APPENDIX BD
BEST AVAILABLE CONTROL TECHNOLOGY DETERMINATION (BACT)

El Paso Belle Glade Energy Center
PSD-FL-317 and 0990594-001-AC
Palm Beach, Florida

BACKGROUND

The applicant, El Paso Merchant Energy Company (El Paso), proposes to install three nominal 175-megawatt (MW) General Electric PG 7241FA (GE 7FA) combustion turbine-electrical generators at the planned Belle Glade Energy Center in Palm Beach County. The proposed project will constitute a New Major Facility per Rule 62-212.400(d)2.b., Florida Administrative Code (F.A.C.). It is therefore subject to review for the Prevention of Significant Deterioration (PSD) and a determination of Best Available Control Technology (BACT) per Rule 62-212.400, F.A.C. Emissions of particulate matter (PM and PM_{10}), carbon monoxide (CO), nitrogen oxides (NO_X), sulfur dioxide (SO_2), and sulfuric acid mist (SAM) will exceed the "Significant Emission Rates" with respect to Table 212.400-2, (F.A.C.). PSD and BACT reviews are required for each of these pollutants.

Two of the units will operate in simple cycle mode and intermittent duty while the third will operate in combined cycle mode and continuous duty. The units will exhaust through separate 135-foot stacks. The units will be fired exclusively with pipeline natural gas. El Paso proposes to operate the simple cycle units up to 5,000 hours per year per unit. Descriptions of the process, project, air quality effects, and rule applicability are given in the Technical Evaluation and Preliminary Determination, accompanying the Department's Intent to Issue dated September 5, 2001.

DATE OF RECEIPT OF A BACT APPLICATION:

The application was received on March 28, 2001 (complete June 27) and included a BACT proposal prepared by the applicant's consultant, ECT.

PREPARED BY:

A. A. Linero, P.E. and Teresa Heron, Permit Engineer.

BACT DETERMINATION REQUESTED BY THE APPLICANT:

POLLUTANT	CONTROL TECHNOLOGY	PROPOSED BACT LIMIT
Nitrogen Oxides	Dry Low NO_X Combustors Selective Catalytic Reduction	9 ppmvd @ 15% O_2 (simple cycle units) 3.5 ppmvd @ 15% O_2 (combined cycle)
Particulate Matter	Pipeline Natural Gas Combustion Controls	18.3 pounds per hour (Front + Back Half, Simple) 20 pounds per hour (Front + Back Half, Combined)
Carbon Monoxide	As Above	7.4 ppmvd (Full load, Simple or Combined) 12 ppmvd (Combined Cycle Steam Augmentation)
Sulfur Oxides	As Above	1.5 grains sulfur/100 std cubic feet

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BACT DETERMINATION PROCEDURE:

In accordance with Rule 62-212.400, F.A.C., this BACT determination is based on the maximum degree of reduction of each pollutant emitted which the Department of Environmental Protection (Department), on a case by case basis, taking into account energy, environmental and economic impacts, and other costs, determines is achievable through application of production processes and available methods, systems, and techniques. In addition, the regulations state that, in making the BACT determination, the Department shall give consideration to:

- Any Environmental Protection Agency determination of BACT pursuant to Section 169, and any emission limitation contained in 40 CFR Part 60 - Standards of Performance for New Stationary Sources or 40 CFR Part 61 - National Emission Standards for Hazardous Air Pollutants.
- All scientific, engineering, and technical material and other information available to the Department.
- The emission limiting standards or BACT determination of any other state.
- The social and economic impact of the application of such technology.

The EPA currently stresses that BACT should be determined using the "Top-Down" approach, particularly when permits are issued by states acting on behalf of EPA. The Department considers Top-Down to be a useful tool, though not a unique or required approach to achieve a BACT under the State regulations. The first step in this approach is to determine, for the emission unit in question, the most stringent control available for a similar or identical emission unit or emission unit category. If it is shown that this level of control is technically or economically unfeasible for the emission unit in question, then the next most stringent level of control is determined and similarly evaluated. This process continues until the BACT level under consideration cannot be eliminated by any substantial or unique technical, environmental, or economic objections.

STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES:

The minimum basis for a BACT determination is 40 CFR 60, Subpart GG, Standards of Performance for Stationary Gas Turbines (NSPS). The Department adopted subpart GG by reference in Rule 62-204.800, F.A.C. The key emission limits required by Subpart GG are 75 ppmvd NO_X @ 15% O_2 (assuming 25 percent efficiency) and 150 ppmvd SO_2 @ 15% O_2 (or <0.8% sulfur in fuel). The BACT proposed by El Paso is well within the NSPS limit, which allows NO_X emissions in the range of 100 - 110 ppmvd for the high efficiency units to be purchased for the El Paso project.

A National Emission Standard for Hazardous Air Pollutants (NESHAP) under development exists for stationary gas turbines. However this facility will not be subject to the NESHAP or to a requirement for a case-by-case determination of maximum achievable control technology because HAP emissions will be less than 10 TPY.

DETERMINATIONS BY EPA AND STATES:

The following tables include some recently permitted simple and combined cycle turbines. The proposed El Paso project is included to facilitate comparison.

TABLE 1

RECENT NO_X EMISSION LIMIT PROPOSALS AND DETERMINATIONS FOR "F-CLASS" SIMPLE CYCLE PROJECTS IN THE SOUTHEAST

Project Location	Power Output (MW)	NO_X Limit ppmvd @ 15% O_2 and Fuel	Technology	Comments
El Paso Belle Glade, FL	350	9 - NG	DLN	2x175 MW GE 7FA CTs Draft 9/2001. Gas Only
El Paso Deerfield, FL	525	9 - NG	DLN	3x175 MW GE 7FA CTs Draft 8/2001. Gas Only
Enron Deerfield, FL	510	9 - NG 42 - No. 2 FO	DLN WI	3x170 MW GE 7FA CTs Draft 06/01. 1000 hrs on oil
Pompano Beach, FL	510	9 - NG 42 - No. 2 FO	DLN WI	3x170 MW GE 7FA CTs Draft 03/01. 1000 hrs on oil
Midway St. Lucie, FL	510	9 - NG 42 - No. 2 FO	DLN WI	3x170 MW GE 7FA CTs Issued 2/01. 1000 hrs on oil
DeSoto County, FL	510	9 - NG 42 - No. 2 FO	DLN WI	3x170 MW GE 7FA CTs Issued 7/00. 1000 hrs on oil
Shady Hills Pasco, FL	510	9 - NG 42 - No. 2 FO	DLN WI	3x170 MW GE 7FA CTs Issued 1/00. 1000 hrs on oil
Vandolah Hardee, FL	680	9 - NG 42 - No. 2 FO	DLN WI	4x170 MW GE 7FA CTs Issued 11/99. 1000 hrs on oil
Oleander Brevard, FL	850	9 - NG 42 - No. 2 FO	DLN WI	5x170 MW GE 7FA CTs Issued 11/99. 1000 hrs on oil
JEA Baldwin, FL	510	10.5 - NG 42 - No. 2 FO	DLN WI	3x170 MW GE 7FA CTs Issued 10/99. 750 hrs on oil
TEC Polk Power, FL	330	10.5 – NG 42 – No. 2 F.O.	DLN WI	2x165 MW GE 7FA CTs Issued 10/99. 750 hrs on oil
Dynegy, FL	510	15 – NG	DLN	3x170 MW WH 501F CTs Issued. Gas only
Dynegy Heard, GA	510	15 – NG	DLN	3x170 MW WH 501F CTs Issued. Gas only
Thomaston, GA	680	15 - NG 42 - No. 2 FO	DLN WI	4x170 MW GE 7FA CTs Issued. 1687 hrs on oil
Dynegy Reidsville, NC	900	15 – NG (by 2002) 42 – No. 2 FO	DLN WI	5x180 MW WH 501F CTs Initially 25 ppm NO_X limit on gas Issued. 1000 hrs on oil.
Lyondell Harris, TX	160	25 – NG	DLN	1x160 MW WH 501F CTs Issued 11/99. Gas only
Southern Energy, WI	525	15/12 – NG 42 - No. 2 FO	DLN WI	3x175 MW GE 7FA CTs 15/12 ppm are on 1/24 hr basis Issued 1/99. 800 hrs on oil
Carson Energy, CA	42	5 – NG (LAER)	Hot SCR	42 MW LM6000PA. Startup 1995. Ammonia limit is 20 ppmvd
McClelland AFB, CA	85	5 – NG (LAER)	Hot SCR	85 MW GE 7EA. Applied 1999 Ammonia proposal 10 ppmvd
Lakeland, FL	250 CON	9/9 – NG (by 2002) 42/15 - No. 2 FO	DLN/HSCR WI/HSCR	250 MW WH 501G CT Initially 25 ppm NO_X limit on gas Issued 7/98. 250 hrs on oil.

