Supplemental Information for Web Application

Environmental Impact

As part of this research, a full life cycle assessment (LCA) was developed for the three scenarios using the software package MSW-DST. The LCA was developed using the composition of residential waste collected in Metropolitan Nashville/Davidson County (CDM Smith, 2018). The LCA evaluates the full management of MSW collected as well are recyclable and yard waste which can be diverted from the landfill. The LCA involved the evaluation of environmental impacts using TRACI (Tool for the Reduction and Assessment of Chemical and other Environmental Impacts) characterization factors which is an environmental impact assessment tool (Jain, Dyson, Tolaymat, & Ingwersen, 2015). The default of the software is to optimize operations for energy, cost, and CO_2 emissions. The results of MSW-DST for the three scenarios are shown show in Table 1 for air and Table 2 for water:

Table 1: Impacts to Air											
Impact Category	Pollutant Name	Scenario 1 - Energy Optimization	Scenario 1 - Cost Optimization	Scenario 1 - CO2 Optimization	Scenario 2 - Energy Optimization	Scenario 2 - Cost Optimization	Scenario 2 - CO2 Optimization	Scenario 3 - Energy Optimization	Scenario 3 - Cost Optimization	Scenario 3 - CO2 Optimization	
		per ton MSW	per ton MSW	per ton MSW	per ton MSW	per ton MSW	per ton MSW	per ton MSW	per ton MSW	per ton MSW	
Global Warming Air	Carbon Dioxide Fossil	-1.2E+02	-1.903E+01	-1.334E+02	-2.058E+02	-1.903E+01	-2.813E+02	-1.006E+02	-1.324E+02	-1.334E+02	kg of CO2-equivalent
	Methane (CH4)	4.043E+02	4.664E+02	5.005E+02	-1.737E+01	4.664E+02	-1.83E+01	5.605E+01	5.005E+02	5.005E+02	kg of CO2-equivalent
Acidification Air	Nitrogen Oxides	-2.141E+01	6.722E-01	-1.075E+01	-3.082E+01	6.722E-01	-2.658E+01	-2.068E+01	-1.044E+01	-1.075E+01	kg of H+ moles-equivalent
	Sulfur Oxides	-7.032E+01	-1.468E+01	-5.512E+01	-1.727E+02	-1.468E+01	-1.717E+02	-6.96E+01	-5.502E+01	-5.512E+01	kg of H+ moles-equivalent
	Ammonia (Air)	-3.661E-01	-1.148E-01	-3.02E-02	-3.888E-01	-1.148E-01	-5.233E-02	-3.268E-01	-3.009E-02	-3.02E-02	kg of H+ moles-equivalent
	Hydrochloric Acid	-5.646E-01	1.262E-01	-5.946E-01	-2.172E+00	1.262E-01	-2.265E+00	-4.716E-01	-5.946E-01	-5.946E-01	kg of H+ moles-equivalent
Human Health Cancer Air	Lead (Air)	-1.158E-09	-3.475E-10	7.487E-11	-1.531E-09	-3.475E-10	-3.216E-10	-1.251E-09	7.497E-11	7.487E-11	Comparative Toxic Units
Human Health Noncancer Air	Lead (Air)	-4.064E-07	-1.22E-07	2.627E-08	-5.367E-07	-1.22E-07	-1.127E-07	-4.385E-07	2.627E-08	2.627E-08	Comparative Toxic Units
Human Health Criteria Air-Point Source	Total Particulate Matter	-5.398E-01	-1.923E-01	-4.685E-01	-7.59E-01	-1.923E-01	-7.28E-01	-5.657E-01	-4.664E-01	-4.685E-01	kg of PM10-equivalent
	Nitrogen Oxides	-1.417E-02	4.447E-04	-7.146E-03	-2.037E-02	4.447E-04	-1.758E-02	-1.365E-02	-6.918E-03	-7.146E-03	kg of PM10-equivalent
	Sulfur Oxides	-2.306E-01	-4.798E-02	-1.81E-01	-5.657E-01	-4.798E-02	-5.646E-01	-2.285E-01	-1.81E-01	-1.81E-01	kg of PM10-equivalent
Eutrophication Air	Nitrogen Oxides	-2.368E-02	7.435E-04	-1.189E-02	-3.413E-02	7.435E-04	-2.937E-02	-2.285E-02	-1.158E-02	-1.189E-02	kg of N-equivalent
	Ammonia (Air)	-4.55E-04	-1.427E-04	-3.754E-05	-4.829E-04	-1.427E-04	-6.494E-05	-4.054E-04	-3.733E-05	-3.754E-05	kg of N-equivalent
Ecotoxicity Air	Lead (Air)	-7.487E-03	-2.244E-03	4.829E-04	-9.876E-03	-2.244E-03	-2.079E-03	-8.077E-03	4.84E-04	4.829E-04	Comparative Toxic Units
	Ammonia (Air)	-2.834E-04	-8.873E-05	-2.337E-05	-2.999E-04	-8.873E-05	-4.043E-05	-2.523E-04	-2.327E-05	-2.337E-05	Comparative Toxic Units

