Enhanced Municipal Solid Waste (MSW) Beneficial Use

Summary:

Pennsylvania is second in the country in terms of generation of the amount of electricity from landfill-gas-to-energy projects, and the Commonwealth's waste-to-energy (WTE) facilities also contribute to greenhouse gas reductions through the production of up to 276.5 MW per hour, and generated of 1,604,742 MWh in 2011 based on US EIA's database. This strategy considers additional greenhouse gas emissions reductions associated with the disposal of municipal solid waste (MSW) in the Commonwealth from these types of facilities, and identifies emerging technologies that may lead to further greenhouse gas reductions in the future once these technologies are successfully commercialized.

Effective waste management practices affect GHG emissions in five ways:

1. Minimizing landfill emissions of methane;
2. Reductions in fossil fuel use through energy recovery from waste combustion (as well as use of captured landfill gas);
3. Reduction in energy consumption and process gas release in industrial operations, from recycling;
4. Forest carbon sequestration from a decrease in paper demand; and
5. Energy used in waste disposal or recycling transport. [1]

Goal:

Ensure that all MSW generated or disposed within the state is disposed of at a permitted waste disposal facility and increase the amount of clean energy generated by existing waste disposal facilities.

Implementation Period:

2015 through 2020

Background Discussion:

The MSW management industry is a comparatively small emitter of GHG. The US EPA estimates that all types of waste (including industrial, water and construction waste) account for only 1.9% of the United States' aggregate GHG emissions, measured in carbon dioxide (CO_2) equivalents[2]. When one considers the impact of the MSW disposal industry, including recycling, electricity and other energy generation from waste, and carbon sequestration, that number falls to a mere 0.1% of total domestic GHG emissions.[3]

GHG emissions from the MSW industry have decreased dramatically in recent years as a direct result of the MSW industry's development of improved technologies. A study commissioned by the National Solid Wastes Management Association ("NSWMA") found that while the volume of MSW disposed increased steadily since 1970, GHG emissions from all MSW management

[1] IPCC, Working Group III: Mitigation. http://www.ipcc.ch/ipccreports/tar/wg3/index.php?idp=120
[2] US EPA *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2011*, April 12, 2013, page 20, http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2013-ES.pdf
[3] NSWMA, (2005) Municipal Solid Waste Industry Reduces Greenhouse Gases through Technical Innovation and Operational Improvements.

activities fell from about 60.5 million metric tons carbon dioxide equivalents in 1970 to just 7.8 million metric tons in 2003.[4,5]

Specifically, MSW management industry has made strides in reducing GHG emissions for three main reasons: (1) the proliferation of landfill gas to energy systems that generate significant quantities of renewable energy, (2) the effective and permanent sequestration of large amounts of biogenic carbon within landfills, and (3) the destruction of methane through landfill gas collection and landfill cover systems. Similarly, the combustion of MSW by WTE facilities generates significant amounts of clean, baseload electricity with significantly lower GHG emissions than traditional fossil-fueled generation because approximately 50% of the GHG emissions from WTE facilities are biogenic in origin[6].

The Pennsylvania Alternative Portfolio Standards Act recognizes electricity generated from landfill gas as a Tier I resource, and electricity generated by the Commonwealth's six WTE facilities is recognized as a Tier II resource. Unlike most other renewable energy resources, the electricity generated from both of these types of facilities is baseload. This is a tremendous asset to electric grid integration and operation.

Moreover, several international and domestic protocols, including the Intergovernmental Panel on Climate Change ("IPCC") and the United States Environmental Protection Agency ("EPA"), recognize landfilled material as a "sink" in calculating carbon emissions inventories. In fact, EPA reports that the national average of net GHG emissions for landfills is actually a *negative* amount when factoring in the fact that landfills are carbon sinks.[7] As a result, many international and domestic protocols and programs either ignore landfills because they are insignificant sources of GHG emissions or treat them as sources of emissions reductions. Similarly, the IPCC recognizes that waste combustion with energy recovery as one of the "complementary mitigation measures to landfill gas recovery" as a strategy for reducing GHG emissions from waste disposal.[8]

