Benefit-Cost Analysis of Potential Food Waste Diversion Legislation

Industrial Economics, Incorporated

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Benefit-Cost Analysis of Potential Food Waste Diversion Legislation

Final Report

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1 Introduction

In New York State, approximately 3.9 million tons of food waste is generated each year as municipal solid waste, of which only three percent is currently diverted from landfills or combustion (waste-to-energy, or WTE) facilities.[1] Disposing of food waste in landfills and WTE facilities results in both economic and environmental costs to society, including the loss of value associated with food that is still safe for consumption or well-suited for animal feed, compost, or anaerobic digestion (AD). In addition, the breakdown of food in landfills produces methane, which is a potent greenhouse gas. Given the magnitude of the problem, the potential for benefits associated with prevention or diversion of food waste is substantial.

1.1 Summary of Potential Legislation

In light of these potential benefits, New York State proposed legislation to phase in a requirement that large generators of food waste divert waste from landfills and WTE facilities by donating edible food, sending food waste to compost, AD, animal feed, or other organics recycling facilities, and ultimately wasting less food.[2] Although the requirements currently under consideration would not address all food waste generated across the State, recycling would apply to all facilities generating at least two tons of food waste per week on average that are located within 50 miles of a food waste management facility. Similar statutory and regulatory actions were adopted by New York City, Connecticut, Massachusetts, Rhode Island, and Vermont, as summarized in Table 1. The potential New York State legislation would not apply to generators in New York City, provided there is a food waste recycling program in place.

1.2 Scope of Analysis

To assist the New York State Energy Research and Development Authority (NYSERDA), the New York State Department of Environmental Conservation (DEC), and New York State policy-makers in assessing the potential economic impacts of food waste diversion legislation in New York State, Industrial Economics, Inc. (IEc) conducted a screening-level benefit-cost analysis (BCA) of the potential impacts of diverting food waste across the State. The BCA estimates benefits that accrue to

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1 Ava Labuzetta, Melissa Hall, and Thomas Trabold. "Initial Roadmap for Food Scrap Recovery and Utilization in New York State." November 2016.

2 New York State Division of the Budget. "FY 2018 New York State Executive Budget - Transportation, Economic Development and Environmental Conservation Article VII Legislation." Part KK. Available here: https://www.budget.ny.gov/pubs/executive/eBudget1718/fy18artVIIbills/TEDArticleVII.pdf

society as a whole, rather than to specific stakeholder groups such as retailers or compost facilities. In addition, because of the screening-level nature of the BCA, the analysis focuses on cost and benefit elements that are most likely to affect a potential policy's cost-effectiveness. For example, the BCA does not consider:

- **Benefits associated with food waste prevention**, because the diversion of food waste is the primary focus of the potential legislation.
- **Diversion from food manufacturing facilities (food processors)**, many of which already divert food waste absent legislation because of the large quantity and reliable, uniform nature of food waste generated.[3]
- **Costs (e.g., labor hours) of negotiating new food waste hauling contracts**, which may be offset by savings from renegotiating collection frequency for nonfood waste.
- Opportunity cost of using land at the generating facility for food waste collection; outside of New York City, space constraints are assumed to be minimal.
- **Changes in energy generation at combustion facilities**, which may experience a decrease in food waste following the implementation of diversion requirements. Interviews conducted with food waste diversion program managers in other states indicated that food waste is a relatively minor component of WTE feedstock.

As described in the following sections, the BCA focuses on two scenarios: the baseline, in which current food waste disposal practices continue; and the policy scenario, in which large generators are required to divert their food waste away from landfills and WTE facilities.

3 BSR. "Analysis of U.S. Food Waste Among Food Manufacturers, Retailers, and Restaurants." Prepared for the Food Waste Reduction Alliance. 2014. Available here: http://www.foodwastealliance.org/wp-content/uploads/2014/11/FWRA_BSR_Tier3_FINAL.pdf

Table 1. Comparison of Existing Food Waste Diversion Policies

Jurisdiction	Policy Summary
New York City[4]	• Distance threshold for compliance: 100-mile radius of the city • Affected facilities: hotels with 150+ rooms; arenas and stadiums with seating capacity of 15,000+ people; food manufacturers with a floor area of 25,000+ square feet; food wholesalers with a floor area of 20,000+ square feet; other generators may be added as processing capacity increases • Implementation: In effect since 2016
Connecticut[5]	• Distance threshold for compliance: 20 miles from recycling facility • Affected facilities: Commercial food wholesalers and distributors, industrial food manufacturers and processors, supermarkets, resorts, restaurants, and conference centers generating more than 104 tons of food waste per year (to decrease to 52 tons per year by 2020) • Implementation: In effect since 2014
Massachusetts[6]	• Distance threshold for compliance: none • Affected facilities: Businesses and institutions disposing of at least one ton of food waste per week • Implementation: In effect since 2014
Rhode Island[7]	• Distance threshold for compliance: 15 miles from recycling facility • Affected facilities: Institutions generating more than 104 tons of food waste per year • Implementation: In effect since 2016
Vermont[8]	• Distance threshold for compliance: 20 miles from recycling facility (after 2020 – none) • Affected facilities: Institutions generating more than 26 tons of food waste per year (started with 104 tons per year with thresholds decreasing steadily until all food waste is banned from landfills by 2020) • Implementation: In effect since 2014

4 NYC Department of Sanitation. "Food Scraps + Yard Waste for Businesses." Accessed January 2017. Available here: http://www1.nyc.gov/assets/dsny/zerowaste/businesses/food-scraps-and-yard-waste.shtml

5 Connecticut Department of Energy & Environmental Protection. "Commercial Organics Recycling Law Information & Guidance for Food Residual Generators." January 2017. Available here: http://www.ct.gov/deep/cwp/view.asp?a=2718&q=552676&deepNav_GID=1645

6 Massachusetts Office of Energy and Environmental Affairs. "Commercial Food Waste Disposal Ban." Accessed January 2017. Available here: http://www.mass.gov/eea/agencies/massdep/recycle/reduce/food-waste-ban.html

7 Institute for Local Self-Reliance. "Rhode Island – Food Waste Recycling Requirements." April 2016. Available here: https://ilsr.org/rule/food-scrap-ban/rhode-island-food-waste-recycling/

8 Chittenden Solid Waste District. "Act 148: Universal Recycling & Composting Law." Accessed January 2017. Available here: https://cswd.net/about-cswd/universal-recycling-law-act-148/

2 Affected Generators and Food Waste Management Entities

The universe of facilities likely to be affected by New York State's potential food waste diversion legislation includes both food waste generators and excess food and food waste management entities. Given the evolving food waste landscape in the State, the facilities included in this analysis are not necessarily those affected by legislation. Instead, as a whole, they represent a reasonable approximation of the affected universe.

2.1 Excess Food and Food Waste Generators

To identify potential food waste generators, IEc relied on past research conducted by the New York State Pollution Prevention Institute (NYSP2I).[9] In a recent white paper, NYSP2I identified large generators producing more than two tons of excess food and food waste per week. Because food product manufacturing facilities (food processors) divert much of their food waste already, this BCA and NYSP2I's analysis both focus on non-manufacturing food retail or service facilities, organized by NYSP2I into three sectors:

- Institutions: Includes colleges and universities, hospitals, nursing homes, and correctional facilities.
- Retail: Includes wholesale facilities, big box stores, convenience stores, supermarkets, and supercenters.
- Service and hospitality: Includes hotels/motels and restaurants.

In addition to sector and location information, NYSP2I's data set includes estimated food waste quantities for each generator. These quantities were calculated by applying general factors from the literature to the number of employees (for generators in the retail and service and hospitality sectors) or number of beds (for generators in the institution sector).[10] After reviewing NYSP2I's data set, IEc removed 13 generators

[9] Results are summarized in: Ava Labuzetta, Melissa Hall, and Thomas Trabold. "Initial Roadmap for Food Scrap Recovery and Utilization in New York State." November 2016.

[10] More information on food waste factors used can be found here: Ava Labuzetta, Melissa Hall, and Thomas Trabold. "Initial Roadmap for Food Scrap Recovery and Utilization in New York State." November 2016.

located in New York City or unlikely to generate large quantities food waste by the nature of their operations (e.g., corporate headquarters initially classified as retail). [11] IEc also adjusted food waste generation quantities from wholesale retailers to align with NYSP2I's assumption that wholesale retailers already divert 42 percent of food waste overall.

