CALIFORNIA AIR RESOURCES BOARD

LCFS Sustainability Workgroup Meeting
January 20, 2011

Stationary Source Emission Limit and Mobile Mitigation Measures Tables
Excerpted from Draft Air Quality Guidance for Siting Biorefineries in California (October 2010)

Tables from Draft Guidance Executive Summary

Tables ES-1, ES-2, and ES-3 below summarize the most stringent permitted emission limits ARB staff identified for stationary source process equipment commonly used at biorefineries.

Table ES-1. Most Stringent Emission Limits Identified for Process Equipment at Biorefineries – Evaporative Loss Sources

Class/Category of Source	NO_x	CO	VOC	SO_x	PM10
Methanol / Sodium Methoxide receiving and storage			Emission limit corresponding to use of a VOC control system capable of 99.5% or better control efficiency		
Fermentation process: yeast, liquefaction, beerwell, and process condensate tanks			Emission limit corresponding to use of a VOC control system capable of 99.5% or better control efficiency		
Distillation and wet cake processes			Emission limit corresponding to use of a VOC control system (wet scrubber or equivalent) capable of 95% or better control efficiency		
Pumps and compressor seals			No leak of methane greater than 100 ppm above background and inspection and maintenance program		
Valves, flanges, and other types of connectors			No leak of methane greater than 100 ppm above background and inspection and maintenance program		
Storage tank (fixed roof)			Emission limit corresponding to use of a VOC		

Table ES-1. Most Stringent Emission Limits Identified for Process Equipment at Biorefineries – Evaporative Loss Sources

Class/Category of Source	NO_x	CO	VOC	SO_x	PM10
			control system capable of 99.5% or better control efficiency		
Storage tank (floating roof)			Emission limit corresponding to use of a VOC control system capable of 98% or better control efficiency		
Liquid fuel loading operations			Emission limit corresponding to use of a VOC control system capable of 98% or better control efficiency		
Liquid fuel transfer and dispensing operations			Emission limit corresponding to use of an ARB certified Phase I vapor recovery system		

Table ES-2. Most Stringent Emission Limits Identified for Process Equipment at Biorefineries – Combustion Sources

Class/Category of Source	NO_x	CO	VOC	SO_x	PM10
Natural gas-fired boiler, ≥2 to <5 MMBtu/hr	Non-atmospheric units: 9 ppmvd @ 3% O_2 (0.011 lb/MMBtu) Atmospheric units: 12 ppmvd @ 3% O_2 (0.015 lb/MMBtu)	Firetube type: 50 ppmvd @ 3% O_2 Watertube type: 100 ppmvd @ 3% O_2	Emission limit corresponding to use of natural gas with fuel sulfur content of no more than 1 gr/100 scf	Emission limit corresponding to use of natural gas with fuel sulfur content of no more than 1 gr/100 scf	Emission limit corresponding to use of natural gas with fuel sulfur content of no more than 1 gr/100 scf
Natural gas-fired boiler, ≥5 to <20 MMBtu/hr	6 ppmvd @ 3% O_2 (0.007 lb/MMBtu)	Firetube type: ≤50 ppmvd @ 3% O_2 Watertube type: ≤100 ppmvd @ 3% O_2	Emission limit corresponding to use of natural gas with fuel sulfur content of no more than 1 gr/100 scf	Emission limit corresponding to use of natural gas with fuel sulfur content of no more than 1 gr/100 scf	Emission limit corresponding to use of natural gas with fuel sulfur content of no more than 1 gr/100 scf

Table ES-2. Most Stringent Emission Limits Identified for Process Equipment at Biorefineries – Combustion Sources

Class/Category of Source	NO_x	CO	VOC	SO_x	PM10
Natural gas-fired boiler, ≥20 MMBtu/hr	5 ppmvd @ 3% O_2 (0.0062 lb/MMBtu)	Firetube type: ≤50 ppmvd @ 3% O_2 Watertube type: ≤100 ppmvd @ 3% O_2 For units ≥250 MMBtu/hr[1]: 10 ppmvd @ 3% O_2	Emission limit corresponding to use of natural gas with fuel sulfur content of no more than 1 gr/100 scf	Emission limit corresponding to use of natural gas with fuel sulfur content of no more than 1 gr/100 scf	Emission limit corresponding to use of natural gas with fuel sulfur content of no more than 1 gr/100 scf
Natural gas-fired dryer	0.018 lb/MMBtu (15 ppmv @ 3% O_2)	0.07 lb/MMBtu	Emission limit corresponding to use of a VOC capture and control with thermal or catalytic incineration (98% control) or equivalent	Emission limit corresponding to use of a wet scrubber (95% control)	Emission limit corresponding to use of high efficiency (1D-3D) cyclones and thermal incinerator in series (98.5% control) or equivalent
Flare (ethanol production)	0.05 lb/MMBtu	0.37 lb/MMBtu	0.063 lb/MMBtu	0.00285 lb/MMBtu	0.008 lb/MMBtu
Biomass-fired boiler	0.012 lb/MMBtu (*9 ppmvd @ 3% O_2*)	0.046 lb/MMBtu (*59 ppmvd @ 3% O_2*) Alternate Limit: 0.01 lb/MMBtu (*22 ppmvd @ 3% O_2*)	0.005 lb/MMBtu (*11 ppmvd @ 3% O_2*)	0.012 lb/MMBtu (*7 ppmvd @ 3% O_2*)	0.024 lb/MMBtu (*0.01 gr/scf @ 12% CO_2*)
Landfill gas-fired flare	0.025 lb/MMBtu	0.06 lb/MMBtu	Emission limit corresponding to 98% VOC destruction efficiency or 20 ppmv @ 3% O_2	Emission limit corresponding to use of a wet scrubber with 98% control efficiency	Emission limit corresponding to use of steam injection and/or knockout vessel
Manure digester and co-digester gas-fired flare	0.03 lb/MMBtu (*25 ppmvd @ 3% O_2*)	Operate per manufacturer specifications to minimize CO	0.03 lb/MMBtu	Emission limit corresponding to use of a H_2S removal system (dry or wet scrubber or equivalent)	Emission limit corresponding to use of smokeless combustion and LPG or natural gas-fired pilot
Biogas-fired microturbine	0.5 lb/MWh	6.0 lb/MWh	1.0 lb/MWh	N/A	N/A

[1] This CO limit may be required for boilers rated at <250 MMBtu/hr if an oxidation catalyst is found to be cost effective, is necessary to meet toxic best available control technology, or for VOC emission control.

Table ES-2. Most Stringent Emission Limits Identified for Process Equipment at Biorefineries – Combustion Sources

Class/Category of Source	NO_x	CO	VOC	SO_x	PM10
	As of 1/1/2013: 0.07 lb/MWh	As of 1/1/2013: 0.10 lb/MWh	As of 1/1/2013: 0.02 lb/MWh		
Biogas-fired reciprocating internal combustion engine	11 ppmvd @ 15% O_2 (or 0.15 g/bhp-hr) in conjunction with an effective and efficient biogas treatment system Alternate Limit for dairy digester gas-fired rich-burn engines: 9 ppmvd @ 15% O_2 (or 0.15 g/bhp-hr)	250 ppmvd @ 15% O_2	20 ppmvd @ 15% O_2	Emission limit corresponding to use of a fuel gas pretreatment system for sulfur removal along with maximum fuel sulfur content limit	0.1 g/bhp-hr
Biogas-fired turbine, <3 MW	9 ppmvd @ 15% O_2	60 ppmvd @ 15% O_2	3.5 ppmvd @ 15% O_2[2]	Landfill gas: Emission limit corresponding to use of landfill gas with sulfur content of no more than 150 ppmv as H_2S Digester gas: Emission limit corresponding to use of digester gas with sulfur content of no more than 40 ppmv as H_2S	Emission limit corresponding to use of a fuel gas pretreatment system for particulate removal
Biogas-fired turbine, ≥3 MW	5 ppmvd @ 15% O_2				
Biomass syngas-fueled reciprocating internal combustion engine	5 ppmvd @ 15% O_2	N/A	25 ppmvd @ 15% O_2	N/A	N/A
Diesel-fueled emergency engine generator	Cleanest available U.S. EPA Tier certification level for applicable horsepower range[3]	Cleanest available U.S. EPA Tier certification level for applicable horsepower range	Cleanest available U.S. EPA Tier certification level for applicable horsepower range	Emission limit corresponding to use of CARB, or very low sulfur, diesel fuel (15 ppm sulfur by weight)	Cleanest available U.S. EPA Tier certification level for applicable horsepower range

[2] Due to limited data set available for this Report on achievable VOC emission levels for landfill and digester gas-fired turbines, ARB staff recommends that regulatory agencies consult with the manufacturers on guaranteed emission levels, as well as, evaluate additional source tests to determine the appropriate VOC limit for a turbine.

