POINT BREEZE RENEWABLE ENERGY, LLC

PRESENTATION TO THE SOLID WASTE AND RECYCLING ADVISORY COMMITTEE (SWRAC)
CITY OF PHILADELPHIA

May 31, 2018
Philadelphia, PA
AGENDA

- Introductions
- RNG Energy Solutions – Who We Are
- Heartland Biogas Project Background
- Point Breeze Renewable Energy AD Project
- Substrate Supply and Approach
- Site Overview and System Technologies
- Permitting Discussion
- Q&A Session
RNG ENERGY SOLUTIONS – WHO WE ARE

- RNG Energy and its members have 100+ combined years of experience successfully developing, financing and managing the construction of complex energy infrastructure projects.

- Our experience includes the development, operation, and asset management of natural gas Combustion Turbine and Combined Cycle projects, Anaerobic Digester (AD) projects, high Btu landfill gas projects, resource recovery and biomass projects.

- Former President of Homeland Renewables in Newtowne, PA, which developed and operated multiple large-scale anaerobic digester projects and biomass combustion facilities.

- Developer experience includes two of the largest landfill gas to pipeline quality gas projects in Pennsylvania including one that was awarded Project of the Year by the EPA Landfill Methane Outreach Program.

- RNG Energy, formerly AgEnergy USA, developed the Heartland Project, the largest AD Project in the world, with a total capital investment of $120 million. The project is currently owned by EDF Renewable Energy with RNG Energy retaining a 20% net profit interest in the project.
HEARTLAND BIOGAS PROJECT DESCRIPTION

- Heartland is an anaerobic digester project using dairy manure and organic waste substrate in a high ratio, complete mix, co-digestion system (960 and 800 TPD).

- Heartland uses Denver Metro region food waste and other commercial organic waste and dairy manure from Weld County.

- The Project includes 6 heated tanks (bio-reactors), Biogas Upgrading System, gas compression and pipeline interconnection to Colorado Interstate Gas Co. (CIG) pipeline.

- Heartland produces up to 4,700 dekatherms (Dt) per day pipeline quality Renewable Natural Gas (RNG) using the Greenlane biogas upgrading system.

- The finished Renewable Natural Gas (RNG) is compressed and then injected into the CIG pipeline for delivery to the Sacramento Municipal Utility District (SMUD) in California.

- The RNG is used to produce low-cost and base load renewable electricity in an existing SMUD-owned natural gas-fired combined cycle power plant.
HEARTLAND – BIOREACTORS AND SUBSTRATE TANKS
HEARTLAND BIOGAS - CONSTRUCTION PHASE
Heartland has installed a Tiger Unit to process a broad spectrum of waste products.

The Tiger Unit’s performance has been exceptional:
- 20 tons per hour of canned goods
- Packaged milk, eggs, bagged waste, SSO, any waste material packaged in plastic, paper or cans (no glass)

The Tiger Unit is reliable, quiet, and easy to operate.

The DPS allows the Heartland Project to receive a broader spectrum of waste material which has increased substrate supply (feed) volumes and augment gas production capacity.

The DPS also receives “de-fill” waste which is stored in a separate tank but provides low solids dilution capacity for the higher solids material processed through the Tiger Unit.

The Tiger de-packaging system produces an excellent quality substrate for pumping and use within the active bio-reactors.
DIGESTER PROCESSING SYSTEM (CONT.)
HEARTLAND BIOGAS, LLC- DIGESTER PROCESSING SYSTEM
DIGESTER PROCESSING SYSTEM (CONT.)
DIGESTED SOLIDS PRODUCTION

- The Heartland Project includes a Digested Solids Separation operation that has also been very successful, consisting of:
  - Two high-efficiency Centrysis Centrifuges
  - Outdoor stacking pad and windrow storage on 15 acres

- The Heartland Digested Solids Separation operation produces a very high quality replacement peat moss material which has obtained OMRI Certification as an organic product.

- The Digested Solids structural characteristics and chemical composition is perfect as a peat moss replacement material (pH adjustment may be required)

- The high efficiency volatile solids destruction rate of the thermophilic operating conditions results is no further composting of the material.

