Waste-to-Energy (WTE) Municipal Solid Waste (MSW)

Summary:
This strategy considers the greenhouse gas emissions reductions associated with an increase at one of Pennsylvania's WTE facilities and the potential of a new facility using gasification technology but at smaller scale.

Goal:
Increase WTE derived from MSW by approximately 9 percent (295,650 tons per year) by 2020, as compared to business as usual (BAU).

Implementation Period:
2013 through 2020

Background Discussion on Waste-to-Energy MSW:
The Department firmly believes that waste reduction is paramount followed by increased recycling and lastly that energy recovery should be maximized from the resulting waste stream. The Commonwealth can reduce greenhouse gas (GHG) emissions by increasing MSW tonnage processed for energy recovery at WTE facilities. This work plan analyzes the savings in life cycle GHG emissions associated with maximizing tonnages of MSW being combusted at the six existing facilities within Pennsylvania, expansions at one of these facilities and construction of a new conversion technology facility (e.g. gasification, waste-to-liquid fuel). This work plan does not consider the additional GHG emissions reductions from the processing of residual solid waste for the same purpose.

The combustion of solid waste reduces GHGs from avoided landfill emissions and the displacement of traditional fossil fuel energy sources, despite the fact that the operation of WTE facilities and the burning of waste also produce GHG emissions.

WTE and landfills have different benefits and drawbacks, depending on technologies, operations, feedstocks and other factors. Data on the comparative emissions benefits and drawbacks are often difficult to compare due to varying assumptions and methodologies. Two EPA-sponsored life-cycle models analyzing MSW management strategies have concluded that there is approximately a one ton difference (reduction) in GHG emissions per ton of waste disposed for waste combustion as compared to landfilling[1] but these studies include a variety of assumptions on landfill operations such as gas utilization and flaring and also do not account for carbon storage. For our analysis we used the U.S. EPA's WARM model, version 10. We assume that all landfills in Pennsylvania incorporate energy recovery of some type despite DEP data indicating that approximately 37% of landfill gas from Pennsylvania's operating landfills is currently flared, vented and/or lost as fugitive emissions. We have also credited landfills with carbon storage. The net result of this analysis is a difference (reduction) of approximately 0.49 tons of GHG emissions per ton of waste disposed via WTE as compared to landfilling.

Comparing power generation (viewing the combustion cycle only) to coal shows WTE emitting about one-third of the GHGs of a coal plant.[2] There are other applications and technologies available that enable utilizing waste as an energy source. Consideration of using waste (as refuse-derived fuel) in coal-

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[1] http://www.epa.gov/epawaste/nonhaz/municipal/wte/airem.htm#6

[2] S. Thorneloe, K. Weitz, and J. Jambeck. (2007). "Application of the US decision support tool for materials and waste management," *Waste Management*, 2007, 27: 1006-1020 http://www.ncbi.nlm.nih.gov/pubmed/17433663

fired power plants, especially waste coal power plants, which utilize circulating fluidized bed combustor technology, has been considered as a way to make use of existing capital and gain the environmental advantages from WTE combustion technologies. These projects would be required to meet all current environmental standards.

Though not currently deployed in Pennsylvania, technologies other than typical combustion are available and should be considered on a case-by-case basis for the future deployment in the processing of MSW. Such technologies include gasification, pyrolysis, torrefaction and others. MSW can be processed and densified into pellets, cubes, etc. for sale as boiler fuel to industrial consumers and for power generation. A plan such as this, converting waste to pellets for resale, is being considered by the City of Philadelphia however, it is the utilization of the fuel and not its production that would be accounted for in a GHG reduction strategy. The organic fraction of MSW can also be processed into liquid fuels to meet a wide variety of needs.

Data sources/Assumptions/Methods for GHG:

The baseline tonnage for MSW WTE combustion in Year 2000 is from data reported to the Department's Bureau of Waste Management. The GHG reduction was calculated by adding the incremental WTE combustion and a corresponding decrease in MSW landfilled to version 10 of the U.S. EPA Waste Reduction Model (WARM). To estimate the GHG savings achieved through the diversion of waste from landfills, all landfills were assumed to have landfill gas to energy systems in place, a generous but largely accurate assertion. Secondly, the default 75% collection efficiency was used, which is consistent with the U.S. EPA's emissions factor database, AP-42,[3,4] and recent U.S. EPA research that found methane abatement efficiencies ranging from 38 – 88%.[5] That study concluded that "The data collected does not support the use of collection efficiency values of 90% or greater as has been published in other studies." A landfill gas collection efficiency of 75% is consistent with the minimum mandated requirements by the PA DEP however, as noted in some landfill permits issued by DEP in certain regions of the Commonwealth, minimum collection efficiencies of 90% to 92% have been incorporated into Title V operating permits. This higher collection efficiency requirement is based upon the design of the landfill gas collection system, based on a radius of influence calculation. Landfill gas collection efficiencies that are based on calculation and not direct measurement vary widely, in part because they rely on modeled rates of gas generation that when compared to actual gas flow rates can and have significantly skewed collection efficiencies, even exceeding 100%. To avoid these discrepancies would require the use of measurement techniques such as flux box monitoring and remote sensing, but no such data is available for landfills in Pennsylvania.

