North Central Texas Biogas Assessment

North Central Texas Council of Governments
August 2020

This document has been prepared by the North Central Texas Council of Governments' Environment and Development Department on behalf of the State Energy Conservation Office, Contract CM20002. The work that provided the basis for this publication was supported by funding under an award with the State Energy Conservation Office. The substance and findings of the work are dedicated to the public. The author and publisher are solely responsible for the accuracy of the statement and interpretations contained in this publication. Such interpretations do not necessarily reflect the view of the State or indicate endorsement or support of the findings and recommendations.

Acronyms

ABC American Biogas Council

AD Anaerobic Decomposition (or Digestion)

BTU British Thermal Units

CF Cubic Feet

CH4 Chemical Formula for Methane

CNG Compressed Natural Gas

DFWCC Dallas-Fort Worth Clean Cities Coalition

DFWIA Dallas-Fort Worth International Airport

EPA Environmental Protection Agency

FOG Fats, Oils, and Greases

GGE Gasoline Gallon Equivalent

GHG Greenhouse Gas

GHGI Greenhouse Gas Inventories

kWh Kilowatt hour

LFG Landfill Gas

LFGF Landfill Gas Facilities

LMOP Landfill Methane Outreach Program (EPA)

MGD Million Gallons per Day

MSW Municipal Solid Waste

NCT North Central Texas

NCTCOG North Central Texas Council of Governments

NOX Nitrogen Oxides

PPB Parts Per Billion

RNG Renewable Natural Gas

TCEQ Texas Commission on Environmental Quality

VOCs Volatile Organic Compounds

WWTP Wastewater Treatment Plant

Definitions

Biogas: Biogas is produced from biomass through the process of anaerobic decomposition. Biogas is composed mostly of methane and carbon dioxide.[1]

Digestate: The material remaining after the anaerobic digestion of a biodegradable feedstock. Anaerobic digestion produces two main products: digestate and biogas. It is produced both by acidogenesis and methanogenesis and each has different characteristics. [2]

Landfill Gas: A natural byproduct of the decomposition of organic material in landfills. LFG is composed of roughly 50 percent methane (the primary component of natural gas), 50 percent carbon dioxide (CO2) and a small amount of non-methane organic compounds.[3]

Renewable Natural Gas: biomethane that is upgraded to natural gas pipeline quality standards such that it may blend with, or substitute for, geologic natural gas, including odorizing. [4]

[1]The U.S. Energy Information Administration (EIA) (https://www.eia.gov/energyexplained/biomass/landfill-gas-and-biogas.php)
[2]American Biogas Council Glossary of Biogas and Anaerobic Digestion-related Terms (https://americanbiogascouncil.org/wp-content/uploads/2019/02/ABC-Glossary-of-Biogas-and-AD-related-Terms.pdf)
[3]Environmental Protection Agency - Landfill Methane Outreach Program (https://www.epa.gov/lmop/basic-information-about-landfill-gas)
[4]American Biogas Council Glossary of Biogas and Anaerobic Digestion-related Terms (https://americanbiogascouncil.org/wp-content/uploads/2019/02/ABC-Glossary-of-Biogas-and-AD-related-Terms.pdf)

North Central Texas Biogas Assessment

The North Central Texas Biogas Assessment provides a view of the existing status of biogas production in the North Central Texas (NCT) region. The Assessment includes an inventory of current biogas projects, including landfill methane capture and biogas production from wastewater treatment plants. The Assessment provided a foundation to build upon to inform the future feasibility of production of renewable natural gas (RNG) from other sources of supply, including but not limited to food waste, and other organics. In addition, the development of additional landfill methane capture and anaerobic digestion programs in the region were evaluated. Evaluating future opportunities for creating additional renewable gas (RNG) generation from new methane capture projects and exploring regional concepts for collecting organic materials as feedstock for increased production of renewable natural gas (RNG) as vehicle fuel are important elements touched upon for consideration as regional strategies to meet regional and local government air quality, renewable energy, landfill capacity, and other sustainability goals.

The intended audience for this Assessment and regional recommendations are NCTCOG's local government members and other regional partners. Municipal, county, school districts, and other special districts, such as: water and wastewater providers, universities, and community colleges, private sector landfill operators and managers, commercial composting and agricultural entities, food processing and distribution operations, and other partners play an important role in advancing projects that have multi-jurisdictional and multiple impacts.

Several regional plans and programs, such as *Planning for Sustainable Materials Management in North Central Texas (NCTCOG, 2015)*, the regional waste management plan, support creating or expanding waste to energy efforts, reducing food waste, and conserving landfill capacity. Developing regional models to collect and transport organic waste, construct anaerobic digestion facilities, and implement programs that utilize the biogas in new ways, will take many partners and organizations working collaboratively together.

Background

By 2045, the North Central Texas (NCT) region, centered around the cities of Dallas and Fort Worth, is expected to grow from 7.7 million to 11.2 million residents. NCT is the fourth largest metropolitan statistical area in the United States and represents 25% of Texas' population. NCT also represents 28% of the state's municipal solid waste disposed (2018), a total of 10.6 million tons disposed in 2018, or 7.59 pounds per person per day. The region's explosive growth, projected to continue over the next 25 years, creates substantial challenges in reducing energy intensity, ensuring long-term landfill capacity, and developing a more sustainable future for all sectors of stakeholders – local governments, commercial entities, and residents. The addition of 4 million people will bring significant economic growth, but will also mean more vehicles on the roads, more buildings and homes being built, more energy and water consumption, and production of more food waste.

EPA's Non-Hazardous Waste Management Hierarchy **(Figure 1)** and EPA's Food Recovery Hierarchy **(Figure 2)** are two well-established waste management concepts that the NCT region supports in the 2015 Planning for Sustainable Materials Management in North Central Texas, 2015 – 2040 (Regional Plan). Great progress has been made to improve source reduction efforts; however, there will continue to be food waste, and other organics, produced through industrial, agricultural, retail, institutional, and residential processes/ uses. Evaluating the efficacy of using organic wastes for production of biogas and renewable energy production, is a recommendation of the Regional Plan, providing the foundational concept to pursue this Assessment of NCT current biogas production.

Figure 1. EPA Non-Hazardous Waste Management Hierarchy (Source: EPA)

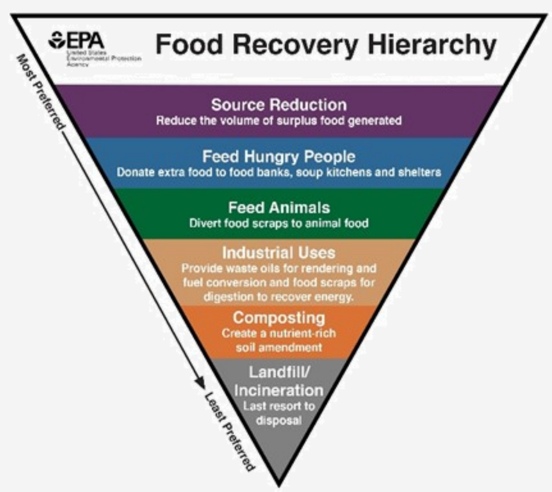


Figure 2. EPA Food Waste Recovery Hierarchy (Source: EPA)

The NCT region has many existing challenges and needs that will remain into the future should efforts not be advanced now to meet the demands of the anticipated population growth. Balancing the need to maintain a low cost of living and a strong economy, while advancing efforts to reduce energy consumption, greenhouse gas (GHG) and other emissions, and food waste, is the goal of regional programs. Several specific needs and challenges exist in NCT, including the following:

Retain and Improve Landfill Capacity
According to the Texas Commission on Environmental Quality (TCEQ), NCT has 36 cumulative years of reserve landfill capacity (TCEQ, 2018). When considering the amount of time to permit and construct new landfills, 36 years of reserve capacity will not last long with the addition of approximately 1,000,000 residents every decade. Reducing, recovering, and diverting as many items as possible from the waste stream will be critical to expanding the lifespan of the 21 existing landfills in the region, some of which have lifespans of less than three years. The region is currently grappling with the challenge of evaluating new landfill capacity in light of several landfills nearing closure. NCTCOG, through partnerships, has implemented recycling, e-recycling, composting, and household hazardous waste collection programs in order to extend the life of landfills in the region. Cities, such as the City of Dallas, have adopted zero-waste plans, and the Dallas-Fort Worth International Airport (DFWIA) is advancing a zero-waste goal. Currently, many initiatives are being performed by individual entities. While the Regional Plan recommends regional approaches to diverting food waste, the NCT has not had a regional focus on organics diversion, specifically food waste, to retain and improve landfill capacity into the future.

Divert Food Waste and Other Organics
EPA estimates that more food reaches landfills and incinerators than any other single material in our everyday trash, constituting 22% of discarded municipal solid waste. A 2019 regional waste characterization study revealed that the NCT regional waste stream is comprised of food waste (31%), other organics (14%), and yard waste (4%), for an approximate 50% of organic material in the waste stream (**Figure 3**). The volume of food waste in the NCT municipal waste stream is almost 10% higher than the national average. These values represent a fraction of the waste stream and do not account for other sectors or other potential organic feedstocks that are known to exist. For example, the EPA's Excess Food Opportunities Map **(Figure 4)** shows 2,542 educational entities that have between 53,284 (low) and 273,763 (high) tons of excess food per year while food manufacturers and processors have and estimated 2.5 to 8.2 million tons per year. These data points represent a tremendous opportunity for NCT to evaluate food waste as a feedstock to support AD infrastructure and renewable energy projects.

Improve Biosolid Management

Many local governments in NCT have composting programs that divert yard waste from landfills. Some programs mix the yard waste with biosolids from the wastewater treatment plants (WWTP) to provide compost for city facilities and/or sell the material to the public. The City of Denton has provided Dyno Dirt products since 1997. Dyno Dirt is compost made using anaerobically digested biosolids from the Pecan Creek Water Reclamation Plant and yard waste, which has prolonged the life of the Denton-owned landfill. Other cities such as the City of Weatherford, currently dispose of their WWTP biosolids in their landfill. Because Weatherford's landfill has approximately 3 years of remaining capacity, the city is currently evaluating opportunities to begin a composting program to mix yard waste with the WWTP biosolids.

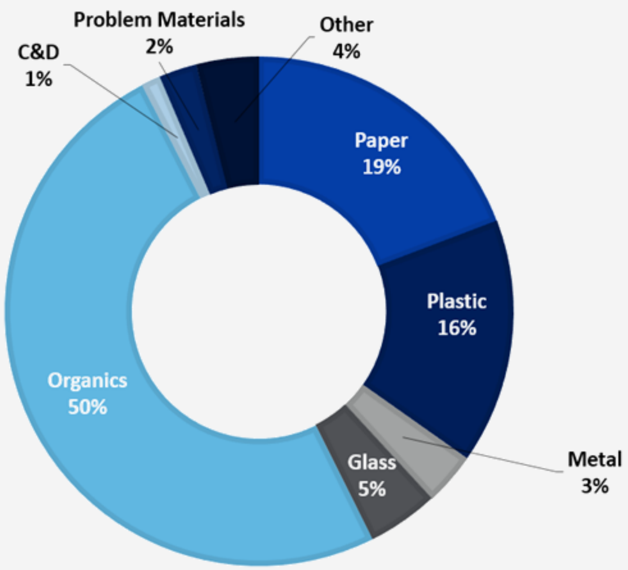


Figure 3. 2019 NCT Regional Waste Characterization Study Results (Source: NCTCOG,