Table 2 summarizes the number of affected generators and associated food waste tonnage by sector, as used in the BCA. Appendix A includes a more detailed table summarizing food waste generation by sector and county. Figure 1 illustrates the geographic distribution of generators across the State, excluding New York City.

Table 2. Excess Food and Food Waste Generation Summary

Sector	Number of Generators	Estimated Excess Food and Food Waste Generated (tons/week)	Estimated Excess Food and Food Waste Generated (tons/year)
Institutions	329	1,392	72,362
Retail	1,164	6,000	312,019
Service & Hospitality	201	620	32,244
Total	**1,694**	**8,012**	**416,625**

Notes:

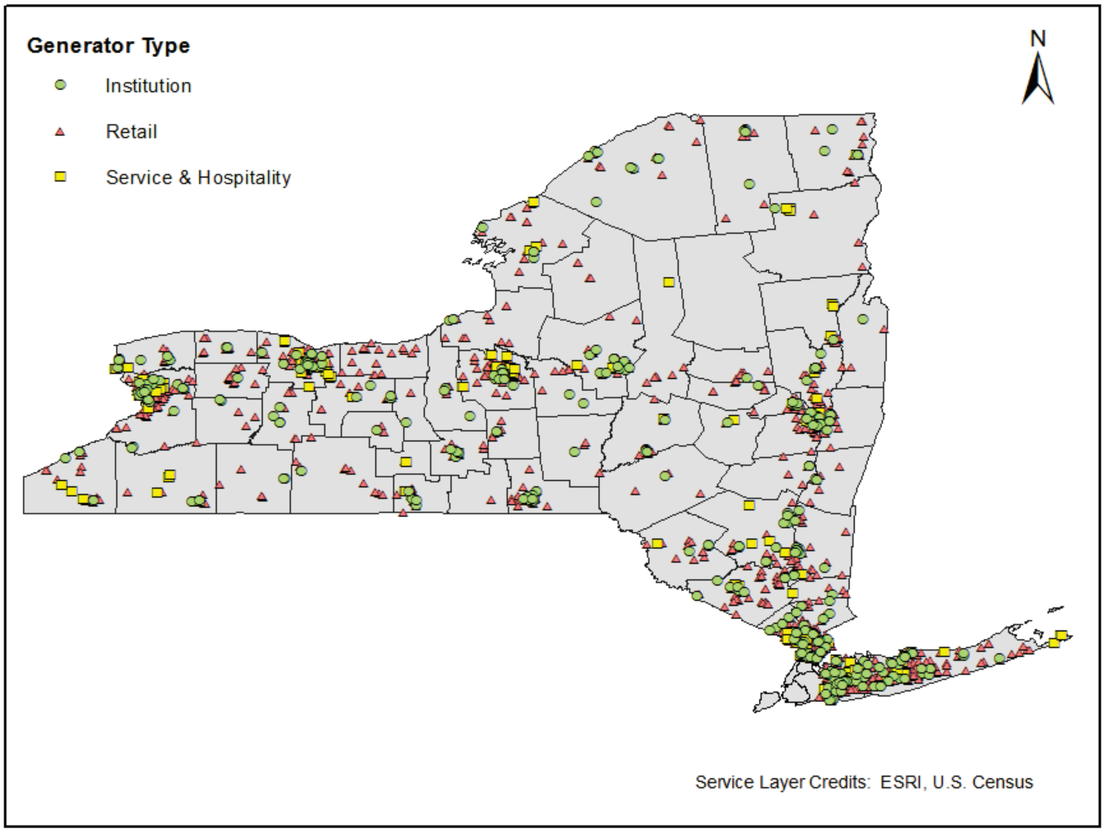
Institutional sector includes colleges and universities, hospitals, nursing homes, and correctional facilities.

Retail sector includes wholesale facilities, big box stores, convenience stores, supermarkets, and supercenters.

Service & hospitality sector includes hotels/motels and restaurants.

[11] IEc reviewed all generators with estimated weekly tonnage above 100 tons (n=11) and removed six that appeared to be corporate headquarters or manufacturing facilities based on publicly available information.

Figure 1. Distribution of Large Food Waste Generators across New York State (Excluding New York City)



2.2 Excess Food and Food Waste Management Entities

Excess food and food waste management entities include disposal and thermal treatment facilities (i.e., landfills and WTE facilities), facilities that could accept diverted food waste (i.e., compost and AD facilities), and entities that manage excess food (i.e., food donation centers). To identify food waste management facilities, IEc relied primarily on publicly available data from the DEC. The DEC regularly updates its lists of active landfills and WTE, compost, and AD facilities.[12] IEc included only those compost facilities that reported currently managing food waste, and AD facilities that reported currently managing food waste or food processing waste. The DEC provided complete addresses to support geospatial analysis.

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12 New York State Department of Environmental Conservation. "Solid Waste Management Facilities." Accessed January 2017. Landfill data available here: http://www.dec.ny.gov/chemical/23682.html. WTE data here: https://data.ny.gov/Energy-Environment/Waste-Combustion-Solid-Waste-Management-Facilities/qpvd-9uim. Compost and AD data here: http://www.dec.ny.gov/docs/materials_minerals_pdf/nysorganicfacility.pdf.

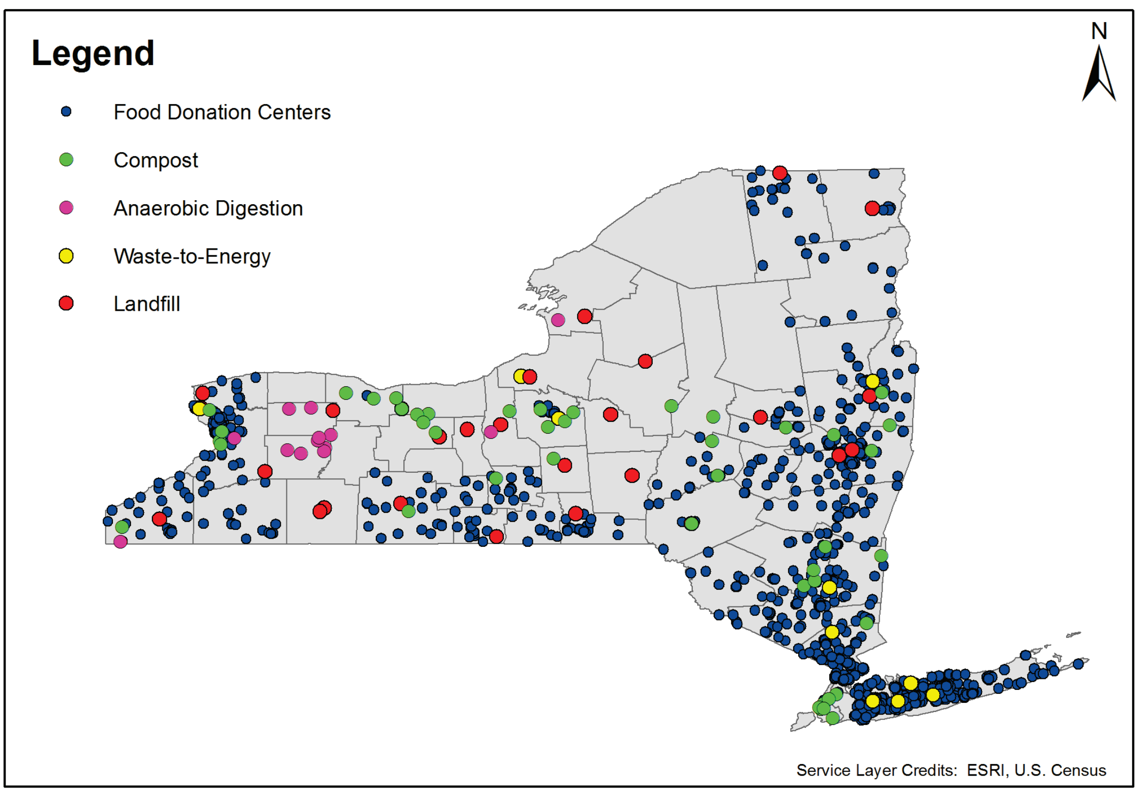
To identify food donation centers, IEc downloaded lists of food pantries and soup kitchens from the websites of the 10 regional food banks in New York State. Complete address information was available for most food donation facilities; where it was not, IEc assumed the facility was located at the centroid of its associated county.