PREPA, PR	248 CON	10 - No. 2 FO	WI & HSCR	3x83 MW ABB GT11N CTs Issued 12/95.

CON = Continuous
SC = Simple Cycle
INT = Intermittent
DLN = Dry Low NO_X Combustion
SCR = Selective Catalytic Reduction
HSCR = Hot SCR
FO = Fuel Oil
NG = Natural Gas
WI = Water or Steam Injection
GE = General Electric
WH = Westinghouse
ABB = Asea Brown Bovari

TABLE 2

RECENT CO, VOC, AND PM EMISSION LIMIT PROPOSALS AND DETERMINATIONS FOR "F-CLASS" SIMPLE CYCLE PROJECTS

Project Location	**CO - ppm (or as indicated)**	**VOC - ppm (or as indicated)**	**PM - lb/hr (or as indicated)**	**Technology and Comments**
El Paso Belle Glade, FL	8 (7.4@15% O_2) - NG	1.4 (1.3@15% O_2)	18 lb/hr (Front & Back)	Clean Fuels Good Combustion
El Paso Deerfield, FL	8 (7.4@15% O_2) - NG	1.4 (1.3@15% O_2)	18 lb/hr (Front & Back)	Clean Fuels Good Combustion
Enron Deerfield, FL	9 - NG 30 - FO	1.4 – NG 1.4– FO	18 lb/hr - NG 34 lb/hr - FO	Clean Fuels Good Combustion
Pompano Beach, FL	9 - NG 30 - FO	1.4 – NG 1.4– FO	10 lb/hr - NG 17 lb/hr - FO	Clean Fuels Good Combustion
Midway St. Lucie, FL	9 - NG 30 - FO	1.4 – NG 1.4– FO	10 lb/hr - NG 17 lb/hr - FO	Clean Fuels Good Combustion
DeSoto County, FL	12 - NG 20 - FO	1.4 – NG 7 – FO	10 lb/hr - NG 17 lb/hr - FO	Clean Fuels Good Combustion
Shady Hills Pasco, FL	12 - NG 20 - FO	1.4 – NG 7 – FO	10 lb/hr - NG 17 lb/hr - FO	Clean Fuels Good Combustion
Vandolah Hardee, FL	12 - NG 20 - FO	1.4 – NG 7 – FO	10 lb/hr - NG 17 lb/hr - FO	Clean Fuels Good Combustion
Oleander Brevard, FL	12 - NG 20 - FO	3 – NG 6 – FO	10% Opacity	Clean Fuels Good Combustion
JEA Baldwin, FL	12 - NG 20 - FO	1.4 – NG/FO Not PSD	9/17 lb/hr – NG/FO 10% Opacity	Clean Fuels Good Combustion
TEC Polk Power, FL	15 - NG 33 - FO	7 – NG 7 – FO	10% Opacity	Clean Fuels Good Combustion
Dynegy, FL	25 - NG	? – NG	? - NG	Clean Fuels Good Combustion
Dynegy Heard Co., GA	25 - NG	? – NG	? - NG	Clean Fuels Good Combustion
Tenaska Heard Co., GA	15 - NG 20 - FO	? – NG ? – FO	? - NG ? lb/hr - FO	Clean Fuels Good Combustion
Dynegy Reidsville, NC	25 - NG 50 - FO	6 lb/hr – NG 8 lb/hr – FO	6 lb/hr - NG 23 lb/hr - FO	Clean Fuels Good

				Combustion
Lyondell Harris, TX	25 - NG			Clean Fuels Good Combustion
Southern Energy, WI	12@>50% load – NG 15@>75% 24@<75% - FO	2 - NG 5 - FO	18 lb/hr – NG 44 lb/hr - FO	Clean Fuels Good Combustion
RockGen Cristiana, WI	12@>50% load – NG 15@>75% 24@<75% - FO	2 - NG 5 - FO	18 lb/hr – NG 44 lb/hr - FO	Clean Fuels Good Combustion
Carson Energy, CA	6 – NG			Oxidation Catalyst
McClelland AFB, CA	23 – NG	3.9 - NG	7 lb/hr	Clean Fuels Good Combustion
Lakeland, FL	25 - NG or 10 by Ox Cat 75 - FO @ 15% O_2	4 – NG 10 – FO	10% Opacity	Clean Fuels Good Combustion
PREPA, PR	9 – FO @15% O_2	11 – FO @15% O_2	0.0171 gr/dscf	Clean Fuels Good Combustion

TABLE 3

RECENT NO_X EMISSION LIMIT DETERMINATIONS FOR "F-CLASS" COMBINED CYCLE PROJECTS IN THE SOUTHEAST

Project Location	**Capacity Megawatts**	**NO_X Limit ppmvd @ 15% O_2 and Fuel**	**Technology**	**Comments**
El Paso Belle Glade, FL	250	2.5 – NG	SCR	175 MW GE 7FA Draft 9/2001
El Paso Deerfield, FL	250	2.5 – NG	SCR	175 MW GE 7FA Draft 8/2001
CPV Pierce, FL	245	2.5 – NG 10 – FO	SCR	170 MW GE 7FA CT 7/2001
Metcalf Energy, CA	600	2.5 – NG	SCR	2x170 MW WH501F & Duct Burners
Enron/Ft. Pierce, FL	~250	3.5 – NG 10 - FO	SCR	170 MW MHI501F CT Repowering
CPV Atlantic, FL	245	3.5 – NG 10 – FO	SCR	170 MW GE 7FA CT
TECO Bayside, FL	1750	3.5 – NG 12 - FO	SCR	7x170 MW GE 7FA CTs Repowering
FPC Hines II, FL	530	3.5 - NG 12 - FO	SCR	2x170 MW WH501F
Calpine Osprey, FL	527	3.5 – NG	SCR	2x170 MW WH501F Draft 5/00
Calpine Blue Heron, FL	1080	3.5 – NG	SCR	4x170 MW WH501F Draft 2/00
Santee Cooper, SC	~500	9 – NG	DLN	2x170 MW GE 7FA CTs ~ 4/00
Mobile Energy, AL	~250	~3.5 - NG ~11 – FO	SCR	178 MW GE 7FA CT 1/99
Alabama Power Barry	800	3.5 - NG	SCR	3x170 MW GE 7FA CTs 11/98
Alabama Power Theo	210	3.5 – NG	SCR	4x170 MW GE 7FA CTs 11/98
KUA Cane Island 3, FL	250	3.5 – NG (12 – simple cycle) 15 - FO	SCR	170 MW GE 7FA. 11/99 DLN on simple cycle
Lake Worth LLC, FL	250	9 or 3.5 – NG 9.4 or 3.5 – NG (CT&DB) 42 or 16.4 - FO	DLN or SCR DLN or SCR WI or SCR	170 MW GE 7FA. 11/99 Increase allowed for DB under DLN.
Miss Power Daniel	1000	3.5 – NG	SCR	4x170 MW GE 7FA CTs 11/98

DB = Duct Burner	DLN = Dry Low NO_X Combustion	GE = General Electric
NG = Natural Gas	SCR = Selective Catalytic Reduction	WH = Westinghouse
FO = Fuel Oil	WI = Water or Steam Injection	CT = Combustion Turbine