- The Centrysis Centrifuge produces a 65-68% moisture material (no free water)
DIGESTED SOLIDS PRODUCTION
PHILADELPHIA ENERGY SOLUTIONS (PES)

- PES processes approx. 335,000 barrels of crude oil per day, making it the largest oil refining complex on the eastern seaboard.

- Headquartered in Philadelphia, PES employs over 1,100 people.

- Currently contracts with Texas Eastern Transmission (TETco) for natural gas supply.
PRIMARY PBRE – PES COMMERCIAL ARRANGEMENTS

- Land Lease
- RNG Sales Agreement
- Master Utility Services Agreement
- Construction Services Agreement
PBRE SITE LOCATION

- Project located in the City of Philadelphia in an I-3 Heavy Industrial zoned parcel of the PES Refinery.

- The 22-Acre Site currently serves as a contractor parking lot and tanker truck staging area.

- Immediate access to Schuylkill Expressway and minutes from I-95 north/south transportation corridor.

- Former Atlantic Refinery tank farm and processing site proposed for repurposing.
SITE LOCATION IN NORTH PARCEL OF THE PES REFINERY ADJACENT TO I–76 AND I-95
PROJECT SITE LOCATION IN NORTH PARCEL
PBRE SITE WITHIN INDUSTRIAL (I – 3) PARCEL
VIEW OF SITE FROM MAIDEN LANE ENTRANCES
PBRE SUBSTRATE SUPPLY

❖ Demographics
  ▪ City of Philadelphia has a population of 1.5 million
  ▪ The greater Philadelphia region has a population of 6.5 million and is the 6th largest statistical region in the U.S.

❖ Waste Supply
  ▪ The broader Philadelphia and metro region has over 3.0 million tons per year of organic waste. This includes Bucks, Philadelphia, Delaware, Montgomery, and Chester counties in PA and Mercer, Burlington, and Camden in NJ.
  ▪ The waste region we are concentrating on includes eastern Pennsylvania, Northern Maryland, Southern and Central NJ and Delaware.
  ▪ Our strategy is to deploy multiple Digester Processing Systems (DPS) to recover organic material to the PBRE Project using the successful Tiger de-packaging system.
  ▪ High waste tipping fees combined with heavily concentrated food production provides viable waste resource recovery and greater collection efficiencies.

❖ Collection/Management Strategy
  ▪ RNG is in negotiations with numerous organic waste collection companies for high strength liquid organic wastes and Fats, Oils, and Grease (FOG).
  ▪ These companies have a customer base desperate for long-term and SUSTAINABLE organic waste disposal solutions.
FEEDSTOCK SOURCING REGION – 60 MILES
The preliminary basis of design for the PBRE facility is based upon up to 350,000 gpd or 1,400 tpd of liquid organic waste processed at the facility. A representative characterization of the waste stream volume is 320 tons per day of fats, oils and greases (FOG) and 1,080 tons per day of source separated organics (SSO). Actual waste stream inputs will vary daily, based upon sourcing, contracts, seasonality, etc.

For this project, PBRE will use advanced anaerobic digesters to convert organic waste into renewable natural gas (RNG) and a valuable soil amendment product that has very similar water retention and soil structure characteristics as peat moss.
ORGANIC WASTE “INPUT” TO THE FACILITY FROM PA DEP PRE-APPLICATION DISCUSSIONS

- Source separated food wastes from food markets, grocery stores, food distribution centers, food banks, schools and cafeterias, academic institutions etc. (residual waste code for food wastes is 430)
- Dewatered restaurant grease trap waste, Fats, Oils and Greases (FOG) from restaurants or grocery stores (residual waste code for grease is 474)
- Dissolved Air Flotation (DAF) waste from food processing operations
- Restaurant waste
- Corrugated paper and cardboard, cardboard trays, serving systems (residual waste code 404)
- Food processing residuals (residual waste code 205)
- Agricultural wastes such as feed and feed supplements (residual waste code 411)
- Breweries, wineries and distilleries (NAICS 312- Beverage and tobacco product manufacturing)
- Food manufacturing (NAICS Code 311) and Seafood Product preparation wastes
- Farm waste products (For Discussion with PA DEP SERO)
ORGANIC WASTE SUPPLY

- The facility will NOT accept wood chips, sawdust, pallets etc., laminated paper and paper pulp waste, or hazardous waste streams (the anaerobic digestion is a biological process).

