# NATURAL GAS: BIOGAS & RNG

**INDUSTRY OVERVIEW SEGMENTS**

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# Overview

## INDUSTRY OVERVIEW

The biogas and renewable natural gas (RNG) industry is seeing renewed interest driven by the demand for clean, reliable energy and its ability to support the crucial agricultural sector in the US. This interest has been spurred by recent technological advancements, business models, and policy support, opening new opportunities for Biogas & RNG production. In 2023, the biogas RNG industry produced about 40 British Cubic Meter equivalent or bcme of natural gas equivalent and 10 bcme of RNG, consisting of about 3% of the global bioenergy production and 1% of natural gas demand. (1) This growth has been driven by the desire for energy security, decarbonization goals, and as a tool to support the crucial agricultural sector.

## BIOGAS & RNG ARE A NON-PARTISAN ISSUE

The biogas industry received a great deal of support from the Biden administration through the Inflation Reduction Act (IRA). This support was from boosting the Production Tax Credit (PTC) and providing access to the Investment Tax Credit (ITC) to biogas projects, along with the Clean Fuel Production (CFP) tax credits accessible to RNG projects. Republicans amended the IRA through the Big Beautiful Bill, maintaining many provisions that will continue to support the biogas industry. These provisions include maintaining the CFP tax credits until 2032, the production tax credit until 2031, and clarifying the provisions around the hydrogen production tax credit use for biogas projects, providing investor confidence for the emerging industry.

## INNOVATION IN THE SPACE

While the core technology of anaerobic digestion is mature, we are seeing a series of innovations that are creating greater efficiencies and opportunities in the sector. The use of better sensors and data collection is creating new analytics methods to both enhance biogas yields and to preempt potential issues that could halt production. Other methods include better pre-treatment solutions or multistage anaerobic digestion processes that can create far higher biogas yields. There has also been a new emphasis on creating co-products and co-benefits through the anaerobic digestion process that can create new revenue streams or reduce operational expenses. New business models, especially in the agricultural sector, have emerged due to these innovations that could open greater growth opportunities, helping to move the agricultural sector into the 21st century.

# What is Biogas & RNG?

Biogas is a gas consisting mainly of methane and carbon dioxide, along with other trace gases such as water or sulfur oxides. The component of biogas which produces energy is methane or natural gas. The methane content of the biogas can range from 45% to 75% of the gas. (2) There are three mainstream methods to produce biogas.

**Biodigesters** – Systems that take in organic waste such as manure, food waste, or herbaceous feedstocks and break these feedstocks down using natural microbes in no oxygen or otherwise known as an anaerobic environment. These are most commonly found on farms and wastewater treatment plants but can also be designed as food waste only systems.

**Landfill Gas Recovery Systems** – Systems that rely on capturing biogas produced from the municipal solid waste decomposing in anaerobic conditions.

**Wastewater Treatment Systems** – These systems take advantage of the high amount of organic compounds in wastewater to produce biogas either through more traditional biodigesters that have long processing times or more fast-paced digestion methods that filter out these organic compounds from the wastewater to go through the anaerobic digestion process. (1)

## HOW IS RNG PRODUCED?

To upgrade biogas to RNG, you need to filter out the impurities such as carbon dioxide, sulfur, and water until your product has similar contents to pipeline-ready natural gas. Usually, RNG once fully upgraded to be pipeline ready is 96 to 98% methane. (2) This concentration is achieved through a few different ways, including water scrubbing, membrane separation, or pressure swing adsorption.

# Market Size and Growth

## CURRENT US CAPACITY

Currently, there are about 2500 biogas sites within the US. These sites consist of 609 farm anaerobic digesters, 1,180 wastewater treatment facilities, 583 landfill Gas Recovery systems, and 113 food waste only facilities. (3)

## US MARKET SIZE

Currently, the US Biogas Industry's value is estimated at $6.08 billion in 2023 and is projected to grow by a Compounded Annual Growth Rate or CAGR of 2.7% in the coming years, reaching $7.34 billion in 2030. (4) The US RNG industry's current value is estimated at $1.76 billion in 2024 and is expected to grow by a CAGR of 13.7 % to $3.79 billion by 2030. (5)

