APPENDIX 8.1C

Top-Down Evaluation of Best Available Control Technology

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TOP-DOWN EVALUATION OF BEST AVAILABLE CONTROL TECHNOLOGY

BACT is defined in San Diego Air Pollution Control District (SDAPCD or District) Regulation 2, Rule 20.1 as:

> *The lowest emitting of any of the following:*
>
> *(A) the most stringent emission limitation, or the most effective emission control device or control technique, which has been proven in field application and which is cost-effective for such class or category of emission unit, unless the applicant demonstrates to the satisfaction of the Air Pollution Control Officer that such limitation, device or control technique is not technologically feasible, or*
>
> *(B) any emission control device, emission limitation or control technique which has been demonstrated but not necessarily proven in field application and which is cost-effective for such class or category of emission unit, as determined by the Air Pollution Control Officer, unless the applicant demonstrates to the satisfaction of the Air Pollution Control Officer that such limitation, device or control technique is not technologically feasible, or*
>
> *(C) any control equipment, process modifications, changes in raw material including alternate fuels, and substitution of equipment or processes with any equipment or processes, or any combination of these, determined by the Air Pollution Control Officer on a case-by-case basis to be technologically feasible and cost-effective, including transfers of technology from another category of source, or*
>
> *(D) the most stringent emission limitation, or the most effective emission control device or control technique, contained in any State Implementation Plan (SIP) approved by the federal EPA for such emission unit category, unless the applicant demonstrates to the satisfaction of the Air Pollution Control Officer that such limitation or technique has not been proven in field application, that it is not technologically feasible or that it is not cost-effective for such class or category of emission unit.*

EPA policy requires the use of a "top-down" approach to determining BACT.[1] Under this procedure, the applicant first examines the most stringent alternative and that alternative is established as BACT unless the applicant demonstrates, and the permitting authority concurs, that the most stringent technology is not available or achievable. For natural gas-fired combined cycle gas turbines, available control techniques are well defined and are consistently required, but emission concentration limits vary. Therefore, this analysis will focus on the emissions limitations that constitute BACT for the proposed project.

8.1C.1 BACT for the Combined-Cycle Combustion Gas Turbines

To evaluate BACT for the South Bay Replacement Project (SBRP) turbines, the SDAPCD permitting and BACT guidance was reviewed. Although the District publishes BACT guidance for some classes and categories of sources (see the discussion regarding the auxiliary boiler below), no BACT determinations are specified for gas turbines. Therefore, the U.S. Environmental Protection Agency (EPA) Reasonably Available Control Technology (RACT)-

[1] EPA OAQPS, "New Source Review Workshop Manual, Prevention of Significant Deterioration and Nonattainment Area Permitting," Draft, October 1990.

BACT-Lowest Achievable Emission Rate (LAER) Clearinghouse (RBLC) was consulted to review recent EPA BACT decisions for gas-fired gas turbines. These recent BACT decisions are summarized in Table 8.1C-1 below. NOx BACT levels from the RBLC range from 2.0 to 3.0 parts per million concentration[2] (ppmc), with averaging periods ranging from one to 24 hours. Carbon monoxide (CO) BACT levels range from 2.0 to 18.0 ppmc for duct-fired units. Volatile organic compound (VOC) levels range from 1.3 to 13 ppmc. Because these projects were recently permitted, no performance data are yet available.

The Air Resources Board's (ARB) BACT Clearinghouse Database was also reviewed for recent BACT decisions regarding large gas turbine projects in California. Relevant BACT decisions are summarized in Table 8.1C-2. Nitrogen oxides (NOx) levels shown in these determinations range from 2.0 to 2.5 ppm, with averaging periods ranging from one to three hours. CO BACT determinations range from 2 to 4 ppmc, with various averaging periods. VOC determinations range from 1 to 2 ppmc, again with various averaging periods.

Finally, the ARB's Guidance for Power Plant Siting and Best Available Control Technology was also reviewed. The relevant BACT levels recommended in the ARB power plant guidance document are summarized in Table 8.1C-3.

The amended Determination of Compliance issued to the Otay Mesa Generating Project (which is also located in the SDCAPCD) in 2003 required the use of dry low-NOx combustors with selective catalytic reduction (SCR) technology to achieve a NOx exhaust concentration of 2.0 ppmc or less (1-hr average)[3], a CO exhaust concentration of 6 ppmc (3-hr average), and a VOC concentration of 2.0 ppmc (1-hr average). The gas turbines will be fueled with natural gas to minimize SO_2 and $PM_{10}/PM_{2.5}$ emissions. The NOx and VOC emissions limitations are generally consistent with the most stringent EPA RBLC Clearinghouse determinations and the ARB BACT guideline for power plants. However, the permitted CO limitation is higher than some of the levels in the EPA RBLC Clearinghouse. A more detailed top down analysis for BACT for CO emissions follows.

