FINAL REPORT

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Analysis of Costs Associated with Separate Residential Collection of Food Waste from Ecomaine Member Municipalities, and A Review of Opportunities to Regionalize Collection

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EXECUTIVE SUMMARY

Ecomaine has entered into a contract with Exeter Agri-Energy under which food waste can be delivered to ecomaine, where it is stored on a dedicated portion of the tipping floor of the WTE facility, and then transported by Exeter Agri-Energy to their digesters in Exeter, Maine. Ecomaine is on pace to divert roughly 5,000 tons of food waste to Exeter Agri-Energy in 2018. Most of this food waste is collected from businesses in the ecomaine member municipalities.

An earlier study by Northern Tilth estimated that between 3,100 and 13,900 tons of food waste could be diverted from households in the member municipalities if separate collection of food waste were to be implemented. Ecomaine has been working with Scarborough and South Portland to test two separate residential food waste collection alternatives. One pilot program provided 6-gallon pails to households in South Portland, with the source separated food waste collected weekly in a separate truck on the same day as refuse collection. The second pilot program provided households with a 35-gallon cart for storing food waste that was collected each week using a split truck, alternating the collection of refuse (one week) with collection of single sort recyclables (the other week).

While these pilot programs have demonstrated a desire by households to separate food waste, both pilot programs have limitations. Separate weekly collection of 6-gallon pails is relatively costly, and there has been push back by households to the idea of every other week collection of refuse.

Given these limitations, ecomaine has recently tested residential organics collection using small, heavy mil colored plastic bags for storing and collecting food waste comingled with the mixed solid waste. The colored food waste bags would then be separated at the ecomaine facility using optical sorting equipment.[1] This alternative is projected to be less costly, with lower environmental impacts associated with collection.

Ecomaine contracted with DSM Environmental Services, Inc. (DSM) to develop an economic model to estimate system costs for four residential food waste collection options; estimate total miles driven under each alternative; estimate the Greenhouse Gas (GHG) emission impacts of the alternative collection systems; and, use the US EPA WARM model to estimate overall system GHG emissions under the four alternative systems.

A second phase of the DSM analysis then examined the institutional issues associated with increased regionalization of the collection system that might compliment a more integrated collection system for residential materials, including food waste.

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[1] The pilot program involved hand sorting of the bags to evaluate the percent of bags that break in the collection truck. Food waste set out in bags that break in the compaction truck would obviously not be recovered as food waste because only the full bags could be optically sorted at the ecomaine WTE facility for delivery to Exeter Agri-Energy.

Residential Collection Systems Analyzed

The following four options for separate collection of residential food waste were analyzed.

1. Distribution of one 96-gallon cart to all curbside residential customers for weekly collection of refuse, recyclables, food waste and if they chose – their bottle bill material -- in the single cart, each separated (by the household) using a different colored plastic bag placed in the cart. The comingled bags would be delivered to ecomaine where they would be optically sorted by color. The single sort and bottle bill material would go to the materials recovery facility (MRF) for processing, refuse to the WTE facility, and the food waste bags stored on the tipping floor for collection by Exeter Agri-Energy.
2. Distribution of two carts – one for recyclables, the second for refuse and separately bagged food waste. Carts would be collected weekly in a split truck, with recyclables tipped at the MRF and refuse and food waste tipped at the WTE facility. As with Option 1, the food waste bags would be removed mechanically using an optical sorter and then stored for transfer to Exeter Agri-Energy, and the refuse would be processed at the WTE facility. Also, as with Option 1, households who wished to redeem their bottle bill containers through ecomaine could place their bottle bill containers in a separate colored bag which would be sorted from the mixed single sort material on the in-feed conveyor to the single sort MRF, with the bottle bill containers then processed to redeem the deposit.
3. Distribution of three carts – one 64-gallon cart for refuse, one 64-gallon cart for single sort recyclables, and one 32-gallon cart for food waste - with separate weekly collection of each stream. Refuse and single sort recycling would be collected weekly in a split truck, with food waste collected in a separate truck weekly.
4. Every Other Week (EOW) collection - Food waste would be collected every week, with refuse and single sort materials collected with the food waste in a split truck on alternate weeks.

Municipalities Included in This Analysis

The focus of this collection cost analysis is on integration of food waste collection within the residential curbside collection system. Municipalities included in this collection analysis are higher density member municipalities more likely to implement residential curbside food waste collection. However, municipalities that rely on transfer stations would also benefit from either Option 1 or 2 through lower transfer station costs for food waste diversion.

Summary of Results

DSM estimates that the current residential collection system for the included municipalities costs roughly $8.2 million[2]. The baseline system does not include separate residential food waste collection (the pilot systems were excluded from the cost estimate) and represents a mix of automated and manual collection using a combination of split trucks and rear loading trucks.

Table E-1 summarizes the estimated costs associated with moving to a fully automated collection system with rolling carts for all households, and the provision of special colored bags by ecomaine for Options 1 and 2, with optical sorting of the bags at ecomaine.

Table E-1. Summary of Total System Costs, Options 1 – 4

Description	Option 1	Option 2	Option 3	Option 4
	Single Cart	Dual Cart	Separate Food Waste Collection	Every Other Week
Collection	$7,911,970	$8,591,856	$11,922,827	$7,595,859
Carts	$723,290	$1,157,264	$1,735,896	$1,735,896
Bags	$977,888	$300,889	$165,489	$165,489
Optical Sorting	$1,662,959	$1,556,446		
Total Cost	$11,276,107	$11,606,455	$13,824,212	$9,497,244
Less Tip Fee Revenue	$147,390	$147,390	$173,400	$173,400
Net Cost	$11,128,717	$11,459,065	$13,650,812	$9,323,844

As illustrated by Table E-1 all four options cost more than the current residential collection system. This is to be expected given that the current residential system does not include separate food waste collection and is not fully automated with carts. Option 4 is estimated to be the lowest cost option, with Options 1 and 2 in the mid-range, while Option 3 – separate food waste collection – is significantly higher in cost then the other three options. While collection costs for Option 1 (single cart) are slightly lower than for Option 2, the added cost of processing at ecomaine increase the total system cost. Option 4 costs are lower because it is assumed that only 45 percent of households will choose to set out food waste – lowering collection stop times - and there are no ecomaine processing costs over and above storage on the tipping floor, as is currently occurring.

[2] This estimate builds on the work of Stuart Axelrod who developed baseline collection costs for ecomaine at the beginning of DSM's analysis.

Table E-2 presents estimated greenhouse gas emissions in metric tons carbon equivalent MTCE)[3] for each *collection* option.

Table E-2. Estimated Total GHG Emissions (MTCE) for the Four Optional Collection Systems

Unit	Baseline	Option 1 Single Cart	Option 2 Dual Cart	Option 3 Sep. Food Waste	Option 4 EOW
Total Miles	603,859	510,704	527,040	867,624	465,745
Gallons, Diesel	182,988	154,759	159,709	262,916	141,135
Metric Tonnes CO2 E	1,863	1,575	1,626	2,676	1,437

Given the number of assumptions necessary to calculate GHG emissions, the difference between Options 1,2 and 4 can be considered relatively insignificant. Option 4 is estimated to generate the smallest quantity of GHG emissions, while Option 3 has significantly greater GHG emissions when compared to the other options. This is due to the need for a separate truck to collect the food waste.

DSM then used the US EPA WARM model[4] to assess the change in CO^2 emissions associated with diverting food waste from ecomaine's WTE facility to Exeter Agri-Energy based on the high residential diversion estimate for food waste of 13,900 tons provided in the Northern Tilth report. As illustrated by Table E-3, *based on the WARM Model assumptions* overall *processing* emissions decrease slightly with diversion of 13,900 tons of residential food waste.

Table E-3. Estimate Change in GHG Emissions Associated with Diverting Food Waste from Ecomaine's WTE Facility to Exeter Agri-Energy

Management	Baseline	Low	Medium	High
	(MTCE)	*(MTCE)*	*(MTCE)*	*(MTCE)*
Single Stream	(18,090)	(18,090)	(18,090)	(18,090)
Food Waste	(327)	(258)	(176)	(18)
Mixed MSW	664	664	664	664
Total:	(17,753)	(17,685)	(17,602)	(17,445)
Change in MTCE:		69	151	309

MTCE: Metric Tons Carbon Equivalent

[3] Metric tons carbon equivalent includes other gasses emitted in much smaller quantities than carbon dioxide, but which create larger impacts on a unit basis, than carbon dioxide. Climate scientists have calculated those impacts in carbon equivalencies and they are included in the calculations in this report.
[4] https://www.epa.gov/sites/production/files/2016-03/documents/warm_v14_organic_materials.pdf

Consolidation of the Collection System

DSM was also asked by ecomaine to examine the potential for ecomaine to take over management of the collection system for the member municipalities, and to consolidate collection where appropriate. Based on DSM's experience in other areas of New England, DSM estimates that consolidation could generate savings of between 10 and 20 percent of the collection costs estimated for Options 1 through 4, above, and might result in an overall reduction in collection GHG emissions of 10 percent, as illustrated in Table E-4, below.

Table E-4. Estimated Cost and GHG Emission Savings Associated with Consolidating Collection Within Ecomaine Municipalities

Collection	**Option 1**	**Option 2**	**Option 3**	**Option 4**
High	$1,582,394	$1,718,371	$2,384,565	$1,519,172
Low	$791,197	$859,186	$1,192,283	$759,586
Administrative	$250,000	$250,000	$250,000	$250,000
Net Savings				
High	$1,332,394	$1,468,371	$2,134,565	$1,269,172
Low	$541,197	$609,186	$942,283	$509,586
Carbon Savings (MTCE)	158	163	268	144

Next Steps and Conclusions

The economic analysis of the potential to add separate collection of food waste for all households raises important issues that will require further investigation by the member municipalities and ecomaine. The most critical are highlighted below.

- First, do member municipalities want to move forward with system-wide collection of residential food waste to significantly increasing the diversion rate and move toward the State recycling goal of 50 percent?
- Second, if they do want to move forward with separate collection of residential food waste, do they want to invest in technology at ecomaine that would make food waste diversion more convenient for households? Investment in this technology would essentially shifts costs from households that want to participate in food waste diversion to ecomaine.
- Third, are member municipalities interested in moving forward with automated collection of municipal solid waste (MSW), single sort materials, and food waste to increase collection efficiency; including adjusting PAYT programs to accommodate rolling carts necessary for automated collection?

