Glossary

Acronyms and Abbreviations

AB	Assembly Bill
AFV	Alternate fuel vehicle
B100	Neat biodiesel, 100% biodiesel
B2	Diesel fuel containing 2% biodiesel
B20	Diesel fuel containing 20% biodiesel
BACT	Best available control technology
BDT	Bone dry tons
BOD	Biological oxygen demand
BRDA	Biomass Research and Development Act (2000)
Btu	British thermal units
CAFO	Confined animal feeding operation
CARB	California Air Resources Board
CBM	Compressed biomethane
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CH_4	Methane
CHP	Combined heat and power
CNG	Compressed natural gas
CO	Carbon monoxide
CO_2	Carbon dioxide
CPUC	California Public Utility Commission
CWC	California Water Code
DGE	Diesel gallon equivalent
DMV	Department of Motor Vehicles
DOE EIA	U.S. Department of Energy, Energy Information Administration
DOT	U.S. Department of Transportation
DTSC	Department of Toxic Substance Control
E10	Gasoline fuel containing 10% ethanol
E85	Gasoline fuel containing 85% ethanol

E100	Gasoline fuel substitute containing 100% ethanol.
EQIP	Environmental Quality Incentives Program
ERC	Emission Reduction Credits
ft^3/d	Cubic feet per day
ft^3/h	Cubic feet per hour
ft^3/y	Cubic feet per year
FTP	Federal Test Procedure (US EPA)
FY	Fiscal year
GGE	Gasoline gallon equivalent
GHG	Greenhouse gas
gpd	Gallons per day
gpm	Gallons per minute
GVW	Gross vehicle weight
GW_e	Gigawatts of electricity (10^9 watts)
H_2	Hydrogen
H_2O	Water
H_2S	Hydrogen sulfide
H_2SO_4	Sulfuric acid
HOV	High-occupancy vehicle
hp	Horsepower
HRT	Hydraulic retention time
IOU	Investor owned utility
kW	Kilowatt (10^3 watts)
kWh	Kilowatt-hour
lb	Pound(s)
LBM	Liquefied biomethane
LCNG	Liquefied-to-compressed natural gas
LFG	Landfill gas
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MM	Millions
MTBE	Methyl tertiary-butyl ether
MW	Megawatt
MWh	Megawatt-hours

MW_e	Megawatts of electricity (10^6 watts)
NO_x	Nitrogen oxides and dioxides, typically NO and NO_2
N_2O	Nitrous oxide
NPDES	National Pollution Discharge Elimination System
PG&E	Pacific Gas and Electric Company
PIER	California's Public Interest Energy Research Program
PING	California's Public Interest Natural Gas Energy Research Program
PM	Particulate matter
POTW	Publicly owned treatment works
ppm	Parts per million
psi	Pounds per square inch
psig	Pounds per square inch, gauge
PURPA	Public Utility Regulatory Policy Act
PZEV	Partial zero-emission vehicle
RCRA	Resources Conservation and Recovery Act
ROG	Reactive organic gases
RPS	Renewable Portfolio Standard
scf	Standard cubic feet
scfm	Standard cubic feet per minute
SB	Senate Bill
SCE	Southern California Edison
SoCalGas	Southern California Gas Company
SULEV	Super ultra low-emission vehicle
TS	Total solids
ULEV	Ultra low-emission vehicle
USDA	US Department of Agriculture
US DOE	US Department of Energy
US EPA	US Environmental Protection Agency
VOC	Volatile organic compounds
VS	Volatile solids
ZEV	Zero-emission vehicle

Definitions

Acetic acid — A carboxylic acid, acetic acid is a relatively weak acid mainly used as a pH buffer (chemical formula CH_3 COOH).

Acidogenic — Acid-forming; used to describe microorganisms that break down organic matter to acids during the anaerobic digestion process

Anaerobic digestion — A naturally occurring biological process in which organic material is broken down by bacteria in a low-oxygen environment resulting in the generation of methane gas and carbon dioxide as its two primary products.