[3] Refer to U.S. EPA regulations and/or Appendix D Table D-29 of this Report for the applicable emission standard.

Table ES-3. Most Stringent Emission Limits Identified for Process Equipment at Biorefineries – Miscellaneous Sources

Class/Category of Source	NO_x	CO	VOC	SO_x	PM10
Grain receiving, conveying, and grinding operations					Emission limit corresponding to use of a baghouse with 99% control, or equivalent
Wet cooling tower					Emission limit corresponding to use of a drift eliminator with 0.0005% drift loss
Compressed gas dispensing operations	No emissions – use of closed loop system with all vent and excess process gas directed to an on site treatment system, used in vehicles, or directed to another combustion or processing facility that can process the biogas and which has been issued a valid air permit				
Biomethane-fueled fuel cell[4]	0.5 lb/MWh Alternate Limit: 0.07 lb/MWh	6.0 lb/MWh Alternate Limit: 0.10 lb/MWh	1.0 lb/MWh Alternate Limit: 0.02 lb/MWh	N/A	N/A
Composting			Emission limit corresponding to use of a VOC control system (enclosure with biofilter or equivalent) capable of 80% or better control efficiency Ammonia: Emission limit corresponding to use of an NH3 control system capable of 80% or better control efficiency		Emission limit corresponding to use of a PM10 control system capable of 99% or better control efficiency

[4] Emission limits are the 2008 standards for waste gas required by the ARB's Distribution Generation (DG) Certification Regulation. Alternate limits represent the 2013 standards for waste gas required by the DG Certification Regulation.

Tables from Draft Guidance Appendix D: Supporting Data for Most Stringent Emission Limits Identified for Stationary Source Process Equipment Used at Biorefineries

Tables D-5, D-6, D-7, D-22, D-23, and D-24 below contain the data set used by ARB staff to identify the lowest permitted emission limits for boilers and select generating equipment used at biorefineries. These tables are excerpted from Appendix D in the Draft Guidance. The entirety of Appendix D contains 29 data tables corresponding to 28 separate source categories of equipment identified by ARB staff. A few equipment categories have been highlighted for purposes of this Sustainability Workgroup meeting so stakeholders can get a sense of the type of information included in the guidance report. Stakeholders are encouraged to access the Draft Guidance on the Internet to view the entire data set used to develop the emission limits in Tables ES-1, ES-2, and ES-3.

Table D-5. Natural Gas-Fired Boiler

Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
1	SJVAPCD Rule 4307 Boilers, Steam Generators, and Process Heaters – 2.0 MMBtu/hr to 5.0 MMBtu/hr	Units 2.0 MMBtu/hr to ≤5.0 MMBtu/hr		Rule	Last amended 10/16/2008	Atmospheric units: 12 ppmvd @ 3% O_2 or 0.014 lb/MMBtu Non-atmospheric units: 9 ppmvd @ 3% O_2 or 0.011 lb/MMBtu	400 ppmvd @ 3% O_2 *(0.296 lb/MMBtu)*	N/A	N/A	N/A
2	SCAQMD Rule 1146.1 Emissions of Oxides of Nitrogen from Small Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters	Units >2 MMBtu/hr to <5 MMBtu/hr		Rule	Last amended 9/5/2008	Atmospheric units: 12 ppm @ 3% O_2 or 0.015 lb/MMBtu Non-atmospheric units: 9 ppmvd @ 3% O_2 or 0.011	N/A	N/A	N/A	N/A

Table D-5. Natural Gas-Fired Boiler

Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
						lb/MMBtu				
3	La Paloma Generating Company, LLC; McKittrick, CA	6.2 MMBtu/hr natural gas boiler	Low NOx burner	BACT (AIP)	3/24/2000	12 ppmv @ 3% O_2 *(0.0146 lb/MMBtu)*	50 ppmv @ 3% O_2 *(0.037 lb/MMBtu)*	30 ppmv @ 3% O_2 *(0.0127 lb/MMBtu)*	N/A	0.007 lb/MMBtu
4	SJVAPCD Rule 4306 Boilers, Steam Generators, and Process Heaters – Phase 3	Units >5 MMBtu/hr to ≤20.0 MMBtu/hr (non-refinery units, non-load following units, units not subject to fuel use restriction)		Rule	Last amended 10/16/2008	Standard Option: 15 ppmvd @ 3% O_2 or 0.018 lb/MMBtu Enhanced Option: 9 ppmvd @ 3% O_2 or 0.011 lb/MMBtu	400 ppmvd @ 3% O_2 *(0.296 lb/MMBtu)*	N/A	N/A	N/A
5	SCAQMD BACT Guidelines – Part D	<20 MMBtu/hr natural gas or propane fired boiler	Ultra low NOx burner, or equal	BACT	10/20/2000 (NOx, SOx), 4/10/1998 (CO, PM10)	≤12 ppmvd @ 3% O_2 *(0.015 lb/MMBtu)*	Firetube type: ≤50 ppmvd @ 3% O_2 *(0.037 lb/MMBtu)* Watertube type: ≤100 ppmvd @ 3% O_2 *(0.074 lb/MMBtu)*	N/A	Natural gas	Natural gas
6	BAAQMD Regulation 9 Rule 7 NOx and CO from Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters	20 MMBtu/hr to <75 MMBtu/hr gaseous fuel-fired boiler		Rule	Last amended 7/30/2008	9 ppmvd @ 3% O_2 *(0.011 lb/MMBtu)*	400 ppmvd @ 3% O_2 *(0.296 lb/MMBtu)*	N/A	N/A	N/A

Table D-5. Natural Gas-Fired Boiler										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
7	SJVAPCD Rule 4306 Boilers, Steam Generators, and Process Heaters – Phase 3	Units >20.0 MMBtu/hr (non-refinery units, non-load following units, units not subject to fuel use restriction)		Rule	Last amended 10/16/2008	Standard Option: 9 ppmvd @ 3% O_2 or 0.011 lb/MMBtu Enhanced Option: 6 ppmvd @ 3% O_2 or 0.007 lb/MMBtu	400 ppmvd @ 3% O_2 *(0.296 lb/MMBtu)*	N/A	N/A	N/A
8	SCAQMD BACT Guidelines – Part D	≥20 MMBtu/hr natural gas or propane fired boiler	Ultra low NOx burner or equal; SCR or equal	BACT	10/20/2000 (NOx, SOx), 4/10/1998 (CO, PM10)	With low NOx burner: ≤9 ppmvd @ 3% O_2 *(0.011 lb/MMBtu)* With add-on controls: ≤7 ppmvd @ 3% O_2 *(0.009 lb/MMBtu)* NH_3: ≤5 ppmvd @ 3% O_2	Firetube type: ≤50 ppmvd @ 3% O_2 *(0.037 lb/MMBtu)* Watertube type: ≤100 ppmvd @ 3% O_2 *(0.074 lb/MMBtu)*	N/A	Natural gas	Natural gas
9	SJVAPCD (Facility unknown)	>20 MMBtu/hr natural gas fired boiler	Ultra low NOx burner or equal	BACT (AIP)	6/30/1999	9 ppmv @ 3% O_2 or 0.0108 lb/MMBtu	N/A	N/A	N/A	N/A

Table D-5. Natural Gas-Fired Boiler										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
10	SJVAPCD (Facility unknown)	≥5 MMBtu/hr steam generator		BACT (AIP)	5/24/2004	14 ppmv @ 3% O_2 *(0.017 lb/MMBtu)*	50 ppmv @ 3% O_2 *(0.037 lb/MMBtu)*	Gaseous fuels	Natural gas, LPG, waste gas treated to remove 95% by weight of sulfur compounds or treated such that the sulfur content does not exceed 1 gr/100 scf, or use of a continuously operating SO_2 scrubber and either achieving 95% by weight control of sulfur compounds or achieving an emission rate of 30 ppmvd SO_2 at stack O_2	Natural gas, LPG, waste gas treated to remove 95% by weight of sulfur compounds or treated such that the sulfur content does not exceed 1 gr/100 scf, or use of a continuously operating SO_2 scrubber and either achieving 95% by weight control of sulfur compounds or achieving an emission rate of 30 ppmvd SO_2 at stack O_2