- Waste streams received at the PBRE facility will only be from known and verifiable sources/generators. Liquid substrate (organic waste) can be received 24/7 but will typically be received at the facility between 5:00 am to 5:00 pm. Delivery will be by tanker trucks (approximately 6,000 to 6,500 gallons capacity).

- The tanker trucks will be weighed and directed to an enclosed unloading building and connected to offload pumps inside the building.

- The liquid substrate will be pumped directly to appropriate storage tanks onsite.
PROCESS FLOW OVERVIEW

TETCO Pipeline → Substrate Tank → Primary and Secondary Digesters → Centrifuge → Solids to Sales → Membrane Bioreactor WWTP → Equalization Tank

Girard Point Fuel Gas System

Gas Handling Plant

Point Breeze WWTP or PWD

M

Compressor

PBRE Flare

M
PBRE DEVELOPMENT PHASE PERMITS AND AUTHORIZATIONS

Federal Permits
- FAA - Notice of Proposed Construction or Alternation - Determination of No Hazard
- USACE Wetlands Presence Jurisdictional Determination (if required)
- USACE Section 404 Permit - PASTGP-5 - Wetland Coordination (if required)
- USACE Nationwide Permit No. 7 PCN (if required) for stormwater outfall
- Rare, Threatened and Endangered Species Consultations (USFWS and NOAA NMFS)

Commonwealth of PA Permits
- Pennsylvania Department of Transportation, Bureau of Aviation (BOA)
- PaDEP Waste Management Permitting – Resource Recovery Facility
- PaDEP Chapter 92/102 Permits - NPDES Stormwater Discharges Associated With Construction - Soil Erosion and Sediment Control Approval
- PaDEP Chapter 105 Permit (if required) for wetlands delineation – PA Bureau of Dams, Waterways and Wetlands
- PaDEP Submerged Lands License (if required)
- PaDEP NPDES Industrial Discharge (PES Modification Confirmation)
- Pennsylvania Coastal Zone Management – Consistency Review
- Pennsylvania Rare, Threatened, and Endangered Species Consultation (Pennsylvania Game Commission, Pennsylvania Fish and Boat Commission, Pennsylvania Department of Conservation and Natural Resources)
- Cultural Resources Consultation - Pennsylvania Historical and Museum Commission (PHMC or SHPO)

City of Philadelphia Permits
- Philadelphia Air Management Services (AMS) air permit
- City of Philadelphia Water Department Act 537 Sewage Planning Module, Base Monitoring Report (BMR)
- City of Philadelphia Water Dept. Stormwater
- City of Philadelphia Licensing & Inspection (L&I) - Zoning/Land Use Regulation Plan
- City of Philadelphia Site Plan/Stormwater Report - City Planning & PWD
- City of Philadelphia Streets Department - Right-of-Way Unit (ROW) and Traffic Engineering Unit (TEU)
CITY OF PHILADELPHIA PERMITTING

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E-BENEFITS FROM BIOMETHANE (RNG) PRODUCTION

- Use of organic waste by PBRE reduces methane emissions from landfills.
- Use of RNG displaces fossil fuel used for transportation. PBRE’s RNG can be used by SEPTA buses
- PBRE produced Digested Solids (peat moss) displaces fossil fuel used to transport Peat Moss from Canada
- GHG offsets per US EPA GHG calculator:
  - 159 metric tonnes per day
  - 55,154 metric tonnes annually
# CARBON REDUCTION PROFILE: GHG AND CO2E REDUCTION FROM BIOMETHANE (RNG) PRODUCTION

<table>
<thead>
<tr>
<th></th>
<th>30,000 therms per day</th>
<th>10,402,500 therms/yr.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHG emissions Carbon Dioxide Equivalent</td>
<td>159 metric tonnes</td>
<td>55,154 metric tonnes</td>
</tr>
<tr>
<td>Miles driven by an average passenger vehicle (GHG basis)</td>
<td>389,853</td>
<td>135,181,507</td>
</tr>
<tr>
<td>Gallons of gasoline consumed (CO2 basis)</td>
<td>17,898</td>
<td>6,206,150</td>
</tr>
<tr>
<td>Barrels of oil consumed (CO2 basis)</td>
<td>368</td>
<td>127,693</td>
</tr>
<tr>
<td>Homes’ energy use for one year (CO2 basis)</td>
<td>17.2</td>
<td>5,956</td>
</tr>
</tbody>
</table>