- Fourth, are member municipalities interested in delegating responsibility for management of this new automated collection system to a regional entity – in this case ecomaine?

In conclusion, this report compares costs and environmental impacts of four distinct collection approaches for food waste, recyclables, bottle bill containers, and refuse. It also considers the savings potential for transitioning to regional automated collection and provides alternatives to fund such a program.

Ecomaine municipalities have already regionalized a portion of solid waste services including recycling, waste-to-energy, and landfilling. Collection remains a service that is managed by the individual municipalities. This report concludes that there are opportunities to add services, improve convenience & efficiencies, and save money if the member municipalities are interested and willing to take the next step in furthering the regionalization of waste management services.

INTRODUCTION

Ecomaine has entered into a contract with Exeter Agri-Energy under which food waste can be delivered to ecomaine, where it is stored on a dedicated portion of the tipping floor of the WTE facility, and then transported by Exeter Agri-Energy to their digesters in Exeter, Maine. Ecomaine pays Exeter Agri- Energy a $45 per ton fee for Exeter Agri-Energy to transfer and process the source separated food waste from ecomaine at Exeter Agri-Energy's food depackaging and co-digestion facility.

In FY 2017, 2,700 tons of food waste were diverted to Exeter Agri-Energy, and in FY 2018 Ecomaine is on pace to recover nearly 5,000 tons – primarily of commercial food waste. Based on the Northern Tilth report[5], it is estimated that between 3,100 and 13,900 tons of residential food waste could be diverted with a comprehensive food waste collection program, as well as between 5,100 and 7,100 tons of commercial food waste from institutional/commercial/industrial (ICI) generators.

Given that the bulk of the food waste currently delivered to ecomaine is from ICI sources, ecomaine is especially interested in expanding food waste collection to residential generators in all member municipalities; and, has been working with Scarborough and South Portland to test two separate residential food waste collection alternatives. One pilot program provided 6-gallon pails to households in South Portland, with the source separated food waste collected weekly in a separate truck on the same day as refuse collection. The second pilot program provided pilot households with a 35-gallon cart for storing food waste that was collected each week using a split truck, alternating the collection of refuse (one week) with collection of single sort recyclables (the other week).

[5] *Ecomaine Organics Recycling Feasibility Study*, Final Report, November 2013, Prepared by Northern Tilth

Recognizing that separate residential food waste collection can significantly increase collection costs, ecomaine has recently tested residential organics collection using small, heavy mil colored plastic bags for storing and collecting food waste comingled with the mixed solid waste. The colored food waste bags would then be separated at the ecomaine facility using optical sorting equipment.[6]

Ecomaine contracted with Stuart Axelrod, formally with Pine Tree Waste/Casella to provide estimates of current baseline curbside collection costs for member municipalities and estimate the number of trucks that would be required under four alternative curbside food waste collection systems. Ecomaine then contracted with DSM Environmental Services, Inc. (DSM) to: review the truck and cost data estimated by Stuart Axelrod; build on that data to develop an economic model to aggregate costs for each alternative; estimate total miles driven under each alternative; estimate the Greenhouse Gas (GHG) emission impacts of the alternative collection systems; and, use the US EPA WARM model to estimate overall system GHG emissions under the four alternative systems.

A second phase of the DSM analysis then examined the institutional issues associated with increased regionalization of the collection system that might compliment a more integrated collection system for residential materials, including food waste.

[6] The pilot program involved hand sorting of the bags to evaluate the percent of bags that break in the collection truck. Food waste set out in bags that break in the compaction truck would obviously not be recovered as food waste because only the full bags could be optically sorted at the ecomaine WTE facility for delivery to Exeter Agri-Energy.

SYSTEMS EVALUATED

The four systems analyzed focus on different alternatives for collecting residential food waste, as discussed below. In all cases the collected food waste must first be delivered to the ecomaine facility and consolidated with other food waste loads before transport to Exeter Agri-Energy where the food waste is co-digested with cow manure to produce bedding, liquid fertilizer and electric energy.

The four collection systems analyzed are:

1. Distribution of one 96-gallon cart to all curbside residential customers for weekly collection of refuse, recyclables, food waste and, if they chose – their bottle bill material - in the single cart, each separated (by the household) using a different colored plastic bag placed in the cart. The comingled bags would be delivered to an expanded tipping floor at ecomaine where they would be optically sorted by color. The single sort and bottle bill containers would go to the MRF for processing, refuse to the WTE facility, and the food waste bags stored on the tipping floor for collection by Exeter Agri-Energy.

   It is important to note here that comingling of all material in a single cart presents three potential issues that would need to be addressed before the system was implemented. These are:
   - Will a single 96-gallon cart be large enough to hold all the material generated by the majority of households in a single week – including corrugated containers which are bulky;
   - Will collection trucks be "stop" (time) or tons (volume) limited during each collection day; and,
   - Will compaction in the trucks to accommodate the combined quantity of material increase breakage of bags containing food waste and/or bottle bill material to the point where the loss rate becomes unacceptable.

2. Distribution of two carts – one for recyclables the second for refuse and separately bagged food waste. Carts would be collected weekly in a split truck, with recyclables tipped at the MRF and refuse and food waste tipped on a new tipping floor at the WTE facility. As with Option 1 (above), the food waste bags would be removed mechanically using an optical sorter and then stored for transfer to Exeter Agri-Energy, and the refuse would be processed at the WTE facility. Also, as with

Option 1, households who wished to redeem their bottle bill containers through ecomaine could place their bottle bill containers in a separate colored bag which would be sorted from the mixed single sort material on the in-feed conveyor to the single sort MRF, with the bottle bill containers then processed to redeem the deposit containers.

3. Distribution of three carts – one 64-gallon cart for refuse, one 64-gallon cart for single sort recyclables, and one 32-gallon cart for food waste[7] with separate weekly collection of each stream. Refuse and single sort recycling would be collected weekly in a split truck, with food waste collected in a separate truck.

4. Every Other Week (EOW) collection of refuse and single sort material using a split truck- food waste would be collected every week, with refuse and single sort materials collected with the food waste in a split truck on alternate weeks.

[7] DSM's research has not identified a 20-gallon cart, which the Scarborough pilot collection would indicate is the correct size, that can be serviced with an automated side-loading truck that is also servicing 64-gallon carts.

DESCRIPTION OF ANALYTIC FRAMEWORK

The ecomaine member municipalities' refuse and recycling collection system is quite complex with a combination of transfer-based collection, subscription collection in some municipalities, contract curbside collection in other municipalities, and municipal collection in Portland. While a majority of households in some member municipalities may use a transfer station, the majority of households in many other member municipalities receive curbside collection.

The focus of this collection cost analysis is on integration of food waste collection within the residential curbside collection system. Municipalities included in this collection analysis are higher density member municipalities more likely to implement residential curbside food waste collection (Table 1), while member municipalities excluded from this curbside collection analysis are lower density municipalities that primarily rely on transfer- based drop-off collection (Table 1.A).

Several municipalities included in this analysis (and listed in Table 1, highlighted in gray) currently have a large number of households using transfer-based drop-offs, but were considered by ecomaine to be logical municipalities for implementation of a curbside collection system should ecomaine move to collection of food waste.

The best information on the current curbside collection system has been provided by Stuart Axelrod. Stuart estimated the number of households receiving curbside collection in each member municipality that might logically adopt curbside collection of food waste, and the estimated number and type of collection trucks used.

Because any residential curbside collection model is built on the number of household stops, and because of the relatively large number of households using transfer stations or subscribing for curbside collection with private haulers in some municipalities, DSM requested that ecomaine contact the member municipalities and attempt to verify the household count and the number of households that would receive curbside collection. Ecomaine surveyed town managers in these member municipalities and provided DSM with the best estimate of a household count for curbside collection in each member municipality. This became the database on which to build the collection models used to analyze the four optional systems and is presented in Table 1.

Table 1. Estimated Household Stops for Municipalities with Higher Population Densities (1)

Municipality	Population	Residential Collection Stops	MSW Tons FY 17	Recycle Tons FY 17
Cumberland	7,211	3,000	1510	881
Falmouth	11,185	3,700	2149	1424
Freeport	7,879	3,580	1543	733
Gorham	16,381	5,447	2700	1149
Gray	7,761	3,044	2656	
Hollis	4,281	1,592	1100	284
Limington	3,713	1,354	1733	85
North Yarmouth	3,565	1,400	671	388
Portland	66,194	17,000	8878	5646
Pownal	1,474	650	231	143
Saco	18,482	7,485	5318	1686
Scarborough	18,919	6,300	5852	2422
South Portland	25,002	8,933	6708	2289
Windham	17,001	5,300	2324	1501
Yarmouth	8,349	3,544	2285	1109

(1) Municipalities highlighted in Grey have a large number of transfer station users; or in the case of Limington, have curbside refuse collection, but drop-off recyclables collection.

Table 1.A. Member Municipalities Assumed to Continue to Use Transfer Stations

Municipality	Population	MSW Tons FY 17	Recycle Tons FY 17
Bridgton	5,210	2423	550
Cape Elizabeth	9,015	2327	1105
Casco	3,742	924	429
Lyman	4,344	1412	258
Harrison	2,730	913	186
Waterboro	7,693	2353	458

Use of Automated Sideloading Trucks and Carts

All systems analyzed assume that households receiving curbside collection are provided with rolling carts for storing refuse, recyclables and food waste. In Option 1 (a single cart for all materials), the largest conventional cart is assumed - a 96-gallon cart. For all other options it is assumed that the refuse and single sort cart will be either 64- or 96-gallon, and that the food waste cart will be a 32-gallon cart.

For purposes of this analysis the difference between a 96-gallon cart and a 64-gallon cart is relatively insignificant in terms of long term costs and because all automated trucks can pick up either a 64 or 96-gallon cart, and because the difference in cart costs is relatively small.

