Marian Massoth

From: Stephanie Salter [stephanie.salter@wla-consulting.com]
Sent: Wednesday, August 03, 2011 8:16 PM
To: Terry Tavener
Cc: Marian Massoth; Mindy Bowman; Sergio Guerra; Robert.Wildgen@bioenergy.abengoa.com; Carl.LaFoy@bioenergy.abengoa.com
Subject: SCR Memo
Attachments: 20110803 SCR Memo_r0.doc; 20110731_ABBK Stoker PTE_r2.xls; 20110731_ABBK Stoker PTE_r2.pdf

Terry,

Please find responses to your questions regarding the SCR operation and SSM contained in the attached memo. Please let me know if you require additional information.

Thanks!

Stephanie

WLA Consulting, Inc.
Engineers & Scientists
WaterLandAir

Memo

To: Terry Tavener, KDHE
From: Stephanie Salter, P.E., WLA Consulting
Re: Response to questions regarding SCR system for NOx control on the biomass-fired boiler, Source ID No. 1890231
Date: August 3, 2011
WLA Project No: 165-009

This memo is being provided in response to the KDHE questions regarding operation of the biomass-fired boiler equipped with an SCR for NOx control. Each KDHE question is repeated herein with the response afterwards.

KDHE Question No. 1. Do you know what kind of SCR will be installed? Will it be a Regenerative SCR/tail gas SCR system?

The final configuration for the SCR system has not been completed until the burn test has been completed. The burn test is scheduled to be performed in October 2011. Once the results are analyzed, the final SCR configuration should be ready for review in the November/December 2011 timeframe.

KDHE Question No. 2. Is 61 MMBtu/hr the maximum heat input the natural gas burners can provide?

The boiler maximum burner heat input is 110 MMBtu/hr; however, the vendor explained that startup will require approximately 25 - 40 MMBtu/hr.

KDHE Question No. 3. Will biomass be added to bring the boiler up to 141 MMBtu/hr and 30% of nominal load?

Only natural gas will be fired until the SDA and SCR are both operational. The exact boiler load when the SDA and SCR will be started has not be finalized. A best engineer estimate of 30% was used for the purposes of the PTE calculations.

KDHE Question No. 4. When will the SCR become operational during start-up and will biomass fuel be burned before the SCR is operational?

The SCR will not be started until the SDA is operational to avoid catalyst deterioration. The SCR will be started following the SDA.

KDHE Question No. 5. Will the boiler remain at 141 MMBtu/hr until the SCR is operational?

Prior to introduction of biomass to boiler, the SCR will be placed in operation.

KDHE Question No. 6. The same start-up and shutdown process information that was provided when the SNCR was proposed is required for the SCR system.

The biomass-fired stoker boiler start-up is based on the use of natural gas to heat the boiler to approximately 400 degF (approximately 4 hours). The spray dry absorber (SDA) scrubber is

started when the appropriate operating temperature is achieved. No fuels other than natural gas will be combusted until the SDA scrubber and SCR are operational. The SCR will be fully functional at greater than 30% load (or 141 MMBtu/hr). The baghouse utilized for PM control will be in service at all times.

Below is an anticipated start-up and planned shutdown outline for the Air Permit development.

Boiler Start-up Outline	**Duration (hours)**
1. Ensure water treatment meets specifications	0
2. Fill boiler/vent air, ensure baghouse is operational	2
3. Start forced circulation grate water circuit	0.3
4. Establish economizer circulation	0.3
5. Vent superheater to provide flow	0.3
6. Fireside purge	0
7. Light natural gas burner	0
8. Raise firebox temperature at ~100 degF/hr	4
9. Start SDA/hydrated lime injection	4
10. Continue to raise boiler output to 30% load with natural gas input	4
11. Start SCR	2
12. Start solid/liquid fuel	2
13. Raise boiler steam production	6
Boiler Shutdown Outline	**Duration (hours)**
1. Slow down boiler to 50% load	3
2. Empty solid fuel metering bins	0.3
3. Stop liquid fuel	0.3
4. Reduce boiler load to minimum on natural gas	3
5. Stop SCR	0.3
6. Stop SDA/hydrated lime injection	0.3
7. Trip boiler	0.3

There will be one (1) planned maintenance outage each year with a scheduled duration of 15 to 20 days. In addition to the annual maintenance outage, three (3) additional cleaning outages with schedule durations of 5 days each are planned roughly 90 days apart throughout the year. The vendor has indicated that the boiler will have an 87% average availability throughout the year, or 317 full days per year availability. Subtracting out the planned 30 to 35 days related to the planned maintenance and cleaning outages, there will be 13 to 18 days lost to unplanned outages. It is anticipated that unplanned outages will last 3 to 5 days each, resulting in approximately 3 to 6 unplanned SSM events. Therefore, the total SSM events, including planned and unplanned is estimated to be approximately 7 to 10 events per year.

KDHE Question No. 6. Would shut down emissions (lb/hr) ever exceed the fully operational boiler emissions?

It is not anticipated that controlled shutdown of the boiler to ever exceed the fully operational boiler emissions. The SCR will remain in operation until the boiler load is significantly reduced and solid/liquid fuels are removed from the boiler.

SES

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SES

Abengoa Bioenergy Biomass of Kansas, LLC
Biorefinery Facility
Hugoton, Kansas

Rev. 5.1

Operations Data

Plant Capacity:	Denatured Ethanol:	31.58 MMgpy	**Biomass:**	589,475 ton/yr
	Anhydrous Ethanol:	30 MMgpy		

Operations:	365 day/yr
	8760 hr/yr

CONTROLLED Potential to Emit Summary (TPY)

