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Appendix 4.1C
Best Available Control Technology

APPENDIX 4.1C

Best Available Control Technology

The gas turbine proposed for the Pomona Repowering Project (PRP) is required to use best available control technology (BACT) in accordance with the requirements of South Coast Air Quality Management District (SCAQMD, or District) rules. BACT is defined in SCAQMD Rule 1302(h) as follows.

> ***BEST AVAILABLE CONTROL TECHNOLOGY (BACT)*** *means the most stringent emission limitation or control technique which:*
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> *(1) has been achieved in practice for such category or class of source; or*
>
> *(2) is contained in any state implementation plan (SIP) approved by the United States Environmental Protection Agency (EPA) for such category or class of source. A specific limitation or control technique shall not apply if the owner or operator of the proposed source demonstrates to the satisfaction of the Executive Officer or designee that such limitation or control technique is not presently achievable; or*
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> *(3) is any other emission limitation or control technique, found by the Executive Officer or designee to be technologically feasible for such class or category of sources or for a specific source, and cost-effective as compared to measures as listed in the Air Quality Management Plan (AQMP) or rules adopted by the District Governing Board.*

As discussed in Section 4.1.2.6.1, the PRP gas turbine will trigger the District New Source Review (NSR) rules BACT requirements for NOx, SOx, VOC, PM_{10}, $PM_{2.5,}$ and ammonia. The emission rates and control technologies determined to be BACT for this project are discussed in detail in the following sections. Separate determinations are provided for normal operation and startup/shutdown operation.

4.1C.1 Steps in a Top-Down BACT Analysis

Step 1 – Identify All Possible Control Technologies

The first step in a top-down analysis is to identify, for the emissions unit and pollutants in question, all available control options. Available control options are those air pollution control technologies or techniques, including alternate basic equipment or processes, with a practical potential for application to the emissions unit in question. The control alternatives should include not only existing controls for the source category in question, but also, through technology transfer, controls applied to similar source categories and gas streams.

BACT must be at least as stringent as what has been achieved in practice (AIP) for a category or class of source. Additionally, EPA guidelines require that a technology that is determined to be AIP for one category of source be considered for transfer to other source categories. There are two types of potentially transferable control technologies: (1) exhaust stream controls, and (2) process controls and modifications. For the first type, technology transfer must be considered between source categories that produce similar exhaust streams. For the second type, technology transfer must be considered between source categories with similar processes.

Candidate control options that do not meet basic project requirements (i.e., alternative basic designs that "redefine the source") are eliminated at this step.

Step 2 – Eliminate Technologically Infeasible Options

To be considered, the candidate control option must be technologically feasible for the application being reviewed.

Step 3 – Rank Remaining Control Options by Control Effectiveness

All feasible options are ranked in the order of decreasing control effectiveness for the pollutant under consideration. In some cases, a given control technology may be listed more than once, representing different levels of control (e.g., the use of SCR for control of NOx may be evaluated at 2 and at 2.5 parts per million by volume, dry [ppmvd], @ 15% O_2). Any control option less stringent than what has been already achieved in practice for the category of source under review must also be eliminated at this step.

Step 4 – Evaluate Most Effective Control Technology Considering Environmental, Energy, and Cost Impacts

To be required as BACT, the candidate control option must be cost effective, considering energy, environmental, economic, and other costs. The most stringent control technology for control of one pollutant may have other undesirable environmental or economic impacts. The purpose of Step 4 is to either validate the suitability of the top control option or provide a clear justification as to why that option should not be selected as BACT.

Once all of the candidate control technologies have been ranked, and other impacts have been evaluated, the most stringent candidate control technology is deemed to be BACT, unless the other impacts are unacceptable.

Step 5 – Determine BACT/Present Conclusions

BACT is determined to be the most effective control technology subject to evaluation, and not rejected as infeasible or having unacceptable energy, environmental, or cost impacts.

4.1C.2 BACT for the Simple Cycle Gas Turbine: Normal Operations

4.1C.2.1 NOx EMISSIONS

Step 1 – Identify All Possible Control Technologies

The emissions unit for which BACT is being considered is a simple-cycle aeroderivative gas turbine with a nominal output of approximately 100 MW (LMS100).

Potential control technologies were identified by searching the following sources for determinations pertaining to combustion gas turbines:

- SCAQMD BACT Guidelines;
- San Joaquin Valley Air Pollution Control District (SJVAPCD) BACT Clearinghouse;
- Bay Area Air Quality Management District (BAAQMD) BACT Guidelines;
- EPA Reasonably Available Control Technology (RACT)/BACT/ Lowest Achievable Emission Rate (LAER) Clearinghouse;

- Other district and state BACT Guidelines; and
- BACT/LAER requirements in New Source Review permits issued by a local air district[1] or other air pollution control agency.

Outlined below are the technologies for control of NOx that were identified.

- Low NOx burner design (e.g., dry low NOx (DLE) combustors)
- Water or steam injection
- Inlet air coolers
- A Selective Catalytic Reduction (SCR) system capable of continuously complying with a limit of 2.5 ppmvd @15% oxygen (O_2) (1-hour average)
- An EMx (formerly SCONOx) system capable of continuously complying with a limit of 2.0 ppmvd @15% O_2 (1-hour average)
- Selective Non-Catalytic Reduction (SNCR) capable of continuously complying with a limit of 4.5 ppmvd @15% O_2 (1-hour average)
- Alternative Basic Equipment:
    - Renewable Energy Source (e.g., solar, wind, etc.)
    - Combined-Cycle Turbine

It should be noted that the use of renewable energy in lieu of a simple-cycle gas turbine would "redefine the source." Renewable energy facilities require significantly more land to construct, and need to be located in areas with very specific characteristics. Wind and solar facilities have power generation profiles that cannot match demand; conventional power plants are needed in order to follow demand. The capital costs for wind or solar facilities are substantially higher than for a comparable conventional facility, making financing of such a project significantly different. Finally, one of the fundamental objectives of the proposed PRP is to provide firming capacity for renewable energy facilities, making the use of renewable energy for the project fundamentally incompatible with the project objective. Nevertheless, these technologies are feasible, and the technical feasibility of renewable energy sources for this specific application will be considered in Step 2.

Step 2 – Eliminate Technologically Infeasible Options

Exhaust Stream Controls

The most recent NOx BACT listings for simple-cycle combustion turbines in this size range are summarized in Table 4.1C-1. The most stringent NOx limit in these recent BACT determinations is a 2.5 ppm[2] limit averaged over a 1-hour averaging period, excluding startups and shutdowns. This level is achieved using water injection and SCR. The LMS100 gas turbine proposed for this project will use water injection to control NOx emissions to 25 ppmvd.

EMx is a NOx reduction system distributed by EmeraChem. This system uses a single catalyst to oxidize both NO and CO, a second catalyst system to absorb NO_2, and then a regeneration system to convert the NO_2 to N_2 and water vapor. The EMx system does not use ammonia as a reagent. The EMx process has been demonstrated in practice on smaller gas turbines, including Redding Electric

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[1] Any Air Quality Management District or Air Pollution Control District in California.

[2] All gas turbine exhaust emissions concentrations shown are by volume, dry corrected to 15% O_2.

Utility's (REU) Units 5 and 6 which are comprised of a 43-MW Alstom GTX100 and a 45 MW Siemens SGT 800 combined-cycle gas turbine, respectively. While the technology has never been demonstrated on a gas turbine the size of the GE LMS100 or on a simple-cycle gas turbine, the technology is considered by the manufacturer to be scalable.

The SCR system uses ammonia injection to reduce NOx emissions. SCR systems have been widely used in simple-cycle gas turbine applications of all sizes. The SCR process involves the injection of ammonia into the flue gas stream via an ammonia injection grid upstream of a reducing catalyst. The ammonia reacts with the NOx in the exhaust stream to form N_2 and water vapor. The catalyst does not require regeneration, but must be replaced periodically; typical SCR catalyst lifetimes are in excess of three years.

Either SCR or EMx technology is capable of achieving a NOx emission level of 2.5 ppmvd @ 15% O_2. Neither has been demonstrated to consistently achieve lower emission levels in simple-cycle turbines in demand-response service. Both technologies are evaluated further in Step 3.

