Following the Waste Stream:

A Sustainability Comparison of Two Cities' Waste Streams

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Abstract

This research project was based on the waste streams from the neighboring cities of Saco and Biddeford, and focused on their associated environmental and social impacts. The two cities are chosen for their geographic, demographic, and waste management option similarities. Although the cities are similar, their approaches to waste management have differing environmental and social impacts associated with local and downstream activities. The waste stream for household waste from each city was followed from waste collection and transport, to incineration, to ultimate disposal at a landfill. Recycling was followed from collection to processing. Environmental impacts focus on quantifying energy consumption/savings and greenhouse gas emissions/avoidance factors resulting from each waste stream. Social impacts are evaluated on the presence and operations of activities related to the waste streams. It was found that Saco's waste stream had greater positive environmental impacts while avoiding social drawbacks, primarily associated with a higher recycling rate, chosen waste management methods, and selected downstream service providers.

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Table of Contents

List of Tables

List of Figures

1. Introduction

1.1 Purpose

Saco and Biddeford Maine, located in the southern coastal area of the state, are known as the "Twin Cities." As the former industrial center of Maine, the sister cities produced textiles and other products that were sold to domestic and international markets, and, together, underwent similar economic downturns with the closing of several mills. The Saco River divides the urban areas of these two cities which are bound by linked Main Streets. Demographically, the cities are very similar. The waste streams of Saco and Biddeford offer a unique case study where shared history, location, and regulatory environment, as well as matching waste management options, provide the opportunity to compare and contrast the benefits and drawbacks of two systems consisting of similar components – collection, transportation, incineration, ash disposal, and recycling – but offer different approaches.

Today's development focus is on sustainability that addresses environmental, social, and economic responsibilities. This broad scope of concerns has reached waste management, pushing it beyond a civic service to a key component in achieving sustainability goals. Local, federal, and international organizations display ongoing and increasing efforts to characterize and improve waste management systems to minimize environmental and social impacts. The focus of this paper is on the environmental and social impacts surrounding the management of these two waste streams.

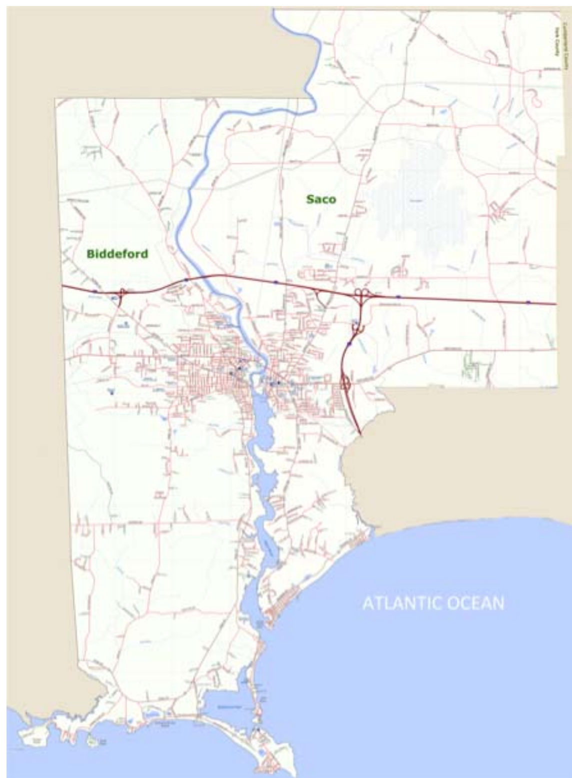


Figure 1: Map of Saco and Biddeford

This paper will offer an overview and compare aspects of the residential solid waste and recycling streams for Saco and Biddeford. To date, no comprehensive sustainability overview of the waste stream emanating from the "Twin Cities" area has been conducted. This is a first attempt at providing a sustainability perspective that is broad and includes a whole system consideration of environmental and social impacts of waste and recycling for materials originating in these two cities. The research is presented in a comparative manner with the purpose of highlighting the advantages and drawbacks of the differing waste management approaches, leading to the identification of opportunities for further consideration and improvement across environmental and social realms. The application for this research is aimed at the local level, to raise awareness among communities and decision-makers, and at a broader audience to encourage further research into the local considerations and decision making processes that influence the sustainability of waste management.

1.2 Scope

Boundaries of research

The scope of this study is limited to residential waste and recyclables for Saco and Biddeford in 2009 and excludes bulky items, hazardous waste, and scrap metal. Exclusions are made based on intermixed commercial wastes and special handling requirements for these materials, maintaining a focus on everyday residential waste. For waste, the process scope includes collection, transport to waste-to-energy-plant, incineration, and ash transport to landfill. For recyclables, discussion has been limited to collection due to a lack of data regarding transportation and the challenge of tracking the widespread distribution of materials beyond processing facilities.

Limitations to the research presented here include lack of actual data in some cases and the use of average case numbers. In the discussion of social impacts, information is gathered from public records, media sources, and direct observation, which may not provide a in-depth analysis of complex issues. However, the author has strived to provide a broad overview of the two waste streams and their impacts in as accurate a manner as possible in order to promote further discussion and analysis that will lead toward the achievement of greater levels of sustainability.

Environmental Impacts

Environmental impacts discussed include energy and greenhouse gas emissions.

Energy– For each waste stream, the impact to the environment is assessed based on resource consumption and recovery covering the following aspects:

- energy expended in the collection and transportation of municipal waste and ash
- energy recovered through recycling
- energy recovered through combustion

Greenhouse Gas Emissions – For each waste stream, direct and indirect greenhouse gas emissions are calculated based on:

- emissions by the municipality or contracted hauler in the collection and transportation of municipal waste to processing facilities[1]
- emissions related to ash transport
- avoided emissions resulting from combustion at waste-to-energy plants
- avoided emissions resulting from recycling based on collected recyclables mix

[1] Fuel from the transport of recyclables are not included due to the inability to quantify related fuel consumption in Biddeford as recyclables are transported by residents' individual vehicles.

Social impact scope

For each waste stream, social impacts discussed will include those related to the presence and operations of the waste management system and related facilities. System and related facilities impacts will be discussed including:

- visual presence
- odor
- noise
- other potential impacts and perceived risks

1.3 Background

Description of waste streams

Saco contracts the collection of municipal solid waste and recyclables to an outside service provider, Blow Brothers Industry (BBI). All residents are provided waste and recyclables rolling containers, which are placed on the sidewalk for collection. BBI dispatches separate waste and recyclables collection trucks equipped with driver-operated automated lift arms that grab the bins, empty materials into the truck, and replace the bins on the sidewalk. Recyclables are collected in a single stream method in which all materials are comingled in one container. Both waste and recyclables are collected from residences on the same day, on a weekly schedule. Both types of materials are transported to EcoMaine, a municipality-owned waste-to-energy (WTE) plant and recycling center. Waste is dumped directly onto the tipping floor of the mass burn facility with no processing prior to combustion. Waste is combusted, producing electricity and ash, which is transported to an ashfill site. Recyclables are processed at EcoMaine's abutting recycling center where materials are sorted along a series of manual and automated systems. Recyclable materials include cardboard, paper, metal cans, glass, and plastics #1–7. Sorted materials are baled and marketed.