TABLE 4

RECENT CO, VOC, AND PM EMISSION LIMIT PROPOSALS AND DETERMINATIONS FOR "F-CLASS" COMBINED CYCLE PROJECTS

Project Location	**CO - ppmvd (or lb/mmBtu)**	**VOC - ppmv (or lb/mmBtu)**	**PM - lb/mmBtu (or gr/dscf or lb/hr)**	**Technology and Comments**
El Paso Belle Glade, FL	9 (7.4 @15% O_2) 15 (12 @15% O_2) (PA)	1.4 - NG	20 lb/hr – (Front & Back) 5 ppmvd Ammonia Slip	Clean Fuels Good Combustion
El Paso Deerfield, FL	9 (7.4 @15% O_2) 15 (12 @15% O_2) (PA)	1.4 - NG	20 lb/hr – (Front & Back) 5 ppmvd Ammonia Slip	Clean Fuels Good Combustion
CPV Pierce, FL	9 - NG (50 - 100% load) 15 - NG (PA) 20 – FO	1.4 – NG 3.5 FO	11 lb/hr – NG (front) 36 lb/hr – FO (front) 5 ppmvd Ammonia Slip	Clean Fuels Good Combustion
Metcalf Energy, CA	6 - NG (100% load)	.00126 lb/mmBtu-NG	12 lb/hr – NG (w DB) 5 ppmvd Ammonia Slip	Clean Fuels Good Combustion
Enron Ft. Pierce, FL	3.5 - NG 10 - Low Load 8 - FO	2.2 - NG 16 – Low Load 10 - FO	10% Opacity	Oxidation Catalyst Clean Fuels Good Combustion
CPV Atlantic, FL	9 - NG (50 - 100% load) 15 - NG (PA) 20 – FO	1.4 – NG 3.5 FO	11 lb/hr – NG (front) 36 lb/hr – FO (front) 5 ppmvd Ammonia Slip	Clean Fuels Good Combustion
TECO Bayside, FL	9 – NG (24-hr CEMS) 20 – FO (24-hr CEMS)	1.3 – NG 3 - FO	12 lb/hr – NG 30 lb/hr - FO	Clean Fuels Good Combustion
FPC Hines II, FL	16 - NG (24-hr CEMS) 30 – FO (24-hr CEMS)	2 – NG 10 – FO	10% Opacity – NG 5/9 ammonia – NG/FO	Clean Fuels Good
Calpine Osprey, FL	10 – NG 17 – NG (DB&PA)	2.3 – NG 4.6 – NG (DB&PA)	24 lb/hr – NG (DB&PA) 10 percent Opacity 9 ppmvd Ammonia Slip	Clean Fuels Good Combustion
Calpine Blue Heron, FL	10 – NG (24-hr CEMS) 17 – NG (DB&PA)	1.2 – NG 6.6 – NG (DB&PA)	31.9 lb/hr – NG (DB&PA) 10 percent Opacity 5 ppmvd Ammonia Slip	Clean Fuels Good Combustion
Mobile Energy, AL	~18 – NG ~26 – FO	~5 – NG ~6 - FO	10% Opacity	Clean Fuels Good Combustion
Alabama Power Barry	~15 – NG(CT) ~25 – NG(DB & CT)	~8 - NG(CT) ~12 – NG(CT & DB)	0.010 lb/mmBtu – (CT) 0.011 lb/mmBtu - (CT/DB) 10% Opacity	Clean Fuels Good
Alabama Power Theo	~36 – CT & DB	~12.5 CT & DB		Clean Fuels Good

				Combustion
KUA Cane Island	10 - NG (CT) 20 - NG (CT&DB) 30 - FO	1.4 - NG (CT) 4 - NG (CT&DB) 10 - FO	10% Opacity	Clean Fuels Good Combustion
Lake Worth LLC, FL	9 - NG (CT) 15 – NG (CT & DB) 20 - F.O. (3-hr)	1.4 - NG (CT) 1.8 - NG (CT & DB) 3.5 – F.O.	10% Opacity	Clean Fuels Good Combustion
Miss Power Daniel	~15 - NG(CT) ~25 – NG(DB & CT	~8 - NG(CT) ~12 – NG(CT & DB)	0.010 lb/mmBtu – (CT) 0.011 lb/mmBtu - (CT/DB) 10% Opacity	Clean Fuels Good Combustion

All of the projects listed above control SO_2 and sulfuric acid mist by limiting the sulfur content of the fuel. In every case, pipeline quality natural gas is used and has a sulfur content less than 2 grains per 100 cubic feet. In some cases, the limits are even lower or are expressed in different terms. However all ultimately rely on a fairly uniform gas distribution network and have very little flexibility in actually controlling sulfur content. Similarly, emissions of these two pollutants are controlled by using 0.05 percent sulfur distillate fuel oil.

Some of the projects listed above include front and back half catch for PM limits. Therefore comparison is not simple.

REVIEW OF NITROGEN OXIDES CONTROL TECHNOLOGIES:

Total annual emissions of NO_X for the project are expected to be approximately 365 tons per year. Some of the discussion in this section is based on a 1993 EPA document on Alternative Control Techniques for NO_X Emissions from Stationary Gas Turbines. Project-specific information is included where applicable.

Nitrogen Oxides Formation

Nitrogen oxides form in the gas turbine combustion process as a result of the dissociation of molecular nitrogen and oxygen to their atomic forms and subsequent recombination into seven different oxides of nitrogen. Thermal NO_X forms in the high temperature area of the gas turbine combustor. Thermal NO_X increases exponentially with increases in flame temperature and linearly with increases in residence time. Flame temperature is dependent upon the ratio of fuel burned in a flame to the amount of fuel that consumes all of the available oxygen.

By maintaining a low fuel ratio (lean combustion), the flame temperature will be lower, thus reducing the potential for NO_X formation. Prompt NO_X is formed in the proximity of the flame front as intermediate combustion products. The contribution of Prompt to overall NO_X is relatively small in near-stoichiometric combustors and increases for leaner fuel mixtures. This provides a practical limit for NO_X control by lean combustion.

In all but the most recent gas turbine combustor designs, the high temperature combustion gases are cooled to an acceptable temperature with dilution air prior to entering the turbine (expansion) section.

The sooner this cooling occurs, the lower the thermal NO_X formation. Cooling is also required to protect the first stage nozzle. When this is accomplished by air cooling, the air is injected into the component and is ejected into the combustion gas stream, causing a further drop in combustion gas temperature. This, in turn, lowers achievable thermal efficiency for the unit.

The relationship between flame temperature, firing temperature, unit efficiency, and NO_X formation can be appreciated from Figure 1 which is from a General Electric discussion on these principles.

Fuel NO_X is formed when fuels containing bound nitrogen are burned. This phenomenon is not important for natural gas-fired projects such as the El Paso Belle Glade Energy Center.

Uncontrolled emissions range from about 100 to over 600 parts per million by volume, dry, corrected to 15 percent oxygen (ppmvd @15% O_2). The Department estimates uncontrolled emissions at approximately 200 ppmvd @15% O_2 for each turbine of the El Paso project. The proposed NO_X controls will reduce these emissions significantly.

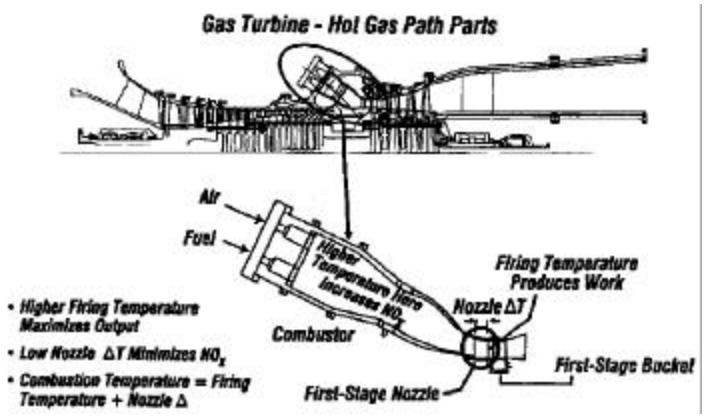

Figure 1 – Relation Between Flame Temperature and Firing Temperature

NO_X Control Techniques

Wet Injection

Injection of either water or steam directly into the combustor lowers the flame temperature and thereby reduces thermal NO_X formation. Typical emissions achieved by wet injection are in the range of 15–25 ppmvd when firing gas and 30 - 42 ppmvd when firing fuel oil in large combustion turbines. These values often form the basis, particularly in combined cycle turbines, for further reduction to BACT limits by other techniques. Carbon monoxide (CO) and hydrocarbon (HC) emissions are relatively low for most gas turbines. However steam and (more so) water injection may increase emissions of both of these pollutants.