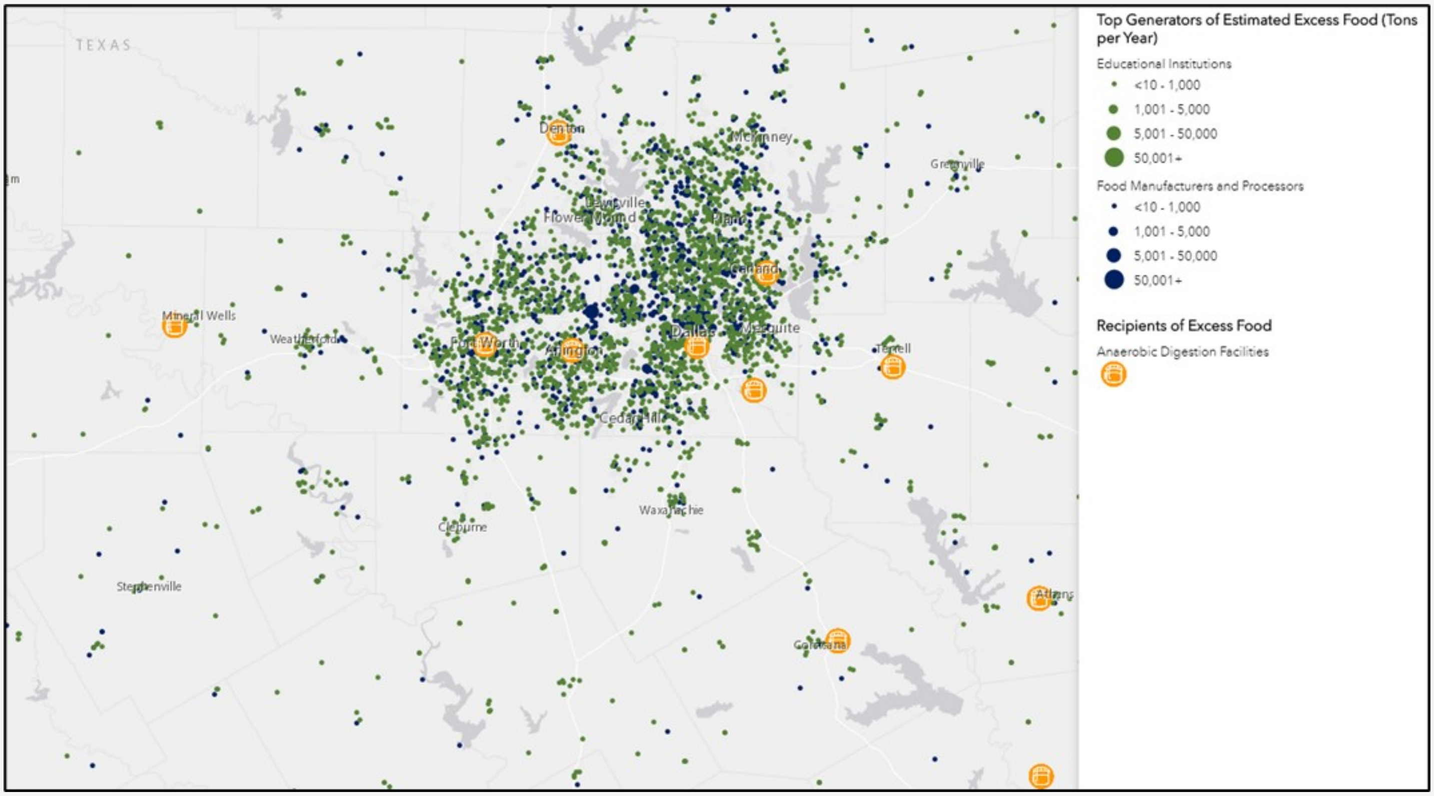


Figure 4. North Central Texas Top Generators of Estimated Excess Food (Tons per Year) – Educational Institutions and Food Manufacturers and Processors (Source: EPA Excess Food Opportunities Map)

As the region continues to grow, the volume of biosolids produced from WWTP operations will grow as well, creating additional demand for landfill space and additional cost to local governments for disposal. Evaluating the economic case and potential for diverting yard and lawn clipping/waste to mix with AD digestate/biosolids, would provide valuable data and support for expanding composting programs. Opportunities to co-locate new AD facilities at existing WWTPs provides economies of scale and the potential for net-zero operations at new or existing WWTP.

Produce Biogas and Renewable Fleet Fuel

In 2009, the 81st Texas Legislature established the Texas Bioenergy Policy Council and Texas Bioenergy Research Committee to promote "the goal of making biofuels a significant part of the energy industry in this state not later than January 1, 2019." According to the American Biogas Council (ABC), Texas ranks 2nd out of 50 states for its biogas production potential. The ABC estimates up to 78.51 billion cubic feet of renewable methane from biogas could be produced each year for energy, fuel, heat, and more. This is equivalent to removing 7.75 million cars from the road (ABC). In support of these Statewide goals, the NCT region is already a leader in the production of landfill gas. Some of these facilities use organics, such as grease and other feedstocks to fuel their biogas production. While the NCT region has established biogas production facilities, growing the number of facilities that can process other forms of biomass into fuels for transportation is supported by multiple regional goals.

As cities strive for more sustainable transportation systems, many are considering renewable fuels for fleets. Biogas has several advantages as an alternative fuel. Composed primarily of methane, it can be cleaned for use in natural gas vehicles or burned in a turbine/engine to generate electricity for electric vehicles. Biogas can reduce air pollutant emissions from fleet vehicles. NCTCOG houses the Dallas-Fort Worth Clean Cities Coalition (DFWCC), which works with local fleets to increase the use of alternative fuels among fleet vehicles. One of the largest natural gas vehicle users in the region, DFWIA, has already transitioned its fuel contracts to renewable natural gas (RNG) using landfill gas, totaling more than 200 vehicles using nearly one million gasoline gallon equivalent (GGE) of RNG. Two other major fleets with natural gas vehicles have recently signed, or are in process of negotiating, RNG contracts for their vehicle fleet fuel, indicating that RNG is gaining momentum in NCT.

Reduce Greenhouse Gas and Other Emissions

According to the American Gas Foundation, RNG has lower lifecycle CO_2 emissions than geologic natural gas. Because of its low to negative life-cycle carbon footprint, RNG has excellent potential to help continue driving down emissions and bring us closer to meeting our region's and nation's emission reduction goals. **Figure 5** depicts the lower lifetime emissions of NOx, VOC, SOx of compressed natural gas. As a region in non-attainment for ozone, the NCT region has aggressively pursued strategies that reduce emissions of nitrogen oxides (NOX) for decades. While attaining the federal standard for ozone in NCT continues to be a primary regional goal, a few cities in NCT have taken steps to produce greenhouse gas inventories (GHGI) and identify GHG emission reduction strategies. Because GHGs do not conform to political boundaries, the NCT region is currently working on production of a regional GHGI to improve data analytics and build regional partnerships that enable the implementation of strategies, policies, and programs that reduce or avoid GHG emissions on a regional scale. Quantifying the emission benefits of increasing AD production and the use of the end products is valuable information to local governments who are implementing GHG and other emission reduction strategies to meet climate action and sustainability goals.

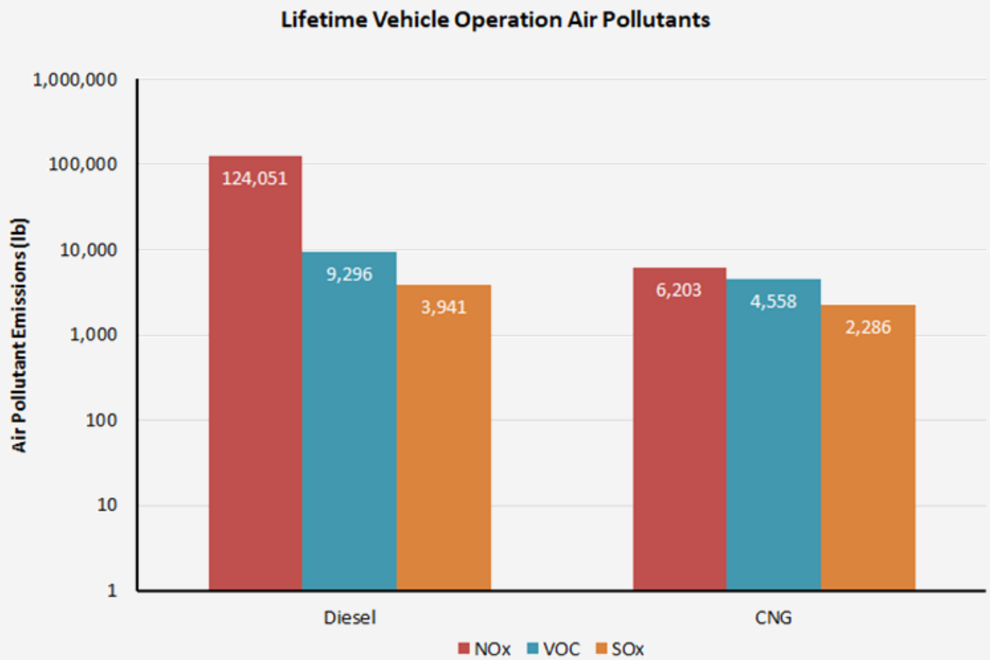


Figure 5. Lifetime Vehicle Operation Air Pollutants (Source: Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET), it was created by Argonne National Laboratory)

As the region continues to grow, these challenges will evolve and change over time, but will continue to remain. These challenges are too large for any one entity to solve on their own, therefore, regional collaboration provides efficiencies and opportunities for new partnership models that provide win-wins for multiple partners. Understanding where NCT is currently informs potential future opportunities to make positive advancements in addressing these challenges.

Biogas Production Processes

Biogas is produced from biomass through the process of anaerobic decomposition. Anaerobic bacteria—bacteria that live without the presence of free oxygen—occur naturally in soils, in water bodies such as swamps and lakes, and in the digestive tracts of humans and animals. These bacteria eat and break down, or digest, biomass and produce biogas. Biogas is composed mostly of methane and carbon dioxide. Methane (CH_4) is the same energy-rich compound found in natural gas. The composition of biogas varies from 40%–60% methane to 60%–40% carbon dioxide (CO_2), with small amounts of water vapor and other gases.

Biogas forms in, and can be collected from, municipal-solid-waste landfills and livestock manure holding ponds. Biogas can also be produced under controlled conditions in special tanks called anaerobic digesters. Biogas can be treated to remove CO_2 and other gases (RNG), and it can be used as a fuel just like natural gas.

[6] Bloomberg NEF Electric Vehicle Outlook 2019, https://about.bnef.com/electric-vehicle-outlook/

The material that is left after anaerobic digestion is complete is called digestate, which is rich in nutrients and can be used as a fertilizer.[5] **Figure 6** depicts the basic sources and processes used to produce biogas either from landfills or anaerobic digestion.

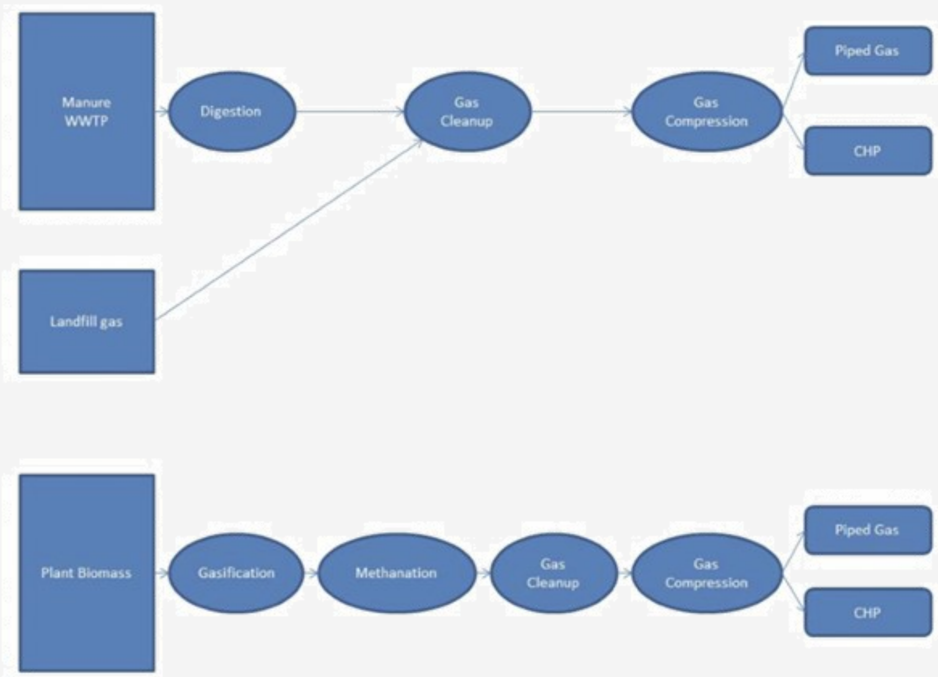


Figure 6. Sources and End Uses of Biogas Production (Source: Landfill Gas (LFG)

Municipal solid waste (MSW) landfills are excellent sources of biogas as it is produced naturally by the anaerobic conditions of a landfill. The biogas produced from landfills is also referred to as landfill gas (LFG). LFG is a natural byproduct of the decomposition of organic material occurring in landfills. It is composed of roughly 50 percent methane (CH_4), 50 percent carbon dioxide (CO_2) and a small amount of non-methane organic compounds.[6] When upgraded to pure methane through refinement and processing, it becomes comparable to conventional natural gas.