Biddeford handles its own waste collection and recyclables processing. Trash bags of household waste are placed on the sidewalk by residents for collection. Bags are collected by packer trucks that employ one driver and two "packers". Waste is transported to the tipping floor of privately-owned Maine Energy Recovery Company (MERC), located in Biddeford, for combustion. MERC is a refuse derived fuel (RDF) waste-to-energy plant that processes waste prior to combustion by grinding materials into small pieces prior to combustion. Waste is combusted and the resulting ash is transported to a landfill site.

Biddeford's collection of recyclables is dependant upon transportation to the Biddeford Public Works Recycling Center by residents who sort recyclables into individual containers. Recyclable materials include cardboard, paper, metal cans, glass, and plastics #1–2. Materials are baled with minimum manual sorting and quality control by public works employees, and then marketed.

Primary differences between the management of the two waste streams include:

- Waste and recyclables collection methods
- Incineration service providers and associated ashfills
- Range of recyclables accepted

2. Approach

The research for this case study was performed through numerous methods. Literature on waste management in general was reviewed to gain a broad perspective of waste streams and issues today. Comparative studies on waste management studies were also reviewed. Following a literature review of journal articles and industry publications, data regarding 2009 waste and recyclables collection was collected from the public works departments of both Saco and Biddeford. Each city provided collection tonnage, fuel consumption related to waste collection, and cost data. BBI provided fuel consumption for Saco. Semi-formal interviews were conducted with the director of public works for Biddeford, and the recycling coordinator for Saco to gain an overall perspective of each city's waste management systems. First-hand information was gathered from a tour of EcoMaine's waste-to-energy facility, and observations were made in the two cities. An informal interview with an environmental specialist at EcoMaine provided information on facility's waste-to-energy, recycling, and landfilling services. Additional data and information was obtained through correspondence with the organization's environmental manager. Attempts to gather first-hand information from MERC were unsuccessful. Therefore, information was gathered through a review of public records and media sources. Demographic information was obtained through an online source based on U.S. Census information. Maps and travel routes were produced from publicly available sources. Greenhouse gas and energy calculations utilized data on actual fuel consumption, historical incineration efficiency, as well as published average case numbers from the U.S. Environmental Protection Agency and Energy Information Administration. Information was consolidated to provide an environmental and social impact overview for the two waste streams.

3. Results and Discussion

3.1 Environmental Impacts

Research on the environmental impacts of the Saco and Biddeford waste streams is focused on energy and greenhouse gas emissions. These two issues have received priority from state and federal government entities. The State of Maine's Governor's Office of Energy Independence and Security is planning steps to achieve energy independence while reducing greenhouse gas emissions (2006). In 2009, President Obama signed an executive order focused on federal leadership in creating a clean energy economy that demonstrates a commitment to reducing emissions (Office of the Press Secretary, 2009), defining the development approach for the country. Within this context, it becomes important for municipalities to understand the impacts of their operations in order to drive development of improved solutions. Following is a discussion of energy and greenhouse has emissions associated with the two waste streams.

Energy

Waste collection and transportation

Energy is consumed along the waste stream in the form of fuel during the collection and transportation of residential waste, recyclables, and ash. BBI reported that it consumed 9,100 gallons of fuel in the collection and delivery of waste to EcoMaine in 2009. Biddeford Public Works reported 10,130 gallons of fuel use during the same period for collection and delivery to MERC. Although Saco's waste is transported 13 (mostly highway) miles to EcoMaine as opposed to the approximate 0.1 miles to Biddeford's waste travels to MERC, Biddeford provided collection service to more households and handled more waste, leading to higher fuel consumption. It should also be noted that waste collection trucks consume the most fuel during stop-and-go collection, and that route efficiency as well as truck fuel consumption averages vary, factors that impact overall fuel consumption.

Although less fuel was consumed overall in the handling of Saco's waste, it can be seen that on a per capita and per ton of waste input, more energy was consumed for collection and transportation to EcoMaine's incineration facility than was consumed on behalf of Biddeford for waste transport to MERC. Energy expended per ton of input waste for Saco is 27% higher, and can be attributed to the additional distance waste travels from the city.

Following combustion, the remaining material, bottom and fly ash, is transported to landfill facilities for final disposal. Estimates on the percentage of original mass that remains following incineration range from 15–35%. For the purposes of this study, 20% is utilized. Data was not available for fuel consumption related to ash transport. Therefore, the energy consumption factor for the transport of ash is drawn from a life cycle analysis of fly ash published by the EPA.

Ash from Saco's waste is transported 2.5 miles to EcoMaine's ashfill. Ash from Biddeford's waste is trucked 162 miles to the Juniper Ridge Landfill. As with waste collection and transport, travel distance is the major factor contributing to energy consumption. Minimal energy was consumed in the transport of Saco's ash, whereas the transport of Biddeford's ash is a large contribution to overall energy consumption. However, consolidated energy consumption numbers reveal that, overall, Saco expended nearly 14% more energy per capita, and nearly 9% more per input ton of waste.

Table 1: Transport Energy Impacts

2009 WASTE COLLECTION AND TRANSPORT ENERGY CONSUMPTION

City	Diesel (gallons)	Total Energy Consumed (million BTU)	Total Energy Consumption (kWh equivalent)	Energy Consumption Per Capita (kWh)	Energy Consumption Per Ton Input Waste (kWh)
Saco (EcoMaine)	9,100	1,265	370,706	20.33	74.7
Biddeford (MERC)	10,130	1,408	412,665	18.70	54.3

2009 ASH TRANSPORT ENERGY CONSUMPTION

City	Ash Produced (tons, assumes 20% of input)	Miles to Landfill	Transportation Combustion Energy, Diesel Fuel (million Btu/ton-mile)*	Total Energy Consumption (million BTU)	Total Energy Consumption (kWh equivalent)	Energy Consumption Per Capita (kWh)	Energy Consumption Per Ton Input Waste (kWh)
Saco (EcoMaine)	991.914	2.5	0.0015	4	1,090	0.06	0.2
Biddeford (Juniper Ridge)	1519.586	162	0.0015	369	108,219	4.90	14.2

*Drawn from Fly Ash Transportation Energy factor from *Background Document for Life-Cycle Greenhouse Gas Emission Factors for Fly Ash Used as a Cement Replacement in Concrete*

2009 TOTAL TRANSPORT ENERGY CONSUMPTION

City	Total Energy Consumption (million BTU)	Total Energy Consumption (kWh)	Energy Consumption Per Capita (kWh)	Energy Consumption Per Ton Input Waste (kWh)
Saco	**1,269**	**371,796**	**20.39**	**75.0**
Biddeford	**1,777**	**520,884**	**23.60**	**68.6**

Recycling

Recycling is the most effective way to reclaim energy from material as remanufacturing reduces the need for energy required in the extraction and processing of virgin materials. Recycling provides energy savings, the significance of which is dependant upon the material and available technology. The U.S. EPA has determined the average case life cycle energy savings from the recycling of materials, and these numbers were used to calculate the savings associated with Saco and Biddeford's recycled materials.

Recycling rates between the two cities differed considerably in 2009, with Saco recycling 26.5% of its residential waste, and Biddeford only recycling 6.8%. These figures exclude scrap metal for reasons stated in the scope of this paper. The energy saved from materials collected shows that Biddeford's material mix had somewhat higher energy savings per ton, but Saco recycled more than 2.5 times the material of Biddeford. Per capita, Saco saved more than 3 times the amount of energy due to recycling. The energy implications of this are significant to the overall energy outlook of the waste streams.