Data Sources/Assumptions/Methods for Costs:

The assumptions for the cost elements of this work plan are $289,630/ton MSW combusted for capital costs and $47/ton MSW combusted for O&M costs. The revenue assumptions include the difference between an average WTE and landfill tipping fees ($76/ton for WTE, $70/ton for landfills) and an estimated wholesale electricity price of $0.05/kWh.

GHG Emissions Reduction Analysis:

[3] U.S. EPA, 1998, *AP-42, Compilation of Air Pollutant Emission Factors*, Chapter 2.4 Municipal Solid Waste Landfills, http://www.epa.gov/ttn/chief/ap42/ch02/final/c02s04.pdf

[4] See page 2.4-8 of U.S. EPA, 2008, *Compilation of Air Pollutant Emission Factors*, Chapter 2.4 Municipal Solid Waste Landfills, DRAFT, http://www.epa.gov/ttn/chief/ap42/ch02/draft/d02s04.pdf

[5] Recent EPA research found methane abatement efficiencies ranging from 38 – 88%. The study concluded that "The data collected does not support the use of collection efficiency values of 90% or greater as has been published in other studies" U.S. EPA, 2012, *Quantifying Methane Abatement Efficiency at Three Municipal Solid Waste Landfills*, EPA/600/R-11/033, http://www.epa.gov/nrmrl/pubs/600r12003.html

The WTE target of a 295,650 tons per year increase by 2020 is multiplied by the value 0.485 which corresponds to the U.S. EPA WARM model value for the incremental reduction in GHG emissions associated with utilizing waste for energy. This work plan assumes the targets will be met by a 600 tpd expansion at one of the existing WTE facilities and a newly signed contract for a small (300 tpd) conversion technology facility, such as gasification or pyrolysis. The expansion and new conversion facility together are estimated to contribute the WTE target of 295,650 tons per year. For modeling purposes, the 600 tpd facility expansion is assumed to come online in 2016 and the 300 tpd conversion technology facility in 2019, although the actual timing could vary significantly.

The increase in annual tonnages associated with this initiative is shown below in Table 1. As described above, this work plan considers the possibility that one facility will pursue and receive approvals for a capacity increase (expansion) effective in 2016. The new, smaller conversion technology facility is projected to come online in 2020. EPA's WARM tool was used to derive an average GHG emissions reduction of 0.485 tons of CO_2e per ton of MSW combusted, as compared to landfilling. The GHG calculation is assumed to be the same for the conversion technology as it is for current WTE. This value is then multiplied by the difference in annual projected tonnage and baseline tonnage. Table 1 displays these results and GHG emissions reductions, which may result, from years 2013 through 2020.

Table 1. Incremental Increase in WTE Tonnages and GHG Reductions

Year	Incremental WTE MSW (tons)	GHG Reduction (MMtCO2e)
2012	-	
2013	-	
2014	-	
2015	-	
2016	197,100	0.09
2017	197,100	0.09
2018	197,100	0.09
2019	197,100	0.09
2020	**295,650**	**0.13**
	Cumulative Total	**0.48**

Cost-Effectiveness Analysis:

The costs associated with the additional WTE MSW combustion analyzed by this work plan are based on annual tonnage received. Tipping fees are used to estimate the total costs for amortized capital and O&M. Several factors can influence tipping fee costs but the fees are structured to cover all of a facility's net expenditures. This methodology was recommended by Joshua Roth, P.E. and Project Director at SCS Engineers. SCS Engineers routinely conducts all manner of assessments and design consultation for the waste industry. In a personal email to Joe Sherrick of PA DEP, Mr. Roth states that, "there is no single method to set tipping fees. Some are based on actual costs to permit, build, operate, maintain, monitor and close a landfill, which can vary considerably with location, size, complexity, regulations, environmental concerns, and other factors, while others may be set by elected officials, financial officers, and administrators considering local tax bases, competition, and landfill lifespan. SCS does assist many communities with tipping fee estimates for their landfills by computing their actual operational costs. However, the final tipping fee may be set higher than the actual costs, which would generate a revenue stream, or may be set lower to attract more waste streams, with the differential picked up in general tax revenue, or the facility may operate at a loss." In this analysis we do not assume that landfills will be operated at a loss or that tipping fees are set lower than the actual fiscal needs. The average tipping fees for landfills in south-central and southeastern PA, where all of the existing WTE combustors are located, is approximately $70 per ton. The average tipping for WTE facilities is approximately $75 per ton