Emission Point No.	Emission Unit(s)	PM	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Single HAP	Total HAPs	Direct $CO_2 + CO_2e$
HAUL ROADS											
EP-01000FUG	Paved Plant Roads	7.51	1.50	0.37	--	--	--	--	--	--	--
EP-01050FUG	Biomass Laydown Roads	2.87	0.73	0.07	--	--	--	--	--	--	--
ENZYMATIC HYDROLYSIS PLANT											
EP-11120	Floor Sweep System DC	1.17	1.17	0.20	--	--	--	--	--	--	--
EP-11110	Bale Grinder DC	21.61	21.61	3.67	--	--	--	--	--	--	--
EP-11170	Classifier Cyclone # 1 DC	3.24	3.24	0.55	--	--	--	--	--	--	--
EP-11270	Classifier Cyclone # 2 DC	3.24	3.24	0.55	--	--	--	--	--	--	--
EP-11711	Boiler Feed System DC	3.24	3.24	0.55	--	--	--	--	--	--	--
EP-11110FUG	Crop Receiving, Grinding and Conveying	0.16	0.07	0.01	--	--	--	--	--	--	--
EP-18185	EH Fermentation CO2 Scrubber	0.44	0.44	0.44	0.29	--	--	11.87	1.47	1.68	88,356.94
EP-19001FUG	Lignin-Rich Stillage Storage	--	--	--	--	--	--	1.29	0.03	0.06	--

CONTROLLED Potential to Emit Summary (TPY)

Emission Point No.	Emission Unit(s)	PM	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	Single HAP	Total HAPs	Direct $CO_2 + CO_2e$
ETHANOL STORAGE AND PIPING											
EP-02000	Fugitive Leaks	--	--	--	--	--	--	1.69	0.00	0.00	0.01
T-02107	EH Product Shift Tank #1	--	--	--	--	--	--	0.15	0.00	0.00	--
T-02108	EH Product Shift Tank #2	--	--	--	--	--	--	0.15	0.00	0.00	--
T-02102	EH Ethanol Product Storage Tank #1	--	--	--	--	--	--	0.22	0.00	0.00	--
T-02112	EH Ethanol Product Storage Tank #2	--	--	--	--	--	--	0.22	0.00	0.00	--
T-02105	EH Denaturant Storage Tank	--	--	--	--	--	--	1.27	0.01	0.01	--
EP-02100	Vapor Recovery System	--	--	--	--	--	--	Emitted Through Flare, EP-09001			--
EP-02100FUG	Loading Losses	--	--	--	--	--	--	0.75	0.01	0.01	--
UTILITIES											
EP-02710	Bulk Fly Ash Load-Out Silo	4.22	4.22	2.11	--	--	--	--	--	--	--
EP-02711	Bulk Fly Ash Load-Out Silo Spout	4.22	4.22	2.11	--	--	--	--	--	--	--
EP-04001	Cooling Water Tower	0.74	0.52	0.31	--	--	--	--	--	--	--
EP-20001	Biomass-Fired Stoker Boiler #1	69.07	65.66	61.68	661.17	464.96	481.99	11.17	5.69	18.40	481,650
EP-20514	Boiler Bottoms Ash Handling DC #1	4.22	4.22	2.11	--	--	--	--	--	--	--
EP-20510	Boiler Fly Ash Handling DC #1	2.11	2.11	1.05	--	--	--	--	--	--	--
EP-20520	Boiler Fly Ash Handling DC #2	2.11	2.11	1.05	--	--	--	--	--	--	--
EP-20512	Lime Handling DC #1	0.30	0.30	0.15	--	--	--	--	--	--	--
EP-09001	Flare	0.003	0.003	0.003	6.92	18.43	37.47	0.27	0.00	0.00	20,166
EP-06001 (EMG)	Firewater Pump Engine	0.004	0.004	0.004	0.13	0.05	0.03	0.00	0.00	0.00	119
EP-08000	High Voltage Circuit Breakers Fugitive Leaks	--	--	--	--	--	--	--	--	--	4.9
Total Plantwide		**130.5**	**118.6**	**77.0**	**668.5**	**483.4**	**519.5**	**29.1**	**5.7**	**20.2**	**590,297**

EP-20001
Biomass-Fired Stoker Boiler

Fuel Configuration

Basis:

AP-42 Section 1.6 Wood Residue Combustion in Boilers, Final Section, September 2003.
The biomass-fired boiler system consists of one (1) water-cooled vibrating grate (stoker) boiler.
Gaseous fuel will be supplied to the biomass-fired stoker boiler system from the wastewater treatment system to optimize the energy available from the biogas.
ABNT Cogeneration Model used to determine blended fuel rate, composition and HHV. Final engineering of the biomass-fired stoker boiler system has not been completed.
California Climate Action Registry (CCAR) General Reporting Protocol, Version 3.1, January 2009.
The fuel moisture contents can vary from 5 to 75 wt% depending of residue type and storage operations.

The typical feed rate volumes differ from the nominal WORST CASE to the nominal TYPICAL scenario due to the actual boiler design basis constant being based on the plant's steam demand requirements. For the fuel balance, a constant amount of steam is generated, which requires a constant energy demand. The energy demand is supplied by the fuel lower heating value after the fuel moisture has been evaporated. The higher heating value energy input does not remain constant because the different fuel scenarios create different blended fuel compositions.

In addition to firing biomass and biogas, the biomass-fired stoker boiler will be capable of firing on natural gas during normal operations as needed, as well as firing on a combination of natural gas, liquid fuel (i.e. EH stillage syrup) and biogas in the event of a solid fuel failure. "Start-up" emissions are based on the combustion of natural gas only, without any add-on control devices. All other firing scenarios will only be possible when the add-on control devices are operational.
Boiler limited to less than 10% natural gas annual capacity.

Criteria:

Number of Solids-Fired Boilers	1		
Total Area 20000 Heat Input - Permit	500	MMBtu/hr	Based on Maximum WORST CASE fuel blend. Includes 20% factor of safety applied to NOMINAL EH Residuals.
Annual Operations	8,760	hr/yr	

Source Details:

		Stack Flow Rate	Stack Diameter	Release Height	Stack Area	Gas Velocity		Gas Exit Temperature	
ID	Emission Source	(cfm)	(in)	(ft)	(ft^2)	(ft/s)	(m/s)	(deg F)	(deg K)
EP-20001	Biomass-Fired Stoker Boiler #1	264,000	120	160	78.54	56.02	17.07	300	422