Table D-5. Natural Gas-Fired Boiler										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
11	BAAQMD BACT Guideline 17.3.1	≥50 MMBtu/hr	Ultra low NOx burner + FGR, good combustion practice	BACT (AIP)	9/22/2005	9 ppmvd @ 3% O_2 *(0.011 lb/MMBtu)*	50 ppmv @ 3% O_2 *(0.037 lb/MMBtu)*	N/A	Natural gas or treated refinery gas fuel w/ <100 ppmv total reduced sulfur	Natural gas or treated refinery gas fuel
			SCR + low NOx burners + FGR, oxidation catalyst	BACT (tech. feasible)		7 ppmvd @ 3% O_2 *(0.009 lb/MMBtu)*	For units ≥250 MMBtu/hr: 10 ppmvd @ 3% O_2[5] *(0.007 lb/MMBtu)*		Natural gas or treated refinery gas fuel w/ <50 ppmv H_2S and <100 ppmv total reduced sulfur	
12	SCAQMD Rule 1146 Emissions of Oxides of Nitrogen from Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters	Units ≥5 MMBtu/hr (excluding electric utility boilers, >40 MMBtu/hr boilers and process heaters used in petroleum refineries, sulfur plant reaction boilers)		Rule	Last amended 9/5/2008	≥5 to <75 MMBtu/hr: 9 ppm @ 3% O_2 or 0.011 lb/MMBtu ≥75 MMBtu/hr: 5 ppm @ 3% O_2 or 0.0062 lb/MMBtu	N/A	N/A	N/A	N/A
13	CalResources; Western Kern County Oil Fields, CA	62.5 MMBtu/hr natural gas boiler	FGR and O_2 controller	BACT (AIP)	11/30/1993	0.036 lb/MMBtu *(30 ppmvd @ 3% O_2)*	0.02 lb/MMBtu *(27 ppmvd @ 3% O_2)*	0.003 lb/MMBtu *(7 ppmvd @ 3% O_2)*	0.0006 lb/MMBtu	0.005 lb/MMBtu

[5] CO limit does not apply to boilers smaller than 250 MMBtu/hr unless an oxidation catalyst is found to be cost effective or is necessary for TBACT or VOC control.

Table D-5. Natural Gas-Fired Boiler										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
14	BAAQMD Regulation 9 Rule 7 NOx and CO from Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters	≥75 MMBtu/hr gaseous fuel-fired boiler		Rule	Last amended 7/30/2008	5 ppmvd @ 3% O_2 *(0.006 lb/MMBtu)*	400 ppmvd @ 3% O_2 *(0.296 lb/MMBtu)*	N/A	N/A	N/A
15	Berry Petroleum; Heavy Oil Central, SJVAPCD, CA	84 MMBtu/hr boiler	SCR, low NOx burner	BACT (AIP): SOx, PM10, VOC BACT (tech. feasible): NOx	3/11/2005	With SCR: 7 ppmvd @ 3% O_2 *(0.009 lb/MMBtu)*; With low NOx burner: 9 ppmvd @ 3% O_2 *(0.0109 lb/MMBtu)*	N/A	Natural gas, treated waste gas or recovered gas as a primary fuel. LPG as backup fuel	Natural gas, treated waste gas or recovered gas as a primary fuel. LPG as backup fuel	Natural gas, treated waste gas or recovered gas as a primary fuel. LPG as backup fuel
16	Genentech, Inc.; San Mateo, CA	97 MMBtu/hr Nebraska Model NS-E-64-ST-CA-HM-AL natural gas watertube boiler	Ultra low NOx burner	BACT	9/27/2005 (startup: 6/14/2006)	9 ppmvd @ 3% O_2 *(0.011 lb/MMBtu)*	50 ppmv @ 3% O_2 *(0.037 lb/MMBtu)*	N/A	N/A	N/A
17	AES Huntington Beach; Huntington Beach, CA	2,088 MMBtu/hr natural gas boiler	Low NOx burners, FGR, SCR, oxidation catalyst	BACT (AIP)	2/1/2006	5 ppmvd @ 3% O_2 *(0.006 lb/MMBtu)*	5 ppmvd @ 3% O_2 *(0.004 lb/MMBtu)*	1354 lb/mo	0.2 lb/MMBtu *(120 ppmvd @ 3% O_2)*	0.01 gr/scf @ 12% CO_2

Table D-5. Natural Gas-Fired Boiler										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
18	SJVAPCD Rule 4320 Advanced Emission Reduction Options for Boilers, Steam Generators, and Process Heaters with a Total Rated Heat Input Greater than 5.0 MMBtu/hr	Units >5.0 to ≤20.0 MMBtu/hr[6] Units >20.0 MMBtu/hr		Rule	10/16/2008	Standard Schedule: 9 ppmvd @ 3% O_2 or 0.011 lb/MMBtu Enhanced Schedule: 6 ppmvd @ 3% O_2 or 0.007 lb/MMBtu Standard Schedule: 7 ppmvd @ 3% O_2 or 0.008 lb/MMBtu Enhanced Schedule: 5 ppmvd @ 3% O_2 or 0.0062 lb/MMBtu	400 ppmvd @ 3% O_2 *(0.296 lb/MMBtu)*	N/A	N/A	N/A

[6] The NOx limits listed here do not apply to oilfield steam generators, refinery units, units with fuel use restrictions, units at wastewater treatment facilities firing on <50% by volume PUC quality gas, and units operated by a small producer where each burner <5 MMBtu/hr but the total rating is 5-20 MMBtu/hr. See rule for additional restrictions.

Table D-6. Biomass-Fired Boiler

Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
1	Musco Olive Products; Tracy, CA	25 MMBtu/hr combined Solar Technologies Model Steamboy fluidized bed boiler producing 3 MW	FGR, SCR, catalyst PM control system (cyclone or in-line bag filter upstream of SCR), baghouse	Authority to Construct	10/2/2009	17.5 ppmvd @ 3% O_2 (*0.023 lb/MMBtu)* NH_3 slip: 10 ppmvd @ 3% O_2	183 ppmvd @ 3% O_2 (*0.144 lb/MMBtu)*	0.02 lb/MMBtu *(45 ppm @ 3% O_2)*	23 ppmvd @ 3% O_2 (*0.041 lb/MMBtu)*	0.045 lb/MMBtu *(0.002 gr/scf @ 12% CO_2)*
2	Massachusetts Department of Environmental Protection BACT Guidance for Biomass Projects	Solid biomass fuel-fired steam electric generating units, ≥1 to <10 MW		BACT (AIP)	4/18/2007[7]	0.093 lb/MMBtu *(72 ppm @ 3% O_2)* NH_3 slip: 25 ppm @ 3% O_2	0.25 lb/MMBtu *(320 ppm @ 3% O_2)*	0.01 lb/MMBtu *(22 ppm @ 3% O_2)*	0.025 lb/MMBtu *(14 ppm @ 3% O_2)*	Filterable: 0.012 lb/MMBtu *(0.006 gr/scf @ 12% CO_2)*
				BACT (tech. feasible)		0.093 lb/MMBtu *(72 ppm @ 3% O_2)* NH_3 slip: 10 ppm @ 3% O_2	0.25 lb/MMBtu *(320 ppm @ 3% O_2)*	0.01 lb/MMBtu *(22 ppm @ 3% O_2)*	0.02 lb/MMBtu *(11 ppm @ 3% O_2)*	Filterable: 0.012 lb/MMBtu *(0.006 gr/scf @ 12% CO_2)*

[7] The guidance indicates it expired on December 31, 2009, and prior to expiration, MassDEP would review its experience with the guidance and initiate a public discussion to determine next steps, such as affirming and/or revising the guidance, or proposing regulations to codify biomass performance standards. According to MassDEP staff, other matters have taken precedence and the public process to update or revise the guidance has not been initiated. However, the guidance is still valid and continues to be available to the public on the MassDEP website at: http://www.mass.gov/dep/air/laws/policies.htm.