A 32-gallon cart has been assumed for food waste based on the Scarborough pilot collections. While a 20-gallon cart would be better given the small volume of food waste generated per week, DSM has not been able to verify that an automated side-loading truck servicing 64-gallon carts could also service the narrow 20-gallon carts. However, as with the difference between 96 and 64-gallon carts, the difference in cost between 20 and 32-gallon carts is relatively insignificant with respect to this economic analysis.[8]

It should also be noted that it is not clear that a single 96-gallon cart used for both refuse and recycling will be sufficient in size for some households because of the volume of corrugated boxes that may be set out. If a second cart is required for a significant number of households, then the stop times increase and the truck needs increase, which may reduce or eliminate any advantage associated with a single cart over a dual cart system. This is an issue where further testing by ecomaine would be required to determine if an educational program designed to convince households to break down their corrugated boxes, so they fit in the large cart, would be sufficient. However, even if the corrugated boxes were broken down, the broken down boxes might not fit into conventional 32-gallon plastic bags required for an optical sorting system (for the one cart option).

It is also the case that packaging is changing. While Amazon, and other on-line retailers have had a big influence on the amount of corrugated packaging generated by households, there is now a trend toward use of more plastic pouches to reduce the weight of packaging and shipping costs. If this trend continues, it may be that the large amounts of corrugated packaging now generated by households will evolve to much less corrugated over time, making a single cart collection system more viable.

Calculation of Truck Needs and GHG Emissions

The number of trucks required to be on route each day drives the cost of the system and contributes to the GHG emission estimates.

Truck needs and miles driven are impacted by several variables including:

- The density of the route – the higher the density, the greater the number of stops per hour;
- Drive time to and from the route and to and from the disposal/transfer/processing site as opposed to on-route productive collection time;
- Parked cars and traffic in the community including main thoroughfares that cross through communities which both contribute to collection time;
- Route distances and whether collection only occurs on the right side of the road – DSM has assumed that the use of side loading trucks dictates ride-side loading only;

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[8] While the majority of households generate a relatively small volume of food waste (the 6-gallon pail appears to be adequate for most households in South Portland), it is quite heavy, and therefore diversion can have a relatively large impact on overall diversion/recycling rates which are often tonnage based.

- The capacity of the truck (in tons) when fully loaded; and,
- Whether the route size is constrained by the amount of time available each day to collect from stops, or by the volume of material collected (tons limited) in that the truck fills up and must leave the route to empty even though there is still time for more stops.

DSM collected data on the total center line miles of roads in each municipality, and the distance from each municipality to ecomaine' s facilities. Centerline miles were doubled to account for right hand side collection only in each municipality, and then 20 percent was added to account for drive time over some portion of the same roads to safely complete routes. Finally, the location of the current garage serving each municipality was determined, and then the travel distance to the center of that municipality estimated and the distance included in the total calculation of truck miles. Note that the current garage location is based on the current contract or subscription service provider and may change over time.

Table 2 presents these key distance estimates for each municipality

Table 2. Estimated Collection and Haul Miles by Municipality

Municipality	Population	Curbsdide Households	Centerline Road Miles	Collection Miles (1)	Distance to Ecomaine	Garage to Route Miles
Cumberland	7,211	3,000	80	192	13	9
Falmouth	11,185	3,700	102	244	11	14
Freeport (2)	7,879	3,580	98	234	23	24
Gorham (2)	16,381	5,447	156	375	8	14
Gray (2)	7,761	3,044	104	250	20	22
Hollis	4,281	1,592	75	179	17	20
Limington (2)	3,713	1,354	72	173	23	26
North Yarmouth	3,565	1,400	41	97	18	21
Portland (3)	66,194	17,000	241	578	5	4
Pownal	1,474	650	44	107	28	29
Saco	18,482	7,485	127	305	14	11
Scarborough	18,919	6,300	169	406	7	2
South Portland	25,002	8,933	117	281	7	6
Windham	17,001	5,300	150	359	11	15
Yarmouth	8,349	3,544	68	163	16	17
(1) Centerline miles doubled plus 20%						
(2) Estimate number of Curbside HH's						
(3) While Portland reports a significantly higher number of HH's, this is the best estimate of actual						

Stops Per Day

For each municipality the number of stops required for collection was used to estimate the number of trucks required to collect from all households in one week. The number of stops varies depending on the density of the municipality, or the average distance between stops, with increasing stops per day as the density increases. Table 3 presents the household density for each municipality calculated by dividing the total number of stops (from Table 1) by the centerline miles. From this, the estimated number of stops that can be served by a single truck each week based on that density is shown for a truck servicing one or two carts. Note that trucks servicing two carts per stop (or household) are assumed to require an additional 8 seconds per stop, reducing the number of stops that can be reasonably serviced per collection day. However, in some cases, the single cart option requires more trucks because a higher set-out rate has been assumed for the single cart (due to lack of capacity when compared to dual carts), making the route tons limited instead of stops limited (see below).

It should also be noted here that the densities shown for each municipality represent stops divided by centerline miles, *not* total household density. For example, according to the US Census there are over 30,000 households in Portland, but municipal collection in Portland is estimated to serve only 17,000 households. For this reason, the densities presented in Table 3 do not necessarily represent total household density by municipality, but instead density based on collection stops.[9]

Table 3. Estimated Density and Resulting Collection Stops Per Week (1)

Municipality	Centerline Miles	Stops	Density, HH's/Mile	Stops/Week Single Cart	Trucks Required	Stops/Week Two Carts	Trucks Required
Cumberland	80	3,000	37	3000	1.0	2429	1.2
Falmouth	102	3,700	36	3000	1.3	2429	1.4
Freeport	98	3,580	37	3000	1.2	2429	1.4
Gorham	156	5,447	39	3000	1.8	2429	2.1
Gray	104	3,044	29	2250	1.3	1929	1.5
Hollis	75	1,592	21	2250	0.7	1929	0.8
Limington	72	1,354	19	1750	0.8	1556	0.8
North Yarmouth	41	1,400	38	3000	0.5	2429	0.5
Portland	241	17,000	71	4000	4.8	2984	5.4
Pownal	44	650	15	1750	0.4	1556	0.4
Saco	127	7,485	59	3500	2.6	2722	2.6
Scarborough	169	6,300	37	3000	3.1	2429	2.9
South Portland	117	8,933	76	4000	2.8	2984	3.2
Windham	150	5,300	35	3000	1.5	2429	2.1
Yarmouth	68	3,544	52	3500	1.1	2722	1.3

(1) https://www1.maine.gov/mdot/csdold/mts/documents/pdf/Cumberland08.pdf

Tons Limited

Typically, in low density collection routes the number of stops that can be accomplished in a day is the determining factor for calculation of total trucks required. However, for high density routes, the capacity of the truck may limit the number of stops if the truck must go off route to unload during the day. For purposes of this analysis the number of stops was multiplied by the estimated quantity of refuse and recycling and

[9] Portland reports that they serve 24,000 households but the pounds collected per household, and observations by Stuart Axelrod indicate that significantly less households actually participate in the collection service.

compared against the capacity of the truck (assumed to be 10 tons), with the number of trips to ecomaine adjusted up if the truck was assumed to pack out during the day.

In the case of split truck capacity, the number of stops for refuse (assumed at a 95 percent set-out rate) and the number of stops for recycling (assumed at an 85 percent set-out rate) were allocated to the split truck to determine the combined weight of the two compartments, which was also assumed to be 10 tons, on average. Note also, that the split truck can make less stops in a day because of the need to empty two carts at each stop.

For this reason, Table 3 presents stops per day for a single cart (Option 1, and Option 3 – for organics collection only), and for two carts per stop (Options 2 and 4). Table 3 also presents estimated truck requirements for both collection systems. Because of the expected higher set-out rate for a single cart containing all materials the difference in truck requirements between the two systems is not as great as one would assume, because the truck serving a single cart fills faster than the split truck serving two carts.

Fuel Use and GHG Emissions

DSM has assumed that collection trucks average 3.3 miles per gallon of diesel fuel. Total annual fuel use was calculated by summing annualized collection route miles, distance to the ecomaine facility from the center of the municipality – and number of trips per day if tons limited, and distance to and from the garage to the route; and then dividing by 3.3 miles per gallon.

The resulting annual fuel use was then first converted to tons of Carbon Dioxide emissions, assuming 22.38 pounds of CO^2 per gallon of diesel fuel based on US EPA data. Total GHG emissions were then converted to metric tonnes, carbon equivalent to be consistent with the WARM model outputs (see discussion below). Metric tonnes of carbon equivalent (in addition to converting from English units to Metric units) includes emissions of two other greenhouse gasses emitted in small amounts from the combustion of diesel fuel; methane (CH^4) and nitrous oxide (N_2O), which add 0.29% to the carbon dioxide emissions for diesel fuel.[10]

COST ANALYSIS

The cost analysis includes *all-in* truck costs together with the costs to sort out the food waste – in all options except the separate food waste collection option – using an optical sorter at the ecomaine facility. Capital costs for the sorting equipment have been provided by ecomaine and have been annualized assuming a 15-year life for major capital improvements and a seven-year life for rolling stock and moving equipment. Equipment maintenance and replacement costs are then estimated assuming 4.5 percent of capex costs, and labor costs are added to calculate total annual costs.

[10] *Fleet Greenhous Gas Emissions Calculator,* NAFA Fleet Management Association and Environmental Defense Fund.

Truck Cost

Truck costs represent annualized per truck costs (capital, labor, other operating costs and profit) based on private sector costs and profit margins. Stuart Axelrod originally provided ecomaine with an all-in annualized cost per truck of $350,000 per year. DSM has adjusted this down slightly (to $320,000 per year) assuming a mix of higher cost private sector subscription collection and lower cost municipal or contract collection.

Cart Costs

Cart costs have essentially been annualized assuming each 96-gallon cart costs $10 per year over the cart's lifetime (including damaged cart replacement costs) and the 64-gallon and 32-gallon carts cost $8 per year over their annualized lifetime. Option 1 assumes a single 96-gallon cart, while the dual cart option (Option 2) assume two carts, and Options 3 and 4 assume a third, food waste only cart.

Bag Costs

Option 1 assumes that all households use special bags paid for by ecomaine for all materials – refuse, food waste, single sort, and bottle bill containers. That is because the bags need to be a specific color for each material (for optical sorting at the ecomaine facility), and a heavier mil thickness then most households would typically purchase at a store. It is assumed that these special bags cost ecomaine 10 cents per bag.

Not all households will choose to participate in one or more of the potential diversion options, reducing the number of bags that ecomaine needs to supply. It has been assumed that 45 percent of households will choose to separate their food waste, and that between 25 and 45 percent will choose to place their deposit containers in a special bag for redemption by ecomaine. In addition, it is assumed that the set-out rate for refuse is 98 percent, and 85 percent for single sort materials, further reducing the number of bags supplied by ecomaine.

