles, metal cans, and light bulbs from the terminals and the airport-owned buildings.[80] The recycling program is managed by the Northern Kentucky Solid Waste Management, which utilizes three major landfills for waste disposal, one of which is a Rumpke facility located in Pendleton, Kentucky, and another in Colerain Township, Ohio.[81] Material is collected in green recycling containers located in the airport buildings and the terminals.[82]

[80] CVG Master Plan: CVG Airport https://www.cvgairport.com/docs/default-source/master-plan-report/4-inventory.pdf?sfvrsn=2

[81] CVG Environmental Assessment: CVG Airport https://www.airportprojects.net/cvg-aircargo-ea/wp-content/uploads/sites/15/2018/09/Public-Draft-EA-Entire-DocumentOPT.pdf

[82] Recycling: CVG Airport https://www.cvgairport.com/about/enviro/recycle

CVG's current waste bin structure is a regular waste container along with a recycle container. However, because the recycling containers are often contaminated from trash material, the entire containers are frequently sent to the landfill.[83]

Table 21: Waste Stream Pathways in Airports

Potential Inputs	Location in Airport	Potential Outputs
Restaurants, Shops, Passengers, Employees	Terminals	Food Waste, Paper, Plastic, Aluminum Cans, Trash, Grease & Oil, Green Waste
Aircraft, Operations	Airfields	Runway Rubber, Green Waste
Goods Movement	Cargo Hangers	Plastic, Wood, Vehicle Waste, Tires & Fluid
Aircraft, GSE	Aircraft	Vehicle Waste, Plastic, Wastewater, Hazmat
Construction, Re-Construction, Demolition	Airport Construction	Reused Concrete, Reused Asphalt, Vehicle Waste, Soils, Building Materials, Wood
Aircraft Food, Services	Flight Kitchens	Food Waste, Wastewater, Plastic, Wood
Employees	Administrative Services	Food Waste, Paper, Plastic, Aluminum Cans, Trash

11.2b Case Studies

Hartsfield-Jackson Atlanta International Airport

Hartsfield-Jackson Atlanta International Airport (ATL) is one of the busiest airports in the US, employing over 63,000 people in more than 8,000 different infrastructures and serving over 96.1 million passengers per year. A 2012 baseline estimated that ATL handles a total of 19,000 tons of waste per year.[84]

[83] CVG Airport Operations Memorandum: B. Cobb https://extranet.cvgairport.com/sites/kcabcs/Shared%20Documents/Operations%20Memorandums/2014%20Archive/OM2014-05%20Waste%20Containers%20and%20Recyling%20Program.pdf

[84] Atlanta Plans Sustainability Facility at Airport to Handle up 200,000 Tons a Year of Trash, Yard Trimmings: D. Pendered https://saportareport.com/atlanta-plans-recycling-facility-at-airport-to-handle-up-200000-tons-a-year-of-trash-yard-trimmings/

ATL Food Waste Program

As of 2019, there were only two composting facilities in Georgia, including one that is 110 miles away from ATL and another 80 miles in the opposite direction.[85] ATL is addressing the lack of nearby composting infrastructure by building its own composting facility as part of the Green Acres project. Because a private composting facility solely for ATL is not cost-effective, ATL intends to make the new composting facility open to Atlanta communities. The Green Acres project is projected to occupy 39-acres of airport-owned land, 30 acres of which will be dedicated to processing organic material diverted by both ATL and the Atlanta Metropolitan Area.[86] The facility is projected to be able to operate most efficiently with a feedstock of 180,000 to 210,000 tons of material annually based on 2017 data, and as of August 2019, the facility is still being built.[87] Additionally, ATL has developed the Food Heroes Program, a zero-waste initiative that "collects food daily from the airport's concessionaires and diverts it to program partners through a verifiable chain of custody.[88] Since July of 2018, this program has diverted more than 1,500 tons from the landfill, or 33% of the airport's food waste, winning the top sustainability award from Environment and Energy Leader in 2019.[89]

ATL Zero Waste Program

ATL has increased its number of recycling bins to make recycling more accessible to passengers. Additionally, ATL has made sustainable branding an integral part of its airport, with initiatives such as "Greening ATL," which partners with Unifi to create a special edition uniform for employees created from plastic bottles recycled at the airport. ATL also introduced the Sustainable Food Court Initiative, which required vendors and concessionaires to transition from Styrofoam to sustainable products by October 1st, 2017.[90]

