HISTORICAL AND FUTURE OPERATING PATTERNS OF UTILITY GAS TURBINE PEAKING UNITS IN CALIFORNIA

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SUMMARY

The historical data (1975 to 1977) and projected output (1980 and 1985) for utility peaking units in three major California metropolitan regions are presented in this report. The boundaries of the regions are defined in terms of the State of California Air Resources Board (CARB) designated air basins, which are: San Francisco Bay Area Air Basin, South Coast Air Basin (including Ventura County), and San Diego Air Basin. Historical peaking unit operating data were compiled for 30 individual peaking units.

With very few exceptions, the major use of peaking units in all of the designated air basins occurred between the hours of 8 a.m. and 9 p.m. Peaking usages each year usually occurred in the months of April through October. There was an increase of power generated by peaking units in the month of January (compared to the other winter months). This increase was probably the result of the refurbishing of base load units and the switch to the usage of peaking units.

The Pacific Gas and Electric Company (PG&E) increased their total power generated from peaking units for the years 1975 to 1977. The significance in this power increase, when applied to yearly trends, was difficult to assess because of the short time that those units have been on line. During the same period, total power generated by peaking units decreased for Southern California Edison (SCE) and Los Angeles Department of Water and Power (LADWP) and increased for Burbank and Pasadena. Total power generated by peaking units at the City of Glendale decreased between the years 1975 and 1976 and increased in 1977. The following San Diego Gas and Electric (SDG&E) stations decreased in total power generated for the years 1975 to 1977: El Cajon, Encina, Kearny, Miramar, and NTC. Naval Station increased its total power generated, while the remaining stations' power output fluctuated for these 3 years.

The gas turbine peaking units in the CARB designated air basins are fired with: natural gas, No. 2 fuel oil, special distillate, JP-5 jet fuel, diesel fuel, combined fuel A, or combined fuel B. The latter two fuels are a combination of natural gas with No. 2 fuel oil and natural gas with diesel fuel, respectively.

Peaking units within the Cities of Los Angeles, Burbank, Glendale, and Pasadena operate alternatively on two types of fuels (i.e., natural gas or JP-5; natural gas or No. 2 fuel oil). Availability of fuels seems to be the determining factor when choosing between the two types of fuels. Sulfur content in the fuels ranged from negligible sulfur in natural gas to 0.35 percent sulfur in a No. 2 fuel oil (LADWP-1975). Generally, utilities in designated air basins have been progressively lowering the sulfur content in their fuels.

The peaking unit power outputs were projected for each of the designated air basins.

$$\begin{bmatrix}\text{Projected}\\ \text{Output}\end{bmatrix} = \begin{bmatrix}\text{Projected}\\ \text{Total Sales}\end{bmatrix} \times \left[\frac{\text{Gas Turbine Output (Baseline Year)}}{\text{Total Sales (Baseline Year)}}\right]$$

To calculate the projected output, it was assumed that the ratio of the baseline year's output to the baseline year's total sales remained constant for the years 1980 and 1985. Examination of the data compiled in this report on an hourly, daily, or monthly time scale for each of the gas turbine units revealed an absence of uniformity in operating patterns. The fluctuating patterns were probably the result of numerous variables that influence them (e.g., construction of new baseload or gas turbine units). Accurate projections for each utility gas turbine would involve the application of sophisticated forecasting methods. The development and application of such a forecasting method was beyond the scope of this project.

1.0 INTRODUCTION

Stationary gas turbines emit nitrogen oxides, carbon monoxide, hydrocarbons, and other types of air pollutants. Many electric utilities located in California use gas turbines to supplement the electric generating capability of base load generating units during periods of peak consumer demand for electricity. These gas turbine units, referred to as "peaking units," also provide standby generating capability during periods when a base load generating unit is not operational due to a scheduled or forced outage. As a result, utility gas turbine peaking units are normally operated intermittently for short periods of time. However, the operation of peaking units located in major California metropolitan regions may occur during periods of severe air pollution.

Historical operating data are required to evaluate the impact of utility peaking unit operations on air quality. Public agencies such as the Federal Energy Regulatory Commission and the State of California Public Utility Commission regularly summarize peaking unit operating data submitted by the individual utilities. However, these data only provide general operating trends (e.g., total number of hours the peaking units are operated per year, the average load generated). To establish daily and seasonal utility peaking unit operating patterns, additional data must be compiled on the hours of the day and days of the year during which the units are in operation.

The purpose of this report is to present historical and future operating patterns for utility peaking units located in three major California metropolitan regions. The boundaries of the regions are defined in terms of the following State of California Air Resources Board (CARB) designated air basins:

1. San Francisco Bay Area Air Basin
2. South Coast Air Basin (including Ventura County)
3. San Diego Air Basin

To meet the project objectives, work was undertaken to:

1. Compile historical data on utility peaking unit operations for the years 1975, 1976, and 1977.

2. Analyze the compiled data to provide summaries of the diurnal and monthly peaking unit operating patterns.

3. Project future utility peaking unit operating patterns for the years 1980 and 1985.

Section 2.0 presents tabulated summaries of historical peaking unit operating patterns for each air basin. Compilation and processing of the data are also described. Section 3.0 presents the projected future peaking unit operating patterns. Detailed tabulations of the daily operating data for each individual peaking unit are presented in Appendixes B through H.

2.0 HISTORICAL PEAKING UNIT OPERATING PATTERNS

Historical utility peaking unit operating patterns are summarized in this section for units located in the San Francisco Bay Area, South Coast (including Ventura County), and San Diego Air Basins. To prepare the summaries, Pacific Environmental Services, Inc. (PES) compiled a detailed data base listing the day-to-day operations of each individual peaking unit located in the three air basins. The compiled data were coded for storage and retrieval from computer data files. A computer program was developed to summarize the data for each utility.

2.1 DATA COMPILATION

To compile the data base, the initial step required identification of the electric utilities operating peaking units in the three air basins. These utilities were:

San Francisco Bay Area Air Basin

Pacific Gas and Electric Company

South Coast Air Basin

Southern California Edison Company
City of Los Angeles
City of Burbank
City of Glendale
City of Pasadena

San Diego Air Basin

San Diego Gas and Electric Company

Inquiries were made to Federal, state, and local public agencies to determine the availability of existing historical peaking unit operating data. The agencies contacted were:

Federal Energy Regulatory Commission

State of California Public Utilities Commission

State of California Energy Resource Conservation and Development Commission

Bay Area Air Pollution Control District

South Coast Air Quality Management District

San Diego County Air Pollution Control District

The utilities submit peaking unit operating data to several of the listed agencies. However, the format and detail of the data allow only general peaking unit operating trends to be identified. Consequently, to obtain the type of data required for the project, all of the utilities operating peaking units in the three air basins were contacted in regard to providing historical operating data. Formal, written requests for data were sent to each utility.

All of the utilities were very cooperative in responding to the request for data. Tabulated peaking unit operating data were received from three of the utilities. The other utilities provided access to their operating logs and records from which a PES engineer was able to tabulate the data. Table 2-1 summarizes the data sources from which historical utility peaking unit operating data were obtained.

General information about individual peaking unit design specifications obtained from the utilities was checked and supplemented with information provided by the gas turbine peaking unit manufacturers (General Electric Company and United Technologies).

Table 2-1. SOURCES OF HISTORICAL GAS TURBINE PEAKING UNIT OPERATING DATA

Air Basin	Data Source	Data Tabulation Method
San Francisco Bay Area	Pacific Gas and Electric Company Steam Generation Department 77 Beale Street San Francisco, California, 94106	Data were tabulated by a PES engineer from gas turbine unit outage records and load curtailment records provided by the utility.
South Coast (including Ventura County)	Southern California Edison Company Environmental Affairs Department 2244 Walnut Grove Avenue Rosemead, California, 91770	Data were tabulated by utility personnel and sent to PES.
	City of Los Angeles Department of Water and Power 111 North Hope Street Los Angeles, California, 90051	Data were tabulated by utility personnel and sent to PES.
	City of Burbank Public Service Department 164 West Magnolia Boulevard Burbank, California, 91503	Data were tabulated by a PES engineer from gas turbine unit daily operating logs and fuel records made available by the utility.
	City of Glendale Public Service Department 800 Air Way Glendale, California, 91201	Data were tabulated by a PES engineer from gas turbine unit daily operating logs and fuel records made available by the utility.
	City of Pasadena Water and Power Department 45 East Glenarm Avenue Pasadena, California, 91105	Data were tabulated by utility personnel and sent to PES.
San Diego	San Diego Gas and Electric Company Results Engineering Section 101 West Ash Street San Diego, California, 92112	Data were tabulated by a PES engineer from gas turbine unit daily operating logs and fuel records made available by the utility.