Table 3 summarizes the number of food waste processing facilities of each type. Figure 2 illustrates the geographic distribution of these facilities across the State.

Table 3. Summary of Excess Food and Food Waste Management Entities by Type

Type	Number of Entities
Food Donation	1,377
Composting	44
Anaerobic Digestion	13
Waste-to-Energy	10
Landfill	27
Total	**1,471**

Figure 2. Distribution of Excess Food and Food Waste Management Entities across New York State



3 Baseline Scenario

The assessment of baseline costs considers four key cost categories:

- Hauling costs associated with transporting food waste from generators to landfills or WTE facilities.
- Tipping costs, based on the per ton tipping fee charged at each landfill or WTE facility.
- Greenhouse gas emissions damage associated with transporting and disposing of food waste.
- Sulfur dioxide (SO_2) emissions damage resulting from food waste hauling.

Analytical methods and key assumptions are discussed in the following sections for each cost category separately. All costs are estimated for the first year of the potential legislation and reported in 2016 dollars; when necessary, cost data are inflated to 2016 dollars using the GDP Implicit Price Deflator.[13] Although estimated costs are on a facility basis, the analysis should not be interpreted as predicting food waste disposal behavior at any given facility. Instead, the results approximate disposal practices across the universe of affected facilities as a whole.

3.1 Hauling Costs

The cost of transporting food waste from generators to landfills or WTE facilities is largely dependent on the distance between the two. To estimate hauling costs, IEc began by calculating the distance (in miles) between each generator and its assigned disposal facility using ArcGIS. IEc assigned each generator to a baseline disposal facility using the following criteria developed with input from DEC:

- **Albany County –** the nearest Albany county landfill.
- **Columbia, Greene, Sullivan, Ulster, Orange, Rockland, and Putnam Counties** – Seneca Meadows landfill.
- **Dutchess County** – the Dutchess WTE facility.
- **Nassau County** – the Nassau WTE facility.
- **Suffolk County –** the nearest Suffolk county WTE facility.
- **Westchester County** – the Westchester WTE facility.
- **All remaining generators** take their food waste to the nearest landfill or WTE facility, excluding those already assigned to specific counties as previously mentioned.

13 Bureau of Economic Analysis. Table 1.1.9. Implicit Price Deflators for Gross Domestic Product. Accessed January 2017. Available here: https://www.bea.gov/itable/

The BCA model uses the results of this geospatial analysis to calculate hauling costs. First, the model calculates the number of truckloads of food waste produced by each generator in a given week, based on NYSP2I's generator-specific estimates of weekly food waste tonnage and an assumed 20-ton capacity of long-haul collection trucks. [14, 15] The model multiplies the number of truckloads of food waste by the hauling distance and the standard $4 per mile cost, based on a 2013 analysis of the economic benefits of food waste collection and composting in New York City.[16] Although the cost factor used in that analysis is now several years out of date, IEc chose not to inflate the value from 2013 dollars to 2016 dollars because diesel prices, assumed to be the primary driver of trucking costs, have fallen since 2013. The model then multiplies weekly costs by 52 to arrive at an annual estimate.

3.2 Tipping Costs

The analysis of baseline tipping costs considers the cost associated with disposing of food waste at a landfill or WTE facility. Recent tipping fees were reported for 20 of 27 existing landfills in NYSP2I's white paper.[17] Tipping fees at most facilities ranged from approximately $40 to $70 per ton, with two outliers at $28 and $105 per ton. For the seven landfills where tipping fees were not readily available, the BCA model assumes the midpoint of the 20 other tipping fees at $56.41 per ton.

Tipping fees were not available for any of the existing 10 WTE facilities in New York State. As a default, the model applies the national average WTE tipping fee of $74.79 per ton from the 2010 Nationwide Survey of Municipal Solid Waste Management in the U.S.[18]

The model calculates tipping costs as the estimated annual tonnage of food waste from each generator, multiplied by the tipping fee at their assigned disposal landfill or WTE facility.

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14 Results summarized in: Ava Labuzetta, Melissa Hall and Thomas Trabold. "Initial Roadmap for Food Scrap Recovery and Utilization in New York State." November 2016. Supporting data provided by: Ava Labuzetta. Email communication on January 9, 2017.

15 Global Green USA, Coalition for Resource Recovery. "The Business of Organics Recycling in Dense Urban Centers: Updates and Case Studies from New York City." January 29, 2013. Accessed January 2017. Available at: http://compostingcouncil.org/wp/wp-content/uploads/2013/02/Houssaye.pdf

16 Ibid.

17 Ava Labuzetta, Melissa Hall, and Thomas Trabold. "Initial Roadmap for Food Scrap Recovery and Utilization in New York State." November 2016.

18 Rob van Haaren, Nickolas Themelis, and Nora Goldstein. "The State of Garbage in America: 17th Nationwide Survey of MSW Management in the U.S." BioCycle. October 2010. Available here: https://www.biocycle.net/images/art/1010/bc101016_s.pdf

3.3 Greenhouse Gas Emissions Damages

Baseline greenhouse gas emissions damages associated with transporting and disposing of food waste are estimated using the most recent version of the U.S. Environmental Protection Agency's (EPA) Waste Reduction Model (WARM).[19] WARM calculates greenhouse gas emissions from waste management scenarios of various food waste types. Based on the criteria outlined in section 3.1, the BCA model calculates the quantity of food waste processed at landfills, the quantity of food waste processed at WTE facilities, and the average hauling distance to each type of disposal facility. These values serve as inputs into WARM.[20]

The BCA model then multiplies the emissions output from WARM by the 2016 social cost of carbon developed for use in federal regulatory impact analyses. For 2016, the estimated value is $38 per metric ton of CO_2-equivalent emissions, assuming a three percent discount rate (2007 dollars).[21] Importantly, the social cost of carbon increases in future years relative to 2016, so emissions damages may account for larger costs in the future.

3.4 Sulfur Dioxide (SO_2) Emissions Damages

The model calculates SO_2 emissions damages from the transport of food waste using the results of the baseline geospatial analysis. The model first multiplies the baseline hauling distance from each generator to its assigned disposal facility by a SO_2 emissions factor of 0.0053 grams per mile.[22] The model then values these emissions at $19,000 per ton (2010 dollars), reflecting the health effects associated with inhalation of SO_2, based on EPA guidance.[23]

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19 U.S. EPA. "Versions of the Waste Reduction Model – Version 14." Released March 2016. Available here: https://www.epa.gov/warm/versions-waste-reduction-model-warm#WARM Tool V14

20 Note: For purposes of running WARM, IEc assumed food waste generated was half meat and half non-meat. However, the emissions output from WARM is the same for meat and non-meat.

21 Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. May 2013, Revised August 2016.

22 Hao Cai, Andrew Burnham, and Michael Wang. "Updated Emission Factors of Air Pollutants from Vehicle Operations in GREET Using MOVES." Argonne National Laboratory. October 2013. Available here: https://greet.es.anl.gov/publication-vehicles-13

23 U.S. EPA. "Estimating the Benefit per Ton of Reducing $PM_{2.5}$ Precursors from 17 Sectors." January 2013. Available here: https://www.epa.gov/sites/production/files/2014-10/documents/sourceapportionmentbpttsd.pdf

3.5 Results

Table 4 presents the results of the baseline analysis. As shown, tipping costs account for more than half of baseline costs at approximately $27 million, followed by hauling costs ($10 million) and greenhouse gas emissions damages ($4 million). SO_2 emissions damages are negligible overall.

Table 4. Baseline Scenario Costs

Cost Category	Value (2016$)
Hauling Costs	$9,997,031
Tipping Costs	$26,593,877
Greenhouse Gas Emissions Damages	$4,411,721
Sulfur Dioxide Emissions Damages	$277
Total Baseline Costs	**$41,002,907**

4 Policy Scenario

The assessment of costs under the policy scenario considers eight cost and benefit categories:

- Hauling costs associated with transporting food waste from generators to compost or AD facilities.
- Tipping costs, based on the per-ton tipping fee charged at each compost or AD facility.
- One-time costs associated with the purchase of collection equipment (i.e., toters for food waste) and staff training.
- Ongoing equipment costs (i.e., purchase of bag liners for the toters).
- Greenhouse gas emissions damages (or benefits) associated with transporting and disposing of food waste.
- Sulfur dioxide (SO_2) emissions damages resulting from food waste hauling.
- Revenues associated with the production of compost or electricity.

