pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

May 6, 2020

Mr. Tim Donnelly
Senior Project Manager
Power Engineers, Inc.
303 U.S. Route 1
Freeport, ME 04032

Re: Proposed Plan Approval 18-00033B
Renovo Energy Center
Renovo Borough, Clinton County

Dear Mr. Donnelly,

The Department of Environmental Protection (Department) has initiated the review of the plan approval application that Power Engineers, Inc. submitted on December 30, 2019, on behalf of Renovo Energy Center (REC), for the proposed construction and operation of a nominally rated 1,240 Megawatt (MW) dual fuel-fired combined cycle electric generating plant located in Renovo Borough, Clinton County. In order to complete the technical review, additional information and further clarification with respect to the following is required:

1. In the application there was no vendor data provided by the oxidation catalyst manufacturer on the emissions of carbon monoxide (CO), volatile organic compounds (VOCs) and formaldehyde emissions. Please provide vendor guarantees on the post control emissions of CO, VOC and formaldehyde from the proposed oxidation catalyst that satisfy the requirements of the Best Available Technology (BAT) pursuant to 25 Pa. Code Sections 127.1 and 127.12 and the Best Available Control Technology (BACT) pursuant to 40 CFR Part 52 Section 52.21. Additionally, please provide vendor guarantee of the VOC emissions that satisfy the requirements of the Lowest Achievable Emission Rate (LAER) pursuant to 25 Pa. Code Sections 127.201 through 127.218.

2. In the application there was no vendor data provided by the selective catalyst reduction (SCR) system manufacturer on the NO_x emissions. Please provide vendor guarantees on the post control NO_x emissions from the proposed SCR that satisfies the requirements of BAT, BACT and LAER.

3. Are the manufacturer-provided combustion turbine (CT) emission data in Appendix E of the application the pre-control emissions prior to the control devices? If these are the post-control emissions, please provide the pre-control emissions from the CT and duct burners (DB).

4. The Department issued a plan approval in August 2019 to ESC Tioga County Power, LLC (ESC) for the construction of a power plant which utilized the same model GE turbine proposed by Renovo Energy Center. For the ESC unit, the carbon monoxide (CO) emission limit from the exhaust of the oxidation catalyst was established at 0.9 parts per million (ppm) while firing the CT only and 1.5 ppm while firing both the CT and DB on natural gas. Please re-evaluate the proposed Renovo CO emissions from the exhaust of the oxidation catalyst while firing the CT only and the combination of the CT and DB that satisfy the requirements of BAT and LAER.

5. In the plan approval for ESC Tioga, the VOC emission limit from exhaust of the oxidation catalyst was established at 1.6 ppm while firing both the CT and DB on natural gas in order to satisfy the requirements of BAT, BACT and LAER. Please re-evaluate the proposed VOC emissions from the exhaust of the oxidation catalyst while firing both the CT and DB that satisfy the requirements of BAT, BACT and LAER.

6. The Department is requiring that emission limitations be established for startup/shutdown (SUSD) emissions per event (cold/warm/hot starts and shutdown) for NO_x, CO, VOC and total (filterable and condensable) particulate matter emissions ($PM/PM_{10}/PM_{2.5}$) that satisfies the requirements of BAT, BACT and LAER. The SUSD limitations for firing on natural gas proposed in the application are higher than the limitations established in ESC Tioga plan approval. Please re-evaluate the SUSD emissions per event for NOx, CO, VOC and $PM/PM_{10}/PM_{2.5}$ to satisfy the requirements of BAT, BACT and LAER.

7. Do the duct burners have the capability of firing on ULSD? If so, please provide the potential emissions with calculations for all criteria pollutants that satisfies the requirements of BAT, BACT and LAER while the duct burners are firing on ULSD?

8. Both the Renovo application narrative and the United States Environmental Protection RACT/BACT/ LAER Clearinghouse website state that the ammonia slip emission limitation established at the Killingly Energy Center plant in Connecticut is 2 parts per million (ppm) of exhaust gas in 2017. Renovo Energy Center is proposing 5 ppm. Please re-evaluate the proposed ammonia slip emission rate to satisfy the requirements of BAT and BACT.

9. In the previous Renovo plan approval 18-00033A issuance, the NO_x emission rate for the emergency generator engine was established at 3.98 grams per brake horsepower. In the current application, the proposed NO_x emission from the engine is 4.48 grams per brake horsepower. Please re-evaluate the proposed NO_x emissions from the emergency generator engine that satisfies the requirements of BACT, BACT and LAER.

Review of the plan approval application is pending upon the receipt of all requested information as indicated above. Please submit the above requested information no later than 30 days from the receipt of this letter.

If you have questions or concerns about the information requested in this letter, please feel free to contact Paul Waldman, Air Quality Engineer, at 570-327-3721, or by e-mail at pwaldman@pa.gov.

Sincerely,

David M. Shimmel, P.E.
Chief, New Source Review Section
Air Quality Program

cc: File: Renovo Energy Center, FAC, FAC OP, 18-00033
Central Office – Air Quality Permits & Modeling Sections

POWER ENGINEERS, INC.

303 U.S. ROUTE ONE
FREEPORT, ME 04032 USA

PHONE 207-869-1200
FAX 207-869-1299

May 28, 2020

Mr. David Shimmel
Chief, New Source Review Section
Air Quality Program
PA DEP Northcentral Regional Office
208 W. Third Street, Suite 101
Williamsport, PA 17701-6448

Subject: Renovo Energy Center LLC, Proposed Plan Approval 18-00033B

Dear Mr. Shimmel:

On behalf of Renovo Energy Center LLC (REC), POWER Engineers, Inc. is submitting the following responses to your letter dated May 6, 2020 requesting additional information and clarification regarding REC's Plan Approval Application 18-00033B. The requests are shown in italics followed by Renovo Energy Center's response.

1. *In the application there was no vendor data provided by the oxidation catalyst manufacturer on the emissions of carbon monoxide (CO), volatile organic compounds (VOCs) and formaldehyde emissions. Please provide vendor guarantees on the post control emissions of CO, VOC and formaldehyde from the proposed oxidation catalyst that satisfy the requirements of the Best Available Technology (BAT) pursuant to 25 Pa. Code Sections 127.1 and 127.12 and the Best Available Control Technology (BACT) pursuant to 40 CFR Part 52 Section 52.21. Additionally, please provide vendor guarantee of the VOC emissions that satisfy the requirements of the Lowest Achievable Emission Rate (LAER) pursuant to 25 Pa. Code Sections 127.201 through 127.218.*

   The oxidation catalyst make and model is not available at this stage of project development and will not be determined until GE procures this equipment during project execution. General Electric (GE) typically utilizes oxidation catalysts from Emerichem, BASF, JMI, or equivalent. GE as the combustion turbine original equipment manufacturer (OEM) is guaranteeing the post control emissions.

2. *In the application there was no vendor data provided by the selective catalyst reduction (SCR) system manufacturer on the NOx emissions. Please provide vendor guarantees on the post control NOx emissions from the proposed SCR that satisfies the requirements of BAT, BACT and LAER.*

   The SCR make and model is not available at this stage of project development and will not be determined until GE procures this equipment during project execution. GE typically utilizes honeycomb vanadium/titanium based catalysts (or equivalent) from a qualified vendor such as Cormetech, Haldor Topsoe, or Hitachi Zosen. GE as the combustion turbine original equipment manufacturer (OEM) is guaranteeing the post control emissions.

3. *Are the manufacturer-provided combustion turbine (CT) emission data in Appendix E of the application the pre-control emissions prior to the control devices? If these are the post-control emissions, please provide the pre-control emissions from the CT and duct burners (DB).*

   The pre-control and post-control emissions from the CT and DB over a range of operating conditions are provided on the second page of Appendix D of REC's Plan Approval Application (page 217 of 588 in the electronic file).

4. *The Department issued a plan approval in August 2019 to ESC Tioga County Power, LLC (ESC) for the construction of a power plant which utilized the same model GE turbine proposed by Renovo Energy Center. For the ESC unit, the carbon monoxide (CO) emission limit from the exhaust of the oxidation catalyst was established at 0.9 parts per million (ppm) while firing the CT only and 1.5 ppm while firing both the CT and DB on natural gas. Please re-evaluate the proposed Renovo CO emissions from the exhaust of the oxidation catalyst while firing the CT only and the combination of the CT and DB that satisfy the requirements of BAT and LAER.*

   REC accepts CO emission limits of 0.9 parts per million (ppm) while firing the CT only and 1.5 ppm while firing both the CT and DB on natural gas. As the proposed plant is in an area of CO attainment, REC's CO emissions are subject to BACT and BAT, not LAER.

5. *In the plan approval for ESC Tioga, the VOC emission limit from exhaust of the oxidation catalyst was established at 1.6 ppm while firing both the CT and DB on natural gas in order to satisfy the requirements of BAT, BACT and LAER. Please re-evaluate the proposed VOC emissions from the exhaust of the oxidation catalyst while firing both the CT and DB that satisfy the requirements of BAT, BACT and LAER.*

   REC accepts a VOC emission limit of 1.6 ppm when firing both the CT and DB.

6. *The Department is requiring that emission limitations be established for startup/shutdown (SUSD) emissions per event (cold/warm/hot starts and shutdown) for NOx, CO, VOC and total (filterable and condensable) particulate matter emissions (PM/PM10/PM2.5) that satisfies the requirements of BAT, BACT and LAER. The SUSD limitations for firing on natural gas proposed in the application are higher than the limitations established in ESC Tioga plan approval. Please re-evaluate the SUSD emissions per event for NOx, CO, VOC and PM/PM10/PM2.5 to satisfy the requirements of BAT, BACT and LAER.*

   REC has evaluated the differences between the SUSD emissions per event that were proposed for REC and those that were approved for ESC Tioga and reaffirms that the proposed values satisfy the requirements of BAT, BACT and LAER. REC believes that all appropriate characteristics of the emission limits for the SUSD events warrant consideration in this determination. REC's proposed NOx emissions per event for both cold and warm starts are lower than ESC Tioga's, and on a pound-per-hour basis, all Cold Start emission values are lower, all Warm Start (except for VOC) values are lower, and NOx Hot Start values are lower.

7. *Do the duct burners have the capability of firing on ULSD? If so, please provide the potential emissions with calculations for all criteria pollutants that satisfies the requirements of BAT, BACT and LAER while the duct burners are firing on ULSD?*

   The duct burners will not have the capability of firing on ULSD

8. *Both the Renovo application narrative and the United States Environmental Protection RACT/BACT/ LAER Clearinghouse website state that the ammonia slip emission limitation established at the Killingly Energy Center plant in Connecticut is 2 parts per million (ppm) of exhaust gas in 2017. Renovo Energy Center is proposing 5 ppm. Please re-evaluate the proposed ammonia slip emission rate to satisfy the requirements of BAT and BACT.*

   Killingly Energy Center is not operating, and the 2-ppm limit is not being achieved in practice. "Achievable" and "achieved in practice" are included in the definitions of BACT and LAER in 40 CFR Part 51. REC's proposed limit of 5-ppm is consistent with levels achieved in practice as well as recently issued permit levels for similar projects.

9. *In the previous Renovo plan approval 18-00033A issuance, the NOx emission rate for the emergency generator engine was established at 3.98 grams per brake horsepower. In the current application, the proposed NOx emission from the engine is 4.48 grams per brake horsepower. Please re-evaluate the proposed NOx emissions from the emergency generator engine that satisfies the requirements of BACT, BACT and LAER.*

   The proposed NOx emission rate is calculated based on EPA's Tier 2 standard contained in 40 CFR Part 60 Subpart IIII, EPA's weighted emissions calculator for constant speed engines (40 CFR Part 89, Table 2 of Appendix B to Section E) and nominal emissions data provided by Caterpillar. See attached calculations and vendor data. Compliance with the NSPS standard combined with good combustion practices and a 500 hour per year limit is proposed at BACT/LAER/BAT for the engine. The previous NOx emission limit of 3.98 g/bhp-hr was erroneously calculated by subtracting the maximum possible VOC emission factor from the weighted cycle average NOx+VOC emission factor. The manufacturer provided emissions data for this unit is identical to that which the limits in Plan Approval 18-00033A were based upon. REC therefore requests that the NOx emission rate limit be established at the correct value of 4.48 g/bhp-hr.

Please do not hesitate to contact me if you require additional information.

