BURNS & McDONNELL

NORTH CENTRAL TEXAS COUNCIL OF GOVERNMENTS

NORTH CENTRAL TEXAS ORGANIC WASTE TO FUEL FEASIBILITY STUDY

SEPTEMBER 30, 2022

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LIST OF ABBREVIATIONS

Abbreviation	Term/Phrase/Name
ABC	American Biogas Council
ACS	American Communities Survey
AD	Anaerobic Digestion
AFDC	Alternative Fuels Data Center
AFFP	Alternative Fueling Facilities Program
ASL	Automated Side Loading Collection Vehicle
BEV	Battery Electric Vehicle
Burns & McDonnell	Burns & McDonnell Engineering Company, Inc.
CAFO	Concentrated Animal Feeding Operation
CCS	Citizen Collection Site
CH_4	Methane
CHP	Combined Heat and Power
CI	Carbon Intensity
CMAQ	Congestion Mitigation and Air Quality
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalents
CPUC	California Public Utility Commission
CY	Cubic Yard
DART	Dallas Area Rapid Transit
DFW	Dallas-Fort Worth
DFWCC	Dallas-Fort Worth Clean Cities Program
ECHO	Enforcement and Compliance History Online
ELD	Electronic Logging Device
EREF	Environmental Research & Education Foundation
EQIP	Environmental Quality Incentives Program
FEL	Front-End Load Collection Vehicle
FEMA	Federal Emergency Management Administration
FMS	Fleet Management Solution

Abbreviation	Term/Phrase/Name
FOG	Fats, Oils and Greases
GGE	Gasoline Gallon Equivalents
GHG	Greenhouse Gas
GHGRP	U.S. EPA Greenhouse Gas Reporting Program
GIS	Geographic Information System
H_2S	Hydrogen Sulfide
ICI	Industrial, Commercial, Institutional
ILA	Interlocal Agreement
IRP	International Registration Plan
ITC	Investment Tax Credits
JWPCP	LA County Sanitation District Joint Water Pollution Control Plan
kg	Kilogram
LCFS	California Low Carbon Fuel Standard
LGFTE	Landfill Gas-to-Energy
LMOP	Landfill Methane Outreach Program
m^3	Cubic Meter
MGD	Million Gallons Per Day
mi	Miles
MJ	Megajoule
MMBtu	Million British Thermal Units
MSW	Municipal Solid Waste
MW	Megawatts
NAAQS	National Ambient Air Quality Standards
NASS	National Agricultural Statistics Service
NCTCOG	North Central Texas Council of Governments
NGV	Natural Gas Vehicle
NO_x	Nitrogen Oxides
NPDES	National Pollution Discharge Elimination System
NTMWD	North Texas Municipal Water District
PAG	Project Advisory Group

Abbreviation	Term/Phrase/Name
PAYT	Pay-As-You-Throw
PFAS	Per- and Poly-fluoroalkyl Substances
PM2.5	Particulate Matter
POWER Framework	Prioritizing Organic Waste to Energy-Renewable (POWER) Framework
POWER Tool	Prioritizing Organic Waste to Energy-Renewable (POWER) Tool
Project Team	Burns & McDonnell Engineering, Inc., Energy Vision, and the University of Texas at Arlington (UTA)
RECs	Renewable Energy Certificates
RIN	Renewable Identification Numbers
RMDP	Recycling Market Development Plan
RNG	Renewable Natural Gas
RSWMP	Regional Solid Waste Management Plan
SA	Semi-Automated Collection Vehicle
scfm	Standard Cubic Feet Per Minute
SO_x	Sulfur Oxides
SSO	Source-Separated Organics
SWANA	Solid Waste Association of North America
TCEQ	Texas Commission on Environmental Quality
TERP	Texas Emissions Reduction Plan
TxDMV	Texas Department of Motor Vehicles
TXNGVA	Texas Natural Gas Vehicle Alliance
U.S. DOT	U.S. Department of Transportation
U.S. EPA	U.S. Environmental Protection Agency
UPS	United Parcel Service
USDA	U.S. Department of Agriculture
U.S. DOE	U.S. Department of Energy
UTA	University of Texas at Arlington
VOCs	Volatile Organic Compounds
WEF	Water Environment Foundation
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

The North Central Texas Council of Governments (NCTCOG) contracted with the Project Team (Burns & McDonnell Engineering, Inc., Energy Vision, and the University of Texas at Arlington (UTA)) to develop the North Central Texas Organic Waste to Fuel Feasibility Study (Study) under a U.S. Environmental Protection Agency (U.S. EPA) administered grant. The Study evaluates the potential for organic materials generated in the North Central Texas region to generate renewable natural gas (RNG) as a source for vehicle fuel and prioritizes potential pilot projects throughout the region based on key technical, financial, and operational factors. Results of the Study will support stakeholders in identifying viable, near-term opportunities to 1) divert organics from landfill disposal, 2) explore regional sludge management solutions, 3) increase adoption of alternative fuel vehicles (e.g., RNG, hydrogen), and 4) leverage funding opportunities and incentives to advance potential pilot projects.

Figure ES-1 presents the project approach and outlines the various steps taken throughout the Study. The Project Team collected and analyzed data compiled through research and outreach to evaluate the supply of organic feedstocks and demand of natural gas vehicle fuel in the North Central Texas region. This analysis provided the basis to evaluate potential pilot project locations and identify the most viable, near-term potential anaerobic digestion (AD) projects that could accept priority feedstocks (e.g., food waste, fats, oils, and grease (FOG)) for conversion to RNG vehicle fuel.

Figure ES-1: Project Approach Overview

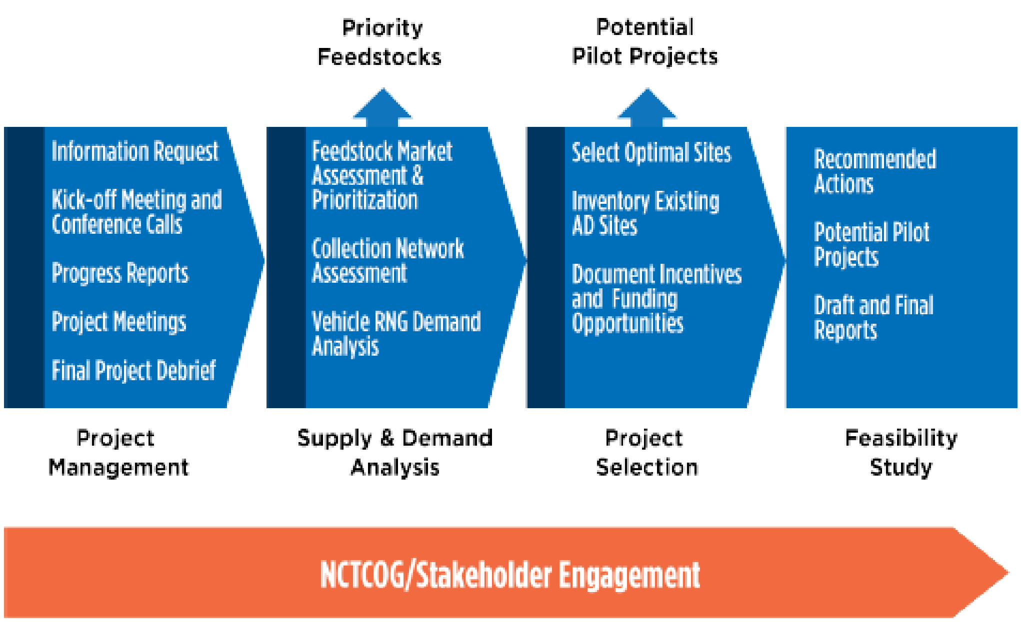

Table ES-1 indicates how the Study is organized, listing each section with a brief description of the content included.

Table ES-1: Study Section Organization and Description

Section	Title	Description
Data Analysis and Prioritization Sections		
1.0	Introduction	Communicates the project background and provides an overview of the project approach, key terms, and report organization.
2.0	Feedstock Market Assessment	Reviews the generation of various organic feedstocks for consideration and indicates the highest priority feedstocks for further evaluation in later sections of the Study.
3.0	Collection Network Evaluation	Reviews the collection networks in the region to provide a planning-level evaluation that compares each on a cost per ton collected basis to indicate the highest priority collection networks for further evaluation in later sections of the Study.
4.0	NGV Fuel Demand	Evaluates the natural gas vehicle (NGV) fuel demand in the region, identifying vehicle types that represent the highest demand of natural gas in the region for further evaluation in later sections of the Study.
5.0	Supply-Demand Comparison	Compares the projected RNG supply based on the conversion of high priority feedstocks and projected NGV fuel demand from increased adoption of NGVs in the North Central Texas region.
Pilot Project Screening and Evaluation		
6.0	Pilot Project Location Screening	Presents the pilot project screening process including use of the POWER Framework and additional screening criteria to identify the optimal digester locations.
7.0	Pilot Project Evaluation	Evaluates the selected optimal digester locations more comprehensively based on technical, financial, and operational feasibility and discusses policy drivers and funding opportunities.
8.0	Key Findings and Recommendations	Presents the key findings of the Study and recommended actions and easy first wins to advance the establishment of food waste collection networks and deployment of additional AD infrastructure and RNG production in the North Central Texas region.
Appendices		
A	Summary of Stakeholder Engagement	Provides a detailed summary of stakeholder engagement activities conducted as part of the Study including a listing of interviews conducted by the Project Team and workshop slides.
B	Collection Network Routing Results	Presents the detailed results of the collection network routing including key assumptions and outputs from the Project Team's Excel-based model.
C	POWER Framework Inputs and Outputs	Provides the key assumptions and outputs used within the POWER Framework in the screening, identification, and evaluation of potential pilot projects.
D	Sludge Generation Database	Documents sludge generation sites in the North Central Texas region.
E	CNG-to-RNG Contract Guide	Provides a high-level guidance document to transition existing wholesale natural gas purchase and sale contracts to biomethane contracts.
F	Funding and Incentive Opportunity Memorandum	Provides a comprehensive listing of funding and incentive opportunities related to key aspects of organics-to-fuel projects including environmental credits, grant opportunities, tax incentives, and public-private partnerships.

The following describes the components of the Study conducted by the Project Team.

Stakeholder Engagement

Throughout the development of the Study, the Project Team conducted several virtual interviews with key stakeholders in the North Central Texas region and conducted a series of workshops with the Project Advisory Group (PAG). See Section 1.1.1 for a description of the PAG and Table 1-2 for a listing of its members.

Stakeholder interviews were a critical component of the Study, providing key context related to the current and future considerations of select facility operators (e.g., composting, wastewater treatment plants (WWTPs)), natural gas distributors, and other industry stakeholders (e.g., trade groups).

In addition to the stakeholder interviews, the Project Team conducted a series of workshops throughout the duration of the Study to review preliminary results and receive feedback from the PAG as the Study progressed:

- Workshop #1: Stakeholder Kick-Off Workshop & SWOT Analysis
- Workshop #2: Supply and Demand Analysis Workshop
- Workshop #3A: Potential Pilot Projects Workshop (Part 1)
- Workshop #3B: Potential Pilot Projects Workshop (Part 2)
- Workshop #4: Final Feasibility Study Workshop

Based on the stakeholder interviews and workshops with the PAG, the Project Team identified key takeaways that informed the development of the Study:

1. There is a demonstrated need to establish sludge management solutions in the North Central Texas region and evaluate the potential of a regional approach.
2. Based on discussions with natural gas distributors and natural gas vehicle (NGV) fleets, there is expected growth in the adoption of these vehicle types and interest to increase utilization of RNG.
3. While hydrogen fueled vehicles and infrastructure are not currently commercially available, potentially generation hydrogen through steam reformation is a long-term solution that is under development among industry stakeholders.

Further detail of the stakeholder engagement conducted as part of this Study is provided in Appendix A.

Data Analysis and Prioritization Evaluations

The Project Team analyzed organic feedstocks, collection networks, and NGV fuel demand in the North Central Texas region to establish the direction of the Study. Further discussion of the methodology specific to each prioritization evaluation is provided in each respective section, including detailed description of the data sources and approach to conducting the data analysis.

Based on a detailed data analysis and modeling of organic waste generation (see Section 2.0), collection network types (see Section 3.0), and NGV fleets (see Section 4.0) in the region, the Project Team collaborated with the PAG to determine the key inputs that served as the basis for screening and selection of potential pilot projects. Food waste and FOG feedstocks were prioritized for high potential biogas yields and expected future growth in generation volumes; commercial collection and high-density residential collection networks were prioritized based on higher comparative collection efficiency and cost effectiveness; and solid waste collection vehicles, buses, and tractor-trailer fleets were prioritized for increased NGV and hydrogen adoption based on fuel demand.

Additionally, the Project Team established the Targeted Organics Collection Area of Collin, Denton, Tarrant Dallas and Erath counties, based on the locations of prioritized organic feedstocks, potential RNG supply, and anticipated NGV demand across the North Central Texas region (see Section 5.0).

Pilot Project Screening and Evaluation

The Project Team developed a comprehensive list of sites containing solid waste management or AD infrastructure within the Targeted Organics Collection Area, which was then screened to identify potential and optimal pilot project sites. Sites were screened based on geographic, technical, and logistical considerations to develop a short-list of potential pilot projects. This short-list was refined collaboratively with the PAG to select two sites (City of Dallas Southside WWTP and City of Denton Landfill Complex) for further evaluation, as these two facilities are currently at the highest level of readiness compared to the other short-listed facilities. As part of the pilot project screening analysis, the Project Team leveraged UTA's Prioritizing Organic Waste to Energy-Renewable (POWER) Framework to conduct aspects of the geographical, technical, and environmental evaluation. An overview of the POWER Framework is provided in Section 1.1.4 with details of the model and assumptions is provided in Appendix C.

Table ES-2 presents the selected potential pilot project locations that were advanced to the short-list and indicates if each site has existing AD processing technology. The full results of the pilot project screening process are presented in Section 6.0, with results of the evaluation for Dallas Southside WWTP and Denton Landfill Complex presented in Section 7.0.

Table ES-2: Short Listed Facility Locations

Facility	Facility Type	County	AD (Y/N)
City of Dallas Southside WWTP	WWTP	Dallas	Y
City of Denton Landfill Complex	Multiple Facilities	Denton	Y
Village Creek Water Reclamation Facility	WWTP	Tarrant	Y
Central Regional WWTP	WWTP	Dallas	Y
Fort Worth Brewery	WWTP	Tarrant	Y
Peach Street WWTP	WWTP	Tarrant	N
City of Dallas Bachman Transfer Station	Transfer Station	Dallas	N
City of Garland Rowlett Creek WWTP	WWTP	Dallas	N
City of Garland Transfer Station	Transfer Station	Dallas	N
City of Mesquite Recycling/Waste	Composting/WWTP	Dallas	N

Significantly more AD capacity will need to be installed to effectively divert prioritized feedstocks across the North Central Texas region, and the short-list represents optimal locations for further evaluation. The Dallas Southside WWTP and the Denton Landfill Complex were selected for further evaluation because in addition to being in optimal locations, these sites have existing AD capacity, are co-located within solid waste systems that provide supporting infrastructure and are municipally owned and operated. While there are other locations on the short-list that fall into these categories, such sites were not identified as the most optimal locations for a regionally focused potential pilot project at this time; however, locations not selected for further evaluation (both on the short-list and long-list) are not disqualified from consideration as future organics-to-fuel projects.

Potential Pilot Project Key Findings and Recommendations

The following presents select key findings and recommendations, focused on those related to recommended potential pilot projects and next steps to advance the development of organics-to-fuel efforts in the North Central Texas region. A comprehensive listing of key findings and recommendations is provided in Section 8.0.

Data Analysis and Prioritization Evaluations (see Sections 2.0– 5.0)

- **Over 8 million tons of organic materials are generated each year from MSW (e.g., residential, commercial), agricultural, and wastewater sources in the North Central Texas region**. Of this, a significant portion of organic waste is already recovered in the region and diverted from disposal.

- **Existing biogas resources (such as landfill gas-to-energy and WWTP AD systems) represent a notable level of existing organics-to-fuels activity and potential RNG supply.** There are opportunities to utilize biogas currently produced within the North Central Texas region. Existing biogas resources is a high priority feedstock with additional opportunity for fuel conversion.

- **Regional organics-to-fuel projects should prioritize food waste and FOG as high priority feedstocks for source-separated collection and conversion to RNG**. Medium priority feedstocks, specifically manure and wastewater treatment sludge, can also be considered for further evaluation. Yard waste and crop residues should not be prioritized at the present time.

- **Residential high-density, commercial slurry collection, and commercial unprocessed collection networks are most cost-effective.** Commercial slurry collection is most cost-effective at an estimated $72.30 per ton followed by commercial unprocessed collection at $87.43 per ton and $156.42 per ton for high-density residential collection. Collection of slurry requires fewer services per customer compared to the other collection types, and although there would be less available food waste available for collection compared to the other collection networks, it is still most cost-effective on a per ton basis.

- **Evaluate pilot projects that collect food waste and FOG from commercial customers.** The most cost-effective collection networks on a per ton basis are in the commercial sector. Selected pilot projects should be evaluated based on the development of collection networks primarily from the commercial sector, including supporting on-site processing and collection via vacuum trucks for transportation to pilot projects. Residential collection of food waste from high-density areas is possible and should be considered in applicable systems but presents implementation challenges.

- **High-volume NGVs make up the current and potential future RNG demand in the North Central Texas region**. The Project Team identified solid waste collection vehicles, tractor-trailers, and buses as high-volume NGVs and focused evaluation of natural gas demand on those vehicle fleet types. Solid waste collection vehicles have the highest rate of adoption among high-volume NGV types. Buses consume the highest amount of fuel on an annual per vehicle basis among high-volume NGV types. Although passenger vehicles and industrial equipment utilize natural gas engines, based on discussions with stakeholders these are not a key target for increased RNG adoption.

- **Hydrogen fueling infrastructure is not commercially available on a widespread basis, but can be produced by further processing RNG.** Although the infrastructure for hydrogen fueling has not yet been implemented, it presents an opportunity to further displace diesel and minimize vehicle emissions.

- **There are opportunities with each of the high-volume NGVs identified for increased adoption in the North Central Texas region.** Due to the many factors that go into decisions on when to invest in new vehicles (e.g., lower fuel pricing of natural gas compared to diesel) and which fuel type best fits the organization's operations and goals, a portfolio approach to prioritizing the increased NGV adoption among solid waste collection vehicles, tractor-trailers, and buses (including both transit buses and charter buses) would best support the development of organics-to-fuel projects in the region.

- **AD projects for consideration should be within the Targeted Organics Collection Area.** Use of the POWER Framework and additional screening to identify optimal digester locations and potential pilot projects should focus within Collin, Dallas, Denton, Erath, and Tarrant counties (the "Targeted Organics Collection Area"). Collin, Dallas, Denton, and Tarrant counties each have over 10 million GGE of potential RNG supply from food waste and existing biogas resources. In these areas, co-digestion projects should be targeted to divert high priority feedstocks such as residential and commercial food waste and FOG, and consideration should be given to projects that are co-located with existing biogas resources. Projects in Erath County should focus on the potential RNG supply of over 6.8 million GGE per year from Concentrated Animal Feeding Operation (CAFO) manure.

Pilot Project Screening and Evaluation (see Sections 6.0 and 7.0)

- **Adding food waste and FOG feedstock quantities determined for each pilot project scenario would increase biogas yields.** Based on the planning-level evaluation generated utilizing the POWER Tool, processing the estimated 52,620 tons of food waste and FOG for co-digestion at the Dallas Southside WWTP could generate 27,500 m^3/day of pipeline quality RNG and significantly decrease emissions compared to landfill disposal. Processing the estimated 14,050 tons of food waste and FOG for co-digestion at the Pecan Creek WWTP could generate an additional 5,930 m^3/day of pipeline quality RNG and decrease emissions compared to composting processing.

- **Both pilot project scenarios would result in decreased emissions compared to current disposal practices.** As part of the Dallas pilot project scenario, processing the additional tonnage through AD units compared to landfilling would result in a significant decrease in emissions (see Table 7-3). As part of the Denton pilot project scenario, processing the additional tonnage through AD units compared to composting would result in some emissions decrease, but not as much as the Dallas pilot project scenario (see Table 7-6).

- **Both pilot project scenarios could provide a potential regional solution for sludge processing and/or disposal at local WWTPs in Denton and Dallas counties, but would require further evaluation.** There are 10 WWTPs generating an estimated 137,000 annual dry metric tons of biosolids in Dallas County and 23 WWTPs generating an estimated 37,000 dry metric tons of biosolids in Denton County. There is a demonstrated need among the WWTPs that do not have AD and/or on-site storage or disposal capacity in Dallas and Denton County for a cost-effective and technically feasible solution for sludge management and disposal. The feasibility of a regional solution would need to be determined by working directly with the potential stakeholders to determine plant-by-plant sludge solids content, average sludge production, and anticipated hauling frequency, as well as the available capacity of the potential pilot projects.

- **Conduct additional engineering and financial analysis to advance the development of the Dallas pilot project scenario as a viable co-digestion project at the Southside WWTP for pipeline-ready RNG.** Additional engineering and financial analysis should include determining the most cost-effective and technically viable approach to 1) upgrade receiving infrastructure, install feedstock storage equipment, and gas conveyance equipment at the Southside WWTP; 2) convey biogas to the gas processing plant at the McCommas Bluff Landfill (e.g., by installing a direct pipeline or compressing gas on site for trucking) or construct gas scrubbing equipment at the Southside WWTP; and 3) generate renewable identification numbers (RINs) based on the volume of RNG that could be utilized by the City of Dallas Sanitation Department solid waste collection vehicles and at other local CNG fueling stations. Developing the necessary capital upgrades at the Southside WWTP in parallel with securing feedstock delivery and biogas offtake agreements will further support project financing.

- **Conduct additional planning and evaluation to determine the most appropriate technology and feedstocks within the Denton Landfill Complex for the Denton pilot project scenario.** The AD technology could include the installation of a separate high-solids modular digester for processing food waste, FOG, and yard trimmings; or the expansion of the existing low-solids continuous-flow digester units for co-digestion of food waste and FOG. Additional evaluation should also explore the most effective approach to generating environmental credits for both this potential project and the ongoing LFG-to-RNG effort.

- **Explore options in both pilot project scenarios to accept sludge from other WWTPs in the region as part of a hub-and-spoke system.** Establishing an interlocal agreement (ILA) to accept sludge from other WWTPs as part of either pilot project scenario would present a technical solution for sludge management but may encounter challenges depending on the amount of pre-processing, moisture content, and delivery frequency of sludge material. A regional approach would require significant stakeholder outreach and further evaluation to establish an ILA and determine if the costs and benefits to each stakeholder would support such an approach. Additionally, there may be an opportunity to process sludge with other feedstocks such as biomass and tire-derived fuels using an alternative conversion technology (e.g., gasification, pyrolysis) to produce hydrogen and biochar; however, there are currently limited proven commercial-scale facilities operating on a continuous basis in the U.S.

- **Explore funding incentives and opportunities available through recent federal legislation, environmental credits, reducing environmental impacts on underserved communities, and alternative vehicle fueling grants for both pilot project scenarios.** Funding incentives and opportunities can support the viability of project financials and attract partners to engage in public-private partnerships. In the near-term, leveraging recently updated investment tax credit (ITC) benefits (e.g., up to 30 percent credit with additional 10 percent credits for both domestic content and energy community, potentially resulting in a 50 percent tax credit) available through the Inflation Reduction Act can minimize project expenses and increase the financial feasibility of pilot project scenarios. Additionally, applying for sustainable materials management grants, regional equipment/consulting grants, and alternative fueling funding will have a high chance of success due to the associated mitigation of environmental impacts on underserved communities. Finally, establishing the contractual relationships to generate of D5 RINs as part of the RFS would support public-private partnership and the development of mutually beneficial long-term contracts.

The information in this Study is not intended to be an engineering or financial analysis of any facilities evaluated, and the pilot project scenarios are presented for planning purposes to support organic diversion programming in the North Central Texas region. Further due diligence is required to estimate capital and operating costs of co-digestion at the Southside WWTP and Denton Landfill Complex. While the Project Team collaborated with the cities of Dallas and Denton to develop the information included in the Study, neither city is obligated to implement the recommendations included in the Study as there is a need for further technical, financial and policy decisions to be made prior to any final actions.

1.0 INTRODUCTION

The North Central Texas Organic Waste to Fuel Feasibility Study (Study) evaluates the organic materials generated in the North Central Texas region to assess the feasibility of converting of organic wastes generated in the North Central Texas region to Renewable Natural Gas (RNG) transportation fuel using new or existing anaerobic digestion (AD) infrastructure throughout the region based on key technical, financial, and operational factors. The Study assess the opportunities to divert organics from landfill disposal to support increases in the number of Natural Gas Vehicles (NGVs) using renewable natural gas (RNG) fuel in the region. The North Central Texas Council of Governments (NCTCOG) contracted with the Project Team (Burns & McDonnell Engineering, Inc., Energy Vision, and the University of Texas at Arlington (UTA)) to develop the Study under a U. S. Environmental Protection Agency (U.S. EPA) administered grant.

The Project Team leveraged its experience leading material management evaluations and stakeholder engagement efforts, including as part of NCTCOG's Regional Solid Waste Management Plan (RSWMP) update, to quantify organic feedstocks generated in the region and how they are managed, identify opportunities to implement feedstock collection for transportation to organics processing, prioritize potential pilot projects for organics-to-fuel implementation, and summarize funding mechanisms that would support project development. This section presents an overview of the Project Team's approach to developing the Study followed by descriptions of key terms. Table 1-1 presents an overview of the report organization.

Table 1-1: Study Section Organization and Description

Section	Title	Description
Data Analysis and Prioritization Sections		
1.0	Introduction	Communicates the project background and provides an overview of the project approach, key terms, and report organization.
2.0	Feedstock Market Assessment	Reviews the generation of various organic feedstocks for consideration and indicates the highest priority feedstocks for further evaluation in later sections of the Study.
3.0	Collection Network Evaluation	Reviews the collection networks in the region to provide a planning-level evaluation that compares each on a cost per ton collected basis to indicate the highest priority collection networks for further evaluation in later sections of the Study.
4.0	NGV Fuel Demand	Evaluates the natural gas vehicle (NGV) fuel demand in the region, identifying vehicle types that represent the highest demand of natural gas in the region for further evaluation in later sections of the Study.
5.0	Supply-Demand Comparison	Compares the projected RNG supply based on the conversion of high priority feedstocks and projected NGV fuel demand from increased adoption of NGVs in the North Central Texas region.

Section	Title	Description
Pilot Project Screening and Evaluation		
6.0	Pilot Project Location Screening	Presents the pilot project screening process including use of the POWER Framework and additional screening criteria to identify the optimal digester locations.
7.0	Pilot Project Evaluation	Evaluates the selected optimal digester locations more comprehensively based on technical, financial, and operational feasibility and discusses policy drivers and funding opportunities.
8.0	Key Findings and Recommendations	Presents the key findings of the Study and recommended actions and easy first wins to advance the establishment of food waste collection networks and deployment of additional AD infrastructure and RNG production in the North Central Texas region.
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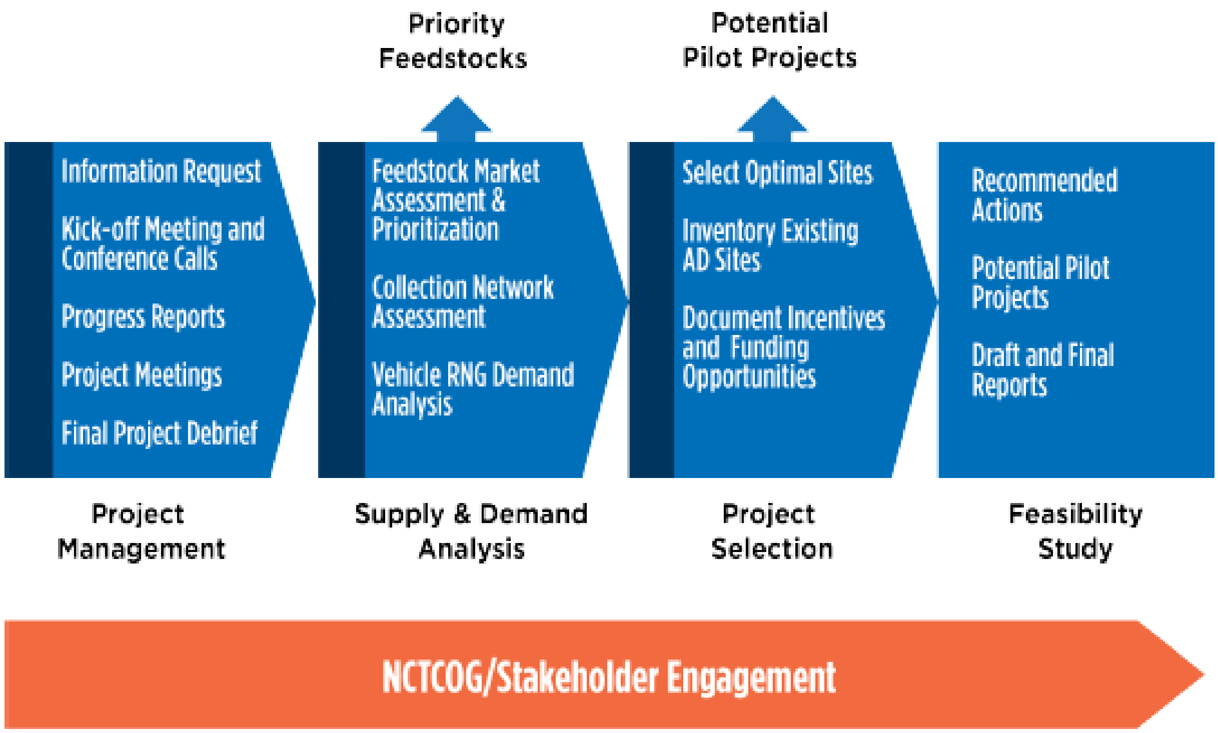
B	Collection Network Routing Results	Presents the detailed results of the collection network routing including key assumptions and outputs from the Project Team's Excel-based model.
C	POWER Framework Inputs and Outputs	Provides the key assumptions and outputs used within the POWER Framework in the screening, identification and evaluation of potential pilot projects.
D	Sludge Generation Database	Documents sludge generation sites in the North Central Texas region.
E	CNG-to-RNG Contract Guide	Provides a high-level guidance document to transition existing wholesale natural gas purchase and sale contracts to biomethane contracts.
F	Funding and Incentive Opportunity Memorandum	Provides a comprehensive listing of funding and incentive opportunities related to key aspects of organics-to-fuel projects including environmental credits, grant opportunities, tax incentives, and public-private partnerships.

1.1 Project Approach

The Project Team conducted the Study by collecting and analyzing data compiled through research and outreach to evaluate the supply and demand of natural gas vehicle fuel in the North Central Texas region. This analysis provided the basis to evaluate potential pilot project locations and identify the most viable, near-term potential AD projects that could accept priority feedstocks (e.g., food waste, fats, oils, and grease (FOG)) for conversion to RNG vehicle fuel. Figure 1-1 provides a project approach overview that outlines the various steps taken throughout the Study.

Figure 1-1: Project Approach Overview



The following sections describe key aspects of the Study conducted by the Project Team.

1.1.1 Stakeholder Engagement

The Project Team incorporated stakeholder input and support throughout the Study by collaborating with NCTCOG staff to seek support and involvement from a broad base of stakeholders. The Project Team invited a series of representatives to participate as part of the Project Advisory Group (PAG), providing technical guidance and regional expertise. Table 1-2 lists the members and respective organizations comprising the PAG.

Table 1-2: Project Advisory Group

Member	Organization
James Keezel	City of Fort Worth
Courtney Carroll	Fort Worth Independent School District
Katelyn Hearon	City of Lewisville
Kathy Fonville	City of Mesquite
Yarcus Lewis	City of Plano
Jaime Bretzmann	City of Plano
Brendan Lavy	Texas Christian University
Sahana Prabhu	Texan by Nature

Member	Organization
Lynn Lyon	U.S. Gain
Clifford Creeks	Dallas Water Utility
Kevin Willey	Dallas Water Utility
Matthew Jalbert	Trinity River Authority

Throughout the course of the Study, the Project Team presented at a series of workshops held with the PAG. The following provides brief descriptions of the five workshops conducted by the Project Team:

- **Workshop #1: Stakeholder Kick-Off Workshop & SWOT Analysis.** Provided an overview of the project, real world perspectives and examples and a strengths, weaknesses, opportunities, and threats (SWOT) analysis.
- **Workshop #2: Supply and Demand Analysis Workshop.** Presented the preliminary results of the feedstock supply analysis, NGV fuel demand analysis, and collection network analysis. The workshop also presented an overview and examples of the types of projects to be further considered as part of the Study.
- **Workshop #3A: Potential Pilot Projects Workshop (Part 1).** Presented the final results of the feedstock, collection network, and NGV prioritization evaluations. The workshop also presented the proposed pilot project location screening process and targeted areas for further evaluation.
- **Workshop #3B: Potential Pilot Projects Workshop (Part 2).** Presented results of the location screening analysis performed in the Targeted Organics Collection Area, including the optimized short-list of potential pilot sites. The PAG provided feedback to finalize the short-list so that the Project Team could complete the detailed evaluation of the elected potential pilot project sites (City of Dallas Southside WWTP and City of Denton Landfill Complex).
- **Workshop #4: Final Feasibility Study Workshop.** Presented the results of the detailed evaluations of the selected potential pilot project sites (City of Dallas Southside WWTP and City of Denton Landfill Complex), including POWER Tool modeling of technical and environmental impacts, GIS screening, funding and incentives opportunities, and project feasibility key findings and recommendations.

In addition to the PAG workshops, the project team conducted several virtual interviews with key stakeholders in the region. Stakeholder interviews were a critical component of the Study, providing key context related to the current and future considerations of select facility operators (e.g., composting, wastewater treatment plants (WWTPs)), natural gas distributors, and other industry stakeholders (e.g., trade groups).

1.1.2 Data Analysis and Prioritization Evaluation

The Project Team analyzed organic feedstocks, collection networks, and NGV fuel demand in the North Central Texas region to establish the direction of the Study. Further discussion of the methodology specific to each prioritization evaluation is provided in each respective section, including detailed description of the data sources and approach to conducting the detailed data analysis.

Based on a detailed data analysis and modeling of organic waste generation (see Section 2.0), collection network types (see Section 3.0), and NGV fleets (see Section 4.0) in the region, the Project Team collaborated with the PAG to determine the key inputs that served as the basis for screening and selection of potential pilot projects. Food waste and FOG feedstocks were prioritized for high potential biogas yields and expected future growth in generation volumes; commercial collection and high-density residential collection networks were prioritized based on higher comparative collection efficiency and cost effectiveness; and solid waste collection vehicles, buses, and tractor-trailer fleets were prioritized for increased NGV and hydrogen adoption based on fuel demand.

Additionally, the Project Team established the Targeted Organics Collection Area of Collin, Denton, Tarrant Dallas, and Erath counties, based on the locations of prioritized organic feedstocks, potential RNG supply, and anticipated NGV demand across the North Central Texas region (see Section 5.0).

1.1.3 Pilot Project Screening and Evaluation

The Project Team developed a comprehensive list of sites containing solid waste management or AD infrastructure within the Targeted Organics Collection Area, which was then screened to identify potential and optimal pilot project sites. Sites were screened based on geographic, technical, and logistical considerations to develop a short-list of potential pilot projects. This short-list was refined collaboratively with the PAG to select two sites (City of Dallas Southside WWTP and City of Denton Landfill Complex) for further evaluation, as these two facilities are currently at the highest level of readiness compared to the other short-listed facilities. As part of the pilot project screening analysis, the Project Team leveraged UTA's Prioritizing Organic Waste to Energy-Renewable (POWER) Framework to conduct aspects of the geographical, technical, and environmental evaluation. Details of the POWER Framework model and assumptions is provided in Appendix C.

1.1.4 POWER Framework

As part of the pilot project screening analysis, the Project Team utilized UTA's POWER Framework to conduct aspects of the geographical, technical, and environmental evaluation. The POWER Framework is comprised of three individual components: the GIS Toolbox, the Optimization Tool, and the POWER Tool. The POWER Framework supported key evaluations in the Study including the spatial evaluation of waste generation, screening of potential pilot project locations, and evaluating biogas yield and emissions reductions for the selected pilot project scenarios. The following provides a brief overview of each component of the POWER Framework:

- **GIS Toolbox.** Estimates quantities of food waste and FOG generated by block group in the North Central Texas region. The inputs of the GIS Toolbox were determined based on the results of the organic feedstock assessment and prioritization, and the results from the GIS Toolbox were used to support the Optimization Tool and POWER Tool.

- **Optimization Tool.** Performs an optimization analysis to provide a planning-level estimate of the distance and level of effort (e.g., time, cost) to transport generated organic wastes to potential pilot project locations. The Optimization Tool evaluated 96 potential locations in the Targeted Organics Collection Area and identified 48 locations that were further screened to develop the short-list of potential pilot projects. This short-list was refined collaboratively with the PAG to select two sites (City of Dallas Southside WWTP and City of Denton Landfill Complex) for further evaluation utilizing the POWER Tool.

- **POWER Tool.** Models the selected potential projects to estimate potential biogas yield and lifecycle emissions reduction compared to generating the equivalent volume of CNG by conventional methods (e.g., drilling). Results from the POWER Tool were incorporated into the broader technical, financial, and environmental evaluation of pilot project locations.

1.2 Key Terms

This section defines and provides context related to key terms used throughout this Study. The key terms are organized into categories generally consistent with the organization of the Study including generator sectors, material types, collection networks, fuel demand, and processing and disposal facilities.

1.2.1 Generator Sectors

The amount of direct control by cities over collection and processing of organic material streams affects the regional capability to divert material to potential organics-to-fuel projects. The material generated and control over material varies by sector and depends on the local collection markets that are further described in Section 1.2.3. The following briefly describes each generator sector and the level of control over organic material streams.

- **Single-family sector.** This sector includes material generated by single-family households including one- to four-unit properties, which generate fairly consistent composition of organic materials. In areas with city-provided or franchised collection markets, the control of material is provided exclusively to typically one collection service provider. Other areas (often rural) have open markets and the control of material is more diverse, causing challenges directing material to specific locations for processing/disposal.

- **Multi-family sector.** This sector consists of multi-tenant complexes (typically those with more than four units). Some multi-tenant complexes are serviced similarly to the commercial sector and others consistent with single-family set outs. Organics generated in this sector are typically not source separated. Depending on the collection market and management, multi-tenant complexes may receive service from one or more haulers. With limited data reporting or source separation required across the region, there is limited control over material generated in the multi-family sector.

- **Commercial sector.** The commercial sector consists of a wide variety of properties, facilities and business operations including offices, retail, wholesale establishments, restaurants and institutional entities such as schools, libraries, and hospitals. The wide variety of commercial establishments produce different volumes and types of organics. Depending on the collection market and management, commercial establishments may receive service from one or more haulers. Some cities in the region service the collection sector, while other cities have some combination of exclusive franchises, non-exclusive franchises and/or open markets.

1.2.2 Material Types

The following describes the several categories of organic material that were considered for this Study:

- **Municipal solid waste (MSW).** MSW is used to refer to the entirety of waste stream that is generated by everyday activities in homes, institutions such as schools and universities, and commercial sources such as restaurants, offices, and small businesses. MSW can be further categorized by material types, as described below. Different categories of MSW require different methods of handling for best management practices. MSW does not include hazardous, medical, hard-to-recycling, industrial, agricultural, or mining wastes.

- **Food waste.** Residential food waste is post-consumer, or "plate waste," discarded by consumers after food has been sold or served and includes fruits, vegetables, meats, grains, eggs, dairy, and coffee grounds. Post-consumer food waste often has contamination of non-organic waste, typically plastic packaging. Industrial/commercial/institutional (ICI) food waste contains both post- and pre-consumer food waste, which includes food preparation surplus or "kitchen waste" and includes uncooked vegetative waste such as peels, cores, tops, and loose coffee grounds or a biproduct from the manufacturing of a food product. Pre-consumer food waste generally contains less contamination and is a higher quality feedstock for incorporation into an AD facility.

- **Yard trimmings.** Yard trimmings are generated from lawn and garden maintenance by both the residential and commercial sectors and includes materials such as leaves, grass clippings, brush, and other plant trimmings.

- **Brush.** Brush can be generated by the residential or commercial sector and includes branches, limbs, and trunks. This material may be self-hauled to processing facilities by generators or transported by private landscapers.

- **Biosolids.** Biosolids are solid, semi-solid, or liquid residue generated during the treatment of domestic sewage in treatment works that has been treated or processed to meet Class A, Class AB, or Class B pathogen standards for beneficial use or other standards.

- **Sludge.** Sludge (or sewage sludge) is the solid, semi-solid, or slurry material that is typically an input to wastewater treatment systems. If further treated to meet Class A, Class AB, or Class B pathogen standards, sludge is considered biosolids, a byproduct of wastewater treatment rather than an input.

- **Manures.** Manures are waste products generated from animal agriculture activities and are generated in large quantities at Concentrated Animal Feeding Operations (CAFOs).

- **Crop residue.** Crop residue includes plant materials such as leaves, stalks and roots that remain after harvest.

1.2.3 Collection Networks

The following describes key components of collection networks (e.g., networks of vehicle fleets that collect and transport organic waste for disposal and/or processing) that were considered in this Study including the storage and separation methods, collection operations, and market types and are described as follows:

- **Storage and source separation methods.** There are various methods of storing and separating materials in the region between generator sectors. Residential collection networks include programs where customers set out either (1) refuse or recycling in durable plastic bags directly at the curb, (2) roll-carts (typically ranging from 32 gallons to 96 gallons in size) or totes directly at the curb or (3) bundles or kraft paper bags for yard trimmings and brush. Residential collection networks also include programs where customers self-haul material to citizen collection station (CCS) locations. Commercial collection networks include programs where customers utilize either (1) front-load dumpsters with dedicated enclosures for refuse or recycling (e.g., 2 CY) or (2) roll-off containers or compactors (e.g., 40 CY). Some commercial entities may store and source separate materials utilizing roll-carts.

- **Source-separated organics (SSO).** SSO programs are operations to collect pre- or post-consumer food waste separately stored by residential or commercial generator sectors for dedicated collection service (e.g., organics are not co-mingled with refuse or bulky item set outs).

- **Residential collection networks.** Collection networks servicing residential customers in the North Central Texas region include the following collection vehicle types: automated side loaders (ASL), semi-automated (SA) or grapple vehicles. ASLs are equipped with a hydraulic arm designed to lift carts into a compacting hopper and only require a single driver to steer the vehicle and operate the grapple arm. SA vehicles have automated tipping mechanisms on the back but require a driver and one or two additional laborers to wheel carts to rear load into the compacting hopper. Grapple vehicles are utilized to collect large brush and bulky items that are not able to be manually collected, where a crane operated grapple lifts large piles into a trailer.

- **Commercial collection networks**. Collection networks servicing commercial customers in the North Central Texas region include front-end loader (FEL), vacuum trucks and ASL/SA vehicles. FELs are equipped with hydraulic forks on the front of the truck, lifting dumpsters by the slots on their sides to deposit material into a compacting hopper. Vacuum trucks are often used to handle large-scale liquid and sludge clean-up, most commonly in sewer and septic system maintenance for industrial cleaning and hygiene purposes. They can also be used in industrial and municipal settings to suction water or debris from hydro-excavation or drilling jobs and support environmental clean-up, storage tank upkeep, and slurry collection.

- **Open market.** An open market indicates that any hauler can operate within the incorporated area without restriction and customers are free to select service providers. In areas of high housing or commercial density, this potentially causes challenges associated with increased numbers of collection vehicles providing additional collection service (e.g., additional trucks on the road) in the same area. The costs for customers may be higher compared to areas with market restrictions.

- **Hauler licensing.** A hauler licensing requirement is legislation that stipulates must have a license to operate in the City. Collection services remain similar to an open market system whereby properties hire their own collection hauler; however, haulers would need to be licensed in order to operate in the incorporated municipality. The municipality could then impose limitations or guidelines on the haulers, just as in the franchise collection option including specifying where materials may be delivered, source separation requirements, operating requirements, data reporting or liability insurance information. Licensing fees can be set to a level to generate, at minimum, adequate revenues to cover the costs of administering the licensing program. The fee may be based on tonnage collected, number of vehicles, a flat fee, or some combination thereof.

- **Exclusive/non-exclusive franchise system.** A franchise collection system is a contract authorizing one or more private companies to provide service in a particular area. A typical franchise agreement for collection services includes several specific elements. It grants rights to a company to haul material from specified properties and it sets specific standards, requirements, and responsibilities for the company such as where material may be delivered, source separation requirements, operating requirements (e.g., hours of operation, conditions of vehicles), penalties for non-performance, data reporting, or liability insurance information. Typically, the franchise service provider pays a franchise fee to the City which can range from nominal to significant. The fee may be based on tonnage collected, number of vehicles, a flat fee, or some combination thereof. Franchise fees are used to cover the costs an incorporated municipality may incur by allowing haulers to operate (e.g., administrative costs, road/alley repair and maintenance, etc.).

1.2.4 Fuel Demand

The following describes key considerations related to fuel demand that were considered in this Study including the alternative fuels, vehicle types and fueling stations:

- **Alternative fuels.** There are a wide range of available fuels utilized by vehicles in the North Central Texas region including gasoline diesel, biodiesel, natural gas, propane, electricity and hydrogen. The Study focuses exclusively on natural gas fuel utilized by NGVs.
- **Natural Gas Vehicles (NGVs).** NGVs in the region make up the fuel demand and include solid waste collection vehicles, buses, tractor-trailers, and light-duty delivery vehicles. Buses include both transit buses operated by municipal systems and other bus types such as charter buses.
- **NGV fueling stations.** Fueling stations for NGVs include two types: fast fill station and time fill stations. Fast fill stations are like typical commercial gasoline fueling stations, and time fill stations require about eight hours to fill the tank. Time fill stations are typical for fleets that park at a centralized truck yard overnight.
- **Gasoline Gallon Equivalent (GGE).** A gasoline gallon equivalent (GGE) is a standard unit used to compare the energy content of all fuels, enabling users to compare a given quantity of energy across multiple fuel types. For example, one gallon of diesel contains approximately 1.136 GGE of energy.

1.2.5 Material Processing and Disposal Facilities

The following describes key considerations related to processing and disposal facilities for organic materials that were considered in this Study:

- **Anaerobic Digestion (AD).** A biological process by which microorganisms convert organic materials in the absence of oxygen (i.e., anaerobic) to produce biogas (comprised of methane (CH_4) carbon dioxide (CO_2), and other trace gases) and biosolids.
- **Composting.** A biological process by which microorganism convert organic materials in the presence of oxygen (i.e., aerobic) to produce compost produce compost and bioproducts (CO_2 and other trace gases).

- **Wastewater Treatment Plants (WWTPs).** Facilities designed and constructed for contaminant removal and the recovery of resources in the form of treated water effluent, biosolids, and biogas. Based on discussions with the PAG, the term WWTP is used throughout this study instead of the synonymous term Water Resource Recovery Facility.

- **Co-digestion facilities.** AD facilities designed for processing biosolids (WWTP digesters) or agricultural materials (on-farm digesters) that also process MSW organics (e.g., food waste) for co-digestion.

- **Landfill gas-to-energy (LFGTE) projects.** Landfill gas-to-energy (LFGTE) projects make beneficial use of biogas produced at landfills through end uses such as electricity or combined heat and power (CHP) generation, direct use in boilers, and the production of RNG for vehicle fuel or pipeline injection.

- **Transfer stations.** Transfer stations are facilities that are used to consolidate MSW from multiple collection vehicles into larger, high-volume transfer vehicles for economical shipment to distant disposal or processing facilities. Transfer stations can be used for material destined for landfilling, recycling, or composting.

- **Material Recovery Facility (MRF).** MRFs are recycling facilities used to segregate single-stream recyclables into commodities sold on the secondary commodities market.

- **Liquid treatment facility.** Liquid treatment facilities are authorized to accept FOG materials for disposal.

- **Greenfield site.** A location where a new facility would be constructed.

2.0 FEEDSTOCK MARKET ASSESSMENT

This section identifies the regional supply of existing and future volumes of feedstocks from pre- and post-consumer organic wastes, yard waste and brush, agricultural wastes produced at CAFOs, residues from crop production, wastewater treatment biosolids, and other commercial and industrial wastewater sources. The identification of sufficient available organic waste feedstocks, combined with the ability to aggregate the feedstocks through waste collection activities, is critical in the development of optimized AD facilities. The economics associated with AD facilities generally improve with corresponding increases in the volume of feedstocks that are processed at a given facility. In addition to estimates of current feedstock generation, this section provides a discussion on the prioritization of the volumes of the regional feedstock supply.

2.1 Methodology

To develop the potential feedstock market assessment for organic materials, the Project Team evaluated data from a variety of sources related to the generation, disposal, and recovery of organic wastes in the North Central Texas region. Data sources were identified from local entities (e.g., individual facilities, municipalities), the NCTCOG, the Texas Commission on Environmental Quality (TCEQ), Federal Agencies (e.g., U.S. EPA, United States Department of Agriculture (USDA), industry groups (e.g., Water Environment Foundation (WEF), American Biogas Council (ABC)), and academic research including work performed by the members of the Project Team at UTA. The following provides descriptions of key data sources used to develop the organic materials feedstock estimates presented in this section.

- **Regional Recycling Survey and Campaign.** The NCTCOG, with assistance from members of the Project Team, developed a recycling survey in 2018 to collect data regarding the material management practices and composition of residential solid waste in the North Central Texas region. As part of this campaign, the Project Team completed waste characterization studies for the NCTCOG that included sorting single-family refuse and recycling samples to understand the composition profile of both disposed and recycled material streams in the region. Data was collected in 2018, 2019 and 2020, from a total of 11 cities in the North Central Texas region. This data was used to estimate per-household and per-capita disposal rates of various organics (e.g., food waste, yard trimmings) for the single-family and multifamily residential sectors.

- **NCTCOG Regional Solid Waste Management Plan (2022-2042).** The Project Team is currently obtaining regional information regarding waste management facilities within the North Central Texas region as part of the development of the Regional Solid Waste Management Plan update for the NCTCOG. The facilities currently being reviewed within the region include landfills, transfer stations, composting facilities, liquid waste processing facilities, and other solid waste management facilities. Information regarding existing organics collection, processing, and disposal facilities, biogas resources, and current and projected future waste generation rates that were aggregated for the Regional Solid Waste Management Plan are incorporated into this feedstock market assessment.
- **Local solid waste management planning studies and analysis.** Members of the Project Team have completed or are in the process of completing solid waste planning efforts for municipalities in the North Central Texas region including in Collin, Denton, Dallas, and Tarrant Counties. Information from these studies was used to develop a more detailed understanding of the types and quantities of materials generated and managed at facilities in the region.
- **TCEQ's Recycling Market Development Plan (RMDP).** Members of the Project Team developed the Texas Recycling Market Development Plan (RMDP), a statewide recycled material feedstock assessment and market development strategy. The RMDP feedstock assessment includes detailed information on the amount of biosolids, food and beverage materials, yard trimmings, brush and green waste generated, recycled, and disposed in Texas in 2019. Results presented in the RMDP report, as well as additional facility-specific information provided from within the North Central Texas region, were used to inform the estimates of the qualities of various organic materials recycled and disposed.
- **TCEQ Solid Waste Annual Reports and Permitting Data.** Owners and operators of municipal solid waste landfills and other waste management facilities submit an annual report to TCEQ each fiscal year (beginning September 1 and ending August 31), detailing the amount and types of solid waste handled at each facility. The data for some facility types are compiled and published in an annual summary report titled *Municipal Solid Waste in Texas: A Year in Review*[1], while others are available through TCEQ reporting and permitting databases. Similarly, permitting information for WWTPs and CAFOs were obtained through the respective TCEQ permitting programs.

[1]Annual Summary of Municipal Solid Waste Management in Texas. Available online: https://www.TCEQ.texas.gov/permitting/waste_permits/waste_planning/wp_swasteplan.html

- **U.S. EPA Excess Food Opportunities Map and supporting data.** The U.S. EPA has developed an interactive map to communicate facility-specific information about potential generators and recipients of excess food in the industrial, commercial, and institutional sectors. The map's supporting analysis provides high and low range estimates of excess food generation based on factors such as number of locations, size, and estimated generation rates (e.g., pounds per employee or pounds per square foot). Map data was mined for excess food generation quantities in the North Central Texas region for all available generator types (i.e., correctional facilities, educational institutions, food banks, healthcare facilities, hospitality industry, food manufacturing and processing facilities, food wholesale and retail, and restaurants and food services).

- **U.S. EPA Landfill Methane Outreach Program (LMOP) database.** The U.S. EPA maintains datasets on current, planned, and candidate landfill gas-to-energy (LFGTE) projects through its voluntary Landfill Methane Outreach Program (LMOP). The LMOP database contains information on over 2,600 MSW landfills including existing LFGTE projects (planned, under-construction, operational and shutdown) as well as sites identified by the U.S. EPA as candidate sites for future LFGTE projects. The Project Team used the LMOP database to identify and confirm existing and potential landfill gas collection and end use information for the landfills in the North Central Texas region.

- **U.S. EPA Greenhouse Gas Reporting Program (GHGRP) datasets.** Each year, certain greenhouse gas (GHG) emissions sources including MSW and industrial landfills, industrial wastewater treatment facilities, fuel and industrial gas supplies, and CO_2 injection sites report emissions and other relevant information to the U.S. EPA through its GHGRP. The Project Team reviewed facility-level information publicly available through the U.S. EPA's Facility Level Information on GreenHouse gases Tool (FLIGHT) and Envirofacts customized search tool to identify and confirm existing and potential landfill gas collection and end use information and identify other existing industrial AD sites in the North Central Texas region.

- **U.S. EPA and USDA AgSTAR Livestock Anaerobic Digester Database.** The U.S. EPA and USDA develop and maintain resources to promote the use of biogas recovery systems to reduce methane emissions from animal livestock waste. The Livestock Anaerobic Digester Database provides information on anaerobic digester projects on livestock farms in the U.S., including information on the location and biogas use (e.g., RNG, electricity). The database includes operational projects, as well as information on projects under construction or that have been shut down. The Project Team used the AgSTAR database to summarize the current state of practice for producing RNG from livestock manure biogas.

- **U.S EPA National Pollutant Discharge Elimination System (NPDES) Biosolids Program reporting data.** The U.S. EPA provides NPDES Biosolids Program reporting data through its Enforcement and Compliance History Online (ECHO) facility search tool. The database provides access to reported information from the portion of WTTPs meeting specific regulatory requirements. The Project Team reviewed available data regarding the amount of biosolids generated and method(s) of management (reported as land application, surface disposal, incineration, and other) to inform estimates for the North Central Texas region.

- **USDA National Agricultural Statistics Service (NASS) data.** The USDA's National Agricultural Statistics Service (NASS) maintains geospatial data related to planted U.S. commodities, crop progress, and condition based on analysis of land cover aerial imagery. The Project Team used the NASS CropScape tool to aggregate cropland data for the North Central Texas region and estimate crop residue generation based on the resulting estimated acreages by crop type.

Additionally, the Project Team conducted select interviews with key facility operators and obtained feedback from members of the Project Advisory Group (PAG) to refine assumptions about facilities and tonnages of organic wastes managed in the region. Finally, where region-specific data were not available, broader industry and academic research reports were used to develop waste generation estimates.

2.2 Organic Waste Generation and Management

Based on analysis of the identified data sources, annual organic waste generation in the region totals an estimated 8.8 million tons of material from MSW (e.g., residential, commercial), agricultural, and wastewater sources. Figure 2-1 provides a summary of the annual organic waste feedstock generation by material type for the North Central Texas region.

By weight, crop residues were estimated as the largest organic waste feedstock, followed by CAFO manures, yard waste, food waste, and wastewater organics (including FOG, biosolids).

Figure 2-1: Annual Organic Waste Feedstock Generation in the North Central Texas Region (tons)

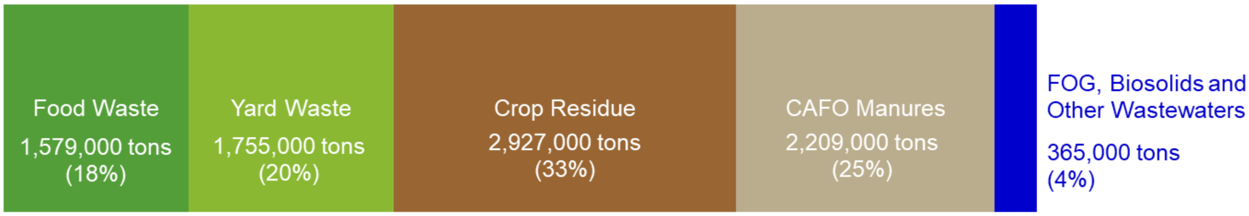
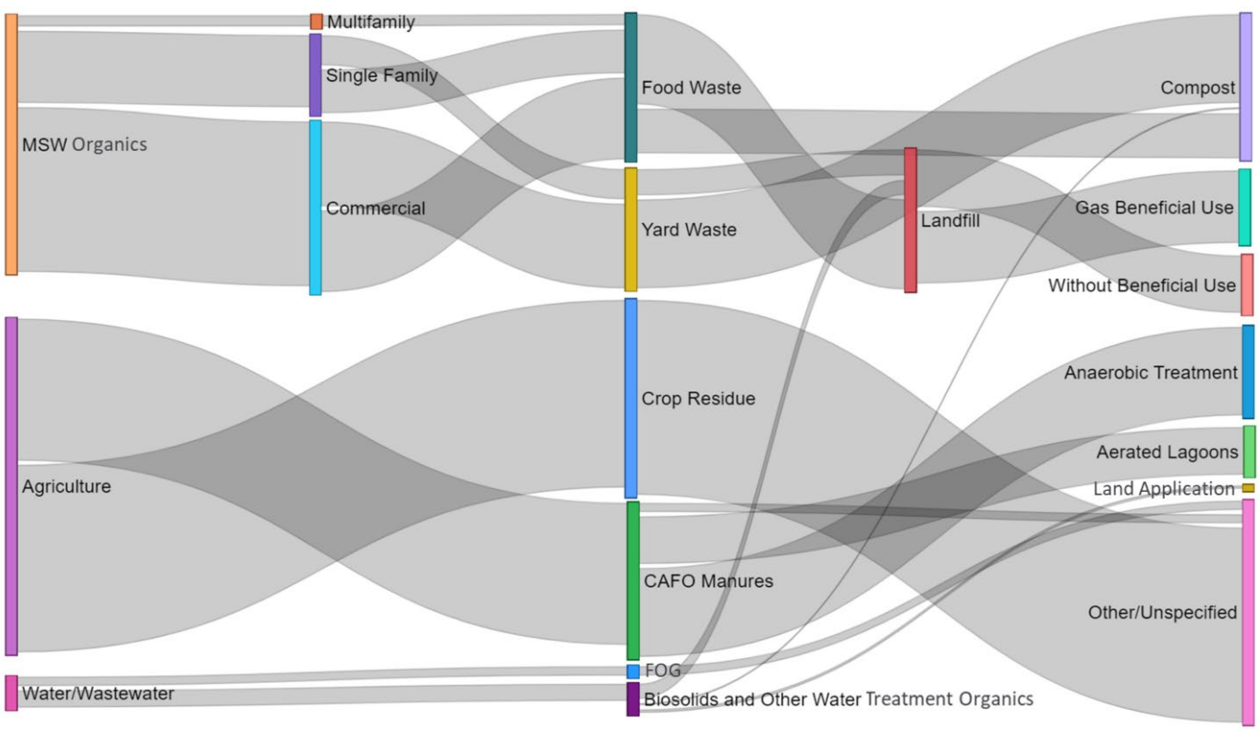


Figure 2-2 presents a mass flow diagram for the identified organic feedstocks and communicates additional information on the generator sectors and management methods for each material type. The following sections provide additional detail and discussion on the generation and management of each of these feedstocks.

Figure 2-2: Mass Flow Diagram of Organics Management in the North Central Texas Region



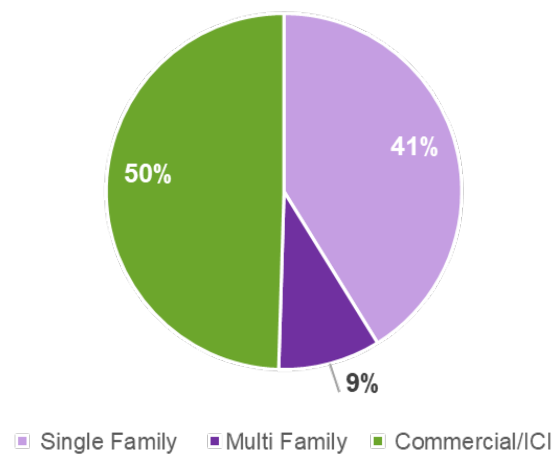
2.2.1 Food Waste

Food waste includes materials such as fruits and vegetables, meats, eggs and dairy, and coffee grounds from residential and commercial (e.g., restaurants, grocery stores, food manufacturing, hotels/hospitality) generators. Food waste can be categorized as:

- Pre-consumer material from food manufacturing, retail (e.g., grocery stores) and preparation including uncooked vegetative waste such as peels, cores, tops, and loose coffee grounds.
- Post-consumer material discarded by consumers after the food has been sold or served.

An estimated 1,579,000 tons of food waste are generated in the region each year. Figure 2-3 shows the total estimated food waste generation from single-family, multifamily, and commercial sources. Half of food waste (50 percent) is generated in the commercial sector, followed by the single-family (41 percent) and multifamily (9 percent) sectors.

Figure 2-3: Food Waste Generation by Sector in the North Central Texas Region



The majority of food waste is landfilled, though diversion opportunities exist through composting or food donation. The Project Team identified 24 composting facilities in the North Central Texas region. Currently, 36 percent of these composting facilities report a willingness to accept food waste from commercial and/or residential sources.

Residential food waste generation and management. Based on waste composition studies conducted in the North Central Texas region, single-family homes disposed of an estimated 13.2 pounds of food waste per household per week (lb/HH-week) to landfill, equivalent to four pounds per person per week. Based on current population and household counts in the region[2], this is equivalent to an estimated 810,000 tons of food waste disposed in landfills each year from the residential sector: 660,000 tons from single-family residents and 149,000 from multifamily residents. One residential food waste composting program is known to exist in the region (City of Plano's Texas Pure Products), which reported diverting approximately 1,400 tons of organics from the single-family sector in 2020. No food waste diversion was assumed from the multifamily sector within the North Central Texas region.[3]

Commercial food waste generation and management. An estimated 769,000 tons of food waste are generated in the commercial sector. Based on regional landfill disposal quantities and statewide waste composition estimates presented in the RMDP, the commercial sector in the North Central Texas region disposes of an estimated 558,000 tons of food waste annually. Comparing disposal estimates to commercial food waste generation estimates from the U.S. EPA Excess Food Opportunities Map data and information provided by composting facilities in the region, an estimated 211,000 tons of food waste was diverted from landfill by the commercial sector including composting (169,000 tons) and food donation (42,000 tons). Interviews with composting facilities in the North Central Texas region were able to confirm over 80,000 tons of commercial food waste composting occurring in the region.

The types and relative quantities of food waste generation vary throughout the commercial sector based on the type of entity (e.g., grocery stores, restaurants, schools, other retail), which has implications for how these materials may be collected as organics-to-fuel feedstock. Table 2-1 communicates the estimated commercial food waste generation in the North Central Texas region by category of commercial establishment based on data from the U.S. EPA Excess Food Opportunities Map. The food wholesale and retail sector generates 43 percent of estimated food waste in the North Central Texas region, followed by restaurants and food service (30 percent), and food manufacturing and processing (15 percent). Institutions (e.g., schools), hospitality, healthcare facilities, and correctional facilities each generate less than 10 percent of total commercial food waste in the region.

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[2] Based on data from the U.S. Census Bureau 2019 American Communities Survey (ACS) for populations and households in the cities that participated in the waste composition studies, and for the 16 counties in the North Central Texas region.

[3] While subscription-based third-party drop-off programs are available in a limited number of cities in the region, and may be used by multifamily residents, data were not available. Quantities diverted from the multifamily sector are likely very small.

These figures are regionwide, and the relative contribution of specific commercial sectors varies by city and county within the region. The potential supply of feedstock from commercial subsectors and areas within the North Central Texas region are discussed in Section 5.0.

Table 2-1: Commercial Food Waste Generation in the North Central Texas Region by Subsector

Commercial Subsector	Estimated Commercial Food Waste Generation (tons)	Percent of Generation
Food Wholesale and Retail	333,000	43%
Restaurants and Food Services	228,000	30%
Food Manufacturers and Processors	116,000	15%
Institutions	53,000	7%
Hospitality Industry	27,000	4%
Healthcare Facilities	8,000	1%
Correctional Facilities	4,000	<1%
Total	**769,000**	**100%**

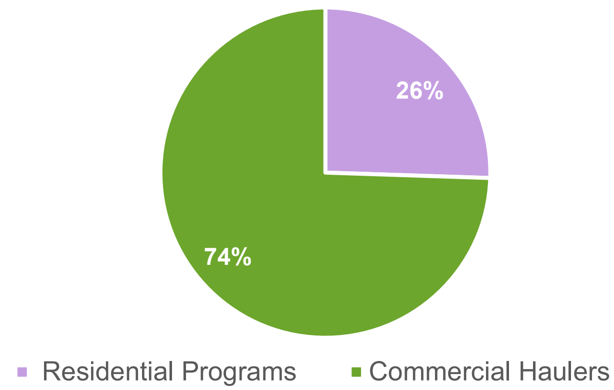
2.2.2 Yard Waste

Yard waste includes materials such as leaves, grass clippings, and small branches, and brush (e.g., large tree branches, stumps). Yard waste is generated in the single-family residential and commercial sectors from activities such as yard and facility maintenance. Brush materials are also generated from land clearing and other construction-related activities.

A total of 1,755,000 tons of yard waste and brush are generated in the North Central Texas region annually. Figure 2-4 shows the total estimated yard waste material managed through residential yard waste programs and from commercial sources/haulers such as landscaping companies.[4]

[4] Commercial sources include landscaping companies likely managing materials generated by both commercial residential customers.

Figure 2-4: Yard Waste Management by Sector in the North Central Texas Region

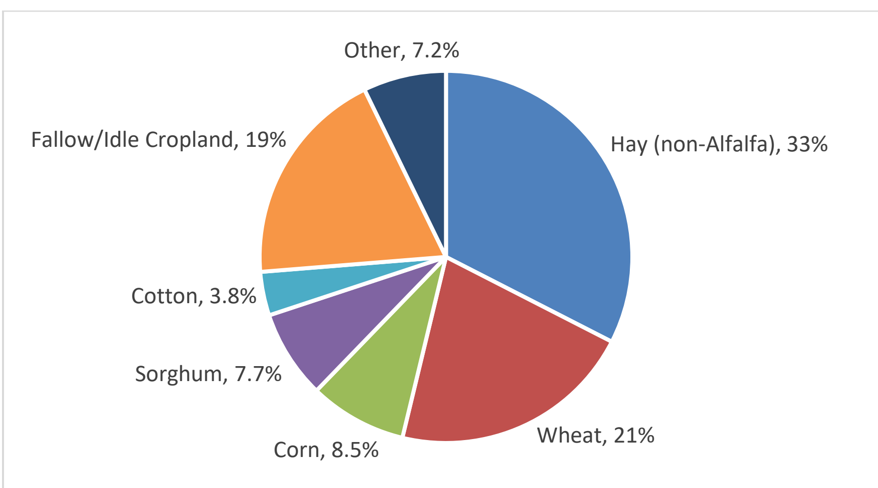


Yard waste and brush may be sent to the landfill for disposal or diverted through composting or mulching programs. Based on data from composting facilities, waste characterization studies, and solid waste planning documents, approximately 1,372,000 tons (78 percent) of yard trimmings and brush were diverted through composting and the remaining 383,000 tons (22 percent) were landfilled.

2.2.3 Crop Residue

Crop residue includes plant materials such as leaves, stalks, and roots that remain after harvest. There are approximately 990,000 acres of cropland in the North Central Texas region, as shown in Figure 2-5. Residue generation rates vary significantly depending on the crop; for example, corn and wheat produce significantly more residue from stalks than perennial tree crops such as pecans.

Figure 2-5: Cropland Acreage in the North Central Texas Region



Based on an assumed generation factor of 10,000 kg of residue per hectare,[5] an estimated 3.5 million tons of crop residue are generated each year in the North Central Texas region; however, of generated crop residues, only a portion can be sustainably removed in order to preserve soil quality and limit erosion. Sustainable soil rates are dependent on a variety of factors including crop type, field slope, crop yield, weather patterns (e.g., drought), and crop rotation. For example, sustainable removal rates of 100 percent are suitable for hay (which is the most common crop by acreage at one-third of cropland in the North Central Texas region). This drops to 50 percent for corn stover (which is the third most common crop by acreage at approximately 8 percent of cropland). After adjusting for sustainable crop removal rates, estimated crop residue feedstock generation is 2,927,000 tons per year for the North Central Texas region.

Crop residues may be managed on-site (e.g., turned under, composted, burned) or hauled off-site for composting or disposal. Crop residues can also be converted to various bioenergy resources through a range of different conversion technologies, though typically not through AD-to-RNG. Crop residues are more commonly used for bioenergy through fermentation for bioethanol, direct combustion, or densification to fuel pellets for heating, and to a lesser extent gasification for co-generation of heat and power. Production of vehicle fuel from commodity crops generally favors the use of the commodity product itself (e.g., corn grain for ethanol production).

2.2.4 Manure

Manure is a waste product generated from animal agriculture activities and is generated in large quantities at CAFOs. There are 44 CAFOs operating in the North Central Texas region, all of which are located in Erath County. Based on permitting data available from the TCEQ, approximately 81,000 animals are raised and/or finished in the region, including 73,718 dairy cattle (91 percent of total), 6,938 head of beef (9 percent) and 200 swine and 150 horses.

[5] From POWER Tool, and applied only to the portion of cropland expected to produce significant quantities of crop residue.

Based on waste generation factors from USDA,[6] an estimated 2,209,000 tons of manure are generated each year from CAFOs in the region as shown in Table 2-2.

