TETRA TECH EC, INC.

February 8, 2013

Eric Solorio, Project Manager
California Energy Commission
Docket No. 11-AFC-3
1516 9th St.
Sacramento, CA 95814

Cogentrix Quail Brush Generation Project - Docket Number 11-AFC-3, Clarified NO2/NOx Ratio Data Analysis Memo

Docket Clerk:

Pursuant to the provisions of Title 20, California Code of Regulations, and on behalf of Quail Brush Genco, LLC, a wholly owned subsidiary of Cogentrix Energy, LLC, Tetra Tech hereby submits the attached Clarified NO2/NOx Ratio Data Analysis Memo for the Cogentrix Quail Brush Generation Project, City of San Diego, San Diego County, California (11-AFC-3). The Quail Brush Generation Project is a 100 megawatt natural gas fired electric generation peaking facility to be located in the City of San Diego, California. The following issue area is addressed in this submittal:

- Air Quality

If you have any questions regarding this submittal, please contact Rick Neff at (704) 525-3800 or me at (303) 980-3653.

Sincerely,

Constance E. Farmer

Constance E. Farmer
Project Manager/Tetra Tech

cc: Lori Ziebart, Cogentrix
John Collins, Cogentrix
Rick Neff, Cogentrix
Proof of Service List

BEFORE THE ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION OF THE STATE OF CALIFORNIA
1516 NINTH STREET, SACRAMENTO, CA 95814
1-800-822-6228 – WWW.ENERGY.CA.GOV

APPLICATION FOR CERTIFICATION FOR THE
QUAIL BRUSH GENERATION PROJECT

DOCKET NO. 11-AFC-03
PROOF OF SERVICE
(Revised 12/28/2012)

SERVICE LIST:

APPLICANT
Cogentrix Energy, LLC
C. Richard "Rick" Neff, Vice President
Environmental, Health & Safety
John Collins, VP Development
Lori Ziebart, Project Manager
Quail Brush Generation Project
9405 Arrowpoint Boulevard
Charlotte, NC 28273
rickneff@cogentrix.com
johncollins@cogentrix.com
loriziebart@cogentrix.com

CONSULTANTS FOR APPLICANT
Tetra Tech EC, Inc.
Connie Farmer
Sr. Environmental Project Manager
Sarah McCall
Sr. Environmental Planner
143 Union Boulevard, Suite 1010
Lakewood, CO 80228
connie.farmer@tetratech.com
sarah.mccall@tetratech.com

Tetra Tech EC, Inc.
Barry McDonald
VP Solar Energy Development
17885 Von Karman Avenue, Ste. 500
Irvine, CA 92614-6213
barry.mcdonald@tetratech.com

COUNSEL FOR APPLICANT
Bingham McCutchen LLP
Ella Foley Gannon
Camarin Madigan
Three Embarcadero Center
San Francisco, CA 94111-4067
ella.gannon@bingham.com
camarin.madigan@bingham.com

INTERVENORS
Roslind Varghese
9360 Leticia Drive
Santee, CA 92071
roslindv@gmail.com

Rudy Reyes
8655 Graves Avenue, #117
Santee, CA 92071
rreyes2777@hotmail.com

Dorian S. Houser
7951 Shantung Drive
Santee, CA 92071
dhouser@cox.net

Kevin Brewster
8502 Mesa Heights Road
Santee, CA 92071
lzpup@yahoo.com

Mr. Rob Simpson, CEO
Helping Hand Tools
1901 First Avenue, Suite 219
San Diego, CA 92101
rob@redwoodrob.com

Sierra Club, San Diego Chapter
c/o Law Office of Robert W. Wright
Robert W. Wright
716 Castro Street
Solana Beach, CA 92075
bob.wright@mac.com

Sunset Greens
Homeowners Association
c/o Briggs Law Corporation
Cory J. Briggs
Isabel E. O'Donnell
99 East "C" Street, Suite 111
Upland, CA 91786
cory@briggslawcorp.com
isabel@briggslawcorp.com

INTERVENORS (cont'd.)
HomeFed Fanita Rancho, LLC
c/o Allen Matkins Leck Gamble
Mallory & Natsis LLP
Jeffrey A. Chine
Heather S. Riley
501 West Broadway, 15th Floor
San Diego, CA 92101
jchine@allenmatkins.com
hriley@allenmatkins.com
jkaup@allenmatkins.com
vhoy@allenmatkins.com

Preserve Wild Santee
Van Collinsworth
9222 Lake Canyon Road
Santee, CA 92071
savefanita@cox.net

Center for Biological Diversity
John Buse
Aruna Prabhala
351 California Street, Suite 600
San Francisco, CA 94104
jbuse@biologicaldiversity.org
aprabhala@biologicaldiversity.org

*California Pilots Association
Andy Wilson
31438 Greenbrier Lane
Hayward, CA 94544
andy.wilson@calpilots.org

*Indicates Change

INTERESTED AGENCIES
California ISO
e-recipient@caiso.com

City of Santee
Department of Development Services
Melanie Kush
Director of Planning
10601 Magnolia Avenue, Bldg. 4
Santee, CA 92071
mkush@ci.santee.ca.us

City of San Diego
Morris E. Dye
Development Services Dept.
1222 First Avenue, MS 501
San Diego, CA 92101
mdye@sandiego.gov

County of San Diego
Mindy Fogg
Land Use Environmental Planner
Advance Planning
Department of Planning & Land Use
5510 Overland Avenue, Suite 310
San Diego, CA 92123
mindy.fogg@sdcounty.ca.gov

ENERGY COMMISSION – PUBLIC ADVISER
Jennifer Jennings
Public Adviser's Office
publicadviser@energy.ca.gov

COMMISSION DOCKET UNIT
California Energy Commission – Docket Unit
Attn: Docket No. 11-AFC-03
1516 Ninth Street, MS-4
Sacramento, CA 95814-5512
docket@energy.ca.gov

OTHER ENERGY COMMISSION PARTICIPANTS (LISTED FOR CONVENIENCE ONLY):

After docketing, the Docket Unit will provide a copy to the persons listed below. Do not send copies of documents to these persons unless specifically directed to do so.