Anaerobic digester — A device for optimizing the anaerobic digestion of biomass and/or animal manure, often used to recover biogas for energy production. Commercial digester types include complete mix, continuous flow (horizontal or vertical plug-flow, multiple-tank, and single tank) and covered lagoon.

Biodiesel — Any liquid biofuel suitable as a diesel fuel substitute or diesel fuel additive or extender. Biodiesel fuels are typically made from oils such as soybeans, rapeseed, or sunflowers, restaurant waste greases, or from animal tallow using a transesterification process (though unprocessed oils are sometimes used). A bio-derived gasoline or diesel substitute can also be made from thermal gasification of biomass followed by a gas-to-liquids process (Fischer-Tropsch liquids).

Biofuel — Technically, any biomass derived substance used for energy (heat, power, or motive). The term ‘biofuel’ usually is used to describe liquid transportation fuels derived from biomass.

Biogas — A naturally occurring gas formed as a by-product of the breakdown of organic waste materials in a low-oxygen (e.g., anaerobic) environment. Biogas is composed primarily of methane (typically 55% – 70% by volume) and carbon dioxide (typically 30% – 45%). Biogas may also include smaller amounts of hydrogen sulfide (typically 50 – 2000 parts per million [ppm]), water vapor (saturated), oxygen, and various trace hydrocarbons. Due to its lower methane content (and therefore lower heating value) compared to natural gas, biogas use is generally limited to engine-generator sets and boilers

adapted to combust biogas as fuel. Biogas includes landfill gas, digester gas (from wastewater treatment plants) and biogas from the decomposition of animal waste or food processing waste. In this study the word biogas usually refers to biogas created by animal manure.

Biogas upgrading — A process whereby a significant portion of the carbon dioxide, water, hydrogen sulfide and other impurities are removed from raw biogas (digester gas) leaving primarily methane. Also referred to as "sweetening." The major biogas upgrading technologies currently identified are water scrubbing, membrane separation, pressure swing adsorption, amine scrubbing (Selexol™ and COOAB™) and mixing with higher quality gases.

Biological oxygen demand — A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. Biological oxygen demand (BOD) is used as an indirect measure of the concentration of biologically degradable material present in liquid organic wastes. It usually reflects the amount of oxygen consumed in five days by biological processes breaking down organic waste. BOD can also be used as an indicator of water quality, where the greater the BOD, the greater the degree of pollution. Also referred to as "biochemical oxygen demand."

Biomass — Biomass is any organic matter that is available on a renewable or recurring basis, including agricultural crops and trees, wood and wood wastes and residues, plants (including aquatic plants), grasses, residues, fibers, and animal wastes, municipal wastes, and other waste materials.

Biomethane — Biogas which has been upgraded or "sweetened" via a process to remove the bulk of the carbon dioxide, water, hydrogen sulfide and other impurities from raw biogas. The primary purpose of upgrading biogas to biomethane is to use the biomethane as an energy source in applications that require pipeline quality or vehicle-fuel quality gas, such as transportation. From a functional point of view, biomethane is extremely similar to natural gas except that it comes from renewable sources. (Note that the term "biomethane" has not yet come into popular usage;

thus the term “biogas” is often used when referring to both the raw and upgraded forms of biogas/biomethane.)

Butyric acid — A carboxylic acid with structural formula $CH_3CH_2CH_2$-COOH. It is notably found in rancid butter, parmesan cheese, or vomit and has an unpleasant odor and acrid taste, with a sweetish aftertaste (similar to ether).

Cellulose — A complex carbohydrate, $(C_6H_{10}O_5)n$, that is composed of glucose units. Cellulose forms the main constituent of the cell wall in most plants.

