3.1.2 Power Supply System

Electric power utilities in the Luzon Grid are: NAPOCOR which is solely responsible for the construction, operation and maintenance of generating plants, transmission lines and substations not only in Luzon but also in other areas of the country as a whole; Manila Electric Company (MERALCO), a privately owned utility distributing electricity to the Metro Manila area; and the local electric cooperatives (COOPS) under the administration of National Electrification Administration (NEA). Most of the COOPS purchase power from NAPOCOR and distribute it to their consumers on a local franchise basis.

The power system of Luzon is composed of three (3) elements: the first is hydraulic power from North Luzon -- Pantabangan 100 MW, Angat 218 MW and other small hydraulic power station groups, and the Bataan Thermal Plant 225 MW; the second, in Metro Manila where oil-fired thermal power plants like Gardner/Snyder (Sucat) 850 MW, and Malaya 650 MW are located; the third, geothermal plants Tiwi 220 MW and Mak-Ban 220 MW and pumping station Kalayaan 300 MW which are located in Southern Luzon.

Most of these power stations are connected with 230 KV transmission line and supply electricity through 230 KV/69 KV transformers, while MERALCO's trunk system is composed mainly of 115 KV lines and supplies load through 115 KV/34.5 KV transformers.

3.2 POWER DEMAND FORECAST AND POWER DEVELOPMENT PLAN

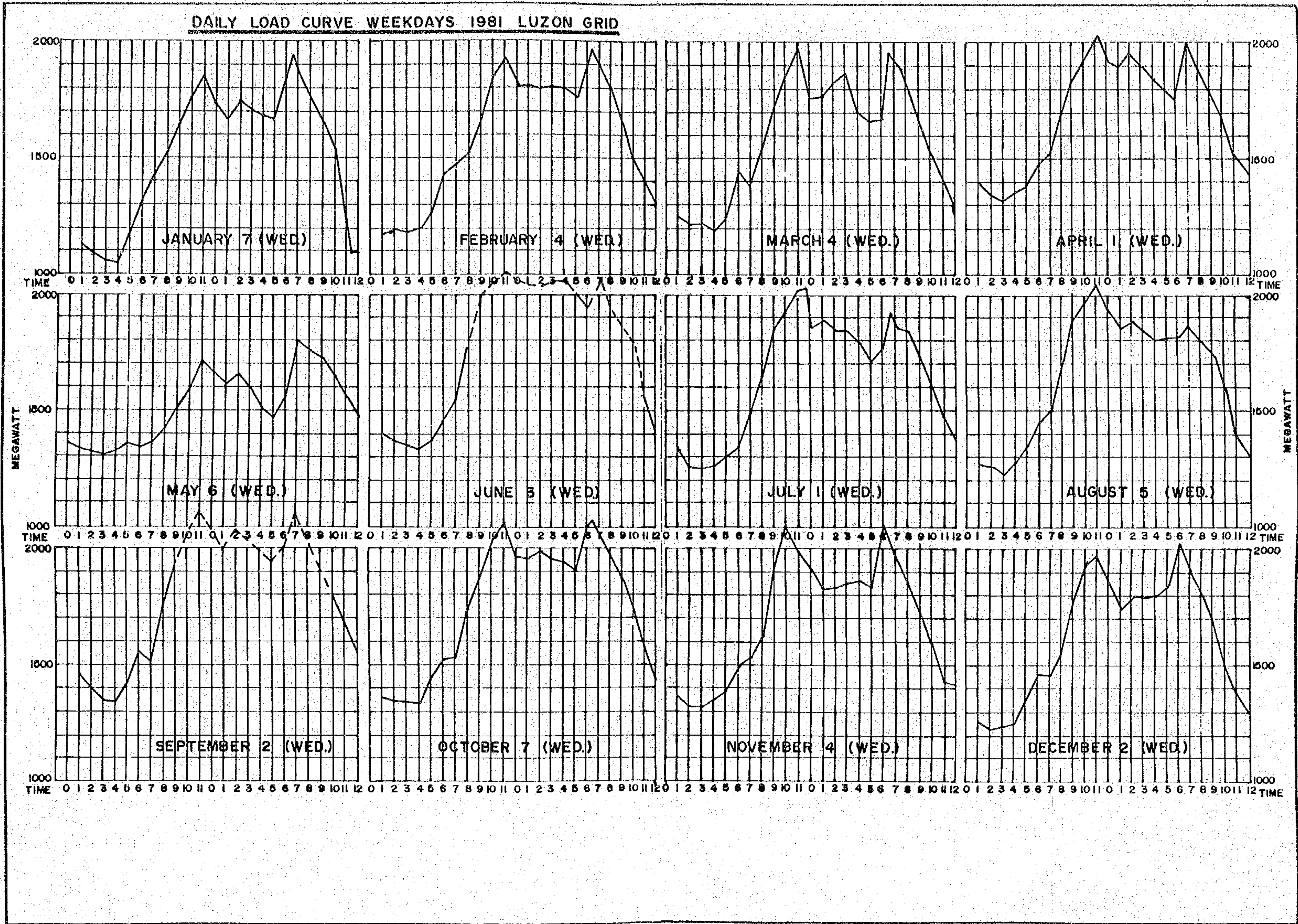
3.2.1 Historical Load Increase

Load increases in the Luzon Grid during the past ten years of 1972 to 1981 are tabulated on Table 3-2. As seen on the table, the peak load and annual energy requirement in 1972 were 1,331 MW and 7,555 x 10^6 KWH. These reached 2,225 MW and 13,647 x 10^6 KWH in 1981 which is nearly twice as much as those in 1972. The average growth rate in this duration was 7% in peak load and 7% in annual energy requirement. Although there are some variations by years, the load factor ranges from 65% to 72% which seems relatively high in recent years.

Fig. 3-2 represents daily load curves in each month of 1981 which indicate no remarkable difference in each other.

Fig. 3-3 shows a monthly peak load curve for three years of January, 1979 to August, 1982. As seen in the load curve there is no particular seasonal load fluctuations observed but a gradual increase only.