Table 2-2: CAFO Manure Generation in the North Central Texas Region

Livestock Category	Number of Head	Annual Manure Generation (Tons)	Percent of Total
Dairy Cattle	73,718	2,018,000	91.3%
Beef Cattle	6,938	190,000	8.6%
Swine	200	< 500	< 0.1%
Horses	150	1,500	< 0.1%
Total	**81,006**	**2,209,000**	**100%**

Manure may be managed in a variety of ways, including in aerobic or anaerobic lagoons, AD with energy recovery, land application, and composting (e.g., horse manures and stable bedding). Table 2-3 presents available information on CAFO manure management in the North Central Texas region, based on publicly available permit data. Previously, 20 facilities (generating 62 percent of manure) reported using anaerobic treatment to manage manure, which could include both anaerobic lagoons and anaerobic digesters; however, with the closure of the Huckabay Ridge Anaerobic Digester, which accepted manure from multiple CAFOs in the area, the current use of anaerobic digesters for manure management is unknown. At least 12 facilities (33 percent of manure) use aerated lagoons to manage manures with an additional 12 smaller facilities (5 percent of manure) not specifying a manure management method.

Table 2-3: CAFO Manure Management in the North Central Texas Region

Reported Manure Management Method	Number of CAFOs	Estimated Manure Generation (TPY)	Percent of Total
Anaerobic Treatment	20	1,370,000	62%
Aerated Lagoon	12	729,000	33%
Unspecified/Other	12	111,000	5%
Total	**44**	**2,209,000**	**100%**

[6] Based on information available from the USDA, CAFO manure generation was estimated as 150 lb/head-day for dairy and beef cattle, 10lb/head-day for swine, and 50 lb/head-day for horses.

2.2.5 Fats, Oils, and Grease, Biosolids and Other Water Treatment Organics

There are a number of organic wastewater materials generated in the region, including FOG which is generated from residential, commercial and industrial sources. If not managed properly, FOG can cause wastewater management and plumbing issues. There are also organic wastes that result from water and wastewater treatment activities, including biosolids and water treatment residuals. Biosolids are solid, semi-solid, or liquid residue generated during the treatment of domestic sewage in WWTPs (e.g., sewage sludge that has been treated or processed to meet Class A, Class B, or other standards).

FOG generation and management. FOG is generally collected from generators in the commercial, institutional (e.g., public and private schools, prisons), and industrial sectors. Materials may be classified as yellow grease (i.e., used cooking oil and other fats and oils from commercial or industrial cooking) or brown grease (i.e., oil from grease traps installed in commercial, industrial or municipal sewage facilities to separate oil and grease from wastewater). FOG is generally collected by specialized commercial collection companies, and may be processed at renewable fuel production facilities (e.g., renewable diesel) or WWTP facilities, de-watered and land applied (where allowed), composted, or disposed in landfill. There are presently six liquid waste processing facilities processing grease in the North Central Texas region based on TCEQ MSW annual reporting data. While these facilities reported processing over 1.2 million tons of grease in 2021 from in-state sources, information was not available specific to the portion that was generated by entities in the North Central Texas region compared to other regions. However, a study for the Southeastern Regional Biomass Energy Program suggests a FOG generation rate of 32.5 gallons per restaurant per week based on a survey of grease haulers and WWTPs in South Carolina. [7] Applying this factor to the North Central Texas region results in an estimated 121,000 tons of FOG per year from restaurants.

Biosolids and other water treatment organics generation and management. Wastewater biosolids are managed in a variety of ways in Texas, including landfill disposal, land application, and composting. Biosolids may be combined with yard trimmings, brush, green waste or other bulking agents to produce nutrient-rich compost. WWTPs are not required to report biosolids generation quantities, therefore the data of total biosolids produced is not readily available.

[7] South Carolina Energy Office (2010). *An Assessment of the Restaurant Grease Collection and Rendering Industry in South Carolina*. Available online at: https://scbiomass.org/Resources/Documents/assessment%20of%20restaurant%20grease%20report%20-%20summer%202010%20_updated_.pdf

Based on available data from composting facility interviews and facility reporting data, an estimated 241,000 tons of biosolids and other water treatment organics are generated and managed in the region annually.[8] The City of Denton is the only WWTP that reported composting biosolids and those quantities are included in this estimate. Table 2-4 presents the estimated biosolids management in the North Central Texas region for 2021. Based on available data, the majority of biosolids generated in the region were landfilled.

Table 2-4: Biosolids Management in the North Central Texas Region (2021)

Management Method[1]	Annual Tonnage	Percent of Total
Land Application[1]		
Class A Biosolids	94,000	39%
Class B Biosolids	500	0.2%
Surface Disposal	24,000	10%
Landfilling[2]	122,000	51%
Total	**241,000**	**100%**

1. Based on data reported by WWTPs and other wastewater treatment facilities as part of the NPDES Biosolids Program. Land Application includes composting.
2. Tonnage based on WWTP reporting. Landfills in the North Central Texas region reported accepting 213,000 tons of sludge in 2021, which likely includes sludge from WWTPs located outside of the region.

2.3 Feedstock Availability Estimates

Based on the estimates presented in Section 2.2, a total of 8.8 million tons of organic materials are generated in the North Central Texas. Of this, 7.2 million tons are not known to be recovered through composting or other beneficial use, and for the purposes of this feedstock market assessment are assumed to be subsequently disposed (in landfills or managed through other non-recycling methods). While many of these disposed materials could be recovered, not all available tonnage can be feasibly source separated, collected, processed, and converted to fuel. Collection system options and considerations are discussed in more detail in Section 3.0; however, based on 20 percent, 40 percent, and 60 percent recovery scenarios as much as 4.3 million tons of currently disposed organics feedstocks could be recovered (as shown in Table 2-5).

[8] TCEQ annual reporting requires landfills to report the total quantities of biosolids disposed annually, and agricultural facilities to report the quantity of Class B biosolids land applied. Class A and Class AB biosolids used beneficially for marketing and distribution purposes do not require a fee so TCEQ does not track their tonnage.

Even though a material can be recovered, the Project Team used a range to recognize that it may be impractical (from a cost, technological, and/or environmental perspective) for all of a given material to be recycled due to lack of recycling infrastructure, contamination of recyclable materials, access to processing or fuel production facilities, and need for additional public education and outreach to facilitate participation in collection programs. Further, while this organic material feedstock can be considered recoverable, not all material categories are equally suitable for AD and RNG production as described and evaluated in more detail in Section 2.5.

Table 2-5: Annual Organic Material Feedstock Disposal in the North Central Texas Region by Material Category

Waste Type	Organic Material Category	Total Tonnage Disposed[1]	Assumed Recovery Rate 20%	40%	60%
MSW	**Food Waste**				
	Residential Sector	810,000	162,000	324,000	486,000
	Commercial Sector	585,000	117,000	234,000	351,000
	Yard Waste				
	Residential Programs	206,000	41,200	82,400	123,600
	Commercial Haulers	177,000	35,400	70,800	106,200
	Subtotal	**1,778,000**	**355,600**	**711,200**	**1,066,800**
Agriculture	CAFO Manures	2,210,000	442,000	884,000	1,326,000
	Crop Residues	2,927,000	585,400	1,170,800	1,756,200
	Subtotal	**5,137,000**	**1,027,400**	**2,054,800**	**3,082,200**
Wastewater	FOG	121,000	24,200	48,400	72,600
	Biosolids and Other	146,000	29,200	58,400	87,600
	Subtotal	**267,000**	**53,400**	**106,800**	**160,200**
TOTAL		**7,182,000**	**1,436,400**	**2,872,800**	**4,309,200**

1. Tonnages are based on landfilled quantities of suitable organics-to-fuel materials where data were available. Total generation used for CAFO manures and FOG because more detailed data on material disposal were not available.

2.4 Existing Biogas Generation Resources

In addition to the quantities of organic waste shown in Figure 2-1 (and Table 2-5), there are facilities in the region such as landfills and WWTP AD systems that produce potential organic-to-fuel feedstock in the form of waste-derived biogas. Biogas currently produced at these sites, which is generally 40-60 percent methane (CH_4), can be upgraded to renewable natural gas through removal of water vapor, CO_2 and other trace impurities including nitrogen, oxygen, hydrogen sulfide (H_2S), siloxanes, and volatile organic compounds (VOCs).

Based on available data, there are 17 landfills that currently collect approximately 44,000 standard cubic feet per minute (scfm) of waste-derived biogas, 8 municipal WWTP AD systems, and at least one industrial AD system in the North Central Texas region.

Landfill gas. When organic waste decomposes in a landfill, it is converted to landfill gas (primarily composed of CH_4 and CO_2) which is collected and managed. Landfill gas-to-energy (LFGTE) projects make beneficial use of landfill gas, and end uses include electricity or combined heat and power (CHP) generation, direct use in boilers, and the production of RNG for vehicle fuel or pipeline injection. If beneficial use systems are not in place, landfill gas may be flared.

Table 2-6 summarizes landfill gas collection and beneficial use in the North Central Texas region. Based on available data representing 17 landfills (open and closed) in the North Central Texas region, at least 44,000 standard cubic feet per minute (scfm) of landfill gas are collected annually. There are presently LFGTE projects at 11 of these sites, as shown in Table 2-6. Six of the existing projects produce RNG for distribution off-site and five generate electricity. Based on data from the TCEQ MSW Annual Reports and the U.S. EPA LMOP and GHGRP datasets, the 11 facilities reported collecting an estimated 38,717 scfm of landfill gas and producing 150 gigawatt-hours of electricity for sale to the grid and 5 billion cubic feet of RNG in 2021. There remains one major landfill (City of Fort Worth Southeast Landfill) that produces significant quantities of landfill gas without an active LFGTE project on site, and the city is presently evaluating options for an RNG project. Once completed, only significantly smaller sites (i.e., less than 800 scfm of landfill gas collected) will remain without active LFGTE projects, and there are notable feasibility challenges for LFGTE projects at these low flowrates.

Table 2-6: Landfill Gas Beneficial Use in the North Central Texas Region

LFGTE System Type	Number of Landfills	Landfill Gas Collected[1]			Annual Reported LFG Beneficial Use[1]
		Average (scfm)	Total (scfm)	Percent of Total	
Renewable Natural Gas (RNG)	6	4,631	25,726	70%	5 billion cubic feet of RNG produced
Power Generation	5	2,186	10,932	30%	150 gigawatt-hours of electricity for sale to the grid
Total / Average	**11**	**3,520**	**36,658**	**100%**	**-**

1. Values shown represent total landfill gas collected and not the quantity of landfill gas converted to beneficial use. A portion of collected biogas is flared, such as during downtime for maintenance or repairs to the LFGTE system. Total reported beneficial use as reported by each facility to TCEQ.

Non-landfill biogas resources in the region are less understood, as data are not as readily available for these other facility types. Available information on the number and types of other biogas resources in the North Central Texas region are summarized below:

- **Municipal WWTPs.** Municipal WWTPs are categorized as major or minor by the U. S. EPA. Publicly owned WWTPs that have a design flow of 1.0 million gallons per day (MGD) or greater are considered major, which applies to 46 of the municipal WWTPs in the North Central Texas region. Eight of the major WWTPs in the region currently have AD systems installed as part of the treatment process. Publicly owned WWTPs that have a design average flow of 1.0 MGD are considered minor, and there are 107 in the North Central Texas region. There are no known AD systems installed at minor WWTPs in the region.

- **Industrial WWTPs.** Industrial WWTPs are categorized as major industrial facilities based on U.S. EPA's specific rating criteria. All facilities not categorized as major are considered minor. There is one major industrial WWTP in the North Central Texas region and there are 92 minor industrial WWTPs. Industrial facilities, such as food and beverage manufacturing, breweries and pulp and paper plants, may have AD systems installed to manage production wastes.

- **Other Industrial AD systems.** Based on information available through the U.S. EPA GHGRP, there is one brewery within the North Central Texas region operating an AD system to convert process wastes to energy. Others may exist but are not required to report activities through available databases.

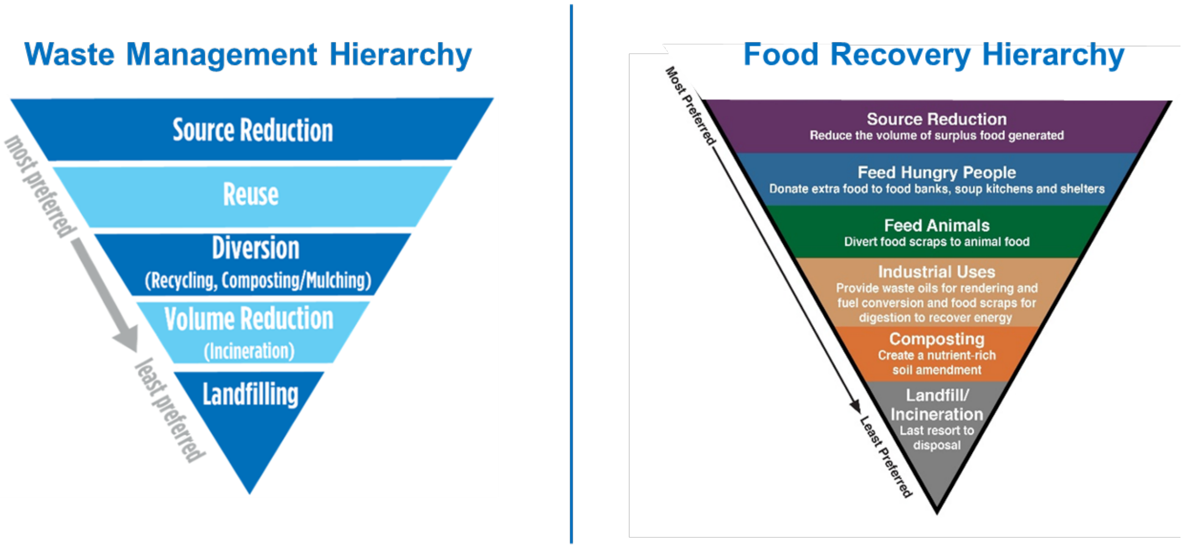
2.5 Feedstock Prioritization and Recommendation

In considering which materials to target for organics-to-fuels projects, the Project Team looked holistically at several factors that could impact the outcome for the North Central Texas region. The following presents an evaluation to identify the feedstocks that should be prioritized specifically to convert organic waste into RNG for vehicle fuel. Prioritization recommendations were developed based on a variety of factors as described below.

- **Existing and future volumes of materials.** The North Central Texas region is home to some of the fastest growing cities in the U.S., and the region as a whole is currently experiencing population growth at rates above both the statewide and national averages. The population and economic growth that the North Central Texas region experiences in the coming years will be the primary factor impacting the quantities and quality of material generated. For MSW materials from residential and commercial sources, population growth and increased economic activity will drive corresponding increases in the amount of food waste and other materials generated in these sectors. Based on population and employment data and projections from the NCTCOG Regional Data Center, the regional population grew at a compound annual growth rate of 1.67 percent per year from 2010-2020. Employment in the region is similarly expected to grow at a 1.67 percent per year average rate. As a result, regional growth is expected to produce increasing quantities of materials such as food waste that require management. The impact of growth on the generation of agricultural waste is less certain. In areas where urban sprawl contributes to changes in land use, there is the potential for available agricultural land to be reduced. However, the existing agricultural industry is well-established within the region, suggesting the impact on overall generation of crop residues and CAFO waste may be limited.

- **Diversion opportunities from landfill.** Consistent with the U.S. EPA's waste management hierarchy and food recovery hierarchy (shown in Figure 2-6), landfilling is the least preferred method of managing organic wastes. Efforts to divert organic materials from landfill to fuel production represent a shift to a more preferred method of managing these materials. Materials currently managed at landfills or through other disposal methods should be prioritized first to ensure efforts result in an overall increase in diversion. As described in Section 2.2, significant portions of organic wastes are already recovered in the region. Some feedstocks that are already diverted to beneficial use should not be prioritized for conversion to vehicle fuel. For example, some commercial food wastes are diverted to food banks or used as animal feed. These activities are more preferred than conversion to fuel ("Industrial Uses") based on the food recovery hierarchy. Currently, yard waste is recovered at the highest rate of all organics in the North Central Texas region. Recovery rates of food waste, biosolids, and other organics are notably lower (where known).

Figure 2-6: U.S. EPA Waste Management and Food Recovery Hierarchies



- **Stability and variability of materials.** Infrastructure for the collection, processing, and conversion of waste materials to fuel includes design and planning considerations specific to the quantities and material types being handled. AD systems perform best when feedstock quantity and properties (e.g., pH, fatty acids, carbon content) are relatively consistent to avoid issues associated with digester upsets. For example, food processing waste from a vegetable canning facility would have very low variability as the quantities and types (i.e., vegetable waste) would be relatively consistent in the quantities generated (i.e., the factory produces similar amount of product each week). Residential food waste is more variable, as the types of materials (e.g., vegetables, meats, dairy) and levels of contamination would not be consistent from house-to-house or week-to-week.

- **Biogas generation and GHG reduction potential.** Biogas generation and emissions are important considerations when evaluating both organic waste diversion opportunities and alternative vehicle fuel options. Biogas (produced when organic wastes decompose at either AD or landfill facilities) contains significant quantities of CH_4, a greenhouse gas with the global warming potential of 25 times that of CO_2. The prioritization of materials based on biogas generation and GHG reduction potential is driven by both the amount of biogas a material can produce and how quickly and fully that material degrades in AD and landfill settings. When disposed of in a landfill, more readily biodegradable organics (such as food waste) are first to produce CH_4 which may be emitted prior to the installation of the landfill gas collection system. For this reason, diverting quicker degrading organics from landfill provides the greatest GHG reduction potential compared to materials like yard trimmings and brush, which degrade more slowly and less completely in landfills. In controlled AD systems, process controls (e.g., moisture, temperature, retention time) can be used to allow materials to degrade more fully and capture the biogas that is produced. The residuals from the AD process (e.g., sludge, biosolids) can be utilized to improve soil health and sequester carbon emissions.

- **Scalability at the regional level.** The regional scalability of efforts to recover potential feedstocks is included as a prioritization consideration. The generation and recovery of some feedstocks (e.g., CAFO manures) are limited geographically and therefore do not provide a solution that is scalable across the 16-county region.

- **Stakeholder support.** Implementing programs to recover organic materials will require the buy-in of a number of stakeholders. These stakeholders include generators (e.g., single-family residents or businesses that source-separate materials), haulers and municipalities managing solid waste programs, and current facilities and material end users (e.g., composting facilities, farmers using food waste as animal feed). Prioritization includes considerations for stakeholder support based on feedback from the PAG and information obtained by the Project Team.

Table 2-7 summarizes the findings for feedstock materials and identifies the prioritization criteria for which each potential feedstock provides notable benefit. Key findings and recommended targeted feedstocks are described in more detail following Table 2-7.

Table 2-7: Summary of Feedstock Prioritization for RNG Fuel Production

Feedstock Type	Material Benefits and Prioritization						
	Existing and Future Volumes	Diversion Opportunities from Landfill	Stability and Variability of Materials	Biogas Production and GHG Reduction Potential	Scalability at the Regional Level	Stakeholder Support	Overall Suitability of Feedstock for RNG Vehicle Fuel
High Priority							
Food Waste	✓	✓	varies	✓	✓	✓	High
Existing Biogas Resources	✓		✓	✓	✓	✓	High
FOG	✓		✓	✓	✓		High
Medium Priority							
CAFO Manures	✓		✓	✓			Medium
Wastewater Treatment Sludge		✓	✓			✓	Medium
Low Priority							
Yard Trimmings	✓		✓		✓		Low
Crop Residues			✓				Low

Highest Priority Feedstocks

1. **Food waste.** Food waste is generated in significant quantities in the North Central Texas region, and quantities are expected to increase with increased population and economic activity in the coming decades. Because of its material properties, food waste presents high biogas generation potential. Food waste degrades quickly in a landfill, and one quarter of total methane production may take place in the first two years after disposal. Because of this, diverting food waste from landfills represents significant GHG reduction potential. Collecting food waste as an organics-to-fuel feedstock has high scalability potential across the region. There are current or planned efforts in the North Central Texas region related to diverting food waste in the commercial and residential sectors that can be used to build momentum and scale at the regional level. The collection networks and associated considerations (e.g., costs, barriers) to efficiently collect food waste from residential, commercial, and industrial generators are evaluated in more detail in Section 3.0.

2. **Existing biogas resources**. Biogas currently produced within the North Central Texas region is a high priority feedstock with untapped opportunity for fuel conversion. Biogas is produced at landfills over many years as organic wastes continue to decompose, and materials such as paper and yard waste disposed in landfills over the prior decades represent an embedded biogas resource in the region. Existing biogas resources can be considered as feedstock resources in a variety of ways: existing biogas-to-electricity projects may be technically feasible and require financial investment to upgrade to RNG; some sites may not have sufficient quantity or quality of biogas for RNG projects but could sufficiently increase gas production through co-digestion with off-site wastes to improve the technical and financial feasibility of these projects. Other sites may be considered too small but developing technologies for small-scale biogas projects may allow for these projects to be feasible in the future. There is a current trend in waste management toward investment in existing landfill sites to upgrade landfill gas systems to RNG for waste collection vehicle fueling. Waste Management, Inc., which owns and operates multiple landfills in the North Central Texas region, has committed to invest significantly in landfill biogas projects across the U.S., with the goal of fueling its entire natural gas fleet with RNG by 2026. The feasibility of using existing biogas resources is explored in more detail as part of the inventory of existing AD sites and pilot project scenario matrix presented in Section 7.0. Existing biogas resources (i.e., landfills, WWTPs) are located throughout the region, meaning use of existing resources has high regional scalability. There is also likely a high stakeholder buy-in, as this

approach invests in improved use of existing resources rather than the development of new large facilities.

3. **FOG.** FOG collected from the food service industry has significant biogas production potential and can be a valuable and desired feedstock to increase biogas quality and power production when co-digested at WWTPs. Addition of significant quantities of FOG into WWTP digesters can also create operational challenges including foaming. Because of these challenges, efforts to increase FOG co-digestion can face difficulty with stakeholder support from WWTP operators. Some FOG can be processed into biodiesel, which bears consideration but is outside the scope of this study. There are multiple facilities in the region permitted or authorized to convert FOG such as vegetable oil and waste cooking oil into biodiesel.

Medium Priority Feedstocks

4. **CAFO manures.** On-farm digesters for manure management have been used successfully in the U.S. and abroad to produce RNG from biogas. The AgSTAR database lists 128 projects in the U.S. that generate RNG from on-farm digesters: 95 operational and 33 under construction. The database also includes six on-farm biogas-to-RNG digesters that have shut down, including the Huckabay Ridge Digester in Stephenville, Texas. For the purposes of this study, CAFO manures were considered to be medium priority feedstocks as:

    - The biogas potential of manures is notable but less than food waste on a per ton basis.
    - CAFO locations in the North Central Texas region are exclusively in Erath County, limiting the regional scalability of the feedstock.
    - While historically successful in other states, the experience with the Huckabay Ridge Digester will likely impact stakeholder support for the development of similar projects.
    - On-farm digester project(s) represent a co-digestion opportunity for food wastes and other organics to be diverted in Erath County to increase biogas yield compared to digesting CAFO manures alone.

5. **Wastewater Treatment Sludge.** While AD is used to manage wastewater treatment sludge at a portion of the region's WWTPs, most do not include AD in the treatment process. Untreated sludge from these facilities may be a suitable feedstock to AD systems at nearby WWTPs for pathogen and odor reduction potential. For the purposes of this study, wastewater treatment sludge was considered to be medium priority feedstock as:

    - Treated and untreated sludge represents a potential landfill diversion opportunity. The majority is landfilled based on TCEQ and NPDES reporting information. Processing these materials through AD can help to facilitate diversion to composting and land application.
    - There is stakeholder concern that landfills may seek to increasingly restrict, reduce, or cease acceptance of sludge in the future which will necessitate other management options.

Low Priority Feedstocks

6. **Yard waste.** Depending on the AD technology, yard waste can be suitable feedstocks. Readily degradable green wastes (i.e., leaves, grass) have higher biogas production potential and are most suitable for AD conversion to RNG fuel. Other yard waste such as branches are valuable to managing high solids byproducts from the AD process via composting (e.g., as a bulking agent, to balance carbon-to-nitrogen ratios), and this material should continue to be diverted for composting. Currently, yard waste is recovered at the highest rate of all organics in the North Central Texas region, and prioritization of yard trimmings as a feedstock would not result in significant increased diversion from landfill; rather, it would likely target materials already diverted to composting.

7. **Crop residues.** As described in Section 2.2.3, not all crop residues are well-suited for conversion to fuel. For example, ethanol can be produced specifically from high sugar-content crops, typically corn or sugar cane. Production of vehicle fuel from commodity crops (e.g., corn-derived biodiesel, AD of sugar beets) generally requires the use of the commodity product (e.g., corn grain, sugar cane) and the residue/waste materials alone have historically been insufficient. Crop residues can be converted to bioenergy through direct combustion or densification to fuel pellets for heating, and to a lesser extent gasification for co-generation of heat and power.

Crop residues have historically not been considered to be a priority feedstock for organics-to-fuel RNG production; however, there is one operating facility in the U.S. that started using crop residues to produce RNG in late 2021,[9] and there are several other facilities/companies that have been considering similar installations. It should be noted that crop residue to RNG conversion facilities are in the infancy stages of development in the U.S. and further project development is necessary to assess commercial viability.

[9] More information on the VERBIO Nevada Biorefinery is available online at: https://www.verbio.us/project/verbio-nevada-biorefinery/

3.0 COLLECTION NETWORK ASSESSMENT

There are several types of collection networks (e.g., networks of vehicle fleets that collect and transport organic waste for disposal and/or processing) in the North Central Texas region that have the capability to separately collect and transport organic waste material. Based on the prioritization of feedstocks and generator sectors presented in Section 2.0 and feedback from stakeholders, the Project Team evaluated collection networks capable of separately collecting food waste that is currently disposed by commercial and residential sector generators. The Project Team established a series of collection network scenarios based on a planning-level evaluation of the operational and financial considerations related to the selected collection networks.

This section presents the results of the evaluation, including an overview of barriers and opportunities for each collection network and applicable case studies. The results of the collection network evaluation, including the estimated tons of food waste that could be collected under each scenario, serve as the basis for further screening and evaluation of potential organics-to-fuel pilot projects.

3.1 Methodology

To evaluate collection networks, the Project Team developed a model based on a variety of sources that supported the evaluation related to the storage, collection, and processing of organic wastes in the North Central Texas region. Data sources are consistent with those identified in Section 2.1 in combination with recently completed public and private sector collection operations evaluations, housing unit data from the U.S. Census, and primary research conducted by the Project Team. Additionally, the Project Team conducted select interviews with collection network operators and obtained feedback from members of the PAG to refine assumptions about collection networks in the region. Finally, where region-specific data were not available, publicly available reports were used to develop key assumptions.

Table 3-1 shows the current storage and source separation method utilized by generator sector to establish the full range of options that could be considered. The methods shaded in green indicate methods considered as part of the collection network analysis. Further description of storage and source separation methods is provided in Section 1.2.3.

Table 3-1: Storage and Source Separation Methods by Generator Sector[1]

Generator Sector	Refuse					Recycling					Organics			
	Bags	Carts/Bins	Dumpsters	CCS	Roll-Offs	Carts/Bins	CCS	Dumpsters	Roll-Offs	Other	Bags/Bundles	Carts/Bins	Dumpsters	Slurry Preprocessing
Residential	✓	✓	✓[2]	✓		✓	✓	✓[2]			✓	✓		
Commercial		✓	✓		✓	✓		✓	✓	✓[3]		✓		✓
Industrial			✓		✓			✓	✓	✓[3]		✓		✓

1. Green shading indicates the storage and source separation methods considered in the collection network evaluation.
2. Residents living in multi-family apartment complexes typically manage refuse and recycling through separate, shared dumpsters.
3. Commercial and industrial entities may process materials on site (e.g., a grocery store separating and baling old corrugated cardboard (OCC)) for collection or for back-hauling to a regional distribution center to aggregate material from multiple stores prior to transporting to end markets.

Based on the feedstock availability estimates and prioritization presented in Section 2.0, the Project Team evaluated the technical and financial requirements of commercial and residential collection networks to meet the projected service demand of food waste generators across the North Central Texas region. The evaluation focuses on generators that utilize storage and source separation methods serviceable by automated side load (ASL), front load (FEL) or vacuum trucks of industry standard size and specifications (reference Section 1.2.3 for detailed descriptions of vehicle types included in residential and commercial collection networks). The results provide a planning-level comparison of the operational and financial requirements to meet the projected tonnage service demand.[10]

[10] The collection network evaluation assumes source-separated organics (SSO) programs are already in place, fully implemented, and operations are able to collect all currently disposed tonnages of food waste for both residential and commercial collection networks. Considerations for the amount of food waste that could be practically collected are incorporated into the optimization modeling presented in Section 6.0. The evaluation does not quantitatively assess the impact on existing collection operations in the region but provides discussion on barriers and opportunities in Sections 3.2.3 and 3.3.3.

Some residents in the region set out bags for curbside or alley collection, requiring service using manual loading, semi-automated, or grapple vehicles; and other commercial locations or Citizen Collection Sites (CCSs) require service via roll-off. While these vehicle types are an important consideration for managing non-food waste material types (e.g., yard waste, agricultural waste), manual collection, semi-automated roll-off, and grapple vehicles are not included in this collection networks evaluation. Further discussion of commercial and residential food waste and FOG collection markets is provided in Section 3.2 and 3.3, respectively.

The location, capacity, and ownership of material management infrastructure in the region determine the time and distance vehicles that have reached maximum capacity must deviate from collection routes to deposit material at processing or disposal facilities. The strategic location of transfer or pre-processing equipment designed to manage food waste has a profound impact on the number of routes, vehicles, and staff required to meet the projected service demand. Currently, there is insufficient existing organics materials management facilities that could accept separately collected food waste.

To provide an equitable comparison between residential and commercial collection networks, the Project Team assumed materials management infrastructure (e.g., transfer stations designed or retrofitted to accept organics, installation of pre-processing facilities at generator sites, etc.) would be developed across the North Central Texas region to adequately transfer, screen and process food waste so it could be accepted by potential organics-to-fuel projects. More detailed evaluation of the proximity of existing materials management infrastructure to potential organics-to-fuel projects is provided in Section 7.0. Tipping fees or gate rates are not considered as direct operational expenses in the collection network evaluation because of the variability of pricing between disposal facilities and customer types in the region. The following describes the methodology and key assumptions specific to commercial and residential collection networks.

3.1.1 Commercial Collection

The types and relative quantities of food waste generation vary throughout the commercial sector based on the type of entity. There are 769,000 tons of commercial food waste generated annually by the subsectors included in the evaluation (see Table 2-1 for detailed tonnages by subsector) of which an estimated 558,000 tons is was disposed in landfills. The basis of tonnage in the commercial collection evaluation excludes tons currently diverted to prioritize opportunities that result in increased landfill diversion rather than compete with current composting or donation efforts.

The total available tonnage for collection was adjusted to reflect that a percentage of commercial locations would have insufficient existing space to install separate food waste storage equipment and enclosures. The percentage varies depending on local permitting requirements, and the Project Team assumed that 30 percent of restaurants and food service locations and 10 percent of food wholesale and retail locations would be unserviceable for separate food waste collection. The Project Team assumed that food wholesale, retail, restaurants, and food service locations could store separated food waste in dumpsters that can be serviced by FEL and sized to provide collection frequency three times per week based on industry standards. While some grocery stores or food retailers with high quantities of pre-consumer food waste might benefit from installing slurry processing equipment, this subcategory was evaluated based on receiving FEL collection. The other commercial subsectors (i.e., food manufacturers and processors, institutions, hospitality industry, healthcare facilities, and correctional facilities) were evaluated based on managing food waste through slurry processing equipment (e.g., macerator system) and stored in a slurry tank.

The Project Team calculated the operational requirements to service this volume of commercial food waste annually. The collection network operational and financial evaluation is based on assumptions determined by the Project Team to provide a comparative analysis of the operational requirements (e.g., vehicles, maintenance, and staff) and cost per route. In practice, commercial collection metrics vary between fleets depending on fleet equipment type, route density, and geography and the evaluation does not include implementation, administration, or business development costs related to establishing food waste collection routes. The complete set of assumptions and results of the modeling are provided in Appendix B.

The operational requirements were determined to meet the needs of servicing all currently disposed food waste tons on an annual basis, including the unprocessed food waste stored in dumpsters and macerated food waste stored in slurry tanks.

3.1.2 Residential Collection

Residential collection programs can take multiple forms across the North Central Texas region, varying by set out method, service frequency, equipment usage, and operator (public versus private sector). As presented in Section 2.0, composition studies conducted in the North Central Texas region indicate that single-family homes dispose of an estimated 660,000 tons of food waste annually based on an estimated 13.2 pounds of food waste per household per week. For residential collection, only single-family detached housing units were evaluated (excluding townhomes, condos, and mobile homes); therefore the total tons utilized in the model is 621,000.

Housing density is a critical component of routing efficiency and cost effectiveness of cart-based curbside solid waste collection. Areas with higher density of single-family houses service more customers per hour and operate more cost effectively. The Project Team evaluated data on the number of single-family detached housing units in the North Central Texas region to estimate the households per acre for incorporated municipalities and unincorporated areas. Table 3-2 describes how the Project Team categorized single-family detached housing units in the region, and the estimated number of single-family houses in each category.

Table 3-2: Residential Single-Family Estimates by Housing Density[1]

Housing Density	Description	Land Area (Acres)	Single-Family Housing Units
High	Incorporated municipalities with a density threshold greater than 1.0 single-family detached housing units per acre.	416,727	997,601
Low	Incorporated municipalities with a density threshold less than 1.0 single-family housing units per acre.	1,566,156	599,245
Rural	All unincorporated areas in the region are less than 1.0 single-family housing units per acre and are considered rural.	1,982,883	212,523
Total		**3,965,767**	**1,809,369**

1. Only includes single-family detached households, and does not include multi-family housing or mixed use developments. Housing density data based on U.S. Census ALS 2019 Community Survey.

The Project Team assumed that to provide collection to generators in single-family detached units, residential collection networks would be mandatory (e.g., customers would all receive a cart and must participate by source separating food waste and setting out the cart on a weekly basis) and that each customer would receive a roll cart serviced exclusively by ASL collection vehicles based on industry standards. Additionally, the evaluation assumes that SSO roll-carts would have a set-out rate consistent with typical refuse set-out rates and customers would consistently place all currently disposed post-consumer food waste in this cart for service. The complete set of assumptions and results of the modeling are provided in Appendix B.

3.2 Commercial Collection Networks

Commercial collection networks are operated in a number of different markets that vary across the North Central Texas region. Further detailed description of collection market types are provided in Section 1.2.3. Figure 3-1 shows an example of FEL and vacuum truck collection.

Figure 3-1: Example of FEL and Vacuum Truck Collection

The Project Team evaluated commercial collection networks utilizing FEL and vacuum trucks, as described in Section 3.1.

Table 3-3 shows the estimated disposed tons of food waste by commercial subsector, and the storage and source separation equipment most applicable to each.

Table 3-3: Commercial Food Waste Disposed Tons and Storage Equipment

Commercial Subsector	Percent of Food Waste Generation[1]	Estimated Disposed Tons[1]	Storage Equipment[2]
Food Wholesale and Retail	44.9%	250,449	Dumpster
Restaurants and Food Services	23.9%	133,552	Dumpster
Food Manufacturers and Processors	17.4%	97,198	Slurry Tank
Institutions	7.9%	43,941	Slurry Tank
Hospitality Industry	4.0%	22,234	Slurry Tank
Healthcare Facilities	1.2%	6,916	Slurry Tank
Correctional Facilities	0.7%	3,711	Slurry Tank
Total	**100.0%**	**558,000**	

1. Percentage of total commercial food waste generated by each subsector includes materials that are currently diverted. These percentages are applied against the total disposed tons to calculate the annual tonnage of food waste disposed (i.e., food waste currently donated or recycled is not included in estimated disposed tons)
2. Dumpsters for SSO are typically two to four CY in size, since the weight of full containers larger than four cubic yards (CY) may exceed a FEL vehicle's ability to service the set out. Based on discussions with industry representatives, slurry tanks range from 2,000 to 6,000 gallons depending on the volume of material generated and are serviced by vacuum trucks.

The following presents the results of the commercial collection network evaluation comparing the operations and costs between FEL and vacuum truck collection followed by a comparison of barriers and opportunities and applicable case studies.

3.2.1 Operations

The following evaluates the operational requirements (e.g., vehicles, staff, supervisors) to meet the projected service demand of collecting food waste currently disposed of by select commercial subsectors. The commercial collection networks that would service slurry tanks are compared to collection networks that would service unprocessed food waste collected by FELs. Table 3-4 calculates the total tons of unprocessed food waste and gallons of macerated slurry that serve as the basis for the evaluation of the commercial collection networks.

Table 3-4: Commercial Collection Networks Food Waste Tons[1]

Description	Slurry	Unprocessed
Disposed Tons[2]	174,000	384,000
Disposed Gallons[3]	173,999,500	N/A

1. Figures rounded for ease of presentation.
2. Disposed tons includes contamination collected and ultimately removed during processing.
3. Disposed gallons are calculated by multiplying the disposed tons by a conversion factor of 2.5 lb/gallon and adding the volume of feed-in water on a basis of 200 gallons per ton of food waste.

Table 3-5 compares the operational requirements of the projected commercial collection networks to provide service across the North Central Texas region.

Table 3-5: Commercial Collection Networks Operational Requirements

Operational Requirements	Slurry	Unprocessed
Customers per Route		
Customers Serviced per Hour	1	10
Customers per Day	4	50
Annual Service Opportunities	5,797	14,629
Collections		
Annual Collections	58,000	2,282,062
Annual Volume Serviced (CY)[1]	2,068,110	4,564,123
Weekly Collections	1,115	43,886
Vehicles		
Front-Line Daily Vehicles	64	176
Back-up Vehicles	13	35
Total	**76**	**211**
Operators		
Front-Line Vehicle Operators	64	176
Back-up Vehicle Operators[2]	13	35
Route Supervisors	6	18
Total	**83**	**228**

1. Annual volume serviced for slurry is estimated based on the volume required to service that amount of tonnage if it were collected via 2 CY dumpsters.
2. Based on industry standard backup levels of 20 percent for vehicles and operators.

The number of required services for collection of slurry is significantly less frequent, which minimizes the annual operating requirements compared to FEL collection of unprocessed food waste; however, the evaluation does not factor in the operational cost of installing or processing material to create the slurry, which would require additional resources (e.g., having an employee load food waste into a macerator).

3.2.2 Cost

The following evaluates the estimated direct operating expenses to meet the operational requirements of collecting food waste disposed by select commercial subsectors. Table 3-6 compares the annualized direct operating expenses for the commercial collection networks to provide service across the North Central Texas region. For the purposes of this evaluation, figures are not rounded to correspond directly with the results presented in Appendix B.

Table 3-6: Commercial Collection Network Annual Expenses

Direct Operating Expenses	Slurry	Unprocessed
Annualized Vehicle Purchase[1]		
Front Line	$3,716,665	$10,236,515
Back-up	$743,333	$1,023,651
Annual Fuel Cost[2]	$1,274,722	$3,510,864
Annual Maintenance[3]	$1,912,082	$5,266,296
Salary and Benefits[4]	$4,334,053	$11,936,938
Other Costs[5]	$599,043	$1,598,713
Total Annual Cost[6]	**$12,579,899**	**$33,572,977**

1. Assumes 4 percent cost of capital over a seven-year vehicle lifecycle.
2. Based on estimated $20,000 per vehicle per year for diesel fueled vehicle, reflecting a 50 percent increase in diesel fuel prices between January 2022 and May 2022.
3. Reflects estimated annual maintenance cost of $30,000 per year.
4. Based on annual compensation of $50,000 per year for vehicle operator and $80,000 per year for supervisors. These estimates are based on recent operational evaluations of municipal collection systems in the North Central Texas region, adjusted upward to reflect recent increases in vehicle operator compensation due to labor shortages and rising demand for vehicle operators. Salary and benefit estimates do not consider cost of overtime or temporary labor.
5. Includes typical direct costs such as supplies, uniforms, and other miscellaneous direct costs. Does not include other financial costs such as profit, overhead, or other indirect costs.
6. Costs may not sum exactly due to rounding.

The total annual costs presented are intended to compare the total potential regional costs for each collection network. The analysis does not indicate that these dollar values must be expended at this order of magnitude; each local SSO collection program would require only a portion of the total annual costs presented on a region-wide basis. The annual direct operating expenses of FEL collection are estimated to exceed slurry collection by approximately $21 million due to the difference in material collected and corresponding number of annual services required. Although the FEL collection requires higher operating expenses to meet the projected service demand, it is more suited to operating on a routed basis due to the frequency of collections. The limited recurring weekly collections for slurry collection customers may require a combination of routed and on-call collection, which would require additional costs.

3.2.3 Barriers, Opportunities and Case Studies

The following provides an overview of barriers and opportunities related to select components of slurry-based and unprocessed commercial collection networks. Table 3-7 presents a side-by-side comparison description that informs the brief case studies that follow.

Table 3-7: Barriers and Opportunities of Commercial Collection Networks

Component	Slurry		Unprocessed	
	Opportunity	Barriers	Opportunity	Barriers
Material Storage/Processing	High-quantity pre-consumer food waste generators can install pre-processing equipment for service via industrial cleaning that minimizes material management cost and footprint.	Only a portion of the pre-consumer generators will be able to install slurry processing and storage equipment on site. There is limited existing organics transfer capacity available.	There is limited additional operational requirements to using an SSO dumpster.	High quantity post-consumer food waste generators are space constrained to install SSO dumpster and/or enclosure. There is limited existing organics transfer capacity available.
Collection Efficiency	Vacuum trucks could co-collect slurry with existing FOG customers to achieve economies of scale or provide appointment-based service.	With fewer services required for slurry collection compared to FEL, dedicated slurry-only service may struggle to achieve optimal route density.	Focusing SSO collection for post-consumer food waste generators in downtown or commercial districts increases route density.	Customers may need to be serviced more frequently due to challenges with odors or vectors, depending on the volume of material generated.
Vehicle Emissions	Co-collecting slurry and FOG would minimize the need for additional vehicles and associated emissions to service customers.	Vacuum trucks have not been identified as a priority for adoption as NGVs.	Implementing new routes and collection vehicles provides opportunity to deploy additional low-emissions NGVs.	Existing fueling infrastructure for NGVs would not support fueling needs of projected additional vehicles.
Hauling Market	There are existing collection networks for FOG collection that could be leveraged to co-collect slurry with existing FOG customers	The hauling market is struggling with challenges related to nationwide labor shortages, prolonged supply chain issues, and rising fuel prices.	Leverage existing exclusive/non-exclusive franchises to incentivize haulers to offer SSO collection for high quantity generators.	Challenges requiring private haulers to offer SSO collection service if policy in the region does not account for disparity between capability of haulers in the region. Additionally, the hauling market is struggling with challenges related to nationwide labor shortages, prolonged supply chain issues, and rising fuel prices.
Partnership Opportunities	Partnership opportunities with school districts to implement SSO programs or regional districts (e.g., NTMWD) that can leverage existing organics processing infrastructure.	Slurry collection vehicle operators may consist of smaller 3rd party operations.	Collaboration with downtown or entertainment districts to support FEL collection in areas of high route density.	The private hauling market is competitive and partnerships or collaboration needs to be structured to create a “win-win” scenario that supports the business objectives of private haulers while developing organics-to-fuel projects that can accept SSO.

The following provides brief descriptions of case studies related to commercial collection networks that highlight key considerations supporting the successful development of organics-to-fuel projects utilizing commercial food waste.

- **Off-site pre-processing, screening and transfer.** In 2009 Waste Management (WM), using its patented CORe technology, developed a large-scale (75 tons/day) centralized approach for processing food waste into a consistently high quality slurry that could be successfully co-digested to produce biogas.[11]. In 2017 WM began providing slurry under a demonstration project agreement to Los Angeles County Sanitation District Joint Water Pollution Control Plant (JWPCP) located in Carson, CA. Slurry produced at WM's transfer facility was delivered to the JWPCP by 5,000 gallon tanker trucks delivering between 20,000 and 25,000 gallons per day, making between four to five trips per day. Slurry was unloaded into sealed storage tanks and injected into the reactor for co-digestion. JWPCP noted that the additional slurry increased biogas production by 100,000 cubic feet per day. Surplus gas can be purified and utilized as RNG to supplement the facility's existing CNG fueling station.

- **On-site pre-processing and screening.** The business unit of Insinkerator called Grind2Energy develops programs to service commercial customers that generate high quantities of food waste.[12] The Grind2Energy program installs commercial-grade macerator equipment and holding tanks on site where food waste is mechanically processed and stored. Then, vacuum trucks are deployed by third parties to empty the holding tanks and the payloads are delivered to local wastewater treatment facilities with AD processing capacity. Insinkerator has developed and deployed these programs for many institutional and commercial customers in the Northeast and Midwest regions of the U.S. such as Notre Dame College, Emory College, University of Illinois, Ohio State University, Whole Foods grocery, J.D. Smuckers, AT&T, and the Omni Hotel Group.

[11] Coker, Craig. Biocycle. "Los Angeles County WRRF Embraces Codigestion." January 2017. Available online: https://www.biocycle.net/los-angeles-county-wrrf-embraces-codigestion/#:~:text=Technology%20to%20produce%20food%20waste,with%20California%20organics%20recycling%20mandates.

[12] Emerson "Insinkerator Products- Commercial equipment." Available online: https://insinkerator.emerson.com/en-us/insinkerator-products/commercial-equipment/grind2energy#:~:text=The%20system%20actually%20recycles%20food,%E2%80%93%20faster%2C%20cleaner%20and%20easier

- **Dallas commercial organics collection.** The City of Dallas is developing a program to support commercial organics recycling with funding from a grant provided by the USDA that will target special events and food service establishments. [13] Dallas is in the process of procuring an organics collection and processing service provider to collect material from businesses and events on a pilot basis. This material will be processed by the collection contractor and the finished compost product is intended to be used at the Dallas County gardens to support its healthy food initiative.

- **Denton commercial organics collection.** The City of Denton is developing a program to divert commercial food waste from targeted businesses within its downtown valet service area. The project received support from the NCTCOG through a regional solid waste implementation grant.[14] Denton is in the process of procuring a channel grinder to allow pre- and post-consumer commercial food scraps to be processed and co-digested at the Pecan Creek WWTP for biogas recovery. Denton is also exploring options long term to upgrade the collected biogas to pipeline quality RNG for use in area businesses and homes.

- **Commercial tonnage driven organics-to-fuel project.** The Wasatch Resource Recovery AD facility in North Salt Lake, UT began receiving food waste, liquid organic waste, and food manufacturing waste in 2019. It operates under both wastewater and solid waste permits. The facility includes two 2.5 million-gallon continuous stirred-tank reactors, a tank to receive FOG, and a hydrolysis tank that feeds the digesters. The first phase of the project is designed to process 180,000 tons per year of source-separated organics from commercial generators, and the second phase will increase the capacity to 250,000 tons per year by adding 70,000 tons of material from residential generators. Phase I is rated to generate up to 3,000 MMBtu a day (or approximately 2,040 scfm) of RNG. Wasatch Resource Recovery is operated under a public-private partnership between ALPRO Energy & Water and the South Davis Sewer District.[15]

[13] City of Dallas. “Local Solid Waste Management Update.” June 2022. Available online: https://dallascityhall.com/departments/sanitation/lswmp/Pages/default.aspx
[14] North Central Texas Council of Governments “Grants” Available online: https://www.nctcog.org/envir/materials-management/grants
[15] Goldstein, Nora. Biocycle. “Food Waste recycling in Salt Lake City.” October 2021. Available online: https://www.biocycle.net/food-waste-recycling-in-salt-lake-city/

3.3 Residential Collection Networks

Areas of the North Central Texas region that have sufficient housing unit density to justify curbside collection are serviced by municipal or private fleets. Curbside collection programs may vary by the material set-out procedures and collection frequency. Single-family customers in rural areas utilize a combination of curbside collection and CCS locations to provide for material management [16]. Based on research conducted by the Project Team, 91 percent of municipalities in the North Central Texas region (148 of 163), contract with private sector collection service providers. Collection programs offer service on a once per week, twice per week, or every other week basis. Figure 3-2 provides an example of typical residential curbside collection via ASL.

Figure 3-2: Example of ASL Collection

3.3.1 Operations

The following evaluates the operational requirements (e.g., vehicles, staff, supervisors) to meet the projected service demand of collecting food waste disposed by single-family detached households in the North Central Texas region.

[16] The City of Fort Worth, even though it is a high-density collection area, has a robust network of CCS that provides drop off services for self-haul customers and minimized illegal dumping. Wise and Hood counties operate solid waste systems that effectively utilize CCS stations in the more rural areas of the region. Since CCS locations are serviced by roll-off vehicles, they are not included in the evaluation, although in practice these locations could provide collection programs for food waste generated by single-family residents.

The residential collection networks are high density, low density and rural areas and material is collected curbside by ASL. Table 3-8 presents the total number of households and the tons of food waste collected by housing unit density.

Table 3-8: Residential Collection Networks Food Waste Tons Collected

Description	High Density	Low Density	Rural
Households per Week	997,601	599,245	212,523
Annual Collection Tons	342,377	205,661	72,938
Weekly Collected Tons	6,584	3,955	1,403

Table 3-9 compares the operational requirements of the commercial collection networks to provide service across the North Central Texas region.

Table 3-9: Residential Collection Networks Operational Requirements

Operational Requirements	High Density	Low Density	Rural
Customers per Route			
Households Serviced per Hour	150	125	100
Households Serviced per Day[1]	750	625	475
Collections			
Annual Service Opportunities	51,875,252	31,160,740	11,051,196
Routes per Day	266	192	89
Vehicles			
Front-Line Daily Vehicles[2]	266	192	89
Backup Vehicles	53	38	18
Total	**319**	**230**	**107**
Operators			
Vehicle Operators	266	192	89
Back-up Vehicle Operators[3]	53	38	18
Route Supervisors	27	19	9
Total	**346**	**249**	**116**

1. While the households serviced per day figures are based on typical operating efficiencies of existing collection programs, it assumes that the access to processing locations is similar across all three residential collection network types. Reference Appendix B for further discussion on the Project Team's modeling assumptions.
2. Front-line daily vehicles represent the total required to service the number of estimated daily routes per day and are the main vehicles in operation. Backup vehicles would only be used to service routes if front-line vehicles require scheduled or unscheduled maintenance.
3. Based on industry standard backup levels of 20 percent for vehicles and operators.

Equipment and personnel required are much higher for high density collection, but the tonnage collected exceeds the low density or rural areas which indicates a greater potential impact by focusing on SSO collection in higher density areas.

3.3.2 Costs

The following evaluates the estimated direct capital and operating expenses to meet the operational requirements of collecting food waste disposed by high-density, low-density, and rural areas of the North Central Texas region. Table 3-10 compares the annualized direct operating expenses for the residential collection networks to provide service across the North Central Texas region. For the purposes of this evaluation, figures are not rounded to correspond directly with the results presented in Appendix B.

Table 3-10: Residential Collection Network Annual Expenses

Direct Operating Expenses	High Density	Low Density	Rural
Annualized Vehicle Purchase[1]			
Front Line	$16,620,992	$11,980,797	$5,590,796
Back-up	$1,662,099	$1,198,080	$559,080
Annual Fuel Cost[2]	$5,320,539	$3,835,168	$1,789,667
Annual Maintenance[3]	$9,310,943	$6,711,544	$3,131,918
Personnel Wages and Benefits[4]	$18,089,831	$13,039,571	$6,084,869
Other Costs[5]	$2,550,220	$1,838,258	$857,816
Total Annual Cost[6]	**$53,554,624**	**$38,603,418**	**$18,014,146**

1. Assumes 4 percent cost of capital over a seven-year vehicle lifecycle.
2. Based on estimated $20,000 per vehicle per year for diesel fueled vehicle, reflecting a 50 percent increase in diesel fuel prices between January 2022 and May 2022.
3. Reflects estimated annual maintenance cost of $35,000 per year.
4. Based on annual compensation of $50,000 per year for vehicle operator and $80,000 per year for supervisors. These estimates are based on recent operational evaluations of municipal collection systems in the North Central Texas region, adjusted upward to reflect recent increases in vehicle operator compensation due to labor shortages and rising demand for vehicle operators. Salary and benefit estimates do not consider cost of overtime or temporary labor.
5. Includes typical direct costs such as supplies, uniforms, and other miscellaneous direct costs. Does not include other financial costs such as profit, overhead, or other indirect costs.
6. Costs may not sum exactly due to rounding.

The total annual costs presented are intended to compare the total potential regional costs for each collection network. The analysis does not indicate that these dollar values must be expended at this order of magnitude, since each local SSO collection program would require only a portion of the total annual costs presented on a region-wide basis. The annual cost of collection in high density areas is higher due to the increased annual services, but has the potential to capture more tonnage while covering less acreage.

3.3.3 Barriers, Opportunities and Case Studies

The following provides an overview of barriers and opportunities related to select components of residential collection networks. Table 3-11 presents a side-by-side comparison description that informs the brief case studies that follow.

Table 3-11: Barriers and Opportunities of Residential Collection Networks

Component	Opportunity	Barriers
Material Storage/Processing	Implementing cart-based collection may be combined with efforts to deploy volume-based incentives to reduce material disposed (e.g., pay as you throw programs). If cart-based SSO programs are deployed, municipalities could pursue collective purchasing strategy to increase economies of scale. Education and outreach efforts could be coordinated with the ongoing Know What to Throw Campaign to support SSO program development.	Education, outreach, and compliance for SSO programs to ensure customers follow set out instructions and minimize contamination requires significant resources.
Collection Efficiency	Residential SSO programs are typically rolled out in phases, which would provide lead time to develop critical transfer and processing infrastructure throughout the region. There may be cost savings related to the reduction in refuse service demand as a result of implementing SSO program, but this may be offset by increased processing costs.	Although the evaluation models residential collection networks as mandatory programs to provide an equitable comparison, existing curbside collection programs are typically voluntary which have lower set out rates and would result in fewer tons collected on a weekly basis and lower routing efficiency due to increased “windshield time,” or time required to drive between clusters of customers.
Vehicle Emissions	Implementing new routes and collection vehicles provides the opportunity to deploy additional NGVs and increase the natural gas fuel demand in the region.	Existing fueling infrastructure for NGVs would not provide adequate natural gas fuel to meet projected service demand.
Hauling Market	Leverage existing exclusive/non-exclusive franchises or hauler licensing programs to incentivize haulers to offer SSO collection for high quantity generators.	Challenges requiring private haulers to offer SSO collection service if policy in the region does not support a level playing field for private haulers. The cost of separately processing organics needs to be competitive with landfill disposal to support the economics of separate collection and processing.
Partnership Opportunities	There are opportunities for partnerships to develop infrastructure that minimizes the need for collection fleets to direct haul to processing facilities. Partnership opportunities with school districts that have cart-based collection.	Challenges may occur related to requiring that SSO collected by private sector entities be delivered to a designated location due to flow control restrictions. Any facility developed as part of public-private partnership will require a guaranteed tonnage expected to flow to the facility.

The following provides brief descriptions of case studies related to residential collection networks that highlight key considerations supporting the successful development of organics-to-fuel projects utilizing residential food waste.

- **Phased curbside SSO program roll-out schedule.** The cities of Austin and San Antonio collect and process food waste from residential customers. Austin implemented curbside collection for composting food scraps, yard trimmings, food-soiled paper, and natural fibers from single-family residential customers in phases over four years. The final expansion of the program was recently completed, and all customers have been provided 48-gallon organics collection roll carts for collection on a weekly basis and is a key part of Austin's pay-as-you-throw (PAYT) system, where customers can separate organics for collection and downsize the size of their refuse roll cart. Organics collected are delivered to the Hornsby Bend facility for processing into compost product.

- **Minimizing contamination in SSO roll carts.** San Antonio has a comprehensive curbside organics collection program. Residents are provided a green cart (96- or 48-gallon) for items that can be composted into nutrient-rich material that is made available back to the community. San Antonio accepts all food waste (pre- and post-consumer), non-recyclable paper, and yard waste in their collection cart for composting. Materials may be either loose or placed in paper bags in the cart. When unaccepted items (contamination) are found in the green cart, the contaminated material is landfilled and customers incur a fee. Fees are collected through the resident's utility bill and most violation fees are $25-$50. In 2020, participation in this program helped divert 70,000 tons of material from the landfill where it is composted by Atlas Organics, San Antonio's contracted processing facility operator.

3.4 Collection Network Prioritization and Recommendation

In considering which collection networks to target for organics-to-fuels projects, the Project Team compared key criteria that indicate the impact of servicing commercial and residential sector food waste generators. The following comparison matrix is based on the evaluation of various models to collect food waste in the North Central Texas region. Table 3-12 compares technical and financial requirements based on the modeling detailed in Appendix B.

Table 3-12: Collection Network Evaluation Matrix

Criteria	Commercial Slurry	Commercial Unprocessed	Curbside Residential Food Waste		
			High Density	Low Density	Rural
Annual Tons Collected	174,000	384,000	342,377	205,661	72,938
Annual Service Opportunities	58,000	2,282,062	51,875,252	31,160,740	11,051,196
Annual CY Collected	2,068,110	4,564,123	-	-	-
Total Households Serviced	-	-	997,601	599,245	212,523
Required Routes per Day	64	176	266	192	89
Vehicles					
Front-Line	64	176	266	192	89
Backup	13	35	53	38	18
Staff	83	228	346	249	116
Cost per Route	**$197,375**	**$191,252**	**$201,313**	**$201,313**	**$201,313**
Total Annual Cost[1]	**$12,579,899**	**$33,572,977**	**$53,554,624**	**$38,603,418**	**$18,014,146**
Cost per Ton	**$72.30**	**$87.43**	**$156.42**	**$187.70**	**$246.98**
Cost per Household per Month	**-**	**-**	**$4.47**	**$5.37**	**$7.06**
Cost per CY Serviced	**$6.08**	**$7.36**	**-**	**-**	**-**

1. Reference Table 3-6 and Table 3-10 for further detail on total annual expense. Cost per route multiplied by required routes per day may not equal to annualized expenses due to rounding.

To focus the analysis on the direct costs and evaluating the relative effectiveness among the collection networks, the analysis assumes widespread adoption and fully optimized SSO collection programs (e.g., carts/dumpsters distributed, high set out rates) with certain costs are omitted (e.g., cart purchase and repair, processing costs, etc.). In practice, implementation of SSO programs may not achieve these economies of scale, or may include other program costs that would impact the unit costs presented.

Additionally, the unit costs calculated by the Project Team consider recent increases (as of 2022) to costs related to equipment purchase, vehicle fueling, and employee hiring and retention due to broader economic impacts of widespread inflation, supply chain bottlenecks, fuel price increases, and labor shortages. The benchmarking cost information provided below is based on figures compiled between 2020 and 2021, and it is reasonable to anticipate that these market rates could rise in response to the broader economic impacts considered in the evaluation.

Based on recent benchmarking of single-family collection costs for once per week cart-based refuse collection programs in the North Central Texas region, costs range from $4.00 to $6.00 per household per month (excluding disposal costs). Residential collection costs on a per household per month basis are consistent with the market rates for refuse collection. Residential curbside SSO program costs would be in addition to existing program costs. While there would be collection efficiencies (e.g., increased households serviced, fewer required trips to disposal facility) related to the reduction in refuse tonnage collected due to the diversion of food waste, cost reductions may be offset by increased processing costs for SSO.

Based on recent benchmarking of commercial front-load refuse collection programs in the North Central Texas region, collection costs range from $2.00 to $6.00 per CY (excluding disposal costs). Commercial collection costs on a per CY basis are higher than benchmarked market rates and may be explained by the smaller two CY dumpsters for FEL SSO collection compared to larger dumpsters used for refuse collection. Commercial front-load collection customers may be able to reduce the number of collections per week for refuse (depending on the commercial subsector) that would provide collection efficiencies (e.g., fewer stops required for refuse routes).

Based on the results of the analysis the Project Team is prioritizing multiple collection networks including commercial FEL collection, commercial slurry collection and residential curbside collection in high density areas of the North Central Texas region.

The priority commercial collection networks for food waste include commercial front-load collection and slurry collection due to their relative cost effectiveness on a dollars per ton basis. Between the two types of commercial collection, slurry collection is more cost effective on a dollars per CY basis but there are fewer customers that could install macerator and slurry tanks for food waste management.

The priority residential collection network for food waste is high density areas based on the significant available tonnage of food waste and relative cost effectiveness on a dollars per household per month basis compared to low density or rural areas of the North Central Texas region. Although there are opportunities for diversion of food waste from low density and rural areas, these areas may be better suited to source reduction efforts (e.g., backyard composting, food donation) as compared to collection for conversion to RNG.

4.0 NATURAL GAS VEHICLE FUEL DEMAND

Natural Gas Vehicles (NGVs) allow owners/operators of heavy-duty truck fleets to displace traditional fuels and fossil-derived CNG. This section evaluates various NGV fleet types in the North Central Texas region, establishes the number of existing NGVs, estimates their fuel usage, and prioritizes fleet types for increased adoption of NGVs.

4.1 Methodology

The Project Team evaluated data provided by the Texas Department of Motor Vehicles (TxDMV), Dallas-Fort Worth Clean Cities program (DFWCC) and other recent reports to identify the number of fleets in the North Central Texas region and assess NGV fuel demand. The following provides descriptions of each data source used to support the development of the following evaluation:

- **TxDMV vehicle registration data.** TxDMV vehicle registration data includes the county in which the vehicle was registered, model year, make, fuel type, vehicle body type, and vehicle class.

- **International Registration Plan (IRP).** The Project Team explored the availability of apportioned registration data for commercial motor vehicles by reaching out to EROAD, a leading Fleet Management Solution (FMS) and Electronic Logging Device (ELD) provider to the trucking industry. The contact at EROAD referred the Project Team to the TxDMV Motor Carrier Division. The TxDMV Motor Carrier Division provided aggregated International Registration Plan (IRP) data. IRP facilitates the apportionment of vehicle registrations for commercial motor vehicles operating in multiple jurisdictions (including across states and Canadian provinces)[17].

- **DFWCC annual survey data.** DFWCC, a U.S. Department of Energy (USDOE) program, works with local fleets to promote practices and decisions to reduce transportation energy use and improve air quality. The Project Team evaluated DFWCC's annual fleet survey, which includes self-reported information for multiple vehicle fleet types including bus, car, pickup/SUV/van, refuse collection vehicle, semi-trailer truck and unknown/other.

[17] Trucking companies often use a fleet management solution (FMS) to track hours of service, comply with electronic logging device regulations and other purposes (e.g., vehicle fuel efficiency, etc.). Motor carriers frequently leverage FMS data to comply with IRP. Carriers registered with IRP pay registration fees to their base jurisdiction and report their vehicle mileage by state to IRP. The states apportion registration fees based on miles driven by the carrier in each state.

For each vehicle fleet type the survey collected fleet/station name, number of vehicles in fleet, miles traveled per vehicle per year, average fuel economy, vehicle type, fuel type, amount of alternative fuel used, fuel units, and Gasoline Gallon Equivalents (GGEs) reduced. A GGE is a standard unit used to compare the energy content of all fuels, enabling users to compare a given quantity of energy across multiple fuel types. The Project Team compared the DFWCC annual fleet survey data including data on mileage and fuel usage to the TxDMV data.

- **Alternative Fuels Data Center (AFDC).** The U.S. Department of Energy (DOE) AFDC lists the alternative fueling stations in the U.S. and Canada. The Project Team filtered this dataset for Compressed Natural Gas (CNG) vehicle fueling stations to identify locations. CNG fueling stations identified as part of this data source include RNG fueling stations.

The Project Team conducted stakeholder interviews to qualitatively confirm the results of the quantitative fuel demand analysis and gain additional insights into local perspectives on current and anticipated fuel demand from NGVs. Table 4-1 presents an overview of each stakeholder interviewed.

Table 4-1: Stakeholder Interview Overview

Stakeholders Interviewed	Description
Texas Natural Gas Vehicle Alliance (TXNGVA) develops and expands natural gas transportation markets, technology, and refueling stations in Texas through industry initiatives, government programs, energy education, safety awareness, environmental advocacy and community relations. TXNGVA membership consists of utilities, private fleets, station equipment operators and equipment suppliers.	The Project Team interviewed representatives from TXNGVA on March 16, 2022 to discuss major policy accomplishments from recent years and trends in the alternative fuel industry. TXNGVA identified three niche markets for NGVs, two of which are dominated by natural gas fuel: solid waste collection vehicles and transit buses. Long haul trucking, the third niche market, has had more volatility in adopting NGVs.
Clean Energy is the largest provider of RNG for transportation in the country, with a network of more than 570 fueling stations across North America. Clean Energy owns and operates 14 public-access natural gas fueling stations in the North Central Texas region.	The Project Team interviewed representatives from Clean Energy on March 17, 2022 to discuss the company’s role in supplying natural gas to vehicle fleets in the North Central Texas region. Clean Energy indicated that the Dallas Area Rapid Transit (DART) system, City of Dallas, DFW Airport, Trinity Metro and various private solid waste collection fleets currently utilize NGVs.

Quantitative and qualitative data gathered from the stakeholder interviews regarding current and future natural gas demand was used to identify priority fleet and vehicle types positioned for increased adoption of NGVs.

Additionally, the Project Team evaluated recently published studies related to NGVs, including the *Study on Imposing Fees on Alternatively Fueled Vehicles*[18] and *The Refuse Revolution Leading the Way to a Sustainable Future* (Refuse Revolution Report)[19].

The TxDMV published the *Study on Imposing Fees on Alternatively Fueled Vehicles* in 2020, which was developed in coordination with other state agencies. The report examines the impact of alternatively fueled vehicles on the state's motor fuel tax revenue and the feasibility and desirability for establishing a registration fee for alternatively fueled vehicles, as well as other revenue-generating options. The study also looks at impacts on the state highway system, vehicle emissions, and direct environmental benefits of alternatively fueled vehicles. The analysis estimates that for every conventional vehicle a consumer replaces with a hybrid vehicle, the State of Texas loses $80 of annual state fuel tax revenue, and for every electric vehicle the State loses $100 per year in state fuel tax revenue, which negatively impacts transportation system funding in the state. The study recommends the State implement increased vehicle registration fees for alternatively fueled vehicles consistent with the approach used by 29 other states to offset the losses to motor fuel tax revenue.

The Refuse Revolution Report evaluates the impacts of alternative fuels and technologies to replace diesel refuse trucks, including the lifecycle emissions of greenhouse gases from diesel-fueled vehicles, air pollution and health impacts, and the comparative benefits of each alternative fuels and technologies. The Refuse Revolution Report includes evaluation of fossil natural gas and RNG collection vehicles.

4.2 Natural Gas Vehicle Types

Specific to the North Central Texas region, the TxDMV dataset available identified 2,442 registered NGVs (compared to the 2,375 identified by the DFWCC data). Reference Section 1.2.3 for detailed descriptions of each NGV type.

[18] Texas Department of Motor Vehicles. *Study on Imposing Fees on Alternatively Fueled Vehicles*. 2020. Available online: https://interchange.puc.texas.gov/Documents/49125_64_1098844.PDF
[19] Energy Vision. *The Refuse Revolution Leading the Way to a Sustainable Future*. 2021. Available online: https://energy-vision.org/wp-content/uploads/2021/12/The_Refuse_Revolution.pdf

Table 4-2 presents the total TxDMV NGV registrations including all vehicle types.

Table 4-2: TxDMV NGV Registrations in the North Central Texas Region

NGV Type	Registrations
Solid Waste Collection	186
Tractor-Trailers[1]	514
Buses[2]	663
Light-Duty Delivery Vehicles[3]	417
Passenger Vehicle[4]	524
Industrial Equipment[5]	138
Total	**2,442**

1. Natural gas tractor-trailers registered in the North Central Texas region through IRP do not consistently fuel in the North Central Texas region and are not included in the total NGVs presented.
2. Includes both transit buses and other bus types such as daycare, charter buses, etc.
3. TxDMV data indicates there are 417 light-duty delivery vehicles within the 613 total registered delivery vans, pickup trucks, and suburbans/SUVs, representing 68 percent.
4. Includes: four-door hardtops, four-door sedans, pickup trucks, 3 and 5-door sedans, hatchbacks, and suburbans.
5. Includes: auto carriers, concrete trucks, convert gears, dump trucks, motor homes, and oil field equipment, refrigerated vans, street sweepers, tanker trucks, well drillers and wreckers.

Table 4-3 presents the total DFWCC NGV registrations including all vehicle types.

Table 4-3: DFWCC NGV Registrations in the North Central Texas Region

NGV Type	Registrations
Solid Waste Collection	125
Tractor-Trailers	683
Buses[1]	1,051
Light-Duty Delivery Vehicles[2]	208
Passenger Vehicle[3]	308
Industrial Equipment	0
Total	**2,375**

1. Includes both transit buses and other bus types such as daycare, charter buses, etc.
2. Light-duty delivery vehicles make up 68 percent of vehicles in the vans, pickup trucks and suburbans/SUVs category in the TxDMV data. The Project Team applied that ratio to the Pickup/SUV/Van included in the DFWCC data to show that 208 of a total 306 vehicles in the Pickup/SUV/Van category are light-duty delivery vehicles.
3. Includes all vehicles categorized as car and the other 98 vehicles from the Pickup/SUV/Van that are not light-duty delivery vehicles.

Given the discrepancy in the range of vehicles identified between the data from the TxDMV and DFWCC, the following information and analysis are presented as ranges. Only high-volume NGVs are considered, including solid waste collection vehicles, tractor-trailers, transit buses and light-duty delivery vehicles. These vehicle types represent the majority of fuel demand among NGVs in the region. Table 4-4 presents the range of registered high-volume NGVs identified based on both the TxDMV and DFWCC datasets.

Table 4-4: Range of Registered High-Volume NGVs in the North Central Texas Region

High-Volume NGV Type	Total High-Volume NGVs [1]	
	Low	High
Solid Waste Collection	125	186
Tractor-Trailers[2]	514	683
Buses[3]	663	1,051
Light-Duty Delivery Vehicles[4]	208	417
Total	**1,510**	**2,337**

1. The low and high ranges reflect the lesser or greater between the TxDMV and DFWCC datasets.
2. Tractor-trailers registered through IRP are not included.
3. Includes both transit buses and other bus types such as daycare, charter buses, etc. Transit buses are estimated to represent 1,675 total NGV buses in the North Central Texas region.
4. TxDMV data indicates there are 417 light-duty delivery vehicles within the 613 total registered delivery vans, pickup trucks, and suburbans/SUVs, representing 68 percent. Since DFWCC data does not break the delivery vans, pickup trucks and suburbans/SUVs at this level, The Project Team adjusted the number of light-duty delivery vehicles provided by the DFWCC dataset downward by 32 percent from 306 vehicles to 208 to show an appropriate comparison.