EP-20001
Biomass-Fired Stoker Boiler

Combined Fuels Specifications:	Nominal TYPICAL Fuel Blend					
Fuel Component (Dry Basis)	EH Lignin-Rich Stillage (wt%)	EH Thin Stillage Syrup (wt%)	Corn Stover (wt%)	Biogas (wt%)	WWTP Sludge (wt%)	Blended Biomass (wt%)
Carbon	48.16	34.98	40.74	46.46	48.05	42.68
Hydrogen	6.28	6.12	5.48	9.97	6.88	6.30
Oxygen	25.04	47.39	35.34	43.49	35.31	34.89
Nitrogen	1.77	1.98	0.40	0.00	7.43	1.40
Sulfur	0.33	2.62	0.04	0.08	0.02	0.86
Ash	18.07	6.39	17.79	0.00	2.30	13.53
Chlorine	0.35	0.52	0.21	0.00	0.01	0.34
Total wt%	100.0	100.0	100.0	100.0	100.0	100.0
Moisture	54.4%	50.0%	15.0%	4.1%	80.0%	45.3%
Feed Rate (dry ton/day)	320.6	209.5	185.3	52.7	3.0	771.10
Feed Rate (wet lb/hr)	58,579	34,917	18,167	4,579	1,250	117,492

Combined Fuels Energy:	Nominal TYPICAL Fuel Blend					
HHV (Btu/dry lb)	7,880	6,250	6,920	9,631	9,225	7,331.35
HHV (MMBtu/dry ton)	15.76	12.50	13.84	19.26	18.45	14.66
Energy (MMBtu/hr)	210.53	109.11	106.86	42.30	2.31	471

Combined Fuels Specifications:	Maximum WORST CASE Fuel Blend					
Fuel Component (Dry Basis)	EH Lignin-Rich Stillage (wt%)	EH Thin Stillage Syrup (wt%)	Corn Stover (wt%)	Biogas (wt%)	WWTP Sludge (wt%)	Blended Biomass (wt%)
Carbon	48.16	34.98	40.74	46.46	48.05	42.95
Hydrogen	6.28	6.12	5.48	9.97	6.88	6.41
Oxygen	25.04	47.39	35.34	43.49	35.31	34.83
Nitrogen	1.77	1.98	0.40	0.00	7.43	1.54
Sulfur	0.33	2.62	0.04	0.08	0.02	0.98
Ash	18.12	6.46	17.76	0.00	2.30	12.98
Chlorine	0.30	0.45	0.24	0.00	0.01	0.31
Total wt%	100.0	100.0	100.0	100.0	100.0	100.0
Moisture	54.4%	50.0%	15.0%	4.1%	80.0%	47.8%
Feed Rate (dry ton/day)	384.7	251.4	109.3	63.2	3.6	812.23
Feed Rate (wet lb/hr)	70,291	41,900	10,718	5,495	1,250	129,655

Combined Fuels Energy:	Maximum WORST CASE Fuel Blend					
HHV (Btu/dry lb)	7,880	6,250	6,920	9,631	9,225	7,388.47
HHV (MMBtu/dry ton)	15.76	12.50	13.84	19.26	18.45	14.78
Energy (MMBtu/hr)	252.62	130.94	63.05	50.72	2.77	500

EP-20001
Biomass-Fired Stoker Boiler

Combined Fuels Specifications:	**Solid Fuel Failure Fuel Blend [Liquid (i.e. EH Stillage Syrup) and Gaseous Fuels Only]**						
Fuel Component (Dry Basis)	EH Lignin-Rich Stillage (wt%)	EH Thin Stillage Syrup (wt%)	Corn Stover (wt%)	Natural Gas (wt%)	Biogas (wt%)	WWTP Sludge (wt%)	Blended Biomass (wt%)
Carbon	48.16	34.98	40.74	64.84	46.46	48.05	45.90
Hydrogen	6.28	6.12	5.48	20.85	9.97	6.88	11.25
Oxygen	25.04	47.39	35.34	1.41	43.49	35.31	32.49
Nitrogen	1.77	1.98	0.40	12.90	0.00	7.43	5.12
Sulfur	0.33	2.62	0.04	0.00	0.08	0.02	1.45
Ash	18.07	6.39	17.79	0.00	0.00	2.30	3.51
Chlorine	0.35	0.52	0.21	0.00	0.00	0.01	0.29
Total wt%	100.0	100.0	100.0	100.0	100.0	100.0	100.00
Moisture	54.4%	50.0%	15.0%	0.001%	4.1%	80.0%	36.8%
Fee Rate (dry ton/day)	0.0	209.5	0.0	119.1	52.7	0.0	381
Feed Rate (wet lb/hr)	0	34,917	0	9,925	4,579	1,250	50,671

Combined Fuels Energy:	**Solid Fuel Failure Fuel Blend [Liquid (i.e. EH Stillage Syrup) and Gaseous Fuels Only]**						
HHV (Btu/dry lb)	5,550	6,250	6,920	20,160	9,631	9,225	11,062.12
HHV (MMBtu/dry ton)	11.10	12.50	13.84	40.32	19.26	18.45	22.12
Energy (MMBtu/hr)	0.00	109.11	0.00	200.09	42.30	0.00	351.50

EP-20001
Biomass-Fired Stoker Boiler

Process Vents Flow:

Fuel Components		12024 Digester Vent Gas (lb/hr)	16023 Propagator Vent (lb/hr)	16012 Saccharification Vent (lb/hr)	19026 Stillage Handling Vent (lb/hr)	2133 Ethanol Loadout Vent (lb/hr)	1916 + 1919 Ammonia Tank Vent (lb/hr)	Combined Process Vents (lb/hr)	Component HHV (Btu/lb)	Carbon (lb-mol/hr)
Oxygen	O_2	407	7,171	17	69	2	0.10	7,666.10	--	--
Nitrogen	N_2	1,341	26,119	61	231	12	0.30	27,764.30	--	--
Hydrogen Sulfide	H_2S	0.07	0.04	0.03	0.008	0.002	4.30E-04	0.15	7,100	--
Nitrogen Dioxide	NO_2	0.40	0.10	0.10	0.04	1.50E-04	4.60E-04	0.64		
Ammonia	NH_3	0	0	0	0	0	0.03	0.03	9,668	--
Methane	CH_4	0.003	0	0.01	0	0	1.20E-04	0.01	23,879	0.00
Ethane	C_2H_6	0	0	0	0	0	0	0.00	22,320	--
Ethanol	C_2H_5OH	0.04	0	0	0.001	3	0	3.04	13,161	1.30E-01
Acetic Acid	$C_2H_4O_2$	13	1	0.02	0	0	0	14.02	6,558	4.67E-01
Furfural	$C_5H_4O_2$	8	0.1	0.005	0.02	8.10E-04	0	8.13	--	4.23E-01
Tars / Fusel Oils	$C_{10}H_8$	0	0	0	0	0.60	0	0.63	--	--
Carbon Dioxide	CO_2	1	1,139	10	0.7	7.50E-05	0.3	1,151.00	--	26.15
Water/Inerts	H_2O/Inerts	1,101	1,272	6	121	0.03	0.02	2,500.05	--	--
	Total (lb-mol/hr)	2,872	35,702	94	422	18	1	39,108.10	--	27.17

