

US EPA ARCHIVE DOCUMENT

Fryer, Tim

From: Carlson, Larry <LCarlson@TENASKA.com>
Sent: Wednesday, May 14, 2014 1:38 PM
To: Nguyen, Quang
Subject: Tenaska Roan's Prairie Generating Station
Attachments: Roan's Prairie CO2 BACT Limits Derivation.pdf

Quang-

Upon reviewing the Golden Spread Antelope Station permit materials, it appears clear to me their BACT limit DOES NOT include startup and shutdown. The proposed limit of 1,304 lb/MWh taken from their table below is calculated by dividing the hourly emissions (189,432 lbs/hr) by the gross output (149.66 MW) and multiplying by their assumed degradation factor (3%) as follows:

$$\frac{189,432 \text{ lbs CO}_2}{\text{hr}} \times \frac{1}{149.66 \text{ MW}} \times 1.03 = \frac{1,304 \text{ lbs}}{\text{MWh}}$$

The hourly emissions and turbine output values are at a STEADY STATE part load of 75% at -10 degrees F. There are no startup or shutdown emissions or output included in the calculation (or margined to include). This is consistent with response #5 in their December 4, 2013 response to your completeness determination (included below). Note the BACT Output Bases table at the end of that document was revised in April 2014 (which is excerpted below). The Statement of Basis also refers to the 75% load basis (excerpt below).

This is the reason our "Margined Blended Load CO2 Emission Rate" (1,310 for the GE 7FA .05, shown in the attachment) is similar to their BACT limit (1,304); they are both on a very similar basis (ours assumes a 90%/10% blend of 100%/50% steady state load whereas theirs assumes 100% at 75% load). There are also some differences in assumed margins and turbine performance due to elevation & ambient temperature differences. I have attached a revised BACT limit basis for Roan's Prairie, with the only revision being the assumed fuel CO2 intensity being changed to match the Part 75 methodology (118.86 lb/MMBtu).

Please let me know if you have any further questions.

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Estimated Performance Data (GE)

Load Condition	BASE	BASE	BASE	BASE	BASE	75% LOAD	75% LOAD	75% LOAD	75% LOAD	75% LOAD
Ambient Temperature, °F	98	-10	110	50	20	98	-10	110	50	20
Turbine Output, MW (gross)	190.117	199.546	185.459	195.287	202.067	142.588	149.65	139.094	146.465	151.551
Heat Rate (LHV), BTU/kWh	8905	8828	8950	8783	8732	9420	9587	9506	9291	9281
Exhaust Flow, 1000 lbs/hr	3688	3877	3620	3710	3818	2930	3181	2907	2956	3108
Exhaust MW, lbs/lb-mol	28.28	28.52	28.22	28.49	28.51	28.39	28.52	28.34	28.49	28.52
UHC, lbs/hr	15	15	14	15	15	12	12	11	12	12
CO ₂ , % vol	3.89	3.89	3.88	3.95	3.95	3.9	3.86	3.87	3.93	3.87
% Efficiency, LHV basis	38.33%	38.66%	38.13%	38.86%	38.09%	35.23%	35.60%	35.90%	36.73%	36.77%

Calculated Performance Parameters

Load Condition	BASE	BASE	BASE	BASE	BASE	75% LOAD	75% LOAD	75% LOAD	75% LOAD	75% LOAD
Ambient Temperature, °F	98	-10	110	50	20	98	-10	110	50	20
CH ₄ , lbs/hr	12	12	11.2	12	12	9.6	9.6	8.8	9.6	9.6
N ₂ O, lbs/hr	5.59	5.81	5.48	5.56	5.82	4.43	4.73	4.36	4.49	4.64
CO ₂ , lbs/hr	213,210	232,674	218,996	226,324	232,748	177,100	189,432	174,666	179,414	185,565
CO ₂ -e, lbs/hr	225,176	234,705	220,909	228,311	234,783	178,660	191,082	176,185	180,992	187,188
CO ₂ , lbs/MWh	1209	1201	1216	1194	1186	1279	1304	1293	1262	1261
CO ₂ -e, lbs/MWh	1221	1213	1228	1205	1198	1292	1316	1306	1274	1273

Red values denote maximum values over range of normal operation, except that BACT limits in lbs/MWh are proposed at 75% load as a rolling

Factors Used for Calculations

CH ₄ /UHC, % as a fraction	0.8	Based on GE data for VOC and total HC emissions.
HHV/LHV	1.1	Typical ratio.
N ₂ O emission factor, lbs/MM BTU (HHV)	0.003	From EPA's AP-42, Table 3.1-2a
GHG warming equivalency factors, lb CO ₂ -e/lb:		From GHG Warming Potential Equivalency Factors (40 CFR Part 98 Subpart A)
- CO ₂	1	
- CH ₄	25	
- N ₂ O	298	
Heat Rate degradation factor, %	3	Based on degradation in heat rate between major overhauls

Response #5 in the December 4, 2013 response to the completeness determination:

5. Are the proposed BACT limits applicable at all times, including startup and shutdown? Please supplement the application by indicating whether your proposed BACT includes startup and shutdown emissions, or provide supplemental information that details why a different BACT limit is needed during startup and shutdown along with a proposed BACT analysis for such startup/shutdown emissions.

GSEC Response: Emissions from startup and shutdown operations are included in the emission rates listed in Table 7, but are not included in the proposed BACT output based limits. Output based limits are very difficult if not impossible to accurately specify for startup and shutdown operations, because emissions occur during parts of these operations without any power production, and because emissions and loads vary substantially during the remaining portions of the startup or shutdown. Emissions in any hour of operation that include startups or shutdowns will be at most no more than 1.5% higher than emissions in any hour of normal maximum load operation, regardless of the establishment of an output based factor. Overall these emissions are minimized by the use of an automated combustion control program. The actual emissions of GHG will be determinable in each hour of operation, including startups and shutdowns, using the plant information system's tracking of fuel usage.