The Project Team evaluated the total NGVs in the region compared to the total registered vehicles to calculate the percentage that NGVs represent each vehicle type. Light-duty delivery vehicles are not evaluated further as part of the NGV fuel demand due to the negligible percentage utilizing CNG/RNG compared to the total light-duty delivery vehicles registered; however, select locations of light-duty delivery vehicle fleets are further considered by the Project Team as part of the evaluation for selecting potential organics-to-fuel pilot projects.

Table 4-5 presents the regional total registered vehicles using all fuels to calculate the percentage of high-volume NGVs by type.

Table 4-5: Percentage of High-Volume NGVs by Vehicle Type

High-Volume NGV Type	Regional Vehicle Total[1]	NGV Adoption Percentage[2]	
		Low	High
Solid Waste Collection	1,725	7.3%	10.8%
Tractor-Trailers	79,620	0.7%	0.9%
Buses[3]	14,887	4.5%	7.1%
Total	**96,232**	-	-

1. Regional total represents the total registered vehicles per the TxDMV vehicle registration data for each high-volume NGV type, including all fuel types. Figures are not rounded to provide exact calculations used by the Project Team.
2. NGV adoption percentage is calculated by dividing the regional total by the high and low ranges presented in Table 4-4.
3. While the adoption of all buses (e.g., transit buses and other bus types) ranges between 4.5 and 7.1 percent, the Project Team estimates that transit buses operated by a transit agency represent 1,675 total vehicles, representing a range between 40 and 62 percent adoption.

4.3 Natural Gas Vehicle Fuel Demand

The Project Team evaluated the number of vehicles registered in each county and individual natural gas consumption by vehicle type to estimate the current and potential natural gas demand in the North Central Texas region. For the purposes of this evaluation, total buses (including both transit buses and other bus types) are considered to provide aggregate NGV fuel demand. Table 4-6 presents the natural gas consumption requirements by vehicle type based on data self-reported to DFWCC by fleet operators as part of DFWCC's annual survey.

Table 4-6: Estimated GGE per High-Volume NGV[1]

High-Volume NGV Type	High-Volume NGVs Surveyed	High-Volume NGV Annual Fuel Usage (GGE)	Estimated Annual GGE per High-Volume NGV
Solid Waste Collection	125	334,228	2,647
Tractor-Trailers	683	5,088,695	7,451
Buses	1,051	11,915,551	11,337
Total	**1,859**	**17,338,474**	-

1. Estimated GGE per high-volume NGV is based on DFWCC data self-reported by fleet operators. Figures are not rounded to provide exact calculations used by the Project Team.

Table 4-7 presents the estimated annual current and future potential natural gas fuel demand. The potential future NGV fuel demand assumes that 100 percent of each vehicle type adopts NGVs. Figures in the following analysis are rounded to the nearest thousand for ease of presentation and clarity.

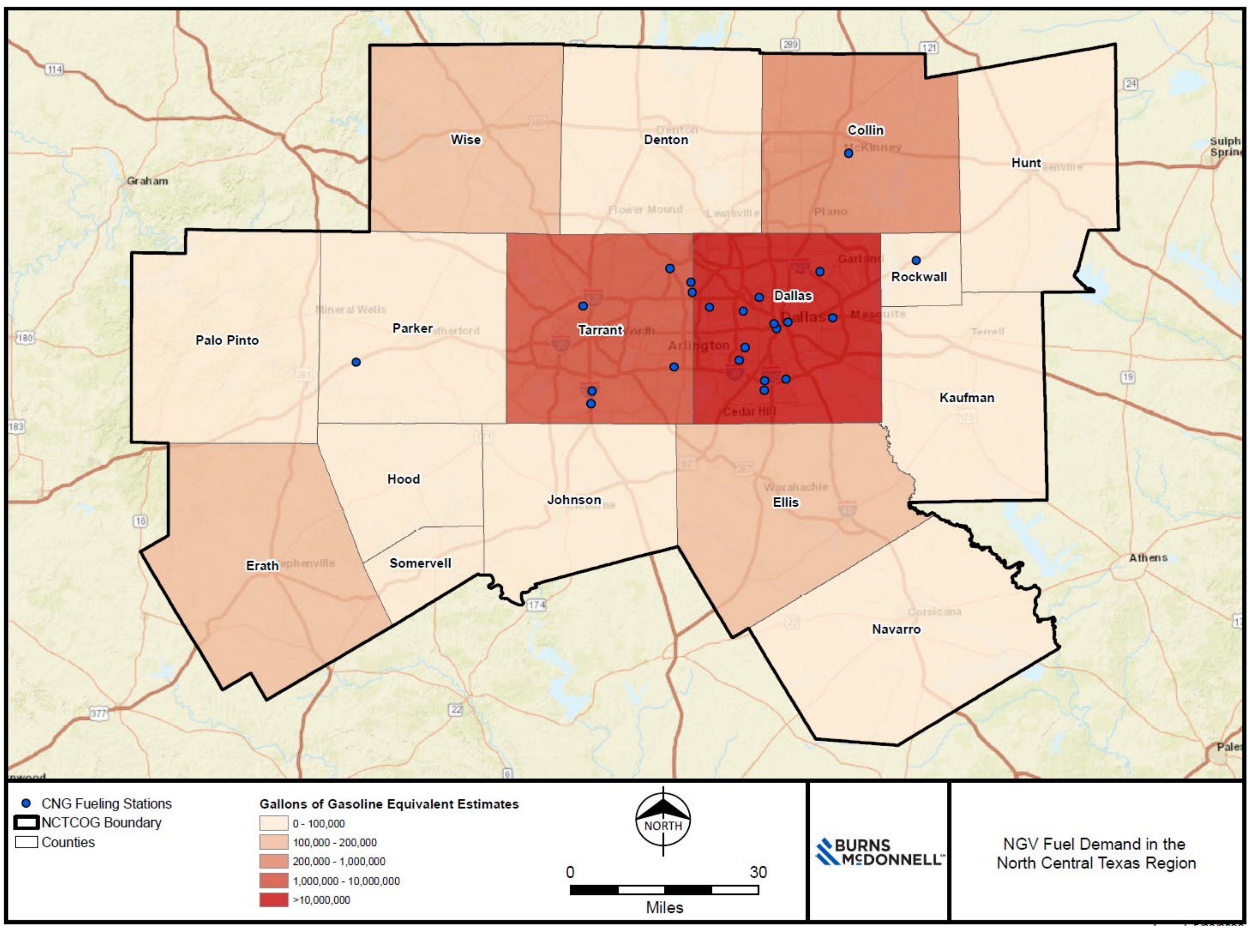
Table 4-7: Current and Potential Future High-Volume NGV Fuel Demand (GGE)

High-Volume NGV Type	Current High-Volume NGV Fuel Demand		Potential Future High-Volume NGV Fuel Demand[1]
	Low	High	
Solid Waste Collection	334,000	497,000	4,278,000
Tractor-Trailers	3,830,000	5,089,000	589,380,000
Buses	7,517,000	11,916,000	161,262,000
Total	**11,681,000**	**17,502,000**	**754,920,000**

1. Estimated Potential future NGV fuel demand based on total registered high-volume NGV per TxDMV dataset.

Figure 4-1 shows the geographic representation of high-volume NGV fuel demand in the North Central Texas region, based on the county in which they are registered.

Figure 4-1: NGV Fuel Demand in the North Central Texas Region



The majority of NGVs in the North Central Texas region are registered in Dallas and Tarrant counties and have the highest fuel demand in the 16-County region. A total of 1,850 NGVs were registered in Dallas County and 408 NGVs were registered in Tarrant County. All other counties in the region collectively had fewer than 200 NGVs registered, with Collin County having the next highest level of NGV registrations at 62.

Table 4-7 identifies the potential demand for NGV fuel if all the included vehicle types would transition entirely to NGV fuel, which is not a realistic scenario. To provide practical estimates of future fuel demand scenarios, the Project Team analyzed two scenarios that reflect more realistic, incremental increases in the adoption of NGVs among solid waste collection fleets, tractor-trailer fleets, and transit bus fleets. Scenario 1 reflects a minor increase in the high-volume NGVs adoption percentage and Scenario 2 reflects a more aggressive increase in the high-volume NGVs adoption percentage. The increases to NGV adoption percentages were selected by the Project Team based on the discussions from stakeholder interviews regarding the anticipated increases in NGVs across the North Central Texas region. Table 4-8 presents compares the current NGV fuel demand to each of the scenarios based on increased adoption of NGVs.

Table 4-8: Potential Future NGV Fuel Demand Scenarios (Annual)

Description	Solid Waste Collection	Tractor-Trailers	Buses[2]	Total
Current				
NGV Adoption (%)[1]	10.8%	0.9%	7.1%	-
Number of NGVs	186	683	1,051	**1,920**
NGV Fuel Demand (GGE)	497,000	5,089,000	11,916,000	**17,502,000**
Scenario 1				
NGV Adoption (%)	13.0%	2.0%	8.0%	-
Number of NGVs	224	1,592	1,192	**3,008**
NGV Fuel Demand (GGE)	600,000	11,864,000	13,502,000	**25,966,000**
Scenario 2				
NGV Adoption (%)	50.0%	5.0%	10.0%	**-**
Number of NGVs	863	3,981	1,489	**6,333**
NGV Fuel Demand (GGE)	2,480,000	29,660,000	16,878,000	**49,018,000**

1. Current percentage of NGV is based on the high estimate presented in Table 4-5.
2. While the adoption of all buses (e.g., transit buses and other bus types) ranges between 4.5 and 7.1 percent, the Project Team estimates that transit buses operated by a transit agency represent 1,675 total vehicles, representing a range between 40 and 62 percent adoption.

The significant increase in solid waste collection vehicles only increases demand by approximately two million GGE due to solid waste collection being a smaller regional fleet and the per vehicle GGE required to fuel solid waste collection vehicles is the lowest of the three priority vehicle types. Increases in GGE would be much higher for tractor-trailers and buses.

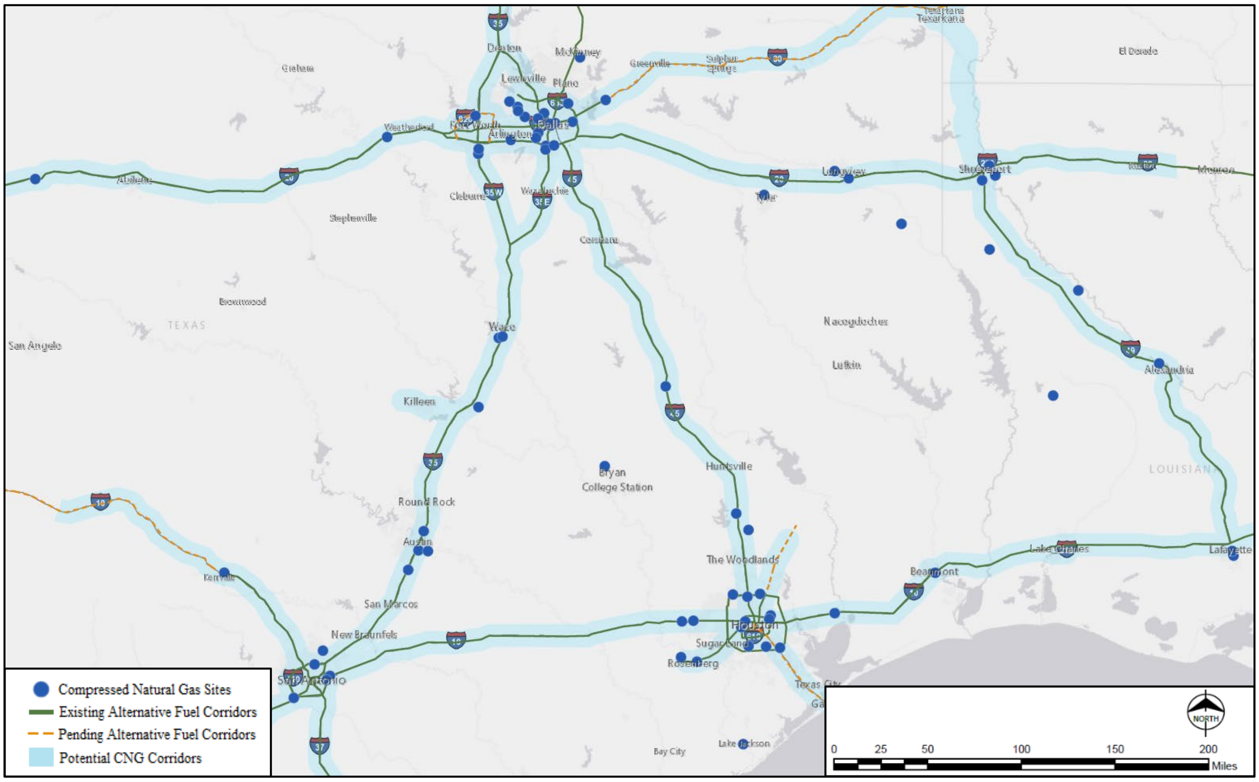
4.4 Fleet Fueling Infrastructure

Based on discussions with stakeholders, the number of CNG fueling stations has increased about 60 percent since 2016, while NGV adoption has been slower by comparison. The following provides a description of the fleet fueling infrastructure for each of the high-volume NGV types considered:

Solid waste collection. Solid waste collection NGVs utilize public or private time-fill or fast-fill stations to refuel vehicles on a nightly basis or at a regular interval, depending on collection operations. Solid waste collection vehicles typically run a daily route repeated each week, returning to a yard where the vehicles are securely stored, maintained, and fueled.

Tractor-trailers. For long-haul trucking, NGV fueling infrastructure is less available compared to conventional fuels (e.g., diesel). TXNGVA indicated that there is a well-established area on high-traffic transportation routes between Dallas, San Antonio, Houston, Laredo, and Corpus Christi known as the Texas Clean Transportation Zone. Figure 4-2 presents the most well-established segment of the Texas Clean Transportation Zone and the available CNG fueling infrastructure along high-traffic transportation routes based on Federal Highway Administration (FHWA) and AFDC data.

Figure 4-2: Major Segment of the Texas Clean Transportation Zone[1,2]



1. Source: https://hub.arcgis.com/maps/a86a599982d8486587863262a460ccf9/explore?location=24.012872%2C-107.447900%2C3.87
2. Potential CNG Corridors represent interstate highways with enough stations to 1) nominate a corridor or 2) create or extend a corridor by adding a station

The Texas Clean Transportation Zone and the Alternative Fueling Facilities Program, a grant program administered by TCEQ through the Texas Emissions Reduction Plan, presents a successful model for promoting NGV adoption and enables large fleets to operate natural gas-powered tractor-trailer and light-duty delivery fleets along these corridors. Because these operations can have more predictable routes, fleet operators have confidence the vehicles will have access to fueling stations that support operational needs. The Alternative Fueling Facilities Program and other funding opportunities are further discussed in Section 7.3.7.

Transit buses. Similar to solid waste collection vehicles, transit bus fleets can use public or private time-fill or fast-fill stations to refuel vehicles at the completion of daily routes (or at a regular interval, depending on operational needs). Transit buses typically run a standard route that is predictable and repeated each day, including a nightly return to a yard where the vehicles are securely stored, maintained, and fueled.

Light-duty delivery vehicles. Light-duty delivery vehicles have varying operating and ownership models. For example, United Parcel Service (UPS) package delivery trucks are owned by UPS and have standard, largely repeatable daily routes. In contrast, Amazon and FedEx Ground use an independent contractor model in which owner-operators control individual delivery routes and territories. Light-duty delivery vehicles also benefit from public natural gas fueling stations, including stations built using grant funding from the Alternative Fueling Facilities Program.

4.5 Vehicle Type Priority Evaluation and Recommendation

The following presents an evaluation to identify the vehicle types that should be prioritized for further transition to NGVs based on the current and potential future demand, infrastructure requirements and financial considerations. Each of the high-volume NGV types are compared against a series of evaluation criteria developed by the Project Team to support the discussion of barriers and opportunities related to increasing the adoption of NGVs.

- **Percentage of NGVs.** Indicates the percentage of NGVs that have been adopted in the North Central Texas region. The data shows that solid waste collection vehicles have the highest adoption percentage to date of the three high-volume NGV types, followed by transit buses and tractor-trailers. Solid waste collection vehicles have significantly fewer total vehicles in their category. In contrast, tractor-trailers have the lowest percentage of NGVs, but there are approximately 60,000 more tractor-trailers in the region than there are transit buses and approximately 78,000 more tractor-trailers in the region than there are solid waste collection vehicles. Adoption rates are relatively high in the solid waste collection industry, signaling a willingness by fleets to invest in NGVs, but the other high-volume NGV categories also have significant adoption opportunities due to larger numbers of total vehicles in the respective categories.

- **Fueling infrastructure availability.** Indicates the availability of existing NGV fueling infrastructure and viability of developing future infrastructure. Transit buses and solid waste collection vehicles need fueling infrastructure to be available on-site at the vehicle yard, where the fleet vehicles are securely parked and serviced. For example, DART invested $40 million in 2011 to build four natural gas fueling facilities for its fleet of natural gas transit buses. Tractor-trailers and light-duty delivery vehicles can have on-site fueling infrastructure or leverage public fueling stations depending on their ownership and operational models.

- **NGV fuel demand.** Indicates the NGV fuel demand for each vehicle type in GGE based on DFWCC data. According to the analysis of the DFWCC data, transit buses require the most fuel per vehicle to operate, followed closely by tractor-trailers. These fuel demand needs are based on fuel efficiency and annual vehicle miles traveled. On average, solid waste collection vehicles travel fewer miles per year than transit buses and tractor-trailers. Tractor-trailers are also generally more fuel efficient than transit buses and solid waste collection vehicles.

- **Ownership and capital investment.** Describes vehicle lifecycle considerations for the high-volume NGV types to indicate when capital investment is required to maintain the fleet. There is less incentive to prescribe a fuel type or fueling station location for tractor-trailers and light-duty delivery vehicle fleets because of the varying ownership and operating models. It may make more sense for transit buses and solid waste collection fleets to have a standardized fuel type and dedicated fueling location. Automated side load solid waste collection vehicles typically have between five- and seven-year replacement cycles (other solid waste collection vehicles, such as roll-off, rear loaders and front-end loaders, may have longer replacement cycles). Tractor-trailers are generally replaced after 750,000 to 1,000,000 miles or between four and ten years depending on resale value, financial position of the fleet, maintenance standards and contractual obligations to shippers. Transit buses are generally expected to last up to 12 years or 250,000 miles.

- **Potential NGV demand.** Describes the estimated potential demand for natural gas fuel, represented as GGE. By far, the largest potential NGV demand opportunity is in the tractor-trailer sector due to the total number of tractor-trailers operating in the region compared to the other high-volume NGV types. Tractor-trailers also have the lowest current adoption rate for NGV among the high-volume NGV types analyzed, suggesting that this sector would be the most challenging to transition from diesel to natural gas, but even limited adoption in the Texas Clean Transportation Zone would support NGV fuel demand in the North Central Texas region. Transitioning solid waste collection and transit bus fleets to NGV represents a significant opportunity to increase NGV fuel demand in the region.

- **Policy and funding considerations.** TXNGVA cited Texas House Bill 963 (2021) as a major recent policy achievement to increase demand for NGVs, specifically in the trucking sector. Effective September 1, 2021, the law better enables large trucking fleets to sell used NGVs to smaller trucking fleets, allowing the smaller, less-capitalized fleets to invest in NGVs. TXNGVA also cited the Texas Emissions Reduction Plan, which administers the Alternative Fueling Facilities Program, as a successful policy approach to incentivizing transition to NGVs. At the federal level, the Bipartisan Infrastructure Law (also known as the Infrastructure Investment and Jobs Act of 2021), provides significant new funding for natural gas and other alternative fuel infrastructure along Alternative Fuel Corridors. Both policy actions are described in further detail in Section 7.3.7.

The Project Team recommends employing a portfolio approach to prioritizing the high-volume NGV types. Due to the many factors that go into decisions on when to invest in new vehicles and which fuel type best fits the organization's operations and goals, a portfolio approach to prioritizing the increased adoption of solid waste collection vehicles, tractor-trailers, transit buses and light-duty delivery vehicles would support the development of organic waste to fuel projects in the region. Table 4-9 compares the opportunities and barriers for each of the high-volume NGV types to increase adoption based on the quantitative and qualitative data collection and analysis conducted by the Project Team.

Table 4-9: Barriers and Opportunities by NGV Type

NGV Type	Opportunity	Barrier
Solid Waste Collection	Large fleets with company-owned vehicles can make significant capital investments in vehicles and fueling infrastructure, allowing for fleet-wide investment to transition to NGVs. Solid waste collection NGVs are the highest adopted among high-volume NGVs, demonstrating commercial viability in this sector. Additionally, the growing trend of sensitivity to environmental considerations among solid waste collection vehicles makes transition an attractive option for fleet owners/operators.	The number of solid waste collection vehicles in the region is smaller than the other high-volume NGV types and has limited available vehicles for adoption. New Battery Electric Vehicles (BEVs) are being piloted for solid waste collection vehicles, which presents an environmentally beneficial alternative fuel other than renewable natural gas; however, based on a recent report by SWANA, there are challenges with scaling BEV adoption for solid waste collection vehicles due to significant capital investment related to vehicle purchase, maintenance, and on-site fueling infrastructure.[20]
Tractor-Trailers	Large fleets with company-owned vehicles can make significant capital investments in vehicles and fueling infrastructure, allowing for fleet-wide investment to transition to NGVs. There is significant opportunity for transition among the North Central Texas region's 80,000 tractor-trailers and available fueling infrastructure within the Texas Clean Transportation Zone. This reduces fueling range anxiety for fleet owners/operators considering transitioning to NGV fleets. Tractor-trailers have the highest per vehicle demand for natural gas fuel and fueling can be accomplished on-site at a private fueling facility or at a public fueling station. Incentives and policy actions have proven to be effective to support the transition to NGVs in this sector. If fueling infrastructure is deployed on a widespread basis in the future, tractor-trailers are also the well positioned as early adopters of hydrogen fuel given the need for long-range trips.	Tractor-trailers have shorter vehicle replacement cycles compared to the other high-volume NGVs and are able to utilize public fueling stations, allowing fleets to be flexible with fuel types. With significant subsidization of all alternative fuel types, tractor-trailer fleets are able to pilot many options and several of the largest regional transit fleets have already transitioned to alternative fuels. For example, BEVs are perceived by some as a better solution for short and medium-haul routes. Cost, especially without incentives, is a barrier for NGV adoption, particularly for fleets using an independent contractor model with less centralized control over vehicle ownership.

[20] Solid Waste Association of North America. "Evaluation of Electricity and Other Alternative Fuels for Solid Waste and Recycling Collection Vehicles." September 12, 2022.

NGV Type	Opportunity	Barrier
Buses	Large fleets with company-owned vehicles can make significant capital investments in vehicles and fueling infrastructure, allowing for fleet-wide investment to transition to NGVs. Buses have the highest fuel demand among the high-volume NGVs and present a key opportunity to increase adoption in the region. Transit buses are estimated to range between 40 and 62 percent adoption, indicating commercial success in adoption of NGVs.	Transitioning a bus fleet to natural gas requires a significant capital investment for on-site fueling infrastructure and there is competition from other alternative fuel types. With relatively long replacement cycles, making major investments in bus fleets is a challenging decision for fleet owners/operators. Additionally, even though transit buses have a higher adoption rate compared to all bus types, they are beginning to conduct more pilot projects for electric buses due to the availability of grant funds and other incentive programs.
Light-Duty Delivery Vehicles	Large multinational companies are investing in pilot projects to further test and demonstrate viability of NGVs in their fleets (e.g., Amazon, UPS), and with the relatively low number of existing NGVs in this sector, there is an opportunity to increase adoption. Large multinational fleets have growing sensitivity to environmental considerations, and smaller vehicle size means lower total capital cost on a per vehicle basis. With the need to streamline national supply chains to shorten delivery times, there is a significant opportunity to increase adoption of light-duty delivery vehicles to NGV. Additionally, incentives and policy actions have proven to be effective to support the adoption in light-duty delivery vehicle fleets.	Significant subsidization of all alternative fuel types enables fleets to pilot many options and shorter vehicle replacement cycles and use of public fueling stations allows fleets to be flexible with fuel types. Battery electric delivery vehicles are perceived by some as a better solution for last mile, short- and medium-haul routes.

5.0 NGV FUEL SUPPLY-DEMAND ANALYSIS

This section compares the NGV fuel demand to the potential supply of organic waste-derived RNG from materials generated in the North Central Texas region. The Project Team estimated potential RNG supply based on high priority feedstocks, specifically food waste from residential and commercial sources, commercial FOG, and existing landfill biogas resources (as determined in Section 2.0 and 3.0) to support the two NGV fuel demand scenarios (as presented in Section 4.3). Additionally, the Project Team examined RNG potential from CAFO manure (which is exclusively located in Erath County) to understand the opportunity for targeted manure management for RNG production.

5.1 NGV Fuel Demand Overview

As described in Section 4.3, current fuel demand from priority vehicle types for NGV conversion (i.e., solid waste collection vehicles, tractor-trailers, and buses) is approximately 17.5 million GGE annually. The majority of NGV fuel demand is in Dallas and Tarrant counties (as shown in Figure 4-1), which have the majority of the 1,920 NGVs registered in the North Central Texas region.

The Project Team developed two potential future scenarios for annual NGV fuel demand for these vehicle types (presented in Section 4.3 and shown in Table 4-8). If adoption of NGVs increases, the Project Team estimates the potential fuel demand could reach 26 million GGE based on Scenario 1 and 49 million GGE based on Scenario 2.

Table 5-1: Potential Future NGV Fuel Demand Scenarios (Annual)

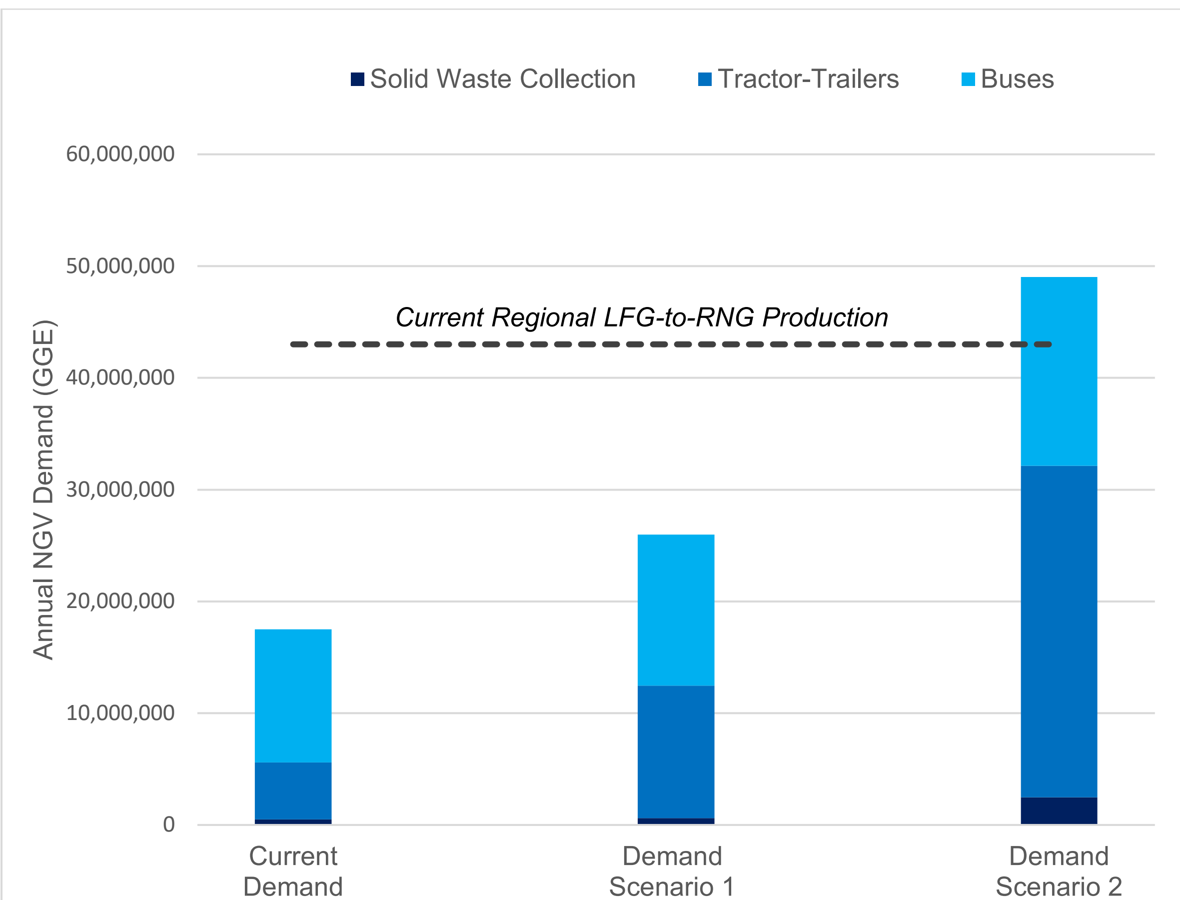
Description	Solid Waste Collection	Tractor-Trailers	Buses[1]	Total
Current				
NGV Adoption (%)[2]	10.8%	0.9%	7.1%	-
Number of NGVs[3]	186	683	1,051	**1,920**
NGV Fuel Demand (GGE)	497,000	5,089,000	11,916,000	**17,502,000**
Scenario 1				
NGV Adoption (%)	13.0%	2.0%	8.0%	-
Number of NGVs	224	1,592	1,192	**3,008**
NGV Fuel Demand (GGE)	600,000	11,864,000	13,502,000	**25,966,000**
Additional Demand from Current (GGE)	+103,000	+6,775,000	+1,586,000	**+8,464,000**

Description	Solid Waste Collection	Tractor-Trailers	Buses[1]	Total
Scenario 2				
NGV Adoption (%)	50.0%	5.0%	10.0%	-
Number of NGVs	863	3,981	1,489	**6,333**
NGV Fuel Demand (GGE)	2,480,000	29,660,000	16,878,000	**49,018,000**
Additional Demand from Current (GGE)	+1,983,000	+24,571,000	+4,962,000	**+31,516,000**

1. Buses category represents all bus types, including municipal transit buses and charter buses.
2. Current percentage of NGV is based on the high estimate presented in Table 4-5.
3. Range of current registered NGVs in the North Central Texas region is presented in Table 4-4.

Figure 5-1 shows current and potential NGV demand under Scenario 1 and Scenario 2. As described in Section 2.4, there are existing landfill biogas-to-RNG resources in the North Central Texas region. Current LFG-to-RNG production (equivalent to approximately 43 million GGE NGV fuel), exceeds current NGV fuel demand and Scenario 1 demand projections, but does not meet Scenario 2 projections.

Figure 5-1: NGV Fuel Demand Scenarios and Current RNG Production



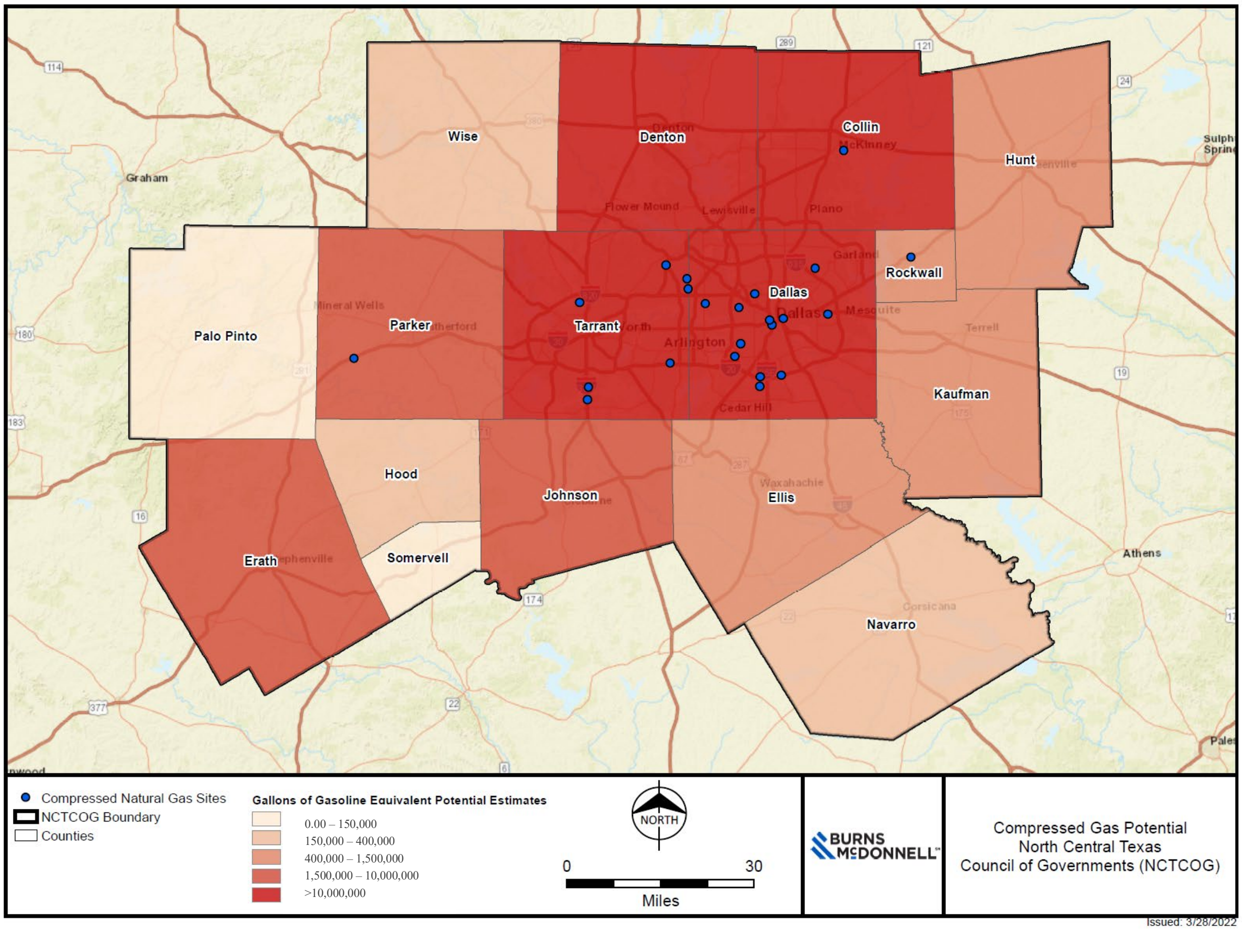
While some of the RNG produced at landfills in the region is used locally as NGV fuel, rising NGV fuel demand does not mean supply will rise to meet it due to existing offtake agreements for other uses and in other states that have incentives to transport RNG to capture the value of environmental credits (e.g., California, Oregon). As a result, future increases in NGV demand would likely need to be met through increased RNG production and new local pilot projects (e.g., food waste collection and conversion to RNG).

5.2 Potential RNG Supply Overview

Based on the prioritization described in Section 2.0, this section explores potential RNG vehicle fuel supply from a variety of feedstocks with a focus on the high priority feedstocks of food waste (from residential and commercial sources), FOG, and existing landfill biogas resources. Figure 5-2 shows the potential RNG production from residential and commercial food waste, existing landfill biogas resources, and CAFO manures (in Erath County only). Biogas and potential RNG yields (in GGE equivalents) were estimated based on reported data from operating AD facilities, including stand-alone MSW digesters (for MSW yields) and on-farm digesters (for CAFO manure). Biogas yields for landfills were based on data reported to TCEQ and the U.S. EPA such as total landfill gas generation and site-specific average methane concentration.

As shown in Figure 5-2, the greatest RNG fuel generation potential exists in Collin, Dallas, Denton, and Tarrant counties, with over 10 million GGE each of potential supply from food waste and existing biogas resources. These areas align geographically with the areas of greatest current NGV fuel demand (see Figure 4-1) and existing CNG fueling locations (shown as blue dots on Figure 5-2) to facilitate the use of RNG derived from the identified feedstocks. These four counties (i.e., Collin, Dallas, Denton, and Tarrant) are further evaluated in this section to understand how targeted collection of MSW organics from residential and commercial sources may provide supply of RNG to meet potential NGV fuel demand. Additionally, CAFO manure (which is exclusively located in Erath County) presents opportunity for targeted manure management via AD-to-RNG, with an estimated 6.8 million GGE of RNG potential.

Figure 5-2: Potential RNG Fuel Supply in the North Central Texas Region



Together, these five counties (Collin, Dallas, Denton, Erath, and Tarrant) are defined as the "Targeted Organics Collection Area." These counties are the focus of the more detailed evaluation through this Study to understand the potential supply-demand balance for RNG vehicle fuel (Section 5.0), potential AD infrastructure locations (Section 6.0), and optimal pilot projects and associated funding opportunities (Section 7.0).

5.2.1 Food Waste Collection

The Project Team calculated the potential RNG fuel supply from food waste generated by commercial and residential sectors by converting tons of diverted food waste to GGEs based on biogas yield from AD facilities.[21] Table 5-2 presents the maximum potential RNG from high priority feedstocks from residential and commercial sectors in Collin, Dallas, Denton and Tarrant counties within the Targeted Organics Collection Area. If all food waste organics were collected from residential and commercial sources, food waste could theoretically provide nearly 17.8 million GGE of RNG for vehicle fuel. Additionally, commercial FOG generated in these counties could theoretically provide as much as 27 million GGE of RNG; however, unlike food waste, much of this FOG is likely already diverted though the six liquid processing facilities and at WWTP digesters in the North Central Texas region.

Table 5-2: Maximum Potential RNG Production from Food Waste Sources (Annual)

County	Commercial Food Waste[1]		Residential Food Waste		Total	
	Tons	GGE Potential	Tons	GGE Potential	Tons	GGE Potential
Collin	90,000	1,115,000	118,000	1,450,000	208,000	2,570,000
Dallas	322,000	3,980,000	294,000	3,625,000	616,000	7,610,000
Denton	80,000	990,000	102,000	1,260,000	182,000	2,250,000
Tarrant	198,000	2,440,000	234,000	2,885,000	432,000	5,325,000
Total	**690,000**	**8,525,000**	**748,000**	**9,220,000**	**1,438,000**	**17,755,000**

1. FOG can be co-collected with commercial food waste via vacuum truck (see Section 3.0 for more detail). An estimated 96,000 tons of FOG is generated by the restaurant and food services sector in these counties, which is equivalent to approximately 27 million GGE of methane content. Much of this FOG is already diverted to beneficial use through liquid processing facilities and WWTP digesters in the North Central Texas region; however, FOG that is not diverted from the sewer system may congeal in the piping, causing sewerage operational challenges.

[21] Biogas yield for commercial and residential food waste based on values reported by AD facilities across the U.S. designed and operated to primarily manage the organic wastes from MSW sources. This data is presented in the EREF report *Anaerobic Digestion of MSW: Report on the State of Practice*. Biogas yield for landfills based on data reported to TCEQ and the U.S. EPA.

However, as described in Section 3.0, the economic and operational feasibility of commercial and residential food waste and FOG collection varies based on factors such as the collection approach (e.g., FEL or slurry for commercial food waste) and housing or route density. To account for these considerations in the supply-demand evaluation, the food waste recovery scenarios evaluated in Section 5.3 explore the relative RNG fuel potential if 20 and 60 percent of available materials could be successfully collected and converted to NGV fuel (as shown in the scenarios in Table 5-4).

5.2.2 Existing Landfill Biogas Resources

Existing waste-derived biogas resources including landfills are included as potential organics-to-fuel feedstock. There are active LFGTE projects at 11 sites in the North Central Texas region, primarily located in Collin, Dallas, Denton, and Tarrant counties. Of the active projects, six are currently LFG-to-RNG and report producing approximately 5 billion cubic feet of RNG annually (see Table 2-6). This is equivalent to 43 million GGE of NGV fuel. The remaining five LFGTE projects currently produce electricity but may be suitable to upgrade to produce RNG.

Conversion of these projects could produce an additional 14 million GGE of potential supply, and at least one such conversion is known to be ongoing in the North Central Texas region. An additional 5,300 scfm of landfill gas is collected and flared at sites in the North Central Texas region without LFGTE projects (equivalent to 46.2 million GGE of potential supply). Of these, there is one site known to be exploring options to develop a LFGTE project, though many of these sites are significantly smaller (i.e., less than 800 scfm of landfill gas collected) and may have feasibility challenges for RNG projects. Table 5-3 presents the estimated potential RNG production from LFG currently collected in the North Central Texas region.

Table 5-3: Estimated Potential RNG Production from Collected Landfill Gas (Annual)

LFG Management System	Landfill Gas Generation (scfm)	Estimated Potential RNG Supply (GGE)
Renewable Natural Gas (RNG)	27,785	43,000,000 (existing)
Power Generation	10,932	14,000,000 (potential)
Collection Only	5,300	8,000,000 (potential)
Total	**44,017**	**65,000,000**

5.3 Regional Supply and Demand Balance and Recommendations

This section explores the relative balance between supply and demand of RNG for NGV fuel based on the results presented in Sections 5.1 and 5.2. This evaluation is intended to provide a practical assessment of the opportunity to increase RNG usage as vehicle fuel in the North Central Texas region, and an understanding of the upper limits of RNG production using the high priority feedstocks generated in the Targeted Organics Collection Area.

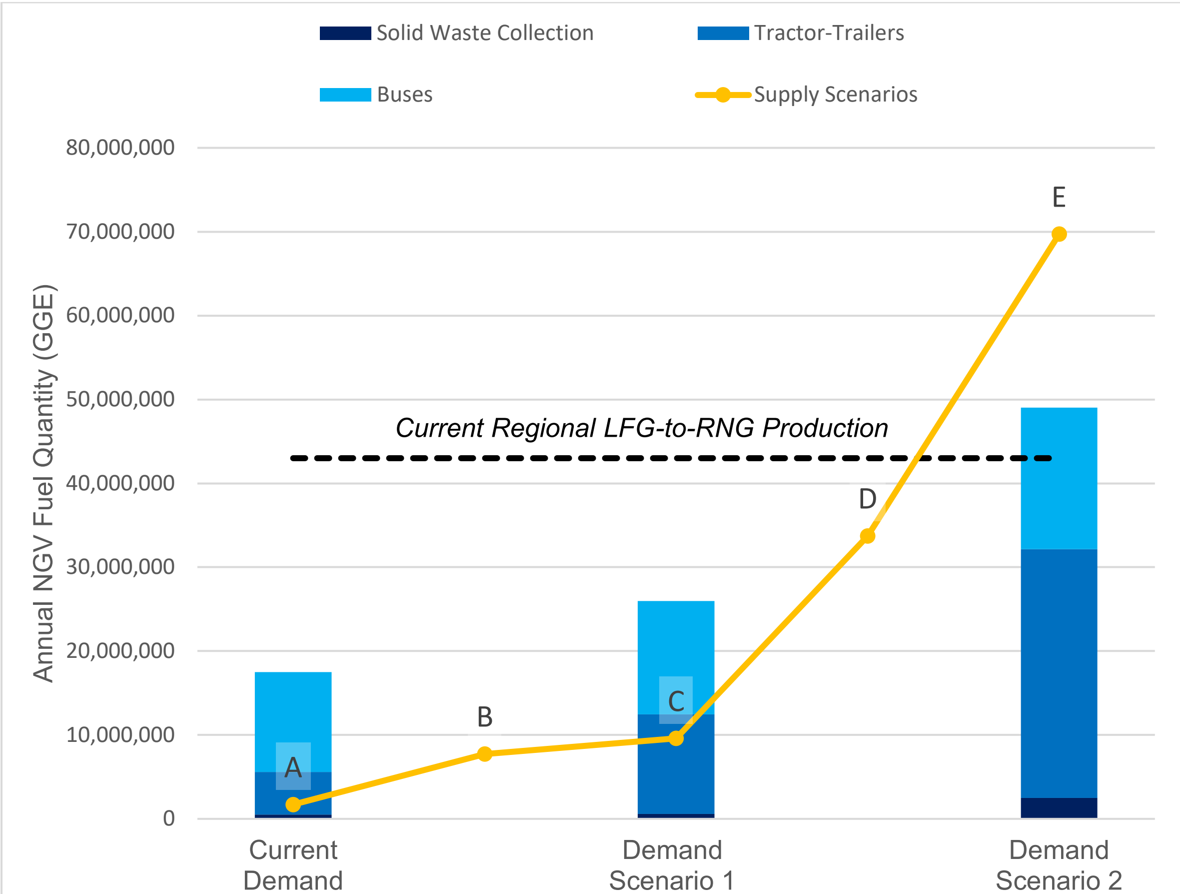
To evaluate how potential supply compares to the demand scenarios presented in Section 5.1, the Project Team developed five potential future RNG supply scenarios based on the highest priority feedstocks (i.e., commercial food waste, residential food waste, and existing biogas resources). Table 5-4 presents these potential supply scenarios, which utilize a range of recovery rates from the commercial and residential sectors (20-100 percent) and conservative to aggressive levels of LFG-to-RNG adoption. The resulting potential RNG supply ranges from 1.5 million GGE for the scenario in which 20 percent of commercial food waste is converted to RNG to over 68 million GGE if all high priority feedstocks are converted to RNG.

Table 5-4: Potential Future RNG Supply Scenarios (Annual)

	Potential Supply Scenario				
Feedstock Type	**A**	**B**	**C**	**D**	**E**
Commercial Food (recovery rate)	20%	20%	20%	60%	100%
Commercial FOG (recovery rate)	-	20%	20%	60%	100%
Residential Food (recovery rate)	-	-	20%	60%	100%
Existing Biogas Resources	-	-	-	*Planned Projects*	*All Sites*
Potential Annual Supply (GGE)	**1,510,000**	**7,570,000**	**9,290,000**	**32,870,000**	**68,250,000**

Figure 5-3 presents a comparison of the potential future demand and supply scenarios.

Figure 5-3: Potential Future Supply and Demand Scenarios (Annual)



No single feedstock provides sufficient supply to meet all potential total demand scenarios described in Section 4.0. Targeted recovery of high priority feedstocks from commercial and residential generators can support increases in NGV adoption and fueling from regional sources; however, Scenario 2 NGV demand targets can only be met through aggressive adoption of both LFG-to-RNG and commercial and residential organics diversion to AD projects.

Table 5-5 presents the NGV adoption rates that could be supported by each supply scenario. For example, if 20 percent of targeted commercial food waste could be converted to RNG (Supply Scenario A), then the resulting RNG supply could meet the fuel demands of 622 additional solid waste collection vehicles, equivalent to converting an additional 36 percent of the current solid waste collection vehicle fleet in the region to NGVs. This scenario is also equivalent to converting 229 tractor-trailers (0.3 percent of current fleet) or 150 buses (1 percent of current fleet).

The most significant increases in NGV adoption are in the solid waste collection fleet, due to the comparatively lower annual fuel demand and fleet size (relative to tractor-trailers and buses). Additionally, existing solid waste collection activities are in close proximity to landfill biogas resources, suggesting this may be an optimal industry to initially target for further increases in NGV adoption.

Table 5-5: Potential Additional NGV Adoption Supported by Each Supply Scenario

Potential Supply Scenario	Potential Annual Supply (GGE)	Equivalent Additional NGV Demand Number of NGVs (Percent of Fleet Total)		
		Solid Waste Collection	Tractor-Trailers	Buses
A	1,710,000	622 (36%)	229 (0.3%)	150 (1%)
B	7,740,000	2,822 (164%)	1,038 (1%)	683 (5%)
C	9,580,000	3,496 (203%)	1,286 (2%)	846 (6%)
D	33,740,000	12,307 (713%)	4,528 (6%)	2,977 (20%)
E	69,710,000	25,427 (1,473%)	9,355 (12%)	6,151 (41%)

6.0 PILOT PROJECT LOCATION SCREENING

This section presents the pilot project screening process and results including use of the POWER Framework and additional screening criteria to identify optimal digester locations. The results of the evaluation serve as the basis for further evaluation of the technical, financial, and operational components of potential organics-to-fuel pilot projects provided in Section 7.0.

6.1 Methodology

The Project Team utilized the POWER Framework to identify potential pilot project locations based on estimated feedstock generation and existing solid waste infrastructure in the region. Refer to Section 1.1.4 for an overview of the components of the POWER Framework. The following provides brief descriptions of the components of the POWER Framework utilized and the additional screening conducted to determine potential pilot project locations.

- **Inventory of regional sites.** The Project Team developed a comprehensive list of sites containing solid waste management and/or AD infrastructure in the North Central Texas region, omitting locations outside the Targeted Organics Collection Area (as defined in Section 5.2) or located at non-pertinent facility types (e.g., material recovery facilities, medical waste treatment facilities, etc.). The inventory of regional sites included 96 total locations that provided the basis for computational analysis carried out by the optimization component of the POWER Framework. The Project Team included one greenfield location as a potential pilot project site in each County of the Targeted Organics Collection Area, for a total of five (Denton, Dallas, Tarrant, Collin and Erath Counties). The detailed inventory of regional sites is provided in Appendix C.

- **Optimal facility location evaluation.** The Project Team utilized the Optimization Tool component of the POWER Framework to determine a "long-list" of optimal locations for further screening. The Optimization Tool was configured to comparatively evaluate the level of effort to transport prioritized feedstocks generated in the Targeted Organics Collection Area to the 96 facilities in the inventory of regional sites. The Project Team ran the Optimization Tool multiple times to cross-compare results based on 20 percent capture rate of feedstock and 60 percent capture rate of feedstock. Based on this analysis, 48 potential pilot locations were identified for further screening. Detailed description of the computational approach and full listing of the results of the Optimization Tool are provided in Appendix C.

- **Short list screening.** The Project Team further screened the resulting 48 potential pilot project locations utilizing quantitative GIS analysis to determine the "short-list." For each of the 48 potential pilot locations key project development criteria were evaluated including proximity to:
    - **High and medium priority organic waste feedstocks.** Annual residential and commercial food waste, FOG, and sludge generated within five miles.
    - **Major roadways.** Number of major highways within 1-mile of the potential project site.
    - **Natural gas pipelines.** Straight-line distance to nearest natural gas pipeline.
    - **NGV fuel demand.** Straight-line distance to nearest fueling demand (e.g., fleet yard, existing fueling facility).
    - **Sludge generators.** Distance to nearest sludge and/or biosolids generator (e.g., WWTP). The listing of sludge and/or biosolids generators compiled by the project team is provided in Appendix D.
    - **Co-Located facility.** Indicates if the location is co-located with another materials management facility.

6.2 Inventory of Regional Sites

The 96 sites mentioned above were derived from the total regional inventory of facilities across North Central Texas included 139 facilities. A subset of the total regional inventory determined by the Project Team served as the baseline for the Optimization Tool. Table 6-1 presents the 96 locations in the Targeted Organics Collection Area that were evaluated for optimal facility locations.

Table 6-1: Inventory of Regional Sites for Further Screening

Facility Type[1]	Total Sites
Landfill	15
LFG Power Generation	5
LFG-to-RNG	3
Transfer Station	16
Mulching & Composting	18
Liquid Waste Treatment Facilities	6
WWTP (without AD)	21
WWTP (with AD)	7
Greenfield[2]	5
Total	**96**

1. Material Recovery Facilities, C&D recycling facilities, medical waste processing facilities, and household hazardous waste facilities were deemed non-pertinent and not included in the optimal facility location evaluation.
2. The Project Team determined one potential greenfield location in each county of the Targeted Organics Collection Area.

The Project Team identified potential greenfield site locations based on proximity to areas with larger quantities of waste generation and strategic considerations related to each county's projected population growth. The potential greenfield sites do not reflect specific parcels of land, but rather a general location for consideration as part of the optimal facility location evaluation. The following provides brief descriptions of the locations of the potential greenfield sites included in the evaluation:

- **Dallas County.** This site is generally located in the City of Dallas' downtown commercial district among various commercial establishments that generate high quantities of food waste and/or FOG (e.g., restaurants, food service establishments, etc.). The Project Team determined this site would be most equitable given that solid waste management infrastructure is located in the southern areas of the city (e.g., McCommas Bluff Landfill, Southside WWTP, etc.) and would minimize the level of effort for collection and processing of feedstock from this area of the city.

- **Tarrant County.** This site is generally located in the northern area of the City of Fort Worth in an area that is expected to experience high growth of residential food waste generators. This location could become a future area of need for utility service as the population continues to grow.

- **Denton County.** This site is generally located in the southern area of the City of Denton in an area that is expected to experience high growth of residential food waste generators. This location could become a future area of need for utility service as the population continues to grow.

- **Collin County.** This site is generally located in the western area of Collin County in an area removed from the existing solid waste disposal and wastewater treatment infrastructure owned and operated by North Texas Municipal Water District (NTMWD).

- **Erath County.** This site is generally located at the previously closed Huckabay Ridge facility which is centrally located in Erath County and would minimize the level of effort for collection and digestion of CAFO manure.

6.3 Optimal Facility Location Evaluation

The Project Team ran the Optimization Tool multiple times to cross-compare results based on a 20 percent capture rate of feedstock and a 60 percent capture rate of feedstock. For the purposes of the screening, the Project Team collection networks would be able to collect and transport 20 percent of material generated, and only in the best case scenario would they be able to achieve 60 percent. Table 6-2 describes the various iterations of the Optimization Tool and how the Project Team utilized the results of each to develop the "long-list."

Table 6-2: Iterations of the Optimization Tool

Feedstocks	Capture Rate	
	20%	60%
Residential Food Waste Commercial Food Waste Commercial FOG	Served as the primary locations for consideration. Reflective of practical capture rate of feedstock compared to the total generated.	Provided a sensitivity analysis to consider additional locations in addition to the results of the 20% capture rate results.
Commercial Food Waste Commercial FOG	Provided a sensitivity analysis to confirm no additional facilities were identified for consideration based on this subset of feedstock.	Provided a sensitivity analysis to confirm no additional facilities were identified for consideration based on this subset of feedstock.

Based on the various iterations of the Optimization Tool, 48 potential pilot locations were identified for further screening. Table 6-3 compares the number of locations from the regional inventory against the locations selected for further screening by facility type.

Table 6-3: Optimization Tool Results by Facility Type

Facility	Regional Inventory	Screened Locations
Landfill/Multiple Facilities[1]	23	6
Transfer Station	16	11
Mulching & Composting	18	6
Liquid Waste Treatment Facilities	6	5
WWTP (without AD)	21	12
WWTP (with AD)	7	4
Greenfield	5	4
Total	**96**	**48**

1. Includes Landfills with multiple facility types excluded from other facility categories (e.g., Denton Landfill Complex contains the Pecan Creek WWTP, which is reflected in the Landfill/Multiple Facilities category rather than in the WWTP (with AD) category).

6.4 Screening Results by Facility Type

This section presents the results of the screening by facility type. Figure 6-1 and Figure 6-2 show the locations in the Target Organics Collection Area further screened in the following sections.

Figure 6-1: Dallas, Denton, Tarrant and Collin County Screened Locations by Facility Type

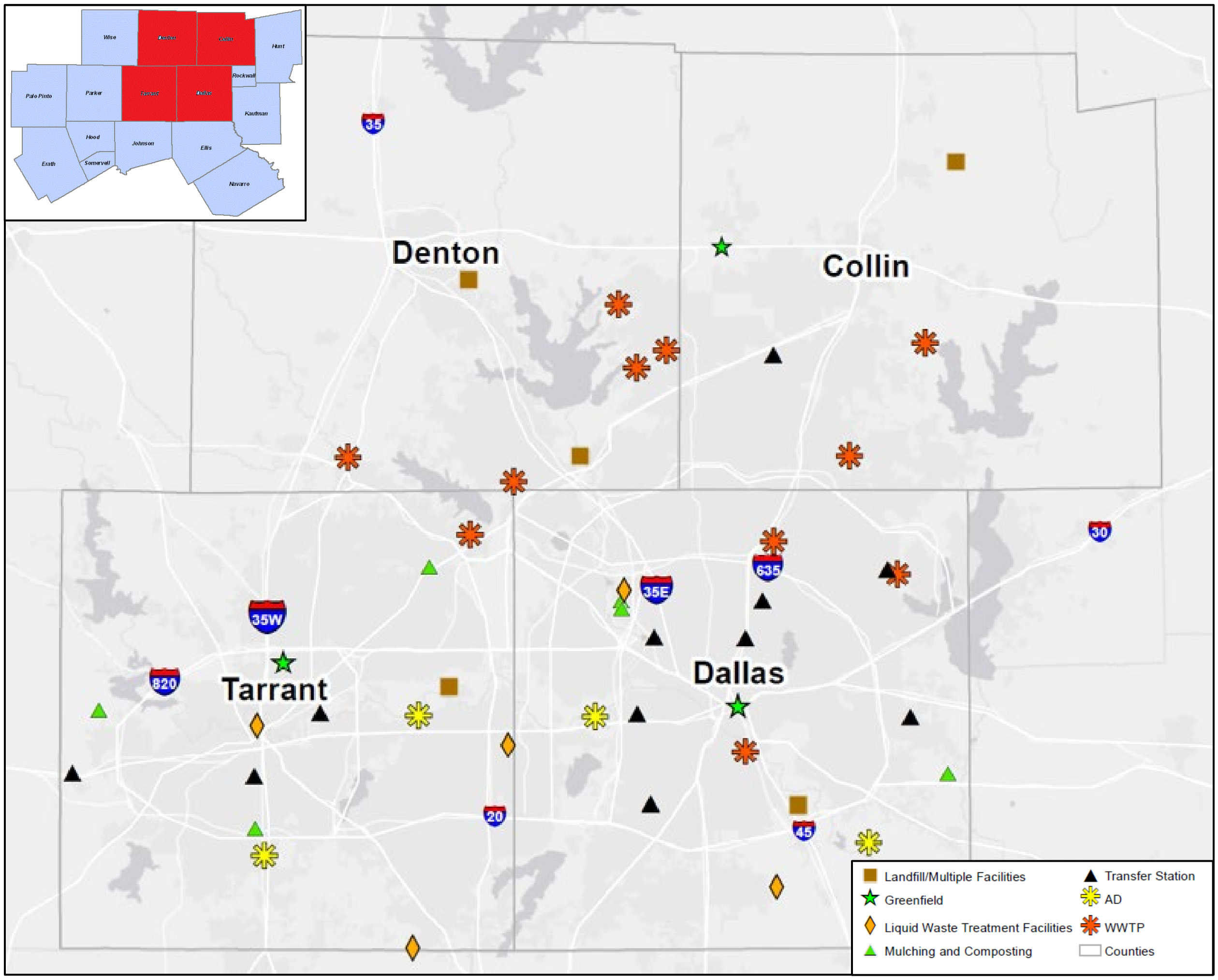
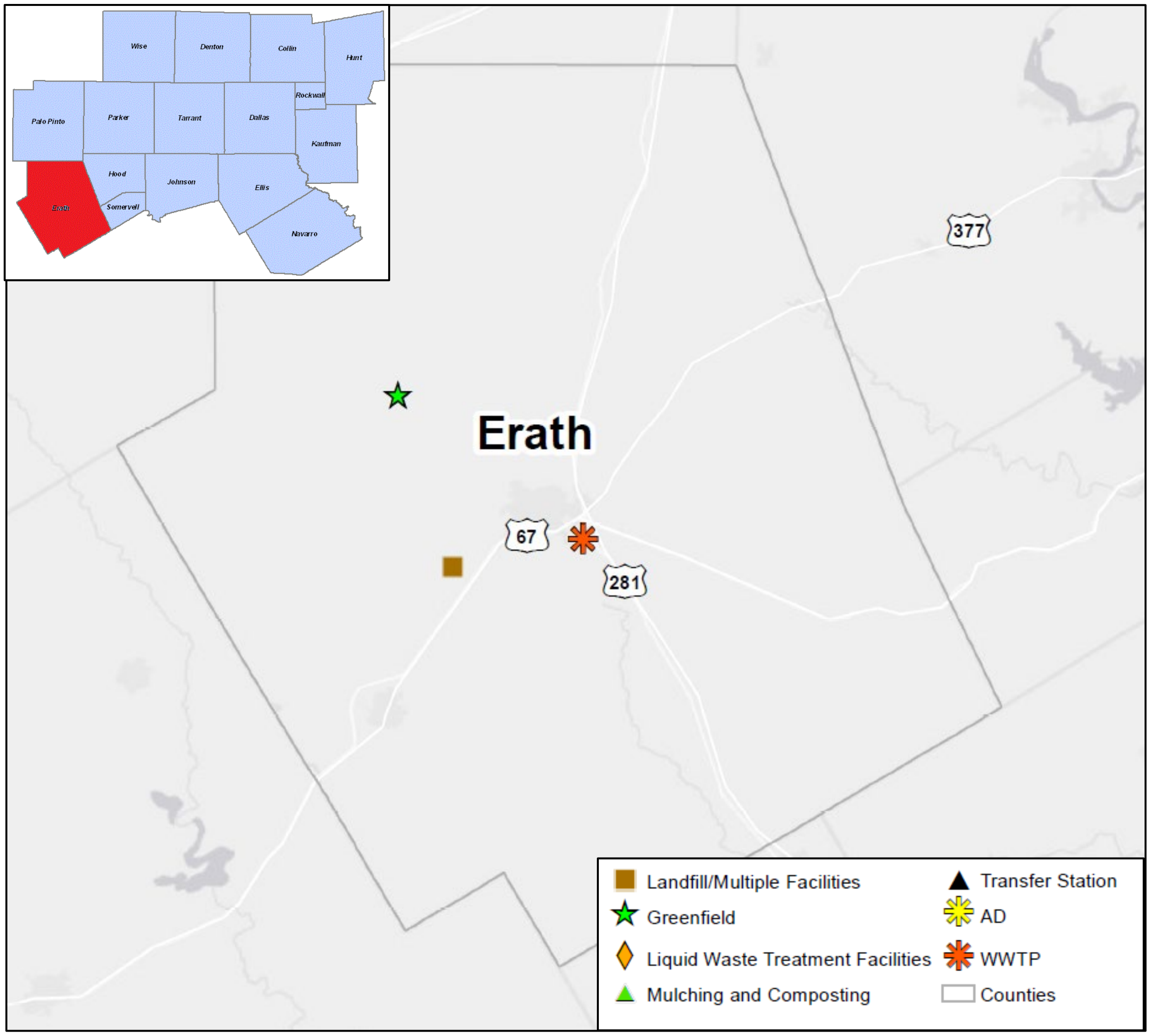


Figure 6-2: Erath County Screened Facilities by Facility Type



6.4.1 Landfill Screening Results

High priority organic waste feedstocks (e.g., residential and commercial food waste) and medium priority feedstocks (e.g., sludge) are primarily disposed in landfills. Since prioritized feedstocks in the North Central Texas region are already being transported to these facilities and some facilities have existing biogas processing operations, they represent locations that could be upgraded to include AD.

Table 6-4 presents the results of the screening among the landfills that were identified as optimal facility locations.

Table 6-4: Landfill Screening Results

Facility	County	Available Feedstock (Tons)	Highways Within 1 Mile	Natural Gas Pipeline (mi)	NGV Fueling (mi)	Sludge Generators (mi)	Co-located Facility (Y/N)
City of Denton Landfill Complex[1]	Denton	8,262	1	0.7	0.0	0.0	Y
DFW Recycling and Disposal Facility	Denton	17,939	2	1.3	5.3	2.3	N
City of Dallas McCommas Bluff Facility[2]	Dallas	11,130	3	1.3	0.7	4.2	Y
City of Arlington Landfill[3]	Tarrant	19,098	0	1.7	3.3	1.9	Y
City of Stephenville Landfill[3]	Erath	2,705,364	1	1.1	N/A	6.0	N
121 RDF Landfill[4]	Collin	929	1	2.5	6.1	3.0	Y

1. Includes Pecan Creek WWTP, City of Denton Composting Facility, and LFGTE project.
2. Includes LFG-to-RNG project.
3. Feedstock tons reflective of CAFO manure only.
4. Includes Plano Pure composting facility.

Based on this screening, the City of Denton Landfill complex has been selected to advance to the short-list because it is closest to infrastructure that supports co-digestion of food waste and FOG with sludge and has several co-located facilities that support the feasibility of a potential pilot project including the landfill, composting facility, and fueling station. The City of Denton is currently pursuing a pilot to support co-digestion at the Pecan Creek WWTP and is in the process of procuring front-end equipment (e.g., channel grinder) to process commercial food waste. The City of Denton is also evaluating upgrading of its existing LFGTE system to produce pipeline-quality RNG.

6.4.2 Transfer Station Screening Results

Transfer stations in the North Central Texas region are strategically located to minimize transportation costs related to solid waste management. These facilities can be designed or upgraded to manage food waste separately, and provide potential locations for the development of AD capacity in the region.

Table 6-5 presents the results of the screening among the transfer stations that were identified as optimal facility locations.

Table 6-5: Transfer Station Screening Results

Facility	County	Available Feedstock (Tons)	Highways Within 1 Mile	Natural Gas Pipeline (mi)	NGV Fueling (mi)	Sludge Generators (mi)	Co-located Facility (Y/N)
City of Dallas Bachman Transfer Station	Dallas	45,740	4	5.8	0.6	0.6	N
City of Garland Transfer Station[1]	Dallas	39,551	1	9.7	0.0	0.6	Y
North Texas Recycling Complex[2]	Tarrant	18,088	2	0.1	3.9	6.2	N
City of Mesquite Transfer Station	Dallas	10,273	1	4.1	0.1	4.5	N
City of Dallas Westmoreland Transfer Station	Dallas	16,284	1	1.8	1.5	6.6	N
City of Dallas Fair Oaks Transfer Station	Dallas	31,777	1	10.2	2.9	3.8	N
Champion Waste Services	Dallas	34,918	1	2.5	0.4	2.0	N
Custer Transfer Station	Collin	17,962	1	3.1	7.3	7.1	N
Southwest Paper Stock	Tarrant	22,234	2	2.7	2.1	10.5	N
City of University Park Transfer Station	Dallas	45,740	1	8.4	0.3	5.7	N
Westside Transfer Station	Tarrant	3,045	2	6.6	12.2	4.1	N

1. Includes City of Garland's Landfill.
2. North Texas Recycling Complex does not operate as a transfer station, only as a MRF operated by Republic and fleet and fueling yard for its collection operation.

Based on this screening, the City of Dallas Bachman Transfer Station and the City of Garland Transfer Station have been selected to advance to the short-list because each respective municipality owns and operates the supporting solid waste facilities (e.g., landfill, transfer station, WWTPs), which position them well for consideration as a potential pilot project. The City of Dallas is currently evaluating significant capital upgrades to its transfer station system, and potential future upgrades could support pre-processing, storage or AD systems.

6.4.3 Mulching and Composting Screening Results

Mulching and composting facilities in the North Central Texas region accept and process organic waste including, in some cases, prioritized feedstocks. Since SSO material is currently transported to this facility type, mulching and composting facilities provide potential locations for the development of AD capacity in the region; however, there are potential challenges managing high moisture content materials at composting facilities (e.g., odors, vectors). Composting facilities are generally more suitable to managing byproducts from AD that have been dewatered (e.g., high solids content biosolids). Table 6-6 presents the results of the screening among the mulching and composting facilities that were identified as optimal facility locations.

Table 6-6: Mulching and Composting Screening Results

Facility	County	Available Feedstock (Tons)	Highways Within 1 Mile	Natural Gas Pipeline (mi)	NGV Fueling (mi)	Sludge Generators (mi)	Co-located Facility (Y/N)
City of Mesquite Recycling/Waste[1]	Dallas	4,429	1	1.0	3.6	0.0	Y
Soil Building Systems	Dallas	28,255	3	2.8	1.0	3.7	N
Alpine Materials	Tarrant	11,360	1	4.6	3.1	3.3	N
Thelin Recycling	Tarrant	16,216	2	3.8	2.8	8.4	N
The Organic Recycler of Texas	Dallas	30,615	3	3.3	0.5	3.3	N
Silver Creek Materials	Tarrant	4,195	0	4.7	10.2	2.2	N

1. Co-located with the City of Mesquite WWTP.

Based on this screening, the City of Mesquite Recycling/Waste facility was selected to advance to the short-list because it is co-located with the local WWTP. Although this location is not surrounded by high-volume generation of prioritized feedstocks as compared to the other mulching and composting facilities in the North Central Texas region, it is strategically co-located with an existing WWTP, and as capital upgrades are required could install AD technology.

6.4.4 WWTP Screening Results

WWTP facilities in the North Central Texas region use AD or aerobic digestion to manage and treat wastewater solids. Pursuing capital upgrades to existing facilities to expand or install AD capacity rather than developing greenfield facilities positions them well for consideration as a potential pilot project.

Table 6-7 presents the results of the screening among the WWTP facilities that were identified as optimal facility locations.

Table 6-7: WWTP Screening Results[1]

Facility	County	Available Feedstock (Tons)	Highways Within 1 Mile	Natural Gas Pipeline (mi)	NGV Fueling (mi)	Sludge Generators (mi)	Co-located Facility (Y/N)
City of Dallas Southside WWTP[2]	Dallas	4,811	0	3.0	2.3	0.0	Y
Village Creek Water Reclamation Facility[3]	Tarrant	19,615	1	0.0	5.7	0.0	N
City of Garland Rowlett Creek WWTP	Dallas	14,870	1	8.9	0.6	0.0	Y
Central Regional WWTP[3]	Dallas	11,410	3	1.6	1.5	0.0	N
Peach Street WWTP[3]	Tarrant	6,881	1	1.5	2.0	0.0	N
Fort Worth Brewery[3]	Tarrant	10,166	1	4.8	1.0	7.9	N
Stewart Creek WWTP	Denton	15,637	0	0.0	9.1	0.0	N
City of Dallas Central WWTP	Dallas	32,851	3	0.7	1.2	8.7	N
Denton Creek Regional WWTP	Denton	3,746	2	2.0	3.9	0.0	N
Little Elm WWTP	Denton	10,976	0	2.3	10.2	1.1	N
Rowlett Creek WWTP	Collin	14,435	0	9.2	5.1	5.7	N
Town of Flower Mound WWTP	Denton	11,783	0	1.4	2.9	0.0	N
Floyd Branch Regional WWTP	Dallas	27,928	1	10.6	2.4	0.0	N
Wilson Creek Regional WWTP	Collin	4,458	0	1.3	3.8	0.0	N
Stewart Creek West Regional WWTP	Denton	18,559	0	1.3	8.7	0.0	N
City of Stephenville WWTP[4]	Erath	1,067,854	3	2.0	48.4	3.4	N

1. Pecan Creek WWTP was considered in the long list as part of the Denton Landfill Complex (see Table 6-4).
2. Facility has existing AD capacity and sludge/biosolids monofill on site.
3. Facility currently has AD capacity installed.
4. Feedstock represents CAFO manure only. NGV fueling location distance does not consider NGV demand outside of the targeted organics collection area.