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[85] Atlanta Airport has High Tech 'Flight Plan' for Food Waste: Q&A with Liza Milagro: A. Danigelis https://www.environmentalleader.com/2019/08/atlanta-airport-food-waste-qa/

[86] Organics Recycling Lands at Major Airports: K. Mendrey https://www.biocycle.net/2017/06/07/organics-recycling-lands-major-airports/

[87] Atlanta Airport Has High Tech 'Flight Plan' for Food Waste: Q&A with Liza Milagro: A. Danigelis https://www.environmentalleader.com/2019/08/atlanta-airport-food-waste-qa/

[88] Hartsfield-Jackson Atlanta International Airport: Food Heroes Program https://www.environmentalleader.com/2019-product-project-awards-hartsfield-jackson-atlanta-international-airport/

[89] Atlanta's Mission to Have the World's "Greenest" Airport: Waste Wise Products Inc. https://www.wastewiseproductsinc.com/blog/atlantas-mission-to-have-the-worlds-greenest-airport/

[90] ATL Fair a 'Win-Win' for Vendors, Concessionaires, Sustainability: R. Deloach http://www.atl.com/atl-fair-a-win-win-for-vendors-concessionaires-sustainability/

Portland, Oregon International Airport

In 2003, the Portland International Airport (PDX) began a food waste program that required all restaurants and passengers to participate via public organic separation stations that are located within the food courts. In 2016, a food waste optimization study conducted by Portland's Waste Minimization Team (WMT) estimated that PDX discards approximately 25 tons of food each month, which makes up about 56% of the waste generated by weight at PDX.[91]

The WMT 2016 food waste optimization study provided for food optimization support and training specific to airport restaurants, with a special focus on increasing the efficiency of the "grab-and-go" markets and increased employee awareness and engagement. PDX focused on a top-down structure, starting with management, by developing best management practices (BMPs) to optimize food management. The BMPs encourage the managers of restaurants to:

1. Create a secondary use station where food scraps are collected for re-use
2. Adapt menus and limit customer choices to reduce overproduction
3. Prepare smaller portions and monitor sales throughout the day
4. Use data and standardized waste logs in order to perform waste audits
5. Educate and engage employees by keeping a food waste idea log, appointing a sustainability leader, and setting a collective goal for food waste

Results and Outcomes

Overall, PDX has been able to collect 25 tons per month of food waste. One challenge that PDX faced was a change in local policy that no longer allowed compostable products and materials with food residue in the organic collection stream. In response, PDX developed a new program and retrained all necessary personnel. In addition to the food waste collection program, PDX also partnered with Urban Gleaners,[92] a Portland non-profit that collects food before it goes to waste and provides it to people experiencing food insecurity, which can collect up to 2.5 tons of food per month for donations.

11.2c Project Options

There are several potential avenues CVG could use to increase diversion that draw upon the case studies above:

[91] 3 Insights to Tackle Food Waste at Airports: Port currents https://portcurrents.portofportland.online/3-insights-to-tackle-food-waste-at-airports/

[92] Urban Gleaners https://urbangleaners.org/

1. Developing clear, percentage-based goals and timelines for waste reduction and diversion
    a. This process could benefit from an audit of the waste and recycling streams at the airport facilities. This could support a better understanding of the opportunities for increased waste diversion, waste reduction, reuse, and decreased contamination in the recycle stream.
2. Creating a “waste optimization” team that will overlook diversion rates, material streams, and sustainability campaigns. This team would focus on the reduction of landfilled waste throughout the airport
3. Creating a zero-waste program and sustainability campaign to increase passenger participation and decrease the amount of non-recyclable material used in the food court
4. Creating a food waste program to divert food waste from landfills. Components may include:
    a. Developing a food donation program to support local non-profit organizations
    b. Developing a food waste collection program and promote local composting facilities
    c. Encourage the managers of restaurants to reduce overproduction in the food court by shrinking portion size, adapting menus, and monitoring sales
5. Educating and engaging airport workers to improve employee participation

11.2d Projected CVG Results and Outcomes

PDX international airport serves 19,891,365 passengers per year, while CVG international airport serves 9,103,554 passengers per year. Using this ratio and knowing that PDX can divert approximately 240 tons of food waste per year, the estimated amount of food waste that CVG could divert is approximately 110 tons of food waste per year.

