From:	Andrew Chartrand
To:	Wilson, Aimee
Cc:	David.Ayers@cheniere.com; MRyan@trinityconsultants.com
Subject:	CCL GHG Draft Permit and Statement of Basis
Date:	Friday, January 31, 2014 4:24:01 PM
Attachments:	Responses CCL Draft SOB Comments_01.31.14.pdf Turbine output based calculation.pdf

Aimee,

Attached are the draft GHG Permit and Statement of Basis documents for the CCL Project. We took the documents that you sent to us, removed the comments that you suggested that we delete during our December meeting, and made suggested edits to address the comments.

There were many comments in the Statement of Basis and we didn't want to clutter the margins any further, so we created a response document (attached) to detail our responses to each comment in the Statement of Basis.

Also attached is a calculation sheet for supporting documentation for changes.

Perhaps we can set up a call for early next week after you have had a chance to review these documents. Thank you.

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Responses to Comments on CCL Draft Statement of Basis

Comment aw1: Asking company for an actual address.

Response: A specific address has been provided.

Comment AJC2: Provide an updated figure that shows the site boundary.

Response: An updated figure has been provided.

Comment CSV3: I understand that these are not combined cycle turbines like those used for electricity generation, but is there a use for the waste heat from the other turbines, that could improve the efficiency of the operation?

Response: Waste heat recovery units installed on the gas turbines driving the ethylene compressors and on the thermal oxidizer provide all the heat required for regenerating the amine used in the acid gas removal unit, to regenerate the molecular sieves used to dehydrate the feed gas, and to provide heat in the heavies removal unit. This is all the process heat required within the LNG trains. This arrangement is typical for most LNG trains utilizing the ConocoPhillips Optimized Cascade® Process.

Comment CSV4: Is an air intake chiller appropriate for this type of turbine? It was included as BACT for Freeport.

Response: Inlet air chilling and inlet air humidification are alternative add-ons to the gas turbine system. The effect of each is to increase annual production by reducing the inlet air temperature to the gas turbine, thus allowing it to produce more power (and therefore more LNG) during high ambient temperatures. CCL selected water injection utilizing the SAC turbine design with inlet air humidification as the most appropriate method to increase gas turbine power and reduce NOx emissions. Note that neither inlet air chilling nor inlet air humidification affects the operating characteristics of the gas turbines themselves. These accessories simply allow the turbine to operate in a more favorable operational range, thus mitigating some of the effects of high ambient temperatures.

Comment AJC5: Provide the percentage of the waste stream that is CO2.

Response: Turbine exhaust is 3.5% (by volume) CO2. A sentence has been added to the text in the CCS section.

Comment CSV6: I don't agree with this – Freeport is using electric drive motors. Granted they haven't built it yet, but it is what they selected as BACT. It should at least be carried through the analysis here.

Response: This has been addressed in revisions to the section on electric-driven compression.

Freeport LNG is in an ozone non-attainment area which requires that project to meet LAER, which likely was an important factor in their selection of electric motors. Electric motors used as the main drivers for LNG refrigeration compressors are currently in operation only on one LNG plant, in

Norway, and have not yet demonstrated the reliability necessary to sustain base load LNG production.

<u>Comment ahb7</u>: So if the waste heat recovery units can heat water or generate steam, then the turbines would be considered combined cycle turbines? If so, then it is not clear that these are in fact simple cycle turbines. I think an explanation (technical reason(s)) is needed as to why these waste heat recovery units cannot or should not heat water or generate steam. P. 10 says The gas turbines that CCL plans to use to provide refrigerant compression will provide 100% of the plant heating needs (hot oil and regeneration services) through waste heat recovery units installed on the gas turbine exhausts of the ethylene compressors

<u>Response:</u> The only conceivable use for steam generated by a HRSG installed on the other gas turbines would be to install steam turbines to generate electrical power. CCL's basic design and business purpose calls for electrical power to be provided through the local grid. Using steam-generated power at the CCL site to supplement the imported electrical power would obstruct CCL's basic business purpose for the following reasons:

1. The capital and operating cost for such additional equipment would be significant, making the project non-competitive with grid supply and other LNG producers.
2. There is not sufficient space on the site to accommodate all of the additional steam and power generation equipment for three trains.
3. The inclusion of steam would add significant complexity to the LNG operation and introduce safety and operational risks that are not warranted by any benefits obtained.