KAREN DOUGLAS
Commissioner and Presiding Member

ANDREW McALLISTER
Commissioner and Associate Member

Raoul Renaud
Hearing Adviser

Eileen Allen
Commissioners' Technical Adviser for Facility Siting

Galen Lemei
Adviser to Commissioner Douglas

Jennifer Nelson
Adviser to Commissioner Douglas

David Hungerford
Adviser to Commissioner McAllister

Patrick Saxton
Adviser to Commissioner McAllister

Eric Solorio
Project Manager

Stephen Adams
Staff Counsel

DECLARATION OF SERVICE

I, Constance Farmer, declare that on February 8, 2013, I served and filed copies of the attached Clarified NO2/NOx Ratio Data Analysis Memo, dated February 8, 2013. This document is accompanied by the most recent Proof of Service, which I copied from the web page for this project at: http://www.energy.ca.gov/sitingcases/quailbrush/index.html.

The document has been sent to the other parties in this proceeding (as shown on the Proof of Service) and to the Commission's Docket Unit, as appropriate, in the following manner:

(C*heck one*)

For service to all other parties and filing with the Docket Unit at the Energy Commission:

_X_ I e-mailed the document to all e-mail addresses on the Service List above and personally delivered it or deposited it in the US mail with first class postage to those parties noted above as "hard copy required"; OR

___ Instead of e-mailing the document, I personally delivered it or deposited it in the US mail with first class postage to all of the persons on the Service List for whom a mailing address is given.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct, and that I am over the age of 18 years.

Dated: February 8, 2013

Constance C. Farmer

MEMO

To: Arthur Carbonell, SDAPCD
Ralph De Siena, SDAPCD
Gerry Bemis, CEC
Joseph Hughes, CEC

From: Richard Booth, AEROWEST
Gregory Darvin, Atmospheric Dynamics, Inc.

Date: February 8, 2013

Re: Clarified NO2/NOx Ratio Data Analysis

Pursuant to CEC staff comments, at the Workshop on 10-3-12, concerning the NO2/NOx ratio utilized in the air quality impact modeling for the Quail Brush Power Project (QBPP) and the conference call meeting between the Applicant and the SDAPCD on 2-7-13, the Applicant is submitting its revised (clarified) analysis of this issue for review.

Background

On January 22, 2010, EPA revised the primary nitrogen dioxide (NO2) NAAQS in order to provide requisite protection of public health. Specifically, EPA established a new 1-hour standard at a level of 100 ppb (188.68 μg/m3), based on the 3-year average of the annual 98th percentile of the daily maximum 1-hour concentrations (form of the standard), in addition to the existing annual secondary standard (100 μg/m3). EPA has also established requirements for a NO2 monitoring network that will include monitors at locations where maximum NO2 concentrations are expected to occur, including within 50 meters of major roadways, as well as monitors sited to measure the area-wide NO2 concentrations that occur more broadly across communities.

The effective date of the new 1-hour standard was 60 days after the final rule was published in the Federal Register. The final rule was published in the Federal Register on February 9, 2010 with an effective date of April 12, 2010.

NOx is a generic term for the total concentration of mono-nitrogen oxides, nitric oxide (NO) and nitrogen dioxide (NO2). NOx is produced from the reaction of nitrogen and oxygen gases in during combustion with air, especially at high temperatures wherein an endothermic reaction produces various oxides of nitrogen. In the ambient air, during daylight, NOX concentrations tend towards a photo-stationary state (equilibrium), where the ratio NO/NO2 is determined by the intensity of sunshine (which converts NO2 to NO) and the concentration of ozone and other reactive species (which react with NO to again form NO2). At night time, NO is converted to NO2 by its reaction with ozone (O3). Also, in the presence of excess molecular oxygen (O2), nitric oxide (NO) reacts with the oxygen to form nitrogen dioxide (NO2). The time required depends on the temperature and the reactant concentrations and is relatively slow in the ambient air but may be much more rapid in combustion systems. For modeling purposes, pursuant to Appendix W of Part 51 of Title 40 of the CFR "Guideline on Air Quality Models", the following methods have been developed to simulate the chemical reaction of NOx to NO2 formation. *Modeling Compliance of the Federal 1-Hour NO2 NAAQS, CAPCOA, 10-27-11*.

- Tier 1 - Total Conversion
- Tier 2 - Ambient Ratio Method or ARM

- Tier 3 - Ozone Limiting Method or OLM. The Plume Volume Molar Ratio Method (PVMRM) is considered by EPA to be a Tier 3 screening method, similar to OLM.

These methods are clearly defined in Appendix W and are not repeated here.

QBPP's present modeling analysis for NO2 relies upon the Tier III approach. This approach requires the following general types of data be available for the analysis:

- Appropriate model (AERMOD)
- A known significant impact level (SIL)
- Hourly ozone background data
- Post-processor in AERMOD
- Hourly NO2 background data
- Paired-sum post-processor (AERMOD)

QBPP's proposed revised analysis for NO2 will also rely upon the Tier III approach, as explained in the sections which follow.

