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AIR PERMITS SECTION
6PD-R

14 March 2013

Ms. Aimee Wilson
Air Permits Section (6PD-R)
U.S. Environmental Protection Agency
1445 Ross Ave
Dallas, TX 75202-2733

ATKINS Project No. 044167600

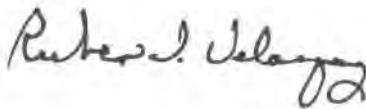
RE: Response to Request for Information
Application for Prevention of Significant Deterioration (PSD) Permit for Greenhouse Gas
Emissions – Proposed Liquefaction Project
Freeport LNG Development, L.P., Brazoria County, Texas

Dear Aimee:

On behalf of Freeport LNG Development, L.P., (Freeport LNG), I am submitting the enclosed response to your requests for information relating to the referenced application for a Greenhouse Gas PSD permit for Freeport LNG's proposed Liquefaction Project. As shown in the attached document, each comment received is listed followed by a response.

Thank you for your consideration. Should you have any questions regarding this updated information, please contact Mr. Mark Mallett, P.E., Freeport LNG Development, L.P., at (713) 333-4271 or me at (512) 342-3395 or by email: Ruben.Velasquez@atkinsglobal.com.

Sincerely,



Ruben I. Velasquez, P.E.
Senior Engineer - Air Quality
Atkins North America, Inc.



Ruben I. Velasquez
3-14-2013

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TBPE REG. #F-474

Enclosures

cc: Mr. Jeff Robinson, Air Permits Section, EPA
Mr. Mike Wilson, Director, Air Permits Division, TCEQ
Mr. Mark Mallett, P.E., Vice-President, Freeport LNG Development, L.P.

**Response to EPA Request for Additional Information
Application for Greenhouse Gas Prevention of Significant Deterioration Permit
Proposed Liquefaction Project
Freeport LNG Development, L.P., Brazoria County, Texas**

1. *I know these facilities are getting a PSD permit from TCEQ - are they also getting non-attainment?*

Response:

The Liquefaction Project as a whole is considered a major source under the Nonattainment New Source Review (NNSR) program for NO_x. Accordingly, applications were submitted to the Texas Commission on Environmental Quality for Prevention of Significant Deterioration (PSD) and New Source Review (NSR) Permits, including Nonattainment Review, for the proposed Liquefaction Project.

2. *Can you provide the BACT for the combustion turbine in tons (or lbs) CO₂e/MWh (gross). The proposed EGU NSPS has everything in gross. Also the other simple cycle turbines that have been permitted, or in the process all have BACT in lbs/MWh (gross) and they are less than the BACT proposed for Freeport (on the net based BACT). If the BACT in gross is still higher, I am going to need additional information on why Freeport cannot meet a more stringent BACT or Freeport will need to request a lower BACT limit.*

Response:

See response to Item 12.

3. *Can you provide more information on the boil-off gas (BOG)? Is the composition similar to natural gas? What is the sulfur content? Will there be any limitation on its use?*

Response:

The proposed liquefaction project will produce a stream of methane and nitrogen called boil-off-gas (BOG) that will need to be removed from the liquefaction process through either venting, flaring or use in a combustion source. BOG is a combination of gas or vapor that is evolved from the Liquefied Natural Gas (LNG) storage tanks and from LNG vessel loading operations. FLNG has estimated that the lowest nitrogen content of the BOG will be about 6 mole%, the balance being 94% methane. The peak or maximum BOG nitrogen content (due to

the cyclic nature of the ship loading process) could be as high as 20 mole% nitrogen with the balance being 80% methane. Natural gas consists of a high percentage of methane (generally above 85%) and varying amounts of ethane, propane, and inerts (typically nitrogen, carbon dioxide, and helium). These two fuels have very similar properties and composition; therefore the use of the GHG Emission Factors for Natural Gas from 40 CFR Part 98, Subpart C, Table C-1 and C-2 are appropriate for both natural gas and BOG.

It is anticipated that sulfur will not be present in the BOG as most sulfur species likely to be found in LNG are removed prior to natural gas liquefaction.