11.3 General Outcomes and Benefits of Commercial Diversion Strategies

As discussed, grocery retailers and the CVG airport are some of the largest employers and most trafficked commercial entities in Cincinnati, which offers an opportunity for these entities to establish themselves as agents of change. These commercial entities can show leadership in waste diversion by enabling beneficial relationships with partners, thereby setting an example for other businesses in Cincinnati and beyond.[93]

[93] Redefining Sustainable Business: Management for a Rapidly Changing World: A. Cramer, Et al https://www.bsr.org/reports/BSR_Redefining_Sustainable_Business.pdf

NOTE: This intervention was prioritized through Beyond 34 Cincinnati community network engagement in 2020 and was refined and consolidated into the Beyond 34 Roadmap to Implementation for the Cincinnati region.

12. Municipal Systems Optimization

MSW generation continues to significantly outpace growth in municipal recycling, creating significant environmental and health consequences. A 2016, report documented best practices and identified opportunities to increase diversion through the development of successful recycling programs in Michigan.[94] The report included a comprehensive overview of national best practices for collection and processing; rate structures; multi-family, rural, and commercial recycling programs; and options for addressing construction and demolition waste. The report identified the following attributes as critical components for a successful municipal recycling program:

1. Recycling education programming
2. Breadth of recycling options
3. Local policies that support diversion
4. Sufficient and dedicated funding (recycling program and education)
5. Participation among households and businesses
6. Local government leadership and capacity
7. Measurement systems

Although the report focused on the state of Michigan, its discussion of the need for wide-ranging tactics that incorporate all of these components and suggestions for municipal-level recycling programs may be applicable to other municipalities. The report's findings highlight the need for robust education and outreach efforts as well as strategies such as opt-out versus opt-in mechanisms for recycling programs to increase diversion across U.S. cities successfully.

Complementing the study, a statewide, community-level assessment of recycling was conducted in Massachusetts to examine policies, practices, and resources in 245 municipalities.[95] This study found that PAYT trash programs were the most significant factor in predicting recycling rates, whereas having communities pay for recycling services resulted in significantly lower average recycling rates. The research also showed that providing residents with recycling information via education and outreach efforts resulted in higher municipal recycling rates and that several important

[94] Recycling in Michigan: https://www.michigan.gov/documents/deq/480235-14_NEMCOG_FINAL_RECYCLING_REPORT_521916_7.PDF

[95] Demographic and community-level predictors of recycling behavior: A statewide assessment: J. Seacat and N. Boileau https://www.sciencedirect.com/science/article/abs/pii/S0272494418300963

demographic variables effectively predicted recycling rates. Specifically, variables such as a larger city population size correlated with a lower recycling rate, while higher mean household income correlated with a higher recycling rate.[96]

Vision Statement

The vision for municipal systems optimization strategies is to adapt known best practices of high diversion cities to the City of Cincinnati and Hamilton County to improve waste diversion rates.

12.1 Case Studies

San Jose, CA – Residential & Commercial Recycling Collaboration

Since 2008, the City of San Jose has sought to increase waste diversion with the goal of becoming a zero-waste city by 2022 and having zero-landfill or incinerator waste by 2040. [97]

San Jose has had many notable achievements. For example, between 2012 and 2015, the city increased its commercial recycling rate from 22% to 43% and diverted 28% of waste to compost. The city credits its success to establishing an exclusive commercial waste management system through collaborations between the city, Republic Services, and Zero Waste Energy Development Company (ZWED). Republic Services manages the collection and processing of recyclables for 8,000+ businesses in San Jose and sends the organic matter to ZWED for processing into energy or compost.

Indianapolis, IN and Colorado Springs, CO – Opt-out versus Opt-in

The Recycling Partnership (TRP) released its 2020 report on the State of Curbside Recycling highlighting the different opportunities, challenges, and strategies that municipalities are currently managing. One key issue discussed in the report pertains to the benefits of opt-out versus opt-in curbside recycling programs. The report found that requiring households to opt-in to curbside recycling programs is detrimental to residential participation and that the conversion to opt-in programs in the U.S. would address this shortcoming.

TRP notes that more than 16.5 million U.S. households with the opportunity to subscribe (opt-in) to curbside services fail to do so in part because of cost barriers and

[96] Demographic and Community-level Predictors of Recycling Behavior: A statewide assessment: J. Seacat and N. Boileau https://www-sciencedirect-com.ezproxy1.lib.asu.edu/science/article/pii/S0272494418300963#tbl2

[97] Recycling Envy: Ten American Cities with Excellent Practices: Busted Cubicle https://www.bustedcubicle.com/outside/top-american-cities-recycling

that there are clear advantages of having opt-out programs and/or automatically providing the service.