Chemical oxygen demand — Chemical oxygen demand (COD) is used to indirectly measure the amount of all organic compounds in a water sample (whereas BOD indicates the amount of biodegradable compounds in solution). COD is widely used in municipal and industrial laboratories to measure the overall level of organic contamination in wastewater. COD is determined by measuring the amount of oxygen required to fully oxidize organic matter in the sample. A COD test requires approximately 3 hours to complete, while BOD requires 3-5 days.

Co-digestion — Co-digestion is the simultaneous digestion of a mixture of two or more feedstocks. The most common situation is when a major amount of a main basic feedstock (e.g., manure or sewage sludge) is mixed and digested together with minor amounts of a single or a variety of additional feedstocks. The expression co-digestion is applied independently to the ratio of the respective substrates used simultaneously.

Compressed biomethane — Compressed biomethane (CBM) is basically equivalent to compressed natural gas (CNG). The main difference is that CNG is made by compressing natural gas (a fossil fuel) whereas CBM is made by compressing biomethane (a renewable fuel).

Compressed natural gas — CNG is natural gas that has been compressed to 3,000 to 3,600 pounds per square inch, gauge (psig), usually for purposes of on-board fuel storage for natural gas vehicles.

Conventional pollutants — As specified under the Clean Water Act, conventional pollutants include suspended solids, coliform bacteria, biochemical oxygen demand, pH, and oil and grease.

Criteria air pollutants	As required by the Clean Air Act, the EPA identifies and sets standards to protect human health and welfare for six pollutants, called criteria pollutants: ozone (O_3). carbon monoxide (CO), particulate matter (PM10, PM2.5), sulfur dioxide (SO_2), lead (Pb), and nitrogen oxides (NO_x). The term "criteria pollutants" derives from the requirement that the EPA must describe the characteristics and potential health and welfare effects of these pollutants. Periodic reviews of new scientific data may lead the EPA to propose revisions to the standards.
Desulfurization	Any process or process step that results in removal of sulfur from organic molecules.
Dew point	The temperature at which vapor in a gas-vapor mixture starts to condense when the mixture is cooled at constant pressure (most commonly used for water vapor in gas mixtures).
Digester gas	Biogas that originates from an anaerobic digester. The term is often used, and used in this report, to represent only biogas from a wastewater treatment plant.
Economy of scale	The principle that higher volume production operations have lower unit costs than smaller volume operations.
Endothermic	A process or reaction that absorbs heat. For example, ice melting is an example of an endothermic process because it absorbs heat from its surroundings.
Enteric fermentation	A digestive process by which carbohydrates are broken down by microorganisms in the rumen to simple molecules for absorption into the bloodstream of a ruminant animal, such as a cow.
Ethanol	A colorless, flammable liquid (CH_3CH_2OH) produced by fermentation of sugars. Can be produced chemically from ethylene or biochemically from the fermentation of sugars. Ethanol from starch, especially corn, and sugar crops is commercial. Ethanol from cellulosic feedstocks (woody material and agricultural residues) is still being developed. Used in the United States as a gasoline octane enhancer and oxygenate, it increases octane 2.5 to 3.0 numbers at 10% concentration. Ethanol also can be used in higher concentration in alternative-fuel vehicles optimized for its use.