As an indirect option, waste minimization (i.e. avoided waste generation, reuse/repurposing materials instead of disposal, etc.) and recycling offer significant GHG emission reductions and are preferable to waste generation and/or disposal. This workplan focuses on ensuring that to the extent that waste is generated, the maximum GHG emission reductions from its disposal/use are achieved. Increasing recycling rates in the Commonwealth is the focus of a separate GHG emission reduction strategy set forth in this action plan. In addition to the recommendations in

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[4] NSWMA, (2005) Municipal Solid Waste Industry Reduces Greenhouse Gases through Technical Innovation and Operational Improvements

[5] In addition, it is documented that the MSW management industry has decreased GHG emissions from MSW management by over 75% from 1974 and 1997. *K. Weitz et al.*, The Impact of Municipal Solid Waste Management on Greenhouse Gas Emissions in the United States, Journal of Air and Waste Management Association, Volume 52, September 2002.

[6] http://www.epa.gov/cleanenergy/energy-and-you/affect/municipal-sw.html

[7] USEPA 1998. Greenhouse Gas Emissions from Management of Selected Materials in Municipal Solid Waste. EPA 530-R-98-013, Exhibit 7-6.

[8] Waste Management, In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change; page 587. See http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter10.pdf

that workplan, WTE facilities offer additional recycling opportunities for certain materials, primarily metals, which are inherent to their operations.

To the extent that waste disposal occurs in landfills, the most important factors for reducing GHG emissions is that an operating landfill gas collection and control system is present to minimize landfill gas emissions. Additional GHG emission reduction benefits occur if the collected gas is beneficially used to create electricity or other forms of energy. These types of projects generally fall into three categories—electrical generation, direct use of medium-BTU gas, and processing landfill gas into natural gas-pipeline quality high-BTU gas (collectively "landfill gas-to-energy" or "LFGTE" projects). To the extent that waste disposal occurs through combustion, the most important factor for reducing GHG emissions is ensuring that the combustion occurs in a properly permitted WTE facility that generates electricity and/or other forms of energy.

The Pennsylvania Department of Environmental Protection (DEP) has considerably more stringent requirements for the installation and operation of landfill gas collection and control systems than those set forth by US EPA. US EPA requires gas collection in certain MSW landfills with waste disposal capacities of 2.5 million megagrams[9]. DEP requires gas collection in all MSW landfills with waste disposal capacities of 1.0 million megagrams[10]. US EPA requires installation of those gas collection systems the earlier of 2 years from reaching final fill grade, or 5 years from the start of active filling[11]. PA DEP requires installation of those gas collection systems as soon as practical to prevent odor migration, typically 10 months from the start of filling. In addition, in certain circumstances, US EPA allows direct venting of landfill gas in a variety of short-term operational scenarios; PA DEP strictly forbids short-term venting of landfill gas. As a result, all active MSW landfills in Pennsylvania have operating gas collection and control systems; Pennsylvania landfills collect a much higher percentage of landfill gas generated by its landfills as compared to landfills in other states; and a higher percentage of that collected gas is beneficially used.

For waste combustion, all six of the operating WTE facilities in the Commonwealth produce electricity from their waste combustion activities. The WTE facilities are all subject to, and comply with, stringent air emission control requirements, set forth generally in 40 CFR Part 60 and/or Part 63, and enforced by US EPA and PA DEP. Construction of facilities that mimic the operations of WTE facilities, but which evade the air emission control requirements which the WTE facilities are subject, represent a serious threat to maintaining the GHG emission reductions that have been achieved.

Energy recovery from excess heat generated from WTE facilities represents a largely untapped option to further increase the GHG emission reductions that occur from these facilities. Close proximity of a potential end-user for the excess heat is an important factor in developing these projects, and for certain industries, use of excess heat (typically in the form of steam) is a

[9] See 40 CFR Part 60, Subpart WWW.
[10] See the Department's *Best Available Technology and Other Permitting Criteria for Municipal Solid Waste Landfills*, Document No. 275-2101-007. http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-75264/7.10%20Best%20Available%20Technology%20and%20Other%20Permitting%20Criteria%20for%20Municipal%20Solid%20Waste%20Landfills.pdf
[11] See 40 CFR Part 60, Subpart WWW.

significant economic benefit. Recently, manufacturers and other types of business with significant process heating requirements have evaluated co-locating at or near WTE facilities.