In Indianapolis, Indiana, subscribers are required to pay $99 per year to opt-in to receive curbside service, resulting in only 10% of households signing up. The city has recently released plans to transition households toward automatically provided curbside service by 2025.

Seattle, WA – Multifaceted Strategies

The City of Seattle has set the goal of reaching a 72% material recovery rate by 2025. When the city passed a law in 2009 that required residents to recycle food scraps, Seattle was seen as a forward-thinking for finding new ways to reduce waste and negative effects of transportation associated with moving waste to landfill. According to the EPA, by 2017, the city was recycling approximately 57% of its waste, with each resident sending less than one pound of waste to landfills each day.[98]

In addition to the success of using policy leverage points targeting recycling food scraps, Seattle's recycling program has also created positive impacts partly due to its three-year phase-in strategy for mandatory recycling. This approach gave the city time to educate residents on proper recycling techniques while simultaneously developing enforcement mechanisms via penalties. Residents now receive notices if they do not comply and are eventually fined after continuing non-compliance. Furthermore, residents are motivated to waste less through the implementation of a PAYT program (e.g., the larger the trash can, the higher the monthly fee). It costs $74.30 for residents to have a 64-gallon container of trash picked up vs. $37.15 per month for a 32-gallon container. Finally, Seattle's local trash is sent to city-owned transfer stations for processing by contracted private companies. The private companies are compensated more when less waste is sent to landfills.

Los Angeles, CA – "Rethink LA"

Nearly four decades ago, the City of Los Angeles' large-capacity Puente Hills Landfill was nearing maximum capacity. The mayor at the time, Tom Bradley, chose to focus on recycling strategies as a solution and sought to bring the issue of waste to the forefront of public minds. In 1990, California imposed statewide goals of 25% recycling by 1995 and 50% by 2000. Statewide management by CalRecycle employed local enforcement agencies to move toward its new statewide goals in overall waste recovery. Los Angeles phased in recycling by combining the efforts of private industry and city-owned

[98] Recycling Envy: Ten American Cities With Excellent Practices: Busted Cubicle https://www.bustedcubicle.com/outside/top-american-cities-recycling

collection services. The city handles the curbside collection and hauls waste to private MRFs.[99]

The city's new target—90% by 2025—is bolstered by a 20-year plan for citizen participation called "Rethink LA." The initiatives educate citizens on the importance of recycling and composting with numerous sub-programs to bolster Los Angeles's commitment to recycling. For example, one program reduces a company's city tax obligations based on its recycling efforts. Los Angeles's recycling achievements and diligent citizen participation are largely due to these community-wide education and campaign efforts. From bilingual recycling education to grassroots outreach in low-income communities, the city has managed to stay on track toward a zero-waste initiative by creating a robust recycling program that caters to diverse citizen needs. The city's economy has also seen a boost from the business of recycling, Californians Against Waste reports that the recycling industry overall adds $1.2 billion annually to the Los Angeles economy.[100]

12.3 Project Options

Potential options to improve recycling performance in Cincinnati are identified below:

1. Shift to opt-out waste collection. Although Cincinnati has a good recycling participation rate within the city (calculated to be 70% in 2015),[101] recycling in Cincinnati is an opt-in program wherein residents request a green recycling bin. Cincinnati could increase its residential recycling participation rate by creating an automatic or opt-out recycling program. In this program, every resident and business with city trash service would receive recycling service unless they specifically opt-out of the program.

2. Create additional collection partnerships that can increase the variety of materials collected from city residents and businesses, especially plastics. Currently, Cincinnati's recycling program can only collect PET and HDPE bottles and jugs.

3. Create a strategic regional waste shed. Under the HCRSWD umbrella, cities and townships in the region could form innovative partnerships for material collections and public-public or public-private infrastructure creation. This may also include regional messaging and education campaigns, and regional policies that will support these new partnerships.

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[99] Recycling Envy: Ten American Cities with Excellent Practices: Busted Cubicle https://www.bustedcubicle.com/outside/top-american-cities-recycling

[100] California's Recycling Industry: Californians Against Waste https://www.cawrecycles.org/californias-recycling-industry

[101] Recycling Participation: CincyInsights https://insights.cincinnati-oh.gov/stories/s/gd3w-zpnu

12.4 Outcomes

Cincinnati has opportunities to leverage the Beyond 34 platform and various forms of local capital (social, intellectual, experiential, cultural, living, financial, and material)[102] to partner with regional municipalities and private entities to create infrastructure and programs to target the divertible materials to ensure they are not landfilled. According to the Hamilton County Solid Waste Composition, 62.2% of Cincinnati's landfilled material is considered divertible material.[103] This creates numerous possibilities for mobilizing local systems optimization to increase diversion rates by creating capacity for increased collections and processing and through further developing end markets.