Current NO2 Analysis Under Review

The current NO2 impact analysis, as submitted by QBPP relies upon the Tier III approach, as explained in the air quality impact analysis section of the AFC (Section 4.7.5). QBPP used an in-stack NO2/NOx ratio of 1.15%, based upon data provided in the CAPCOA document referenced above, for engines firing natural gas, lean burn design, equipped with SCR and CO catalyst control systems, with engine power ratings greater than 4,000 bhp. The proposed power engines at the QBPP facility are Wartsila 20V34SG-C2 units rated at approximately 12,874 bhp, consuming fuel at a rate of 80.18 mmbtu/hr. Each engine is equipped with SCR and CO catalyst control systems.

In previous submittals to CEC staff, the Applicant has presented and summarized a number of engine NO2/NOx ratio studies in support of the chosen ratio for the QBPP analysis. This data is re-iterated herein, as follows:

<u>Applicant's Response to CEC Data Request #13, March 2012:</u>

The Applicant is not aware of any publicly available source test data for the Wartsila 20V34SG-C2 engines pertinent to establishing NO_2/NO_x ratios. In order to perform the various levels of compliance modeling for NO_2, a reasonable estimate of the in-stack NO_2/NO_x ratio must be made. For purposes of the QBGP NO_2 modeling, the Applicant's modeling staff used the recommended ratio as presented in the Appendix C table in the "*Modeling Compliance of the Federal 1-Hour NO_2 NAAQS, CAPCOA Guidance Document, CAPCOA, 2011*". The recommended NO_2/NO_x ratio for the QBGP power cycle engines was 1.15% (natural gas, IC engines, for a HP rating at 4175 using SCR and CO/VOC catalysts). The Applicant's modeling staff believes this value is both appropriate and reasonable for use for the QBGP NO_2 modeling based on the following:

- The above noted CAPCOA guidance lists the recommended NO_2/NO_x ratios for all of the natural gas fired IC engines (non-compressor duty) from 120 to 4,175 bhp as being the "statistical average of all data points". For the large engine listing (i.e., 4,175 bhp), the range of values as noted is 0.0 – 21.28%, with a statistical average of 1.15%. In order to obtain a statistical average of 1.15% from a range of values of 0.0 to 21.28%, a significant number of the data points have to be well below 1%, and we note that in this case, as well as other engine cases, many of the data ranges include "0.0" values. Values of 0.0 must be included in the data analysis, and in the case of the CAPCOA data, they were included. The proposed QBGP power cycle engines are lean burn, natural gas fired, medium speed design, with horsepower ratings of approximately 12,800 each. These engines will be equipped with both SCR and CO/VOC oxidation catalysts. As such, the Applicants modeling staff believes that an NO_2/NO_x ratio of 1.15% is a reasonable and justifiable value for use in the NO_2 compliance modeling analysis.

- The Applicant notes that the CAPCOA default value for the engine type and fuel is listed at 10%. This value was not used by the Applicant because it ignores the statistical average data presented for the larger engine categories (i.e., 4,175 bhp) and it represents a value that is approximately 8.7 times higher than the statistical average for this engine class. In other words, it ignores the fact that a large preponderance of data for this engine class were in the range of 0.0 to less than 1.0%.

The Applicant's consultant staff also reviewed a number of publicly available technical and research papers on the topic of NO_2/NO_x ratios. Our general comments on these are summarized below.

1. The Applicant, per the CAPCOA guidance (Section 7.2), consulted the EPA SCRAM webpage to ascertain if any new or recent data on any EPA generated NO_2/NO_x ratio databases were available. No such data was noted as of March 6, 2012.
2. A moderate amount of NO_2/NO_x ratio data obtained by the Applicant for this review were directly applicable to reciprocating engines. Although some of this data is not directly applicable to large lean-burn IC engines such as the proposed QBGP engines, the data indicated the following:
   a. The NFCRC Tutorial on Combustion indicates that NO production suddenly increases at temperatures around 2,800°F and thus an opportunity exists to control NO by staying below this temperature window. The tutorial also states that the formation of NO_2 is not significant during the combustion process, but that NO oxidizes to NO_2 in the atmosphere and thus all NO is potential NO_2. (see http://www.nfcrc.uci.edu/EnergyTutorial/combustion.html)
   b. In Chapter 106 – Permits by Rule, the TNRCC states in subchapter W, sections 106.511 and 106.512 that the default NO_2/NO_x ratio for engines emitting NO_x at less than 2.0 g/hp-hr is 0.4. The QBGP engines emit NO_x at rates well below 2.0 g/hp-hr. The Applicant notes that the IC engine default values are very general in nature, and are not specific to any particular engine design, i.e., lean burn, rich burn, etc., nor are they specific to any fuel (gas or liquid), or add-on control technology. In addition, we note that these values were established based on information prior to the rule adoption date of 8-9-2000, thus the values do not, in the Applicant's opinion, represent current research for large lean burn natural gas fired IC engines equipped with SCR and oxidation catalyst controls.
   c. In a technical presentation by ICAC dated 7/2008, a gross range of values for in-stack NO_2 is presented as 30-70% for a wide range of combustion devices such as turbines, diesel engines, 2 stroke engines, and reciprocating gas lean burn engines. No references accompany this presentation, so it not known where or how this data range was established, what accuracy levels the data range represents, or how old the data are that make up the data range. (*ICAC, Advances in NO_x Testing with Portable Analyzers, Advances in Emission Control and Monitoring Technology for Industrial Sources, July 2008*)
   d. Data presented in a technical paper in the Journal of the Air and Waste Management Association (*Impact of Oxidation Catalysts on Exhaust NO_2/NO_x Ratio from Lean-Burn Natural Gas Engines, D.B. Olsen, et.al., JAWMA, Volume 60, July 2010*) indicates that: (1)