<u>Comment aw8</u>: 4 have a waste heat recovery unit, but claim they are simple cycle since they do not heat water or generate steam.

<u>Response:</u> See response to Comment ahb7 above.

<u>Comment AHB9:</u> This sentence is not related logistical hurdles. I gather later on there would be a more detailed discussion re. the project being simple cycle as opposed to combined cycle? I suggest moving this statement to the more detailed discussion on this topic.

<u>Response:</u> As previously explained in a May 24, 2012 response to questions, the propane and methane turbines are simple cycle. The ethylene compressor turbines are considered combined cycle since the waste heat from them is utilized to heat a synthetic hot oil. The waste heat recovery from the ethylene compressor turbines will provide all of the heating required for the LNG trains.

<u>Comment ACJ10:</u> Can we further clarify why only 6 turbines have WHRU? How much excess heat will there be?

<u>Response:</u> See response to Comment ahb7 above.

<u>Comment ahb11:</u> And is such conversion technically infeasible or otherwise inappropriate and, if so, why?

<u>Response:</u> See response to Comment ahb7 above.

Comment AHB12: Is it readily apparent why a HRSG cannot be installed? If not, can a sentence or 2 be added to explain? Does this amount to redefining the source – fundamentally changing the purpose and objective of the facility? If it is, then the Guidance addresses refining source in Step 1 (not including it as an available technology and explains why it amounts to redefining the source).

Response: See response to Comment ahb7 above.

Comment ahb13: 6 CTs have WHRU.

Response: See response to Comment ahb7 above.

Comment CSV14: They must have some use for it, as 6 of the units are equipped with heat recovery units?

Response: See response to Comment ahb7 above.

Comment ahb15: You mean no need other than for the CCS to work? There is nothing else at the facility that can use the generated heat/power? If I understand correctly, this does not sound like a technical infeasibility scenario. Maybe it is more of an energy impact issue b/c energy will be created and unused/wasted?

Response: See response to Comment ahb7 above.

Comment CSV16: Are these liquefaction trains operated intermittently? If they are not, then this argument doesn't make sense.

Response: The LNG Trains are designed to run continuously, but can be shut down for maintenance or to be on standby for commercial reasons. The CCL facility is designed to be bi-directional, having the flexibility to either import or export LNG. It should be noted that the WHRUs on each LNG train provide the process heat for just that LNG train itself. If the LNG train is not operating there is no need for process heat to be generated by a WHRU in that train and then sent elsewhere.

Comment ahb17: Cost effectiveness is not a technical issue and is therefore not appropriate for eliminating a control technology under Step 2.

Response: Recommend deleting the sentence that this comment refers to.

Comment AHB18: How does the longer period of time to come on line impede or otherwise affect the operation of the project?

Response: See response to Comment ahb7 above.

Comment AHB19: Is it readily apparent why potential transient loading of the turbines makes combined cycle a non-viable alternative? If not, can 1 more 2 sentences be added to explain this?

Response: Combined cycle is of no benefit to the plant operation unless used to generate steam for supplemental power generation, which is not feasible due to a lack of available plot space for such equipment on the site.

Comment AHB20: Step 2 does not consider cost.

Response: See response to Comment CSV9 above.

Comment AHB21: Please clarify whether we consider this to be a logistical hurdle and how so.

Response: A 160-mile pipeline is obviously a significant logistical hurdle, as it requires obtaining rights-of-way from many landowners, the construction of multiple compressor stations, and the construction and operation of the pipeline.

Comment ahb22: Since this technology is being eliminated here, it would not be considered in Step 4, including its cost. That said, the cost analysis is part of the permit application and therefore part of the permit record.

Response: See response to Comment CSV9 above.