Table 4.1C-1
Recent NOx BACT Determinations for Simple-Cycle Combustion Turbines

Facility	District	NOx Limit	Averaging Period	Control Method Used	Date Permit Issued	Source
El Colton (LM6000)	SCAQMD	3.5 ppmvd	3 hrs	Water injection and SCR	1/10/03	SCAQMD website
MID Ripon (LM6000)	SJVAPCD	2.5 ppmvd	3 hrs	Water injection and SCR	2004	ATC
San Francisco Electric Reliability Project (LM6000)	BAAQMD	2.5 ppmvd	1 hr	Water injection and SCR	2/8/06 (FDOC)	CEC Siting Div website
EIF Panoche (LMS100)	SJVAPCD	2.5 ppmvd	1 hr	Water injection and SCR	7/13/07 (FDOC)	CEC Siting Div website
Walnut Creek Energy (LMS100)	SCAQMD	2.5 ppmvd	1 hr	Water injection and SCR	2/27/08	FDOC
Miramar Energy Facility II (LM6000)	SDCAPCD	2.5 ppmvd	3 hrs	Water injection and SCR	11/4/08	ATC
Orange Grove Energy, LLP (LM6000)	SDAPCD	2.5 ppmvd	1 hr	Water injection and SCR	12/4/08	CEC Siting Div website
El Cajon Energy, LLC (LM6000)	SDAPCD	2.5 ppmvd	1 hr	Water injection and SCR	12/11/09	ATC
TID Almond 2 Power Plant (LM6000)	SJVAPCD	2.5 ppmvd	1 hr	Water injection and SCR	2/16/2010	FDOC
CPV Sentinel (LMS100)	SCAQMD	2.5 ppmvd	1 hr	Water injection and SCR	12/1/2010	FDOC
Mariposa Energy Project (LM6000)	BAAQMD	2.5 ppmvd	1 hr	Water injection and SCR	Nov. 2010	FDOC
Pio Pico Energy Center (LMS100)	SDAPCD	2.5 ppmvd	1 hr	Water injection and SCR	9/12/2012	FDOC
El Segundo Power Facility Modification (Rolls Royce Trent 60)	SCAQMD	2.5 ppmvd	1 hr	Water injection and SCR	8/26/2014	FDOC
Carlsbad Energy Center Project (CECP)	SDAPCD	2.5 ppmvd	1 hr	Water injection and SCR	8/3/15	FDOC

Note: All concentrations expressed as parts per million by volume dry, corrected to 15% O_2.

Alternative Basic Technology

Combined Cycle Gas Turbines

The use of combined-cycle turbines instead of the proposed simple-cycle turbines would be technically infeasible for the project. The simple-cycle turbines are needed to effectively handle variable loads and perform multiple startups/shutdowns per day. While advanced combined-cycle turbines can start relatively quickly (within approximately 12 minutes to reach 100% rated capacity of the gas turbine generator), they may need as much as 2 hours to reach full combined-cycle output (combined output of gas turbine and steam turbine generators).[3] While operating in simple-cycle mode (while waiting for the steam system to warm up), fast-start combined-cycle units will have efficiencies that are no better than, and are likely worse than, those achieved with advanced simple-cycle turbines such as the LMS100. Further, such units cannot perform up to four starts per day – as required for this project – without substantially shortening the life of the unit. Therefore, combined-cycle turbines are eliminated because they do not meet the basic project requirements.

Finally, advanced combined-cycle gas turbines require an auxiliary steam source to achieve fast startup times. This steam must be provided by an auxiliary boiler, which would be an additional source of emissions and is not a part of this project.

Solar Thermal

Solar thermal facilities collect solar radiation, then heat a working fluid (water or a hydrocarbon liquid) to create steam to power a steam turbine generator. All solar thermal facilities require considerable land for the collection field and are best located in areas of high solar incident energy per unit area. In addition, power is only generated while the sun shines, so the units do not supply power at night or on cloudy days. The PRP parcel is not sufficiently large to be feasible for a commercial solar power plant. Furthermore, a solar power plant would not meet the project's objective of providing firming capability for intermittent renewable resources such as solar and wind energy projects. For these reasons, a solar thermal power plant is rejected as BACT for this application.

Wind

Wind power facilities use a wind-driven rotor to turn a generator to generate electricity. Only limited sites in California have an adequate wind resource to allow for the economic construction and operation of large-scale wind generators. Most of these sites have already been developed or are remote from electric load centers and have little or no transmission access. Even in prime locations, the wind does not blow continuously, so power is not always available. Due to the lack of availability of good sites, limited dependability, and relatively high cost, this technology is not feasible for this project. Furthermore, a wind power plant would not meet the project's objective of providing firming capability for intermittent renewable resources such as solar and wind energy projects. For these reasons, a wind power plant is rejected as BACT for this application.

Other Alternatives

A number of other alternative generating systems are described in the Alternatives Analysis Section (Section 5.0). These additional analyses failed to identify an alternative generating technology that was technically feasible for this site and that would meet the project's objectives.

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[3] El Segundo Energy Center LLC, 00-AFC-014C: Petition to Amend, 4/23/13, Section 2.2.7

Step 3 – Rank Remaining Control Technologies by Control Effectiveness

Both SCR and EMx technologies, each in combination with combustion controls, are capable of achieving a NOx emission level of 2.5 ppmvd @ 15% O_2. They are therefore ranked together in terms of control effectiveness, and the evaluation of these technologies continues in Step 4.

Step 4 – Evaluate the Most Effective Control Technology Considering Environmental, Energy, and Cost Impacts

The use of SCR will result in ammonia emissions due to an allowable ammonia slip limit of 5 ppmvd @ 15% O_2. A health risk screening analysis of the proposed project using air dispersion modeling has been prepared to demonstrate that both the acute health hazard index and the chronic health hazard index are much less than 1, based on an ammonia slip limit of 5 ppmv @ 15% O_2. In accordance with currently accepted practice, a hazard index below 1.0 is not considered significant. Therefore, the toxic impact of the ammonia slip resulting from the use of SCR is deemed to be not significant, and is not a sufficient reason to eliminate SCR as a control alternative.

A second potential environmental impact that may result from the use of SCR involves the storage and transport of aqueous or anhydrous ammonia.[4] Although ammonia is toxic if swallowed or inhaled and can irritate or burn the skin, eyes, nose, or throat, it is a commonly used material that is typically handled safely and without incident. The project operator is currently reviewing the potential need to develop and maintain a Risk Management Plan (RMP) and to implement a Risk Management Program to prevent accidental releases of ammonia. The RMP provides information on the hazards of the substance handled at the facility and the programs in place to prevent and respond to accidental releases. The accident prevention and emergency response requirements reflect existing safety regulations and proven industry safety codes and standards. Thus, the potential environmental impact due to aqueous ammonia use at the project is minimal and does not justify the elimination of SCR as a control alternative.

Regeneration of the EMx catalyst is accomplished by passing hydrogen gas over an isolated catalyst module. The hydrogen gas is generated by reforming steam, so steam would be required. This would require installation of an auxiliary boiler, which is not currently proposed for this project. There would also be additional natural gas consumption, and increased emissions, per megawatt hour of electricity produced.

"Achieved in Practice" Criteria

In general, the method for determining when emission control technologies are achieved in practice (AIP) is similar in each District. The SCAQMD has established formal criteria for determining when emission control technologies should be considered AIP for the purposes of BACT determinations. The criteria include the elements outlined below.

- Commercial Availability: At least one vendor must offer this equipment for regular or full-scale operation in the United States. A performance warranty or guarantee must be available with the purchase of the control technology, as well as parts and service.
- Reliability: All control technologies must have been installed and operated reliably for at least six months. If the operator did not require the basic equipment to operate daily, then the equipment must have at least 183 cumulative days of operation. During this period, the basic equipment must have operated: (1) at a minimum of 50% design capacity; or (2) in a

[4] The project proposes to use the less concentrated, safer aqueous form of ammonia.

manner that is typical of the equipment in order to provide an expectation of continued reliability of the control technology.

- Effectiveness: The control technology must be verified to perform effectively over the range of operation expected for that type of equipment. If the control technology will be allowed to operate at lesser effectiveness during certain modes of operation, then those modes of operation must be identified. The verification shall be based on a performance test or tests, when possible, or other performance data.

Each of these criteria is discussed separately below for SCR and for EMx.