Table 8.1C-4 summarizes the proposed BACT determination for the SBRP CTGs.

[2] Parts per million concentration means parts per million by volume on a dry basis at the appropriate reference oxygen concentration of 15% for turbines and 3% for boilers.

[3] The 2003 Otay Mesa permit allows excursions from the 2.0 ppmc/1-hour average limit under certain specific conditions, consistent with the excursions allowed for other similar CTG plants with extremely low NOx limitations.

Table 8.1C-1

Gas Turbine BACT Determinations (EPA RBLC Clearinghouse}

Facility/Location	Date Permit Issued	Equipment/Rating	NOx Limit/Control Technology	CO Limit/Control Technology	VOC Limit/Control Technology
Forsyth Energy Plant Forsyth Co, NC	9/29/2005	1844.3 MMBtu/hr combined cycle turbine w/ duct burner	2.5 ppm, 24-hour average (SCR and DLN)	11.6 ppm, 3-hr average (good combustion practices)	No BACT determination
Sierra Pacific Power Company Tracy Station Storey Co, NV	8/16/2005	306 MW combined-cycle turbine w/ duct burner	2 ppm, 3-hr average (SCR and DLN)	3.5 ppm, 3-hr average (oxidation catalyst)	4 ppm, 3-hr average
North Star Power Co Ramsey Co, MN	8/12/2005	330 MW total, 2 combined-cycle turbines w/ duct burners	No BACT determination	10 ppm w/o duct firing 18 ppm w duct firing (good combustion practices)	2 ppm w/o duct firing 13 ppm w/ duct firing
Wanapa Energy Center Umatilla Co, OR	8/8/2005	GE Frame 7FA gas turbine and duct burner	2 ppm, 3-hr average (SCR and DLN)	2 ppm, 3-hr average (oxidation catalyst)	No BACT determination
Hines Power Block 4 Polk Co, FL	6/8/2005	530 MW combined cycle gas turbine	2.5 ppm (SCR)	8 ppm (good combustion practices)	No BACT determination
Florida Power and Light Turkey Point Power Plant Dade Co, FL	6/8/2005	Four GE 7FA gas turbines with duct firing	2.0 ppm, 24-hr average (DLN and SCR)	8 ppm, 24-hr average (good combustion practices)	1.3 ppm (good combustion practices)
Berrien Energy, LLC Berrien Co, MI	4/13/2005	1584 MMBtu/hr gas turbine with duct firing	2.5 ppm, 24-hr average (SCR and DLN)	2 ppm, 3-hr average (oxidation catalyst)	3.2 lb/hr
Duke Energy Hanging Rock Energy Facility Lawrence Co, OH	12/28/2004	Four GE 7FA gas turbines with duct firing	3.0 ppm, 3-hr average (SCR and DLN)	9 ppm, 24-hr average	20.4 lb/hr
Wellton Mohawk	12/1/2004	GE 7FA gas turbines	2.0 ppm, 3-hr	3.0 ppm, 3-hr	2.0 ppm, 3-hr

Table 8.1C-1

Gas Turbine BACT Determinations (EPA RBLC Clearinghouse}

Facility/Location	Date Permit Issued	Equipment/Rating	NOx Limit/Control Technology	CO Limit/Control Technology	VOC Limit/Control Technology
Generating Station Yuma Co, AZ		with duct firing	average (SCR and DLN)	average (oxidation catalyst)	average (oxidation catalyst)

Table 8.1C-2

Summary of BACT Determinations (ARB BACT Clearinghouse)