Comment AHB23: If Pio document identifies barriers different from the barriers discussed above, it should be discussed in detail here as opposed to just a reference. It is not clear what project is involved in the Pio Pico permit and how it is similar or comparable to the current project. If Pio issues are the same and already discussed, you can note the specific issues that were addressed in Pio Pico and with the same outcome.

Response: No comment.

Comment AHB24: I assumed these issues were all discussed above. If not, please do so. It really does not matter whether we or the applicant raise the issues, as long as all of the technical and logistical issues are discussed above in this step.

Response: No comment.

Comment CSV25: Not sure that the Pio Pico argument really applies here. Pio Pico was able to reject CCS because of the intermittent operation, right? Will these be intermittent?

Response: See response to Comment CSV16 above.

Comment CSV26: Is there some other reason (such as needing to meet LAER?) that freeport chose to use these? If so, then I would make those arguments further down. I think it is going to be very difficult to make the claim that they are technically infeasible here, when we determined they were BACT elsewhere.

Response: Freeport LNG is in a non-attainment area for ozone and therefore needed to meet LAER. Statements have been added to the text to indicate that Freeport LNG's selection of electric-driven compression was not driven by BACT.

Comment CSV27: Actually, it was selected for Freeport.

Response: It was not selected as BACT for Freeport.

Comment ahb28: What is the consequence of not achieving 100% capacity? Is this a fatal flaw?

Response: Not achieving design capacity likely would impact the commercial viability of the project significantly.

Comment AHB29: According to p.36 of guidance, unproven alone does not show "technical infeasibility." We also need to consider whether it is available and applicable to the source type under review. Does the fact that one facility cannot achieve 100% nameplate capacity makes this design inapplicable here?

Response: See response to CSV9 above.

Comment AJC30: EPA would like to augment the "redefining the source" argument with additional rationale.

Response: Additional rationale for not using electric-driven compression has been added to this section.

Comment CSV31: Freeport LNG is using an oxidation catalyst? I understand that it is a different turbine design, and may have done so for VOC control, but why is it technically infeasible here?

Response: Freeport is using catalytic oxidation on a combined cycle turbine with waste heat recovery that is used for power generation at the natural gas pretreatment site, not liquefaction. We said originally that catalytic oxidation was infeasible due to temperature. This is not true for the ethylene turbines with the WHRU. The level of control on 1 ppmv of CH_4 in the exhaust stream would be minimal and would actually generate more CO_2.

Comment j32: Do we know the design energy efficiency measures they will use. I would anticipate Sierra Club commenting on this and requesting that these be specified in the permit. AW: Asking company for a thermal efficiency.

Response: CCL proposes an output-based limit of 369 lb CO_2e/MMscf of outlet LNG, on a 12-month, rolling average. This is based on CO_2e emissions per turbine that have been updated with new GWP for methane and LNG production of 1.8 billion scf/day.

Comment ahb33: Same comment as in Freeport: Can you add a sentence or two on what these operational parameters are?

Response: Text has been added to this section to define the operational parameters of the project.

Comment CSV34: Is this an output based limit, or an input based limit? Wouldn't an output based limit be based on lb CO_2e/ some measure of compression? Like hp-hr as in Copano? What about a thermal efficiency limit, like Copano?

Response: A proposed output-based limit has been added here.

Comment CSV35: Is there a thermal efficiency limit?

Response: Yes, there is a limit to thermal efficiency. Typical simple-cycle aeroderivative combustion turbines have an efficiency limit of approximately 40%. GE advises that LM2500+G4 gas turbines have a thermal efficiency of approximately 37.3 to 37.7% and are one of the manufacturer's latest advances in developing the maximum power and efficiency for this size of combustion turbine.

Comment ahb36: In other SOBs I see description of flare destruction efficiency. Should that also be specified here for these flares?

Response: A sentence on the flare destruction efficiency has been added.

Comment AHB37: Why "generally" if there are no emissions being routed there during normal operation?

Response: Generally there is only leakage from valves and seals that go to flare.

Comment AHB 38: GHG destruction efficiency?

Response: A sentence has been added in a previous paragraph regarding destruction efficiency. See response to Comment ahb36.