Sincerely,

Tim Donnelly

cc: Rick Franzese, Bechtel Development Company
Bill Bousquet, Innovative Power Solutions, LLC

Renovo Energy Center

Supporting Documentation for Responses to Questions #4 & #5

May 28, 2020

Renovo Energy Center
Facility-Wide Maximum Potential Emissions
Tons Per Year

Pollutant	Power-blocks	Auxiliary Boilers	Diesel Generator	Diesel Fire Pump	Heater	ULSD storage tank	Circuit Breakers	Facility-Wide Total
NOx	355.17	0.87	5.45	0.18	2.72	---	---	364.4
CO	325.86	5.23	1.50	0.059	5.93	---	---	338.6
PM_{10}	211.92	0.28	0.16	0.0065	0.27	---	---	212.6
VOC	102.43	0.29	0.97	0.0065	0.73	0.042	---	104.5
SO_2	53.48	0.084	0.0055	0.00032	0.084	---	---	53.6
NH_3	277.36	---	---	---	---	---	---	277.4
Lead	0.042	---	---	---	---	---	---	0.042
CO_2	5,413,496	16,949	582.92	33.44	16,852	---	---	5,447,914
CH_4	82.26	0.32	0.024	0.0014	0.32	---	---	82.9
N_2O	10.21	0.032	0.0047	0.00027	0.032	---	---	10.3
SF_6	---	---	---	---	---	---	0.0080	0.0080
CO_{2e}	5,418,594	16,967	584.92	33.55	16,869	---	182.97	5,453,232
H_2SO_4	35.40	0.013	---	---	---	---	---	35.4
HAPs	19.87	0.27	0.014	0.00078	0.27	---	---	20.4
Hexane[1]	7.36	0.26	---	---	0.25	---	---	7.9

[1] *Hexane is the single HAP with the highest potential emissions.*

Renovo Energy Center
Raw Data for General Electric Equipment

OPERATING POINT		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Ambient Temperature	°F	-20	95.8	59	95.8	-0.7	59	95.8	-20	35	59	95.8	-0.7	59	95.8	-20	95.8	59	95.8	-20	59	95.8
Ambient Pressure	psia	14.35	14.35	14.35	14.35	14.35	14.35	14.35	14.35	14.35	14.35	14.35	14.35	14.35	14.35	14.35	14.35	14.35	14.35	14.35	14.35	14.35
Ambient Relative Humidity	%	60	35	60	35	60	60	35	60	60	60	35	60	60	35	60	35	60	35	60	60	35
PLANT STATUS																						
SCR/CO Catalyst		Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating
Evaporative Cooler State[1]	on/off	Off	Off	On	On	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	On	On	Off	On	On
Gas Turbine Load	%	100%	100%	100%	100%	38%	30%	32%	100%	100%	100%	100%	60%	50%	50%	100%	100%	100%	100%	100%	100%	100%
Duct Burner Status	on/off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	On	On	On	On	On	Off	Off
Turbine Diluent Injection Type		None	None	None	None	None	None	None	Water	Water	Water	Water	Water	Water	Water	None	None	None	None	None	Water	Water
Diluent Injection Flow	klb/hr	--	--	--	--	--	--	--	260.8	266.4	266.4	249.8	151.8	120.1	109.8	--	--	--	--	--	266.4	254.2
FUEL DATA																						
Fuel Type		NG	NG	NG	NG	NG	NG	NG	DO	DO	DO	DO	DO	DO	DO	NG	NG	NG	NG	NG	DO	DO
HHV	Btu/lb	23,607	23,607	23,607	23,607	23,607	23,607	23,607	20,130	20,130	20,130	20,130	20,130	20,130	20,130	23,607	23,607	23,607	23,607	23,607	20,130	20,130
LHV	Btu/lb	21,292	21,292	21,292	21,292	21,292	21,292	21,292	18,300	18,300	18,300	18,300	18,300	18,300	18,300	21,292	21,292	21,292	21,292	21,292	18,300	18,300
Fuel Molecular Weight	lb/lbmole	16.52	16.52	16.52	16.52	16.52	16.52	16.52	n/a	n/a	n/a	n/a	n/a	n/a	n/a	16.52	16.52	16.52	16.52	16.52	n/a	n/a
Fuel Bound Nitrogen	Wt %	0	0	0	0	0	0	0	≤ 0.015%	≤ 0.015%	≤ 0.015%	≤ 0.015%	≤ 0.015%	≤ 0.015%	≤ 0.015%	0	0	0	0	0	≤ 0.015%	≤ 0.015%
Fuel Sulfur Content	ppmw	13.1	13.1	13.1	13.1	13.1	13.1	13.1	15	15	15	15	15	15	15	13.1	13.1	13.1	13.1	13.1	15	15
GT Heat Consumption[2]	MMBtu/hr HHV	3,523.8	3,230.1	3,541.1	3,459.2	1,837.7	1,516.3	1,470.6	3,940.4	3,892.8	3,848.4	3,588.7	2,646.6	2,258.0	2,109.7	3,523.8	3,230.1	3,541.1	3,459.2	3,523.8	3,914.6	3,824.7
DB Heat Consumption[2]	MMBtu/hr HHV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,001.9	821.6	906.8	878.2	1,005.3	0.0	0.0
Total Heat Consumption	MMBtu/hr HHV	3,523.8	3,230.1	3,541.1	3,459.2	1,837.7	1,516.3	1,470.6	3,940.4	3,892.8	3,848.4	3,588.7	2,646.6	2,258.0	2,109.7	4,525.7	4,051.7	4,447.9	4,337.4	4,529.1	3,914.6	3,824.7
HRSG EXIT EXHAUST GAS																						
Stack N2 mole fraction	-	0.7474	0.7326	0.7374	0.7266	0.75	0.7445	0.7377	0.7058	0.7001	0.6947	0.6889	0.7147	0.7113	0.7071	0.738	0.7244	0.7289	0.7184	0.738	0.6938	0.6862
Stack O2 mole fraction	-	0.1149	0.1115	0.1108	0.1086	0.1233	0.126	0.1262	0.09819	0.09532	0.09332	0.09369	0.1035	0.103	0.1052	0.08825	0.08783	0.08635	0.0846	0.08816	0.09297	0.09254
Stack AR mole fraction	-	0.0089	0.008724	0.008781	0.008653	0.008932	0.008865	0.008785	0.008406	0.008338	0.008274	0.008205	0.008511	0.008471	0.008422	0.008788	0.008626	0.008679	0.008554	0.008788	0.008263	0.008172
Stack H2O mole fraction	-	0.0852	0.1039	0.09875	0.1122	0.07808	0.0831	0.09079	0.1243	0.132	0.1391	0.1459	0.1121	0.1163	0.1205	0.1092	0.125	0.1206	0.1335	0.1093	0.1402	0.1496
Stack CO2 mole fraction	-	0.04344	0.04314	0.04418	0.04381	0.03958	0.03744	0.03641	0.06314	0.06407	0.06444	0.06312	0.06111	0.06083	0.05857	0.05561	0.05397	0.05533	0.05478	0.05565	0.06453	0.0634
Molecular Weight	lb/lbmole	28.42	28.21	28.28	28.13	28.46	28.39	28.29	28.27	28.19	28.12	28.03	28.38	28.33	28.26	28.26	28.08	28.14	27.99	28.26	28.11	28.00
Temperature	°F	185.2	190.5	181.4	194	163.1	160.3	166.9	291.5	284.5	280	288.3	259.6	243.4	251.2	172.8	178.6	176.3	182.2	180.5	281.3	293.8
Mass Flow	lb/hr	6,111,200	5,598,900	6,007,200	5,885,500	3,505,200	3,050,800	3,032,500	6,366,300	6,181,400	6,059,300	5,751,100	4,436,300	3,795,900	3,674,700	6,155,800	5,635,400	6,047,500	5,924,500	6,155,900	6,152,600	6,093,500
Volume Flow	scf/hr (60°F)	81,604,584	75,312,363	80,617,373	79,407,353	46,734,281	40,781,955	40,670,960	85,461,030	83,198,246	81,767,914	77,853,532	59,317,047	50,841,652	49,342,117	82,647,962	76,167,998	81,561,722	80,321,905	82,651,494	83,061,790	82,598,636
	acf/hr	103,700,000	96,501,000	101,850,000	102,280,000	57,353,000	49,823,000	50,219,000	126,510,000	122,010,000	119,190,000	114,760,000	84,074,000	70,446,000	69,122,000	103,010,000	95,811,000	102,230,000	101,600,000	104,270,000	121,290,000	122,650,000
	acf/min	1,728,333	1,608,350	1,697,500	1,704,667	955,883	830,383	836,983	2,108,500	2,033,500	1,986,500	1,912,667	1,401,233	1,174,100	1,152,033	1,716,833	1,596,850	1,703,833	1,693,333	1,737,833	2,021,500	2,044,167
	fps	75.778	70.517	74.426	74.740	41.910	36.408	36.697	92.446	89.157	87.097	83.860	61.436	51.478	50.510	75.273	70.013	74.703	74.243	76.194	88.631	89.625
HRSG EXIT EXHAUST GAS EMISSIONS																						
NOx (pre-control)[3]	ppmvd @ 15% O_2	25	25	25	25	25	25	25	42	42	42	42	42	42	42	25	25	25	25	25	42	42
	lb/hr as NO_2	320.00	292.50	321.25	313.75	166.25	137.50	133.75	745.00	736.25	727.50	678.75	500.00	426.25	398.75	416.25	371.25	408.75	397.50	416.25	740.00	722.50
NOx (post-control)	ppmvd @ 15% O_2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	2	2	2	2	2	4	4
	lb/MMBtu	0.0073	0.0072	0.0073	0.0073	0.0072	0.0073	0.0073	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.0074	0.0073	0.0074	0.0073	0.0074	0.015	0.015
	lb/hr as NO_2	25.6	23.4	25.7	25.1	13.3	11	10.7	59.6	58.9	58.2	54.3	40	34.1	31.9	33.3	29.7	32.7	31.8	33.3	59.2	57.8
CO (pre-control)[3]	ppmvd @ 15% O_2	9	9	9	9	9	9	9	25	25	25	25	25	25	25	9	9	9	9	9	25	25
	lb/hr	31.50	28.80	31.50	31.05	16.65	13.50	13.05	81.45	80.55	79.65	74.25	54.90	46.80	43.65	68.40	61.20	67.05	65.25	68.40	81.00	79.20
CO (post-control)	ppmvd @ 15% O_2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	2	2	2	2	2	2	2	1.5	1.5	1.5	1.5	1.5	2	2
	lb/MMBtu	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0034	0.0034	0.0033	0.0033	0.0034	0.0046	0.0046
	lb/hr	7.00	6.40	7.00	6.90	3.70	3.00	2.90	18.10	17.90	17.70	16.50	12.20	10.40	9.70	15.20	13.60	14.90	14.50	15.20	18.00	17.60
VOC (pre-control)[3]	ppmvd @ 15% O_2	1.4	1.4	1.4	1.4	1.4	1.4	1.4	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.3	3.3	3.3	3.3	3.3	3.5	3.5
	lb/hr as methane	6.20	5.80	6.20	6.20	3.20	2.60	2.60	18.20	18.03	17.68	16.63	12.25	10.50	9.80	19.18	17.12	18.77	18.36	19.18	18.03	17.68
VOC (post-control)	ppmvd @ 15% O_2	0.7	0.7	0.7	0.7	0.7	0.7	0.7	2	2	2	2	2	2	2	1.6	1.6	1.6	1.6	1.6	2	2
	lb/MMBtu	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0026	0.0026	0.0026	0.0026	0.0026	0.0027	0.0027	0.0021	0.0020	0.0020	0.0021	0.0021	0.0026	0.0026
	lb/hr as methane	3.10	2.90	3.10	3.10	1.60	1.30	1.30	10.40	10.30	10.10	9.50	7.00	6.00	5.60	9.30	8.30	9.10	8.90	9.30	10.30	10.10
CO_2	lb/hr	432,000	396,000	434,000	424,000	225,000	186,000	180,000	657,000	649,000	642,000	598,000	441,000	377,000	352,000	560,000	501,000	550,000	536,000	560,000	653,000	638,000
	lb/MMBtu w/margin	134.9	134.9	134.8	134.8	134.7	134.9	134.6	183.4	183.4	183.5	183.3	183.3	183.7	183.5	136.1	136.0	136.0	135.9	136.0	183.5	183.5
	lb/hr w/10% margin[4]	475,200	435,600	477,400	466,400	247,500	204,600	198,000	722,700	713,900	706,200	657,800	485,100	414,700	387,200	616,000	551,100	605,000	589,600	616,000	718,300	701,800
	lb/MW-hr	836	819	813	821	931	953	979	1,259	1,228	1,223	1,235	1,282	1,283	1,315	894	874	872	876	892	1,210	1,220
NH_3	ppmvd @ 15% O_2	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	lb/MMBtu	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0068	0.0068	0.0068	0.0068	0.0068	0.0070	0.0070
	lb/hr	23.7	21.7	23.8	23.2	12.3	10.2	9.9	27.6	27.2	26.9	25.1	18.5	15.8	14.8	30.8	27.5	30.2	29.5	30.8	27.4	26.8
	lb/hr w/5% margin[4]	24.89	22.79	24.99	24.36	12.92	10.71	10.40	28.98	28.56	28.25	26.36	19.43	16.59	15.54	32.34	28.88	31.71	30.98	32.34	28.77	28.14
SOx[5]	lb/hr as SO_2 (+20%)	4.70	4.30	4.70	4.60	2.40	2.00	2.00	7.00	7.00	6.90	6.40	4.70	4.00	3.80	6.10	5.40	6.00	5.80	6.10	7.00	6.80
PM	lb/hr	11.3	11.1	11.3	11.3	10.0	9.7	9.7	48.2	48.2	48.1	47.9	39.6	39.2	39.0	22.5	20.3	21.5	21.1	22.5	48.2	48.1
	lb/MMBtu	0.0032	0.0034	0.0032	0.0033	0.0054	0.0064	0.0066	0.0122	0.0124	0.0125	0.0133	0.0150	0.0174	0.0185	0.0050	0.0050	0.0048	0.0049	0.0050	0.0123	0.0126
H_2SO_4	lb/hr	2.60	2.40	2.70	2.60	1.40	1.10	1.10	4.00	3.90	3.90	3.60	2.70	2.30	2.10	3.70	3.30	3.70	3.60	3.70	3.90	3.90
	lb/hr w/10% margin[4]	2.86	2.64	2.97	2.86	1.54	1.21	1.21	4.40	4.29	4.29	3.96	2.97	2.53	2.31	4.07	3.63	4.07	3.96	4.07	4.29	4.29
CH_2O[6]	ppbvd @ 15% O_2	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5
	lb/MMBtu	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012
	lb/hr	0.42	0.38	0.42	0.41	0.22	0.18	0.17	0.47	0.46	0.46	0.43	0.31	0.27	0.25	0.54	0.48	0.53	0.52	0.54	0.46	0.45
	lb/hr w/10% margin[4]	0.46	0.42	0.46	0.45	0.24	0.20	0.19	0.51	0.51	0.50	0.47	0.35	0.30	0.28	0.59	0.53	0.58	0.57	0.59	0.51	0.50

[1] Operating points included list evaporative coolers as "off," however evaporative coolers may be operated when firing ULSD.