For option 2 (dual carts), it is assumed that ecomaine will need to provide a special bag for food waste and for deposit containers for those households who choose to participate.

Options 3 and 4 assume residents place their food waste in bags they supply, and the cost of a standard kitchen garbage bag is used, which is estimated to be two cents per bag[11].

Existing/Baseline Costs

All options are compared against the current baseline cost – which does not include separate food waste collection. In cases where the majority of residents in a member municipality use a transfer station, average per household costs for curbside households in the remaining municipalities are used to estimate what it would cost if these households had curbside collection today. As a result, the "Baseline" does not necessarily

[11] Quick research on Amazon and at a local Aubuchon Hardware store indicated that there is a wide range of costs for kitchen bags, with the range typically falling between 2 and 3 cents per bag.

reflect current costs in those municipalities, but what it would cost if those households were using a curbside collection system.

RESULTS

Table 4 compares the estimated total annual collection cost for each option against the cost of the baseline existing system. Baseline collection costs are estimated using truck requirements for each municipality provided by Stuart Axelrod multiplied by the annual truck cost of $330,000 per truck. Note that these baseline costs are a simplification of the current system which, as stated above, is a mix of subscription, contract and municipal collection, with actual costs determined by a range of factors, including: the percent of households in the municipality subscribing for collection; competing haulers in some cases setting prices based on availability of trucks in surrounding areas; and the time and circumstances (in contract municipalities) when the contract was bid. As a result, in some cases the baseline may under-represent, or over-represent actual costs for comparison against the collection options analyzed.

For this reason, "baseline costs" should be viewed as a simplified way to compare the four alternatives against a common denominator. It should also be noted that the baseline costs do not include: (1) the new service of separate food waste collection and processing; (2) the cost of transitioning to fully automated collection with carts; and, (3) the cost of bags used for setting out MSW, food waste and recyclables.

Option 3, Separate Organics Collection, adds the cost of a second truck collecting food waste only to the Option 2 or 4 dual cart, split truck collection system for refuse and single sort recycling. Note also that while Options 2 and 4 both assume split truck collection of two carts each week, the EOW collection system (Option 4) is estimated to require fewer trucks because it is assumed that only 45 percent of households will set out food waste each week, reducing collection times. In addition, there are added costs to Option 2, as shown in Table 5, for the special food waste bag, and the addition of the optical sorting equipment at the WTE facility (Table 6).

Table 5 then presents annualized cart and bag costs for each municipality and each option. Note that, as discussed above, bag costs assume that only 45 percent of households choose to separate their food waste, and therefore purchase or use separate food waste bags. However, all households are provided with the appropriate cart.[12] Similarly, truck costs for the separate food waste collection in Option 3 assume that only 45 percent of households choose to participate in separate food waste collection.

[12] An option would be to only provide a separate food waste cart for Option 3 to those households who requested one.

Table 4. Collection Costs, Baseline, and Options 1-4

Municipality	HH Stops	Baseline No Food Waste	Option 1 Single Cart	Option 2 Two Carts	Option 3 Separate Organics Collection	Option 4 EOW Collection
	Number	Annual Collection Cost	Annual Collection Cost	Annual Collection Cost	Annual Collection Cost	Annual Collection Cost
Cumberland	3,000	$387,314	$313,600	$375,529	$528,588	$336,000
Falmouth	3,700	$387,314	$422,270	$463,153	$654,311	$414,400
Freeport	3,580	$441,054	$374,229	$448,132	$627,529	$400,960
Gorham (2)	5,447	$561,800	$569,393	$681,836	$969,048	$610,064
Gray	3,044	$375,019	$424,266	$479,825	$640,095	$442,915
Hollis	1,592	$196,133	$221,889	$250,946	$360,366	$231,643
Limington	1,354	$101,027	$242,637	$264,610	$365,434	$249,045
North Yarmouth	1,400	$143,138	$146,347	$175,247	$249,405	$156,800
Portland	17,000	$1,797,760	$1,525,476	$1,731,830	$2,411,225	$1,479,927
Pownal	650	$81,041	$116,480	$127,029	$184,037	$119,556
Saco	7,485	$731,787	$841,380	$835,876	$1,153,605	$731,391
Scarborough	6,300	$851,271	$988,576	$788,612	$1,110,670	$705,600
South Portland	8,933	$1,030,439	$889,729	$910,026	$1,258,714	$777,658
Windham (3)	5,300	$680,598	$474,880	$663,435	$940,851	$593,600
Yarmouth	3,544	$436,619	$360,819	$395,771	$494,503	$346,299
Total	72,329	$8,202,314	$ 7,911,970	$8,591,856	$11,948,380	$7,595,859

(1) Baseline cost extrapolated from average of cubside communities
(2) Gorham's current cost is lower than the average for most communities
(3) Windham's current cost is high due to number of private, narrow roads; costs for options assumes central cart locations

Table 5. Added Bag and Cart Costs

Municipality	Option 1 Single Cart		Option 2 Two Carts		Option 3 Separate Organics Collection		Option 4 Every Other Week	
	Carts	Bags	Carts	Bags	Carts	Bags	Carts	Bags
Cumberland	$30,000	$40,560	$48,000	$12,480	$72,000	$6,864	$72,000	$6,864
Falmouth	$37,000	$50,024	$59,200	$15,392	$88,800	$8,466	$88,800	$8,466
Freeport	$35,800	$48,402	$57,280	$14,893	$85,920	$8,191	$85,920	$8,191
Gorham	$54,470	$73,643	$87,152	$22,660	$130,728	$12,463	$130,728	$12,463
Gray	$30,440	$41,155	$48,704	$12,663	$73,056	$6,965	$73,056	$6,965
Hollis	$15,920	$21,524	$25,472	$6,623	$38,208	$3,642	$38,208	$3,642
Limington	$13,540	$18,306	$21,664	$5,633	$32,496	$3,098	$32,496	$3,098
North Yarmouth	$14,000	$18,928	$22,400	$5,824	$33,600	$3,203	$33,600	$3,203
Portland	$170,000	$229,840	$272,000	$70,720	$408,000	$38,896	$408,000	$38,896
Pownal	$6,500	$8,788	$10,400	$2,704	$15,600	$1,487	$15,600	$1,487
Saco	$74,850	$101,197	$119,760	$31,138	$179,640	$17,126	$179,640	$17,126
Scarborough	$63,000	$85,176	$100,800	$26,208	$151,200	$14,414	$151,200	$14,414
South Portland	$89,330	$120,774	$142,928	$37,161	$214,392	$20,439	$214,392	$20,439
Windham	$53,000	$71,656	$84,800	$22,048	$127,200	$12,126	$127,200	$12,126
Yarmouth	$35,440	$47,915	$56,704	$14,743	$85,056	$8,109	$85,056	$8,109
Total	$ 723,290	$ 977,888	$ 1,157,264	$ 300,889	$1,735,896	$ 165,489	$1,735,896	$ 165,489

Transfer Station Based Collection

Users of a number of municipal transfer stations can already deliver source separated food waste to the transfer station where it is stored in rolling carts and collected by a hauler as part of their collection of commercial food waste.

If ecomaine adopts a residential curbside collection system for bagged food, with an optical separation system for the bagged food waste bags, then transfer station users would also be able to utilize the same bags, which could be placed in the compactor with refuse and sorted at ecomaine. This would provide four potential benefits to transfer stations.

- First, transfer stations would not need to provide separate containers for food waste storage.
- Second, it is likely that participation by transfer station users would increase with the convenience of placing their bagged food waste in with the refuse.
- Third, it would reduce food waste collection costs because all of the food waste would now be delivered to the ecomaine facility where it could be transferred as consolidated loads.
- Fourth, it would reduce the amount of MSW from member municipalities that would need to be processed by ecomaine, allowing ecomaine to process additional MSW at the WTE facility at the current tipping fee ($70.50 per ton), while shipping the separated food waste to Exeter Agri-Energy at $45 per ton, generating additional revenue for ecomaine member municipalities.

Separation Costs

Option 1 assumes that ecomaine will invest in a four-way optical separation system at the WTE facility to separate intact food waste bags, refuse bags, single sort bags, and bottle bill bags. Ecomaine provided DSM with a preliminary estimate of the capital cost associated with the optical sortation system, as well as the expansion to the WTE tipping floor to accommodate the sortation equipment.

Option 2 assumes that refuse and food waste will be delivered to the WTE tipping floor from one side of the split truck, and ecomaine will invest in a two-way optical separation system for food waste bags mixed with refuse. The recycling side of the split truck will then be delivered to the single sort facility, where ecomaine will pull bottle bill bags manually from the incline conveyor at the single sort facility.[13]

For purposes of this analysis, DSM has used an estimated capital cost of $9.5 million for the separation technology for Option 1 and $8 million for Option 2 to process 50,000 tons of refuse and food waste bags, which represents the throughput from the municipalities analyzed for this report. An additional $5 million has been added for expansion of the WTE tip floor to accommodate the new sorting equipment, and then engineering costs have been added to the total, at 15 percent of capital costs.

The capital costs have been amortized over 15 years, and an annual cost in equipment O&M added at 4.5 percent of capex costs. Labor costs are then added to these costs to estimate total additional costs associated with sorting the bagged materials.

Table 6 presents the estimated added cost per ton for amortized capital plus operating costs divided by 50,000 tons of throughput.[14]

As illustrated by Table 6, construction and operation of the optical sorting equipment necessary to sort out intact food waste bags, plus an addition to the WTE tip floor adds between $1.6 and $1.7 million (rounded) in annual costs, or roughly $31 to $33 per ton of refuse/food waste processed.

Table 6. Estimated Capital and Operating Cost to Sort Food Waste Bags from Refuse, Options 1 & 2

Description	Option 1, 4 Sort		Option 2, 2 Sort	
	Capital Cost	Annual Costs	Capital Cost	Annual Costs
Capital				
Sorting Equipment	$ 9,500,000		$ 8,000,000	
Tip Floor Expansion, WTE Facility (1)	$ 5,000,000		$ 5,000,000	
Engineering & Site Work @15%	$ 2,175,000		$ 1,950,000	
Total Capital	$ 16,675,000	($1,447,808)	$ 14,950,000	($1,298,035)
Operations				
Equipment O&M	4.5% of cap ex	($65,151)	4.5% of cap ex	($58,412)
Labor		($150,000)		($200,000)
Total Operations		($215,151)		($258,412)
Total Annual Cost		($1,662,959)		($1,556,446)
Annual MSW Tons Processed/Cost/Ton	50,000	($33)		($31)
(1) D&B Estimate, October 2013, Northern Tilth Report, less processing equipment				

[13] Costs for the bottle bill sorting equipment and additional room at the single sort facility for both Options 1 and 2 are detailed subsequently in this report.