Table 2: Impacts to Water											
Impact Category	Pollutant Name	Scenario 1 - Energy Optimization	Scenario 1 - Cost Optimization	Scenario 1 - CO2 Optimization	Scenario 2 - Energy Optimization	Scenario 2 - Cost Optimization	Scenario 2 - CO2 Optimization	Scenario 3 - Energy Optimization	Scenario 3 - Cost Optimization	Scenario 3 - CO2 Optimization	Units
		per ton MSW	per ton MSW	per ton MSW	per ton MSW	per ton MSW	per ton MSW	per ton MSW	per ton MSW	per ton MSW	
Human Health Cancer Water	Cadmium	-2.234E-11	4.292E-12	-2.172E-11	-4.385E-11	4.292E-12	-4.219E-11	5.491E-11	-2.161E-11	-2.172E-11	Comparative Toxic Units
	Arsenic	3.164E-09	3.092E-09	3.113E-09	-5.574E-09	3.092E-09	-5.791E-09	8.687E-10	3.113E-09	3.113E-09	Comparative Toxic Units
	Mercury (Water)	4.654E-11	4.902E-11	4.664E-11	-1.E-11	4.902E-11	-1.03E-11	8.521E-12	4.664E-11	4.664E-11	Comparative Toxic Units
	Lead (Water)	8.128E-12	8.087E-12	8.056E-12	-9.276E-12	8.087E-12	-9.628E-12	3.847E-11	8.056E-12	8.056E-12	Comparative Toxic Units
Human Health Noncancer Water	Copper	1.018E-12	6.112E-13	7.456E-13	-3.02E-11	6.112E-13	-3.133E-11	2.327E-11	7.456E-13	7.456E-13	Comparative Toxic Units
	Cadmium	-6.008E-09	1.148E-09	-5.822E-09	-1.179E-08	1.148E-09	-1.138E-08	1.479E-08	-5.801E-09	-5.822E-09	Comparative Toxic Units
	Arsenic	2.347E-07	2.285E-07	2.306E-07	-4.126E-07	2.285E-07	-4.292E-07	6.432E-08	2.306E-07	2.306E-07	Comparative Toxic Units
	Mercury (Water)	5.512E-09	5.801E-09	5.522E-09	-1.179E-09	5.801E-09	-1.22E-09	1.008E-09	5.522E-09	5.522E-09	Comparative Toxic Units
	Chromium	2.265E-13	2.823E-13	2.254E-13	-3.382E-13	2.823E-13	-3.454E-13	2.565E-14	2.254E-13	2.254E-13	Comparative Toxic Units
	Lead (Water)	2.854E-09	2.834E-09	2.823E-09	-3.247E-09	2.834E-09	-3.371E-09	1.344E-08	2.823E-09	2.823E-09	Comparative Toxic Units
	Zinc	1.52E-07	4.995E-08	-8.376E-09	-4.654E-09	4.995E-08	-1.696E-07	2.844E-07	-8.345E-09	-8.376E-09	Comparative Toxic Units
Eutrophication Water	BOD	3.04E-02	3.33E-02	3.485E-02	3.526E-03	3.33E-02	6.236E-04	1.044E-02	3.485E-02	3.485E-02	kg of N-equivalent
	COD	6.246E-02	8.48E-02	9.483E-02	-1.179E-02	8.48E-02	-7.249E-05	3.454E-02	9.483E-02	9.483E-02	kg of N-equivalent
	Ammonia (Water)	1.675E+01	1.675E+01	1.675E+01	-1.934E-03	1.675E+01	-1.127E-03	3.547E+00	1.675E+01	1.675E+01	kg of N-equivalent
	Phosphate	5.336E-03	5.998E-03	5.222E-03	-5.016E-04	5.998E-03	-8.542E-04	2.472E-02	5.222E-03	5.222E-03	kg of N-equivalent
Ecotoxicity Water	Iron	1.923E+01	7.373E+00	-9.38E+00	-1.644E+01	7.373E+00	-4.695E+01	3.65E+01	-9.38E+00	-9.38E+00	Comparative Toxic Units
	Copper	6.515E-02	3.909E-02	4.778E-02	-1.934E+00	3.909E-02	-2.006E+00	1.489E+00	4.778E-02	4.778E-02	Comparative Toxic Units
	Cadmium	-1.365E-01	2.616E-02	-1.324E-01	-2.678E-01	2.616E-02	-2.575E-01	3.351E-01	-1.324E-01	-1.324E-01	Comparative Toxic Units