SCR Technology – SCR has been used in practice at numerous combustion turbine installations throughout the world. There are numerous aeroderivative simple-cycle gas turbine projects that limit NOx emissions to 2.5 ppmc using SCR technology, as shown in Table 4.1C-1. An evaluation of the proposed AIP criteria as applied to the achievement of 2.5 ppmc, and to extremely low NOx levels (below 2.5 ppmc) using SCR technology, is summarized below.

- Commercial Availability: Turbine-out NOx from the LMS100 aeroderivative gas turbines is generally guaranteed at 25 ppmc. Achieving a controlled NOx limit below 2.5 ppmc would require SCR technology to achieve reductions greater than 90 percent. Furthermore, because of the relatively high temperature of exhaust from simple-cycle turbines compared with combined-cycle units, there is a more limited selection of SCR technology available. Consequently, it is not clear that this criterion is satisfied for limits below 2.5 ppmc for the LMS100 gas turbines. As shown in Table 4.1C-1 above, this criterion is satisfied for aeroderivative gas turbines at a 2.5 ppmc permit level.

- Reliability: SCR technology has been shown to be capable of achieving NOx levels consistent with a 2.5 ppmc permit limit during extended, routine operations at many commercial power plants. There are no reported adverse effects of operation of the SCR system at these levels on overall plant operation or reliability. There has been no demonstration of operation at levels below 2.5 ppmc during extended, routine operation of simple-cycle aeroderivative gas turbines; consequently, this criterion is not satisfied for NOx limits below 2.5 ppmc.

- Effectiveness: SCR technology has been demonstrated to achieve NOx levels of 2.5 ppmc with aeroderivative turbines, but not at lower limits for this generating technology. Short-term excursions have resulted in NOx concentrations above the permitted level of 2.5 ppmc; however, these excursions are not frequent, and have not been associated with diminished effectiveness of the SCR system. Rather, these excursions typically have been associated with SCR inlet NOx levels in excess of those for which the SCR system was designed, or with malfunctions of the ammonia injection system. Consequently, this criterion is satisfied at a NOx limit of 2.5 ppmc, but not at lower NOx limits.

- Conclusion: SCR technology capable of achieving NOx levels of 2.5 ppmc is considered to be achieved in practice. The permit limits for the proposed gas turbine include a NOx limit of 2.5 ppmc. This proposed limit is consistent with the available data. The AIP criteria are not met for SCR on simple-cycle aeroderivative gas turbines at NOx limits lower than 2.5 ppmc.

EMx Technology – EMx has been demonstrated in service in five applications: the Sunlaw Federal cogeneration plant, the Wyeth BioPharma cogeneration facility, the Montefiore Medical Center cogeneration facility, the University of California San Diego facility, and the City of Redding Power Plant. The combustion turbines at these facilities are much smaller than for the proposed project turbine, and none of the existing installations are simple-cycle turbines. The largest installation of the EMx system is at the Redding Power Plant. The Redding Power Plant includes two combined-cycle combustion turbines—a 43 MW Alstom GTX100 with a permitted NOx emission rate of 2.5 ppmc (Unit 5), and a 45 MW Siemens SGT 800 with a permitted NOx emission rate of 2.0 ppmc (Unit 6).

A review of NOx continuous emissions monitoring (CEM) data obtained from the EPA's Acid Rain program website[5] indicates a <u>mean</u> NOx level for the Redding Unit 5 of less than 1.0 ppm during the period from 2002 to 2007, but not continuous compliance with a 2.5 ppmc limit. After the first year of operation, Unit 5 experienced only a few hours of non-compliance per year (fewer than 0.1% of the annual operating hours exceed that plant's NOx permit limit of 2.5 ppmc). The experience at the City of Redding Plant indicates the ability of the EMx system to control NOx emissions to levels of 2.5 ppmc. These data do not indicate the ability to consistently achieve NOx levels below 2.0 ppm, notwithstanding the lower annual average emission rate. This is due to the cyclical nature of EMx NOx levels between plant shutdowns and scheduled catalyst cleanings. Redding Unit 6 started up on October 2011 and has had an average of 1,476 hours per year of operation since startup.

Based on this information, the following paragraphs evaluate the proposed AIP criteria as applied to the achievement of low NOx levels (2.5 ppmc) using EMx technology.

- Commercial Availability: While a proposal has not been sought, presumably EmeraChem would offer standard commercial guarantees for the proposed project. Consequently, this criterion is expected to be satisfied. However, no EMx units are currently in operation on simple-cycle units.
- Reliability: Redding Unit 5 was originally permitted with a 2.0 ppmc permit limit. It was subsequently found that the unit could not maintain compliance with a 2.0 ppmc limit on a consistent basis, and the limit was eventually changed to 2.5 ppmc. As discussed above, based on a review of the CEM data for Redding Unit 5, the EMx system complied with the 2.5 ppmc NOx permit limit but with a few hours each year of excess emissions (approximately 3% of annual operating hours following the first year, and approximately 2% following the second year, dropping to approximately 0.1% after 4 years). This level of performance was also associated with some significant operating and reliability issues. According to a June 23, 2005 letter from the Shasta County Air Quality Management District,[6] repairs to the EMx system began shortly after initial startup and have continued during several years of operation. Redesign of the EMx system was required due to a problem with the reformer reactor combustion production unit that led to sulfur poisoning of the catalyst, despite the sole use of low-sulfur, pipeline quality natural gas as the combustion turbine fuel. In addition, the EMx system catalyst washings had to occur at a frequency several times higher than anticipated during the first three years of operation, which resulted in substantial downtime of the combustion turbine. Since the REU installation is the most representative of all of the EMx-equipped combustion turbine facilities for comparison to the proposed project, the problems encountered at REU bring into question the reliability of the EMx system for the proposed project. In addition, the EMx unit has not been demonstrated in use in a simple cycle application.
- Effectiveness: The EMx system at REU Unit 5 has recently been able to demonstrate compliance with a NOx level of 2.0 ppmc, and the new REU Unit 6 has been permitted with a

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5 Available at *http://camddataandmaps.epa.gov/gdm/index.cfm?fuseaction=prepackaged.results*.

6 Letter dated June 23, 2005, from Shasta County Air Quality Management District to the Redding Electric Utility regarding Unit 5 demonstration of compliance with its NOx permit limit.

2.0 ppmc NOx limit. As discussed above, there have been no known excursions beyond the permit limit for Unit 6 in the recent limited operation; however, there are no EMx-equipped facilities on simple-cycle facilities in demand-response service. In addition, this is a combined-cycle unit. Consequently, due to the lack of actual performance data in a comparable installation, there is some question regarding the effectiveness of the EMx systems on simple-cycle, demand-response combustion turbine projects.

There are additional issues with the application of EMx technology to simple-cycle gas turbines. First, simple cycle turbines have significantly higher turbine exhaust gas temperatures (over 800^{o} F) than the typical combined cycle temperature (around 500^{o} F) at the location of the emission control systems. The higher temperature would require the use of larger tempering air fans to cool the exhaust gas before it reaches the catalyst. Additionally, simple cycle units do not produce steam, which is needed as a carrier gas for the regeneration hydrogen. As a result, the project would have to add a small auxiliary steam boiler, which is not currently part of the facility. The auxiliary boiler would also use natural gas fuel and produce emissions, resulting in reduced overall plant efficiency as well as higher criteria and GHG emissions.

- Conclusion: EMx systems are capable of achieving NOx levels of 2.5 ppmc and less. However, the operating history does not support a conclusion that this technology is achieved in practice for simple-cycle, demand-response gas turbines, based on the above guidelines.

Summary of Achieved in Practice Evaluation

SCR's capability to consistently achieve 2.5 ppmc NOx (1-hour average) in simple-cycle gas turbines has been demonstrated by numerous installations. EMx's ability to consistently achieve a NOx emission rate of 2.5 ppmc in smaller combined-cycle gas turbines has been demonstrated; however, the technology has not been demonstrated to consistently achieve a NOx emission rate below 2.5 ppmc. An emission level of 2.5 ppmc NOx has therefore been achieved in practice, and any BACT determination must be at least as stringent as that.

Technologically Feasible/Cost Effective Criterion

No candidate technology with lower emission levels than those achieved in practice has been identified.

