

**CONSIDERATION OF STAFF
RECOMMENDATION REGARDING
FINANCING PROJECTS USING NEW
BIOGAS CONVERSION TECHNOLOGY**
March 25, 2009

STAFF SUMMARY – CPCFA

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Issue. As a matter of policy, should the State allow tax-exempt bonds to be used for projects that use biomethane gas to produce renewable energy?

Background. In recent months there has been interest in using tax-exempt bonds to finance projects that use conversion technology to turn landfill gas (LFG) and Raw Anaerobic Digester Gas (DG) into renewable energy.

CPCFA has received two requests from BioFuels Energy, LLC. (the “Company”) to fund methane purification and compression sites in San Diego county. This review will cover technology used by both projects.

BioFuels Energy. BioFuels Energy, LLC. is a privately held corporation located in San Diego, California. BioFuels is currently developing renewable energy projects where it collects biomethane gas from landfills and waste water treatment facilities. The Company then purifies and condenses the biomethane and transports the product to customer locations. The biomethane product can be used in clean-burning fuel cells producing energy, input directly into existing power generation units and/or used as Compressed Natural Gas (CNG) to provide fuel for vehicles.¹

Otay Landfill project. The project will be constructed in Chula Vista on a ½ acre site at the Otay Landfill. The project will generate pollution control benefits by reducing Greenhouse Gas (GHG) emission’s and by reducing the amount of LFG flared at the Otay Landfill by 1.872 million standard cubic feet per day. The Company’s primary customer for this project will be the University of California, San Diego (UCSD). The Company is estimating delivery of 400,000 Million British Thermal Units per year which would equate to approximately 12% of the power generated on the UCSD campus. CNG from this project will also be used to be used to provide fuel for vehicles.

San Diego Point Loma Waste Water Treatment Facility Project. The project will be constructed in San Diego on a ½ acre site at the Point Loma Waste Water Treatment Facility. The project will generate pollution control benefits by reducing GHG emissions and by reducing the amount of DG flared at the Point Loma WWTF by 1.1 million standard cubic feet per day. This project will provide 2.8 Megawatts of power to UCSD and 1.4 Megawatts to the City of San Diego.

¹ BioFuels Energy, LLC. company description. Retrieved January 7, 2009 from www.biofuelsenergyllc.com/about_us.htm

California Greenhouse Gas Emission. In California, landfills are the number one anthropogenic source of methane, which has 21 to 23 times the global warming potential of carbon dioxide. The decomposition of organic waste generates gas consisting of approximately 50 % methane, 40 % carbon dioxide, 9% nitrogen and approximately 1% non-methane organic compounds. In 2004, landfill methane accounted for almost six percent of the total California GHG emissions, according to the California Energy Commission.²

In 2005, Governor Schwarzenegger issued Executive Order S-3-05 establishing a goal to reduce GHG emissions to 1990 levels by 2020 and to 80 percent below 1990 levels by 2050.³ In 2006, the passage of AB32 set the 2020 emissions goal into law and commissioned the California Air Resources Board (ARB) to develop a scoping plan for how California will achieve this emissions goal.

On June 21, 2007, the ARB adopted the Landfill Methane Capture Strategy as a discrete early-action measure. Accordingly, ARB staff, in collaboration with California Intergrated Waste Management Board (CIWMB) staff, developed a regulatory (mandatory) control measure to provide enhanced control of methane emissions from landfills. The control measure aimed to reduce methane emissions from landfills by requiring gas collection and control systems on landfills generating significant methane where these systems were not required and established statewide performance standards to maximize methane capture efficiencies.

The CIWMB retained SCS Engineers to develop a guidance document, Technologies and Management Options for Reducing Greenhouse Gas Emissions from Landfills, to help landfill operators and regulators evaluate potential actions to achieve additional GHG emission reductions from landfills beyond what are currently occurring with existing landfill practices. The SCS Engineers recommended anaerobic digestion as an effective way to reduce GHG emissions. They also identified hundreds of organic digestion facilities at landfills in other countries that mitigate the release of GHG emissions and produce electricity. The technology is well documented so others can learn from their implementation.⁴

Landfill Gas. Most landfill gas is produced by bacterial decomposition, which occurs when organic waste is broken down by bacteria naturally present in the waste and in the soil used to cover the landfill. Organic wastes include food, garden waste, street sweepings, textiles, and wood and paper products. Bacteria decompose organic waste in four phases and the composition of the gas changes during each phase.