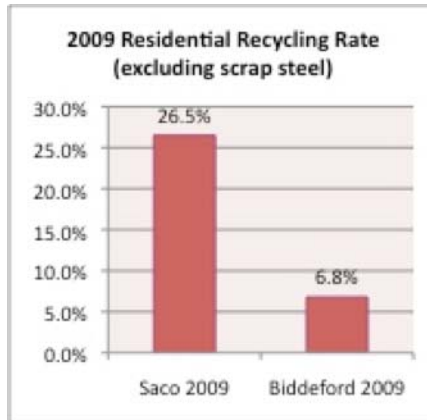


Figure 2: Recycling Rates

Table 2: Recycling Energy Savings

2009 Recycling Energy Savings Comparison

Commodity	Total Tonnage	EPA Energy Savings Factor (million BTU/ton)*	Energy Savings (million BTU)	Total Energy Savings (kWh)	Energy Savings Per Capita (kWh)	Energy Savings Per Ton Input Recyclables (kWh)
SACO						
Newspaper	1,017.41	16.49	16777	4,916,880		
Office Paper	11.08	10.08	112	32,732		
Aluminum	2.65	206.42	547	160,314		
Cardboard	386.68	15.42	5963	1,747,467		
HDPE Milk Jugs	15.32	50.9	780	228,533		
PET #1 Plastic	14.26	52.83	753	220,787		
HDPE Mixed #2 Plastic	15.47	50.9	787	230,771		
Mixed #3-#7 Plastic	17.48	56.01	979	286,933		
Steel Cans	37.29	19.97	745	218,245		
Glass	63.93	2.13	136	39,908		
Mixed Metal	8.93	19.97	178	52,264		
SACO TOTAL	1,590.50	501.12	**27757**	**8,134,833**	**446**	**4554**
BIDDEFORD						
Newspaper	264.06	16.49	4354	1,276,134		
Office Paper	15.40	10.08	155	45,494		
Aluminum	1.67	206.42	345	101,028		
Cardboard	267.21	15.42	4120	1,207,564		
HDPE Milk Jugs	4.48	50.9	228	66,830		
PET #1 Plastic	3.95	52.83	209	61,158		
HDPE Mixed #2 Plastic	7.00	50.9	356	104,421	**134**	**4951**

Steel Cans	13.34	19.97	266	78,074		
Glass	19.25	2.13	41	12,017		
BIDDEFORD TOTAL	596.36	**425.14**	**10075**	**2,952,719**		

*Drawn from *Management of Selected Materials in Municipal Solid Waste*, EPA

Combustion energy recovery
Saco and Biddeford's waste is transported to waste-to-energy plants that incinerate waste to reduce volume and recover energy to produce electricity. Energy recovery based on 2009 waste tonnage delivered to the two facilities is calculated below. It should be noted that RDF facilities tend to produce more energy per ton of input waste. EcoMaine's recovery rate is based on an average rate for the period spanning 2007–2009. Data was not available for MERC; therefore, the average case rate for RDF facilities published by the EPA is used. A more accurate calculation would be possible with actual average energy recovery rate data from MERC. As the table shows, energy recovery from combustion is more significant in the case of Biddeford's waste stream.

Table 3: Combustion Energy Recovery

2009 Combustion Energy Recovery Comparison				
City (WTE Facility)	**Combusted Waste (ton)**	**Combustion Facility Average Energy Recovery Rate* (kWh/ton)**	**Total Energy Recovered through Combustion (kWh)**	**Energy Recovered Per Capita (kWh)**
Saco (EcoMaine)	4,959.57	532	**2,638,491**	**145**
Biddeford (MERC)	7,597.93	572	**4,346,016**	**197**
*EcoMaine's recovery rate is based on an average rate of recovery for the period spanning 07-09. The rate for MERC is based on EPA's published average for RDF facilities.				

SUMMARY
Consolidation of the above figures provides a comprehensive look at the energy implications of Saco and Biddeford's waste streams. It is shown that Saco's total energy savings and per capita savings far exceeded those of Biddeford's waste stream, primarily due to Saco's higher recycling volume.

Table 4: Total Waste and Recycling Energy Impacts

2009 TOTAL WASTE AND RECYCLING ENERGY IMPACTS (kWh)								
City	Waste Transport	Energy Recovered, Combustion	Ash Transport	Recycling	TOTAL ENERGY SAVINGS (kWh equivalent)	# of Maine Households Annual Power Usage Equivalent*	Total Energy Savings Per Capita	Total Energy Savings per Ton Input Waste
Saco	-370,706	2,638,491	-1,090	8,134,833	**10,401,528**	**1664**	**571**	**1588**
Biddeford	-412,665	4,346,016	-108,219	2,952,719	**6,777,851**	**1084**	**307**	**827**

*The average Maine household consumes 6,252kWh of power annually
(Source: http://www.eia.doe.gov/ask/electricity_faqs.asp)

Greenhouse Gas Emissions

Greenhouse gas emissions are recognized for their contribution to climate change; therefore, they should be mitigated to the extent possible. The burning of fossil fuels in the handling and transport of waste contributes to emissions in the atmosphere; recycling and waste-to-energy are acknowledged for providing net avoided emissions through replacement of virgin resources. This section will explore greenhouse gas emissions associated with Saco and Biddeford waste streams. Calculations are made from the waste generation standpoint and expressed in carbon dioxide equivalents.

Transportation

For each waste stream, gas emissions from the collection and transportation of municipal waste to incineration facilities are calculated based on actual fuel consumption. Emissions resulting from transport of ash from the incineration facility to the landfilling facility are calculated utilizing the published EPA emissions factor for the transport of fly ash. Calculations for transport of ash assume ash equals 20% of original mass of input waste. Emissions factors are expressed per ton of input waste.

Following calculations, it is evident that the collection and transport of waste to the incineration facility represents the greater source of emissions. Based on these calculations, the additional distance Saco's waste is transported to EcoMaine results in greater overall emissions, despite the short distance ash is transported to the landfill. However, numerous factors could impact these results including trucking efficiencies and incinerator outputs. If ash output is more than 20%, ash from Biddeford's waste stream could potenially contribute proportionately greater emissions due to the longer distance ash is transported. For instance, 30% ash output places Biddeford's total transport emissions above Saco's. A more accurate calculation could be derived from actual fuel use.

Combustion and Recycling
Waste combustion and recycling are recognized for their contribution to *avoided* greenhouse gas emissions. For Saco and Biddeford's waste stream, avoided emissions were calculated for combustion based on the EPA's published factors for mass burn and RDF waste-to-energy facilities. According to the EPA, net avoided emissions at mass burn facilities are higher than RDF facilities. Therefore, Saco's waste sent to EcoMaine, a mass burn facility, is responsible for more avoided emissions per ton.

Avoided emissions were calculated based on actual collected recyclables mix and published EPA emissions factors. Recycling provides a greater avoided emissions benefit over combustion. Due to Saco's higher rate of recycling, the city's waste stream provided significantly more avoided emissions per ton of combined waste and recyclables input. Calculation details are provided in the Appendix.

