PennState College of Earth and Mineral Sciences

John and Willie Leone Family Department of Energy and Mineral Engineering

Landfills as Methane Emission Offsets for Penn State

Naya Pandey

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Introduction

Penn State campuses require lots of energy, which results in lots of greenhouse gases emitted into the atmosphere. They have been trying to reduce their carbon footprint by getting these emissions down with the goal of 85% from 2005 levels by 2050 and are currently only down by 32%. Penn State's carbon footprint comes from a variety of sources, as depicted in Figure 1. Among the greenhouse gases emitted, methane has a significant warming potential. It has a CO_2 equivalent factor of 25, meaning that the metric tons of methane emitted is multiplied by 25 to convert it to metric tons of carbon dioxide equivalent. For the fiscal year 2019-2020, Penn State's greenhouse gas emissions were 368,809 metric tons of CO_2e, and about 10% of them can be attributed to methane. Penn State cannot reduce all of their emissions directly, so this is where potential offset projects they can purchase come in. Power plants that can capture methane from landfills and convert it to energy are an option, considering that there are approximately 50 landfills throughout Pennsylvania emitting methane.

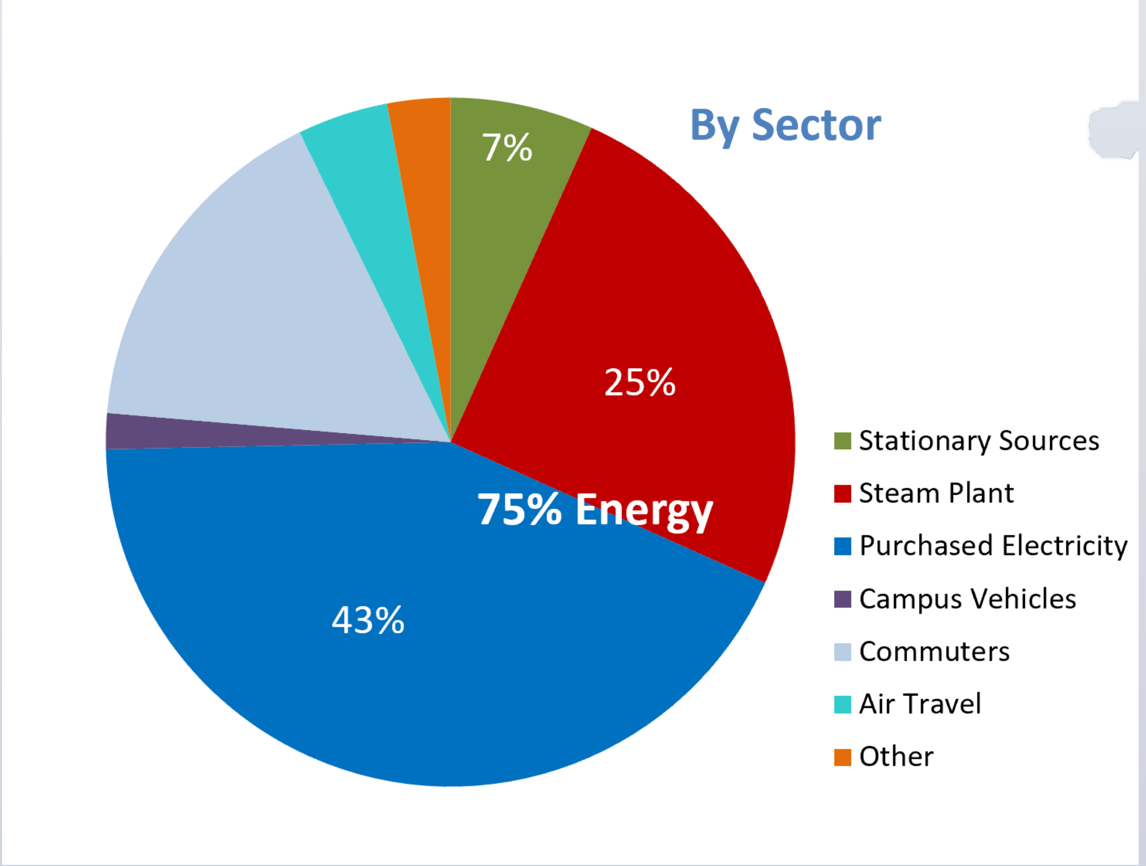

Figure 1 [4]

OBJECTIVES

- Consider ways for Penn State to reduce its carbon footprint through methane reductions
- Determine the amount of methane emitted from Pennsylvania landfills
- Evaluate the cost-effectiveness of power plants to convert methane from landfills to energy
- Calculate the levelized cost of theoretical and actual power plants
- Compare landfill projects to other methods on a scale that is realistic for Penn State

TERMS

- CO_2e – Carbon Dioxide equivalent
- MMTCO_2e – million metric tons of carbon dioxide equivalent
- Btu – unit measure of heat content from energy sources
- RGGI – Regional Greenhouse Gas Initiative

MATERIALS & METHODS

Municipal solid waste landfills are the largest human-generated source of methane in the United States. The waste decomposes in a natural, anaerobic process, generating landfill gas that is 50% methane. The gas is collected in underground pipes so it can be used to convert to renewable energy. The PA Department of Energy Protection report gives useful insight on potential methane emissions from landfills that can be captured and re-used.