Fig. 3-2 DAILY LOAD CURVE WEEKDAYS 1981 LUZON GRID



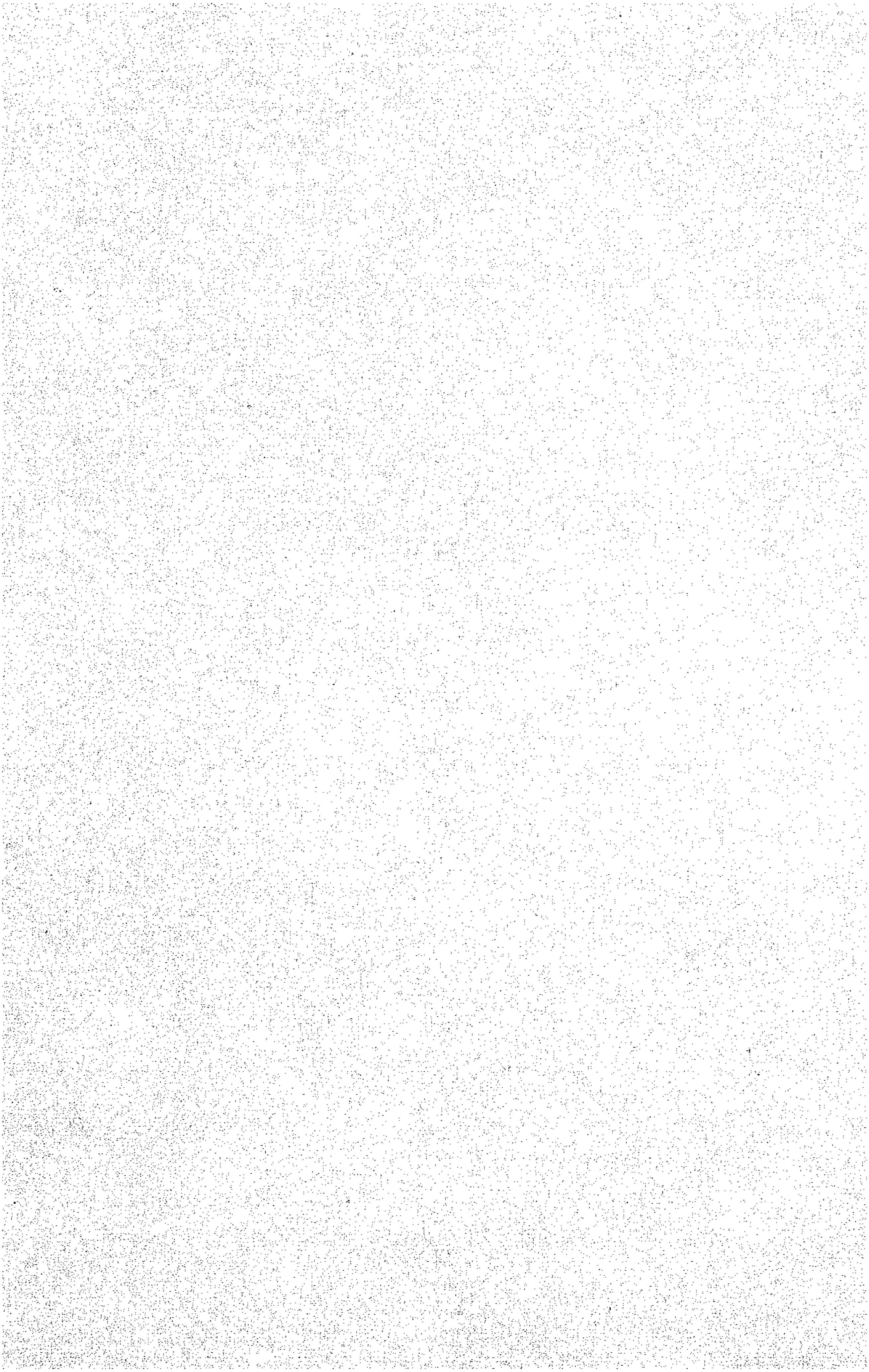
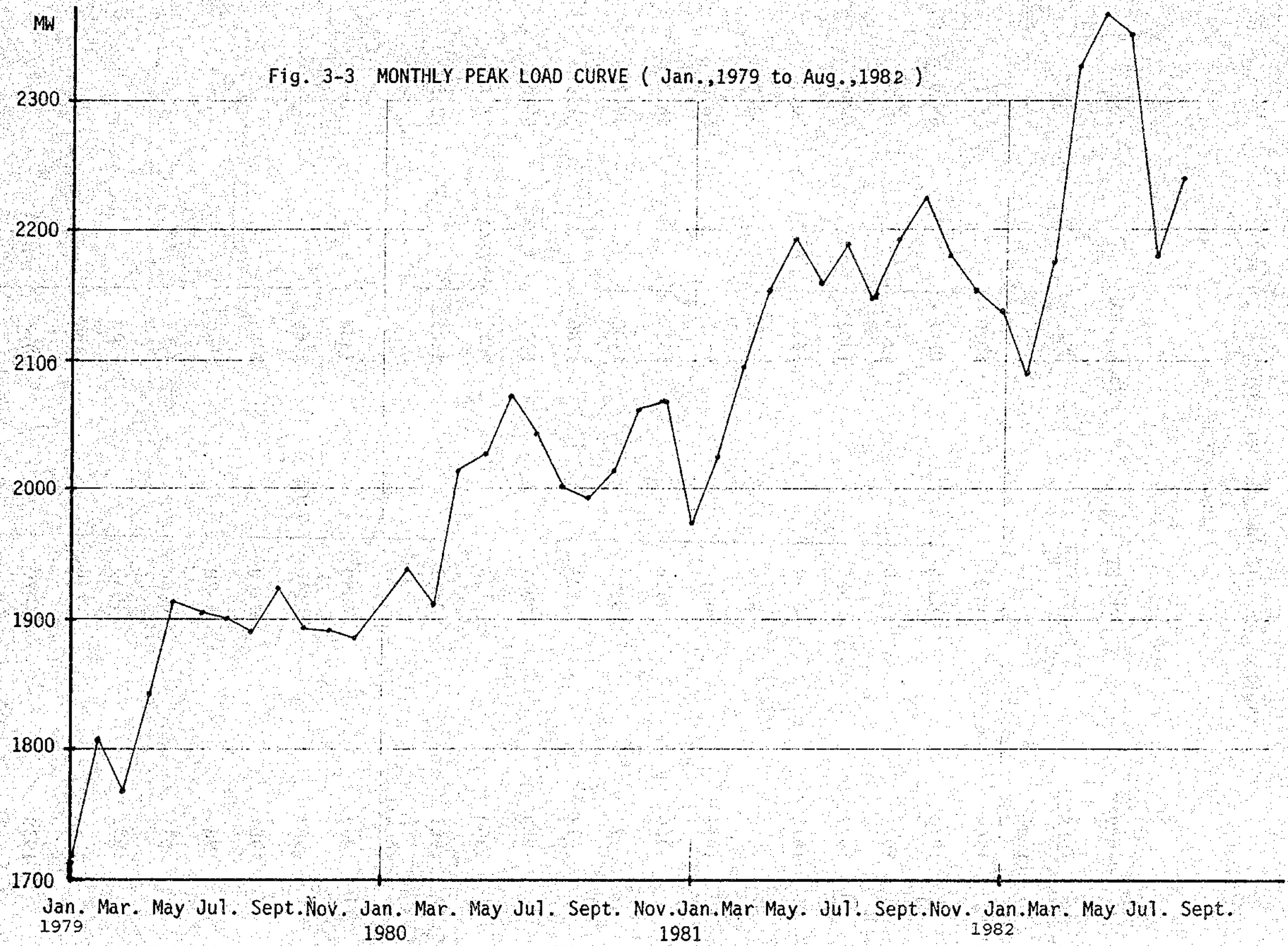