Process Vents Energy:	12024 Digester Vent Gas	16023 Propagator Vent	16012 Saccharification Vent	19026 Stillage Handling Vent	2133 Ethanol Loadout Vent	1916 + 1919 Ammonia Tank Vent	Combined Process Vents
HHV (Btu/lb)	30.07	0.19	6.19	0.17	2,239.80	394.08	3.42
Volumetric Flow (lb-mol/hr)	2,871.51	35,702.24	94.17	421.79	17.63	0.75	39,108.10
Energy (MMBtu/hr)	0.09	0.01	0.00	0.00	0.04	0.00	0.13

EP-20001
Biomass-Fired Stoker Boiler

Biomass-Fired Stoker Boiler Emissions (Nominal TYPICAL Fuel Blend)

Emission Factors: Nominal TYPICAL Fuel Blend		Combined Fuels	Process Vents	Total		
Criteria Pollutants		(lb/dry ton)	(lb/hr)	(lb/hr)	(lb/MMBtu)	Notes:
NOx		10.12	0.64	325.79	0.70	Predicted NOx for similar fuel combustion for stoker from vendor proposal (approximately 11% fuel N conversion to NOx). Staged combustion to minimize thermal NOx.
SO_2		34.40	0.301	1,105.54	2.35	Predicted SOx for similar fuel combustion for stoker from vendor testing (100% fuel S conversion to SOx).
H_2SO_4 (SAM)		--		67.68	0.14	Based on 4% SO_2 conversion to SO_3 and 100% conversion SO_3 to H_2SO_4.
CO		3.23	Negligible	103.62	0.22	Note 1. Predicted CO for similar fuel combustion for stoker from vendor proposal. Modern combustion practices, staged combustion, fuel/air mixing, large firebox/residence time.
VOC		0.25	Negligible	8.01	0.017	Table 1.6-3, 70% control efficiency for use of modern stoker boiler based on performance test data from similar fuel combustion for stoker.
PM	Filterable	--		3,568.67	7.58	Table 1.6-1 Filterable PM from wood residue combustion, bark and wet wood. Adjusted to account for increased ash content of fuel blend.
PM_{10}	Filterable	--		3,186.32	6.77	Table 1.6-1 Filterable PM_{10} from wood residue combustion, bark and wet wood. Adjusted to account for increased ash content of fuel blend.
$PM_{2.5}$	Filterable	--		2,740.23	5.82	Table 1.6-1 Filterable $PM_{2.5}$ from wood residue combustion, bark and wet wood. Adjusted to account for increased ash content of fuel blend.
PM	Condensible	--		8.01	0.017	Table 1.6-1 Condensible PM from wood residue combustion, bark and wet wood.
PM_{10}	Condensible	--		8.01	0.017	Table 1.6-1 Condensible PM from wood residue combustion, bark and wet wood.
$PM_{2.5}$	Condensible	--		8.01	0.017	Table 1.6-1 Condensible PM from wood residue combustion, bark and wet wood.
Lead		0.0007	Negligible	0.02	4.80E-05	Table 1.6-4
NH_3		--		6.03	0.0128	Note 2 - Predicted 25 ppmv NH_3 slip. Includes NH_3 from gaseous fuel source.
GHG Pollutants						
Natural Gas CO_2		3,130	1,195.93	101,755.94	216.04	Boiler fuel criteria engineering calculations - 100% conversion fuel carbon to CO_2.
CH_4		--		33.23	0.071	CCAR Table C.8 (0.032 kg CH_4/MMBtu). Methane is a combustible boiler fuel.
N_2O		--		4.36	0.009	CCAR Table C.8 (0.0042 kg N_2O/MMBtu).

(1) Emission factors for CO in parts per million (ppm) converted to lb/MMBtu as follows:

EF (lb/MMBtu) = (ppm) x (k) x (F) x (20.9/(20.9-%O_2))

where:

CO =	260	ppm	Vendor Proposal
%O_2 =	3	%	
k =	unit conversion, (2.59E-09 x Molecular Weight (M)) lb/dscf = 1 ppm		
k (for CO) =	7.25E-08	(lb/scf)/ppm	
F =	9939.40	dscf/MMBtu	Based on stoichiometric flow
Molecular weight of CO =	28.01		

(2) Emission factors for NH_3 in parts per million (ppm) converted to lb/MMBtu as follows:

EF (lb/MMBtu) = (ppm) x (k) x (F) x (20.9/(20.9-%O_2))

where:

NH_3 =	25	ppm	Vendor Proposal
%O_2 =	3	%	
k =	unit conversion, (2.59E-09 x Molecular Weight (M)) lb/dscf = 1 ppm		
k (for NH_3) =	4.41077E-08	(lb/scf)/ppm	
F =	9939.40	dscf/MMBtu	Based on stoichiometric flow
Molecular weight of NH_3 =	17.03		