SUMMARY
A summary table of emissions provides a system perspective on the sources of emissions. Negative values represent avoided emissions. The table illustrates that recycling provides by far the greatest overall benefits to the waste stream.

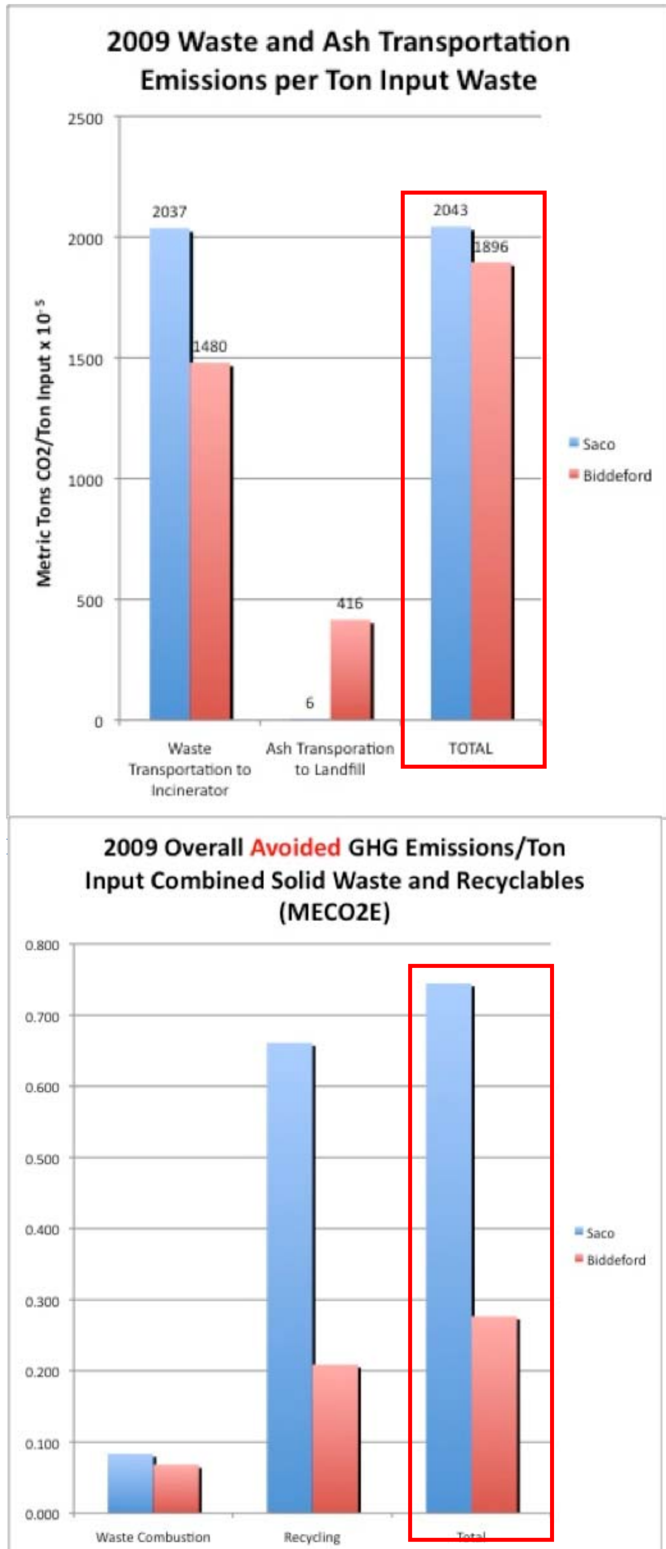


Figure 3: Avoided Emissions from Combustion and Recycling

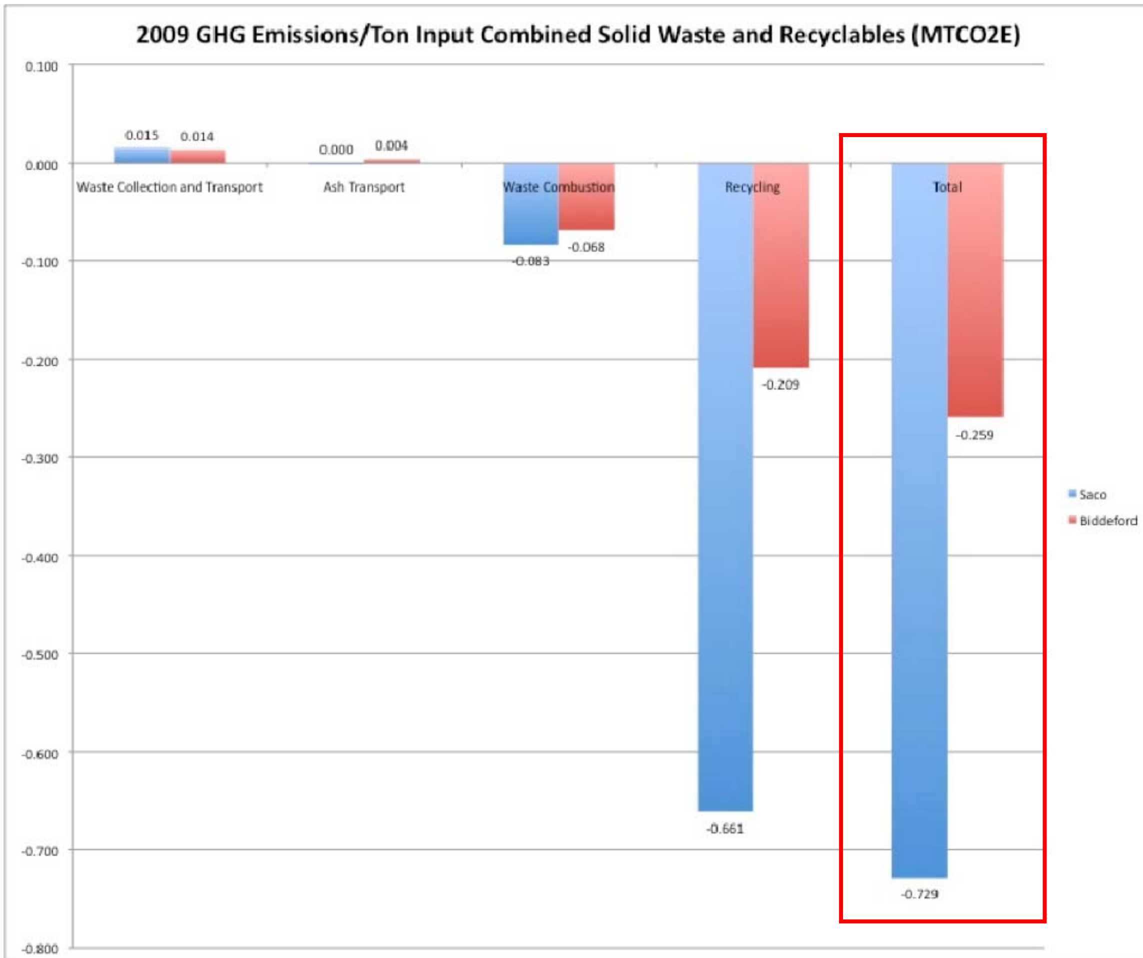


Figure 4: Consolidated Greenhouse Gas Emissions Impacts

3.2 Social Impacts

Social impacts can be difficult to quantify. However, the research below presents researched and observed indicators of these impacts. At the city level, discussed impacts can be directly attributed to each city's own waste and recyclables. Moving downstream to incineration and landfilling facilities, impacts are discussed in broader terms. At those stages, it would be impossible to attribute impacts specifically to waste or recyclables generated in Saco or Biddeford; however, as part of the larger scope of impacts related to these facilities, the stance is taken that the cities' waste streams contribute to those broader impacts.