[14] DSM understands that the total throughput of the ecomaine WTE facility is significantly greater than 50,000 tons, however for the analysis to be consistent with the collection analysis, it has been assumed that the throughput reflects the same tons from the member municipalities.

Table 7 then adds the cost to separate the food waste bags at the ecomaine facility for Options 1 and 2 to the total collection cost to derive a total system cost associated with each system. As illustrated by Table 7, collection of all material in a single, large cart with separation at the ecomaine facility is roughly equivalent to the lowest cost Option 4 (EOW collection), but with less uncertainty associated with Option 4.

This is especially the case because it is not clear that all material generated by a single household, including recyclable corrugated containers, will fit in a single 96-gallon cart, even with weekly collection. If a significant number of households request a second cart, or an optional system for collecting corrugated is necessary, then the cost for Option 1 will increase[15].

Option 2, which includes a more conventional dual cart collection system is only estimated to be 11 percent higher in cost which, given the preliminary nature of the analysis and the large number of assumptions, would indicate that both options are likely to be fairly close in cost when the final system is implemented.

Only Option 3, with separate weekly collection of food waste, is estimated to be significantly greater in cost, which is not surprising given the need for a separate truck to collect the food waste each week.

Table 7 also includes an assumption that for every ton of food waste diverted to Exeter Agri-Energy, ecomaine replaces that ton with additional MSW at the going rate of $70.50; essentially increasing system revenues by $25.50 per replacement ton, given that ecomaine pays Exeter Agri-Energy $45 per ton to take the food waste. The amount replaced is adjusted down for the two bagged food waste options (Options 1 and 2) to reflect losses due to food waste bag breakage that require that material to be processed at the WTE facility.

Table 7. Summary of Collection and Sorting Costs, Options 1 - 4

Description	Option 1	Option 2	Option 3	Option 4
	Single Cart	Dual Cart	Separate Food Waste Collection	Every Other Week
Collection	$7,911,970	$8,591,856	$11,922,827	$7,595,859
Carts	$723,290	$1,157,264	$1,735,896	$1,735,896
Bags	$977,888	$300,889	$165,489	$165,489
Optical Sorting	$1,662,959	$1,556,446		
Total Cost	$11,276,107	$11,606,455	$13,824,212	$9,497,244
Less Tip Fee Revenue	$147,390	$147,390	$173,400	$173,400
Net Cost	$11,128,717	$11,459,065	$13,650,812	$9,323,844

As illustrated by Table 7, all four options cost more than the current residential collection system. This is to be expected given that the current residential system does not include separate food waste collection and is

15 DSM recently completed a project for Mecklenburg County (Charlotte, NC) which determined that the primary use of drop-off recycling locations was for corrugated containers that would not fit in Charlotte's 96- gallon recycling carts

not fully automated with carts. Option 4 is estimated to be the lowest cost option, with Options 1 and 2 in the mid-range, while Option 3 – separate food waste collection – is significantly higher in cost then the other three options.

Finally, Table 8 then compares miles driven, fuel used and GHG emissions (expressed as metric tonnes carbon equivalent) for each option.

Table 8. Comparison of GHG Collection Emissions, Options 1 -4

Unit	Baseline	Option 1 Single Cart	Option 2 Dual Cart	Option 3 Sep. Food Waste	Option 4 EOW
Total Miles	603,859	510,704	527,040	867,624	465,745
Gallons, Diesel	182,988	154,759	159,709	262,916	141,135
Metric Tonnes CO2 E	1,863	1,575	1,626	2,676	1,437

As illustrated by Table 8, Option 3, Separate Food Waste Collection has the highest carbon footprint associated with collection, ignoring any additional carbon footprint associated with construction and operation of the optical sorting equipment at the WTE facility, or with the manufacturing and maintenance of the trucks and carts. The carbon footprint for Options 1, 2, and 4 are essentially equivalent given the accuracy of the estimates, but all three of these options reduce GHG emissions when compared to emissions under the baseline.

IMPACT OF DIVERTING FOOD WASTE TO EXETER AGRI-ENERGY FROM ECOMAINE WTE

DSM has used the US EPA WARM model[16] to assess the change in CO^{2} emissions associated with diverting food waste from ecomaine's WTE facility to Exeter Agri-Energy based on the high residential diversion estimate for food waste of 13,900 tons provided in the Northern Tilth report. As illustrated by Table 9, *based on the WARM Model assumptions* overall *processing* emissions decrease slightly with diversion of 13,900 tons of residential food waste.

Table 10 then presents the results of re-running the WARM model assuming that an additional 7,100 tons of commercial food waste are diverted from ecomaine member municipalities.

Key assumptions used by DSM and in the WARM model include:

- Average distance to the ecomaine WTE is 15 miles, and 120 miles to Exeter Agri-Energy; and,
- The WARM model accounts for both the increase in soil carbon storage from application of digestate to soils, and the avoided synthetic fertilizer use due to land application of digestate.

As illustrate by Tables 9 and 10, diversion of food waste from ecomaine's WTE facility to Exeter Agri-Energy produces relatively minor savings in GHG emissions based on the WARM model assumptions. It should be noted however that the WARM model is a complex model with many assumptions imbedded in it, and there are limitations to how it can be run that preclude addressing some issues that might impact the final outcome.

Specifically, it is not possible to account for a change in the BTU value of the waste burned at the WTE facility with removal of the wet food waste, and there are disagreements within the solid waste profession as to whether the WARM model accurately accounts for the GHG savings associated with application of digestate and solids to agricultural lands; and, whether the model accurately portrays the result of combustion of biogenic wastes at a WTE facility.

However, there is general agreement that the most significant reductions in GHG emissions are associated with materials recycling, not organics diversion, and these are reflected in the WARM model, and in other models available, both in the U.S. and in Europe.

[16] https://www.epa.gov/sites/production/files/2016-03/documents/warm_v14_organic_materials.pdf

Table 9. WARM Model Results, Run 1

Management	Baseline	Low	Medium	High
	(MTCE)	*(MTCE)*	*(MTCE)*	*(MTCE)*
Single Stream	(18,090)	(18,090)	(18,090)	(18,090)
Food Waste	(327)	(258)	(176)	(18)
Mixed MSW	664	664	664	664
Total:	(17,753)	(17,685)	(17,602)	(17,445)
Change in MTCE:		69	151	309

Table 10. WARM Model Results, Run 2

Management	Baseline	High
	(MTCE)	*(MTCE)*
Single Stream	(18,111)	(18,111)
Food Waste	(499)	66
Mixed MSW	558	558
Total:	(18,053)	(17,487)
Change in MTCE:		565

INCORPORATING BOTTLE BILL CONTAINERS

If ecomaine decides to move forward with optical sorting of separate colored bags for food waste, one other potential option would be to sort other materials set out in colored bags using the same optical sort system (Option 1), or by manually pulling colored bags off the incline conveyor at the single sort MRF (Option 2). This could allow for "one stop" convenience for collection of all recyclables including bottle bill containers, which households currently must return to a redemption center or retail location.

Households could choose to bag their deposit containers in a separately colored thick mil plastic bag. They could then attach a sticker with a unique identification number to the bag and place the bags in the single sort cart together with their loose, single sort recyclables.

The bagged bottle bill containers would be sorted at the ecomaine single sort facility, where the identification number would be scanned to identify the household receiving the credit, and then the deposit containers emptied from the bags and run through a whole bottle counting machine which would read the bar codes on each container, counting by brand to allocate returns and assign deposit refunds as well as handling fees. Ecomaine would then bale and sell the resulting deposit containers, crediting the distributors with the material revenues.[17]

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[17] Note that this system would require that ecomaine be approved by the State of Maine as a licensed redemption center; and would require an agreement with the distributors to allow ecomaine to bale and sell the resulting material and pay the distributors the material value.

There are two potential benefits to ecomaine households which may make it worthwhile for ecomaine to further investigate this service, under the scenarios presented below. The first is potential cost savings to participating households in not having to make a special trip to redeem their containers. The second is GHG emission savings associated with households not needing to drive their deposit containers to a redemption center, and GHG emission savings associated with redemption centers not needing to drive loose containers to a processing facility - or have a processing center collect the loose containers.

DSM has surveyed the behavior of Vermont and Massachusetts household who redeem their deposit containers at either a retail location or an independent redemption center. Based on the most recent survey data of Vermont households delivering deposit containers to redemption and retail locations, the average household drove 85 miles out of their way during the course of the year to redeem deposit containers.

Assuming similar behavior for ecomaine households, and assuming participation rates of either 45 or 25 percent of households this represents a savings of between $1.5 million and $800,000 (rounded) in annual household driving costs, and an additional $64,000 to $34,000 (rounded) in loose container transport costs. These estimated savings, together with estimated reductions in transport GHG emissions (Table 11), are significant enough to warrant a more thorough evaluation by ecomaine.

Table 11. Estimated Costs and GHG Emissions Associated with the Current Redemption System

HH Participation Rate	High	Low
Participating Households	32,548	18,082
Miles Driven Per Year/HH	85	85
Annual Miles	2,766,584	1,536,991
Annual Cost (IRS rate)	$1,507,788	$837,660
Redemption Trucking		
Annual Miles	58,929	31,015
Annual Cost ($1.1/Mile)	$64,821	$34,117
Total Annual Cost	$1,572,610	$871,777
GHG Emissions		
HH Miles		
Miles per gallon	24	24
Annual Gallons	117,228	65,127
CO emisions/gallon (lbs)	18.9	18.9
MTCE, HHs	997	554
Redemption Truck Emissions	75	39
Total MTCE	1,072	593

Background on Deposit Container Redemption System

Estimating the cost to ecomaine associated with this potential container redemption scheme requires a basic understanding of how the redemption system works, and therefore what steps ecomaine would have to take to be certified as a redemption center – which would be required under Maine law.