Step 5 – Determine BACT/Present Conclusions

BACT must be at least as stringent as the most stringent level achieved in practice, federal NSPS, or district prohibitory rule. Based upon the results of this analysis, the NOx BACT determinations of 2.5 ppmc on a 1-hour average basis made for recently permitted simple-cycle gas turbine projects in the SCAQMD and SDAPCD reflect the most stringent NOx emission limit that has been achieved in practice. No more stringent level has been suggested as being technologically feasible. Therefore, BACT/LAER for NOx for this application is any technology capable of achieving 2.5 ppmc on a 1-hour average basis.

Both SCR and EMx are expected to achieve the proposed BACT NOx emission limit of 2.5 ppmc averaged over one hour. However, concerns remain regarding the long-term effectiveness of EMx as a control technology because the technology has not been demonstrated on the type of gas turbine used in this project—a simple-cycle demand-response application. For the reasons described in the "achieved in practice" discussion above, EMx technology is eliminated as BACT and SCR has been selected as the NOx control technology to be used for the project.

The gas turbine used for the proposed PRP will be designed to meet a NOx level of 2.5 ppmc on a 1-hour average basis using SCR.

4.1C.2.2 VOC EMISSIONS

Step 1 – Identify All Possible Control Technologies

Most VOCs emitted from natural gas-fired turbines are the result of incomplete combustion of fuel. Therefore, most of the VOCs are methane and ethane, which are not effectively controlled by an oxidation catalyst. However, oxidation catalyst technology designed to control CO can also provide some degree of control of VOC emissions, especially the more complex and toxic compounds formed in the combustion process. Therefore, the use of good combustion practices is generally considered BACT for VOC, with some additional benefit provided by an oxidation catalyst.

Alternative basic equipment—including renewable energy sources, such as solar and wind, and combined cycle technology—was already discussed above (Step 1 for NOx BACT on the gas turbine). For the same reasons, solar, wind and other renewable energy sources are rejected as VOC BACT for this application.

Step 2 – Eliminate Technologically Infeasible Options

The only technology under consideration is combustion controls, with some additional benefit provided by an oxidation catalyst. This combination of technologies has been demonstrated to be feasible in many applications. No other technologies have been identified that are capable of achieving the same level of control. As a result, the goal of the remainder of this analysis is to determine the appropriate emission limit that constitutes BACT for this application.

As shown in Table 4.1C-2, CARB's BACT guidance document for electric generating units rated at greater than 50 MW indicates that BACT for the control of VOC emissions for simple-cycle power plants is 2 ppmvd @ 15% O_2.

Table 4.1C-2
CARB BACT Guidance For Power Plants

Pollutant	BACT
Nitrogen Oxides	2.5 ppmv @ 15% O_2 (1-hour average) 2.0 ppmv @ 15% O_2 (3-hour average)
Sulfur Dioxide	Fuel sulfur limit of 1.0 grains/100 scf
Carbon Monoxide	Nonattainment areas: 6 ppmv @ 15% O_2 (3-hour average) Attainment areas: District discretion
VOC	2 ppmv @ 15% O_2 (3-hour average)
NH_3	5 ppmv @ 15% O_2 (3-hour average)
PM_{10}	Fuel sulfur limit of 1.0 grains/100 scf

The BAAQMD's BACT guidelines do not include a BACT determination for simple-cycle gas turbines greater than 40 MW.

The SJVAPCD's most recent BACT determination for gas turbines rated at larger than 47 MW with variable load and without heat recovery was for the TID Almond 2 Power Plant project. The SJVAPCD concluded that a VOC exhaust concentration of 2.0 ppmvd @ 15% O_2, 3-hour average basis, constituted BACT that is considered technologically feasible.

The SCAQMD's most recent BACT determination for simple-cycle gas turbines was for the El Segundo Facility Modification. The SCAQMD determined that a VOC exhaust concentration of 2.0 ppmc, 1-hour average basis, was BACT for two 60 MW Rolls Royce Trent gas turbines.

In May 2012, the SDAPCD determined that 2.0 ppmc, 1-hour average basis, was BACT for VOC for the LMS100 gas turbines to be used at the Pio Pico Energy Center project. This same BACT VOC level was determined by the SDAPCD in 2015 for the LMS100 gas turbines for the Carlsbad Energy Center project.

Published prohibitory rules from the BAAQMD, SMAQMD, SDCAPCD, SJVAPCD, and SCAQMD were reviewed to identify the VOC standards that govern existing natural gas-fired simple-cycle combustion gas turbines. None of the prohibitory rules for combustion gas turbines specify an emission limit for VOC. The applicable NSPS (40 CFR 60 Subpart KKKK) does not include a VOC limit.

This "top-down" VOC BACT analysis will consider the following VOC emission limitations:

- 2.0 ppmvd @ 15% O_2, 1-hour average
- 2.0 ppmvd @ 15% O_2, 3-hour average

A summary of recent VOC BACT determinations is shown in Table 4.1C-3.

Table 4.1C-3
Recent VOC BACT Determinations for Simple-Cycle Combustion Gas Turbines[a]

Facility	District	VOC Limit[b]	Averaging Period	Control Method Used	Date Permit Issued	Source
EIF Panoche (LMS100)	SJVAPCD	2.0 ppmc	1 hr	Oxidation Catalyst	7/13/07 (FDOC)	CEC Siting Div website
Starwood Midway Firebaugh/Panoche (P&W SwiftPac)	SJVAPCD	2.0 ppmc	1 hr	Oxidation Catalyst	9/5/07 (FDOC)	CEC Siting Div website
Walnut Creek Energy (LMS100)	SCAQMD	2.0 ppmc	1 hr	Oxidation Catalyst	2/27/08	FDOC
Orange Grove Energy, LLP (LM6000)	SDAPCD	2.0 ppmc	1 hr	Oxidation Catalyst	12/4/08	CEC Siting Div website
El Cajon Energy, LLC (LM6000)	SDAPCD	2.0 ppmc	1 hr	Oxidation Catalyst	12/11/09	ATC
TID Almond 2 Power Plant (LM6000)	SJVAPCD	2.0 ppmc	1 hr	Oxidation Catalyst	2/16/2010	FDOC
CPV Sentinel (LMS100)	SCAQMD	2.0 ppmc	1 hr	Oxidation Catalyst	12/1/2010	FDOC
Pio Pico Energy Center (LMS100)	SDAPCD	2.0 ppmc	1 hr	Oxidation Catalyst	9/12/2012	FDOC
El Segundo Power Facility Modification	SCAQMD	2.0 ppmc	1 hr	Oxidation Catalyst	8/26/2014	FDOC
Carlsbad Energy Center Project (CECP)	SDAPCD	2.0 ppmc	1 hr	Oxidation Catalyst	8/3/15	FDOC

Note: All concentrations expressed as parts per million by volume dry, corrected to 15% O_2 (ppmc).

Step 3 – Rank Remaining Control Technologies by Control Effectiveness

The control technologies under consideration are ranked as follows:

- 2.0 ppmvd @ 15% O_2, 1-hour average

Step 4 – Evaluate the Most Effective Control Technology Considering Environmental, Energy, and Cost Impacts

This step evaluates any source-specific environmental, energy, or economic impacts that demonstrate that the top alternative listed in the previous step is inappropriate as BACT.

The Applicant has proposed to meet a 2.0 ppmvd limit on a 1-hour average basis. This level meets BACT.

Step 5 – Determine BACT/Present Conclusions

BACT must be at least as stringent as the most stringent achieved in practice, required in a federal NSPS or district prohibitory rule, or considered technologically feasible. Based upon the results of this analysis, the VOC emission limit of 2.0 ppmc is considered to be BACT for the proposed project.

4.1C.2.3 SULFUR OXIDE EMISSIONS

Step 1 – Identify All Possible Control Technologies

Natural gas fired combustion turbines have inherently low SOx emissions due to the small amount of sulfur present in the fuel. With typical pipeline quality natural gas sulfur content well below 1 grain/100 scf, the SOx emissions for natural gas-fired combustion turbines are generally far less than those from oil-fired turbines. Firing by natural gas, and the resulting minimization of SOx emissions, has been used by numerous combustion turbines throughout the world. Due to the prevalence of the use of natural gas to control SOx emissions from combustion turbines, only an abbreviated discussion of post-combustion controls will be addressed in this section.

Post-combustion SOx control systems include dry and wet scrubber systems. These types of systems are typically installed on high SOx emitting sources such as coal-fired power plants. Post-combustion control systems for combustion turbines also include ESx catalyst systems. These systems trap the sulfur in the exhaust stream on an ESx catalyst. During a regeneration process, the sulfur is removed from the ESx catalyst and is either reintroduced back into the exhaust stream or sent to a sulfur scrubbing system. If the sulfur removed from the ESx catalyst is reintroduced back into the exhaust stream, there is no SOx control associated with the system.