high oxygen levels favor more conversion to NO_2, whereas low oxygen levels favor more conversion to NO; (2) for oxygen levels above 10%, which is the case for most lean-burn natural gas engines (including the QBGP proposed engines), the NO_2/NO_x ratio is relatively insensitive to oxygen level, therefore the dominant factor influencing equilibrium composition in lean burn natural gas engine exhaust is temperature. Data presented for a large lean burn, 4-stroke, natural gas fired engine (Waukesha 3521, rated at ~740 HP) indicated that the post-catalyst NO_2/NO_x ratio was 0.0. The value ranges are consistent with the range of values presented in the CAPCOA guidance document listed above. In addition, the paper indicates that post-oxidation catalyst NO_2/NO_x ratios decrease significantly across the catalyst. NO_2 to NO conversion ranges from 8.5 to 100%. In most cases, most of the NO_2 is converted to NO by the catalyst. The paper indicates that this conversion may be counter-intuitive because the function of the catalyst is "oxidation", however oxidation catalysts for natural gas engines are designed to oxidize CO, VOCs, and aldehydes, and that NO_2 is a very effective oxidation agent.

e. Data presented in EPA 454/R-00-037 (*Final Report-Volume 1, Testing of a 4-Stroke Lean Burn Gas-Fired Reciprocating Internal Combustion Engine to Determine the Effectiveness of an Oxidation Reduction Catalyst System for Reduction of HAPs Emissions, OAQPS, September 2001*) for a Waukesha 3512 GL lean burn, natural gas fired engine rated at ~738 HP, equipped with an oxidation catalyst, showed post-catalyst NO_2/NO_x ratios of 0.0%. The Applicant has reviewed the test data summaries presented in this report and has constructed the following table to show the various test measurements for NO, NO_x, and NO_2 for the pre- and post-catalyst scenarios. These data indicate that the in-stack NO_2 for the post-catalyst scenario is 0.0%.

Summary of NO, NO_2, and NO_x data from EPA 454/R-00-0037, Sept 2001.

	PPM, wet							
Data/Run Case #	1	2	3	4	5	6	7	8
NO pre-cat	34.762	15.089	16.156	37.505	13.288	98.067	55.238	9.314
NO post-cat	90.771	60.962	60.266	85.112	58.462	168.311	117.94	47.021
NO_2 pre-cat	52.508	43.941	41.465	47.879	43.621	67.85	60.557	38.29
NO_2 post-cat	0	0	0	0	0	0	0	0
NO_x pre-cat	87.271	59.029	57.621	85.385	56.908	165.917	115.794	47.602
NO_x post-cat	90.771	60.962	58.79	85.112	58.462	168.311	117.94	47.021
Calculated values								
NO_2 post-cat, ppm	0	0	-1.476	0	0	0	0	0
% NO_2 pre-cat	60.2	74.4	72.0	56.1	76.7	40.9	52.3	80.4
% NO_2 post-cat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	PPM, wet							
Data/Run Case #	9	10	11	12	13	14	15	16
NO pre-cat	33.413	45.902	33.405	35.26	10.02	77.413	26.79	34.488
NO post-cat	89.705	104.997	89.422	90.195	52.452	145.274	79.062	90.15
NO_2 pre-cat	52.027	57.475	52.693	53.089	39.757	63.298	49.092	52.342
NO_2 post-cat	0	0	0	0	0	0	0	0
NO_x pre-cat	85.442	103.377	86.098	88.348	49.776	140.711	75.883	86.83
NO_x post-cat	89.705	104.997	89.422	90.195	52.452	145.274	79.062	90.15
Calculated values								
NO_2 post-cat, ppm	0	0	0	0	0	0	0	0
% NO_2 pre-cat	60.9	55.6	61.2	60.1	79.9	45.0	64.7	60.3
% NO_2 post-cat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Assumptions:

1. $NO_x = NO + NO_2$, or variations of this equation for calculated values Avg % NO_2, pre-cat 62.5

2. $NO_2 = NO_x – NO$ Avg % NO_2, post-cat 0.0

3. $NO = NO_x - NO_2$

The Applicant also obtained for review a number of publicly available articles, technical papers, and research summaries on the issue of NO_2/NO_x ratios. Most, if not all of these sources, addressed the ratio issue in general terms or in terms of application to devices such as turbines and boilers, and as such, little information related to reciprocating lean burn, 4-stroke, natural gas fired engines was gleaned from these sources. These sources and references are listed as follows:

