APPENDIX 5.1F

Evaluation of Best Available Control Technology

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Evaluation of Best Available Control Technology

To evaluate BACT for the proposed turbine, the guidelines for large simple cycle gas turbines (< 50 MW) as delineated in the District, state, and federal BACT listings were reviewed. The relevant BACT determinations for this analysis are shown in Tables 5.1F-1 through 5.1F-4.

TABLE 5.1F-1 BACT DATA FOR SIMPLE CYCLE GAS TURBINES

Pollutant	BACT	Typical Technology
Nitrogen oxides (NO_x)	5 ppm dry @ 15% O_2 , 1 or 3 hr avg	1. SCR + DLN, or, 2. SCR + water or steam injection
Sulfur dioxide (SO_2)	Natural gas fuel	PUC regulated gas
Carbon monoxide (CO)	6 ppm dry @ 15% O_2, 1 or 3 hr avg	Catalytic oxidation
VOC	2 ppm dry @ 15% O_2	Catalytic oxidation
PM_{10}	Natural gas fuel	PUC regulated gas

Achieved in practice, from SCAQMD website August 2005.

TABLE 5.1F-2 RECENT BACT DECISIONS FOR SIMPLE CYCLE GAS TURBINES (ACHIEVED IN PRACTICE)

Facility	NO_x	CO	VOC	PM_{10}/SO_x
Colton	3.5*	6	2	Natural gas
Indigo	5	6	2	Natural gas
LADWP-Valley	5	6	2	Natural gas

Ammonia slip BACT is 5 ppmv for all listings. SCR for NO_x all listings. CO catalyst for CO and VOC all listings.

From SCAQMD website, August 2005.

* Dated 2-17-04, applicant proposed 3.5 ppm NO_x, while AQMD states 5 ppm NO_x is BACT/LAER.

TABLE 5.1F-3 SUMMARY OF BACT RECOMMENDATIONS FROM ARB-CEC BACT GUIDANCE (SIMPLE CYCLE)*

NO_X	CO	VOC	SO_X	PM_{10}
5 ppm dry @15% O_2, 3 hr avg 5 ppm NH_3 slip @ 15% O_2	6 ppm dry @15% O_2, 3 hr avg	2 ppm dry @ 15% O_2, 3 hr avg	Natural gas fuel Fuel S < 1gr/100 scf	Natural gas fuel

* CARB, July 1999.

TABLE 5.1F-4 RECENT FACILITY BACT DETERMINATIONS FOR LARGE SIMPLE CYCLE GAS TURBINES

Facility/Location	NO_x (ppm)	CO (ppm)	VOC (ppm)	PM_{10}/SO_x
GWF Tracy	5	6	2	Natural gas
Enpower Corp. CPA Peaker Analysis*	5-8	6-10	2-3	Natural gas
Henrietta Peakers	3.6	6	2	Natural gas
Los Esteros	5	6	2	Natural gas
Calpeak-Enterprise	5	6	2	Natural gas
Calpeak-Border	5	6	2	Natural gas
RAMCO	5	6	2	Natural gas

* Not a public domain document.

The USEPA RACT-BACT-LAER Clearinghouse (RBLC) was also consulted to review recent USEPA BACT decisions for simple cycle gas-fired gas turbines. These recent BACT decisions are summarized in Table 5.1F-5.

TABLE 5.1F-5 SIMPLE CYCLE TURBINE RBLC BACT DETERMINATIONS (NATURAL GAS)

RBLC ID	Unit Size (MMBtu/hr)	NO_x (ppm)	CO (ppm)	VOC (ppm)
CA0997	1,611	2	4	1.4
VA0263	1,624	10.5	9	
VA0266	1,624	9	9	
VA0262	866	9	51	2.6
VA0261	2,132		2	1.7
IA0060		3	5	
SC0064	1,751	2.5	14	
OK0072	1,832	3.5	17.2	
VA0250	1,887	2.5		
FL0232	1,591	25	10	
IN0095	469	25	25	
MI0327	1,679	15		
CA0593	412	5	6	2
MI0296	855	9	25	
IN0096	1,146	9	25	