## POTENTIAL US GROWTH

The American Biogas Council a biogas trade organization, has assessed that there are 17,000 sites with favorable conditions to host a biogas or RNG site. This breaks down to 11,200 dairy, poultry, and swine farms; 3,750 wastewater treatment plants; 730 landfills; and 1,370 food-waste-only systems.(3) The US Energy Information Administration or EIA 2025 outlook has the US currently producing 3 bcme of RNG in 2023, with the potential to produce over 100 bcme. (1)

## GLOBAL MARKET POTENTIAL

Some regions, such as the European Union, have a robust Biogas & RNG industry accounting for 50% of production globally and achieving 40% of its projected potential. 80% of the global potential for production is in emerging and developing countries such as India, China, and Brazil. (1)

## LEADING STATES

California is by far the leader in biogas production, having 411 operational projects. This is due to having larger farms, leading to greater economies of scale with 131 agricultural digesters. Also, California has supportive policies such as grant programs, the low carbon fuels standard, and organic waste landfilling restrictions. Other leading states include Texas, Pennsylvania, Michigan, and New York. (3)

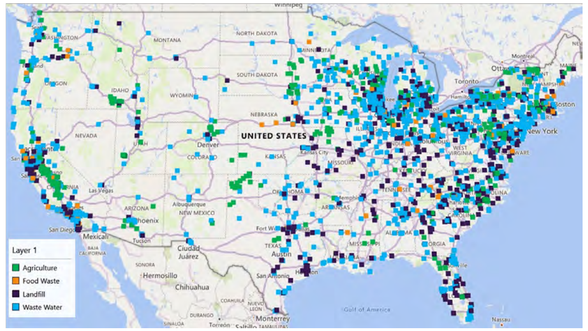


Photo: https://americanbiogascouncil.org/biogas-market-snapshot/



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# Market Drivers

## GOVERNMENT SUPPORT

Along with maintaining the IRA tax credits that support Biogas & RNG projects, there are other core incentives available to the industry. Two of the most notable are California's Low Carbon Fuel Standard, which has created a trading system using credit generated by low carbon fuels. The other is the Renewable Fuel Standard, setting requirements for how much of the fuel used for transportation fuel, home heating oil, or jet fuel. Nonrenewable fuel producers need to purchase credits to comply with the standard. (6) Federal plans have been discussed to introduce an "e-RIN" for biogas-based electricity for electric vehicles. If this form of support becomes a reality, it would create a new and potentially lucrative incentive for producing electricity from biogas.

## CORPORATE ENVIRONMENTAL GOALS

Though it may seem counterintuitive to say burning RNG or biogas reduces carbon emissions, but in many cases it does, when compared to traditional disposal/treatment of organic wastes. This is due to the significant reduction in methane emissions, a more potent greenhouse gas, by collecting and burning the methane, turning it into less potent CO2. This makes reliable carbon accounting easier than many other forms of carbon offsets, giving greater credibility to carbon reduction pledges. The companies interested in purchasing RNG to meet these targets range from chemical industries to utilities and industrial companies.

## ADVANCEMENTS IN FOOD WASTE PROCESSING

Anaerobic Digesters require steady, carefully controlled conditions to maintain optimal biogas production. While food waste has greater production yields, it is also much harder to manage in a digester compared to more traditional feedstock such as manure. Most early biodigesters used mostly manure as the feedstock with slight additions of food waste. This model is pivoting with the advancement of sensor and data analytics technologies, which can greatly improve how well these biodigesters can be managed. This is allowing new business models that partner with smaller farms with lower manure quantities and make the majority of the feedstock as food waste, resulting in a high biogas output. Some wastewater treatment facilities have also found ways to incorporate food waste into their digester systems, leading to much higher biogas yields. This new trend is opening new potential sites, providing bigger biogas yields, and opening opportunities for food processing plants to reduce or eliminate waste disposal fees.

## RISE OF RNG

In 2023, 69% of biogas was used for electricity production, but RNG is expanding quickly, with 91% of all new biogas projects choosing to upgrade to RNG. (7) The main factors driving this are access to the Renewable Fuel Standard and California's Low Carbon Fuel Standard or LCFS, which provide valuable credits for biofuels, including RNG produced for use by the federal government or California's transportation fleets.