1. APTI-EPA Combustion Evaluation Course #427, Control of Oxides of Nitrogen, (Acurex Corp.).
2. Energy, Technology, and the Environment, by Paul Ih-fei Liu, ASME Press, 2005 (ISBN 0-7918-0222-1), Chapter 4.
3. Clarkson College, Course text on "Thermodynamics of NO and NO_2 Formation", web2.clarkson.edu.
4. Observations of NO2 Formation in Two Large NG Fired Boilers, IJPG2000-15103, V. Bland et. al., July 2000.
5. Tri-Mer Corporation, Tri-NO_x Control System Brochure, www.tri-mer.com, 2004.
6. University of Leeds, United Kingdom, An Investigation Into NO-NO_2 Conversion and CO Emissions from Gas Turbine Exhaust, Grant #GR/M20167/01, M. Pourkashanian, et.al., 2001.
7. Johnson Matthey, Gas Turbine Oxidation Catalyst Brochure, Combined and Simple Cycle Turbines, Stationary Emissions Control, 2009.
8. Engelhard-BASF, CatCO 600S Oxidation Catalyst Brochure, BF-8350, 02/2007.
9. The Combustion Institute, 27th Annual Symposium on Combustion, An Experimental and Kinetic Calculation of the Promotion Effect of Hydrocarbons on the NO-NO_2 Conversion in a Flow Reactor, M. Hori, et.al., Takushoku University, Japan, 1998.
10. 24th International Symposium on Combustion, Control of Combustion-Generated NO_x Emissions: Technology Driven by Regulation, C.T. Bowman, Stanford University, 2007.
11. 2000 International Joint Power Generation Conference, Observations of NO_2 formation in Two Large Natural Gas Fired Boilers, V. Bland, et.al., IJPGC2000-15103, 2000.
12. ASME, Combustion Characteristics and NO_x Formation of Gas Turbine System with Steam Injection and Two-Staged Combustion, Y. Ohno, et.al., Research Center for Advanced Energy Conversion, Nagoya University, Japan, 2000.
13. GE Oil and Gas-Nuovo Pignone S.p.A, A Simple Model for NO_x Formation in Diffusion Gas Turbine Combustors: Rig Test Validation with a Wide Range of Fuel Gases, S. Cocchi, et. al., not dated.
14. ASME Turbo Expo 2005, The Nature of NO_x Formation Within an Industrial Gas Turbine Dry Low Emission Combustor, K. Syed, et.al., 2005.
15. Personal Communication, Robert Finken, Delta Air Quality Services, 9/10/10.
16. Power Engineering Magazine, Progress Continues in Gas Turbine NO_x Control, J.C. Zink, Managing Editor, not dated.
17. GE Power Systems, Development of the GE Quiet Combustor and Other Design Changes to Benefit Quality, H. Miller, GER-3551.
18. GE Power Systems, Gas Turbine Emissions Control, R. Pavri, et. al., GER-4211, 2001.
19. ASME Turbo Expo, Advanced Gas Turbine Combustion System Development for High Hydrogen Fuels, J. Wu, et.al., GT2007-28337, 2007.

The Applicant concludes that based on the data presented above, the use of an in-stack NO_2/NO_x ratio of 1.15% per the CAPCOA guidance document for the proposed Wartsila 4-stroke, lean-burn, natural gas fired reciprocating engines, is a reasonable and appropriate value for use in the NO_2 compliance and impact modeling.

Applicant Responses dated June 4, 2012, to CEC Data Requests 71-74

71. Perform source testing for nitrogen dioxide and nitric oxide on an existing Wartsila 20V34G-C2 engine or similar model. The Applicant objects to this request as it is seeks information that is not reasonably available to the applicant. The Applicant is also not aware of any recently certified facilities that have been subjected to pre-AFC certification testing. Our reasons for the objection are as follows:

1. The Applicant does not presently own a 20V34SG-C2 engine that can be tested to establish or verify the requested ratio data.
2. The Applicant sought this information from the manufacturer but was informed that no such data for the 20V34SG engines or variants is available.

3. The Applicant is not aware of any operating facility where it can obtain this information. The Applicant is aware of three (3) facilities in the US that have used the –C2 variant engine. These facilities are as follows:

   a. Hutchinson Utilities Commission
   225 Michigan St.
   Hutchinson, MN 55350
   # of engines installed = 1 (not PSD)
   Permit most likely issued by the State of Minnesota-Dept of Health
   Contract awarded 10/2011, operations expected in late 2012.

   b. Golden Spread Electric Coop
   905 South Filmore
   Suite 300
   Amarillo, TX 79101
   # of engines installed = 18 (not PSD, prior to GHG Tailoring Rule)
   At the Antelope Station in Abernathy, TX
   Permit most likely issued by Texas CEQ-Air Div
   Operations began in 6/2011.

   c. Lea County Electric Coop
   1300 W Ave D
   Lovington, NM 88260
   # of engines installed = 5 (not PSD)
   At the LCEC Generation, LLC site
   Permit most likely issued by NM Environment Dept-Air Quality Bureau
   Contract awarded early 2010, operations expected in early fall 2012.

   Based on preliminary contacts with these sources, as well as searches on the websites of the above-referenced permitting agencies, the one facility that is operational (GSEC-Antelope) has either not tested for NO_2/NO_x ratios, or if tests have been done, they have not been released for public use. The Applicant cannot compel this facility to conduct such testing or to release the results of any non-publicly available testing that has been completed. We also note that these three facilities were most likely permitted or started construction before the NO2 standard applicability date of April 12, 2010.

4. The Applicant also believes that this information is not reasonably necessary to evaluate the potential impacts of the proposed project or for the CEC to make a decision on the AFC. The justification presented in the background section preceding this data request includes what the Applicant believes to be premised on a misunderstanding of the data already submitted in these proceedings.

The background section states that the Applicant's use of the CAPCOA "statistical average value" for the source category is not appropriate for an engine that is 3 times larger than the units proposed by QBPP. The Applicant disagrees with this statement because the CAPCOA recommended value and the data used in the Applicant's modeling, constitutes the best available scientific data and is appropriate. Further, as is discussed below, this data is representative of the source class.

The Applicant notes that both the CAPCOA referenced document as well as the San Joaquin Valley APCD modeling guidance document titled "Assessment of Non-Regulatory Options in AERMOD-

Specifically OLM and PVMRM, 9/2010", indicate that *"Currently, limited information is available on in-stack NO_2/NO_x ratios nation-wide. A literature search of available data revealed in-stack NO_2/NO_x ratios for a limited number of sources, see Appendix C. If a source is not listed, the source type that best represents the source under review will be used."* The Applicant, in its use of the CAPCOA "recommended value" for large natural gas fired, lean burn engines, with controls such as SCR and CO catalysts, is simply following the guidance document. The value used may well be for an engine that is smaller than what is proposed by QBPP, but the basic engine characteristics for the category delineated in the CAPCOA listing are present, i.e., 4000 HP or above, natural gas fired, lean burn design, 4-stroke configuration, equipped with SCR and CO catalyst.