Note: This project was not initially prioritized by the Beyond 34 Cincinnati community in 2020, but it can be revisited as an additional solution in the future.

13. Conclusion

As detailed in this report, Cincinnati has multiple opportunities to increase diversion and continue the city's transition towards a circular economy. The projects outlined in this Opportunity Analysis identify viable solutions that will increase the diversion rate in Cincinnati while positively impacting the city economically, socially, and environmentally. This analysis drew extensively upon the 2018 waste stream data for Cincinnati shared by the city and the HCSWRD and the 2018 GCP.

This analysis characterized the potential impact for each project in terms of material diverted and long-term benefits such as education and infrastructure creation, while also considering relevant best practices from cities around the world that can be adapted to meet Cincinnati's unique needs. Implementing these ten solutions could transform Cincinnati's waste and recycling system in both traditional and innovative ways. State of the art technologies, education, and social and economic leverage points relating to citizens and businesses are key factors for enabling these project options and driving the development of a circular economy in Cincinnati. Compostable material (i.e. organics), paper (including cardboard), and plastic material make up the largest divertible material categories. As such, the ten solutions described are focused on increasing diversion of these material streams,

[102] Eight forms of capital: E. Roland http://appleseedpermaculture.com/wp-content/uploads/2011/04/8_Forms_of_Capital_PM68.pdf

[103] Hamilton County waste characterization: http://www.hamiltoncountyrecycles.org/UserFiles/Servers/Server_3788196/File/EnvironmentalServices/SolidWaste/About/Hamilton%20County%20WCS%202018%20Final%20Report.pdf

Analysis shows that a 30% increased landfill capture rate across the 10 solutions is estimated to increase the diversion rate by 11.6% from the current 23.1% to 34.7%, and a 60% increase in landfill capture rate is estimated to increase the diversion rate by 24.2% to 47.3%.

In addition to this Opportunity Analysis, the U.S. Chamber of Commerce Foundation's Beyond 34 initiative, in coordination with ASU, has developed a Current State Assessment of the recycling system in Cincinnati, an Economic Impact Assessment of recycling in the region, and an Institutional Analysis. Using these resources in conjunction with feedback from local stakeholders' workgroups, Beyond 34 has developed a Roadmap for the implementation of the identified potential projects. This Roadmap identifies ways to positively impact the recycling and recovery system in Cincinnati, both in the short and long-term, by leveraging the solutions described in this Opportunity Analysis.

Appendix A

Waste Characterization Breakdown by Specific Materials

Table-A 1: 2018 Cincinnati landfill breakdown by specific material

Material Category	Specific Material	Tonnage Amount of Specific Material Landfilled	Tonnage Amount of Specific Material Diverted	Total Amount of Specific Material	% of Waste
Paper	Corrugated Cardboard	5110.75	2,492.45	7603.20	7.75%
	Newspaper/Print	626.48	1,163.50	1789.98	0.95%
	Cartons	626.48	13.12	639.60	0.95%
	Mixed Recyclable Paper	3923.74	6,148.49	10072.23	5.95%
	Compostable Paper	3264.28	0	3264.28	4.95%
	Non-Recyclable Paper	395.67	0	395.67	0.60%
Plastic	PET Bottle/Jugs	1154.04	680.11	1834.15	1.75%
	HDPE Bottle/Jugs	527.56	341.98	869.54	0.80%
	Other Bottle/Jugs	32.97	225.68	258.65	0.05%
	Trays and Tubes	989.18	0	989.18	1.50%
	Rigid Plastics	1088.09	0	1088.09	1.65%
	Other Plastics	989.18	0	989.18	1.50%
	Films	4385.35	0	4385.35	6.65%
	Grocery Bags	857.29	0	857.29	1.30%
Glass	Glass Bottles	1681.60	0.00	1681.60	2.55%
	Glass Jars	494.59	0	494.59	0.75%
	Other Glass	494.59	2034.88	2529.47	0.75%
Metal	Steel/Tin Cans	260.48	301.14	561.62	0.40%
	Aluminum Cans	659.45	207.20	866.65	1.00%
	Other Aluminum	65.95	0	65.95	0.10%
	Other Ferrous	2341.05	0.00	2341.05	3.55%
	White Goods	0.00	0.00	0	0.00%
Yard Waste	Grass	2143.22		15127.70	3.25%
	Leaves	2110.24			3.20%