Table D-6. Biomass-Fired Boiler										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
3	Rio Bravo; Fresno, CA	352 MMBtu/hr circulating fluidized bed boiler with steam turbine producing 24.3 MW	SNCR, ESP	Permit	2009	0.08 lb/MMBtu (*62 ppmvd @ 3% O_2)*; 27.5 lb/hr	22.0 lb/hr; 0.06 lb/MMBtu ; 400 ppmv @ 3% O_2; 310 ppmv @ 12% CO_2 and 7% O_2	10.4 lb/hr; 0.03 lb/MMBtu	10.0 lb/hr; 0.2% by volume	Filterable: 0.01 gr/dscf @ 12% CO_2; 5.8 lb/hr, 0.02 lb/MMBtu Condensable : 17.4 lb/hr; 0.05 lb/MMBtu
4	Massachusetts Department of Environmental Protection BACT Guidance for Biomass Projects	Solid biomass fuel-fired steam electric generating units, ≥10 to <25 MW		BACT (AIP)	4/18/2007	0.075 lb/MMBtu *(58 ppm @ 3% O_2)* NH_3 slip: 13 ppm @ 3% O_2	0.17 lb/MMBtu *(220 ppm @ 3% O_2)*	0.01 lb/MMBtu *(22 ppm @ 3% O_2)*	0.025 lb/MMBtu *(14 ppm @ 3% O_2)*	Filterable: 0.012 lb/MMBtu *(0.006 gr/scf @ 12% CO_2)*
				BACT (tech. feasible)		0.015 lb/MMBtu *(12 ppm @ 3% O_2)* NH_3 slip: 2 ppm @ 3% O_2	0.01 lb/MMBtu *(13 ppm @ 3% O_2)*	0.01 lb/MMBtu *(22 ppm @ 3% O_2)*	0.02 lb/MMBtu *(11 ppm @ 3% O_2)*	Filterable: 0.012 lb/MMBtu *(0.006 gr/scf @ 12% CO_2)*

Table D-6. Biomass-Fired Boiler										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
5	Massachusetts Department of Environmental Protection BACT Guidance for Biomass Projects	Solid biomass fuel-fired steam electric generating units, ≥25 MW		BACT (AIP)	4/18/2007	0.075 lb/MMBtu *(58 ppm @ 3% O_2)* NH_3 slip: 13 ppm @ 3% O_2	0.1 lb/MMBtu *(128 ppm @ 3% O_2)*	0.01 lb/MMBtu *(22 ppm @ 3% O_2)*	0.025 lb/MMBtu *(14 ppm @ 3% O_2)*	Filterable: 0.012 lb/MMBtu *(0.006 gr/scf @ 12% CO_2)*
				BACT (tech. feasible)		0.015 lb/MMBtu *(12 ppm @ 3% O_2)* NH_3 slip: 2 ppm @ 3% O_2	0.01 lb/MMBtu *(13 ppm @ 3% O_2)*	0.01 lb/MMBtu *(22 ppm @ 3% O_2)*	0.02 lb/MMBtu *(11 ppm @ 3% O_2)*	Filterable: 0.012 lb/MMBtu *(0.006 gr/scf @ 12% CO_2)*
6	Valley Bio-Energy; Modesto, CA	402 MMBtu/hr McBurney Corporation biomass-fired boiler with Detroit stoker vibrating grate feeder serving a steam turbine producing 33 MW (gross)	SNCR, SCR, dry powder scrubber w/ trona injection, multiclone, ESP	Authority to Construct		0.012 lb/MMBtu (24-hr block avg.)[8] *(9 ppm @ 3% O_2)* NH_3 slip: 50 ppmvd @ 3% O_2	0.046 lb/MMBtu (24-hr block avg.) *(59 ppm @ 3% O_2)*	0.005 lb/MMBtu *(11 ppm @ 3% O_2)*	0.012 lb/MMBtu (1-hr avg.) *(7 ppm @ 3% O_2)*	0.024 lb/MMBtu *(0.011 gr/scf @ 12% CO_2)*

[8] This limit is subject to a 12-month evaluation period to assess the operational variability and optimum control effectiveness of the emission control system to meet the target emission limit. In no event shall emissions exceed 0.065 lb/MMBtu (3-hr rolling avg.), except during startup and shutdown.

Table D-6. Biomass-Fired Boiler

Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
7	SJVAPCD BACT analysis for San Joaquin Solar 1 & 2	(4) 425 MMBtu/hr Energy Products of Idaho (EPI) fluidized bubbling bed boiler with (1) 15 MMBtu/hr and (3) 50 MMBtu/hr natural gas-fired startup burners serving two steam turbines producing 53.4 MW each	RSCR or equal, limestone injection, baghouse or ESP, natural gas auxiliary fuel	BACT (AIP)	10/8/2009	0.075 lb/MMBtu *(58 ppm @ 3% O_2)*	0.1 lb/MMBtu *(128 ppm @ 3% O_2)*	0.01 lb/MMBtu *(22 ppm @ 3% O_2)*	0.025 lb/MMBtu *(14 ppm @ 3% O_2)*	0.045 lb/MMBtu *(0.002 gr/scf @ 12% CO_2)*
			Option 1: SNCR + SCR + wet scrubber or equal, limestone injection, baghouse + multiclones+ wet scrubber or equal, natural gas auxiliary fuel Option 2: SCR or equal, limestone injection, baghouse + multiclones+ wet scrubber or equal, natural gas auxiliary fuel	BACT (tech. feasible)		Option 1: 0.012 lb/MMBtu *(9 ppm @ 3% O_2)* Option 2: 0.065 lb/MMBtu *(50 ppm @ 3% O_2)*	0.046 lb/MMBtu *(59 ppm @ 3% O_2)*	0.005 lb/MMBtu *(11 ppm @ 3% O_2)*	0.012 lb/MMBtu *(7 ppm @ 3% O_2)*	0.024 lb/MMBtu *(0.011 gr/scf @ 12% CO_2)*
8	Wheelabrator; Delano, CA (changed name to AES Delano)	400 MMBtu/hr circulating fluidized bed boiler with steam turbine producing 31 MW	SNCR, limestone injection, sodium bicarbonate injection, multiclone and baghouse	Authority to Construct	1998	0.1 lb/MMBtu *(78 ppm @ 3% O_2)*	181 ppmv @ 3% O_2 *(0.14 lb/MMBtu)*	0.02 lb/MMBtu *(50 ppm @ 3% O_2)*	23 ppm @ 3% O_2 *(0.041 lb/MMBtu)*	0.01 gr/scf @ 12% CO_2 *(0.022 lb/MMBtu)*

Table D-6. Biomass-Fired Boiler										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
9	Thermal Energy Development Corporation, Ltd.; Tracy, CA	259 MMBtu/hr boiler (powers a 20.5 MW steam turbine electric generator)	Lime/ limestone injection, ammonia injection, ESP, SNCR	Permit	7/31/2005	0.105 lb/MMBtu *(82 ppm @ 3% O_2)* NH_3 slip: 100 ppm @ 3% O_2	0.21 lb/MMBtu *(270 ppm @ 3% O_2)*	0.049 lb/MMBtu *(110 ppm @ 3% O_2)*	0.024 lb/MMBtu *(13 ppm @ 3% O_2)*	0.034 lb/MMBtu *(0.016 gr/scf @ 12% CO_2)*
10	AES Unit 2; Delano, CA	400 MMBtu/hr bubbling fluidized bed boiler with (2) steam turbines producing 32 MW total	SNCR, limestone and sand injection, baghouse	Source test	6/12 to 13/2007	0.08 lb/MMBtu; 63 ppmvd @ 3% O_2	0.05 lb/MMBtu; 60 ppmvd @ 3% O_2	<0.0005 lb/MMBtu as methane	0.0001 lb/MMBtu as SO_2; 0.07 ppmvd @ 3% O_2	0.002 gr/dscf @ 12% CO_2 (total); (*0.004 lb/MMBtu*)
11	Rio Bravo; Fresno, CA	352 MMBtu/hr circulating fluidized bed boiler with steam turbine producing 24.3 MW	SNCR, ESP	Source test	11/11/2009	0.068 lb/MMBtu; 52 ppmvd @ 3% O_2 NH_3: 11.7 ppm @ 3% O_2	0.0004 lb/MMBtu; 0.47 ppmvd @ 3% O_2	0.75 lb/hr as methane; 4.1 ppm @ 3% O_2	0.0003 lb/MMBtu; 0.15 ppmvd @ 3% O_2	0.002 gr/dscf @ 12% CO_2 (filterable); 1.6 lb/hr (filterable); 7.7 lb/hr (condensable)
12	Pacific Industries; Lincoln, CA	289.3 MMBtu/hr fixed grate boiler with steam turbine producing 20 MW	SNCR, multiclone, ESP	Source test	2/9/2006	54 ppmvd @ 12% CO_2	N/A	N/A	N/A	0.0005 gr/dscf @ 12% CO_2 (total)
13	Madera Power; Madera, CA	460 MMBtu/hr fluidized bed boiler with steam turbine producing 28.5 MW	SNCR	Source test	8/25/2004	0.09 lb/MMBtu; 69 ppm @ 3% O_2	N/A	N/A	N/A	0.006 gr/dscf @ 12% CO_2 (total)