# Market Drivers

### EMPHASIS ON GENERATING CO-PRODUCTS

The traditional farm digester model sells itself not only by producing energy for the farm but also the variety of co-benefits from owning a digester. This includes using solid digestate as bedding, reduction of fertilizer requirements by using liquid digestate as fertilizer, receiving tipping fees by taking in food waste, and reductions in pathogens and odors present in traditional manure. Wastewater treatment facilities can both reduce the volume and mass of wastewater sludge through the anaerobic digestion process to kill pathogens. While the reduction and volume can reduce operational costs, the reduction in pathogens and removal of some harmful compounds open up new, less costly forms of disposal or new opportunities to recycle waste as products such as biofertilizer. The RNG sector is starting to see a similar focus on potential co-products to RNG. These potential co-products can include selling the carbon removed from the biogas to chemical or beverage companies, producing fertilizers by extracting valuable nitrogen and phosphorus from the digestate, selling filtered out sulfur as a soil amendment, or even producing potting mixes from the digestate, among other opportunities.

### ORGANIC WASTE REDUCTION LAWS

Nine states have passed organic waste bans that can incentivize the use of food waste in anaerobic digesters, including New York and Maryland. (8) While some states have seen mixed results in growing food recycling industries, Massachusetts has successfully implemented doubling the amount of food waste recycled from 2016 to 2024, the majority being used for anaerobic digestion. (9)

### Community Digester Model

The largest farms can produce RNG at lower costs due to the economies of scale that having huge volumes of manure comes with. This limits the number of possible farm operations available. The community digester model is one way to create more economically viable projects with more numerous smaller farms by locating a central digester close to multiple smaller farms, creating the same economy of scale as a larger farm.

### CLEAN SOLUTION FOR HARD-TO-DECARBONIZE SECTORS

While there are many different options to decarbonize industries like steel, cement, and chemical industries (which require high temperature heat), RNG has uniquely low barriers to entry. RNG's greatest advantage compared to other options is that RNG can take advantage of all existing natural gas infrastructure, compared to alternatives that need new infrastructure to be developed. This has made the use of RNG attractive to industries interested in reducing their carbon footprint.

# Challenges

## COMPETITION WITH FOSSIL NATURAL GAS AND RENEWABLES

Natural gas prices within the US are extremely low compared to the rest of the world, making it a more difficult use case compared to other countries. The IEA 2025 report estimated that the top 10% of resources in North America could be developed at $9 USD per gigajoule or (GJ), while the average natural gas wholesale price in North America is about $4 USD per GJ. On the electrical generation side, anaerobic digesters have a levelized cost of energy of $100 USD per megawatt hour or (MWH), coming up more expensive than other renewables such as solar at $30 USD per MWH and wind at $50 USD per MWH. (1) Anaerobic digesters have two advantages that can close this price gap. First is the potential for co-benefits. Using a Combined Heat and Power generator or (CHP) to produce heat for operations and electricity, using the digestate for various purposes, and taking advantage of the contaminant and pathogen reduction effects can increase the value proposition. Biogas generators can, to a certain degree, be a dispatchable source of energy and are not intermittent like other renewables.

## CORE TECHNOLOGY MATURITY

While there is room for greater production yields through data collection, feedstock processing, additional co-products, and other methods, the core technology is already mature and has less room to reduce costs as compared to other newer technologies like solar.

## SOCIAL LICENSE TO OPERATE

While projects have moved forward easily in the past, there has been greater community pushback as the industry has developed. Accidents such as the Lowell AD Energy Digester in 2016 have brought concerns of injuries and potential contamination of the surrounding environment. While communities have accepted farmer owned digesters fairly well, rural communities have a level of distrust towards larger third party owned digesters, raising concerns about overloading the surrounding land with the nutrients from digestate and traffic, among other concerns.

## PERMITTING AND REGULATIONS

Anaerobic digesters can be subject to a variety of federal, state, and local permitting restrictions. The lack of a uniform standard between states and local communities creates difficulties in navigating the process. Local permitting could especially become a challenge if community opposition continues to increase, which could cause similar delays or rejections of projects from local governments as we have seen with solar and wind projects.