Step 2 – Eliminate Technically Infeasible Options

All of the control options discussed above are technically feasible.

Step 3 – Rank Remaining Control Technologies by Control Effectiveness

The typical SOx control level for a well-designed wet or dry scrubber installed on a coal fired boiler ranges from approximately 70% to 90%,[7] with some installations achieving even higher control levels. According to EmeraChem literature,[8] the ESx system is capable of removing approximately 95% of the SOx emissions from the exhaust stream of natural gas fired combustion turbines. With the sulfur scrubber option, during the regeneration cycle of the ESx system the sulfur captured on the ESx catalyst is sent to a sulfur scrubbing unit. A high-efficiency sulfur scrubbing unit would achieve a control level similar to that of the wet/dry scrubbers discussed above.

Step 4 – Evaluate Most Effective Controls and Document Results

The use of low sulfur content pipeline natural gas has been achieved in practice at numerous combustion turbine installations throughout the world, and the use of this fuel minimizes SOx emissions. While it would be theoretically feasible to install some type of post-combustion control such as a dry/wet scrubber system or an ESx catalyst with a sulfur scrubber on a natural gas fired turbine, due to the inherently low SOx emissions associated with the use of natural gas, these systems are not cost effective and regulatory agencies do not require them. Consequently, no further discussion of post-combustion SOx control is necessary.

Step 5 – Determine BACT/Present Conclusions

BACT for this project is the use of pipeline-quality natural gas. The SOx control method for the proposed project is the use of pipeline-quality natural gas. Consequently, the proposed project is consistent with BACT requirements.

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7 Air Pollution Control Manual, Air and Waste Management Association, Second Edition, page 206.

8 High Performance EMx Emissions Control Technology for Fine Particles, NOx, CO, and VOCs from Combustion Turbines and Stationary IC Engines, by Steven DeCicco and Thomas Girdlestone, EmeraChem Power, June 2008, page 19.

4.1C.2.4 $PM/PM_{10}/PM_{2.5}$ EMISSIONS

Step 1 – Identify All Possible Control Technologies

Alternative basic equipment—including renewable energy sources, such as solar and wind—has also been identified as a technology for the control of $PM/PM_{10}/PM_{2.5}$ emissions. Such alternative basic equipment was already discussed above (Step 1 for NOx BACT on the gas turbine). For the same reasons, solar, wind and other renewable energy sources are rejected as $PM_{10}/PM_{2.5}$ BACT for this application.

Achievable Controlled Levels and Available Control Options

PM emissions from natural gas-fired combustion turbines primarily result from carryover of noncombustible trace constituents in the fuel. PM emissions are minimized by using clean-burning pipeline quality natural gas with low sulfur content.

The CARB BACT Clearinghouse, as well as the BAAQMD BACT guideline, identify the use of natural gas as the primary fuel as "achieved in practice" for the control of $PM_{10}/PM_{2.5}$ for combustion gas turbines.

CARB's BACT guidance document for stationary gas turbines used for power plant configurations[9] indicates that BACT for the control of PM emissions is an emission limit corresponding to natural gas with a fuel sulfur content of no more than 1 grain/100 standard cubic foot.

Title 40 CFR Part 60 Subpart KKKK contains the applicable NSPS for combustion gas turbines. Subpart KKKK does not regulate $PM_{10}/PM_{2.5}$ emissions.

Published prohibitory rules from the SCAQMD, SJVAPCD, SMAQMD, and SDCAPCD were reviewed to identify the PM_{10} standards that govern natural gas-fired combustion gas turbines. These prohibitory rules do not regulate $PM_{10}/PM_{2.5}$ emissions.

As part of the Prevention of Significant Deterioration (PSD) permitting effort for the Pio Pico Energy Center, an extensive BACT analysis for PM_{10} was performed. This analysis included a review of data specifically for the GE LMS100 simple cycle gas turbines, the same model proposed for the PRP. SDAPCD considered what PM limit would be technically feasible to meet on an ongoing basis, in addition to reviewing source test data from GE LMS100 gas turbines installed at other locations, and reviewing permit limits for other installations with the same model and size gas turbine, operated in simple-cycle mode. Based on this data, the SDAPCD is requiring BACT $PM_{10}/PM_{2.5}$ emission limits of 5.0 lbs/hr (short-term average) and 3.5 lbs/hr (long-term average) in the most recent final permit issued the Pio Pico Energy Center (FDOC issued on August 25, 2015). These limits are identical to the BACT $PM_{10}/PM_{2.5}$ limits in the final permit for the LMS100 gas turbines for the Carlsbad Energy Center issued on April 15, 2015 - 3.5 lb/hr (annual) and 5.0 lb/hr (short-term). These are the lowest BACT $PM_{10}/PM_{2.5}$ limits approved for GE LMS100 simple-cycle gas turbines.

The "top-down" $PM_{10}/PM_{2.5}$ BACT analysis will consider the following emission limitations:

LMS100

- 3.5 lb/hr (annual)
- 5.0 lb/hr (short-term)

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9 Ibid, Table I-2.

Step 2 – Eliminate Technologically Infeasible Options

As discussed above, solar, wind and other renewable energy alternatives are not considered technologically feasible for this application.

Step 3 – Rank Remaining Control Technologies by Control Effectiveness

No control technology other than use of clean natural gas fuel has been identified for this application.

Step 4 – Evaluate the Most Effective Control Technology Considering Environmental, Energy, and Cost Impacts

No control technology other than use of clean natural gas fuel has been identified for this application.

Step 5 – Determine BACT/Present Conclusions

Based upon the results of this analysis, the use of natural gas as the exclusive fuel source constitutes BACT for $PM_{10}/PM_{2.5}$ emissions from the combustion turbine. Based on information provided by the PRP gas turbine vendor, General Electric, the new PRP gas turbine is expected to be able to meet a short-term $PM_{10}/PM_{2.5}$ emission limit of 3.5 lbs/hr. Based on a review of the $PM_{10}/PM_{2.5}$ stack tests performed on the LMS100 gas turbines provided to EPA for the Pico Pio Energy Center PSD permitting effort (see enclosed letter), the Applicant is proposing an annual average $PM_{10}/PM_{2.5}$ emission limit of 2.0 lbs/hr. While this proposed short-term average emission rate is below the emission limits for the recently permitted Pio Pico Energy Center (revised permit) and Carlsbad Energy Center, a review of the source tests data provided during the PSD permitting of the Pio Pico Energy Center indicates that this emission limit is achievable on a long-term average basis given that the average of enclosed test results is 1.7 lbs/hr. As required by the SDAPCD for the Pio Pico Energy Center, compliance with the annual average $PM_{10}/PM_{2.5}$ emission limit for the PRP gas turbine will be done by averaging the results of several source test results. For example, for the Pio Pico Energy Center the SDAPCD requires the averaging of the six most recent source test results with each source test comprised of at least three valid test runs.

4.1C.2.5 AMMONIA EMISSIONS

Ammonia (NH_3) emissions from the proposed simple cycle unit result from the use of SCR for NO_x control. The maximum NH_3 slip from the SCR system is 5 ppm. An NH3 slip limit of 5 ppmvd @ 15% O_2 (1-hour avg) is the most rigorous control requirement that has been imposed to date on any gas turbine power plant project in California, and is thus considered to represent BACT level for this project. This is also the level listed in the SCAQMD BACT guidelines for gas turbine power plant projects.

4.1C.3 BACT for the Simple-Cycle Gas Turbine: Startup/Shutdown

Startup and shutdown periods are a normal part of the operation of simple-cycle power plants such as PRP. BACT must also be applied during the startup and shutdown periods of gas turbine operation. The BACT limits discussed in the previous section apply to steady-state operation, when the turbine has reached stable operations and the emission control systems are fully operational.

4.1C.3.1 NOx EMISSIONS

Step 1 – Identify All Possible Control Technologies

The following technologies for control of NOx during startups and shutdowns have been identified:

- A Selective Catalytic Reduction (SCR) system capable of continuously complying with a limit of 2.5 ppmc (1-hour average);
- Fast-start technologies; and
- Operating practices to minimize the duration of startup and shutdown.