In summary, when a distributor sells a container subject to the deposit in Maine, the distributor charges the retailer a five-cent deposit on each container. The retailer then charges the consumer the five-cent deposit, making the retailer whole and leaving the consumer with a container worth five cents, after the contents have been consumed.

The consumer can choose to bring the container back to a store or redemption center where they receive the five cents, which is paid out by the redemption center or retailer. The redemption center/retailer counts the containers by brand and then receives the five cents from the distributor, as well as a 3.5 cent or 4 cent handling fee which theoretically reimburses the redemption center for the cost of redeeming or "handling" the container. The distributor or a third party contracted by the distributor then collects the redeemed containers and can now sell the redeemed containers for their scrap value, which offsets some portion of the handling fee the distributor has paid to the redemption center.

Alternatively, the consumer can choose not to redeem the container, either throwing it away in the refuse, or simply placing it in the recycling container. In this case the consumer is out the five cents they paid for the container. If the consumer chooses to recycle it, then under the current system ecomaine receives the container, processes it, and gets the scrap value of the container.

Just as importantly, whether the consumer throws the container away or recycles it through ecomaine, the distributor keeps the escheat – the five-cent deposit that the retailer has paid to the distributor at the beginning of the chain of sale which has not been redeemed by the consumer.

This combination of deposits and handling fees, and scrap value and escheats all contribute to the final cost to the distributor, redemption center, and consumer,[18] and will factor into how this system would work if ecomaine became a redemption center, for the following reasons.

First, bag breakage will be an important factor in the potential success of the system because bags which break in the collection truck allow their contents to commingle with the other single sort recyclables. This will mean that the consumer does not receive their deposit back, and the distributor does not realize the market value of the scrap, since these containers will now be sold by ecomaine. Since the distributor will not have to refund the consumer for the deposit, it is possible that the distributor will not be financially impacted since the escheat value is typically greater than the material value for glass and plastic, and is normally greater than the aluminum value, except during periods of very high aluminum scrap value.

However, the consumer who was expecting to receive their deposit back will now be out the value of the deposits. Some consumers may not care and will accept that bag breakage is one possible outcome associated with the convenience of setting the deposit containers in with the recyclables, as opposed to

[18] There are hidden costs to the retailer as well, but for purposes of this analysis, these costs are not significant.

driving them to a redemption center. Other consumers may object and will stop participating in the system if it happens frequently enough.

In addition, consumers may lose some portion of their deposits because of scavengers on the route who will now know that a certain colored bag contains deposit containers that can be redeemed for five cents each. Given the number of scavengers who currently collect deposit containers from curbside recycling programs which were simply set out for recycling (with no expectation on the part of the consumer that they would receive their deposit), this problem could become significant enough that it required enforcement of anti-scavenging ordinances.

Second, bags that remain intact will require, in all likelihood, manual scanning of the bar code sticker, followed by emptying into the TOMRA whole bottle counter where the count will be made, and it will be necessary to match the count against the bar code to accurately credit the correct consumer. Ecomaine will then need to issue a credit to that consumer, and account for the redeemed containers to bill the distributor for the deposit. The resulting material will then have to be consolidated by ecomaine and sold, with the material value credited to the distributors based on the container count.

System Cost Estimate

DSM has made an initial attempt to cost out the system described above, recognizing that such a system does not currently exist (the closest system being the CLINK system which DSM is not privy to cost information on).

Rough costs have been estimated for the following:

- Purchase of the whole bottle sorting machinery;
- In-feed conveyor modifications at the MRF, and installation of storage bunkers for deposit beverage bags;
- Construction of an area to house the manual scanning and sorting, and the whole bottle sorters;
- Labor and equipment costs to operate the system;
- Administrative costs to send out required bar code stickers, redeem deposits, and bill the distributors; and,
- Auditing costs to assure that the system meets the requirements of the Maine deposit law.

Table 12 presents estimated costs for the items specified above. It should be noted that DSM is not an engineering firm and therefore is not qualified to estimate building construction or equipment erection costs but has instead presented rough estimates to test the concept of moving forward.

The key to the analysis is the estimated number of containers that are assumed to be placed at the curb by participating households. Data do not exist for container sales in Maine, but DSM does have data for Rhode Island (2008) and Vermont (2011). We have used these state-wide sales data divided by total households (after subtracting on-premise -bar and restaurant sales) to derive an annual number of containers sold per household. Assuming that Maine household beverage consumption is similar to Vermont's (the more recent sales data), then the average ecomaine household consumes 1,384 beverages in deposit containers per year.

Assuming an 85 percent redemption rate (Maine data), this results in roughly 1,176 deposit containers per ecomaine household potentially available for redemption.

It is then necessary to estimate what percent of ecomaine households might participate in an ecomaine redemption program. DSM has assumed a high participation rate of 45 percent and a low rate of 25 percent.

It is also necessary to account for redemption bags that break during collection. DSM currently only has one data point - the pilot run by ecomaine on December 1, 2017, which resulted in a bag breakage rate of 25 percent. This bag breakage rate is outside of the bounds of what ecomaine considers acceptable for implementation of the program. As such, ecomaine plans on running a subsequent test using thicker bags in an attempt to reduce the bag breakage rate. Absent data on the second test, DSM is assuming bag breakage rates of 5 and 10 percent to evaluate the feasibility of this approach[19], with the lower bag breakage rate applied to the high participation assumption and the higher bag breakage rate applied to the lower participation assumption.

The combination of these assumptions results in total redemption containers delivered to ecomaine for sorting (whole bags) in a year ranging from a high of 36.4 million (rounded) to a low of 19.1million containers. All costs included in Table 11 are run off these container counts.

[19] DSM tested the higher bag breakage rate of 25%, with the analysis showing losses for ecomaine assuming households needed to be reimbursed for the losses.

Table 12. Estimated Costs to Manage Deposit Containers at Ecomaine

Description	Capital	Annual Cost/Revenue	
		High	Low
Throughput, Containers/Year		36,369,758	19,141,978
Capital			
Conveyor Extension/Storage Bunkers	$500,000		
TOMRA Whole Bottle Sorter	$495,000		
Sorting/Storing Area	$1,500,000		
Sub-Total	$2,495,000		
Engineering and Permitting	$384,230		
Total Capital Cost	$2,879,230	**$249,989**	**$249,989**
Operations			
Full Time Administrator (billing and redemption payments)		$75,000	$75,000
Equipment Operator		$50,000	$50,000
Two Bag Sorters		$25,000	$25,000
Four Temp Workers, 40 hours/week		$100,000	$75,000
Equipment Operation/Maintenance		$11,250	$11,250
Production and Mailing of Bar Code Stickers		$50,000	$25,000
Total Annual Operating Cost		**$311,250**	**$261,250**
Total Cost		**$561,239**	**$511,239**
Handling Fee Revenue		$1,345,681	$708,253
Net Cost/Revenue		**$784,442**	**$197,014**
Reimbursement For Broken Bagged Material		$86,800	$96,444
Adjusted Net Cost/Revenue		**$697,642**	**$100,570**

As illustrated by Table 12, which is also consistent with DSM's analysis of redemption center economies of scale in other states, if ecomaine receives the high range of redemption containers, then a blended average revenue of 3.7 cents per container handling fee should be sufficient to cover the cost to ecomaine of redeeming containers collected curbside.[20]

If participation is on the low end of the range and bag breakage at the high end of the range estimated by DSM, then the handling fee received by ecomaine, while still sufficient is low enough that a much more careful analysis of the feasibility will need to be completed by ecomaine before any decision to move forward is made.

[20] DSM does not know the exact split between distributors with comingling agreements and those without these agreements. Because the larger distributors do have commingling agreements DSM has used a blended average between 3.5 cents (comingled) and 4 cents (separated) of a 3.7 cent handling fee to ecomaine.

POTENTIAL FOR COLLECTION SYSTEM CONSOLIDATION

Given all the potential changes analyzed in this report, it is useful to analyze whether ecomaine should consolidate the collection system, taking over management from the member municipalities. There are five potential benefits to this proposal.

First, consolidation of the collection system *should* reduce costs because of the potential for collection trucks to cross municipal lines and optimize routing.

Second, ecomaine could create a single system and messaging for all ecomaine municipalities, integrating collection of recyclables, food waste and refuse with processing at ecomaine facilities.

Third, member municipalities could shift the burden of collection management to ecomaine of this important aspect of solid waste management. These management costs are not insignificant but are typically hidden and absorbed into municipal public works and municipal manager budgets. They can include health and safety issues associated with households who do not choose to participate in a solid waste collection system; as well as significant management time spent on negotiating collection contracts in municipalities who choose to organize collection. In addition, time spent fielding calls and complaints, contract administration, and management of the PAYT programs all contribute to time and energy spent on solid waste programing by municipalities.

And forth, it might also be possible for ecomaine to consolidate transfer stations, providing fewer regional transfer stations for bulky and hard to handle wastes streams, while reducing driving to transfer stations just to drop of waste and recyclables.

This analysis provides a first cut look at these issues but does not purport to be a detailed and complete analysis of how such a system would be implemented. This is because consolidation of disparate collection systems managed by multiple private and public entities is complex, requiring several iterations of analysis based on the initial analysis, followed by discussions among stakeholders and then further analysis of a more defined system.

POTENTIAL COST SAVINGS

Consolidation of residential collection can take several forms. The first is to organize collection within a municipality where there are currently several private haulers providing subscription services. This is relatively common, and available literature would indicate that, depending on the number of competing haulers, costs savings ranging from 20 to 35 percent might be realized.

It is, however, harder to find data on savings associated with consolidation across municipal boundaries, especially for ecomaine municipalities where many municipalities already have a single hauler (under contract), or in the case of Portland, municipal collection.

DSM has conducted two studies associated with consolidated collection (Middletown, RI, 2006, and the Chittenden Solid Waste District, 2012). The most relevant is Chittenden County (Burlington, VT) area where DSM estimated savings of roughly 25 percent associated with consolidated collection. However, there were 19 private haulers providing collection services in Chittenden County at the time of the study, and most municipalities relied on subscription collection as opposed to organized collection which is more prevalent in ecomaine member municipalities.

In addition, DSM has also assisted several communities with bidding on consolidated collection contracts across two municipalities. The results have not been productive, with limited interest by private haulers in bidding across two municipalities. As such, DSM does not have any real bid data to point to associated with consolidation across two or more municipalities.