## LIMITED POTENTIAL

While there is potential for the growth of the Biogas & RNG industries, that growth is limited, well below the current natural gas demand of the US. The International Energy Agency or (IEA) estimates that 10% of North America's natural gas demand could be met by Biogas & RNG. (1) The American Gas Association estimated that enough resources existed that RNG could reasonably cover the whole of residential natural gas demand, which is about 14% of all natural gas demand. (10)

# Types of Anaerobic Digesters

There are quite a few designs that exist for creating and collecting biogas, but these are a few examples of more common types of digesters.

**Lagoon Digester** – A relatively low-maintenance method of capturing biogas from manure or wastewater by putting a flexible cover over a waste storage lagoon. This cover helps create an anaerobic environment and contains the methane gas to be collected by pipelines. (11)

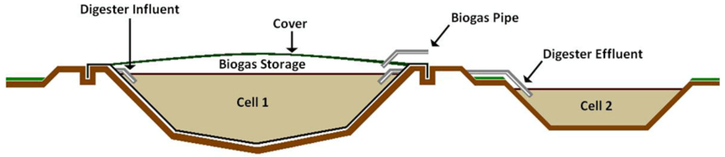


Photo: https://www.epa.gov/agstar/anaerobic-system-design-and-technology

**Plug Flow Digester** – Is a tank with a tight cover designed for waste with higher solids content. Slurry is pumped into the tank, and the tank is designed to allow an equal amount of slurry to flow out as is pumped in. (11)

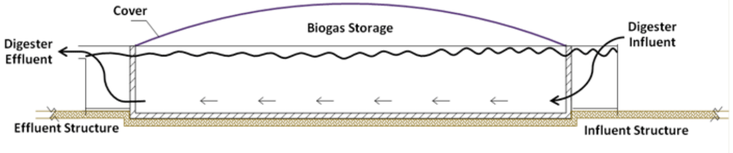


Photo: https://www.epa.gov/agstar/anaerobic-system-design-and-technology

**Complete Mix Digester** – This system is much like a plug flow system, except complete mix systems are meant for higher liquid content slurries. These higher liquid contents require active agitation to keep particles from settling at the bottom. They have the same function to have equal amounts of slurry pumped in as flows out is retained. (11)