The Applicant used the "recommended value" which was established by CAPCOA (Engineering Managers) and was based on a statistical average. The Applicant did not use the range, because, as we stated in response to CEC Data Request #13 (docketed on March 8, 2012 as one of Applicant's responses to the CEC's Data Request Set 1), the calculation of a statistical average of 1.15%, with a range of values from 0% to 21.28% requires that an overwhelming majority of the values in the range be less than 1%. For this reason the average or "recommended value" was used. Furthermore we note that the CAPCOA document was a collaborative effort between such agencies as the Air Resources Board, various APCDs/AQMDs, the CEC, and EPA Region 9. As such, the Applicant should be afforded the option of relying upon the CAPCOA document until such time as the database(s) provide a more robust data set covering a wider variety and size of sources, as well as operational scenarios. Additionally, the applicant notes that the data submitted in response to CEC Data Request #13 included data for similar engine configurations that shows very low NO_2/NO_x ratios which are consistent with the CAPCOA listing. The Applicant has used, to the best of its ability, the best data available.

At the request of EPA Region 9, the Applicant also contacted San Joaquin Valley APCD on March 26, 2012 in an effort to obtain information on potentially similar engines and their emissions. In response, Leland Villalvazo at the San Joaquin Valley APCD has recently supplied the Applicant with the following additional information:

a. **Stationary Source data**, included as Attachment #1 was an excel spreadsheet that contains data on four (4) engine models. Data set 1 was for a Cooper-Bessemer, NG fired, 2-stroke engine rated at 4000 hp, this engine had no add-on controls for NOx or CO. Data set 2 was for a marine MaK/8M32 engine rated at 5046 hp, firing diesel fuel only, equipped with SCR and CO catalyst. Data set 3 was for a marine Stork/8TM410 engine rated at 5720 hp, firing diesel fuel only, with no controls. Data set 4 was for a Fairbanks Morse 38ETDD8-1/6, 2-stroke, dual-fueled engine rated at 4410 hp, equipped with SCR only. The Applicant determined that none of these data sets were applicable to the proposed project. None of these engines are similar to the QBPP Wartsila engines in one or more of the following categories: fuel type, stroke configuration, HP, or service (peaking power units). Therefore, the Applicant did not rely on these data sets in analyzing the proposed project.

b. **Compliance Verification Report**, included as Attachment #2 was a variance compliance report dated February 2010 for California Power Holdings, LLC, Unit 12, which is a Deutz, natural gas fired engine, rated at 4157 hp, equipped with SCR, with **no** CO catalyst. The compliance report was accompanied by a summary of 70 "short term" source tests on Unit 12 for CO, NO, NO_2, NO_x, and CO_2. The statistical average NO_2/NO_x ratio from these tests was 0.67%, with 45 of the tests showing NO_2/NO_x ratios of 0.0%. Since the subject of the variance was emissions compliance at or near full rated load, the Applicant assumed that the emissions tests were taken during operations that would fulfill the requirements of the variance, i.e., to show compliance at or near full rated load.

Data contained in Attachment #2, is for an engine with similar characteristics as the QBPP engines, but notably has no CO catalyst. Even without the CO catalyst, this engine showed NO_2/NO_x ratios that are consistent with the CAPCOA listed values, and as such, the Applicant believes its use of the CAPCOA value is both representative of the source class, and is a reasonable value for use in the impact analysis.

72. Provide NO_2/NO_x ratios during the times post combustion equipment are not operating or operating at reduced removal efficiencies. Quail Brush objects to this data request as it seeks information that is not reasonably available and which is not necessary to evaluate the proposed project's potential impacts. For the reasons discussed in response to DR 71 above, the current NO_2/NO_x ratio databases and available information do not provide any applicable data on which to establish such ratios for any operational scenario other than normal or steady state operations with respect to large, natural gas-fired, lean burn, 4-stroke, internal combustion engines such as those proposed for the Quail Brush project.

The Applicant is also not aware of any basis for utilizing a lower or different ratio for non-steady state operational periods such as start-ups and commissioning. Being unaware of any basis for utilizing a lower NO_2/NO_x ratio for periods such startup, commissioning, etc., the Applicant's decision to refrain from using different values for these non steady-state operational scenarios is reasonable and justified. Therefore, no further calculations should be required.

CEC October 3rd, 2012 Workshop Issues

Based on staff comments at the 10-3-12 workshop which indicated that there was still a "confidence" issue with respect to the NO2/NOx ratio value used by QBPP, the Applicant submits the following comments and data for staff review.

1. Per EPA, a default NO2/NOx ratio of 50% can be used without justification. QBPP is not proposing to use this default value as we believe it does not accurately represent the design and operational characteristics of the proposed power cycle engines. In addition, the Applicant has not been able to identify any NO2/NOx ratio data for any similar designed or control equipped engines that have ratios approaching 50%.
2. CEC staff presented a graph of NO2/NOx ratio data derived from the California Power Holdings, LLC data noted in Response 71(b) above. Staff opined that there were a number of these test values that showed "zero" values, and that the values may be questionable. The Applicant cannot speculate on the presence of the "zero" values. We do note that, (a) the testing was accepted by the SJVAPCD as part of its variance compliance enforcement for the engine in question, and (b) based upon a review of the variance order, we believe the tests were conducted at or near full load conditions, as this is the subject of the variance and the required testing. Additionally, we note that this data was not presented by the Applicant as the sole justification for the value chosen in our analysis, but was, just one facet of the support data presented, and that this particular data set supports the ratio value proposed by QBPP.
3. In addition to the data presented in item 2 above, the Applicant notes that a significant amount of data that is presented in the CAPCOA listings also contain "0" values, which were included in the statistical averages as calculated by CAPCOA. Therefore, we must conclude that a NO2/NOx ratio of "0" is a valid measurement for a wide variety of these category engines.
4. CEC staff also asked about the stoichiometry of the proposed engine as compared to other similar Wartsila variant engines. Data supplied by Wartsila indicates the following:

a. The C2 engine, and the "B" version installed at the Modesto Irrigation District, facility are running on the Miller cycle, which is a modified Otto cycle.
b. The C2 engine has a per cylinder rating of 480 kWm, and an engine rating of 9.3 MWe, while the B version has a cylinder rating of 435 kWm, and an engine rating of 8.4 MWe.
c. Both engines have individual cylinder controls for air, fuel, injection timing and spark timing. This allows each cylinder to be optimized for stable combustion in a narrow window between "knocking" and "misfiring".
d. The proposed C2 engine design achieves stable combustion in a matter of a few minutes, i.e., from a start the engine ramps to speed (720 rpm for 60 Hz power generation) in under 30 seconds. The total time for the engine to achieve full load is 5 minutes. Two of the contributing factors to such quick combustion stabilization are the use of the "warm start" and "fuel" heaters proposed for the plant. The warm start heaters are used to pre-heat the engine blocks and components, while the fuel heaters are used to provide a heated fuel stream to the engine which increases fuel mixing and promotes optimized combustion.
e. Both engine variants are lean burn, i.e., an excess air ratio of about 2:1, and both are firing PUC grade natural gas.

In a lean burn gas engine, the mixture of air and fuel in the cylinder is "lean", i.e., more air is present in the cylinder than is needed for combustion. With leaner combustion, the peak combustion temperature is reduced and less NOx is produced. Higher output can be reached while avoiding "knocking" and the efficiency is increased as well, although a too lean mixture will result in misfiring. Ignition of the lean air-fuel mixture is accomplished with a spark plug located in the pre-chamber, giving a high-energy ignition source for the main fuel charge in the cylinder. Stable and well controlled combustion also contributes to less mechanical and thermal load on the engine components.

The main parameters governing the rate of NOx formation in internal combustion engines are peak combustion temperature and residence time. The temperature is reduced by the combustion chamber air-fuel ratios, i.e., the higher the air-fuel ratio the lower the temperature, and consequently the lower NOx emissions. In the proposed engine, the air-fuel ratio is very high and is uniform throughout the cylinder, due to premixing of the fuel and air before introduction into the cylinders. Maximum temperatures and subsequent NOx formation are therefore low, since the same specific heat quantity released by combustion is used to heat up a larger mass of air. Benefiting from this unique feature of the lean–burn principle, the NOx emissions from the Wartsila 34SG family of engines (B and C2 versions) are extremely low. Appendix F.1 of the AFC and APCD application documents present a detailed discussion and description of the engine technology and operating and combustion principles (Attachment F.1-2 Wartsila 34SG Technical Brochure).

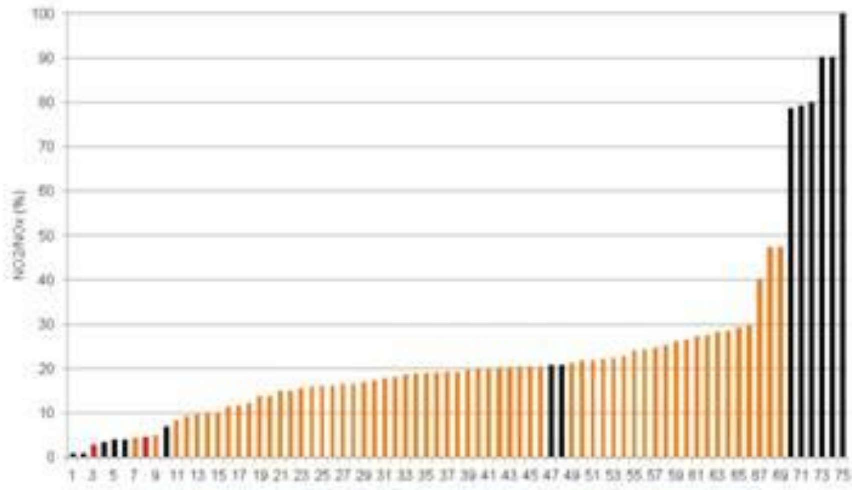
Pursuant to the Applicants response to DR #13 (March 2012, discussed above), the Applicant again sought this information from the manufacturer but was informed that no such data for the 20V34SG engines or variants is available. Notwithstanding the foregoing, in late September 2012, the manufacturer did supply some pre-catalyst NO_2/NOx ratio data for the SG "family" of engines, which is discussed further below.

Additional Data Review

In addition to the above the Applicant has reviewed the following existing data sets in an attempt to identify an applicable NO_2/NOx ratio value that may represent a more conservative value as compared to the current value at 1.15%.