TABLE 3-2 HISTORICAL AND PROJECTED ENERGY

LUZON GRID

Calendar Year	Energy Reqt. GWH		Peak Load Mw		Load Factor %
Actual					
1969	6087		1020		68.1
1970	6386		1111		65.6
1971	7048		1205		66.8
1972	7555		1331		64.8
1973	8212		1335	7%	70.2
1974	8240	7.0%	1379		68.2
1975	9014		1513		68.0
1976	9626		1659		66.2
1977	10357		1709		69.2
1978	11223		1780		71.9
1979	12054		1926	7.2%	69.5
1980	13126		2074	7.4%	71.6
1981	13647		2225		72.5
Forecast					
1982	15080		2380	6.8%	
1983	16140	7.0%	2565		
1984	17240		2745		
1985	18420		2940		
1986	19680		3145	7%	
1987	21030		3365		
1988	22475	6.9%	3600		
1989	24020		3850		
1990	25675		4120		

Fig. 3-3 MONTHLY PEAK LOAD CURVE (Jan.,1979 to Aug.,1982)



3.2.2 Power Demand Forecast

NAPOCOR prepared the power demand forecast up to the year 1990 in October 1981. This demand forecast indicates that the growth rates of peak demand and energy requirement are estimated at 7% and 6.9%, respectively, from 1980 to 1990.

In view of the current worldwide energy saving efforts, the Philippine government's policy of oil import reduction, use of non-oil energy for new industrial development and diversification of industry to the areas other than Luzon, a sharp demand increase inside the Luzon Grid would not be expected in coming decade, according to"NAPOCOR Power Expansion Program" prepared in October 1981. The projected growth rate of 6.9% per annum from 1981 to 1990 seems to be reasonable for the time being.