Given limited data available in the literature, and DSM's relevant analyses in two other New England locations, we estimate that consolidation could lead to savings of between 10 and 20 percent for ecomaine municipalities. The low end of the range reflects the fact that so many ecomaine municipalities already have organized collection, so consolidation only impacts more efficient use of collection trucks between adjoining municipalities. The high end of the range reflects the fact that some member municipalities currently are subscription curbside collection programs, where the savings should be higher.

Table 13 takes the collection cost data summarized in Table 7 and assumes the 10 and 20 percent cost savings. But then it adds in additional administrative costs to ecomaine associated with: organizing and administering the consolidated collection bidding; contract award; and, contract monitoring.

As illustrated by Table 13, given the high cost of collection, even a 10 percent savings could be significant, assuming that ecomaine would administer the collection system efficiently.

Table 13. Estimated Cost Savings Associated with Consolidating Collection, High and Low Estimates

Collection	Option 1	Option 2	Option 3	Option 4
High	$1,582,394	$1,718,371	$2,384,565	$1,519,172
Low	$791,197	$859,186	$1,192,283	$759,586
Administrative	$250,000	$250,000	$250,000	$250,000
Net Savings				
High	$1,332,394	$1,468,371	$2,134,565	$1,269,172
Low	$541,197	$609,186	$942,283	$509,586
Carbon Savings (MTCE)	158	163	268	144

Table 13 also presents a rough estimate of potential GHG emissions savings associated with consolidated collection. In this case the savings are assumed to be no more than 10 percent of annual collection emissions, because the same collection miles have to be driven, and the only savings are likely to be in less trips to the ecomaine facility, and slightly fewer trucks collecting refuse and recyclables.

INSTITUTIONAL ISSUES

Organizing collection through ecomaine raises a whole series of institutional issues which would need to be resolved prior to any final decision on moving forward. Some of these issues arise whether or not ecomaine takes over management of collection, while others are directly related to joint management of collection.

PAYT Pricing

All of the options analyzed for this report assume households are provided with rolling carts, allowing for fully automated collection, which typically is the most efficient collection system. There are essentially three PAYT options when carts are used:

- Fees based on cart size
- RFID based systems
- Use of PAYT bags inside of the refuse cart

Each system is summarized below.

CART SIZE

Typically, under this PAYT system each household is offered a choice of refuse cart sizes – typically ranging from 32 to 96-gallon carts. The monthly (or semi-annual or annual) fee is scaled such that the household pays less for the 32-gallon collection than for 64-gallon collection or 96-gallon collection. Assuming that the collection truck will not collect refuse that is not in the cart, then enforcement is relatively easy, and can be done by the driver by simply leaving any waste not in the refuse cart.

The primary issue associated with cart based PAYT is pricing of the carts. This is because the actual cost to collect a 32-gallon cart compared to a 64 or 96-gallon cart is quite small. Virtually all the collection costs remain the same, but there is less refuse in the cart. But basing the price differential solely on the avoided disposal savings is typically not sufficient to induce households to use the smaller cart.

For example, if the average ecomaine household generates roughly 2000 pounds of refuse per year, divided by 52 weeks, the actual cost to dispose of the refuse at the ecomaine facility (at the rate of $70.50 per ton) equals $1.36 per week. Assuming that the household with a 32-gallon cart puts out half as much refuse as a household with a 64-gallon cart, then the difference in monthly fees for the smaller cart, based purely on tipping fees would only be $1.84 per month compared to $3.70 per month for the 64-gallon cart. This savings of less than $20 per year for twice the capacity is often insufficient to entice significant numbers of households to risk the 32-gallon cart when compared to the 64-gallon cart.

As a consequence, most municipalities that use PAYT pricing for carts either price smaller carts to encourage their use, irrespective of actual differences in costs, or lump in all other solid waste management costs to increase the refuse cost and therefore the differential.

For example, Seattle, WA has had cart based PAYT pricing for many years and is often considered a leader in waste diversion in the U.S. Monthly rates for refuse carts are: 32-gallon, $37.15; 64-gallon, $74.30, and 96-gallon, $111.45. Seattle does not charge for recycling, but does charge for food and yard waste collection, with prices of: 13-gallon, $6.05; 32-gallon, $9.10; and, 96-gallon, $11.65.

As illustrated by Seattle's rates, the refuse rate is clearly set to encourage waste reduction (you can also sign up for 12 and 20-gallon carts), with a price for a 32-gallon cart one-half of the price for a 64-gallon cart. Food and yard waste carts are not free but are priced much closer to the change in cost associated with managing the quantity set out when compared to the refuse cart.

RFID BASED BILLING

Most cart manufacturers now offer imbedded RFID chips in their carts. These chips could be used to bill residential customers each time they use their cart, based on the size of the cart. The City of Grand Rapids, MI has implemented this system. All residents pre-pay for services, which are then deducted each time a cart is serviced by the collection truck. This system is similar to the "EZ Pass" system in place on the Maine Turnpike.

Such a system would require additional analysis on the part of ecomaine to address the following issues:

- In the past, RFID readers on refuse trucks were unreliable – if ecomaine were to implement such a system it would be necessary to verify how reliable the readers have become, and what to do in cases where the reader fails – especially in the middle of the route.
- Ecomaine would need to establish a system for households to safely and securely pre-pay by credit card, or in person for the system. Costs for web site development and maintenance would need to be incorporated in the total system cost.
- It would be necessary to investigate whether up-loading of the data could happen automatically via a cloud-based system while the trucks were on the road, or whether it would be necessary for the data to be store on-board during the day and then downloaded to a server at the end of the day.
- A decision would have to be made by the member municipalities with respect to enforcement of use – that is, would households who chose not to participate be allowed to contract with a hauler not participating in the system, or would only participating haulers be allowed to operate in the municipality. In that case, how would enforcement against households who did not pre-pay for the service occur?

PAYT BAGS INSIDE CARTS

It is possible to implement a cart-based PAYT program with PAYT bags. This has the advantage of allowing member municipalities that already have PAYT bag programs to continue with their programs, while expanding the program to include all member municipalities. It is also simple to incorporate PAYT bag programs into transfer station systems. And, if ecomaine decides to implement colored food waste bags (and separately colored deposit container bags), PAYT bags are a logical component of a complete bagged program inside of carts.

The primary problem with PAYT bags inside carts is that when the carts are collected using automated trucks, the driver cannot enforce against households placing waste in non-PAYT bags. However, this problem is not insurmountable. DSM assisted Middletown, RI with implementation of PAYT plastic bags inside carts over seven years ago. The keys to enforcement included a requirement that the automated collection trucks maintain functioning cameras so that the driver can observe the waste as it is dumped from the cart, and that the driver write down or somehow record the address of each household where a violation is observed. It is then necessary for a municipal (or ecomaine) enforcement official to go out in front of the truck the following week, opening up carts at addresses cited by the driver the previous week. If non-PAYT bags are observed, then the enforcement officer places a colored tag on top of the cart which notifies the driver to not pick up that cart.

Middletown's experience with the system indicates that with adequate enforcement, in a relatively short period of time use of non-PAYT bags declines to very low levels, significantly reducing the enforcement effort.

One benefit to a regionalized ecomaine collection system would be that a single colored PAYT bag could be distributed and sold in all supermarkets in the ecomaine region. This is important when compared to separate municipalities implementing PAYT programs with separate bags which have to be carried by supermarkets serving multiple municipalities.

INCORPORATION OF FOOD WASTE COLLECTION COSTS IN PAYT PROGRAMS

One goal of this analysis is to evaluate the added PAYT bag cost of adding separate food waste collection, assuming all costs of the solid waste management system are covered by the PAYT bag fee ("all in" costs).

Table 14 compares estimated Baseline PAYT bag costs against the addition of food waste collection under the four options examined in this report. It should be noted that "Baseline" does not necessarily represent actual costs for several member municipalities which rely on a combination of subscription collection and high use of transfer stations, instead estimating what the cost in these municipalities would be if there were organized curbside collection – which all four options assume.

All cases assume that the average household uses six bags per month.

Table 14. Comparison of Monthly Baseline Cost for Ecomaine Member Municipalities with Addition of Food Waste Collection Under the Four Options Analyzed

System	All In	Food Impact	PAYT Bag
Baseline			(6/Month)
Cost/HH/Month	$16.20		$2.92
Option 1, Single Cart			
Cost/HH/Month	$19.57	$3.37	$3.48
Option 2, Dual Carts			
Cost/HH/Month	$19.95	$3.75	$3.55
Option 3, Separate Collection			
Cost/HH/Month	$22.29	$6.09	$3.93
Option 4, EOW Collection			
Cost/HH/Month	$17.30	$1.10	$3.10

As illustrated by Table 14, "all in" costs for a baseline household today average roughly $16.20 per month. Assuming that the average household would use 6, 32- gallon PAYT bags per month (1.5 per week), then the "all in" PAYT bag cost would cost $2.92 under baseline; and, would range from $3.10 to $3.93 under the "all in" options that add food waste. These costs include an assumed $0.22 cents per bag fee assessed by the bag manufacturer to produce and label the bags, maintain inventory for local stores, bill the stores, and pay ecomaine the PAYT revenue, minus the bag charge.

While there is no particular upper end limit on what municipalities can charge for PAYT bags, it is DSM's professional opinion, based on a review of PAYT programs, and experience assisting municipalities with implementation of PAYT programs, that rates above $2.50 to $3.00 per 32-gallon bag are likely to generate a significant amount of push back from residents. As such, all of the options, with the exception of the Baseline, and possibly Option 4 would require some type of subsidization of total costs to hold PAYT bag prices to an acceptable cost per bag.

CART BASED SERVICE FEE

Table 14 can also be used to project what a cart-based fee would have to be to cover all costs. As illustrated by the "All In" Cost column, monthly costs for an average size cart (64-gallon) would have be between $16.20 and $22.29 to fully cover ecomaine's costs.

Alternative Revenue Sources

Ecomaine currently has the authority to assess its member municipalities. Therefore, it would be possible for ecomaine to simply increase the assessment to each member municipality to cover all the costs associated with the new collection system. However, for many member municipalities this would represent a large increase in the annual assessment given that some municipalities do not pay for curbside collection because households subscribe for the service and pay the hauler directly, and other municipalities utilize PAYT fees to pay for the service.