Based on this screening the City of Dallas Southside WWTP, Village Creek Water Reclamation Facility, Central Regional WWTP, and Fort Worth Brewery have been selected to advance to the short-list because they contain existing AD capacity. Additionally, the City of Garland Rowlett Creek WWTP has been selected because it is co-located with the City's transfer station and the Peach Street WWTP has been selected because it is located close to Dallas-Fort Worth Airport, a source of high NGV fueling demand.

The City of Denton Pecan Creek WWTP was also selected to advance to the short-list, although it is not reflected in the table above and rather as part of the Denton Landfill Complex facility (as shown in Table 6-4).

6.4.5 Liquid Waste Processing Screening Results

Liquid processing facility locations process FOG material, including grease and grit from grease traps. Since these facilities currently accept this material type, they provide potential locations for the development of AD capacity. Table 6-8 presents the results of the screening among the liquid waste processing facilities that were identified as optimal facility locations.

Table 6-8: Liquid Waste Processing Screening Results

Facility	County	Available Feedstock (Tons)	Highways Within 1 Mile	Natural Gas Pipeline (mi)	NGV Fueling (mi)	Sludge Generators (mi)	Co-located Facility (Y/N)
Liquitek Arlington Liquid Waste Processing Facility	Tarrant	14,066	3	0.5	3.3	6.3	N
Clean Earth Environmental Solutions	Dallas	4,881	1	2.7	1.6	5.9	N
Dallas Grease Trap Grit Trap Treatment Facility	Dallas	26,164	3	2.2	1.6	4.3	N
Cold Springs Processing & Disposal	Tarrant	21,260	6	1.5	0.9	10.6	N
Southwaste Disposal Facility	Tarrant	3,137	1	0.8	10.7	4.4	N

Although liquid waste processing facilities aggregated FOG materials, none have been selected to advance to the short-list based on their relative proximity to key project feasibility criteria.

6.4.6 Greenfield Facility Site Screening Locations

Greenfield facility site locations present potential locations for future AD processing capacity. Table 6-9 presents the results of the screening among the greenfield sites that were identified as optimal facility locations.

Table 6-9: Greenfield Facility Sites

Facility	County	Available Feedstock (Tons)	Highways Within 1 Mile	Natural Gas Pipeline (mi)	NGV Fueling (mi)	Sludge Generators (mi)	Co-located Facility (Y/N)
Dallas County	Dallas	44,975	6	4.0	0.3	3.8	N
Collin County	Collin	8,772	3	0.4	12.0	2.9	N
Tarrant County	Tarrant	17,261	2	1.8	5.1	6.5	N
Erath County[1]	Erath	1,272,500	0	2.0	45.1	8.1	N

1. Tons of CAFO manure only.

Although greenfield sites were selected strategically and the Dallas County greenfield site is relatively competitive with other potential pilot project locations, none have been selected to advance to the short-list based on their relative proximity to key project feasibility criteria.

6.5 Short-List and Project Selection

This section presents the short-listed locations and the projects selected for further evaluation. Locations that are not being further evaluated (both on the short-list and long-list) are not disqualified because that would not be a suitable location for future AD development projects, but rather because they are not the most optimal locations for a potential pilot project at this time. To effectively divert prioritized feedstocks across the North Central Texas region, significantly more AD capacity will need to be installed and the locations on the short-list represent optimal locations for future potential pilot projects that could be further evaluated or implemented in the future.

Table 6-10 lists the potential pilot project locations that were advanced to the short-list and indicates if they have AD processing capacity.

Table 6-10: Short-Listed Facility Locations

Facility	Facility Type	County	AD (Y/N)
City of Dallas Southside WWTP	WWTP	Dallas	Y
City of Denton Landfill Complex	Multiple Facilities	Denton	Y
Village Creek Water Reclamation Facility	WWTP	Tarrant	Y
Central Regional WWTP	WWTP	Dallas	Y
Fort Worth Brewery	WWTP	Tarrant	Y
Peach Street WWTP	WWTP	Tarrant	N
City of Dallas Bachman Transfer Station	Transfer Station	Dallas	N
City of Garland Rowlett Creek WWTP	WWTP	Dallas	N
City of Garland Transfer Station	Transfer Station	Dallas	N
City of Mesquite Recycling/Waste	Composting/WWTP	Dallas	N

Based on discussions with the PAG, the Project Team selected the City of Dallas Southside WWTP and City of Denton Landfill Complex as the most optimal project locations for further detailed evaluation. These facilities have been selected because in addition to being in optimal locations they have existing AD capacity, are co-located within solid waste systems that provide supporting infrastructure, and are municipally owned and operated. While there are other locations on the short-list that fall into these categories, the combination of synergies among the Southside WWTP and City of Denton Landfill Complex makes them the most uniquely positioned for further evaluation as potential pilot projects. Based on discussion of this short-list with the PAG, the City of Dallas Southside WWTP and City of Denton Landfill Complex have been selected for further evaluation, provided in Section 7.0.

7.0 PILOT PROJECT FEASIBILITY EVALUATION

This section presents the evaluation of selected pilot projects, assessing the viability of co-digestion of municipal wastewater sludge, food waste, and other organic waste streams such as FOG based on key technical, financial, and operational factors.

7.1 Methodology

The Project Team determined scenarios for co-digestion of food waste and FOG with sludge at the selected facilities, utilizing the POWER Tool to comparatively analyze technical requirements and environmental impacts of each pilot project location selected collaboratively among the Project Team, NCTCOG staff and the PAG. Reference Appendix A for information regarding the stakeholder engagement efforts and Appendix C for the detailed inputs of the POWER Tool. The Project Team evaluated two scenarios for co-digestion of food waste and FOG with sludge based on the results of the feedstock analysis in Section 2.0, location screening analysis in Section 6.0, and discussions with the PAG throughout the Study to determine that these project types presented the best available near-term opportunity for organics-to-fuel projects in the North Central Texas region. The Dallas and Denton pilot project scenarios are detailed in Section 7.2. Section 7.3 presents the comparative analysis based on the following criteria:

- **Feedstock.** Estimated food waste and FOG tonnage that could feasibly be separately collected and delivered to the selected facilities on an annual basis. The Dallas pilot project scenario analyzes the impacts of accepting an additional 43,300 tons of pre-consumer commercial food waste and 9,300 tons of FOG at the Dallas Southside WWTP on an annual basis. The Denton pilot project scenario analyzes the impacts of accepting an additional 10,350 tons of pre-consumer commercial food waste, 1,640 tons of post-consumer residential food waste, and 2,060 tons of FOG on an annual basis. Further description of the assumptions used to calculate the annual feedstock tonnage is presented in Table 2-2.

- **Infrastructure.** Existing and new infrastructure to store, process, and distribute AD byproducts (e.g., biosolids, biogas) to end-users. The Project Team identified the nearest major roadways, natural gas pipelines, locations of potential NGV fuel demand and hydrogen fueling infrastructure.

- **Potential biogas yield and emissions reduction.** Comparison of the potential biogas yield and planning-level emission reductions of each pilot project scenario. The Project Team utilized the POWER Tool to estimate the potential biogas yield as part of each pilot project scenario. The POWER Tool then estimates the potential emissions reductions of generating biogas via AD compared to producing CNG via conventional methods (e.g., drilling).

- **Byproduct management.** Number of WWTPs generating sludge on a county-wide basis that require disposal and/or further processing. The Project Team identified locations and estimated tonnages that could potentially direct solid byproducts (e.g., sludge, biosolids) to the pilot projects and considers regional approaches to managing these byproducts.

- **Environmental permitting.** Land use designation, location in relation to floodplains and wetlands, and existing TCEQ permit requirements.[22] The Project Team identified these criteria to provide a planning-level indication of potential challenges related to accepting additional food waste, FOG and/or sludge at each pilot project scenario.

- **Environment justice.** County-wide demographic information related to poverty, limited English proficiency, and minority population. The Project Team determined the portion of each block group with income below the census designated poverty level, the portion with limited English proficiency based on population five years and older who reported speaking English less than "very well" as classified by the U.S. Census Bureau, and the block groups with greater than 50 percent minority population based on U.S. Census Bureau data.[23]

- **Funding incentives.** Applicable funding incentives that could be leveraged for each pilot project based on location, feedstock processing technology, byproduct management, ownership structure, and impact on surrounding community. A comprehensive listing of funding incentives is provided in Appendix F.

[22] North Central Texas Council of Governments. *NCTCOG 2015 Land Use Inventory*. April 2017. https://rdc.dfwmaps.com/MethodologyDocs/NCTCOG%202015%20Land%20Use%20Description.pdf
[23] Census Bureau information was evaluated by block group, a Census-designated division typically containing between 600 and 3,000 people. Poverty level was evaluated based on the Census Bureau official poverty threshold, which ranges from $13,000 to $50,000 depending on family size.

This Study does not provide detailed engineering or financial estimates of potential pilot projects in part due to limitations related to the amount of surveying that could be conducted among WWTP operators in the region. Additionally, while the POWER Tool includes some capabilities for planning-level cost comparisons across projects, it does not currently provide the level of detail required to estimate the costs of potential pilot projects.

7.2 Pilot Project Scenario Descriptions

The following section provides a brief description of each pilot project scenario based on the information compiled by the Project Team. The review of each pilot project's overall capacity, processing system, estimated additional feedstock, and biogas processing capabilities support the following feasibility evaluation and served as the basis for modeling via the POWER Tool.

7.2.1 City of Dallas Southside WWTP

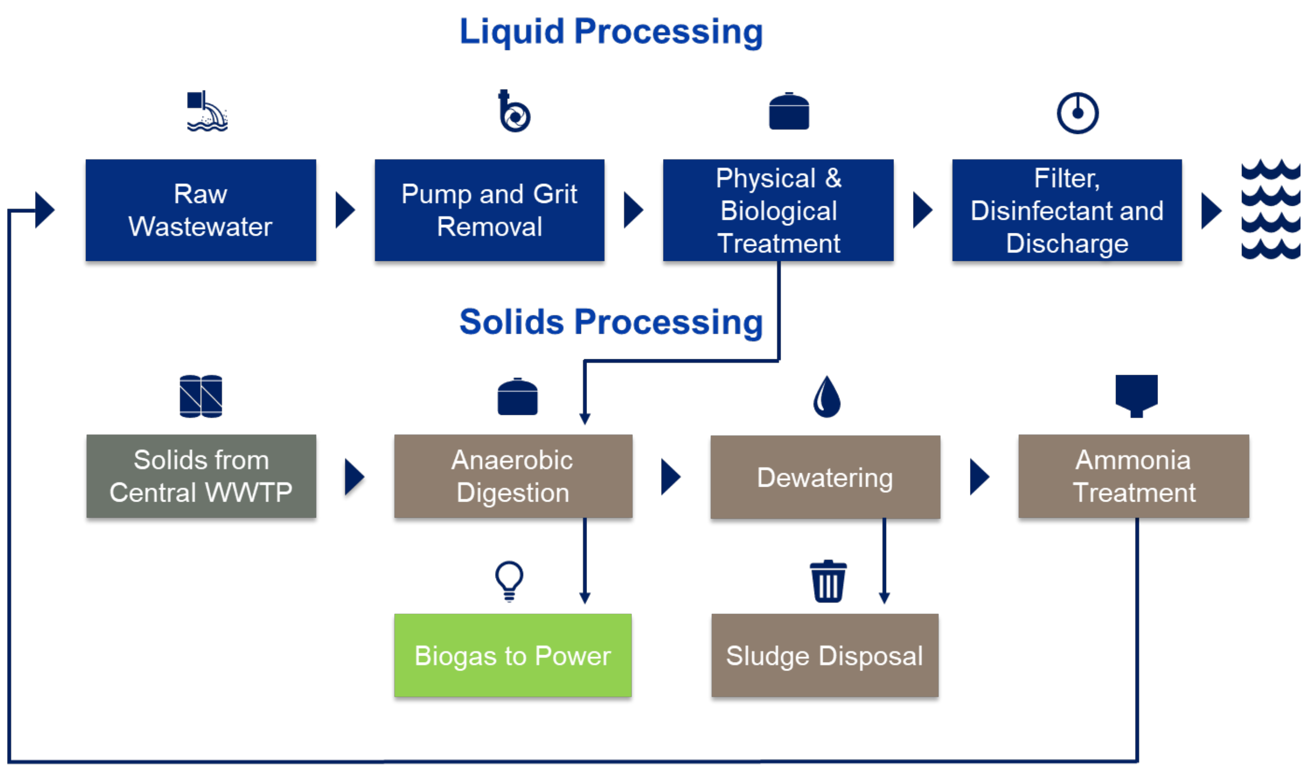
The City of Dallas Southside WWTP facility is located within five miles of the McCommas Bluff Landfill. As part of pilot the Dallas pilot project scenario, the Southside WWTP facility would receive food waste and FOG by vacuum truck and roll-off vehicle (depending if material is pre-processed as a slurry at the generator site or delivered via open top or compaction units for subsequent processing prior to digestion). Figure 7-1 shows an arial image of the Southside WWTP.

Figure 7-1: Southside Wastewater Treatment Plant

Facility capacity. The Southside WWTP accepts an inbound flow of 50-55 MGD and treats and discharges water effluent into the Trinity River. A combined 3 MGD of inbound sludge is processed from the City of Dallas' Central WWTP and Southside WWTP. Sludge from both facilities is treated at the Southside WWTP using AD. The facility currently operates with about 55 MGD of excess treatment capacity as a result of prior water conservation efforts that reduced the incoming wastewater volume. While the capacity of the AD units is sufficient to accept additional feedstock, the facility is not designed to accept material from solid waste collection vehicles on a consistent basis, or to pre-process, store, and pump off-site material into the existing AD units. Additionally, further evaluation is required to determine the AD units' loading capacities with co-digestion (as compared to the overall plant-wide available capacity).

Treatment system. Treatment at the Southside WWTP is a multi-stage process for the treatment of wastewater influent and inbound sludge processing. Figure 7-2 presents a high-level process flow of the plant for liquids treatment (shown in blue) and solids processing (shown in brown).

Figure 7-2: Dallas Southside WWTP Current Processing System



The wastewater treatment processing includes screening, grit removal, clarifiers, diffused aeration, final clarifiers, filtration, and chlorine disinfection. Sludge generated during physical and biological treatment is treated via AD. Southside WWTP has a total of 11 mesophilic AD units that process solids, followed by dewatering (to about 15 percent solids) and land applied or disposed of at the co-located sludge monofill. Undigested sludge may be accepted at the sludge monofill.

Additional feedstock. The Project Team estimates that 43,300 tons of pre-consumer commercial food waste and 9,300 tons of FOG could be delivered to the facility from Dallas County as part of an organics-to-RNG project.[24] Section 7.3.1 provides further description of the basis of these tonnage assumptions and analysis of the quantity of additional biogas that would be generated at the Southside WWTP.

Gas processing. Biogas from the digesters is transported to the on-site Ameresco co-generation facility to produce electricity and heat, which has the capacity to produce 4.3 megawatts (MW) of power. The co-generation facility provides hot water for heating digesters and buildings on site, and provides over 40 percent of the facility's electricity demand. The engines currently utilize about 95 percent of the biogas generated when operating at full capacity, and any excess gas is flared.

7.2.2 Denton Landfill Complex

The Denton Landfill Complex contains several facilities including the Denton Landfill, Pecan Creek WWTP, Dyno Dirt Composting facility, CNG vehicle fueling station, and landfill gas processing facility. As part of the Denton pilot project scenario, the Pecan Creek WWTP facility would increase capacity to receive and process pre-consumer and post-consumer food waste and FOG, including receiving by vacuum truck and roll-off vehicle (depending if food waste is pre-processed as a slurry at the generator site or delivered via roll-off truck). Additionally, the facility would seek to accept co-mingled source-separated food waste and yard waste. The City of Denton is in the process of procuring equipment for grinding source separated organics at the Pecan Creek WWTP. Currently, the facility is not designed to accept material from solid or liquid waste collection vehicles, although the Dyno Dirt composting facility regularly accepts yard waste from solid waste collection vehicles. Figure 7-3 presents the Pecan Creek WWTP.

[24] Includes the estimated 900 gallons per month of FOG that is currently delivered to Southside WWTP.

Figure 7-3: City of Denton Pecan Creek WWTP

Facility capacity. The Pecan Creek WWTP accepts an inbound flow of 15 MGD and discharges treated effluent into Lake Lewisville. [25]

Treatment System. The wastewater treatment system at Pecan Creek WWTP includes screening, grit removal, clarifiers, diffused aeration, final clarifiers, filtration, chlorination, and UV disinfection. Currently, wastewater treatment sludge generated at the Pecan Creek WWTP is treated via two AD units operating on site. With continued population growth, the City is exploring the addition of a third digester to support future capacity needs. Treated sludge is thickened and composted at the co-located Dyno Dirt composting facility which manages about 30,000 tons per year of residential and commercial yard waste and biosolids from the City of Denton. The composting facility is covered by a pole barn structure, processes the material in open air windrows and houses various screening and material management equipment. The Pecan Creek WWTP staff is responsible for the oversight, operation, and maintenance of the composting facility.

[25] Further information about the City of Denton's wastewater treatment system is available at the following hyperlink: https://www.cityofdenton.com/393/Wastewater-Sanitary-Sewers

Additional feedstock. The Project Team estimates that 10,350 tons of pre-consumer commercial food waste, 1,640 tons of post-consumer residential food waste, and 2,060 tons of FOG could be delivered to the facility from Denton County as part of an organics-to-RNG project. Section 7.3.1 provides further description of the basis of these tonnage assumptions and analysis of the quantity of additional biogas that would be generated at the Pecan Creek WWTP.

Gas processing. Currently, biogas from the digesters is used to produce electricity at the facility.

7.3 Feasibility Evaluation

The Project Team utilized the POWER Tool and additional analysis to evaluate the technical and environmental impacts of multiple material management approaches to collect, transport, process and dispose additional feedstock detailed in Section 7.3.1.

The Dallas pilot project scenario estimates the planning-level biogas yield (e.g., estimated volume of pipeline quality RNG) and air emissions reduction (e.g., VOCs, nitrogen oxides (NO_x), sulfur oxides (SO_x), particulate matter (PM2.5), carbon dioxide equivalents (CO_2e)) from generating biogas by co-digesting food waste and FOG with sludge at the City of Dallas Southside WWTP to compare against the biogas yield and emissions reduction from disposal of the same tonnage of organic waste material at the McCommas Bluff Landfill.

The Denton pilot project scenario estimates the planning-level biogas yield generated from co-digesting food waste and FOG with sludge at the Pecan Creek WWTP to compare against the biogas yield and air emissions reduction from management of the same tonnage of organic waste material at the Dyno Dirt composting facility.

The following information is not intended to be an engineering or financial analysis of any facilities evaluated, and the pilot project scenarios are presented for planning purposes to support organic diversion programming in the North Central Texas region. Further due diligence is required to estimate capital and operating costs of co-digestion at the Southside WWTP and Pecan Creek WWTP. Section 8.0 provides specific recommendations for next steps to pursue pilot projects based on the results of the feasibility evaluation. While the Project Team collaborated with the cities of Dallas and Denton to develop the information included in the Study, neither city is obligated to implement the recommendations included in the Study as there is a need for further technical, financial and policy decisions to be made prior to any final actions.

7.3.1 Feedstock

This section compares the estimated additional feedstocks that served as the basis for the POWER Tool modeling, including potential biogas yields and life-cycle emissions estimates. The tonnage estimates are provided for comparison purposes, and do not reflect any guaranteed feedstock supply agreements in place. Table 2-2 compares the annual feedstock tonnage estimates for the Dallas pilot project scenario (to be managed at Southside WWTP) and Denton pilot project scenario (to be managed at the Pecan Creek WWTP) by material and generator type.

Table 7-1: Annual Tonnage Estimates

Feedstock	Generator Sector	Dallas Scenario (Tons)	Denton Scenario (Tons)
Pre-consumer food waste[1]	Commercial	43,320	10,350
FOG[2]	Commercial	9,300	1,640
Post-consumer food waste[3]	Residential	0	2,060
Total Additional Material		**52,620**	**14,050**

1. Assumes 50 percent capture rate from correctional facilities, healthcare facilities, hospitality locations, institutions and food manufacturers and processors.
2. Assumes 75 percent capture rate of material county-wide from restaurants and food service location based on a generation rate of 32.5 gallons per location per week (reference Section 2.2.5).
3. Assumes 20 percent capture rate based on estimated 10,308 tons of food waste generated annually from City of Denton residential customers.

The estimated tonnage of pre-consumer food waste generated by select categories of commercial establishments makes up 82 percent of total additional material from Dallas County, and 73 percent of the total additional material from Denton County. This material would be delivered to the respective facilities by vacuum trucks and roll-off trucks, depending on the pre-processing and storage capabilities of individual generators. Commercial FOG would be delivered by vacuum or tanker trunk, and could potentially be co-collected with pre-consumer food waste slurry pre-processed at generator sites to capture collection route efficiencies. The tonnage of post-consumer food waste material from the City of Denton assumes it is collected only from the city's residential customers, and not the broader Denton County area, because the current municipal collection system only services city residents (e.g., City of Denton residential collection does not provide service to residents of neighboring municipalities).

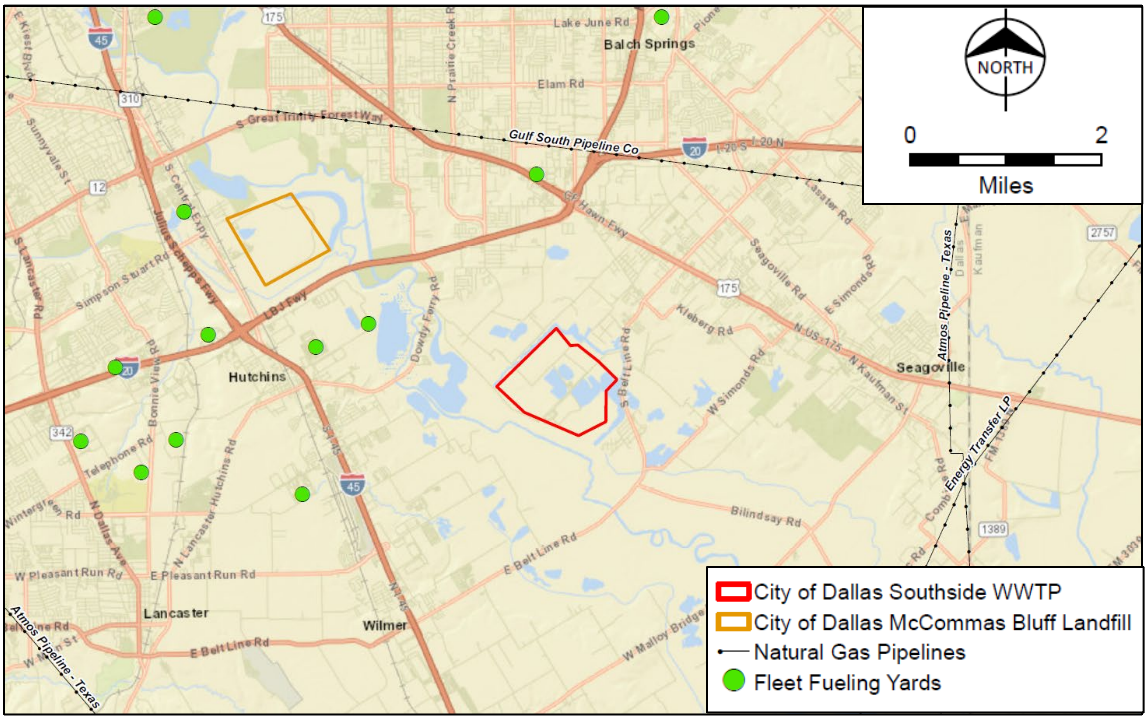
7.3.2 Infrastructure

This section analyzes key existing infrastructure related to pilot project scenarios including the major roadways, natural gas pipelines, potential NGV fleet fueling demand, and hydrogen fueling infrastructure.

7.3.2.1 Dallas Pilot Project Scenario

Figure 7-4 presents the general Dallas pilot project location including the approximated permit boundaries of the Southside WWTP, McCommas Bluff Landfill, locations of natural gas transmission pipelines, and potential NGV fueling demand.

Figure 7-4: Southside WWTP and McCommas Bluff Landfill Permit Boundaries, Natural Gas Transmission Pipelines and NGV Fleets

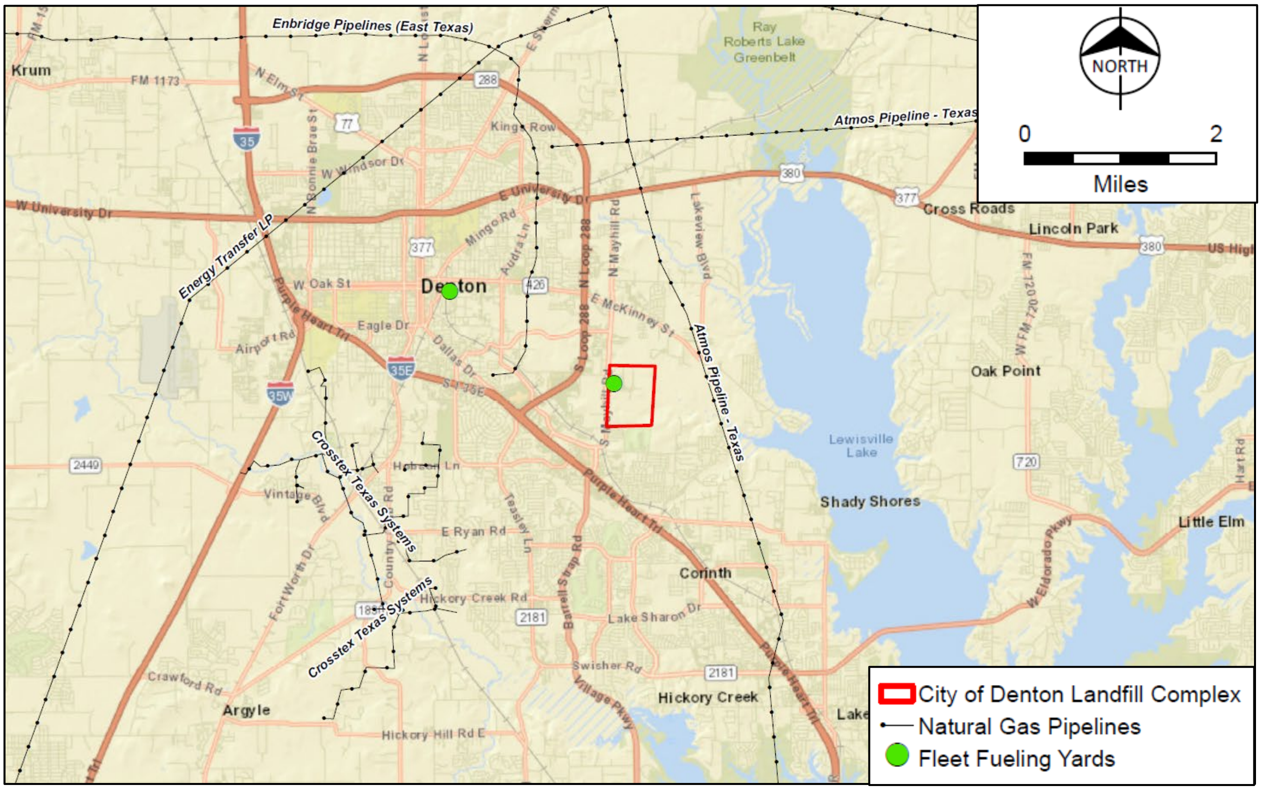


Both the Southside WWTP and McCommas Bluff Landfill are located near existing high-traffic trucking routes near the intersection of I-45 and I-20, within about five miles of interstate natural gas transmission pipelines, and near several fleet fueling yards and potential NGV fleets including long-haul shipping distribution centers (e.g., DHL, FedEx, Amazon) and solid waste collection vehicle yards, including one of the City of Dallas' solid waste operations centers that does not contain existing fueling infrastructure. There is no hydrogen fueling infrastructure identified near the Southside WWTP or McCommas Bluff Landfill.

7.3.2.2 Denton Pilot Project Scenario

Figure 7-5 presents the general Denton pilot project location including the approximated permit boundaries of the Denton Landfill Complex, locations of natural gas transmission pipelines, and potential NGV fueling demand.

Figure 7-5: Denton Landfill Complex Permit Boundaries, Natural Gas Lines and Potential NGV Fleets



The Denton Landfill Complex has several existing co-located facilities within its permit boundaries, including a CNG fueling facility for its own vehicle fleet. While there are fewer fleet fueling yards and potential NGV fleets near the Denton Landfill Complex, the City's internal demand and existing CNG usage present an opportunity to displace is current CNG with RNG. There is no hydrogen fueling infrastructure identified near the Denton Landfill Complex.

7.3.3 Potential Biogas Yield and Emissions Reduction

This section compares the biogas generated by the estimated additional feedstock for each pilot project scenario (reference Section 7.3.1) and the potential emissions reductions. Multiple counties in the North Central Texas region are in non-attainment for the National Ambient Air Quality Standards (NAAQS) ozone standard, indicating the importance of emissions reductions in the region. The potential biogas yield and emissions reductions for each pilot project scenario are evaluated below to demonstrate the environmental impact of processing organics via AD.

7.3.3.1 Dallas Pilot Project Scenario

Table 7-2 presents the potential biogas yields from the Dallas pilot project scenario generated from co-digestion via AD or landfill disposal with LFG-to-RNG, assuming that all additional feedstock material is processed on a continuous basis.

Table 7-2: Dallas Pilot Project Scenario Biogas Yield Comparison[1]

Feedstock	Potential Biogas Yield (m^3/day)		
	Anaerobic Digestion	Landfill Disposal	Difference
Food Waste	9,800	4,400	5,400
Commercial FOG	17,800	6,400	11,400
Total	**27,600**	**10,800**	**16,800**

1. Biogas yields represent planning level estimates of the volume of pipeline quality gas that would be generated from each processing/disposal facility type for only the quantity of feedstock being considered for co-digestion at the AD facility.

Biogas yield from AD is significantly higher than via landfill gas collection, as process controls (e.g., moisture, temperature, retention time) can be used in AD units to allow materials to degrade more fully and capture the biogas that is produced. When disposed of in a landfill, a significant portion of the biogas generated by more readily biodegradable organics (such as food waste) is emitted to the atmosphere before the installation of the landfill gas collection system. Due to its higher biogas production potential, commercial FOG would generate a higher volume of biogas than the food waste feedstocks, while comprising a smaller fraction of total feedstock tonnage.

Table 7-3 compares the potential lifecycle emissions reduction of AD and landfill disposal by calculating the difference in emissions compared to producing the same amount of biogas via conventional methods (e.g., drilling).

Table 7-3: Dallas Pilot Project Scenario Potential Emissions Comparison[1]

Pollutant Emissions	Potential Emissions Reduction (kg/year)[2]		
	Anaerobic Digestion	Landfill Disposal	Difference
Volatile Organic Compounds (VOCs)	780	1,050	(270)
Nitrogen Oxides (NO_x)	(21,350)	(4,730)	(16,620)
Particulate Matter (PM2.5)	(1,460)	210	(1,670)
Sulfur Oxides (SO_x)	(351,660)	(98,720)	(252,940)
Carbon Dioxide Equivalents (CO_2e)[3]	(4,000,000)	18,500,000	(22,500,000)

1. Presents planning level estimates of emissions based on the incremental increased tonnage processed/disposed. Emissions do not reflect full emissions generated by a specific AD or landfill facility.
2. Emissions reduction shown are calculated based on the difference in emissions to produce the equivalent potential biogas yield presented in Table 7-2 as CNG via conventional methods (e.g., drilling).
3. Represents the combined volume of CO_2, methane and dinitrogen oxide converted to CO_2e.

Processing organics through AD as compared to LFG-to-RNG provides a significant reduction in NO_x and SO_x as compared to the increased pollutant emissions related to drilling and transportation of fossil-derived CNG. The CO_2e generated by landfill is much higher than drilling and transportation of fossil-derived CNG due to the comparatively higher fugitive emissions associated with landfill operations.

7.3.3.2 Denton Pilot Project Scenario

Table 7-4 compares the potential biogas yields from the Denton pilot project scenario generated via AD compared to composting, assuming that all additional feedstock material is processed on a continuous basis. The Denton pilot project scenario compares AD to composting because biosolids and limited amounts of pre-consumer commercial food waste is currently composted at the Denton Landfill Complex.

As shown, processing the estimated additional feedstock via AD would generate nearly 6,000 cubic meters per day of biogas.

Table 7-4: Denton Pilot Project Scenario Biogas Yield Comparison[1]

Feedstock	Potential Biogas Yield (m^3/day)	
	Anaerobic Digestion	Composting
Food Waste	2,800	0
Commercial FOG	3,130	0
Total	**5,930**	**0**

1. Biogas yields represent planning level estimates of that volume of pipeline quality gas that would be generated from each processing/disposal facility type.

Table 7-5 compares the potential lifecycle emissions reduction of AD and composting by calculating the difference in emissions compared to producing the same amount of biogas via conventional methods (e.g., drilling).

Table 7-5: Denton Pilot Project Scenario Potential Emissions Comparison[1]

Pollutant Emissions	Potential Emissions Reduction (kg/year)[2]		
	Anaerobic Digestion	Composting	Difference
Volatile Organic Compounds (VOCs)	90	30	60
Nitrous Oxide (NO_x)	(4,080)	190	(4,270)
Particulate Matter (PM2.5)	(240)	4	(244)
Sulfur Oxides (SO_x)	(37,700)	70	(37,770)
Carbon Dioxide Equivalents[3] (CO_2e)	(1,100,000)	481,260	(1,581,260)

1. Presents planning level estimates of emissions based on the incremental increased tonnage processed. Emissions do not reflect full emissions generated by a specific AD or landfill facility.
2. Emissions reduction shown are calculated based on the difference in emissions to produce the equivalent potential biogas yield presented in Table 7-4 as CNG via conventional methods (e.g., drilling).
3. Represents the combined volume of CO_2, methane and dinitrogen oxide converted to CO_2e

Processing organics through AD provides a significant reduction in NO_x and SO_x as compared to the increased pollutant emissions related to drilling and transportation of fossil-derived CNG. The potential emissions reduction of all pollutants generated by composting is higher than the emissions generated to produce zero kg/year of fossil-derived CNG (because composting process does not produce any RNG).

7.3.4 Sludge Management

This section evaluates the number of WWTPs generating sludge on a county-wide basis that require disposal and/or further processing and provides key considerations for potential regional solutions to sludge management. For the purposes of this evaluation, the term sludge is used generally to describe the byproduct from WWTPs in the region because the Project Team has not confirmed the amount of processing at each WWTP in Dallas and Denton County. Further description of the definitions of sludge and biosolids are provided in Section 1.2.2.

7.3.4.1 Dallas Pilot Project Scenario

Figure 7-6 presents the locations of WWTPs in Dallas County to provide context about sludge management opportunities at the Southside WWTP. The identification of each WWTP shown on the map is provided in Table 7-6.

Figure 7-6: Dallas County WWTPs

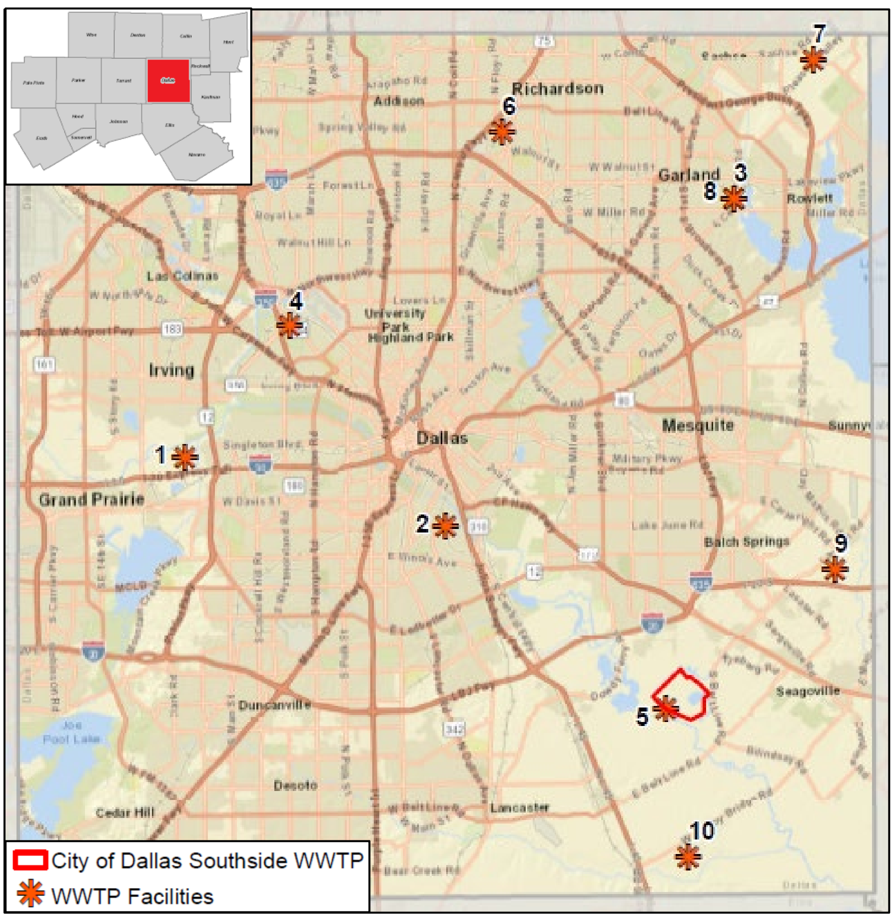


Table 7-6: Dallas County WWTP and Reported Annual Biosolids Generation[1]

Map ID	Facility Name	Biosolids Generation (dry metric tons)
1	Central Regional WWTP	68,597
2	Central WWTP[2]	23,571
3	City of Garland Rowlett Creek WWTP	1,570
4	Dallas County Park Cities MUD WWTP	1,568
5	Dallas Southside WWTP	24,178
6	Floyd Branch Regional WWTP	387
7	Muddy Creek Regional WWTP	2,071
8	Rowlett Creek Regional WWTP	5,122
9	South Mesquite Creek WWTP	7,515
10	Ten Mile Creek WWTP	1,941
	Total	**136,520**

1. Annual dry metric tons based on U.S EPA National Pollutant Discharge Elimination System (NPDES) Biosolids Program reporting. Actual volumes managed may fluctuate from year-to-year.
2. Central WWTP currently transports sludge to the Southside WWTP for processing.

There are about 136,000 metric tons of biosolids generated by WWTPs in Dallas County among 10 facilities. While this corresponds to a significant amount to sludge generated, the facilities in Dallas County generally have storage and/or disposal capacity given the higher volume of annual tonnage generated per facility.

The Southside WWTP has available capacity to support sludge management on a regional basis by accepting sludge from other WWTPs in Dallas County to 1) process solids through its existing AD units, 2) land apply treated biosolids, and/or 3) deposit material in its sludge monofill. However, a plant-by-plant analysis of sludge solids content, average sludge production, and anticipated hauling frequency must be performed to determine if regionalization of existing solids processing options may cause technical challenges for the Southside WWTP. If sludge is dewatered and transported in a high-solids form, it may require the Southside WWTP to procure additional equipment to process the material into a pumpable form or obtain a high-solids pump. If a significant amount of dewatered material is received, the existing process may have operations problems associated with pumping and digester upset. Further, if sludge hauling quantities vary significantly on a daily or weekly basis, the digestion system may experience foaming or other nuisance events. Additionally, accepting sludge from WWTPs in Dallas County would increase the vehicle traffic at the facility.

While some additional off-site sludge or biosolids could be accepted at the Southside WWTP, the feasibility of accepting material from other facilities would be determined by the comparison of the process and financial benefits (e.g., additional biogas yield, revenue from accepting off-site materials) and costs (e.g., additional equipment, unit processes, or operational requirements). It is worth noting that the biogas potential of sludge is lower than the prioritized co-digestion feedstocks (i.e., food waste and FOG), and utilizing digester capacity to manage off-site sludge rather than food waste or FOG would reduce the biogas yield and resulting RNG potential. A detailed analysis of existing and projected sludge production, anticipated food waste and FOG quantities available for co-digestion, and optimal feedstock blending must be completed to help determine limitations of the existing infrastructure.

7.3.4.2 Denton Pilot Project Scenario

Figure 7-7 presents the locations of WWTPs in Denton County to provide context about sludge management opportunities at the Denton Landfill Complex. The identification of each WWTP shown on the map is indicated in Figure 7-7.

Figure 7-7: Denton County WWTPs

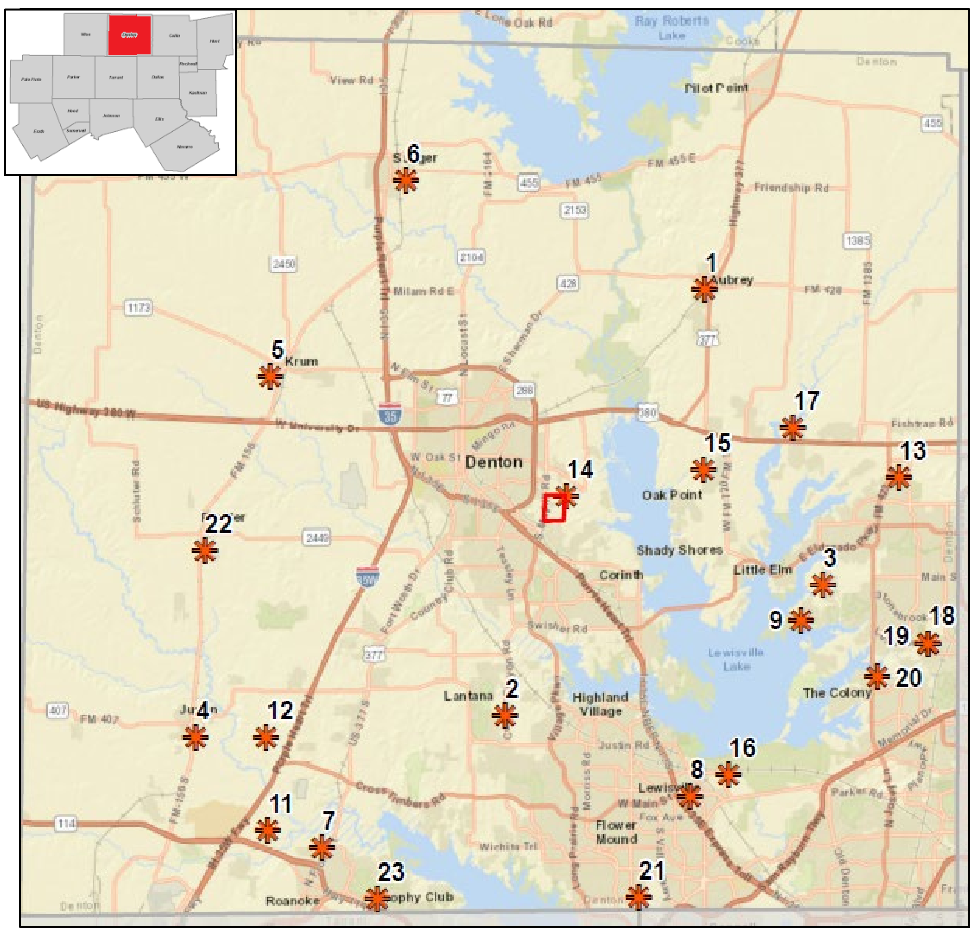


Table 7-7: Denton County WWTP and Reported Annual Biosolids Generation[1]

Map ID	Facility Name	Biosolids Generation (dry metric tons)
1	Aubrey WWTP	29
2	Briarwood Retreat WWTP	1
3	City of Hackberry WWTP	1,218
4	City of Justin WWTP	337
5	City of Krum WWTP	80
6	City of Sanger WWTP	793
7	Denton Creek Regional WWTP	2,729
8	Doe Branch WWTP	578
9	Hidden Cove Park WWTP	18
10	Lakeview Regional Water Reclamation	1,257
11	Northlake Village MHP WWTP	2
12	Northlake WWTP	1
13	Panther Creek WWTP	1
14	Pecan Creek Water Reclamation Plant	2,174
15	Peninsula Reg Water Rec Plant	4,668
16	Prairie Creek WWTP	260
17	Riverbend Reg Water Reclamation Facility	17,330
18	Robson Ranch WWTP	1,035
19	Stewart Creek West WWTP	57
20	Stewart Creek WWTP	1,536
21	Town of Flower Mound WWTP	914
22	Town of Ponder WWTP	1,644
23	Trophy Club MUD 1	80
	Total	**36,742**

1. Annual dry metric tons based on U.S EPA National Pollutant Discharge Elimination System (NPDES) Biosolids Program reporting. Actual volumes managed may fluctuate from year-to-year.

There are about 37,000 metric tons of biosolids generated by WWTPs in Denton County among 23 facilities. While this is about 100,000 tons fewer than the tonnage generated in Dallas County, there are more than twice the number of WWTPs generating this material. The smaller WWTPs in Denton County struggle to store and dispose of sludge generated on site and there is a likely greater need for sludge disposal outlets in this portion of the Targeted Organics Collection Area.

The Pecan Creek WWTP could potentially support the needs of the smaller WWTPs in Denton County but does not have the same capacity availability as the Southside WWTP. While there is a greater need among smaller WWTPs in Denton County for sludge management options, developing an Interlocal Agreement (ILA) to accept material at the Denton Landfill Complex would require significant coordination among participating municipalities to ensure that the material that would be delivered has been appropriately pre-processed to minimize operational challenges at the Pecan Creek WWTP. The feasibility of this type of regional system would need to be determined by working directly with the potential stakeholders (e.g., owners and operators of the smaller WWTPs in Denton County) to determine 1) the solids content, average production and hauling frequency of sludge from these facilities, 2) the current and future capacity of the Pecan Creek WWTP and Dyno Dirt composting facility (e.g., identify if current infrastructure is sized appropriately to meet needs of growing population and additional material from smaller WWTPs in Denton County), and 3) the costs and benefits of a regional system to the potential stakeholders that would participate.

Alternatively, processing sludge through an alternative conversion technology (e.g., pyrolysis, gasification) in combination with other organic feedstocks (e.g., biomass, tires) could be used to generate biochar and syngas that is further processed into hydrogen for sale; however, there are currently limited proven commercial-scale facilities operating on a continuous basis in the U.S. While this option is not evaluated in detail, pursuing a hub-and-spoke approach to transporting pre-treated sludge to the Denton Landfill Complex could support the development of a pilot project for hydrogen generation. Further description of available funding opportunities for hydrogen pilot projects is provided in Appendix F.

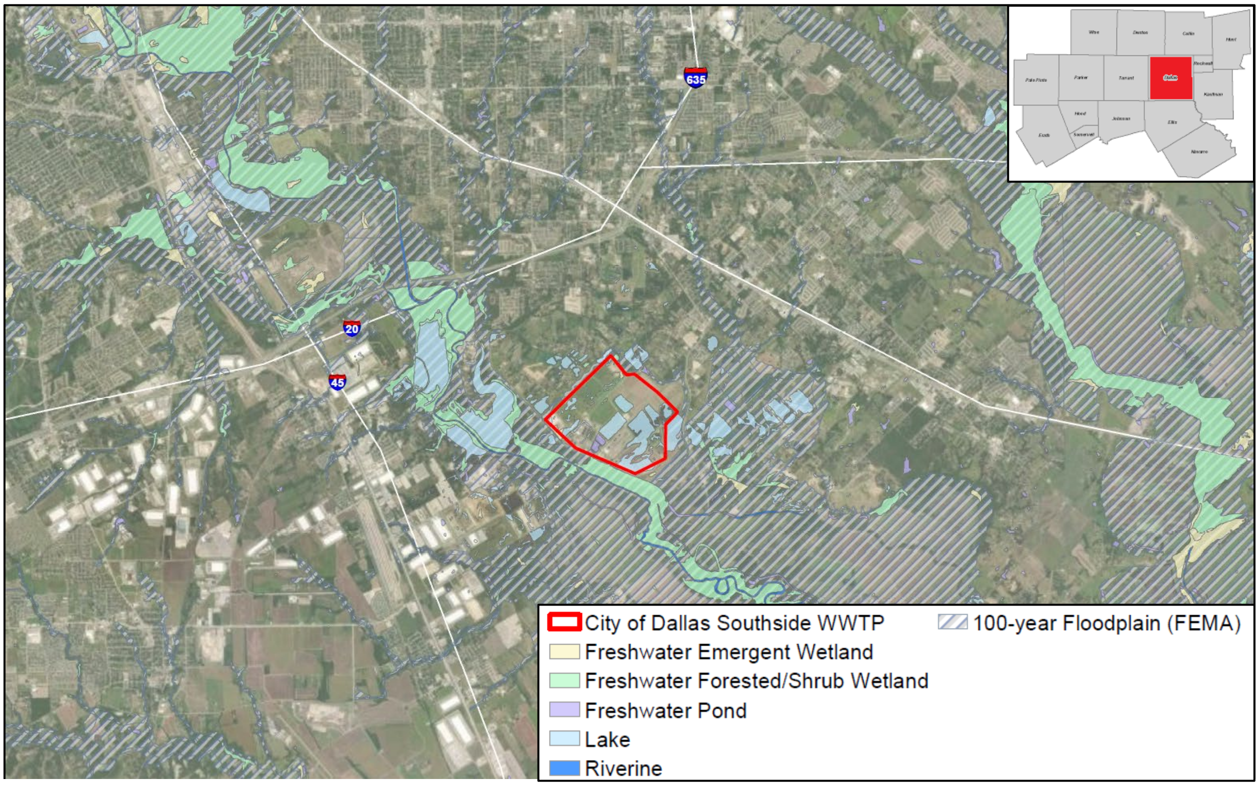
7.3.5 Environmental Permitting

This section presents information about the land class, wetlands and floodplains at the Southside WWTP and Denton Landfill Complex and describes permitting implications of the pilot project scenarios.

7.3.5.1 Dallas Pilot Project Scenario

Figure 7-8 identifies the Federal Emergency Management Administration (FEMA) 100-year floodplain and wetland boundaries surrounding the Southside WWTP.

Figure 7-8: Southside WWTP Floodplain and Wetland Boundaries



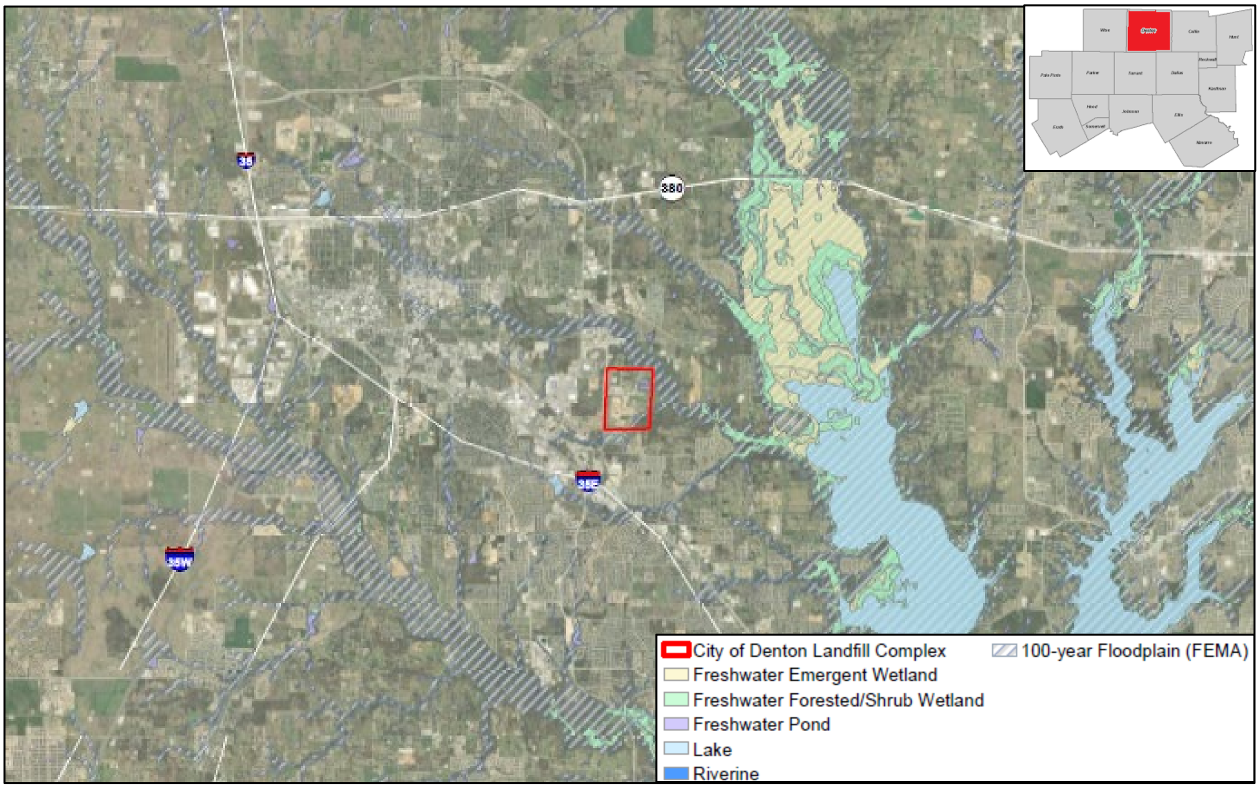
The Southside WWTP is considered a grassland/herbaceous land class and is bordered by floodplains to the south, east and west of the approximate permit boundaries. The facility has small lakes and freshwater wetlands to its south. The facility has a discharge permit with TCEQ and currently accepts FOG as a feedstock for its AD system. Typically, FOG generators are required to send this material to an authorized facility, and since the Southside WWTP already accepts this material it could expand on its current authoritzation to accept additional FOG material as part of the Dallas pilot project scenario. Further due diligence and permit analysis would be required to identify if there are any restrictions on the volume of FOG that could be accepted under the existing authorization with TCEQ.

To accept additional food waste, FOG or sludge, it would be critical that the material is categorized as a feestock (rather than a waste product) and that it is required to support the AD system. From a permitting perspective, the feedstock must be shown to be a necessary component of the AD process so it is not mischaracterized as “sham recycling” (e.g., claiming to beneficially reuse a waste product without actually doing so). TCEQ may look at how the purchase of the material is conducted, where if the Southside WWTP is puchasing feedstock it would be viewed as a product, but if they are charging a tipping fee to recieve the feedstock it could be considered a waste for disposal.

7.3.5.2 Denton Pilot Project Scenario

Figure 7-9 identifies the FEMA 100-year floodplain and wetland boundaries surrounding the Denton Landfill Complex.

Figure 7-9: Denton Landfill Complex Floodplain and Wetland Boundaries



The Denton Landfill Complex is considered a medium intensity development land class and located on a floodplain that runs through the northeast corner of the approximate permit boundary. From an operational perspective, incresed contamination, odors and vectors are associated with accepting post-consumer food waste material, and the addition large volumes of these non-vegetative materials may raise concerns about the ability to manage this material under the current permit. Further due diligence and permit analysis would be required to identify if there are any restrictions on the volume of food waste that could be accepted under the existing authorization with TCEQ.

To accept FOG the Denton Landfill Complex would need to be considered an authorized facility for receiving this type of material. Accepting additional food waste and FOG may require adjustments to the Denton Landfill Complex's existing registration with TCEQ. Additionally, accepting sludge to support a potential regional approach would require that the material is a feedstock necessary for the existing AD process so it is not mischaracterized as "sham recycling."

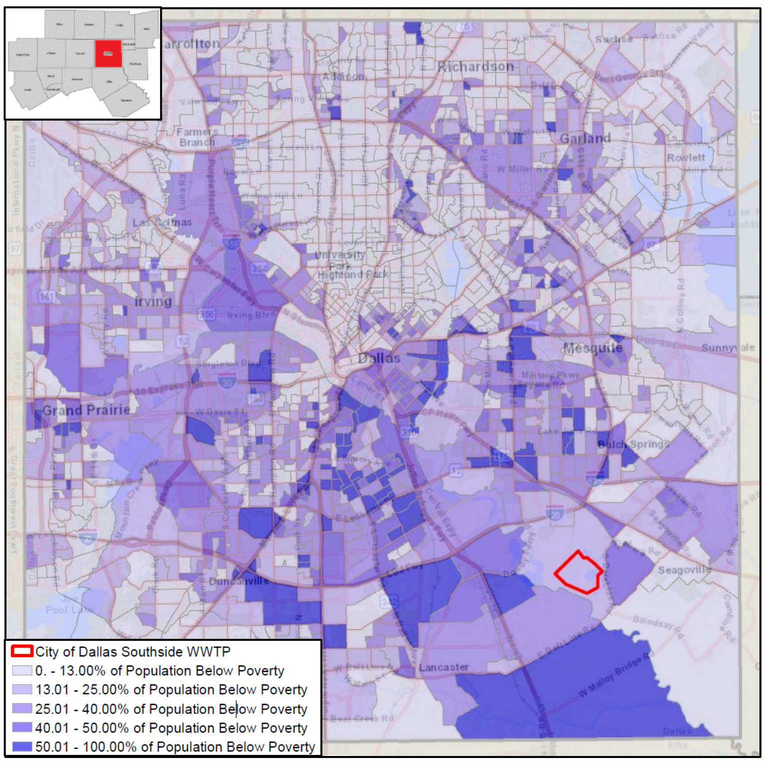
7.3.6 Environmental Justice

This section presents a series of environmental justice maps that identify, on a county-wide basis the percentage below poverty threshold, percentage with low English proficiency, and minority population over 50 percent. The underserved communities in Dallas and Denton counties are a critical factor to the successes of both pilot project scenarios, where a successful pilot project mitigates key environmental challenges such as higher than average levels of vehicle emissions, traffic, mobility, and economic opportunity.

7.3.6.1 Dallas Pilot Project Scenario

Figure 7-10 presents the percentage below poverty threshold by block group in Dallas County.

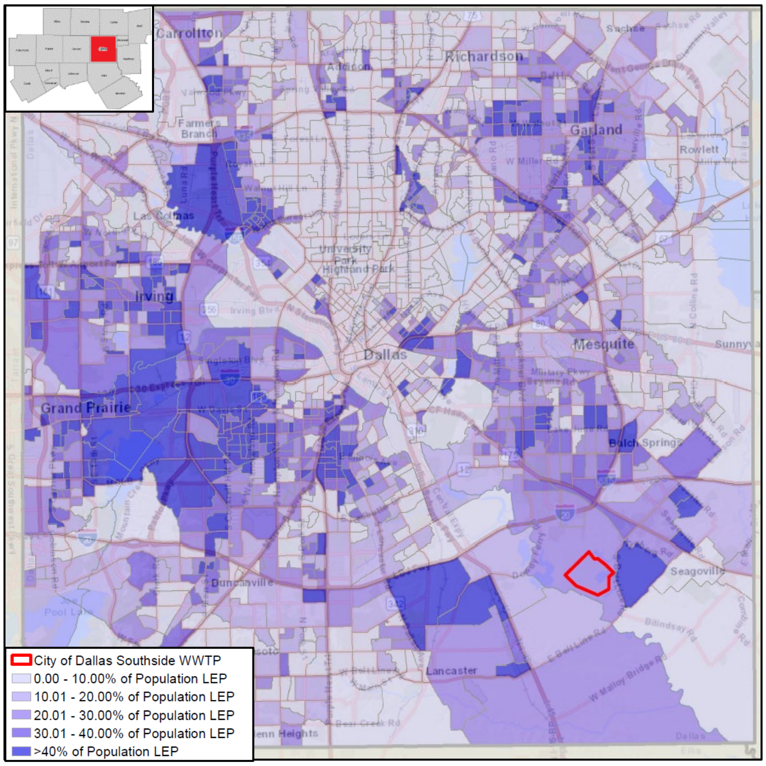
Figure 7-10: Dallas County Population Percentage Below Poverty Threshold



The Southside WWTP is located in an industrial area where between 13-25 percent of the population is below the poverty threshold. The pilot project would be a clear opportunity to displace diesel vehicles in this area of the County and reduce greenhouse gas emissions by generating RNG for vehicle fuel. As shown in Table 7-3, RNG results significant emissions reductions from a lifecycle perspective. Additionally, shifting the location of collection vehicles to deliver material to the Southside WWTP would reduce vehicle traffic at the McCommas Bluff Landfill.

Figure 7-11 presents the percentage identified as limited English proficiency by block group in Dallas County.

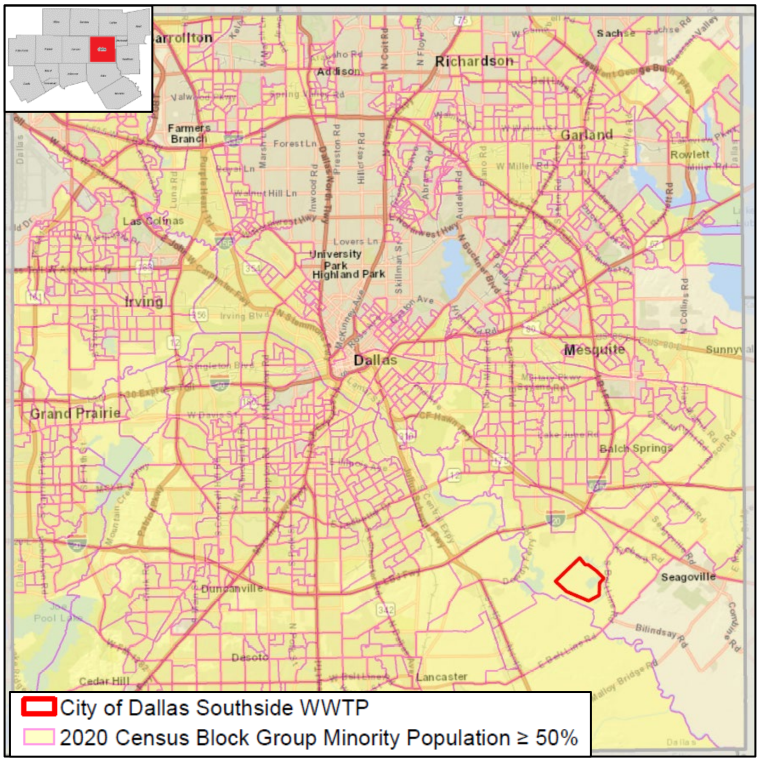
Figure 7-11: Dallas County Population Percentage With Limited English Proficiency



The Southside WWTP is located in a block group with 20-30 percent of the population identified as limited English proficiency. As part of the Dallas pilot project scenario, reaching out to the community to gain consensus and identify challenges is critical. As this area of Dallas County is adjacent to areas with greater than 40 percent of limited English proficiency, the outreach plan for any pilot project should include communications are provided on a bilingual basis to support needs of local community.

Figure 7-12 presents the block groups in Dallas County with minority populations above 50 percent.

Figure 7-12: Dallas County Block Groups with Minority Population Above 50 Percent

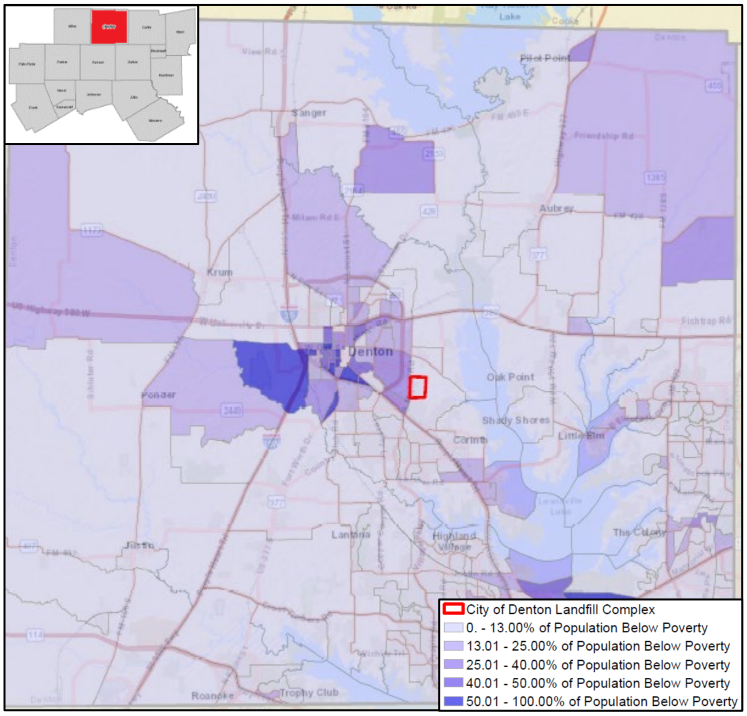


The Southside WWTP is located within and adjacent to communities with greater than a 50 percent minority population. This figure is presented to provide a planning level understanding and would require further environmental justice evaluations as part of the Dallas pilot project scenario. Based on the communities with environmental justice sensitivities within and adjacent to the facility, there are several potential funding opportunities that could support the development of a pilot project based on potential emissions reductions and opportunities for grant funding to obtain equipment that ensures underserved communities would not be adversely affected by the Dallas pilot project scenario.

7.3.6.2 Denton Pilot Project Scenario

Figure 7-13 presents the percentage below poverty threshold by block group in Denton County.

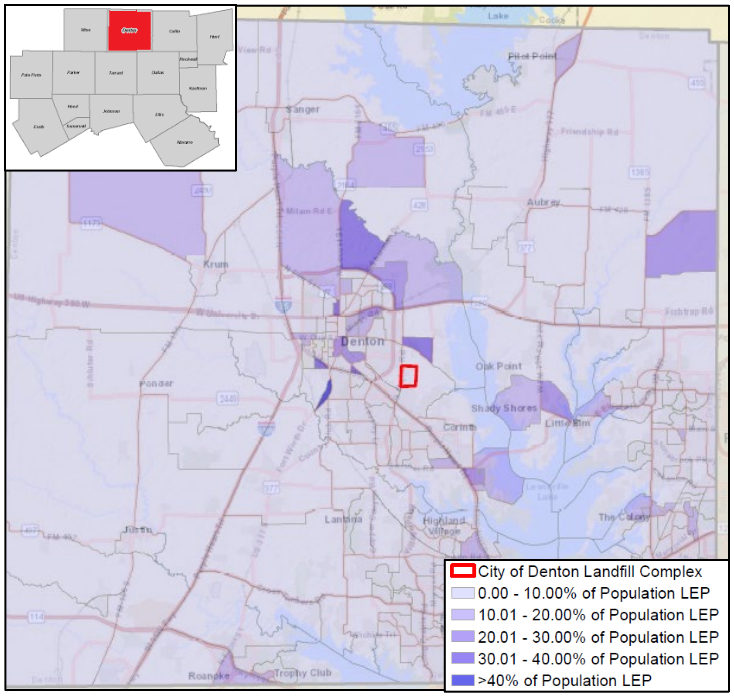
Figure 7-13: Denton County Population Percentage Below Poverty Threshold



The Denton Landfill complex located in an industrial area where between 0-13 percent of the population is below poverty the poverty threshold and is directly adjacent to potentially underserved communities. Depending on the direction and strength of prevailing winds, composting organics could potentially increase odors in those communities. As part of the Denton pilot project scenario, installing storage capacity that eliminates odors and vectors from these operations would be critical for project success.

Figure 7-14 presents the percentage identified as limited English proficiency by block group in Denton County.

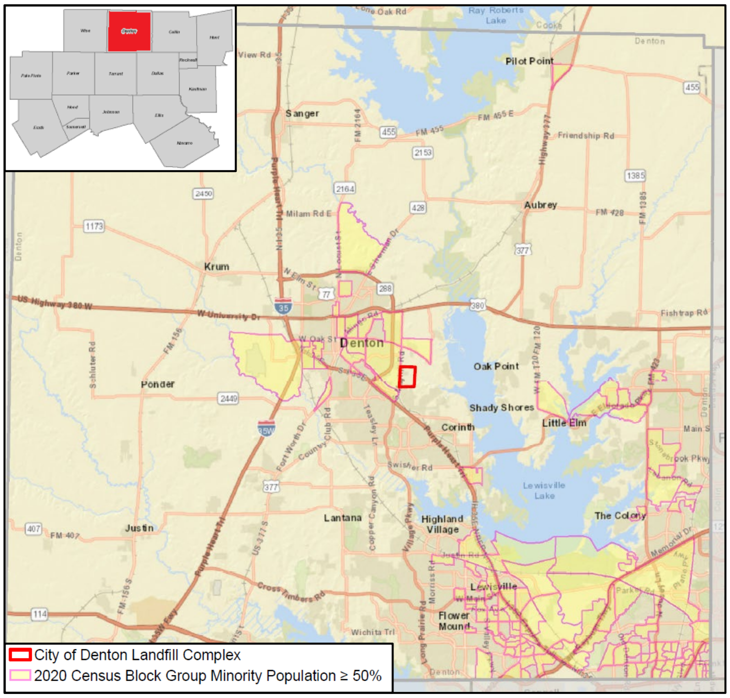
Figure 7-14: Denton County Population Percentage With Limited English Proficiency



The Denton Landfill Complex is located in a block group with 0-10 percent of the population identified as limited English proficiency, although there are pockets of Denton County that have limited English proficiency. As part of the Denton pilot project scenario, reaching out to these communities in their native languages (e.g., Spanish, Vietnamese, etc.) would be critical to gain consensus and identify challenges from to community, particularly if source separate material is planned to be collected curbside.

Figure 7-15 presents the block groups in Denton County with minority populations above 50 percent.

Figure 7-15: Denton County Block Groups with Minority Population Above 50 Percent



The Denton Landfill Complex is located adjacent to communities with minority populations greater than 50 percent. This figure is presented to provide a planning level understanding, and would require further environmental justice evaluations as part of the Denton pilot project scenario. Installing storage capacity that eliminates odors and vectors from these operations would be critical to advancing the Denton pilot project to ensure that increased vehicle traffic, odors or vectors would not disproportionately impact communities with minority populations above 50 percent.

7.3.7 Incentives and Funding Opportunities

This section provides an overview of the applicable environmental credits and other funding opportunities that would be available to pursue for each pilot project scenario. Further description of the funding opportunities and incentives, including detailed explanations of each type of environmental credit, are provided in Appendix F.

Table 7-8 indicates the environmental credits that would be applicable to each pilot project scenario.