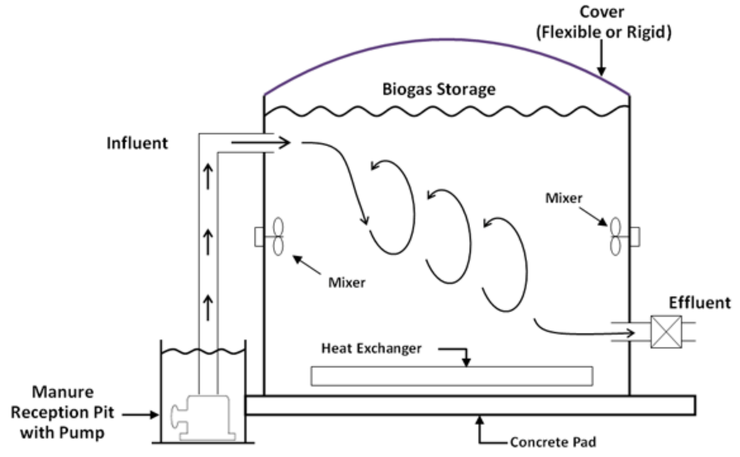


Photo: https://www.epa.gov/agstar/anaerobic-system-design-and-technology



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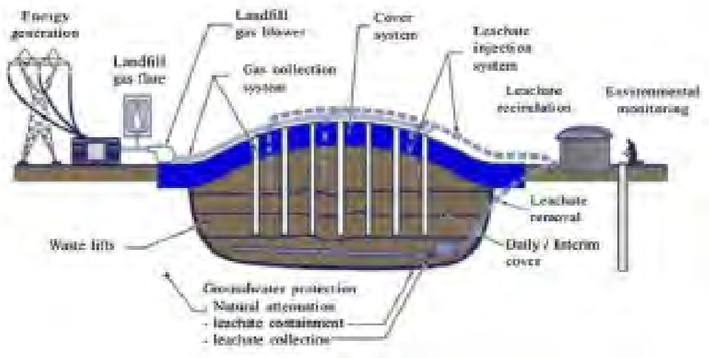
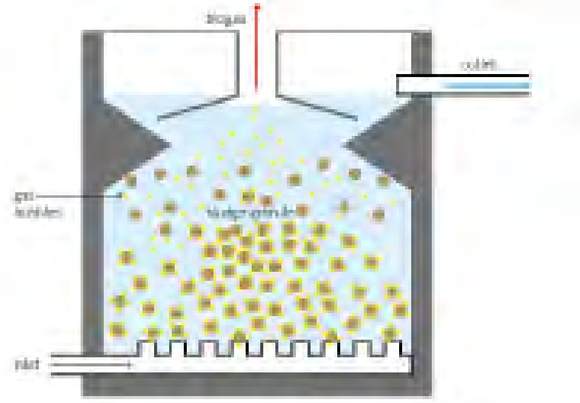
# Types of Anaerobic Digesters

**Landfill Gas Recovery System** – This system takes advantage of the natural anaerobic environment created when making a landfill. A lining will be placed at the bottom of the landfill to contain the waste, and waste will be piled and compacted until the landfill is full. Once it is full, a cap will be created to contain the biogas that forms inside and keep oxygen from hampering the process. A series of vertical and horizontal piping is installed in the landfill pit that collects biogas and transports it to the upgrading equipment.




https://www.sciencedirect.com/science/article/pii/S0956053X17306268?via%3Dihub

**Up flow Activated Sludge Blanket Digester** – These systems are primarily used for industrial wastewater treatment because they can handle high organic loading rates and quickly process wastewater. They process wastewater by creating a granular sludge blanket in the digester tank that floats at the bottom of the tank. Wastewater is pumped from the bottom through the sludge, capturing the organic solids while allowing the wastewater through. The organic solids are then converted to biogas and collected while the treated wastewater is pumped out from the top of the tank.(12)




https://www.eawag.ch/en/department/sandec/publications/compendium/



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# Biogas & RNG Components

| COMPONENT | NAICS CODE | NAICS CODE DESCRIPTION |
|---|---|---|
| Electric Water Heater | 333415 | Different types of digesters are designed to run at different temperatures, but maintaining this temperature is crucial to the process. Electric water heaters are most often used to maintain these temperatures of 86 to 100 degrees F for mesophilic digester types and 122 to 140 degrees F for thermophilic types. |
| Heat Exchanger | 332410 | Transfers the heat produced by an electric water heater, boiler, or CHP from the heating fluid produced to the digester tank to heat the slurry. Heat exchangers can also be used in the gas upgrading stages for preparing biogas to be burned or upgrading to RNG by cooling the biogas, causing condensation, which can reduce the water content of the biogas. |
| Lagoon Cover | 326199 | For Lagoon type digesters, a cover for the lagoon is necessary to trap the biogas within the lagoon, so that it can be collected and used. Though anaerobic conditions already exist under the surface of an uncovered manure lagoon, the lagoon cover acts as this surface, allowing all of the manure to be used to produce biogas. |
| Digester Tank | 332420 | For plug flow and complete mix digesters, an airtight sealed tank is necessary to hold the slurry created from the feedstock and create an anaerobic environment for biogas production. These tanks can also be used as a pretreatment tank that mixes and prepares feedstocks to be ready to be incorporated into the digester. |
| Electric Motors | 335312 | Agitating the digester slurry is necessary to maintain the proper consistency of the mix, promoting the chemical reactions that produce biogas and distributing heat to maintain a consistent temperature. These electric motors are used to move rotors or paddles, which agitate the digester influent. |
| Gas Compressor | 333912 | Another method for agitating the digester mix is to compress a fraction of the biogas produced and to pump it back into the tank. |
| Hydraulic Pump | 333996 | Instead of using gas, some digesters will pump out a fraction of the slurry and then pump it back into the digester tank, mixing the slurry. Hydraulic pumps are sometimes used to move the slurry into and out of the digester. |
| Combined Heat and Power Generator | 335312 | Digesters that opt to produce electricity will often use CHP generators to take advantage of the heat as well as the electricity for on-site use. These generators can burn minimally processed biogas to produce energy for the site as well as excess electricity to sell to the grid. The heat can be put towards a variety of options, including maintaining the heat of the digester. |
| Sensors | 335314 | Sensors monitor and collect real time data on factors important to optimal production of biogas, including temperature, pH, gas production rate, microbe health, slurry flow rate, and other chemical processes. This allows for timely interventions of any issues that may arise in the digester. |
| Conveyor System | 333922 | Used to load solid feedstocks such as manure or food waste into the digester or into a pre-treatment tank before the solids are incorporated into the system. |