Facility/District	Permit No./Date	Equipment/Rating	NOx Limit/ Control Technology	CO Limit/Control Technology	VOC/HC Limit/ Control Technology
Western Midway Sunset Power Project San Joaquin Valley Air Pollution Control District (SJVAPCD)	S-1135-313-0 12/12/2003	GE 7FA or S-W 501F	2 ppm, 1-hr average SCR	4 ppm, 3-hr average Oxidation catalyst	1.4 ppm, 3-hr average Oxidation catalyst
Three Mountain Power, LLC Shasta County AQMD	99-PO-01 10/10/2003	GE 7FA or S-W 501F	2.5 ppm, 1-hr average SCR	4 ppm, 3-hr average Oxidation catalyst	2 ppm, 1-hr average Oxidation catalyst
Magnolia Power Project SCAQMD	386305 5/27/2003	GE 7FA	2 ppm, 3-hr average SCR	2 ppm, 1-hr average Oxidation catalyst[a]	2 ppm, 1-hr average Oxidation catalyst
Elk Hills Power Project SJVAPCD	S-3523-1-0	GE 7FA	2.5 ppm, 1-hr average SCR	4 ppm, 3-hr average Oxidation catalyst	2 ppm, 3-hr average Oxidation catalyst
Sutter Power Project Feather River AQMD	97-AFC-2 12/1/2000	S-W 501F	2.5 ppm, 1-hr average SCR	4 ppm, 24-hr average Oxidation catalyst	1 ppm, 24-hr average Oxidation catalyst

Note:

a. District indicates that applicant proposed 2 ppm to lower offset liability.

Table 8.1C-3

ARB 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

Table 8.1C-4

Proposed BACT Determination for SBRP Combined-Cycle Gas Turbines

Pollutant	Proposed BACT Determination
Nitrogen Oxides	2.0 ppmc[a], 1-hour average, with excursions under specific conditions
Sulfur Dioxide	Natural gas fuel (sulfur content not to exceed 0.75 grain/100 scf)
Carbon Monoxide	4.0 ppmc, 3-hour average; good combustion practices
VOC	2.0 ppmc, 1-hour average; good combustion practices
PM_{10}	7.75 lb/hr without duct firing; 10.28 lb/hr with duct firing; natural gas fuel

Note:

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

8.1C.1.1. Top Down CO BACT Analysis for Combined-Cycle Combustion Turbines

This analysis follows EPA and SDAPCD guidance for the preparation of "top down" BACT analyses focusing specifically on identifying emission limitations or control techniques that are achieved in practice and technically feasible.

The "top-down" analysis format used here, consistent with guidance provided in EPA's October 1990 Draft New Source Review Workshop Manual, consists of the following five steps:

1. Identify all control technologies
2. Eliminate technically infeasible options
3. Rank remaining control technologies by control effectiveness

4. Evaluate most effective controls and document results
5. Select BACT.

The SDAPCD indicates that if the top-listed, technically feasible control option is selected, no further analysis is required. However, if the most stringent option is not selected, the applicant must review and determine the cost-effectiveness of each less stringent option. A control option is considered cost-effective if the annualized cost of implementing that option is less than or equal to the District's reference cost-effectiveness value. The SDAPCD BACT guidelines provide no CO cost threshold. The SJVAPCD uses a CO cost threshold of $300 per ton in 1999 dollars, and the SCAQMD uses a CO cost threshold of $400/ton average, and $1,150/ton incremental in 2003 dollars. These thresholds will be used for this cost-effectiveness determination.

1. Identify All Control Technologies

The baseline for this analysis is a CO emission rate of 6 ppmc, which can be achieved by a natural gas-fired combined-cycle gas turbine equipped with a dry low-NOx combustor using good combustion practices and no add-on controls. The control levels that are considered to be technically feasible as BACT are in the range of 2 to 4 ppmc. Although two CTGs have been permitted in the SCAQMD with a CO limit of 2 ppmc, these determinations are not considered to be achieved in practice because:

- the CO emission rates were requested by the applicants to minimize their offset requirements;
- these units have not been tested to demonstrate that the 2 ppmc limit is being achieved; and
- the SCAQMD is currently designated a nonattainment area for the federal CO standard, while the San Diego Air Basin is an attainment area.

Therefore, the 2 ppmc CO limit may be considered technically feasible but not achieved in practice, and both potential emission limits must be subjected to a cost-effectiveness evaluation.

An oxidation catalyst would probably be required to achieve either the 2 ppmc or the 4 ppmc limitation. Therefore, catalytic oxidation control technology must be evaluated as a control option.

2. Eliminate Technically Infeasible Options

Catalytic oxidation is technically feasible, so it cannot be eliminated from consideration as BACT for CO for this project.

3. Rank Remaining Control Technologies by Control Effectiveness

The technically feasible CO control technologies are ranked in Table 8.1C-5 below.