Table D-6. Biomass-Fired Boiler

Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
14	Colmac Energy Inc.; Mecca, CA (Cabazon Reservation)	Boilers 1 and 2 – (2) 300 MMBtu/hr circulating fluidized bed boilers producing 47 MW total[9]	Thermal de-NOx system, cyclone / baghouse, limestone injection	Permit	8/2/2000	30.0 lbs/hr per boiler; 94 ppmvd @ 3% O_2 (3-hr avg.); 648 lbs/day per boiler; 0.30 lb/MMBtu (30-day rolling avg.)	45.0 lbs/hr per boiler; 231 ppmvd @ 3% O_2 (3-hr avg.)	10.0 lbs/hr per boiler	12.0 lbs/hr per boiler; 27 ppmvd @ 3% O_2 (3-hr avg.); 70 tpy daily rolling avg.	7.5 lbs/hr per boiler; 0.010 gr/dscf @ 12% CO_2; 0.10 lb/MMBtu

Table D-7. Sewage Digester and Landfill Gas-Fired Fuel Cell

Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
1	ARB Distributed Generation Certification Regulation	DG unit subject to regulation and fueled by digester gas, landfill gas, or oil-field waste gas	Not specified	Regulation (effective date 9/7/2007)	On or after 1/1/2008 On or after 1/1/2013	0.5 lb/MWh 0.07 lb/MWh	6.0 lb/MWh 0.10 lb/MWh	1.0 lb/MWh 0.02 lb/MWh		
2	El Estero Wastewater Treatment Plant; El Estero, CA	(2) Fuel Cell Energy Model DFC 300A fuel cells	Digester gas cleanup system to remove excess sulfur compounds, moisture, particulates, H_2S, halogenated compounds, and silohexanes (total sulfur content ≤12 ppmv)	Permit		0.07 lb/MWh; 0.018 lb/hr	0.10 lb/MWh; 0.025 lb/hr	0.02 lb/MWh; 0.005 lb/hr	0.007 lb/hr	0.026 lb/hr

[9] Boiler may be fired on natural gas and petroleum coke in addition to biomass (i.e., wood). Permit limits listed reflect biomass combustion.

Table D-7. Sewage Digester and Landfill Gas-Fired Fuel Cell										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
3	New York Power Authority/Red Hook Water Pollution Control Plant; Red Hook, NY	United Technologies Corp. PC25C phosphoric acid fuel cell producing 200 kW		Source test	5/19 to 6/19/2004	0.013 lb/MWh; 0.43 ppm @ 15% O_2	0.029 lb/MWh; 1.64 ppm @ 15% O_2	0.78 lb/MWh; 120 ppm @ 15% O_2		
4	Orange County Sanitation District; Fountain Valley, CA	Fuel Cell Energy Model DFC300 fuel cell		Permit (Manufacturer emission factor data)	11/12/2008	0.01 lb/MWh; 0.0035 lb/hr; 0.08 lb/day	0.1 lb/MWh; 0.035 lb/hr; 0.84 lb/day	0.01 lb/MWh; 0.003 lb/hr; 0.07 lb/day	0.0001 lb/MWh; 0.00003 lb/hr; 0 lb/day	0.00002 lb/MWh; 0.000007 lb/hr; 0 lb/day
5	Palmdale Water Reclamation Plant; Palmdale, CA	Fuel Cell Energy Model DFC300 fuel cell producing 251 kW		Source test	1/19/2005	0.0017 lb/MWh; 0.05 ppm @ 15% O_2; 0.1 ppm @ 3% O_2	0.025 lb/MWh; 1.2 ppm @ 15% O_2; 3.7 ppm @ 3% O_2	0.016 lb/MWh (as CH_4); 0.30 ppm @ 3% O_2 (as hexane)		
6	Penrose Landfill; Los Angeles, CA	International Fuel Cells PC25 phosphoric acid fuel cell producing 200 kW		Source test	2/17/1995	0.0053 lb/MWh; 0.12 ppmvd @ 15% O_2	0.021 lb/MWh; 0.77 ppmvd @ 15% O_2		<0.014 lb/MWh; <0.23 ppmvd @ 15% O_2	

Table D-22. Landfill Gas-Fired Reciprocating Internal Combustion Engine										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
1	SCAQMD Rule 1110.2 Emissions from Gaseous- and Liquid-Fueled Engines	Stationary and portable engines >50 bhp, landfill and digester gas-fired		Rule	2/1/2008	<500 bhp: 45 x ECF[10] ppmvd @ 15% O_2 ≥500 bhp: 36 x ECF ppmvd @ 15% O_2 On and after 7/1/2012: 11 ppmvd @ 15% O_2	2,000 ppmvd @ 15% O_2 On and after 7/1/2012: 250 ppmvd @ 15% O_2	40 ppmvd @ 15% O_2 On and after 7/1/2012: 30 ppmvd @ 15% O_2	N/A	N/A
2	8309 Tujunga Ave. Corp. (Austin Rd. Landfill); Stockton, CA	1,100 hp landfill gas-fired IC engine		Source test	12/13/2006	0.3 g/bhp-hr; 20 ppmv @ 15% O_2	3.0 g/bhp-hr; 291 ppmv @ 15% O_2	0.2 g/bhp-hr; 38 ppmv @ 15% O_2	Non-detected	0.01 g/bhp-hr; 0.001 gr/dscf
3	ARB DG Guidance[11]	Waste gas-fired reciprocating engine used in electrical generation (that are required to obtain a district permit)	Lean-burn technology	BACT	2002	0.6 g/bhp-hr; 50 ppmvd @ 15% O_2; 1.9 lb/MWh	2.5 g/bhp-hr; 300 ppmvd @ 15% O_2; 7.8 lb/MWh	0.6 g/bhp-hr; 130 ppmvd @ 15% O_2; 1.9 lb/MWh	N/A	N/A
4	Apollo Energy III (Bowerman Landfill); Irvine, CA	1,468 bhp landfill gas IC engine, producing 1.06 MW	Lean burn technology, turbocharged, aftercooled	Permit		0.5 g/bhp-hr	0.3 g/bhp-hr	0.2 g/bhp-hr (NMHC)	N/A	N/A
5	Apollo Energy III (Bowerman Landfill); Irvine, CA	1,468 bhp landfill gas IC engine, producing 1.06 MW	Lean burn technology, turbocharged, aftercooled	Source test	7/05 to 06/2007	0.4 g/bhp-hr; 32 ppm @ 15% O_2	0.2 g/bhp-hr; 19 ppm @ 15% O_2	0.01 g/bhp-hr (CH_4) TGNMO	N/A	0.004 gr/dscf @ 12% CO_2

[10] ECF is the efficiency correction factor. ECF = 1.0 unless the engine operator has measured the engine's net specific energy consumption, in compliance with ASME Performance Test Code PTC 17-1973, at the average load of the engine (see rule for details).

[11] Emission levels based on permit and source test data from the following facilities: County of Sacramento (Kiefer Landfill), Energy Developments (Azusa Landfill), Minnesota Methane (Tajiguas Landfill), Riverside County Waste Management (Badlands), Minnesota Methane (Lopez Landfill), Minnesota Methane (Corona), Ogden Power Pacific (Stockton), Orange County Sanitation District (Huntington Beach).