The production of landfill gases takes several years to occur after waste is in place in a MSW landfill, undergoing changes several times throughout the process. During the initial phase, when MSW is first deposited in a landfill, it undergoes an aerobic (with oxygen) decomposition stage in which biodegradable wastes react with oxygen present in the landfill, beginning the formation of carbon dioxide. During the next phase, which typically sets in within less than 1-year, anaerobic (without oxygen) conditions are fully underway. Methane-producing bacteria decompose the waste, breaking it down into hydrogen, ammonia, carbon dioxide, and inorganic acids which begin to generate methane.[7] The anaerobic phase of decomposition varies from landfill to landfill but it can last 20 or more years, during which time the composition of gases present continue to change. Carbon dioxide, which increased in the short term during

[5]The U.S. Energy Information Administration (EIA) (https://www.eia.gov/energyexplained/biomass/landfill-gas-and-biogas.php)
[6]Environmental Protection Agency - Landfill Methane Outreach Program (https://www.epa.gov/lmop/basic-information-about-landfill-gas)

[7]Environmental Protection Agency - Landfill Methane Outreach Program (https://www.epa.gov/lmop/basic-information-about-landfill-gas)

the early phases, begins to level off while nitrogen and hydrogen decline significantly. In contrast, methane increases steadily once a landfill is in the anaerobic phase before leveling off at a steady rate along with carbon dioxide **(See *Graph 1*)**[8].

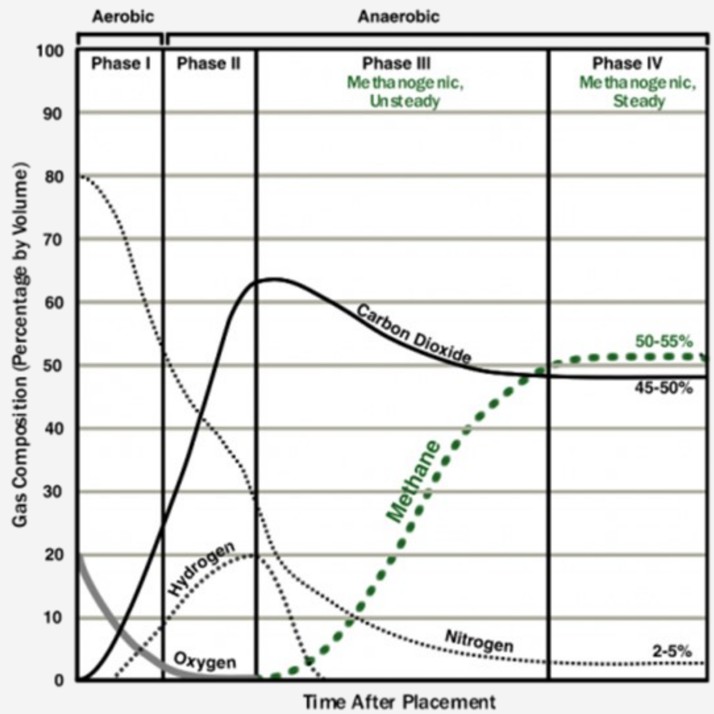
Two types of systems, passive and active, exist for controlling the production of methane gas generated by landfills. Passive systems vent the landfill gas into the atmosphere naturally. Active systems utilize mechanical methods to remove and collect methane gas.

Landfill gas collection from active systems has several end-use project category types which each require different amounts of processing or refinement. As shown in **Figure 7**, landfill gas may be collected, processed and used:

- In the generation of electricity (including engines, turbines, and cogeneration),
- Applied to a direct use (including medium-Btu technologies such as boilers or other direct thermal uses), and
- Refined and upgraded to pure methane for use as a renewable natural gas.

Anaerobic Digestion

Biogas can be produced under controlled conditions in special tanks called anaerobic digesters. In an anaerobic digestion process, organic material, or feedstock, provides the needed food for microorganisms that produce methane under controlled conditions. The result of the microorganisms processing of the organic materials, is biogas, or methane, and digestate. Digestate, also known as biosolids, is rich in nutrients and can be used as a fertilizer, soil amendments, or combined with other biosolids or organic waste to produce compost. The resultant biogas can be used to produce heat or electricity and if further treatment is applied, the biogas can be turned into RNG to fuel vehicles or exported back to the natural gas pipeline for use as gas. **(Figure 8)**[9] depicts the biogas production process from anaerobic digestion.



Graph 1. Changes in typical LFG composition after waste placement (Source: EPA: Landfill Gas Energy Basics)

Wastewater treatment plants are common applications of anaerobic digestion facilities, as are farms or other processes where there is high availability of organic feedstocks. Many wastewater treatment plants use food waste in the form of fats, oils, and grease to fuel their anaerobic digester to produce energy.

Environmental Benefits and Impacts of Biogas and Landfill Gas Emissions

The capture and use of methane from landfills and WWTPs provide positive outcomes such as improved air and water quality, improved human health, enhanced

[8]Environmental Protection Agency - Landfill Gas Energy Basics (https://www.epa.gov/sites/production/files/2016-07/documents/pdh_chapter1.pdf)

[9] Environmental and Energy Study Institute (EESI)

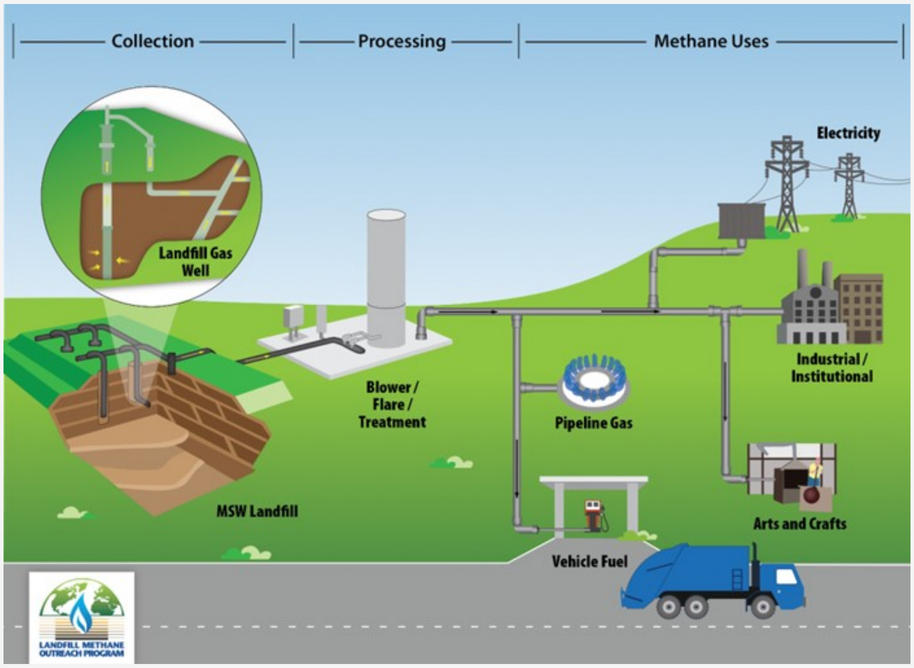


Figure 7. Collecting and Treating Landfill Gas (Source: EPA: Landfill Gas Energy Basics)

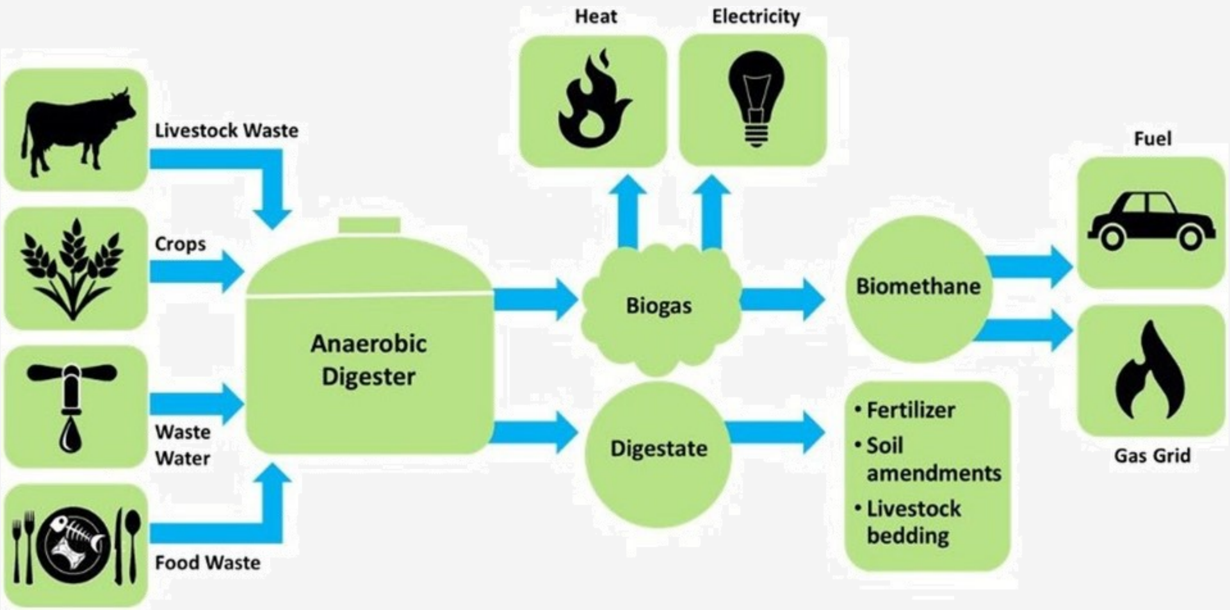


Figure 8. Biogas Production from Anaerobic Digester (Source: Environmental and Energy Study Institute (EESI))

energy security, economic growth and reduced odors.

As a potent greenhouse gas (GHG), methane is 28 to 36 times more effective than CO_2 at trapping heat in the atmosphere over a 100-year period, according to the latest Intergovernmental Panel on Climate Change (IPCC) assessment report (AR5). This warming effect is important to note as GHGs work to insulate the Earth much like a blanket, trapping heat inside the Earth's atmosphere. GHGs from man-made sources and activities are, in particular, responsible for a significant increase of the Earth's temperature above previous levels. The last three decades have seen the greatest warming effect as each has successively been the

the warmest decade on record since 1850. A lingering impact, and unintended consequence of the industrial revolution, the atmospheric concentrations of methane have increased by roughly 165 percent, since 1750 from 700 ppb to 1,857 ppb in 2018.[10] However, an increased warming of the atmosphere is not the only observable effect of the imbalance of GHGs. Changes to rainfall patterns, snow and ice cover, and rising sea levels have all been observed and well documented.

When it comes to methane emissions in the United States, MSW landfills are the third-largest source of human-related methane emissions, exceeded only by agriculture and oil and natural gas systems respectively.[11] In 2018, methane emissions from landfills accounted for approximately 17.4 percent of the total U.S. methane emissions, domestic and industrial wastewater treatment accounted for another 2.2 percent, while the composting of organic materials accounted for just 0.4 percent of all methane emissions.[12] Despite being only the third-largest source of methane emissions from human-related activities, the capture of methane from landfills represents a positive way to reduce GHG emissions.

Methane capture and use from landfills not only prevents its harmful release into the atmosphere, but when processed into renewable natural gas (RNG) it lessens the use and dependence on other geological fuels, such as natural gas, allowing them to remain sequestered in the ground. According to the American Gas Foundation, RNG has lower lifecycle CO_2 emissions than geologic natural gas.[13] This low to negative life-cycle carbon footprint of RNG has excellent potential to help continue driving down emissions, as any reductions of methane release into the air that are implemented today can have an immediate impact on slowing the warming of the atmosphere, bringing us closer to meeting our region's environmental goals.

Since 1990, overall methane emissions from landfills has decreased by 40%. This decrease coincides with an increase in landfill gas collection programs and control systems as well as a reduction in decomposable materials entering MSW landfills.[14] However, the amount of landfill gas being collected for beneficial use, such as RNG, has not kept pace with the rate of methane generation from MSW landfills due to the growing U.S. population.[15] This signals an area of opportunity for new, and the expansion of existing, landfill gas collection programs.