The composition of the gas produced changes with each of the four phases of decomposition. Landfills often accept waste over a 20 to 30-year period, so waste in a landfill may be

² California Air Resources Board “Controlling Landfill Gas Workshop Notice” 24 September 2007.
<http://www.climatechange.ca.gov/events/2007-10-10_workshop/2007-10-10_WORKSHOP_NOTICE.PDF>
(19 February 2009)

³ Executive Order S-3-05, Governor Schwarzenegger, June 1, 2005

⁴ Climate Change and Solid Waste Management-Landfill Methane Capture Strategy (Revised 25 June 2008)
<<http://www.ciwmb.ca.gov/climate/Landfills/default.htm>> (13 February 2009)

undergoing several phases of decomposition at once. This means that older waste in one area might be in a different phase of decomposition than more recently buried waste in another area.

Phase I

During the first phase of decomposition, aerobic bacteria (bacteria that live only in the presence of oxygen) consume oxygen while breaking down the long molecular chains of complex carbohydrates, proteins, and lipids that comprise organic waste. The primary byproduct of this process is carbon dioxide. The nitrogen content is high at the beginning of this phase, but declines as the landfill moves through the four phases. Phase I continues until available oxygen is depleted. Phase I decomposition can last for days or months, depending on how much oxygen is present when the waste is disposed of in the landfill. Oxygen levels will vary according to factors such as how loose or compressed the waste was when it was buried.

Phase II

Phase II decomposition starts after the oxygen in the landfill has been used up. Using an anaerobic process (a process that does not require oxygen), bacteria convert compounds created by aerobic bacteria into acetic, lactic, and formic acids and alcohols such as methanol and ethanol. The landfill becomes highly acidic. As the acids mix with the moisture present in the land-fill, they cause certain nutrients to dissolve, making nitrogen and phosphorus available to the increasingly diverse species of bacteria in the landfill. The gaseous byproducts of these processes are carbon dioxide and hydrogen. If the landfill is disturbed or if oxygen is somehow introduced into the landfill, microbial processes will return to Phase I.

Phase III

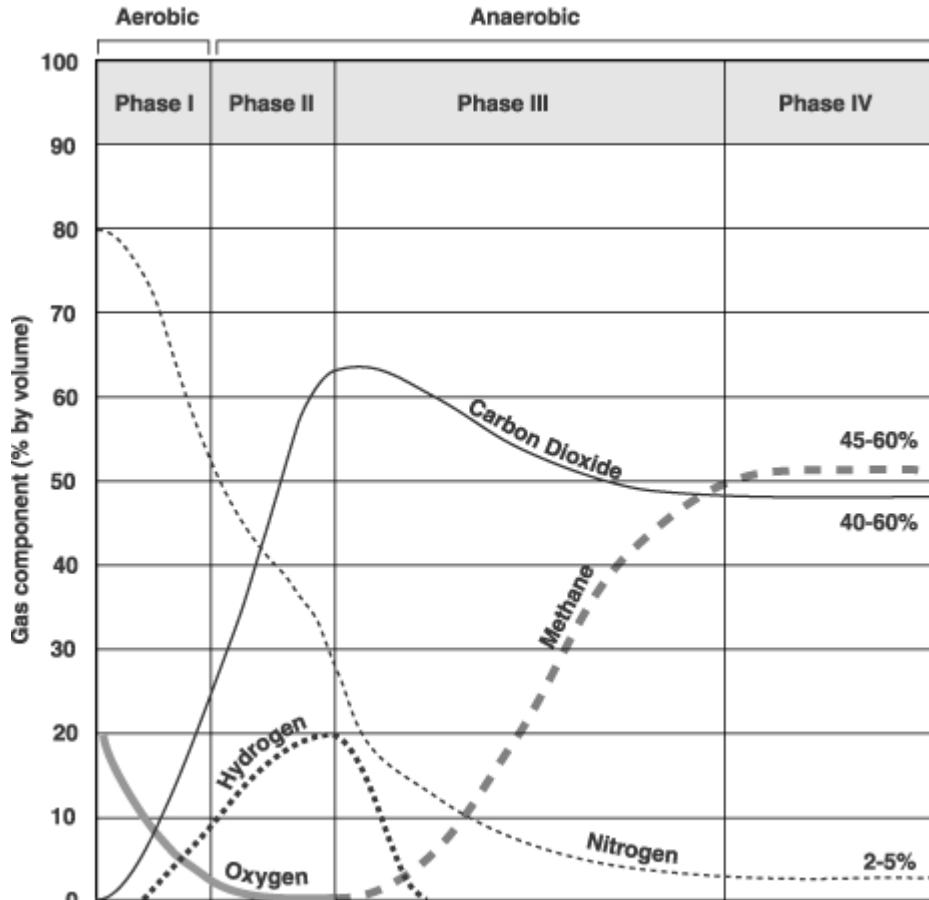
Phase III decomposition starts when certain kinds of anaerobic bacteria consume the organic acids produced in Phase II and form acetate, an organic acid. This process causes the landfill to become a more neutral environment in which methane-producing bacteria begin to establish themselves. Methane-and acid-producing bacteria have a symbiotic, or mutually beneficial, relationship. Acid-producing bacteria create compounds for the methanogenic bacteria to consume. Methanogenic bacteria consume the carbon dioxide and acetate, too much of which would be toxic to the acid-producing bacteria.