TABLE 5.1F-5 SIMPLE CYCLE TURBINE RBLC BACT DETERMINATIONS (NATURAL GAS)

RBLC ID	Unit Size (MMBtu/hr)	NO_x (ppm)	CO (ppm)	VOC (ppm)
FL0227	1,803	9	7.4	1.4
FL0229	1,910	9	9	1.4
MI0321	849	9	25	
CA0951	464	5	6	2
SC0058	3,296	3.5	11.7	3.5
AR0042	6,077	3.5	7	
NM0043	1,500	9	9	7
Average	-	8.5	13.9	2.55
Range	412 - 6,077	2 - 25	2 - 51	1.4 - 7

A recent compilation of BACT determinations is presented in AWMA Paper #42752 (June 2002), "Comparison of the Most Recent BACT Determinations for Combustion Turbines by State Air Pollution Control Agencies". Data presented in this paper was derived from surveys conducted nationwide. Simple cycle BACT data is summarized as follows:

- NO_x 5-12 ppm
- CO 9-25 ppm
- VOC No Data
- PM_{10} Nat gas fuel
- SO_2 Nat gas fuel

Based on the above data, it would seem that the most appropriate and current range for BACT for simple cycle combustion turbines (achieved in practice) is as follows:

- NO_x 5 ppm (DLN, DLN+SCR, SCR + water/steam injection)
- CO 6 ppm (good combustion practices [GCP], GCP + CO catalyst)
- VOC 2 ppm (GCP, GCP + CO catalyst)
- PM_{10} Nat gas fuel (clean fuel)
- SO_x Nat gas fuel (clean fuel)

Cooling Tower BACT

There are no proposals for cooling towers at the MMC Chula Vista site.

Diesel Fired IC Engine BACT

BACT levels for the diesel fired IC engines are shown in Table 5.1F-6.

TABLE 5.1F-6 SUMMARY OF BACT RECOMMENDATIONS FROM SCAQMD GUIDANCE FOR DIESEL FIRED CI-IC ENGINES

	NO_x, g/bhp	CO, g/bhp	VOC, g/bhp	SO_x, %S wt.	PM_{10}, g/bhp
CI-IC Engines	3.9 - 6.9	0.45 - 8.5	0.09 - 1.0	≤ 0.05	0.14 - 0.38

The proposed diesel engine will also comply with the EPA Tier II and/or Tier III standards as applicable based upon engine size and year of manufacture.

The proposed diesel engine will comply with the CARB proposed Air Toxic Control Measure (ACTM) for Stationary Compression Ignition Engines (upon adoption by the South Coast AQMD). Since the EGS engine is classified as emergency standby, with a rating greater than 50 hp, and operational hours less than 100 hours per year, the PM10 performance standard to be met will be 0.1g/hp-hr using CARB certified diesel fuel. Add-on controls would not be required, and a HRA would also not be required. In addition the engine will comply with AQMD Rules and the Tier standards as delineated in Title 13 CCR Section 2423, based upon engine size and year of manufacture.

The pages which follow present the BACT text for rejection of the combined cycle alternative for the RAMCO Miramar facility.

App5.1F-BACT-doc-1.doc and App5.1F-BACT –doc-2.xls

Proposed BACT Review of a Lower-Emitting Project Configuration for the Ramco Miramar Energy Facility (MEF)

Comparing a Proposed 46 Mw Simple-Cycle Aeroderivative Unit to an Equivalent Sized Combined-Cycle Unit for NOx

Introduction

Ramco Generating One (Ramco) is proposing to build a nominal 46 Mw simple-cycle intermediate load plant fired solely by natural gas fuel, using a combination of combustion/water injection and SCR catalyst systems to reduce the NOx emission rate to 2.5 ppmvd @ 15%O_2. The project is proposed to operate not more than 5,000 hours a year.