The gas turbine proposed for this project is controlled by SCR, which will operate at all times that the stack temperature is in the proper operating range.

Step 2 – Eliminate Technologically Infeasible Options

During gas turbine startup, there are equipment and process requirements that must be met in sequential order to protect the equipment.

For all gas turbine technologies, incomplete combustion at low loads results in higher CO and VOC emission rates. Furthermore, the post-combustion controls that are used to achieve additional emissions reductions (SCR and oxidation catalyst) require that specific exhaust temperature ranges be reached to be fully effective. The use of SCR to control NOx is not technically feasible when the surface of the SCR catalyst is below the manufacturer's recommended operating range. When catalyst surface temperatures are low, ammonia will not react completely with the NOx, resulting in excess NOx emissions or excess ammonia slip or both. The oxidation catalyst is not effective at controlling CO emissions when the exhaust temperature is below the optimal temperature range. Therefore, exhaust gas controls used to achieve BACT for normal operations are not feasible control techniques during startups and shutdowns.

This "top-down" BACT analysis will consider the following NOx emission limitations:

- Operating practices to minimize emissions during startup and shutdown; and
- Design features to minimize the duration of startup and shutdown.

Step 3 – Rank Remaining Control Technologies by Control Effectiveness

Operating Practices to Minimize Emissions during Startup and Shutdown

There are basic principles of operation, or Best Management Practices, that minimize emissions during startups and shutdowns. These Best Management Practices are outlined below.

- During a startup, bring the gas turbine to the minimum load necessary to achieve compliance with the applicable NOx and CO emission limits as quickly as possible, consistent with the equipment manufacturers' recommendations and safe operating practices.
- During a startup, initiate ammonia injection to the SCR system as soon as the SCR catalyst temperature and ammonia vaporization system have reached their minimum operating temperatures.
- During a shutdown, once the gas turbine reaches a load that is below the minimum load necessary to maintain compliance with the applicable NOx and CO emission limits, reduce the gas turbine load to zero as quickly as possible, consistent with the equipment manufacturers' recommendations and safe operating practices.
- During a shutdown, maintain ammonia injection to the SCR system as long as the SCR catalyst temperature and ammonia vaporization system remain above their minimum operating temperatures.

A key underlying consideration of these Best Management Practices is the overall safety of the plant staff by promoting operation within the limitations of the equipment and systems, and allowing for operator judgment and response times to respond to alarms and trips during the startup sequence.

Design Features to Minimize the Duration of Startup and Shutdown

An additional technique to reduce startup emissions is to minimize the amount of time the gas turbine spends in startup. The use of simple-cycle gas turbine technology inherently minimizes this time, in that simple-cycle gas turbines generally start up and shut down much more quickly than combined-cycle gas turbines.

Step 4 – Evaluate the Most Effective Control Technology Considering Environmental, Energy, and Cost Impacts

Utilizing best operating practices to minimize emissions during startups and shutdowns has no adverse environmental or energy impacts, nor does it require additional capital expenditure.

The approach of reducing startup/shutdown duration has no adverse environmental or energy impacts, and the use of simple-cycle generating technology minimizes startup/shutdown duration.

Step 5 - Determine BACT/Present Conclusions

BACT for NOx during startups/shutdowns is the use of operating systems/practices that reduce the duration of startups and shutdowns to the greatest extent feasible, and the use of operational techniques to initiate ammonia injection as soon as possible during a startup. Therefore, BACT is determined to be the use of simple-cycle gas turbine technology and the application of operating systems/practices that minimize startup and shutdown durations, in combination with the use of operational techniques to initiate ammonia injection as soon as possible during a startup.

4.1C.3.2 VOC EMISSIONS

Step 1 – Identify All Possible Control Technologies

The VOC control technologies under consideration for startups and shutdowns are ranked as follows:

- Operating practices to minimize the duration of startup and shutdown

Step 2 – Eliminate Technologically Infeasible Options

None of the proposed alternatives is infeasible for this application.

Step 3 – Rank Remaining Control Technologies by Control Effectiveness

The only proposed control technology is operating practices to minimize the duration of startups and shutdowns.

Step 4 – Evaluate the Most Effective Control Technology Considering Environmental, Energy, and Cost Impacts

VOC emissions during startup and shutdown are minimized by minimizing the duration of startup and shutdown.

Step 5 – Determine BACT/Present Conclusions

BACT for VOC during startups/shutdowns is the use of simple-cycle gas turbine technology and operating practices that reduce the duration of startups and shutdowns to the greatest extent feasible.

4.1C.3.3 SULFUR OXIDE EMISSIONS

Step 1 – Identify All Possible Control Technologies

The SOx control technologies under consideration for startups and shutdowns are ranked as follows:

- Use of natural gas as a fuel
- Operating practices to minimize the duration of startup and shutdown

Step 2 – Eliminate Technologically Infeasible Options

None of the proposed alternatives is infeasible for this application.

Step 3 – Rank Remaining Control Technologies by Control Effectiveness

Ranking for the control technologies is as indicated in Step 1.

Step 4 – Evaluate the Most Effective Control Technology Considering Environmental, Energy, and Cost Impacts

SOx emissions during startup and shutdown are minimized by minimizing duration of startup and shutdown.

Step 5 – Determine BACT/Present Conclusions

BACT for SOx during startups/shutdowns is the use of simple-cycle gas turbine technology and operating practices that reduce the duration of startups and shutdowns to the greatest extent feasible.

4.1C.3.4 PM/PM_{10}/$PM_{2.5}$ EMISSIONS

Step 1 – Identify All Possible Control Technologies

The analysis for particulate is identical to the analysis for SOx.

Step 2 – Eliminate Technologically Infeasible Options

The analysis for particulate is identical to the analysis for SOx.

Step 3 – Rank Remaining Control Technologies by Control Effectiveness

The analysis for particulate is identical to the analysis for SOx.

Step 4 – Evaluate the Most Effective Control Technology Considering Environmental, Energy, and Cost Impacts

The analysis for particulate is identical to the analysis for SOx.

Step 5 – Determine BACT/Present Conclusions

BACT for particulate during startups/shutdowns is the use of simple-cycle gas turbine technology and operating practices that reduce the duration of startups and shutdowns to the greatest extent feasible.

4.1C.3.5 SUMMARY

Proposed BACT determinations for the PRP gas turbine are summarized in Table 4.1C-4.

Table 4.1C-4
Proposed BACT Determinations for PRP Gas Turbine

Pollutant	Proposed BACT Determination
Nitrogen Oxides	Water injection and SCR system, 2.5 ppmc,[a] 1-hour average, with exemptions for startup/shutdown conditions
Sulfur Dioxide	Natural gas fuel (sulfur content not to exceed a maximum of 0.75 grains(gr)/100 scf short-term average, and 0.25 gr/100 scf annual average)
VOC	Good combustion practices, 2.0 ppmc, 1-hour average
PM_{10}	Natural gas fuel, 3.5 lbs/hr (short-term average), 2.0 lbs/hr (annual average)
$PM_{2.5}$	Natural gas fuel, 3.5 lbs/hr (short-term average), 2.0 lbs/hr (annual average)
Ammonia	5 ppmc ammonia slip, 1-hour average
Startup/Shutdown	Best operating practices to minimize startup/shutdown times and emissions

Note:

a. ppmc: parts per million by volume, corrected to 15% O_2.

BACT ANALYSIS - ATTACHMENT 1

LETTER TO EPA REGARDING PIO PICO ENERGY CENTER PM_{10} EMISSIONS

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August 15, 2013

Mr. Gerardo Rios
Chief, Permits Office
U.S. EPA Region 9
75 Hawthorne Street
San Francisco, CA 94105

Subject: Pio Pico Energy Center PSD Permit Application, PM BACT Determination

Dear Mr. Rios:

On August 2, 2013, EPA's Environmental Appeals Board (EAB) completed its review of petitions concerning the Pio Pico Energy Center (PPEC) PSD permit application. In its response to the petitions, the EAB affirmed virtually all of Region 9's decisions and analyses in support of the permit, but issued a narrow remand to Region 9 to "prepare a revised PM BACT analysis and reopen the public comment period to provide the public with an opportunity to comment on it."

