Biogas:

Accessing Methane Recovery In Nebraska

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Nebraska Methane Working Group

Methane 101
- What is it?
- Where does it come from?
- Why is it important?

Methane Recovery Basics
- What is it?
- Anaerobic Digestion
- Methane Recovery Systems
- Anaerobic Digesters
- End Uses and Markets

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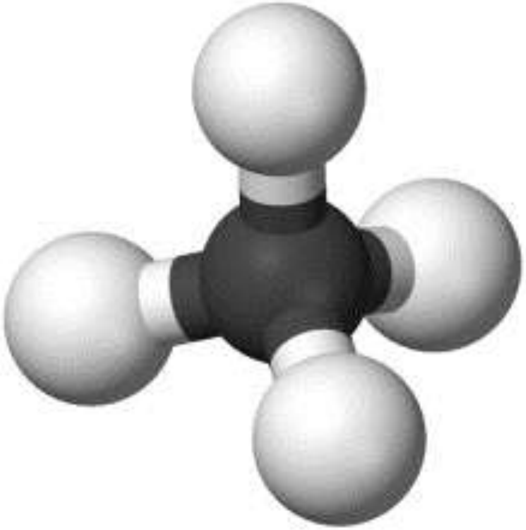
- Case studies in Agriculture
- Case studies in Municipalities
- Case studies in Industry

Developing a Methane Recovery Project in Nebraska
- The Process
- Project Resources
- Challenges and Opportunities



Methane (CH_4) is a compound gas produced during the decomposition of organic matter. A molecule of methane is comprised of 4 hydrogen atoms bonded to 1 carbon atom.

Biogenic methane is produced by bacteria.

Thermogenic methane is produced by heat.

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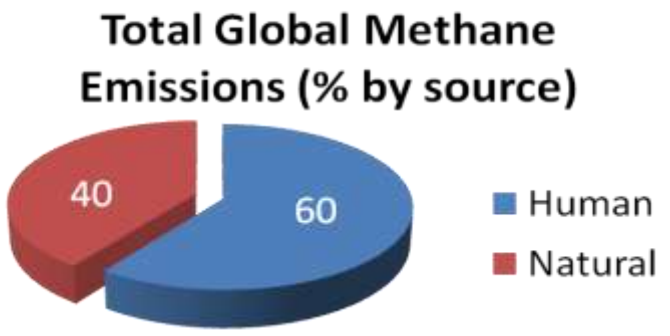

The U.S. Environmental Protection Agency (EPA) and Intergovernmental Panel on Climate Change (IPCC) estimate that 60% of total global methane emissions are associated with human activities. Natural sources of methane emissions comprise the remaining 40%.

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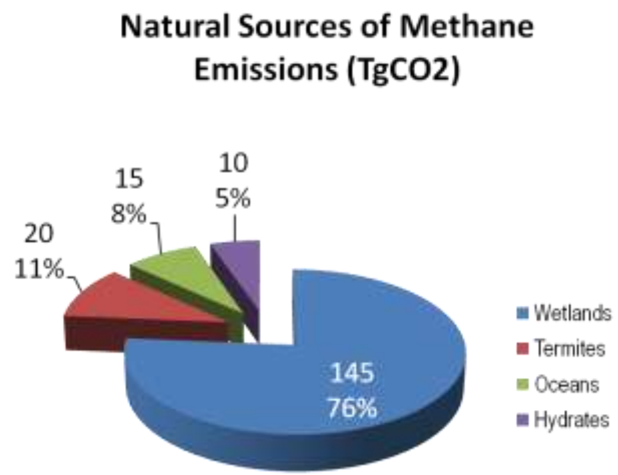

Wetlands: provide a conducive environment for anaerobic bacteria. As vegetation and wildlife wastes accumulate in the water, oxygen is consumed and reduced at the bottom layers where bacteria breakdown the organic materials.

Termites: produce methane as a normal function of digestion. Emissions depend on the specific species and total population.

Oceans: emit methane from anaerobic digestion of marine zooplankton and fish as well as methanogenesis in sediments along coastal drainage areas.

Hydrates: are solid deposits of water molecules that trap methane molecules, which form as organic sediments in the water decay during the formation process. Hydrates form deep underground in polar regions and along outer continental shelf (OCS) regions where high-pressure and low-temperature conditions exist.