2.2 DATA PROCESSING

Historical peaking unit operating data were compiled for 30 individual peaking units. To facilitate processing the large volume of data, an approach was adopted for recording the data on standardized data sheets using a numerical code format. A sample data sheet and the coding instructions are presented in Appendix A. A PES engineer reviewed and transferred the tabulated data received from the utilities to the data sheets. When it was necessary to visit a utility in order to compile data, the PES engineer recorded the appropriate data from the utility operating log and records directly on to the data sheets.

Coding of the compiled data allowed the keypunching of the data onto a computer data tape. A Fortran computer program was written to retrieve the coded data from the data tape and to produce two types of output listings. The first type of listing tabulates the entire data base for each of the seven utilities. The second output listing summarizes the peaking unit operating patterns for each utility generating station.

2.3 DATA BASE

The historical peaking unit operations data base spans a three year period beginning January 1, 1975 and ending December 31, 1977. Data were compiled only for gas turbine units designated by the utilities as peaking units. No data were compiled for baseload combined cycle, or cogeneration gas turbine units. The types of data presented for each individual peaking unit are:

1. Days of the year the unit was in operation
2. Hours of the day the unit was in operation
3. Type of fule burned
4. Sulfur content of the fuel burned
5. Net unit generating load

The complete data bases compiled for each utility are presented in Appendixes B through H.

2.4 RESULTS

The purpose of this section is to provide background information about the utility peaking units operated in the three air basins, and to present an overview of the historical peaking unit operating trends during the years 1975, 1976, and 1977. The reader is referred to Appendixes B through H for more detailed summaries of the historical peaking unit operating patterns.

2.4.1 SAN FRANCISCO BAY AREA AIR BASIN

A total of five gas turbine peaking units are currently in commercial operation at three utility generating stations located in the San Francisco Bay Area Air Basin. All of the units are owned by Pacific Gas and Electric Company. The one unit at Hunters Point Station and the three units at Potrero Station began commercial operation in 1976. A new unit was placed in commercial service at the Oakland Station in 1978 (no historical data was compiled for this unit). Table 2-2 presents selected design specifications for each unit.

Summaries of the peaking unit daily operations at each generating station are presented in Tables 2-3 and 2-4. Monthly summaries of the peaking unit operations are presented in Tables 2-5 and 2-6.

Table 2-2
UTILITY GAS TURBINE PEAKING UNITS
LOCATED IN THE
SAN FRANCISCO BAY AREA AIR BASIN

Utility	Station	Unit	Number of Engines	Manufacturer	Model Number	Total Generating Capacity	Fuel Capability	NO_x Control	Date First On Line
Pacific Gas and Electric Company	Hunters Point	1	2	Turbo-Power and Marine	FT4C-1D(LF)	57.4 MW[a] 52.0 MW[b]	Special distillate	Special fuel nozzle	June 1976
	Potrero	4	2	Turbo-Power and Marine	FT4C-1D(LF)	57.4 MW[a] 52.0 MW[b]	Special distillate	Special fuel nozzle	Feb 1976
		5	2	Turbo-Power and Marine	FT4C-1D(LF)	57.4 MW[a] 52.0 MW[b]	Special distillate	Special fuel nozzle	Mar 1976
		6	2	Turbo-Power and Marine	FT4C-1D(LF)	57.4 MW[a] 52.0 MW[b]	Special distillate	Special fuel nozzle	Mar 1976
	Oakland	1	6	Turbo-Power and Marine	FT4C-3F(LF)	171.4 MW[a]	Special distillate	Water injection	1978

[a] Manufacturer rated generating capacity expressed in units of electric megawatts

[b] Utility rated net generating capacity expressed in units of electric megawatts

Table 2-3

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: Pacific Gas and Electric Company (PG&E)

Station: PG&E Hunters Point

Daily Operating Period \ Year	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	0.0	0.0	26.0
1:00 to 2:00	0.0	0.0	0.0
2:00 to 3:00	0.0	0.0	52.0
3:00 to 4:00	0.0	0.0	0.0
4:00 to 5:00	0.0	0.0	0.0
5:00 to 6:00	0.0	0.0	26.0
6:00 to 7:00	0.0	0.0	650.0
7:00 to 8:00	0.0	156.0	1,716.0
8:00 to 9:00	0.0	312.0	2,756.0
9:00 to 10:00	0.0	572.0	3,952.0
10:00 to 11:00	0.0	832.0	4,225.0
11:00 to 12:00	0.0	910.0	3,718.0
12:00 to 13:00	0.0	884.0	3,224.0
13:00 to 14:00	0.0	962.0	3,328.0
14:00 to 15:00	0.0	1,144.0	3,328.0
15:00 to 16:00	0.0	1,196.0	3,354.0
16:00 to 17:00	0.0	1,040.0	3,510.0
17:00 to 18:00	0.0	1,482.0	4,706.0
18:00 to 19:00	0.0	884.0	4,368.0
19:00 to 20:00	0.0	572.0	3,276.0
20:00 to 21:00	0.0	312.0	3,120.0
21:00 to 22:00	0.0	156.0	1,898.0
22:00 to 23:00	0.0	52.0	806.0
23:00 to 24:00	0.0	0.0	52.0
T o t a l	0.0	11,465.0	52,091.0

Table 2-4

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: Pacific Gas and Electric Company (PG&E)

Station: PG&E Potrero

Daily Operating Period \ Year	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	0.0	52.0	0.0
1:00 to 2:00	0.0	208.0	45.0
2:00 to 3:00	0.0	52.0	48.0
3:00 to 4:00	0.0	52.0	0.0
4:00 to 5:00	0.0	52.0	0.0
5:00 to 6:00	0.0	104.0	104.0
6:00 to 7:00	0.0	312.0	1,950.0
7:00 to 8:00	0.0	546.0	6,099.0
8:00 to 9:00	0.0	1,612.0	10,372.0
9:00 to 10:00	0.0	3,068.0	12,882.0
10:00 to 11:00	0.0	3,900.0	13,740.0
11:00 to 12:00	0.0	4,043.0	12,352.0
12:00 to 13:00	0.0	4,186.0	11,264.0
13:00 to 14:00	0.0	5,616.0	12,077.0
14:00 to 15:00	0.0	7,878.0	11,742.0
15:00 to 16:00	0.0	6,994.0	11,529.0
16:00 to 17:00	0.0	6,448.0	11,777.0
17:00 to 18:00	0.0	7,761.0	16,743.0
18:00 to 19:00	0.0	5,382.0	16,369.0
19:00 to 20:00	0.0	3,510.0	12,911.0
20:00 to 21:00	0.0	2,392.0	11,069.0
21:00 to 22:00	0.0	1,534.0	7,247.0
22:00 to 23:00	0.0	494.0	2,958.5
23:00 to 24:00	0.0	52.0	182.0
T o t a l	0.0	66,248.0	183,463.5

Table 2-5

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: Pacific Gas and Electric Company (PG&E)

Station: Hunters Point

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	0	0	2,392.
February	0	0	4,680.
March	0	0	12,259.
April	0	0	4,160.
May	0	0	3,666.
June	0	4,472.	6,396.
July	0	2,548.	2,106.
August	0	416.	4,212.
September	0	364.	1,924.
October	0	104.	2,054.
November	0	2,002.	3,354.
December	0	1,560.	4,888.
T o t a l	0	11,466.	52,091.

Table 2-6

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: Pacific Gas and Electric Company (PG&E)

Station: Potrero

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	0	0	23,256.
February	0	442.	16,059.
March	0	2,158.	31,835.
April	0	1,560.	19,058.
May	0	12,480.	11,440.
June	0	20,852.	18,337.
July	0	11,908.	13,364.
August	0	2,288.	13,858.
September	0	2,236.	5,252.
October	0	923.	5,434.
November	0	4,212.	11,661.
December	0	7,189.	13,910.
Total	0	66,248.	183,464.