Climate Impact

In an energy analysis on biogas potential in the United States released by the National Renewable Energy Laboratory (NREL) in 2013, the methane potential from landfills, animal manures, wastewater, industrial, institutional, and commercial organic wastes to create RNG from biogas in the United States alone was estimated to be around 7.9 million tonnes per year. This would be the equivalent of about 420 billion cubic feet or 431 trillion British thermal units (Btu). If fully

[10] IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp. (https://www.ipcc.ch/report/ar5/syr/)
[11] Environmental Protection Agency – US Inventory of Greenhouse Gas Emissions and Sinks: 1990-2018 (https://www.epa.gov/sites/production/files/2020-04/documents/us-ghg-inventory-2020-main-text.pdf)
[12] Environmental Protection Agency – Overview of Greenhouse Gases (https://www.epa.gov/ghgemissions/overview-greenhouse-gases)
[13] Environmental Protection Agency – US Inventory of Greenhouse Gas Emissions and Sinks: 1990-2018 (https://www.epa.gov/sites/production/files/2020-04/documents/us-ghg-inventory-2020-main-text.pdf)
[14] American Gas Foundation: Renewable Sources of Natural Gas: Supply & Emissions Reduction Assessment Study (December 2019)
[15] Environmental Protection Agency – US Inventory of Greenhouse Gas Emissions and Sinks: 1990-2018 (https://www.epa.gov/sites/production/files/2020-04/documents/us-ghg-inventory-2020-main-text.pdf)

realized, this could displace about 56% of current natural gas consumed by the transportation sector and 5% in the electric power sector. [16]

Per Texas Commission on Environmental Quality's (TCEQ) most recent *Municipal Solid Waste in Texas: A Year in Review* report, there were two permitted and 25 registered landfill gas recovery facilities in the state of Texas in 2018. Of these facilities recovering landfill gas for beneficial use, in 2018 alone they were responsible for an estimated 24.9 billion cubic feet of gas processed; 9.5 billion cubic feet of gas distributed off-site; 435 million kilowatt hours of power generated and sold; and 80 million kilowatt hours of power generated and used on-site.[17] The kilowatt hours of power generated and sold and used on-site for just the year 2018 is equivalent to the following GHG emissions, CO2 emissions, and sequestered carbon as shown in **Figure 9.**

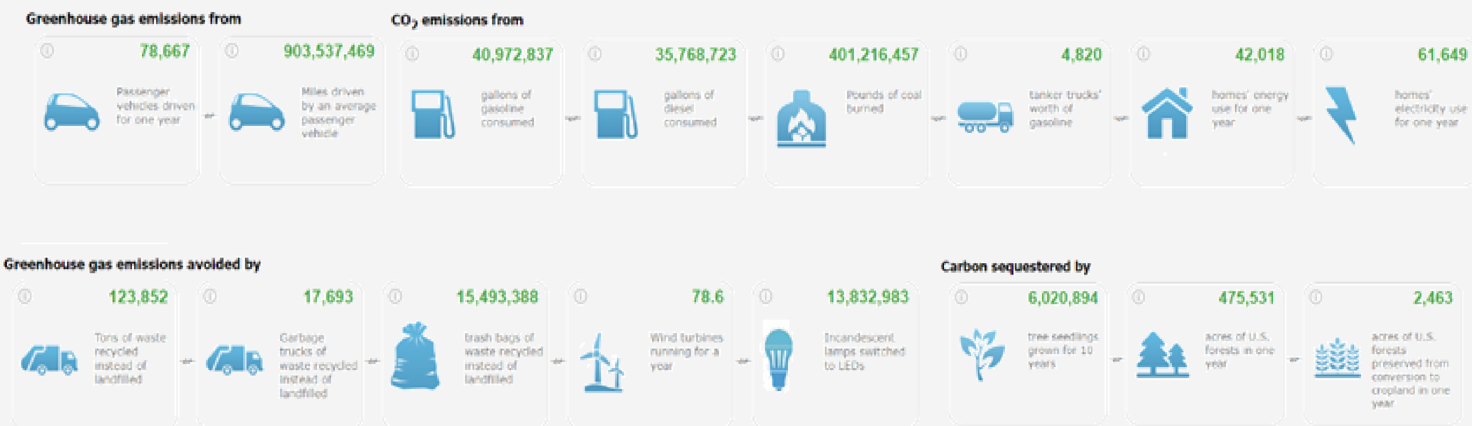


Figure 9. Greenhouse Gas Equivalencies Calculator (Source: EPA: Energy and the Environment)

Economic Benefits of Biogas Collection and Production

The lack of capture and use of methane emissions from landfills represents a huge lost opportunity to capture and use what could otherwise be a significant energy resource. The benefits of collecting and using LFG are significant and vary from energy cost savings, to revenue generation to climate change mitigation. If LFG can be captured and converted, instead of being flared or escaping into the air, it can be used as a cost-effective renewable energy resource. Furthermore, the capture and use of LFG prevent methane from otherwise migrating into the atmosphere, contributing to smog and global climate change.

[16] Environmental Protection Agency – US Inventory of Greenhouse Gas Emissions and Sinks: 1990-2018 (https://www.epa.gov/sites/production/files/2020-04/documents/us-ghg-inventory-2020-main-text.pdf)
[17] NREL Biogas Potential in the United States (https://www.nrel.gov/docs/fy14osti/60178.pdf)

LFG energy projects provide environmental and economic benefits to multiple stakeholders (landfill owners, energy services providers, businesses, communities, and local governments). They can reduce GHGs emissions that are a contributor to global climate change; help offset the use of non-renewable resources such as geological natural gas; improve air quality locally, regionally, nationally and globally; provide a source of revenue for landfills; reduce energy costs for the users of LFG energy; and finally create jobs. [18]

Transportation Sector Benefits

The primary component of natural gas is methane and when landfill gas is refined and upgraded to pure methane by removing the water, carbon dioxide, hydrogen sulfide and other trace elements, it becomes valuable as *renewable* natural gas (RNG). This RNG is comparable to conventional natural gas and can thus be injected into the pipeline grid or used as fuel in a compressed or liquified form.

From 2015 to 2019, RNG used as a fuel for transportation nationwide increased by 291 percent. This displaced the equivalent of nearly 7.5 million tons of carbon dioxide (CO_2) from entering the atmosphere. NGVAmerica and RNG Coalition reported that 277 million gallons out of a total of 717 million gallons of natural gas used as motor fuel in 2019 were renewable. [19]

The NCT region is ripe for additional RNG supply to fill natural gas fleet needs. Based on fleet reports submitted to DFWCC, over 2,000 additional natural gas vehicles across the region consumed nearly 16.5 million GGE of conventional CNG in 2019. This is a readily available market of end-users for RNG, which is an easy "drop-in" fuel solution for these fleets who are already using CNG. Moreover, because this represents just a portion of CNG activity in the region, based on the approximately 40 local fleets who self-reported fuel consumption data to DFWCC, the potential demand for RNG is much broader. DFWCC evaluated registration data received from the Texas Department of Motor Vehicles and identified over 250 diesel-powered vehicles labeled as "garbage trucks" that are registered within the NCTCOG/DFWCC service territory. These vehicles also represent low-hanging fruit for RNG transition, as natural gas fuel is particularly well-suited to use in refuse vehicles due to lower fuel costs and a well-matched duty cycle that results in a lower total cost of ownership over the vehicle life.

In fact, natural gas-powered refuse vehicles represented over 50 percent of new truck orders industry-wide in 2015.[20] Transitioning half of the remaining 250 diesel-powered refuse vehicles would demand another 42,120 GGE RNG per year. This transition would also lead to reductions in air pollutant emissions. With an assumed vehicle lifetime of 15 years, the greatest criteria pollutant reductions are in ozone-forming pollutants, including a 95% reduction in NOX emissions and 50% reduction in VOCs. This RNG scenario also leads to an over 80% reduction in well-to-wheel GHGs. Compared to diesel vehicles, externality costs are also reduced by over $10 million.[21] These impact estimates truly represent low-hanging fruit, a minimum level of RNG adoption, as they are based solely on self-reported fleet data and vehicles registered as "garbage trucks." Potential adoption may be much broader as many other heavy-duty diesel vehicles operating in and around NCT may also transition to RNG fuel. Many organizations, especially in the private sector, have begun adopting climate goals, and RNG presents an opportunity for substantial reductions in carbon emissions, even more so than fleet electrification.

[18] TCEQ's Municipal Solid Waste in Texas: A Year in Review, 2019
[19] EPA Landfill Gas Energy Basics (https://www.epa.gov/sites/production/files/2016-07/documents/pdh_chapter1.pdf)

[20] NGVAmerica: Renewable Natural Gas On-Road Fuel Use Continues to Grow, April 20, 2020
[21] https://www.cleanenergyfuels.com/compression/blog/refuse-truck-fleets-switch-natural-gas-power-who-when-where-why/

Many fleets may have been hesitant to consider CNG fleet fuel as a climate strategy because it still results in substantial well-to-wheel carbon emissions. In contrast, RNG, on a well-to-wheels basis, represents a net reduction in carbon emissions. These fleets also have the potential to realize renewable credits that can create an economic incentive for RNG use above and beyond sustainability goals.

North Central Texas Biogas Production

Landfill Gas Capture

As of 2018, the North Central Texas region had 25 active landfills.[22] Type I landfill facilities accounted for 84% of all active landfills (21 landfills) and 16% (4) facilities were Type IV landfills. Municipal Solid waste (MSW) facilities in Texas are classified according to the method of processing or disposal (30 TAC §330.5). Type I landfills are the standard landfills for MSW disposal in Texas while Type IV landfills only accept brush, construction or demolition waste, and other similar non putrescible waste (organic waste that decomposes without causing odors or attracting pests). **Figure 10** provides the locations of the Type I and Type IV landfills in NCT.

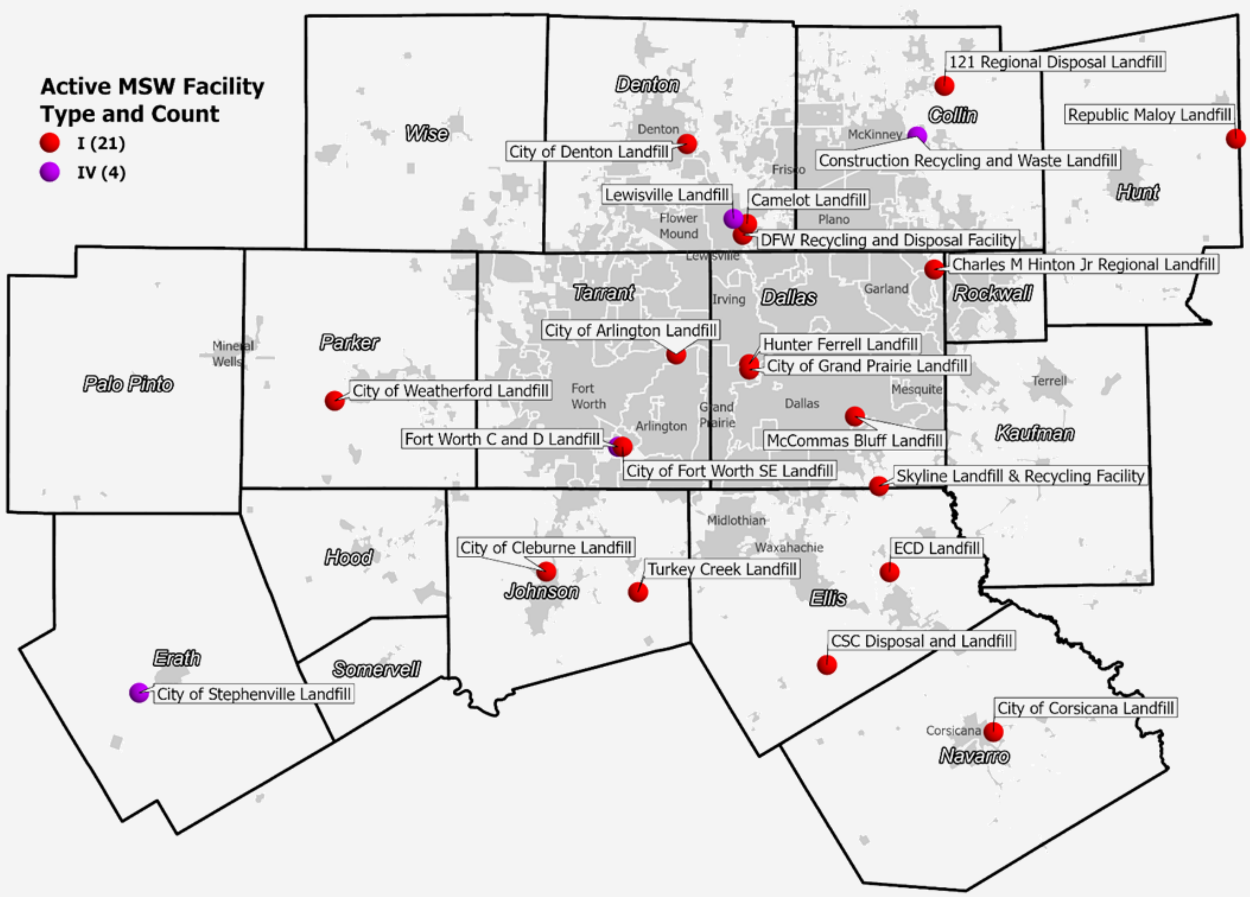


Figure 10. North Central Texas 2018 Type I and Type IV Landfill Locations (Source: TCEQ and NCTCOG)

[22] Calculated using Argonne National Laboratory Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool, https://greet.es.anl.gov/afleet

Closed MSW facilities are of interest due to their potential of biogas collection. Although methane content at open landfills is on average 6.2 percent higher than at closed ones, closed landfills have been found to be 17 percent more efficient than open landfills at capturing biogas (Powell et al. 2015). Type and count of closed landfills in the region is shown in **Figure 11**. These closed landfills potentially represent an opportunity that should be explored to expand the capacity of landfill gas capacity in the North Central Texas region.