Combustion Controls: Dry Low NO_X (DLN)

The excess air in lean combustion cools the flame and reduces the rate of thermal NO_X formation. Lean premixing of fuel and air prior to combustion can further reduce NO_X emissions. This is accomplished by minimizing localized fuel-rich pockets (and high temperatures) that can occur when trying to achieve lean mixing within the combustion zones.

The above principle is incorporated into the General Electric DLN-2.6 can-annular combustor shown in Figure 2.

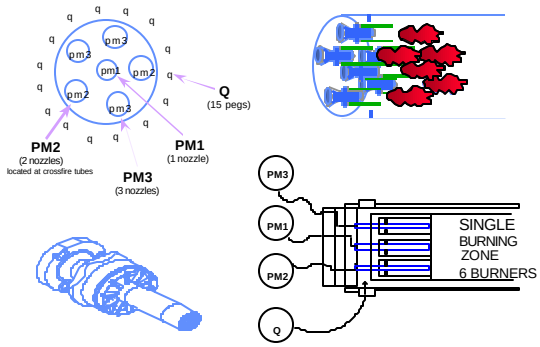

Figure 2 – DLN-2.6 Fuel Nozzle Arrangement

Each combustor includes six nozzles within which fuel and air have been fully pre-mixed. There are 16 small fuel passages around the circumference of each combustor can known as quarternary fuel pegs. The six nozzles are sequentially ignited as load increases in a manner that maintains lean pre-mixed combustion and flame stability.

Design emission characteristics of the DLN-2.6 combustor while firing natural gas are given in Figure 3 for a unit tuned to meet a 15 ppmvd NO_X limit (by volume, dry corrected to at 15 percent oxygen) at JEA's Kennedy Station. The combustor can be tuned differently to achieve emissions as low as 9 ppm of NO_X.

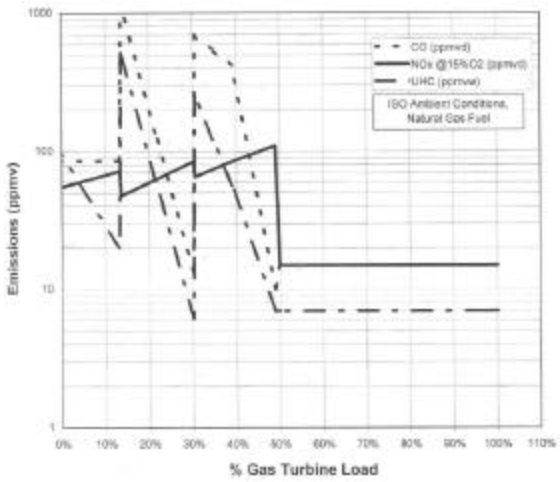

Figure 3 – Emissions Characteristics for DLN-2.6 (if tuned to 15 ppmvd NO_X)

The combustor emits NO_X at concentrations of 15 ppmvd at loads between 50 and 100 percent of capacity, but concentrations as high as 100 ppmvd may occur at less than 50 percent of capacity. Note that VOC comprises a very small amount of the "unburned hydrocarbons" which in turn is mostly non-VOC methane.

Following are the results of the new and clean tests conducted on a dual-fuel GE 7FA combustion turbine operating in combined cycle mode and burning natural gas at the City of Tallahassee Purdom Station Unit 8.[1] The DLN-2.6 combustors for this project were guaranteed to achieve 9 ppmvd of NO_X while burning natural gas although the permit limit is 12 ppmvd. The results are all superior to the emission characteristics given in Figure 3.

Percent of Full Load	NO_X (ppmvd @15% O_2)	CO (ppmvd)
70	7.2	
80	6.1	
90	6.6	
100	8.7	0.85
Limit	12	25

Following are the results of the new and clean tests conducted on a dual-fuel GE 7FA combustion turbine operating in simple cycle mode and burning natural gas at the Tampa Electric Polk Power Station.[2] The DLN 2-6 combustors for this project were guaranteed to achieve 9 ppmvd of NO_X while burning natural gas although the permit limit is 10.5 ppmvd. Again, the results are all superior to the emission characteristics given in Figure 3.

Percent of Full Load	NO_X (ppmvd @15% O_2)	CO (ppmvd)	VOC (ppmvd)
50	5.3	1.6	0.5
70	6.3	0.5	0.4
85	6.2	0.4	0.2
100	7.6	0.3	0.1
Limit	10.5	15	7

Recent conversations with other operators indicate that the "Dry Low NO_X" characteristics extend to operations less than 50 percent of full load, though such operation is not (yet) guaranteed by GE.[3]

An important consideration is that power and efficiency are sacrificed in the effort to achieve low NO_X by combustion technology. This limitation is seen in Figure 4 from an EPRI report.[4] Developments such as single crystal blading, aircraft compressor design, high technology blade cooling have helped to greatly increase efficiency and lower capital costs. Further improvements are more difficult in large part because of the competing demands for air to support lean premix combustion and to provide blade cooling. New concepts are under development by GE and the other turbine manufacturers to meet the challenges implicit in Figure 4.

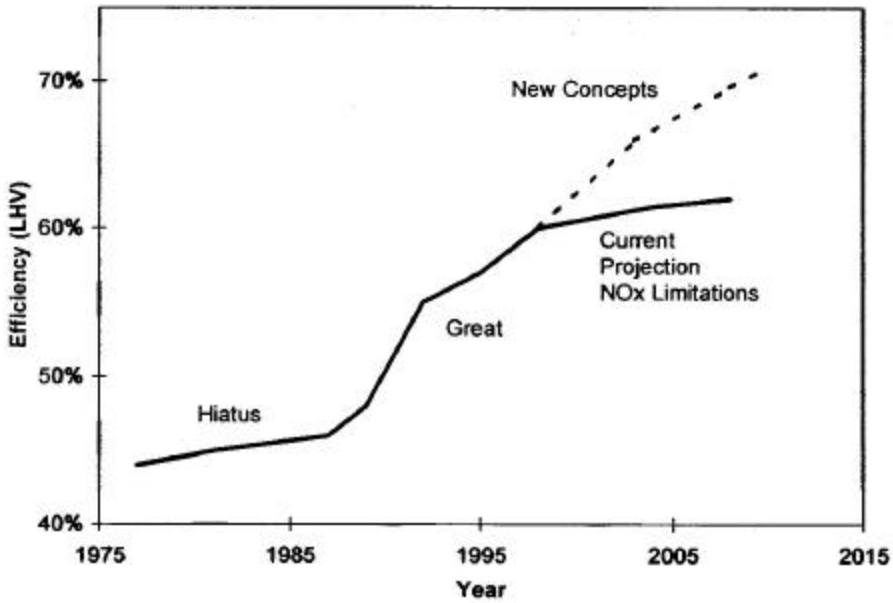

Figure 4 – Efficiency Increases in Combustion Turbines

Further NO_X reductions related to flame temperature control are possible such as closed loop steam cooling. This feature is available only in larger units (G or H Class technology) than the units planned by El Paso. It is more feasible for a combined cycle unit with a heat recovery steam generator (HRSG). In simple cycle, a once-through steam generator would be required. Steam is circulated through the internal portion of the nozzle component, the transition piece between the combustor and the nozzle, or certain turbine blades. The difference between flame temperature and firing temperature into the first stage is minimized and higher efficiency is attained. Flame temperatures and NO_X emissions can therefore be maintained at comparatively low levels even at high firing temperatures (refer back to figure 1). At the same time, thermal efficiency should be greater when employing steam cooling instead of air cooling.