Landfill gas represents another alternative source of energy production that has been used primarily for the generation of electricity, but has also been used for other purposes such as direct thermal and for the conversion of liquefaction into transportation fuels. The most recent survey in 2010 indicated 42 active projects, four planned projects, and the potential for another 17 projects occurring at the various 28 landfill sites. If all planned and potential projects were realized, the state could have a total of 74 projects by 2017.

Using landfill gas as a fuel is beneficial to the environment since it prevents the release of methane and carbon dioxide into the atmosphere and offsets the consumption of other fuels. In the past, it was simply collected and flared, but now many landfills are taking advantage of their waste gas, using it to produce heat and power. Landfill gas is similar to natural gas, but with a smaller percentage of methane and half the BTU content resulting in fewer emissions.

Landfills in Pennsylvania were an early adopter of LFGTE projects. The Commonwealth has 40 operating projects[12] and is second in the nation (behind only California) in the number of LFGTE projects operating. PA's electrical projects generate 171 MW of baseload electricity. The engines and turbines used to produce this electricity typically have annual utilization factors of 95-98%. In addition, there are four medium-BTU pipeline projects, where the landfill gas is piped and directly used as a replacement fuel by asphalt plants, cement kilns, industrial boilers, commercial heating, potato dehydration and greenhouses. The Commonwealth has eight landfills with high-BTU operations, more than any other state in the country and nearly 25% of all high-BTU projects in the country[13]. High BTU operations process the collected landfill gas into "pipeline grade" natural gas standards by essentially removing all non-methane components.

According to US EPA's Landfill Methane Outreach Program's (LMOP's) website, in most states, there are more landfills that are "candidates" for an LFGTE project than there are landfills with operating LFGTE projects. Pennsylvania stands in stark contrast to the national landscape—LMOP reports that as of July 2013, 43 out of 51 landfills in Pennsylvania have operating LFGTE projects, a rate that significantly exceeds California's rate and is in the top-4 nationally. Despite all of these successes, only 59% of collected landfill gas at Pennsylvania landfills was used for beneficial use in 2011. [14] The annual generating capacity of the 42 active plants in Pennsylvania exceeds 37 billion cubic feet. If all currently planned projects were developed, this generating capacity would increase to over 40 billion cubic feet per year by 2015. An additional 28 projects with a total capacity of over 17 billion cubic feet per year are described as "potential projects." These potential projects would not come online until approximately 2017. Clearly, there are significant opportunities to improve the rate of LFGTE generation in the Commonwealth.

[12] Differences in the reported number of projects in Pennsylvania is due to competing methodologies on classifying "projects" at landfills with multiple beneficial use operations.
[13] US EPA's LMOP website reports that there are 33 high-BTU projects operating at a total of 34 landfills nationwide. See *Upgraded LFG (XLS)* spreadsheet at http://www.epa.gov/lmop/projects-candidates/operational.html .
[14] Based on an analysis of 2011 Annual Reports on file at DEP's Bureau of Solid Waste.

The primary barriers to increasing landfill gas utilization include:

1. The remaining few landfills without LFGTE projects are smaller sites, with smaller quantities of landfill gas generation. Economies of scale make development of these projects more difficult.
2. For all electricity generating projects, low wholesale electric prices[15].
3. For medium and high-BTU projects, low natural gas prices.
4. DEP regional emission testing requirements that exceed US EPA requirements as well as those set forth in the Department's *Best Available Technology and Other Permitting Criteria for Municipal Solid Waste Landfills*.
5. Engine overhaul and core change-out requirements that exceed federal standards, which reduce operation at existing LFGTE projects.
6. Obtaining right-of-way easements for pipelines and powerlines.
7. Uncertainty over long-term LFG supply (waste volumes down, diversion of organics, etc.)

For existing LFGTE projects, GHG emission reductions can occur from:

1. Reducing project downtime.
2. Beneficial use of waste heat.
3. Incremental increases in projects as landfill gas generation warrants (for example, installation of a 4th engine at an existing 3-engine project).