1. The CAPCOA data set for natural gas-fired, lean burn engines, equipped with a combination of SCR, CO catalysts, or 3-way catalysts indicates a range of recommended values of 0.9% to 19.46%, with an engine category default value of 10%. The average of the recommended values for the eight (8) engines listed is 4.04%. This average value accounts for a significant number of “0” values in the various engine result tabulations.
2. The data contained in the EPA ISR database, which duplicates data in the CAPCOA database to some extent shows that for the four (4) engines listed in the database which match the design, control, and fuel characteristics noted earlier, that the average NO2/NOx ratios range from 1.14% to 3.59%, with the average of all values being 1.48%. This average value accounts for a significant number of “0” values in the various engine result tabulations.
3. The data contained in the recent listing obtained from the SDAPCD for the seven (7) engines listed as being lean burn, natural gas-fired, with SCR and CO catalysts, etc., indicates a range of recommended (average) values of 6.5% to 24.6%, with the average of all values being 14.03%.
4. The overall range of averages from the above is 1.48% to 14.03%, with an overall average of 6.51%. If we increase this value to 10% to account for variances in design, control equipment efficiencies, and catalyst differences, we are essentially at the CAPCOA engine category default value of 10%.
5. In the PPEC data response to EPA dated 1-5-12, regarding modeling questions raised by Region 9 staff, the project applicant presented data that the project was revising its NO2/NOx ratio (for the turbines) at the direction of the APCD to the following values; (1) steady state hour at 13%, and a startup/commissioning hour at 24%. The ratio of a startup hour to a steady state hour is 1.85. We note in the CAPCOA document noted above that the default value for turbines is 10%. Assuming a 30 minute turbine start followed by 30 minutes of steady state operations results in a worst case hourly ratio of 18.5%. In our discussion with the APCD staff (2-7-13) they indicated that PPEC may have been required to use the higher startup ratio for commissioning modeling to account for hours when controls may not be operating, or operating at reduced efficiency. In the case of Quail Brush, the higher startup/commissioning value per the CEC is 20% (Wartsila uncontrolled value), and noting that the QBPP application clearly indicates that only three (3) engines will be commissioned at any one time, we are confident that compliance with the 1 hour NO2 standard can be shown in this situation. The PPEC data is only delineated herein for purposes of noting the multiplier ratio, i.e., startup vs. steady state.
6. Per item #4, if we use the IC engine default value of 10% (per CAPCOA) and apply the same ratio of startup to steady state hours as established for PPEC, i.e., 1.85, the resulting ratio value for all hours is 18.5%, which coincidentally is the average of the PPEC values for the worst case hour (non-commissioning) noted in item 5 above.
7. Wartsila supplied some preliminary data (late September 2012) on pre- oxidation catalyst NO2/NOx ratio data for Wartsila engines at 100% load in the graph below.

Engine family ID key: (orange-SG engines, black-DF engines, red-GD engines):



Wartsila's analysis of this preliminary data is as follows:

All measurements (all engines), pre-catalyst (uncontrolled)
Average - 23.6%
Median - 19.3%

SG Engines only, pre-catalyst (uncontrolled)
Average - 20%
Median - 19.3%

Wartsila notes that the oxidation catalyst used on the SG engines typically reduces NO2 by approximately 40%. Application of this reduction value to the SG engine pre-catalyst average values results in a NO2/NOx ratio value of 12%, which is well below the estimated worst case hour value of 18.5% established in item #6 above.

8. Communications between the APCD and CEC (2-5-13) indicate that the CEC staff is using a ratio value of 16%. The CEC value is based on the SG engine family data above. The CEC has assumed that the 20% average value represents a reasonable startup value (uncontrolled), and that a 40% control reduction in this value, or 12%, represents a reasonable steady state value (controlled). Using a startup hour which consists of 30 minutes at the 20% value and the remaining 30 minutes at the 12% value, results in a worst case hour ratio value of 16%. This procedure results in a ratio multiplier of 1.67 as compared to the PPEC multiplier of 1.85 noted in item #5 above.

The following table presents a summary of the preceding data.

Value Reference	NO2/NOx Ratio, %
CAPCOA default value for the ICE category (NG, lean burn, non-compressor service)	10
CAPCOA recommended value for ICEs (4175 hp, NG, lean burn, non-compressor service)	1.15
JAWMA, 2010 (D.B. Olsen, Technical Paper)	0
EPA 454/R-00-037, 9/01 (see summary table in text above)	0
California Power Holdings test data (SJVAPCD, Feb 2010)	0.67
EPA default ratio (applicable to all combustion processes, if no data is available)	50
EPA ISR database (per item #2 above for matching or similar ICEs)	1.48
SDAPCD data (supplied by APCD for 7 engines of similar design, etc.) average of the recommended averages	14.03
SDAPCD data (supplied by APCD for 7 engines of similar design, etc.) average of the entire data range	6.51
Wartsila SG engine family data (pre-catalyst average)	20
Wartsila SG engine family data (post-catalyst average assuming 40% reduction per Wartsila)	12
CEC derived value from Wartsila data (SG engine family data)	16
Calculated Results	
Average of the above values (including the EPA default value)	11
Average of the above values (excluding the EPA default value)	7.4
Average of the above values (excluding the EPA default value and the “zero” data sets), i.e., the high and low outliers removed.	9.1
Proposed Ratio for QBPP	***18.5***

Applicants Revised Ratio Proposal

Based on the preceding data discussion and the summary table above, the Applicant concludes that a NO2/NOx ratio value of 18.5% (per item #6 above) is a reasonable and conservative default value for the QBPP engines for all modes of operation, i.e., steady state, start-up, and shutdown. For commissioning periods, where the engine control may or may not be operating at full efficiency, the Applicant is proposing a value of 20% (Wartsila uncontrolled value used by the CEC), with the caveat that per the QBPP application, only three (3) engines will be undergoing commissioning at any one time.

Upon approval of the above values, the revised NO2 modeling analysis will be prepared using the new ratio values, and will be consistent with the CAPCOA Tier III requirements, with the final results, including the input and output modeling files supplied to CEC, EPA, and APCD staff.