EP-20001
Biomass-Fired Stoker Boiler

Emissions: **Nominal TYPICAL Fuel Blend**		Control Efficiency	EP-20001 Biomass-Fired Stoker Boiler Uncontrolled		EP-20001 Biomass-Fired Stoker Boiler Controlled		BACT	
Criteria Pollutants		(%)	(lb/hr)	(ton/yr)	(lb/hr)	(ton/yr)	(lb/MMBtu)	
NOx		57%	325.79	1,426.95	140.09	613.59	0.30	As guaranteed by vendor with SCR.
SO_2		92%	1,105.54	4,842.28	88.44	387.38	0.188	
H_2SO_4 (SAM)		99%	67.68	296.43	0.68	2.96	0.001	
CO		0%	103.62	453.87	103.62	453.87	0.220	
VOC		70%	8.01	35.07	2.40	10.52	0.005	
PM	Filterable	99.8%	3,568.67	15,630.79	7.14	31.26	0.015	
PM_{10}	Filterable	99.8%	3,186.32	13,956.06	6.37	27.91	0.014	
$PM_{2.5}$	Filterable	99.8%	2,740.23	12,002.21	5.48	24.00	0.012	
PM	Condensible	0%	8.01	35.07	8.01	35.07	0.017	
PM_{10}	Condensible	0%	8.01	35.07	8.01	35.07	0.017	
$PM_{2.5}$	Condensible	0%	8.01	35.07	8.01	35.07	0.017	
Lead		0%	0.02	0.10	0.02	0.10	--	
NH_3		0%	--	--	6.40	28.03	--	
GHG Pollutants								
CO_2		0%	101,756	445,691	101,756	445,691	--	
CH_4		0%	33.23	145.56	33.23	145.56	--	
N_2O		0%	4.36	19.11	4.36	19.11	--	

EP-20001
Biomass-Fired Stoker Boiler

Biomass-Fired Stoker Boiler Emissions (Maximum WORST CASE Fuel Blend)

Emission Factors: Maximum WORST CASE Fuel Blend		Combined Fuels	Process Vents	Total		
Criteria Pollutants		(lb/dry ton)	(lb/hr)	(lb/hr)	(lb/MMBtu)	Notes:
NOx		11.13	0.64	377.38	0.76	Predicted NOx for similar fuel combustion for stoker from vendor proposal (approximately 11% fuel N conversion to NOx). Staged combustion to minimize thermal NOx.
SO_2		39.20	0.301	1326.94	2.65	Predicted SOx for similar fuel combustion for stoker from vendor testing (100% fuel S conversion to SOx).
H_2SO_4 (SAM)		--		81.23	0.16	Based on 4% SO_2 conversion to SO_3 and 100% conversion SO_3 to H_2SO_4.
CO		3.25	Negligible	110.04	0.22	Note 1. Predicted CO for similar fuel combustion for stoker from vendor proposal. Modern combustion practices, staged combustion, fuel/air mixing, large firebox/residence time.
VOC		0.25	Negligible	8.50	0.017	Table 1.6-3, 70% control efficiency for use of modern stoker boiler based on performance test data from similar fuel combustion for stoker.
PM	Filterable	--		3,634.40	7.27	Table 1.6-1 Filterable PM from wood residue combustion, bark and wet wood. Adjusted to account for increased ash content of fuel blend.
PM_{10}	Filterable	--		3,245.00	6.49	Table 1.6-1 Filterable PM_{10} from wood residue combustion, bark and wet wood. Adjusted to account for increased ash content of fuel blend.
$PM_{2.5}$	Filterable	--		2,790.70	5.58	Table 1.6-1 Filterable $PM_{2.5}$ from wood residue combustion, bark and wet wood. Adjusted to account for increased ash content of fuel blend.
PM	Condensible	--		8.50	0.017	Table 1.6-1 Condensible PM from wood residue combustion, bark and wet wood.
PM_{10}	Condensible	--		8.50	0.017	Table 1.6-1 Condensible PM from wood residue combustion, bark and wet wood.
$PM_{2.5}$	Condensible	--		8.50	0.017	Table 1.6-1 Condensible PM from wood residue combustion, bark and wet wood.
Lead		0.0007	Negligible	0.02	4.80E-05	Table 1.6-4
NH_3		--		6.43	0.0129	Note 2 - Predicted 25 ppmv NH_3 slip. Includes NH_3 from gaseous fuel source.
GHG Pollutants						
CO_2		3,150	1,195.93	107,789.44	215.58	Boiler fuel criteria engineering calculations - 100% conversion fuel carbon to CO_2.
CH_4		--		35.28	0.071	CCAR Table C.8 (0.032 kg CH_4/MMBtu). Methane is a combustible boiler fuel.
N_2O		--		4.63	0.009	CCAR Table C.8 (0.0042 kg N_2O/MMBtu).

(1) Emission factors for CO in parts per million (ppm) converted to lb/MMBtu as follows:

EF (lb/MMBtu) = (ppm) x (k) x (F) x (20.9/(20.9-%O_2))

where:

CO =	260	ppm	Vendor Proposal
%O_2 =	3	%	
k =	unit conversion, (2.59E-09 x Molecular Weight (M)) lb/dscf = 1 ppm		
k (for CO) =	7.25E-08	(lb/scf)/ppm	
F =	9988.31	dscf/MMBtu	Based on stoichiometric flow
Molecular weight of CO =	28.01		

(2) Emission factors for NH_3 in parts per million (ppm) converted to lb/MMBtu as follows:

EF (lb/MMBtu) = (ppm) x (k) x (F) x (20.9/(20.9-%O_2))

where:

NH_3 =	25	ppm	Vendor Proposal
%O_2 =	3	%	
k =	unit conversion, (2.59E-09 x Molecular Weight (M)) lb/dscf = 1 ppm		
k (for NH_3) =	4.41077E-08	(lb/scf)/ppm	
F =	9988.31	dscf/MMBtu	Based on stoichiometric flow
Molecular weight of NH_3 =	17.03		