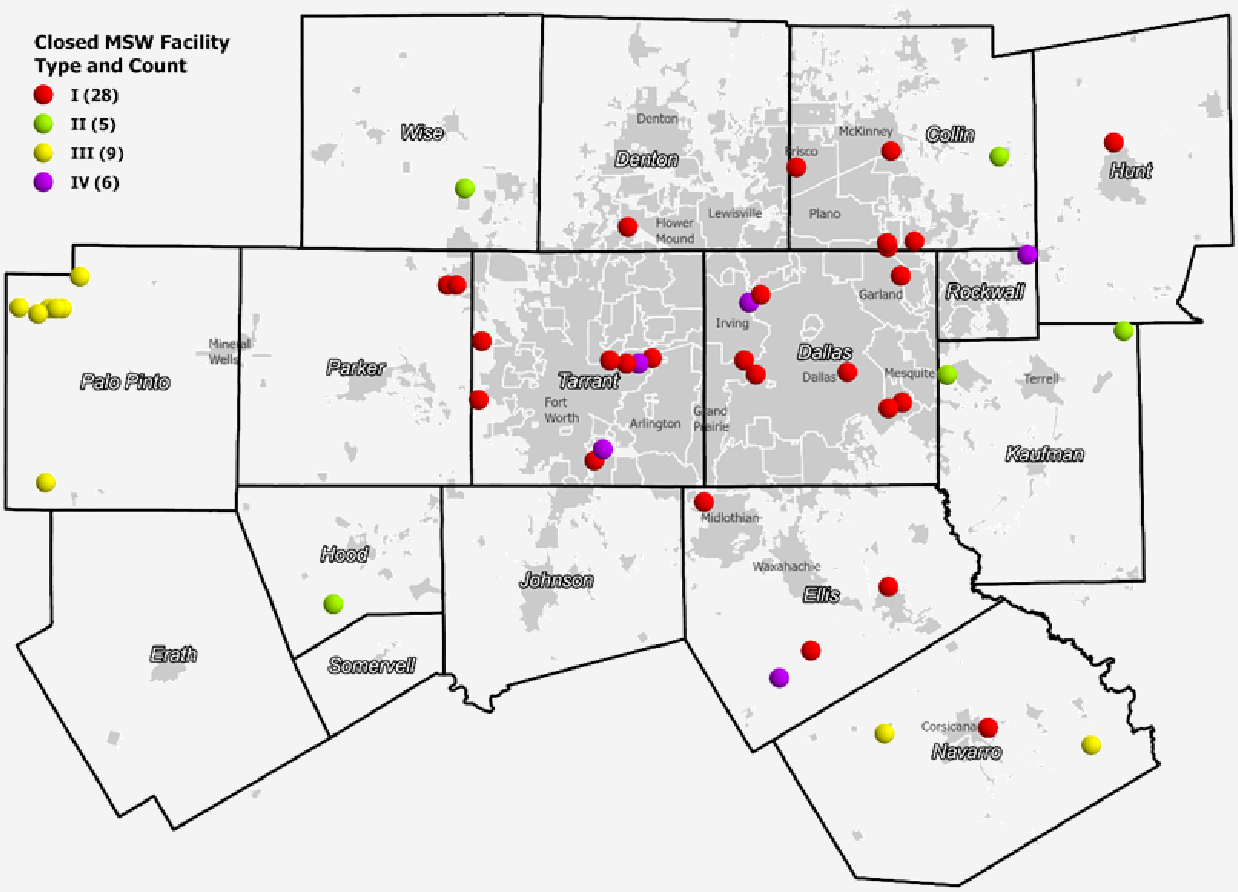


Figure 11. Spatial distribution of closed MSW facilities in the region. (Source: TCEQ)

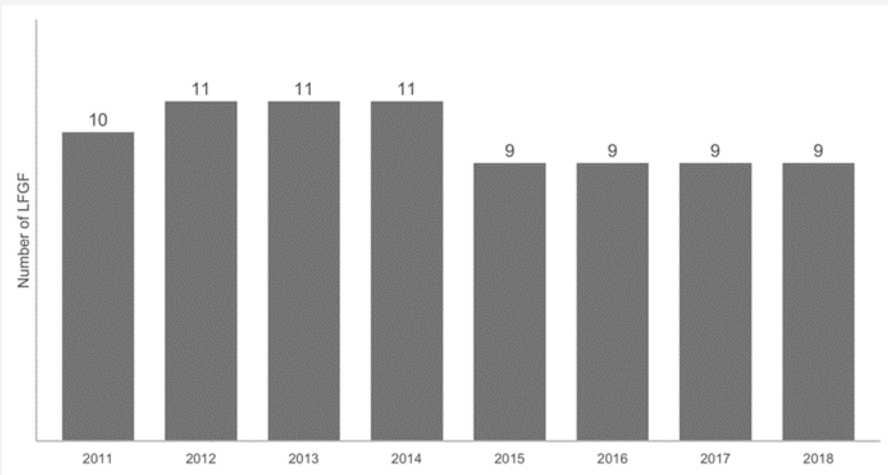
Existing Landfill Gas Capture Locations in NCT

Table 1. represents the active facilities that recovered landfill gas for beneficial use (Type 9GR) in NCT in 2018. Of the 25 landfills in NCT, nine facilities are actively recovering LFG for use. Data for MSW facilities recovering landfill gas for beneficial use is submitted every year to TCEQ by owners and operators of these facilities and goes back to 2011. A historical count of landfill gas (LFG) recovering facilities in the NCTCOG region from 2011 to 2018 are shown in the **Graph 2.** NCT hit a peak of 11 recovery facilities from 2012 – 2014 but has since decreased to 9 facilities.

According to the EPA's Landfill Methane Outreach Program (LMOP) data, there were 8 active LFG recovering facilities in the region. Additionally, the LMOP database contains information on candidate landfills, those LFG projects that are under construction, and landfills that have future potential for biogas energy. Geographic locations of facilities from LMOP's database for the NCTCOG region is shown in Figure 5.

COG	Permit or Registration	Site Name	County	Landfill	Gas Processed (ft³)	Gas Distributed Off-site (ft³)	Power Generated and Sold (kWh)	Power Generated and Used On-Site (kWh)
4	48042	121 RDF Landfill Gas Treatment Facility	Collin	2294	1,646,129,000	806,603,000	0	0
4	48018	Skyline Landfill Gas to Electric Facility	Dallas and Ellis	42D	932,325,000	0	44,071,000	1,377,896
4	48033	McCommas Bluff Landfill Gas Processing Facility	Dallas	62	3,887,922,000	1,932,584,000	0	0
4	1025B	DFW Recycling and Disposal Landfill Gas to Energy Facility	Denton	1025B	1,639,544,000	0	76,872,875	2,214,253
4	48016	City of Denton Landfill Gas to Energy Facility	Denton	1590A	360,681,932	0	11,715,177	12,745
4	48028	Camelot Landfill Gas to Energy Facility	Denton	1312B	0	0	23,690,185	977,963
4	48032	Turkey Creek Landfill Gas Treatment Facility	Johnson	1417B	507,159,000	1,035,018,000	0	0
4	48012	City of Arlington Landfill Gas Processing Plant	Tarrant	358B	627,382,000	627,382,000	0	0
4	48027	Westside Landfill Gas to Electric Facility	Tarrant	1019A	640,375,000	0	31,573,442	1,428,510

Table 1. List of Facilities Recovering Landfill Gas for Beneficial Use in 2018 (Source: TCEQ)



Graph 2. Number of LFG Facilities in NCT from 2011 – 2018 (Source: TCEQ)

In addition to the 8 active landfill gas facilities (LFGF), there were 1 planned and 2 under construction projects in the region as of March 2020. EPA also identifies candidate landfills as part of LMOP. According to the database there are 5 candidate landfills, 1 landfill with future potential and 9 sites with low potential for biogas production in the region. EPA classifies candidate landfills as those that are accepting waste or have been closed for 5 years or less, have at least one million tons of waste in place, and do not have an operational, under construction, or planned LFG projects. Sites with future potential are open but do not currently meet the technical criteria for candidate status or have been operational in the past but there is opportunity for additional biogas recovery. Low potential landfills are closed and do not meet the technical criteria for candidate status or are not considered a candidate due to site-specific information.

Figure 12 shows the geographical distribution of the 7 active and 1 closed landfill (Westside Recycling and Disposal Facility) that are currently producing biogas as part of their operations as identified in the EPA's LMOP database . Production at these facilities ranges from capturing biogas for on-site electricity generation, to conditioning it, to pipeline quality. Out of the 7 active landfills with landfill gas recovery projects whose type category is designated for renewable natural gas, 3 currently have projects that are operational. These facilities include 121 Regional Disposal Facility in Collin county, McCommas Bluff Landfill in Dallas county, and Turkey Creek Landfill in Johnson county. There are 2 landfills with landfill gas recovery projects that are under construction: Skyline Landfill in Ellis county and the Arlington landfill in Tarrant county.

There are 2 landfills with landfill gas recovery projects that are planned projects: DFW Recycling & Disposal Facility in Denton county and the City of Fort Worth Southeast Landfill in Tarrant County. Table 2 demonstrates specific data attributes provided from the EPA LMOP database for each LFG landfill.

Biogas Production in North Central Texas

Key data for landfill gas recovery facilities was obtained from TCEQ annual MSW reports. The data submitted to TCEQ by owners or operators of LFGF includes the following attributes: estimated standard cubic feet of gas processed at the facility; estimated standard cubic feet of gas distributed off -site from the facility; estimated kilowatt hours of power generated and sold by the facility; and, estimated kilowatt hours of power generated and used on-site by the facility.

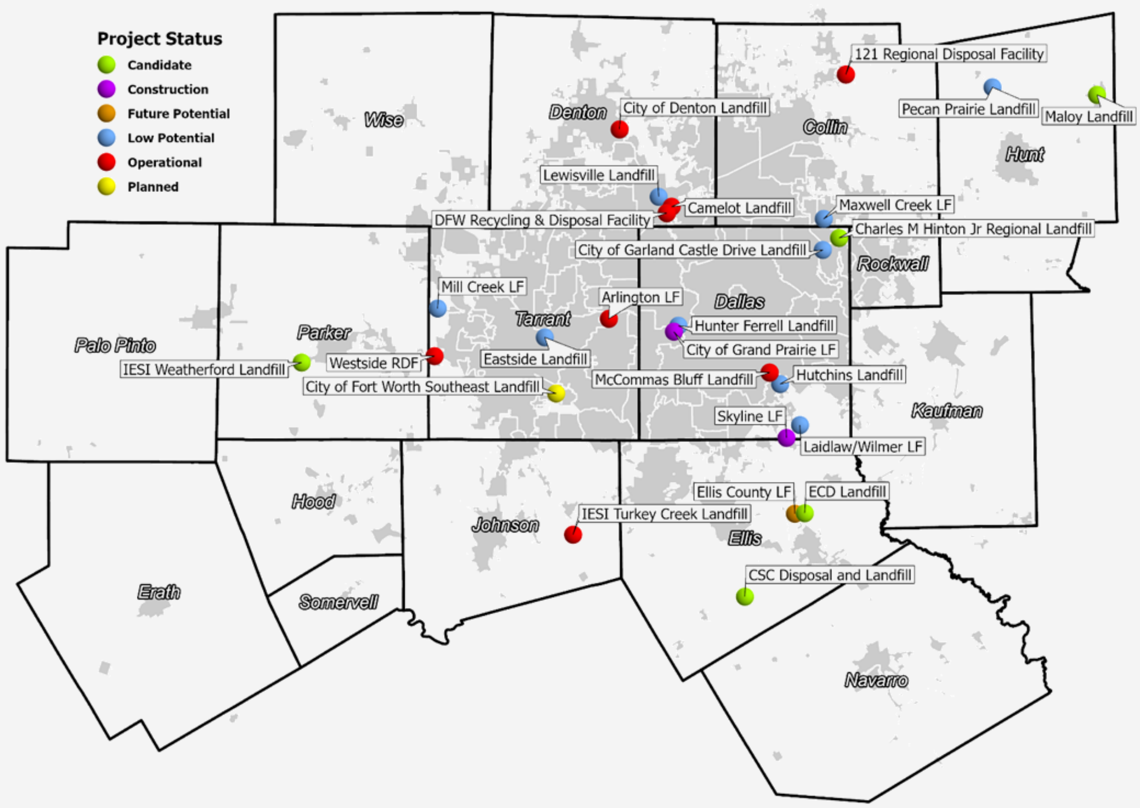


Figure 12. Geographical locations of Landfill Methane Outreach Program identified facilities in NCT. (Source: EPA, LMOP)