Phase IV

Phase IV decomposition begins when both the composition and production rates of landfill gas remain relatively constant. Phase IV landfill gas usually contains approximately 45% to 60% methane by volume, 40% to 60% carbon dioxide, and 2% to 9% other gases, such as sulfides. Gas is produced at a stable rate in Phase IV, typically for about 20 years; however, gas will continue to be emitted for 50 or more years after the waste is placed in the landfill (Crawford and Smith 1985). Gas production might last longer, for example, if greater amounts of organics are present in the waste, such as at a landfill receiving higher than average amounts of domestic animal waste.⁵

⁵ U.S. Agency for Toxic Substances and Disease Registry "Landfill Gas Primer-An Overview for Environmental Health Professionals; Landfill Gas Basics" November 2001
<<http://www.atsdr.cdc.gov/hac/landfill/html/ch2.html>> (8 January 2009)

The chart below shows LFG productions at the four stages:



Note: Phase duration time varies with landfill conditions

Source: EPA 1997

Landfill gas collection/Treatment. Landfill gas can be collected by either a passive or an active collection system. A typical collection system, either passive or active, is composed of a series of gas collection wells placed throughout the landfill. Passive gas collection systems use existing variations in landfill pressure and gas concentrations to vent landfill gas into the atmosphere or a control system. Active gas collection systems include vacuums or pumps to move gas out of the landfill. Piping connects the collection wells to the vacuum. Vacuums or pumps pull gas from the landfill by creating low pressure within the gas collection wells. The low pressure in the wells creates a preferred migration pathway for the landfill gas.

Common methods to treat landfill gas include combustion and noncombustion technologies, as well as odor control technologies. Combustion is the most common technique for controlling and treating landfill gas. Combustion technologies such as flares, incinerators, boilers, gas turbines, and internal combustion engines thermally destroy the compounds in landfill gas. Over 98% destruction of organic compounds is typically achieved. Methane is converted to carbon dioxide, resulting in a large greenhouse gas impact reduction. Noncombustion technologies were

developed in the 1990s as an alternative to combustion, which produces compounds that contribute to smog, including nitrogen oxides, sulfur oxides, carbon monoxide, and particulate matter. Noncombustion technologies fall into two groups: energy recovery technologies and gas-to-product conversion technologies. Odor control technologies prevent odor-causing gases from leaving the landfill. Installing a landfill cover will prevent odors from newly deposited waste or from gases produced during bacterial decomposition.⁶

Wastewater Treatment and Methane. Wastewater treatment processes can produce anthropogenic methane emissions. Wastewater from domestic (municipal sewage) and industrial sources is treated to remove soluble organic matter, suspended solids, pathogenic organisms, and chemical contaminants. Treatment may either occur on site, most commonly through septic systems or package plants, or off site at centralized treatment systems. Centralized wastewater treatment systems may include a variety of processes, ranging from lagooning to advanced tertiary treatment technology for removing nutrients. In the United States, approximately 21% of domestic wastewater is treated in septic systems or other on-site systems, while the rest is collected and treated centrally.