EP-20001
Biomass-Fired Stoker Boiler

Emissions: **Maximum WORST CASE Fuel Blend**		Control Efficiency	EP-20001 Biomass-Fired Stoker Boiler Uncontrolled		EP-20001 Biomass-Fired Stoker Boiler Controlled		BACT	
Criteria Pollutants		(%)	(lb/hr)	(ton/yr)	(lb/hr)	(ton/yr)	(lb/MMBtu)	
NOx		60%	377.38	1,652.92	150.95	661.17	0.30	As guaranteed by vendor with SCR.
SO_2		92%	1,326.94	5,811.99	106.16	464.96	0.212	
H_2SO_4 (SAM)		99%	81.23	355.79	0.81	3.56	0.002	
CO		0%	110.04	481.99	110.04	481.99	0.220	
VOC		70%	8.50	37.24	2.55	11.17	0.005	
PM	Filterable	99.8%	3,634.40	15,918.67	7.27	31.84	0.015	
PM_{10}	Filterable	99.8%	3,245.00	14,213.10	6.49	28.43	0.013	
$PM_{2.5}$	Filterable	99.8%	2,790.70	12,223.27	5.58	24.45	0.011	
PM	Condensible	0%	8.50	37.23	8.50	37.23	0.017	
PM_{10}	Condensible	0%	8.50	37.23	8.50	37.23	0.017	
$PM_{2.5}$	Condensible	0%	8.50	37.23	8.50	37.23	0.017	
Lead		0%	0.02	0.11	0.02	0.11	--	
NH_3		0%	--	--	0.00	0.00	--	
GHG Pollutants								
CO_2		0%	107,789	472,118	107,789	472,118	--	
CH_4		0%	35.28	154.53	35.28	154.53	--	
N_2O		0%	4.63	20.28	4.63	20.28	--	

EP-20001
Biomass-Fired Stoker Boiler

Biomass-Fired Stoker Boiler Emissions (Solid Fuel Failure Fuel Blend)

Emission Factors: Solid Fuel Failure Fuel Blend [Liquid (i.e. EH Stillage Syrup) and Gaseous Fuels Only]		Combined Fuels (Excluding	Process Vents	Total		
Criteria Pollutants		(lb/dry ton)	(lb/hr)	(lb/hr)	(lb/MMBtu)	Notes:
NOx		11.42	0.64	190.10	0.55	Predicted NOx for similar fuel combustion for stoker from vendor proposal (approximately 11% fuel N conversion to NOx) with use of low NOx technology. Staged combustion to minimize thermal NOx. Natural gas added into emission factor based on LNB emission rate.
SO_2		58.00	0.301	921.78	2.62	Predicted SOx for similar fuel combustion for stoker from vendor testing (100% fuel S conversion to SOx).
H_2SO_4 (SAM)		--		56.43	0.16	Based on 4% SO_2 conversion to SO_3 and 100% conversion SO_3 to H_2SO_4.
CO		4.20	Negligible	66.78	0.190	Note 1. Predicted CO for similar fuel combustion for stoker from vendor proposal. Modern combustion practices, staged combustion, fuel/air mixing, large firebox/residence time.
VOC		0.38	Negligible	5.98	0.017	Table 1.6-3, 70% control efficiency for use of modern stoker boiler based on performance test data from similar fuel combustion for stoker.
PM	Filterable	--		690.91	1.97	Table 1.6-1 Filterable PM from wood residue combustion, bark and wet wood. Adjusted to account for increased ash content of fuel blend.
PM_{10}	Filterable	--		616.88	1.76	Table 1.6-1 Filterable PM_{10} from wood residue combustion, bark and wet wood. Adjusted to account for increased ash content of fuel blend.
$PM_{2.5}$	Filterable	--		530.52	1.51	Table 1.6-1 Filterable $PM_{2.5}$ from wood residue combustion, bark and wet wood. Adjusted to account for increased ash content of fuel blend.
PM	Condensible	--		5.98	0.017	Table 1.6-1 Condensible PM from wood residue combustion, bark and wet wood.
PM_{10}	Condensible	--		5.98	0.017	Table 1.6-1 Condensible PM from wood residue combustion, bark and wet wood.
$PM_{2.5}$	Condensible	--		5.98	0.017	Table 1.6-1 Condensible PM from wood residue combustion, bark and wet wood.
Lead		0.0011	Negligible	0.02	4.80E-05	Table 1.6-4
NH_3		--		4.00	0.0114	Note 2 - Predicted 25 ppmv NH_3 slip. Includes NH_3 from gaseous fuel source.
GHG Pollutants						
CO_2		3,366	1,195.93	54,673.26	155.54	Boiler fuel criteria engineering calculations - 100% conversion fuel carbon to CO_2.
CH_4		--		24.80	0.071	CCAR Table C.8 (0.032 kg CH_4/MMBtu). Methane is a combustible boiler fuel.
N_2O		--		3.26	0.009	CCAR Table C.8 (0.0042 kg N_2O/MMBtu).

(1) Emission factors for CO in parts per million (ppm) converted to lb/MMBtu as follows:

EF (lb/MMBtu) = (ppm) x (k) x (F) x (20.9/(20.9-%O_2))

where:

CO =	260	ppm	Vendor Proposal
%O_2 =	3	%	
k =	unit conversion, (2.59E-09 x Molecular Weight (M)) lb/dscf = 1 ppm		
k (for CO) =	7.25E-08	(lb/scf)/ppm	
F =	8838.72	dscf/MMBtu	Based on stoichiometric flow
Molecular weight of CO =	28		

(2) Emission factors for NH_3 in parts per million (ppm) converted to lb/MMBtu as follows:

EF (lb/MMBtu) = (ppm) x (k) x (F) x (20.9/(20.9-%O_2))

where:

NH_3 =	25	ppm	Vendor Proposal
%O_2 =	3	%	
k =	unit conversion, (2.59E-09 x Molecular Weight (M)) lb/dscf = 1 ppm		
k (for NH_3) =	4.41077E-08	(lb/scf)/ppm	
F =	8838.72	dscf/MMBtu	Based on stoichiometric flow
Molecular weight of NH_3 =	17.03		