There will be no limitation upon the use of this BOG even with the maximum expected nitrogen content of 20%. First, it is highly unlikely that this BOG will satisfy all of the natural gas fuel requirements in the overall facility so it will be blended with clean, low nitrogen content, natural gas that has been treated prior to the liquefaction process. Second, even if the BOG was to fully satisfy the fuel demand for the overall facility, both the proposed combustion turbine and heating medium combustion heaters will be able use this BOG without restriction. To date, all equipment vendors have been apprised of the nitrogen content range and have confirmed that their fired equipment will accommodate this high nitrogen BOG without impacting emissions guarantees or performance.

4. ***On the use of an oxidation catalyst - can you estimate the amount of CH₄ that would be reduced? Or do you not claim a credit due to the fact that the CH₄ reduction is not very high? Or is there some other reason a reduction is not noted?***

Response:

The proposed combustion turbine (CT) will be equipped with an oxidation catalyst used to reduce carbon monoxide and volatile organic compound (VOC) emissions. Due to the high operating temperature of the CT, it is anticipated that most, if not all, of the methane present in the fuel gas to the CT will be combusted and will not be present except in minute, residual amounts in the exhaust gas stream.

While the use of the oxidation catalyst is designed to reduce VOC emissions, it is also expected to have a collateral effect in minimizing residual methane emissions from the combustion process. Although not readily demonstrated for CTs, the literature suggests that the use of an oxidation catalyst has been found to reduce emissions from liquid propane gas engines burning

a mixture of short-chained hydrocarbons.¹ As discussed in the literature, short-chain hydrocarbons are difficult to convert in the catalyst unless the catalyst is exposed to high operating exhaust temperatures. The expected CT exhaust temperature upstream of the oxidization catalyst should be sufficient to activate the catalyst; which for a liquid propane gas engine, for example, could achieve from 35 – 45% conversion of methane to CO₂ based on the referenced literature. However, in estimating methane emissions from the CT exhaust in support of Freeport LNG's application for a GHG PSD Permit, no credit was used for control of methane emissions that might result from the use of the oxidation catalyst because it was not readily demonstrated in the literature or by the catalyst manufacturer for use with a combustion turbine.

5. ***Why was BACT for the amine units/RTO determined to be a limit on the natural gas pretreatment rate? Not sure how that would ensure compliance with good combustion practices, operating, and maintenance practices.***

Response:

As discussed in Section 10.4 of the GHG PSD permit application, the primary source of CO₂ emissions from the thermal oxidizers will be from routing of CO₂ emissions from the amine units. The amine units will remove CO₂, hydrogen sulfide (H₂S) and other sulfur and light organic compounds (e.g., benzene, toluene, and xylene) in order to satisfy the downstream liquefaction system requirements. Stripped CO₂, H₂S, and the other sulfur and organic compounds in the stream will be routed to regenerative thermal oxidizers (EPNs: TO1, TO2, and TO3).

The thermal oxidizers are not intended to provide a reduction in CO₂ emissions from the amine units. Processed-based CO₂ emission rates for the thermal oxidizers were estimated based on the estimated flow rate of CO₂, assuming a two percent concentration in the incoming natural gas stream is CO₂. The limit on the natural gas pretreatment rate is proposed as a surrogate to limit the amount of CO₂ that may be emitted from the thermal oxidizer, and thus, proposed as a BACT limit.

The purpose of the thermal oxidizers is to provide for a reduction in emissions of sulfur compounds and VOCs that may be present in the vent gas stream from the amine units. Thus, the good combustion practices, operating and maintenance practices proposed by Freeport LNG

¹ NETT Technologies Inc., available at <http://www.nett.ca/faq/lpg-6.html>

for the thermal oxidizers are intended to maintain a high level of VOC destruction with reduced auxiliary fuel consumption in the thermal oxidizers.

6. ***On the flare NGLFLARE - it was stated that vent releases would be limited to no more than 3 MMscf/yr during planned startup and shutdown events. Is this per event? If yes, how many events are anticipated in a year?***

Response:

As a basis for estimating emissions from a planned startup and shutdown event, the vent release from the NGL unit was estimated to be 3 MMscf/yr (379,981 scf/hr x 8 hour event) to the flare. Only one planned startup/shutdown event per year is anticipated at this time.