Analytical methods and key assumptions are discussed in the following sections for each cost or benefit category separately. As in the baseline analysis, all estimated costs for the first year of the potential legislation are reported in 2016 dollars. Costs in subsequent years would be lower due to the exclusion of one-time equipment and training costs.

4.1 Capacity Considerations

Previous research demonstrates that New York State does not currently have the necessary capacity at compost and AD facilities to handle the quantity of food waste likely to result from food waste diversion legislation.[24] Similar to other states that have adopted food waste legislation, New York State intends to build this capacity over time prior to implementation of the requirements. However, given uncertainty as to where this new capacity will be developed and how much will be at compost vs. AD facilities, the BCA considers two alternatives for assigning generators to a food waste recycling facility:

- **Primary policy scenario:** This alternative assumes that one new food waste recycling facility is constructed in each county outside of New York City, and for purposes of the GIS analysis, places this facility at the county centroid (see Appendix B). New food waste recycling facilities are not modeled for the New York City counties under the assumption that land is too scarce and costly to justify the construction of new facilities. Under this alternative, generators haul their food waste to the nearest food waste recycling facility; the BCA assumes no capacity

[24] Ava Labuzetta, Melissa Hall, and Thomas Trabold. "Initial Roadmap for Food Scrap Recovery and Utilization in New York State." November 2016.

constraints at these new facilities. The BCA assesses lower- and upper-bound impacts by assuming, first, that all new recycling facilities are compost facilities and, second, that all are AD facilities.

- **Highest cost scenario:** This alternative assumes that each generator transports food waste the maximum distance required for compliance with the potential legislation. To evaluate the sensitivity of impacts to the legislation's distance threshold, the BCA considers both 50-mile and 20-mile thresholds.

A third option could assume that existing food waste recycling facilities are able to expand to meet the demand; in practice, the ability and desire of existing facilities to expand may be limited. Although the BCA does not consider this option quantitatively, Figures 3 and 4 illustrate the effects of this assumption on the number of generators required to comply with the potential legislation. As shown in Figure 3, only 84 generators, primarily located in the North Country region of New York State, are farther than 50 miles from an existing compost or AD facility. Figure 4 shows that 475 generators are farther than 20 miles from an existing compost or AD facility. Table 5 summarizes the number of generators and food waste tonnage that are likely by each distance threshold.

Figure 3. Generators Not Included in 50-Mile Radius from Existing Facilities

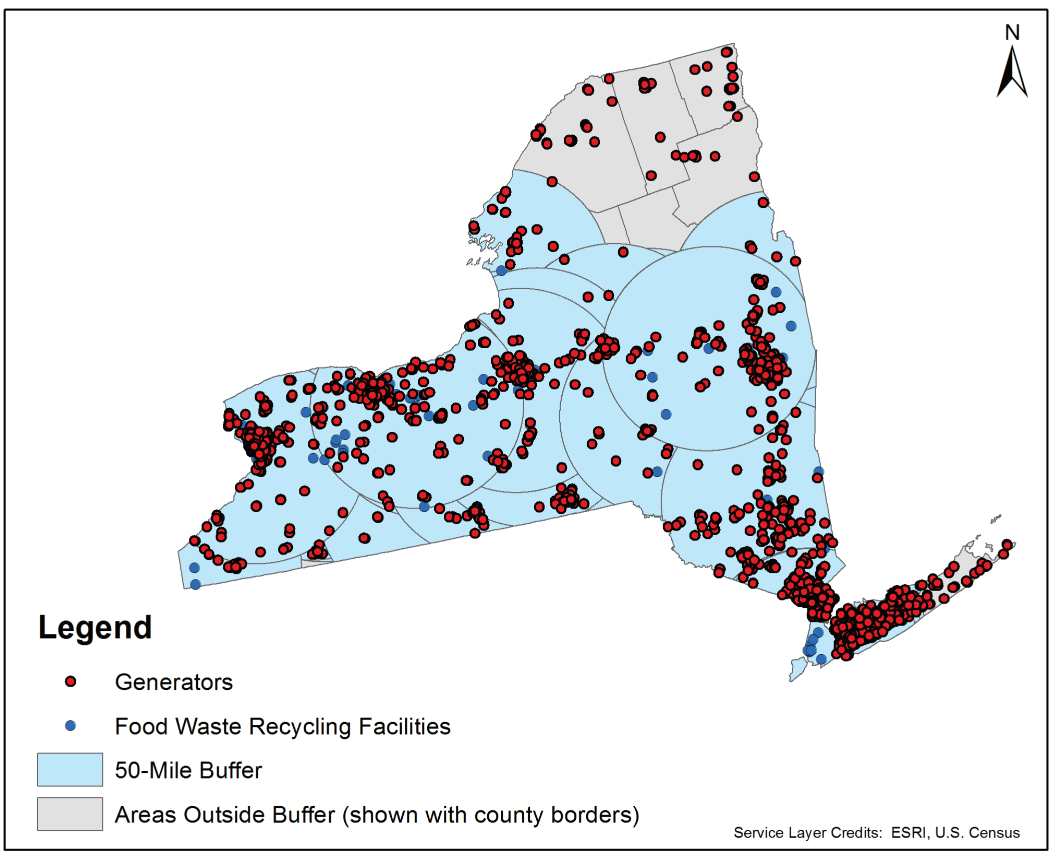

Figure 4. Generators Not Included in 20-Mile Radius from Existing Facilities

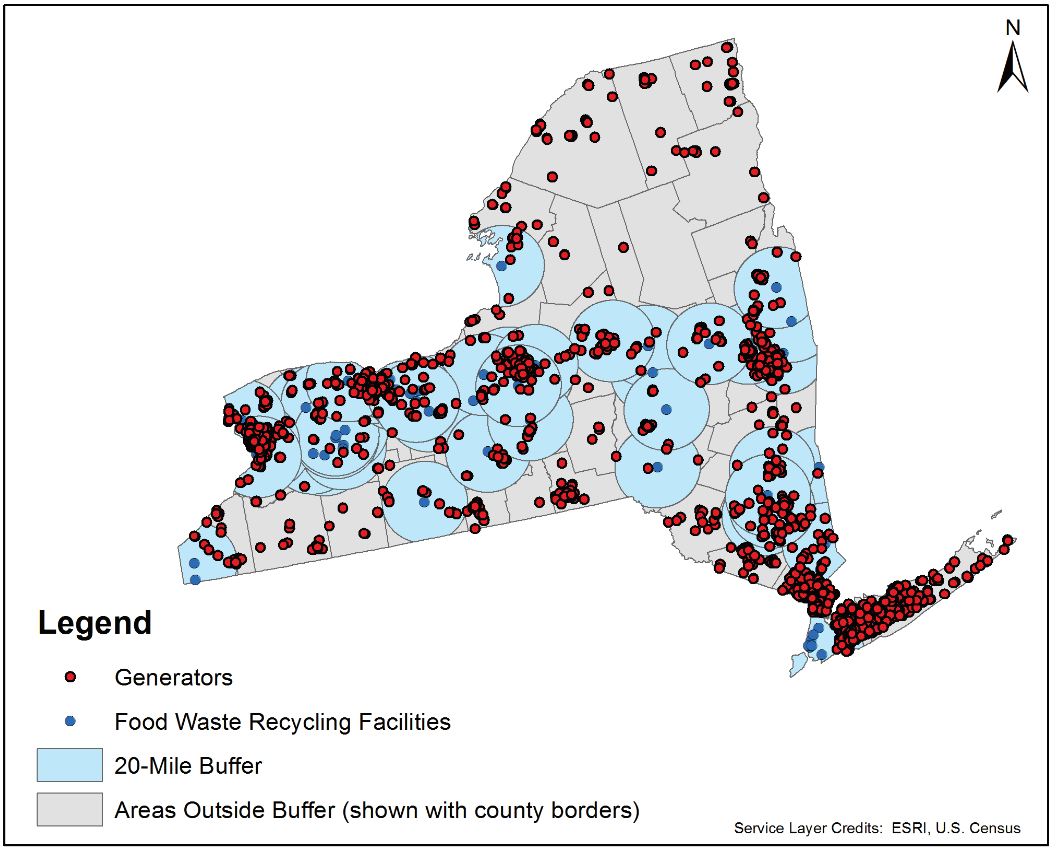

Table 5. Summary of Generators Affected Under Alternative Distance Thresholds

Summary of Existing Capacity	Value
Total Generation	
Number of large generators	1,694
Weekly tonnage of food waste	8,012
50-Mile Radius Threshold	
Large generators outside 50-mile radius	84
Weekly tonnage outside 50-mile radius	319
20-Mile Radius Threshold	
Large generators outside 20-mile radius	475
Weekly tonnage outside 20-mile radius	2,033

The policy scenario considered in the following sections assumes that new food waste recycling facilities are constructed at county centroids, and that all generators are required to comply. Section 5.1 considers the highest cost scenario, as previously defined, as well as other sensitivity analyses. Importantly, the scenario analyzed in the following sections does not model increased food donation, which can significantly alter the results (see Table 9 in section 5.1).