[2] The heat consumption provided by G.E. included a ~5% margin to account for equipment degradation and site variability.

[3] Pre-control emissions rates when firing natural gas were provided by G.E. on a ppm basis. The same control efficiency for ppm values was used for the lb/hr pre-control emission rates. For emission rates when firing ULSD, the same control efficiency as determined for natural gas emissions was used to determine pre-control emissions when firing ULSD.

[4] A 10% margin was added to lb/hr emission values of CO_2, H_2SO_4, NH_3, and CH_2O to account for equipment degradation and site variability.

[5] SOx emission rates provided by G.E. included a margin of 20% to account for fuel and site variability.

[6] CH_2O emission rate of 91 ppb @ 15% O_2 is the turbine outlet concentration provided by G.E. (91 ppb) with a 50% control efficiency applied for the oxidation catalyst.

Renovo Energy Center
Determination of Maximum Potential Emissions
Powerblocks- Turbines, HRSGs firing Natural Gas

Maximum Fuel Flow Rate:	150,002	lb/hr each	
Fuel Gross Heating Value:	23,607	Btu/lb	
Maximum GT heat input capacity:	3,541	MMBtu/hr each	
Maximum GT+DB heat input capacity:	4,529	MMBtu/hr each	
Annual capacity factor:	100	%	
Maximum emissions scenario operating hours:	7,540	hours each	*(not including SUSD or ULSD operations)* [1]
Maximum emissions scenario annual heat input:	34,149,414	MMBtu/yr each	*(not including SUSD or ULSD operations)*

Maximum annual emissions calculated based on maximum potential operating hours.
Values below represent emissions from each individual unit.

Pollutant[2]	Emission Factor (ppmvd @ 15% O_2)	Maximum Short-term Emission Rate (GT only) (lb/hr)	Maximum Short-term Emission Rate (GT+DB) (lb/hr)	Maximum Potential Annual Emissions[5] (ton/yr)
NOx	2	25.70	33.30	125.54
CO	0.9 (GT); 1.5 (GT+DB)	7.00	15.20	57.30
PM_{10}	--	11.30	22.50	84.83
VOC	0.7 (GT); 1.6 (GT+DB)	3.10	9.30	35.06
SO_2	--	4.70	6.10	23.00
NH_3	5	24.99	32.34	121.92
H_2SO_4	--	2.97	4.07	15.34
GHGs [3]	(kg/MMBtu)	(lb/hr)	(lb/hr)	(ton/yr)
CO_2	--	477,400	616,000	2,322,320
CH_4	1.0E-03	7.81	7.81	29.43
N_2O	1.0E-04	0.78	0.78	2.94
$CO_{2equivalent}$		477,827.8	616,427.8	2,323,933
HAPs [4]	GT (lb/MMBtu)	DB (lb/MMscf)	GT+DB (lb/hr)	(ton/yr)
1,3-butadiene	2.2E-07	0	7.6E-04	0.0029
acetaldehyde	2.0E-05	0	7.0E-02	0.27
acrolein	3.2E-06	0	1.1E-02	0.043
benzene	6.0E-06	1.2E-03	2.2E-02	0.08
dichlorobenzene	0	6.6E-04	6.5E-04	0.0025
ethyl benzene	1.6E-05	0	5.6E-02	0.21
formaldehyde[2]	--	--	5.9E-01	2.23
hexane	0	9.9E-01	9.8E-01	3.68
naphthalene	6.5E-07	3.4E-04	2.6E-03	0.010
PAH	1.1E-06	0	3.9E-03	0.015
POM	0	4.9E-05	4.8E-05	0.00018
propylene oxide	1.5E-05	0	5.1E-02	0.19
toluene	6.5E-05	1.9E-03	2.3E-01	0.87
xylenes	3.3E-05	0	1.1E-01	0.43

HAPs [4]	GT (lb/MMBtu)	DB (lb/MMscf)	GT+DB (lb/hr)	(ton/yr)
arsenic	0	2.0E-04	2.0E-04	0.00074
beryllium	0	1.2E-05	1.2E-05	0.000045
cadmium	0	1.1E-03	1.1E-03	0.0041
chromium	0	1.4E-03	1.4E-03	0.0052
cobalt	0	8.4E-05	8.3E-05	0.00031
lead	0	0	0	0
manganese	0	3.8E-04	3.7E-04	0.0014
mercury	0	2.6E-04	2.6E-04	0.00097
nickel	0	2.1E-03	2.1E-03	0.0078
selenium	0	0	2.4E-05	0.000089
TOTAL HAPs		1.00	2.14	8.06

[1]Maximum potential operating hours not including SUSD or ULSD operations was used to estimate emissions.

[2]Emission factors provided by vendor. The maximum emissions rate from all available operating scenarios was used to calculate maximum potential emissions.

[3]Emission factor for CO_2 provided by vendor. Emission factors for CH_4 and N_2O obtained from 40 CFR 98.

[4]HAP emission factors for GT obtained from EPA's AP-42, Table 3.1-3 and reflect control level of 50% by the oxidation catalyst for organic HAPs, except for formaldehyde, which was obtained from the vendor. HAP emission factors for DB obtained from EPA's AP-42, Tables 1.4-3 and 1.4-4 and reflect control level of 45% by the oxidation catalyst for organic HAPs, except for formaldehyde, which was obtained from vendor.

[5]Potential annual emissions based on the GT + DB scenario, as this is considered worst-case.

Renovo Energy Center
Determination of Maximum Potential Emissions
Powerblocks- Turbines firing ULSD

Maximum Fuel Flow Rate:	195,748	lb/hr each	
Fuel Gross Heating Value:	20,130	Btu/lb	
Maximum heat input capacity:	3,940	MMBtu/hr each	
Annual capacity factor:	100	%	
Maximum potential operating hours:	720	hours each	*(not including SUSD)* [1]
Maximum annual heat input:	2,837,088	MMBtu/yr	*(not including SUSD)*

Maximum annual emissions calculated based on maximum potential operating hours.
Values below represent emissions from each individual unit.

Pollutant[2]	Emission Factor (ppmvd @ 15% O_2)	Maximum Short-Term Emission Rate (lb/hr)	Maximum Potential Annual Emissions (ton/yr)
NOx	4	59.60	21.46
CO	2	18.10	6.52
PM_{10}	--	48.20	17.35
VOC	2	10.40	3.74
SO_2	--	7.00	2.52
NH_3	5	28.98	10.43
H_2SO_4	--	4.40	1.58
GHGs [3]	(kg/MMBtu)	(lb/hr)	(ton/yr)
CO_2	--	722,700	260,172
CH_4	3.0E-03	26.06	9.38
N_2O	6.0E-04	5.21	1.88
$CO_{2equivalent}$	--	724,904.8	260,966
HAPs [4]	(lb/MMBtu)	(lb/hr)	(ton/yr)
1,3-butadiene	1.1E-05	4.4E-02	0.016
acetaldehyde	0	0	0
acrolein	0	0	0
benzene	3.9E-05	1.5E-01	0.055
dichlorobenzene	0	0	0
ethyl benzene	0	0	0
formaldehyde[2]	--	5.1E-01	0.19
hexane	0	0	0
naphthalene	2.5E-05	9.7E-02	0.035
PAH	2.8E-05	1.1E-01	0.040
POM	0	0	0
propylene oxide	0	0	0
toluene	0	0	0
xylenes	0	0	0
arsenic	1.1E-05	4.3E-02	0.016
beryllium	3.1E-07	1.2E-03	0.00044
cadmium	4.8E-06	1.9E-02	0.0068
chromium	1.1E-05	4.3E-02	0.016
cobalt	0	0	0
lead	1.4E-05	5.5E-02	0.020

Renovo Energy Center
Determination of Maximum Potential Emissions
Powerblocks- Turbines firing ULSD

HAPs [4]	(lb/MMBtu)	(lb/hr)	(ton/yr)
manganese	7.9E-04	3.11	1.12
mercury	1.2E-06	4.7E-03	0.0017
nickel	4.6E-06	1.8E-02	0.0065
selenium	2.5E-05	9.9E-02	0.035
TOTAL HAPs		4.31	1.55

[1]Maximum potential operating hours not including SUSD was used to estimate emissions.

[2]Emission factors provided by vendor. The maximum emissions rate from all available operating scenarios was used to calculate maximum potential emissions.

[3]Emission factor for CO_2 provided by vendor. Emission factors for CH_4 and N_2O obtained from 40 CFR 98.

[4]HAP emission factors obtained from EPA's AP-42, Tables 3.1-4 and 3.1-5 and reflect control level of 30% by the oxidation catalyst for organic HAPs, except for formaldehyde, which was obtained from the vendor.

Renovo Energy Center
Startup and Shutdown Operations Emissions Data
Natural Gas Firing

SUSD Parameter	Amount per Event - GE Provided	Pro-Rated Amount per Hour	Amount per Event with Time Increase[1]
Cold Start			
Time from Ignition until Compliance (minutes)	45	--	60
Fuel Consumed (lb)	39,451	52,602	52,602
Fuel Consumed (MMBtu LHV)	840	1,120	1,120
Fuel Consumed (MMBtu HHV)	931	1,242	1,242
Maximum Potential NOx Emissions (lb)	123.0	164.0	164.0
Maximum Potential CO Emissions (lb)	699.0	932.0	932.0
Maximum Potential VOC Emissions (lb)	53.0	70.7	70.7
Maximum Potential $PM_{10}/_{2.5}$ Emissions (lb)	8.3	11.1	11.1
Warm Start			
Time from Ignition until Compliance (minutes)	40	--	55
Fuel Consumed (lb)	38,277	57,416	52,631
Fuel Consumed (MMBtu LHV)	815	1,223	1,121
Fuel Consumed (MMBtu HHV)	904	1,355	1,242
Maximum Potential NOx Emissions (lb)	81.0	121.5	111.4
Maximum Potential CO Emissions (lb)	190.0	285.0	261.3
Maximum Potential VOC Emissions (lb)	24.0	36.0	33.0
Maximum Potential $PM_{10}/_{2.5}$ Emissions (lb)	7.3	11.0	10.0
Hot Start			
Time from Ignition until Compliance (minutes)	20	--	35
Fuel Consumed (lb)	15,264	45,792	26,712
Fuel Consumed (MMBtu LHV)	325	975	569
Fuel Consumed (MMBtu HHV)	360	1,081	631
Maximum Potential NOx Emissions (lb)	53.0	159.0	92.8
Maximum Potential CO Emissions (lb)	177.0	531.0	309.8
Maximum Potential VOC Emissions (lb)	22.0	66.0	38.5
Maximum Potential $PM_{10}/_{2.5}$ Emissions (lb)	4.0	12.0	7.0
Shutdown from 50% load			
Time to Shutdown (minutes)	12	--	27
Fuel Consumed (lb)	9,393	46,966	21,135
Fuel Consumed (MMBtu LHV)	200	1,000	450
Fuel Consumed (MMBtu HHV)	222	1,109	499
Maximum Potential NOx Emissions (lb)	14.0	70.0	31.5
Maximum Potential CO Emissions (lb)	152.0	760.0	342.0
Maximum Potential VOC Emissions (lb)	19.0	95.0	42.8
Maximum Potential $PM_{10}/_{2.5}$ Emissions (lb)	3.0	15.0	6.8

Annual Totals[2]		
Total SUSD Operating Hour Limitation Per Unit:	460	hrs
Total Annual SUSD Fuel Consumption Per Unit:	25,302,027	lbs
Total Annual SUSD Heat Input Per Unit:	538,731	MMBtu LHV
Total Annual SUSD Heat Input Per Unit:	597,305	MMBtu HHV
Total Maximum Potential NOx Emissions Per Unit:	25.2	tons
Total Maximum Potential CO Emissions Per Unit:	90.8	tons
Total Maximum Potential VOC Emissions Per Unit:	11.4	tons
Total Maximum Potential $PM_{10/2.5}$ Emissions Per Unit:	2.7	tons