# Biogas & RNG Components

| COMPONENT | NAICS CODE | NAICS CODE DESCRIPTION |
|---|---|---|
| Piping | 332996 | Piping is the main method of moving liquid slurry into the digester between the digester tanks and removing the liquid digestate from the digester. |
| Membrane Separator | 333998 | Biogas is pressurized and sent through a polymeric fiber that is designed to allow unwanted particles like CO2 to pass through while keeping methane within the fiber. |
| Pressure Swing Absorber | 333998 | Biogas is pressurized within a tank with an absorptive media that can absorb CO2 and nitrogen. These smaller molecules can be absorbed into the small pores of the absorptive media under pressure, while the methane remains untouched. After the methane is removed, the chamber is depressurized, and the CO2 and Nitrogen are released from the pores and removed as tall gas. |
| Amine Scrubber | 333998 | This process is done in two steps. The first step is that biogas is exposed to a solvent material that chemically reacts and removes gases like CO2 from the biogas. The methane gas is moved from the reactor section. The system is reset for the next batch by heating the solvent to a boiling temperature, causing the CO2 to leave the solvent and be released, potentially for reuse. |
| Water Wash | 333998 | This process involves a pressurized reactor where water is moved through the reactor absorbing the CO2, similar to how carbonated drinks are formed. This water can also absorb hydrogen sulfide gas, leaving the methane, which is water-soluble, to pass through the water. It is then depressurized in a separate chamber, releasing the CO2, and either reused if hydrogen sulfide has already been removed or released if it contains hydrogen sulfide. |

# Natural Gas: Biogas & RNG Industry Developers

**Clean Energy Fuels Corp.** - One of America's largest providers of RNG, offering fueling solutions for vehicle fleets and partnering mainly with dairy farms for RNG projects.

Website - https://www.cleanenergyfuels.com/

**Archaea Energy** – A US Biogas and RNG project developer specializing in landfill gas collection systems. Archaea was acquired by British Petroleum in 2022.

https://www.bp.com/en_us/united-states/home/what-we-do/gas-and-low-carbon-energy/archaea-energy.html

**Vanguard Renewables** – A US RNG project developer that specializes in agricultural and food waste solutions. Vanguard Renewables was acquired by BlackRock in 2022.

Website - https://www.vanguardrenewables.com/

**Ameresco** - Is a US-based energy solutions provider. Ameresco designs, builds, and operates landfill, wastewater, and agricultural RNG projects.

Website - https://www.ameresco.com/

**Align Renewable Natural Gas** – An agricultural waste to RNG project developer who is part of a half billion dollar joint venture between Dominion Energy and Smithfield Farms to produce RNG for Dominion Energy.

**Nature Energy** – A Denmark based company and a leader in RNG and biogas production in Europe. This company was acquired by Shell in 2022 for 2 billion dollars.

Website - https://nature-energy.com/

# Biogas Upgrading and Electricity Production Companies

**Air Liquide** – A French corporation that provides industrial gases for various industries. Part of their business model is developing RNG projects as well a producing RNG upgrading equipment.

Website - https://www.airliquide.com/

**Greenlane Renewables** - A global provider of Biogas to RNG upgrading equipment based in Canada.

Website - https://greenlanerenewables.com/

**Malmberg Water** – A European leader in biogas upgrading equipment with over 120 RNG upgrading facilities across Europe.

Website - https://www.malmberg.se/en/

**AB Group** - An energy solutions company that produces CHP generators for electric producing projects and has expanded into RNG upgrading and liquefaction solutions.

Website - https://www.gruppoab.com/en-us/

**2G Energy** – One of the leading producers of CHP generators tailored to use with biogas. 2G Energy is based in Germany and has 9,000 installations globally.