Catalytic Combustion: XONON™

Catalytic combustion involves using a catalytic bed to oxidize a lean air and fuel mixture within a combustor instead of burning with a flame as described above. In a catalytic combustor the air and fuel mixture oxidizes at lower temperatures, producing less NO_X.[5] In the past, the technology was not reliable because the catalyst would not last long enough to make the combustor economical.

There has been increased interest in catalytic combustion as a result of technological improvements and incentives to reduce NO_X emissions without the use of add-on control equipment and reagents. Westinghouse, for example, is working to replace the central pilot in its DLN technology with a catalytic pilot in a project with Precision Combustion Inc.

Catalytica has developed a system know as XONON™, which works by partially burning fuel in a low temperature pre-combustor and completing the combustion in a catalytic combustor. The overall result is low temperature partial combustion (and thus lower NO_X production) followed by flameless catalytic combustion to further attenuate NO_X formation.

In 1998, Catalytica announced the startup of a 1.5 MW Kawasaki gas turbine equipped with XONON™.[6] The turbine is owned by Catalytica and is located at the Gianera Generating Station of Silicon Valley Power, a municipally owned utility serving the City of Santa Clara, California. Previously, this turbine and XONON™ system had successfully completed over 1,200 hours of extensive full-scale tests at a project development facility in Oklahoma that documented XONON's ability to limit emissions of NO_X to less than 3 ppmvd.

Catalytica and GE initially announced that the XONON™ combustion system has been specified as the *preferred* emissions control system for Enron's proposed 750 MW Pastoria Energy Facility.[7] The project will enter commercial in 2003. However SCR will be installed instead of XONON™.

In principle, XONON™ will work on a simple cycle project. However, the Department does not have information regarding the status of the technology for fuel oil firing and cycling operations.

Selective Catalytic Combustion: SCR

Selective catalytic reduction (SCR) is an add-on NO_X control technology that is employed in the exhaust stream following the gas turbine. SCR reduces NO_X emissions by injecting ammonia into the flue gas in the presence of a catalyst. Ammonia reacts with NO_X in the presence of a catalyst and excess oxygen yielding molecular nitrogen and water. The catalysts used in combined cycle, low temperature applications (conventional SCR), are usually vanadium or titanium oxide and

account for almost all installations. For high temperature applications (Hot SCR up to 1100 ^{o}F), such as simple cycle turbines, zeolite catalysts are available but used in few applications to-date. SCR units are typically used in combination with wet injection or DLN combustion controls.

In the past, sulfur was found to poison the catalyst material. Sulfur-resistant catalyst materials are now becoming more available. Catalyst formulation improvements have proven effective in resisting sulfur-induced performance degradation with fuel oil in Europe and Japan, where conventional SCR catalyst life in excess of 4 to 6 years has been achieved, while 8 to 10 years catalyst life has been reported with natural gas.

Excessive ammonia use tends to increase emissions of CO, ammonia (slip) and particulate matter (when sulfur-bearing fuels are used).

Kissimmee Utilities Authority (KUA) will install SCR at the Cane Island Unit 3 project. The KUA project will meet a limit of 3.5 ppmvd with a combination of DLN and SCR. Permits were issued recently to Competitive Power Ventures (CPV), Calpine, Florida Power Corporation, and Tampa Electric to achieve 3.5 ppmvd. More recently a permit was issued to CPV for its Pierce, Polk County project with a limit of 2.5 ppmvd @15% O_2 by SCR.

Figure 5 below is a diagram of a HRSG including an SCR reactor with honeycomb catalyst and the ammonia injection grid. The SCR system lies between low and high-pressure steam systems where the temperature requirements for conventional SCR can be met. Figure 6 is a photograph of FPC Hines Energy Complex. The external lines to the ammonia injection grid are easily visible. The magnitude of the installation can be appreciated from the relative size compared with nearby individuals and vehicles.

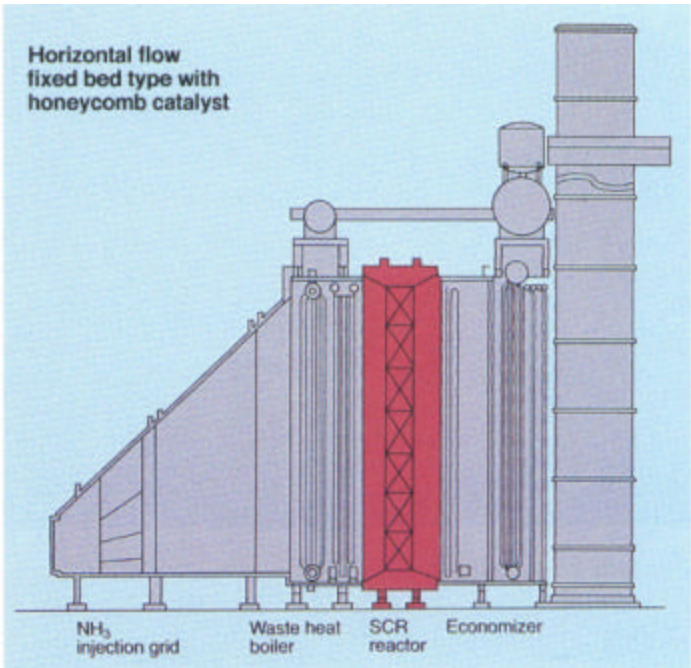

Figure 5 – SCR System within HRSG

Figure 6 – FPC Hines Power Block I

Selective Non-Catalytic Combustion

Selective non-catalytic reduction (SNCR) works on the same principle as SCR. The differences are that it is applicable to hotter streams than conventional or hot SCR, no catalyst is required, and urea can be used as a source of ammonia. No applications have been identified wherein SNCR was applied to a gas turbine because the exhaust temperature of 1100 ^{o}F is too low to support the NO_X removal mechanism.

The Department did, however, specify SNCR as one of the available options for the combined cycle Santa Rosa Energy Center. The project will incorporate a large 600 MMBtu/hr duct burner in the heat recovery steam generator (HRSG) and can provide the acceptable temperatures (between 1400 and 2000 ^{o}F) and residence times to support the reactions.

$SCONO_X$™

$SCONO_X$™ is a catalytic add-on technology that achieves NO_X control by oxidizing and then absorbing the pollutant onto a honeycomb structure coated with potassium carbonate. The pollutant is then released as molecular nitrogen during a regeneration cycle that requires dilute hydrogen gas. The technology has been demonstrated on small units in California and has been purchased for a small source in Massachusetts.[8]

California regulators and industry sources stated that the first 250 MW block to install $SCONO_X$™ will be at PG&E's La Paloma Plant near Bakersfield.[9] The overall project includes several more 250 MW blocks with SCR for control.[10] USEPA has identified an "achieved in practice" BACT value of 2.0 ppmvd over a three-hour rolling average based upon the recent performance of a Vernon, California natural gas-fired 32 MW combined cycle turbine equipped with $SCONO_X$™.

$SCONO_X$™ technology (at 2.0 ppmvd) is considered to represent LAER in non-attainment areas where cost is not a factor in setting an emission limit. It competes with less-expensive SCR in those areas, but has the advantages that it does not cause ammonia emissions in exchange for NO_X reduction. Advantages of the $SCONO_X$ ™ process include in addition to the reduction of NO_X, the elimination of ammonia and the control of VOC and CO emissions. $SCONO_X$™ has not been applied on any major sources in ozone attainment areas.

Recently EPA Region IX acknowledged that $SCONO_X$™ was demonstrated in practice to achieve 2.0 ppmv NO_X. [11] Permitting authorities planning to issue permits for future combined cycle gas turbine systems firing exclusively on natural gas, and subject to LAER must recognize this limit which, in most cases, would result in a LAER determination of 2.0 ppmvd. More recently, Goal Line announced that $SCONO_X$™ has in practice achieved emissions of 1.3 ppmvd.[12]

According to a recent press release, the Environmental Segment of ABB Alstom Power offers the technology (with performance guarantees) to "all owners and operators of natural gas-fired combined cycle combustion turbines, regardless of size."[13]

$SCONO_X$ requires a much lower temperature regime that is not available in simple cycle units and is therefore not feasible for the simple cycle units proposed in this application.