May 2020

Renovo Energy Center
Startup and Shutdown Operations Emissions Data
ULSD Firing

SUSD Parameter	Amount per Event - GE Provided	Pro-Rated Amount per Hour	Amount per Event with Time Increase[1]
Cold Start			
Time from Ignition until Compliance (minutes)	45	--	60
Fuel Consumed (lb)	54,208	72,277	72,277
Fuel Consumed (MMBtu LHV)	992	1,323	1,323
Fuel Consumed (MMBtu HHV)	1,100	1,466	1,466
Maximum Potential NOx Emissions (lb)	221.0	294.7	294.7
Maximum Potential CO Emissions (lb)	704.0	938.7	938.7
Maximum Potential VOC Emissions (lb)	141.0	188.0	188.0
Maximum Potential $PM_{10}/_{2.5}$ Emissions (lb)	36.0	48.0	48.0
Warm Start			
Time from Ignition until Compliance (minutes)	40	--	55
Fuel Consumed (lb)	54,645	81,967	75,137
Fuel Consumed (MMBtu LHV)	1,000	1,500	1,375
Fuel Consumed (MMBtu HHV)	1,109	1,663	1,525
Maximum Potential NOx Emissions (lb)	172.0	258.0	236.5
Maximum Potential CO Emissions (lb)	286.0	429.0	393.3
Maximum Potential VOC Emissions (lb)	33.0	49.5	45.4
Maximum Potential $PM_{10}/_{2.5}$ Emissions (lb)	32.0	48.0	44.0
Hot Start			
Time from Ignition until Compliance (minutes)	20	--	35
Fuel Consumed (lb)	18,579	55,738	32,514
Fuel Consumed (MMBtu LHV)	340	1,020	595
Fuel Consumed (MMBtu HHV)	377.0	1,131	660
Maximum Potential NOx Emissions (lb)	112.0	336.0	196.0
Maximum Potential CO Emissions (lb)	273.0	819.0	477.8
Maximum Potential VOC Emissions (lb)	30.0	90.0	52.5
Maximum Potential $PM_{10}/_{2.5}$ Emissions (lb)	16.0	48.0	28.0
Shutdown from 50% load			
Time to Shutdown (minutes)	8	--	23
Fuel Consumed (lb)	7,213	54,098	20,738
Fuel Consumed (MMBtu LHV)	132	990	380
Fuel Consumed (MMBtu HHV)	146	1,098	421
Maximum Potential NOx Emissions (lb)	43.0	322.5	123.6
Maximum Potential CO Emissions (lb)	48.0	360.0	138.0
Maximum Potential VOC Emissions (lb)	7.0	52.5	20.1
Maximum Potential $PM_{10}/_{2.5}$ Emissions (lb)	10.0	75.0	28.8

Annual Totals[2]		
Total SUSD Operating Hour Limitation Per Unit:	40	hrs
Total Annual SUSD Fuel Consumption Per Unit:	3,092,896	lbs
Total Annual SUSD Heat Input Per Unit:	56,600	MMBtu LHV
Total Annual SUSD Heat Input Per Unit:	62,755	MMBtu HHV
Total Maximum Potential NOx Emissions Per Unit:	5.4	tons
Total Maximum Potential CO Emissions Per Unit:	8.4	tons
Total Maximum Potential VOC Emissions Per Unit:	1.0	tons
Total Maximum Potential $PM_{10/2.5}$ Emissions Per Unit:	1.1	tons

May 2020

[1] REC is proposing to add 15 minutes of margin to each SUSD scenario in order to allow operational flexibility in order to ensure that the SUSD can be completed in the permitted length of time. All heat input and emission parameters have been pro-rated for the increased time.

[2] Annual totals are based on warm starts and the corresponding amount of shutdowns. For the natural gas scenarios, 460 hours of SUSD corresponds to 308.5 hours of warm starts and 151.5 hours of shutdowns. For the ULSD scenarios, 40 hours of SUSD corresponds to 28.2 hours of warm starts and 11.8 hours of shutdowns.

Renovo Energy Center
Startup and Shutdown Emission Parameters for Modeling Purposes
Natural Gas and ULSD Firing

NOx: 1-hour Averaging Period

SUSD Scenario	Natural Gas[1] Cold Start	Warm Start	Hot Start	Shut Down	ULSD[2] Cold Start	Warm Start	Hot Start	Shut Down
Duration (minutes)	60	55	35	27	60	55	35	23
NOx per event (lb)	164.00	111.38	92.75	31.50	294.67	236.50	196.00	123.63
Stack Temperature (°F)	174				270			
Stack Flow Rate (acfm)	942,329				1,190,426			
Steady State Low Load Parameters								
Emission Rate (lb/hr)	10.70		*Operating Point #7*		31.90		*Operating Point #14*	
Stack Temperature (°F)	166.9				251.2			
Exhaust Flow Rate (acfm)	836,983				1,152,033			
Steady State Max Load Parameters								
Emission Rate (lb/hr)	33.30		*Operating Point #19*		59.60		*Operating Point #8*	
Stack Temperature (°F)	180.5				291.5			
Exhaust Flow Rate (acfm)	1,737,833				2,108,500			
Steady State Average Load Parameters								
Emission Rate (lb/hr)	22				45.75			
Stack Temperature (°F)	173.7				271.35			
Exhaust Flow Rate (acfm)	1,287,408				1,630,267			
Remaining Duration of Hour (minutes)	0	5	25	33	0	5	25	37
SS Contribution (lb)	0.00	1.83	9.17	12.10	0.00	3.81	19.06	28.21
Hourly Emission Rate for Modeling (lb/hr)	164.00	113.21	101.92	43.60	294.67	240.31	215.06	151.84
Average Stack Temperature for Modeling (°F)	174.00	173.98	173.88	173.84	270.00	270.11	270.56	270.83
Average Flow Rate for Modeling (acfm)	942,329	971,086	1,086,112	1,132,123	1,190,426	1,227,079	1,373,693	1,461,661

[1]For natural gas SUSD scenarios, the average stack temperature will be 174°F when the LP economizer is in service, and 214°F when bypassed. The average stack flow rate for all scenarios will be 960 lb/second (equivalent to 942,329 acfm for 174°F stack temperature, and 1,101,782 acfm for 214°F stack temperature.

[2]For ULSD SUSD scenarios, the average stack temperature will be 270°F, assuming the LP economizer is bypassed. The average stack flow rate for all scenarios will be 1,050 lb/second (equivalent to 1,190,426 acfm).

Renovo Energy Center
Startup and Shutdown Emission Parameters for Modeling Purposes
Natural Gas and ULSD Firing

NOx: Annual Averaging Period

Operating Point[1]	1	2	3	4	5	6	7	15	16	17	18	19
SS NG Emission Rate (lb/hr)	25.6	23.4	25.7	25.1	13.3	11	10.7	33.3	29.7	32.7	31.8	33.3
SS NG Duration (hrs)	7,540	7,540	7,540	7,540	7,540	7,540	7,540	7,540	7,540	7,540	7,540	7,540
Maximum SS ULSD Emission Rate (lb/hr)	59.60	59.60	59.60	59.60	59.60	59.60	59.60	59.60	59.60	59.60	59.60	59.60
Maximum SS ULSD Duration (hrs)	720	720	720	720	720	720	720	720	720	720	720	720
Maximum NG SUSD Emission Rate (lb/hr)	164.0	164.0	164.0	164.0	164.0	164.0	164.0	164.0	164.0	164.0	164.0	164.0
Maximum NG SUSD Duration (hrs)	460	460	460	460	460	460	460	460	460	460	460	460
Maximum ULSD SUSD Emission Rate (lb/hr)	294.7	294.7	294.7	294.7	294.7	294.7	294.7	294.7	294.7	294.7	294.7	294.7
Maximum ULSD SUSD Duration (hrs)	40	40	40	40	40	40	40	40	40	40	40	40
Hourly Emission Rate for Modeling (lb/hr)	36.89	35.00	36.98	36.46	26.30	24.32	24.07	43.52	40.42	43.00	42.23	43.52

[1]The stack temperature and flow rate from each operating point as numbered in the raw data will be used for these scenarios, as the majority of the duration (~86%) is spent at that operating point.

Renovo Energy Center
Startup and Shutdown Emission Parameters for Modeling Purposes
Natural Gas and ULSD Firing

CO: 1-hour Averaging Period

	Natural Gas[1]				ULSD[2]			
SUSD Scenario	Cold Start	Warm Start	Hot Start	Shut Down	Cold Start	Warm Start	Hot Start	Shut Down
Duration (minutes)	60	55	35	27	60	55	35	23
CO per event (lb)	932.00	261.25	309.75	342.00	938.67	393.25	477.75	138.00
Stack Temperature (°F)	174				270			
Stack Flow Rate (acfm)	942,329				1,190,426			
Steady State Low Load Parameters								
Emission Rate (lb/hr)	2.90		*Operating Point #7*		9.70		*Operating Point #14*	
Stack Temperature (°F)	166.9				251.2			
Exhaust Flow Rate (acfm)	836,983				1,152,033			
Steady State Max Load Parameters								
Emission Rate (lb/hr)	15.20		*Operating Point #19*		18.10		*Operating Point #8*	
Stack Temperature (°F)	180.5				291.5			
Exhaust Flow Rate (acfm)	1,737,833				2,108,500			
Steady State Average Load Parameters								
Emission Rate (lb/hr)	9.05				13.9			
Stack Temperature (°F)	173.7				271.35			
Exhaust Flow Rate (acfm)	1,287,408				1,630,267			
Remaining Duration of Hour (minutes)	0	5	25	33	0	5	25	37
SS Contribution (lb)	0.00	0.75	3.77	4.98	0.00	1.16	5.79	8.57
Hourly Emission Rate for Modeling (lb/hr)	932.00	262.00	313.52	346.98	938.67	394.41	483.54	146.57
Average Stack Temperature for Modeling (°F)	174.00	173.98	173.88	173.84	270.00	270.11	270.56	270.83
Average Flow Rate for Modeling (acfm)	942,329	971,086	1,086,112	1,132,123	1,190,426	1,227,079	1,373,693	1,461,661

[1]For natural gas SUSD scenarios, the average stack temperature will be 174°F when the LP economizer is in service, and 214°F when bypassed. The average stack flow rate for all scenarios will be 960 lb/second (equivalent to 942,329 acfm for 174°F stack temperature, and 1,101,782 acfm for 214°F stack temperature.

[2]For ULSD SUSD scenarios, the average stack temperature will be 270°F, assuming the LP economizer is bypassed. The average stack flow rate for all scenarios will be 1,050 lb/second (equivalent to 1,190,426 acfm).

Renovo Energy Center
Startup and Shutdown Emission Parameters for Modeling Purposes
Natural Gas and ULSD Firing

CO: 8-hour Averaging Period

	Natural Gas[1]				ULSD[2]			
SUSD Scenario	Cold Start	Warm Start	Hot Start	Shut Down	Cold Start	Warm Start	Hot Start	Shut Down
Duration (minutes)	60	55	35	27	60	55	35	23
CO per event (lb)	932.00	261.25	309.75	342.00	938.67	393.25	477.75	138.00
Stack Temperature (°F)	174				270			
Stack Flow Rate (acfm)	942,329				1,190,426			
Steady State Max Load Parameters								
Emission Rate (lb/hr)	15.2				18.1			
Stack Temperature (°F)	180.5		*Operating Point #19*		291.5		*Operating Point #8*	
Exhaust Flow Rate (acfm)	1,737,833				2,108,500			
Remaining Duration of Hour (minutes)	420	425	445	453	420	425	445	457
SS Contribution (lb)	106.40	107.67	112.73	114.76	126.70	128.21	134.24	137.86
Hourly Emission Rate for Modeling (lb/hr)	129.80	46.11	52.81	57.10	133.17	65.18	76.50	34.48
Average Stack Temperature for Modeling (°F)	179.69	179.76	180.03	180.13	288.81	289.04	289.93	290.47
Average Flow Rate for Modeling (acfm)	1,638,395	1,646,682	1,679,828	1,693,086	1,993,741	2,003,304	2,041,557	2,064,509

[1]For natural gas SUSD scenarios, the average stack temperature will be 174°F when the LP economizer is in service, and 214°F when bypassed. The average stack flow rate for all scenarios will be 960 lb/second (equivalent to 942,329 acfm for 174°F stack temperature, and 1,101,782 acfm for 214°F stack temperature.

[2]For ULSD SUSD scenarios, the average stack temperature will be 270°F, assuming the LP economizer is bypassed. The average stack flow rate for all scenarios will be 1,050 lb/second (equivalent to 1,190,426 acfm).