For landfills without LFGTE projects, GHG emission reductions can occur from:

1. Installation of an LFGTE project.

For existing WTE facilities, GHG emission reductions can occur from:

1. Reducing WTE facility downtime
2. Beneficial use of waste heat.

According to the United States Environmental Protection Agency's Landfill Methane Outreach Program's Benefits Calculator, the electricity produced at LFGTE facilities from PA landfills reduces greenhouse gases by 7.23 million metric tons per year[16]. The GHG emission reductions from the state's medium-BTU and high-BTU projects are not quantified at this time, but those reductions are meaningful, and those projects have provided an economical source of energy for numerous Pennsylvania manufacturing facilities, as well as providing the basis for "green" marketing claims relating to the use of renewable energy.

The six WTE facilities in the Commonwealth generated approximately 1,604,742 MWh of electricity in 2011, directly offsetting consumption of other fuels for electricity generation. Electricity generated using WTE facilities are assumed to have a GHG emission value of 1843 lbs/MWh[17].

[15] By way of comparison, California leads the country in LFGTE generation. California's wholesale electricity prices are typically double to triple Pennsylvania's prices.
[16] See slide 19 of the PA DEP Landfill Gas to Energy presentation, February 7, 2013.
[17] US EPA notes, at http://www.epa.gov/cleanenergy/energy-and-you/affect/municipal-sw.html, that "the average air emission rates in the United States from municipal solid waste-fired generation are: 3685 lbs/MWh of carbon dioxide, (it is estimated that the fossil fuel-derived portion of carbon dioxide emissions represent approximately one-

Recommended Actions/Implementation Steps

In 2011 the Keep Pennsylvania Beautiful program identified nearly fifty-eight-hundred illegal dump sites in Pennsylvania, accounting for more than seventeen thousand tons of illegally dumped trash. Eliminating illegal dumping will reduce GHG emissions, which occur when the waste in these sites breaks down without any gas collection or control. The Commonwealth does not have any statutes or regulations banning open burning of household generated solid waste, although some municipalities do have local ordinances that set forth bans. Clearly, many communities in Pennsylvania either allow, or do not enforce restrictions, on the open burning of waste by residents. Open burning of waste generates significantly more GHG emissions than disposal through permitted landfills or WTE facilities.

Through the LMOP program, the Department signed a Memorandum of Understanding with US EPA establishing a partnership to promote the use of landfill gas, including the removal of unnecessary state barriers. The Department should convene a working group of representatives from the Bureau of Air Quality, the Bureau of Solid Waste, and industry stakeholders to identify existing barriers to further development of LFGTE projects. This working group should specifically address the necessity of continued regional deviations from the Department's *Best Available Technology and Other Permitting Criteria for Municipal Solid Waste Landfills* policy that currently occur. The working group should also consider whether a revision to the Landfill Gas Primer, published by the Department in 2004 but currently unavailable, would be an appropriate vehicle for removing any identified barriers.

The transition to competitive electric generation supply, as well as the development of natural gas resources 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 LFGTE projects and WTE facilities. 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 procurement contracts with alternative energy sources generally and these sources specifically. The ability to enter into long-term contracts for electricity sales could provide a hedge against low wholesale electricity prices for LFGTE projects and WTE facilities. In addition, the ability to enter into such contracts would assist in obtaining financing for the development/expansion of LFGTE projects.

The Commonwealth, through its various economic development arms, should encourage co-locating industrial and institutional facilities and commercial business centers to facilitate the utilization of waste heat from LFGTE projects and WTE facilities. Such efforts would offset consumption of fossil fuels, and would also provide additional revenue to these facilities. Generally, the focus should be on promoting co-development at WTE facilities, which have higher waste heat loads and more centrally located facilities.

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half of the total carbon emissions)…". Because 50% of the carbon emissions would occur regardless of combustion, half of the emission rate has been used. This is consistent with other calculation methodologies set forth on US EPA's website.

Municipal solid waste is a valuable feedstock for generation of electricity by landfills and WTE facilities. Currently, significant quantities of MSW travel from New York and New Jersey, through Pennsylvania, to Ohio and Virginia landfills. The Department should adopt policies to capture this trans-state transported MSW for beneficial use inside the Commonwealth. This would have the added benefit of significantly increasing revenue to the Department and funding of statewide recycling programs.