In the San Diego County Air Pollution Control District's role as Lead Agency, it has requested that Ramco (the Applicant) prepare an analysis of the proposed project to determine the cost effectiveness of potentially converting the project to a more efficient project configuration alternative, a similar sized combined-cycle plant with appropriate emission rates for NOx, as well as to determine the incremental cost effectiveness ($ per ton of NOx reduced) of using this more efficient system on annual NOx emissions.

Source for all Cost Data – California Energy Commission (CEC)

Two sources of cost information (e.g., equipment costs, installed costs, etc.) were reviewed – California Energy Commission (CEC) and California Public Utilities Commission (CPUC) – in order to conduct the cost effectiveness analysis.

The following analysis was performed using public information on the costs of respective simple and combined-cycle equipment based on proxy plant cost estimates prepared by the CEC. This data was derived from "Comparative Cost of California Central Station Electricity Generation Technologies," California Energy Commission Staff Report, 100-03-001, August 2003.

The raw data is summarized in Table 1 and shows a 2004 installed cost of $660 per kW for a new combined-cycle and $464 per kW for a simple-cycle (also referred to as combustion turbine (CT)) plant built in California. Therefore, the difference is $196 per kW.

For comparative purposes and as another benchmark on the projected installed costs for these two technologies, Ramco has summarized the capital costs presented in testimony from various participants in the California Public Utilities Commission's (CPUC) Market Price Refinement Methodology process (Rulemaking 04-04-026), currently in hearings and workshops being held at the CPUC (Table 2). This information, presented in

Table 2, suggests a range of installed costs for combined-cycle configuration from $650-865 per kW, and for simple-cycle configuration from $516-570 per kW.

In both cases, the difference in capital costs between a "generic" simple-cycle and combined-cycle plant ranged from a low of $80 per kW to a high of $295 per kW. Therefore, the CEC difference of $196 per kW seemed representative for this analysis. Across the $80 and the $295 range, the incremental dollars per ton removed of NOx (on a straight capital invested analysis) is greater than $1,000,000 per ton, which is an order of magnitude greater than historical BACT economic levels.

Description of Proposed MEF Project and Alternative Combined-Cycle Proxy

Proposed MEF Project

The proposed intermediate load plant will operate in a simple-cycle mode at an approximate net output to the grid of 46 Mw. Its heat rate will be at or below 8,581 Btu/KW-hr (Lower Heating Value), or 9,491 Btu/KW-hr (Higher Heating Value) at annual average site conditions. As outlined in Table 3, at a controlled emission rate of less than 2.5 ppm for NOx, the plant will emit 4.1 lbs NOx/hr, or 0.0891 lbs/Mw-hr. Under annual operating conditions of 5,000 hours, the facility would produce less than 10.25 tons of NOx per year (see Table 4).

Combined-Cycle Proxy

The combined-cycle alternative is assumed to have a net output to the grid of approximately 46 Mw and use a dry cooling system consistent with the CEC proxy plant (resulting in little or no water consumption but increased noise impacts). Its heat rate would be at or below 6,329 Btu/KW-hr (Lower Heating Value), or 7,000 Btu/KW-hr (Higher Heating Value) at annual average site conditions (GE Sales Rep Personal Communication). As outlined in Table 3, at a controlled emission rate of less than 2.5 ppm, the plant will generate 3.02 lbs NOx/hr, or 0.0657 lbs NOx/Mw-hr. Under annual operating conditions of 5,000 hours, the facility would produce less than 7.56 tons of NOx per year (See Table 4).

Alternate Potential Options based on a Review of the BACT Clearinghouse

Table 5 is a listing of existing gas turbine projects considered to be combined-cycle (< 50 Mw) units. This list is based on the California Air Resources Board's BACT Clearinghouse database. Given the determinations described for each of these projects, a review of the determinations finds no comparable project configuration (as highlighted in Table 5, "Comments/Highlights") that is a less than 50 Mw combined-cycle (and that is not a cogeneration unit) with an emission rate of 2.5 ppmvd for NOx or less.

