



A Green Gas Alliance Company
Biogas, RNG, and Biofuels

Release 2024-10

COMPANY PROFILE

Green Gas Inc. is a pioneering biogas and renewable natural gas solutions provider in North America established in 2020 by industry experts and veterans. We specialize in the production, distribution, and utilization services for sustainable energy derived from organic waste. Our mission is to reduce greenhouse gas emissions and foster a cleaner, greener future.

At Green Gas Inc., we utilize a diverse range of organic wastes, including dairy manure, food wastes, wastewater treatment sludge, source separated organics, and industrial process wastes. Through advanced hydrolysis and anaerobic digestion technologies, we convert these waste streams into high-quality biogas and renewable natural gas. We offer a comprehensive suite of services, covering the entire value chain from feedstock to wheels and feedstock to pipelines. We take pride in being a one-stop solution provider, ensuring a seamless transition to renewable energy for our customers, buyers, and partners. Our biogas and renewable natural gas solutions deliver numerous benefits beyond reduced carbon emissions. By effectively utilizing organic waste, we minimize landfill waste, reduce methane emissions, and improve air quality. Furthermore, our solutions contribute to the circular economy by promoting waste reduction and resource recovery.

Through our expertise in project development, we undertake notable projects and establish strategic partnerships across North America. These collaborations enable us to demonstrate our leadership in the biogas and renewable natural gas industry, driving innovation and paving the way for a more sustainable energy future. We are committed to community engagement and stakeholder collaboration, ensuring transparency and fostering long-lasting relationships. By actively involving local communities, industry leaders, and government agencies, we strive to create meaningful change and promote the adoption of renewable energy solutions.

At Green Gas Inc., we place a strong emphasis on research and development to continually improve our biogas and renewable natural gas delivery processes for our trusted customers, buyers, partners, and investors. Our team of experts bring together diverse backgrounds and qualifications, enabling us to push the boundaries of innovation and unlock the full potential of organic waste as a renewable energy resource.

COMPANY EXPERIENCE

The promoters of Green Gas Inc. possess extensive decades-long expertise in the development of Power Generation, Biogas, and Renewable Natural Gas (RNG) Assets across the United States and Canada. Their notable accomplishments include some of the initial dairy biogas and RNG projects and renewable CNG stations in the US. Drawing upon this extensive and finely-honed knowledge, Green Gas Inc. leverages its unique proficiency to guide every facet of project development, spanning from feedstock to wheels and feedstock to pipelines.



This comprehensive solution serves as a single point of access throughout the project's lifecycle, encompassing everything from inception to operational commencement for both M&A and Greenfield assets. It encompasses a wide array of facets such as initial project screening, technology assessment, cost projections for both capital and operational expenses, meticulous asset due-diligence, feedstock management, execution oversight, performance evaluation, interconnections, gas marketing, and carbon credits management.

What We Do

Developer Services

- Feedstock Analysis
- Technology Solutions
- Heat and Mass Balance
- Capex, Opex, Proformas
- CI Score Modeling
- Agreements and Contracts
- Permit Applications
- Funding Support
- Carbon Credit Applications
- Gas and Electric Interconnections
- Virtual Pipeline Infrastructure

Lender Services

- Scoping Audits
- Lender Due-Diligence
- Onsite Assessment
- Proforma Analysis
- Independent Estimates
- 5Y and 10y Capital Plans
- Operating Budgets
- Performance Analysis
- MIPA, Purchase Agreements
- Transaction Support
- Independent Reports

Engineering Services

- Pre-Feasibility Studies
- Feasibility Studies
- Design Basis
- Heat and Mass Balance
- Technology RFP's
- Technology Evaluation
- Technology Selection
- Detailed Engineering
- EPC RFP Package
- Field Engineering
- Safe Operating Procedures

What We Do

Owner's Engineering

- Engineering RFP's
- Engineering Oversight
- Progress Certifications
- Engineering Review and Approval
- Value Engineering
- Contract Administration
- Vendor Management
- Preconstruction Planning
- Construction Support
- Inspection and Punch Lists
- Completion Certification

Independent Engineering

- Technology Assessments
- Contracts and Agreements Review
- Feasibility Assessment
- Engineering Design Review
- Fatal Flaw Analysis
- Schedule and Budget Analysis
- Monte Carlo Simulations
- Interconnections Review
- Sensitivity Analysis
- Performance Measurements
- Progress Certification

Project Management

- Project Execution Plans
- FEL Road Maps
- Schedules and Cost Reports
- Project Controls
- Document Control
- Risk Management
- Change Management
- Procedures and Guidelines
- PMO Support
- Project Audits
- Progress Reports