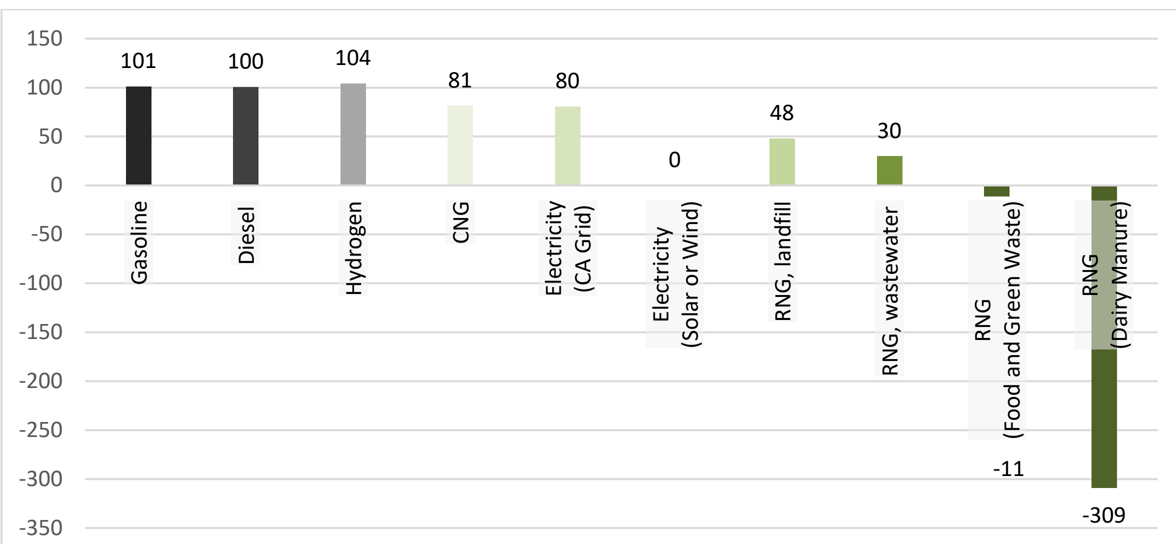
Table 7-8: Applicable Environmental Credits

Environmental Credit	Dallas Pilot Project	Denton Pilot Project
Renewable Fuel Standard (D5 RINs Only)[1]	Yes	Yes
California Low Carbon Fuel Standard (LCFS)	No	No
Renewable Energy Certificate (RECs)	No	No
Carbon Offset Credits	Yes	Yes

1. Co-digestion is considered applicable for D5 RINs, rather than D3 RINs which are traded at higher value.

Environmental credits present a significant opportunity to increase the financial performance of a pilot project scenario, but should not be the sole justification for pursuing a co-digestion project. Biogas generated at either pilot project could be cleaned and transported into the LCFS program or another state program, but would best meet the needs of NGV fleets located in the North Central Texas region by utilizing RNG or hydrogen locally rather than exporting for use in out-of-state NGV fleets. Figure 7-16 compares the carbon intensity (CI) between petroleum and alternative fuels generated via various pathways.

Figure 7-16: Lifecycle Carbon Intensity of Petroleum and Alternative Fuels (gCO_2e/MJ)[1]



1. Source: California Air Resources Board

The value of RINs and CI scores for the LCFS program generally follow the lifecycle CI of RNG generated via WWTPs compared to dairy manure, where RNG generated using dairy manure has a more environmentally advantageous impact. The LCFS market for environmental credits based on RNG generated using WWTPs is not as strong as other pathways. [26]

In addition to environmental incentives, the pilot projects should both consider leveraging federal incentives including Inflation Reduction Act and Justice40 Initiative to take advantage of Investment Tax Credits (ITC) and funding to minimize adverse environmental impacts on potentially underserved communities. Additionally, there is significant funding available for mitigating Per- and Polyfluoroalkyl substances (PFAS) through the Infrastructure Investment and Jobs Act of 2021 that could be utilized to support alternative sludge management options in the region, including potential processing technologies that would ultimately generate hydrogen (e.g., pyrolysis, gasification).

Additionally, leveraging grants including sustainable materials management grants to support one or more aspects of a pilot project scenario, secure funds to procure equipment or support technical feasibility studies, and pursue funding to develop hydrogen demonstration project grants would all be applicable to either pilot project scenario.

From an alternative fuel incentive perspective, there are several opportunities to secure funding for the aspects of the pilot projects that would reduce emission such as the Congestion Mitigation and Air Quality (CMAQ) Improvement Program and Alternative Fueling Facilities Program (AFFP). Multiple counties in the North Central Texas region are in non-attainment for the NAAQS ozone standard and the potential emissions reductions (particularly related to NO_x and VOC, which are precursors to ozone generation) under each pilot project scenario would help the region move toward attainment status. Funding to support the transition from diesel to RNG or hydrogen fueled vehicles could increase the pace of adoption among vehicle fleets.

Finally, exploring hydrogen demonstration projects could become incredibly important to advancing alternative fueling as part of a long-term strategy for transportation in the region. Hydrogen could be manufactured as part of demonstration projects by 1) installing additional fractionation equipment at the McCommas Bluff Landfill gas cleaning facility and 2) procuring alternative conversion technologies (e.g., pyrolysis, gasification) for installation at the Denton Landfill Complex to process regional sludge and other organic feedstock to generate syngas for further processing into hydrogen.

[26] The following link summarizes all LCFS projects that have been published: https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/fuelpathways/current-pathways_all.xlsx

There are several Texas specific opportunities including the Texas Emissions Reduction Plan (TERP) program which funds specific projects to implement hydrogen fueling to replace diesel. Additionally, there are federal opportunities such as the U.S. Department of Transportation (U.S. DOT) community alternative fuel infrastructure grant to fill gaps in publicly accessible alternative fueling infrastructure. Further description of specific funding opportunities is provided in Appendix F.

8.0 KEY FINDINGS AND RECOMMENDATIONS

This section presents a comprehensive listing of key findings and recommendations from each applicable section of the Study, identifying recommended opportunities and next steps for the region to support potential pilot projects to increase organics diversion through the development of RNG projects.

The following sections are organized consistently with the Study, where the results of each section informs the evaluation of the following section. For the purposes of this key findings and recommendations section, key terms and acronyms are re-introduced for clarity.

8.1 Priority Feedstocks

Determining the priority feedstocks in the North Central Texas region served as the basis for the collection, NGV fuel demand, and ultimately the selection of the pilot projects. The following key findings and recommendations are based on the analysis presented in Section 2.0:

Key Findings

- **Over 8 million tons of organic materials are generated each year from MSW (e.g., residential, commercial), agricultural, and wastewater sources in the North Central Texas region.** Organic waste generation in the region includes crop residue (33 percent of total), concentrated animal feeding operation (CAFO) manures (25 percent), yard waste (20 percent), food waste (18 percent) and fats oils and grease (FOG), biosolids and other wastewater (4 percent). Future volumes of these materials, especially MSW organics, are expected to grow as a result of population and economic growth over the coming decades as the North Central Texas region is home to some of the fastest growing cities in the U.S.

- **A significant portion of organic waste is already recovered in the region and diverted from disposal.** The North Central Texas region includes significant composting infrastructure, and an estimated 78 percent of generated yard trimmings and brush are diverted through composting programs. Additional organic materials are recovered in the region, including food waste and FOG. There are multiple facilities in the region permitted or authorized to convert FOG into products such as vegetable oil and waste cooking oil into biodiesel.

- **Existing biogas resources represent a notable level of existing organics-to-fuels activity and potential renewable natural gas (RNG) supply.** Facilities in the region such as landfills and WWTP systems with anaerobic digestion (AD) units produce potential organic-to-fuel feedstock in the form of waste-derived biogas. Based on available data, there are 17 landfills that currently collect approximately 44,000 scfm of waste-derived biogas, eight municipal WWTP AD systems, and at least one industrial AD system in the North Central Texas region. Currently, landfills in the region convert over 25,000 scfm of landfill biogas to produce an estimated 5 billion cubic feet of RNG each year (at six sites). Projects at other landfills (such as those currently producing electricity) or wastewater treatment plants (WWTPs) could potentially be upgraded for RNG production.

Recommendations

- **Prioritize food waste and FOG as high priority feedstocks for source-separated collection and conversion to RNG.** Food waste is generated in significant quantities in the North Central Texas region, and quantities are expected to increase with increased population and economic activity in the coming decades. Because of its material properties, food waste presents high biogas generation potential. Food waste degrades quickly in a landfill, and because of this, diverting food waste from landfills represents significant greenhouse gas (GHG) reduction potential. FOG collected from the food service industry has significant biogas production potential and can be a valuable and desired feedstock to increase biogas quality and power production when co-digested at WWTPs.

- **Target opportunities to utilize biogas currently produced within the North Central Texas region is a high priority feedstock with additional opportunity for fuel conversion.** Biogas is produced at landfills over many years as organic wastes continue to decompose, and materials such as paper and yard waste disposed in landfills over the prior decades represent an embedded biogas resource in the region.

- **Consider medium priority feedstocks, specifically manure and wastewater treatment sludge, for further evaluation.** Although the previous manure digester project in Erath County has been shut down, on-farm digesters for manure management have been used successfully in the U.S. and abroad to produce RNG from biogas. The high density of CAFO manure generation in Erath County suggests that CAFO manure warrants further consideration as a medium priority feedstock.

Additionally, many WWTPs in the region (especially rural areas) do not include AD in the treatment process. Untreated sludge from these facilities may be a suitable feedstock to AD systems at nearby WWTPs for pathogen and odor reduction potential, especially given stakeholder concern that landfills may seek to increasingly restrict, reduce, or cease acceptance of sludge in the future which will necessitate other management options.

- **Yard waste and crop residues should not be prioritized at the present time, as these materials are not as well-suited for organics-to-fuel production via AD.** Yard waste such as branches are valuable to managing high solids byproducts from the AD process via composting (e.g., as a bulking agent, to balance carbon-to-nitrogen ratios), and this material should continue to be diverted for composting. Production of vehicle fuel from commodity crops (e.g., corn-derived biodiesel, AD of sugar beets) generally requires the use of the commodity product (e.g., corn grain, sugar cane) and the residue/waste materials alone have historically been insufficient. Crop residue to RNG conversion facilities are in the infancy stages of development in the U.S. and further project development is necessary to assess commercial viability. Crop residues can instead be converted to bioenergy through direct combustion or densification to fuel pellets for heating, and to a lesser extent gasification for co-generation of heat and power.

8.2 Collection Networks

Collection networks in the region are critical to advancing organics-to-fuel projects based on the need to consistently receive deliveries of source-separated organic feedstocks. The collection network evaluation provided a comparative analysis of the operational and financial requirements to collect food waste generated throughout the North Central Texas region.

The collection network evaluation considers the costs of collecting all food waste generated for comparison purposes and is not intended to evaluate the full cost of operating a collection network (e.g., costs related to tipping fees, profit margins or other administrative costs were not included in the evaluation). Additionally, the evaluation is not intended to provide projections of organics collected separately from refuse.

The following key findings and recommendations are based on the analysis presented in Section 3.0:

Key Findings

- **Collection networks and equipment vary by customer and material type.** Collection networks for food waste from residential generators are typically cart-based compared to commercial generators which are typically collected via dumpster. Food waste processed into a slurry and stored at the generator site and FOG from the commercial sector can also be serviced via vacuum trucks.

- **Management of unprocessed commercial food waste requires additional equipment.** Management and storage of food waste requires a dedicated dumpster, available storage space and potentially a dedicated enclosure. To collect the estimated 384,000 tons of unprocessed food waste from restaurant and food service generators in the North Central Texas region, customers would need to obtain additional storage equipment on a widespread basis.

- **Collection from commercial food waste generators located in downtown or commercial districts increases route density.** Longer distances to collection infrastructure and lower route densities reduce the operational efficiency of collection networks. Route-based collection operations that can minimize drive time between customers and time off-route can provide more cost-effective service.

- **Collection of food waste slurry can be collected more efficiently due to pre-processing at generator site.** Slurry collection is estimated at $6.08 per cubic yard (CY) compared to $7.36 per CY at unprocessed collection locations. Although there is more food waste generated at food service and restaurant locations throughout the region, fewer required number of annual services for slurry collection drives down the cost on a per CY basis and makes collection more efficient if material is pre-processed by the generator.

- **Food waste from residential customers in high-density areas can be collected more efficiently compared to low-density or rural areas.** There is a larger volume of food waste generated by residences in high-density areas compared to low-density and rural areas, about 342,000 tons per year in high-density areas compared to low-density areas at about 205,600 tons per year and rural areas at about 72,900 tons per year. Additionally, the increased customers per route allow collection operators to service high-density areas more efficiently and low-density or rural areas may utilize drop-off stations rather than curbside collection.

- **Food waste collection from residential customers in high-density regions is more cost-effective compared to low-density or rural areas.** Collection cost is estimated at $4.47 per household (HH) per month for high-density areas, compared to $5.37 per HH per month in low-density areas and $7.06 per HH per month in rural areas.

- **Residential high-density, commercial slurry collection, and commercial unprocessed collection networks are most cost-effective.** Commercial slurry collection is most cost-effective at an estimated $72.30 per ton followed by commercial unprocessed collection at $87.43 per ton and $156.42 per ton for high-density residential collection. Collection of slurry requires fewer services per customer compared to the other collection types, and although there would be less available food waste available for collection compared to the other collection networks, it is still most cost-effective on a per ton basis.

Recommendations

- **Evaluate pilot projects that collect food waste and FOG from commercial customers.** The most cost-effective collection networks on a per ton basis are in the commercial sector. Selected pilot projects should be evaluated based on the development of collection networks primarily from the commercial sector.

- **Residential collection of food waste from high-density areas is possible and should be considered in applicable systems but presents implementation challenges.** Residential food waste collection in high-density residential areas should be considered, but may encounter implementation challenges due to low participation, high contamination rates, and high costs.

- **Leverage pilot project locations that have existing established collection networks for post-consumer commercial organics.** Pilot projects that would receive food waste from existing collection networks (e.g., residential and commercial routes already in place) at locations close to where material is currently aggregated or disposed are best positioned for project feasibility. Operators of collection networks will become key components of any pilot projects and if material is currently disposed at a facility close to the selected pilot projects it will temper rising costs associated with increased distance to disposal.

- **Support on-site processing and collection via vacuum trucks for transportation to pilot projects.** Although there are few commercial locations that pre-process food waste for storage of slurry on site and delivery to a processing facility with AD units, supporting the expansion of on-site processing equipment will increase the viability of potential pilot projects and future organics-to-fuel efforts in the region.

8.3 NGV Fuel Demand

Existing and potential future natural gas vehicle (NGV) adoption supports organics-to-fuel projects by providing long-term demand for RNG produced. The NGV fuel demand evaluation estimates the current compressed natural gas (CNG) consumption in the North Central Texas region, indicates the NGV fleet types that should be prioritized for further CNG adoption and provides considerations for hydrogen fueled vehicles. The following key findings and recommendations are based on the analysis presented in Section 4.0:

Key Findings

- **High-volume NGVs make up the current and potential future RNG demand in the North Central Texas region.** The Project Team identified solid waste collection vehicles, tractor-trailers, buses and light-duty delivery vehicles as high-volume NGVs and focused evaluation of natural gas demand on those vehicle fleet types. Although passenger vehicles and industrial equipment utilize natural gas engines, based on discussions with stakeholders these are not a key target for increased RNG adoption.

- **Solid waste collection vehicles have the highest rate of adoption among high-volume NGV types.** The estimated adoption percentage for solid waste collection vehicles is 10.8 percent, followed by buses at 7.1 percent and tractor trailers at 0.9 percent. Transit buses operated by transit authorities represent a total of 1,675 vehicles and are estimated to have an adoption rate of ranging between 40 and 62 percent, significantly higher than the total buses. Solid waste collection vehicles and transit buses have the highest adoption rate among high-volume NGVs, demonstrating commercial viability.

- **Buses consume the highest amount of fuel on an annual per vehicle basis among high-volume NGV types.** NGV buses (both transit buses and other bus types) consume the highest volume of natural gas on an annual per vehicle basis, estimated at about 11,300 gasoline gallon equivalents (GGE) per vehicle, followed by tractor-trailers at 7,400 GGE and solid waste collection vehicles at 2,600 GGE.

- **The Texas Clean Transportation Zone presents a successful model for promoting NGV adoption.** The Texas Clean Transportation Zone enables large multinational companies to operate natural gas-powered tractor-trailer and light-duty delivery fleets along these corridors. This model could also potentially apply to future hydrogen vehicle fuel corridors along the same routes.

- **Battery electric vehicles (BEVs) are being piloted for solid waste collection vehicles, buses and tractor-trailers.** Although BEVs are not as beneficial from a lifecycle perspective compared to NGVs, BEVs present an environmentally beneficial alternative fuel. BEVs are perceived by some as a better solution for short and medium-haul routes, although recent demonstration projects have raised challenges including high up front capital costs and maintenance expenses.

- **Hydrogen fueling infrastructure is not commercially available on a widespread basis, but can be produced by further processing RNG.** Although the infrastructure for hydrogen fueling has not yet been implemented, it presents an opportunity to further displace diesel and minimize vehicle emissions.

- The Texas Department of Motor Vehicles (TxDMV)'s *Study on Imposing Fees on Alternatively Fueled Vehicles* indicates that for every electric vehicle on the road, the state of Texas loses $100 per year in state fuel tax revenue. The report examines the impact of alternatively fueled vehicles on the State's motor fuel tax revenue and the feasibility and desirability for establishing a registration fee for alternatively fueled vehicles as well as other revenue-generating options. The financial loss is expected to negatively impact transportation system funding in the state and the study recommends the implementation of increased vehicle registration fees for alternatively fueled vehicles to offset the losses to motor fuel tax revenue.

- Cost is a key barrier for NGV adoption, especially for fleets using an independent contractor model with less centralized control over vehicle ownership. Transitioning a fleet to natural gas requires a significant capital investment for on-site fueling infrastructure and there is competition from other alternative fuel types. With relatively long replacement cycles, making major investments in centralized fleets (e.g., solid waste collection vehicles, tractor-trailers, transit buses) is a challenging decision for fleet owners/operators.

Recommendations

- **Leverage opportunities with each of the high-volume NGVs identified for increased adoption in the North Central Texas region.** Due to the many factors that go into decisions on when to invest in new vehicles (e.g., lower fuel pricing of natural gas compared to diesel) and which fuel type best fits the organization's operations and goals, a portfolio approach to prioritizing the increased NGV adoption among solid waste collection vehicles, tractor-trailers, and buses (including both transit buses and charter buses) would best support the development of organics-to-fuel projects in the region.

- **Minimize cost barriers to increasing NGV adoption by leveraging funding and incentive opportunities.** Large fleets with company-owned vehicles can make significant capital investments in vehicles and fueling infrastructure, allowing for fleet-wide investment to transition to NGVs. Supporting the increased adoption by leveraging funding opportunities and the Texas Clean Transportation Zone to minimize operating challenges (e.g., limited number of CNG fueling stations) will support increasing adoption of solid waste collection vehicles, buses, and tractor-trailers.

- **Explore opportunities to generate hydrogen through steam reformation for use as vehicle fuel.** Although the infrastructure for widespread hydrogen fueling does not exist yet, there are opportunities to fund demonstration projects and develop pilot projects that focus on local fueling stations to support increased adoption of this alternative vehicle fuel over time.

8.4 Supply-Demand Analysis

The supply-demand analysis compares the NGV fuel demand scenarios to the potential supply of RNG from high priority feedstocks. This analysis provided insight into the relative demand that could be met by the priority feedstocks and collection scenarios and informed the locations and feedstocks for inclusion in the pilot project location screening.

The following key findings and recommendations are based on the analysis presented in Section 5.0:

Key Findings

- **The geographic areas of greatest NGV fuel demand and potential RNG supply align in the region.** Collin, Denton, Dallas, and Tarrant counties represent the areas of highest current NGV fuel demand and potential RNG supply. These areas also include the majority of existing NGV fueling stations to help facilitate the use of RNG derived from the identified organics-to-fuel feedstocks.

- **Landfill gas provides the largest opportunity for RNG supply.** On a GGE basis, existing landfill biogas resources represent the largest RNG supply opportunity of over 65 million GGE per year (including current RNG projects, electricity generation projects, and landfills with gas collection but no beneficial use). Landfill biogas also represents an organics-to-fuel pathway to leverage the biogas from materials discarded in prior years, including those that may not be well-suited for AD such as yard trimmings and brush.

- **CAFO activity in Erath County presents an opportunity for manure management via AD.** While manure has a lower biogas generation potential on a per-ton basis than other organics (e.g., food waste, FOG), the large concentration of CAFOs in Erath County presents a potential opportunity for RNG production via a central AD facility for manure management. Based on estimated manure generation rates, CAFOs represent a potential RNG supply of over 6.8 million GGE per year. There can be challenges with dry lot dairy CAFO operations, which represents the primary CAFO activity in the North Central Texas region, due to the manured collection methods and lower stall density compared free stall dairies more typical in the Midwest. Dry lot RNG project development has been limited to date to a handful of projects in North America, some of which have been shut down due for financial reasons. For this reason, few if any dry lot RNG projects are known to currently be in development.

- **Meeting aggressive organics-to-fuel and NGV adoption targets would require leveraging multiple potential sources of RNG supply.** No single feedstock provides sufficient supply to meet all potential total demand scenarios described in Section 4.0; however, current LFG-to-RNG projects provide enough supply to meet the demand targets. To support increased adoption of NGVs through increased RNG fuel supply, multiple materials or approaches should be considered.

- **Solid waste collection NGV adoption targets are most achievable.** Due to comparatively lower annual fuel demand and fleet size (relative to tractor-trailers and buses), all potential RNG supply scenarios included in Section 4.0 meet or exceed at least one of the demand scenarios for solid waste collection vehicles. The proximity of existing waste collection fleets (and fueling yards) and landfill biogas resources suggests this may be an optimal industry to initially target for further increases in NGV adoption.

Recommendations

- **AD projects for consideration should be within the Targeted Organics Collection Area.** Use of the POWER Framework and additional screening to identify optimal digester locations and potential pilot projects should focus within Collin, Dallas, Denton, Erath, and Tarrant counties (the "Targeted Organics Collection Area"). Collin, Dallas, Denton, and Tarrant counties each have over 10 million GGE of potential RNG supply from food waste and existing biogas resources. In these areas, co-digestion projects should be targeted to divert high priority feedstocks such as residential and commercial food waste and FOG, and consideration should be given to projects that are co-located with existing biogas resources. Projects in Erath County should focus on the potential RNG supply of over 6.8 million GGE per year from CAFO manure.
- Consider the proximity to potential NGV fleets and existing natural gas transmission pipelines when evaluating AD pilot projects. Connecting RNG production to NGV demand requires the local transmission and distribution of RNG to fueling and fleet locations. This can be achieved most cost effectively when RNG is produced nearby to an existing fueling station, offloading facility, or pipeline. In these instances, RNG can be delivered via local transmission and distribution piping. Otherwise, delivery to market may require compressing RNG for over-the-road trucking to an fueling station or offloading facility.
- **Support efforts and opportunities to upgrade existing landfill gas systems to produce RNG.** An estimated 22 million GGE of potential RNG supply exists from landfill gas (LFG) from electricity generation projects and landfills with gas collection but no beneficial use. Upgrades at existing LFG-to-electricity sites may be technically feasible but require financial investment. Other sites may be considered too small, but developing technologies for small-scale biogas projects may allow for these projects to be feasible in the future.

8.5 Pilot Project Location Screening

The pilot project location screening process evaluated potential locations in the Targeted Organics Collection Area utilizing the POWER Framework and additional screening criteria to identify optimal digester locations. The following key findings and recommendations are based on the analysis presented in Section 6.0:

<u>**Key Findings**</u>

- **The Optimization Tool of the POWER Framework evaluated 96 locations in the Targeted Organics Collection Area.** The inventory of regional sites for further screening included landfills, LFG-to-electricity, LFG-to-RNG, transfer stations, mulching and composting facilities, liquid waste treatment facilities, and WWTPs with and without AD units. Additionally, five greenfield facilities were considered.

- **There were 48 facility locations identified by the Optimization Tool for further screening.** The Optimization Tool compared the 96 locations based on 20 percent capture and 60 percent capture of residential food waste, commercial food waste and commercial FOG. The Project Team considered the results of 20 percent capture rate as the primary screening because 20 percent capture rate of feedstocks is more achievable based on industry experience. The 60 percent capture rate was used as a sensitivity analysis to identify facility locations that would only become optimal if the capture of material was operating at high efficiency.

- **The locations identified do not represent all potentially feasible sites in the North Central Texas region.** The Optimization Tool is designed to identify the most suitable locations for a potential pilot project. There may be sites inside and outside of the Targeted Organics Collection Area that would support an organics-to-fuel project. The screening process is not meant to eliminate other locations for consideration, but rather prioritizes the facility locations to provide direction for further evaluation of potential pilot projects that can be pursued in the near-term.

- **The most advantageous facility locations at existing landfills, transfer stations, mulching and composting facilities, and WWTPs were advanced to the short-list.** Liquid waste processing facilities and greenfield facility sites could be considered for further evaluation in the future, but are considered least feasible based on key project feasibility criteria. Table 6-10 provides the complete listing of short listed facilities.

Recommendations

- **Further evaluate the City of Dallas Southside WWTP and City of Denton Landfill Complex as potential pilot projects.** Based on discussion with the Project Advisory Group (PAG), these two facilities are currently at the highest level of readiness compared to the other short-listed facilities and have been selected for further evaluation by the Project Team.

- **Consider further evaluation of the other short-listed facilities for potential increased diversion of food waste and FOG.** While other short-listed facilities are not further evaluated as part of this Study, they should be considered for further evaluation going forward as entities in the North Central Texas region continue to increase efforts to divert organics from disposal, displace diesel vehicles, or provide regional solutions for sludge management.

8.6 Pilot Project Feasibility Evaluation

The Project Team evaluated two scenarios for co-digestion of food waste and FOG. The Dallas pilot project scenario analyzes the impacts of accepting an additional 43,300 tons of pre-consumer commercial food waste and 9,300 tons of FOG at the Dallas Southside WWTP. The Denton pilot project scenario analyzes the impacts of accepting an additional 10,350 tons of pre-consumer commercial food waste, 1,640 tons of post-consumer residential food waste, and 2,060 tons of FOG. While the Project Team collaborated with the cities of Dallas and Denton to develop the information included in the Study, neither city is obligated to implement the recommendations included in the Study as there is a need for further technical, financial and policy decisions to be made prior to any final actions. The following key findings and recommendations are based on the analysis presented in Section 7.0:

Key Findings

- **The Southside WWTP has sufficient capacity in its AD units to accept additional tonnage of food waste and FOG, but requires key infrastructure upgrades to accept material on a consistent basis.** The Southside WWTP accepts an inbound flow of 50-55 million gallons per day (MGD), treats an estimated 3 MGD of wastewater sludge, and discharges treated water effluent into the Trinity River. The facility currently operates with about 55 MGD of excess capacity across the entire facility as a result of previous city-wide water conservation efforts that reduced the incoming wastewater volume dramatically. While the capacity of the AD units is sufficient for additional feedstock, further evaluation is required to determine the AD units' loading capacities with co-digestion (as compared to the plant-wide available capacity). Additionally, the facility is not designed to accept material from solid waste collection vehicles on a consistent basis, or to pre-process, store, and pump off-site material into the existing AD units.

- **The Denton Landfill Complex contains several co-located facilities that support organics-to-fuel feasibility, but requires key infrastructure upgrades to accept material on a consistent basis.** The Denton Landfill complex includes the Denton Landfill, Pecan Creek WWTP, Dyno Dirt Composting facility, CNG vehicle fueling station, and landfill gas processing facility; however, the Pecan Creek WWTP is not designed to accept solid waste materials as influent. Solid waste feedstocks (e.g., yard waste, food waste, sludge) are accepted at the Dyno Dirt composting facility, and the Pecan Creek WWTP is not designed to accept material from solid or liquid waste collection vehicles directly. However, the City of Denton is in the process of procuring equipment for grinding source-separated organics for co-digestion at the Pecan Creek WWTP and is pursuing the development of an LFG-to-RNG project.

- **Adding food waste and FOG feedstock quantities determined for each pilot project scenario would increase biogas yields.** Based on the planning-level evaluation generated utilizing the POWER Tool, processing the estimated 52,620 tons of food waste and FOG for co-digestion at the Dallas Southside WWTP could generate 27,500 m^3/day of pipeline quality RNG and significantly decrease emissions compared to landfill disposal. Processing the estimated 14,050 tons of food waste and FOG for co-digestion at the Pecan Creek WWTP could generate an additional 5,930 m^3/day of pipeline quality RNG and decrease emissions compared to composting processing.

- **Both pilot project scenarios would result in decreased emissions compared to current disposal practices.** As part of the Dallas pilot project scenario, processing the additional tonnage through AD units compared to landfilling would result in a significant decrease in emissions (see Table 7-3). As part of the Denton pilot project scenario, processing the additional tonnage through AD units compared to composting would result in some emissions decrease, but not as much as the Dallas pilot project scenario (see Table 7-6).

- **Both pilot project scenarios could provide a potential regional solution for sludge processing and/or disposal at local WWTPs in Denton and Dallas Counties, but would require further evaluation.** There are 10 WWTPs generating an estimated 137,000 annual dry metric tons of sludge in Dallas County and 23 WWTPs generating an estimated 37,000 dry metric tons of sludge in Denton County. There is a demonstrated need among the WWTPs that do not have AD and/or on-site storage or disposal capacity in Dallas and Denton County for a cost-effective and technically feasible solution for sludge disposal. The feasibility of a regional solution would need to be determined by working directly with the potential stakeholders to determine plant-by-plant sludge solids content, average sludge production, and anticipated hauling frequencyand the available capacity of the potential pilot projects.

- **There are likely minimal wetland- and floodplain-related challenges for the pilot project scenarios, but there may be Texas Commission on Environmental Quality (TCEQ) permitting considerations that must be addressed.** Accepting material as a waste for disposal (e.g., food waste, FOG) through AD would not present a challenge if the pilot project scenarios are able to expand on existing TCEQ authorization (e.g., expanding FOG acceptance at the Southside WWTP and expanding food waste acceptance at the Denton Landfill Complex). However, further permit evaluation is required to ensure that the additional feedstock would not exceed the existing permit authorizations. Additionally, feedstock would need to be considered essential to the operation of the AD process so it would not be mischaracterized as "sham recycling."
- **The locations of the pilot project scenarios require further consideration of impacts that may disproportionally impact underserved communities.** Based on the environmental justice evaluation of poverty threshold, limited English proficiency, and minority population as presented in Section 7.3.5, emissions reductions associated with the pilot project scenarios would be a benefit to nearby communities and could be leveraged to attract funding.
- **There are numerous funding incentives and opportunities related to the generation of RNG, hydrogen fuels, and biosolids management**. Both pilot project scenarios could be supported, in part, by funding and incentives related to minimizing environmental impacts to underserved communities, alternative fueling grants, and the generation of environmental credits (e.g., renewable fuel standards (RFS), renewable energy certificates (RECs), carbon offset credits). Additionally, there is available funding to pursue hydrogen demonstration projects and alternative fueling infrastructure.

Recommendations

- **Conduct additional engineering and financial analysis to advance the development of the Dallas pilot project scenario as a viable co-digestion project at the Southside WWTP for pipeline-ready RNG.** Additional engineering and financial analysis should include determining the most cost-effective and technically viable approach to 1) upgrade receiving infrastructure, install feedstock storage equipment, and gas conveyance equipment at the Southside WWTP; 2) convey biogas to the gas processing plant at the McCommas Bluff Landfill (e.g., by installing a direct pipeline or compressing gas on site for trucking) or construct gas scrubbing equipment at the Southside WWTP; and 3) generate renewable identification numbers (RINs) based on the volume of RNG that could be utilized by the City of Dallas Sanitation Department solid waste collection vehicles and other existing local CNG fueling stations. Developing these capital upgrades at the Southside WWTP in parallel with securing feedstock delivery and biogas offtake agreements will further support project financing.

- **Conduct additional planning and evaluation to determine the most appropriate technology and feedstocks within the Denton Landfill Complex for the Denton pilot project scenario.** The AD technology could include the installation of a separate high-solids modular digester for processing food waste, FOG, and yard trimmings; or the expansion of the existing low-solids continuous-flow digester units for co-digestion of food waste and FOG. Additional evaluation should also explore the most effective approach to generating environmental credits for both this potential project and the ongoing LFG-to-RNG effort.

- **Explore options in both pilot project scenarios to accept sludge from other WWTPs in the region as part of a hub-and-spoke system.** Establishing an interlocal agreement (ILA) to accept sludge from other WWTPs as part of either pilot project scenario would present a technical solution for sludge management but may encounter challenges depending on the amount of pre-processing, moisture content, and delivery frequency of sludge material for processing. A regional approach would require significant stakeholder outreach further evaluation to establish an ILA and determine if the costs and benefits to each stakeholder would support such an approach. Additionally, there may be an opportunity to process sludge with other feedstocks such as biomass and tire-derived fuels using an alternative conversion technology (e.g., gasification, pyrolysis) to produce hydrogen and biochar; however, there are currently limited proven commercial-scale facilities operating on a continuous basis in the U.S.

- **Explore funding incentives and opportunities available through recent federal legislation, environmental credits, reducing environmental impacts on underserved communities, and alternative vehicle fueling grants for both pilot project scenarios.** Funding incentives and opportunities can support the viability of project financials and attract partners to engage in public-private partnerships. In the near-term, leveraging recently updated investment tax credit (ITC) benefits (e.g., up to 30 percent credit with additional 10 percent credits for both domestic content and energy community, potentially resulting in a 50 percent tax credit) available through the Inflation Reduction Act can minimize project expenses and increase the financial feasibility of pilot project scenarios. Additionally, applying for sustainable materials management grants, regional equipment/consulting grants, and alternative fueling funding will have a high chance of success due to the associated mitigation of environmental impacts on underserved communities. Finally, establishing the contractual relationships to generate of D5 RINs as part of the RFS would support public-private partnership and the development of mutually beneficial long-term contracts.

APPENDIX A
SUMMARY OF STAKEHOLDER ENGAGEMENT

A. - SUMMARY OF STAKEHOLDER ENGAGEMENT

This appendix summarizes the stakeholder engagement efforts conducted as a part of this Study. Stakeholder engagement was a critical aspect of understanding the regional feedstocks, identifying potential pilot projects, and developing recommendations that align with the needs of the diverse set of stakeholders in the North Central Texas region. The primary stakeholder engagement efforts included in the Study were virtual interviews and multiple Project Advisory Group (PAG) workshops.

Interviews

Throughout the development of the Study, several virtual interviews were conducted by the Project Team. The following provides brief summaries of the discussions:

- **Composting companies in the North Central Texas Region.** The Project Team interviewed representatives from three companies representing the majority of privately-operated composting facilities and composted tonnage in the North Central Texas region. Interviews were conducted throughout February – April 2022 to discuss materials and quantities accepted, capacity, and existing equipment for grinding and/or composting. Information provided by these facilities was used to inform the feedstock generation and composting estimates presented in Section 2.0 and the identification of optimal potential pilot project locations in Section 6.0.

- **Insinkerator.** The Project Team interviewed representatives from Insinkerator's Grind2Energy program in June 2022 to discuss operational considerations associated with commercial food waste collection via slurry tank. Information provided by Insinkerator was used to validate assumptions used in the collection network evaluation (e.g., time to service slurry tanks) for relevant commercial subsectors (i.e., food manufacturers and processors, institutions, hospitality industry, healthcare facilities, and correctional facilities).

- **Texas Natural Gas Vehicle Alliance (TXNGVA).** The Project Team interviewed representatives from TXNGVA on March 16, 2022, to discuss major policy accomplishments from recent years and trends in the alternative fuel industry. TXNGVA identified three niche markets for natural gas vehicles (NGVs), two of which are dominated by natural gas fuel: solid waste collection vehicles and transit buses. Long haul trucking, as the third niche market, has had more volatility in adopting NGVs.

- **Clean Energy Fuels Corp (Clean Energy).** The Project Team interviewed representatives from Clean Energy on March 17, 2022, to discuss the company's role in supplying natural gas to vehicle fleets in the North Central Texas region. Clean Energy indicated that the Dallas Area Rapid Transit (DART) system, City of Dallas, DFW Airport, Trinity Metro and various private solid waste collection fleets currently utilize NGVs.

- **City of Dallas Waste Utility.** The Project Team interviewed representatives from Dallas Water Utilities (DWU) on June 28, 2022, to discuss technical specifications and co-digestion feasibility at the City of Dallas Southside WWTP. Information provided by DWU was used in the evaluation of the potential pilot project presented in Section 7.0.

Workshops

Throughout the development of the Study, several workshops were held by the Project Team with the PAG (see Section 1.1.1 for a description of the PAG and Table 1-2 for a listing of its members). The following provides brief summaries of the workshops:

- **Workshop #1: Stakeholder Kick-Off Workshop & SWOT Analysis.** Workshop #1, held on November 30, 2021, included an overview of the project, real world perspectives and examples, and a strengths, weaknesses, opportunities, and threats (SWOT) analysis.

- **Workshop #2: Supply and Demand Analysis Workshop.** Workshop #2, held on March 29, 2022, included the preliminary results of the feedstock supply analysis, natural gas vehicle (NGV) fuel demand analysis, and collection network analysis. The workshop also presented an overview and examples of the types of projects to be further considered as part of the Study.

- **Workshop #3A: Potential Pilot Projects Workshop (Part 1).** Workshop #3A, held on July 12, 2022, included final results of the feedstock, collection network, and NGV prioritization evaluations. The workshop also presented the proposed pilot project location screening process and targeted areas for further evaluation.

- **Workshop #3B: Potential Pilot Projects Workshop (Part 2).** Workshop #3B, held on August 30, 2022, included results of the location screening analysis performed in the Targeted Organics Collection Area and presented the optimized short-list of potential pilot sites. The PAG provided feedback to finalize the short-list so that the Project Team could complete the detailed evaluation of the elected potential pilot project sites (City of Dallas Southside WWTP and City of Denton Landfill Complex).

- **Workshop #4: Final Feasibility Study Workshop.** Workshop #4, held on September 20, 2022, included the results of the detailed evaluations of the selected potential pilot project sites (City of Dallas Southside WWTP and City of Denton Landfill Complex), including POWER Tool modeling of technical and environmental impacts and GIS screening of existing infrastructure, byproduct management, environmental permitting, and environmental justice considerations. The workshop also presented funding and incentives opportunities and feasibility key findings and recommendations.

Meeting summaries and/or workshop slides are provided in Attachment A1 for each workshop.

ATTACHMENT A1 - WORKSHOP SUMMARIES AND PRESENTATION SLIDES

WORKSHOP #1

BURNS & McDONNELL

North Central Texas Organic Waste to Fuel Feasibility Study

PAG Kick-Off Workshop
November 30, 2021 | 2 p.m. – 3:30 p.m.

Workshop Attendees

Project Advisory Group

- Brendan Lavy, TCU
- Courtney Carroll, Fort Worth ISD
- Jaime Bretzmann, City of Plano
- Joao Pimentel, City of Fort Worth
- Katelyn Hearon, City of Lewisville
- Kathy Fonville, City of Mesquite
- Lynn Lyon, US Gain
- Sahana Prabhu, Texan by Nature
- Yarcus Lewis, City of Plano

Study Team

- Breanne Johnson, NCTCOG
- Lori Clark, NCTCOG
- Soria Adibi, NCTCOG
- Cassidy Campbell, NCTCOG
- Melanie Sattler, UTA
- Scott Pasternak, Burns & McDonnell
- Scott Martin, Burns & McDonnell
- Tiffany Moss, Burns & McDonnell
- Andrew Mitrisin, Burns & McDonnell
- Eric Weiss, Burns & McDonnell
- Matt Tomich, Energy Vision
- Phil Vos, Energy Vision

Workshop Overview

The Project Advisory Group (PAG) has been formed to provide technical guidance and regional expertise as the study explores the potential for organic waste, anaerobic digestion, and renewable natural gas (RNG) technologies in the region. The PAG Kick-Off Workshop held on November 30, 2021 included an overview of the project, real world perspectives and examples and a SWOT analysis. Three additional workshops will be held in the first half of 2022 (dates have not yet been determined) to review study data and gather additional input from the PAG.

SWOT Analysis

A SWOT Analysis was conducted to identify strengths, weaknesses, opportunities and threats that will need to be evaluated during the study. Responses for each category are provided below.

Strengths

- Air quality betterment in a non-compliant region
- Food/organic composition of the municipal solid waste
- Huge available feedstocks, local government interest in new technologies
- Lots of corporate headquarters in Plano in case there is need for additional corporate funding
- Existing oil, gas and chemical infrastructure outside of region in Texas
- Demand for biosolid management other than land application
- Several cities have organic waste programs, mostly yard waste diversion, in the region and a few have anaerobic digestors. Within the transportation sector, there are probably many opportunities to create demand for renewable gas within corporate fleets. Also, great regional partners with academic institutions and environmental groups to support this effort.
- S - Industry leadership with companies like WM and end users like DFW Airport, Texas understands CH_4, strong infrastructure with Texas triangle
- Other than landfill projects, of which there are already quite a few, there's a lot of potential for developing projects in wastewater, food waste, agriculture
- Limited regional landfill air capacity
- Availability of organic waste. Multiple interested stakeholders in the region.
- Regarding food waste, it seems like contamination is the trickiest part of collection

Weaknesses

- Wastewater treatment plants (WWTPs) hesitant to accept food waste or require major capital upgrades to process into RNG
- No statewide RNG incentive programs
- Large capital cost
- The cost of infrastructure
- Lack of infrastructure
- Landfill gas (LFG) competes with AD operations
- Existing landfill gas (LFG) operations
- The sheer size of the metroplex and the impact on transportation costs
- Lack of understanding carbon intensity (CI) scores
- Data is not comprehensive; hard to determine the number of processing facilities in the region
- In some ways, agricultural waste may be a limited resource. Cattle RNG projects are generally dairy, beef cattle produce less manure and less biogas. Also, open lot feed yards promote drying out and contamination of manure.

- Lack of resources in rural communities
- Evolving end-game for the generated gas
- Lack of understanding what RNG is, called "greenwashing"
- Would echo mention of "greenwashing" critique of RNG
- Cost of converting to anaerobic digestion. Cost/difficulty converting fleet to RNG.
- Few existing organics collection networks

Opportunities

- Substantial wastewater infrastructure in DFW region
- Commercial organics diversion (e.g., F&B, produce suppliers, etc.)
- Public/private partnerships
- Lots of opportunities for collaboration between local governments, private entities, and educational institutions, etc.
- Grant funding for infrastructure. Collaboration between local government and industry.
- Leverage existing infrastructure
- Leverage area expertise with CH_4
- Hyliion trucks combine RNG and electric drive train Cummins 15L coming soon

Threats

- Cost of implementation vs. relative inexpense of continued landfilling
- Cost of implementation
- Challenges guaranteeing feedstock uniformity and volume make it hard to finance capital projects/new build digesters
- Issue of contamination not being solved
- Electrify everything – all eyes on electric vehicles (EVs) and policy dollars
- Advancement in electric vehicles
- Pushback on pipelines
- Focusing too much on zero emissions
- Lack of demand for digestate product
- Difficulty connecting with landowners
- Lack of political will
- Misinformation about RNG

BURNS McDONNELL

North Central Texas Organic Waste to Fuel Feasibility Study

Project Advisory Group
Kick-Off Workshop
November 30, 2021

AGENDA

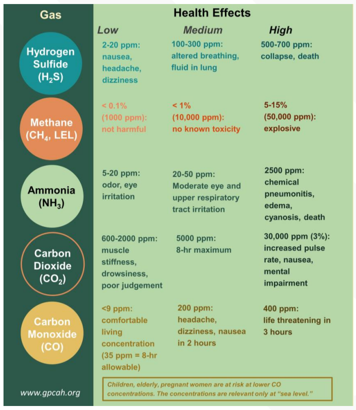
- Safety Moment
- Welcome & Introductions
- Project Overview
- Real World Perspectives
- SWOT Analysis
- Final Thoughts & Questions
- Next Steps

Virtual Meeting Reminders

1. Please leave your microphone muted unless speaking
2. Use the chat box or raise hand button to ask a question or provide a comment
3. Please state your name prior to asking a question a making a comment
4. Please note that the presentation is being recorded

Safety Moment

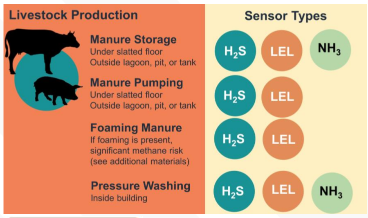
Biogas Safety Awareness

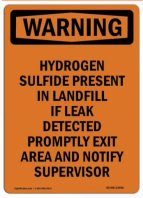


Gas	Health Effects: Low	Medium	High
Hydrogen Sulfide (H_2S)	2-20 ppm: nausea, headache, dizziness	100-300 ppm: altered breathing, fluid in lung	500-700 ppm: collapse, death
Methane (CH_4, LEL)	< 0.1% (1000 ppm): not harmful	< 1% (10,000 ppm): no known toxicity	5-15% (50,000 ppm): explosive
Ammonia (NH_3)	5-20 ppm: odor, eye irritation	20-50 ppm: Moderate eye and upper respiratory tract irritation	2500 ppm: chemical pneumonitis, edema, cyanosis, death
Carbon Dioxide (CO_2)	600-2000 ppm: muscle stiffness, drowsiness, poor judgement	5000 ppm: 8-hr maximum	30,000 ppm (3%): increased pulse rate, nausea, mental impairment
Carbon Monoxide (CO)	<9 ppm: comfortable living concentration (35 ppm = 8-hr allowable)	200 ppm: headache, dizziness, nausea in 2 hours	400 ppm: life threatening in 3 hours

Children, elderly, pregnant women are at risk at lower CO concentrations. The concentrations are relevant only at "sea level."

www.gpcah.org





WELCOME & INTRODUCTIONS

Introductions

- **Breanne Johnson**
  Environment & Development Planner
  NCTCOG
- **Lori Clark**
  Air Quality Program Manager
  NCTCOG
- **Soria Adibi**
  Senior Air Quality Planner
  NCTCOG
- **Melanie Sattler**
  Civil Engineering Professor & Researcher
  University of Texas at Arlington

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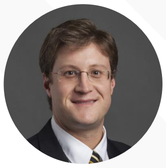
Scott Pasternak
Project Manager
Burns & McDonnell



Scott Martin
Deputy Project Manager
Burns & McDonnell

Tiffany Moss
Strategic Communications
Burns & McDonnell

Drew Mitrisin
Transportation Planning & Policy
Burns & McDonnell

Matt Tomich
President
Energy Vision

Phil Vos
Program Director
Energy Vision

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  The City of Lewisville is interested in finding sustainable options for sludge disposal.
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  Chair of Resource Conservation Council at NCTCOG--interested in how RCC can support this regional initiative.
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  Achieving greater emissions reductions from the dual benefits of redirecting organic waste emissions to displace fossil fuel usage.
- Jaime Bretzmann, City of Plano
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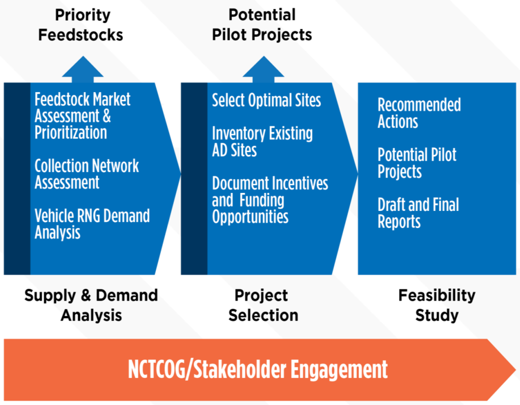
  Assistant Professor of Sustainability Science at TCU and interested in research that supports sustainability transitions in North Texas.
- Courtney Carroll, Fort Worth ISD
  Would like to better understand the possible uses of all the organic waste produced in school cafeterias.
- Sahana Prabhu, Texan by Nature
  I am interested to learn about anaerobic digestion and renewable energy potentials in North Texas.
- Lynn Lyon, US Gain

PROJECT OVERVIEW

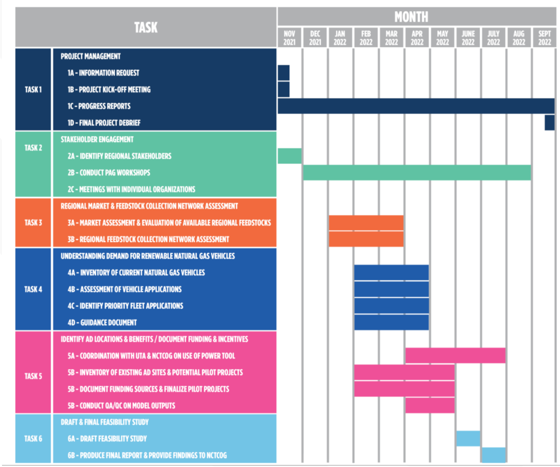
Project Background

- Goal of the study is to assess the feasibility of using of local organic wastes to produce renewable natural gas (RNG) in new or existing digesters within the region and use the RNG as a transportation fuel.
- NCTCOG and UTA partnering on the study which is supported by a grant from the Environmental Protection Agency (EPA).
- Prior to the study, NCTCOG hosted a series of virtual roundtables to share existing anaerobic digestion and organic waste collection efforts in the region.
- As North Central Texas continues to grow, waste diversion will become increasingly important to both retain landfill capacity and reduce methane emissions.

Project Approach



Project Schedule



REAL WORLD PERSPECTIVES

Expansion of U.S. RNG Projects

There are now ~200 operating projects, up from just ~40 RNG facilities in 2015

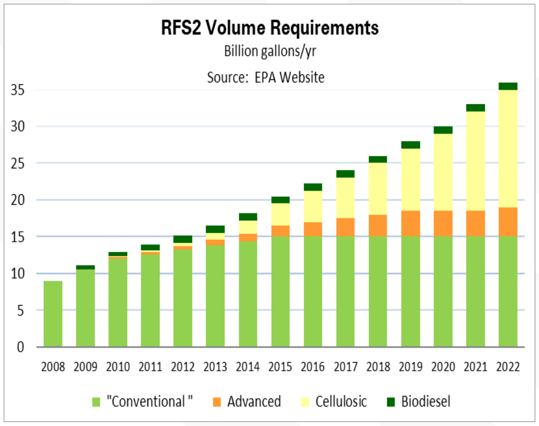
Federal Policy Driver

Renewable Fuel Standard

- **Enacted in 2005 and Amended in 2007**
  "The Ethanol Mandate" but also a push to develop waste-derived fuels
- **Designed to Incent Biofuel Production**
  Requires "Obligated Parties" (e.g., oil producers and refiners) to produce/blend biofuels OR purchase credits (RINs) to meet yearly Obligations

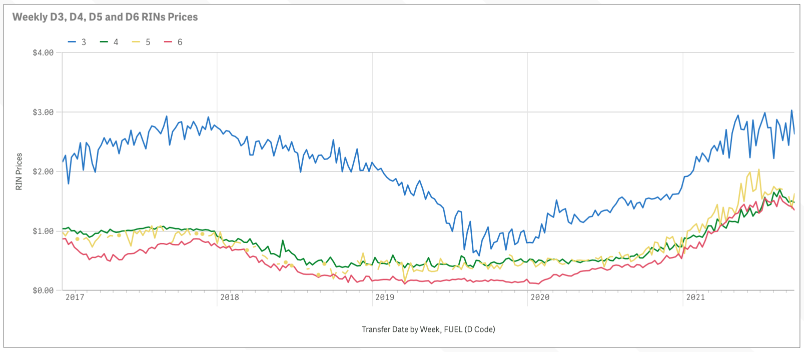
Federal Policy Driver

Renewable Fuel Standard



Federal Policy Driver

Renewable Fuel Standard



State Policy Drivers

Low Carbon Fuel Standards (LCFS)

Existing Policies

- **California**
  First state to implement a LSFS in 2009. Achieved 10% reduction in transport fuels "carbon intensity" in 10 years; mandated 20% target by 2030.
- **Oregon**
  "Clean Fuels Program" passed in 2016. Mirrored after California program and ramping up.
- **Washington**
  Passed LCFS Legislation in 2021

Pending Programs

- **New York State**
  Legislation first introduced in 2019 (pending)
- **New Mexico**
- **Upper Midwest Regional LCFS**
  Legislation introduced in 2021 (pending)

A **Low Carbon Fuel Standard** is a market-based program that mandates reductions in the overall carbon intensity (CI) of fuels used within a given region.

Real World Examples: Two Waste-to-Fuel Case Studies

South San Francisco Scavengers

- Small-scale, closed-loop food and green waste-to-RNG project
- Fueling 10-12 private refuse collection trucks
- "High Solids" in-vessel AD plant equipped to process ~12,000 tons of food and green waste;
- Displacing ~120,000 gallons of diesel fuel per year in the local private refuse fleet

Grand Junction, CO

- 8 MGD Wastewater Biogas-to-RNG for Local Fleets
- Fueling ~40 municipal/county NGVs
- $3M project with anticipated 7-year payback
- Displacing 170,000 gallons of diesel per year

Many additional WWTP co-digestion projects

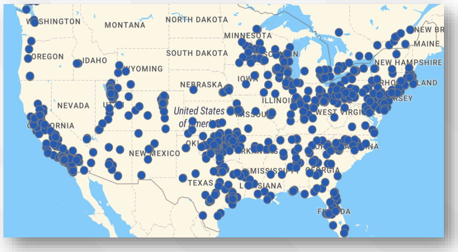
RNG End Markets

- Commercial CNG Fleets (e.g., UPS, Waste Management)
- CNG Fueling Station Companies (e.g., Trillium, US Gain, Clean Energy)
  - California
  - Oregon
  - Washington
- Renewable Fuel Production Facilities
  - Ethanol, Renewable Diesel
- Natural Gas Utilities
  - Cost Recovery States
  - Individual Consumers (voluntary, state based)
    - Institutional Facilities (Universities, Health Care, etc.)
    - Commercial Entities with ESG Commitments / Goals

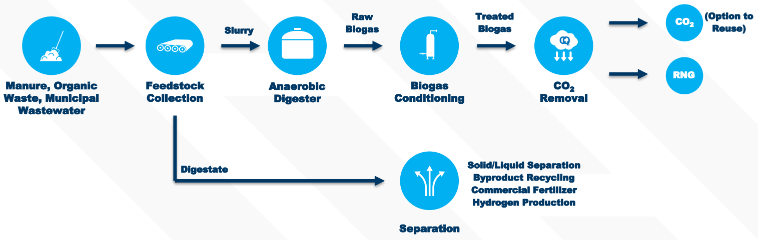
Utility Customer
Pipeline
Renewable Transportation
Renewable Electricity

Institutional O&G – Renewable Investments

- Approximately 20 Natural Gas Utilities
  - Operating in approximately 40 States
- Midstream Companies
  - Corporations and MLP's
- Major Oil Companies
  - BP
  - Chevron
  - Marathon
  - Shell
  - Valero
- Commercial Supply
  - Graphics:
    - USDOE AFDC
    - Clean Cities



Anaerobic Digestion Process Overview



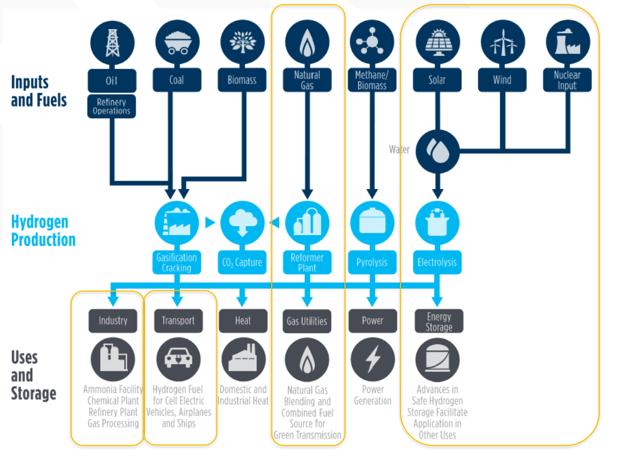
General AD Considerations

- Manure AD
  - Routine collection / conveyance optimizes gas production
  - Water usage drives digester sizing
  - Farmers don't like to be told what to do on their farms
  - Understand nutrient management plan requirements
- Food Waste / Organics AD
  - Contamination in = Contamination out
  - Digestate marketability depends on the quality of the digestate and proximity to end markets
  - State regulations are variable with respect to composting
- Both
  - Develop a robust contingency plans for odor management and facility O&M

Summary

- Agricultural wastes are the fastest growing types of RNG projects
- Food waste / co-digestion starting to gain momentum due to regional food waste policy drivers
- Biogas to Electricity Projects are being converted to RNG Upgrading Projects due to:
  - Decreased market value of renewable electricity
  - Improved ROI given the available market incentives
- Multiple end markets for RNG are considered technically viable
  - Transportation
  - Power (select locations)
  - Commercial/residential use (ESG)
- Feedstock processing and digestate management represent large project costs
- Viable recovery and reuse opportunities of digestate is not a given
- Effective biogas conditioning/treatment is critical to successful project outcomes

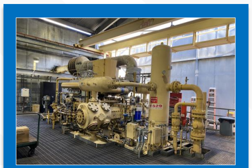
Hydrogen Overview



Hydrogen Project Examples

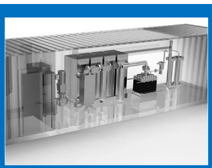
Gas Utility P2H Conceptual Design and Siting Study

- Evaluated the market for P2H and P2G applications identifying electrical and natural gas interconnection facilities for a 10 MW electrolyzer at locations along the distribution system
- 21 locations identified and ranked with an agreed upon site selection criteria
- Two locations chosen to complete a conceptual design and economic study



H2 Blending and Fueling Facility

- Providing detailed design and turn-key pricing on a 2MW Electrolyzer and storage system to blend 10% hydrogen into gas compressor fuel gas
- Includes Engine testing with H2 Blend
- Includes a H2 fueling station for company fleet private use



H2 Pilot Project
Orlando Utilities Commission

- Providing detailed engineering for the overall plant integration of a hydrogen pilot project
- System includes a 90 Nm3/hr electrolyzer, hydrogen compressor, tube trailers for storage, FCEV fueling station, and a 600-kW fuel cell for electricity production

SWOT ANALYSIS

SWOT Analysis

A SWOT analysis is a strategic planning tool used to identify Strengths, Weaknesses, Opportunities, and Threats for a specific project or situation.

Information gathered during the SWOT analysis will be used to identify key issues that will need to be evaluated during the study.

Poll Everywhere

How to Join

WEB

1. Go to PollEv.com/bmcdonnell555
2. Enter your name
3. Type your response

TEXT

1. Text bmcdonnell555 to 22333 once to join
2. Text your response

What are some strengths within the region related to organic waste, anaerobic digestion and renewable gas technologies?

" air quality betterment in a non-compliant region "

" Regarding food waste, it seems like contamination is the trickiest part of collection. "

" food/organic composition of the msw "

What are some weaknesses within the region related to organic waste, anaerobic digestion and renewable gas technologies?

“ Would echo mention of "greenwashing" critique of RNG ”

“ WWTPs hesitant to accept food waste or require major capital upgrades to process into RNG ”

“ No statewide RNG incentive programs ”

What are some opportunities within the region to divert organic waste and generate RNG as a source of fuel?

“ Substantial wastewater infrastructure in DFW region ”

“ Commercial organics diversion (e.g. F&B, produce suppliers, etc.) ”

“ public/private partnerships ”

“ Lots of opportunities for

What are some threats within the region to divert organic waste and generate RNG as a source of fuel?

“ Advancement in electric vehicles. ”

“ Lack of political will ”

“ Lack of demand for digestate product ”

“ Misinformation about RNG ”

FINAL THOUGHTS QUESTIONS?

Next Steps

- Three additional workshops will be held to gather input from the Project Advisory Group
- Topics for each workshop:
  - Workshop #2 – Supply and Demand Analysis
  - Workshop #3 – Project Selection
  - Workshop #4 – Feasibility Study Conclusion
- Dates for the workshops have not yet been determined but will take place in the first half of 2022

THANK YOU!

CREATE AMAZING.

WORKSHOP #2

BURNS & McDONNELL

North Central Texas Organic Waste to Fuel Feasibility Study

Workshop # 2

March 29, 2022 | 9:30 a.m. – 11:00 a.m.

Workshop Attendees

Project Advisory Group

- Katelyn Hearon, City of Lewisville
- Kathy Fonville, City of Mesquite
- Sahana Prabhu, Texan by Nature
- Katie Klein, Town of Shady Shores
- Brandon Evers, City of Dallas
- Susan Shifflett, Texas NGV Alliance
- Julie Winchell, City of Cleburne
- Leanna Kelleher, Shell RNG
- Sergio Gonzalez, Organix Recycling
- Nick Alford, DFWIA
- Darren Turley, Dairy Farmers of America
- Melissa Stewart, Texas Restaurant Association

Study Team

- Breanne Johnson, NCTCOG
- Lori Clark, NCTCOG
- Soria Adibi, NCTCOG
- Cassidy Campbell, NCTCOG
- Edith Marvin, NCTCOG
- Jared Wright, NCTCOG
- Melanie Sattler, UTA
- Scott Pasternak, Burns & McDonnell
- Scott Martin, Burns & McDonnell
- Julie Davis, Burns & McDonnell
- Andrew Mitrisin, Burns & McDonnell
- Eric Weiss, Burns & McDonnell
- Matt Tomich, Energy Vision
- Phil Vos, Energy Vision

Workshop Overview

The purpose of the workshop is to highlight work completed to date by NCTCOG's contractor – Burns & McDonnell – and included an overview of the regional market assessment and feedstock collection network for organics, as well as an understanding of the demand for RNG vehicles.

Feedstock Supply Analysis

- Methodology: estimated quantities of organic material generation based on local and regional studies and plans, waste characterization studies, TCEQ reported data, and population.
- Feedstock supply materials include food waste (residential and commercial), yard waste, brush, manures, crop residue, grease/sludge/biosolids.
- 8.3 million tons of organics generated annually
  - Food waste (25%), yard waste (20%), crop residues (25%), CAFO manures (27%), biosolids (3%)
- Existing biogas generation resources include landfill gas and existing digesters (WWTP and on-farm).
  - 17 landfills (opened and closed) collecting 44,000 scfm of biogas
  - 47 "major" WWTP in NCTCOG, 8 with AD

Fuel Demand Analysis

- Presented an overview of findings related to the fuel demand analysis for natural gas-powered vehicles in the North Central Texas region.
  - Described the methodology used to determine a range of counts of bus, commercial truck and refuse truck vehicles in the region based on Texas Department of Motor Vehicle data and DFW Clean Cities data.
- Presented estimates of current and future natural gas demand for vehicles in the three primary vehicle types, including projects based on realistic scenarios for NGV adoption in the region.
  - To tie the supply and demand analysis together, the project team described how future scenarios compare to existing and potential biomethane supply.
- Demonstrated how existing landfill gas-to-pipeline supply is sufficient to meet incremental increases in natural gas-powered vehicle adoptions and that total collected landfill gas supply is sufficient for further increases in demand beyond what is currently sent to the pipeline.
- Summarized the key findings from two recent stakeholder interviews as well as recent public policymaking activities cited by stakeholders that will increase NGV adoption.
- Presented an overview of the three primary vehicle types prioritized for adoption and why they are attractive candidates for further adoption.

Collection Network Analysis

- Presented an overview of organics collection network types and material types
  - Collection networks include residential, commercial, and agricultural/FOG
  - Material types include bag/bundled yard trimmings/brush, roll-cart based organics collection, and on-site commercial storage of pre-consumer food waste.
- Presented the municipal solid waste collection fleets in the region
  - Indicated if they collect from residential or commercial customers and any fleets that utilize natural gas vehicles
- Brief overview of the commercial solid waste collection markets
  - Discussed considerations related to exclusive/non-exclusive franchises, hauler licensing, and closed markets

- Reviewed Dallas' commercial organics collection pilot and commercial organics slurry collection and processing programs in the market
- Briefly reviewed the materials management infrastructure and ownership in the region
    - Included landfills, transfer stations, commercial composting facilities and wastewater treatment plants with AD capacity
- Discussion of next steps for the collection network analysis
    - Detailed evaluation of collection networks, operational requirements, and evaluation of potential partnership models

Potential RNG to Vehicle Fuel Projects

- Presented an overview of potential projects for further evaluation, including the following:
    - Leverage Existing AD Capacity - City of Dallas Southside WWTP
    - Leverage Existing AD Capacity - City of Denton
    - New Organics Digestion Facility Pilot – Discussed two options: 1. Greenfield facility accepting only organics waste (not a WWTP) and 2. Capital upgrades to add co-digestion at existing WWTP with AD

Next Steps

- Two additional workshops will be held to gather input from the Project Advisory Group
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BURNS McDONNELL

Supply and Demand Analysis Workshop

North Central Texas Organic Waste to Fuel Feasibility Study

Project Advisory Group
March 29, 2022

AGENDA

- Welcome & Introductions
- Project Status Update
- Feedstock Supply Analysis
- Fuel Demand Analysis
- Collection Network Analysis
- Potential RNG to Vehicle Fuel Projects
- Next Steps

Virtual Meeting Reminders

1. Please leave your microphone muted unless speaking
2. Use the chat box or raise hand button to ask a question or provide a comment
3. Please state your name prior to asking a question a making a comment
4. Please note that the presentation is being recorded

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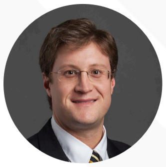
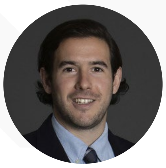


Scott Martin
Deputy Project Manager
Burns & McDonnell

Debra Kantner
Market Assessment & Feasibility
Burns & McDonnell

Drew Mitrisin
Transportation Planning & Policy
Burns & McDonnell



Eric Weiss
Collection Network Assessment
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PROJECT STATUS UPDATE

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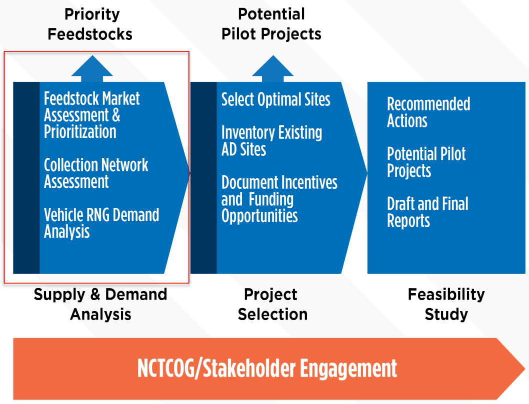
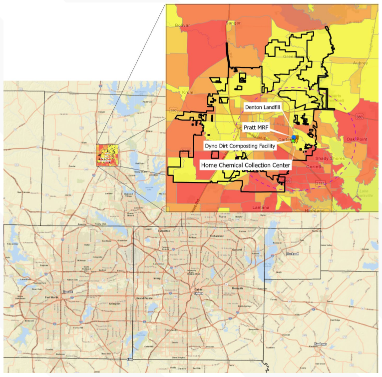
Project Approach



Workshop Approach

- Analysis presented on a regional level to provide context for high-level discussion.
- As project continues GIS evaluation will advance with a greater level of precision based on ongoing stakeholder engagement and data analysis*.
- Further GIS analysis will be focused on the identified areas of natural gas fuel supply, demand, transportation and distribution infrastructure



*Geographic location shown for example purposes only

FEEDSTOCK ANALYSIS

Feedstock Supply Analysis Methodology

Estimate Organic Waste Quantities

Use available data to:

- Estimate quantities of organic materials generated annually
- Understand other waste-derived biogas resources in the region
- Understand organics-to-fuel potential

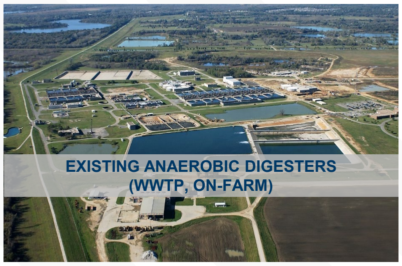
Identify Priority Feedstocks

Consider factors such as:

- Types of materials generated
- Existing and future volumes
- Stability and Variability
- Regional scalability
- Stakeholder input
- Others…

Feedstock Supply Materials and Resources

Existing Biogas Generation Resources

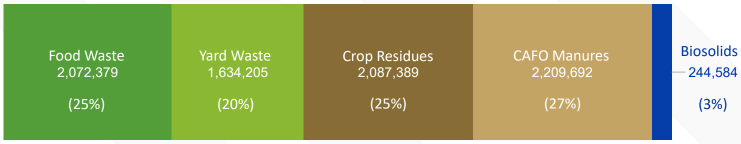


Feedstock Prioritization Considerations

Attribute	Importance
Volumes of Waste	Defines total potential feedstock, and factors such as collection and processing capacity needs.
Material Type	Influences biogas production potential based on properties such as carbon content, lignin, cellulose, etc. Suitable AD technologies vary by material type.
Current Management	Impacts the diversion, environmental, and economic impacts of converting the material to fuel.
Generator Types	Indicate differences in the types of materials, quality (e.g., contamination), consistency (e.g., food production vs. home).
Location of Generated Wastes	Defines collection and routing needs and affects feasibility of potential projects.
Future Volumes and Stability	Indicates future supply and long-term fuel production potential.