Additionally, an LM 6000 combined-cycle project (for the California Municipal Utility) was considered for comparison purposes, but this unit is duct-fired and was rated at greater than 80 Mw, and therefore does not meet the proposed project criteria.

Alternative Technology BACT Analysis

Table 6 outlines the comparable costs per ton for NOx removal due to improved energy efficiency of the combined-cycle alternative compared to the proposed MEF simple-cycle project. At 5,000 hours of operation, the cost is$3.351 million/ton removed. The numbers in Table 6 indicate that a combined-cycle alternative operating for any number of annual hours would not be a cost effective BACT for the MEF.

Evaluation of Cost Effectiveness – 10 Year Amortization of Capital Costs of Removal

The San Diego APCD BACT guideline document prescribes a NOx cost-effectiveness value of $18,000/ton of NOx removed. This document (May 2002) can be found on the County's website at http://www.sdapcd.co.san-diego.ca.us/permits/BACTab/bact.pdf. The guideline prescribes that an equipment life of 10 years and a discount rate of 10% be assumed in the cost-effectiveness evaluation.

Therefore, further cost effectiveness evaluation was conducted taking the increased capital cost for the alternate unit and spreading those costs of removal over 10 years at a 10% discount rate. The results are summarized in Table 7, and show a cost of more than $545,000 per ton for up to 5,000 hours of operation per year. This number is much greater than the APCD's cost-effectiveness criteria.

Additional Reasons Why the Combined-Cycle Alternative is Not Feasible

The following are additional factors that demonstrate a combined-cycle alternative configuration to the Proposed MEF infeasible:

Commercial Operation Date - SDG&E has indicated that it has a critical need for the MEF project to be online and producing power before June 1, 2005. Ramco has bid, been selected and negotiated a Term Sheet and Contract with SDG&E to meet that commercial operation date, which is in less than 12-months. Even if it were economically feasible, shifting to a combined-cycle alternative would delay project approval, construction and operation until at least late 2006, which would violate Ramco's Term Sheet and Contract with SDG&E. A critical component of the combined-cycle option is the steam turbine, which typically takes 15-20 months to design, procure, build and install.

Site Size – The proposed site is about 2 acres in size. It is estimated that an additional 2 acres might be needed to accommodate the added equipment (e.g., dry cooling system, steam handling and treatment) needed for a combined-cycle alternative. The existing Miramar site may not be feasible given required set backs for protected habitat that is a condition of the San Diego City Land Use Exemption.

Environmental Impacts – A combined-cycle alternative at the MEF site, compared to the proposed simple-cycle, would have more impact on land use (e.g., requiring more land),

on water supply and usage for the additional steam make up, and on noise, particularly if using a dry cooling fan system (which is extremely noisy).

Air Emissions – On an annual basis, a combined-cycle alternative typically operate more than 7,500 hours per year to be cost effective to the ratepayers The additional 3,500 annual operating hours would add at least 3.5 tons of NOx into the air basin, for power not needed from this project.

Additional Costs – The Analysis presented here is conservative and uses public information for the evaluation of BACT economic feasibility. Ramco estimates that, in fact, converting an LM6000 to a combined-cycle configuration would increase total MEF costs to more than $800/kW. If this cost were used, the BACT analysis would render a combined-cycle alternative to be even less feasible.

Non-Spin Start up Requirement – As part of the SDG&E RFP, the unit needs to be designed for grid reliability, including being able to start up to full load within 10-15 minutes. A plant operating in the full combined-cycle mode cannot meet this requirement, from the California Independent System Operator (ISO). While some portion (about 65 %) of the combined-cycle plant could be operating within 10-15 minutes, not having 100% of the plant capacity would have a significant impact on project economics. The balance of the capacity from a combined-cycle plant could be operational in 2 hours.

References

"Comparative Cost of California Central Station Electricity Generation Technologies," California Energy Commission Staff Report, 100-03-001, August 2003.