3.2.3 Generation Expansion Plan

NAPOCOR's power expansion program for 1981 to 1990 will contribute to the implementation policies of government to hasten the electrification of the country and to reduce reliance of the electricity on imported oil. NAPOCOR worked out its generation expansion program in October 1981, which is designed to increase the total installed capacity of the Luzon Grid to 5941 MW in 1990, composed of hydro 1604 MW (27%), geothermal 1192 MW (20%), nuclear 620 MW (10%), coal-fired thermal 600 MW (10%), and oil-fired thermal 1925 MW (33%). This latest Generation Expansion Plan is presented on Table 3-3. The retirement of Rockwell oil-fired thermal plant (305 MW) is considered in early 1980 due to its deterioration. Fig. 3-4 presents the relation between peak demand and capability; Fig. 3-5 between energy requirement and supply.

Table 3-3 LUZON POWER GRID GENERATION EXPANSION PROGRAM

YEAR OF COMM.	PLANT ADDITION	INSTALLED CAPACITY (MW) HYDRO	GEO	COAL THER	NUCL.	OIL THER	TOTAL	/1 DEP. CAP.	PEAK DEMAND	RES. CAP.	% RES.	AVAIL-ABLE ENERGY (GWH)	ENERGY CAPABILITY AND REQUIREMENT (GWH) HYDRO	GEO	COAL THER	NUCL.	OIL THER	TOTAL	GENE-RATION LEVEL	SUR-PLUS (DEF.)
1980	Existing	542	440			2230	3212	2880	2070	470	23	19097	2050	2283			13871	18204	13113	5091
1981	Masiway (1 x 12)	554	440			2105	3099	2816	2240	236	11	48	2098	3176			13297	18571	13750	4821
82/3	Tiwi Geo 5 (55)	354	495			1925	3274	3016	2400	276	12	397	2261	3507			13510	19278	15080	4198
82/5	Kalayaan 2 (150)											150								
82/7	Kalayaan 1 (150)											150								
1983	Tiwi Geo 6 (55)	1214	550			1925	3689	3337	2565	432	17	397	2766	3970			13510	20246	16140	4106
83/6-12	Magat 1-4 (360)											1103								
84/7	Mak-Ban 5-6 (110)	1214	660			1925	3799	3437	2745	352	13	794	3501	4367			13510	21378	17240	4138
1985	PNPP 1 (620)	1214	660	300	620	1925	4718	4107	2940	767	26	3910	3501	4764	1989	1684	13510	25448	18420	7028
	Coal Ther. I (300)											1989								
1986	Tiwi Geo 7-8 (110)	1214	1210	300	620	1925	5269	4657	3145	1062	34	794	3501	8734	1989	3367	13510	31101	19680	11421
	Tongonan 4-5 (110)											794								
	Tongonan 6-11 (330)											2382								
1987	-	1214	1210	300	620	1925	5269	4707	3365	842	25		3501	8734	1989	3639	13510	31373	21030	10343
1988	Coal Ther. II (300)	1214	1210	600	620	1925	5569	5027	3600	877	24	1989	3501	8734	3978	3856	13510	33579	22475	11104
1989	-	1214	1198 /2	600	620	1925	5557	5056	3850	616	16		3501	8647 /2	3978	3910	13510	33546	24020	9526
1990	San Roque H.E.	1604	1192 /3	600	620	1925	5941	5339	4120	629	15	1153	4654	8607 /3	3978	3910	13510	34659	25675	8984

NOTE :

/1 Dependable capacity is the sum of the dependable capacities of all plants. For hydro plants it is the capacity that can be delivered at low or worst reservoir condition. For thermal plants it is the derated capacity.

/2 12 MW and 87 GWH drawn for Leyte & Samar grid requirement.

/3 6 MW and 40 GWH additional power for Leyte & Samar grid requirement.