REVIEW OF SULFUR DIOXIDE (SO_2) AND SULFURIC ACID MIST (SAM)

SO_2 control processes can be classified into five categories: fuel/material sulfur content limitation, absorption by a solution, adsorption on a solid bed, direct conversion to sulfur, or direct conversion to sulfuric acid. A review of the BACT determinations for combustion turbines contained in the BACT Clearinghouse shows that the exclusive use of low sulfur fuels constitutes the top control option for SO_2 from natural gas and fuel oil-fired combustion turbines.

For this project, the applicant has proposed as BACT the use of pipeline natural gas. The applicant estimated total emissions for the project at 69 TPY of SO_2 and 10 TPY of SAM. The Department expects the emissions to be lower because the typical natural gas in Florida contains less than the 1.5 grains of sulfur per 100 standard cubic feet (gr S/100scf) specification proposed by El Paso. This value is well below the "default" maximum value of 20 gr S/100 scf characteristic of natural gas, but is still high enough to require a BACT determination.

REVIEW OF PARTICULATE MATTER (PM/PM_{10}) CONTROL TECHNOLOGIES:

Particulate matter is generated by various physical and chemical processes during combustion and will be affected by the design and operation of the NO_X controls. The particulate matter emitted from this unit will mainly be less than 10 microns in diameter (PM_{10}).

Natural gas will be the only fuel fired and is efficiently combusted in gas turbines. Clean fuels are necessary to avoid damaging turbine blades and other components already exposed to very high temperature and pressure. Natural gas is an inherently clean fuel and contains no ash.

A technology review indicated that the top control option for PM/PM_{10} is a combination of good combustion practices, fuel quality, and filtration of inlet air. Total annual emissions of PM_{10} for the project are expected to be approximately 181 tons per year (including filterable and condensable particulate fractions).

Drift eliminators will be installed on the freshwater mechanical draft cooling tower to reduce PM/PM_{10}. The drift eliminators proposed by El Paso will reduce drift to 0.0005 percent of the circulating water flow rate. This is equivalent to approximately 1 and 1.6 tons per year of PM_{10}.and PM respectively.

REVIEW OF CARBON MONOXIDE (CO) CONTROL TECHNOLOGIES

CO is emitted from combustion turbines due to incomplete fuel combustion. Combustion design and catalytic oxidation are the control alternatives that are viable for the project. The most stringent control technology for CO emissions is the use of an oxidation catalyst.

CO is emitted from combustion turbines due to incomplete fuel combustion. Most combustion turbines incorporate good combustion to minimize emissions of CO. There is a great deal of uncertainty regarding actual CO emissions from installed units. Despite the relatively high BACT limits typically proposed when using combustion controls, much lower emissions have actually been reported from several facilities without use of oxidation catalyst. For example, although Westinghouse does not offer a single digit CO guarantee on the 501F, the units installed at the FPC Hines Energy Complex achieved CO emissions in the range of 1-3 ppmvd on both gas and fuel oil at full load.[14] As previously discussed, GE 7FA units achieved similar results when firing gas at the City of Tallahassee Purdom Unit 8 and the TECO Polk Power Station Unit 2 at loads between 50 and 100 percent.

CO emissions *should* be low (at least at full load) because of the very high combustion temperatures characteristic of "F-Class" turbines. It appears that contract writing has not yet "caught up" with the field experience to consistently guarantee low CO emissions for F-Class units, at least at high loads.

One alternative is to complete the combustion by installation of an oxidation catalyst. Among the most recently permitted projects with oxidation catalyst requirements are the 500 MW Wyandotte Energy project in Michigan, the El Dorado project in Nevada, Ironwood in Pennsylvania, Millennium in Massachusetts, and Sutter Calpine in California. The permitted CO values of these units are between 3 and 5 ppmvd.

A recent permit was issued by the Bay Area AQMD in California for the Metcalf Energy Center. The limit for CO from a Siemens-Westinghouse 501F gas turbine is 6 ppmvd (at full load). No Catalyst is required. However it is doubtful that performance can be maintained at low load.

A recent draft permit was issued by the Department that limits CO to 3.5 ppmvd on a Mitsubishi 501F combustion turbine.[15] Enron will install an oxidation catalyst at Ft. Pierce in order to avoid high CO emissions at low load (<70 percent of full load). This results in the ability to obtain a guarantee for the low permitted level at full load. This would not have been a concern if the units were GE7FAs for the reasons discussed above.

The limit originally proposed by El Paso for the Belle Glades Energy Center under normal operation is 7.4 ppmvd @15% O_2 at full load. This is consistent with the description of the DLN-2.6 technology. The expected results are 1-2 ppmvd and are actually better than what the Enron and Metcalf projects will likely achieve across the 50-100 percent operating range.

A higher limit of 12 ppmvd @15% O_2 was originally proposed during power augmentation for the combined cycle unit. Under this mode, steam from the HRSG is re-injected into the combustors to boost power production. One consequence is that CO emissions can increase.

Since the original review, El Paso proposed oxidation catalyst to allow continuous power augmentation and to minimize startup emissions. Total annual emissions of CO for the project are now expected to be little more than 100 tons per year based on the new proposed limits of 2.5 ppmvd under normal modes and 4 ppmvd during power augmentation. Actual emissions will probably be much lower.

REVIEW OF VOLATILE ORGANIC COMPOUND (VOC) CONTROL TECHNOLOGIES

Volatile organic compound (VOC) emissions, like CO emissions, are formed due to incomplete combustion of fuel. The high flame temperature is very efficient at destroying VOC. The applicant has proposed good combustion practices to control VOC. The limit proposed by El Paso for this project is 1.1 ppmvd @ 15% O_2 for all modes of operation. According to GE (and Department data), VOC emissions less than 1.4 ppm were achieved during recent tests of the DLN-2.6 technology when firing natural gas.[16]

Based on the chosen equipment, the Department believes that annual VOC emissions will be less than 40 TPY. Therefore a BACT determination is not required.

BACKGROUND ON PROPOSED GAS TURBINE

El Paso plans to install three nominal 175-MW General Electric 7FA gas turbines, one of which will operate in combined cycle mode. Per the discussion above, such units are capable of achieving and have achieved (with DLN and SCR technology) all of the emission limits proposed by El Paso as BACT.

The GE Speedtronic™ Mark VI Gas Control System will be used. This control system is designed to fulfill all gas turbine control requirements. These include fuel control in accordance with the requirements of the speed, load control under part-load conditions, temperature control under maximum capability conditions, or during start-up conditions. The Mark VI also monitors the DLN process and controls fuel staging and combustion modes to maintain the programmed NO_X values.[17]

STARTUP AND SHUTDOWN EMISSIONS

The Department defines "Startup" as follows[18]:

"Startup" - The commencement of operation of any emissions unit which has shut down or ceased operation for a period of time sufficient to cause temperature, pressure, chemical or pollution control device imbalances, which result in excess emissions.

The Department permits excess emissions during startup and shut down as follows:[19]

Excess emissions resulting from startup, shutdown or malfunction of any emissions unit shall be permitted providing (1) best operational practices to minimize emissions are adhered to and (2) the duration of excess emissions shall be minimized but in no case exceed two hours in any 24 hour period unless specifically authorized by the Department for longer duration.

The Department defines "Excess Emissions" as follows:[20]

"Excess Emissions" - Emissions of pollutants in excess of those allowed by any applicable air pollution rule of the Department, or by a permit issued pursuant to any such rule or Chapter 62-4, F.A.C. The term applies only to conditions which occur during startup, shutdown, sootblowing, load changing or malfunction.

The U.S. EPA Region IV office recently recommended that the Department consider "establishment of startup and shutdown BACT for CO and NO_X such as mass emission limits (e.g., pounds of emissions in any 24-hour period) that include startup and shutdown emissions, or future emission limits derived from monitoring results during the first few months of commercial operation."[21]

The Department reviewed a number of emission estimates and permit conditions addressing startup and shutdowns for projects in California, Georgia, Washington, and Mississippi and has determined that much of the information is based on estimates that are very difficult to verify.