Table D-22. Landfill Gas-Fired Reciprocating Internal Combustion Engine										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
6	Kiefer Landfill; Sacramento, CA – 5 units	4,230 bhp landfill gas-fired IC engine, producing 3.05 MW each	Lean burn technology, turbocharged	Permit		0.4 g/bhp-hr OR 30.0 ppmv @ 15% O_2 (both 3-hr avg)	2.6 g/bhp-hr OR 366 ppmv @ 15% O_2 (both 3-hr avg)	0.1 g/bhp-hr	0.3 g/bhp-hr	0.1 g/bhp-hr
7	Kiefer Landfill; Sacramento, CA – 5 units	4,230 bhp landfill gas-fired IC engine, producing 3.05 MW each	Lean burn technology, turbocharged	Source test Unit 1	11/10/2005	0.3 g/bhp-hr; 24 ppm @ 15% O_2	1.9 g/bhp-hr; 253 ppm @ 15% O_2	Failed	Fuel: 0.6 gr/100 scf	0.06 g/bhp-hr
8	Kiefer Landfill; Sacramento, CA – 5 units	4,230 bhp landfill gas-fired IC engine, producing 3.05 MW each	Lean burn technology, turbocharged	Source test Unit 1	10/25/2006	0.3 g/bhp-hr; 2 ppm @ 15% O_2	2.2 g/bhp-hr; 241 ppm @ 15% O_2	N/A	Fuel: 29 ppmv	Failed
9	Kiefer Landfill; Sacramento, CA – 5 units	4,230 bhp landfill gas-fired IC engine, producing 3.05 MW each	Lean burn technology, turbocharged	Source test Unit 1	1/31/2007	N/A	N/A	N/A	Fuel: 22 ppmv	0.04 g/bhp-hr
10	Kiefer Landfill; Sacramento, CA – 5 units	4,230 bhp landfill gas-fired IC engine, producing 3.05 MW each	Lean burn technology, turbocharged	Source test Unit 1	3/28/2007	0.3 g/bhp-hr; 23 ppm @ 15% O_2	2.0 g/bhp-hr; 241 ppm @ 15% O_2	0.06 g/bhp-hr; 2.3 ppmv @ 15% O_2 as hexane	Fuel: 22 ppmv	0.04 g/bhp-hr
11	Kiefer Landfill; Sacramento, CA – 5 units	4,230 bhp landfill gas-fired IC engine, producing 3.05 MW each	Lean burn technology, turbocharged	Source test Unit 2	11/09/2005	0.3 g/bhp-hr; 26 ppm @ 15% O_2	2.0 g/bhp-hr; 224 ppm @ 15% O_2	Failed	Fuel: 0.2 gr/100 scf	0.10 g/bhp-hr
12	Kiefer Landfill; Sacramento, CA – 5 units	4,230 bhp landfill gas-fired IC engine, producing 3.05 MW each	Lean burn technology, turbocharged	Source test Unit 2	10/26/2006	0.4 g/bhp-hr; 24 ppm @ 15% O_2	1.7 g/bhp-hr; 233 ppm @ 15% O_2	N/A	Fuel: 29 ppmv	0.07 g/bhp-hr
13	Kiefer Landfill; Sacramento, CA – 5 units	4,230 bhp landfill gas-fired IC engine, producing 3.05 MW each	Lean burn technology, turbocharged	Source test Unit 2	3/27/2007	0.3 g/bhp-hr; 25 ppm @ 15% O_2	1.9 g/bhp-hr; 245 ppm @ 15% O_2	0.05 g/bhp-hr; 2.2 ppmv @ 15% O_2 as hexane	Fuel: 22 ppmv	0.04 g/bhp-hr
14	Kiefer Landfill; Sacramento, CA – 5 units	4,230 bhp landfill gas-fired IC engine, producing 3.05 MW each	Lean burn technology, turbocharged	Source test Unit 3	11/08/2005	0.3 g/bhp-hr; 21 ppm @ 15% O_2	1.8 g/bhp-hr; 220 ppm @ 15% O_2	0.08 g/bhp-hr as CH_4	Fuel: 0.3 gr/100 scf	0.05 g/bhp-hr
15	Kiefer Landfill; Sacramento, CA – 5 units	4,230 bhp landfill gas-fired IC engine, producing 3.05 MW each	Lean burn technology, turbocharged	Source test Unit 3	1/30/2007	0.3 g/bhp-hr; 23 ppm @ 15% O_2	1.7 g/bhp-hr; 199 ppm @ 15% O_2	0.1 g/bhp-hr as CH_4	Fuel: 22 ppmv	0.05 g/bhp-hr

Table D-22. Landfill Gas-Fired Reciprocating Internal Combustion Engine										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
16	Kiefer Landfill; Sacramento, CA – 5 units	4,230 bhp landfill gas-fired IC engine, producing 3.05 MW each	Lean burn technology, turbocharged	Source test Unit 4	5/11/2006	0.3 g/bhp-hr; 21 ppm @ 15% O_2	1.6 g/bhp-hr; 209 ppm @ 15% O_2	0.05 g/bhp-hr as hexane	Fuel: 34 ppmv	0.08 g/bhp-hr
17	Kiefer Landfill; Sacramento, CA – 5 units	4,230 bhp landfill gas-fired IC engine, producing 3.05 MW each	Lean burn technology, turbocharged	Source test Unit 4	4/04/2007	0.3 g/bhp-hr; 26 ppm @ 15% O_2	2.4 g/bhp-hr; 304 ppm @ 15% O_2	0.10 g/bhp-hr; 4.0 ppmv as hexane	Fuel: 22 ppmv	0.09 g/bhp-hr
18	Kiefer Landfill; Sacramento, CA – 5 units	4,230 bhp landfill gas-fired IC engine, producing 3.05 MW each	Lean burn technology, turbocharged	Source test Unit 5	5/12/2006	0.3 g/bhp-hr; 22 ppm @ 15% O_2	1.7 g/bhp-hr; 205 ppm @ 15% O_2	0.06 g/bhp-hr as hexane	Fuel: 34 ppmv	0.08 g/bhp-hr; 0.009 gr/dscf
19	Kiefer Landfill; Sacramento, CA – 5 units	4,230 bhp landfill gas-fired IC engine, producing 3.05 MW each	Lean burn technology, turbocharged	Source test Unit 5	3/29 to 30/2007	0.4 g/bhp-hr; 27 ppm @ 15% O_2	2.0 g/bhp-hr; 253 ppm @ 15% O_2	0.07 g/bhp-hr; 2.9 ppmv as hexane	Fuel: 22 ppmv	0.08 g/bhp-hr; 0.009 gr/dscf
20	MM San Bernardino Energy, LLC (Milliken Landfill); Ontario, CA	1850 bhp (14.7 MMBtu/hr) Deutz Model TBG620V16K landfill gas-fired IC engine	Engine design, air/fuel ratio controller, turbocharger, intercooler	BACT (NOx, CO, VOC)	2/20/2003	0.6 g/bhp-hr	2.5 g/bhp-hr	0.8 g/bhp-hr	0.10 lb/hr; *0.02 g/bhp-hr; 0.007 lb/MMBtu*	0.20 lb/hr; *0.05 g/bhp-hr*; *0.014 lb/MMBtu*
21	Minnesota Methane Tajiguas Corp.; Goleta, CA	4314 bhp Caterpillar Model 3616 landfill gas-fired engine driving a 3 MW generator with exhaust routed to afterburner/standby flare	Lean-burn technology w/ spark ignition controls, air/fuel ratio controls, intake air turbocharger and intercooler, fuel pretreatment to remove gas condensate and filter particles	BACT	1/9/1998	0.59 g/bhp-hr	N/A	0.24 g/bhp-hr	N/A	0.34 g/bhp-hr
22	Puente Hills Landfill; Whittier, CA – 3 units	4,261 bhp landfill gas-fired engine, with natural gas as secondary fuel	Lean burn technology, turbocharged, aftercooled, producing 3 MW	Permit		0.6 g/bhp-hr	2.5 g/bhp-hr	ROC: 0.8 g/bhp-hr; NMHC: 20 ppmv @ 3% O_2 OR 98% reduction	N/A	N/A

Table D-22. Landfill Gas-Fired Reciprocating Internal Combustion Engine										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
23	Puente Hills Landfill, Whittier, CA Unit 1	4,261 bhp landfill gas-fired IC engine, with natural gas as secondary fuel	Lean burn technology, turbocharged, aftercooled, producing 3 MW	Source test	7/11 to 14/2006	0.4 g/bhp-hr	1.7 g/bhp-hr	0.2 g/bhp-hr; 18.4 ppm @ 3% O_2 (as hexane)	N/A	N/A
24	Ridgewood Olinda Management, LLC; Brea, CA – 3 units	2,650 bhp landfill gas-fired IC engine, no auxiliary fuel, producing 1.875 MW each	Siloxane scrubber	Permit	11/17/2004	36 ppm @ 15% O_2; *0.7 g/bhp-hr*	2000 ppm @ 15% O_2; 22.7 g/bhp-hr	250 ppm as CH_4 @ 15% O_2	N/A	N/A
25	Ridgewood Olinda Management, LLC; Brea, CA Unit 1	2,650 bhp landfill gas-fired IC engine, no auxiliary fuel, producing 1.875 MW each	Siloxane scrubber	Source test[12]	6/13/2007	31 ppm @ 15% O_2; 0.5 g/bhp-hr	2 ppm @ 15% O_2; 0.0 g/bhp-hr	4 ppm @ 15% O_2 as CH_4, TGNMO; 0.02 g/bhp-hr	1.85 ppm	0.0006 gr/dscf @ 12% CO_2
26	Simi Valley Landfill; Simi Valley, CA – 2 units	1,877 bhp landfill gas-fired IC engine	Lean burn technology, turbocharged, aftercooled	Permit		35 ppmvd @ 15% O_2 OR 0.6 g/bhp-hr	280 ppmvd @ 15% O_2; *3.2 g/bhp-hr*	28 ppmvd @ 15% O_2; *1.0 g/bhp-hr*	0.02 lb/MMBtu	N/A
27	Waste Management; Livermore, CA	(2) 1,877 bhp Deutz IC engines fueled by landfill gas, LNG, or LNG Plant waste gas (Units S-23 and S-24)		Permit		0.6 g/bhp-Hr OR 36 ppmvd @ 15% O2	2.1 g/bhp-hr OR 207 ppmvd @ 15% O2	98% destruction efficiency by weight OR <120 ppmv @ 3% O2[13]	N/A	N/A
28	BAAQMD Guideline 96.2.2	IC engine – landfill gas fired <250 bhp output	Modified rich burn technology	BACT (AIP)	6/15/2006	2.5 g/bhp-hr	10.0 g/bhp-hr	1.5 g/bhp-hr	0.5 g/bhp-hr	N/A