Comment ahb39: Can we briefly describe why flares cannot be enclosed? In oil and gas NSPS rulemaking, we received comment that seems to suggest some partial enclosure can or should be allowed. We disagree but it may be worth explaining here why an enclosure cannot be used.

Response: The installation of ground flares is outside of the basic design and business purpose of the project. Due to its complex design, the capital cost of ground flares is two to three times more than a conventional elevated flare. Moreover, periodic maintenance every two to three years is a significant impact to plant reliability and emissions required to facilitate such maintenance. Finally, the CCL site has very limited space to accomodate a ground flare. Therefore, CCL elected to propose elevated flares in lieu of enclosed ground flares.

Comment ahb40: Is it readily apparent that flare gas recovery requires a continuous stream and, if not, can you add a sentence or 2 to explain why flare gas recovery is not feasible without continuous stream? Since there is no description of how flare gas recovery works, it is hard to know why it is not feasible here (at least for lay persons).

Response: The flares are designed to handle emergency reliefs, with flows varying from 0 to 3 million pounds per hour (the worst case blocked outlet relief scenario). Such reliefs are extremely rare and generally of short duration, less than 10 minutes. It is not feasible to recover such high volume, short duration reliefs and they must be sent to flare to avoid overpressure conditions. Text has been added to clarify this.

Comment ahb41: It is not clear from this write-up whether this technology is being eliminated as technically infeasible. In the BACT analysis for the other emission sources, there is usually a statement upfront identifying the technology(ies) that are technically infeasible. Can you do the same here? Or can you clarify whether this one is considered technically feasible?

Response: CCL has designed the systems for operability and maintainability and to minimize leaks and flaring.

Corpus Christi Liquefaction, LLC
Corpus Christi Liquefaction Project

Refrigeration Compressor Turbines - Greenhouse Gases

No. of Turbines =	18	
Average Operating Rate =	6656	BTU/Hp-hr/compressor turbine [1]
Annual Operating Time =	8760	hrs/yr [1]
Power of Compressor=	32075	kW/ each compressor turbine [1]
	43013	HP / each compressor turbine [1]

Pollutant	Emission Factor		References	Emission Rates per Turbine		
				Average (lb/hr)	Maximum (lb/hr)	Annual (tpy)
CO_2	53.02	kg/MMBtu	[2]	3.35E+04	3.68E+04	1.47E+05
CH_4	1.0E-03	kg/MMBtu	[2]	6.31E-01	6.94E-01	2.77E+00
N_2O	1.0E-04	kg/MMBtu	[2]	6.31E-02	6.94E-02	2.77E-01
CO_2e	--	--	[3]	3.35E+04	3.69E+04	1.47E+05

LNG production = 1.8 billion scf/day

Output based limit

Total CO2e emissions =	6.63E+05	lb/hr (for all 18 turbines)
Daily CO2e emissions =	1.59E+07	lb/day (for all 18 turbines)
Output based limit =	491.41	lb CO2e/MMscf LNG produced

[1] Data provided by Cheniere.
[2] Based on EPA default factors in U.S. EPA, 40 CFR 98 Subpart C, Tables C-1 and C-2 for natural gas.
[3] CH_4, CO_2, and N_2O are included in the emissions of CO_2 equivalent (CO_2e), weighted according to their global warming potentials (GWP). The GWP of CH_4 is 21, of CO_2 is 1, and of N_2O is 310.

Sample Calculations:

$$CH_4 = \frac{0.001\ \text{kg}}{\text{MMBtu}} \left| \frac{6656.00\ \text{Btu}}{\text{Hp-hr}} \right| \frac{43013.00\ \text{Hp}}{1000000} \left| \frac{2.205\ \text{lb}}{\text{kg}} = \frac{0.6313\ \text{lb}}{\text{hr}} \right.$$

$$CO_2e = \frac{33470.44\ \text{lb}}{\text{hr}} + 21* \frac{0.6313\ \text{lb}}{\text{hr}} + 310* \frac{0.0631\ \text{lb}}{\text{hr}} = \frac{33505.03\ \text{lb}}{\text{hr}}$$