Soluble organic matter is generally removed using biological processes in which microorganisms consume the organic matter for maintenance and growth. The resulting biomass (sludge) is removed from the effluent prior to discharge to the receiving stream. Microorganisms can biodegrade soluble organic material in wastewater under aerobic or anaerobic conditions, where the latter condition produces methane emissions. During collection and treatment, wastewater may be accidentally or deliberately managed under anaerobic conditions. In addition, the sludge may be further biodegraded under aerobic or anaerobic conditions.

The principal factor in determining the methane generation potential of wastewater is the amount of degradable organic material in the wastewater. Common parameters used to measure the organic component of the wastewater are the Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). Under the same conditions, wastewater with higher COD (or BOD) concentrations will generally yield more methane than wastewater with lower COD (or BOD) concentrations. BOD represents the amount of oxygen that would be required to completely consume the organic matter contained in the wastewater through aerobic decomposition processes, while COD measures the total material available for chemical oxidation (both biodegradable and non-biodegradable). Because BOD is an aerobic parameter, it is preferable to use COD to estimate Methane production.

In 2006, Methane emissions from domestic wastewater treatment were 16.0 teragrams of carbon dioxide equivalent (Tg CO₂ Eq.) Emissions gradually increased from 1990 through 1997, but have decreased since 1998 due to decreasing percentages of wastewater being treated in anaerobic systems, including reduced use of on-site septic systems and central anaerobic treatment systems. In 2006, Methane emissions from industrial wastewater treatment were estimated to be 7.9 Tg CO₂ Eq. Industrial emission sources have increased across the time series through 1999 and then fluctuated up and down in keeping with production changes associated

⁶ U.S. Agency for Toxic Substances and Disease Registry “Landfill Gas Primer-An Overview for Environmental Health Professionals Landfill Control Measures” November 2001
<<http://www.atsdr.cdc.gov/hac/landfill/html/ch5.html>> (8 February 2009)

with the treatment of wastewater from the pulp and paper manufacturing, meat and poultry processing, fruit and vegetable processing, and starch-based ethanol production industries. The table below provides Methane emission estimates from domestic and industrial wastewater treatment.⁷

Methane Emissions from Domestic and Industrial Wastewater Treatment (Tg CO ₂ Eq.)									
Activity	1990	1995	2000	2001	2002	2003	2004	2005	2006
Methane	23.0	24.3	24.6	24.2	24.1	23.9	24.0	23.8	23.9
Domestic	16.4	16.9	16.8	16.6	16.5	16.4	16.3	16.2	16.0
Industrial	6.6	7.4	7.8	7.5	7.6	7.6	7.7	7.6	7.9
Total	29.3	31.2	32.2	32.0	31.7	31.6	31.8	31.8	32.0

Technology. *Biogas Purification and Compression.* The Biogas for both projects will be drawn from the methane gas collection unit using a vacuum. Pressure will be increased to 6 pound-force per square inch gauge (psig) using centrifugal blowers. The Biogas will be cooled in an air to LFG heat exchanger. The Biogas will then be compressed to 205 psig, then chilled to 40 degrees F and reheated to 70 degrees F to reduce the relative humidity.

Below is a picture of a landfill gas clean-up skid:



The compressed Biogas will then be treated with non-regenerative media to remove Sulfur, Siloxanes and Non-Methane Organic Compounds. The purified Biogas will flow to a two-stage, membrane-based Carbon Dioxide separation skid. After the biogas has moved through the Carbon Dioxide Separation Skid it is known as Compressed Natural Gas I (CNG I). Some of the CNG I will then flow to a molecular sieve (pressure swing absorption skid). The molecular sieve will remove Nitrogen and will produce a gas known as CNG II. The CNG I will be compressed to 2,400 psig in preparation for transportation.