A review of published General Electric information indicates that features are incorporated into the design of the DLN-2.6 technology specifically aimed at minimizing emissions. One of the key elements was to incorporate lean pre-mixed burning while operating the unit in low load and startup.[22] This is in contrast with the previous DLN-2.0 technology that relied on diffusion mode combustion at four of the burners in each combustor during startup and low load operation.

During startup of a GE 7FA <u>simple cycle</u> unit, NO_X concentrations in the exhaust are greater than during full-load operation. The concentrations are estimated at 20 to 80 ppmvd @15% O_2 during the first 10

minutes or so after the unit is actually firing fuel. This occurs while only one to four of the six nozzles shown in Figure 2 are in operation on each combustor.

Within the following 5 minutes, the unit switches to Mode 5 (or 5 Q), during which NO_X concentrations are typically less than 10 ppmvd even though the unit is not yet at full load.[23] The Low-NO_X modes occurs when at least the five outer nozzles are in operation.

Given the short duration and the relatively low exhaust rate (and load) during the high pollutant concentration phases of simple cycle startup, the Department believes that the NO_X emissions during the first hour of startup and operation will be approximately equal to emissions during an hour of full load steady-state operation. Arguments covering shutdown are similar and the time is more compressed so that the Department believes the conclusion is the same for startup as for shutdown.

NO_X concentrations in the exhaust during startup and shutdown will be less than the New Source Performance Standard limit of approximately 110 ppmvd @15% O_2 applicable to F-Class turbines. A simple cycle unit will typically have one startup and shutdown every day that it is used.

The startup scenarios for a GE 7FA <u>combined cycle</u> unit are as follows:

Hot Start: One hour following a shutdown less than or equal to 8 hours.
Warm Start: Two hours following a shutdown between 8 and 48 hours.
Cold Start: Four hours following a shutdown greater than or equal to 48 hours.

During a combined cycle cold unit startup, the gas turbine will operate at a very low load (less than 10 percent) while the heat recovery steam generator and the steam turbine-electrical generator are heated up. During a portion of the 4 hour startup, emissions will be roughly 60 to 80 ppmvd NO_X @15% O_2. Once the HRSG is heated sufficiently, the ammonia system is turned on to abate emissions.

While NO_X emissions during the initial phase of startup (low load and no ammonia injection) are greater than during full load steady state operation, such startups are infrequent. Also, it is noted that such a cold startup would be preceded by a shutdown of at least 48 hours. Therefore the startup emissions would not cause annual emissions greater than the potential-to-emit under continuous operation. Similar analyses can be performed for warm startups and hot startups.

The combined cycle startup scenario described above can (at least in theory) be modified by use of a bypass stack and damper.[24] Under this scenario, the steam cycle can be slowly brought up to load while the gas turbine reaches full load as fast as it would under simple cycle mode. The exhaust gas can be modulated in such a fashion that the HRSG and steam turbine are ramped up slowly in accordance with their respective specifications. At the same time, the gas turbine will quickly accelerate to the DLN modes (5Q or 6Q) thus minimizing emissions. In this manner the startup NO_X and CO concentrations are reduced to the values observed during simple cycle startup. Thereafter the unit will exhibit the same characteristics (for about three hours) as a simple cycle unit in steady-state operation until the ammonia system is actuated.

Implementation of bypass modulation requires an additional stack and design features to minimize stratification and uneven heating of boiler tube bundles in the HRSG. The initial response from GE is that

such a configuration at a project in Hungary resulted in equipment damage and leakage of exhaust gas to the atmosphere resulting in a significant loss in performance.[25]

The Department is gathering information from recently commissioned 7FA units to more accurately estimate startup emissions for NO_X and address carbon monoxide too.

DEPARTMENT BACT DETERMINATION

Following are the BACT limits determined for the El Paso project assuming full load. Values for NO_X and CO are corrected to 15% O_2 on a dry volume basis. These emission limits or their equivalents in terms of pounds per hour and NSPS units, as well as the applicable averaging times, are specified in the permit.

POLLUTANT	CONTROL TECHNOLOGY	DEPARTMENT'S PROPOSED BACT LIMIT
Nitrogen Oxides	Dry Low NO_X Combustors Selective Catalytic Reduction	9 ppmvd @ 15% O_2 (simple cycle units) 2.5 ppmvd @ 15% O_2 (combined cycle) 5 ppm ammonia slip from combined cycle unit
Particulate Matter	Pipeline Natural Gas Combustion Controls	20 pounds per hour (filterable plus condensable) 0.0005 % drift of circulating rate – cooling tower
Visible Emissions	As Above	10 Percent (surrogate for PM_{10})
Carbon Monoxide	As Above	7.4 ppmvd @15% O_2 (full load, simple or combined) 12 ppmvd@15% O2 (limited power augmentation)
Sulfur Oxides	As Above	1.5 grain sulfur/100 std cubic feet
All (Ancillaries)	Low Sulfur Fuels Drift Eliminators on Cooling Tower	1.5 grain sulfur/100 std cubic feet 0.05% sulfur (oil) 0.0005 percent drift

RATIONALE FOR DEPARTMENT'S DETERMINATION

- Certain control options are feasible on combined cycle units but not on simple cycle units. This rules out Low Temperature (conventional) SCR, and $SCONO_X$ on simple cycle units. XONON is claimed to be available for F Class gas-fired projects.
- The Top technology and Lowest Achievable Emission Rate (LAER) for simple cycle combustion turbines are high temperature (Hot) SCR and an emission limit of 5 ppmvd NO_X.
- It is conceivable that catalytic combustion technology such as XONON™ can be applied to this project. Theoretically XONON can achieve the 5-ppmvd NO_X value and would equate to the top technology.
- An example of the top technology is the Carson Plant in Sacramento, California where there is a Hot SCR system on a simple cycle LM6000PA combustion turbine with a limit of 5 ppmvd.

- Hot SCR is proposed as LAER for the Sacramento Municipal Utilities District simple cycle GE 7EA project at McClelland Air Force Base to achieve 5 ppmvd.
- The levelized costs of NO_X removal by Hot SCR for the El Paso project were estimated by El Paso at $22,052 per ton assuming 5,000 hours of operation. The estimates are based on reducing NO_X emissions from 9 to 3.5 ppmvd @15% O_2.
- The Department does not accept the precise Hot SCR cost calculations presented by El Paso and considers them on the high end. But even at half the cost estimated by El Paso, the Department would agree that Hot SCR is not cost-effective for this project.
- XONON is rejected because it has not yet been demonstrated in large combustion turbines and is likely to be even less cost-effective than Hot SCR.
- The Department accepts El Paso's BACT proposal of 9 ppmvd NO_X @15% O_2 for the simple cycle units and exclusive use of natural gas. The Department notes that data from the City of Tallahassee and TECO demonstrate that the GE 7FA units actually achieve 6 to 8 ppmvd @15% O_2.
- The proposed BACT limit of 9 ppmvd for the simple cycle units is less than one-tenth of the applicable NSPS limit per 40 CFR 60, Subpart GG for units as efficient as the 7FA.
- The Department's overall BACT determination for the simple cycle units is equivalent to approximately 0.35 lb of NO_X per megawatt-hour (lb/MWH) by Dry Low NO_X. For reference, the new NSPS promulgated on September 3, 1998 requires that new conventional power plants (based on boilers, etc.) meet a (fuel independent) limit of 1.6 lb/MW-hr.
- The Department will limit operation of the two units to an average of 5,000 hours per year per simple cycle unit. The Department will further limit the operation of each and every individual unit to the fuel-equivalent of 5,000 full load hours of operation. The purpose is to maintain the conclusion regarding cost-effectiveness under intermittent duty operation.
- Although startup and shutdown emissions are generally exempt, emissions during startup and shutdown are less than the NSPS limit of 110 ppmvd @15% O_2 (that applies during steady-state operation).
- The Department does not yet have sufficient information from field experience to set start-up and shutdown emissions limits. However, the modes that give rise to high NO_X concentration have been identified. The Department will therefore set a work practices standard as BACT.
- The Work Practice BACT for simple cycle startup is that the unit(s) will reach Mode 5Q (i.e. five burners plus quaternary pegs in operation) within 15 minutes following gas turbine ignition and crossfire. The shutdown case is trivial.
- The Lowest Achievable Emission Rate (LAER) for a combined cycle unit is approximately 2 ppmvd NO_X at 15 percent oxygen (@15% O_2) while firing natural gas. It has been achieved at the 32 MW Federal Merchant Plant in Los Angeles. The owner, Goal Line, has requested recognition of a 1.3 ppmvd NO_X value as *achieved in practice*.
- There are several projects for large turbines in Massachusetts, Connecticut, New York, and California requiring SCR with a NO_X emission limit of 2 ppmvd @15% O_2.