* Notes: 3000 DTh/d rated RNG output = 30,000 Th/d = 10,402,500 Th/yr. (95% capacity)  
Source: [https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator](https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator)
PROJECT BENEFITS

- Provides an economical regional solution for sustainable organic waste management
- Provides the City of Philadelphia with installed capacity to meet its long-term waste reduction and alternative energy goals, including green gas fuel supply to the regional bus and trucking fleet
- Provides 450 direct and indirect construction jobs over a two-year period with a regional impact of $45M in labor during construction
- Provides 20 direct operations phase jobs with 40 indirect jobs associated with organics (food waste and residuals) hauling to the site.
- Creates an organic soil amendment that is high in demand and a natural by-product of the AD process
- One of the Largest Carbon Reduction Projects in Pennsylvania
RNG Energy Solutions, LLC

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WHAT IS ANAEROBIC DIGESTION?

What is anaerobic digestion?

Anaerobic Digestion (AD) is the natural breakdown of organic matter to produce biogas – a mixture primarily composed of carbon dioxide, methane and water vapour. The biogas produced can be used to make electricity, heat, gas and fuel. A co-product of anaerobic digestion is a valuable biofertiliser, referred to as digestate, which is the remaining solid and liquid organic matter – a stable, nutrient-rich substance which can help restore organic matter and nutrients in soil. AD can utilise a variety of feedstocks, one of which is food waste, with others being agricultural residues, manures, sludges and energy crops. Only through separately collecting food waste for AD can the full energy benefits be realised and the quality of the resulting digestate product be assured.

FOOD WASTE PROCESSING – OPPORTUNITIES FOR MITIGATING CLIMATE CHANGE AND PROMOTING SUSTAINABLE GROWTH

<table>
<thead>
<tr>
<th>TECHNOLOGY</th>
<th>SUPPORTS FOOD WASTE REDUCTION</th>
<th>COST SCALE 1-5 (LOW-TO-HIGH)</th>
<th>ENERGY PRODUCTION</th>
<th>NUTRIENT RECOVERY</th>
<th>CAN BUILD SOIL ORGANIC MATTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaerobic digestion</td>
<td>✓</td>
<td>4</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>In-vessel composting</td>
<td>✓</td>
<td>3</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Windrow composting</td>
<td>✓</td>
<td>2</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Liquefaction</td>
<td>✓</td>
<td>Dependent on context</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Rendering</td>
<td>✓</td>
<td>Dependent on context</td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

FOOD WASTE SEPARATELY COLLECTED

<table>
<thead>
<tr>
<th>TECHNOLOGY</th>
<th>SUPPORTS FOOD WASTE REDUCTION</th>
<th>COST SCALE 1-5 (LOW-TO-HIGH)</th>
<th>ENERGY PRODUCTION</th>
<th>NUTRIENT RECOVERY</th>
<th>CAN BUILD SOIL ORGANIC MATTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasification</td>
<td>x</td>
<td>5</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Incineration and energy recovery</td>
<td>x</td>
<td>4</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Landfill without gas extraction</td>
<td>x</td>
<td>1</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>LFG extraction</td>
<td>x</td>
<td>2</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>MBT</td>
<td>x</td>
<td>2</td>
<td>✓(with AD)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Pyrolysis</td>
<td>x</td>
<td>5</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Source: GLOBAL FOOD WASTE MANAGEMENT: AN IMPLEMENTATION GUIDE FOR CITIES – World Biogas Association 2018
WHAT CAN AD DELIVER FOR YOUR CITY?