2.4.2 SOUTH COAST AIR BASIN

A total of 16 gas turbine peaking units are currently in commercial operation at nine utility generating stations located in the South Coast Air Basin. The units are owned by an investor-owned utility and four municipal utilities. Southern California Edison operates five peaking units at five generating stations. Four units are in commercial operation at the City of Los Angeles Harbor Station. The City of Burbank operates three units at the adjacent Olive-Magnolia Stations. Both the Cities of Glendale and Pasadena have two peaking units in commercial service. All of the units with the exception of one in Burbank and two in Pasadena were in commerical service prior to the year 1975. The City of Pasadena units were first on-line in 1976. The City of Burbank has not formally accepted Unit 4 from the manufacturer for commercial service. Table 2-7 presents selected design specifications for each unit.

Summaries of the peaking unit daily operations at each generating station are presented in Tables 2-8 through 2-12 (SCE), 2-18 (LADWP), 2-20 (Burbank), 2-22 (Glendale), and 2-24 (Pasadena). Monthly summaries of the peaking unit operations at each generating station are presented in Tables 2-13 through 2-17 (SCE), 2-19 (LADWP), 2-21 (Burbank), 2-23 (Glendale), and 2-15 (Pasadena).

Table 2-7

UTILITY GAS TURBINE PEAKING UNITS

LOCATED IN THE

SOUTH COAST AIR BASIN (including Ventura County)

Utility	Station	Unit	Number of Engines	Manufacturer	Model Number	Total Generating Capacity	Fuel Capability	NO_x Control	Date First On Line
Southern California Edison Company	Alamitos	7	8	Turbo-Power and Marine	GC4A-4(DF)	145.0 MW[a] 121.0 MW[b]	Natural gas Jet fuel JP-5		July 1969
	Ellwood	1	2	Turbo-Power and Marine	FT4C-1(DF)	59.4 MW[a] 54.0 MW[b]	Natural gas Jet fuel JP-5	Water injection	Jan 1974
	Etiwanda	5	8	Turbo-Power and Marine	GC4A-4(DF)	145.0 MW[a] 121.0 MW[b]	Natural gas Jet fuel JP-5		Jan 1969
	Huntington Beach	5	8	Turbo-Power and Marine	GC4A-4(DF)	145.0 MW[a] 121.0 MW[b]	Natural gas Jet fuel JP-5		May 1969
	Mandalay	3	8	Turbo-Power and Marine	GC4A-4(DF)	145.0 MW[a] 121.0 MW[b]	Natural gas Jet fuel JP-5		Apr 1970
City of Los Angeles	Harbor	6	1	General Electric	PB 5251	23.1 MW[a] 19.0 MW[b]	Natural gas Distillate fuel oil		July 1972
		7	1	General Electric	PB 5251	23.1 MW[a] 19.0 MW[b]	Natural gas Distillate fuel oil		June 1972
		8	1	General Electric	PB 5251	23.1 MW[a] 19.0 MW[b]	Natural gas Distillate fuel oil		May 1972
		9	1	General Electric	PB 5251	23.1 MW[a] 19.0 MW[b]	Natural gas Distillate fuel oil		May 1972
City of Burbank	Olive	3	1	Turbo-Power and Marine	FT4A-11(DF)	24.1 MW[a] 23.5 MW[b]	Natural gas Jet fuel JP-5		July 1972
		4	1	Turbo-Power and Marine	GC4C-1DB(DF)	28.0 MW[a] 34.0 MW[b]	Natural gas Jet fuel JP-5	Water injection	1974[c]
	Magnolia	5	1	Turbo-Power and Marine	FT4A-9(DF)	21.9 MW[a] 21.7 MW[b]	Natural gas Jet fuel JP-5		Aug 1969
City of Glendale	Grayson	6	1	General Electric	PG 5251	23.7 MW[a] 25.0 MW[b]	Natural gas Distillate fuel oil	Water injection	Apr 1972
		7	1	Turbo-Power and Marine	GC4C-1(DF)	27.0 MW[a] 34.0 MW[b]	Natural gas Distillate fuel oil	Water injection	Dec 1973
City of Pasadena	Glenarm	GT-1	1	Turbo-Power and Marine	GC4C-1D(DF)	31.4 MW[a] 30.0 MW[b]	Natural gas Distillate fuel oil	Water injection	Jan 1976
		GT-2	1	Turbo-Power and Marine	GC4C-1D(DF)	31.4 MW[a] 30.0 MW[b]	Natural gas Distillate fuel oil	Water injection	Jan 1976

[a] Manufacturer rated generating capacity expressed in units of electric megawatts
[b] Utility rated net generating capacity expressed in units of electric megawatts
[c] The City of Burbank has not formally accepted Unit 4 from the manufacturer for commercial service.

Table 2-8

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: Southern California Edison Company (SCE)

Station: SCE Alamitos

Daily Operating Period \ Year	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	0.0	4.0	0.0
1:00 to 2:00	0.0	121.0	0.0
2:00 to 3:00	0.0	43.4	0.0
3:00 to 4:00	0.0	0.0	0.0
4:00 to 5:00	0.0	0.0	0.0
5:00 to 6:00	0.0	0.0	0.0
6:00 to 7:00	0.0	0.0	0.0
7:00 to 8:00	0.0	0.0	0.0
8:00 to 9:00	0.0	0.0	0.0
9:00 to 10:00	304.5	0.0	26.2
10:00 to 11:00	439.6	117.0	0.0
11:00 to 12:00	393.3	187.5	0.0
12:00 to 13:00	189.6	151.3	2.0
13:00 to 14:00	513.4	121.0	203.7
14:00 to 15:00	1,014.6	205.7	282.3
15:00 to 16:00	1,067.6	326.7	367.0
16:00 to 17:00	961.7	324.7	242.0
17:00 to 18:00	387.2	106.9	8.1
18:00 to 19:00	278.3	42.3	0.0
19:00 to 20:00	145.2	92.8	0.0
20:00 to 21:00	224.7	0.0	2.0
21:00 to 22:00	76.5	0.0	88.7
22:00 to 23:00	0.0	0.0	0.0
23:00 to 24:00	0.0	0.0	0.0
T o t a l	5,996.2	1,849.3	1,222.1

Table 2-9

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: Southern California Edison Company (SCE)

Station: SCE Ellwood

Daily Operating Period \ Year	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	0.0	0.0	0.0
1:00 to 2:00	0.0	0.0	0.0
2:00 to 3:00	0.0	0.0	0.0
3:00 to 4:00	0.0	0.0	0.0
4:00 to 5:00	0.0	0.0	0.0
5:00 to 6:00	0.0	0.0	0.0
6:00 to 7:00	0.0	0.0	0.0
7:00 to 8:00	0.0	0.0	0.0
8:00 to 9:00	0.0	0.0	0.0
9:00 to 10:00	0.0	0.0	0.0
10:00 to 11:00	0.0	0.0	0.0
11:00 to 12:00	0.0	0.0	0.0
12:00 to 13:00	0.0	0.0	0.0
13:00 to 14:00	52.0	0.0	45.9
14:00 to 15:00	80.0	13.5	54.0
15:00 to 16:00	81.8	11.7	54.0
16:00 to 17:00	26.0	0.0	53.1
17:00 to 18:00	25.0	0.0	0.0
18:00 to 19:00	15.2	36.9	0.0
19:00 to 20:00	18.9	40.5	0.0
20:00 to 21:00	4.5	0.0	0.0
21:00 to 22:00	0.0	0.0	0.0
22:00 to 23:00	0.0	0.0	0.0
23:00 to 24:00	0.0	0.0	0.0
T o t a l	304.4	102.6	207.0

Table 2-10

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: Southern California Edison Company (SCE)

Station: SCE Etiwanda

Daily Operating Period \ Year	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	0.0	0.0	0.0
1:00 to 2:00	0.0	121.0	0.0
2:00 to 3:00	0.0	52.4	26.2
3:00 to 4:00	0.0	0.0	0.0
4:00 to 5:00	0.0	0.0	0.0
5:00 to 6:00	0.0	0.0	0.0
6:00 to 7:00	0.0	0.0	0.0
7:00 to 8:00	30.3	0.0	0.0
8:00 to 9:00	330.7	0.0	22.2
9:00 to 10:00	845.0	0.0	32.3
10:00 to 11:00	1,214.0	84.7	60.5
11:00 to 12:00	1,288.6	179.3	0.0
12:00 to 13:00	1,100.7	143.4	24.2
13:00 to 14:00	2,359.6	195.8	262.2
14:00 to 15:00	3,138.5	113.9	135.1
15:00 to 16:00	2,576.5	106.1	121.0
16:00 to 17:00	1,445.9	167.4	108.9
17:00 to 18:00	856.9	286.4	28.2
18:00 to 19:00	873.3	469.2	92.8
19:00 to 20:00	926.7	315.9	0.0
20:00 to 21:00	450.5	180.8	0.0
21:00 to 22:00	375.1	39.0	0.0
22:00 to 23:00	0.0	0.0	0.0
23:00 to 24:00	0.0	0.0	0.0
T o t a l	17,812.3	2,455.2	913.5