EP-20001 Biomass-Fired Stoker Boiler						
Emissions: Solid Fuel Failure Fuel Blend [Liquid (i.e. EH Stillage Syrup) and Gaseous Fuels Only]		Control Efficiency	EP-20001 Biomass-Fired Stoker Boiler Uncontrolled		EP-20001 Biomass-Fired Stoker Boiler Controlled		BACT
Criteria Pollutants		(%)	(lb/hr)	(ton/yr)	(lb/hr)	(ton/yr)	(lb/MMBtu)
NOx		60%	190.10	832.63	76.04	333.05	0.216
SO_2		92%	921.78	4,037.38	73.74	322.99	0.210
H_2SO_4 (SAM)		99%	56.43	247.16	0.56	2.47	0.002
CO		0%	66.78	292.52	66.78	292.52	0.190
VOC		70%	5.98	26.17	1.79	7.85	0.005
PM	Filterable	99.3%	690.91	3,026.17	4.84	21.18	0.014
PM_{10}	Filterable	99.3%	616.88	2,701.94	4.32	18.91	0.012
$PM_{2.5}$	Filterable	99.3%	530.52	2,323.66	3.71	16.27	0.011
PM	Condensible	0%	5.98	26.17	5.98	26.17	0.017
PM_{10}	Condensible	0%	5.98	26.17	5.98	26.17	0.017
$PM_{2.5}$	Condensible	0%	5.98	26.17	5.98	26.17	0.017
Lead		0%	0.02	0.07	0.02	0.07	--
NH_3		0%	--	--	5.69	24.92	--
GHG Pollutants							
CO_2		0%	54,673	239,469	54,673	239,469	--
CH_4		0%	24.80	108.63	24.80	108.63	--
N_2O		0%	3.26	14.26	3.26	14.26	--

Abengoa Bioenergy Biomass of Kansas, LLC **Rev. 5.1**
Biorefinery Facility
Hugoton, Kansas

EP-20001
Biomass-Fired Stoker Boiler During Start-Up and at Reduced Loads

Fuel Configuration

Basis: Emissions from biomass combustion presented for a stoker boiler during normal operations are still applicable.

In addition to firing biomass and biogas, the biomass-fired stoker boiler will be capable of firing on natural gas during normal operations as needed, as well as firing on a combination of natural gas, liquid fuel (i.e. EH stillage syrup) and biogas in the event of a solid fuel failure. "Start-up" emissions are based on the combustion of natural gas only, without any add-on control devices. All other firing scenarios will only be possible when the add-on control devices are operational.

Biomass-fired stoker boiler start-up based on the use of natural gas to heat the boiler to 400 ^{o}C (approximately 4 hours). The spray dry absorber (SDA) scrubber is started when the appropriate operating temperature is achieved. No fuels other than natural gas will be combusted until the SDA scrubber and SCR are operational. The SCR will be fully functional at greater than 30% load. The baghouse utilized for PM control will be in service at all times.

Gaseous fuel to be supplied to the biomass-fired stoker boiler from the wastewater treatment system will not be feed to the boiler system during SSM.

AP-42 Section 1.4 Natural Gas Combustion, Final Section, July 1998.

California Climate Action Registry (CCAR) General Reporting Protocol, Version 3.1, January 2009.

Criteria:

Number of Solids-Fired Boilers	1		
Total Area 20000 Heat Input - Permit	500	MMBtu/hr	
Maximum Heat Input Per Boiler When Fully Operational	500	MMBtu/hr	
Heat Input During Initial Start-up	61	MMBtu/hr	Natural gas used for start-up.
30% of Nominal Heat Input When Fully Operational	141	MMBtu/hr	Approximately 30% Load of Nominal Design (Baghouse, SDA Scrubber and SCR Operational).
50% of Nominal Heat Input When Fully Operational	236	MMBtu/hr	Approximately 50% Load of Nominal Design (Baghouse, SDA Scrubber and SCR Operational).
75% of Nominal Heat Input When Fully Operational	353	MMBtu/hr	Approximately 75% Load of Nominal Design (Baghouse, SDA Scrubber and SCR Operational).
100% of Nominal Heat Input When Fully Operational	471	MMBtu/hr	100% Load of Nominal Design, Approximately 83.5% Load of Boiler Nameplate.
Annual Operations	8,760	hr/yr	

Source Details:

	Stack Flow Rate	Stack Diameter	Release Height	Stack Area	Gas Velocity		Gas Exit Temperature	
Percent Load	(cfm)	(in)	(ft)	(ft^2)	(ft/s)	(m/s)	(deg F)	(deg K)
30% Reduced Load	66,000	120	160	78.54	14.01	4.27	250	394
50% Reduced Load	110,000	120	160	78.54	23.34	7.11	280	411
75% of Nominal Design Load	165,000	120	160	78.54	35.01	10.67	300	422
100% of Nominal Design Load	220,000	120	160	78.54	46.69	14.23	300	422
120% of Nominal Design Load	264,000	120	160	78.54	56.02	17.07	300	422

EP-20001
Biomass-Fired Stoker Boiler During Start-Up and at Reduced Loads

Biomass-Fired Boiler Emissions (Maximum WORST CASE Fuel Blend)

Emission Factors: (Maximum WORST CASE Fuel Blend)		Combined Fuels	Process Vents	Total		Notes:	
Criteria Pollutants		(lb/dry ton)	(lb/hr)	(lb/hr)	(lb/MMBtu)		
NOx		11.13	0.64	377.38	0.76	Predicted NOx for similar fuel combustion for stoker from vendor proposal (approximately 11% fuel N conversion to NOx). Staged combustion to minimize thermal NOx.	
SO_2		39.20	0.301	1326.94	2.65	Predicted SOx for similar fuel combustion for stoker from vendor testing (100% fuel S conversion to SOx).	
CO		3.25	Negligible	110.04	0.22	Note 1. Predicted CO for similar fuel combustion for stoker from vendor proposal. Modern combustion practices, staged combustion, fuel/air mixing, large firebox/residence time.	
VOC		0.25	Negligible	8.50	0.017	fuel combustion for stoker.	
PM	Filterable	--		3,634.40	7.27	Table 1.6-1	Filterable PM from wood residue combustion, bark and wet wood. Adjusted to account for increased ash content of fuel blend.
PM_{10}	Filterable	--		3,245.00	6.49	Table 1.6-1	Filterable PM_{10} from wood residue combustion, bark and wet wood. Adjusted to account for increased ash content of fuel blend.
$PM_{2.5}$	Filterable	--		2,790.70	5.58	Table 1.6-1	Filterable $PM_{2.5}$ from wood residue combustion, bark and wet wood. Adjusted to account for increased ash content of fuel blend.
PM	Condensible	--		8.50	0.017	Table 1.6-1	Condensible PM from wood residue combustion, bark and wet wood.
PM_{10}	Condensible	--		8.50	0.017	Table 1.6-1	Condensible PM from wood residue combustion, bark and wet wood.
$PM_{2.5}$	Condensible	--		8.50	0.017	Table 1.6-1	Condensible PM from wood residue combustion, bark and wet wood.
Lead		0.0007	Negligible	0.02	4.80E-05	Table 1.6-4	
NH_3		--		6.43	0.0129	Note 2 - Predicted 25 ppmv NH_3 slip. Includes NH_3 from gaseous fuel source.	
GHG Pollutants							
CO_2		3,150	1,195.93	107,789.44	215.58	Boiler fuel criteria engineering calculations - 100% conversion fuel carbon to CO_2.	
CH_4		--		35.28	0.071	CCAR Table C.8 (0.032 kg CH_4/MMBtu). Methane is a combustible boiler fuel.	
N_2O		--		4.63	0.009	CCAR Table C.8 (0.0042 kg N_2O/MMBtu).	