4.2 Hauling Costs

As in the baseline analysis, IEc began the analysis of hauling costs by calculating the distance between each generator and its nearest food waste recycling facility using ArcGIS. The BCA model calculates hauling costs based on this distance, multiplied by a standard hauling cost of $4 per mile and the estimated number of truckloads of food waste generated per year.

Of note, the BCA model assumes that generators may increase the frequency of food waste collection to help control odors; this effect was noted by interviewees from several jurisdictions that have already enacted food waste legislation. To account for the potential increase in collection frequency, the BCA assumes any generator producing up to 20 tons (one truckload) of food waste per week would increase food waste collection to two times (or two, partially empty 20-ton truckloads) per week. For generators producing more than 20 tons of food waste per week, the BCA assumes collection frequency, as approximated by truckloads per week, remains unchanged.

4.3 Tipping Costs

As in the baseline scenario, tipping costs are calculated as the estimated annual tonnage of food waste from each generator, multiplied by the average tipping fee at that generator's assigned food waste recycling facility. As described previously, the BCA considers a bounding analysis in which all facilities are (1) compost facilities, and then (2) AD facilities. Information on tipping fees at existing compost and AD facilities in New York State was taken from DSNY's 2016 Organics Capacity Survey; the BCA model calculates the average of these values for use in this analysis.[25] For compost facilities,

[25] Data provided by: Kathryn Garcia, Commissioner, NYC Department of Sanitation. Email communication on January 13, 2017.

the average tipping fee is $51 per ton; for AD facilities, the average tipping fee is $40 per ton. These values align with anecdotal information from interviewees in jurisdictions that already implemented food waste diversion requirements.

4.4 One-Time Equipment and Training Costs

Generators may incur initial costs for equipment and staff training when beginning to divert food waste. Depending on the amount of food waste produced, generators may choose to invest in large onsite compactors or toters for food waste collection. This analysis assumes that most facilities will purchase toters, which are smaller and require less space for storage. To estimate purchase costs, the BCA relies on a 2005 Supermarket Composting Handbook from Massachusetts. The handbook estimates that a facility generating two tons of food waste each week requires eight 64-gallon toters, at a cost of $60 each (2005 dollars).[26] The BCA model converts this value to approximately $291 per ton in 2016 dollars, and multiplies this cost by the estimated food waste tonnage at each generator. The BCA does not consider opportunity costs associated with the use of land for toter storage, assuming that space constraints are likely to be minimal outside of New York City.

Other upfront costs may include printing training materials and educating staff on food waste sorting requirements. The Supermarket Composting Handbook estimates printing costs at approximately $200 per facility, and staff training at $450, assuming one hour of training for 30 employees at an average wage rate of $15.[27] The BCA model inflates these costs to 2016 dollars and applies them to each generator. Although training costs may vary depending on employment and other facility characteristics, IEc assumes that these costs represent a reasonable facility average. In addition, based on the information in the Supermarket Composting Handbook, IEc assumes these costs only occur in the first year of the potential legislation. In practice, some incremental training costs may recur each year at facilities that do not already train staff on waste management practices or that experience significant employee turnover.

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26 Massachusetts Department of Environmental Protection. “Supermarket Composting Handbook.” November 2005. Available here: http://www.mass.gov/eea/docs/dep/recycle/reduce/m-thru-x/smhandbk.pdf

27 Ibid.

4.5 Ongoing Equipment Costs

In addition to upfront costs, some equipment costs may recur annually. For example, the Supermarket Composting Handbook estimates annual costs associated with the purchase of liner bags for the toters. IEc estimates that a facility generating one ton of food waste per week will need to purchase 208 liner bags per year (one bag per week for four toters, multiplied by 52 weeks), or approximately 3.5 60-bag cases. Online research shows cases cost approximately $90 each. This equates to an annual cost of approximately $320 for a facility generating one ton of food waste each week. However, some facilities may choose not to use liners and will not incur this cost.

4.6 Greenhouse Gas Emissions Damages

Although some greenhouse gas emissions result from the transport and disposal of food waste by composting and anaerobic digestion, both diversion methods ultimately lead to greenhouse gas emissions reductions by increasing soil carbon storage and, in the case of anaerobic digestion, offsetting utility electricity generation. In this analysis, these reductions are estimated using EPA's WARM.

The BCA model first calculates the amount of food waste sent to compost and AD facilities, as well as the average hauling distance to each type of recycling facility. These values serve as inputs into WARM.[28] As in the baseline analysis, WARM's emissions outputs use the 2016 social cost of carbon.[29] Because the social cost of carbon increases in future years relative to 2016, the BCA may understate the value of future emissions reductions.

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[28] Note: For purposes of running WARM, IEc assumed food waste generated was half meat/half non-meat. The GHG emissions output from WARM was the same for meat and non-meat.

[29] Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. May 2013, Revised August 2016.

4.7 Sulfur Dioxide Emissions (SO_2) Damages

The model calculates SO_2 emissions damages from the transport of food waste using the results of the geospatial analysis. As in the baseline analysis, the model first multiplies the distance from each generator to its assigned diversion facility by a SO_2 emissions factor of 0.0053 grams per mile.[30] The model then values SO_2 emissions at $19,000 per ton.[31]

4.8 Commodity Value of Compost

One economic benefit of composting is the potential new revenue stream from compost sales. The model estimates the commodity value of compost based on the total amount of food waste sent to compost facilities, a factor of 0.5 tons of compost produced per ton of food waste, and an assumed market price of $20.24 per ton (2005 dollars).[32] Because compost prices for New York State were not readily available for this analysis, this price represents the low-end average price for regions in the U.S. with available data.[33] The model inflates the price to 2016 dollars using the GDP Implicit Price Deflator.

4.9 Commodity Value of Electricity

By generating electricity, anaerobic digestion also creates the potential for a new revenue stream. The model calculates the commodity value of electricity based on the total amount of food waste sent to AD facilities, a factor of 550 kWh generated per ton food waste, and the 2016 statewide average wholesale electricity price of $0.04 per kWh.[34, 35]

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30 Hao Cai, Andrew Burnham, and Michael Wang. "Updated Emission Factors of Air Pollutants from Vehicle Operations in GREET Using MOVES." Argonne National Laboratory. October 2013. Available here: https://greet.es.anl.gov/publication-vehicles-13

31 U.S. EPA. "Estimating the Benefit per Ton of Reducing $PM_{2.5}$ Precursors from 17 Sectors." January 2013. Available here: https://www.epa.gov/sites/production/files/2014-10/documents/sourceapportionmentbpttsd.pdf

32 Sally Brown. "Connections: CO2 Math For Compost Benefits." BioCycle. August 2013. Available here: https://www.biocycle.net/2013/08/21/connection-co2-math-for-compost-benefits/

33 Ken McEntee. "National Compost Prices." Recycle.CC. 2005. Available here: http://www.recycle.cc/compostprices.pdf

34 Waste-to-Energy Research and Technology Council. "The ABC of Sustainable Waste Management (SWM)." Accessed January 2017. Available here: http://www.seas.columbia.edu/earth/wtert/faq.html

35 New York Independent System Operator. "Power Trends 2016 - The Changing Energy Landscape." 2016. Available here: http://www.nyiso.com/public/webdocs/media_room/publications_presentations/Power_Trends/Power_Trends/2016-power-trends-FINAL-070516.pdf

4.10 Results

Table 6 presents the results of the policy scenario analysis. As shown, tipping fees account for the vast majority of costs, ranging from $17 to $21 million depending on whether new recycling facilities are compost or AD facilities. The policy scenario also includes substantial economic benefits associated with the reduction and storage of greenhouse gas emissions, as well as commodity values of compost and electricity. All costs are estimated for the first year of the potential legislation; costs in subsequent years would be 13-19 percent lower due to the exclusion of one-time equipment and training costs.