- The "Top" technology in a top/down analysis for a combined cycle unit will achieve approximately 2 ppmvd @15% O_2 by either $SCONO_X$ or SCR.
- El Paso estimated the cost effectiveness of $SCONO_X$ at $24,187 per ton of NO_X removed. The Department does not necessarily accept the precise $SCONO_X$ cost calculations presented by El Paso. However, even at half the cost estimated by El Paso, the Department agrees that $SCONO_X$ would not be cost-effective for this project.
- El Paso estimated the cost-effectiveness of conventional (cold temperature) SCR at $3,535 per ton of NO_X while reducing emissions from 9 to 3.5 ppmvd @15% O_2. The Department accepts El Paso's estimate and believes this cost-effectiveness can be maintained while achieving an NO_X emission rate of 2.5 ppmvd @15% O_2.
- The National Park Service advised in its review of the application that BACT determinations of 2.5 ppmvd NO_X @15% O_2 have recently been issued for combined cycle projects in Maine and Washington. The Park Service also agreed that 9 ppmvd represents BACT for simple cycle units.[26]
- The Department concludes that 2.5 ppmvd NO_X @15% O_2 (with 5 ppmvd ammonia slip) while firing natural gas in a combined cycle unit constitutes BACT. This value for the conventional SCR option takes into consideration the measurement uncertainties at low emission rates and minimizes particulate emissions due to ammonia emissions.
- EPA advised that the proposed 2.5 ppmvd limit is equal to the lowest value established in Region IV, that the 24-hour averaging time is acceptable in light of the low limit, and that the ammonia limit is consistent with projects outside the Region (notwithstanding lack of rule authority or a policy within EPA).
- The effects of aqueous ammonia use and ammonia slip are not unacceptable. In fact, ammonia is used throughout the fertilizer complexes in Hillsborough, Polk, and Manatee County.
- The Department's overall BACT determination for the combined cycle unit is less than 0.07 lb of NO_X per megawatt-hour (lb/MWH) by Dry Low NO_X and SCR.
- The Work Practice BACT for combined cycle startup is that the combustion turbine will start up and operate as a simple cycle unit and modulate exhaust to the HRSG. This requires installation of a bypass stack and damper. The unit shall reach Mode 5Q (i.e. five burners plus quaternary pegs in operation) within 15 minutes following gas turbine ignition and crossfire. Ammonia injection will be practiced within three hours after gas turbine ignition and crossfire.
- The Department does not have a cost estimate for the additional stack and design requirements, but believes the additional power and flexibility offered by full load simple cycle operation during the cold startup of the steam cycle more than compensates for the additional costs.
- In lieu of the Department's determination regarding Work Practice BACT, the company will install dampers (but no bypass stack) to retain as much heat as possible during periods of shutdown. This will tend to reduce the number of long cold startups in comparison with the shorter hot startups.
- The applicant estimates VOC emissions of 1.1 ppmvd @15% O_2 (or less) for all firing modes. These levels will not trigger PSD or a requirement for a BACT determination.

- El Paso estimated levelized costs at $9,000 per ton to reduce emissions at the simple cycle units from about 7.4 to 0.7 ppmvd CO @15% O_2. The Department does not adopt this estimate, but would agree that even much lower estimates would not be cost-effective for removal of CO.
- In view of the performance of GE 7FA units without add-on control (~ 0 - 4 ppmvd), it is obvious that oxidation catalyst is definitely not cost-effective for the simple cycle units based on *actual* emissions and appears to not be cost-effective based on permitted emissions.
- El Paso estimated levelized costs for CO catalyst control at $2,475 to reduce emissions from 11.7 to 1.2 ppmvd @15% O_2 for the combined cycle unit operating in power augmentation mode.
- In view of the performance of GE 7FA units cited in the discussion above (Tallahassee and TECO Polk Power data) without add-on control (~ 1 ppmvd), it appears to the Department that oxidation catalyst costs are substantially biased to the low side based on *actual* emissions.
- The Department determines BACT for CO achievable by good combustion as 7.4 ppmvd @15% O_2 at full load and 8 ppmvd @15% O_2 over the full operational range for simple cycle and combined cycle operation. Additionally, the Department determines BACT for CO as 7.4 ppmvd @15% O_2 for the combined cycle unit during power augmentation if unlimited and 12 ppmvd @15% O_2 if limited to 2000 hours per year.
- The CO BACT determination of 8 ppmvd @15% O_2 under normal combined cycle operation and 12 ppmvd @15% O_2 under (limited) power augmentation are low and within the range of recent BACT determinations for combustion turbines in the Southeast.
- El Paso proposes to install CO catalyst to allow <u>unlimited</u> power augmentation. The catalyst will also reduce emissions of CO (and VOC and HAPs) during startup and under all modes of operation. El Paso proposes to reduce CO emission limits to 2.5 and 4.0 ppmvd @15% O_2 for normal and (unlimited) power augmentation conditions respectively.
- The Department acknowledges El Paso's request and will lower the emissions accordingly. This does not imply that the Department has determined that BACT for is 2.5 ppmvd for normal operation or that BACT is 4.0 for (limited) power augmentation or that oxidation catalyst is required to meet the Department's BACT determination.
- BACT for sulfur oxides for this project (including the ancillary equipment emission units) is the exclusive use of pipeline natural gas with a specification of 1.5 grains per 100 standard cubic feet. Pipeline quality natural gas in Florida contains less than this value.
- The Department agrees that inlet air filtration, good combustion, and use of inherently clean fuels constitute BACT for PM/PM_{10} for this project (including ancillary equipment emission units).
- The emission limit for PM_{10} from the combustion turbines will be set at 11 pounds per hour. This value is based on filterable fraction only per the Department's definition of PM/PM_{10}. Expected particulate emissions based on filterable plus condensable particulate matter are 20 pounds per hour.
- The Department will set a visible emissions BACT limit at 10 percent. The Department will rely on VE observation as a surrogate for PM/PM_{10} BACT compliance (after the initial PM/PM_{10} test).

- BACT for the Cooling Tower was determined to be use of fresh water and drift eliminators designed and maintained to reduce drift to 0.0005 percent of the circulating water flow rate. A lower drift rate would be reasonable for project where reused wastewater is the cooling medium.

POLLUTANT	COMPLIANCE PROCEDURE
Visible Emissions (initial, annual)	Method 9
PM/PM_{10} (initial)	Method 5 (Front-half catch)
VOC	Method 25A corrected by methane from Method 18
CTM-027(initial, quarterly, annual)	Procedure for Collection and Analysis of Ammonia in Stationary Sources
SO_2/SAM	Record keeping for the sulfur content of fuels delivered to the site
CO (initial, annual, CEMS)	Method 10; CO-CEMS (continuous 3-hr block average)
NO_X (continuous 24-hr)	NO_X CEMS, O_2 or CO_2 diluent monitor, and flow device as needed
NO_X (initial and annual)	Annual Method 20 (can use RATA if at capacity); Method 7E

DETAILS OF THE ANALYSIS MAY BE OBTAINED BY CONTACTING:

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Bureau of Air Regulation
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Recommended By:

_____
C. H. Fancy, P.E., Chief
Bureau of Air Regulation

_____
Date

Approved By:

_____
Howard L. Rhodes, Director
Division of Air Resources Management

_____
Date

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