Table 2-11

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: Southern California Edison Company (SCE)

Station: SCE Huntington Beach

Daily Operating Period \ Year	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	0.0	106.9	0.0
1:00 to 2:00	0.0	121.0	0.0
2:00 to 3:00	0.0	64.5	0.0
3:00 to 4:00	0.0	0.0	0.0
4:00 to 5:00	0.0	0.0	0.0
5:00 to 6:00	0.0	0.0	0.0
6:00 to 7:00	0.0	0.0	0.0
7:00 to 8:00	0.0	0.0	0.0
8:00 to 9:00	171.0	0.0	22.2
9:00 to 10:00	432.0	0.0	0.0
10:00 to 11:00	615.3	64.5	0.0
11:00 to 12:00	446.5	46.3	0.0
12:00 to 13:00	755.5	157.3	30.2
13:00 to 14:00	1,569.8	115.0	415.4
14:00 to 15:00	2,069.6	201.7	411.4
15:00 to 16:00	1,601.7	363.0	302.5
16:00 to 17:00	1,109.5	268.3	242.0
17:00 to 18:00	618.8	224.4	92.8
18:00 to 19:00	560.6	209.7	20.2
19:00 to 20:00	310.6	121.0	0.0
20:00 to 21:00	351.9	121.0	2.0
21:00 to 22:00	251.7	28.2	72.6
22:00 to 23:00	0.0	0.0	0.0
23:00 to 24:00	0.0	0.0	0.0
T o t a l	10,865.6	2,212.9	1,611.3

Table 2-12

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: Southern California Edison Company (SCE)

Station: SCE Mandalay

Daily Operating Period \ Year	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	0.0	96.0	0.0
1:00 to 2:00	0.0	221.0	0.0
2:00 to 3:00	0.0	138.4	0.0
3:00 to 4:00	0.0	90.0	0.0
4:00 to 5:00	0.0	90.0	0.0
5:00 to 6:00	0.0	90.0	0.0
6:00 to 7:00	0.0	90.0	0.0
7:00 to 8:00	0.0	90.0	0.0
8:00 to 9:00	0.0	90.0	68.6
9:00 to 10:00	4.0	60.0	28.2
10:00 to 11:00	266.2	0.0	45.4
11:00 to 12:00	83.7	0.0	28.2
12:00 to 13:00	0.0	26.0	135.1
13:00 to 14:00	366.8	121.0	558.6
14:00 to 15:00	600.2	42.3	605.0
15:00 to 16:00	759.5	177.5	605.0
16:00 to 17:00	541.5	167.4	401.3
17:00 to 18:00	151.3	26.2	197.6
18:00 to 19:00	121.0	100.8	6.0
19:00 to 20:00	131.1	125.5	0.0
20:00 to 21:00	266.2	211.0	0.0
21:00 to 22:00	149.2	194.9	0.0
22:00 to 23:00	40.3	90.0	0.0
23:00 to 24:00	0.0	90.0	0.0
T o t a l	3,481.1	2,418.1	2,680.1

Table 2-13

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: Southern California Edison Company (SCE)

Station: Alamitos

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	0	44.	0
February	0	0	0
March	1085.	111.	0
April	501.	30.	0
May	214.	125.	0
June	1,268	907.	117.
July	1,194.	407.	799.
August	472.	0	16.
September	710.	224.	290.
October	379.	0	0
November	0	0	0
December	173.	0	0
Total	5,996.	1,849.	1,222.

Table 2-14

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: Southern California Edison Company (SCE)

Station: Ellwood

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	0	0	0
February	0	0	0
March	0	77.	0
April	0	0	0
May	0	0	0
June	145.	25.	0
July	136.	0	0
August	0	0	0
September	23.	0	207.
October	0	0	0
November	0	0	0
December	0	0	0
Total	304.	103.	207.

Table 2-15

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: Southern California Edison Company (SCE)

Station: Etiwanda

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	313.	411.	0
February	722.	0	0
March	3,046.	896.	0
April	1,780.	48.	0
May	2,398.	0	0
June	3,137.	488.	250.
July	2,142.	253.	0
August	948.	0	28.
September	1,738.	359.	466.
October	1,101.	0	26.
November	222.	0	22.
December	264.	0	121.
Total	17,812.	2,455.	914.

Table 2-16

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: Southern California Edison Company (SCE)

Station: Huntington Beach

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	145.	155.	0
February	169.	0	0
March	2,610.	536.	0
April	1,515.	42.	0
May	1,486.	196.	0
June	1,292.	662.	311.
July	1,602.	276.	653.
August	657.	0	52.
September	1,182.	345.	538.
October	0	0	0
November	0	0	22.
December	208.	0	34.
Total	10,866.	2,213	1,611.

Table 2-17

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: Southern California Edison Company (SCE)

Station: Mandalay

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	0	0	0
February	0	0	0
March	550.	448.	0
April	175.	167.	0
May	631.	111.	0
June	296.	0	994.
July	1,154.	282.	557.
August	0	0	450.
September	417.	1,410.	611.
October	258.	0	0
November	0	0	69.
December	0	0	0
Total	3,481.	2,418.	2,680.

Table 2-18

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: City of Los Angeles Department of Water and Power

Station: LADWP Harbor

Daily Operating Period \ Year	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	0.0	0.0	20.0
1:00 to 2:00	0.0	0.0	8.1
2:00 to 3:00	0.0	0.0	8.1
3:00 to 4:00	0.0	0.0	8.1
4:00 to 5:00	0.0	0.0	8.1
5:00 to 6:00	0.0	0.0	8.1
6:00 to 7:00	0.0	0.0	8.1
7:00 to 8:00	15.9	0.6	45.0
8:00 to 9:00	123.3	77.0	113.7
9:00 to 10:00	238.8	149.6	110.2
10:00 to 11:00	540.6	240.9	223.2
11:00 to 12:00	594.2	322.2	282.6
12:00 to 13:00	560.6	442.3	226.4
13:00 to 14:00	867.8	693.2	357.8
14:00 to 15:00	1,299.3	892.9	349.5
15:00 to 16:00	1,613.9	1,076.3	249.6
16:00 to 17:00	1,375.3	890.6	167.4
17:00 to 18:00	935.5	586.6	96.2
18:00 to 19:00	467.7	315.0	110.0
19:00 to 20:00	119.1	43.3	19.2
20:00 to 21:00	156.9	7.3	15.2
21:00 to 22:00	155.9	0.0	20.8
22:00 to 23:00	63.0	0.0	0.0
23:00 to 24:00	44.6	0.0	0.0
T o t a l	9,172.3	5,737.8	2,455.1

Table 2-19

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: City of Los Angeles Department of Water and Power

Station: LADWP Harbor

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	13.	332.	99.
February	280.	383.	711.
March	88.	152.	157.
April	975.	782.	92.
May	479.	723.	30.
June	417.	1,219	459.
July	2,654.	692.	86.
August	1,632.	725.	477.
September	1,457.	549.	74.
October	519.	140.	230.
November	474.	9.	22.
December	184.	31.	18.
Total	9,172.	5,738.	2,455.

Table 2-20

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: City of Burbank, Public Service Department

Station: Olive-Magnolia

Daily Operating Period \ Year	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	0.0	10.0	19.9
1:00 to 2:00	0.0	3.9	25.8
2:00 to 3:00	0.0	0.0	11.2
3:00 to 4:00	0.0	0.0	11.2
4:00 to 5:00	5.9	0.0	11.2
5:00 to 6:00	11.1	0.0	14.1
6:00 to 7:00	2.4	3.3	67.5
7:00 to 8:00	25.2	45.1	125.0
8:00 to 9:00	55.7	150.4	206.2
9:00 to 10:00	79.4	275.1	323.7
10:00 to 11:00	169.0	394.8	496.5
11:00 to 12:00	222.4	534.5	471.6
12:00 to 13:00	273.8	616.1	528.4
13:00 to 14:00	355.3	713.4	625.1
14:00 to 15:00	378.6	741.8	633.6
15:00 to 16:00	371.3	717.2	467.2
16:00 to 17:00	244.0	582.3	351.1
17:00 to 18:00	167.8	288.1	316.9
18:00 to 19:00	91.1	173.5	345.4
19:00 to 20:00	38.8	122.6	228.1
20:00 to 21:00	23.8	39.9	127.9
21:00 to 22:00	8.4	22.7	60.8
22:00 to 23:00	0.0	9.6	40.3
23:00 to 24:00	0.0	7.8	13.4
T o t a l	2,524.0	5,452.0	5,522.0

Table 2-21

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: City of Burbank, Public Service Department

Station: Olive - Magnolia

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	535.	100.	468.
February	79.	460.	283.
March	0	870.	600.
April	0	160.	296.
May	30.	130.	30.
June	22.	1,223.	1,025.
July	365.	978.	1,210.
August	937.	433.	693.
September	506.	355.	492.
October	10.	229.	40.
November	40.	407.	113.
December	0	107.	272.
Total	2,524.	5,452.	5,522.