Table 6. Summary of Policy Scenario Costs and Benefits

Cost or Benefit Category	Value (2016$)	
	All Compost	All AD
Hauling Costs	$6,901,351	$6,901,351
Tipping Costs	$21,247,894	$16,665,015
One-Time Equipment and Training Costs	$3,430,730	$3,430,730
Ongoing Equipment Costs	$2,541,415	$2,541,415
Greenhouse Gas Emissions Damages	($3,221,688)	($999,990)
Sulfur Dioxide Emissions Damages	$191	$191
Commodity Value of Compost	($5,107,471)	$0
Commodity Value of Electricity	$0	($10,102,957)
Total Policy Scenario Costs	**$25,792,422**	**$18,435,755**
Note: Benefits are presented as negative values.		

5 Evaluation of Net Benefits

Table 7 compares costs and benefits of the baseline and primary policy scenarios to evaluate net societal benefits. As shown, despite additional equipment and training costs incurred by generators in the policy scenario, benefits outweigh costs by $15 to $23 million. The largest societal benefits come from the reduction of greenhouse gas emissions and avoided tipping fees in the compost policy scenario, and revenues from electricity production and avoided tipping fees in the AD policy scenario. In both scenarios, avoided hauling costs are smaller, but still positive, while avoided SO_2 emissions damages contribute negligibly. Net benefits are estimated for the first year of the potential legislation; net benefits in subsequent years would be 15-23 percent higher due to the exclusion of one-time costs.

Table 7.Cost-Benefit Comparison

Cost or Benefit Category	Value (2016$)	
Baseline Scenario		
Hauling Costs		$9,997,031
Tipping Costs		$26,593,877
Greenhouse Gas Emissions Damages		$4,411,721
Sulfur Dioxide Emissions Damages		$277
Total Baseline Costs		**$41,002,907**
Policy Scenario		
	All Compost	**All AD**
Hauling Costs	$6,901,351	$6,901,351
Tipping Costs	$21,247,894	$16,665,015
One-Time Equipment and Training Costs	$3,430,730	$3,430,730
Ongoing Equipment Costs	$2,541,415	$2,541,415
Greenhouse Gas Emissions Damages	($3,221,688)	($999,990)
Sulfur Dioxide Emissions Damages	$191	$191
Commodity Value of Compost	($5,107,471)	$0
Commodity Value of Electricity	$0	($10,102,957)
Total Policy Scenario Costs	**$25,792,422**	**$18,435,755**
Note: Benefits are presented as negative values.		
Avoided Hauling Costs	$3,095,680	$3,095,680
Avoided Tipping Costs	$5,345,983	$9,928,863
Additional Equipment and Training Costs	($5,972,145)	($5,972,145)
Avoided Greenhouse Gas Emissions Damages	$7,633,409	$5,411,712
Avoided Sulfur Dioxide Emissions Damages	$86	$86
Commodity Value of Compost	$5,107,471	$0
Commodity Value of Electricity	$0	$10,102,957
Total Net Benefits	**$15,210,485**	**$22,567,152**
Note: Net benefits are defined as baseline costs minus policy costs, and are therefore presented as positive values.		

Table 8 presents net benefits for the first year of the potential legislation for each sector. As shown, food waste diversion by the retail sector is responsible for the vast majority of net benefits. Importantly, these estimates do not represent benefits that will accrue to entities in these sectors since some cost savings (e.g., avoided emissions, commodity values for electricity and compost) may accrue to other entities or to society as a whole. Potential distributional impacts are discussed in section 6.2.

Table 8. Net Benefits by Sector

Sector	Net Benefits (2016$)	
	All Compost	All AD
Institutions	$2,858,955	$4,136,572
Retail	$11,255,832	$16,765,413
Service & Hospitality	$1,095,966	$1,665,340

Notes:

Net benefits by sector do not sum to total net benefits in Table 7 due to rounding error resulting from running EPA's WARM separately for each sector.

Institutional sector includes colleges and universities, hospitals, nursing homes, and correctional facilities.

Retail sector includes wholesale facilities, big box stores, convenience stores, supermarkets, and supercenters.

Service and hospitality sector includes hotels/motels and restaurants.

5.1 Sensitivity Analyses

The BCA considers several sensitivity analyses of key variables. As described previously, two of these sensitivity analyses consider the highest cost scenario requiring every generator hauls food waste the maximum distance for compliance with the legislation (i.e., either 20 or 50 miles). These analyses likely overstate costs since many generators are located closer than 20 or 50 miles to a food waste recycling facility. The primary policy scenario discussed in section 4, for example, uses generator-specific hauling distances that average approximately 10 miles. As shown in Table 9, societal benefits still outweigh costs if every generator hauls waste 20 miles, although costs would outweigh benefits in the unlikely scenario that every generator hauls food waste 50 miles.

A second set of sensitivity analyses considers the impact of an increase in food donations. Although limited information is available on the extent donations are likely to increase, interviews with diversion program managers in other jurisdictions suggested that donations could increase by up to 40 percent, as was the case in Vermont. The BCA model assesses two donation scenarios, one in which retail facilities donate five percent of their food waste overall, and one in which retailers donate 10 percent. The model estimates these impacts by reducing the quantity of food waste sent from retailers to compost or AD facilities by five or 10 percent, while leaving baseline quantities unchanged. These scenarios assume the same generator-specific hauling distances from the primary policy scenario.

In the five percent scenario, 300 tons of food are donated each week (15,600 tons per year); in the 10 percent scenario, 600 tons of food are donated each week (31,200 tons per year). Based on an estimate of one meal per 1.2 pounds of food, this equates to more than 500,000 and a million meals each week in each scenario, respectively.[36] However, these are ambitious scenarios. Vermont, which has a population equal to approximately three percent of New York State's, saw approximately 500 tons of food waste donated in 2016.[37] As shown in Table 9, increasing the percentage of food donated increases net benefits substantially, as a result of avoiding the cost required to purchase these meals (assumed to be $1.47 per meal, in 2014 dollars, based on information from Vermont Foodbank).[38] Net benefits may be understated overall because the BCA does not model avoided environmental impacts associated with agricultural production of those meals. By one estimate, the prevention or recovery of one ton of food waste can have greenhouse gas benefits two to 10 times larger than food waste recycling.[39]

Table 9. Sensitivity Analysis Results

Scenario	Net Benefits (2016$)	
	All Compost	All AD
New Capacity (Primary) – hauling distances are generator-specific and average 10 miles	$ 15,210,485	$22,567,152
20-Mile Hauling Distance – hauling distance is 20 miles for every generator	$7,911,000	$15,267,668
50-Mile Hauling Distance – hauling distance is 50 miles for every generator	($13,433,525)	($6,076,858)
5% Food Donation – hauling distances same as Primary scenario	$55,021,646	$62,105,614
10% Food Donation – hauling distances same as Primary scenario	$94,840,378	$101,642,597
Note: Net benefits are defined as baseline costs minus policy costs, and are therefore presented as positive values.		