- Production of renewable energy - electricity, heat or transport fuel
- Provision of low carbon fertilizer
- Organic matter to help build soils
- Off-grid, localized energy production
- Enhanced energy security from domestic sources
- Substitution of fossil-fuel energy
- Generation of heat from co-generating units within biogas plants (green power)
- Production of baseload energy
- Climate change mitigation
- Improvement in urban air quality
- Contribution towards a circular economy
- Contribution towards food security
- Solid waste management improving health and sanitation
- Protection of water bodies
- Provide employment

Source: GLOBAL FOOD WASTE MANAGEMENT: AN IMPLEMENTATION GUIDE FOR CITIES – World Biogas Association 2018
THE MAIN DRIVERS AND SOURCES OF WASTE

- **Manufacturing:**
  - Over-production resulting from pressure to meet contractual requirements,
  - Appearance quality standard for produce,
  - Damaged products,
  - Cheap disposal alternatives,
  - Inedible parts of produce.

- **Wholesale and retail:**
  - Temperature changes leading to spoilage,
  - Aesthetic standards expected by the consumers and retailers,
  - Packaging defects making produce not fit for sale,
  - Over supply due to consumer choices,
  - Overstocking due to poor planning and excess surplus.

- **Food services:**
  - Lack of flexibility in portion sizes,
  - Insufficient planning in forecasting and ordering ingredients,
  - Consumer attitudes towards taking leftovers home,
  - Refused food due not meeting customer preferences.

- **Households:**
  - Buying too much due to poor planning,
  - Bad storage resulting from lack of awareness,
  - Confusion over freshness and safety labels,
  - Discarding edible parts of produce like bread crusts or apple peals,
  - Discarding leftovers,
  - Large portion sizes.

Source: GLOBAL FOOD WASTE MANAGEMENT: AN IMPLEMENTATION GUIDE FOR CITIES – World Biogas Association 2018
BENEFITS OF BIOGAS FOR RENEWABLE ENERGY PRODUCTION

- Production of baseload energy for sustained energy use;
- Production of energy that can be stored and used to meet peak load demand;
- Generation of electricity for on-site, local or injection into the electricity grid;
- Off-grid, localized energy production;
- Enhanced energy security from domestic sources;
- Reduced dependence on fossil-fuel energy;
- Generation of heat from CHP units within biogas plants;
- Generation of biomethane for vehicle fuel;
- Generation of biomethane for onsite, local or injection into the natural gas distribution network.
- Generation of energy in combination with other forms of power generation (e.g. together with wind and solar power)

Source: GLOBAL FOOD WASTE MANAGEMENT: AN IMPLEMENTATION GUIDE FOR CITIES – World Biogas Association 2018
ROLE OF BIOGAS IN CLIMATE CHANGE MITIGATION

- Reduced greenhouse gas emissions and particulate emissions by substituting fossil fuels such as coal and oil as energy supplies to buildings, homes and industry.
- Reduced greenhouse gas emissions from vehicles by substitution of diesel and gasoline with biomethane as fuel.
- Reduction of uncontrolled methane emissions in dumps and landfills and generation of renewable energy from untreated food and other organic wastes.
- Capture of biogas from landfills avoiding methane emissions. Substitution of synthetic and mineral fertilizers with digestate bio-fertilizer.
- Reduction of deforestation by replacing solid-biomass-based domestic fuels with biogas.
- Using digestate to restore the carbon storage and sequestration capacity of soils.

Source: GLOBAL FOOD WASTE MANAGEMENT: AN IMPLEMENTATION GUIDE FOR CITIES – World Biogas Association 2018
BIOGAS BENEFITS

❖ CONTRIBUTING TOWARDS A CIRCULAR ECONOMY
  ▪ Improving the self-sufficiency and sustainability of industries by extracting the energy from their own effluents and using it for the self-generation of electricity and/or heat;
  ▪ Recirculating nutrients and organic matter in organic wastes through AD and returning them to the soil in the form of digestate bio-fertilizer.

❖ IMPROVING URBAN AIR QUALITY
  ▪ Substituting biomethane for fossil fuel in vehicles;
  ▪ Substituting biogas for solid fuel for domestic cooking and heating.
  ▪ Avoiding the uncontrolled release of methane from landfills, which then acts as an ozone precursor in the atmosphere, deteriorating air quality

❖ CONTRIBUTING TOWARDS FOOD SECURITY:
  ▪ Restoring soils through the recycling of nutrients, organic matter and carbon;
  ▪ Increasing crop yields through use of nutrient-rich digestate bio-fertilizer; and Recirculating phosphorus, which is essential for the growth of plants.