Table 2-22

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: City of Glendale Public Service Department

Station: Grayson

Daily Operating Period \ Year	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975 [a]	1976	1977
0:00 to 1:00		0.0	25.1
1:00 to 2:00		0.0	25.1
2:00 to 3:00		0.0	25.1
3:00 to 4:00		2.0	19.8
4:00 to 5:00		0.0	11.2
5:00 to 6:00		0.0	10.5
6:00 to 7:00		2.0	35.8
7:00 to 8:00		10.0	220.8
8:00 to 9:00		104.9	345.9
9:00 to 10:00		180.9	470.5
10:00 to 11:00		241.0	588.7
11:00 to 12:00		308.8	668.0
12:00 to 13:00		337.5	658.2
13:00 to 14:00		490.2	664.9
14:00 to 15:00		527.1	752.7
15:00 to 16:00		577.1	806.0
16:00 to 17:00		680.0	852.1
17:00 to 18:00		872.6	923.1
18:00 to 19:00		927.3	1,012.9
19:00 to 20:00		765.5	898.5
20:00 to 21:00		522.6	725.8
21:00 to 22:00		198.1	362.6
22:00 to 23:00		18.3	140.3
23:00 to 24:00		0.0	59.4
T o t a l	11,951.7	6,766.0	10,303.0

[a] Gas turbine peaking units were operated a total of 11,952 hours in 1975. However, the hours of the day the units were in operation were not readily available from utility records.

Table 2-23

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: City of Glendale

Station: Grayson

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	440.	617.	2,770.
February	1,407.	233.	637.
March	592.	884.	355.
April	719.	384.	89.
May	640.	65.	148.
June	2,173.	247.	938.
July	754.	902.	528.
August	660.	528.	1,037.
September	1,683.	438.	489.
October	994.	664.	772.
November	990.	1,171.	1,611.
December	899.	633.	929.
Total	11,952.	6,766.	10,303.

Table 2-24

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: City of Pasadena Water and Power Department

Station: Glenarm

Daily Operating Period \ Year	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	0.0	18.9	10.0
1:00 to 2:00	0.0	1.9	4.7
2:00 to 3:00	0.0	1.2	24.5
3:00 to 4:00	0.0	0.0	40.0
4:00 to 5:00	0.0	0.0	13.3
5:00 to 6:00	0.0	2.8	0.0
6:00 to 7:00	0.0	13.0	30.2
7:00 to 8:00	0.0	44.9	84.4
8:00 to 9:00	1.7	293.5	244.5
9:00 to 10:00	15.0	613.1	695.8
10:00 to 11:00	19.3	680.0	1,004.5
11:00 to 12:00	96.3	862.7	1,114.5
12:00 to 13:00	70.7	970.9	1,193.0
13:00 to 14:00	63.5	1,063.2	1,276.4
14:00 to 15:00	363.5	1,158.3	1,354.0
15:00 to 16:00	414.2	983.4	1,452.0
16:00 to 17:00	245.0	837.8	1,366.0
17:00 to 18:00	102.3	634.9	1,080.0
18:00 to 19:00	2.4	419.2	816.1
19:00 to 20:00	0.0	374.2	519.4
20:00 to 21:00	0.0	247.0	398.9
21:00 to 22:00	0.0	162.4	319.6
22:00 to 23:00	0.0	107.6	188.7
23:00 to 24:00	0.0	58.7	59.0
T o t a l	1,394.0	9,549.8	13,289.8

Table 2-25

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: City of Pasadena

Station: Glenarm

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	0	548.	1,646.
February	0	1,062.	568.
March	0	1,364.	283.
April	0	274.	464.
May	0	397.	163.
June	0	2,011.	1,987.
July	0	1,269.	5,391.
August	82.	827.	1,787.
September	156.	269.	161.
October	548.	555.	212.
November	449.	563.	231.
December	158.	410.	395.
Total	1,394.	9,550.	13,290.

2.4.3 SAN DIEGO AIR BASIN

A total of nine gas turbine peaking units are currently in commercial service at seven utility generating stations located in the San Diego Air Basin. All of the units are owned by San Diego Gas and Electric Company. Three additional gas turbine units operated by SDG&E at Naval Station, North Island Station, and NTC Station are designated by the utility as baseload units. Operating data for these units are included in this section. All of the units with the exception of the Naval Station unit were in commercial service prior to the year 1975. The Naval Station unit was placed in service in 1976. Table 2-26 presents selected design specifications for each unit.

Summaries of the peaking unit daily operations at each generating station are presented in Tables 2-27 through 2-35. Monthly summaries of the peaking unit operations are presented in Tables 2-36 through 2-45.

Table 2-26
UTILITY GAS TURBINE PEAKING UNITS
LOCATED IN THE
SAN DIEGO AIR BASIN

Utility	Station	Unit	Number of Engines	Manufacturer	Model Number	Total Generating Capacity	Fuel Capability	NO_x Control	Date First On Line
San Diego Gas and Electric Company	Division	1	1	General Electric	PG 5211	18.9 MW[a] 16.0 MW[b]	Diesel	Water injection	Nov 1968
	El Cajon	1	1	General Electric	PG 5211	18.9 MW[a] 17.0 MW[b]	Diesel	Water injection	Nov 1968
	Encina	1	1	General Electric	PG 5211	18.9 MW[a] 16.0 MW[b]	Natural gas Distillate fuel oil	Water injection	Nov 1968
	Kearny	1	1	General Electric	PG 5221	22.8 MW[a] 17.0 MW[b]	Natural gas Distillate fuel oil	Water injection	Apr 1972
		2	4	General Electric	PB 5211	78.4 MW[a] 65.0 MW[b]	Natural gas Distillate fuel oil	Water injection	Dec 1969
		3	4	General Electric	PB 5211	78.4 MW[a] 65.0 MW[b]	Natural gas Distillate fuel oil	Water injection	Dec 1969
	Miramar	1	2	General Electric	PG 5251	45.6 MW[a] 38.0 MW[b]	Natural gas Diesel	Water injection	May 1972
	Naval Station	1[c]	1	Turbo-Power and Marine	FT4C-1D(LF)	31.1 MW[a] 26.0 MW[b]	Diesel	Steam injection	Sept 1976
	North Island	1	1	General Electric	PG 5251	22.8 MW[a] 21.0 MW[b]	Diesel	Water injection	June 1972
		2[c]	1	General Electric	PG 5211	22.8 MW[a] 20.0 MW[b]	Diesel	Water injection	June 1972
	N T C	1[c]	1	General Electric	PG 5211	18.9 MW[a] 16.0 MW[b]	Natural gas Diesel	Water injection	July 1970[d]
	South Bay	1	1	Turbo-Power and Marine	FT4A-8(LF)	21.3 MW[a] 18.0 MW[b]	Jet fuel JP-5	Steam injection	Oct 1966

[a] Manufacturer rated generating capacity expressed in units of electric megawatts

[b] Utility rated net generating capacity expressed in units of electric megawatts. Capabilities based on gas turbines burning distillate fuel and a 111°F inlet temperature.

[c] Gas turbine unit is base loaded

[d] Gas turbine at NTC was originally installed at Kearny in November, 1968 and relocated to NTC in July, 1970.