Regional Annual Feedstock Generation

8.3 Million Tons of Organics Generated Each Year



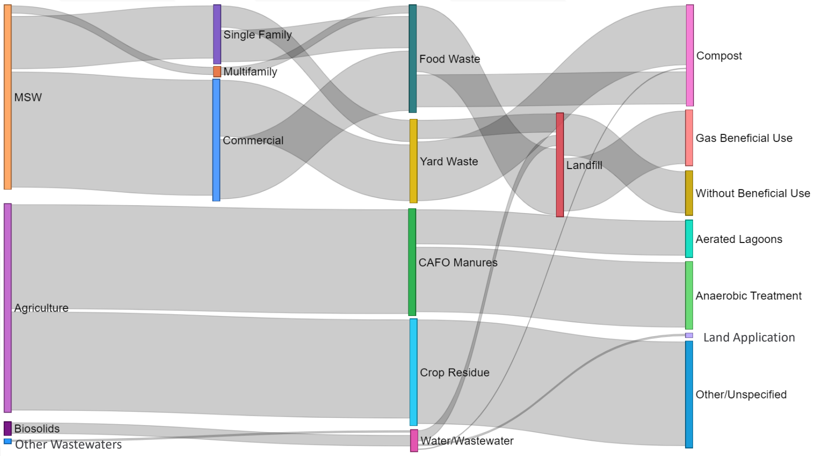
Landfill Biogas:

17 landfills (open and closed)
Collecting 44,000 scfm of biogas

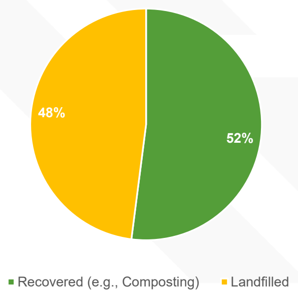
Wastewater Treatment:

47 WWTPs in NCTCOG
8 utilizing anaerobic digestion

Organic Feedstock Material Flow



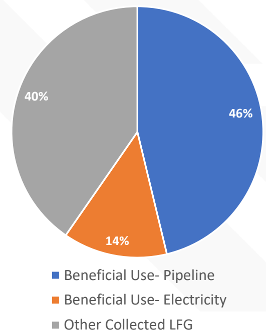
MSW Organics Management in NCTCOG



3.7 million tons MSW organics generated in NCTCOG

- 52% Currently recovered such as through composting
  - Approximately 1.9 million tons total
  - Includes at least 1.38 million tons of composting
- 48% Landfilled
  - Approximately 1.8 million tons

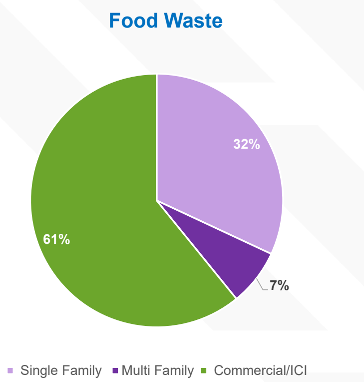
Landfill Gas Management in NCTCOG

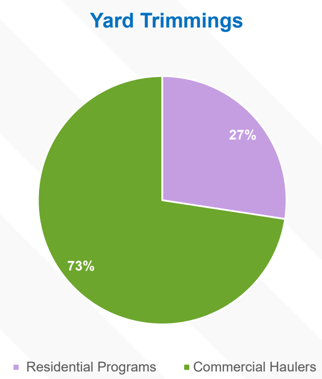


44,000 scfm biogas collected

- 46% to high-BTU pipeline gas
  - ~40 million gasoline gallon equivalents (GGE)
- 14% to energy recovery, such as combined heat and power (CHP) projects
- 40% is managed through destruction (flare)

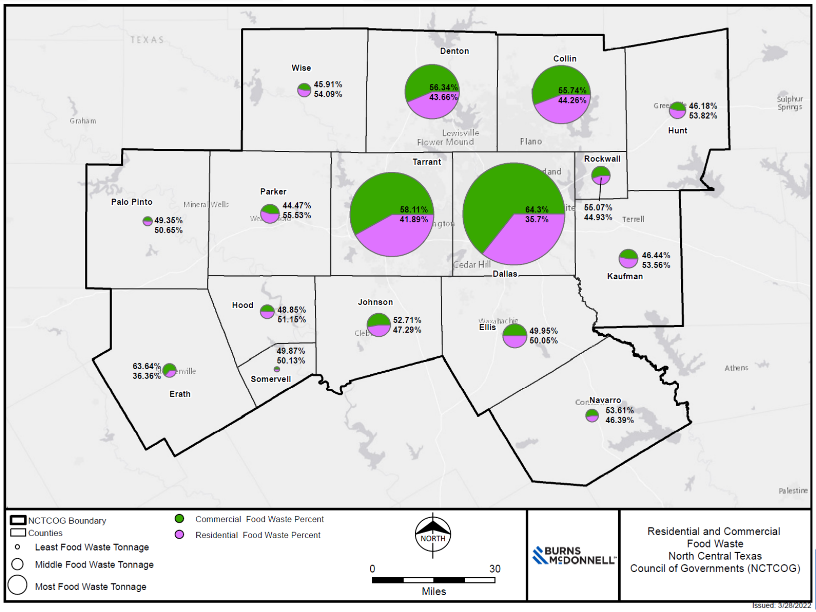
Understanding Material Generators





Food Waste Generation by MSW Sector

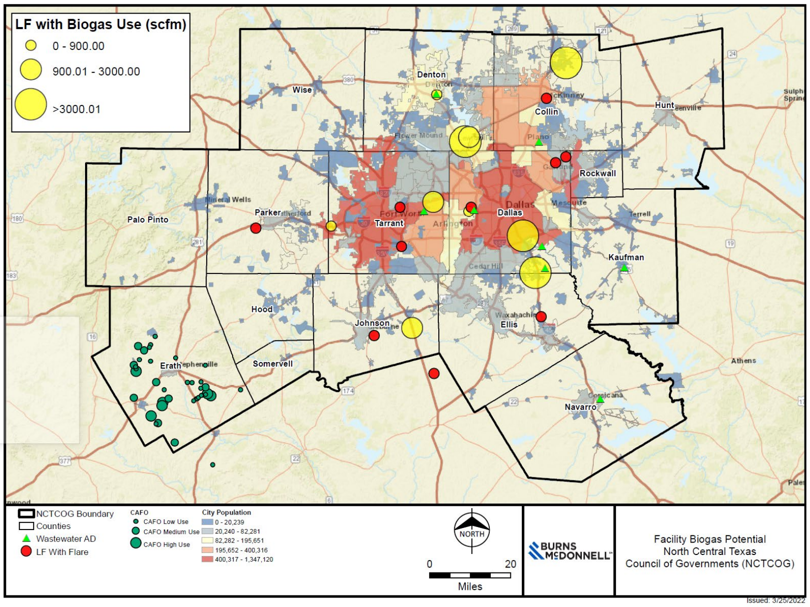
County	Generated Food Waste (tons)	% from Residential Sector	% from Commercial Sector
Dallas	822,622	36%	64%
Tarrant	557,994	42%	58%
Collin	265,944	44%	56%
Denton	233,986	44%	56%
Ellis	44,933	50%	50%
Johnson	42,676	47%	53%
Parker	27,853	56%	44%
Kaufman	27,166	54%	46%
Rockwall	27,160	45%	55%
Hunt	20,890	54%	46%
Hood	14,808	51%	49%
Erath	14,221	36%	64%
Wise	13,669	54%	46%
Navarro	12,416	46%	54%
Palo Pinto	6,474	51%	49%
Somervell	2,254	50%	50%

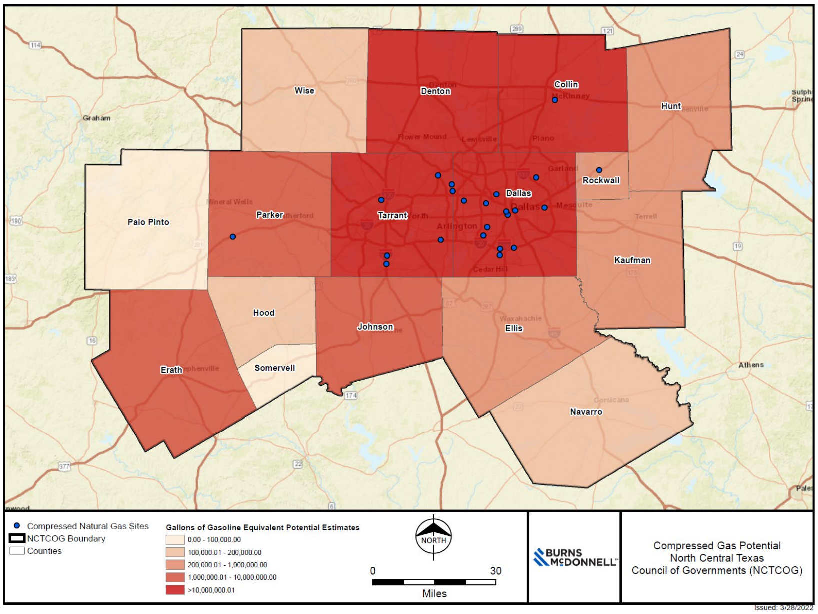


CAFO Manure Management in NCTCOG

Reported Management Method	Number of Facilities	Estimated Waste Generation (tons per year)	% of Total
Anaerobic Treatment	20	1,370,000	62%
Aerated Lagoon	12	725,000	33%
Unspecified/Other	12	120,000	5%

2.2 million tons of CAFO manures are managed in NCTCOG



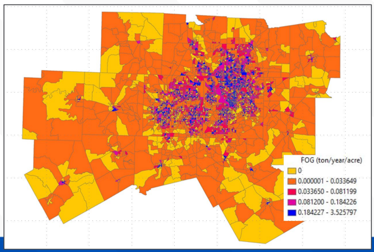


Feedstock Evaluation Next Steps

Detailed geographic and feasibility analysis

- Incorporate region-specific data and findings into UTA's Prioritizing Organic Waste to Energy – Renewable (POWER) Tool
- Evaluate site feasibility of specific projects, based on factors such as:
  - Transportation distance
  - Environmental justice considerations
  - Existing land use
  - Proximity to regional fleets and fuel demand
  - Collection feasibility and needs

Example POWER tool output



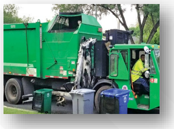
FUEL DEMAND ANALYSIS

Methodology: Count and Proportion of Natural Gas Vehicles in the Region

- Burns & McDonnell used the DFW Clean Cities and Texas Department of Motor Vehicles (DMV) datasets to determine counts for the number of natural gas vehicles among three primary vehicle categories
- Using the total "universe" of vehicles in the region (e.g., all powertrains) within each category of the DMV dataset, the proportion of each vehicle category using natural gas was determined

Vehicle Type	NG Vehicle Count		Total Vehicles in Region	NG % of Total Vehicles	
	Low	High		Low	High
Truck: Semi-Trailer	514	683	79,620	**0.7%**	**0.9%**
Bus: Transit	663	1,051	14,887	**4.5%**	**7.1%**
Truck: Refuse	125	186	1,725	**7.3%**	**10.8%**





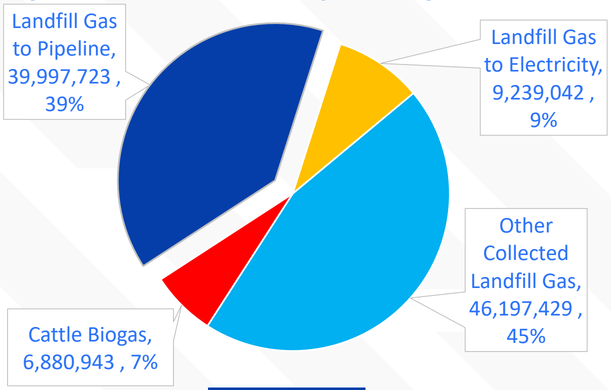
Methodology: Natural Gas Demand

- Burns & McDonnell used the Clean Cities dataset to determine the annual gasoline gallon equivalent (GGE) demand of natural gas for the three primary vehicle categories
- Using the low and high estimates from both datasets, the range of current natural gas demand in the region was determined, as well as the potential natural gas demand based on the "universe" of vehicles in the region

Vehicle Type	Current Natural Gas Demand		Potential Natural Gas Demand
	Low	High	Estimate
Truck: Semi-Trailer	3,830,000	5,089,000	589,380,000
Bus: Transit	7,517,000	11,916,000	161,262,000
Truck: Refuse	334,000	497,000	4,278,000
Total	**11,681,000**	**17,502,000**	**754,920,000**

All units in table are GGE

Existing Biomethane Supply in Region



All units are GGE

Additional biomethane available from WWTP

What-If Scenario 1: Increasing Use of Existing Supply

Vehicle Type	Current % Natural Gas (High Est)	Scenario 1 % Natural Gas	Current Demand (GGE)	Scenario 1 Demand (GGE)
Truck: Semi-Trailer	0.9%	**2.0%**	5,089,000	11,864,000
Bus: Transit	7.1%	**8.0%**	11,916,000	13,502,000
Truck: Refuse	10.8%	**13.0%**	497,000	600,000
Total			**17,502,000** →	**25,966,000**

+8.4M

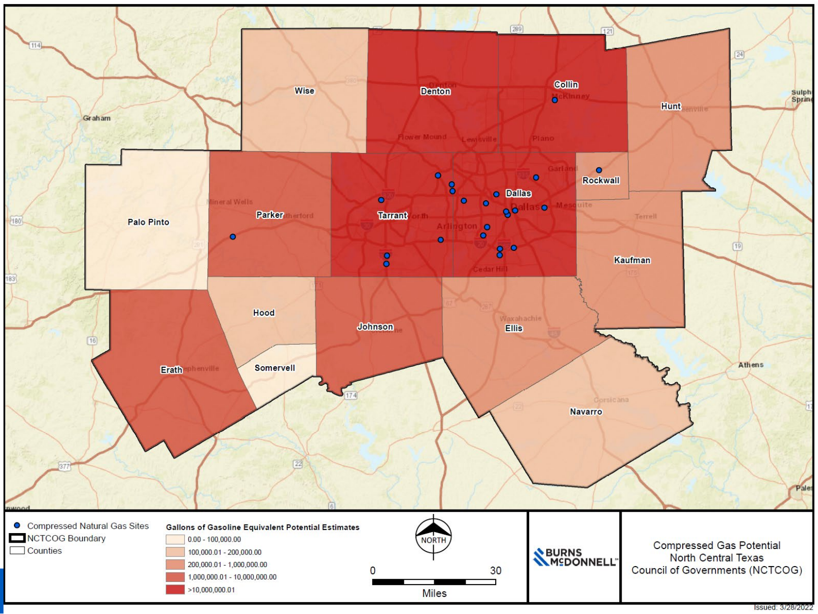
Existing landfill gas-to-pipeline supply sufficient for incremental targets

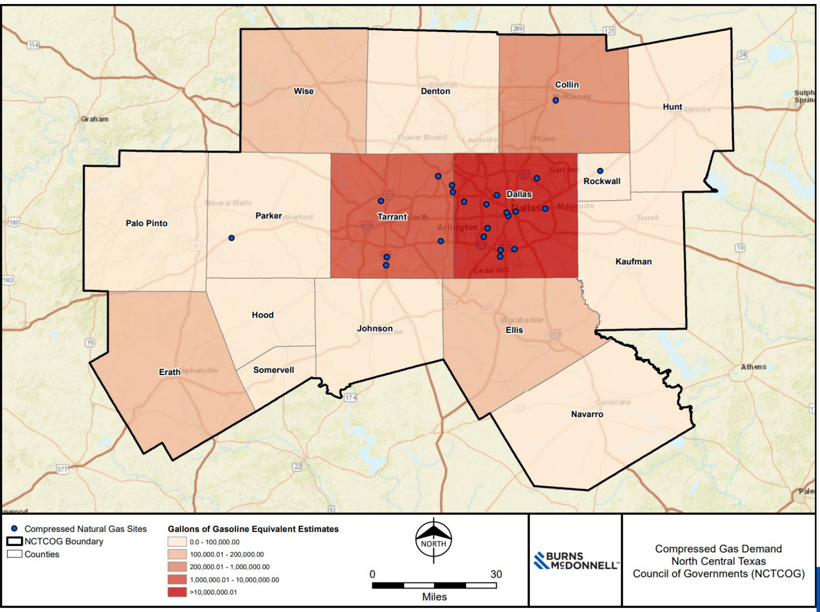
What-If Scenario 2: Increasing Use Beyond Ready Supply

Vehicle Type	Current % Natural Gas (High Est)	Scenario 2 % Natural Gas	Current Demand (GGE)	Scenario 2 Demand (GGE)
Truck: Semi-Trailer	0.9%	**5.0%**	5,089,000	29,660,000
Bus: Transit	7.1%	**10.0%**	11,916,000	16,878,000
Truck: Refuse	10.8%	**50.0%**	497,000	2,480,000
Total			**17,913,000** →	**49,018,000**

+31.1M

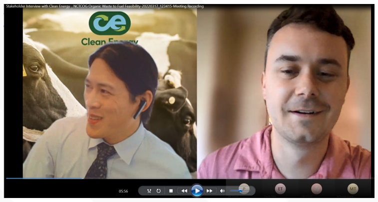
Total collected landfill gas supply sufficient for further increases in demand

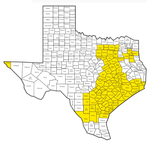




Overview of current/planned stakeholder interviews

- TX NGV Alliance and Clean Energy
  - CLNE confirmed number of vehicles matches their ballpark number
  - Policymaking/incentives can support sustained growth
  - Opportunities for growth in the transit, refuse truck and trucking markets.
  - Large, multinational trucking companies are a major growth opportunity. Delivery vans are an opportunity for electrification or natural gas.
  - Texas Clean Transportation Zone has been a major target for trucking industry fleet transitions, especially for dedicated routes.





TEXAS NATURAL GAS VEHICLE ALLIANCE

Clean Energy

and more to come!

Policymaking Considerations

Texas HB 963 (2021)

- Effective as of September 1, 2021
- Creates a used natural gas truck market for larger fleets to sell used trucks
- Allows less capitalized, smaller fleets to invest in NGV
- Policymaking needs to reduce barrier to entry to sustain growth

Texas Emissions Reduction Plan (TERP)

- Administered by Texas Commission on Environmental Quality (TCEQ)
- Offers significant grants for new and upgraded equipment to reduce pollution and improve air quality

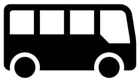
Prioritization of Vehicles for Conversion

Tractor-Trailers

Delivery Vans

- Largest conversion opportunity, slowest rate of conversion to date
- Dedicated routes along TX Clean Transportation Zone
- Large fleets first, smaller fleets to follow

Buses



- Largest per-vehicle source for natural gas demand
- Local transit agencies should continue evaluating natural gas and electric powertrains for their operations

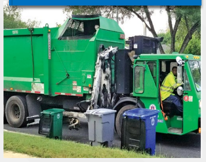
Refuse Trucks

- Highest percentage of natural gas conversions to date
- 50% conversion to RNG by 2025 a viable opportunity

COLLECTION NETWORK ANALYSIS

Organics Collection Network Overview

Residential



- Single-family dwelling units
- Generate yard trimmings, brush and post-consumer food waste
- Serviced using automated side load or rear load solid waste vehicles
- Utilize diesel or natural-gas engine vehicles to provide service

Commercial/Industrial

- Various types of commercial establishments or industrial operations
- Generate pre-consumer and post consumer food waste
- Utilize diesel or natural-gas engine vehicles to provide service

Agricultural/FOG

- Includes agricultural operations such as farming, livestock management and fats, oils and greases
- Generates crop waste, surplus and manure
- Utilize diesel or natural gas engine vehicles to provide service

Separate Organics Collection Considerations

Bag/Bundle

- Collected using rear-load or grapple vehicles.
- Many municipalities collect commingled with other bulky items.
- Consider compostable durable bags that can be manually separated at a transfer station.

Roll-Cart

- Collected using automated side-load vehicles
- Few municipalities in the region have roll-cart organics collection
- Provides capability to commingle yard trimmings and food waste if there is available processing capacity.

On-Site Storage

- Commercial pre-consumer food waste processed and stored on-site.
- Tank serviced via vacuum truck and delivered to available organics processing location.
- Programs being developed to increase commercial establishments implementing this solution around the country.

Municipal Solid Waste Collection Fleets

City	Population	Residential	Commercial	% Natural Gas Vehicles*
Dallas	1,314,610	Y	N	15-30%
Plano	286,980	Y	N	0%
Irving	245,690	Y	N	0%
Garland	242,830	Y	N	0%
Mesquite	145,750	Y	N	0%
Denton	141,000	Y	Y	30-50%
Richardson	117,050	Y	Y	0%
Cleburne	32,270	Y	N	0%
Weatherford	29,060	Y	Y	0%
University Park	22,920	Y	Y	0%

*Based on responses from recent NCTCOG SWMP Vol II Survey and other recent fleet analysis. Percent of Natural Gas Vehicles presented as ranges given ongoing fleet replacement.

- There are opportunities to increase the number of natural gas vehicles that are used by municipal collection programs in the region
- Adopting natural gas vehicles in fleet requires fueling and maintenance infrastructure
- Municipalities need support to overcome challenges with fueling capacity and maintenance equipment and expertise

Commercial Solid Waste Collection Markets

Exclusive/Non-Exclusive Franchise

- Contract authorizing one or more private companies to provide service in a particular area.
- Provides high degree of influence of the collection and processing of material.

Hauler Licensing

- Stipulates haulers of recyclable materials must have a license to operate in the City
- License requirements provide limited influence of the collection and processing of material

Closed Market

- Only the municipality is authorized to collect in a particular service area
- Provides highest degree of control of the collection and processing of material

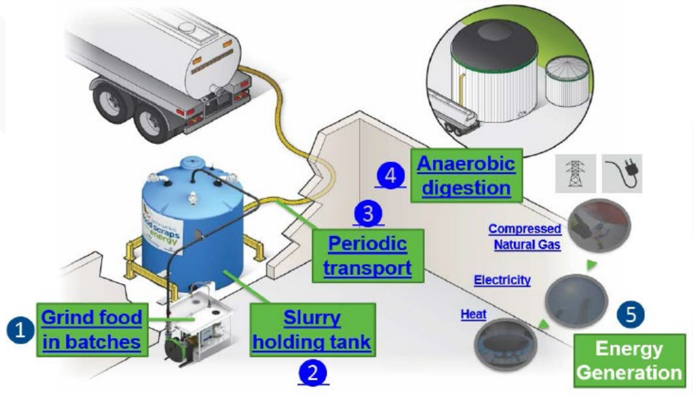
Private Hauler Refuse Vehicle Fleets

- Private sector haulers service commercial generators among the majority of municipalities in the region.
- Large hauling fleets active in the region have existing CNG and RNG vehicles and fueling.
- Commercial market requirements represent opportunity to incentivize private haulers to utilize more natural gas vehicles.
  - Requirements as part of exclusive/non-exclusive franchise systems.
  - Licensing requirements to operate within municipality.

Dallas Commercial Organics Collection Pilot

- Program funded by USDA to target special events and food service establishments.
- Partnership with Dallas County to support healthy food initiative.
- Working with local food waste hauler.
- Intended to be a closed-loop organics recycling program
  - Material processed by collection contractor
  - Compost product to be used at Dallas County Gardens to grow produce.

Commercial Organics Slurry Collection/Processing



Regional Material Management Infrastructure

Ownership of infrastructure in region impacts feasibility of potential projects

Facility*	Public	Private	Total
Landfills	12	10	22
Transfer Stations	7	8	15
Commercial Composting Facilities	2	13	15
WWTP w/ AD	8	0	8

*Based on responses from recent NCTCOG RSWMP Vol II Survey and other recent analysis. Facility information may be updated based on ongoing stakeholder engagement.

Number and location of public facilities determines the ability to pursue opportunities for public-private partnership

Collection Network Assessment Next Steps

Detailed evaluation of collection networks

- Identify strategic geographic areas in the NCTCOG region near potential pilot projects

Operational requirements

- Barriers and opportunities
- Planning level costs based on route densities, distance to end markets
- Financial feasibility of fueling infrastructure (fueling stations, pipelines)

Evaluation of potential partnership models

- Corporate campus
- School district
- Commercial districts
- Private haulers

POTENTIAL RNG TO VEHICLE FUEL PROJECTS

Leverage Existing AD Capacity - City of Dallas Southside WWTP

- Inbound flow of 50-55 Million Gallons per Day (MGD)
  - Solids land applied as a soil amendment
  - Digester biogas fuels internal combustion engines to provide over 40 percent of the plant's electrical needs
  - Treated liquid discharged to Trinity River
- City-wide water conservation efforts reduced the volume of influent flow
  - Facility able to operate with excess capacity
- Co-digestion challenges
  - Accepting solid waste organics
  - Cleaning and transporting biogas to end users

Leverage Existing AD Capacity - City of Denton

- City provides a premium valet service to the downtown area commercial entities
  - 50 premium valet customers are bars or restaurants.
- City awarded grant from NCTCOG to offer high quantity organic waste generators the opportunity to join the pilot.
  - Materials accepted in the pilot include pre- and post-consumer food scraps to include dairy, meat, bread, left overs, fruits, veggies, coffee grounds, and meal discards.
- The material will be macerated and then processed by composting and/or anaerobic digestion at the Pecan Creek WWTP

New Organics Digestion Facility Pilot

- Key considerations for new facility
  - Existing transfer station, gas piping infrastructure and local fueling demand determines feasibility
  - Collection program encourages collection of organics that are separated from the traditional MSW waste stream
  - Requires feedstock guarantees OR municipal control of waste streams
  - Contamination levels and pre-processing requirements
  - Reliable revenue streams including competitive tipping fee (e.g., same or less than local landfills) and financial incentives/credits (e.g., RINs, RECs)
- **Option 1:** Greenfield facility accepting only organic waste (not a WWTP)
- **Option 2:** Capital upgrades to add co-digestion at existing WWTP w/ AD

Next Steps

- Two additional workshops will be held to gather input from the Project Advisory Group
- Topics for each workshop:
  - Workshop #3 – Project Selection
  - Workshop #4 – Feasibility Study Conclusion
- Dates for the workshops have not yet been determined but will take place in 2022

THANK YOU!

CREATE AMAZING.

WORKSHOP #3A

BURNS McDONNELL

Organic Waste to Fuel Project Screening and Prioritization

North Central Texas Organic Waste to Fuel Feasibility Study

Project Advisory Group
July 12, 2022

AGENDA

- Welcome & Introductions
- Project Status Update
- Feedstock Prioritization Results
- Natural Gas Vehicle (NGV) Fleet Prioritization Results
- Collection Network Evaluation Results
- Pilot Project Location Screening Process
- Next Steps

Virtual Meeting Reminders

1. Please leave your microphone muted unless speaking
2. Use the chat box or raise hand button to ask a question or provide a comment
3. Please state your name prior to asking a question a making a comment
4. Please note that the presentation is being recorded

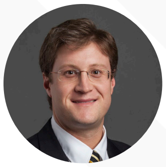
WELCOME & INTRODUCTIONS

Introductions

- **Breanne Johnson**
  Environment & Development Planner
  NCTCOG
- **Lori Clark**
  Air Quality Program Manager
  NCTCOG
- **Soria Adibi**
  Senior Air Quality Planner
  NCTCOG
- **Melanie Sattler**
  Civil Engineering Professor & Researcher
  University of Texas at Arlington

Introductions

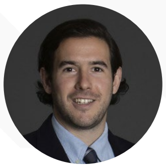
Scott Pasternak
Project Manager
Burns & McDonnell



Scott Martin
Deputy Project Manager
Burns & McDonnell

Debra Kantner
Market Assessment & Feasibility
Burns & McDonnell

Drew Mitrisin
Transportation Planning & Policy
Burns & McDonnell



Eric Weiss
Collection Network Assessment
Burns & McDonnell

Matt Tomich
President
Energy Vision

Phil Vos
Program Director
Energy Vision

Project Advisory Group

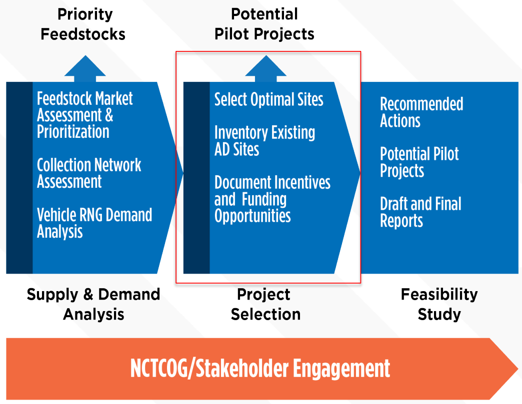
- Joao Pimentel, City of Fort Worth
  This has the potential to benefit the whole Metroplex, and, consequently, Fort Worth.
- Katelyn Hearon, City of Lewisville
  The City of Lewisville is interested in finding sustainable options for sludge disposal.
- Kathy Fonville, City of Mesquite
  Chair of Resource Conservation Council at NCTCOG--interested in how RCC can support this regional initiative.
- Yarcus Lewis, City of Plano
  Achieving greater emissions reductions from the dual benefits of redirecting organic waste emissions to displace fossil fuel usage.
- Jaime Bretzmann, City of Plano
  Interested to learn more about the regional opportunities for waste organics and also about use of the generated fuel gas and digestate.
- Brendan Lavy, Texas Christian University
  Assistant Professor of Sustainability Science at TCU and interested in research that supports sustainability transitions in North Texas.
- Courtney Carroll, Fort Worth ISD
  Would like to better understand the possible uses of all the organic waste produced in school cafeterias.
- Sahana Prabhu, Texan by Nature
  I am interested to learn about anaerobic digestion and renewable energy potentials in North Texas.
- Lynn Lyon, US Gain

PROJECT STATUS UPDATE

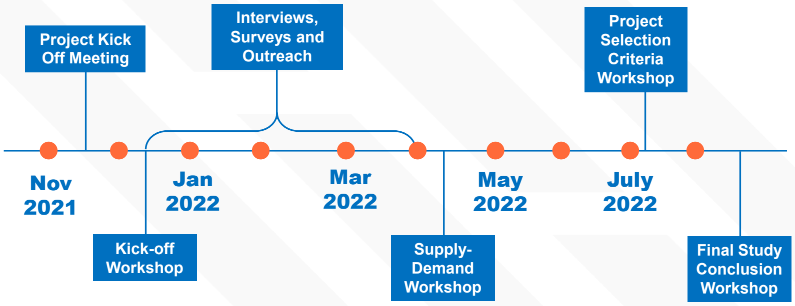
Project Background

- Goal of the study is to assess the feasibility of using of local organic wastes to produce renewable natural gas (RNG) in new or existing digesters within the region and use the RNG as a transportation fuel.
- NCTCOG and UTA partnering on the study which is supported by a grant from the U.S. Environmental Protection Agency (U.S. EPA).
- Prior to the study, NCTCOG hosted a series of virtual roundtables to share existing anaerobic digestion and organic waste collection efforts in the region.
- As North Central Texas continues to grow, waste diversion will become increasingly important to both retain landfill capacity and reduce methane emissions.

Project Approach



Stakeholder Engagement



FEEDSTOCK PRIORITIZATION RESULTS

Regional Annual Feedstock Generation

8.8 Million Tons of Organics Generated Each Year

Landfill Biogas: 17 landfills (open and closed)
Collecting 44,000 scfm of biogas

Wastewater Treatment:
47 WWTPs in NCTCOG
8 utilizing anaerobic digestion

Feedstock Prioritization Considerations

ATTRIBUTE	IMPORTANCE
Existing and Future Volumes of Waste	Consider future supply and long-term fuel production potential.
Diversion Opportunity from Landfill	Materials currently managed at landfills or through other disposal methods should be prioritized first to ensure efforts result in an overall increase in diversion.
Stability and Variability of Materials	Infrastructure requires design and planning considerations specific to the quantities and material types being handled.
Biogas Generation and GHG Reduction Potential	Material type influences biogas production and GHG reduction potential based on properties such as carbon content, lignin, cellulose, etc.
Scalability at the Regional Level	Focus on materials with the potential to provide a solution that is scalable across the 16-county region.
Stakeholder Support	Prioritization includes considerations for stakeholder support based on feedback from the PAG and information obtained by the Project Team.

Feedstock Type	Material Benefits and Prioritization						
	Existing and Future Volumes	Diversion from Landfill	Stability and Variability of Materials	Biogas Production and GHG Reduction Potential	Scalability at the Regional Level	Stakeholder Support	Overall Suitability of Feedstock for RNG Vehicle Fuel
Food Waste	✓	✓	varies	✓	✓	✓	High
Existing Biogas Resources	✓		✓	✓	✓	✓	High
Fats, Oils, and Grease (FOG)	✓		✓	✓	✓		Medium
CAFO Manures	✓		✓	✓			Medium
Yard Trimmings	✓		✓		✓		Low
Crop Residues			✓				Low

Feedstock Prioritization Results

Low
- Yard Trimmings
- Crop Residues

Medium
- Fats, Oils, and Grease (FOG)
- CAFO Manures

High
- Food Waste
- Existing Biogas Resources

NGV FLEET PRIORITIZATION RESULTS

Opportunities for High-Volume NGV Fleets

Solid Waste Collection
- Highest adoption percentage with demonstrated commercial viability
- Requires fueling at fleet yards and centralized ownership supports capital investments
- Travel fewer road miles compared to tractor trailers or transit busses

Tractor-Trailers
- Lowest adoption percentage but highest number of vehicles in service among all fuel types.
- Off-site fueling in Texas Clean Transportation Zone supports long-hauling routes.

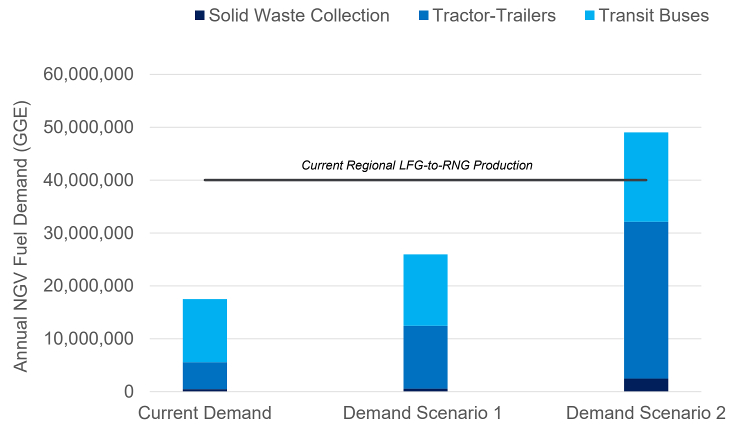
Transit Buses
- Requires fueling at fleet yards and centralized ownership supports capital investments.
- Highest fuel demand on a per vehicle basis.

Light-Duty Delivery
- Growing sensitivity to environmental impact among large multi-national fleets (e.g., UPS, Amazon)
- Texas House Bill 963 (2021) supports smaller, less-capitalized fleets to invest in NGVs.

NGV Fuel Demand Scenarios

	Solid Waste Collection	Tractor-Trailers	Transit Buses
CURRENT DEMAND			
% Adoption	10.8%	0.9%	7.1%
NGV Fuel Demand (GGE)	497,000	5,089,000	11,916,000
SCENARIO 1 (MINOR)			
% Adoption	13.0%	2.0%	8.0%
NGV Fuel Demand (GGE)	600,000	11,864,000	13,502,000
SCENARIO 2 (AGGRESSIVE)			
% Adoption	50.0%	5.0%	10.0%
NGV Fuel Demand (GGE)	2,480,000	29,660,000	16,878,000

NGV Fuel Demand Scenarios

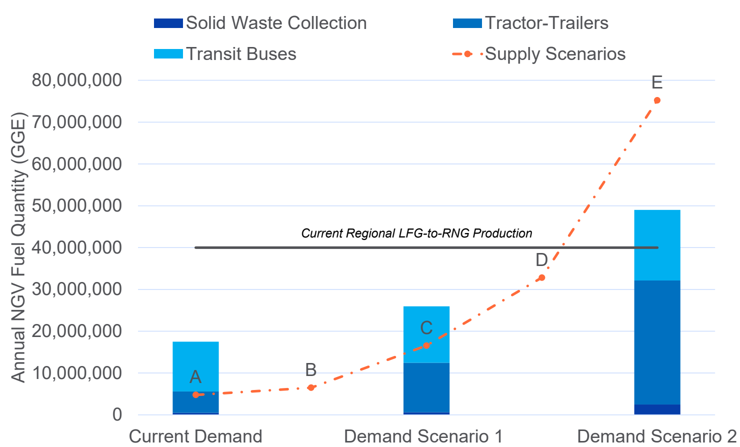


RNG Supply Scenarios

- Five scenarios of potential supply:

Feedstock Type	Potential RNG Supply Scenarios				
	A	B	C	D	E
Commercial Food	60%	60%	100%	100%	**100%**
Residential Food	-	20%	100%	100%	**100%**
Existing Biogas Resources	-	-	-	*Potential Projects*	*All Sites*
Potential Supply (GGE)	**4,773,989**	**6,495,748**	**16,565,440**	**32,817,023**	**75,232,881**

NGV Fuel Supply and Demand Scenarios



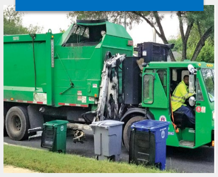
COLLECTION NETWORK EVALUATION RESULTS

SSO Collection Network Analysis Overview

- Routing model compares technical and financial elements of potential collection networks
  - Operational requirements (e.g., staffing, vehicles, other direct costs)
  - Route densities (e.g., households per acre)
  - Collection efficiency (e.g., customers serviced per hour)
- Assumes collection programs are fully implemented and fully optimized (intended to compare financial feasibility)
  - Assumes carts already in place (purchase of new carts approximately $0.50 per household per month)
  - Enclosures installed and dumpsters purchased
  - Slurry tanks and macerators installed
  - Access to processing infrastructure with available capacity
- Calculates required routes and direct costs to collect food waste currently disposed from commercial and residential generators
  - Cost per ton collected
  - Cost per household per month
  - Cost per cubic yard

Collection Networks Evaluated

Residential Single-Family

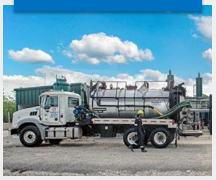


- Estimates costs of low density, high density and rural areas
- All tons currently disposed are collected
- Organics processing infrastructure operating with available capacity

Commercial Front-Load

- 3x per week per week collection
- 2 CY food waste dumpsters
- Included 90 percent of food retail and 70 percent of food service locations (remaining customers unable to fit additional dumpster/enclosure)

Commercial Slurry



- Every other week collection on a routed basis (consistent with FEL collection)
- Service provided by 5,500-gallon vacuum trucks
- Each pump out takes 45 minutes to complete

Residential Collection Network Cost Comparison

	High Density	Low Density	Rural
Annual Tons Collected	342,377	205,661	72,938
Total Households Serviced	997,601	599,245	212,523
Cost per Ton Collected	$156.42	$187.70	$246.98
Cost per Household per Month	$4.47	$5.37	$7.06

- Cost per household per month in addition to existing costs for refuse and recycling collection (excluding cost of purchasing carts and organics processing)
- Cost per household per month lowest in high density regions and highest in low density regions
- Recent benchmarking indicates costs range between $4.00 to $6.00 per household per month for refuse collection in the North Central Texas region

Commercial Collection Network Cost Comparison

	Front-Load	Slurry
Annual Tons Collected	384,000	174,000
Total Customers Serviced	14,629	5,797
Cost per Ton Collected	$87.43	$72.30
Cost per CY Serviced	$7.36	$6.08

- Lower costs for slurry collection due to more efficient storage (via tanks) and fewer required collections per customer
- Converted gallons of food waste processed into slurry to CY to compare between collection networks
- Recent benchmarking indicates front-load refuse collection programs in the North Central Texas region, collection costs range from $2.00 to $6.00 per CY (excluding disposal costs)

Overall Comparison

	Commercial		Residential		
	Front-Load	Slurry	High Density	Low Density	Rural
Annual Tons Collected	384,000	174,000	342,377	205,661	72,938
Total Customers Serviced	14,629	5,797	997,601	599,245	212,523
Cost per Ton Collected	$87.43	$72.30	$156.42	$187.70	$246.98

- Highest tonnage of material available from commercial front-load and high-density residential areas of the North Central Texas region
- Priority collection networks include commercial front-load, slurry based on cost effectiveness and high density residential based on significant available tonnage

PILOT PROJECT LOCATION SCREENING PROCESS

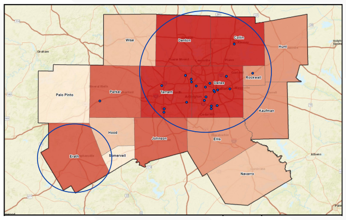
Inventory Regional Sites to Determine Scenarios

Inventory of Regional Sites
↓
Optimization Tool Screening to Create Long List
↓
Short List of Pilot Projects
↓
POWER Tool Screening
↓
Prioritization Evaluation
↓
Analysis of Selected Pilot Projects

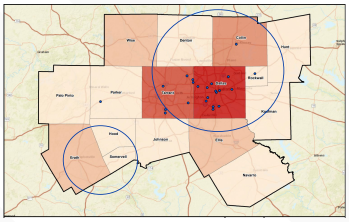
- Inventory of existing infrastructure sites provides baseline for screening for potential project sites.
- Potential project sites considered for four project types:
  - Co-locate with WRRF and/or existing digester
  - Co-locate with LFGTE project
  - Co-locate with transfer station
  - Greenfield development
- Focus scenarios in targeted areas of North Central Texas region

Targeted Organics Collection Areas

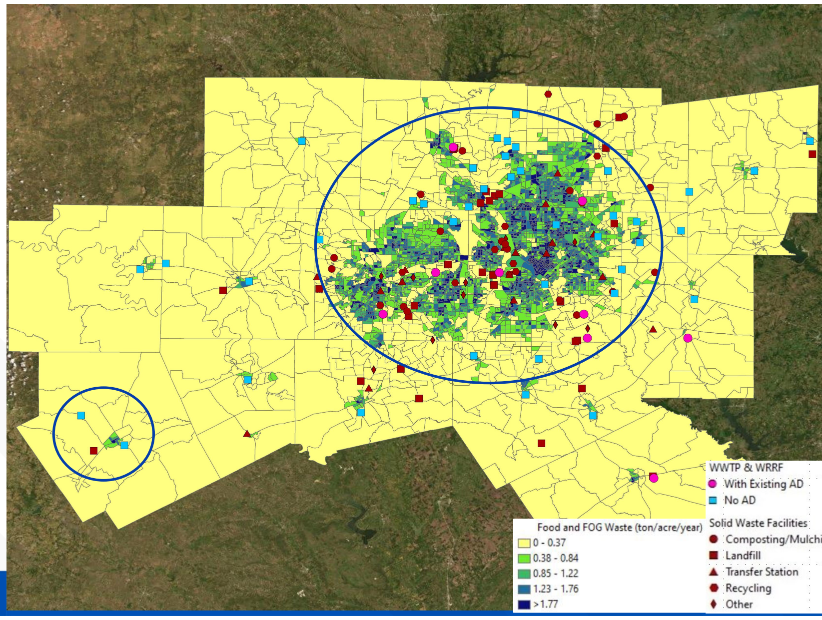
POTENTIAL RNG SUPPLY



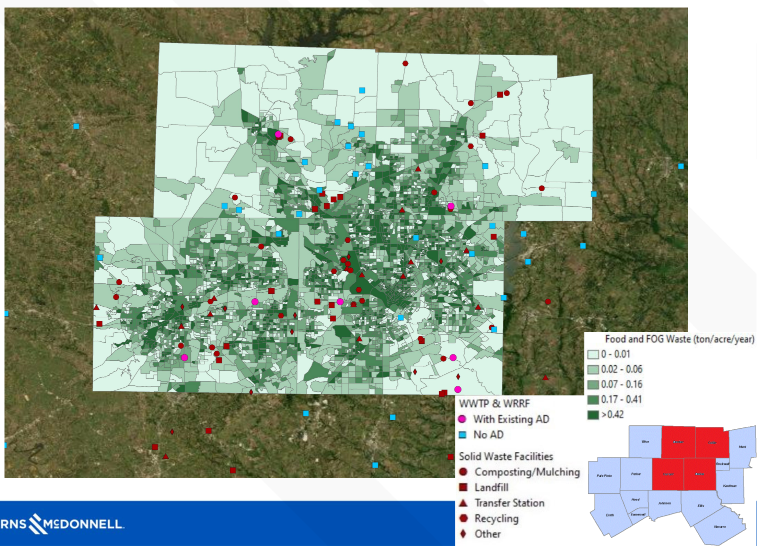
NGV FUEL DEMAND



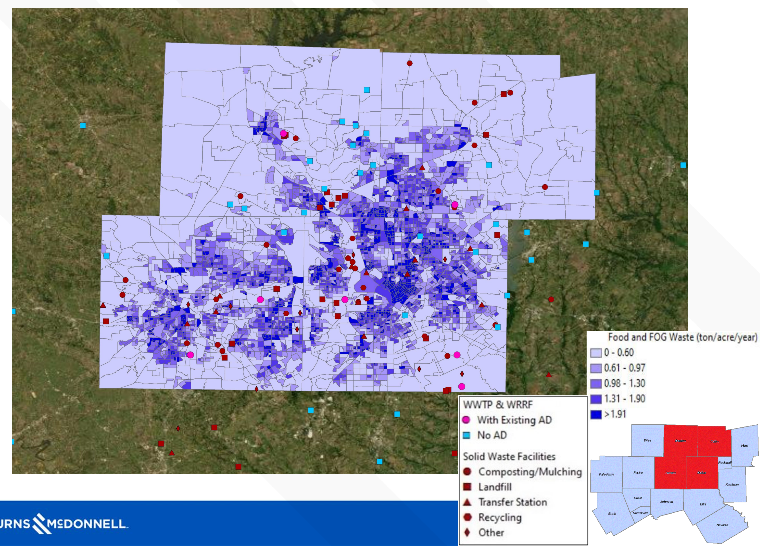
- Location of supply of high priority feedstocks (commercial and residential food waste) and demand from NGVs indicate Collin, Dallas, Denton, and Tarrant Counties as focus areas for further evaluation
- Location of supply of medium priority feedstocks (CAFO manure) indicates Earth County as a focus area for further evaluation



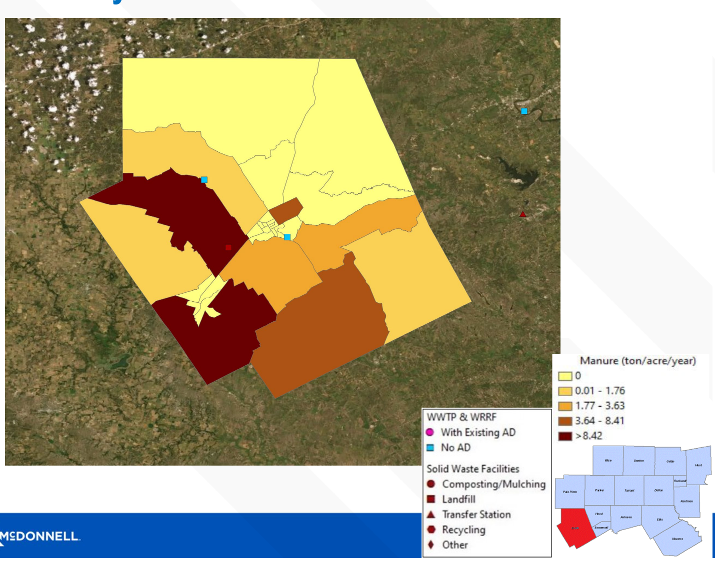
Select Subsectors of Commercial Food Waste; FOG



Residential & Commercial Food Waste; FOG



Erath County CAFO Manure

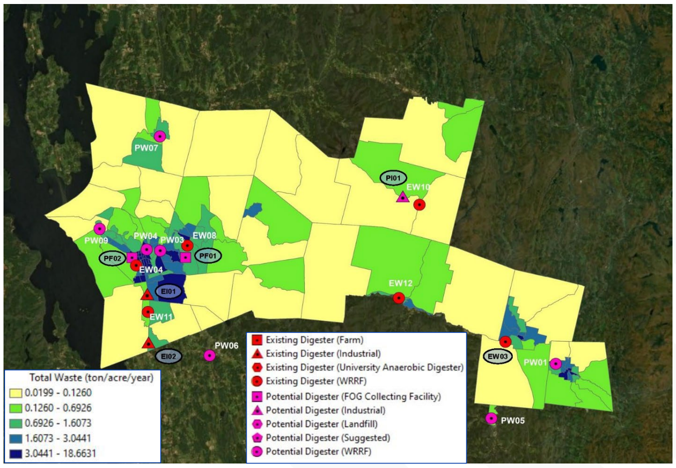


Optimization Tool Generates "Long List"

- Inventory of Regional Sites
- Optimization Tool Screening to Create Long List
- Short List of Pilot Projects
- POWER Tool Screening
- Prioritization Evaluation
- Analysis of Selected Pilot Projects

- Determine optimal facility locations for each scenario
  - Based on facility type and distance to critical mass of feedstock generation
- Optimization tool creates "Long List" of locations for each scenario
  - Commercial food waste and FOG
  - Residential & commercial food waste and FOG
  - CAFO Manure
- Each potential location/project type further screened

Example Optimization Results from State of Vermont



Generate "Short List" of Potential Pilot Projects

- Inventory of Regional Sites
- Optimization Tool Screening to Create Long List
- **Short List of Pilot Projects**
- POWER Tool Screening
- Prioritization Evaluation
- Analysis of Selected Pilot Projects

- Additional high-level engineering, operational, and economic screening to identify locations:
  - Access to feedstock
  - Land use/zoning
  - Proximity to floodplains
  - Roadway and pipeline infrastructure
  - Supporting solid waste infrastructure
  - Distance to NGV fuel demand
- Identify 3-4 locations that meet needs of a viable AD pilot project

POWER Tool Provides Initial Evaluation

- Inventory of Regional Sites
- Optimization Tool Screening to Create Long List
- Short List of Pilot Projects
- **POWER Tool Screening**
- Prioritization Evaluation
- Analysis of Selected Pilot Projects

- POWER Tool evaluates key project criteria
  - Facility capacity
  - Biogas output and electricity/fuel generation
  - GHG emissions
  - Capital expenses
  - Operating expenses
  - Air pollutant emissions
- Project Team will run POWER Tool for each identified pilot project

Prioritization Builds on POWER Tool Results

- Inventory of Regional Sites
- Optimization Tool Screening to Create Long List
- Short List of Pilot Projects
- POWER Tool Screening
- **Prioritization Evaluation**
- Analysis of Selected Pilot Projects

- Prioritization evaluation criteria include
  - Distance to existing collection networks
  - Proximity to NGV fleets
  - Availability of utility interconnections
  - Distance to solid waste infrastructure
- Environmental Justice considerations including
  - Income
  - Race
  - English proficiency

Project Assessments Describe Projects

- Inventory of Regional Sites
- Optimization Tool Screening to Create Long List
- Short List of Pilot Projects
- POWER Tool Screening
- Prioritization Evaluation
- **Analysis of Selected Pilot Projects**

- Project assessments provide comprehensive development considerations of each project Funding/financing considerations
  - Estimated costs and revenues
  - Infrastructure requirements
  - Local biogas utilization opportunities

Next Steps

- Complete optimization evaluation and advance screening process
- Hold additional workshop to review results of the optimization and initial screening
- Complete evaluation of identified pilot projects assessments including financial and contracting considerations
- Hold workshop #4 – Feasibility Study conclusion in mid-August time-frame

THANK YOU!

CREATE AMAZING.

WORKSHOP #3B

Organic Waste to Fuel Potential Pilot Project Short-List Screening Workshop

North Central Texas Organic Waste to Fuel Feasibility Study

Project Advisory Group
August 30, 2022

AGENDA

- Project Advisory Group Update
- Project Status Update
- Pilot Project Short-List Screening
- Discuss and Finalize Short List
- Next Steps

Virtual Workshop Reminders

1. Please leave your microphone muted unless speaking
2. Use the chat box or raise hand button to ask a question or provide a comment
3. Please state your name prior to asking a question a making a comment
4. Please note that the presentation is being recorded

Key Terms and Acronyms

- Anaerobic Digestion (AD)
- Water Resource Recovery Facility (WRRF)
- Landfill Gas (LFG)
- Landfill Gas to Energy (LFGTE)
- Renewable Natural Gas (RNG)
- Natural Gas Vehicle (NGV)
- Renewable Fuel Standard (RFS)
- Environmental Credits

WELCOME & INTRODUCTIONS

Introductions

- **Breanne Johnson**
  Environment & Development Planner
  NCTCOG
- **Lori Clark**
  Air Quality Program Manager
  NCTCOG
- **Soria Adibi**
  Senior Air Quality Planner
  NCTCOG
- **Melanie Sattler**
  Civil Engineering Professor & Researcher
  University of Texas at Arlington

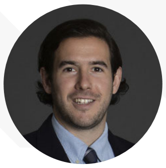
Introductions

Scott Pasternak
Project Manager
Burns & McDonnell

Scott Martin
Deputy Project Manager
Burns & McDonnell

Debra Kantner
Market Assessment & Feasibility
Burns & McDonnell

Drew Mitrisin
Transportation Planning & Policy
Burns & McDonnell



Eric Weiss
Collection Network Assessment
Burns & McDonnell

Matt Tomich
President
Energy Vision

Phil Vos
Program Director
Energy Vision

Project Advisory Group Update

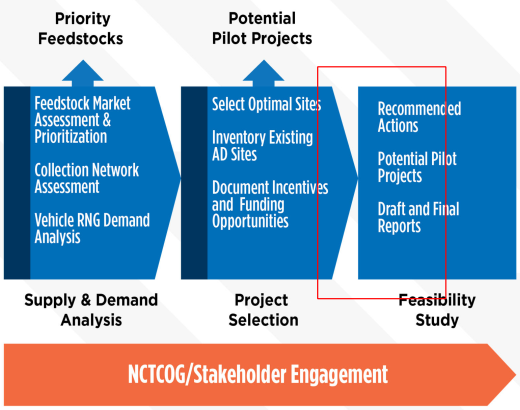
- James Keezell, City of Fort Worth
- Katelyn Hearon, City of Lewisville
- Kathy Fonville, City of Mesquite
- Jaime Bretzmann, City of Plano
- Brendan Lavy, Texas Christian University
- Courtney Carroll, Fort Worth ISD
- Sahana Prabhu, Texan by Nature
- Lynn Lyon, US Gain

PROJECT STATUS UPDATE

Project Background

- Study assess the feasibility of collecting and transporting organic wastes to produce renewable natural gas (RNG) for use as a transportation fuel.
- NCTCOG and UTA partnering on the study which is supported by a grant from the U.S. Environmental Protection Agency (U.S. EPA).
- Prior to the study, NCTCOG conducted regional waste characterizations and a series of virtual roundtables to share organic waste management efforts and challenges in the region.
- Key considerations for the evaluation include determining the most critical organic wastes to divert (e.g., sludge and biosolids, food waste, FOG) from disposal at MSW landfills (e.g., Type I Landfills) or in sanitation piping.
- Workshops and stakeholder engagement provide key input on preliminary results to collaboratively identify feasible pilot projects based on a series of minimum technical, operational and financial criteria.

Project Approach



Stakeholder Engagement

PILOT PROJECT SHORT-LIST SCREENING

Scope and Methodology of Short-List Screening

- Inventory of Regional Sites
- Optimization Tool Screening to Create Long List
- Short List of Pilot Projects
- POWER Tool Screening
- Prioritization Evaluation
- Analysis of Selected Pilot Projects

- Compares a series of operational criteria to presents options for consideration and facilitate discussion
- Inventory of regional sites screened based on the existing solid waste and wastewater facilities and select “Greenfield” locations
- Evaluation focuses on a target organics collection area, and does not screen every facility that has potential to develop AD processing capacity
- Combination of optimization tool and solid waste industry experience used to identify subset of inventory of regional sites to screen to a short list of potential pilot projects
- Results of short-list screening will be further evaluated and presented at Workshop 4

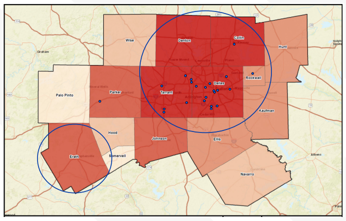
Inventory Regional Sites to Determine Scenarios

- **Inventory of Regional Sites**
- Optimization Tool Screening to Create Long List
- Short List of Pilot Projects
- POWER Tool Screening
- Prioritization Evaluation
- Analysis of Selected Pilot Projects

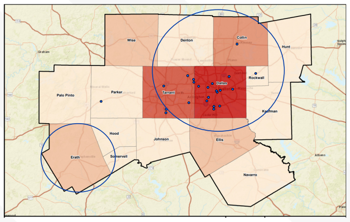
- Inventory of existing infrastructure sites provides baseline for screening for potential project sites
- Coordination between Burns & McDonnell and UTA to determine inventory of regional sites
- Targeted organics collection area determined based on supply and demand analysis
- 96 total sites considered in the targeted organics collection area including:
  - Landfills, LFGtE, LFG to RNG
  - Transfer Station
  - Mulching & Composting
  - Liquid Waste Treatment Facilities
  - WRRF (with and without AD)
  - Greenfield sites

Targeted Organics Collection Areas

POTENTIAL RNG SUPPLY



NGV FUEL DEMAND



- Location of supply of high priority feedstocks (commercial and residential food waste, FOG) and demand from NGVs indicate Collin, Dallas, Denton, and Tarrant Counties as focus areas for further evaluation
- Location of supply of medium priority feedstocks (CAFO manure) indicates Earth County as a focus area for further evaluation

Inventory of Regional Material Management Sites

FACILITY TYPE	TOTAL SITES
Landfill	15
Landfill Gas to Energy	5
Landfill Gas to RNG	3
Transfer Station	16
Mulching & Composting	18
Liquid Waste Treatment Facilities	6
WRRF (without AD)	21
WRRF (with AD)	7
Greenfield	5
Total	**96**

- Excludes non-pertinent facility types (MRFs, medical waste treatment facilities)
- One potential greenfield site selected in each County within the targeted organics collection area
- Potential greenfield site locations identified based on proximity to waste generation projections

Optimization Tool Generates “Long List”

- Inventory of Regional Sites
- **Optimization Tool Screening to Create Long List**
- Short List of Pilot Projects
- POWER Tool Screening
- Prioritization Evaluation
- Analysis of Selected Pilot Projects

- Determine optimal facility locations for each scenario
  - “Levelized” optimization tool to focus on spatial analysis - assumes cost of digester development/processing equal
- Ran several scenarios that adjusted key inputs as a sensitivity analysis
  - 20% capture of food waste and FOG
  - 60% capture of food waste and FOG
- Results of optimization tool runs compiled into “Long List” of locations
  - Screened facilities based primarily on 20% capture rate
  - 60% capture rate provided as sensitivity analysis

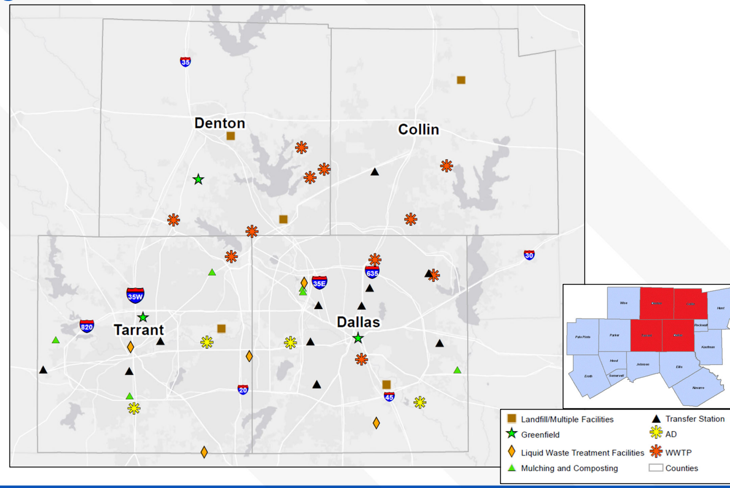
Optimization Results by Facility Type

- Burns & McDonnell and UTA collaboratively developed four optimization analysis scenarios to evaluate the targeted organics collection area
  - Residential food waste, commercial food waste, FOG at 20% and 60% capture rate
  - Commercial food waste, FOG at 20% and 60% capture rate
  - Three additional facilities identified from 60% capture rate sensitivity analysis

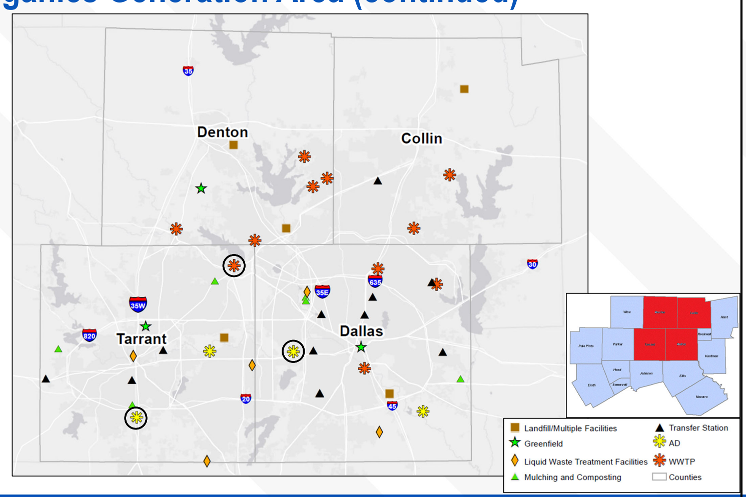
FACILITY TYPE	REGIONAL INVENTORY	SCREENED LOCATIONS[1]
Landfill/multiple facilities	23	6
Transfer Station	16	11
Mulching & Composting	18	6
Liquid Waste Treatment Facilities	6	5
WWTP (without AD)	21	12
WWTP (with AD)	7	4
Greenfield sites[2]	5	4
Total	**96**	**48**

Notes:
1. Screened locations by facility type re-categorizes some facilities into the appropriate category compared to the regional inventory if multiple facility types are co-located (e.g., Pecan Creek WWTP co-located with Denton Landfill is reflected as part of landfill/multiple facility rather than WWTP (with AD)).
2. Tarrant, Dallas, Collin and Denton County greenfield sites selected based on locations with high feedstock. Erath County greenfield site at the location of closed Huckaby Ridge project site.

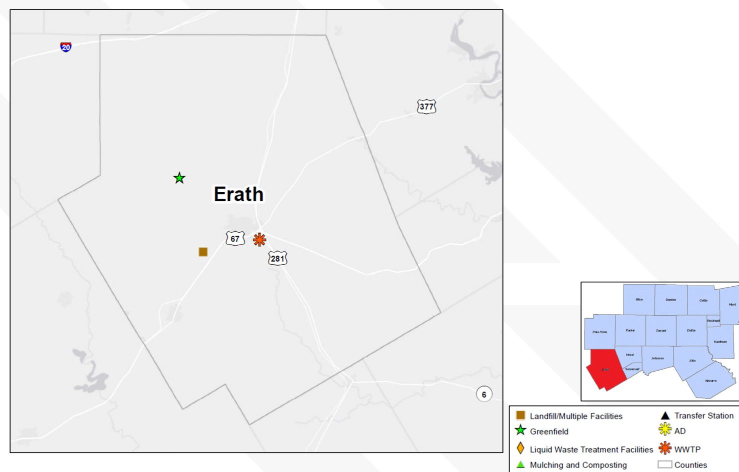
Screened Sites by Facility Type - Targeted Organics Generation Area



Screened Sites by Facility Type - Targeted Organics Generation Area (continued)



Screened Sites by Facility Type - Targeted Organics Generation Area (continued)



Generate "Short List" of Potential Pilot Projects

- Inventory of Regional Sites
- Optimization Tool Screening to Create Long List
- Short List of Pilot Projects
- POWER Tool Screening
- Prioritization Evaluation
- Analysis of Selected Pilot Projects

SCREENING CRITERIA	DEFINITION
Feedstock[1]	Annual residential and commercial food waste, FOG, manure tonnage generated within five miles
Major Roadways	Number of major highways within one mile
Natural Gas Pipelines	Linear distance to nearest natural gas pipeline
NGV Fuel Demand	Linear distance to nearest fueling demand (e.g., fleet yard, existing fueling facility)
Sludge/Biosolids Generators	Distance to nearest sludge/biosolids generator (e.g., WRRF)

Notes:
1. Feedstock does not indicate expected tonnage to be processed by facility, only the total generation within five miles. Manure generation only considered for Erath County.

Landfills/Multiple Facilities Results

FACILITY	COUNTY	FEEDSTOCK (TONS)	HIGHWAYS	NG PIPELINE (MI)	NGV FUELING (MI)	SLUDGE GENERATOR (MI)
City of Denton Landfill Complex[1]	**Denton**	**8,262**	**1**	**0.7**	**0.0**	**0.0**
DFW Recycling and Disposal Facility	Denton	17,939	2	1.3	5.3	2.3
City of Dallas McCommas Bluff Facility	Dallas	11,130	3	1.3	0.7	4.2
City of Arlington Landfill	Tarrant	19,098	0	1.7	3.3	1.9
City of Stephenville Landfill[2]	Erath	2,705,364	1	1.1	N/A	6.0
121 RDF Landfill	Collin	929	1	2.5	6.1	3.0

Notes:
1. City of Denton Landfill Complex includes Denton Landfill and Pecan Creek WWTP.
2. City of Stephenville Landfill feedstock only includes CAFO manure tons.

- City of Denton Landfill Complex is close to required infrastructure
- Erath County has significant quantities of CAFO manure, but is the location of a previously failed AD facility

Bolded facilities indicate proposed short-list candidate

Transfer Station Facilities Results

FACILITY	COUNTY	FEEDSTOCK (TONS)	HIGHWAYS	NG PIPELINE (MI)	NGV FUELING (MI)	SLUDGE GENERATOR (MI)
City of Dallas Bachman Transfer Station	**Dallas**	**45,740**	**4**	**5.8**	**0.6**	**0.6**
City of Garland Transfer Station	**Dallas**	**39,551**	**1**	**9.7**	**0.0**	**0.6**
North Texas Recycling Complex[1]	Tarrant	18,088	2	0.1	3.9	6.2
City of Mesquite Transfer Station	Dallas	10,273	1	4.1	0.1	4.5
City of Dallas Westmoreland Transfer Station	Dallas	16,284	1	1.8	1.5	6.6
City of Dallas Fair Oaks Transfer Station	Dallas	31,777	1	10.2	2.9	3.8
Champion Waste Services	Dallas	34,918	1	2.5	0.4	2.0
Custer Transfer Station	Collin	17,962	1	3.1	7.3	7.1
Southwest Paper Stock	Tarrant	22,234	2	2.7	2.1	10.5
City of University Park Transfer Station	Dallas	45,740	1	8.4	0.3	5.7
Westside Transfer Station	Tarrant	3,045	2	6.6	12.2	4.1

Notes:
1. North Texas Recycling Complex does not operate as a transfer station, only as a MRF operated by Republic and fleet and fueling yard for its collection operation.

Composting & Mulching Facilities Results

FACILITY	COUNTY	FEEDSTOCK (TONS)	HIGH WAYS	NG PIPELINE (MI)	NGV FUELING (MI)	SLUDGE GENERATOR (MI)
City of Mesquite Recycling/Waste[1]	**Dallas**	**4,429**	**1**	**1.0**	**3.6**	**0.0**
Soil Building Systems	Dallas	28,255	3	2.8	1.0	3.7
Alpine Materials	Tarrant	11,360	1	4.6	3.1	3.3
Thelin Recycling	Tarrant	16,216	2	3.8	2.8	8.4
The Organic Recycler of Texas	Dallas	30,615	3	3.3	0.5	3.3
Silver Creek Materials	Tarrant	4,195	0	4.7	10.2	2.2

Notes:
1. City of Mesquite Recycling/Waste facility co-located with South Mesquite Regional Wastewater Treatment Plant.

- City of Mesquite has fewer tons in surrounding area, but synergy with co-located wastewater treatment and AD
- Other composting facilities have more feedstock but are further from key infrastructure

AD/WRRF Facilities Results

FACILITY	COUNTY	FEEDSTOCK (TONS)	HIGH WAYS	NG PIPELINE (MI)	NGV FUELING (MI)	SLUDGE GENERATOR (MI)
City of Dallas Southside WWTP[1]	**Dallas**	**4,811**	**0**	**3.0**	**2.3**	**0.0**
Village Creek Water Reclamation Facility[1]	**Tarrant**	**19,615**	**1**	**0.0**	**5.7**	**0.0**
City of Garland Rowlett Creek WWTP	**Dallas**	**14,870**	**1**	**8.9**	**0.6**	**0.0**
City of Dallas Central WWTP	Dallas	32,851	3	0.7	1.2	8.7
Stewart Creek WWTP	Denton	15,637	0	0.0	9.1	0.0
Denton Creek Regional WWTP	Denton	3,746	2	2.0	3.9	0.0
Little Elm WWTP	Denton	10,976	0	2.3	10.2	1.1
Rowlett Creek WWTP	Collin	14,435	0	9.2	5.1	5.7
Town of Flower Mound WWTP	Denton	11,783	0	1.4	2.9	0.0
Floyd Branch Regional WWTP	Dallas	27,928	1	10.6	2.4	0.0
Wilson Creek Regional WWTP	Collin	4,458	0	1.3	3.8	0.0
Stewart Creek West Regional WWTP	Denton	18,559	0	1.3	8.7	0.0
City of Stephenville WWTP[3]	Erath	1,067,854	3	2.0	48.4	3.4

Notes:
1. Facility currently has AD capacity installed.
2. Pecan Creek WWTP was considered in the long list as part of the Denton Landfill Complex
3. Feedstock represents CAFO manure only. NGV fueling location distance does not consider NGV demand outside of the targeted organics collection area.

Liquid Treatment Facilities Results

FACILITY	COUNTY	FEEDSTOCK (TONS)	HIGH WAYS	NG PIPELINE (MI)	NGV FUELING (MI)	SLUDGE GENERATOR (MI)
Liquitek Arlington Liquid Waste Processing Facility	Tarrant	14,066	3	0.5	3.3	6.3
Clean Earth Environmental Solutions	Dallas	4,881	1	2.7	1.6	5.9
Dallas Grease Trap Grit Trap Treatment Facility	Dallas	26,164	3	2.2	1.6	4.3
Cold Springs Processing & Disposal	Tarrant	21,260	6	1.5	0.9	10.6
Southwaste Disposal Facility	Tarrant	3,137	1	0.8	10.7	4.4

- Liquid treatment facilities present interesting opportunity to aggregate FOG materials
- Other solid waste or wastewater facilities (as compared to industrial facilities) are more likely to pursue co-digestion projects

Potential Greenfield Facilities Results

FACILITY	COUNTY	FEEDSTOCK (TONS)	HIGH WAYS	NG PIPELINE (MI)	NGV FUELING (MI)	SLUDGE GENERATOR (MI)
Dallas County Greenfield Site	Dallas	44,975	6	4.0	0.3	3.8
Collin County Greenfield Site	Collin	8,772	3	0.4	12.0	2.9
Tarrant County Greenfield Site	Tarrant	17,261	2	1.8	5.1	6.5
Erath County Greenfield Site[1]	Erath	1,272,500	0	2.0	45.1	8.1

Notes:
1. Erath County greenfield site at the location of closed Huckaby Ridge project site. Feedstock represents CAFO manure only. NGV fueling location distance does not consider NGV demand outside of the targeted organics collection area.

- Development of a greenfield facility is typically more expensive, but may be feasible if located advantageously for industrial digester (e.g., brewery)
- Dallas County greenfield site feedstock comparatively higher because location is in downtown/commercial area of City of Dallas
- Erath County has significant quantities of CAFO manure, but is the location of a previously failed AD facility

Sensitivity Analysis Results

- Majority of sites identified in sensitivity analysis supported facilities identified in 20% capture scenario
- Some identified sites were not further screened based on small footprint or proximity to proposed short-listed candidates (e.g., small WRRFs without AD near Denton Landfill Complex)
- Three sites were identified that should be considered for further evaluation but would require higher capture rate (e.g., 60%) of feedstock to be considered optimal locations

FACILITY	COUNTY	DESCRIPTION
Central Regional WWTP	Dallas	WRRF with AD operated by the Trinity River Authority and located between Dallas and Fort Worth.
Fort Worth Brewery	Tarrant	Miller-Coors brewery with AD and high-volume beverage production capabilities.
Peach Street WWTP	Tarrant	Small WRRF with no AD located adjacent to the DFW Airport, a high NGV demand site.