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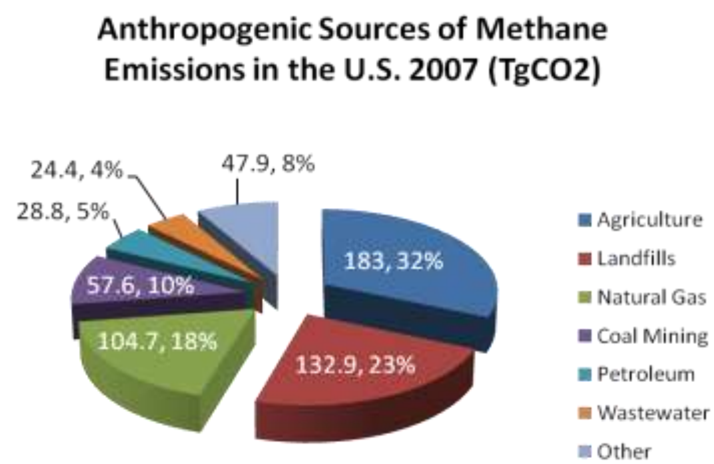

Agriculture: is the leading source of methane emissions in the U.S. Emissions are the result of enteric fermentation and manure management practices. Enteric fermentation contributes far more emissions than manure management. However, manure management emissions have increased 44.7% since 1990 compared to 4.3% for enteric fermentation.

Landfills: are the most significant source of methane emissions in the U.S. linked to human activity. Methane is produced in open dumps and landfills as wastes decompose under anaerobic conditions. As waste accumulates, pressure and temperature increase differentially below the surface. This creates pockets of trapped natural gas that ultimately seep to the surface via pore spaces in the ground.

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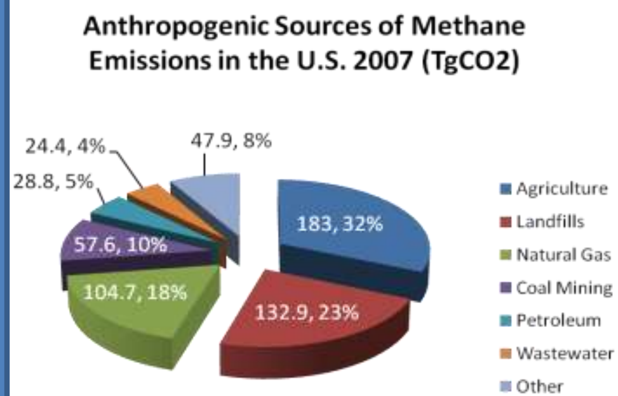

Natural Gas: is comprised of 95% methane. Emissions occur via production, processing storage, transmission and distribution operations. Natural gas is the most abundant by-product associated with petroleum production, refinement, transportation and storage.

Coal Mining: emits methane trapped in coal mines and surrounding geologic strata. Coal is organic carbon. Methane is formed as organic sediments decompose and is emitted via normal underground and surface mining operations.

Wastewater: produces methane during the treatment process of municipal and industrial wastes under anaerobic conditions. Wastewater treatment facilities use anaerobic digestion to stabilize organic solids and remove pathogens from the water prior to discharge into the hydrologic system. In many cases, wastewater treatment facilities use methane to provide electricity.

Other: sources of methane emissions account for 8% of methane emissions linked to human activity. The greatest of these *(stationary combustion)* contributes 6.6 $TgCO_2$.

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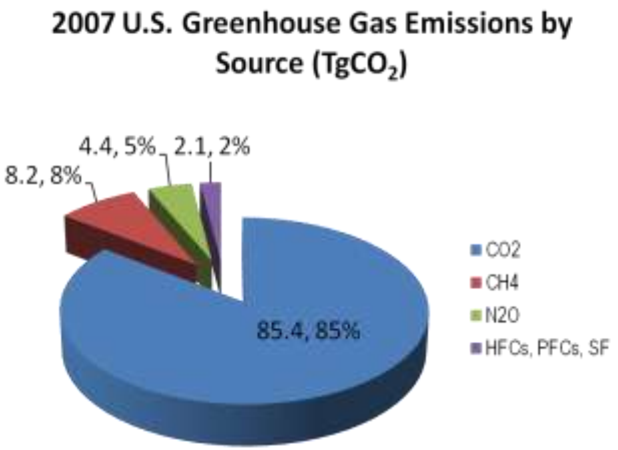
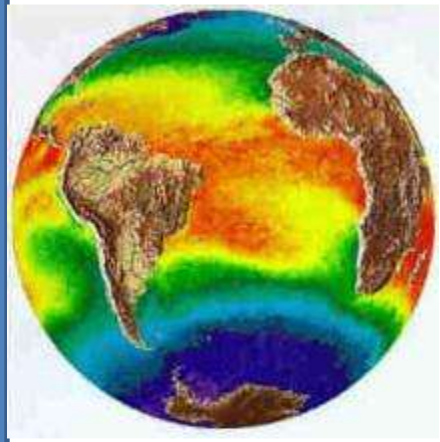


Methane accounts for more than 8% of GHG emissions in the United States. Second only to carbon dioxide, which accounts for more than 85%.