Exothermic	A process or reaction that releases heat. For example, wood burning in the presence of oxygen is an example of an exothermic reaction.
Global warming	An increase in the near surface temperature of the Earth. Global warming has occurred in the distant past as the result of natural influences, but the term is most often used to refer to the warming that occurs as a result of increased emissions from human activity of greenhouse gases, such as carbon dioxide, methane, and nitrous oxide, which trap the sun's heat.
Hemicellulose	A carbohydrate polysaccharide that is similar to cellulose and is found in the cell walls of many plants
Hydraulic retention time	HRT is the average time a 'volume element' of fluid resides in a reactor. It is computed from liquid-filled volume of an anaerobic digester divided by the volumetric flow rate of liquid medium.
Landfill gas	Biogas produced as a result of natural, anaerobic decomposition of material in landfills. Landfill gas (LFG) is typically composed of approximately 55% methane and 45% CO_2, with variable air content due to air introduced during the LFG collection process. Small amounts of H_2S, siloxanes, other sulfur compounds, various trace hydrocarbons and other impurities can be present which provide a significant challenge in LFG handling and upgrading.
Ligno-cellulosic	Consisting of cellulose intimately associated with lignin, an amorphous polymer related to cellulose that has strength and rigidity. Wood is the most abundant ligno-cellulosic material, though almost all plant biomass contains lignin. Lignin does not degrade anaerobically (and is the most recalcitrant component of biomass for aerobic decomposition). Because of the structural nature of ligno-cellulosic material, much of the cellulose is difficult to access for anaerobic digestion.
Liquefied biomethane	Liquefied biomethane (LBM) is basically equivalent to LNG (liquid natural gas). The main difference is that LNG is made using natural gas (a fossil fuel) as a feedstock whereas liquefied biomethane is made using biomethane (a renewable fuel) as a feedstock.

Liquefied natural gas	A natural gas in its liquid phase. Liquefied natural gas (LNG) is a cryogenic liquid formed by cooling natural gas to approximately - 260º F at atmospheric pressure. In practice, LNG is typically stored at somewhat elevated pressures (e.g., 50 to 75 psig) to reduce cooling requirements and allow for pressure increases due to LNG vapor "boil off." LNG is stored in double-insulated, vacuum-jacketed cryogenic tanks (pressure vessels) to minimize warming from the external environment. LNG is typically greater than 99% methane.
Mesophilic	Conditions in a biological reactor where temperatures are around 95° F (35° C).
Methanogenic	Methane-forming; In the anaerobic digestion process, methanogenic bacteria consume the hydrogen and acetate (from the hydrolysis and the acid forming stages) to produce methane and carbon dioxide
Methane	Methane is the main component of natural gas and biogas. It is a natural hydrocarbon consisting of one carbon atom and four hydrogen atoms (CH_4). The heat content of methane is approximately 1,000 Btu/scf (standard cubic feet). Methane is a greenhouse gas with 21 times the global warming potential of carbon dioxide on a weight basis.
Nameplate rating	The initial capacity of a piece of electrical equipment as stated on the attached nameplate in watts, kilowatts or megawatts. Actual capability can vary from the nameplate rating due to age, wear, maintenance, fuel type or ambient conditions.
Natural gas	Natural gas typically contains more than 90% methane; it may also contain traces of propane and butane. Natural gas is generally found either above crude oil deposits or in a relatively pure form in "stranded" natural gas fields. The methane content varies considerably in natural gas geologic reservoirs (deposits). Low-methane natural gas (sour gas) must be sweetened or upgraded before it can enter the natural gas grid. Sour gas or stranded gas often occurs in quantities too small to be economically processed and gathered into the pipeline network. Thus, it is often burned off near the well (i.e., flared) as a low-value by-product during the oil pumping process. Natural gas is a vital fossil fuel that is used in electricity generation, heating,

	fertilizer production, the creation of plastics, and other industrial processes and products.
Net metering	A method of crediting customers for electricity that they generate on-site in excess of their own electricity consumption. Customers with their own generation offset the electricity they would have purchased from their utility. If such customers generate more than they use in a billing period, their electric meter turns backwards to indicate their net excess generation. Depending on individual state or utility rules, the net excess generation may be credited to their account (in some cases at the retail price), carried over to a future billing period, or ignored.
Nitrogen or nitric oxides	NO_x is a regulated criteria air pollutant, primarily NO (nitric oxide) and NO_2 (nitrogen dioxide). Nitrogen oxides are precursors to photochemical smog and contribute to the formation of acid rain, haze and particulate matter.
Nitrous oxide	N_2O, a greenhouse gas with 310 times the global warming potential of carbon dioxide.
Nonconventional pollutants	Pollutants not classified as conventional or toxic but which may require regulation. They include nutrients such as nitrogen and phosphorus.
Nonpoint source	Pollution source that is diffuse, without a single identifiable point of origin, including runoff from agriculture, forestry, and construction sites.
Point source	Contamination or impairment from a known specific point of origination, such as sewer outfalls or pipes.
Priority (toxic) pollutants	Pollutants that are particularly harmful to animal or plant life. They are grouped primarily into organics (including pesticides, solvents, polychlorinated biphenyls (PCBs and dioxins) and metals (including lead, silver, mercury, copper, chromium, zinc, nickel, and cadmium).
Propionic acid	The chemical compound propionic acid (systematically named propionic acid) is a naturally occurring carboxylic acid with chemical formula CH_3CH_2COOH. In the pure state, it is a