Specifically, in its instructions to Region 9, the EAB sought additional documentation regarding the PM BACT determination:

> *The record does not reflect the Region's considered judgment in selecting the BACT emission limits for PM. The Region, in conducting its PM BACT analysis, failed to adequately consider significant information in the record regarding two simple-cycle plants* [Panoche Energy Center and CPV Sentinel] *that use the same turbine model as proposed for the Facility. Neither the "Fact Sheet and the Ambient Air Quality Impact Report" nor the response to comments document analyzed this information in detail nor explain how it affects the Region's PM BACT determination. In addition, the Region's explanation for its selection of 80 percent load as the defining criterion for applying two different emission limits and the selection of 5.5 pounds per hour ('lb/hr') as BACT for loads under 80 percent are not adequately explained in the record.*

The "significant information" referred to by the EAB regarding Panoche is the test data provided by the Applicant in its January 5, 2012 letter.[1] The Panoche data were provided by the Applicant, at EPA's request, because it was a major factor in Applicant's determination that it could meet a permit limit of 5.5 lb PM/hour at all times over the lifetime of the project, even though the vendor would not guarantee that level of emissions.

There is already information in the record to satisfy the EAB's instructions on remand promptly and without delay. Specifically, the EAB's directive to address the relevance of the Panoche data to the BACT analysis can be satisfied by considering information provided by the Applicant, which is already in the record, in EPA's analysis.

> *The Panoche Energy Center source test data are summarized in Table 3. Please note that these few source tests are not sufficient to demonstrate that the measured emission rates are achievable under all conditions and for the lifetime of the turbines. Furthermore, the test method used to measure PM is not very accurate at the low levels being measured; there is considerable variability in the results. For these reasons, the applicant has proposed a compliance level that takes into account (a) the vendor guarantee; (b) the emission levels demonstrated in the source tests; (c) reasonable variability in performance that can be expected over the lifetime of a well-maintained unit; and (d) the variability inherent in the source test methodology.*
>
> *Taking all of the above into account, test results provide sufficient support for the Applicant to determine that it can comply with a 5.5 lb/hr emission limit, which is equivalent to 0.0065 lb/MMBtu measured at or near peak turbine load.*[2]

The "significant information" referred to by the EAB regarding CPV Sentinel is that it was alleged to have a vendor guarantee of 5 lb/hr.[3] The EAB explained that "[t]he existence of a similar facility with a lower emissions limit creates an obligation for the permit applicant and permit issuer to *consider and document* whether the same emission level can be achieved at the proposed facility"[4] [emphasis in original].

EPA, in its response to this comment, explained that the vendor guarantee was 5 lb/hour, and an emission limit of 5 lb/hr <u>is the same value</u> as a permit limit of 5.5 lb/hr, due to

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[1] Letter from Steve Hill to Gerardo Rios, *Pio Pico Energy Center PSD Permit Application, Modeling Questions* (January 5, 2012), p. 12-13

[2] Letter from Steve Hill to Gerardo Rios, *Pio Pico Energy Center PSD Permit Application, Modeling Questions* (January 5, 2012), p. 12

[3] Email from Johannes Epke to Roger Kohn (July 24, 2012), p. 6: "For the CPV sentinel Project which utilizes the LM-100 turbine GE has provided vendor guarantees that LM-100 can achieve a 5 pound per hour limit. GE revised the PM10 emissions from the CTG to 5 lb/hr instead of 6 lb/hr, see guarantee e-mail dated 10/21/09.5 The 5 pound per hour limit represents BACT for the LM-100 for PM-10 emissions."

[4] In *Re Pio Pico Energy Center, PSD Appeal Nos. 12-04 through 12-06, Order Remanding in Part and Denying Review In Part* (August 2, 2013), ("Pio Pico Slip Op.") p. 96

conventions for rounding.[5] EPA thus directly confronted and disposed of the claim that Sentinel has a lower emissions limit than that proposed for PPEC. Sentinel's actual PM emission limit (11 lb PM/hour) was not a part of the record.[6]

Despite this record, the EAB found that "none of the documents that form the basis of the Region's BACT analysis discuss [the Panoche emission data] or explain why this information is not part of the BACT analysis."[7] Similarly, the EAB found that EPA did not investigate the CPV Sentinel emission data or explain why such investigation was not necessary for the BACT determination. As explained here, there already is sufficient information in the record for EPA to promptly respond to the EAB's direction and make any appropriate amendments to its analysis in a prompt and timely fashion.

New Test Information Is Now Available

Compliance source tests have recently been performed on LMS-100 turbines at CPV Sentinel and Walnut Creek Energy Park. Source test reports for these facilities were previously submitted to EPA by the facility owners; copies are included on the CD accompanying this letter. The Panoche data and source tests were previously provided to EPA.[8] The data are summarized and discussed below.

CPV Sentinel – Compliance source tests were conducted in January and February of 2013. $PM_{2.5}$ measurements are shown in Table 1. There are eight identical LMS-100 turbines at CPV Sentinel. Tests were performed at three load levels (nominally 100%, 75%, and 50%).

Walnut Creek Energy Park – Test results from Walnut Creek are summarized in Table 2. There are five identical LMS-100 turbines at Walnut Creek. Tests were performed at one load level (nominally 100%).

Panoche – Test results from Panoche are summarized in Table 3. There are four identical LMS-100 turbines at Panoche. Tests were performed at one load level (nominally 100%).

[5] EPA, *Responses to Public Comments on the Proposed Prevention of Significant Deterioration Permit for the Pio Pico Energy Center* (November 2012), p. 51.
[6] EPA incorrectly characterized the 5 lb/hr emission rate as an "emission limit" for CPV Sentinel. In fact, the only PM mass emission limit for CPV Sentinel is 11 lb/hr (SCAQMD Facility Permit 152707, Section H).
[7] Pio Pico Slip Op., p. 94
[8] Letter from Steve Hill to Gerardo Rios, *Pio Pico Energy Center PSD Permit Application, Modeling Questions* (January 5, 2012)

Table 1
$PM_{2.5}$ Emission Tests Results

Walnut Creek Energy Park Units 1-5
5 x 100 MW GE Model LMS100 combustion turbines

Date	Unit	Run #	Unit Load, % of capacity	Fuel Flow, hscfm	Mass Emission, lb/hr	Emission rate, lb/MMscf	Emission rate, lb/MMBtu
1/19/2013	1	W-1/STK-2.5-100-1	99.6%	8,039	1.86	2.32	0.0023
1/20/2013	1	W-1/STK-2.5-100-2	99.6%	8,039	1.07	1.34	0.0013
1/21/2013	1	W-1/STK-2.5-100-3	100.0%	8,073	1.47	1.8	0.0017
1/29/2013	2	W-2/STK-2.5-100-1	98.8%	7,975	0.369	0.463	0.0004
1/30/2013	2	W-2/STK-2.5-100-2	98.3%	7,935	0.576	0.726	0.0007
1/30/2013	2	W-2/STK-2.5-100-3	97.3%	7,858	1.162	1.478	0.0014
2/21/2013	3	W-3/STK-2.5-100-2	98.8%	7,975	1.2	1.51	0.0015
2/23/2013	3	W-3/STK-2.5-100-5	99.9%	8,062	1.1	1.36	0.0013
2/24/2013	3	W-3/STK-2.5-100-6	97.8%	7,892	0.73	0.92	0.0009
2/27/2013	4	W-4/STK-2.5-100-1	95.7%	7,724	0.68	0.88	0.0009
2/28/2013	4	W-4/STK-2.5-100-2	96.6%	7,798	0.86	1.1	0.0011
2/28/2013	4	W-4/STK-2.5-100-3	96.3%	7,774	0.75	0.96	0.0009
3/25/2013	5	W-5/STK-2.5-100-1	90.4%	7,295	1.81	2.48	0.0024
3/27/2013	5	W-5/STK-2.5-100-2	90.1%	7,276	1.71	2.35	0.0023
3/27/2013	5	W-5/STK-2.5-100-3	90.4%	7,300	2.11	2.88	0.0028