	Arsenic	1.303E-01	1.272E-01	1.282E-01	-2.296E-01	1.272E-01	-2.389E-01	3.588E-02	1.282E-01	1.282E-01	Comparative Toxic Units
	Mercury (Water)	8.563E-03	9.018E-03	8.583E-03	-1.841E-03	9.018E-03	-1.892E-03	1.562E-03	8.583E-03	8.583E-03	Comparative Toxic Units
	Selenium	1.138E-01	1.107E-01	1.117E-01	-2.451E-01	1.107E-01	-2.544E-01	3.64E-02	1.117E-01	1.117E-01	Comparative Toxic Units
	Chromium	9.669E-02	1.21E-01	9.638E-02	-1.448E-01	1.21E-01	-1.479E-01	1.096E-02	9.648E-02	9.638E-02	Comparative Toxic Units
	Lead (Water)	8.904E-03	8.862E-03	8.821E-03	-1.017E-02	8.862E-03	-1.055E-02	4.219E-02	8.821E-03	8.821E-03	Comparative Toxic Units
	Zinc	4.592E+00	1.499E+00	-2.523E-01	-1.396E-01	1.499E+00	-5.109E+00	8.552E+00	-2.513E-01	-2.523E-01	Comparative Toxic Units

Land Impacts:

Scenario 1: The total acreage of a Class I landfill varies depending on design expectations. The facility often consists of buffer and borrow soils area which increases the overall need for land to site the facility. For example, Class I landfill located in Rutherford County, south east of Metropolitan Nashville is 808 acres (https://middlepointlandfill.com/). The county landfill located in Montgomery County Tennessee, north west of Nashville sits on 550 acres, with 75 acres of closed landfill areas and 53 acres of active landfill area (https://mcgtn.org/bi-county/facts-about-landfill).

Scenario 2: For waste to energy facilities, several structures are needed for facility operation. Two main structure include the waste to energy incinerator facility and associated landfill for fly ash and bottom ash. In a waste-to-energy plant, 2,000 pounds of garbage is reduced to 300 pounds–600 pounds of ash (U.S. Energy Information Administration, n.d.). Therefore, the process allows for a reduction in disposed of volume. The Solid Waste Disposal Authority of the City of Huntsville which operated a waste to energy facility achieves a 90 percent reduction to MSW mass processed at the facility. At this facility, the Landfill property consists of 286 acres with a total disposal area of 178.23 acres. Of that, exists closed landfill areas, a construction and demolition landfill, and a current landfill area of 35 acres permitted for a variety of wastes including incinerator disposal ash (Solid Waste Disposal Authority of the City of Huntsville, n.d.). For this system, after the facility is decommissioned, the waste to energy plant can be demolished and removed from the site. The associated landfill will remain on the property after facility closure.

Scenario 3:

The areas required for a composting operation varies depending on the amount of waste that is managed. For a MSW composting facility in Portland, Oregon, the active composting area was about 7.5 acres in size, contains nearly two-thirds of the total area of the facility (Jones & Talbott, n.d.). A processing building is located on the site to separate the compostable and non-compostable fractions of MSW. The non-compostable fraction, or residue, is conveyed away from the trommel screen for ultimate disposal in a landfill (Jones & Talbott, n.d.). In this scenario the landfill is located adjacent to the composting facility and will require adequate acreage for disposal of non-compostable waste. Based on waste characterization used in this study, less than 30 percent of the MSW is compostable organics. Therefore, the remaining material will be disposed of in an associated landfill. Once operations cease, the composting facility will be decommissioned, and the landfill will remain.

Economic Criterion

The Economics Criteria involves the financial elements involved with the short and long term operations of the MSW management system. The attributes of the criteria include capital investments, operations and maintenance costs necessary for day to day operations of the facility and infrastructure, economic incentives that may be provide to communities located in the vicinity of the facility, and property values of land located around the facility. Below are several economic indicators that calculated during the LCA evaluation for the three scenarios. Operational costs were developed for the optimized system scenarios and are presented in Table 4.

Table 4: Annual Operation Costs			
Scenario	Annual Operation Cost (US Dollar per Year per 1 ton MSW)		
	Optimized for Energy	Optimized for Cost	Optimized for CO_2 Emissions
Scenario 1	97	89	107
Scenario 2	137	89	148
Scenario 3	162	102	107

The Technical Feasibility Criteria considers of several attributes such as the availability of land/land use, energy efficiency, distance from community/ transfer station, beneficial reuse/resource conservation, available infrastructure. Table 5 below presents the annual energy usage that was calculated during the LCA evaluation. The operational costs were developed for the optimized system scenarios.

Annual Energy Usage

Table 5: Annual Energy Usage			
Scenario	Energy Usage (one million British Thermal Units (MMBTU) 1 ton MSW per year)		
	Optimized for Energy	Optimized for Cost	Optimized for CO_2 Emissions
Scenario 1	-2.5	0.1	-1.6
Scenario 2	-8.1	0.1	-7.8
Scenario 3	-2.7	-1.7	-1.6

Note: Negative value indicated energy production for scenario and optimized condition