Renovo Energy Center
Summary of Worst-Case Maximum Potential Annual Emissions Scenario
Powerblocks- Turbines, HRSGs

ULSD Normal Operating Hours:	720	each powerblock
ULSD SUSD Operating Hours:	40	each powerblock
Natural Gas Normal Operating Hours:	7,540	each powerblock
Natural Gas SUSD Operating Hours:	460	each powerblock
Total Operating Hours:	8,760	each powerblock

Pollutant	Annual Emissions from ULSD Firing[1] (tons)	Annual Emissions from ULSD SUSD[2] (tons)	Annual Emissions from NG Firing[3] (tons)	Annual Emissions from Natural Gas SUSD[4] (tons)	Total Maximum Potential Annual Emissions from Both Powerblocks (tons)	Total Maximum Potential Annual Emissions from Each Powerblock (tons)
NOx	42.91	10.75	251.08	50.42	355.17	177.58
CO	13.03	16.70	114.61	181.52	325.86	162.93
PM_{10}	34.70	2.10	169.65	5.47	211.92	105.96
VOC	7.49	2.00	70.12	22.82	102.43	51.22
SO_2	5.04	0.28	45.99	2.16	53.48	26.74
NH_3	20.87	1.16	243.84	11.50	277.36	138.68
H_2SO_4	3.17	0.18	30.69	1.37	35.40	17.70
GHGs						
CO_2	520,344	28,908	4,644,640	219,604	5,413,496	2,706,748
CH_4	18.76	1.04	58.86	3.59	82.26	41.13
N_2O	3.75	0.21	5.89	0.36	10.21	5.10
$CO_{2equivalent}$	521,931	28,996	4,647,866	219,801	5,418,594	2,709,297
HAPs						
1,3-butadiene	0.032	0.0018	0.0057	0.00035	0.040	0.020
acetaldehyde	0	0	0.53	0.033	0.56	0.28
acrolein	0	0	0.085	0.0052	0.09	0.045
benzene	0.11	0.0061	0.17	0.010	0.29	0.15
dichlorobenzene	0	0	0.0049	0	0.0049	0.0025

Renovo Energy Center
Summary of Worst-Case Maximum Potential Annual Emissions Scenario
Powerblocks- Turbines, HRSGs

Pollutant	Annual Emissions from ULSD Firing[1] (tons)	Annual Emissions from ULSD SUSD[2] (tons)	Annual Emissions from NG Firing[3] (tons)	Annual Emissions from Natural Gas SUSD[4] (tons)	Total Maximum Potential Annual Emissions from Both Powerblocks (tons)	Total Maximum Potential Annual Emissions from Each Powerblock (tons)
ethyl benzene	0	0	0.43	0.026	0.45	0.23
formaldehyde	0.37	0.021	4.46	0.21	5.06	2.53
hexane	0	0	7.36	0	7.36	3.68
naphthalene	0.070	0.0039	0.020	0.0011	0.09	0.047
PAH	0.079	0.0044	0.029	0.0018	0.11	0.057
POM	0	0	0.00036	0	0.00036	0.00018
propylene oxide	0	0	0.39	0.024	0.41	0.20
toluene	0	0	1.74	0.11	1.85	0.92
xylenes	0	0	0.86	0.053	0.92	0.46
arsenic	0.031	0.0017	0.0015	0	0.034	0.017
beryllium	0.00088	0.000049	0.000089	0	0.0010	0.00051
cadmium	0.014	0.00076	0.0082	0	0.023	0.011
chromium	0.031	0.0017	0.010	0	0.043	0.022
cobalt	0	0	0.00062	0	0.00062	0.00031
lead	0.040	0.0022	0	0	0.042	0.021
manganese	2.24	0.12	0.0028	0	2.37	1.18
mercury	0.0034	0.00019	0.0019	0	0.0055	0.0028
nickel	0.013	0.00073	0.016	0	0.029	0.015
selenium	0.071	0.0039	0.00018	0	0.075	0.038
TOTAL HAPs	3.11		16.12		19.87	9.93

[1]Annual Emissions from ULSD Firing based on 720 nornal operating hours on ULSD for each powerblock.

[2]Annual Emissions from ULSD SUSD based on 40 SUSD hours per powerblock when firing ULSD, using emission rates for Warm Starts and Shutdowns for emissions of NOx, CO, PM, and VOC. All other pollutant emissions based on the maximum emission rate for all operating loads when firing ULSD.

[3]Annual Emissions from Natural Gas Firing based on 7,540 normal operating hours firing natural gas in the CT and DB for each powerblock.

[4]Annual Emissions from Natural Gas SUSD based on 460 SUSD hours per powerblock when firing natural gas, using emission rates for Warm Starts and Shutdowns for emissions of NOx, CO, PM, and VOC. All other pollutant emissions based on the maximum emission rate for all operating loads when firing natural gas.

SIZE	DWG NO	SH	REV
A		1	D

THIS DOCUMENT SHALL BE REVISED IN ITS ENTIRETY ALL SHEETS OF THIS DOCUMENT ARE THE SAME REVISION LEVEL AS INDICATED IN THE REVISION BLOCK

REVISIONS

REV	DESCRIPTION	DATE (dd-mmm-yyyy)	APPROVED
-	Preliminary Issue	01-Oct-2019	A. Dicke
A	Preliminary Issue	08-Oct-2019	A. Dicke
B	Preliminary Issue	22-Nov-2019	A. Dicke
C	Preliminary Issue	11-Dec-2019	A. Dicke
D	Preliminary Issue	26-May-2020	A. Dicke

Combined Cycle Systems

Combined Cycle Systems Emissions Estimates

7HA.02

SIGNATURES		DATE (dd-mmm-yyyy)
PREPARED BY	Mike Boisclair	01-Oct-2019
SYSTEM ENGINEER	n/a	01-Oct-2019
PROJECT ENGINEER	n/a	01-Oct-2019
ISSUED	Andrew Dicke	01-Oct-2019

GE Power

GENERAL ELECTRIC COMPANY
GENERAL ELECTRIC INTERNATIONAL, INC.
POWER PLANT SYSTEMS

Renovo

MADE FOR: IPS # 1270381 | MDL - T218

FIRST MADE FOR: Renovo

SIZE **A**	CAGE CODE **NONE**		DWG NO
SCALE **NONE**			SHEET 1

Drawing Revision Status

Revision	Date	Description
-	01-Oct-2019	Initial issue
A	08-Oct-2019	Additional cases
B	22-Nov-2019	Reduce VOC
C	11-Dec-2019	Reduce CO/VOC increased ULSD Stack Temp
D	26-May-2020	Reduce fired CO/VOC

Combined Cycle Systems Emissions Estimates: Renovo

Operating Point		**1**	**2**	**3**
Case Description		1 GT @ 100%	1 GT @ 100%	1 GT @ 100%
Ambient Conditions				
Ambient Temperature	°F	-20.0	95.8	59.0
Ambient Pressure	psia	14.350	14.350	14.350
Ambient Relative Humidity	%	60	35	60
Gas Turbine				
GT Fuel Type		Gas	Gas	Gas
GT load fraction	-	1	1	1
Evap Cooler status		off	off	On
Gas turbine water injection flow rate	klb/h	0.0	0.0	0.0
Plant Performance (not guaranteed)				
CC Net Plant output	kW	516571	482965	533150
Abatement Status				
CO Catalyst Operating status		Operating	Operating	Operating
SCR Operating status		Operating	Operating	Operating
GT Fuel				
Gas Turbine fuel LHV	Btu/lb	21292	21292	21292
Gas Turbine fuel HHV	Btu/lb	23607	23607	23607
Gas Turbine gas fuel molecular weight	lb/lbmole	16.52	16.52	16.52
Gas Turbine sulfur ppm (by mass)	ppm	13.1	13.1	13.1
Duct Burner				
Duct Burner fuel LHV	Btu/lb	21292	21292	21292
Duct Burner fuel HHV	Btu/lb	23607	23607	23607
Duct Burner fuel molecular weight	lb/lbmole	16.52	16.52	16.52
Duct Burner fuel sulfur content (by mass)	ppm	13.1	13.1	13.1
Duct Burner status		Off	Off	Off
Duct Burner gas fuel flow	lb/h	0.0	0.0	0.0
Duct Burner load fraction	%	0.0	0.0	0.0
Heat Consumption for permitting (per unit)				
GT Heat Cons (HHV), with permitting margin	MMBtu/h	3523.8	3230.1	3541.1
DB Heat Cons (HHV)	MMBtu/h	0.0	0.0	0.0
HRSG Exit Exhaust gas (per unit)				
Stack N2 mole fraction	-	0.7474	0.7326	0.7374
Stack O2 mole fraction	-	0.1149	0.1115	0.1108
Stack AR mole fraction	-	0.0089	0.008724	0.008781
Stack H2O mole fraction	-	0.0852	0.1039	0.09875
Stack CO2 mole fraction	-	0.04344	0.04314	0.04418
Stack Molecular Weight	lb/lbmole	28.42	28.21	28.28
Stack Temperature	°F	185.2	190.5	181.4
Stack Mass flow, including Permitting Margin, per stack	lb/h	6111200	5598900	6007200
Margined exhaust vol flow (incl. permitting margin)	Mft3/h	103.7	96.501	101.85
Normalized vol flow, SCF @ 60F (incl. permitting margin)	SCF/h	81604421	75312214	80617209
HRSG Exit Emissions (per unit)				
NOx Volume fraction, dry, at 15 % O2	ppm	2	2	2
NOx mass flow rate (as NO2)	lb/h	25.6	23.4	25.7
CO Volume fraction, dry, at 15 % O2	ppm	0.9	0.9	0.9
CO mass flow rate	lb/h	7.0	6.4	7.0
VOC Volume fraction, dry, at 15 % O2	ppm	0.7	0.7	0.7
VOC mass flow rate (as methane)	lb/h	3.1	2.9	3.1
NH3 Volume fraction, dry, at 15 % O2	ppm	5	5	5
NH3 mass flow rate	lb/h	23.7	21.7	23.8
SOx mass flow rate (as SO2)	lb/h	4.7	4.3	4.7
Total Particulates	lb/h	11.3	11.1	11.3
Sulfur Mist as H2SO4	lb/h	2.6	2.4	2.7
Stack CO2 mass flow rate, including Permitting margin	lb/h	432000	396000	434000
Stack CO2 rate (per Net Plant CC Power per stack)	lb/MWh	836	819	813

The notes page is an integral part of this document and must be reviewed prior to use of this data.

4	5	6	7	8	9	10	11	12
1 GT @ 100%	1 GT @ 38% load,	1 GT @ 30% load,	1 GT @ 32% load,	1 GT @ 100%	1 GT @ 100%	1 GT @ 100%	1 GT @ 100%	1 GT @ 60% load,
95.8	-0.7	59.0	95.8	-20.0	35.0	59.0	95.8	-0.7
14.350	14.350	14.350	14.350	14.350	14.350	14.350	14.350	14.350
35	60	60	35	60	60	60	35	60
Gas	Gas	Gas	Gas	Liquid	Liquid	Liquid	Liquid	Liquid
1	0.38	0.3	0.32	1	1	1	1	0.6
On	off	off	off	off	off	off	off	off
0.0	0.0	0.0	0.0	260.8	266.4	266.4	249.8	151.8
516252	241852	194994	184161	521793	528537	524694	484380	344384
Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating
Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating
21292	21292	21292	21292	18300	18300	18300	18300	18300
23607	23607	23607	23607	20130	20130	20130	20130	20130
16.52	16.52	16.52	16.52	n.a.	n.a.	n.a.	n.a.	n.a.
13.1	13.1	13.1	13.1	15.0	15.0	15.0	15.0	15.0
21292	21292	21292	21292	21292	21292	21292	21292	21292
23607	23607	23607	23607	23607	23607	23607	23607	23607
16.52	16.52	16.52	16.52	16.52	16.52	16.52	16.52	16.52
13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1
Off	Off	Off	Off	Off	Off	Off	Off	Off
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3459.2	1837.7	1516.3	1470.6	3940.4	3892.8	3848.4	3588.7	2646.6
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.7266	0.7501	0.7445	0.7377	0.7058	0.7001	0.6947	0.6889	0.7147
0.1086	0.1233	0.126	0.1262	0.09819	0.09532	0.09332	0.09369	0.1035
0.008653	0.008932	0.008865	0.008785	0.008406	0.008338	0.008274	0.008205	0.008511
0.1122	0.07808	0.0831	0.09079	0.1243	0.132	0.1391	0.1459	0.1121
0.04381	0.03958	0.03744	0.03641	0.06314	0.06407	0.06444	0.06312	0.06111
28.13	28.46	28.39	28.29	28.27	28.19	28.12	28.03	28.38
194.0	163.1	160.3	166.9	291.5	284.5	280.0	288.3	259.6
5885500	3505200	3050800	3032500	6366300	6181400	6059300	5751100	4436300
102.28	57.353	49.823	50.219	126.51	122.01	119.19	114.76	84.074
79407194	46734196	40781885	40670892	85461030	83198246	81767914	77853532	59317047
2	2	2	2	4	4	4	4	4
25.1	13.3	11.0	10.7	59.6	58.9	58.2	54.3	40.0
0.9	0.9	0.9	0.9	2	2	2	2	2
6.9	3.7	3.0	2.9	18.1	17.9	17.7	16.5	12.2
0.7	0.7	0.7	0.7	2.0	2.0	2.0	2.0	2.0
3.1	1.6	1.3	1.3	10.4	10.3	10.1	9.5	7.0
5	5	5	5	5	5	5	5	5
23.2	12.3	10.2	9.9	27.6	27.2	26.9	25.1	18.5
4.6	2.4	2.0	2.0	7.0	7.0	6.9	6.4	4.7
11.3	9.97	9.72	9.68	48.2	48.2	48.1	47.9	46.8
2.6	1.4	1.1	1.1	4.0	3.9	3.9	3.6	2.7
424000	225000	186000	180000	657000	649000	642000	598000	441000
821	931	953	979	1259	1228	1223	1235	1282