Table 2-27

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E Division

Daily Operating Period \ Year	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	0.0	2.0	0.0
1:00 to 2:00	0.0	6.0	0.0
2:00 to 3:00	0.0	0.0	0.0
3:00 to 4:00	0.0	10.7	0.0
4:00 to 5:00	0.0	26.0	0.0
5:00 to 6:00	0.0	42.7	0.0
6:00 to 7:00	0.0	44.0	0.0
7:00 to 8:00	0.0	63.3	7.3
8:00 to 9:00	0.0	102.3	57.7
9:00 to 10:00	11.7	162.7	155.0
10:00 to 11:00	49.3	181.0	178.3
11:00 to 12:00	52.7	172.0	143.0
12:00 to 13:00	41.0	121.0	122.0
13:00 to 14:00	64.3	133.3	122.0
14:00 to 15:00	27.3	121.0	55.0
15:00 to 16:00	5.3	81.3	53.0
16:00 to 17:00	0.0	82.3	44.0
17:00 to 18:00	0.0	270.3	141.3
18:00 to 19:00	0.0	367.0	106.7
19:00 to 20:00	0.0	247.7	52.7
20:00 to 21:00	0.0	160.7	39.0
21:00 to 22:00	0.0	54.0	32.7
22:00 to 23:00	0.0	4.3	1.7
23:00 to 24:00	0.0	0.0	0.0
T o t a l	251.7	2,455.7	1,311.3

Table 2-28

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E El Cajon

Daily Operating Period \ Year	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	0.0	2.1	0.0
1:00 to 2:00	0.0	5.9	0.0
2:00 to 3:00	0.0	0.0	0.0
3:00 to 4:00	0.0	11.2	13.6
4:00 to 5:00	0.0	22.7	21.0
5:00 to 6:00	0.0	21.0	20.6
6:00 to 7:00	38.1	39.2	0.0
7:00 to 8:00	213.1	42.0	0.0
8:00 to 9:00	417.9	61.9	21.3
9:00 to 10:00	569.8	131.9	127.0
10:00 to 11:00	706.3	295.4	228.2
11:00 to 12:00	668.5	416.8	275.1
12:00 to 13:00	602.7	382.2	375.2
13:00 to 14:00	677.9	447.3	403.5
14:00 to 15:00	567.0	404.2	377.3
15:00 to 16:00	508.2	331.4	287.3
16:00 to 17:00	399.0	231.7	227.8
17:00 to 18:00	573.6	340.2	325.1
18:00 to 19:00	557.2	349.6	263.2
19:00 to 20:00	417.9	235.9	138.9
20:00 to 21:00	353.8	194.9	143.1
21:00 to 22:00	114.4	74.2	118.3
22:00 to 23:00	25.2	19.9	35.3
23:00 to 24:00	1.4	0.0	26.2
T o t a l	7,412.3	4,062.1	3,428.6

Table 2-29

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E Encina

Daily Operating Period \ Year	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	0.0	2.0	0.0
1:00 to 2:00	0.0	6.0	0.0
2:00 to 3:00	0.0	0.0	0.0
3:00 to 4:00	0.0	0.0	32.3
4:00 to 5:00	0.0	0.0	38.3
5:00 to 6:00	9.3	0.0	0.3
6:00 to 7:00	6.7	13.0	4.0
7:00 to 8:00	48.3	28.0	29.3
8:00 to 9:00	115.0	45.0	62.0
9:00 to 10:00	277.7	100.0	101.3
10:00 to 11:00	427.0	149.7	76.7
11:00 to 12:00	459.3	227.0	114.0
12:00 to 13:00	420.7	253.7	152.3
13:00 to 14:00	450.3	359.3	144.3
14:00 to 15:00	392.0	278.3	169.3
15:00 to 16:00	372.3	213.0	143.7
16:00 to 17:00	436.0	197.3	92.0
17:00 to 18:00	563.7	232.3	111.3
18:00 to 19:00	467.7	188.0	79.3
19:00 to 20:00	351.0	130.7	36.3
20:00 to 21:00	252.0	91.7	21.0
21:00 to 22:00	131.3	39.3	32.3
22:00 to 23:00	28.7	0.0	9.7
23:00 to 24:00	0.0	0.0	10.0
T o t a l	5,209.0	2,554.3	1,460.0

Table 2-30

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E Kearny

Year / Daily Operating Period	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	71.7	18.1	143.9
1:00 to 2:00	164.3	92.9	18.3
2:00 to 3:00	64.0	150.7	0.0
3:00 to 4:00	34.0	211.5	33.5
4:00 to 5:00	0.0	259.1	2.9
5:00 to 6:00	0.0	315.5	0.0
6:00 to 7:00	17.8	460.7	130.7
7:00 to 8:00	283.6	871.3	222.4
8:00 to 9:00	1,477.4	1,407.5	898.0
9:00 to 10:00	2,898.0	2,166.4	2,053.7
10:00 to 11:00	4,292.1	2,818.2	3,006.1
11:00 to 12:00	4,485.8	3,373.5	3,279.9
12:00 to 13:00	3,506.4	3,370.8	3,294.9
13:00 to 14:00	3,875.8	4,118.6	3,478.0
14:00 to 15:00	3,664.5	4,000.2	3,139.9
15:00 to 16:00	3,139.1	3,316.2	2,711.7
16:00 to 17:00	2,451.1	2,297.4	2,206.8
17:00 to 18:00	3,389.1	2,764.5	3,799.0
18:00 to 19:00	3,517.6	2,644.2	3,871.8
19:00 to 20:00	3,334.3	2,196.3	1,899.5
20:00 to 21:00	2,570.7	1,888.5	1,135.0
21:00 to 22:00	1,231.3	829.1	689.3
22:00 to 23:00	526.6	181.2	356.6
23:00 to 24:00	159.3	0.0	347.6
T o t a l	45,155.1	39,752.7	36,719.5

Table 2-31

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E Miramar

Daily Operating Period \ Year	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	19.2	2.3	29.5
1:00 to 2:00	23.0	7.7	0.0
2:00 to 3:00	47.1	19.5	0.0
3:00 to 4:00	68.2	23.4	30.7
4:00 to 5:00	46.0	60.6	15.3
5:00 to 6:00	46.0	57.9	0.0
6:00 to 7:00	93.9	95.1	20.3
7:00 to 8:00	233.5	160.2	69.8
8:00 to 9:00	543.4	327.4	256.1
9:00 to 10:00	1,067.3	646.7	542.4
10:00 to 11:00	1,357.7	1,104.0	877.8
11:00 to 12:00	1,394.1	1,276.5	1,080.2
12:00 to 13:00	1,279.3	1,485.0	1,146.5
13:00 to 14:00	1,282.0	1,708.1	1,270.7
14:00 to 15:00	1,100.1	1,564.0	1,149.2
15:00 to 16:00	1,040.9	1,374.6	1,070.3
16:00 to 17:00	868.8	997.0	734.1
17:00 to 18:00	1,540.3	1,497.3	1,999.1
18:00 to 19:00	1,573.7	1,512.6	2,014.8
19:00 to 20:00	1,363.5	1,314.1	1,228.2
20:00 to 21:00	1,152.2	1,036.9	655.5
21:00 to 22:00	471.8	459.2	329.3
22:00 to 23:00	124.6	118.4	158.3
23:00 to 24:00	65.2	47.1	121.5
T o t a l	16,801.8	16,895.8	14,799.7

Table 2-32

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E Naval Station

Year / Daily Operating Period	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	43.3	109.2	935.6
1:00 to 2:00	26.0	114.0	910.0
2:00 to 3:00	26.0	117.4	918.7
3:00 to 4:00	26.0	105.7	906.5
4:00 to 5:00	26.0	119.2	935.6
5:00 to 6:00	26.0	104.0	869.7
6:00 to 7:00	29.5	104.0	867.1
7:00 to 8:00	52.0	107.0	998.8
8:00 to 9:00	102.3	195.4	1,136.2
9:00 to 10:00	236.2	316.8	1,318.2
10:00 to 11:00	272.6	379.2	1,383.6
11:00 to 12:00	270.0	388.7	1,460.3
12:00 to 13:00	138.2	388.3	1,442.1
13:00 to 14:00	132.6	428.6	1,493.3
14:00 to 15:00	270.0	458.9	1,449.5
15:00 to 16:00	241.4	444.6	1,410.5
16:00 to 17:00	142.1	375.7	1,380.6
17:00 to 18:00	91.4	394.3	1,504.1
18:00 to 19:00	84.5	349.3	1,512.8
19:00 to 20:00	85.4	251.8	1,312.6
20:00 to 21:00	78.0	237.0	1,130.1
21:00 to 22:00	78.0	165.5	1,016.6
22:00 to 23:00	78.0	156.9	962.9
23:00 to 24:00	71.5	160.3	937.7
T o t a l	2,626.9	5,971.8	28,193.1