Landfill Name	121 Regional Disposal Facility	McCommas Bluff Landfill	Turkey Creek Landfill	Skyline Landfill	Arlington Landfill	DFW Recycling & Disposal Facility	City of Fort Worth Southeast Landfill
Current Project	Operational	Operational	Operational	Under Construction	Under Construction	Planned	Planned
County	Collin	Dallas	Johnson	Ellis	Tarrant	Denton	Tarrant
Landfill Owner	North Texas Municipal Water Dis-	City of Dallas	Waste Connections, Inc.	Waste Management, Inc.	City of Arlington, TX	Waste Management, Inc.	City of Fort Worth, TX
Current Landfill	Open	Open	Open	Open	Open	Open	Open
LFG Collected (mmscf/ day)	6.142	11.31542203	2.784	5.582	4.422	8.369	4.32
LFG Flared (mmscfd)	0	0	0	N/A	4.422	N/A	4.32
Project Start Date	12/15/2017, 1/1/2019	1/1/2008, 1/1/2012,	9/30/2012	11/30/2019	12/31/2019	1/1/2020	1/1/2020
Project Type Category	Renewable Natural Gas	Renewable Natural Gas	Renewable Natural Gas	Renewable Natural Gas	Renewable Natural Gas	Renewable Natural Gas	Renewable Natural Gas
LFG Energy Project	Vehicle Fuel	Vehicle Fuel	Electricity	Vehicle Fuel	Vehicle Fuel	Vehicle Fuel	Vehicle Fuel
RNG Delivery Meth-	Pipeline Injection	Pipeline Injection	Pipeline Injection	Pipeline Injection	Pipeline Injection	Unknown	Unknown

Table Descriptions: LFG Collected (mmscfd): Amount of landfill gas being collected in million standard cubic feet per day; LFG Flared (mmscfd): Amount of landfill gas flared (if project is operational, amount of landfill gas flared in back-up flare(s)) in million standard cubic feet per day; Project Type Category*: Category of LFG energy project type (Electricity, Direct, Renewable Natural Gas); LFG Energy Project Type*: Specific type of LFG energy project technology; RNG Delivery Method: Method for delivery of the renewable natural gas (Pipeline Injection, Local Use, Unknown)

Table 2. EPA's Landfill Methane Outreach Program Landfill Profiles LFG Collection Sites in NCT (Source: LMOP)

Estimated standard cubic feet of gas processed:

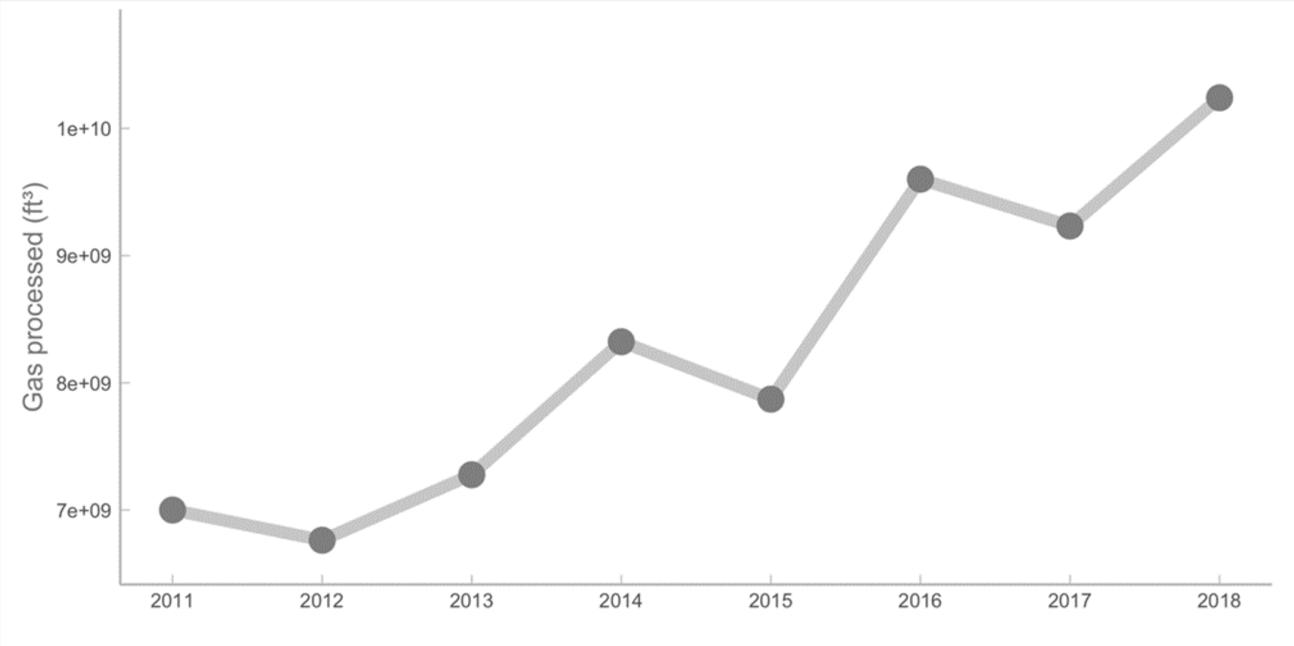
Amount of gas processed by active landfill gas recovering facilities increased significantly from 7 billion ft^3 in 2011 to 10.2 billion ft^3 2018, an increase of 45.7% over 7-year period, as shown in Graph 3. From 2011 to 2012, 2014 to 2015 and 2017 to 2018 there was a slight decrease in the gas processed in the region, but the rest of the periods are consistent with the overall upward trend shown in Graph 4.

Estimated standard cubic feet of gas distributed off-site:

Amount of gas distributed off-site from the facilities increased between the years 2011 and 2018. In 2011, landfill gas recovering facilities in the NCTCOG region distributed 1.24 billion ft^3 of biogas. By 2018, the amount of gas distributed was 4.4 billion ft^3, an increase of 254.8%. Over a half of this change (53.7%) is attributed to a steep increase from 2017 to 2018.

Estimated kilowatt hours of power generated and sold:

For the power generated and used there was a downward trend for the 7-year period. In 2011 energy generated and used was 165 million kWh and by 2018 it changed to 6.01 million kWh, a percent decrease equivalent to 96.4%. Power generated and sold exhibited high level of variability over the same time period. There were three time periods for which the amount of energy sold decreased and four for which it increased. Over the entire time period there is no clear trend. See Graph 5.



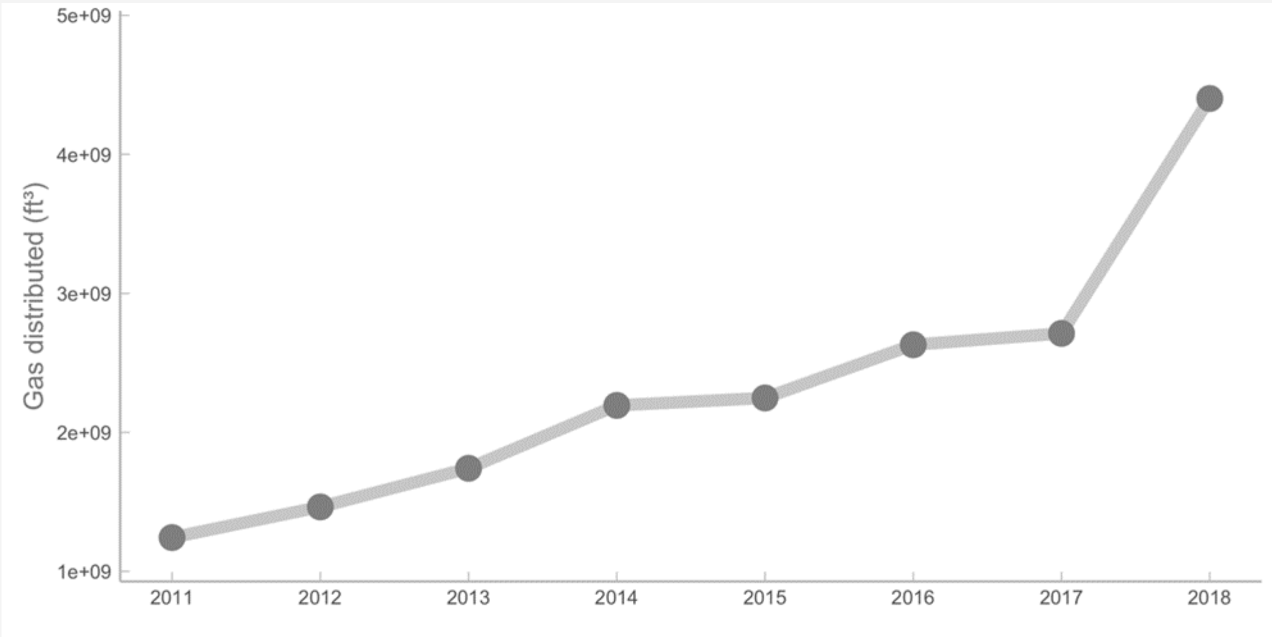
Graph 3. Amount of gas processed by active LFGF from 2011 to 2018. (Source: TCEQ, 2012-2019)

One notable LFG facility, the City of Dallas McCommas Bluff landfill, provides a good case study for using LFG as RNG that is injected into a pipeline to fuel CNG vehicles. The McCommas Bluff Biomethane Extraction Plant is one of the largest RNG facility in the nation. The following articles and references provide additional information about the RNG facility located at the City of Dallas McCommas Bluff Landfill.

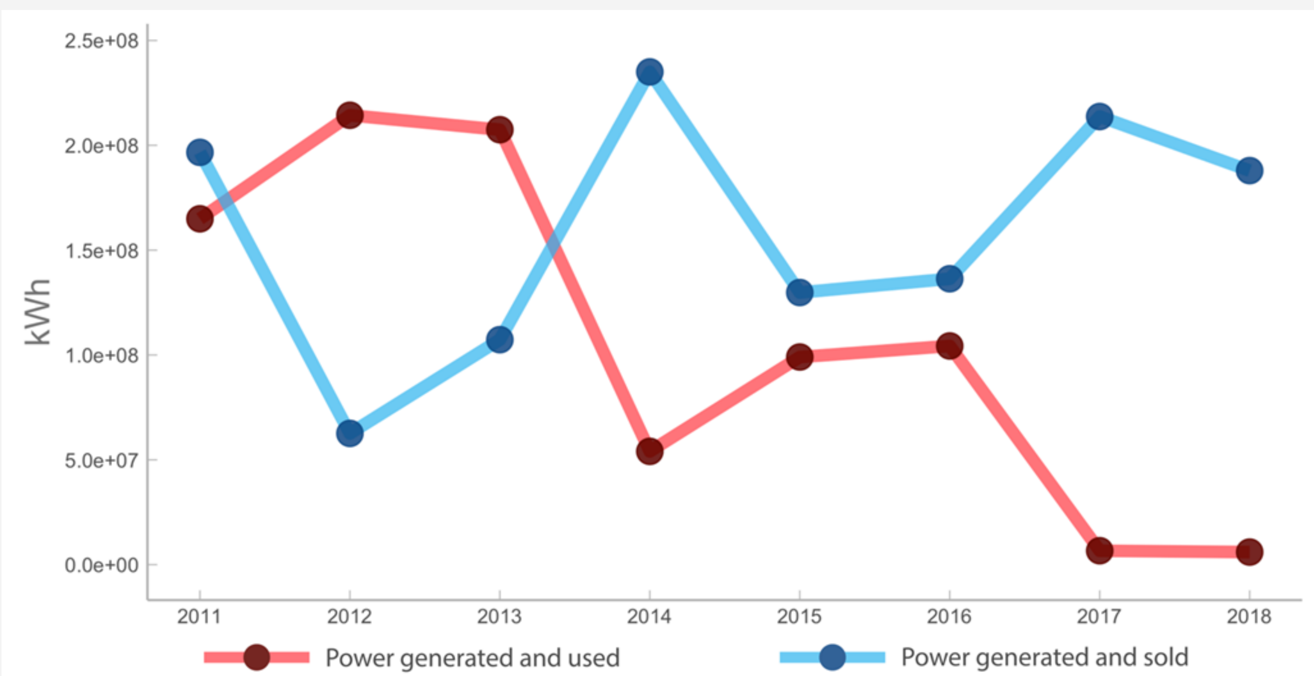
https://www.tdindustries.com/projects/mccommas-bluff

https://www.scsengineers.com/scs-project-case-stu/biogas-conversionclean-up-anaerobic-digestion-gas-plant-mccommas-bluff/

https://www.energypowerpartners.com/epp-completes-acquisitions-of-mccommas-bluff-renewable-natural-gas-production-facility/