EP-20001
Biomass-Fired Stoker Boiler During Start-Up and at Reduced Loads

Natural Gas Emission Factors:					
Criteria Pollutants	EF	Unit	EF	Unit	Notes:
NOx	190	lb/MMscf	0.04	lb/MMBtu	Note 1 - Maximum BACT Low-NOx Burner (LNB) = 0.04 MMBtu/hr (or 30 ppm @ 3% Oxygen)
SO_2	0.6	lb/MMscf	5.88E-04	lb/MMBtu	Table 1.4-2
CO	84	lb/MMscf	0.04	lb/MMBtu	Note 1 - Maximum BACT for CO with Good Combustion Practices = 0.04 MMBtu/hr (or 50 ppm @ 3% Oxygen)
VOC	5.5	lb/MMscf	5.39E-03	lb/MMBtu	Table 1.4-2
$PM/PM_{10}/PM_{2.5}$ Filterable	1.9	lb/MMscf	1.86E-03	lb/MMBtu	Table 1.4-2 All PM is assumed to be less than 1.0 micrometer in diameter.
$PM/PM_{10}/PM_{2.5}$ Condensible	5.7	lb/MMscf	5.59E-03	lb/MMBtu	Table 1.4-2 All PM is assumed to be less than 1.0 micrometer in diameter.
Lead	0.0005	lb/MMscf	4.90E-07	lb/MMBtu	Table 1.4-2
GHG Pollutants					
Natural Gas CO_2	119,337.25	lb/MMscf	117.00	lb/MMBtu	CCAR Table C.7 (53.06 kg CO_2/MMBtu, 100% Oxidization)
CH_4	2.2491	lb/MMscf	0.002205	lb/MMBtu	CCAR Table C.8 (0.001 kg CH_4/MMBtu)
N_2O	0.22491	lb/MMscf	0.0002205	lb/MMBtu	CCAR Table C.8 (0.0001 kg N_2O/MMBtu)

(1) Vendor emission factors for natural gas NO_x and CO emissions in parts per million (ppm) converted to lb/MMBtu as follows:

NOx EF (lb/MMBtu) = (ppm) x (k) x (F) x (20.9-(20.9-$\%O_2$))

Where:

NO_x =	30	ppm
CO =	50	ppm
$\%O_2$ =	3	%
k =	unit conversion, (2.59E-09 x M) lb/dscf = 1 ppm	
k (for NO_2) =	1.19E-07	(lb/scf)/ppm
k (for CO) =	7.25E-08	(lb/scf)/ppm
F =	8710	dscf/MMBtu
Molecular weight of NO_x as NO_2 =	46	
Molecular weight of CO =	28	

EP-20001
Biomass-Fired Stoker Boiler During Start-Up and at Reduced Loads

Emissions: Worst Case Emissions During Start-up and at Reduced Loads		Control Efficiency	Fully Operational Biomass-Fired Stoker Boiler Controlled	**Boiler During Initial Start-up Burning Natural Gas Only**	**Boiler Operating at 30% Reduced Nominal Load**	**Boiler Operating at 50% Reduced Nominal Load**	**Boiler Operating at 75% Reduced Nominal Load**	**Boiler Operating at 100% Nominal Load**	
Criteria Pollutants		(%)	(lb/hr)	**(lb/hr)**	**(lb/hr)**	**(lb/hr)**	**(lb/hr)**	**(lb/hr)**	
NOx		60%	150.95	**2.44**	**42.30**	**70.80**	**105.90**	**141.30**	As guaranteed by vendor with SCR.
SO_2		92%	106.16	**0.04**	**29.94**	**50.11**	**74.95**	**100.00**	
CO		0%	110.04	**2.44**	**31.02**	**51.92**	**77.66**	**103.62**	
VOC		70%	2.55	**0.33**	**2.40**	**1.20**	**1.80**	**2.40**	
PM	Filterable	99.8%	7.27	**0.11**	**2.05**	**3.43**	**5.13**	**6.85**	
PM_{10}	Filterable	99.8%	6.49	**0.11**	**1.83**	**3.06**	**4.58**	**6.11**	
$PM_{2.5}$	Filterable	99.8%	5.58	**0.11**	**1.57**	**2.63**	**3.94**	**5.26**	
PM	Condensible	0%	8.50	**0.34**	**2.40**	**4.01**	**6.00**	**8.01**	
PM_{10}	Condensible	0%	8.50	**0.34**	**2.40**	**4.01**	**6.00**	**8.01**	
$PM_{2.5}$	Condensible	0%	8.50	**0.34**	**2.40**	**4.01**	**6.00**	**8.01**	
Lead		0%	0.02	**0.00**	**0.007**	**0.011**	**0.017**	**0.023**	
NH_3		0%	--	**--**	**--**	**3.03**	**4.54**	**6.06**	
GHG Pollutants									
Natural Gas CO_2		0%	107,789	**0.13**	**25,222**	**50,877**	**76,099**	**101,538**	
CH_4		0%	35.28	**0.01**	**0.48**	**16.65**	**24.91**	**33.23**	
N_2O		0%	4.63	**0.00**	**0.05**	**2.19**	**3.27**	**4.36**	