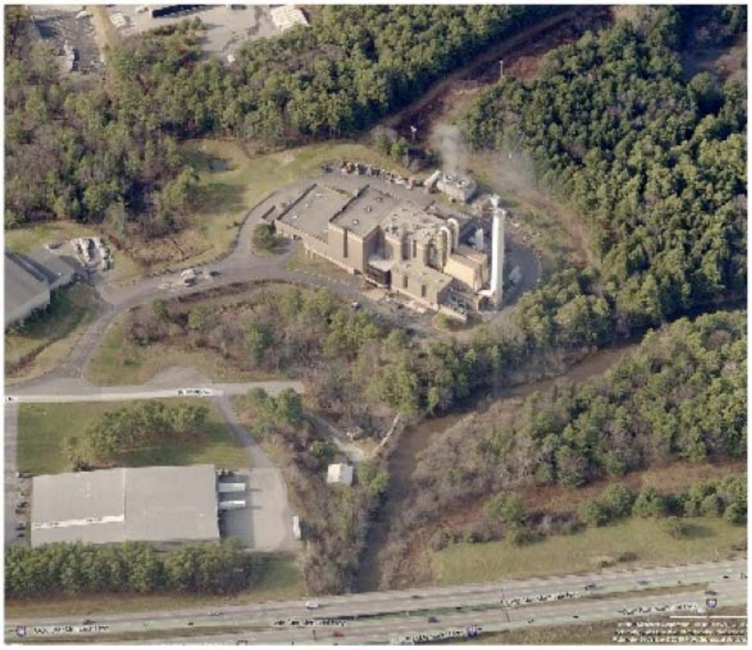
Visual Presence

<u>Collection</u>–Saco residents utilize rolling containers for their waste and recyclables. Uniform containers provide a neat, clean appearance and are less likely to be tipped over or torn apart by animals, reducing litter potential. Biddeford residents place trash bags directly on sidewalks and have a disorganized appearance. Some piles are bulky and can interfere with sidewalk clearances.

<u>Incineration</u>– Saco's waste and recycling is processed at EcoMaine, which is visible from the interstate, but due to its location in an industrial area and a surrounding tree buffer, does not present a strong visual presence. MERC, Biddeford's waste incinerator, is located at the heart of the Saco-Biddeford urban area. It is the tallest structure in downtown Biddeford, visible from Main Street, and is neighbor to many residences and businesses, including those located in nearby redeveloped mills.

Figure 5: Images from Trash Day

EcoMaine Location



MERC Location

Figure 6: Incinerator Locations

<u>Landfill</u>– EcoMaine states that its landfill in South Portland facility is "virtually undetectable and unknown to the population around us" (EcoMaine, 2010), a claim backed up by the lack of negative media and one 2009 newsletter from the State Planning Office described the facility as "not in sight."(Maine State Planning Office , 2009). On the other hand, media reports suggest the Juniper Ridge landfill in Old Town has a negative visual impact. It is known for its "onerous presence" (Haskell, Big expansion at Old Town landfill sought , 2009) and is reputed to be the "highest point in town" (Dolan, 2010).

Odor

<u>Collection</u>– For waste collection, covered containers help mitigate odor and health concerns (Pitchel, 2005). Odors from waste are minimized by closed lids on Saco's rolling containers. In Biddeford, odor is a potential issue, particularly during warm summer months.

<u>Incineration–</u> The combustion process destroys all odor-emitting substances in waste. Therefore, odor emissions are primarily emitted from the handling and storing of waste before combustion (World Bank, 2000).

Following collection, Saco's residential waste is directly transported to EcoMaine and deposited on the tipping floor of the combustion facility. EcoMaine is a mass burn facility, which employs no further processing prior to combustion. Waste remains on the tipping floor for a short period of time before being fed into the boilers. The tipping floor is enclosed and emits minimal odors to the environment, confirmed by a site visit. Additionally, EcoMaine demonstrates its low-odor operations by holding its annual meeting adjacent to the facility. In 2009, no odor complaints were made against the facility (personal correspondence, Mark Maritato, June 24, 2010).

Figure 7: EcoMaine Annual Event

Biddeford transports its waste directly to MERC, depositing it on the tipping floor. MERC is a refuse-derived fuel plant, where waste is processed prior to combustion. Hazardous and explosive materials are picked from the waste. Waste is then shredded into smaller pieces to produce a more efficient combustion fuel. MERC has an ongoing odor problem that affects the cities of Saco and Biddeford. The odor is believed to result from the failure to maintain negative pressure in the tipping floor and processing facility. MERC has admitted to odor problems at its plant that have resulted in legal actions against the facility (Cote, 2010). Due to citizen concerns, a dedicated hotline was established to field odor complaints. In 2009, the hotline received a total of 94 complaints, 70 of which were investigated, 33 of which the odor was attributed to MERC (City of Biddeford, 2010).

Landfilling– Following combustion, incinerator ash is transported to its final destination in a landfill. Waste generated in Saco ultimately is deposited in EcoMaine's landfill. Waste generated in Biddeford is transported to the Juniper Ridge landfill.

EcoMaine reported no odor complaints related to the landfill in 2009. A search of media reports revealed no results. At the Juniper Ridge landfill, the Maine State Planning Office maintains a public record of odor complaints, begun in August 2009. From August through December of 2009, the facility received 26 complaints, 10 of which were confirmed to emanate from the landfill (Maine State Planning Office, 2010). A media search revealed numerous references to odor, including one by the host community's town manager, suggesting gases released from the facility are a nuisance to the surrounding community (Haskell, 2010).

Noise

Noise from waste management activities provide a potential nuisance to surrounding communities.

Collection– During collection, noise emanates from hauler trucks. No records of related noise complaints were filed for Saco or Biddeford.

Incineration–Noise is generated from the transportation of waste and treatment residues to and from the WTE plant, handling of waste, and noise emissions from installed equipment. The highest levels of noise takes place on roads near the plant from vehicles arriving or leaving. Draught fans, flue gas fans and the stack are also significant sources of noise, normally operating 24 hours a day, seven days a week (World Bank, 2000).

In 2009, EcoMaine had no reported complaints related to noise. In Biddeford, one complaint was recorded (Phinney, 2010).

Landfilling– No records of noise complaints were identified for either landfill location.

Traffic

Traffic impacts are related to the collection and transport of waste and recyclables to related facilities. Areas en route to facilities will experience greatest impacts from congestion, road wear, and emissions. A significant source of air pollution is the high levels of truck traffic travelling to and from the waste management facilities. Diesel exhaust is recognized by the EPA as a significant contributor to air pollution across New England, and the fine particulates emitted from its combustion pose a considerable health risk (U.S. EPA, 2010). Potential for traffic-related impacts are discussed in relation to travel routes, distances, and transport tonnages.