36 ReFED. "A Roadmap to Reduce U.S. Food Waste by 20 Percent." 2016.

37 Vermont Foodbank. "Universal Recycling Law Boosts Fresh Food Donations." Available here: https://www.vtfoodbank.org/2016/09/universal-recycling-law-boosts-fresh-food-donations.html

38 Ibid.

39 ReFED. "A Roadmap to Reduce U.S. Food Waste by 20 Percent." 2016.

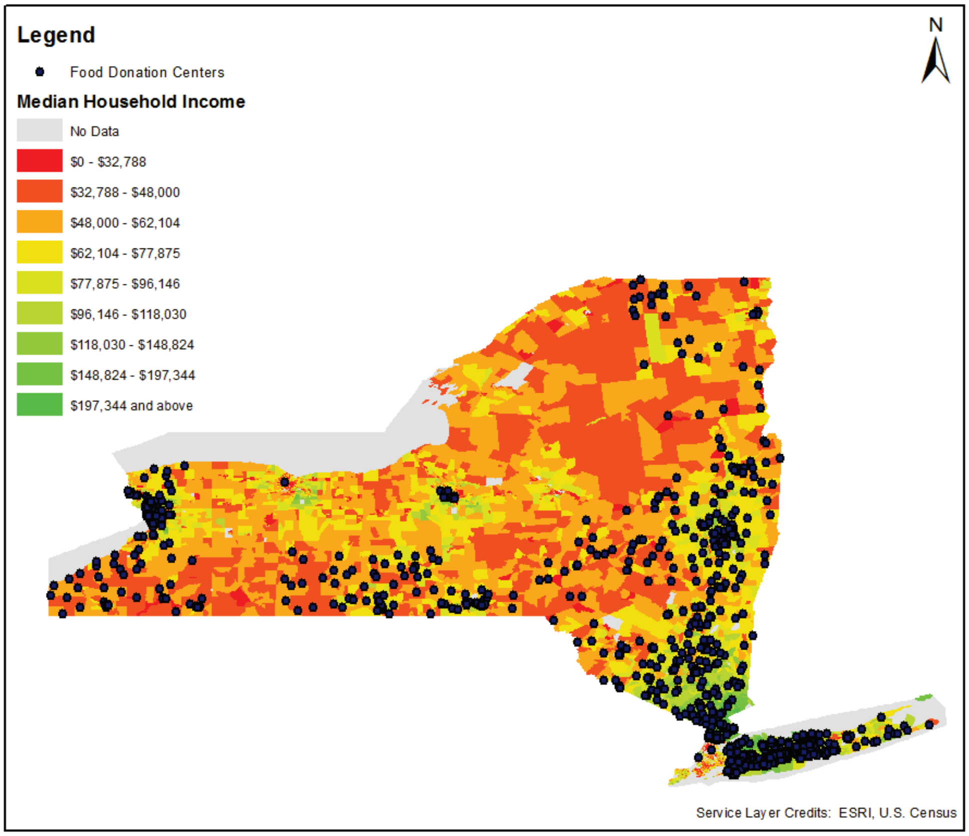
6 Distributional Impacts and Considerations

Food waste diversion legislation may have other benefits not captured in the analyses above. Several of these benefits have been noted in the preceding discussion as limitations of the analysis, while others may be inherently difficult to monetize. In particular, food donation may lead to significant societal benefits by increasing the quantity and quality of food moving through the donation system, and by reducing the number of food insecure individuals in New York State. In addition, generators may benefit from the estimated cost savings, as well as those associated with renegotiating nonfood waste hauling contracts. The potential for such benefits is described qualitatively in sections 6.1 and 6.2, respectively.

6.1 Societal Benefits from Food Donation

For some types of pre-consumer food waste, donation to food banks, food pantries, and soup kitchens are a viable food waste diversion method. Because food donation simultaneously helps address problems associated with food insecurity, donation is preferable to composting or anaerobic digestion. As shown in Figure 5, many food donation centers are located outside of urban areas or in areas with relatively low median household incomes. Residents of these areas may therefore be at greater risk of food insecurity and could benefit from donations of high-quality, fresh food. The scale of the food waste problem overall also suggests that the potential societal benefits of donations are large. As previously described, if donations of pre-consumer food waste from retail facilities increase to five percent overall, food donation centers would receive more than 500,000 meals per week. At 10 percent, food donation centers would receive a million meals per week.

Figure 5. Food Donation Centers and Median Household Income



6.2 Potential Generator Cost Savings

Costs or cost savings that may accrue to generators are likely to be of interest to policymakers and, in particular, to potentially affected facilities. Although this BCA focused on estimating net benefits to society as a whole, some information is available to quantify potential cost savings to generators. Consideration of these costs includes:

- Analysis of those cost and benefit categories estimated in the primary analysis in sections 3 and 4 that are likely to accrue directly to generators. These include equipment and training costs, and hauling and tipping cost savings.
- Estimation of additional cost savings. Interviews with food waste diversion program managers from jurisdictions that already implemented diversion requirements noted the potential for businesses to achieve cost savings through reducing hauling frequency for nonfood waste or preventing food waste through reduced purchases. Cost savings associated with less frequent nonfood waste collection can be estimated using evidence from case studies of commercial food waste diversion in Massachusetts and the same hauling cost per mile used in the primary analysis. No information is available to estimate cost savings from food waste prevention.

This section estimates such cost savings for the "average" generator in each sector.

The analysis first considers costs and cost savings as previously estimated. Assuming that all hauling and tipping costs pass through to generators, generator cost savings can be estimated as the difference between average hauling and tipping costs in the baseline, and average hauling and tipping costs, minus increased equipment and training costs, in the policy scenario. This calculation alone yields annual cost savings for the average generator in each sector ranging from almost $400 for a generator in the service and hospitality sector under the compost policy scenario, to more than $4,500 for an institutional generator in the AD policy scenario.

The analysis then considers additional cost savings that could accrue from reducing nonfood waste collection frequency. According to anecdotal information from food waste program managers, such savings can be important to businesses, although they may wait several months before renegotiating nonfood waste contracts to ensure their new food diversion system is successful. Data quantifying these savings are limited, however. Case studies of two hotels in Massachusetts suggest those facilities were able to reduce nonfood waste collection frequency from once or twice per week to "on-call service." In one of these cases, on-call collection occurred approximately once per month.[40] To estimate hauling cost savings, this analysis assumes that:

- Food waste accounts for 22 percent of commercial waste, as it does in New York City.[41]
- Generators wait six months before renegotiating nonfood waste hauling contracts.
- After renegotiating contracts, generators move to one collection per month.
- The cost of hauling nonfood waste is $4 per vehicle mile (same as the cost of hauling food waste, as estimated in the baseline and policy scenarios).

First-year cost savings associated with renegotiating nonfood waste hauling contracts after six months range from approximately $100 to $200 for the average generator in each sector.

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40 Devens Eco-Efficiency Center and the Center for EcoTechnology. "A Case Study: The Great American Grill at the Hilton Garden Inn Devens Commons." Available here: http://www.ecostardevens.com/Hilton_Case_Study%20v2.pdf; and RecyclingWorks Massachusetts. "Food Materials Composting Program Case Study: The Lenox Hotel." Available here: http://recyclingworksma.com/wp-content/uploads/2016/06/Lenox-Hotel-Written-Case-Study.pdf

41 NYC Department of Sanitation. "2015 Regional Composting and Conversion Capacity Study." 2015. (2)

The results of this analysis, incorporating both cost savings estimated in the primary analysis and additional cost savings associated with renegotiating nonfood waste hauling contracts, are shown in Table 10 for the average generator in each sector. If the average cost savings from contract renegotiation were applied to each of the 1,694 generators included in the primary analysis in sections 3 and 4, total net benefits could increase by approximately one to two percent.

Table 10. Cost Savings for Average Generator in Each Sector

Sector	Characteristics of Average Generator	First Year Cost Savings (2016$)	
		All Compost	All AD
Institutions	• 4.2 tons food waste per week • 15 tons nonfood waste per week • 28.7 miles from landfill	$2,320 • $2,148 from primary analysis • $172 from renegotiation	$4,740 • $4,568 from primary analysis • $172 from renegotiation
Retail	• 5.2 tons food waste per week • 18.3 tons nonfood waste per week • 28.3 miles from landfill	$1,654 • $1,447 from primary analysis • $207 from renegotiation	$4,602 • $4,395 from primary analysis • $207 from renegotiation
Service & Hospitality	• 3.1 tons food waste per week • 10.9 tons nonfood waste per week • 23.8 miles from landfill	$495 • $391 from primary analysis • $104 from renegotiation	$2,260 • $2,156 from primary analysis • $104 from renegotiation

Notes:

Institutional sector includes colleges and universities, hospitals, nursing homes, and correctional facilities.

Retail sector includes wholesale facilities, big box stores, convenience stores, supermarkets, and supercenters.

Service & hospitality sector includes hotels/motels and restaurants.