Table 2
PM Emission Tests Results

CPV Sentinel Units 1-8
8 x 100 MW GE Model LMS100 combustion turbines

Date	Unit	Run #	Unit Load, % of capacity	Fuel Flow, hscfm	Mass Emission, lb/hr	Emission rate, lb/MMscf	Emission rate, lb/MMBtu
2/2/2013	3	1-PM-100	97.4%	8,901	4.99	5.61	0.0054
2/13/2013	3	2-PM-100	100.0%	9,138	0.71	0.77	0.0007
2/4/2013	3	S-3STK-PM-75-1	77.0%	7,038	0.64	0.91	0.0009
2/4/2013	3	S-3STK-PM-50-1	58.0%	5,298	0.59	1.12	0.0011
1/15/2013	1	1-PM-100	94.2%	8,609	0.91	1.06	0.0010
1/15/2013	1	2-PM-100	98.2%	8,977	0.81	0.91	0.0009
1/17/2013	1	6/PM-75	76.9%	7,026	0.78	1.11	0.0011
1/17/2013	1	7-PM-75	77.0%	7,032	0.28	0.4	0.0004
1/16/2013	1	3-PM-50	58.6%	5,354	0.81	1.51	0.0015
1/16/2013	1	4-PM-50	58.4%	5,339	0.72	1.34	0.0013
2/11/2013	4	S-4/STK-PM-100-1	96.8%	8,845	4.38	4.96	0.0048
2/11/2013	4	S-4/STK-PM-75-1	76.3%	6,974	1.12	1.6	0.0016
2/12/2013	4	S-4/STK-PM-50-1	58.6%	5,354	1.42	2.65	0.0026
3/23/2013	7	S-7/STK-PM-100-1	91.8%	8,390	0.76	0.9	0.0009
3/24/2013	7	S-7/STK-PM-75-1	76.3%	6,972	0.75	1.07	0.0010
3/24/2013	7	S-7/STK-PM-50-1	58.9%	5,381	0.71	1.32	0.0013
1/30/2013	2	S-2/STK-PM-100-1	92.6%	8,459	1.02	1.21	0.0012
1/30/2013	2	S-2/STK-PM-100-2	90.2%	8,239	0.54	0.66	0.0006
1/31/2013	2	S-2/STK-PM-100-3	90.4%	8,260	0.67	0.82	0.0008
2/1/2013	2	S-2/STK-PM-75-1	75.8%	6,923	0.49	0.71	0.0007
2/1/2013	2	S-2/STK-PM-50-1	58.8%	5,373	0.42	0.78	0.0008
2/27/2013	6	S-6/STK-PM-100-1	95.9%	8,764	1.87	2.14	0.0021
2/27/2013	6	S-6/STK-PM-75-1	76.2%	6,960	1.02	1.47	0.0014
2/28/2013	6	S-6/STK-PM-50-1	59.4%	5,431	1.03	1.89	0.0018
2/25/2013	5	S-6/STK-PM-100-1	95.7%	8,747	0.85	0.97	0.0009
2/25/2013	5	S-6/STK-PM-75-1	77.3%	7,063	0.84	1.19	0.0012
2/26/2013	5	S-6/STK-PM-50-1	59.0%	5,392	1.02	1.9	0.0018
4/5/2013	8	S-8/STK-PM-100-1	99.8%	9,122	2.37	2.6	0.0025
2/25/2013	8	S-8/STK-PM-75-1	76.0%	6,946	0.9	1.3	0.0013
2/26/2013	8	S-8/STK-PM-50-1	58.2%	5,316	1.02	1.91	0.0019

Table 3. PM Emission Tests Results, lb/MMBtu

Panoche Energy Center

4 x 100 MW GE Model LMS100 combustion turbines

Date	5/13/2011	**5/12/2011**	**5/11/2011**	**5/10/2011**	**5/11/2010**	**5/12/2010**	**5/18/2010**	**5/19/2010**	**4/30/09 - 5/1/09**	**4/27/2009**	**4/23/2009**	**4/24/2009**
Unit	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Unit Load									100%	100%	100%	100%
Run 1	0.00298	0.00402	0.00314	0.00184	0.00279	0.00141	0.00168	0.00249	0.002	0.005	0.012	0.002
Run 2	0.00261	0.00192	0.00420	0.00182	0.00213	0.00107	0.00176	0.00198	0.002	0.003	0.002	0.007
Run 3	0.00167	0.00169	0.00605	0.00185	0.00169	0.00155	0.00149	0.00310	0.004	0.001	0.002	0.006
Average	0.00242	0.00254	0.00446	0.00184	0.00220	0.00134	0.00164	0.00252	0.003	0.003	0.005	0.005
Lb/hr	2.388	2.649	4.557	1.834	2.24	1.375	1.724	2.559	2.53	2.69	4.98	4.63

Discussion

These data demonstrate the extreme variability (and hence uncertainty) in measuring PM emissions from gas fired turbines. These are 17 LMS100 gas turbines, tested under very similar conditions. Some of the variability could be due to individual differences between ostensibly identical units; however, replicate tests on the same unit at the same conditions result in measurements that differ by as much as a factor of seven.[9]

The BACT limit for PPEC must take this measurement uncertainty into account. If the design and performance of these units are to form the basis of a BACT determination for PPEC, the emission limit proposed must be set at a level with which these units, and these measurements, would be in compliance. Furthermore, the fact that these test results are for new units must be taken into account. The compliance limit must be set at a level for which continuous compliance can reasonably be assured based on the test methods required to demonstrate compliance.

Table 4 shows some of the key statistics for the combined test data.

Table 4
Statistics for Combined PM Source Test Data

Combined (run avgs)		
lb/hr		**Overall**
	Maximum	4.98
	Average	1.74395
	Std Deviation	1.22441
	Relative Std Deviation	70%
	Mean plus 2 S.D	4.1928
lb/MMBtu		**Overall**
	Maximum	0.00533
	Average	0.00204
	Std Deviation	0.00119
	Relative Std Deviation	59%
	Mean plus 2 S.D	0.0044
Sample size:	38	

Table 4 shows that the mean PM measurement was 1.74 lb/hr, with a standard deviation of 1.22 lb/hr. The value of the mean plus 2 standard deviations is 4.19 lb/hr. If the distribution of measurement values is normal, 98% of all measurements would be expected to be below this level. Reliance on two standard deviations is necessary to ensure that these units can meet the BACT emission

[9] See test results for Sentinel Unit 3, Table 2, 100% load.

limitation at all times. To account for the fact that these data are for new units, which will inevitably suffer diminished performance over time, it is necessary to apply an additional 20% margin so that the BACT emission limitation can be met over the units' entire useful lifetime. Such a safety factor is necessary because no data exist for LMS-100 units nearing the end of their useful life.[10] If a 20% margin is applied to this value (to account for the fact that these data are for new units, whereas the facility must comply with a BACT list over its lifetime, and no data exist for LMS100s nearing the end of their useful life), the resulting value is 5.0 lb/hr.

Applying the same logic to the lbs/MMbtu values, a value of 0.0053 lbs/MMbtu would be calculated.

Table 4 shows that the highest measured PM emission rate was just under 5.0 lb/hr. This was not an isolated result: there were two other high measurements (4.56 and 4.38 lb/hr). As discussed above, any proposed BACT emission limit based on these data must allow all of the measurements to be complying values.

For the reasons presented above, the lowest emission limit that can be derived from available source test data, with margins to ensure that compliance can be maintained for the life of the facility based on required test methods is, 5.0 lb PM/hr. This emission limit would be lower than the emission limit for Sentinel (11 lb/hr), Walnut Creek (11 lb/hr), or Panoche (6.00 lb/hr).

PPEC is willing to accept a permit limit of 5.0 lb/hr and 0.0053 lb/MW-hr_{net}, applicable at all times, under all allowable operating loads, to be enforced based on the test methods specified in the proposed PSD permit at Condition IX.G.1.c.

Sincerely,

Gary Rubenstein

Encl (CD)

cc w/o encl:

David Jenkins, Apex Power Group
Jim Wedeking, Sidley Austin

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[10] The EAB has frequently allowed the necessary use of such safety factors due to uncertainties surrounding future unit performance. *See Prairie State Generating*, 13 E.A.D. 1, 75-76 (EAB 2006) ("Variability in the observed performance of a control technology is an appropriate circumstance for the permitting authority to use a safety factor in setting the permit's BACT limit."); *Russell City Energy Center*, 15 E.A.D. (EAB 2010), Slip Op. at 77 (citing cases authorizing use of safety factors). A 20% safety factor is in line with those previously approved by the EAB. *See, e.g., id.* at 74-75 (safety factor of between 22% and 42%); *In re Cardinal FG Co.*, 12 E.A.D. 153, 169-70 (EAB 2005) (upholding 21% safety factor for nitrogen oxide BACT emission limit).