Table 8.1C-5

Technically Feasible CO Control Technologies

CO Control Alternative	Available?	Technically Feasible?	CO Emissions (@ 15% O_2)	Environmental Impact	Energy Impacts
Good combustion practices	Yes	Yes	6 ppm	None	None
Oxidation catalyst	Yes	Yes	2 - 4 ppm	Collateral control of HAPs	Decreased Efficiency

4. Evaluate Most Effective Controls and Document Results

The principal differences between the two technologies are associated with whether the low emission levels proposed have been achieved in practice using these technologies, their cost-effectiveness in achieving these levels, and secondary environmental impacts.

Achieved in Practice Evaluation. The SJVAPCD BACT guideline indicates that the 6 ppmc level has been achieved in practice, but that 4 ppmc is technically feasible. The Bay Area Air Quality Management District (BAAQMD) BACT guideline indicates that 4 ppmc has been achieved in practice at the Sacramento Power Authority (103 MW nominal output Siemens V84 combustion turbine with DLN combustion, SCR, and oxidation catalyst) and at Valero Cogeneration Project (achieved in practice for LM6000 CTG in combined-cycle mode). Therefore, we conclude that 4 ppmc has been achieved in practice. As discussed above, the 2 ppmc level has not been achieved in practice, but is considered technically feasible.

Commercial Availability. At least one vendor should offer this equipment for regular or full-scale operation in the United States. A performance warranty or guarantee should be available with the purchase of the control technology, as well as for parts and service. At least three vendors offer oxidation catalyst systems for Frame 7 class natural gas-fired CTGs, so the technology is commercially available.

Reliability. All control technologies should have been installed and operated reliably for at least six months. Oxidation catalyst technology has been in reliable operation on the facilities in the several air districts for more than six months.

Effectiveness. The control technology should be verified to perform effectively over the range of operation expected for that type of equipment. Catalytic oxidation has been verified to perform effectively at the 4 ppmc level over the expected operating range of the SBRP CTGs, although it is not fully effective during turbine startups and shutdowns. Continuous compliance with the 2 ppmc level has not been demonstrated in practice.

Cost and Cost-Effectiveness. Reducing the CO emissions limit from 6 ppmc to 4 ppmc would reduce the annual CO emissions from the two CTGs by 69.2 tons per year.[4] This corresponds to a reduction of 34.6 tons per year per CTG. The total annual oxidation catalyst cost for a GE PG 7231FA CTG was calculated by EPA[5] in 1999 to be $1,673,902 over three years, or $557,967 per year per CTG. These costs must be adjusted to 2006 dollars. A value of 1.19 is used to inflate the 1999

[4] The tons per year CO reduction is not directly proportional to the reduction in the concentration limit because no credit is taken for reducing emissions during turbine startups.

[5] U.S. EPA, Memorandum from Sims Roy, Emission Standards Division, Combustion Group, to Docket A-95-51, "Oxidation Catalyst Costs for New Stationary Combustion Turbines," December 30, 1999.

costs to current dollars.[6] Therefore, the cost-effectiveness of oxidation catalyst systems for the SBRP CTGs is

$557,967 * 1.19 per year ÷ 34.6 tons per year = $19,190 per ton in 2006 dollars

This is well above the cost-effectiveness thresholds in the SJVAPCD and SCAQMD rules. At a level of 2 ppmc using the oxidation catalyst, the cost effectiveness would be over $9,500 per ton and would still be well in excess of the cost-effectiveness thresholds.

$557,967 per year * 1.19 ÷ 69.2 tons per year = $9,595 per ton in 2006 dollars

5. Select BACT

Based on the above analysis, a CO emission limit of 2 to 4 ppmc is technically feasible using catalytic oxidation. However, the cost-effectiveness of these limits is well in excess of current BACT cost-effectiveness guidance in the SJVAPCD and the SCAQMD. Therefore, we conclude that 6 ppmc is BACT for CO emissions for the SBRP CTGs. Although 6 ppmc CO is BACT, the SBRP proposes to go beyond BACT and implement an emission limit of 4 ppmc CO on a 3-hour average basis.

[6] The NASA Cost Estimation Website, CPI Inflation Calculator (http://www1.jsc.nasa.gov/bu2/ inflateCPI.html) yielded a factor of 113.4 to 2004; the Federal Reserve Bank of Minneapolis inflation calculator (http://minneapolisfed.org/research/data/us/calc/) yielded a factor of 1.22; the Bureau of Labor Statistics CPI inflation calculator (http://data.bls.gov/cgi-bin/cpicalc.pl) yielded a factor of 1.19.