13	14	15	16	17	18	19	20	21
1 GT @ 50% load,	1 GT @ 50% load,	1 GT @ 100%	1 GT @ 100%	1 GT @ 100%	1 GT @ 100%	1 GT @ 100%	1 GT @ 100%	1 GT @ 100%
59.0	95.8	-20.0	95.8	59.0	95.8	-20.0	59.0	95.8
14.350	14.350	14.350	14.350	14.350	14.350	14.350	14.350	14.350
60	35	60	35	60	35	60	60	35
Liquid	Liquid	Gas	Gas	Gas	Gas	Gas	Liquid	Liquid
0.5	0.5	1	1	1	1	1	1	1
off	off	off	off	On	On	off	On	On
120.1	109.8	0.0	0.0	0.0	0.0	0.0	266.4	254.2
293649	267593	626058	572742	630208	612004	627850	533260	515753
Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating
Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating
18300	18300	21292	21292	21292	21292	21292	18300	18300
20130	20130	23607	23607	23607	23607	23607	20130	20130
n.a.	n.a.	16.52	16.52	16.52	16.52	16.52	n.a.	n.a.
15.0	15.0	13.1	13.1	13.1	13.1	13.1	15.0	15.0
21292	21292	21292	21292	21292	21292	21292	21292	21292
23607	23607	23607	23607	23607	23607	23607	23607	23607
16.52	16.52	16.52	16.52	16.52	16.52	16.52	16.52	16.52
13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1
Off	Off	Operating	Operating	Operating	Operating	Operating	Off	Off
0.0	0.0	42441.2	34804.6	38413.1	37201.3	42584.9	0.0	0.0
0.0	0.0	99.7	81.7	90.2	87.4	100.0	0.0	0.0
2258.0	2109.7	3523.8	3230.1	3541.1	3459.2	3523.8	3914.6	3824.7
0.0	0.0	1001.9	821.6	906.8	878.2	1005.3	0.0	0.0
0.7113	0.7071	0.738	0.7244	0.7289	0.7184	0.738	0.6938	0.6862
0.103	0.1052	0.08825	0.08783	0.08635	0.0846	0.08816	0.09297	0.09254
0.008471	0.008422	0.008788	0.008626	0.008679	0.008554	0.008788	0.008263	0.008172
0.1163	0.1205	0.1092	0.125	0.1206	0.1335	0.1093	0.1402	0.1496
0.06083	0.05857	0.05561	0.05397	0.05533	0.05478	0.05565	0.06453	0.0634
28.33	28.26	28.26	28.08	28.14	27.99	28.26	28.11	28.00
243.4	251.2	172.8	178.6	176.3	182.2	180.5	281.3	293.8
3795900	3674700	6155800	5635400	6047500	5924500	6155900	6152600	6093500
70.446	69.122	103.01	95.811	102.23	101.6	104.27	121.29	122.65
50841652	49342122	82647962	76167998	81561722	80321905	82651494	83061790	82598636
4	4	2	2	2	2	2	4	4
34.1	31.9	33.3	29.7	32.7	31.8	33.3	59.2	57.8
2	2	1.5	1.5	1.5	1.5	1.5	2	2
10.4	9.7	15.2	13.6	14.9	14.5	15.2	18.0	17.6
2.0	2.0	1.6	1.6	1.6	1.6	1.6	2.0	2.0
6.0	5.6	9.3	8.3	9.1	8.9	9.3	10.3	10.1
5	5	5	5	5	5	5	5	5
15.8	14.8	30.8	27.5	30.2	29.5	30.8	27.4	26.8
4.0	3.8	6.1	5.4	6.0	5.8	6.1	7.0	6.8
46.4	46.3	22.5	20.3	21.5	21.1	22.5	48.2	48.1
2.3	2.1	3.7	3.3	3.7	3.6	3.7	3.9	3.9
377000	352000	560000	501000	550000	536000	560000	653000	638000
1283	1315	894	874	872	876	892	1224	1236

Estimated Steady State Emission Notes

HRSG Emission Notes:

1. Gas turbine(s) and steam plant are in steady-state operation.
2. Steady State Emissions data above are estimated values based on GE recommended measurements and analysis procedures, per GEK 28172.
3. Reference conditions for exhaust gas SCF are: 68°F, and 14.6959 psia.
4. Reference conditions for gas fuel SCF are: 60°F, and 14.6959 psia.
5. SO2 emission values have been estimated by assuming that all the sulfur in the fuel is converted to SO2.
6. Consistent with previous emission calculations, the SO2 and sulfur mist emission values are based on maximum sulfur content of 13.1 ppm (0.4 grains/100 scf) for gas and 15 ppm for liquid fuel.
7. SO2 and sulfur mist values are margined by 20 % to account for variation in fuel sulfur content and measurement error.
8. The CO2 estimate derived from the heat rate does not include any margin for measurement errors assuming that the compliance will be demonstrated using the heat rate from the performance test results. If CO2 compliance is to be demonstrated using actual CO2 measurements from the HRSG stack, GE recommends adding 10% margin to the estimated values.
9. Sulfur mist emission calculations conservatively assume that all SO3 combines with water to form sulfur mist. In actuality, some SO3 may form other chemical species. This would include ammonium sulfates in the presence of NH3. The maximum sulfur mist is reported to be conservative.
10. The estimated values for heat consumption and exhaust flows are margined in this document to account for equipment variations, site operating conditions, and life-cycle operating parameters.The Plant Performance section does not include permitting margin, for more information on performance please refer to the Heat Balance.
11. Distillate oil fuel-bound nitrogen is less than or equal to 0.015 % by weight.

Additional Notes for Particulate Emissions

1. Particulate Matter estimates over the entire emissions compliance region of GT operation are based on field data obtained at base load for the GT. In reality, particulate matter emissions measured in lb/h are expected to decrease at part load operation and the lb/MMBTU values at part load operation are expected not to exceed the lb/MMBTU value for PM at baseload.
2. PM10 and PM2.5 are estimated at the same rate as Total Particulates.
3. Consistent with previous emission calculations, the PM estimates are based on maximum S content in the fuel of 13.1 ppm (0.4 grains/100 scf) for gas fuel and 15 ppm for liquid fuel.

Renovo Energy Center

Supporting Documentation for Response to Question #9

May 28, 2020

Renovo Energy Center - Emergency Generator
Calculation of NOx and CO Emission Limits

40 CFR Part 89 Section E, Appendix B, Table 2

mode	1	2	3	4	5		
%	100	75	50	25	10		
weighting factor	0.05	0.25	0.3	0.3	0.1		
%	100	75	50	25	10		Caterpillar 1500 kW
NOx nominal data (g-hp-hr)	5.48	3.68	3.55	4.87	7.62		Nominal data
						total	
NOx weighted emissions (g/hp-hr)	0.274	0.92	1.065	1.461	0.762	**4.48**	
%	100	75	50	25	10		Caterpillar 1500 kW
CO nominal data (g-hp-hr)	0.48	0.4	0.81	1.74	3.4		Nominal data
						total	
CO weighted emissions (g/hp-hr)	0.024	0.1	0.243	0.522	0.34	**1.23**	

5/28/2020

PERFORMANCE DATA[DM8260]

January 13, 2016

Performance Number: DM8260 **Change Level: 05**

SALES MODEL:	3512C	**COMBUSTION:**	DI
ENGINE POWER (BHP):	2,206	**ENGINE SPEED (RPM):**	1,800
GEN POWER WITH FAN (EKW):	1,500.0	**HERTZ:**	60
COMPRESSION RATIO:	14.7	**FAN POWER (HP):**	88.5
RATING LEVEL:	STANDBY	**ASPIRATION:**	TA
PUMP QUANTITY:	2	**AFTERCOOLER TYPE:**	ATAAC
FUEL TYPE:	DIESEL	**AFTERCOOLER CIRCUIT TYPE:**	JW+OC, ATAAC
MANIFOLD TYPE:	DRY	**INLET MANIFOLD AIR TEMP (F):**	122
GOVERNOR TYPE:	ADEM3	**JACKET WATER TEMP (F):**	210.2
ELECTRONICS TYPE:	ADEM3	**TURBO CONFIGURATION:**	PARALLEL
CAMSHAFT TYPE:	STANDARD	**TURBO QUANTITY:**	4
IGNITION TYPE:	CI	**TURBOCHARGER MODEL:**	GTB4708BN-52T-0.96
INJECTOR TYPE:	EUI	**CERTIFICATION YEAR:**	2006
FUEL INJECTOR:	2664387	**CRANKCASE BLOWBY RATE (FT3/HR):**	2,203.4
UNIT INJECTOR TIMING (IN):	64.34	**FUEL RATE (RATED RPM) NO LOAD (GAL/HR):**	9.9
REF EXH STACK DIAMETER (IN):	10	**PISTON SPD @ RATED ENG SPD (FT/MIN):**	2,244.1
MAX OPERATING ALTITUDE (FT):	3,937		

INDUSTRY	SUBINDUSTRY	APPLICATION
ELECTRIC POWER	STANDARD	PACKAGED GENSET
OIL AND GAS	LAND PRODUCTION	PACKAGED GENSET

General Performance Data

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	BRAKE MEAN EFF PRES (BMEP)	BRAKE SPEC FUEL CONSUMPTN (BSFC)	VOL FUEL CONSUMPTN (VFC)	INLET MFLD PRES	INLET MFLD TEMP	EXH MFLD TEMP	EXH MFLD PRES	ENGINE OUTLET TEMP
EKW	%	BHP	PSI	LB/BHP-HR	GAL/HR	IN-HG	DEG F	DEG F	IN-HG	DEG F
1,500.0	100	2,206	307	0.332	104.6	77.5	120.9	1,145.6	74.6	756.6
1,350.0	90	1,983	276	0.336	95.2	72.2	116.1	1,102.7	68.8	727.5
1,200.0	80	1,768	246	0.343	86.6	66.9	113.2	1,069.1	63.0	713.4
1,125.0	75	1,662	232	0.346	82.0	63.4	111.5	1,052.3	59.5	706.7
1,050.0	70	1,556	217	0.348	77.4	59.7	109.8	1,035.2	55.8	700.0
900.0	60	1,349	188	0.352	67.9	51.1	107.1	1,000.5	47.6	687.3
750.0	50	1,144	159	0.355	58.0	40.6	107.5	963.6	38.4	696.7
600.0	40	940	131	0.359	48.2	30.0	108.4	921.9	29.4	702.2
450.0	30	736	103	0.368	38.6	20.9	107.1	856.0	21.9	685.3
375.0	25	632	88	0.376	33.9	16.9	106.2	809.5	18.8	664.9
300.0	20	527	73	0.388	29.2	13.3	105.2	754.5	16.0	636.4
150.0	10	312	43	0.443	19.7	7.3	103.2	609.7	11.4	540.6

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	COMPRESSOR OUTLET PRES	COMPRESSOR OUTLET TEMP	WET INLET AIR VOL FLOW RATE	ENGINE OUTLET WET EXH GAS VOL FLOW RATE	WET INLET AIR MASS FLOW RATE	WET EXH GAS MASS FLOW RATE	WET EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)	DRY EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)
EKW	%	BHP	IN-HG	DEG F	CFM	CFM	LB/HR	LB/HR	FT3/MIN	FT3/MIN
1,500.0	100	2,206	82	449.8	4,937.2	11,734.1	21,796.5	22,529.1	4,743.3	4,317.6
1,350.0	90	1,983	77	428.8	4,734.5	10,945.3	20,885.8	21,551.9	4,532.9	4,136.4
1,200.0	80	1,768	71	409.0	4,506.7	10,265.9	19,853.4	20,459.8	4,302.7	3,938.4
1,125.0	75	1,662	68	396.6	4,371.2	9,868.8	19,223.0	19,797.6	4,160.2	3,812.8
1,050.0	70	1,556	64	382.6	4,218.1	9,442.4	18,511.1	19,053.3	4,003.2	3,672.9
900.0	60	1,349	55	350.3	3,862.4	8,508.3	16,857.2	17,332.4	3,647.3	3,352.3
750.0	50	1,144	44	309.9	3,375.7	7,435.0	14,666.1	15,072.5	3,161.3	2,907.1
600.0	40	940	33	266.6	2,868.4	6,329.0	12,406.6	12,744.3	2,678.2	2,465.5
450.0	30	736	23	224.6	2,431.9	5,278.8	10,481.3	10,752.0	2,266.9	2,093.3
375.0	25	632	19	204.3	2,243.0	4,776.5	9,654.1	9,891.7	2,088.3	1,933.3
300.0	20	527	15	184.2	2,069.9	4,283.3	8,899.4	9,103.9	1,921.3	1,784.5
150.0	10	312	9	148.8	1,782.1	3,338.5	7,648.3	7,786.4	1,641.0	1,539.0