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Appendix A – Food Waste Generation by Facility Type and County

County	Sector	Number of Generators	Estimated Food Waste (tons/week)
Albany	Institution	11	59
	Retail	50	191
	Service & Hospitality	16	50
Allegany	Institution	2	7
	Retail	4	11
	Service & Hospitality	0	0
Broome	Institution	8	37
	Retail	22	85
	Service & Hospitality	3	5
Cattaraugus	Institution	3	11
	Retail	10	56
	Service & Hospitality	5	21
Cayuga	Institution	3	12
	Retail	4	20
	Service & Hospitality	0	0
Chautauqua	Institution	3	13
	Retail	18	119
	Service & Hospitality	4	30
Chemung	Institution	6	19
	Retail	14	45
	Service & Hospitality	4	7
Chenango	Institution	1	2
	Retail	2	5
	Service & Hospitality	0	0
Clinton	Institution	4	29
	Retail	11	41
	Service & Hospitality	1	2
Columbia	Institution	2	6
	Retail	6	18
	Service & Hospitality	0	0
Cortland	Institution	2	11
	Retail	7	24
	Service & Hospitality	0	0
Delaware	Institution	1	4
	Retail	5	12
	Service & Hospitality	0	0

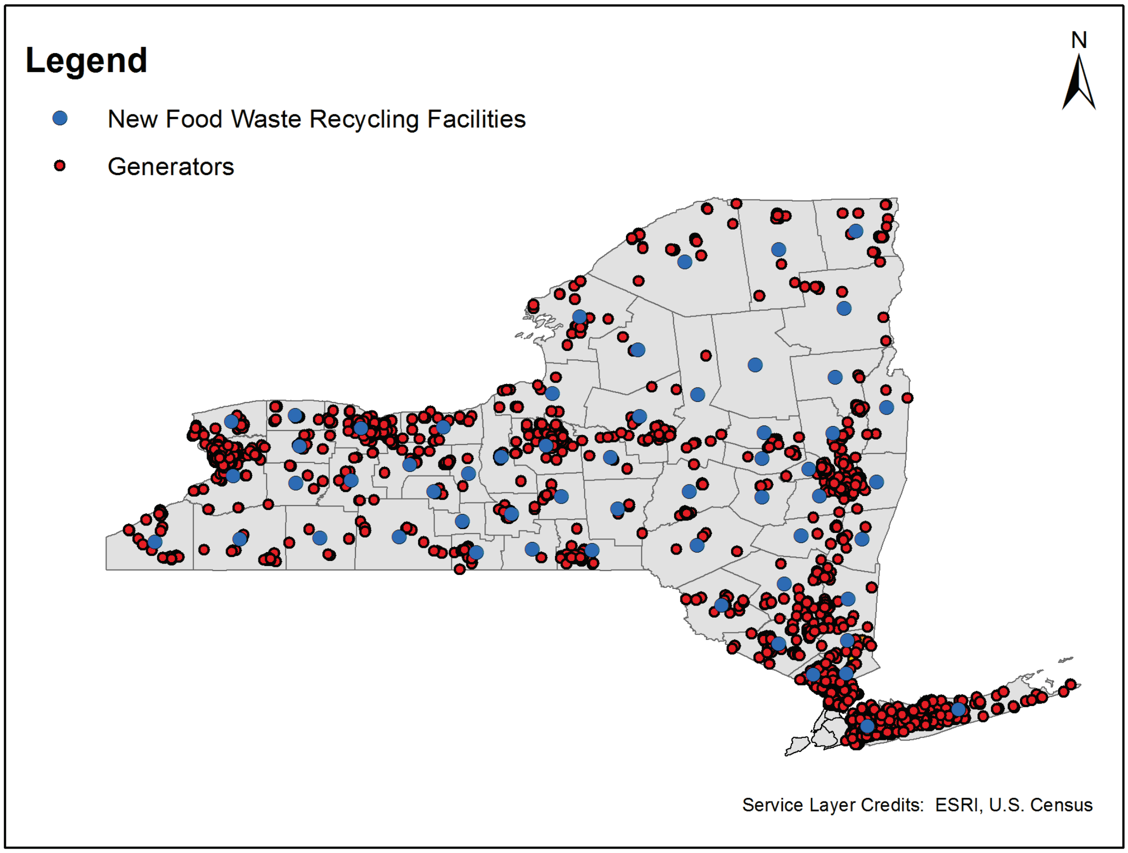
County	Sector	Number of Generators	Estimated Food Waste (tons/week)
Dutchess	Institution	12	56
	Retail	22	76
	Service & Hospitality	2	4
Erie	Institution	25	124
	Retail	112	786
	Service & Hospitality	25	66
Essex	Institution	1	2
	Retail	6	16
	Service & Hospitality	6	14
Franklin	Institution	4	18
	Retail	5	26
	Service & Hospitality	0	0
Fulton	Institution	1	2
	Retail	8	53
	Service & Hospitality	0	0
Genesee	Institution	1	2
	Retail	10	100
	Service & Hospitality	0	0
Greene	Institution	2	9
	Retail	5	15
	Service & Hospitality	0	0
Herkimer	Institution	0	0
	Retail	5	15
	Service & Hospitality	1	4
Jefferson	Institution	4	11
	Retail	21	69
	Service & Hospitality	3	5
Lewis	Institution	0	0
	Retail	4	51
	Service & Hospitality	0	0
Livingston	Institution	4	16
	Retail	6	83
	Service & Hospitality	0	0
Madison	Institution	2	8
	Retail	6	20
	Service & Hospitality	0	0
Monroe	Institution	17	98
	Retail	73	403
	Service & Hospitality	18	47
Montgomery	Institution	1	3
	Retail	7	41
	Service & Hospitality	0	0

County	Sector	Number of Generators	Estimated Food Waste (tons/week)
Nassau	Institution	31	138
	Retail	97	566
	Service & Hospitality	20	52
Niagara	Institution	7	16
	Retail	17	69
	Service & Hospitality	5	13
Oneida	Institution	12	38
	Retail	30	133
	Service & Hospitality	4	63
Onondaga	Institution	15	76
	Retail	67	381
	Service & Hospitality	21	46
Ontario	Institution	4	8
	Retail	12	35
	Service & Hospitality	3	6
Orange	Institution	8	25
	Retail	47	231
	Service & Hospitality	4	9
Orleans	Institution	2	8
	Retail	9	32
	Service & Hospitality	0	0
Oswego	Institution	2	12
	Retail	12	30
	Service & Hospitality	0	0
Otsego	Institution	4	16
	Retail	7	20
	Service & Hospitality	1	4
Putnam	Institution	1	4
	Retail	4	16
	Service & Hospitality	0	0
Rensselaer	Institution	6	21
	Retail	14	67
	Service & Hospitality	0	0
Rockland	Institution	8	22
	Retail	24	99
	Service & Hospitality	5	16
Saint Lawrence	Institution	8	28
	Retail	9	57
	Service & Hospitality	0	0
Saratoga	Institution	6	21
	Retail	23	150
	Service & Hospitality	3	8

County	Sector	Number of Generators	Estimated Food Waste (tons/week)
Schenectady	Institution	5	13
	Retail	15	98
	Service & Hospitality	3	6
Schoharie	Institution	1	3
	Retail	2	7
	Service & Hospitality	1	3
Schuyler	Institution	0	0
	Retail	2	5
	Service & Hospitality	1	7
Seneca	Institution	1	3
	Retail	1	3
	Service & Hospitality	0	0
Steuben	Institution	1	2
	Retail	13	108
	Service & Hospitality	0	0
Suffolk	Institution	32	150
	Retail	144	640
	Service & Hospitality	17	44
Sullivan	Institution	3	7
	Retail	12	63
	Service & Hospitality	1	4
Tioga	Institution	0	0
	Retail	1	2
	Service & Hospitality	0	0
Tompkins	Institution	4	41
	Retail	10	48
	Service & Hospitality	2	5
Ulster	Institution	10	34
	Retail	24	115
	Service & Hospitality	5	24
Warren	Institution	1	5
	Retail	12	42
	Service & Hospitality	3	14
Washington	Institution	1	6
	Retail	2	8
	Service & Hospitality	0	0
Wayne	Institution	0	0
	Retail	18	145
	Service & Hospitality	0	0
Westchester	Institution	33	119
	Retail	87	434
	Service & Hospitality	14	40

County	Sector	Number of Generators	Estimated Food Waste (tons/week)
Wyoming	Institution	2	14
	Retail	4	12
	Service & Hospitality	0	0
Yates	Institution	1	3
	Retail	2	4
	Service & Hospitality	0	0
Total		**1,694**	**8,012**

Appendix B – Assumed Locations of New Food Waste Recycling Facilities (County Centroids)



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