California Public Utilities Commission's (CPUC) Market Price Refinement Methodology process (Rulemaking 04-04-026).

Personal Communications with GE Sales Representative (regarding heat rate for combined-cycle proxy)

California Air Resource Board, BACT Clearinghouse Database, Category – Gas Turbine: Combined-Cycle < 50 MW

"New Source Review Requirements for Best Available Control Technology (BACT) Guidance Document," May 2002, http://www.sdapcd.co.san-diego.ca.us/permits/BACTab/bact.pdf.

Comparison of Combined-Cycle and Combustion Turbine Capital Cost Estimates by the CEC

Capital Cost Detail	Combined Cycle	Combustion Turbine	Difference
Component Costs			
Turbine/Engine ($)	234,597,182	31,000,000	203,597,182
Misc fitting & hoses ($)	4,691,944	620,000	4,071,944
Total Component Costs ($)	239,289,126	31,620,000	207,669,126
Land Costs ($)			
Acreage/Plant (acres)	15	15	-
Cost per acre ($)	100,000	100,000	-
Acquisition Cost ($)	1,470,588	1,470,588	-
Land Prep Costs ($/acre)	500	500	-
Total Land Prep Costs ($)	7,353	7,353	-
Total Land Costs ($)	1,477,941	1,477,941	-
Permitting Costs			
Air Permits ($)	5,868,000	100,440	5,767,560
Total Permitting Costs ($)	5,868,000	100,440	5,767,560
Interconnection Costs ($)	-	-	-
Environmental Controls			
Installation costs ($)	25,000,000	5,000,000	20,000,000
Total Environmental Controls ($)	25,000,000	5,000,000	20,000,000
Total Capital Costs ($)	271,635,067	38,198,381	233,436,686
Plant Size (MW)	500	100	400
Total Capital Costs ($2002) ($/kW)	543	382	161
Total Installed Cost ($2002) ($/kW)	634	446	188
Total Installed Cost ($2004) ($/kW)	660	464	196
Other Fixed Costs			
Fixed O&M ($/kW-yr levelized)	5	14	(9)
Insurance ($/kW-yr levelized)	11	8	3

Source: "Comparative Cost of California Central Station Electricity Generation Technologies," California Energy Commission Staff Report, 100-03-001, August 2003.

Notes:

1. Land area for the CT was shown as "50 acres" in CEC report but it is assumed that

the land area is actually same as assumed for the CC (15 acres).
2. Air emission offest costs are for the San Diego region, as estimated by CEC.
3. Interconnection costs are not included in the CEC report. Generic CC and CT plants are assumed to have the same interconnection costs.
4. Total Installed Cost includes AFUDC and sales tax.
5. Fixed O&M includes labor costs and overhead.

Construction Financing and Sales Tax (Note: the AFUDC method used replicates that used by the CEC, however the calculation appears to be incorrect.)

	Interest Rate	10.30%					
CC	Years Out from Online Date		0	-1	-2	-3	-4
	Cost %/Year		75%	20%	5%	0%	0%
	Carry Over		552	137	27		
	California Sales Tax	7.67%					
	Installed Cost		594				
CT	Years Out from Online Date		0	-1	-2	-3	-4
	Cost %/Year		75%	20%	5%	0%	0%
	Carry Over		388	96	19		
	California Sales Tax	7.67%					
	Installed Cost		418				

Construction Financing and Sales Tax (Note: the AFUDC method used by the CEC is corrected in the calculations below)

	Interest Rate	10.30%					
CC	Years Out from Online Date		0	-1	-2	-3	-4
	Cost %/Year		75%	20%	5%	0%	0%
	Carry Over		589	146	29		
	California Sales Tax	7.67%					
	Installed Cost		634				
CT	Years Out from Online Date		0	-1	-2	-3	-4
	Cost %/Year		75%	20%	5%	0%	0%
	Carry Over		414	102	20		
	California Sales Tax	7.67%					
	Installed Cost		446				