7. ***BACT for the emergency generators and firewater pumps - was an oxidation catalyst considered?***

Response:

Because of limited and intermittent operations throughout the year, GHG emissions from the emergency generator engines and firewater pumps are relatively insignificant compared to the other emission sources. Operation of the backup diesel firewater pump engine at the Pretreatment Facility (PTF) and the diesel firewater pump engines at the Liquefaction Plant will be limited to no more than 2 hours per day and 100 hours per year for routine testing, maintenance, and inspection purposes only. The emergency generator engines and emergency air compressor engines at both facilities will be limited for a maximum of 2 hours per day and 50 hours per year for routine testing, maintenance, and inspection purposes only. Because of limited and intermittent operations throughout the year and the relatively small emission rates, the addition of an oxidization catalyst was not considered for this emergency equipment.

8. ***What make or type of engine will be used for the emergency generators and fire water pumps? Will they meet any efficiency standard or NSPS? What emission standards will they meet?***

Response:

The emergency generators and firewater pump engines to be used for this project have not been selected at this time. However, for purposes of TCEQ NSR permit applications, the estimate of emissions from these proposed engines is based on the corresponding Tier 3

Emission Standard for (NO_x + HC), CO, and PM₁₀ for non-road engines listed in 40 CFR §89.112(a), Table 1 (October 23, 1998).

9. *The BACT proposed for the combustion turbines is about 35% higher than those proposed for similar units. See table below.*

Table 1: Output-Based CO₂ Limits for Simple Cycle Combustion Turbines Referenced by the EPA

Company / Location	Process Description	Control Device	BACT Emission Limit / Requirements	Year Issued	Reference
Cheyenne Light, Fuel & Power / Black Hills Power, Inc. Laramie County, WY	Simple cycle combustion turbine r	Energy Efficiency/ Good Design & Combustion Practices	GHG BACT limit of 1,600 lbs CO ₂ e/MWhr (gross) 365-day average, rolling daily	2012	PSD-WY-000001-2011.001
York Plant Holding, LLC Springettsbury Township, PA	Simple cycle combustion turbine	Energy Efficiency/ Good Design & Combustion Practices	Combustion turbine annual net heat rate limited to 11,389 Btu/kWh (HHV) when firing natural gas GHG BACT limit of 1,330 lb CO ₂ e/MWhr (net) 30-day rolling average	2012	67-05009C ⁷
Pio Pico Energy Center, LLC Otay Mesa, CA	300 MW simple cycle power plant	Energy Efficiency/ Good Design & Combustion Practices	GHG BACT limit of 1,328 lb CO ₂ e/MWhr (gross) 720 rolling operating-hour average	2012	SD 11-01

Company / Location	Process Description	Control Device	BACT Emission Limit / Requirements	Year Issued	Reference
EFS Sandy Hills LLC EPA Region 4	Simple cycle combustion turbine	Energy Efficiency/ Good Design & Combustion Practices	GHG BACT limit of 1,377 lb CO ₂ e/MWhr (gross) when firing natural gas	*	
LADWP Scattergood	Simple cycle combustion turbine	Energy Efficiency/ Good Design & Combustion Practices	GHG BACT limit of 1,271 lb CO ₂ e/MWhr (net) 12-month rolling average	*	
Puget Sound Energy, Freedomia Generating Station Bellevue, WA	Simple cycle combustion turbine	Energy Efficiency/ Good Design & Combustion Practices	GHG BACT limit of 1,299 lb CO ₂ e/MWhr (net) for GE 7FA.05 GHG BACT limit of 1,310 lb CO ₂ e/MWhr (net) for GE 7FA.04 GHG BACT limit of 1,278 lb CO ₂ e/MWhr (net) for SGT6-5000F4 GHG BACT limit of 1,138 lb CO ₂ e/MWhr (net) for GE LMS100	*	PSD-11-05

Note: Summary table provided by EPA

Please provide a lower BACT limit or a written analysis and justification on why Freeport cannot meet a more stringent BACT limit.

Response:

For the Combustion Turbine, Freeport LNG is proposing an output-based CO₂ limit based on equivalent useful energy produced of 738 pounds CO₂ per megawatt-hour. This is based on an adjusted Gross CT Energy Heat Rate for the CT of 5,210 Btu per kilowatt-hour (Btu/kWh) after allowances for initial and long-term degradation in equipment performance. A summary showing the basis for the proposed equivalent useful energy output-based limit is shown in the attached Table 2.