	colorless, corrosive liquid with a sharp, somewhat unpleasant odor. Found in milk, sweat, and fuel distillates
Reactive organic gases	A term used by the California Air Resources Board as interchangeable with *volatile organic compounds*.
Rumen	The large first compartment of a ruminant's stomach in which cellulose is broken down by the action of symbiotic microorganisms.
Scrubbing	Cleaning emission gases from a chemical reactor, generally with sprays of solutions that will absorb gases.
Stoichiometric	Pertaining to the proportion of chemical reactants in a specific reaction in which there is no excess of any reactant. For combustion, stoichiometric is the theoretical condition at which the proportion of the air-to-fuel is such that all combustible reactants will be completely burned with no oxygen or fuel remaining in the products.
Thermal gasification	Thermal gasification typically refers to conversion of solid or liquid carbon-based materials by direct internal heating provided by partial oxidation. The process uses substoichiometric air or oxygen to produce fuel gases (synthesis gas, producer gas), principally CO, H_2, methane, and lighter hydrocarbons in association with CO_2 and N_2 depending on the process used. Thermal gasification can convert all of the organic components of the feedstock, whereas anaerobic digestion cannot convert lignin and some lignin/cellulose matrices. Generally lower moisture feedstocks are candidates for thermochemcial conversion while high moisture feedstocks are best converted by biochemical means.
Thermophilic	Conditions in a biological reactor where temperatures are around 130° F (55° C) or higher.
Total Solids	Used to characterize digester systems input feedstock. Total solids (TS) means the dry matter content, usually expressed as % of total weight, of the prepared feedstock. By definition, TS = 100% – moisture content % of a sample. Also, TS = VS plus ash content.

Volatile organic compounds VOCs are non-methane, non-ethane, photoreactive hydrocarbon gases that vaporize at room temperature (methane and ethane are not photoreactive). The quantity of VOC is sometimes determined by measuring non-methane non-ethane organic compounds. When combined with NO_x and sunlight, VOCs produce ozone, a criteria air pollutant. Anthropogenic sources of VOCs include products of incomplete combustion, evaporation of hydrocarbon fuels, fugitive emissions from oil refineries and petro-chemical plants, fermented beverage manufacturing, large animal feeding operations and feed ensiling. However, natural VOC emissions account for the majority of VOC emissions (approximately 60% of the US VOC emission inventory). Vegetation, especially hardwood and pine trees account for most of the natural VOC emissions. They are also an intermediate product in the creation of methane during anaerobic digestion and are produced during enteric fermentation.

Volatile Solids Used to characterize digester systems input feedstock Volatile Solids (VS) are the organic (carbon containing) portion of the prepared reactor feedstock. Usually expressed as a fraction of total solids, but sometimes expressed as a fraction of total sample (wet) weight. The amount of VS in a sample is determined by an analytical method called “loss on ignition.” It is the amount of matter that is volatilized and burned from a sample exposed to air at 550 ºC for 2 hours. The inorganic (ash) component of total solids remains after the loss on ignition procedure. VS + ash = TS. Not all of the VS component of a feedstock is digestible.

Wheeling The process whereby owners of electricity or natural gas pay to transport and distribute their commodity through another entity’s, distribution system (wire or pipeline grid).