PERFORMANCE DATA[DM8260]

Heat Rejection Data

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	REJECTION TO JACKET WATER	REJECTION TO ATMOSPHERE	REJECTION TO EXH	EXHUAST RECOVERY TO 350F	FROM OIL COOLER	FROM AFTERCOOLER	WORK ENERGY	LOW HEAT VALUE ENERGY	HIGH HEAT VALUE ENERGY
EKW	%	BHP	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN
1,500.0	100	2,206	28,541	7,072	79,477	38,355	11,956	29,539	93,547	224,476	239,123
1,350.0	90	1,983	26,761	6,706	72,346	33,940	10,882	26,874	84,110	204,315	217,647
1,200.0	80	1,768	25,085	6,393	66,713	30,942	9,897	24,071	74,958	185,825	197,950
1,125.0	75	1,662	24,176	6,249	63,549	29,350	9,376	22,404	70,466	176,039	187,526
1,050.0	70	1,556	23,227	6,110	60,309	27,693	8,845	20,631	66,004	166,069	176,905
900.0	60	1,349	21,222	5,841	53,634	24,225	7,759	16,788	57,205	145,683	155,189
750.0	50	1,144	19,059	5,564	46,826	21,662	6,636	12,311	48,509	124,586	132,716
600.0	40	940	16,790	5,286	39,874	18,604	5,512	8,066	39,882	103,489	110,241
450.0	30	736	14,427	4,840	32,601	14,897	4,416	4,955	31,201	82,917	88,327
375.0	25	632	13,189	4,570	28,900	12,838	3,876	3,774	26,809	72,772	77,520
300.0	20	527	11,900	4,299	25,149	10,707	3,336	2,793	22,353	62,628	66,715
150.0	10	312	9,090	3,818	17,468	6,020	2,253	1,375	13,214	42,301	45,061

Emissions Data

RATED SPEED POTENTIAL SITE VARIATION: 1800 RPM

GENSET POWER WITH FAN		EKW	1,500.0	1,125.0	750.0	375.0	150.0
PERCENT LOAD		%	100	75	50	25	10
ENGINE POWER		BHP	2,206	1,662	1,144	632	312
TOTAL NOX (AS NO2)		G/HR	14,366	7,266	4,835	3,673	2,831
TOTAL CO		G/HR	1,890	1,176	1,665	1,965	1,898
TOTAL HC		G/HR	351	381	358	283	329
PART MATTER		G/HR	97.6	99.1	150.9	184.0	112.2
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	2,848.7	1,803.1	1,671.1	2,214.1	2,967.2
TOTAL CO	(CORR 5% O2)	MG/NM3	427.2	336.3	712.5	1,486.6	2,381.4
TOTAL HC	(CORR 5% O2)	MG/NM3	68.8	95.6	123.3	175.3	360.2
PART MATTER	(CORR 5% O2)	MG/NM3	18.2	23.5	54.8	110.0	115.7
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,388	878	814	1,078	1,445
TOTAL CO	(CORR 5% O2)	PPM	342	269	570	1,189	1,905
TOTAL HC	(CORR 5% O2)	PPM	128	178	230	327	672
TOTAL NOX (AS NO2)		G/HP-HR	6.58	4.41	4.26	5.85	9.14
TOTAL CO		G/HP-HR	0.87	0.71	1.47	3.13	6.13
TOTAL HC		G/HP-HR	0.16	0.23	0.32	0.45	1.06
PART MATTER		G/HP-HR	0.04	0.06	0.13	0.29	0.36
TOTAL NOX (AS NO2)		LB/HR	31.67	16.02	10.66	8.10	6.24
TOTAL CO		LB/HR	4.17	2.59	3.67	4.33	4.18
TOTAL HC		LB/HR	0.77	0.84	0.79	0.62	0.73
PART MATTER		LB/HR	0.22	0.22	0.33	0.41	0.25

RATED SPEED NOMINAL DATA: 1800 RPM

GENSET POWER WITH FAN		EKW	1,500.0	1,125.0	750.0	375.0	150.0
PERCENT LOAD		%	100	75	50	25	10
ENGINE POWER		BHP	2,206	1,662	1,144	632	312
TOTAL NOX (AS NO2)		G/HR	11,972	6,055	4,029	3,061	2,359
TOTAL CO		G/HR	1,050	653	925	1,092	1,055
TOTAL HC		G/HR	264	286	269	213	248
TOTAL CO2		KG/HR	1,096	853	602	352	204
PART MATTER		G/HR	69.7	70.8	107.8	131.4	80.1
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	2,373.9	1,502.6	1,392.6	1,845.1	2,472.7
TOTAL CO	(CORR 5% O2)	MG/NM3	237.3	186.8	395.9	825.9	1,323.0
TOTAL HC	(CORR 5% O2)	MG/NM3	51.7	71.9	92.7	131.8	270.9
PART MATTER	(CORR 5% O2)	MG/NM3	13.0	16.8	39.1	78.6	82.6
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,156	732	678	899	1,204
TOTAL CO	(CORR 5% O2)	PPM	190	149	317	661	1,058
TOTAL HC	(CORR 5% O2)	PPM	97	134	173	246	506
TOTAL NOX (AS NO2)		G/HP-HR	5.48	3.68	3.55	4.87	7.62
TOTAL CO		G/HP-HR	0.48	0.40	0.81	1.74	3.40
TOTAL HC		G/HP-HR	0.12	0.17	0.24	0.34	0.80

PERFORMANCE DATA[DM8260]

PART MATTER	G/HP-HR	0.03	0.04	0.09	0.21	0.26
TOTAL NOX (AS NO2)	LB/HR	26.39	13.35	8.88	6.75	5.20
TOTAL CO	LB/HR	2.32	1.44	2.04	2.41	2.32
TOTAL HC	LB/HR	0.58	0.63	0.59	0.47	0.55
TOTAL CO2	LB/HR	2,417	1,881	1,327	776	449
PART MATTER	LB/HR	0.15	0.16	0.24	0.29	0.18
OXYGEN IN EXH	%	11.2	12.3	12.9	13.9	15.8
DRY SMOKE OPACITY	%	1.0	1.3	2.9	5.0	3.0
BOSCH SMOKE NUMBER		0.37	0.45	1.06	1.60	1.11

Regulatory Information

EPA TIER 2		2006 - 2010		
GASEOUS EMISSIONS DATA MEASUREMENTS PROVIDED TO THE EPA ARE CONSISTENT WITH THOSE DESCRIBED IN EPA 40 CFR PART 89 SUBPART D AND ISO 8178 FOR MEASURING HC, CO, PM, AND NOX. THE "MAX LIMITS" SHOWN BELOW ARE WEIGHTED CYCLE AVERAGES AND ARE IN COMPLIANCE WITH THE NON-ROAD REGULATIONS.				
Locality	**Agency**	**Regulation**	**Tier/Stage**	**Max Limits - G/BKW - HR**
U.S. (INCL CALIF)	EPA	NON-ROAD	TIER 2	CO: 3.5 NOx + HC: 6.4 PM: 0.20

EPA EMERGENCY STATIONARY		2011 - ----		
GASEOUS EMISSIONS DATA MEASUREMENTS PROVIDED TO THE EPA ARE CONSISTENT WITH THOSE DESCRIBED IN EPA 40 CFR PART 60 SUBPART IIII AND ISO 8178 FOR MEASURING HC, CO, PM, AND NOX. THE "MAX LIMITS" SHOWN BELOW ARE WEIGHTED CYCLE AVERAGES AND ARE IN COMPLIANCE WITH THE EMERGENCY STATIONARY REGULATIONS.				
Locality	**Agency**	**Regulation**	**Tier/Stage**	**Max Limits - G/BKW - HR**
U.S. (INCL CALIF)	EPA	STATIONARY	EMERGENCY STATIONARY	CO: 3.5 NOx + HC: 6.4 PM: 0.20

Altitude Derate Data

ALTITUDE CORRECTED POWER CAPABILITY (BHP)

AMBIENT OPERATING TEMP (F)	30	40	50	60	70	80	90	100	110	120	130	140	NORMAL
ALTITUDE (FT)													
0	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,096	2,206
1,000	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,162	2,074	2,206
2,000	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,176	2,118	2,007	2,206
3,000	2,206	2,206	2,206	2,206	2,206	2,206	2,206	2,173	2,135	2,098	2,052	1,919	2,206
4,000	2,201	2,201	2,201	2,201	2,201	2,171	2,132	2,094	2,057	2,021	1,963	1,831	2,201
5,000	2,129	2,129	2,129	2,129	2,129	2,092	2,054	2,017	1,982	1,947	1,853	1,677	2,129
6,000	2,059	2,059	2,059	2,059	2,053	2,015	1,978	1,943	1,909	1,876	1,699	1,522	2,059
7,000	1,992	1,992	1,992	1,992	1,976	1,940	1,904	1,870	1,838	1,787	1,522	1,368	1,992
8,000	1,927	1,927	1,927	1,927	1,902	1,867	1,833	1,800	1,769	1,699	1,368	1,213	1,927
9,000	1,865	1,865	1,865	1,865	1,831	1,797	1,764	1,733	1,699	1,610	1,235	1,081	1,865
10,000	1,805	1,805	1,805	1,795	1,761	1,729	1,697	1,667	1,610	1,522	1,081	949	1,805
11,000	1,522	1,522	1,522	1,522	1,522	1,500	1,390	1,279	1,191	1,081	971	838	1,522
12,000	1,478	1,478	1,478	1,478	1,434	1,346	1,235	1,147	1,037	971	860	772	1,478
13,000	1,434	1,434	1,434	1,390	1,279	1,191	1,103	1,015	927	860	772	706	1,434
14,000	1,390	1,390	1,346	1,235	1,147	1,059	971	882	816	772	706	640	1,390
15,000	1,346	1,302	1,191	1,103	1,015	927	860	794	750	706	662	596	1,346

Cross Reference

Engine Arrangement			
Arrangement Number	**Effective Serial Number**	**Engineering Model**	**Engineering Model Version**
2673949	EBG00001	GS335	-
3869723	CT200001	GS656	LS
4869923	CT200001	GS656	LS

Test Specification Data						
Test Spec	**Setting**	**Effective Serial Number**	**Engine Arrangement**	**Governor Type**	**Default Low Idle Speed**	**Default High Idle Speed**
0K7015	GG0288	EBG00001	2673949			
4183066	GG0760	CT200001	3869723			

Supplementary Data

Type	Classification	Performance Number
SOUND	SOUND PRESSURE	DM8779

General Notes

General Notes DM8260 - 05

SOUND PRESSURE DATA FOR THIS RATING CAN BE FOUND IN PERFORMANCE NUMBER - DM8779

Performance Parameter Reference

Parameters Reference:DM9600-08
PERFORMANCE DEFINITIONS

PERFORMANCE DEFINITIONS DM9600

APPLICATION:
Engine performance tolerance values below are representative of a typical production engine tested in a calibrated dynamometer test cell at SAE J1995 standard reference conditions. Caterpillar maintains ISO9001:2000 certified quality management systems for engine test Facilities to assure accurate calibration of test equipment. Engine test data is corrected in accordance with SAE J1995. Additional reference material SAE J1228, J1349, ISO 8665, 3046-1:2002E, 3046-3:1989, 1585, 2534, 2288, and 9249 may apply in part or are similar to SAE J1995. Special engine rating request (SERR) test data shall be noted.

PERFORMANCE PARAMETER TOLERANCE FACTORS:

Power	+/- 3%
Torque	+/- 3%
Exhaust stack temperature	+/- 8%
Inlet airflow	+/- 5%
Intake manifold pressure-gage	+/- 10%
Exhaust flow	+/- 6%
Specific fuel consumption	+/- 3%
Fuel rate	+/- 5%
Specific DEF consumption	+/- 3%
DEF rate	+/- 5%
Heat rejection	+/- 5%
Heat rejection exhaust only	+/- 10%
Heat rejection CEM only	+/- 10%

Heat Rejection values based on using treated water.

Torque is included for truck and industrial applications, do not use for Gen Set or steady state applications.

On C7 - C18 engines, at speeds of 1100 RPM and under these values are provided for reference only, and may not meet the tolerance listed.

These values do not apply to C280/3600. For these models, see the tolerances listed below.

C280/3600 HEAT REJECTION TOLERANCE FACTORS:

Heat rejection	+/- 10%
Heat rejection to Atmosphere	+/- 50%
Heat rejection to Lube Oil	+/- 20%
Heat rejection to Aftercooler	+/- 5%

TEST CELL TRANSDUCER TOLERANCE FACTORS:

Torque	+/- 0.5%
Speed	+/- 0.2%
Fuel flow	+/- 1.0%
Temperature	+/- 2.0 C degrees
Intake manifold pressure	+/- 0.1 kPa

OBSERVED ENGINE PERFORMANCE IS CORRECTED TO SAE J1995 REFERENCE AIR AND FUEL CONDITIONS.