What We Do

Feedstocks we work with

- Dairy Manure
- Swine Manure
- Food Waste
- Inedible Renderings
- WWTP Sludge
- Fats, Oils, Grease
- Ag Byproducts
- Brewery Spent Grains
- Institutional, Commercial and Industrial (IC&I)
- Source Separated Organics (SSO)

What We Do

Upstream Biogas Solutions

- Thermal Hydrolysis
- Covered Lagoons
- Dry Digesters
- Complete-Mix Tanks
- Plug-Flow Digesters
- Fixed Film Digesters
- Induced Blanket Digesters

Biogas Upgrading Solutions

- Membrane Separation
- Pressure Swing Adsorption (PSA)
- Biological Scrubbing
- Amine Scrubbing
- Organic Physical Scrubbing
- Water Scrubbing
- Cryogenic Separation

PROJECT DEVELOPMENT MODEL

The Project Development model offers a comprehensive and integrated solution designed specifically for Biogas, Renewable Natural Gas (RNG), and Biofuels projects. Aligned seamlessly with the Front-End Loading (FEL) methodology, it covers the entire spectrum from the initial conceptual study (FEL1) to the execution phase (FEL4).

By integrating the essential FEL principles, the model ensures a strategic, well-informed, and collaborative approach to asset development, guiding projects smoothly through diverse phases. This innovative approach transforms the development process, providing businesses with the necessary tools and expertise to navigate asset development intricacies, including permitting, proforma refinement, various agreements and contracting requirements, and project execution.



This innovative approach transforms the development process, providing businesses with the necessary tools and expertise to navigate asset development intricacies, including permitting, proforma refinement, various agreements and contracting requirements, and project execution.

PROJECT DEVELOPMENT MODEL

The FEL process typically starts with a brief due diligence task to assess the status of the project, whether it is a greenfield or acquisition. This is followed by the creation of a detailed project development and execution plan and roadmap. These could entail an onsite assessment and review of current project documentation and data room, followed by an initial customized project execution plan.



PROJECTS

The projects that we work with are at the forefront of innovation, tirelessly aimed at developing the most carbon efficient fuels for the market. Employing a variety of cutting-edge technologies, such as Anaerobic Digestion, Renewable Natural Gas (RNG), Biogas-to-Power Generation, Ethanol production, Biogas-to-Thermal Energy for Boilers and District Energy applications, Biomass Power Generation, and Digestate Biosolids and Fertilizers, we specialize in pioneering initiatives that harness organic waste to generate renewable energy and valuable by-products.

With low Carbon Intensity Scores, they provide access to EPA RIN Credits, CARB LCFS Credits, Tax Credits, and other Voluntary RNG Programs, in addition to Gas Sales, offering both environmental benefits and economic returns to our clients, investors, and communities alike.

Whether it is transforming organic waste into beneficial energy, producing renewable natural gas and ethanol for transportation, or creating biosolids and fertilizers from digestates, we leverage innovative technologies and best practices to optimize efficiency and create significant value and positive impacts.

ANAEROBIC DIGESTER TO RNG PROJECTS

The Anaerobic Digester to Renewable Natural Gas (RNG) projects make use of a variety of organic feedstocks, including dairy manure, food waste, source-separated organics (SSO), institutional, commercial, and industrial (IC&I) waste, yard waste, agricultural waste, vegetable biomass, and fats, oils, and grease (FOG), among others. The total solids content of the feedstocks we utilize ranges from 5% to 15%. For feedstocks with higher total solids contents, up to 35%, we implement additional feedstock processing, sand and grit removal, hydrolysis, and alternate digester technologies. Pre-digester separation technologies are also deployed to manage feedstocks with lower total solid contents while minimizing volatile solids losses on a case-by-case basis. Typically, the hydraulic retention times for standard heated mesophilic digesters range from 21 to 25 days, while for higher temperature



thermophilic digesters, they are around 12 to 14 days. The biogas yields from these anaerobic digesters vary depending on the organic content of the feedstock, such as carbohydrates, proteins, lipids, vegetable oils, and lactose, ranging from 3 cubic feet of biogas per pound of feedstock to 12 cubic feet per pound of feedstock.

ANAEROBIC DIGESTERS TO RNG PROJECTS

The raw biogas usually contains approximately 50%-70% methane prior to further processing and conditioning to around 99% methane to meet the pipeline quality RNG specifications for injection into the natural gas transmission or distribution system. To meet RNG specifications, we employ various technologies for processing and conditioning biogas, including hydrogen sulfide (H₂S) scrubbing, pretreatment and dehydration, volatile organic compound (VOC) and contaminants removal, and carbon dioxide (CO₂) removal or recovery, as well as methane (CH₄) upgrading systems.