Table 1 [1]

Table 18– GHG Emissions Associated with Landfilling Operations (MMTCO_2e)

	2005	2010	2015	2016	2017
Potential Landfill CH_4	8.81	9.78	9.93	9.97	10.01
CH_4 Avoided	-6.85	-8.89	-9.02	-9.06	-9.10
Oxidation	-0.20	-0.09	-0.09	-0.09	-0.09
Total CH_4 Emissions (Landfills)[15]	1.76	0.80	0.81	0.82	0.82

Looking at the most recent column, 10 MMTCO_2e from methane are emitted from landfills. Approximately 90% of this is already avoided or oxidized, leaving roughly 10% of methane that still could potentially be captured to reduce emissions.

For Penn State, this means they have the option to invest in landfill capture projects in Pennsylvania to offset the emissions that are not directly controllable, such as air and commuter travel.

A single landfill capture project avoids about 25,000 metric tons of CO_2e, meaning that Penn State would have to invest in several to offset all uncontrollable emissions.

Table 2 [1]

Emissions Totals

Source	MTCO2e
Stationary Sources	25,626
Steam Plant	97,734
Purchased Electricity	153,787
Campus Vehicles	5,987
Commuters	59,945
Air Travel	14,097
Other	11,633
Total	368,809

- Penn State campuses' air and commuter travel combined resulted in 74,000 metric tons of CO_2e for the fiscal year 2019-2020.

RESULTS

There are about 50 landfills in Pennsylvania, so if the total is 10 MMTCO_2e, then they each still release about 200,000 metric tons of methane. Using a variety of conversion factors for power plant capacity and electricity output along with the assumption of 10 MMTCO_2e emitted from PA landfills, a sample levelized cost was calculated to be \$3.12/ton CO_2e avoided. This is similar to the levelized cost calculations for actual PA landfill facilities shown in Table 3 using their heat input in Btu's and mega Watt capacity.

Table 3

Landfill	Blue Ridge Landfill	Broad Mountain	GLRA Landfill
Levelized cost	\$2.45/ton	\$3.45/ton	\$3.91/ton

$$\left(\frac{\text{TIC} \times r}{1 - (1 + r)^{-T}} \div Q\right)$$

Figure 2

Carbon offset prices can range anywhere from \$1 to \$50 per ton with very few reaching \$100 or higher. The RGGI carbon market price has risen to \$8.38 per metric ton, so landfill projects with a high enough capacity are on the relatively cheap side comparatively.

CONCLUSIONS

Landfill power plants that can convert emitted methane to electricity have lots of potential for reducing methane emissions across the state. Penn State can not directly control or reduce some of their carbon footprint, so looking to the broader carbon market for offsets might be the next best option. Landfill methane capture projects look to be a very feasible way for Penn State to invest in to reduce their carbon footprint. However, methane emissions come from many different sources, and this is just one of many possible avenues out there.

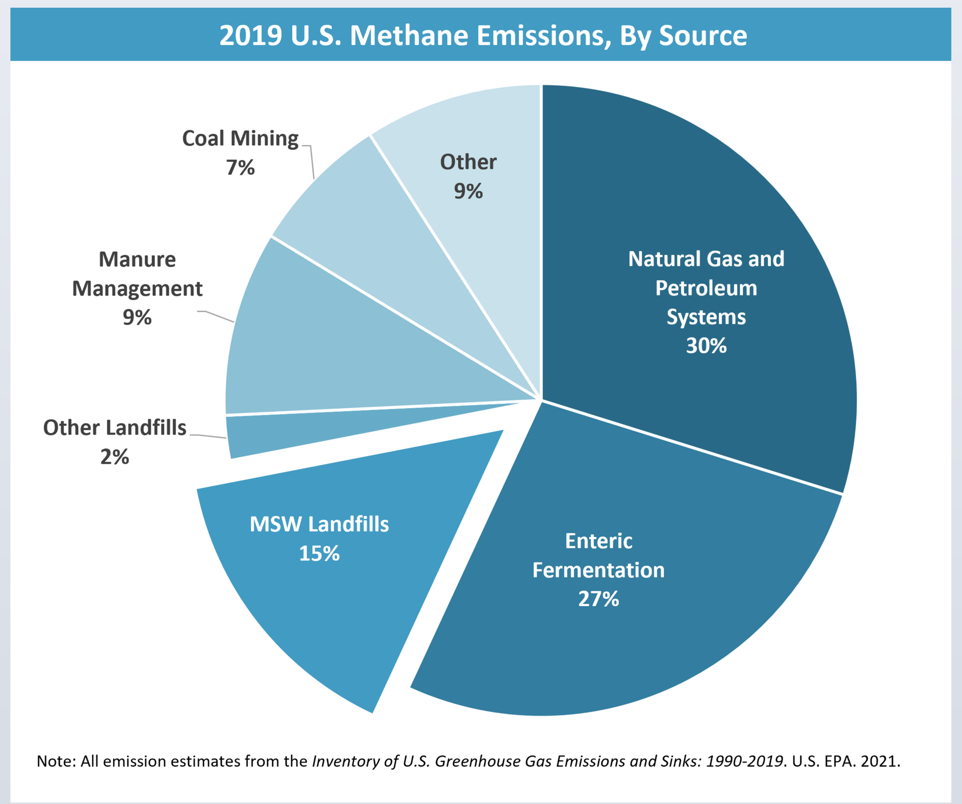

Figure 2 [3]

Other big contributors of methane emissions include natural gas, coal mining, and animal agriculture. For example, methane emitted from leaks in natural gas could be reduced through improving technology for leak detection and repair. Just like power plants for landfill emissions, many more offset strategies are being developed and priced in the market, according to their cost-effectiveness to reduce greenhouse gases in the atmosphere.

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