Statement of Basis:

The company is responsible for demonstrating compliance with the permitted emission limit and should evaluate its actual emissions and verify actual compliance from recorded operational data. The operating scenario provided by the applicant (4,572 hours at 100% loading per year) was used to calculate the worst-case annual emission rates from the facility; however, the applicant has proposed a BACT emission limit based on a 75% operational load scenario. To account for the additional hours of operation associated with the startup and shutdowns, each turbine is limited by fuel use associated with the 4,572 hours of operation per year. Limiting the fuel use achieves the same objective as limiting the number of hours of operation for the turbine to 4,572 hours. The fuel use limit for the combustion turbine that corresponds to the 4,572 hour of operation per 12-month rolling basis is 8,873,053 MMBtu (HHV).

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Tenaska Roan's Prairie Generating Station CO₂ BACT Limit Derivation - Annual Average Basis

Operating Mode	Parameter	Units	Siemens SGT6-5000F	GE 7FA.05	GE 7FA.04
		Annual Avg. Ambient Condition Basis	(°F)	69	69
Operating Mode	Min Load Definition	(% of Full Load)	40.2%	46.2%	51.8%
	Full/Base Load Annual Avg.	(MW _{gross})	231.1	212.4	176.3
	Min Load Annual Avg.	(MW _{gross})	93.0	98.1	91.3
	Full/Base Load Steady State Operation	(% of annual hours)	90%	90%	90%
	Min Load Steady State Operation	(% of annual hours)	10%	10%	10%
	Startup	Start Time to 100% Load	(min)	12.7	20
Ramp Rate		(MW/min)	30	---	---
		(%/min)	---	9	9
Time in Load Ramp to Min Load		(min)	3.1	5.1	5.7
Start Time to Min Load		(min)	8.1	14.1	8.7
Estimated Power Generated During Start		(MW _{gross} hrs)	2.4	4.1	4.3
Starts per Year		(#)	365	365	365
Total Time in Start		(min)	2,955	5,148	3,182
Total Power Generated in Start		(MW _{gross} hrs)	877	1,511	1,576
Fuel Use: Turning Gear to Min Load		(MMBtu)	---	113	95
Start CO ₂ Emissions to 100% Load		(lb/event)	23,954	---	---
Estimated Start CO ₂ Emissions to Min Load		(lb/event)	9,150	13,431	11,291
Estimated Start CO ₂ Emissions		(tons/yr)	1,670	2,451	2,061
Shutdown	Shutdown Time from 100% Load	(min)	7.7	13	13
	Shutdown Ramp Rate	(MW/min)	30	---	---
		(%/min)	---	9.125	9.125
	Shutdown Time from Min Load	(min)	3.1	7	7
	Time in Load Ramp from Min Load	(min)	3.1	---	---
	Power Generated during Shutdown	(MW _{gross} hrs)	2.4	5.5	5.2
	Shutdowns per Year	(#)	365	365	365
	Total Time in Shutdown	(min)	1,130	2,555	2,555
	Total Power Generated in Shutdown	(MW _{gross} hrs)	877	2,008	1,898
	Fuel Use: Min Load to Turning Gear	(MMBtu)	---	91	85
	Shutdown CO ₂ Emissions (from 100%)	(lb/event)	21,743	---	---
	Estimated Shutdown CO ₂ Emissions from Min Load	(lb/event)	8,748	10,816	10,103
Estimated Shutdown CO ₂ Emissions	(tons/yr)	1,597	1,974	1,844	
Steady State (Balance of Hours)	Remaining Time in 2,920 hr Period	(min)	171,116	167,497	169,463
		(hrs)	2,852	2,792	2,824
	Generation at Full/Base Load	(MW _{gross} hrs)	593,291	533,645	448,145
	Generation at Min Load	(MW _{gross} hrs)	26,523	27,386	25,787
	New & Clean Gross Heat Rate at Full/Base Load	(Btu/kWh, HHV)	10,053	9,883	10,017
	New & Clean Gross Heat Rate at Min Load	(Btu/kWh, HHV)	13,425	13,104	12,737
	Assumed CO ₂ Intensity	(lb/MMBtu)	118.9	118.9	118.9
	New & Clean CO ₂ Emission Rate at Full/Base Load	(lb/MWh)	1,195	1,175	1,191
	New & Clean CO ₂ Emission Rate at Min Load	(lb/MWh)	1,596	1,557	1,514
	New & Clean Blended Load Steady State Emissions	(tons/yr)	375,631	334,768	286,291
	Degradation Margin	(%)	6%	6%	6%
	Commercial Margin	(%)	2%	2%	2%
	Margined Blended Load CO ₂ Emission Rate	(lb/MWh)	1,334	1,310	1,321
	Margined Blended Load Steady State CO ₂ Emissions	(tons/yr)	413,355	367,485	312,967
Annual (2,920 hrs) Average Emission Rate Basis	New and Clean	(tons/yr)	378,897	339,193	290,195
		(lb/hr avg)	259,518	232,324	198,764
		(MW _{gross} hrs)	595,045	537,164	451,619
		(lb/MWh_{gross})	1,274	1,263	1,285
	Margined	(tons/yr)	416,621	371,910	316,871
		(lb/hr avg)	285,357	254,733	217,035
		(MW _{gross} hrs)	595,045	537,164	451,619
		(lb/MWh_{gross})	1,400	1,385	1,403