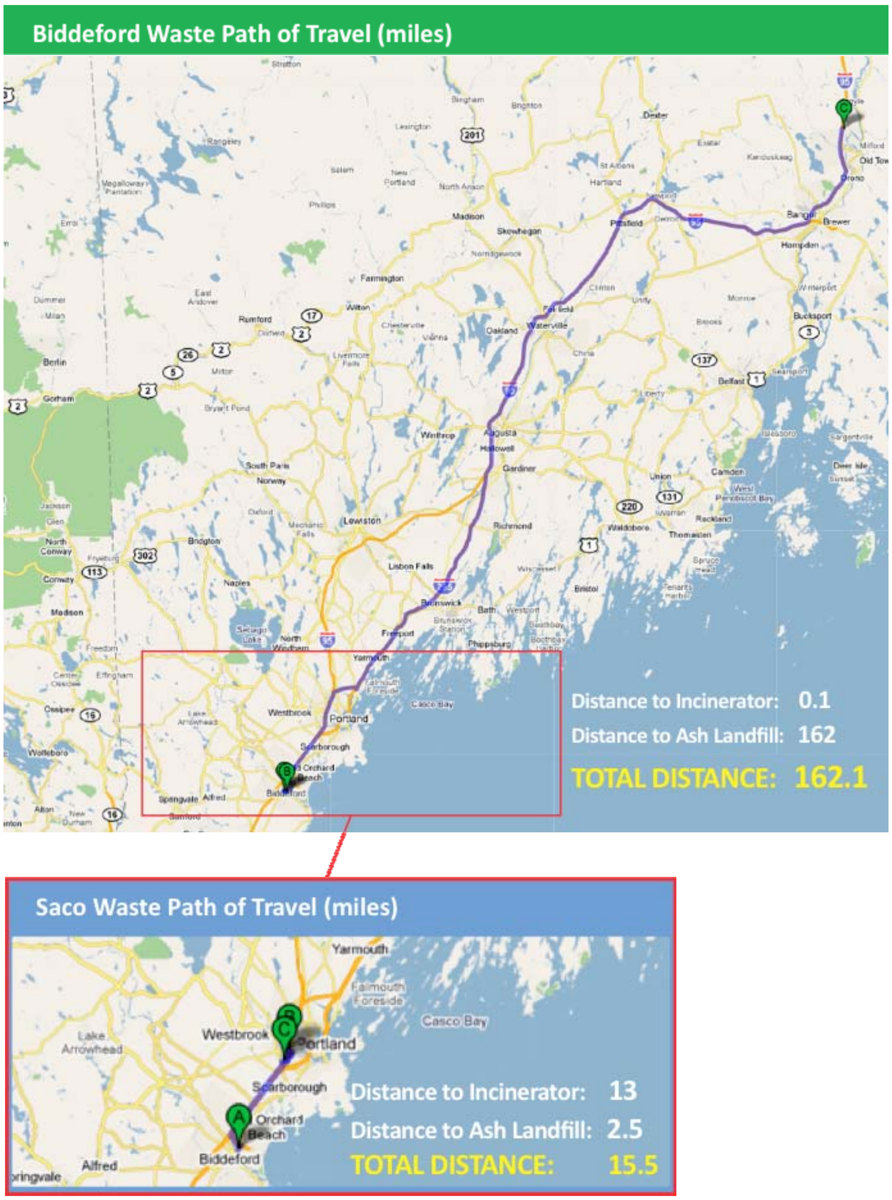


Figure 8: Waste path of travel

<u>Collection and transport to WTE plant and recycling facilities</u>– BBI dispatches separate waste and recyclables collection trucks along Saco's streets, resulting in two trucks travelling each street. Waste and recyclables are then transported out of the city 13 miles to EcoMaine, primarily along highways. The waste-to-energy plant is located in an industrial area with a low population.

Biddeford's dispatches its own trucks for waste collection, resulting in one hauler truck travelling each street. Waste is hauled to MERC, located downtown, in an area of high population density. A travel distance of 0.1 miles is attributed to waste collection. Recyclables are not collected curbside, but are transported by residents to the recycling center. Although records do not exist for the number of cars travelling to the recycling center, it can be stated that traffic due to residents transporting recyclables to the Biddeford center increases daytime road traffic Monday through Saturday along a road that passes an elementary and middle school.

Transport to landfill– Incinerator ash from Saco's waste is transported 2.5 miles to EcoMaine's landfill along a sparsely populated road. Ash from Biddeford's waste is transported 1.8 miles through a densely populated area of Biddeford and neighboring Saco before connecting with the highway, which accounts for the majority of the 162 miles of travel. The landfill is located off the highway in a sparsely populated region.

Another strategy for examining indicators of traffic impacts is determining the total ton-miles for each waste stream. As vehicles travel along streets and highways, they impact the road surface and surrounding environment. Although it is beyond the scope of this paper to quantify those impacts in relation to Saco and Biddeford's waste, the potential risk for those impacts could arguably be expressed as a relationship of weight transported over distance. As the table below illustrates, Biddeford's total ton-miles per input ton of waste is more than double that of Saco's waste stream.

Table 5: Ton-mile Comparison

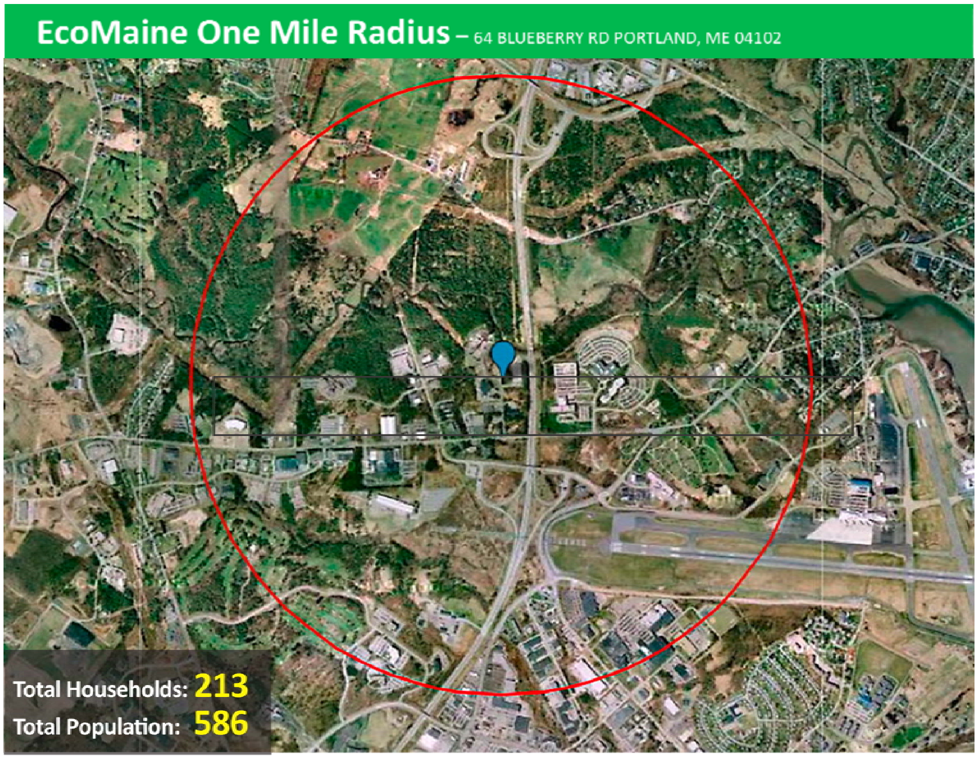
2009 Waste and Ash Ton-Mile Transportation Comparison								
City	Combusted Waste (ton)	Distance to Incineration Facility (mile)	Waste Transport Ton-Miles	Ash (ton)*	Distance to Ash Landfill (mile)	Ash Transport Ton-Miles	Total Ton-Miles	Ton-Miles Per Input Ton of Waste
Saco	4,959.57	13	**64474**	992	2.1	**2083**	**66557**	**13.4**
Biddeford	7,597.93	0.1	**760**	1,520	162	**246173**	**246933**	**32.5**
*Assumes average ash weight of 20% of MSW input.								