DISCUSS AND FINALIZE SHORT-LIST

Short-Listed Locations

FACILITY	FACILITY TYPE	COUNTY	AD (Y/N)
City of Dallas Southside WWTP[1]	WRRF (with AD)	Dallas	Y
City of Denton Landfill Complex[1]	Multiple Facilities	Denton	Y
Village Creek Water Reclamation Facility	WRRF (with AD)	Tarrant	Y
Central Regional WWTP	WRRF (with AD)	Dallas	Y
Fort Worth Brewery	WRRF (with AD)	Tarrant	Y
Peach Street WWTP	WRRF (without AD)	Tarrant	N
City of Dallas Bachman Transfer Station	Transfer Station	Dallas	N
City of Garland Rowlett Creek WWTP	WRRF (without AD)	Dallas	N
City of Garland Transfer Station	Transfer Station	Dallas	N
City of Mesquite Recycling/Waste	Composting/WRRF	Dallas	N

Notes:
1. Dallas Southside WWTP and Denton Pecan Creek WWTP facilities proposed to be evaluated via the POWER Tool

NEXT STEPS

POWER Tool Provides Initial Evaluation

- Inventory of Regional Sites
- Optimization Tool Screening to Create Long List
- Short List of Pilot Projects
- POWER Tool Screening
- Prioritization Evaluation
- Analysis of Selected Pilot Projects

- POWER Tool evaluates key project criteria for existing AD facilities
  - Facility capacity
  - Biogas output and electricity/fuel generation
  - GHG emissions
  - Capital expenses
  - Operating expenses
  - Air pollutant emissions
- POWER Tool results will be incorporated into project assessments

Leverage POWER Tool to Evaluate Existing AD Capacity

Dallas Southside WWTP

- Dallas Water Utility (DWU) has agreed to provide information and support further evaluation as part of this project
- Facility has available capacity and is open to co-digestion of food waste
- Facility contains large biosolids/sludge disposal area and would consider accepting material from other entities

Denton Landfill Complex

- Denton wastewater has agreed to provide information and support further evaluation as part of this project
- Co-located with landfill, composting facility and fleet fueling demand

Prioritization Builds on POWER Tool Results

- Inventory of Regional Sites
- Optimization Tool Screening to Create Long List
- Short List of Pilot Projects
- POWER Tool Screening
- Prioritization Evaluation
- Analysis of Selected Pilot Projects

SCREENING CRITERIA	DEFINITION
Feedstock	Estimated additional influent volume if residential and commercial food waste and FOG tonnage were transported to site.
Infrastructure Requirements	Existing ability to receive collection vehicles and store material at site.
Natural Gas Processing and Transmission	Linear distance to nearest natural gas pipeline interconnections.
NGV Fuel Demand	Linear distance to existing fuel distribution locations/fleets.
Sludge/Biosolids Generators	Estimated biosolids generation within 20 miles.
Byproduct Management	Number of byproduct management facilities (e.g., composting, landfills) within 20 miles.
Environmental Permitting	Evaluation of facility land class, location in relation to floodplains and wetland delineations.
Environmental Justice	Comparative analysis of income, race, and English proficiency at facility location.

Potential Pilot Project Scenarios Matrix

- Funding/financing considerations
  - Environmental credits (RFS, LCFS, etc.)
  - Renewable Energy Credits (RECs)
  - Federal policy and legislation (Inflation Reduction Act, Bipartisan Infrastructure Bill, etc.)
  - Infrastructure development grants/loans
  - Utility investments
  - Alternative fuel transportation incentives
- Matrix will indicate project viability with and without available incentives and funding opportunities

Next Steps

- Move ahead to conduct POWER Tool runs on Pecan Creek and Dallas Southside WRRFs
- Complete screening evaluation of short-listed pilot projects
- Develop potential pilot project scenarios matrix indicating viability with and without financial and funding opportunities/incentives
- Hold workshop #4 – Feasibility Study conclusion in mid-September

THANK YOU!

CREATE AMAZING.

WORKSHOP #4

BURNS McDONNELL

Organic Waste to Fuel Study Conclusion Workshop

North Central Texas Organic Waste to Fuel Feasibility Study

Project Advisory Group
September 20, 2022

AGENDA

- Project Status Update
- Overview of POWER Tool
- Dallas Southside WWTP
- Denton Landfill Complex
- Funding and Incentive Opportunities
- Pilot Project Key Findings and Recommendations

Virtual Workshop Reminders

1. Please leave your microphone muted unless speaking
2. Use the chat box or raise hand button to ask a question or provide a comment
3. Please state your name prior to asking a question a making a comment
4. Please note that the presentation is being recorded

Key Terms and Acronyms

Anaerobic Digestion (AD)

Water Resource Recovery Facility (WRRF)

Landfill Gas (LFG)

Landfill Gas to Energy (LFGTE)

Renewable Natural Gas (RNG)

Natural Gas Vehicle (NGV)

Renewable Fuel Standard (RFS)

Environmental Credits

WELCOME & INTRODUCTIONS

Introductions

- **Breanne Johnson**
  Environment & Development Planner
  NCTCOG
- **Cassidy Campbell**
  Environment & Development Program Manager
  NCTCOG
- **Lori Clark**
  Air Quality Program Manager
  NCTCOG
- **Soria Adibi**
  Senior Air Quality Planner
  NCTCOG
- **Melanie Sattler**
  Civil Engineering Professor & Researcher
  University of Texas at Arlington

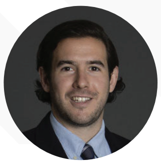
Introductions

Scott Pasternak
Project Manager
Burns & McDonnell

Scott Martin
Deputy Project Manager
Burns & McDonnell

Debra Kantner
Market Assessment & Feasibility
Burns & McDonnell

Drew Mitrisin
Transportation Planning & Policy
Burns & McDonnell



Eric Weiss
Collection Network Assessment
Burns & McDonnell

Matt Tomich
President
Energy Vision

Phil Vos
Program Director
Energy Vision

PROJECT STATUS UPDATE

Project Background

- Study assesses the feasibility of collecting and transporting organic wastes to produce renewable natural gas (RNG) for use as a transportation fuel.
- NCTCOG and UTA partnering on the study which is supported by a grant from the U.S. Environmental Protection Agency (U.S. EPA).
- Prior to the study, NCTCOG conducted regional waste characterizations and a series of virtual roundtables to share organic waste management efforts and challenges in the region.
- Key considerations for the evaluation include determining the most critical organic wastes to divert (e.g., sludge and biosolids, food waste, FOG) from disposal at MSW landfills (e.g., Type I Landfills) or in sanitation piping.
- Workshops and stakeholder engagement provide key input on preliminary results to collaboratively identify feasible pilot projects based on a series of minimum technical, operational and financial criteria.

Project Approach

Priority Feedstocks ↑ | **Potential Pilot Projects** ↑

Supply & Demand Analysis
- Feedstock Market Assessment & Prioritization
- Collection Network Assessment
- Vehicle RNG Demand Analysis

Project Selection
- Select Optimal Sites
- Inventory Existing AD Sites
- Document Incentives and Funding Opportunities

Feasibility Study
- Recommended Actions
- Potential Pilot Projects
- Draft and Final Reports

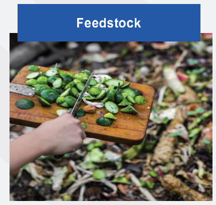
NCTCOG/Stakeholder Engagement

Stakeholder Engagement

- Nov 2021 — Project Kick Off Meeting
- Jan 2022 — Kick-off Workshop; Interviews, Surveys and Outreach
- Mar 2022
- May 2022 — Supply-Demand Workshop
- July 2022 — Project Selection Criteria Workshop
- Sept 2022 — Short-List Screening Workshop; Final Study Conclusion Workshop

Key Findings Support Selection of Pilot Projects

Feedstock



- Significant available feedstock to divert from disposal
- Sludge management key challenge among WWTPs in region
- High priority feedstocks identified as food waste, FOG, and existing biogas resources

Collection Network

- Commercial collection comparatively more cost effective than residential
- Collection via vacuum truck supports combined FOG and food waste collection
- Food waste would be delivered by roll-off or vacuum truck

NGV Fueling

- Key fleet types identified for adoption include solid waste, buses, and long-haul vehicles
- Buses include both transit buses and charter buses
- Currently more demand for RNG than supply

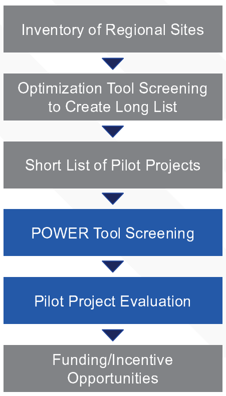
PILOT PROJECT EVALUATION OVERVIEW

Review of Short-Listed Locations

Facility	Facility Type	County	AD (Y/N)
City of Dallas Southside WWTP	**WWTP**	**Dallas**	**Y**
City of Denton Landfill Complex	**Multiple Facilities**	**Denton**	**Y**
Village Creek Water Reclamation Facility	WWTP	Tarrant	Y
Central Regional WWTP	WWTP	Dallas	Y
Fort Worth Brewery	WWTP	Tarrant	Y
Peach Street WWTP	WWTP	Tarrant	N
City of Dallas Bachman Transfer Station	Transfer Station	Dallas	N
City of Garland Rowlett Creek WWTP	WWTP	Dallas	N
City of Garland Transfer Station	Transfer Station	Dallas	N
City of Mesquite Recycling/Waste	Composting/WWTP	Dallas	N

- Short-list screening process and results determined as part of Workshop 3B
- Selected facilities provide "north" and "south" pilot projects for opportunities in multiple areas of the metroplex region

Pilot Project Evaluation Overview



- Dallas Southside WWTP and Denton Landfill Complex selected for further evaluation
- POWER Tool estimates technical, environmental impacts by comparing the existing system to preliminary co-digestion pilot project scenarios
- The evaluation utilizing the POWER Tool is provided for discussion purposes only, and is subject to change based on the outcomes of the workshop
- Additional analysis includes GIS screening of existing infrastructure, byproduct management, environmental permitting and environmental justice considerations
- Key findings and next steps developed to advance pilot projects

Feedstock Volumes and Delivery Vehicles

Feedstock (Annual Tons)	Southside WWTP	Denton Landfill Complex
Commercial pre-consumer food waste	43,320	10,350
Fats, oils, and greases	9,300	1,640
Residential post-consumer food waste	0	2,060
Total Additional Material	**52,620**	**14,050**

- Commercial pre-consumer food waste
  - Assumes 50 percent capture rate county-wide from correctional facilities, healthcare facilities, hospitality locations, institutions and food waste manufacturers and processors.
  - Material delivered via vacuum trucks and roll off trucks, as applicable
- Fat, oils and greases
  - Assumes 75 percent capture rate of material county-wide from restaurants and food service location
  - Material delivered via vacuum and tanker trucks
- Residential post-consumer food waste
  - Assumes 20 percent capture rate from City of Denton only
  - Includes only food waste from Denton residents as feedstock for AD for comparison purposes only

Material Acceptance, Screening and Pre-Processing

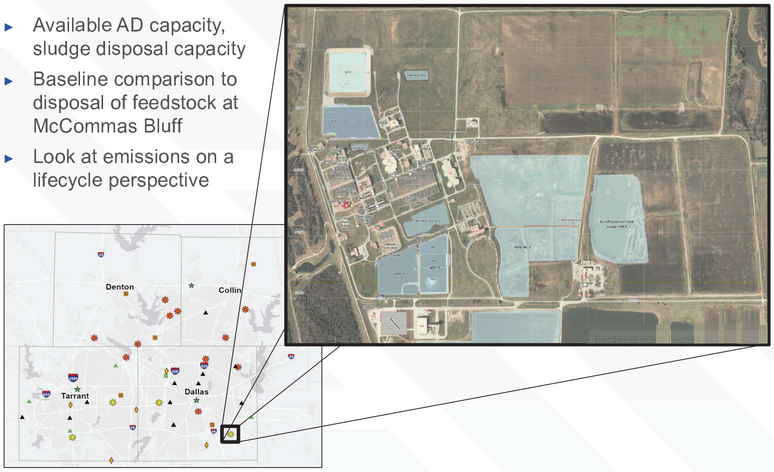
Equipment	Dallas Southside WWTP	Denton Landfill Complex
Receiving area	Unable to receive increased vehicle traffic	Facility designed to receive collection vehicles
Pre-processing and screening equipment	Unable to process and screen solid waste	In the process of procuring processing equipment (channel grinder)
Storage tank	Unable to store materials on site to meter into AD system.	Unable to store materials on site to meter into AD system.
Gas cleaning equipment	Scrubs gas for use in electricity but does not purify for RNG usage.	Scrubs gas for use in electricity but does not purify for RNG usage.

- Additional acceptance, screening and pre-processing infrastructure required
- Additional engineering assessment and cost estimates required to advance both potential pilot projects

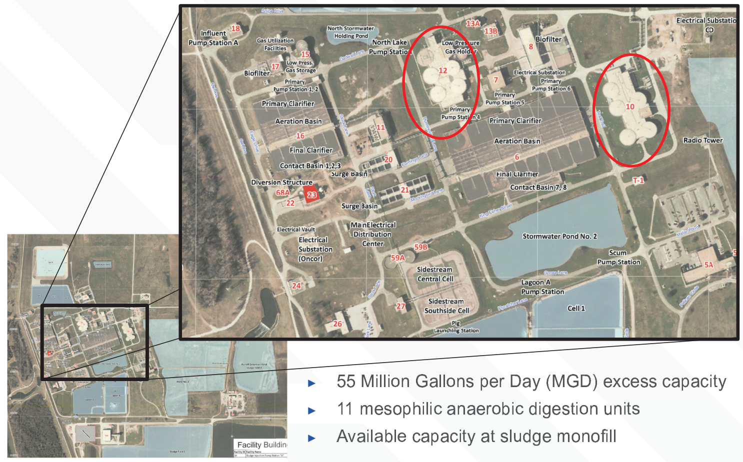
DALLAS SOUTHSIDE WWTP

Dallas Southside WWTP Pilot Project Overview

- Available AD capacity, sludge disposal capacity
- Baseline comparison to disposal of feedstock at McCommas Bluff
- Look at emissions on a lifecycle perspective

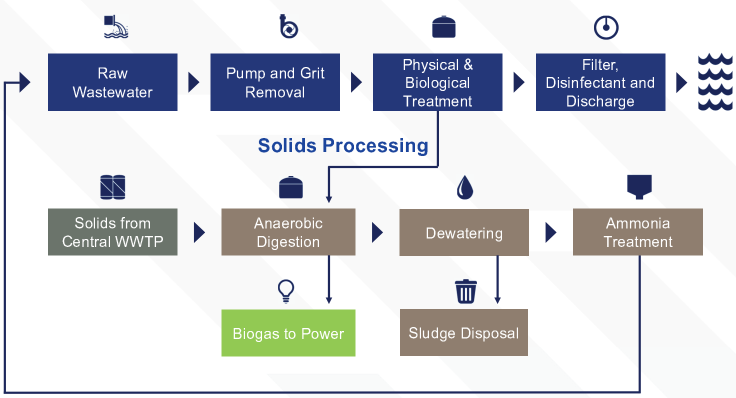


Dallas Southside WWTP Facility Description



- 55 Million Gallons per Day (MGD) excess capacity
- 11 mesophilic anaerobic digestion units
- Available capacity at sludge monofill

Dallas Southside WWTP Liquids and Solids Processing (current process)



POWER Tool Potential Biogas Production Comparison

	Potential Biogas Production (m³/day)		
Feedstock	**Anaerobic Digestion**	**Landfill**	**Difference**
Food Waste	9,800	4,400	5,400
Commercial FOG	17,800	6,400	11,400
Total	**27,500**	**10,700**	**16,800**

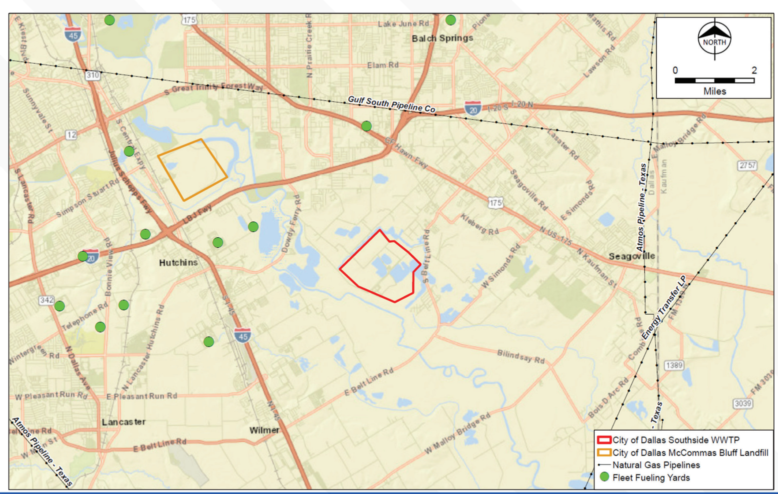
- POWER Tool assumes co-digestion at Southside WWTP is running at full projected capacity
- POWER Tool provides a planning level estimate of pipeline quality biogas generation
- Yield rates for FOG disposed at Southside WWTP are much higher than landfill

POWER Tool Results Emissions Comparison

	Potential Emissions (kg/year)		
Emissions	**Anaerobic Digestion**	**Landfill**	**Difference**
Volatile Organic Compounds (VOC)	860	1,100	(240)
Nitrogen Oxide (NO_x)	(3,430)	5,160	(8,590)
Particulate Matter (PM2.5)	(160)	210	(370)
Sulfur Dioxide (SO_2)	(172,080)	80	(172,160)
Carbon Dioxide Equivalents (CO_2-e)	(2,399,760)	279,500	(2,679,260)

- Significant emissions savings by processing material at Southside WWTP compared to McCommas Bluff
- Represents incremental emission from processing additional feedstock
  - Includes waste transport, storage, pre-processing, digestion/disposal, gas cleaning, digestate management, fueling
- Significant reductions in NOx and SOx emissions utilizing AD instead of landfill disposal

Dallas Southside WWTP Existing Infrastructure



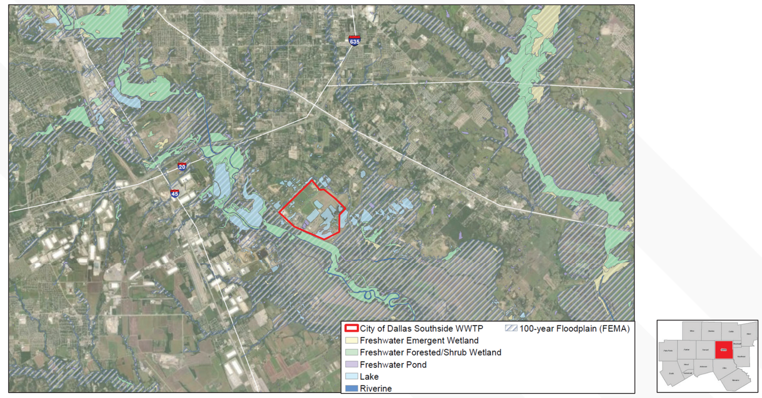
Dallas County WWTP Sludge Generators

- 10 WWTPs in Dallas County managing about 136,000 tons of sludge annually
- Dallas Central WWTP currently transfers material to Southside WWTP
- Sludge from other facilities could be delivered for processing and/or disposal capacity for secondary treatment
- Processing requirements (e.g., direct to disposal, processed as influent) would depend on level of treatment at each facility

Facility Name	Generation Tons
Central Regional WWTP	68,597
Central WWTP	23,571
City of Garland Rowlett Creek WWTP	1,570
Dallas County Park Cities MUD WWTP	1,568
Dallas Southside WWTP	24,178
Floyd Branch Regional WWTP	387
Muddy Creek Regional WWTP	2,071
Rowlett Creek Regional WWTP	5,122
South Mesquite Creek WWTP	7,515
Ten Mile Creek Plant	1,941
Total	**136,518**

Source: U.S EPA National Pollutant Discharge Elimination System (NPDES) Biosolids Program reporting

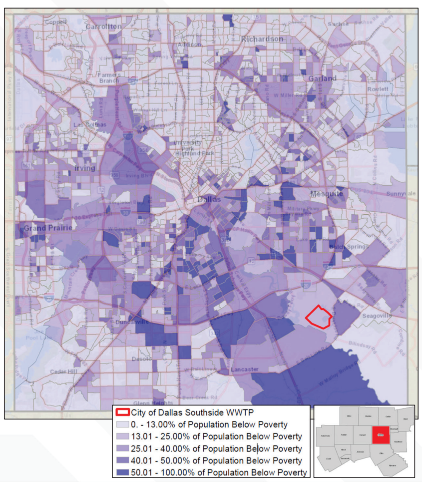
Dallas Southside WWTP Environmental Permitting



- No changes to facility footprint minimize challenge with floodplain and wetland locations
- Upgrades to storage and receiving infrastructure may require TCEQ permit modification depending if facility is considered storing waste or feedstock

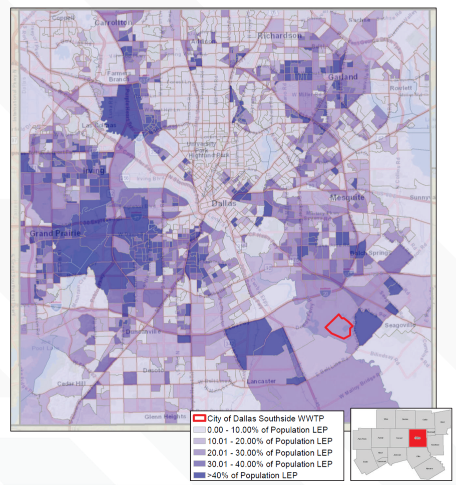
Dallas Southside WWTP Population Below Poverty Threshold

- Southside WWTP located in industrial area between 13-25 percent below poverty
- Impact on residential areas small, since area consists of industrial operations rather than single- or multi-family homes
- Opportunity to displace diesel as part of pilot project would minimize emissions
- Shifting location of collection vehicles to dispose at Southside WWTP would minimize vehicle traffic at Landfill



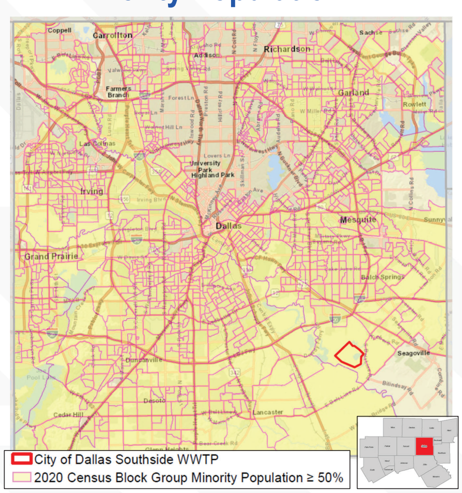
Dallas Southside WWTP Limited English Proficiency

- 20-30 percent identified as limited English proficiency
- Limited residential housing in this area of Dallas County
- Outreach plan should be developed to ensure communications are provided on a bilingual basis to support needs of local community



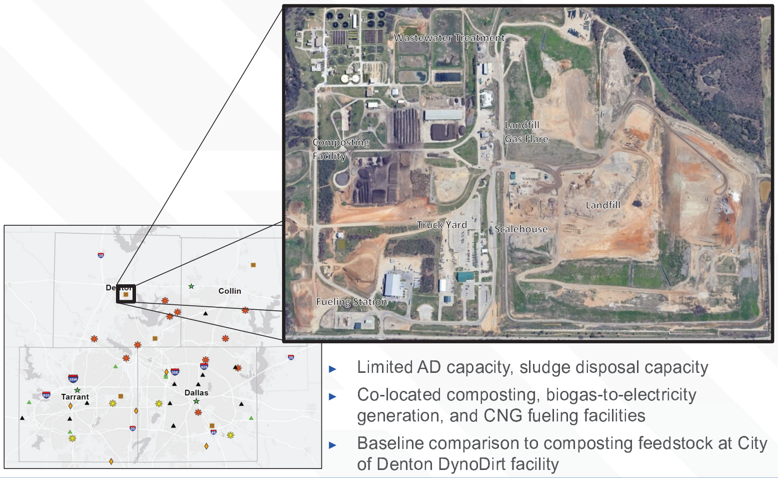
Dallas Southside WWTP Minority Population

- Located within and near surrounding communities with >50% minority population
- Provided as a planning-level understanding of minority population
- Further environmental justice evaluations may support funding opportunities to support pilot project (e.g., equipment to minimize odors/vectors)
- Emissions reductions from usage of RNG would have a beneficial impact on all surrounding community



DENTON LANDFILL COMPLEX

Denton Landfill Complex Pilot Project Overview



- Limited AD capacity, sludge disposal capacity
- Co-located composting, biogas-to-electricity generation, and CNG fueling facilities
- Baseline comparison to composting feedstock at City of Denton DynoDirt facility

Denton Landfill Complex Facility Description

POWER Tool Potential Biogas Production Comparison

	Potential Biogas Production (m^3/day)	
Feedstock	**Anaerobic Digestion**	**Composting**
Food Waste	2,800	0
Commercial FOG	3,130	0
Total	**5,930**	**0**

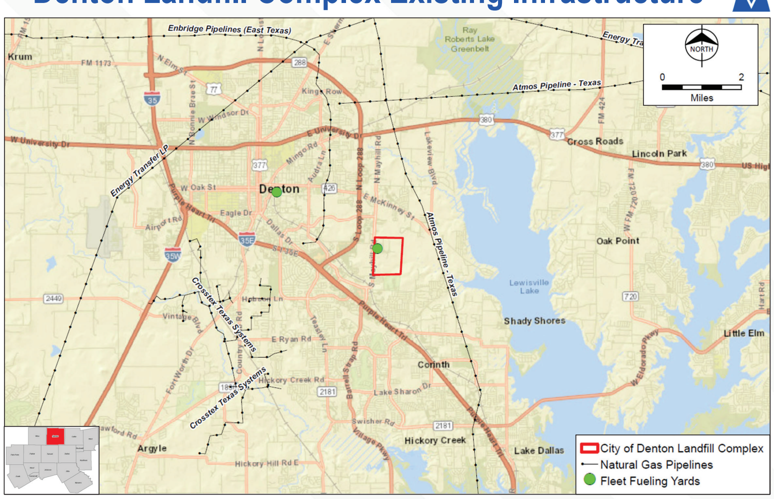
- POWER Tool assumes co-digestion processing all estimated annually collected tons to achieve biogas yields presented
- No biogas production from composting facility
- POWER Tool provides a planning level estimate of vehicle fuel quality biogas generation

POWER Tool Results Emissions Comparison

	Potential Emissions (kg/year)		
Emissions	**Anaerobic Digestion**	**Composting**	**Difference**
Volatile Organic Compounds (VOC)	70	30	40
Nitrogen Oxide (NO_x)	(580)	190	(770)
Particulate Matter (PM2.5)	(40)	4	(44)
Sulfur Dioxide (SO_2)	720	70	(650)
Carbon Dioxide Equivalents (CO_2-e)	(651,140)	481,260	(1,132,400)

- Some savings from anaerobic digestion compared to composting, but not as significant as scenario one
- Represents incremental life-cycle emissions from processing additional feedstock
  - Includes waste transport, storage, pre-processing, digestion/disposal, gas cleaning, digestate management, fueling

Denton Landfill Complex Existing Infrastructure



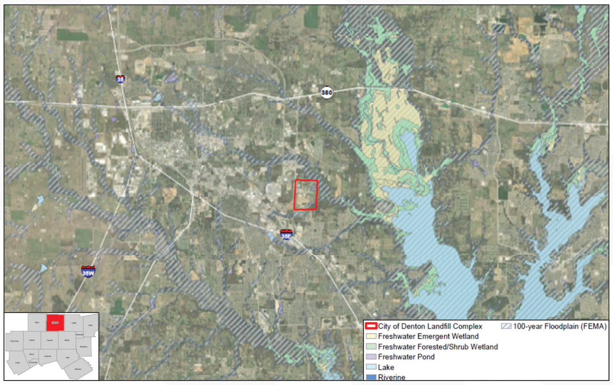
Denton Landfill Complex Sludge Generators

- 23 other WWTPs in Denton County managing about 36,000 tons of sludge annually
- Smaller WWTPs have limited storage/disposal capacity on-site
- Denton Landfill Complex could consider accepting sludge from other facilities by developing ILA for disposal
- Ability to process sludge from other facilities depends on Pecan Creek WWTP capacity and treatment level at other facilities
- Potential opportunity for to pursue hydrogen manufacturing pilot

Facility Name	Generation Tons
Aubrey WWTP	29
Brairwood Retreat WWTP	1
City of Hackberry WWTP	1,218
City of Justin WWTP	337
City of Krum WWTF	80
City of Sanger WWTP	793
Denton Creek Regional WWTF	2,729
Doe Branch Reg Water Rec Plant	578
Hidden Cove Park WWTP	18
Lakeview Regional Water Reclamation	1,257
Northlake Village MHP WWTP	2
Panther Creek WWTP	1
Pecan Creek Water Reclamation Plant	2,174
Peninsula Reg Water Rec Plant	4,668
Prairie Creek WWTP	260
Riverbend Reg Water Reclamation Facility	17,330
Robson Ranch WWTP	1,035
Stewart Creek West WWTP	57
Stewart Creek WWTP	1,536
Town of Flower Mound WWTP	914
Town of Ponder WWTP	1,644
Trophy Club MUD 1	80
Total	**36,891**

Source: U.S EPA National Pollutant Discharge Elimination System (NPDES) Biosolids Program reporting

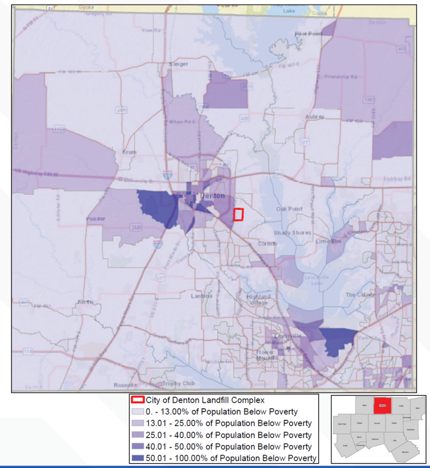
Denton Landfill Complex Environmental Permitting



- Upgrades to facility may require changes to discharge permit if pollutant loading changes
- Storing and receiving solid waste may require additional permitting by TCEQ, depending where storage and processing occurs in Landfill Complex

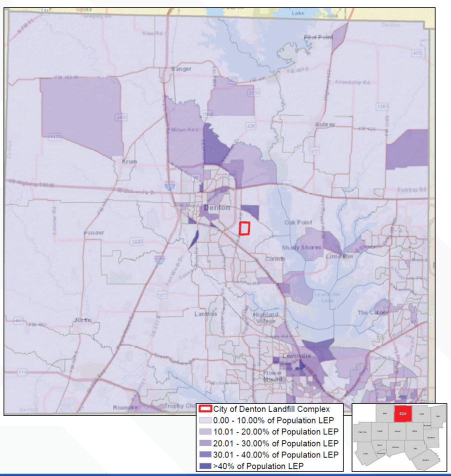
Denton Landfill Complex Population Below Poverty Threshold

- Located in industrial area between 13-25 percent below poverty threshold
- Landfill Complex adjacent to sensitive area
- Increased odors/vectors could be a significant challenge
- Opportunity to explore funding to minimize negative impact to areas with environmental justice concerns (e.g., storage equipment to minimize odors/vectors)



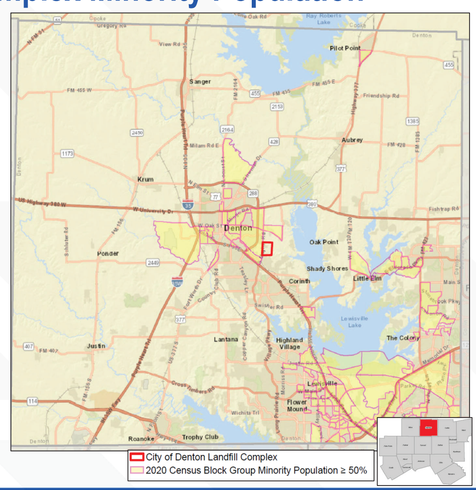
Denton Landfill Complex Limited English Proficiency

- 0-10 percent identified as limited English proficiency
- Pockets of Denton County have limited English proficiency
- Multi-language communications should be developed to engage community related to potential pilot
- Cooperative effort with other municipalities in County should consider multi-language communications



Denton Landfill Complex Minority Population

- Denton Landfill Complex adjacent to communities with minority population greater than 50 percent
- Pilot project should may require further environmental justice evaluations
- Deeper dive on odor, traffic and emissions reductions impacts of minority populations adjacent to the Denton Landfill Complex
- Critical pilot project prioritize needs of underserved communities



FUNDING AND INCENTIVES OPPORTUNITIES

Funding Incentives and Opportunities

Inventory of Regional Sites
↓
Optimization Tool Screening to Create Long List
↓
Short List of Pilot Projects
↓
POWER Tool Screening
↓
Prioritization Evaluation
↓
Funding/Incentive Opportunities

- Funding/Incentives
  - Environmental credits (RFS, LCFS, etc.)
  - Federal policy and legislation (Inflation Reduction Act, Bipartisan Infrastructure Bill, etc.)
  - Infrastructure development grants/loans
  - Public-Private Partnerships
  - Alternative fuel transportation incentives
- There are many funding incentives and opportunities available
- Status of funding incentives is constantly in flux, and funding availability is subject to change based on a wide variety of reasons

Environmental Credits

Environmental Credit	Description	Value
Renewable Fuel Standard (RFS)	U.S. EPA categorizes RINs based on how alternative fuels (RNG, hydrogen) are manufactured including D3 RINs (derived from cellulosic sources) and D5 RINs (derived from other biomass, food waste material).	D3 RINs: $3.00 - $3.30 per credit D5 RINs $1.50 – $1.75 per credit (GGE basis)
California Low Carbon Fuel Standard (LCFS)	The Carbon Intensity (CI) score is a key component of the LCFS, ultimately determining the value that can be realized from environmental credits.	$86.50 per credit (metric ton basis)
Oregon Clean Fuels Program (CFS)	Similar to California's LCFS, credits are issued in a compliance-based market.	Credits trading at a value ranging between $110-$115 per credit (metric ton basis)
Forthcoming CFS	The State of Washington and Canada are each developing CFS frameworks intended to be enacted in 2023.	TBD

- Credits shown are directly applicable to organics to fuel projects utilizing RNG.
- Other environmental credits available as part of separate pathways or mechanisms (e.g., Renewable Energy Credit, Carbon Offset Credits). These are further discussed in the draft report.

Federal Policy/Legislation

- **Inflation Reduction Act** provides new and expanded tax credits for biogas projects and extends an alternative fuel tax credit for all biogas sectors
- **Infrastructure Investment and Jobs Act of 2021** provides new and expanded funding opportunities and appropriations for AD and associated infrastructure.
- **Volkswagen Clean Air Act Civil Settlement** supports the Texas Volkswagen Environmental Mitigation Program (TxVEMP), which provides grant opportunities to replace or upgrade older vehicles or equipment, or install alternative fueling equipment.
- **Justice40 Initiative** sets the goal of allocating 40 percent of the federal investments to disadvantaged communities that are marginalized, underserved, and overburdened by pollution.
- **Alternative Fuel Excise Tax Credit** provides $0.50 per gallon is available for the following alternative fuels: natural gas, liquefied hydrogen, propane, P-Series fuel, liquid fuel derived from coal through the Fischer-Tropsch process,and compressed or liquefied gas derived from biomass.
- **Alternative Fuel Tax Exemption** provides tax exemption from alternative fuels used in a manner that the Internal Revenue Service (IRS) deems as nontaxable are exempt from federal fuel taxes.

Inflation Reduction Act

- Provides new and expanded tax credits for biogas and hydrogen projects
  - Up to 30 percent rate of Investment Tax Credit (ITC) and Production Tax Credit (PTC) for facilities which begin construction before 2034
  - Additional 10 percent tax credit for domestic content bonus (e.g., for projects utilizing materials fabricated and manufactured in the U.S.)
  - Additional 10 percent tax credit for energy community bonus (e.g., for projects located in communities located on brownfield sites, high industrial activity, or high unemployment rates)
  - Extends alternative fuel tax credit of $0.20 per gallon up to $1.00 per gallon if prevailing wage and apprenticeship requirements are met

Public-Private Partnerships

Stakeholder	City-Owned and Operated	City-Owned with Private Operations	Privately Owned and Operated on City Land	Operating Services Agreement
Land Ownership	City	City	City	Private
Capital Investment	City	City	Private	Private
Operations	City	Private	Private	Private

- Key stakeholders for RNG projects include the biogas producer, gas distributor and vehicle fleet operator
- Stakeholders must collaborate to develop long-term projects to realize the financial benefits of environmental credits
  - Producers and distributors must provide biogas reliably to fleets
  - Fleets must use RNG for environmental credits to be recognized
- Revenue sharing is typical among the stakeholders to develop equitable long-term contractual relationships for RNG projects

RNG Offtake Management Companies

- RNG offtake management companies and other end users of RNG were engaged to determine level of interest and anticipated cost of services.
- A brief description of each company and a summary of each discussion is below.
  - U.S. Gain has fueling stations in the region and is a project developer offering services for RNG credit management.
  - Element Markets is an RNG marketing and environmental commodities company.
  - Clean Energy has fueling stations in the region and is a project developer.

Grants, Loans and Cost Sharing

- **Sustainable Materials Management Grants** are released by the U.S. EPA specific to supporting AD as an alternative to landfill disposal. Funding may vary by region.
- **Equipment/Consulting Grants** are released by NCTCOG from funding provided by the TCEQ supported by landfill disposal surcharges in Texas
- **Environmental Quality Incentives Program (EQIP)** is a cost-sharing program, sometimes referred to as cash reimbursement, that allows project owners to purchase and construct AD systems, and then apply for cost-sharing funds after the project is completed.
- **Hydrogen Demonstration Project Grants** fund hydrogen demonstration projects that can help lower the cost of hydrogen, reduce carbon emissions and local air pollution, and provide benefits to disadvantaged communities
- **Regional Clean Hydrogen Hubs** fund the development of at least four regional networks of hydrogen producers, potential hydrogen consumers, and connective infrastructure located in close proximity.

Alternative Fuel Transportation Incentives

Alternative Fuel Transportation Incentive	Administrator	Description
Alternative Fuel Corridor (AFC)	U.S. DOT	Deploy publicly accessible electric vehicle charging and hydrogen, propane, and natural gas fueling infrastructure along designated AFCs.
Electric Vehicle Charging and Clean Transportation Grants	U.S. DOE	Support transportation decarbonization research projects.
Clean School Bus program	U.S. EPA; TCEQ	Provide funding for the replacement of existing school buses with clean, alternative fuel school buses or zero-emission school buses. TCEQ administers a similar grant program for school bus retrofits or up to 80 percent of the cost to replace a school bus.
Congestion Mitigation and Air Quality (CMAQ) Improvement Program	U.S. EPA	Provide funding to state departments of transportation, local governments, and transit agencies for projects and programs that help meet the requirements of the Clean Air Act by reducing mobile source emissions and regional congestion on transportation networks.

Alternative Fuel Transportation Incentives (cont'd)

Alternative Fuel Transportation Incentive	Administrator	Description
Texas Clean Fleet Program (TCFP)	TCEQ	Incentivize owners of large fleets in Texas (75 or more vehicles) to replace diesel-powered vehicles with alternative fuel or hybrid vehicles.
Texas Natural Gas Vehicle Grant Program (TNGVGP).	TCEQ	Provides grants to encourage an entity that owns and operates a heavy-duty or medium-duty motor vehicle to retrofit the vehicle with a natural gas engine or replace the vehicle with a natural gas vehicle.
Alternative Fueling Facilities Program (AFFP)	TCEQ	Provides grants for eligible alternative fuel fueling facility projects in Texas' Clean Transportation Zone including $6 million for CNG and/or LNG.

PILOT PROJECT KEY FINDINGS AND RECOMMENDATIONS

Draft Dallas Southside WWTP Pilot Project Key Findings

1. Facility has capacity to accept additional material without developing additional AD processing capacity
   - Limited ability to accept solid waste material continuously or store and pre-processing feedstock
2. Processing additional food waste and FOG would result in significant biogas yield increases
   - Limited ability to process surplus biogas
3. Location near McCommas Bluff Landfill and industrial trucking yards presents opportunity for biogas offtake
4. Shifting vehicle traffic from McCommas Bluff Landfill to Southside WWTP would reduce traffic congestion at disposal site
5. Although there are limited residents near the project location, increasing adoption of CNG/RNG to displace diesel would minimize airborne pollutants in the area

Draft Dallas Southside WWTP Pilot Project Next Steps

1. Conduct further engineering and financial analysis to determine feasibility of transporting biogas to the gas processing facility at McCommas Bluff Landfill
2. Capital upgrades for pre-processing and biogas processing/transportation
   - Tipping area, preprocessing, storage tank
   - Gas processing infrastructure to support increased gas yield (thermal processor, gas scrubbing unit, etc.)
3. Develop contracts with future feedstock suppliers and offtake customers to support capital investment in facility upgrades
4. Identify applicable environmental credits, tax credits, and grant funding incentives and opportunities to support project
5. Develop testing protocol for increasing volume of solid waste and wastewater
6. Reach out to RNG offtake management firms to determine approach to generating environmental credits

Applicable Environmental Credits and Incentives

Environmental Credit	Applicable	Description
Renewable Fuel Standard (RFS)	Yes	If the additional biogas is utilized as vehicle fuel the Southside WWTP could generate D5 RINs at a value of $1.50 – $1.75 per credit
California Low Carbon Fuel Standard (LCFS)	No	Projects with CI scores that are not well below zero (e.g., landfill biogas projects) will not be able to compete with other projects that have more beneficial environmental impacts (e.g., dairy digester to RNG).
Renewable Energy Credits (REC)	No	Electricity generated would need to be sold to the grid rather than used on site.

- Consider federal incentives including Inflation Reduction Act and Justice40 Initiative
- Leverage grants including sustainable materials management grants, equipment/consulting grants, and hydrogen demonstration project grants.
- Support alternative fuel incentives such as the Congestion Mitigation and Air Quality (CMAQ) Improvement Program based on the facility location and Alternative Fueling Facilities Program (AFFP)

Draft Denton Landfill Complex Pilot Project Key Findings

1. Pecan Creek WWTP and Dyno Dirt composting facility have some, but limited, existing capacity to accept additional material
2. There is a need for sludge disposal and processing capacity to support smaller WWTPs in Denton County
3. The Landfill Complex co-locates several facilities that increase the viability of an organics to fuel project (e.g., landfill, fueling station, scalehouse)
4. The City of Denton is currently planning and pursuing several projects related to organic waste processing and biogas utilization
   - Procuring a channel grinder to pre-process food waste
   - Pursuing landfill gas to RNG project
   - Considering development of third AD unit
5. Coordination between the City's solid waste, wastewater, and transportation groups is critical to pursuing organics to fuel project

Draft Denton Landfill Complex Pilot Project Next Steps

1. Advance procurement of channel grinder and development of landfill biogas to RNG project
2. Determine most appropriate AD technology and potential location for installation at Pecan Creek WWTP or Dyno Dirt composting facility
   - New high-solids modular food waste and FOG digester
   - Expanded low-solids continuous flow digester for sludge management as part of hub-and-spoke system
3. Pursue capital upgrades for material storage and surplus biogas processing to process food waste and FOG while minimizing negative impacts of odors and vectors to nearby communities with environmental justice sensitivities
4. Develop contracts with future additional feedstock suppliers to support capital investment in facility upgrades
5. Pursue applicable environmental credits, tax credits, and grant funding incentives and opportunities to support acceptance of food waste, FOG and sludge from the nearby WWTPs as part of an ILA
6. Reach out to RNG offtake management firms to determine approach to generating environmental credits

Applicable Environmental Credits and Incentives

Environmental Credit	Applicable	Description
Renewable Fuel Standard (RFS)	Yes	If the additional biogas is utilized as vehicle fuel the Pecan Creek WWTP could generate D5 RINs at a value of $1.50 – $1.75 per credit.
California Low Carbon Fuel Standard (LCFS)	No	Projects with CI scores that are not well below zero (e.g., landfill biogas projects) will not be able to compete with other projects that have more beneficial environmental impacts (e.g., dairy digester to RNG).
Renewable Energy Credits (REC)	No	Electricity generated would need to be sold to the grid rather than used on site.

- Explore PFAS and pathogen mitigation funding available through the Infrastructure Investment and Jobs Act of 2021
- Leverage grants including sustainable materials management grants, and equipment/consulting grants
- Take advantage of federal tax credits, exemptions and grant funding related to alternative fuel usage
- Explore hydrogen demonstration projects related to alternative sludge management

Overall Conclusions and Next Steps

- Overall, there is a demonstrated need for food waste and FOG diversion in the North Central Texas region
- WWTPs with limited storage or disposal capacity require cost-effective disposal solutions
- The Dallas Southside WWTP and Denton Landfill Complex pilot projects evaluated are viable starting points to increase co-digestion, but are not the only opportunities in the region
- RNG for use as vehicle fuel is a key near-term opportunity for the region
- Increased RNG to manufacture hydrogen is a potential long-term opportunity for the region for further consideration
- The Project Team is in the process of finalizing the report expected to be published in October
- Thank you to the PAG for participating in this effort, NCTCOG staff, and all on the Project Team in advancing organics diversion in the North Central Texas region!

THANK YOU!

CREATE AMAZING.

APPENDIX B
COLLECTION NETWORK ROUTING EVALUATION

B. - COLLECTION NETWORK ROUTING EVALUATION

The following provides a brief description of the key operating assumptions for commercial and residential collection routing, followed by the results of the collection routing modeling.

Commercial Collection Routing Metrics

Operating Assumption	Description
Schedule	Collection of unprocessed and slurry food waste material is assumed to be collected on an eight-hour per day, five day per week schedule. FELs are assumed to provide service three times per week. Vacuum trucks are assumed to provide pump-outs, on average, 10 times per customer per year. For the purposes of this analysis, collection was evaluated on a routed basis to compare cost per route on an equitable basis.
Vehicle Capacity	Front-end load collection vehicles are assumed to have 28 CY of capacity and vacuum trucks are assumed to contain 5,500 gallons of capacity. These sizes maximize the amount of material that can be collected before traveling to the processing facility. In practice, vehicle sizes and capacities may vary depending on the fleet ownership.
Average Round-Trip Time to Processing Facility (min)	The Project Team assumed that all FEL routes would be capable of achieving an average round-trip turnaround time of 90 minutes, including leaving the route, scaling into and tipping at a facility equipped to receive source separated organics, and returning to the route. In practice, this would require significantly more organics transfer and processing capacity across the region than is currently in place.
Required Daily Trips to Processing Facility	Based on the assumption of utilizing large body collection vehicles (e.g., 28 CY, 5,500 gal.), the Project Team assumed that all FEL routes would only require one round-trip time to processing facility. Vacuum trucks were assumed to require two trips to the processing facility because they collect more material per customer than FEL collection. In practice, the number of trips would be dependent on the amount of material set out on a customer-by-customer basis (e.g., if dumpsters or slurry tanks are partially full, the collection vehicle could service more customers).
Collection Efficiency (customers/hr)	The collection efficiency depends on route density and time per stop. The Project team leveraged collection efficiency data points from representative municipal and private sector collection evaluations in the North Central Texas region to estimate collection efficiency for FEL commercial collection. The Project Team leveraged discussions with private sector vacuum truck haulers to estimate the time per slurry tank pump-out.
Cost per Route	Cost per route was evaluated based on industry metrics for equipment, salary and benefits, vehicle maintenance, fuel and other typical direct operational costs. Financial considerations outside direct operational costs (e.g., overhead, profit margins, overtime, litigation, etc.) are not considered as part of the evaluation. Additionally, cost for installing or operating macerator/slurry tanks and processing costs are not included in the cost per route.

Residential Collection Routing Metrics

Operating Assumption	Description
Schedule	Collection of cart-based food waste material is assumed to be collected on an eight-hour per day, five day per week schedule and each customer would receive one service per week. In practice, collection schedules may vary by collection operation and fleet ownership.
Vehicle Capacity	ASL collection vehicles are assumed to have 28 CY of capacity. This vehicle size can service curbside roll cart set outs and maximizes the amount of material that can be collected before traveling to the processing facility. In practice, vehicle sizes and capacities may vary depending on the fleet and needs to service challenging collection environments.
Average Round-Trip Time to Processing Facility (min)	The average round-trip time to a processing facility can vary widely depending on the centroid of collection, roadway infrastructure and processing facility operating efficiency. The Project Team assumed that all routes would be capable of achieving an average round-trip turnaround time of 90 minutes, including leaving the route, scaling into and tipping at a facility equipped to receive source separated organics, and returning to the route.
Required Daily Trips to Processing Facility	Based on the assumption of utilizing large body collection vehicles (e.g., 28 CY), the Project Team assumed that all required daily trips to the processing facility could be accomplished in the 90 minute average round-trip time to processing facility. In practice, this would require significantly more organics transfer and processing capacity across the region than is currently in place.
Collection Efficiency (customers/hr)	The collection efficiency depends on route density, set out rate and accessibility. The Project team leveraged collection efficiency data points from representative municipal and private sector collection evaluations in the North Central Texas region to estimate collection efficiency for high density, low density, and rural areas.
Cost per Route	Cost per route was evaluated based on industry metrics for equipment, salary and benefits, vehicle maintenance, fuel and other typical direct operational costs. Financial considerations outside direct operational costs (e.g., overhead, profit margins, overtime, litigation, etc.) are not considered as part of the evaluation. Additionally, costs for cart purchase, maintenance and material processing are not included in the cost per route.

Annual Collection Tonnage

Storage Equipment	Dipsosed Tons	Units	Notes
Slurry Tank	174,000	Tons	
Dumpster	384,000	Tons	
Total	**558,000**		
Slurry Gallons			
Unprocessed Food Waste	174,000	Tons	
Unprocessed Food Waste	139,199,619	Gallons	Estimated based on conversion factor of 2.5 lb/gallon.
Feed in Water	34,799,905	Gallons	200 gallons of feed-in water per ton of food waste required to maintain 10-12% total solids.
Annual Slurry Gallons	**173,999,500**	Gallons	Rounded for ease of presentation.

Routing Evaluation

Description	Unprocessed	Slurry	Notes
Round Trip Time to Processing Facility (min)	90	180	Minutes
Pre-trip Inspection	15	15	Minutes
Morning Meeting	15	15	Minutes
Time to Route	15	15	Minutes
Post-trip/Fueling	15	15	Minutes
Breaks	30	30	Minutes
Non-Route Time	**180**	**270**	Minutes
Route Time	**300**	**210**	Minutes
Total Workday	**480**	**480**	Minutes
Customers Serviced per Hour	10	1	Account for time to pump out and travel to next customer
Customers per Day	50	4	Based on review of recently completed commercial collection study and stakeholder outreach.
Annual Customers	14,629	5,797	
Annual Collections	2,282,062	58,000	Based on estimated 3x/wk service for FEL and every other week collection for slurry pump-out.
Annual Volume Serviced	4,564,123	2,068,110	Based on 2 CY dumpsters for unprocessed collection and equivalent CY volume of tons processed through slurry
Weekly Collections	43,886	1,115	
Front-Line Daily Vehicles	176	64	
Back-up Vehicles	35	13	Based on industry standard 20% backup ratio.
Vehicle Operators	176	64	
Back-up Vehicle Operators	35	13	Based on industry standard 20% backup ratio.
Route Supervisors	18	6	Based on industry standard requirement of one route supervisor for every 10 routes.

Daily Tons Collected	1,477	669	
Tons per Front-Line Vehicle	8.41	10.50	

Financial Evaluation

Financial Evaluation	Unprocessed	Slurry	Notes
Annualized Vehicle Purchase			
Front Line	$10,236,515	$3,716,665	Based on 4% cost of capital and 7 year life of vehicle.
Back-up	$1,023,651	$743,333	Used vehicle cost half of new vehicle purchase price.
Annual Fuel Cost	$3,510,864	$1,274,722	
Annual Maintenance	$5,266,296	$1,912,082	Only reflects maintenance cost of front-line vehicles.
Personnel Wages and Benefits	$11,936,938	$4,334,053	Includes $50,000 in salary and benefit salaries for front-line and backup vehicle operators.
Other Costs	$1,598,713	$599,043	Includes supplies, uniforms, water coolers and other miscellaneous direct costs.
Total Annual Cost	**$33,572,977**	**$12,579,899**	
Cost per Route	$191,252	$197,375	Cost per route does factoring in profit, overhead, or other administrative costs.
Cost per Ton Collected	**$87.43**	**$72.30**	
Cost per CY Serviced	**$7.36**	**$6.08**	

Annual Collection Tonnage

Description	High Density	Low Density	Rural	Notes
Households per Week	997,601	599,245	212,523	Estimated number of single-family detached housing units.
Working Hours per Day	8	8	8	Routing evaluation based on an eight hour workday. No overtime considerations are evaluated.
Collection Days per Week	5	5	5	Routing evaluation based on M-F work schedule.
Annual Collection Tons	342,377	205,661	72,938	Based on once per week collections with 100% set out rate generating 13.2 lb/customer/week. Total annual collection tons totals to 620,975. This is slightly below the 660,000 tons disposed because it only considers single-family detached households.
Weekly Collected Tons	6,584	3,955	1,403	

Routing Evaluation

Routing Evaluation	High Density	Low Density	Rural	Notes
Round Trip Time to Processing Facility (min)	90	90	90	Assumed pre-processing/transfer infrastructure would be implemented with collection programs and all vehicles would only spend a total of 90 minutes to travel off route, tip, and return to route.
Pre-trip Inspection	15	15	15	
Morning Meeting	15	15	15	
Time to Route	15	15	30	
Post-trip/Fueling	15	15	15	
Breaks	30	30	30	
Non-Route Time	180	180	195	
Route Time	300	300	285	
Total Workday	480	480	480	
Housholds Serviced per Hour	150	125	100	Estimated based on review of recently completed residential collection evaluations for public and private collection operations.
Households Serviced per Day	750	625	475	
Annual Services	51,875,252	31,160,740	11,051,196	Based on one service per household per week.
Routes per Day	266	192	89	
Back-up Vehicles	53	38	18	Based on industry standard 20% backup ratio.
Vehicle Operators	266	192	89	Assumes one vehicle operator with no temporary labor.
Back-up Vehicle Operators	53	38	18	Based on industry standard 20% backup ratio.
Route Supervisors	27	19	9	Based on industry standard requirement of one route supervisor for every 10 routes.

Non-Route Time	47,885	34,517	17,449	
Route Time	79,808	57,528	25,503	
Total Workday	127,693	92,044	42,952	
Daily Round Trip Time to Processing Facility	16,931	10,170	3,607	
Daily Tons Collected	1,317	791	281	
Tons per Front-Line Vehicle	4.95	4.13	3.14	

Financial Evaluation

Collection Network Cost	High Density	Low Density	Rural	Notes
Operations				
Annualized Vehicle Purchase Cost				
Front Line	$16,620,992	$11,980,797	$5,590,796	Based on 4% cost of capital and 7 year life of vehicle.
Back-up	$1,662,099	$1,198,080	$559,080	Used vehicle cost half of new vehicle purchase price.
Annual Fuel Cost	$5,320,539	$3,835,168	$1,789,667	
Annual Maintenance	$9,310,943	$6,711,544	$3,131,918	Only reflects maintenance cost of front-line vehicles
Personnel Wages and Benefits	$18,089,831	$13,039,571	$6,084,869	Includes salaries for front-line and backup vehicle operators
Other Costs	$2,550,220	$1,838,258	$857,816	Includes supplies, uniforms, water coolers and other miscellaneous direct costs
Total Annual Cost	**$53,554,624**	**$38,603,418**	**$18,014,146**	
Cost per Route	**$201,313**	**$201,313**	**$201,313**	Cost per route does not factor in profit, overhead, or other administrative costs.
Cost per Ton Collected	**$156.42**	**$187.70**	**$246.98**	
Cost per Household per Month	**$4.47**	**$5.37**	**$7.06**	

Tonnage Generation and Storage Assumptions

Generators	Regional Total Disposed	Notes
Residential Single-Family	660,000	Total tons of residential single-family household food waste disposed per feedstock market assessment analysis. Rounded to nearest thousand for purposes of analysis. Does not include multi-family tons.
Commercial Sector	558,000	Total tons of food waste disposed by commercial sector per feestock market assessment. Excludes off-spec bulk liquid tonnage disposed at landfills in the region.

Residential Single Family Generators	High Density	Low Density	Rural	Notes
Lb per Single-Family Household per Week	13.2	13.2	13.2	May vary between 8.22 and 16.97 lb/HH/week depending on refuse composition profiles of participating cities from regional waste characterization study. Project Team selected 13.2 as average applied to all households across the region consistent with feedstock generation evaluation.
Land Area (Acres)	416,727	1,566,156	1,982,883	
Single-Family Households	997,601	599,245	212,523	Only Single-Family detached households considered.

Commercial Generator by NAICS Code	Customers (Adjusted for Unserviceable)	Tonnage Generated (Adjusted for Unserviceable)	Generation Breakdown	Collection Tonnage	Storage Equipment	Notes
Food Wholesale and Retail	3,868	299,364	44.9%	250,449	Dumpster	Identified as storage type to be serviced by FEL based on high volume of post-consumer food waste.
Restaurants and Food Services	10,760	159,635	23.9%	133,552	Dumpster	Identified as storage type to be serviced by FEL based on high volume of post-consumer food waste.
Food Manufacturers and Processors	1,266	116,182	17.4%	97,198	Slurry Tank	Identified as storage type to be serviced by Vacuum truck based on high volume of pre-consumer food waste.
Institutions	2,489	52,523	7.9%	43,941	Slurry Tank	Identified as storage type to be serviced by Vacuum truck based on high volume of pre-consumer food waste.
Hospitality Industry	1,808	26,576	4.0%	22,234	Slurry Tank	Identified as storage type to be serviced by Vacuum truck based on high volume of pre-consumer food waste.
Healthcare Facilities	183	8,267	1.2%	6,916	Slurry Tank	Identified as storage type to be serviced by Vacuum truck based on high volume of pre-consumer food waste.
Correctional Facilities	51	4,435	0.7%	3,711	Slurry Tank	Identified as storage type to be serviced by Vacuum truck based on high volume of pre-consumer food waste.
Total	**20,426**	**666,982**	**100.0%**	**558,000**		

Commercial	Value	Unit	Notes
Conversion Factor	202	gal/CY	
Food Waste Density	2.5	lbs/gal	Campus FW density of unprocessed FW based on 2013 Biocycle article.
Food Waste Density	500	lbs/CY	Two references listed at 396 lbs/CY for restaurants and 463 lbs/CY. Assumption estimated slightly higher density at 500 lb/CY based on collection in ASL compacting hopper (does not reflect density of unprocessed food waste).
Slurry Feed in Water	200	gal/ton	Assumption provided by macerator equipment manufacturers.
Average Dumpster Size	2	CY	Average food waste storage size limited to 2 CY based on high density and weight of material compared to refuse or recycling.
Average Slurry Tank Size	3,000	Gallons	Average slurry storage tank size based on discussions with representative of Insinkerator Grind2Energy Program.

Routing Assumptions

Residential	High Density	Low Density	Rural	Notes
Hours per Day	8	8	8	
Days per Week	5	5	5	
Collection Vehicle Storage Capacity (CY)	28	28	28	
Collection Frequency per Week	1	1	1	Assumed once per week collection, even in locations with other collection frequencies for refuse or recycling.
Households per Hour	150	90	75	Based on review of existing municipal collection program evaluations.
Average round trip distance to processing facility	90	90	90	Assumed up to two trips to processing facility - 15 min to facility, 15 min unload time, 15 minutes back to route from any collection area in the region. These may vary in practice depending on existing infrastructure locations and transportation routes.
Number of daily trips to processing facility	188	113	40	
Back-up Percentage	20%	20%	20%	

Commercial	Front-End Loader	Slurry	Notes
Hours per Day	8	8	
Operating Days	5	5	
Collection Vehicle Storage Capacity (CY, gal)	28	5,500	CY ; Gal
Collection Frequency per week	3	0.19	Based on evaluations of commercial-sector collection 3x/wk represents average across commercial subsector. Service every other week estimated based on discussion with representative of Insinkerator Grind2Energy Program.
Customers per day	50	-	Estimated based on ability to collect about 7 tons per vehicle.
Pump-out (min)	-	60	Estimated pump out time per customer based on discussion with representative of Insinkerator Grind2Energy Program. 45 minutes to pump out, 15 minutes to drive to next customer.
Average round trip time to processing facility (min)	90	90	Assumed 2 up to two trips to processing facility - 15 min to facility, 15 min unload time, 15 minutes back to route from any collection area in the region for FEL. Trips to processing for slurry calculated based on up to 4 trips. These may vary in practice depending on existing infrastructure locations and transportation routes.
Back-up Percentage	20%	20%	Based on industry standard. Acutal back-up percentage may vary depending on fleet maintenance and purchasing on a program-by-program basis.

Staffing Assumptions

Residential	Value	Unit	Notes
Crew	1	vehicle operator	per ASL
Route Supervisor	10	Routes per supervisor	
Back-up Percentage	20%		

Commercial	Unprocessed	Pre-Processed	Notes
Crew	1	1	
Route Supervisor	10	10	Routes per supervisor based on typical municipal collection program staffing.
Back-up Percentage	20%	20%	Based on industry standard. Acutal back-up percentage may vary depending on fleet maintenance and purchasing on a program-by-program basis.

Financial Assumptions

Description	Value	Unit	Notes
Cost of Capital	4%		
Crew Salary and Benefits	$50,000	$	Estimated based on typical industry compensation, accounting for ongoing labor shortages and increased demand for vehicle operators.
Supervisor Salary and Benefits	$80,000	$	Estimated based on typical industry compensation, accounting for ongoing labor shortages and increased demand for vehicle operators.
Other Costs	5%	%	Estimated 5% of other total costs for typical items including uniforms, supplies, water coolers, etc.
ASL Vehicle Costs			
Lifecycle	7	Years	Based on typical lifecycle replacement for ASL vehicles.
Front-Line Purchase	$375,000	$	Based on typical purchase price, accounting for ongoing supply chain challenges.
Backup Purchase	$187,500	$	Assumed half price for used backup vehicle.
Fuel	$20,000	$	Based on fuel cost per vehicle of municipal collection programs, accounting for recently increased fuel prices.
Maintenance	$35,000	$	Based on average maintenance cost per vehicle of municipal collection programs, accounting for recently increased fuel prices.
FEL Vehicle Costs			
Lifecycle	7	Years	Based on typical lifecycle replacement for ASL vehicles.
Front-Line Purchase	$350,000	$	Based on typical purchase price, accounting for ongoing supply chain challenges.
Backup Purchase	$175,000	$	Assumed half price for used backup vehicle.
Fuel	$20,000	$	Based on fuel cost per vehicle of municipal collection programs, accounting for recently increased fuel prices.
Maintenance	$30,000	$	Based on average maintenance cost per vehicle of municipal collection programs, accounting for recently increased fuel prices.
Vacuum Vehicle Costs		$	
Lifecycle	7	Years	Assumed same lifecycle replacement as ASL and FEL vehicles.
Front-Line Purchase	$350,000	$	Estimated between $100k-$500k https://www.hydrovactrucksforsale.com/new-and-used-hydro-vac-trucks-for-sale-usa/. Sewer vacuum trucks available on HGAC range between $100k-$300k.
Backup Purchase	$175,000	$	Assumed half price for used backup vehicle.
Fuel	$20,000	$	Assumed same fuel cost as FEL vehicles.
Maintenance	$30,000	$	Assumed same maintenance costs as FEL vehicles.

APPENDIX C

POWER FRAMEWORK INPUTS AND OUTPUTS

C. - POWER FRAMEWORK Inputs and Outputs

The POWER Framework (previously called the “Food & Flora Waste to Fleet Fuel (F^4) Framework”) is composed of three individual components including the GIS Toolbox, the Optimization Tool and the POWER Tool. The Project Team developed various models to developed based on assumptions specific to the North Central Texas region to produce appropriate and realist results and support UTA to advance the Technology Readiness Level (TRL), as appropriate. The following summarizes the inputs and results of the POWER Framework that supports the resulting analysis and recommendations developed in the Study.

GIS Toolbox

The automated geographic information system (GIS) Toolbox was used to estimate quantities of food waste and FOG generated by block group in the North Central Texas region. The GIS Toolbox uses the U.S. EPA’s Excess Food Opportunities map to provide institution-specific food waste generation values in tons/year for seven food-waste generator categories (e.g., K-12 educational institutions, food banks, food manufacturers/processors, restaurants & food services). For other food waste-generator categories (single-family households, multi-family units, and universities), as well as FOG, waste production per block group is estimated by multiplying a waste generation rate by the activity per block group. Table C-1 shows food waste and FOG waste generation and activity data inputs used by the GIS Toolbox.

Table C-1: Food Waste and FOG Generation Rates and Activity Data

Feedstock generator	Waste Generation Rate		GIS Data	
	Rate	Reference	Activity Data (per block group)	Source
Single-family households (HH)	13.2 lb/household/ week	NCTCOG Regional Recycling Survey and Educational Campaign Waste Characterization Data (2018-2020)	Number of single-family households	US Census Bureau - ACS 2019, www.census.gov/
Multi-family units	10 lb/household/ week	NCTCOG Regional Recycling Survey and Educational Campaign Waste Characterization Data (2020)	Number of multi-family units	
Universities	0.39 lb/ student/ day	SWANA (2016)	Number of university students	Homeland Infrastructure Foundation-Level Data
Other food waste categories[1]	Institution-specific, low estimates, tons/yr	EPA Excess Food Opps. Map (U.S. EPA)	N/A (activity data is not needed because rate is provided in tons/year)	EPA Excess Food Opportunities Map
FOG (restaurants)	32.5 gal/ restaurant/ week	Moore and Myers (2010)	Number of restaurants	EPA Excess Food Opportunities Map

1. Includes educational institutions (not universities), correctional facilities, food banks, food manufacturers/processors, food wholesale/retail, health-care facilities, hospitality industry, restaurants/food services. Waste from special event centers was not included due to data limitation.

2. CAFO manure was not estimated based on a generation rate, used existing permit information

For animal manure, estimates for CAFOs were based on publicly available permit data, as discussed in Section 2.0, rather than using GIS Toolbox estimates. The generation rate calculated by the GIS Toolbox assumes that all material generated would be able to be collected separately for diversion, but that is not practical based on the existing collection networks in the North Central Texas region. To calculate more realistic estimates, the Project Team configured the GIS Toolbox to evaluate the waste generation at 20 percent and 60 percent to compare achievable and optimistic scenarios rates of food and FOG waste collection, respectively. The Project Team developed maps showing the estimated annual food waste and FOG generation in the 4-county Targeted Organics Collection Area reflecting generation among residential and commercial entities.

Figure C-1 present the annual estimated food waste and FOG waste generation estimates based on a 20 percent collection rate for the 4-county Targeted Organics Collection Area (Collin, Dallas, Denton, and Tarrant Counties).

Figure C-1: Food Waste and FOG Estimates for 20% Collection Rate, Collin, Dallas, Denton, and Tarrant Counties

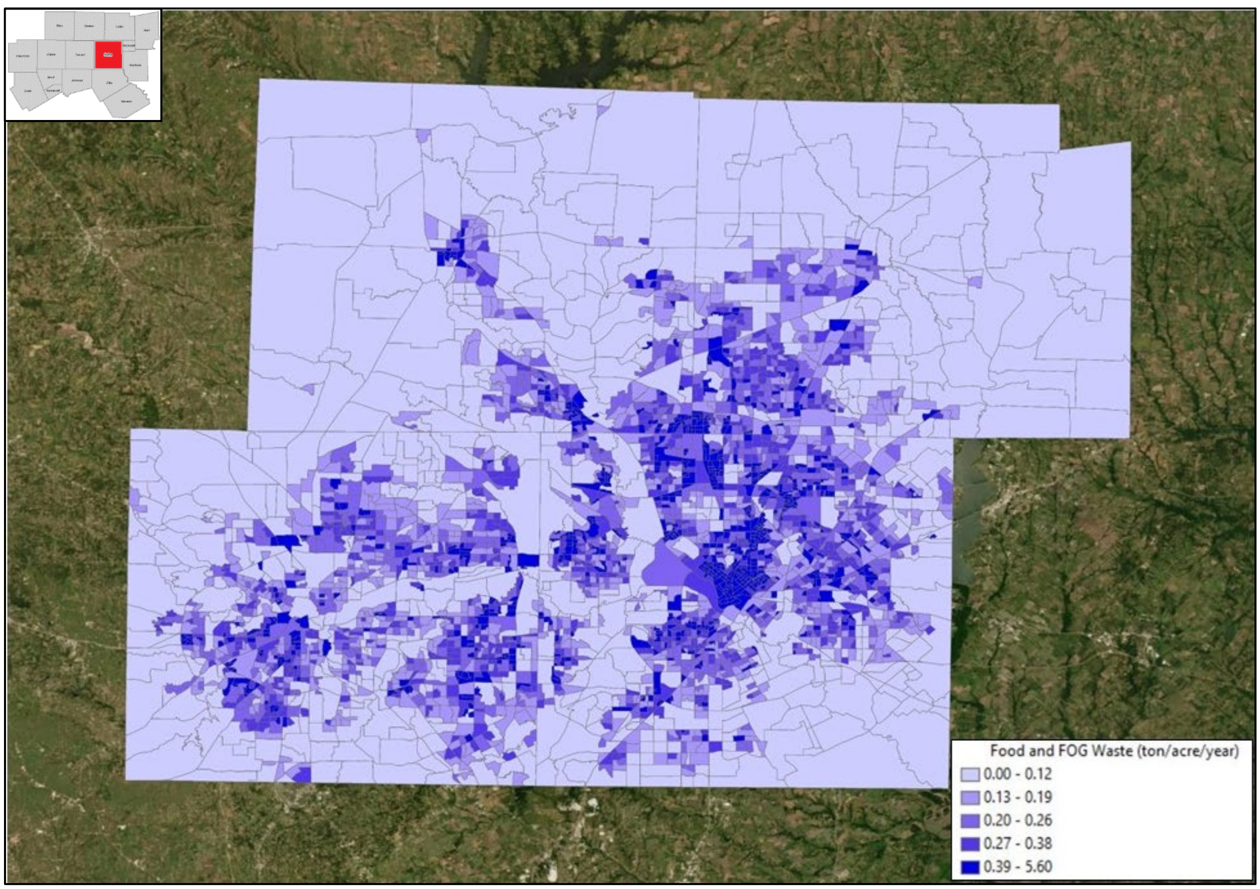


Figure C-2 shows the estimates of commercial food waste and FOG assuming a 20 percent collection of for the 4-county Targeted Organics Collection Area (Collin, Dallas, Denton, and Tarrant Counties).