Table 2-33

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E NTC

Daily Operating Period \ Year	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	5,299.5	3,957.9	2,994.1
1:00 to 2:00	5,317.9	3,955.5	2,992.0
2:00 to 3:00	5,337.3	3,964.0	2,976.0
3:00 to 4:00	5,335.2	3,936.0	2,952.3
4:00 to 5:00	5,317.9	3,921.1	2,927.7
5:00 to 6:00	5,312.0	3,927.7	2,865.1
6:00 to 7:00	5,309.9	3,953.9	2,806.1
7:00 to 8:00	5,261.9	3,927.5	2,786.4
8:00 to 9:00	5,197.1	3,886.7	2,798.7
9:00 to 10:00	5,188.8	3,926.4	2,775.5
10:00 to 11:00	5,188.0	3,957.3	2,723.7
11:00 to 12:00	5,225.6	3,889.3	2,742.9
12:00 to 13:00	5,413.1	3,933.9	2,791.7
13:00 to 14:00	5,433.1	3,969.6	2,873.1
14:00 to 15:00	5,466.4	4,000.3	2,928.0
15:00 to 16:00	5,480.3	4,034.4	3,048.0
16:00 to 17:00	5,530.9	4,098.4	3,174.4
17:00 to 18:00	5,549.6	4,104.3	3,207.5
18:00 to 19:00	5,566.9	4,116.8	3,245.3
19:00 to 20:00	5,568.0	4,106.7	3,226.7
20:00 to 21:00	5,541.9	4,077.9	3,239.7
21:00 to 22:00	5,536.0	4,055.2	3,212.0
22:00 to 23:00	5,520.8	4,000.0	3,190.4
23:00 to 24:00	5,509.3	3,985.9	3,176.0
T o t a l	129,407.0	95,686.1	71,653.3

Table 2-34

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E North Island

Daily Operating Period \ Year	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	0.0	11.5	0.0
1:00 to 2:00	0.0	13.8	0.0
2:00 to 3:00	0.0	0.0	0.0
3:00 to 4:00	0.0	24.5	0.0
4:00 to 5:00	0.0	50.6	0.0
5:00 to 6:00	0.0	45.2	0.0
6:00 to 7:00	35.0	70.9	0.0
7:00 to 8:00	188.2	200.9	33.0
8:00 to 9:00	288.3	379.1	161.0
9:00 to 10:00	330.0	512.5	378.3
10:00 to 11:00	463.8	573.8	505.2
11:00 to 12:00	530.5	617.5	646.7
12:00 to 13:00	494.9	502.5	524.0
13:00 to 14:00	509.1	440.8	555.4
14:00 to 15:00	441.6	459.2	560.4
15:00 to 16:00	339.6	372.2	508.7
16:00 to 17:00	225.0	384.9	355.7
17:00 to 18:00	246.1	630.2	682.3
18:00 to 19:00	291.3	899.3	566.2
19:00 to 20:00	217.0	573.1	309.3
20:00 to 21:00	207.0	326.6	95.1
21:00 to 22:00	180.2	141.1	86.3
22:00 to 23:00	113.5	60.6	61.3
23:00 to 24:00	75.9	44.8	33.7
T o t a l	5,178.1	7,335.8	6,062.8

Table 2-35

GAS TURBINE PEAKING UNIT DAILY OPERATING PATTERN

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E South Bay

Daily Operating Period \ Year	Megawatt-hours Generated by Gas Turbine Peaking Units		
	1975	1976	1977
0:00 to 1:00	0.0	0.0	0.0
1:00 to 2:00	0.0	3.7	0.0
2:00 to 3:00	0.0	0.0	0.0
3:00 to 4:00	0.0	0.0	0.0
4:00 to 5:00	0.0	0.0	0.0
5:00 to 6:00	0.0	0.0	0.0
6:00 to 7:00	0.0	0.0	0.0
7:00 to 8:00	0.7	0.0	8.1
8:00 to 9:00	86.5	128.0	75.2
9:00 to 10:00	220.7	181.9	62.7
10:00 to 11:00	183.3	157.3	28.2
11:00 to 12:00	55.7	168.3	38.5
12:00 to 13:00	40.3	142.3	72.6
13:00 to 14:00	10.3	139.3	46.6
14:00 to 15:00	2.9	134.9	53.9
15:00 to 16:00	0.0	60.1	35.9
16:00 to 17:00	0.0	27.9	15.0
17:00 to 18:00	0.0	45.1	1.8
18:00 to 19:00	3.7	58.3	0.0
19:00 to 20:00	0.0	20.9	0.0
20:00 to 21:00	0.0	28.6	0.0
21:00 to 22:00	0.0	0.0	0.0
22:00 to 23:00	0.0	0.0	0.0
23:00 to 24:00	0.0	0.0	0.0
T o t a l	604.3	1,296.5	438.5

Table 2-36

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E Division

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	28.	137.	30.
February	0	578.	0
March	70.	583.	0
April	0	147.	70.
May	0	35.	197.
June	21.	153.	0
July	12.	87.	329.
August	28.	40.	79.
September	63.	73.	19.
October	0	72.	470.
November	9.	513.	0
December	21.	37.	116.
Total	252.	2,456.	1,311.

Table 2-37

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E El Cajon

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	361.	294.	119.
February	18.	0	142.
March	422.	535.	30.
April	949.	84.	72.
May	269.	304.	133.
June	191.	709.	76.
July	466.	542.	1,275.
August	43.	552.	580.
September	1,767.	167.	248.
October	1,522.	98.	403.
November	782.	639.	305.
December	622.	139.	46.
Total	7,412.	4,062.	3,429.

Table 2-38

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E Encina

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	57.	248.	41.
February	0	420.	75.
March	408.	0	11.
April	808.	43.	0
May	44.	35.	317.
June	71.	295.	29.
July	599.	321.	319.
August	625.	451.	52.
September	936.	228.	80.
October	571.	60.	127.
November	485.	168.	391.
December	604.	284.	19.
Total	5,209.	2,554.	1,460.

Table 2-39

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E Kearny 2 - 3

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1 9 7 5	1 9 7 6	1 9 7 7
January	1,193.	2,158.	1,721.
February	1,212.	1,301.	496.
March	2,411.	1,175.	422.
April	3,504.	729.	2,547.
May	2,970.	1,826.	1,161.
June	2,729.	5,278.	599.
July	2,066.	4,609.	10,966.
August	2,337.	5,535.	2,569.
September	9,257.	2,305.	2,136.
October	3,719.	1,782.	3,342.
November	2,290.	3,345.	3,553.
December	3,532.	1,839.	1,658.
T o t a l	37,220.	31,882.	31,170.

Table 2-40

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E Kearny 1

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	173.	449.	806.
February	175.	519.	493.
March	431.	1,201.	268.
April	898.	302.	322.
May	899.	0	309.
June	117.	882.	87.
July	998.	702.	699.
August	262.	1,010.	408.
September	1,538.	561.	593.
October	703.	674.	298.
November	579.	856.	823.
December	1,162.	715.	443.
Total	7,934.	7,871.	5,550.

Table 2-41

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E Miramar

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	1,238.	903.	862.
February	607.	409.	376.
March	1,096.	743.	498.
April	1,648.	1,484.	542.
May	625.	2,039.	947.
June	99.	3,926.	375.
July	1,326.	2,079.	2,103.
August	1,628.	1,401.	1,494.
September	3,829.	658.	1,557.
October	1,131.	714.	2,586.
November	1,931.	1,707.	2,016.
December	1,643.	832.	1,444.
Total	16,802.	16,896.	14,800.

Table 2-42

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E Naval Station

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	0	0	3,774.
February	0	0	2,860.
March	0	0	1,757.
April	0	0	0
May	0	380.	0
June	0	976.	987.
July	331.	172.	1,014.
August	416.	1,046.	0
September	1,088.	377.	57.
October	32.	857.	402.
November	565.	1,244.	6,911.
December	195.	920.	10,432.
Total	2,627.	5,972.	28,193.

Table 2-43

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E North Island

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	230.	1,007.	921.
February	166.	1,009.	169.
March	485.	1,592.	92.
April	595.	685.	205.
May	209.	595.	705.
June	21.	287.	389.
July	359.	190.	777.
August	407.	156.	607.
September	686.	237.	74.
October	186.	150.	256.
November	1,719.	678.	1,475.
December	116.	751.	393.
Total	5,178.	7,336.	6,063.