The result, as noted in Table 2, is a cost of $1.06 million in 2020 with a cumulative net present value cost, expressed in 2010 dollars, of $4.25 million. The cost-effectiveness over the period 2013–2020 is $8/tCO-$_2$e, indicative of the fact that this measure cannot succeed without economic incentives or changes in the cost assumptions.

Table 2. Cost-effectiveness of Incremental WTE MSW Combustion

Year	Annual WTE Combustion (tons)	Combined Capital and O&M Cost Differential ($MM)	Discounted Cost ($MM)	Cost-Effectiveness ($/tCO2e)
2013	-	$0.00	$0.00	
2014	-	$0.00	$0.00	
2015	-	$0.00	$0.00	
2016	197,100	$1.15	$0.86	
2017	197,100	$1.15	$0.82	
2018	197,100	$1.15	$0.78	
2019	197,100	$1.15	$0.74	
2020	295,650	$1.72	$1.06	$8.14
Total (2013-2020)	1,084,050	**$6.32**	**$4.25**	**$8.91**

Implementation Steps:

Fundamentally, expanding WTE capacity in the Commonwealth will rely on consistent access to waste markets, combined with predictable energy markets, in order to provide the relatively certain and adequate revenue streams needed to encourage and sustain specific projects. The ratio of waste tipping fee revenues to energy sales revenues varies from project-to-project; and, from a policy perspective, the relationship between these two revenue streams is important. The policy advantage afforded by this dual revenue stream business model is that strengthening one revenue stream can help offset shortcomings in the other (at least to some extent). For example, policies resulting in higher yet stable waste tipping fees can make up for low electricity prices.

On a per ton basis, capital and operating costs for WTE facilities typically exceed those of landfills, creating an economic incentive for landfilling. The magnitude of that incentive, as reflected in local market pricing, varies across the Commonwealth. Nonetheless, in most locales landfilling is less expensive than WTE. Policies and actions that reduce the impact of this pricing advantage can help facilitate the goal of this work plan; these include:

- Consideration and financial encouragement of WTE as a tool for urban redevelopment; and
- Consideration of financial incentives to promote WTE as a source of alternative energy.
- Efforts to encourage co-locating industrial and institutional facilities and commercial business centers to facilitate the utilization of waste heat from WTE facilities. Such efforts provide additional revenue to WTE facilities and decreased energy costs to ultimate consumers while eliminating or significantly limiting the need for other energy generation.

Both the transition to competitive electric generation supply and development of natural gas in the Commonwealth have contributed to a decline in the wholesale price of electricity. In addition, the current regulatory preference for short term wholesale electric supply contracts between electric generation suppliers (EGSs) and electric distribution companies (EDCs) undermines the predictability and stability of revenues for all alternative energy projects, including WTE. It may be possible to mitigate this impact by providing facilitated access to retail energy markets and by encouraging EDCs to enter into long-term (10+ years) procurement contracts with alternative energy sources.

Potential Overlap:

- Statewide Recycling Initiative

No backsliding of mandated recycling requirements is envisioned or suggested in this work plan. Furthermore, the Statewide Recycling Initiative focuses on venues that currently have limited or no recycling programs in place, aiding in reaching the goal of that work plan. An overlap may exist between the WTE and the Statewide Recycling Initiative work plans, but it is not quantifiable based on the limited data available at this time. Overlap would exist only to the extent that the same waste would be subject to both work plans. The largest impact to the Landfill Methane Displacement of Fossil Fuels is expected to result from the now lower costs of natural gas. Any losses of revenue that may result either as a consequence from low natural gas prices displacing interest in direct use of landfill gas by other industrial consumers or from any potential impact that may be realized from increased WTE may result in landfill tip fee price reductions that could result in additional landfilling, particularly of out-of-state wastes, to make up for lost revenue at landfills, potentially partially nullifying GHG benefits of WTE-driven landfill diversion.

Uncertainty:

The work plan envisions the deployment of capital in the state to expand WTE. As with any capital expenditure, the prospects and timing are dependent on a variety of factors, including but not limited to the economy; changes in waste tip fees, electricity pricing, and commodity prices; and changes in federal or other policies that could have an impact, positive or negative, on the viability of the project. As a consequence, more or less energy recovery capacity may be added than estimated in this work plan.