Processing of landfill gas into a mobile source fuel has occurred in other states. Because trash pickup trucks travel routes that by definition include a waste disposal facility, conversion of trash pickup trucks to compressed natural gas (including fuel produced from landfill gas) is a viable option. In Pennsylvania, the primary barrier to these conversions is Chapter 90 of the Pennsylvania Vehicle Code, the Liquid Fuels and Fuels Tax Act, which requires alternative fueled vehicles to pay tax on use of alternative fuels at the same rate of fossil fueled vehicles. This tax essentially eliminates any economic incentive to produce mobile source fuel from landfill gas. The Commonwealth should survey other state's fuel taxing provisions and determine if changes to the Liquid Fuels and Fuels Tax Act should be considered by the General Assembly to promote natural gas-type fuels as a mobile source fuel.

The Future

The Commonwealth has been a very good partner in helping many of these projects come to fruition. Many LFGTE projects, particularly those at smaller landfills, were seeded with Energy Harvest and other grant money. Industry stakeholders note that the central office of the Department of Environmental Protection's (DEP) Bureau of Air Quality has been particularly helpful in removing air permitting hurdles for these projects, and the Public Utility Commission has similarly been helpful in assisting with landfill gas pipeline siting and distribution issues, as well as interconnection issues for electricity generating projects. Continued assistance from these Commonwealth stakeholders is critical.

Though not widely deployed in Pennsylvania, new technologies beyond WTE and LFGTE are in active development and should be evaluated for future deployment in the disposal of MSW. Such emerging technologies include gasification, pyrolysis, and legitimate fuel production. MSW can be processed into a fuel, and the City of Philadelphia has recently contracted with Waste Management, Inc. for such a project. The CCAC has recommended that these emerging technologies be actively evaluated during preparation of the next Climate Change Action Plan.

GHG Emissions Reduction Analysis:

Increasing the amount of landfill gas utilized for electricity generation by 10% would decrease GHG emissions by 0.723 million metric tons per year. This is a reasonable goal, beginning in 2015, assuming adoption of some, but not all, of the recommendations in this workplan specific to electricity generation form LFGTE projects at landfills. Increasing the amount of electricity generated by the existing WTE facilities through increased operational efficiency will result in an additional decrease in GHG emissions. A 1% increase in efficiency—i.e. generating 1% more electricity from the same amount of waste—would correlates to an increase of approximately 16,000 MWh of electricity per year. Using the average thermal mix (50% coal, 50% natural gas)

and a CO_2 intensity of approximately 0.69 metric tons (t)/MWh, this would reduce GHG emissions by 11,040 metric tons (0.011 million metric tons) GHG reduction. Co-locating facilities that require process heat will generate additional GHG emission reductions. Each 1 mmBTU of fossil fuel generation from waste heat reduces GHG emissions by 0.0003 million metric tons per year, and as average waste heat usage rate of 2 mmBTU per hour for 4000 hours per year, combined industry-wide, would yield an additional annual GHG reduction of 2.4 million metric tons per year. Implementation of the other recommendations in this workplan all would result in GHG emission reductions, although they are not quantified at this time. These three potential GHG emission reductions total just under 3.2 million metric tons per year.

Based on the amount of reductions possible, and assuming that some but not all of the workplan's recommendations are adopted (and/or fully implemented), it is reasonable to assume a decrease of at least 1.0 million metric tons of GHG emissions per year, starting in 2015.

Cost-Effectiveness Analysis:

The costs associated with most of these recommendations are minimal—primarily Commonwealth staff time (DEP and/or DCED). Several recommendations would generate additional revenue for the Commonwealth and industry while reducing GHG emissions, particularly the two strategies with the largest reductions—waste heat use and increasing LFGTE deployment. Additional cost-effectiveness occurs due to reduced illegal dumping and trans-state transported waste. The costs that would occur from changes to the Liquid Fuels and Fuels Tax Act are not quantified, as no specific change is recommended, but could be substantial.

Overall, it appears that an annual 1.0 million metric ton GHG reduction could be achieved on a cost-neutral or better basis.

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 this workplan and the Statewide Recycling Initiative work plan, 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 Alternative Fueled Transit Bus Fleet and Alternative Fueled Taxicab Fleet workplans may work synergistically with this workplan, depending on the specific implementation steps taken to implement those workplans and the potential for additional fueling stations.