Table 2-44

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E NTC

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	10,063.	11,388.	11,751.
February	10,538.	10,592.	4,149.
March	11,406.	6,451.	8,890.
April	7,877.	3,770.	3,052.
May	11,508.	9,697.	541.
June	11,386.	11,083.	6,354.
July	11,904.	9,734.	0
August	11,303.	6,587.	5,209.
September	11,355.	0	4,571.
October	8,853.	8,558.	10,555.
November	11,388.	6,351.	5,330.
December	11,825.	11,476.	11,251.
Total	129,407.	95,686	71,653.

Table 2-45

GAS TURBINE PEAKING UNIT ELECTRICAL GENERATION

Utility: San Diego Gas and Electric Company (SDG&E)

Station: SDG&E South Bay

Year / Monthly Operating Period	Total Megawatt-hours Generated		
	1975	1976	1977
January	58.	64.	16.
February	43.	63.	63.
March	69.	101.	13.
April	56.	106.	22.
May	73.	54.	122.
June	32.	112.	0
July	38.	60.	29.
August	60.	53.	4.
September	37.	55.	17.
October	42.	458.	41.
November	43.	65.	92.
December	52.	104.	20.
Total	604.	1,297.	439.

3.0 FUTURE OPERATING PATTERNS

3.1 PROJECTION METHODOLOGY

Each of the air basin's total gas turbine outputs was projected for the years 1980 and 1985. The projected outputs, in units of megawatt-hours, were determined in the following manner:

$$\left[\begin{matrix}\text{Projected}\\ \text{Output}\end{matrix}\right] = \left[\begin{matrix}\text{Projected}\\ \text{Total Sales}\end{matrix}\right] \times \left[\frac{\text{Gas Turbine Output (Baseline Year)}}{\text{Total Sales (Baseline Year)}}\right]$$

The projected total sales were supplied by the California Energy Resources Conservation and Development Commission in their 1977 Biennial Report (refer to Table 3-1). A brief explanation of the methods used to determine these projected values for each air basin is found in the subsequent sections of this chapter. Except for the San Francisco Bay Area Air Basin (SFBAAB), the baseline year's total sales were located in the Commission's Biennial Report. Pacific Gas and Electric Company (PG&E), the only SFBAAB utility recognized in this report, did not have any gas turbine peaking units in 1975 (the baseline year in the Commission's report). The baseline year for PG&E was changed to 1977, and the appropriate sales value substituted. The baseline year's gas turbine output is the total power generated for that particular year. This information was determined by adding the peaking unit hourly data compiled in this report for each air basin.

To calculate the projected output, it was assumed that the ratio of the baseline year's output to the baseline year's total sales remained constant for the years 1980 and 1985. Unfortunately, this assumption is not satisfactory. Examination of the data compiled in this report on an hourly, daily, or monthly time scale for each of the gas turbine units revealed an absence of uniformity in operating patterns. The fluctuating operating patterns are probably the

Table 3-1. COMMISSION ADOPTED SALES FORECASTS[a]
(Thousand MWH)

Utility	1975	1980	1985	Growth Rate (75-85)
P G & E				
Adopted	58,100[b]	68,039	79,798	3.7%
High	58,100	75,759	105,427	6.6
Low	58,100	64,359	69,266	2.2
L A D W P				
Adopted	18,625	22,898	26,487	3.6%
High	18,625	24,277	30,621	5.1
Low	18,625	19,630	19,216	0.3
S C E				
Adopted	50,108	64,252	79,157	4.7%
High	50,108	72,249	96,969	6.8
Low	50,108	58,972	66,842	2.9
S D G & E				
Adopted	8,141	10,785	14,500	5.9%
High	8,141	14,034	20,032	9.4
Low	8,141	10,347	11,728	3.7

[a] The utilities listed account for 97.7 percent of statewide total sales. The remaining 2.3 percent are accounted for by the California Department of Water Resources, Imperial Irrigation District, Pacific Power and Light, California Pacific Utility Company, Sierra Pacific Power Company, and Surprise Valley Electrification Corporation.

[b] This value is the PG&E total sales for 1977. See reference 10.

result of the numerous variables that influence them. Variables that influence the operating patterns include, but are not limited to, the following:

1. The availability of fuels
2. Construction of new baseload or gas turbine units
3. The frequence of baseload or peaking unit outages
4. The utility's policy on the usage of gas turbine units
5. Meteorological conditions
6. Adoption of the Energy Commission's Load Management Standards[a]

The influence of the above variables on the use of gas turbine peaking units is complex. In the case of long term projections, some of the variables are fairly unpredictable. Accurate projections of operating patterns for each utility gas turbine would involve the application of[a] sophisticated forecasting method. The development and application of such a forecasting method is beyond the time frame of this project.

Time-of-day and seasonal load forecasting methods are presently in the development stages. However, predictions of this kind are well-suited to time series analysis such as the Box-Jenkins approach and other more recently developed techniques.[b] Time-Series and econometric researchers are therefore examining the possibility of combining previously separate approaches to deal with the load forecasting problem.[c]

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[a] Load management is any utility program or activity that is intended to reshape a utility's load duration curve deliberately. See Reference 7

[b] See Reference 2.

[c] See Reference 3.

3.2 RESULTS

3.2.1 SAN FRANCISCO BAY AREA AIR BASIN

The gas turbine projected outputs are based on the data compiled in this report and the historical and projected values supplied by the California Energy Resources Conservation and Development Commission (ERCDC).

The ERCDC forecast is based on its own residential model and, in the commercial, industrial, and other sectors, on equations developed by Pacific Gas and Electric (PG&E) Company. There were differences between PG&E's forecast and projections from a forecast made by the Commission. According to the Commission, the differences were a result of (1) different assumptions about future energy prices; (2) non-price conservation adjustments in the commercial and industrial sectors; and (3) a different residential sales forecasting methodology and assumptions. Forecasts for the residential sector were derived from a macroeconomic model partially adjusted to consider mandatory conservation measures.

The gas turbine projected output for the year 1980 is 275,900 MWH. The gas turbine projected output for the year 1985 is 323,500 MWH.

3.2.2 SOUTH COAST AIR BASIN

The gas turbine projected outputs are based on the data compiled in this report and the historical and projected values supplied by the ERCDC.

3.2.2.1 LADWP, Glendale, Burbank, and Pasadena

The ERCDC projections of the total sales in the residential sector are based on the Commission's staff report. Projections

in the commercial and industrial sectors were established from an econometric forecast submitted by the Los Angeles Department of Water and Power (LADWP). The forecast relates commercial and industrial sales to the ratio of electricity and gas prices to Los Angeles County personal income. Forecasts for other sectors in this area were determined by the following methods:

1. Applying equations to estimate sales for street and highway lighting
2. Assuming a constant 93 gigawatt hours for other city government usage, and
3. Using a forecast equation to relate total system sales to Owens Valley sales.

Non-residential sales to Glendale, Pasadena, and Burbank were based on the growth rate of total sales.

3.2.2.2 Southern California Edison (SCE)

The Commission's adopted forecast for the SCE service area is based on the Commission's staff residential model and equations developed by SCE for the commercial, industrial, and "other" sectors.

The South Coast gas turbine projected output for the year 1980 is 80,500 MWH. The South Coast gas turbine projected output for the year 1985 is 97,600 MWH.

3.2.3 SAN DIEGO AIR BASIN

The gas turbine projected outputs are based on the data compiled in this report and the historical and projected values supplied by the ERCDC (refer to Table 3-2).

The ERCDC projections of total sales were derived from the San Diego Gas and Electric (SDG&E) Company's forecast as revised in compliance with the Commission's January 12, 1977 order. The

residential sector of the forecast was established on household projections supplied by the San Diego Comprehensive Planning Organization, and a macroeconomic forecast of sales per customer adjusted to incorporate the impact of mandatory and voluntary conservation measures upon household consumption patterns. The commercial, industrial, and other sectors of the forecast were based on equations submitted by SDG&E.

The gas turbine projected output for the year 1980 is 281,700 MWH. The gas turbine projected output for the year 1985 is 378,700 MWH.

Table 3-2. GAS TURBINE PROJECTIONS

California Air Basin	Base Line Year[a] (MWH)	1980 (MWH)	1985 (MWH)
San Francisco Bay Area	235,555	275,900	323,500
South Coast	63,501	80,500	97,600
San Diego	212,645	281,700	378,700

[a] 1977 for the San Francisco Bay Area Air Basin
1975 for the South Coast and San Diego Air Basins

4.0 REFERENCES

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