	Brush	626.48	5,664.57[104]		0.95%
	Wood	3429.15			5.20%
	Other Yard Waste	1154.04			1.75%
Electronics	Cathode Ray Tubes	0.00	0	0.00	0.00%
	Appliances	623.48	0	623.18	0.95%
	Portable Electronics	65.95	0	65.95	0.10%
Food Waste	Vegetative Food	7352.88	0	7352.88	11.15%
	Non-Vegetative Food	3692.93	0	362.93	5.60%
Other Waste	Diapers	1163.93	0	1163.93	1.77%
	Textiles	2407.00	59.66	2466.66	3.65%
	C&D Debris	1450.79	0	1450.79	2.20%
	Mattresses	329.73	0	329.73	0.50%
	Other Uncharacterized	5407.50	0	5407.50	8.20%
	Pet Waste	362.70	0	362.70	0.55%
	Carpet	1747.55	0	1747.55	2.65%
	Fines	1582.68	0	1582.68	2.40%
HHW	Batteries	0.00	0	0.00	0.00%
	Paint	230.81	0	230.81	0.35%
	Automotive fluids	29.68	0	29.68	0.05%
	Other (HHW)	65.95	0	65.95	0.10%
One-off Programs (Tons)		-	232.842	232.842	
Tires (Tons)		-	197.82	197.82	
Total (Tons)		65945.13	19763.44	85708.57	

[104] Yard Waste is collected and not sorted to the specific material level, thus, the total amount diverted is for the entire category.

Table-A 2: 2018 Specific materials % captured, potential amount captured, and percent impact to diversion

Material Category	Specific Material	Percentage of material capture	Potential Amount to be Captured (tons)	Impact to Diversion
Paper	Corrugated Cardboard	2.33%	1,533	1.79%
	Newspaper/Print	0.29%	188	0.22%
	Cartons	0.29%	188	0.22%
	Mixed Recyclable Paper	1.79%	1,177	1.37%
	Compostable Paper	1.49%	979	1.14%
	Non-Recyclable Paper	0.18%	0	0.00%
Plastic	PET Bottle/Jugs	0.53%	346	0.40%
	HDPE Bottle/Jugs	0.24%	158	0.18%
	Other Bottle/Jugs	0.02%	10	0.01%
	Trays and Tubes	0.45%	297	0.35%
	Rigid Plastics	0.50%	326	0.38%
	Other Plastics	0.45%	297	0.35%
	Films	2.00%	1,316	1.53%
	Grocery Bags	0.39%	257	0.30%
Glass	Glass Bottles	0.77%	504	0.59%
	Glass Jars	0.23%	148	0.17%
	Other Glass	0.23%	0	0.00%
Metal	Steel/Tin Cans	0.12%	78	0.09%
	Aluminum Cans	0.30%	198	0.23%
	Other Aluminum	0.03%	20	0.02%
	Other Ferrous	1.07%	702	0.82%
	White Goods	0.00%	0	0.00%
Yard Waste	Grass	0.98%	643	0.75%
	Leaves	0.96%	633	0.74%
	Brush	0.29%	188	0.22%
	Wood	0.00%	0	0.00%
	Other Yard Waste	0.00%	0	0.00%

Electronics	Cathode Ray Tubes	0.00%	0	0.00%
	Appliances	0.28%	187	0.22%
	Portable Electronics	0.03%	20	0.02%
Food Waste	Vegetative Food	3.35%	2,206	2.57%
	Non-Vegetative Food	1.68%	1,108	1.29%
Other Waste	Diapers	0.53%	0	0.00%
	Textiles	1.10%	722	0.84%
	C&D Debris	0.66%	435	0.51%
	Mattresses	0.15%	99	0.11%
	Other Uncharacterized	2.46%	0	0.00%
	Pet Waste	0.17%	0	0.00%
	Carpet	0.80%	524	0.61%
	Fines	0.72%	0	0.00%
HHW	Batteries	0.00%	0	0.00%
	Paint	0.11%	69	0.08%
	Automotive fluids	0.01%	9	0.01%
	Other (HHW)	0.03%	20	0.02%