Other potential impacts and perceived risks
Waste management facilities have been and continue to be the subject of publicly perceived environmental and health risks. In regards to the facility types that exist along the Saco and Biddeford waste streams, a review of media reports returns numerous articles regarding citizen environmental and health concerns regarding WTE plants and landfills. A wide range of health effects on people working at and living in proximity to waste incinerators have been demonstrated in past studies (Global Alliance for Incinerator Alternatives, 2008); however, most of these studies were conducted in relation to older incinerators. Improvements in emissions controls in the United States have shown significant emissions reductions since the 1990s and have minimized these health risks to a statistically insignificant level (U.S. EPA, 2007). Both EcoMaine and MERC waste-to-energy plants employ continuous emissions monitoring and undergo annual stack tests that have show them to operate under legal emissions limits during standard operation (TRC Environmental Corporation, 2009)(Eastmont Environmental Services, 2009).

Important to this discussion, is that perception of environmental and health risks may drive other adverse social impacts, and the extent to which the surrounding community is at risk for experiencing those impacts. A study by Jason D. Boardman *et al* (2008) demonstrated that proximity to industrial activity experience leads to greater levels of psychological distress among residents. Undesirable facilities have shown a negative effect upon surrounding land values (Farber, 1997). Landfills have also been linked to decreased land values (Reichert, 2009). A waste facility may have an adverse effect on local economics if businesses leave the affected area or decide not to locate there. Public perceptions may amplify risks and lead to the stigmatization of affected communities (Committee on Health Effects of Waste Incineration, 2000). It is beyond the scope of this paper to attempt to quantify these social impacts; however, the *potential* for adverse social impacts may be expressed through the use of demographic data from regions immediately surrounding waste facilities.

An examination of the two waste-to-energy facilities present within the waste handling cycles for Saco and Biddeford reveals a large disparity in the potential for social impacts associated with the waste incineration facilities. Saco's municipal solid waste is delivered to EcoMaine, located in an industrial park; Biddeford's is delivered to MERC, located at the heart of the two cities. Based on Census 2000 data, 213 households with a total population of 586 are sited within a one-mile radius of the incinerator. In comparison, a one-mile radius of MERC contains 7,091 households with a population of 15,811 people. With nearly 27 times the population within one mile, the potential for impacts upon populations of people is vastly increased in the area surrounding MERC.

The two landfills that served as destinations for incinerator ash in 2009 also have potential impacts on surrounding populations. The population immediately surrounding the landfill facilities is significantly smaller than those surrounding the incinerators. Based on Census 2000 data, 127 households, with a total population of 277, were located within a one-mile radius of the EcoMaine landfill. Within one mile of the Juniper Ridge landfill are located 38 households with a total population of 80 (U.S. Census 2000, 2010).



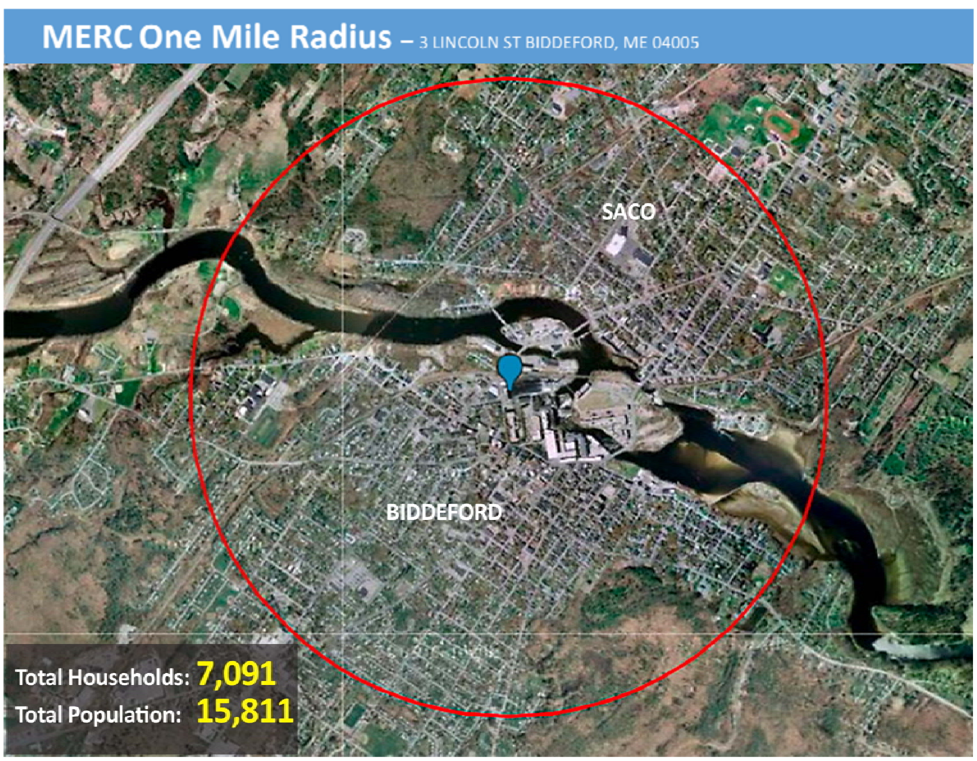


Figure 9: Incinerators potential for Impact

4. Conclusions

4.1 Environmental Implications

From energy and greenhouse gas emissions perspectives, the Biddeford waste stream demonstrates greater efficiency in the transport of waste and ash, which can be attributed primarily to the in-town location of the MERC incinerator. Overall, more energy is consumed during transport of materials to waste-to-energy plants per ton than the transport of ash. This can be attributed to the efficiencies of transporting a dense, uniform material, such as ash, in trailer trucks on highway conditions, over the transportation of mixed and less dense material collected in a stop-and-go manner with smaller waste hauler trucks.

Recycling has the greatest impact upon energy and emissions along the waste stream. Energy recovery and avoided emissions were directly related to recyclable material recovery rates. Biddeford's low recycling rate can be attributed primarily to collection methods. The Maine State Planning Office identified barriers to increased recycling which include:

- Consumer perception of difficulty or inconvenience
- Lack of investment in recycling programs and infrastructure
- Not all municipal recycling programs accept the full range of recyclables (Maine State Planning Office, 2010b)

Recycling in Biddeford is not available at curbside and relies on citizen's motivations and capabilities to store and transport materials to the recycling station and sort them upon arrival. Proposals by the director of Public Works to invest in curbside recycling have been rejected numerous times by the city dating back to 1996 (City of Saco, 2009). Finally, Biddeford does not accept the full range of plastic materials. These factors all contribute to low recycling rates.