Additionally, these projects utilize spent digestate from anaerobic digesters to produce Class A or B biosolids and fertilizers with optimal nitrogen, phosphorus (P₂O₅), potassium (K₂O), sulfur, carbon, and carbon to nitrogen (C:N) ratio. The sale of fertilizers creates additional value streams alongside valuable RNG sales.

LAGOON DIGESTERS TO RNG PROJECTS

The Lagoon Digester to Renewable Natural Gas projects are specifically tailored for low total solids, typically ranging from 1% to 2%. These projects make use of either an existing lagoon equipped with liner and a cover or a newly constructed lagoon suitable for dairy manure from sand lanes, pull-plug swine manure, and wastewater with substantial organic loading rates, such as rendering wastes from a food process or municipal wastewater, with typical COD/VS Ratios of 1.5 to 1.7.



Retention times generally exceed 35 days, contingent upon ambient temperature conditions. Biogas yields typically range between 20% to 40% lower than the heated anaerobic digesters on an annual basis, varying depending on geographic location and seasonal ambient temperature fluctuations through the year. Provisions are in place to deploy feedstock heating systems during colder months, which can boost biogas yields by 20% to 30%.

The raw biogas composition and the technologies utilized for processing and conditioning biogas to RNG mirror those employed in Anaerobic Digester to RNG projects.

LANDFILL GAS TO RNG PROJECTS

These projects extract landfill gas under a high vacuum, typically ranging from -40" w.c. to -80" w.c., to the gas collection system. The gas is collected from multiple above-ground or below-ground wells through horizontal trenches. New landfills implement a gas collection and flare system that includes dehydration equipment, centrifugal blowers, and enclosed flares. The configuration of landfill gas tie-ins varies, typically involving either a Ring Header design, Herringbone design, or a combination of both, achieving around 75% gas recovery. The technologies used for converting landfill gas to renewable natural gas (RNG) are



tailored to the specific composition of the raw gas and its key components, such as Nitrogen (N_2), Siloxanes (SiO), Oxygen (O_2), Volatile Organic Compounds (VOCs), and Hydrogen Sulfide (H_2S). Common processing systems include solid media vessels for H_2S removal, compression systems, activated carbon vessels, or temperature swing adsorption (TSA) systems for VOC and Siloxane removal.

For removal of carbon dioxide and nitrogen, various systems are employed such as vacuum pressure swing adsorption (VPSA) vessels or VPSA with membrane separation system, water wash systems, amine scrubbing, and organic solvent scrubbing. Additionally, a thermal oxidizer and/or an enclosed flare is typically required to manage tail gas exhaust and any product gas that fails to meet sales gas specifications.

WASTEWATER DIGESTERS TO RNG PROJECTS

The Wastewater to Renewable Natural Gas projects are commonly situated alongside municipal wastewater treatment plants. These initiatives make use of primary sludge and waste activated sludge (WAS) as feedstock, sourced from various points such as the primary clarifier, secondary clarifiers, or Dissolved Air Flotation (DAF) system.

The Anaerobic Digester technology for these applications are in a continuous 2-Phase/2-Stage Process, incorporating Gravity Belt and Rotary Drum Thickeners for WAS thickening, alongside 2-Stage Anaerobic Digester Tanks with Recirculation Pumps and Heat Exchangers to ensure the production of high-quality biogas. Given the diverse sludge handling methods and process designs at municipal wastewater treatment plants, we customize technology deployment to suit the unique characteristics of incoming sludge materials on a case-by-case basis.

Retention times for these projects typically align with the standard anaerobic digester projects, resulting in biogas compositions with approximately 65% to 70% Methane (CH₄) and 30% to 35% Carbon Dioxide (CO₂).



The biogas yields from these anaerobic digesters utilizing primary sludge and WAS typically average around 5 cubic feet of biogas per pound of sludge.

The technologies deployed for these projects are akin to biogas processing and conditioning technologies used for other organic feedstocks, albeit with some degree of variability in biogas quality. The spent digestate from these projects exhibit a high degree of sludge stabilization, with smaller amounts of lighter scum solids and supernatant liquids.

BIOGAS TO POWER PROJECTS

The Biogas to Power projects utilize a range of organic feedstocks similar to the RNG projects, including dairy manure, food waste, source-separated organics (SSO), Industrial, commercial, and institutional (IC&I) waste, yard waste, agricultural waste, vegetable biomass, and fats, oils, and grease (FOG).