[12] There are two test result tables for this test. The numbers differ between the tables. The data shown here came from the table with the higher reported emissions.

[13] Requirement from District Rule 8-34-301.4 (last amended June 15, 2005).

Table D-22. Landfill Gas-Fired Reciprocating Internal Combustion Engine										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
29	BAAQMD Guideline 96.2.2	IC engine – landfill gas fired >250 bhp output, low-NOx engine bias	Lean burn technology	BACT (AIP)	3/5/2009	0.5 g/bhp-hr	Initial standard: 2.5 g/bhp-hr Not to exceed standard: 3.9 g/bhp-hr CO emissions based on overhaul schedule	120 ppm @ 3% O2 (0.16 g/bhp-hr)	N/A	N/A
30	BAAQMD Guideline 96.2.2	IC engine – landfill gas fired >250 bhp output, low-CO engine bias	Lean burn technology	BACT (AIP)	3/5/2009	0.6 g/bhp-hr	Initial standard: 2.1 g/bhp-hr Not to exceed standard: 3.6 g/bhp-hr CO emissions based on overhaul schedule	120 ppm @ 3% O2 (0.16 g/bhp-hr)	N/A	N/A

Table D-23. Sewage Digester Gas-Fired Reciprocating Internal Combustion Engine										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
1	SCAQMD Rule 1110.2 Emissions from Gaseous- and Liquid-Fueled Engines	Stationary and portable engines >50 bhp, landfill and digester gas-fired		Rule	2/1/2008	<500 bhp: 45 x ECF[14] ppmvd @ 15% O_2 ≥500 bhp: 36 x ECF ppmvd @ 15% O_2 On and after 7/1/2012: 11 ppmvd @ 15% O_2	2,000 ppmvd @ 15% O_2 On and after 7/1/2012: 250 ppmvd @ 15% O_2	250 x ECF ppmvd @ 15% O_2 On and after 7/1/2012: 30 ppmvd @ 15% O_2	N/A	N/A
2	ARB DG Guidance[15]	Waste gas-fired reciprocating engine used in electrical generation (that are required to obtain a district permit)	Lean-burn technology, pre-stratified charge system	BACT	2002	0.6 g/bhp-hr; 50 ppmvd @ 15% O_2; 1.9 lb/MWh	2.5 g/bhp-hr; 300 ppmvd @ 15% O_2; 7.8 lb/MWh	0.6 g/bhp-hr; 130 ppmvd @ 15% O_2; 1.9 lb/MWh	N/A	N/A
3	Hill Canyon Wastewater Treatment Plant; Camarillo, CA – 2 units	396 bhp sewage digester gas-fired IC engines, producing 250 kW each	Catalytic carbon control systems for removing H_2S and ROCs, lean burn technology, turbocharged and aftercooled, low NO_x combustion chambers	Permit		0.6 g/bhp-hr OR 35 ppmvd @ 15% O_2	*13.6 g/bhp-hr;* 1200 ppmvd @ 15% O_2	*1.0 g/bhp-hr;* 28 ppmvd @ 15% O_2	Fuel: 20 ppmvd	N/A

[14] ECF is the efficiency correction factor. ECF = 1.0 unless the engine operator has measured the engine's net specific energy consumption, in compliance with ASME Performance Test Code PTC 17-1973, at the average load of the engine (see rule for details).

[15] Emission levels based on permit and source test data from the following facilities: City of Stockton, Hemet/San Jacinto Regional Water Reclamation Facility, South East Regional Reclamation Authority (Dana Point).

Table D-23. Sewage Digester Gas-Fired Reciprocating Internal Combustion Engine										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
4	San Bernardino City Municipal Water Dept.; San Bernardino, CA – 2 units	999 bhp sewage digester gas (w/ natural gas augmentation)-fired IC engine	Lean burn technology, turbocharged and aftercooled	Permit		0.6 g/bhp-hr; 36 ppmvd @ 15% O_2	2.5 g/bhp-hr; 2000 ppmvd @ 15% O_2	0.3 g/bhp-hr; 250 ppmvd @ 15% O_2	500 ppmv	0.1 gr/dscf @ 12% CO_2
5	San Bernardino City Municipal Water Dept.; San Bernardino, CA Unit 1	999 bhp sewage digester gas (w/ natural gas augmentation)-fired IC engine	Lean burn technology, turbocharged and aftercooled	Source test (85% load, 100% digester gas)	11/3 to 4/2005	0.2 g/bhp-hr; 13 ppmvd @ 15% O_2 (1 run)	1.3 g/bhp-hr; 115 ppmvd @ 15% O_2 (1 run)	0.1 g/bhp-hr; 18 ppmvd @ 15% O_2 TGNMNEO (2-run avg)	N/A	0.002 gr/dscf @ 12% CO_2 (1 run)
6	San Bernardino City Municipal Water Dept.; San Bernardino, CA Unit 2	999 bhp sewage digester gas (w/ natural gas augmentation)-fired IC engine	Lean burn technology, turbocharged and aftercooled	Source test (85% load, 100% digester gas)	11/1 to 2/2005	0.2 g/bhp-hr; 11 ppmvd @ 15% O_2 (1 run)	1.4 g/bhp-hr; 121 ppmvd @ 15% O_2 (1 run)	0.1 g/bhp-hr; 13 ppmvd @ 15% O_2 TGNMNEO (2-run avg)	N/A	0.001 gr/dscf @ 12% CO_2 (1 run)
7	San Francisco South East Treatment Plant; San Francisco, CA	21 MMBtu/hr sewage digester gas +/or natural gas-fired IC engine		Permit		0.5 g/bhp-hr	2.1 g/bhp-hr	0.6 g/bhp-hr (POC)	0.3 g/bhp-hr (equivalent to fuel H_2S content of 300 ppmv)	N/A
8	Stockton RWCF; Stockton, CA	1,408 bhp sewage digester/natural gas-fired IC engine	Lean burn technology, with precombustion chamber and siloxane scrubber	Source test (digester gas)	10/11 to 12/2006	0.4 g/bhp-hr; 22 ppm @ 15% O_2	2.6 g/bhp-hr; 264 ppm @ 15% O_2	0.1 g/.bhp-hr TNMHC	0.1 g/bhp-hr	<0.1 g/bhp-hr; <0.01 gr/dscf @ 12% CO_2

Table D-23. Sewage Digester Gas-Fired Reciprocating Internal Combustion Engine										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
9	BAAQMD Guideline 96.5.2	IC engine – digester gas fired, >50 bhp output	Lean burn technology, digester gas pretreatment to remove H_2S	BACT (AIP)	5/14/2009	1.25 g/bhp-hr	Initial standard: 2.65 g/bhp-hr Not to exceed standard: 3.77 g/bhp-hr CO emissions based / minimum overhaul schedule	1.0 g/bhp-hr	0.3 g/bhp-hr	N/A
10	BAAQMD Guideline 96.5.2	IC engine – digester gas fired, >50 bhp output	Digester gas pretreatment w/ >80% H_2S removal	BACT (tech. feasible)	5/14/2009	1.0 g/bhp-hr	2.1 g/bhp-hr	0.6 g/bhp-hr	N/A	N/A