Website - https://www.2g-energy.com/

# Notable Utilities and Natural Gas Producers

**Chevron** – A US fossil fuels company who is recently partnered with California Bioenergy to produce RNG from dairy farms.

Website: https://www.chevron.com/

**Engie** – A Renewable and electrical infrastructure company that is based in France and the largest supplier of RNG in France.

Website: https://www.engie.com/

**SolCalGas** – A California based gas utility is a leader in adopting RNG with the goal of sourcing RNG as 20% of its supply.

Website - https://www.socalgas.com/

**Vermont Gas Systems** – A Northern Vermont thermal energy provider with 50,000 customers, which is working with RNG producers, such as Vanguard Renewables, to reach 20% of sourced from RNG.

Website: https://vgsvt.com/

# Biogas & RNG Industry Associations and Resources

**World Biogas Association** – a global trade association formed to facilitate the growth of the biogas, landfill gas recovery, and anaerobic digestion industries.

Website - https://www.worldbiogasassociation.org/

**American Biogas Council** – The United States' lead biogas trade organization representing over 400 companies throughout the biogas supply chain, to promote the industry.

Website - https://americanbiogascouncil.org/

**RNG Coalition** – A North American RNG industry trade association with over 400 members dedicated to advocating for and educating the industry.

Website - https://www.rngcoalition.com/

**Bioenergy Association of California** – An association representing bioenergy companies, public agencies, local governments, investors, consultants, and non-profits interested in promoting bioenergy. Bioenergy includes a focus on landfills, wastewater, and on-farm waste use for electricity and RNG production.

Website: https://bioenergyca.org/

**Canadian Biogas Association** – An industry association meant to promote the development of a strong Biogas & RNG industry in Canada.

Website: https://www.biogasassociation.ca/

**European Biogas Association** – A group representing over 300 associations across Europe and beyond through the Biogas & RNG value chain.

Website: https://www.europeanbiogas.eu/

**EPA AgStar** – A collaborative program between the US Environmental Protection Agency and the United States Department of Agriculture to promote agricultural anaerobic digesters. They offer various resources, including a list of all registered-on farm digesters, along with developer, operational, and permitting resources.

Website - https://www.epa.gov/agstar

**Department of Energy Bioenergy Technologies Office** – The DOE Bioenergy Office works with Industry, academia, and national laboratories to advance innovation in the Bioenergy space, including Biogas & RNG production. They offer technical assistance and funding for innovative practices along with other resources.

Website: https://www.energy.gov/eere/bioenergy/bioenergy-technologies-office

**International Energy Agency** – A global provider of energy analysis, data, policy recommendations, and solutions. This includes Biogas & RNG with their 2025 "Outlook for Biogas and Biomethane".

Website: https://www.iea.org/

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ENERGY & MANUFACTURING in Appalachia

# Energy & Manufacturing in Appalachia Program

This energy overview research and report was created under the Energy & Manufacturing in Appalachia (EMA) program made possible with grant funding from the Appalachian Regional Commission. EMA provides technical assistance and business support to small and medium manufacturers and enterprises seeking to expand business, production and jobs in the energy supply chains. Energy is a big expense for manufacturing companies. EMA helps companies save money with energy efficiency and emissions reductions.

The Natural Gas: Biogas & RNG report was drafted by the Penn State Extension Energy Team, which gathered content and information from a variety of sources referenced within the document. The Penn State Extension Energy Team is committed to providing science-based, general education on numerous energy-related topics. To contact the team or for more information, go to www.extension.psu.edu/energy.

The EMA program supports Appalachia in 156 counties of Maryland, New York, Ohio, Pennsylvania, and West Virginia. This program was established to help small and medium manufacturers be a part of this Energy Economy. This program is managed by Manufacturing Extension Partnership (MEP) organizations from five Appalachian states. The activities and intended outcomes of EMA align with the National Institute of Standards and Technology (NIST) MEP and its mission to enhance the productivity and technological performance of U.S. manufacturing.

**Learn more about the Energy & Manufacturing in Appalachia program by visiting: https://www.wemakeithere.org/energy/ and join the EMA LinkedIn group. Contact EMA Program Manager, Tom Reed, directly at Tom@WeMakeItHere.org and (412) 918-4269 with any questions or assistance.**



ENERGY & MANUFACTURING in Appalachia