The biogas yields from anaerobic digesters or lagoon digesters for these projects are comparable to the anaerobic digester to RNG projects, containing 50% to 70% methane or approximately 500 to 700 Btu/scf heating value. To meet fuel quality requirements from reciprocating engine generator manufacturers, we condition the raw biogas through customized biogas conditioning equipment, desulfurizing and dehydrating it. These Biogas to Power projects employ high efficiency reciprocating engines, typically ranging from 250 kW to 4,500 kW capacities, in single or multiple parallel configurations. These engines boast electric efficiencies between 38% to 42% and overall efficiencies exceeding 85%, or 4,015 Btu/kWh heat rate, by utilizing waste heat for digester heating or space heating purposes.



The sizing of the power generation island is determined by various factors, including biogas generation potential, coincidental power and thermal demand, and grid economics.

These Biogas to Power projects are typically sized to meet or exceed PURPA efficiency for FERC Qualifying Facility certification, with NO_x emissions of 0.6 g/bhp.hr and lower.

BIOGAS TO INDUSTRIAL BOILER PROJECTS

The Biogas to Industrial Boiler projects utilize similar organic feedstocks as Biogas to Power projects, yielding comparable biogas quantities and heating values from anaerobic digesters or lagoon digesters.

The technology for conditioning the biogas are typically determined by the fuel quality and wobble index requirement set by industrial boiler manufacturers. These projects span a range of boiler sizes, from 200 BHP (6,900 lb/hr) to 800 BHP (27,600 lb/hr), operating either in multiple lead-lag configurations or with pressure trim achieving efficiencies between 80% to 85%. Biogas conditioning equipment typically includes bulk H₂S removal systems, chillers, and dehydration equipment to process the biogas, ensuring it meets or exceeds the fuel specifications required by the boiler manufacturer.



BIOGAS TO DISTRICT ENERGY PROJECTS

In areas where distances and proximities are advantageous, the Biogas to District Energy Projects are strategically situated near communities with residential, institutional, and commercial space heating demands. Similar to Biogas to Power and Biogas to Industrial Boiler projects, these initiatives utilize comparable organic feedstocks and technology, yielding similar biogas quantities and heating values from anaerobic digesters or lagoon digesters.



From these projects, biogas is supplied to either Central District Energy Boilers Power Generation Equipment , which in turn provide thermal energy in the form of hot water and chilled water to customer locations for heating and cooling purposes via insulated underground pipes. Chilled water is generated using Lithium Bromide Single Stage Absorption Chillers with a high coefficient of performance (COP) of approximately 0.60.

BIOGAS TO DISTRICT ENERGY PROJECTS



The overall efficiencies for Biogas to District Energy range from 85% using central boilers for heating and above 90% using waste heat from power generation equipment for heating and cooling.

BIOGAS TO HYDROGEN PROJECTS



The Biogas to Hydrogen projects closely resemble Anaerobic Digester to RNG projects with additional Hydrogen production equipment. These projects utilize RNG with low Carbon Intensity Scores as the primary feedstock to produce hydrogen.

The additional technology deployed for these projects include a Steam Methane Reformer (SMR) utilizing high-pressure and high-temperature steam, a Water-Gas Reactor, Waste Heat Recovery Generator, and Pressure Swing Adsorption (PSA) Vessels to purify hydrogen to 99.99% purity and above. The reforming conversion ratio from methane to hydrogen typically ranges around 1:2 or 2 cubic feet of hydrogen per cubic feet of methane.

ETHANOL PROJECTS

The primary feedstocks for these Ethanol projects consist of corn and grain (sorghum), yielding an average of around 80 gallons per ton, which is comparable to other feedstocks such as barley, molasses, and wheat.

These Ethanol projects typically involve Greenfield developments and employ the latest technologies for various systems including feedstock preparation, wet milling, mash cooker plant, liquefaction, batch and continuous fermentation system, fractional distillation plant, molecular sieve system, and tank farm. In addition to producing Ethanol as fuel blend for the market, these projects also generate Distillers Grains, which are commonly sold as feed for cattle and poultry industry.



In contrast to Biogas and Renewable Natural Gas projects, these Ethanol projects offer a higher potential for economically recovering Carbon Dioxide (CO₂) and converting it into Dry Ice with a Food Grade purity of 99.99%. Typically, the CO₂ by-product from the fermentation process averages around 0.5 pounds of CO₂ per pound of fermented sugar.

Green Gas Inc.

300, 85 Shawville Blvd SE

Calgary, AB T2Y 3W0

800-714-2955

inquiries@greengasinc.com

www.greengasinc.com