Table D-24. Manure Digester and Co-Digester Gas-Fired Reciprocating Internal Combustion Engine										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
1	SCAQMD Rule 1110.2 Emissions from Gaseous- and Liquid-Fueled Engines	Stationary and portable engines >50 bhp, landfill and digester gas-fired		Rule	2/1/2008	<500 bhp: 45 x ECF[16] ppmvd @ 15% O_2 ≥500 bhp: 36 x ECF ppmvd @ 15% O_2 On and after 7/1/2012: 11 ppmvd @ 15% O_2	2,000 ppmvd @ 15% O_2 On and after 7/1/2012: 250 ppmvd @ 15% O_2	250 x ECF ppmvd @ 15% O_2 On and after 7/1/2012: 30 ppmvd @ 15% O_2	N/A	N/A
2	Fiscalini Farms & Fiscalini Dairy; Modesto, CA	1,057 bhp Guascor Model SFGLD-560 dairy digester gas-fired lean-burn IC engine driving 750 kW generator	Oxidation catalyst, SCR	Authority to Construct	12/17/2008	0.15 g/bhp-hr (11.0 ppmvd @ 15% O2) and shall not exceed 0.60 g/bhp-hr (44 ppmvd @ 15% O2)[17] NH3 limit: 10 ppmvd @ 15% O2	1.75 g/bhp-hr (210 ppmvd @ 15% O2)	0.13 g/bhp-hr (28 ppmvd @ 15% O2)	Fuel sulfur content ≤50 ppmv	0.036 g/bhp-hr

[16] ECF is the efficiency correction factor. ECF = 1.0 unless the engine operator has measured the engine's net specific energy consumption, in compliance with ASME Performance Test Code PTC 17-1973, at the average load of the engine (see rule for details).

[17] Permit includes a 24-month trial period to reduce NOx to the target 0.15 g/bhp-hr. The final NOx BACT level shall be determined by the District after 24 months operating history.

Table D-24. Manure Digester and Co-Digester Gas-Fired Reciprocating Internal Combustion Engine										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
3	ARB DG Guidance	Waste gas-fired reciprocating engine used in electrical generation (that are required to obtain a district permit)	Lean-burn technology, pre-stratified charge system	BACT	2002	0.6 g/bhp-hr; 50 ppmvd @ 15% O_2; 1.9 lb/MWh	2.5 g/bhp-hr; 300 ppmvd @ 15% O_2; 7.8 lb/MWh	0.6 g/bhp-hr; 130 ppmvd @ 15% O_2; 1.9 lb/MWh	N/A	N/A
4	Chino Basin Desalter Authority; Chino, CA – 2 units	1,158 bhp manure digester gas- or natural gas-fired IC engine, producing 1.9 MW combined	Lean burn technology, turbocharged and aftercooled, custom engine control, air/fuel module	Permit		*0.9 g/bhp-hr;* 47 ppmv @ 15% O_2 (@ 32.7% eff.)	*22.7 g/bhp-hr;* 2000 ppmv @ 15% O_2	*11.3 g/bhp-hr;* 325 ppmv @ 15% O_2 (@ 32.7% eff.)	N/A	N/A
5	BAAQMD Guideline 96.5.2	IC engine – digester gas fired, >50 bhp output	Lean burn technology, digester gas pretreatment to remove H_2S	BACT (AIP)	5/14/2009	1.25 g/bhp-hr	Initial standard: 2.65 g/bhp-hr Not to exceed standard: 3.77 g/bhp-hr CO emissions based / minimum overhaul schedule	1.0 g/bhp-hr	0.3 g/bhp-hr	N/A
6	BAAQMD Guideline 96.5.2	IC engine – digester gas fired, >50 bhp output	Digester gas pretreatment w/ >80% H_2S removal	BACT (tech. feasible)	5/14/2009	1.0 g/bhp-hr	2.1 g/bhp-hr	0.6 g/bhp-hr	N/A	N/A
7	Gallo Cattle Company; Atwater, CA	575 bhp Caterpillar Model G399NA rich burn digester gas-fired IC engine, producing 400 kW	3-way non-selective catalyst, PCV or equivalent, fuel sulfur scrubber	Permit	9/30/2012 (expiration date)	9.0 ppmvd @ 15% O_2 (or 0.15 g/bhp-hr)	1,100 ppmvd @ 15% O_2	20 ppmvd @ 15% O_2 as methane	Fuel sulfur limit of 59 ppmv as H_2S	0.1 g/bhp-hr

Table D-24. Manure Digester and Co-Digester Gas-Fired Reciprocating Internal Combustion Engine										
Ref. No.	Facility Name	Basic Equipment	Method(s) of Control	Type of Document	Date of BACT Det., Permit, or Rule	Emissions, per unit				
						NOx	CO	VOC	SO_2	PM10
8	Gallo Cattle Company; Atwater, CA	575 bhp Caterpillar Model G399NA rich burn digester gas-fired IC engine, producing 400 kW	3-way non-selective catalyst, PCV or equivalent, fuel sulfur scrubber	Source test	1/28/2010	3.18 ppmvd @ 15% O_2	384.64 ppmvd @ 15% O_2	11.19 ppmvd @ 15% O_2	<1.0 ppm fuel H_2S	N/A

Table from Draft Guidance Chapter IX: Mitigation of Mobile Source Emissions Associated with Biorefineries

Table IX-1 contains a list of strategies to further mitigate emissions from mobile sources associated with biorefineries. These include strategies to reduce diesel PM emissions, fugitive PM emissions, vehicle miles traveled (VMT), single occupancy vehicles (SOV), and exposure to sensitive receptors.

Table IX-1. Other Strategies to Mitigate Air Emissions from Mobile Sources Associated with Biorefineries

	Mitigation Strategy	Description
1.	Reduce Diesel PM Emissions	• Encourage the use of low emission locomotives for the rail transport of raw material and finished fuel product. • Reduce emissions from idling locomotives used to transport raw material and finished fuel product. • Reduce emissions from idling vehicles by improving traffic flow by signal synchronization, or improved road infrastructure. • Use “clean” street sweepers. • Maintain diesel engines and retrofit air pollution control device according to manufacturer’s specifications
2.	Reduce Fugitive PM Emissions	• Cover, wet all material, or maintain at least two feet of vertical space between the top of the load and the top of the trailer for all trucks hauling, dirt, sand, soil or other loose materials. • Wash off trucks and any equipment exiting unpaved roads onto paved roads using wheel washers, trackout devices, etc. • Limit or remove mud or dirt from adjacent public streets at the end of each workday. • Consider watering roads on days of moderate to high traffic to improve moisture and control PM. • Consider dust suppressants to control PM, • Cover, wet to limit visible dust emissions, and maintain at least six inches of freeboard space from the top of the container when materials are transported off-site. • Pave access roads at least 100 feet onto the site from main road. • Sweep streets once a day if visible soil materials are carried to adjacent streets (recommend water sweepers with reclaimed water). • Apply water three times daily, or non-toxic dust suppressant to all unpaved parking or staging areas or unpaved road surfaces. • Reduce traffic speeds on all unpaved roads to 15 miles per hour or less.

	Mitigation Strategy	Description
3.	Reduce Product (Raw and Finished) VMT	• Provide incentives for on-site fueling to minimize fuel export traffic.
4.	Reduce Passenger VMT and SOVs Reduce Passenger VMT and SOVs (cont.)	• Design and locate buildings to facilitate transit access (e.g., locate building entrances near transit stops, eliminate building setbacks). • Establish new cooperative relationships among employers and employees to reduce VMT. • Work with large employers and commercial/industrial complexes to create Transportation Management Associations and to implement trip/VMT reduction strategies. • Cooperate with surrounding jurisdictions to provide incentives, adopt regulations and develop transportation demand management programs that reduce vehicle trips and VMT. • Develop programs and educate employers about employee rideshare and transit • Establish mass transit mechanisms for the reduction of work related and non-work related vehicle trips • Promote mass transit ridership through careful planning of routes. • Provide electrical charging station for electric vehicles. • Identify and develop non-motorized transportation corridors (e.g., bicycling & walking trails). • Provide incentives for car-pool, van-pool, or zero emissions vehicles to discourage single occupancy commuters. • Provide on-site eating, refrigeration and food vending facilities to reduce lunchtime SOV trips. • Implement compressed work schedules (i.e., 9–80s or 4–10s). • Implement a telecommuting program. • Implement a lunchtime shuttle to reduce single occupant vehicle trips. • Construct satellite worksites.
5.	Reduce Exposure to Sensitive Receptors	• Consider co-located operations that consolidate truck traffic. • Develop routes for truck traffic that discourage use of roads in sensitive receptor neighborhoods. • Reduce vehicle miles traveled through adjacent residential property.