Biddeford displayed higher levels of energy recovered from waste incineration as a city and per capita. However, based on average case numbers for the differing technologies between the two waste-to-energy plants, fewer greenhouse gas emissions were produced per input ton of waste from combustion at the EcoMaine plant associated Saco's waste stream. Energy recovery rates were directly related to recycling rates. Although energy recovered from combustion is significant, combustion does not provide the same level of energy benefits as recycling, and therefore played a smaller role in the energy outlook for the waste streams.

Overall, Saco's waste stream provided much higher levels of energy savings and avoided greenhouse gas emissions on a city level and per capita, which can be primarily attributed to recycling rates. To provide some context, the total energy savings for the Saco's waste stream equalled the annual power usage equivalent of 1,664 Maine homes. On the other hand, Biddeford's energy savings equalled the annual power usage of 1,084 homes. Regarding greenhouse gas emissions, the average household emits approximately 4 tons per year (U.S. EPA, 2010b). As a city, Saco's overall avoided emissions compensated for green house gases equal in weight to that emitted by 1,182 households. Biddeford's avoided emissions equalled 530 households.

4.2 Social Implications

Social impacts were primarily associated with collection methods and facility locations. Waste collection in the two cities presented potential visual, odor, and pedestrian interference impacts. Rolling bins utilized by Saco's residents mitigated these issues. However, these issues are very present in Biddeford due to trash bag disposal on sidewalks.

The location of the WTE plant facilities associated with Saco and Biddeford's waste streams presented potential social impacts related to visual presence, odor, and noise. EcoMaine, located in an industrial park, exhibited far less potential for exhibiting these impacts, and research on these issues yielded no evidence of public concern. On the other hand, impacts related to MERC were considerable as evidenced by the density of the surrounding community and records of odor and noise complaints. Impacts from the associated landfills followed in manner with EcoMaine's landfill displaying low-impact operations, and Juniper Ridge exhibiting a negative community presence. Beyond location, the implication is that the quality of management at these facilities has significant influence on social impacts.

5. Recommendations

It is important to encourage thinking at the municipal level that supports a broader sustainability perspective that focuses not only on the economics of differing solutions, but also environmental and social implications. In light of the evidence presented here, it is apparent that Saco's waste stream, from environmental and social aspects, provides a more sustainable solution.

Recycling has been shown to be the most effective means of avoiding energy consumption and green house gas emissions for both cities and increasing rates should therefore be prioritized in the cities' waste management systems. Biddeford should particularly focus on providing a convenient means of curbside recyclables collection, and should explore automated pickup systems that would provide not only this service, but also mitigate visual, odor, and sidewalk obstruction issues associated with trash bags and the current collection system.

At the local level, the scope of consideration in waste management decision-making needs to extend beyond the boundaries of the municipality and its direct involvement within the waste stream. When considering service contracting for waste combustion and recycling, downstream environmental and social implications should be considered. As demonstrated, waste generated within city limits has impacts upon a broader set of communities and population. Therefore, efforts should be made to minimize those adverse impacts. In particular, the location and management quality of service facilities and the total distances waste travels should demand high priority in the decision-making process.

As this report provides only a broad overview of Saco and Biddeford's waste streams focused on a specific time frame, more in-depth study of particular aspects of the waste stream over time would yield further information that would potentially modify the conclusions presented here. Additionally, further study is needed to determine the specific factors that Saco and Biddeford consider in their waste management system in order to identify barriers to furthering sustainability efforts.

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Appendix

2009 Saco GHG Emissions Summary

Waste Collection and Transport				
Diesel Fuel (Gallons)		**CO2 Emissions (tons/gallon)**		**Waste Collection Emissions (MTCO2E)**
9,100		0.0111		101.01
Incineration				
Incinerated MSW (tons)		**Net Emissions (MTCE)**	**Avoided Utility CO2 emissions (MTCE)**	**Combustion Emissions (MTCO2E)**
4,959.57		-0.03	-148.7871	-545.55
Ash Transport				
Ash Produced (20% of Input MSW)	**Miles trucked to EcoMaine landfill**	**60 mile Transport Energy Emissions Factor (MTCE/Ton)****	**Ash Transport Energy Emissions (MTCE)**	**Ash Transport Emissions (MTCO2E)**
991.914	2.5	0.0021	0.09	0.32
Recycling				
RECYCLING 2009 (does not include mixed metal)	**Total Tonnage**		**Emissions Factor from a Waste Generation Standpoint (MTCO2E/Ton) ********	**Recycling Emissions (MTCO2E)**
Newspaper	1,017.41		-2.79	-2838.6
Office Paper	11.08		-2.85	-31.6
Aluminum	2.65		-13.57	-36.0
Cardboard	386.68		-3.11	-1202.6
HDPE Milk Jugs	15.32		-1.39	-21.3
PET #1 Plastic	14.26		-1.54	-22.0
HDPE Mixed #2 Plastic	15.47		-1.39	-21.5
Mixed #3-#7 Plastic	17.48		-1.49	-26.0
Steel Cans	37.29		-1.79	-66.7
Glass	63.93		-0.28	-17.9
Total		**TOTAL CO2 Equivalents--GHG EMISSIONS REDUCTION**		-4284
SUMMARY TOTAL				-4728.4
TOTAL GHG Emissions/ Ton Generated Waste and Recyclables				-0.953

2009 Biddeford GHG Emissions Summary

Waste Collection and Transport				
Diesel Fuel (Gallons)		**CO2 Emissions (tons/gallon)**		**Waste Collection Emissions (MTCO2E)**
10,130		0.0111		**112.4**
Incineration				
Incinerated MSW (tons)		**Net Emissions (MTCE)**	**Avoided Utility CO2 emissions (MTCE)**	**Avoided Utility CO2 Emissions (MTCO2E)**
7,597.93		-0.02	-151.9586	**-557.2**
Ash Transport				
Ash Produced (20% of Input MSW)	**Miles trucked to Casella landfill**	**60 mile Transport Energy Emissions Factor (MTCE/Ton)****	**Ash Transport Energy Emissions (MTCE)**	**Ash Transport Emissions (MTCO2E)**
1519.586	**162**	0.0021	8.62	**31.6**
Recycling				
RECYCLING 2009 (does not include mixed metal, nor transportation)	**Total Tonnage**		**Emissions Factor from a Waste Generation Standpoint (MTCO2E/Ton)**	**Recycling Emissions (MTCO2E)**
Newspaper	264.06		-2.79	-736.7
Office Paper	15.40		-2.85	-43.9
Aluminum	1.67		-13.57	-22.6
Cardboard	267.21		-3.11	-831.0
HDPE Milk Jugs	4.48		-1.39	-6.2
PET #1 Plastic	3.95		-1.54	-6.1
HDPE Mixed #2 Plastic	7.00		-1.39	-9.7
Steel Cans	13.34		-1.49	-19.9
Glass	19.25		-1.79	-34.5
Total				**-1710.6**
SUMMARY TOTAL				**-2123.8**
TOTAL GHG Emissions/ Ton Generated Waste and Recyclables				**-0.280**