REFERENCE ATMOSPHERIC INLET AIR
FOR 3500 ENGINES AND SMALLER
SAE J1228 AUG2002 for marine engines, and J1995 JAN2014 for other engines, reference atmospheric pressure is 100 KPA (29.61 in hg), and standard temperature is 25deg C (77 deg F) at 30% relative humidity at the stated aftercooler water temp, or inlet manifold

temp.

FOR 3600 ENGINES
Engine rating obtained and presented in accordance with ISO 3046/1 and SAE J1995 JANJAN2014 reference atmospheric pressure is 100 KPA (29.61 in hg), and standard temperature is 25deg C (77 deg F) at 30% relative humidity and 150M altitude at the stated aftercooler water temperature.

MEASUREMENT LOCATION FOR INLET AIR TEMPERATURE
Location for air temperature measurement air cleaner inlet at stabilized operating conditions.

REFERENCE EXHAUST STACK DIAMETER
The Reference Exhaust Stack Diameter published with this dataset is only used for the calculation of Smoke Opacity values displayed in this dataset. This value does not necessarily represent the actual stack diameter of the engine due to the variety of exhaust stack adapter options available. Consult the price list, engine order or general dimension drawings for the actual stack diameter size ordered or options available.

REFERENCE FUEL
DIESEL
Reference fuel is #2 distillate diesel with a 35API gravity;
A lower heating value is 42,780 KJ/KG (18,390 BTU/LB) when used at 29 (84.2), where the density is 838.9 G/Liter (7.001 Lbs/Gal).

GAS
Reference natural gas fuel has a lower heating value of 33.74 KJ/L (905 BTU/CU Ft). Low BTU ratings are based on 18.64 KJ/L (500 BTU/CU FT) lower heating value gas. Propane ratings are based on 87.56 KJ/L (2350 BTU/CU Ft) lower heating value gas.

ENGINE POWER (NET) IS THE CORRECTED FLYWHEEL POWER (GROSS) LESS EXTERNAL AUXILIARY LOAD
Engine corrected gross output includes the power required to drive standard equipment; lube oil, scavenge lube oil, fuel transfer, common rail fuel, separate circuit aftercooler and jacket water pumps. Engine net power available for the external (flywheel) load is calculated by subtracting the sum of auxiliary load from the corrected gross flywheel out put power. Typical auxiliary loads are radiator cooling fans, hydraulic pumps, air compressors and battery charging alternators. For Tier 4 ratings additional Parasitic losses would also include Intake, and Exhaust Restrictions.

ALTITUDE CAPABILITY
Altitude capability is the maximum altitude above sea level at standard temperature and standard pressure at which the engine could develop full rated output power on the current performance data set.

Standard temperature values versus altitude could be seen on TM2001.

When viewing the altitude capability chart the ambient temperature is the inlet air temp at the compressor inlet.

Engines with ADEM MEUI and HEUI fuel systems operating at conditions above the defined altitude capability derate for atmospheric pressure and temperature conditions outside the values defined, see TM2001.

Mechanical governor controlled unit injector engines require a setting change for operation at conditions above the altitude defined on the engine performance sheet. See your Caterpillar technical representative for non standard ratings.

REGULATIONS AND PRODUCT COMPLIANCE

PERFORMANCE DATA[DM8260]

TMI Emissions information is presented at 'nominal' and 'Potential Site Variation' values for standard ratings. No tolerances are applied to the emissions data. These values are subject to change at any time. The controlling federal and local emission requirements need to be verified by your Caterpillar technical representative.

Customer's may have special emission site requirements that need to be verified by the Caterpillar Product Group engineer.

EMISSIONS DEFINITIONS:
Emissions : DM1176

HEAT REJECTION DEFINITIONS:
Diesel Circuit Type and HHV Balance : DM9500

HIGH DISPLACEMENT (HD) DEFINITIONS:
3500: EM1500

RATING DEFINITIONS:
Agriculture : TM6008

Fire Pump : TM6009

Generator Set : TM6035

Generator (Gas) : TM6041

Industrial Diesel : TM6010

Industrial (Gas) : TM6040

Irrigation : TM5749

Locomotive : TM6037

Marine Auxiliary : TM6036

Marine Prop (Except 3600) : TM5747

Marine Prop (3600 only) : TM5748

MSHA : TM6042

Oil Field (Petroleum) : TM6011

Off-Highway Truck : TM6039

On-Highway Truck : TM6038

SOUND DEFINITIONS:
Sound Power : DM8702

Sound Pressure : TM7080

Date Released : 7/7/15

From: tim.donnelly@powereng.com
To: Waldman, Paul R
Cc: Zaman, Muhammad; Shimmel, David
Subject: [External] RE: Renovo Energy Center Response Letter
Date: Thursday, June 18, 2020 4:32:52 PM

Thank you gentlemen, I have conferred with Bechtel and response to both will be forthcoming. Rick is reaching out to GE re: ammonia slip, but also pointed out the same GE turbine at Tioga was permitted at 5 ppm in August 2019 while Hilltop is also at 5 ppm, though permitted in 12/17.

Will submit response ASAP, probably next week given need for GE to weigh in.

Thanks again, stay healthy and sane down there!

From: Waldman, Paul R <pwaldman@pa.gov>
Sent: Thursday, June 18, 2020 10:40 AM
To: Donnelly, Tim <tim.donnelly@powereng.com>
Cc: Zaman, Muhammad <mzaman@pa.gov>; Shimmel, David <dshimmel@pa.gov>
Subject: [EXTERNAL] Renovo Energy Center Response Letter

Tim,

Thank you for the response letter dated May 28, 2020, to the Department's technical deficiency letter dated May 6, 2020. The Department has reviewed the responses and request additional information to the following:

1. The Department's review of other combustion turbine engines with duct burners with the same model number have demonstrated compliance with ammonia slip limitation of 2.0 parts per million (ppm). Please provide an explanation why Renovo Energy Center (REC) is requesting a higher limitation of 5.0 ppm than similar configurations that have demonstrated compliance with the ammonia slip limitation of 2.0 ppm.

2. As for the proposed Startup/Shutdown (SUSD), the Department is requesting an explanation on the discrepancy between the duration of each scenario between REC and ESC Tioga for the same make and model number. In addition, please provide an explanation why REC is proposing a higher number of SUSD as compared to other similar projects.

Review of the plan approval application is pending REC's responses to the above requested information.

Any questions or concerns about the requested information please feel free to contact me at any time.

Sincerely,

Paul Waldman | Project Manager
Department of Environmental Protection | Air Quality Program
North Central Regional Office
208 West Third Street Suite 101 | Williamsport PA 17701
Phone: 570-327-3721 | Fax: 570.327.3420

POWER ENGINEERS, INC.

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FREEPORT, ME 04032 USA

PHONE 207-869-1200
FAX 207-869-1299

July 1, 2020

Mr. Paul Waldman
Project Manager
Air Quality Program
PA DEP Northcentral Regional Office
208 W. Third Street, Suite 101
Williamsport, PA 17701-6448

Subject: Renovo Energy Center LLC, Proposed Plan Approval 18-00033B

Dear Mr. Waldman:

On behalf of Renovo Energy Center LLC (REC), POWER Engineers, Inc. is submitting the following responses to your email dated June 18, 2020 requesting additional information regarding REC's Plan Approval Application 18-00033B. The requests are shown in italics followed by Renovo Energy Center's response.

1. *The Department's review of other combustion turbine engines with duct burners with the same model number have demonstrated compliance with ammonia slip limitation of 2.0 parts per million (ppm). Please provide an explanation why Renovo Energy Center (REC) is requesting a higher limitation of 5.0 ppm than similar configurations that have demonstrated compliance with the ammonia slip limitation of 2.0 ppm.*

   REC's proposed ammonia slip limitation of 5.0 ppm is consistent with most similar operating equipment configurations. While the Bridgeport Harbor Station's Unit #5 (BHS) in Connecticut is permitted and currently operating the GE 7HA.02 combustion turbine at a 2 ppm NH_3 slip limit while firing natural gas, BHS' duct burner is of a significantly smaller size than REC's (BHS's maximum gross heat input is ~27% of REC's proposed duct burner heat input). Also, BHS' Unit #5 has operated for less than one full year, thus the long-term viability of the 2 ppm NH_3 slip limitation for this particular combustion turbine has not yet been demonstrated.

   While it is believed a Selective Catalytic Reduction (SCR) system could be designed to meet such an extremely low NH_3 slip level, REC's OEM provider (GE) has outlined several reasons that operating an SCR consistently in compliance with a 2 ppm NH_3 slip limit will be problematic from an equipment operations perspective over the life of the equipment (25 – 30 years) including:

- Operational flexibility may be significantly compromised/limited. Given the current and forecasted electricity market REC anticipates operational flexibility as essential to accommodate daily load swings that may be required for regional electrical grid stability. When the combustion turbine transitions from baseload to low turndown, the exhaust flow and NOx distribution across the catalyst will vary. The NH_3 injection must be balanced across the entire operating range to maintain the slip requirement. A slip requirement below 5 ppm NH_3 will be difficult to maintain during rapid and frequent load changes over the course of equipment operating life (typical degradation).
- The NH_3 injection and control system will require fine tuning and be more complex to operate to meet the more restrictive ammonia slip requirements. The ammonia injection across the face of the catalyst must match the NOx distribution across the catalyst face to effectively limit the unreacted ammonia "slip" through the catalyst. While it may be possible to meet a stringent 2 ppm NH_3 slip limit at the time of commissioning and early operation, there is no evidence supporting compliance with such a stringent limit over the course of a facility's commercial life (25 – 30 years).

GE will only guarantee emissions compliance (including NH_3 slip) during commissioning and the first year of operation, after which the REC operators will have the responsibility and associated liability of maintaining compliance with permit limits throughout the commercial life of the units.

In addition to the flexibility and complexity concerns, meeting an NH_3 slip limit of 2 ppm will result in substantial increases in capital and operational costs. Operating to meet an NH_3 slip level of 2 ppm will shorten the catalyst life as it degrades over time and will require changing out the catalyst beds on a more frequent schedule. Catalyst beds are typically changed out during annual shutdowns, however with an NH_3 slip limit of 2 ppm the catalyst may have to be changed out during an unscheduled outage, which may result in significant penalties for not being available as well as lost revenue. REC's commercial life is expected to be 25 to 30 years; thus the frequency of catalyst changes will have a significant impact on REC's ability to provide consistent and cost-effective electricity into the regional electrical grid.

The ESC Tioga power plant permitted in August 2019 and the Hill Top power plant (located in Greene County, PA) permitted in December 2017 include the same GE 7HA.02 combustion turbine with a duct burner that is nearly identical in size as REC's, and both of these projects were permitted with an NH_3 slip limit of 5 ppm.

Based on the reasons listed above, REC respectfully requests the proposed slip limit be approved as submitted.

2. *As for the proposed Startup/Shutdown (SUSD), the Department is requesting an explanation on the discrepancy between the duration of each scenario between REC and ESC Tioga for the same make and model number. In addition, please provide an explanation why REC is proposing a higher number of SUSD as compared to other similar projects.*

   REC is not aware of or privy to the ESC Tioga project's commercialization or anticipated operating strategy so cannot comment on the basis of their requests.

   The durations of each SUSD scenario REC is proposing includes an appropriate margin on the SUSD durations provided by the original equipment manufacturer (GE), in accordance with their recommendation. GE previously provided the following justification for the requested margin on the duration limits of SUSD events:

   > "GE provides start durations and associated emission capabilities for the Rapid Response designed plant. These values represent the plant capabilities during the start event. GE recommends the addition of margin for any individual start to provide operational flexibility in the event of any delay during an individual start event due to Balance of Plant equipment delays. While the GE Rapid Response plants reliably start within the quoted capabilities, these are very complex systems and delays can occasionally occur during a start event. The flexibility provided by the start margin will allow the plant to continue the start sequence for a reasonable period of time to resolve a specific equipment issue within the complex plant start sequence without the need to abort the start and re-initiate to avoid a violation. An aborted start and re-initiation of a start sequence would ultimately lead to higher plant emissions."

   Additionally, the input and feedback received from the investment community, without whose support the REC Project will not happen, is that the operational flexibility enabled by the inclusion of an appropriate number and hours of SUSD events is critical to their investment in a CCGT powerplant in the current and anticipated future operating environment. Although the plant was originally contemplated for baseload dispatch and not as a peaking plant, investors are now requiring maximum operational flexibility based on significant changes in the electricity market, both during the past decade and expected during the next decade(s), as a result of the continuing shift to intermittent renewable energy generating capacity.

REC also plans to interconnect the units to separate ISOs (one to PJM and one to NYISO), each of which could have differing dispatch profiles which in turn could lead to additional SUSDs than if both units were dispatched to the same ISO. The total number of hours a facility estimates for SUSD is a question of operating flexibility, not one of the level of control and should not impact a control technology determination for a specific plant. Again, while it is REC's preference to have a minimal number of SUSD, consideration must be given for potential changing electricity market conditions resulting in the units cycling on a regular basis.

Please do not hesitate to contact me if you require additional information.

Sincerely,

Tim Donnelly

cc: David Shimmel, Pennsylvania DEP
Muhammad Zaman, Pennsylvania DEP
Rick Franzese, Bechtel Development Company
Bill Bousquet, Innovative Power Solutions, LLC