Methane is a potent greenhouse gas. The EPA and IPCC estimate the global warming potential (GWP) of methane to be 21 times greater than that of CO_2.

By definition, GWP is the ratio of heat trapped by one unit of a given GHG to that of one unit of carbon dioxide.

Over 100 years, one molecule of methane will trap 21 times more heat in the Earth’s atmosphere than one molecule of CO_2.

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Methane is one of several volatile organic compounds (VOC) that contribute to the production of tropospheric ozone (O_3). Tropospheric ozone refers to ozone levels in the troposphere. The troposphere is the level of the atmosphere humans live in and it contains 75% of the Earth's atmospheric mass and 99% of its water vapor. Photosynthetic reactions in tropospheric ozone are a leading cause of air pollution such as smog and are responsible for a variety of respiratory health issues in humans, animals and plants.

Ozone exists in various concentrations throughout the Earth's atmosphere. Ozone in the lower atmosphere poses significant risks to the overall health of all life on the planet. However, in the upper atmosphere, ozone provides considerable benefits by preventing ultraviolet solar radiation from reaching the Earth's surface.

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NEWS ITEM - Methane gas emissions from India's 280 million cows are contributing to global warming. This newly published cartoon from Australia suggests collecting the methane gas and using it as fuel for power stations.

Methane recovery creates economic opportunities by converting existing organic waste streams into a source of reliable renewable energy for electricity, heat or fuel and a host of other value-added by-products and materials.

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Methane recovery refers to the processes by which methane is captured, sequestered, and/or removed from the atmosphere. There are anthropogenic methods and natural processes of methane recovery.

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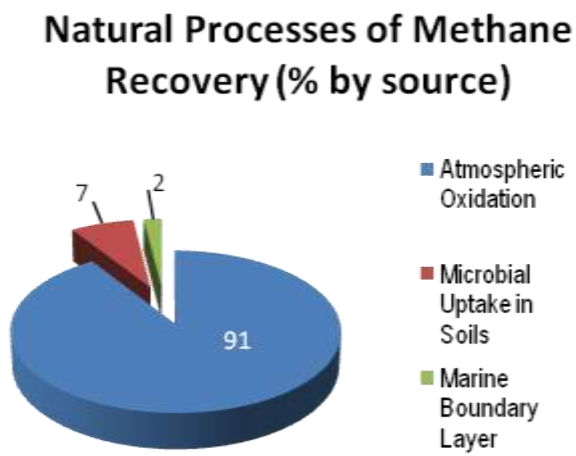

Atmospheric Oxidation: is the process by which gases are broken down and released into space. This process accounts for 91% of total methane removal. The production of tropospheric ozone is a significant limiting factor to the efficiency of Earth's oxidation system.

Microbial Uptake in Soils: accounts for 7% of total methane removal

Chlorine Reactions in the Marine Boundary Layer: account for 2% of total methane removal.

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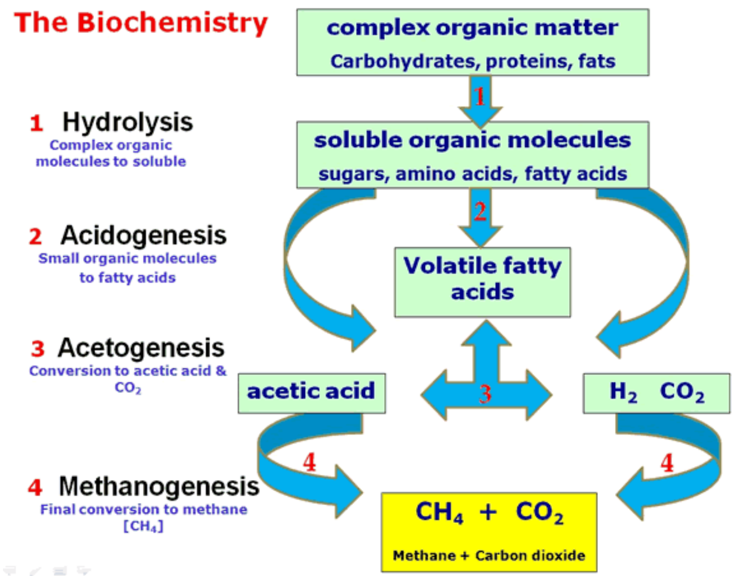

http://www.readigesters.com/digesterbasics.php

Anaerobic digestion (AD) refers to the process by which bacteria digest organic materials in an oxygen-free *(anaerobic)* environment.