The most logical alternative source of funding for ecomaine might be to enact a utility fee, or non-ad valorem tax on all households in the member municipalities.[21] A non-ad valorem tax on property "is based on the service cost allocated to the property (in this case for solid waste management), and levied based on the benefit on a unit basis rather than on the value of the property"[22].

Keeping with the simplified analysis of PAYT presented in Table 14, above, Table 15 places only the collection cost on the PAYT bag (or cart), assuming the remaining tipping fees and other ecomaine costs are covered by a utility fee or non-ad valorem tax levied evenly against all households in the member municipalities. This fee would need to raise roughly $5.6 million dollars, spread over all households, requiring an estimated fee of $81 per household per year.

As illustrated by Table 15, if the PAYT bag cost represented collection costs only, it would result in PAYT bag costs ranging from $1.58 for current, or baseline collection costs, and $1.76 to $2.59 for the options including food waste collection. Cart costs would then range from $9.45 to $15.54 per month depending on the collection system. All options result in PAYT bag prices that are consistent with PAYT bag charges in other communities.

Table 15. Calculation of Typical PAYT Bag Cost Sufficient to Cover Collection Costs Only

System	Collection Only	PAYT Bag
Baseline		(6/Month)
Cost/HH/Month	$9.45	$ 1.58
Option 1, Single Cart		
Cost/HH/Month	$12.82	$ 2.14
Option 2, Dual Carts		
Cost/HH/Month	$13.20	$ 2.20
Option 3, Separate Collection		
Cost/HH/Month	$15.54	$ 2.59
Option 4, EOW Collection		
Cost/HH/Month	$10.55	$ 1.76

[21] According to an initial review by ecomaine's attorney, ecomaine would not be allowed under Maine law to assess a fee on property as described here without approval from the Maine legislature.
[22] This description is taken from Florida, and may or may not be accurate for Maine municipalities, http://www.seminoletax.org/property-tax/property-taxes-assessments.html

It should be noted that Tables 14 and 15 are simplified examples of per bag and cart costs and assume all households behave the same and generate the same average amount of waste per year. Obviously, this is not the case, but these tables serve the purpose of illustrating how PAYT bag costs (or cart costs) might be set, and how much a PAYT bag (or cart) would have to be priced to cover all included costs. Each household would then purchase, and use bags based on their waste generation rate, and their diversion of single sort recyclables and yard waste.

One important caution concerning this analysis that many municipalities face when implementing PAYT pricing is that it assumes households continue to behave the way they did before adoption of PAYT. In reality, especially if separate food waste collection is implemented, many households will reduce the amount of refuse they dispose of through higher levels of materials and food waste recycling. This then requires that the PAYT bag rate go up to generate the revenue projected to be raised. For this reason, it is likely that the rates illustrated in Table 15 would need to be raised by around 20 to 25 percent to reflect this change in behavior.

ADMINISTRATIVE COSTS AND ISSUES

Moving to a consolidated collection system run by ecomaine would require a significant effort on the part of ecomaine and the member municipalities to unwind the current systems for collection and replace it with a consolidated ecomaine managed system. It is beyond the scope of this analysis to provide a detailed analysis of the implementation issues, but the following list of issues that would need to be addressed presents a first step in describing the process.

- Coordination of current contracts – there would need to be a phase in period over which existing contracts expired and were replaced by one or more ecomaine administered contracts.
- A decision would have to be made by Portland and ecomaine as to whether Portland's municipal collection would continue, or would be consolidated with ecomaine privatized contracts -in which case a decision would need to be made as to what would happen to Portland's municipal collection crews
- Ecomaine member municipalities would need to evaluate the potential size of newly consolidated collection districts, with potentially competing goals of realizing economies of scale and geography, while potentially also providing opportunities for smaller waste collection companies to compete against the two largest waste management companies operating in the region
- Ecomaine would need to carefully evaluate its management and billing capacity to determine how many staff would need to be added, and how billing could occur to all 69,500 households – would it be possible to merge billing with current municipal systems, or would a complete database have to be developed for the member municipalities.

- A legal opinion would be needed on whether ecomaine or the member municipalities would be allowed to place a lien against property associated with either a utility bill or a non-ad valorem tax – having the capacity to enforce payment significantly reduces overall costs by reducing the need to carry a certain percent of non-paying households.
- A decision would need to be made as to how ecomaine could take over enforcement of collection requirements of the household – failure to use PAYT bags, refuse accumulating at a house, etc.

Consolidation of Transfer Stations

It is commonly assumed that it is less costly (both economically and environmentally) for a household to drive their refuse and recyclables to a transfer station when compared to contracting with a private waste hauler for curbside collection. However, when the real cost of driving private automobiles is factored in, this may not be the case.

DSM has analyzed the behavior of households using drop-off recycling in a number of states, and has always been able to demonstrate that drop-off recycling costs more (both economically and environmentally) than curbside collection of recyclables. DSM has done less work on the cost to deliver both refuse and recyclables to a transfer station. However, one study, completed for Middletown, RI (an island community located next to Newport, RI) demonstrated, based on surveys of users of the Middletown transfer station, that the average household drove 167 miles per year to deliver their waste and recyclables.

Given the compact nature of Middletown when compared to Maine municipalities, it is likely that the drive distance would be further, but without any other data point, a simple analysis was completed assuming that all member municipalities behaved like Middletown, RI households, and drove an average of 167 miles per year to deliver refuse and recycling. Assuming the US EPA fleet average of 24.8 miles per gallon, and 17.6 pounds of CO^2 emissions per gallon, then households would generate roughly 4,100 tons of CO^2 per year. This can be compared against the four curbside collection options analyzed which ranged from 1,600 to 2,800 tons of CO^2 per year.

Given the large increase in carbon emissions associated with transfer station based collection versus curbside collection, if ecomaine were to consolidate curbside collection it might also make sense to consolidate transfer stations by providing all households with curbside collection of recyclables, food waste and refuse, and then operating several large regional transfer stations for hard to handle wastes and special wastes that are difficult to incorporate in a curbside collection program.

Food Waste Collection from Commercial Accounts

The Northern Tilth report estimates that roughly 7,200 tons of additional food waste could be diverted from institutional/commercial/industrial (ICI) customers in ecomaine member municipalities. While it is beyond the scope of this analysis to examine the costs in detail associated with this diversion, some general conclusions can be made based on other recent analyses DSM has conducted on food waste diversion.

DSM's most recent analysis was for the Delaware Solid Waste Authority (2017), which evaluated diversion impacts and costs for ICI food waste across Delaware. DSM's general conclusion was that separate collection of food waste would cost roughly $182 per ton over and above their current collection costs for MSW, as outlined in the following excerpt from the DSWA report[23].

"*It is difficult to find examples in the literature of increased collection costs associated with separate organics collection of ICI generators because collection costs are typically negotiated between the hauler and each individual business. However, because of the amount of activity in organics processing occurring in certain areas of California, Waste Management's posted prices for Castro Valley, CA provide an example of current pricing.*[24] *While commercial prices in Delaware are probably different, the relative impact is likely to be fairly representative of what would occur in Delaware if an organics processing facility was operating.*

Using these published monthly rates for commercial MSW collection for a six and four cubic yard MSW dumpster and for a two-yard organics dumpster, it is possible to calculate the impact of a business reducing their overall MSW dumpster size by approximately 30 percent (from six to four yards) and adding a two-cubic yard dumpster for organics in Castro Valley. As illustrated by Table 12, the business will pay roughly $182 per ton more to have their food waste collected separately when compared to having the food waste collected as part of MSW".

Description	**Monthly Charge**
6 Cubic Yard MSW Dumpster	$837.39
4 Cubic Yard MSW Dumpster	$569.68
MSW Collection Cost Savings	$267.71
Cost Of 2 Cubic Yard Organics Dumpster	$349.54
Additional Cost of Adding Organics	$81.83
Calculating Cost Per Ton	
Pounds/Cubic Yard, Food Waste	450
2 Cubic Yard (pounds)	900
Cost Per Pound	$0.09
Cost Per Ton	$181.84

DSM reached out to Exeter Agri-Energy concerning what they charge for separate collection of food waste, but they were reluctant to release this proprietary data. Given that costs in Maine are likely to be less than in the Bay Area of California, a rough estimate might be that separate collection of ICI food waste from businesses that do not generate primarily food waste (supermarkets, restaurants and food processors) might cost an additional $150 per ton for businesses in the ecomaine area. Assuming that roughly one-half

[23] *Appendix A: Detailed Analysis of Organics Processing Alternatives, Report to Delaware Solid Waste Authority, September 2017,* prepared by DSM Environmental Services, Inc.
[24] https://www.wm.com/location/california/bay_area/castrovalley/commercial/rates.jsp

of the food waste is generated by large food waste generators, costs to the remaining generators might be roughly $500,000 per year.

These costs would be eliminated if ecomaine implemented optical sorting of bagged food waste because there would be no need for separate food waste collection for these generators.

NEXT STEPS AND CONCLUSION

The economic analysis presented in this report of the potential to add separate collection of food waste for all households raises important issues that will require further investigation by the member municipalities and ecomaine. The most critical are highlighted below.

- First, do member municipalities want to move forward with a system-wide collection approach for residential food waste, as a means of significantly increasing the diversion rate?

- Second, if they do want to move forward with separate collection of residential food waste, do they want to invest in technology at ecomaine that would make food waste diversion more efficient in collection and convenient for households? Investment in this technology would essentially shift costs from households that want to participate in food waste diversion to ecomaine.

- Third, are member municipalities interested in moving forward with automated collection of MSW and food waste to increase collection efficiency; including adjusting PAYT programs to accommodate rolling carts necessary for automated collection?

- Fourth, are member municipalities interested in delegating responsibility for management of this new automated collection system to ecomaine?

In conclusion, this report compares costs and environmental impacts of four distinct collection approaches for food waste, recyclables, bottle bill containers, and refuse. It also considers the savings potential for transitioning to regional automated collection and provides alternatives to fund such a program.

Ecomaine municipalities have already regionalized a portion of solid waste services including recycling, waste-to-energy, and landfilling. Collection remains a service that is managed by the individual municipalities. This report concludes that there are opportunities to add services, improve convenience and efficiencies, and save money if the member municipalities are interested and willing to take the next step in furthering the regionalization of waste management services.