The simple-cycle combustion turbines that are listed in the Table 1 are all either aero derivative or F-class frame machines which do have very good simple cycle heat rates and are, indeed, intended for simple-cycle operation in the applications listed. The net electrical energy being produced by these turbines is the only useful output being recovered from the fuel burned. Given this, the use of the combustion turbine net electrical output alone for calculating the lb CO₂/MWh is an appropriate measure of GHG BACT for these installations.

The combustion turbine proposed by Freeport LNG for the Pretreatment Facility, however, is not being installed as a simple-cycle machine. The PTF combustion turbine is being installed in a combined heat and power (CHP) configuration, and it is a model that is well suited to this application. Since combustion turbine exhaust energy is being recovered and harnessed for use along with electrical energy from the generator, more of the fuel burned in a CHP application is recovered as useful energy than in a simple-cycle combustion turbine application. As such, and in order to have a more direct comparison with the BACT examples in Table 1, the useful thermal energy recovered from the combustion turbine exhaust must be added to the combustion turbine net electrical output to determine the total useful energy recovered from burned fuel in order to calculate the lb CO₂/MWh in any meaningful way. This is the same methodology that requires the electrical output of a steam turbine be added to the electrical output of the combustion turbine in order to arrive at the total useful energy recovered in a combined-cycle combustion turbine application. In the case of CHP at the PTF, the useful thermal energy recovered from the combustion turbine exhaust converted to the same unit of measure, kW, as the combustion turbine electrical output is analogous to the steam turbine electrical output.

The basis for calculation of the Btu/kWh for the CHP at the PTF is shown in Table 2. Converting the useful process thermal energy recovered from the PTF combustion turbine exhaust, in MMBtu/hr, to an equivalent value in kWh:

$$406 \text{ MMBtu/hr} \times 1,000,000 \text{ Btu/MMBtu} \times \text{kW-hr}/3415 \text{ Btu} = 118,887 \text{ kW equivalent}$$

Combining the net electrical energy output of the combustion turbine with the equivalent value for the combustion turbine exhaust energy recovered:

$$\begin{aligned} &84,409 \text{ kW (net electrical energy output)} + 118,887 \text{ kW equivalent} \\ &= 203,296 \text{ kW (equivalent total net combustion turbine useful energy output recovered)} \end{aligned}$$

Expressing performance in terms of heat input per kilowatt-hour:

$$\begin{aligned} &906.2 \text{ MMBtu/hr (LHV)} \times 1,000,000 \text{ Btu/MMBtu} / 203,296 \text{ kW} \\ &= 4458 \text{ Btu/kWh (equivalent total net combustion turbine useful energy output recovered)} \end{aligned}$$

To establish an enforceable BACT condition that can be achieved over the life of the facility, the output-based CO₂ limit must account for short-term degradation in performance as the unit is broken in; anticipated degradation of the combustion turbine over time between regular maintenance cycles; and potential degradation of other elements of the system over time.

Gas turbine degradation can be classified as recoverable or non-recoverable over time. Recoverable loss is usually associated with compressor fouling and can be partially recovered by water washing or mechanical cleaning of the compressor blades and vanes. Non-recoverable loss is due primarily to increased turbine and compressor clearances and changes in surface finish and airfoil contour. This type of loss is recovered through replacement of affected parts at recommended inspection intervals. Performance degradation during the first 24,000 hours of operation is estimated to be about 2% to 6% from the performance test measurements when corrected to guaranteed conditions. Even with replacement of degraded parts, the expected performance degradation is from 1% to 1.5%. For purposes of establishing a BACT condition that can be achieved over the life of the unit, a 6% margin was incorporated into the determination of the adjusted net heat rate to account for performance degradation.

In addition to recoverable and non-recoverable degradation of the CT, degradation of the CT's waste heat recovery system as well as the other elements of the Pretreatment Facility that depend on the waste heat recovery system (e.g., amine regeneration units) that can potentially cause the overall plant heat rate to rise were also considered. Therefore, a 5% margin was incorporated into the determination of the adjusted net heat limit rate.