Figure C-2: Commercial Food Waste and FOG Estimates for 20% Collection Rate, Collin, Dallas, Denton, and Tarrant Counties

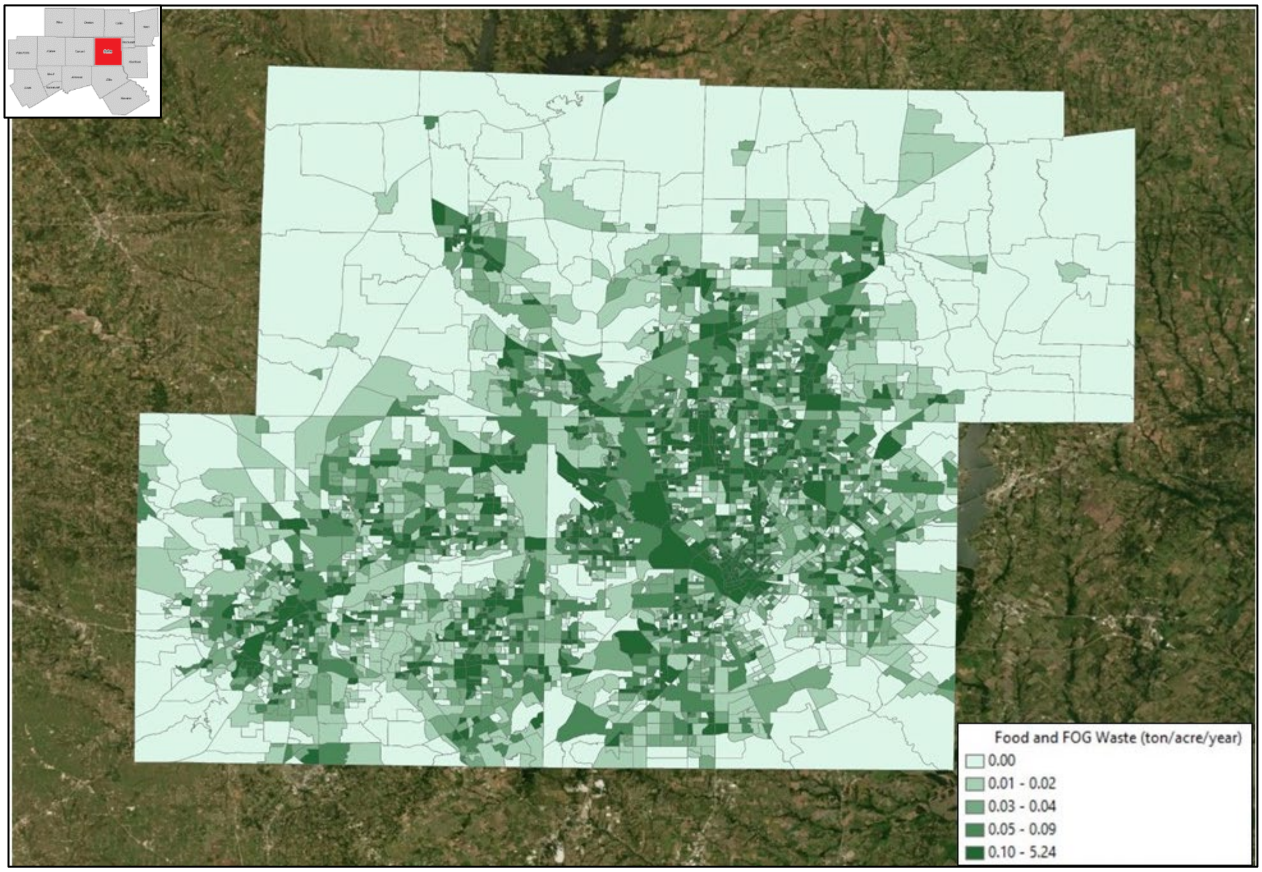
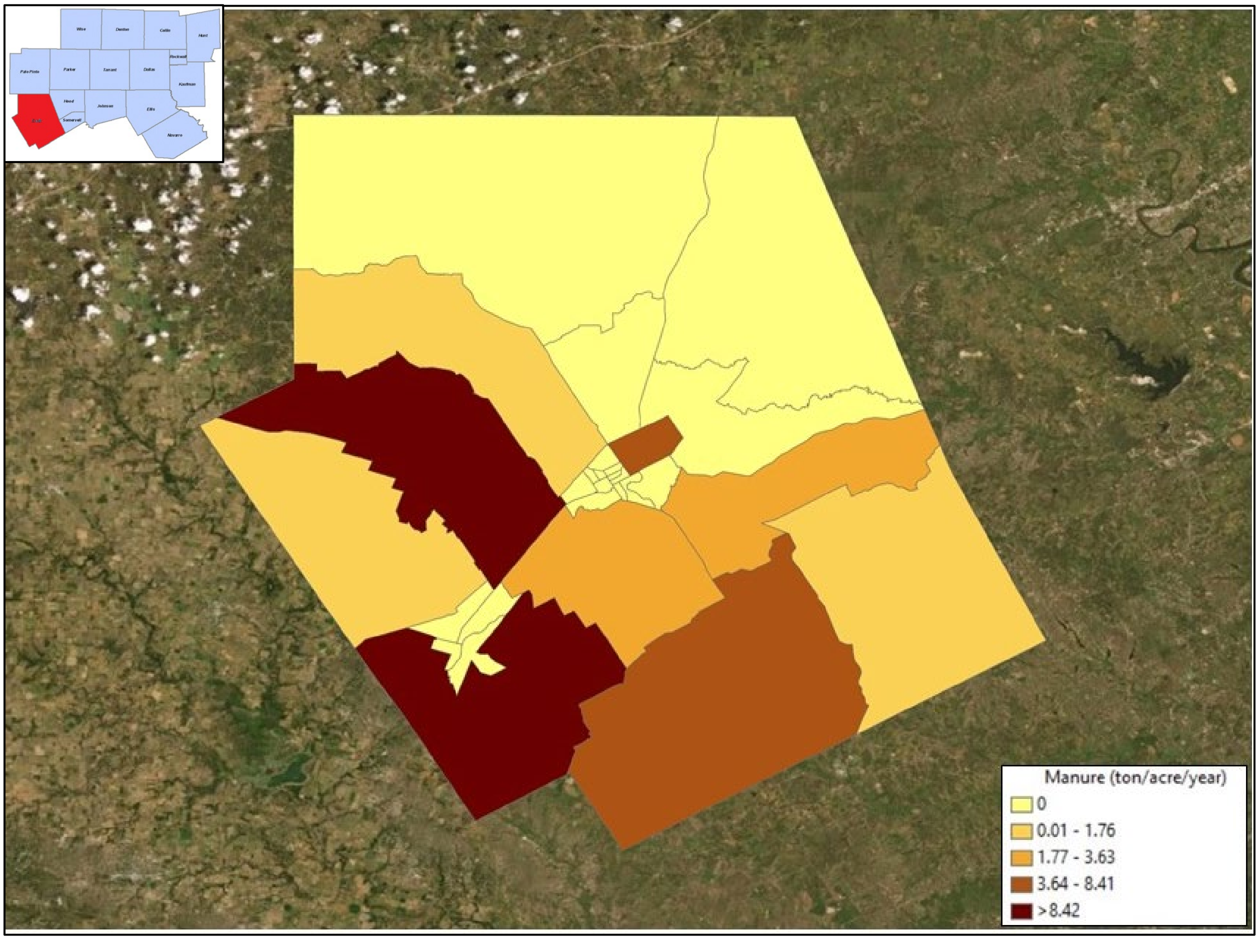


Figure C-3 shows the estimates of manure generation assuming 100 percent collection of CAFO manure for Erath County.

Figure C-3: Manure from CAFOs at 100 Percent Collection Rate, Erath County



In addition, the GIS Toolbox contains the shortest path algorithm, which was used to determine the shortest distance as well as average velocity to each of the potential pilot project locations subsequently evaluated by the Optimization Tool and POWER Tool

Optimization Tool

The Optimization Tool was used to the evaluate optimal potential pilot project locations based on the estimated level of effort (e.g., distance, time, cost) to transport organic waste generated in the Targeted Organics Collection Area. The distribution of waste generation is based on the outputs of the GIS Toolbox. The Optimization Tool is programmed using Python and estimates the planning-level costs for organic waste transportation and processing to identify the potential pilot project locations that comparatively result in the least costs. Potential pilot project locations that result in the least costs for transportation and processing are identified as the most optimal.

The Optimization Tool includes the capability to estimate planning-level operating costs for organic waste transport (e.g., fuel cost and driver salary), capital costs (e.g., estimated costs to construct a new digester, as applicable) and processing costs for waste pre-treatment (e.g., grinding, storage, and de-packaging), AD, cleaning biogas/generating electricity, and refueling stations. The Project Team only considered the planning-level costs for organic waste transport so the Optimization Tool would generate results based on spatial analysis. Costs for waste processing, digestion, and biogas post-processing were assumed to be equal, so only the distance of organic waste to each potential pilot project location would be considered.

To determine the potential pilot facility locations that would be evaluated by the Optimization Tool, the Project Team reviewed a total regional inventory of 139 solid waste management and wastewater treatment facilities across North Central Texas. The total regional inventory was culled down to only reflect facilities located in the Targeted Organics Collection Area and five greenfield locations were added. Further description of the greenfield locations is provided in Section 6.2. Table C-2 presents the list of facilities evaluated including the assigned identification number, name, type, and county. [27]

[27] The facility identification numbers labeled S indicates it is a solid waste facility; W indicates it is a WWTP; and, G indicates it is a greenfield site. All 139 facilities in the regional inventory were assigned facility identification numbers. Facilities presented in Table C-2 show a subset of the full regional inventory of sites.

Table C-2: Inventory of Regional Facilities Located in Targeted Organics Collection Area

Facility ID	Facility Name	Facility Type	County
S01	121 RDF LFG Treatment Facility	LFG_Renewable Natural Gas (RNG)	Collin
S02	McCommas Bluff LFG Processing Facility	LFG_Renewable Natural Gas (RNG)	Dallas
S03	Waste Management Skyline Landfill	LFG_Renewable Natural Gas (RNG)	Ellis
S04	City of Arlington Landfill Gas Processing Plant	LFG_Renewable Natural Gas (RNG)	Tarrant
S05	City of Grand Prairie Landfill	LFG_Power Generation	Dallas
S06	City of Denton Landfill Gas to Energy Facility	LFG_Power Generation	Denton
S07	Camelot Landfill Gas to Energy Facility	LFG_Power Generation	Denton
S08	DFW Recycling and Disposal Facility	LFG_Power Generation	Denton
S09	Westside Recycling and Disposal Facility	LFG_Power Generation	Tarrant
S10	Clean Earth Environmental Solutions	Liquid Waste Treatment Facilities	Dallas
S11	Dallas Grease Trap Grit Trap Treatment Facility	Liquid Waste Treatment Facilities	Dallas
S12	Wilmer Processing Facility	Liquid Waste Treatment Facilities	Dallas
S13	Cold Springs Processing & Disposal	Liquid Waste Treatment Facilities	Tarrant
S14	Southwaste Disposal Facility	Liquid Waste Treatment Facilities	Tarrant
S15	Liquitek Arlington Liquid Waste Processing Facility	Liquid Waste Treatment Facilities	Tarrant
S16	Stericycle Garland	Medical Waste Treatment Facilities	Dallas
S17	Oncore Technology	Medical Waste Treatment Facilities	Tarrant
S18	Champion Waste Services	Material Recovery Facility	Dallas
S19	Osttend C&D Waste Landfill/380 McKinney	MSW (Type IV) Landfill	Collin
S20	121 Regional Disposal Facility	MSW (Type I) Landfill	Collin
S21	City of Dallas McCommas Bluff Landfill	MSW (Type I) Landfill	Dallas
S22	City of Grand Prairie Landfill	MSW (Type I) Landfill	Dallas
S23	Hunter Ferrell Landfill	MSW (Type I) Landfill	Dallas
S24	Charles M Hinton Jr Regional Landfill	MSW (Type I) Landfill	Dallas
S25	DFW Recycling and Disposal Facility	MSW (Type I) Landfill	Denton
S26	Camelot Landfill	MSW (Type I) Landfill	Denton
S27	City of Denton Landfill	MSW (Type I) Landfill	Denton
S28	Lewisville Landfill	MSW (Type IV) Landfill	Denton
S29	Skyline Landfill & Recycling Facility	MSW (Type I) Landfill	Ellis
S30	Living Earth - City of Arlington Landfill	Mulching & Composting	Tarrant
S31	Fort Worth C&D Landfill	MSW (Type IV) Landfill	Tarrant

Facility ID	Facility Name	Facility Type	County
S32	Bachman Transfer Station	Transfer Station	Dallas
S33	City of Garland Transfer Station Facility	Transfer Station	Dallas
S34	City of Mesquite Service Center	Transfer Station	Dallas
S35	Westmoreland Transfer Station	Transfer Station	Dallas
S36	City of University Park Transfer Station	Transfer Station	Dallas
S37	Custer Solid Waste Transfer Station	Transfer Station	Collin
S38	Southwest Paper Stock	Transfer Station	Tarrant
S39	WC Minnis Drive Transfer Station	Transfer Station	Tarrant
S40	Champion C&D Recycling	C&D Recycling Facility	Collin
S41	Community Waste Disposal Transfer Station	Transfer Station	Dallas
S42	Fair Oaks Transfer Station	Transfer Station	Dallas
S43	CWD Recycling Facility	Material Recovery Facility	Dallas
S44	Plano Recycle Center	Material Recovery Facility	Collin
S45	North Texas Recycling Complex	Material Recovery Facility	Tarrant
S46	Waste Connections MRF - McKinney	Material Recovery Facility	Collin
S47	Waste Management - Arlington	Material Recovery Facility	Tarrant
S48	Pratt - Denton	Material Recovery Facility	Denton
S49	FCC - Dallas	Material Recovery Facility	Dallas
S50	Balcones - Dallas	Material Recovery Facility	Dallas
S51	Silver Creek Materials Recovery Facility	Mulching & Composting	Tarrant
S52	Alpine Materials	Mulching & Composting	Tarrant
S53	Plano Pure Products	Mulching & Composting	Collin
S54	The Organic Recycler of Texas - Hutchins	Mulching Only	Dallas
S55	The Organic Recycler of Texas - Melissa	Mulching Only	Collin
S56	Living Earth - Lakeside	Mulching & Composting	Tarrant
S57	Soil Building Systems	Mulching & Composting	Dallas
S58	Living Earth - Flower Mound	Mulching & Composting	Denton
S59	City of Fort Worth ECC	Household Hazardous Waste Collection Facility	Tarrant
S60	City of Denton Yard Waste Facility	Mulching & Composting	Denton
S61	Waste Management Dallas Metroplex	Material Recovery Facility	Dallas
S62	Living Earth - Dallas	Mulching & Composting	Dallas
S63	Thelin Recycling	Mulching & Composting	Tarrant
S64	Parkway Transfer Station	Transfer Station	Collin

Facility ID	Facility Name	Facility Type	County
S65	Fort Worth Southeast Landfill	MSW (Type I) Landfill	Tarrant
S66	Westside Transfer Station	Transfer Station	Tarrant
S67	The Organic Recycler of Texas - Forest Hills	Mulching & Composting	Tarrant
S68	Living Earth - Plano	Mulching Only	Collin
S69	City of Mesquite Composting Facility	Mulching & Composting	Dallas
S70	North Texas Recycling Complex	Transfer Station	Tarrant
S71	Champion Waste Services	Transfer Station	Dallas
S72	Westside Recycling and Disposal Facility	LFG_Power Generation (Closed Landfill)	Tarrant
S73	Dallas Recycling Facility	Material Recovery Facility	Dallas
S74	City of Arlington Landfill	MSW (Type I) Landfill	Tarrant
S75	Living Earth - Fort Worth SELF	Mulching & Composting	Tarrant
S76	Sustainable Soil Solutions	Mulching & Composting	Collin
S77	The Organics Recycler of Texas (Dallas)	Mulching & Composting	Dallas
S90	Stephenville Landfill	MSW (Type IV) Landfill	Erath
W01	Fort Worth Brewery	AD	Tarrant
W02	Rowlett Creek Regional WWTP	AD	Collin
W03	Central Regional WWTP	AD	Dallas
W04	Ten Mile Creek WWTP	AD	Dallas
W05	Dallas Southside WWTP	AD	Dallas
W06	Pecan Creek WWTP	AD	Denton
W07	Village Creek WWTP	AD	Tarrant
W08	Wilson Creek Regional WWTP	WWTP	Collin
W09	City of Garland Rowlett Creek WWTP	WWTP	Dallas
W10	South Mesquite Creek Regional WWTP	WWTP	Dallas
W11	City of Dallas Central WWTP	WWTP	Dallas
W12	Floyd Branch Regional WWTP	WWTP	Dallas
W13	Muddy Creek Regional WWTP	WWTP	Dallas
W14	Talley Ranch WWTP	WWTP	Denton
W15	Denton Creek Regional WWTP	WWTP	Denton
W16	Panther Creek WWT	WWTP	Denton
W17	Town of Flower Mound WWTP	WWTP	Denton
W18	Little Elm WWTP	WWTP	Denton
W19	Riverbend Regional WWTP	WWTP	Denton

Facility ID	Facility Name	Facility Type	County
W20	Prairie Creek WWTP	WWTP	Denton
W21	Trophy Club MUD WWTP	WWTP	Denton
W22	Stewart Creek West Regional WWTP	WWTP	Denton
W23	Lakeview Regional WWTP	WWTP	Denton
W24	Stewart Creek WWTP	WWTP	Denton
W25	Branch Regional WWTP	WWTP	Denton
W40	Stephenville WWTP	WWTP	Erath
W26	Peach Street WWTP	WWTP	Tarrant
W27	Ash Creek WWTP	WWTP	Tarrant
G01	N/A	Greenfield	Denton
G02	N/A	Greenfield	Collin
G03	N/A	Greenfield	Dallas
G04	N/A	Greenfield	Tarrant
G05	N/A	Greenfield	Erath

The Project Team deemed several solid waste facility types as non-pertinent for the purpose of the optimal potential pilot project location evaluation including MRFS, C&D recycling facilities, medical waste processing facilities, and household hazardous waste facilities. Additionally, the Project Team consolidated certain facilities that were co-located (e.g., S06 - City of Denton Landfill Gas to Energy Facility and S27 - City of Denton Landfill). Table C-3 presents the 96 sites in the 5-county Targeted Organics Collection Area by facility type.

Table C-3: Inventory of Regional Sites for Further Screening

Facility Type	Total Sites
Landfill	15
LFG Power Generation	5
LFG-to-RNG	3
Transfer Station	16
Mulching & Composting	18
Liquid Waste Treatment Facilities	6
WWTP (without AD)	21
WWTP (with AD)	7
Greenfield	5
Total	**96**

The Project Team ran the Optimization Tool to calculate the optimal potential pilot project locations based on the 3,697 waste zones in Collin, Dallas, Denton, and Tarrant Counties.[28] The Optimization Tool evaluated 354,912 unique combinations of planning-level transportation costs from each waste zone to each of the 96 potential pilot project locations.[29] The Project Team ran the Optimization Tool to generate results for five distinct scenarios:

1. 20 percent capture of food waste and FOG generated by both residential and commercial entities for Collin, Dallas, Denton, and Tarrant Counties, representing a practical capture rate;
2. 20 percent capture of food waste and FOG generated by only commercial entities for Collin, Dallas, Denton, and Tarrant Counties, representing a practical capture rate;

[28] Census block groups were used as waste zones. Collin County contains 473 waste zones, Dallas County contains 1,669 waste zones, Denton County contains 378 waste zones, and Tarrant County contains 1,177 waste zones totaling 3,697 waste zones.

[29] Initially, the Project Team configure the Optimization Tool to compare the estimated transportation costs from waste zones in Collin, Dallas, Denton, and Tarrant Counties to each of the 96 sites resulting in 3,697 * 96 = 354,912 combinations to evaluate. This approach exceeded the memory capacity of mainframe computers available on the UTA campus (e.g., Linux), as well as Gurobi Cloud. To overcome this computational challenge, the Project Team ran the Optimization Tool on each county in the Targeted Organics Collection Area with a 20-mile buffer rather than the region as a whole on each run. This approach minimized the computational demand of the Optimization Tool and the results of each individual run were later combined into an individual result.

3. 60 percent capture of food waste and FOG generated by both residential and commercial entities for Collin, Dallas, Denton, and Tarrant Counties, representing an optimistic capture rate;
4. 60 percent capture of food waste and FOG generated by only commercial entities for Collin, Dallas, Denton, and Tarrant Counties, representing a practical capture rate;
5. 100 percent capture of CAFO manure for Erath County.

Table C-4 lists potential pilot projects sites identified by the Optimization Tool showing the results of each scenario.

Table C-4: Combined Optimization Tool Results (Including Erath County Sites)

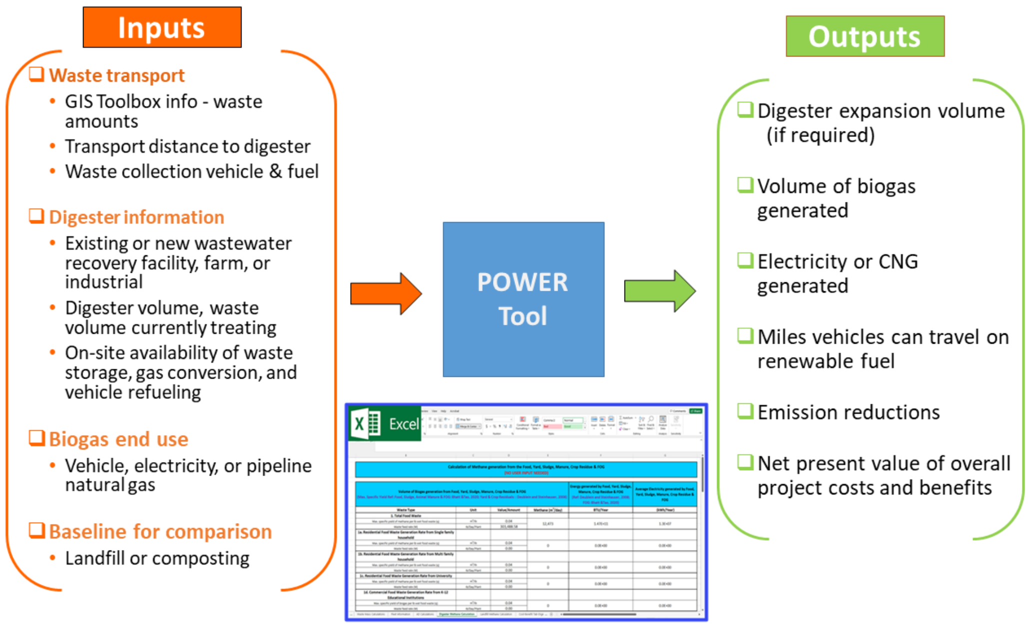
Residential Food Waste, Commercial Food Waste, Commercial FOG		Commercial Food Waste, Commercial FOG	
20% Capture	**60% Capture**	**20% Capture**	**60% Capture**
G02	S01	G02	S01
S01	S37	S01	S37
S37	S64	S37	S64
S64	S68	S64	S76
S76	S76	S76	W02
W02	W02	W02	W08
W08	W08	W08	S10
G03	W22	G03	S11
S02	S02	S02	S15
S10	S10	S10	S33
S11	S11	S11	S34
S15	S15	S15	S35
S32	S32	S33	S36
S33	S33	S34	S42
S34	S34	S35	S57
S35	S35	S36	S71
S36	S36	S42	W11
S42	S42	S57	W12
S57	S57	S71	S06
S71	S64	W12	W15
W09	S71	S06	W17
W11	W03	W15	W18
W12	W05	W17	W24
S06	W09	W18	S04
S08	W11	W24	S09
W15	W12	G04	S13
W17	W17	S09	S14
W18	S06	S14	S15
W24	S08	S15	S51
G04	S64	S30	S52
S09	W15	S38	S63
S14	W17	S51	S67
S15	W18	S52	S70

Residential Food Waste, Commercial Food Waste, Commercial FOG		Commercial Food Waste, Commercial FOG	
S30	W19	S63	W07
S38	W20	S67	W15
S51	W23	S70	S90
S52	W24	W07	W40
S63	S04	S90	W41
S67	S09	W40	
S70	S13	W41	
W07	S14		
W15	S15		
S90	S38		
W40	S51		
W41	S52		
	S56		
	S63		
	S67		
	S70		
	W01		
	W07		
	W15		
	W26		
	S90		
	W40		
	W41		

POWER Tool

The POWER Tool provides planning-level estimates of potential biogas yields and lifecycle emissions reductions that could be generated by processing organic waste via AD. Figure C-4 provides a high-level overview of the inputs and outputs that the POWER Tool provides.

Figure C-4: Overview of POWER Tool Inputs and Outputs



The Project Team developed two pilot project scenarios that were evaluated using the POWER Tool. Detailed descriptions of the Dallas pilot project scenario and Denton pilot project scenario are provided in Section 7.2. Table C-5 presents the key inputs for the POWER Tool runs.

Table C-5: Key Inputs for POWER Tool Runs

Input Category	Value	
	Dallas Pilot Project Scenario	Denton Pilot Project Scenario
Available digester capacity	Enough for all food waste/FOG in Table ___	None
Current end use for digester gas	Pipeline RNG	Vehicle RNG
Available gas conversion capacity (RNG)	0	0
Current fuel for garbage trucks	Diesel	CNG
Baseline facility – current disposal facility for food waste and FOG	Landfill with energy recovery	Compost

Table C-6 presents the values utilized to determine raw biogas production and calculate the constituent fraction of methane.

Table C-6: POWER Tool Assumed Values for Biogas Production

Parameter	Value	Reference
Biogas production from food waste	0.073 m^3/lb raw material	Bhatt and Tao (2020)
Fraction methane for biogas from food waste	0.56	
Biogas production from FOG	0.499 m^3/lb raw material	
Fraction methane for biogas from FOG	0.7	

APPENDIX D

SLUDGE GENERATION DATABASE

D. - SLUDGE GENERATION DATABASE

This appendix presents the entities identified by the Project Team that generate and manage sludge in the North Central Texas region. Information provided in the table is based on U.S. EPA National Pollutant Discharge Elimination System (NPDES) Biosolids Program reporting. The U.S. EPA provides NPDES Biosolids Program reporting data through its Enforcement and Compliance History Online (ECHO) facility search tool.

The U.S. EPA database provides access to reported information from the portion of WTTPs meeting specific regulatory requirements, including:

- A publicly-owned treatment works (POTW) that serves 10,000 people or more
- A POTW with a design flow rate equal to or greater than one million gallons per day
- A Class I Sludge Management Facility as defined in 40 CFR 503.9

The Project Team reviewed available data regarding the amount of biosolids generated and method(s) of management (reported as land application, surface disposal, incineration, and other) to inform estimates for the North Central Texas region and to assess the extent to which potential pilot project sites could support the regional need for non-landfill sludge management options. Table D-1 presents the available sludge generation and management information used in this Study.

Table D-1: Sludge Generation and Management Information for the North Central Texas Region

County	Facility Name	City	Biosolids Generation (dry tons)	Sludge Management Practice			
				Landfill or Other	Land Application	Surface Disposal	Biosolids Treatment Class
Collin	Bear Creek WWTP	Lavon	54	✓			
Collin	Celina WWTP	Celina	63	✓			Class B
Collin	City of Josephine WWTF	Josephine	14	✓			
Collin	Farmersville WWTP 1	Farmersville	54	✓			
Collin	Farmersville WWTP 2	Farmersville	48	✓			
Collin	Sabine Creek Regional WWTP	Wylie	492	✓			
Collin	Seis Lagos WWTP	Wylie	19	✓			
Collin	Slayter Creek WWTP	Anna	31	✓			
Collin	Wilson Creek Regional WWTF	Wylie	16,076	✓			
Dallas	Central Regional WWTF	Arlington	68,597	✓	✓		Class A EQ
Dallas	Central WWTF	Dallas	23,571	✓			Class B
Dallas	City of Garland Rowlett Creek WWTF	Garland	1,570	✓			
Dallas	Dallas County Park Cities MUD WWTP	Dallas	1,568	✓			
Dallas	Dallas Southside WWTF	Dallas	24,178			✓	Class B
Dallas	Floyd Branch Regional WWTP	Wylie	387	✓			
Dallas	Muddy Creek Regional WWTP	Wylie	2,071	✓			
Dallas	Rowlett Creek Regional WWTP	Wylie	5,122	✓			
Dallas	South Mesquite Creek WWTP	Wylie	7,515	✓			
Dallas	Ten Mile Creek Plant	Arlington	1,941	✓			
Denton	Aubrey WWTF	Aubrey	29	✓			Class A
Denton	Briarwood Retreat WWTP	Argyle	1	✓			
Denton	City of Hackberry WWTP	Frisco	1,218	✓			Class B
Denton	City of Justin WWTP	Justin	337	✓			Class B

County	Facility Name	City	Biosolids Generation (dry tons)	Sludge Management Practice: Landfill or Other	Land Application	Surface Disposal	Biosolids Treatment Class
Denton	City of Krum WWTF	Krum	80	✓			Class B
Denton	City of Sanger WWTP	Sanger	793	✓			
Denton	Denton Creek Regional WWTF	Arlington	2,729	✓			
Denton	Doe Branch Reg Water Rec Plant	Lewisville	578	✓			
Denton	Hidden Cove Park WWTP	Southlake	18	✓			
Denton	Lakeview Regional Water Reclamation	Lewisville	1,257	✓			
Denton	Northlake Village MHP WWTP	Northlake	2	✓			
Denton	Northlake WWTP	Dallas	1	✓			
Denton	Panther Creek WWTP	Wylie	2,174	✓			
Denton	Pecan Creek Water Reclamation Plant	Denton	4,668		✓		Class A
Denton	Peninsula Reg Water Rec Plant	Lewisville	260	✓			
Denton	Prairie Creek WWTP	Lewisville	17,330	✓			Class B
Denton	Riverbend Reg Water Reclamation Facility	Lewisville	1,035	✓			
Denton	Robson Ranch WWTP	Denton	57		✓		Class A
Denton	Stewart Creek West WWTP	Wylie	1,536	✓			
Denton	Stewart Creek WWTP	The Colony	914	✓			
Denton	Town of Flower Mound WWTP	Flower Mound	1,644	✓			Class B
Denton	Town of Ponder WWTP	Ponder	80	✓			
Denton	Trophy Club MUD 1	Trophy Club	150	✓			Class B
Ellis	City of Italy WWTF	Italy	412	✓			
Ellis	City of Waxahachie WWTP	Waxahachie	7,013	✓			Class B
Ellis	Lakeview Camp WWTP	Waxahachie	6	✓			
Ellis	Mountain Creek Reg WWTF	Arlington	667	✓			
Ellis	Oak Grove WWTF	Ennis	1,969	✓			Class B

County	Facility Name	City	Biosolids Generation (dry tons)	Sludge Management Practice			
				Landfill or Other	Land Application	Surface Disposal	Biosolids Treatment Class
Ellis	Red Oak Creek Regional WWTP	Arlington	685	✓			
Erath	City of Dublin WWTP	Dublin	458		✓		Class B
Erath	Northside Water WWTP	Stephenville	0	✓			
Erath	Stephenville WWTP	Stephenville	299	✓			Class B
Hood	Acton MUD WWTF	Granbury	112	✓			
Hood	Acton MUD WWTP	Granbury	88	✓			
Hood	City of Granbury WWTP	Granbury	279	✓			Class B
Hunt	City of Caddo Mills WWTF	Caddo Mills	16	✓			Class B
Hunt	City of Commerce WWTF	Commerce	333	✓			
Hunt	City of Greenville WWTP	Greenville	1,213	✓			
Hunt	City of Josephine WWTP 2	Josephine	14	✓			
Johnson	Blue Water Oaks WWTP	Alvarado	2	✓			
Johnson	City of Cleburne WWTF	Cleburne	670	✓			
Johnson	City of Godley WWTP	Godley	130	✓			
Johnson	Grandview WWTP	Grandview	12	✓			Class B
Johnson	Johnson County SUD WWTP	Cleburne	98	✓			
Johnson	Lillian Elementary School WWTF	Alvarado	3	✓			
Kaufman	Adelphi WWTP	Quinlan	0	✓			
Kaufman	City of Kaufman WWTP	Kaufman	43	✓			
Kaufman	City of Kemp WWTP	Kemp	11	✓			Class A
Kaufman	Crandall WWTP	Crandall	55	✓	✓		Class B
Kaufman	Duck Creek Plant	Sunnyvale	6,974	✓			
Kaufman	Kaufman County FWSD 1A WWTP	Dallas	98	✓	✓		Class B
Navarro	City of Corsicana - WWTP 2	Corsicana	256	✓			Class A
Palo Pinto	Pollard Creek WWTP	Mineral Wells	612	✓			Class B

County	Facility Name	City	Biosolids Generation (dry tons)	Sludge Management Practice			
				Landfill or Other	Land Application	Surface Disposal	Biosolids Treatment Class
Palo Pinto	Willow Creek WWTP	Mineral Wells	32	✓			Class B
Parker	Abraxas WWTP	North Richland Hills	7	✓			
Parker	City of Aledo WWTP	Aledo	11	✓			
Parker	City of Springtown WWTP	Springtown	578	✓			Class B
Parker	City of Willow Park WWTP	Willow Park	719	✓			
Parker	Cowtown RV Park WWTF	Aledo	2	✓			Class A
Parker	Weatherford Facility	Weatherford	721	✓			
Rockwall	Buffalo Creek WWTP	Wylie	509	✓			
Rockwall	Squabble Creek WWTF	Wylie	60	✓			
Somervell	City of Glen Rose WWTP	Glen Rose	39			✓	Class B
Somervell	Happy Hill Farm Childrens Home WWTP	Granbury	1	✓			
Tarrant	Ash Creek WWTP	Azle	2,021	✓			
Tarrant	Eagle Mountain RV Park WWTP	Fort Worth	1	✓			
Tarrant	Fort Worth Boat Club WWTP	Fort Worth	6	✓			
Tarrant	Peach Street WWTP	Grapevine	655	✓			
Tarrant	SigmaPro WWTP	Fort Worth	0	✓			
Tarrant	St. Francis Village WWTP	Crowley	18				Class B
Tarrant	Village Creek WWTF	Fort Worth	24,284	✓	✓		Class A
Wise	City of Alvord WWTP	Alvord	3	✓			
Wise	City of Bridgeport WWTP	Bridgeport	11			✓	Class A
Wise	City of Chico	Chico	23	✓			Class B
Wise	City of Decatur	Decatur	103	✓			
Wise	City of Newark WWTP	Newark	3	✓			

County	Facility Name	City	Biosolids Generation (dry tons)	Sludge Management Practice			
				Landfill or Other	Land Application	Surface Disposal	Biosolids Treatment Class
Wise	Rhome WWTF	Rhome	31	✓			
Wise	Westside WWTP	Rhome	32	✓			

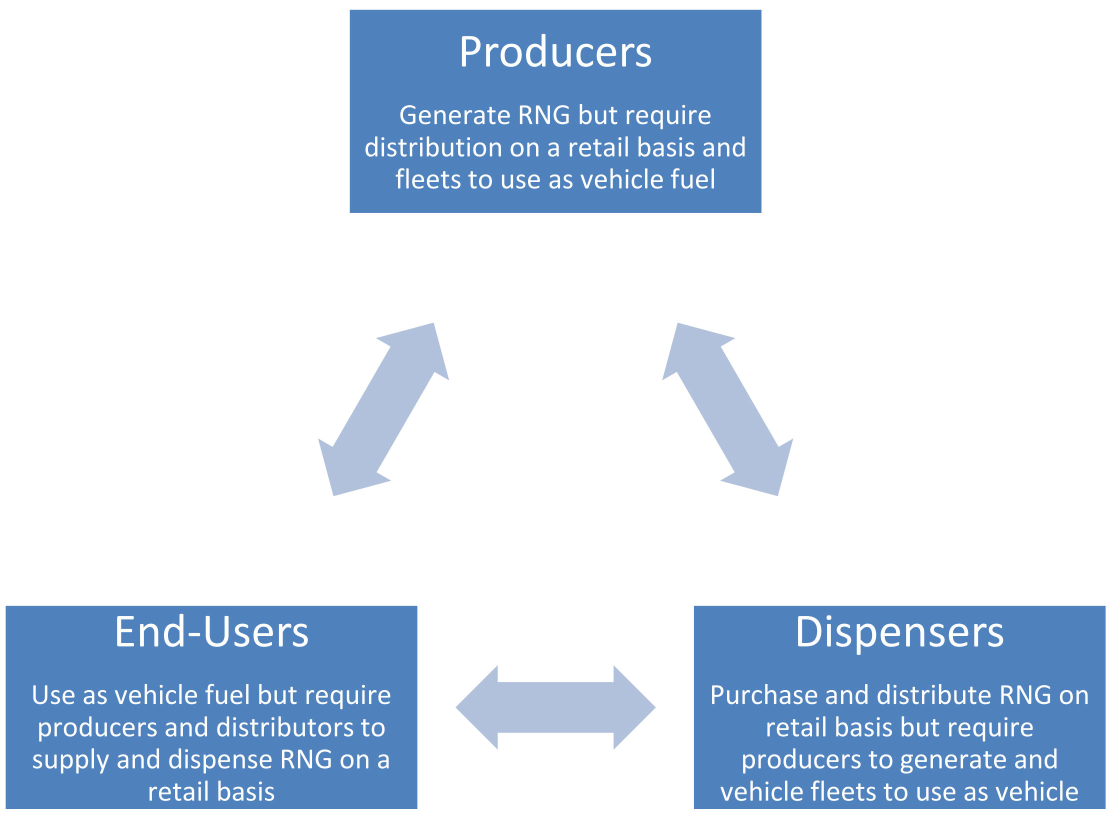
APPENDIX E

CNG-TO-RNG CONTRACT GUIDE

E. - CNG-TO-RNG CONTRACT GUIDE

Implementing Renewable Natural Gas (RNG) as part of a fleet's fueling mix significantly reduces tailpipe emissions – NOx and PM2.5 – compared to diesel and gasoline, and also reduces lifecycle greenhouse gas emissions from petroleum-derived fuels and fossil natural gas. Existing producers, dispensers and end-users of natural gas may be well positioned to utilize RNG, or biomethane, and as RNG usage increase in the North Central Texas region the contractual arrangements must be set up correctly to receive the financial benefits of environmental credits.[30] All the stakeholders of the biomethane supply chain support the ability to generate environmental credits including producers (e.g., an AD facility generating biogas and upgrading it to biomethane), dispensers (e.g., fueling stations dispensing the gas) and end-users (e.g., transportation fleet operators). Figure E-1 shows the parties that are dependent on each other to drive demand for RNG as part of the biomethane supply chain.

Figure E-1: Coordination Among RNG Stakeholders



[30] Biomethane is non-fossil derived natural gas that (i) meets applicable pipeline quality standards, (ii) qualifies as a cellulosic biofuel when converted to transportation vehicle fuel, (iii) contains Environmental Attributes indicating that the all or part of the commodity is considered biomethane, and (iv) qualifies to generate credits under applicable programs (e.g., RFS2, LCFS, etc.).

Regardless of the volume and source of RNG utilized in an end-user's fuel mix, the Environmental Attributes associated with this fuel include valuable environmental credits.[31] The Renewable Fuel Standard (RFS), Low Carbon Fuel Standard (LCFS) and other applicable programs generating environmental credits allow producers, dispensers and end-users to capitalize on the positive Environmental Attributes of producing and utilizing biomethane as vehicle fuel.[32] Adoption of other alternative fuels and engine types that reduce vehicle emissions compared to diesel (e.g., battery electric, hydrogen, etc.) is incentivized by the same state and federal clean transportation policies but are not included as part of this contract guide.

Agreement and cooperation between the producer, dispenser, and end-user of biomethane is critical to realizing the economic and environmental benefits and value associated with RNG. The purpose of this document is to support that cooperation by describing how to update existing wholesale CNG supply contracts considerations related to adding a biomethane transaction confirmation to generate environmental credits. This contract guide addresses select contractual elements required to transition from CNG-to-RNG but is not intended to provide legal advice nor to address every contractual or financial provision included in natural gas purchase, sale or distribution contracts.

Natural Gas Purchase and Sale Agreement

To successfully transition from fossil natural gas-based (e.g., CNG) purchase and sale agreements to biomethane-based (e.g., RNG) agreements, the base contract must be amended to ensure that the producer (e.g., the party generating the gas), the dispenser (e.g., the party dispensing the gas), and the end-user (e.g., the party utilizing the gas for vehicle fuel) are aligned on key terms and conditions.[33] Amending standard terms and conditions of a base contract so they are mutually beneficial among producers, dispensers, and end-users of RNG allows all parties to support each other to generate environmental credits. A typical base contract only includes producer and dispenser and established the agreement for

[31] Environmental Attributes include greenhouse gas Greenhouse Gas (GHG) attributes (e.g., certificates issued under a biofuel certification program and avoided emissions of carbon dioxide, methane or other GHGs), renewable energy certificates, any avoided emissions of pollutants to the air, soil or water, and any attributes required to generate RINs or LCFS Credits and any reporting rights associated with the foregoing. Various pathways are assigned Environmental Attributes of different values and are further discussed in Section 7.3.7.

[32] To generate environmental credits such as Renewable Identification Numbers (RINs) under RFS2 or LCFS credits, biomethane must be utilized as fuel in transportation vehicles. Further detailed description of applicable programs including program administrators responsible for oversight is provided in Section 7.3.7.

[33] The standard terms and conditions for the sale and purchase of natural gas were adopted on September 5, 2006, by the North American Energy Standards Board. More information on wholesale gas contract standard terms and conditions adopted by the North American Energy Standards Board can be found online here: https://www.naesb.org/wgq/cont.asp

the purchase and sale of natural gas (meaning natural gas without any Environmental Attributes such as fossil-derived fuel). The following describes considerations related to select standard terms and conditions that should be updated to transition from the supply of CNG to the supply of RNG for generation of environmental credits:

- **Transaction confirmation.** A document provided by the agreed upon party that confirms a transaction's contract price, delivery period, delivery point (e.g., specific geographic and pipeline location) and special conditions. Key information about the transaction should be updated when transitioning from CNG-to-RNG, including the pricing, cost adjustment indices, payment schedule, facility location(s), delivery point, and Quality Assurance Program (QAP).[34] Further description of transitioning to a biomethane transaction confirmation is provided in the following section of this guide.

- **Transport fees.** Fees related to transportation of natural gas to or from the delivery points. These fees must be clearly defined because the available infrastructure, owners, operators and ultimately the cost of transporting RNG may be different than CNG. Parties should carefully evaluate how transportation fees are considered as part of the contract price, including situations where the producer does not meet the minimum quantities established as part of the performance obligations.

- **Delivery period.** The period of time agreed between the producer and dispenser over which deliveries of natural gas are made. The length of the delivery period and terms of contract termination informs the pricing that can be achieved. Longer term contracts minimize risk for entities across the biomethane supply chain compared to spot pricing contracts.

- **Performance obligations.** Establishes that the producer agrees to sell and deliver, and the dispenser agrees to purchase and receive a specified quantity of natural gas at a specified delivery point.[35] Additionally, to transition from CNG-to-RNG the contract should be adjusted to establish

[34] QAP is a voluntary validity program where independent third-parties may audit and verify that environmental credits have bene properly generated and are valid for compliance purposes. Further information about the RFS QAP program can be found here: https://www.epa.gov/renewable-fuel-standard-program/quality-assurance-plans-under-renewable-fuel-standard-program

[35] The contract quantity is provided in MMBtu per day and can be firm or interruptible. Firm contract quantities can be fixed (e.g., a fixed or quantity of MMBtus per day) or variable (e.g., ranging between a designated minimum and maximum MMBtus per day). Contract quantities may include stored natural gas.

that the dispenser will use any biomethane delivered as vehicle fuel and determine the programs that will be used to generate environmental credits.

- **Supply disruption.** A key consideration when transitioning from CNG-to-RNG is updating the contract quantity and ability to revise the contract quantity over time in the case that RNG production levels fall, and the full contractual volume cannot be met. The conditions of how biomethane should be managed and environmental credits generated in the case of supply disruptions should be detailed as part of the transition from a CNG-to-RNG contract.

Biomethane Transaction Confirmation

While the full contract and key terms described above should be reviewed and adjusted, as applicable to specific projects, transition between CNG and RNG contracts is based on the development of a biomethane transaction confirmation that fundamentally amends a base contract of a wholesale natural gas sale and purchase agreement. The biomethane transaction confirmation bifurcates natural gas and biomethane commodities so they can be purchased and sold individually. The environmental credits associated with biomethane generated from AD and used as vehicle fuel drive are governed by the biomethane transaction confirmation.

Registration

The biomethane transaction confirmation identifies the applicable program(s) that the producer and/or dispenser must register with to generate environmental credits. Contracts should clearly indicate the federal and/or state program(s) that will be used to generate environmental credits, as well as which party is responsible for generating the credits from each program(s). Typically, the producer is responsible for generating environmental credits and would never be the end-user’s responsibility. Responsibilities related to generating environmental credits include the registration, government filings, verification, and any other actions required to meet the needs of applicable program(s), as well as any costs that may be incurred. Documentation for applicable programs may include pathway registration, quarterly progress reporting and annual compliance reporting. Future program requirements may change, and new programs may be established after an RNG contract is executed. Contract language should maximize the parties’ collective flexibility to add or adjust programs that allow them to take advantage of future markets that are currently unavailable.

Contract Price

The contract price is determined for each unit of biomethane sold and delivered by the producer to the dispenser at the contractual point of delivery.[36] To transition from a CNG-to-RNG contract, the contract price for natural gas and the value of each type of environmental credit should be clearly established, although neither are likely to be fixed prices. The following describes the components of the contract price that should be carefully considered when amending base contract terms to transition from CNG-to-RNG:

- **Gas contract price.** Typically, a pre-determined daily or monthly pricing index (e.g., U.S. Energy Information Administration) is used to calculate the price of conventional natural gas, less any transportation fees. The quantity of biomethane sold and delivered determines the quantity of environmental credits that are generated in a given time frame.

- **Environmental credit price.** The contract should establish the basis of the value of the environmental credits, if an index (e.g., Argus D3 RIN Price) is utilized and how to identify the appropriate pricing (e.g., average prices for the applicable month). Additionally, the contract should indicate the procedure in the case that prices or publications used to determine the value of environmental credits become discontinued, changed or replaced.

- **Environmental credit percentage.** The contract should establish a percentage for each type of environmental credit (e.g., 50 percent of D5 RINs, 60 percent of D3 RINs, etc.) that is allocated to the producer and/or dispenser. Environmental credit percentages should be explicit for each applicable program and/or pathway.

While the contract price must be explicitly established between the producer and dispenser as part of the transition from a CNG-to-RNG contract, it is not unusual for the producer and dispenser to provide a portion of the revenue generated from environmental credits to the end-user. Providing revenue sharing to the end-user is not a requirement of the transition from a CNG-to-RNG contract, but the arrangement further encourages end-users to use RNG by reducing the overall fuel costs. If RNG is not used as vehicle fuel, then environmental credits cannot be generated and depending on contract term and volume, a typical end-user might expect to receive a 4-8 percent share of RIN and/or LCFS revenue.

[36] Biomethane units are typically MMBtu for the producer or distributor and Diesel Gallon Equivalent (DGE) for end-users.

Generation of Environmental Credits

When biomethane is injected into the gas grid, the volume of physical gas is tracked separately from the biomethane containing Environmental Attributes capable of generating environmental credits under one or more program(s). The contract should specify the party responsible for making commercially reasonable efforts to maximize value of environmental credits and establish the procedure related to any unsold environmental credits. Typically, the responsible party for generating environmental credits is the producer, but individual contracts can assign either the producer or dispenser as responsible party. Dispensers in the industry have worked to build out internal capabilities to generate environmental credits. As part of the transition from a CNG-to-RNG contract, the parties responsible for monetizing any environmental credits should be specified, along with the time period allowed for that party to generate, transfer (as applicable) and monetize environmental credits.

APPENDIX F

FUNDING OPPORTUNITY MEMORANDUM

F. - FUNDING OPPORTUNITY MEMORANDUM

Both government incentives and private funding sources can provide financial benefits for a variety of alternative fuel projects. These grants and other funding sources are often provided on a competitive basis and are not always specific to the alternative fuel industry. If a project can secure additional funding, it will typically allow for a reduction in the capital or operating costs

This memorandum documents federal, state, and local incentives and funding opportunities to support infrastructure upgrades and development. The information presented is intended to build on descriptions of programs related to policy drivers, incentives and funding opportunities identified in the *U.S. EPA AgSTAR Project Development Guidebook.* [37] The following summarizes available funding programs intended to stimulate development of AD facilities, critical ancillary infrastructure (e.g., byproduct management), and alternatively fueled fleets. This section concludes with a discussion of public-private partnership options for structuring alternative fuel projects.

Environmental Credits

Environmental credits are a critical component of financing, development and operations of AD projects and other alternative fuel development projects. The Renewable Fuel Standard (RFS) was established under the Energy Policy Act of 2005 (later expanded under the Energy Independence and Security Act of 2007) and is administered by the U.S. EPA with the primary goals of reducing dependence on foreign oil and promoting biofuel use for reduction of emissions.[38] Environmental credits are generated when biofuels are used for transportation purposes.[39] Each environmental credit is assigned a Renewable Identification Number (RIN) by the U.S. EPA.

[37] U.S. EPA. *AgSTAR Project Development Guidebook.* 3rd Edition. https://www.epa.gov/sites/default/files/2014-12/documents/agstar-handbook.pdf.

[38] The U.S. EPA is currently in the process of re-evaluating the RFS to adjust various programmatic elements including contemplating RINs for electricity under certain fuel pathways as well as adjusting the basis for the valuation of D3 and D5 RINS.

[39] There are several different categories of renewable fuels within the RFS including both biomethane and hydrogen. Refiners that produce gasoline or diesel fuel, and importers that import gasoline or diesel fuel are required to purchase RIN credits if they do not produce or import a sufficient quantity of biofuels to meet the limits that are set annually by EPA. Refiners and importers are referred to as an “obligated party” and are subject to Renewable Volume Obligation (RVO) under the RFS.

The U.S. EPA categorizes RINs based on how alternative fuels are manufactured, including D3 (derived from cellulosic sources) and D5 (derived from other carbonaceous material) RINs. D3 RINs are currently valuated at a range of $3.00 - $3.30 per credit, where D5 RINs are valued at less than half of that at a range of $1.50 – $1.75 per credit.[40]

Some states with goals to reduce the Carbon Intensity (CI) of transportation fuels have implemented programs that utilize environmental credits to incentivize reductions of carbon intensity of vehicle fuels. The following summarizes available programs in the U.S. and Canada:

- **California low-carbon fuel standard (LCFS).** The LCFS is a program administered by the California Air Resources Board (CARB) to reduce greenhouse gas emissions in transportation fuels. Physical molecules are not required to be conveyed to California; however, any LCFS pathway using pipeline-injected biomethane must maintain chain-of-custody evidence (e.g., if biomethane is used as vehicle fuel before injected into the pipeline, the pilot project would not be able to take advantage of this program). The link between the environmental attributes of biomethane injected and natural gas withdrawn for transportation purposes in California is demonstrated by providing records, including invoices and contracts, between all applicable parties along the supply chain. The Carbon Intensity (CI) score is a key component of the LCFS, ultimately determining the value that can be realized from environmental credits. Lower CI scores are assigned to various pathways, and similar to the RFS landfill gas and co-digestion projects are not as competitive as biomethane generated from cellulosic sources. LCFS credits are trading at a range of $86.00 - $88.00 per credit.
- **Oregon Clean Fuels Program (CFP).** The Oregon Legislature passed SB 324 allowing full implementation of the CFP beginning in 2016. RNG from biomethane is considered a tier 1 fuel under the program. Similar to California's LCFS, credits are issued in a compliance-based market. The CFP is just beginning to impact the overall marketplace, and credits are trading at a range between $110 - $115 per credit.
- **Washington Clean Fuel Standard (CFS).** Washington's CFS requires fuel suppliers to gradually reduce the carbon intensity of transportation fuels to 20 percent below 2017 levels by 2038. Washington's Department of Ecology announced rulemaking for the CFS in July 2021 and invited public comment on proposed rules in August 2022. The program is expected to begin in January 2023.

[40] Aegis Hedging. LCFS & RIN Pricing Report August 26, 2022. https://aegis-hedging.com/insights/lcfs-rin-pricing-report-2022-08-26

- **Canada's Clean Fuel Standard (CFS).** Canada's CFS sets a targets for reductions in liquid transportation fuel carbon intensity and allows renewable fuels produced from various feedstock pathways, similar to state programs in the U.S. Canada's CFS framework allows for importing of renewable fuels from outside Canada, so RNG generated in the U.S. would be eligible under compliance category three.

While all the programs summarized would be capable of accepting for biogas generated by co-digestion in Texas, there are projects generating fuels that have a lower CI score and are more preferable. For example, the LCFS is inundated with projects of various sizes and pathways and a co-digestion facility in Texas at a lower CI score may not be as competitive as other candidate projects in California's LCFS program. Identifying the current number of existing projects generating environmental credits in each program and the feedstock/technology pathways utilized would determine the most appropriate program to generate environmental credits as part of a co-digestion facility in Texas.

In addition to the RFS and programs intended to reduce the CI of vehicle fuels, Renewable Energy Certificates (REC) are available as another form of environmental credit are tradable, non-fungible energy commodities representing proof that 1 MWh of electricity was generated from a qualified renewable energy resource. In some cases, electric utilities provide project funding in return for the rights to the RECs generated by an AD facility to meet requirements of state-wide renewable energy portfolio standards.

There are also voluntary markets for carbon offset credits that may be earned by reducing greenhouse gas emissions, including methane recovered from an AD facility. These environmental credits have an economic value and can be bought and sold on commodity exchanges, through private transactions, or through credit aggregators. Besides serving as an additional revenue source, carbon offset credits can also provide incentives for outside parties to provide project funding for AD facilities. These transactions can be based on the volume avoided emissions or the amount of electric power generated. Organizations and individuals can purchase carbon offset credits through voluntary offset companies as an opportunity to reduce their environmental impact.

Federal Policy and Legislation

Various recent federal legislative efforts have targeted provisions intended specifically support AD project development. The following summarizes applicable federal legislation that could be leveraged to AD project development:

- **Inflation Reduction Act (IRA).** This act was passed on August 12, 2022 and provides new and expanded tax credits for qualified biogas property (e.g., biogas generation or cleaning projects) and extends an alternative fuel tax credit for all biogas sectors (e.g., wastewater, farm, food waste, projects producing renewable electricity, and renewable natural gas and heat). The legislation is financially supported by introducing a one percent excise tax on stock buybacks and a 15 percent corporate minimum tax. Prior to this effort, there had only been one- to two-year extensions available for tax credits which caused challenges from competing industries and projects that benefitted from long-term tax credits when seeking investments. The act includes the following key incentives for qualified biogas property (e.g., systems that convert biomass into gas no less than 52 percent methane by volume):
  - Up to 30 percent rate of Investment Tax Credit (ITC) and Production Tax Credit (PTC) for facilities which begin construction before 2034
  - Additional 10 tax credit for domestic content bonus (e.g., for projects utilizing materials fabricated and manufactured in the U.S.)
  - Additional 10 percent tax credit for energy community bonus (e.g., for projects located in communities located on brownfield sites, high industrial activity, or high unemployment rates)
  - Extends alternative fuel tax credit of $0.20 per gallon up to $1.00 per gallon if prevailing wage and apprenticeship requirements are met
  - More information and the full text of the IRA is located at the following hyperlink: https://www.congress.gov/bill/117th-congress/house-bill/5376/text
- **Infrastructure Investment and Jobs Act of 2021.** This law was passed on November 15, 2021 and provides new and expanded funding opportunities and appropriations for AD and associated infrastructure. There is $10 billion to be made available for PFAS mitigation, $7.5 billion to be made available for the adoption of low-carbon and zero-emissions school busses (including hydrogen, propane, Liquified Natural Gas (LNG), compressed natural gas, biofuel, and electric technologies), and $8 billion to be made available to support hydrogen fuel production and utilization.

In addition, $1 billion over five years would be authorized for a research, demonstration, and commercialization program aimed at reducing the cost of hydrogen and authorize $75 million per year (through fiscal 2026) for research grants to address water pollution and training at water treatment facilities.

For more information: https://www.congress.gov/bill/117th-congress/house-bill/3684

- **Volkswagen Clean Air Act Civil Settlement.** Through a series of three partial settlements dating back to 2016, the U.S. EPA has resolved a civil enforcement case against Volkswagen based on computer software designed to cheat on federal emissions tests. Through the Volkswagen diesel emissions environmental mitigation trust, disbursements are made to state beneficiaries which has provided for the development of the Texas Volkswagen Environmental Mitigation Program (TxVEMP).[41] TxVEMP provides grant opportunities to replace or upgrade older vehicles or equipment, or install alternative fueling equipment.

  For more information: https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement

- **Justice40 Initiative.** This initiative sets the goal of allocating 40 percent of the federal investments to disadvantaged communities that are marginalized, underserved, and overburdened by pollution. The categories of investments include climate change, clean energy and energy efficiency, clean transit and the development of critical clean water and wastewater infrastructure.

  For more information: https://www.whitehouse.gov/environmentaljustice/justice40/

- **Electricity Production Tax Credit (PTC)**. The federal Electricity Production Tax Credit (PTC) is an inflation-adjusted per-kWh (cents/kWh) tax credit for renewable electricity generated by qualified resources and then sold to an unrelated person. The credit's duration is 10 years after the date the facility is placed in service. The current PTC is 2.3 cents/kWh. AD/biogas systems may elect to claim an Investment Tax Credit (ITC) in lieu of a PTC. The ITC provides a tax credit equal to 10 percent of the eligible property used, and usually is the better of the two federal incentives from a financial perspective. However, pursuing the ITC instead of the PTC requires a tax opinion from a qualified professional.

[41] Information on grant opportunities made available through TxVEMP can be found here: https://www.tceq.texas.gov/airquality/air-emissions/air-grants

As a result, a project should use a PTC in any initial evaluation. PTC and ITC are only available for projects that utilize at least 75 percent of their biogas to generate electricity; there is not an equivalent program for RNG projects.

For more information: https://www.epa.gov/lmop/renewable-electricity-production-tax-credit-information

- **Alternative Fuel Excise Tax Credit** A tax incentive is available for alternative fuel that is sold for use or used as a fuel to operate a motor vehicle. A tax credit in the amount of $0.50 per gallon is available for the following alternative fuels: natural gas, liquefied hydrogen, propane, P-Series fuel, liquid fuel derived from coal through the Fischer-Tropsch process, and compressed or liquefied gas derived from biomass. For propane and natural gas sold after December 31, 2015, the tax credit is based on the gasoline gallon equivalent (GGE) or diesel gallon equivalent (DGE). For taxation purposes, one GGE is equal to 5.75 pounds (lbs.) of propane and 5.66 lbs. of compressed natural gas. One DGE is equal to 6.06 lbs. of liquefied natural gas. For an entity to be eligible to claim the credit they must be liable for reporting and paying the federal excise tax on the sale or use of the fuel in a motor vehicle. Tax exempt entities such as state and local governments that dispense qualified fuel from an on-site fueling station for use in vehicles qualify for the incentive. Eligible entities must be registered with the Internal Revenue Service (IRS). The incentive must first be taken as a credit against the entity's alternative fuel tax liability; any excess over this fuel tax liability may be claimed as a direct payment from the IRS. The tax credit is not allowed if an incentive for the same alternative fuel is also determined under the rules for the ethanol or biodiesel tax credits.

  For more information: https://afdc.energy.gov/laws/319

- **Alternative Fuel Tax Exemption.** Alternative fuels used in a manner that the IRS deems as nontaxable are exempt from federal fuel taxes. Common nontaxable uses in a motor vehicle are: on a farm for farming purposes; in certain intercity and local buses; in a school bus; for exclusive use by a non-profit educational organization; and for exclusive use by a state, political subdivision of a state, or the District of Columbia. This exemption is not available to tax exempt entities that are not liable for excise taxes on transportation fuel.

  For more information: https://www.irs.gov/pub/irs-drop/n-22-39.pdf

Infrastructure Grants, Loans and Cost-Sharing

Various recent infrastructure development grant and loan opportunities can be leveraged to support AD project development. The following summarizes applicable infrastructure development grants and loans:

- **Sustainable Materials Management Grants.** Each year the U.S. EPA releases grant funding opportunities specific to supporting AD as an alternative to landfill disposal. Funding may vary by region.

  For more information: https://www.epa.gov/grants/region-8-fiscal-year-2022-sustainable-materials-management-grant

- **Environmental Quality Incentives Program (EQIP).** The USDA EQIP is an example of a cost-sharing program, sometimes referred to as cash reimbursement, that allows project owners to purchase and construct AD systems, and then apply for cost-sharing funds after the project is completed. Cost-sharing arrangements do not require repayment.

  For more information: https://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcseprd1919229.pdf\

- **Industrial Revenue Bonds (IRB).** Industrial revenue bonds (IRB) raise capital by issuing bonds that are used to build or buy a facility like an AD system. A bond is a fixed income investment, set for a defined time period using either a variable or fixed interest rate. A state or local public entity issues the bond to secure the loan's funding source from an investor that buys the bond. The public entity owns the facility or some of its equipment for the length of the bond. IRB loans typically have a lower interest rate and a longer term than a simple interest loan provided by a bank. An IRB can sometimes provide property tax relief to the operator because a public entity owns the assets during the loan period. Asset ownership reverts once the IRB is repaid. An operator can re-purchase the IRB when an arbitrage profit margin can take advantage of lower interest rates and longer terms. In general, only larger, centralized AD/biogas system projects rely on IRB bonds.

  For more information: https://gov.texas.gov/business/page/industrial-revenue-bonds

- **Regional Solid Waste Grants Program**. In Texas, grant funds are awarded to regional and local governments for municipal solid waste (MSW) management projects through the state's Regional Solid Waste Grants Program. State law dedicates a portion of the revenue generated by state fees on MSW disposed at landfills to grants for regional and local MSW projects. Funding is allocated to Texas' 24 Councils of Government (COGs) – including NCTCOG – based on a formula that takes into account population, area, solid waste fee generation, and public health needs. More information on the allocation of these funds can be found in Section 361.014 of the Texas Health and Safety Code.

  Grant funds can be used for illegal dumping cleanup, source reduction and recycling projects, developing or updating local solid waste management plans, HHW management, educational and training projects, and other MSW projects. Eligible applicants include cities, counties, public schools and school districts, general and special law districts, and COGs. Projects should promote cooperation between public and private entities, although private and nonprofit entities are not eligible to receive direct grant funding from the COGs. However, the private and nonprofit entities could enter into a partnership with any of the eligible applications listed above.

  For more information: https://www.nctcog.org/envir/materials-management/grants

- **Hydrogen Demonstration Project Grants.** This grant program is administered by the U.S. Department of Energy (U.S. DOE) with the goal to reduce the cost of clean hydrogen by 80 percent to $1.00 per by funding hydrogen demonstration projects that can help lower the cost of hydrogen, reduce carbon emissions and local air pollution, and provide benefits to disadvantaged communities. Hydrogen Shot focuses on various projects that bridge technical gaps in hydrogen production, storage, and distribution and utilization technologies, including fuel cells.

  For more information: https://afdc.energy.gov/laws/12696

- **Regional Clean Hydrogen Hubs.** The U.S. DOE administers the Regional Clean Hydrogen Hubs (H2Hubs) program. H2Hubs funds the development of at least four regional networks of hydrogen producers, potential hydrogen consumers, and connective infrastructure located in close proximity.

  For more information: https://www.energy.gov/oced/regional-clean-hydrogen-hubs

Transportation Grants

Various grant and loan opportunities can be leveraged to support the implementation of alternative fuel vehicles. The following summarizes applicable transportation grants and describes the components that are applicable to alternative fuels:

- **Alternative Fuel Corridor (AFC) Grants.** The U.S. Department of Transportation (U.S. DOT) administers a competitive grant program to strategically deploy publicly accessible electric vehicle charging and hydrogen, propane, and natural gas fueling infrastructure along designated U.S. DOT Federal Highway Administration AFCs. The grant will provide funding to install infrastructure to install alternative fuel infrastructure to provide station redundancy and meet higher demand. Eligible entities include states, metropolitan planning organizations, local governments, political subdivisions, and tribal governments.

  For more information: https://afdc.energy.gov/laws/12730

- **Electric Vehicle Charging and Clean Transportation Grants**. The U.S. DOE provides grants for transportation decarbonization research projects. Priority will be given to projects that include: cost-effective deployment of Battery Electric Vehicle (BEV) charging, innovative solutions to improve mobility options for underserved communities, community engagement to accelerate clean transportation options in underserved communities, research and development to optimize BEV batteries (e.g., size and cost, battery range), use of the alternative fuels in commercial off-road vehicle technologies, including natural gas, hydrogen, and renewable propane; planning and development of medium- and heavy-duty BEV charging, hydrogen fueling corridors, and advanced engine and fuel technologies to improve fuel economy and reduce greenhouse gas emissions.

  For more information: https://afdc.energy.gov/laws/13034

- **Clean School Bus.** The U.S. EPA's Clean School Bus program provides funding to eligible applicants for the replacement of existing school buses with clean, alternative fuel school buses or zero-emission school buses. U.S. EPA may award up to 100% of the cost of the replacement bus, charging equipment, or fueling infrastructure. Alternative fuels include electricity, natural gas, hydrogen, or propane. Eligible applicants are school districts, state and local government programs, federally recognized Indian tribes, non-profit organizations, and eligible contractors.

- U.S. EPA will prioritize funding for high-need local education agencies; low income, rural and tribal schools; and, applications that cost share through public-private partnerships, grants from other entities, or school bonds.

  For more information: https://www.epa.gov/cleanschoolbus

- **The Texas Clean School Bus (TCSB) Program.** TCEQ administers a comprehensive program designed to reduce emissions of diesel exhaust from school buses. Grants may reimburse up to 100 percent of the cost to retrofit a school bus, or up to 80 percent of the cost to replace a school bus.

  For more information: https://www.tceq.texas.gov/airquality/terp/school-buses.html

- **Congestion Mitigation and Air Quality (CMAQ) Improvement Program.** The CMAQ Program provides funding to state departments of transportation, local governments, and transit agencies for projects and programs that help meet the requirements of the Clean Air Act by reducing mobile source emissions and regional congestion on transportation networks. Eligible activities include transit improvements, travel demand management strategies, congestion relief efforts (such as high occupancy vehicle lanes), diesel retrofit projects, alternative fuel vehicles and infrastructure, and medium- or heavy-duty zero emission vehicles and related charging equipment. Projects supported with CMAQ funds must demonstrate emissions reductions, be located in or benefit a U.S. EPA-designated nonattainment or maintenance area, and be a transportation project.

  For more information: https://www.fhwa.dot.gov/fastact/factsheets/cmaqfs.cfm

- **Texas Emissions Reduction Plan (TERP).** The TERP program, administered through TCEQ, provides financial incentives to eligible individuals, businesses, and local governments to reduce emissions from mobile sources and equipment. The TERP program is comprised of nine separate grant programs, and each program has its own eligibility requirements and may accept applications at different time periods of the year. Programs that may be of specific interest include:
  - **Texas Clean Fleet Program (TCFP).** Provides incentives to owners of large fleets in Texas to replace diesel-powered vehicles with alternative fuel or hybrid vehicles.
  - **Texas Natural Gas Vehicle Grant Program (TNGVGP).** Provides grants to encourage an entity that owns and operates a heavy-duty or medium-duty motor vehicle to retrofit the vehicle with a natural gas engine or replace the vehicle with a natural gas vehicle.

- **Alternative Fueling Facilities Program (AFFP).** Provides grants for eligible alternative fuel fueling facility projects in Texas' Clean Transportation Zone, including Compressed Natural Gas (CNG) and/or Liquified Natural Gas (LNG) projects.

For more information: http://www.terpgrants.org

Public-Private Partnerships

Public-private partnerships can be an effective model to provide needed infrastructure without the full financial risk falling on either the City or the private business. Effective public-private partnerships exist when the stakeholders of an RNG project including the biogas producers, distributors and end users collaborate to share resources, capital investment, risk, and revenue. When considering a public-private partnership, a local government should consider the degree to which it wants to be involved in the operations and capital investment of a facility.

There are advantages and disadvantages to the different types of arrangements and which entity takes ownership of the land, capital investment, and operations. While the processing services agreement is the most common option, public-private partnerships are gaining more appeal as a means to share risk among market volatility. Table F-1 provides an overview of the different public-private partnership options available to local governments and private businesses.

Table F-1: Examples of Public-Private Partnership Options for Recycling Operations

Responsibility	City-Owned and Operated	City-Owned with Private Operations*	Privately Owned and Operated on City Land	Processing Services Agreement
Land Ownership	City	City	City	Private
Capital Investment	City	City	Private	Private
Operations	City	Private	Private	Private

Both utilities and private sector companies are setting renewable fuel goals and are seeking potential partners for RNG projects. For example, the California Public Utilities Commission (CPUC) recently set renewable natural gas (biomethane, RNG) procurement targets for utilities to reduce short-lived climate pollutant (SLCP) emissions in their decision implementing Senate Bill 1440 Regulation and Waste Management recently released notice that it plans to invest $825 million in its renewable energy footprint from 2022-2025 by expanding its RNG infrastructure.

Other natural gas utilities are investing in RNG for cost recovery or sale to residential, commercial, and institutional end users. Some examples of utilities that are investing RNG include the Southern California Gas Company, Pacific Gas and Electric Company, Black Hills, Nicor, Piedmont, Northwest Natural, Dominion Energy, CenterPoint Energy, and Vermont Gas.

Several utilities utilize voluntary feed in tariff programs, purchasing RNG between $12-$25 per MMBtu.

Several companies offer services to manage the offtake of the RNG once it enters the pipeline and are active in the RNG project space.

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