Graph 4. Amount of gas distributed off-site by active LFGF from 2011 to 2018. (Source: TCEQ, 2012-2019)



Graph 5. Power generated used and sold by LFGF from 2011 to 2018. (Source: TCEQ, 2012-2019)

Existing Anaerobic Digestion Facilities

Production of biogas also occurs at some wastewater treatment plants (WWTP) in the region. Type and count of WWTP in the region are shown in the **Figure 13**. As can be observed in **Figure 13,** there are currently 8 WWTP in the region that utilize anaerobic digestion (AD) of biosolids for biogas production. Currently these are only major WWTP with effluent of 1 mega gallons per day or greater, and the produced energy is used for on-site electricity generation.

Several WWTPs in the NCT region, such as the City of Dallas Southside WWTP and the City of Fort Worth Village Creek WWTP provide good case studies for using AD and biogas production. The City of Denton's Pecan WWTP is smaller facility that also uses the biosolids produced from the treatment of the wastewater as compost, called Dino Dirt. The following articles and references provide additional information for these three WWTP biogas facilities and some of the co-benefits and feedstocks used for each.

Dallas Southside WWTP:

- http://www.chptap.org/Data/projects/southside-wastewater-treatment-plant.pdf
- https://dfw.cbslocal.com/2015/08/14/check-out-the-waste-water-treatment-plant-turning-you-know-what-into-electricity/
- http://greendallas.net/tag/cease-the-grease/

Fort Worth Village Creek WWTP:

- http://fortworthtexas.gov/water/village-creek/facts/
- https://fortworthtexas.gov/water/village-creek/
- https://fortworthtexas.gov/water/wastewater/energy-recovery/
- http://www.chptap.org/Data/projects/village-creek-water-reclamation-facility.pdf

City of Denton Pecan Creek WWTP:

- https://www.cityofdenton.com/en-us/all-departments/utilities/water-wastewater/water-utilities-(1)/water-utilities-accordion/wastewater-and-treatment
- https://weatnts.files.wordpress.com/2016/03/awards2015-29.pdf
- https://www.cityofdenton.com/en-us/all-departments/quality-of-life/dyno-dirt

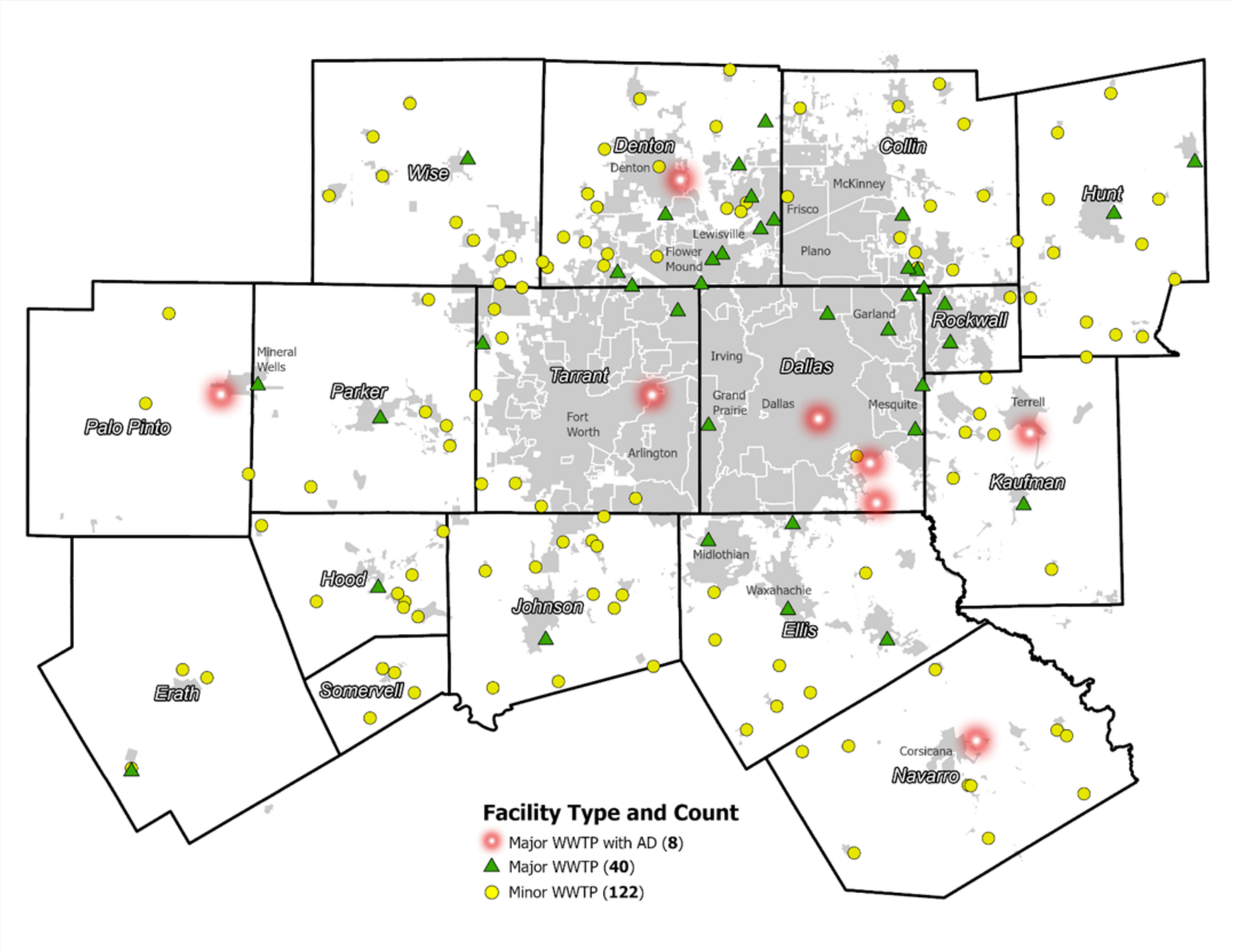
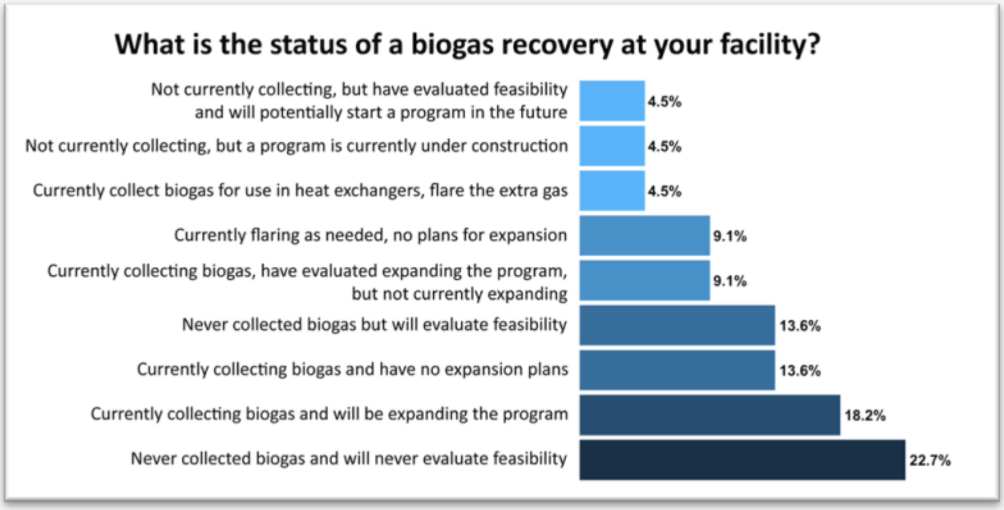


Figure 13. Spatial distribution of AD facilities and WWTP in the region (Source: TCEQ and NCTCOG)

North Central Texas Biogas Surveys Results

In order to accurately depict the current state of biogas production in NCT, NCTCOG initiated a survey of all landfills and major wastewater treatment plants (WWTP). Graph 6 illustrates the status of biogas recovery at both WWTPs and MSW landfills in NCT as provided by respondents of the survey. As shown in **Graph 6**, of the 28 respondents, 22% of them indicated that biogas has never been collected and there are no plans to evaluate the feasibility of collection at their facilities. However, a combined 31% of the respondents indicated that they are currently collecting biogas with 13% having no expansion plans and 18% working to expand their programs. 70% of respondents said that cost is the barrier that prevents them from developing biogas energy at their facilities.

According to the collected survey data, since TCEQ and EPA reports were published, two new LFGF came online in the NCT region. The City of Grand Prairie landfill indicated that they are currently collecting landfill gas and will be expanding the program, though the date for planned expansion has not yet been established. The closed McKinney landfill, owned and operated by North Texas Municipal Water District, disclosed that their facility is currently collecting biogas but has no expansion plans. The biogas energy generated at both of these facilities is sold to an intermediary company that sells it to the end user. Additionally, it was revealed that the City of Fort Worth Southeast Landfill has a landfill gas to energy project under construction. The Fort Worth Southeast Landfill is currently collecting LFG, but the collected gas is currently being flared off until a high Btu landfill gas to energy project can be completed.

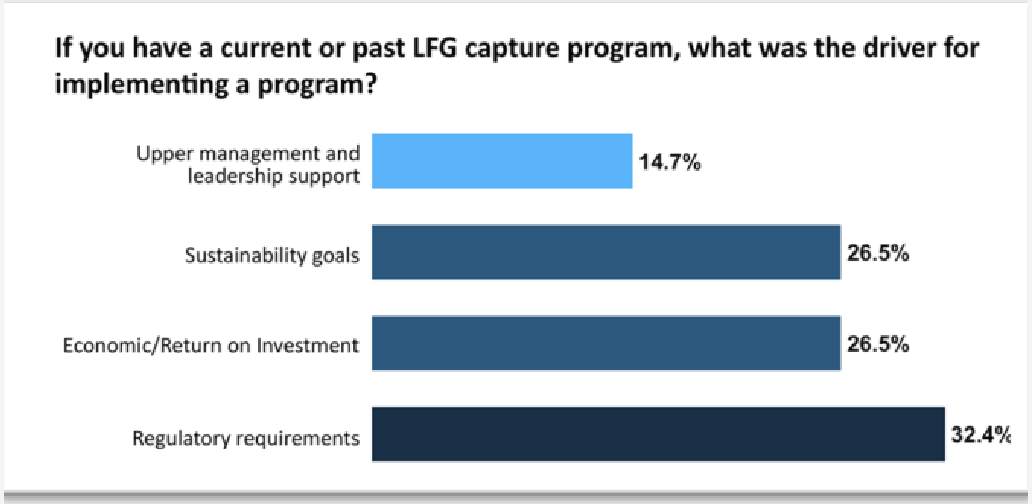


Graph 6. Status of biogas collection at NCT MSW and WWTP Facilities.