These additional margins were added to the base net heat rate to arrive at the adjusted net heat rate for the CT of 5210 Btu/kWh as follows:

$$4458 \text{ Btu/kWh} \times (1 + 0.05) \times (1 + 0.06) \times (1 + 0.05) = 5210 \text{ Btu/kWh}$$

Converting the CO₂ emission rate for the combustion turbine calculated for the GHG PSD permit application, 64 tons CO₂/hr, to mass per Btu gives:

$$64.17 \text{ tons CO}_2/\text{hr} \times 2000 \text{ lb/ton} / 906.02 \text{ MMBtu/hr (LHV)} = 141.65 \text{ lb CO}_2/\text{MMBtu}$$

Finding the lb CO₂ / MWh of equivalent useful energy produced by the combustion turbine:

$$141.65 \text{ lb CO}_2/\text{MMBtu} \times \text{MMBtu}/1000000 \text{ Btu} \times 5210 \text{ Btu/kWh} \times 1000 \text{ kWh/MWh} \\ = 738 \text{ lb CO}_2/\text{MWh (net electric and useful thermal converted to kW)}$$

On the basis of total useful energy recovered in exchange for fuel consumed, the BACT for the CHP combustion turbine proposed at PTF is essentially 35% lower than the “best” simple-cycle BACT example (LMS100 for Puget Sound Energy) that you provided in your table:

$$[(1,138 - 738)/1138] = 35\%$$

When total useful energy recovered is properly taken into consideration, Freeport LNG's selection of CHP for its combustion turbine installation very much validates the EPA website statement on CHP:

“Because less fuel is burned to produce each unit of energy output, CHP reduces air pollution and greenhouse gas emissions.”²

Thus, the selection of the CHP configuration is designed to meet a very stringent GHG BACT in comparison to simple-cycle combustion turbine applications.

² <http://www.epa.gov/chp/basic/index.html>, accessed 4 March, 2013.

Table 2

**Calculation of Output-Based BACT CO₂ Limit
Pretreatment Facility - Combustion Turbine
Freeport LNG Development, L.P.**

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Manufacturer Combustion Turbine CT Cycle Operating Mode	General Electric Frame 7EA CHP	
CT Inlet Dry Bulb, F	60	
Gross CT Power Out, kW	87,470	
CT Fuel Input, MMBtu/hr LHV	906.2	Note: CT Performance from Manufacturer's Data
Process Thermal Energy Required, MMBtu/hr	406	
Process Thermal Energy from CT Exhaust, MMBtu/hr	406	
Process Thermal Energy from CT Exhaust, kW	118,873	
Fired Heater Fuel Input, MMBtu/hr LHV	-	
CT Plant Auxiliary Loads, kW (estimated)	(3,061)	-3.5%, percent of gross output
Net CT Plant Electrical Output, kW	84,409	
Total Useful Energy Produced, MMBtu/hr	694	Note: Includes net electrical and process thermal output
CT Plant Thermal Efficiency	76.6%	
Gross CT Energy Output, kW equivalent net electric and useful thermal converted to kW	203,281	
Gross CT Energy Heat Rate: Btu/kWh	4,458	CT Fuel Input / Gross CT Energy Output
Design Margin	0.05	Allowance for short-term degradation in performance as the unit is broken in
Performance Margin	0.06	Allowance for efficiency Loss due to equipment degradation prior to maintenance overhauls
Degradation Margin	0.05	Allowance for degradation of other elements of the Pretreatment Facility that could cause overall combustion turbine heat rate to rise
Adjusted Gross CT Energy Heat Rate with Compliance Margin, Btu/kWh	5,210	Gross CT Energy Heat Rate * (1 + 0.05) * (1 + 0.06) * (1 + 0.05)
CO ₂ tons/hr	64.17	Estimated based on Mandatory Greenhouse Gas Reporting Rule, 40 CFR Part 98, Subpart C, Table C-1 for Natural Gas
CO ₂ lb/hr	128,340	
CO ₂ lb/MMBtu	141.62	CO ₂ lb/hr / CT Fuel Input (LHV)
Proposed Output-based CO ₂ Limit, lb CO ₂ /MWhr equivalent useful energy produced	738	Based on Gross CT Energy Output, MWh ()