Source: GLOBAL FOOD WASTE MANAGEMENT: AN IMPLEMENTATION GUIDE FOR CITIES – World Biogas Association 2018
IMPROVING HEALTH AND SANITATION THROUGH BETTER SOLID WASTE MANAGEMENT

- Treating and recycling organic wastes to reduce odors and the spread of diseases from uncontrolled dumping;
- Preventing spread of diseases through collection and proper management of organic waste;
- Improving sanitation and hygiene through decentralized and local treatment of organic and sewage waste;
- Protecting water bodies
- Reducing the carbon load of wastewater to reduce impact on water bodies.

Source: GLOBAL FOOD WASTE MANAGEMENT: AN IMPLEMENTATION GUIDE FOR CITIES – World Biogas Association 2018
ECONOMIC DEVELOPMENT AND JOB CREATION

- Generating short-term construction employment and long-term equipment manufacturing and maintenance employment, as well as plant operations employment.
- Encouraging growth of new enterprises by providing reliable electricity that can be stored and used when needed (i.e., baseload energy).
- Generating employment in the waste sector by collecting food and other biogenic wastes separately and through sales of digestate.
- Improving quality of life in marginal farming communities and reducing migration from these by improving crop yields and sanitation, lighting and heating.

Source: GLOBAL FOOD WASTE MANAGEMENT: AN IMPLEMENTATION GUIDE FOR CITIES – World Biogas Association 2018
POTENTIAL BIOGAS YIELDS

https://www.renewableenergyworld.com/articles/2012/04/biogas-technology-cow-power-catching-on-in-us.html
GREENHOUSE GAS EMISSIONS REDUCTION BY ALTERNATIVE USES OF FOOD WASTE BASED BIOGAS

<table>
<thead>
<tr>
<th>Food waste feedstock source</th>
<th>Biogas produced (m³/wet tonne)</th>
<th>GHG emissions reduction if used in transport (kg CO₂e)</th>
<th>GHG emissions reduction if used in electricity (kg CO₂e)</th>
<th>GHG emissions reduction if used for heat (kg CO₂e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potatoes (18%-20% TS)</td>
<td>100-120</td>
<td>1,946</td>
<td>1,899</td>
<td>1,976</td>
</tr>
<tr>
<td>Bread</td>
<td>400-500</td>
<td>2,506</td>
<td>2,315</td>
<td>2,631</td>
</tr>
<tr>
<td>Cheese</td>
<td>&gt;600</td>
<td>2,753</td>
<td>2,499</td>
<td>2,920</td>
</tr>
<tr>
<td>Vegetables</td>
<td>50-80</td>
<td>1,872</td>
<td>1,844</td>
<td>1,890</td>
</tr>
<tr>
<td>Mixed food (e.g. supermarket, restaurant)</td>
<td>75-140</td>
<td>1,942</td>
<td>1,896</td>
<td>1,972</td>
</tr>
<tr>
<td>Molasses (80-90% TS)</td>
<td>450-579</td>
<td>2,612</td>
<td>2,394</td>
<td>2,756</td>
</tr>
<tr>
<td>Brewery waste (20% TS)</td>
<td>60-100</td>
<td>1,896</td>
<td>1,862</td>
<td>1,919</td>
</tr>
<tr>
<td>Abbatoir waste</td>
<td>120-160</td>
<td>1,995</td>
<td>1,936</td>
<td>2,034</td>
</tr>
</tbody>
</table>

*Assumed the food waste would have gone to an open landfill instead with no landfill gas recovery; when used for transport, diesel vehicles are used as a comparator; when used for electricity, the global electricity mix is used as a comparator; when used for heating, the EU fossil heat average is used as a comparator.

COMPARATIVE GHG EMISSIONS FROM PASSENGER CARS RUNNING ON DIFFERENT FUELS

Sources: Dahl (2015); Hoornweg (2012); FNR (2016); Official Journal of the European Union (2009)
http://www.irena.org/media/Files/IRENA/Agency/Publication/2017/Mar/IRENA_Biogas_for_Road_Vehicles_2017.pdf?la=en&hash=9261CA2381C7847A515E230D03C9487AE4392B88