*Other biomass energy processes include: fermentation, gasification, and combustion. AD and fermentation primarily produce CH_4 and CO_2. Gasification and combustion primarily produce N, CO and H with trace amounts of CH_4.

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Waste(s) Collection System: includes one or more methods for collecting and transporting wastes to the digester. May also include pre-treatment methods for separating and mixing multiple feedstock.

Anaerobic Digester: a covered lagoon or tank system designed to stabilize manure and other organic materials and optimize methane production.

Gas Handling System: required for the collection, treatment and transport of biogas.

Gas End-Use Device(s): are typically an electric generator set or gas flare. May also include compression, storage and distribution technologies.

Effluent Storage: methane recovery systems result in liquid and solid or slurry effluents. These may be used as nutrient-rich irrigation and soil supplement resources or processed into value-added products and raw materials for industry.

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Anaerobic digesters are manmade oxygen-free environments designed to expedite and facilitate the AD process. Digester designs can range in scale from inner-tubes and 55-gallon drum barrels to concrete and steel containers and structures. The main product of the AD process is referred to as *biogas*. On average, biogas is comprised of 60% methane and 40% carbon dioxide with some trace elements such as hydrogen sulfide. The process also generates solids, liquids, or slurry waste streams.

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Type of Digester:	COVERED LAGOON	PLUG FLOW	COMPLETE MIX	FIXED FILM
Vessel:	Deep Lagoon	In-Ground Tank	In/Above Ground Tank	Above-Ground Tank
Level of Technology:	Low	Low	Medium	Medium
Additional Heat	No	Yes	Yes	No
Total Solids	0.5% - 1.5%	11% - 13%	3% - 11%	3%
Hydraulic Retention Time (HRT)	40 - 60 days	15 days	15 days	2-3 days
Farm Type:	Cattle/Hog/ Poultry	Cattle Only	Cattle/Hog/ Poultry	Cattle/Hog/ Poultry
Climate:	Temperate/Warm	All	All	Temperate

There are five basic anaerobic digester designs: *batch reactors, covered lagoons, plug flow, complete mix,* and *fixed film.* The different designs reflect adaptations to a variety of environmental and operational considerations.

Environmental considerations are operating temperature, climate, types and availability of feedstock, and the amount of available land. Digesters can operate in a wide range of temperatures from below freezing *(0°C/32°F)* to above 57°C/134.6°F. Most agricultural and industrial methane digester operations in the U.S. operate under *mesophilic* conditions, which are temperatures around 38°C/100°F.

Covered Lagoons: In a covered lagoon system, an impermeable cover is placed over an anaerobic waste lagoon. Covered lagoons are the least cost option in materials, particularly for existing lagoons. Covered lagoon systems are designed for cattle or hog operations. The system requires the largest land area, lowest concentration of solids, and the slowest rate of production among designs.

Plug Flow: Plug flow systems are engineered as in-ground concrete tanks with a flexible cover for biogas collection. The system is designed for dairy cattle only. The system increases the amount of total solids concentration and reduces the *hydraulic retention time.* The plug flow design also takes advantage of heat produced in the electric generation process to maintain operating temperature, making it optimal for use in all climates.

Complete Mix: digester systems are engineered of concrete or steel and can be located above or below ground and offer similar benefits as plug flow digesters to non-dairy cattle and hog operations. Complete mix digesters have a wider range of total solids concentrations and a comparable hydraulic retention time. The design also takes advantage of system heat to maintain operating temperature, making it optimal for use in all climates as well.

Fixed Film: digester systems are engineered above ground for agricultural and industrial operations with less available land area. In a fixed film system, bacteria attach to layers of film within the digester unit. The film layers increase the available surface area for bacteria to grow. As a result, fixed film digesters produce the highest composition of methane and have the shortest retention time. Fixed film digesters require a low total solids concentration to avoid clogging, and are optimal for use in warm climates.