⁷ U.S. Environmental Protection Agency “Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006” 15 April 2008 <http://epa.gov/climatechange/emissions/downloads/08_Waste.pdf> (13 February 2009)

The end result will be renewable energy which will displace fossil fuels. CNG I will be used as electricity and CNG II will be used as vehicle fuel. See the composition of the biogas from each project below:

Otay Landfill project.

	Original Landfill Gas	CNG I	CNG II
Methane	47.0%	74.1%	95.7%
Carbon Dioxide	37.0%	1.0%	0.0%
Nitrogen	14.5%	23.8%	4.0%
Oxygen	<u>1.5%</u>	<u>1.1%</u>	<u>0.3%</u>
	<u>100%</u>	<u>100%</u>	<u>100%</u>

San Diego Point Loma Waste Water Treatment Facility Project.

	Original Digester Gas	CNG I
Methane	61.80%	85.0%
Carbon Dioxide	38.10%	15.0%
Nitrogen	0.05%	0.0%
Oxygen	<u>0.05%</u>	<u>0.0%</u>
	<u>100%</u>	<u>100%</u>

CPCFA Statutory Authority. In general, CPCFA’s statute permits financing of projects related to resource recovery and/or to reduce environmental pollution. Health & Safety Code Sections 44508(a), 44511, 44535 (a), 44535 (b), 44535 (c), 44536 read, in part:

44508. (a) "Project" and "pollution control facility", respectively, mean any land, building, improvement thereto, work, property or structure, real or personal, providing or designed to provide for the control, reduction, abatement, elimination, remediation, or prevention of pollution, including, but not limited to, hydrostatic control facilities, dust collectors, smoke bags, construction, operation, and maintenance of systems that extract, contain, or treat groundwater, soil vapor, gas, or leachate, and all other structures, systems, or facilities now or hereafter developed or useful in the control of pollution of any type or character, including any structure, equipment, or other facilities for the purpose of the purchase, production, distribution, or sale of water, or of reducing, treating, neutralizing, or cooling the temperature of any liquid, gaseous, or solid or hazardous waste substance or discharge resulting from the process of manufacture, industry, or commerce,

44511. "Renewable energy resource device" means any device, or any combination of devices, which produces heat, process heat, space heating, water heating, steam, space cooling, refrigeration, mechanical energy, electricity, or energy in any form convertible to such uses, which do not expend or use fossil or nuclear fuels except when used for pumps, fans, or other minor controls.

Agenda Item - 4.A.

44535 (a) The authority may separately approve financing for projects, the purpose of which is to prevent, remediate, or reduce environmental pollution resulting from the disposal of solid, hazardous, or liquid waste.

44535 (b) The following projects shall be considered for financing: . (2) Projects utilizing new technologies or processes for resource recovery or energy conversion.

44535 (c) The projects specified in subdivision (b) may include elements that provide for new refuse removal vehicles, transfer stations, resource recovery or energy conversion plants, source separation, or any solid or liquid waste disposal facilities involved in resource recovery systems. "Solid, hazardous, or liquid waste disposal facilities" means any property, or portion thereof, used for the collection, storage, treatment, utilization, processing, or final disposal of solid, hazardous, or liquid waste in resource recovery systems.

Recommendation. Staff finds that there is evidence of pollution control benefits to be derived from tax-exempt financing of qualifying projects using LFG and DG to produce renewable energy. Therefore, staff recommends that the CPCFA Board direct staff to consider applications for tax-exempt financing of renewable energy using LFG and DG; to evaluate each application on its individual merits. Staff acknowledges that applications for Biogas conversion projects will be evaluated on their individual, public and pollution control benefits (including climate change, air quality and water quality), financing structure, and legal status. Applications for Biogas conversion projects will be subject to the same degree of scrutiny by staff and by counsel, and subject to the same standards of documentation, as other applications received.