Combined with TCEQ and EPA data, our survey data shows that as of June 2020, there are 10 landfill gas to energy facilities in the 16 county NCTCOG region:

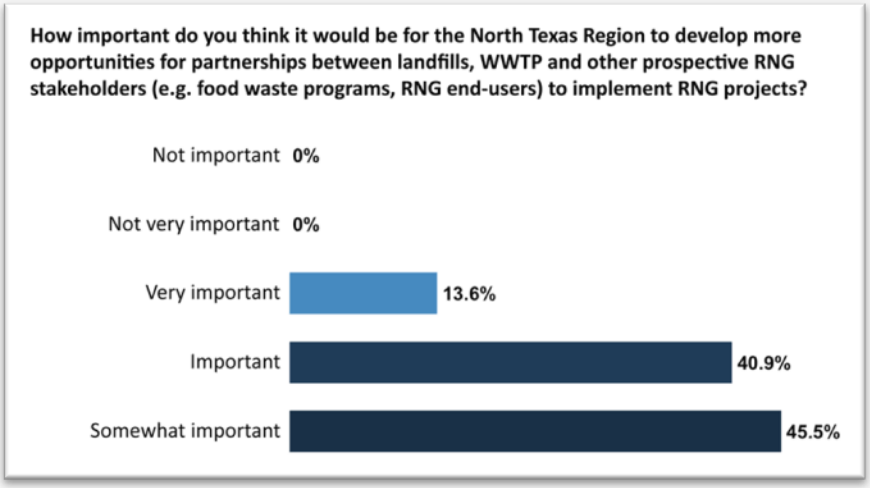
- 121 Regional Disposal Facility
- McCommas Bluff Landfill
- Turkey Creek Landfill
- City of Denton Landfill
- Arlington Landfill
- DFW Recycling and Disposal Facility
- Westside Recycling and Disposal Facility
- Camelot Landfill
- McKinney Landfill
- City of Grand Prairie Landfill

Graph 7 summarizes the driving factors behind existing LFG projects in the NCT region. Charts 2-3 summarize the openness of respondents to the expansion of biogas recovery projects within the region and developing opportunities or partnerships to further RNG projects.



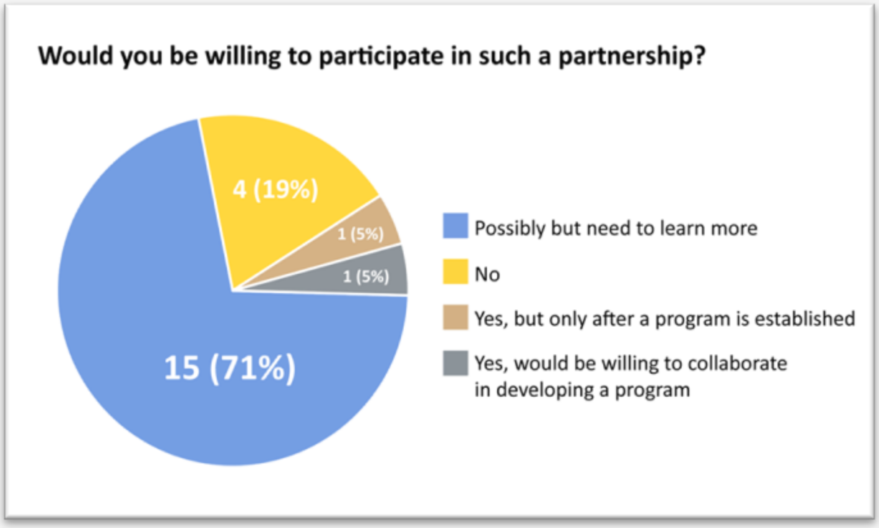
Graph 7. Driving factors for LFG capture programs.

The key drivers for implementing LFG projects are regulatory requirements, followed by sustainability goals and economic/return on investment. When combined, the sustainability and return on investment categories account for more than 50% of the key drivers, providing an important lens which to encourage new projects through. As entities in the NCT region consider new or expanding LFG projects, providing materials that speak to the sustainability goals and return on investment of these project types could be an important role NCTCOG and other partners could play to support local governments in the decision-making process.



Graph 8. Importance of developing partnerships and opportunity.

Graph 8 indicates that 22 respondents, there is some level of importance to the region to develop additional opportunities for partnerships between landfills, WWTPs, and other stakeholders to implement RNG projects. While the "Very Important" category is a small percentage of the responses, overall, the responses indicate support for developing partnerships and identifying opportunities to implement RNG projects. As a follow up to this question, **Graph 9** indicates that there is strong potential for local governments willing to participate in developing future RNG projects in NCT, dependent on learning more about the opportunity.



Graph 9. Willingness to participate in RNG partnerships.

While the data sample is small from these surveys, the data points indicate support for NCTCOG and local government partners exploring future opportunities and partnerships to expand RNG and LFG projects in the NCT region. NCTCOG could serve as a convenor of local government entities interested in exploring these concepts and provide future resources to the region related to these topics.

Regional Opportunities for Further Evaluation to Advance RNG Projects

The North Central Texas Biogas Assessment indicates that the NCT region is a leader in LFG collection. Existing projects such as McCommas Bluff RNG project, the largest RNG project in the country, demonstrate that RNG projects can be successful and provide on-the-ground case studies that other local governments can learn from. Additionally, survey data from NCTCOG's local government members and private sector partners, who own and operate landfills and WWTPs, indicate general support for looking to advance LFG and RNG projects in the region.

Several elements exist that support the future identification and development of opportunities to advance RNG projects at the regional level including the following:

Planning for Sustainable Materials Management in North Central Texas 2015 - 2040

The North Central Texas Regional Solid Waste Management Plan, Planning for Sustainable Materials Management in North Central Texas 2015 – 2040, includes several objectives and recommendations for the region that are relevant to advancing RNG projects:

- *Objective*: Encourage establishment, maintenance, and expansion of government, single and multi-family residential, and commercial waste source reduction, reuse, and recycling programs
- *Action Recommendation:* Encourage city and county programs that promote and provide opportunities for residents to participate in source reduction, recycling, composting, and waste diversion programs, including food waste programs.

- *Action Recommendation:* Encourage partnerships between local governments and large venues and event centers to establish recycling and food waste minimization programs.

- *Objective:* Expand existing collection and management alternatives for other wastes, and establish and expand new product markets
- *Action Recommendation:* Encourage local government and public/private sector collaboration to decrease food waste disposed of in landfills such as: educating the public and private sector about food waste source reduction, developing food waste disposal and processing infrastructure (e.g. community gardens or compost center), and increasing the convenience of food waste disposal.
- *Action Recommendation:* Support new or the expansion of existing energy recovery programs to decrease landfill discards.

- *Objective:* Facilitate the development and implementation of integrated solid waste management plans
- *Action Recommendation:* Encourage innovative reuse of landfill and waste disposal sites including energy recovery, renewable energy, and redevelopment opportunities

- *Objective:* Encourage the maintenance of disposal and processing capacity to meet the needs of the region
- *Action Recommendation:* Support source reduction and reuse, recycling and composting, and energy recovery initiatives to reduce additional landfill capacity needs

- *Objective:* Encourage innovative technologies to reduce, manage, and process emerging waste streams
- *Action Recommendation:* Encourage pilot programs and partnerships with local governments and private sector to demonstrate viability, feasibility, and cost effectiveness of technologies
- *Action Recommendation:* Promote innovative approaches to establish new product markets through development of technologies and processes that maximize waste value and create economic opportunity

The goals, objectives and action recommendations of the Regional Solid Waste Management Plan form a strong vision and foundation for continuing efforts to expand programs and explore opportunities for innovative partnerships and projects that preserve landfill capacity and provide economic value. Using waste products, such as food waste, as a fuel for anaerobic digestion facilities and creating renewable energy (RNG) is supported by the Regional Plan goal and objectives. Further exploration of these concepts are also supported by other priorities and initiatives at the regional level as expounded upon below.

Local Government Priorities and Initiatives

In addition to the Regional Plan identifying removal of food waste and organic materials from the municipal waste streams as a regional priority, several local governments in NCT are focusing on sustainability and climate action planning activities that support reduction of food waste and increasing renewable energy projects. In May 2020, the City of Dallas adopted its first Comprehensive Environmental and Climate Action Plan (CECAP) and is currently working on updating the Dallas Zero Waste Plan. The CECAP included an action to adopt an ordinance to implement a city-wide organics management program.

Currently, Dallas' landfill is permitted for composting and a composting operation for brush, yard waste, biosolids, and food waste from large commercial establishments is under consideration. The CECAP committed Dallas to adopt a new commercial waste ordinance (or expand requirements of another ordinance) that prevents food enterprises including restaurants, and supermarkets that prepare, process or serve food from sending organic waste to the landfill. Dallas will also be evaluating the feasibility of a residential organics management program that includes curbside pickup for yard and food waste.

The DFWIA is currently conducting a feasibility assessment to evaluate the economics of building an anaerobic co-digester on their property using food waste from the hotels, airline catering operations, terminal concessions, and other operations. This effort to evaluate an on-site anaerobic digestion supports DFWIA's goals of becoming a zero waste airport; reduces their food waste impact (currently at 30% of their waste stream); uses onsite renewable resiliency fuel to replace renewable energy credits they are currently purchasing; and, advances the concept beyond net zero energy to potentially accept waste from off-site sources. The DFWIA's study will be completed in September 2020 and lessons learned will be shared with other local governments in the region.

Strategies, such as those implemented by Dallas and DFWIA, could be considered for support amongst a larger cohort of local governments in the NCT region to bring efficiencies and economies of scale. Evaluating potential projects from a regional perspective, instead of a city by city perspective, could provide cost savings and make projects viable that would otherwise not be viable if only one city were implementing them.

Similar to a regional approach to addressing air quality and other challenges, it is apparent that a regional approach to planning for and implementing actions to increase biogas production in the region is needed. The region already has a good start as shown by this Assessment, but together innovative ideas can be developed that serve multiple entities and provide opportunities for many partners to be involved to expand production of LFG and RNG in NCT.

Next Steps

The North Central Texas Biogas Assessment has indicated that the NCT region is on a good path forward as it relates to collection of LFG and WWTPs that have active biogas applications. Expanding the opportunities in NCT to advance additional biogas collection projects could be important to assist local governments in meeting a variety of goals. NCTCOG has identified a few next steps that could be undertaken as a result of this Assessment including, but not limited to the following:

- Evaluate supply of organic materials in the region including food waste, agricultural, and other pre- and post-consumer materials.
- Further evaluate potential organic material feedstock collection networks and models for collecting feedstocks
- Evaluate closed landfill inventories and those landfills that are not currently producing LFG for potential LFG applicability
- Evaluate opportunities to form partnerships between landfills and RNG production companies

- Evaluate compressed natural gas vehicle demand in the region to better understand the potential for future CNG fleets and to ensure future fleet demand would support additional RNG capacity
- Evaluate leveraging of existing biogas production facilities to expand these operations
- Evaluate and inventory the regional emission and other benefits of expanding LFG and RNG production
- Evaluate cost-benefit analysis and return on investment of future LFG and RNG facilities

As resources are identified and efforts are supported by NCTCOG's local government members, these identified next steps could provide further clarity and opportunities to advance biogas projects, including both LFG and anaerobic digestion facilities.

Resources

American Biogas Council - Glossary of Biogas and Anaerobic Digestion-related Terms (https://americanbiogascouncil.org/wp-content/uploads/2019/02/ABC-Glossary-of-Biogas-and-AD-related-Terms.pdf)

Argonne National Laboratory Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool, https://greet.es.anl.gov/afleet

Clean Energy Fuels (https://www.cleanenergyfuels.com/compression/blog/refuse-truck-fleets-switch-natural-gas-power-who-when-where-why/)

Environmental Protection Agency – Energy and the Environment: Greenhouse Gas Equivalencies Calculator (https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator)

Environmental Protection Agency - Landfill Methane Outreach Program (https://www.epa.gov/lmop/basic-information-about-landfill-gas)

Environmental Protection Agency - Landfill Gas Energy Basics (https://www.epa.gov/sites/production/files/2016-07/documents/pdh_chapter1.pdf)

Environmental Protection Agency – US Inventory of Greenhouse Gas Emissions and Sinks: 1990-2018 (https://www.epa.gov/sites/production/files/2020-04/documents/us-ghg-inventory-2020-main-text.pdf)

Environmental Protection Agency – Overview of Greenhouse Gases (https://www.epa.gov/ghgemissions/overview-greenhouse-gases)

IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp. (https://www.ipcc.ch/report/ar5/syr/)

NGV America: Renewable Natural Gas On-Road Fuel Use Continues to Grow, April 20, 2020

NREL Biogas Potential in the United States (https://www.nrel.gov/docs/fy14osti/60178.pdf)

Texas Commission on Environmental Quality - Municipal Solid Waste in Texas: A Year in Review, Published 2019

The U.S. Energy Information Administration (EIA) (https://www.eia.gov/energyexplained/biomass/landfill-gas-and-biogas.php)