Fig. 3-4 RELATION BETWEEN ENERGY REQUIREMENT AND SUPPLY

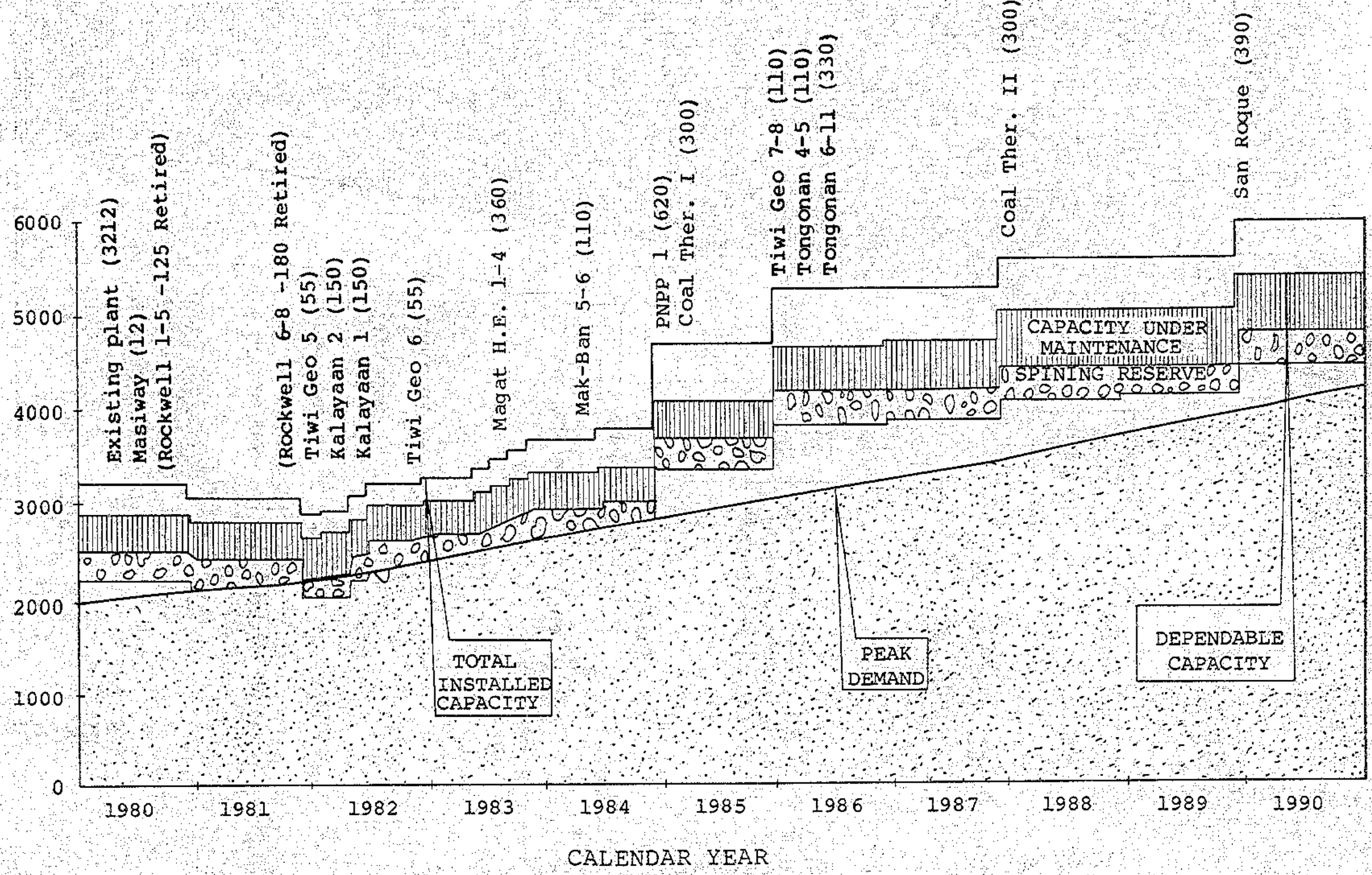
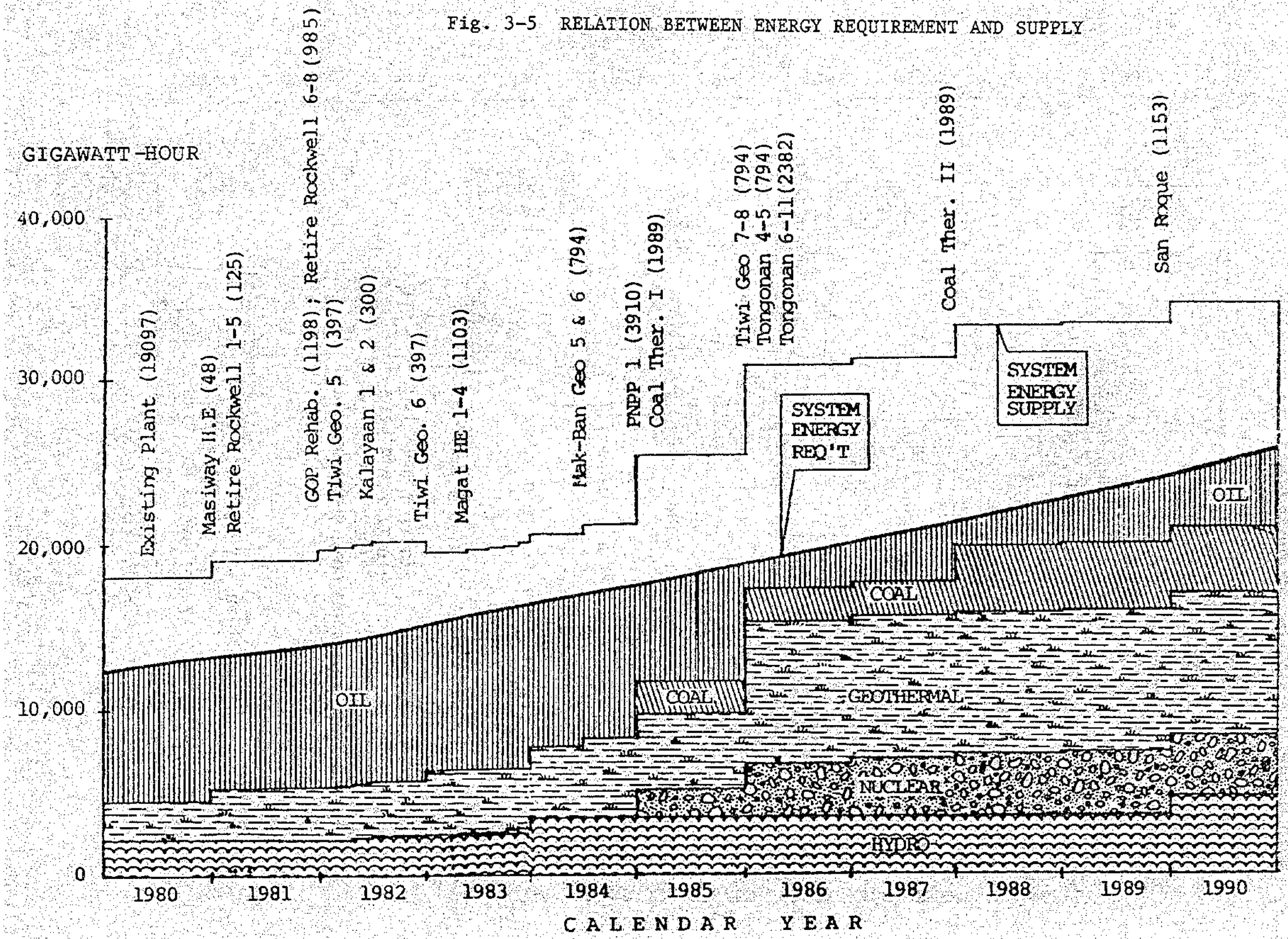


Fig. 3-5 RELATION BETWEEN ENERGY REQUIREMENT AND SUPPLY



3.3 ELECTRIC SUPPLY GRID IN METRO MANILA

Electric supply for Metro Manila is supplied by means of 230 KV/115 KV transformer and Gardner/Snyder, Tegen and Rockwell thermal plants. Electric power for Metro Manila is directly taken from 115 KV system as shown on Fig. 3-6.

In Metro Manila, network is connected with 230 KV and 115 KV transmission lines for loop system and substation bus is being applied by 1 - çCB scheme, so system reliability is rather high grade, and in case an accident occurs in any substation, transmission line, power supply will be continuing or will recover in short time.

The service area of MERALCO is about 2600 km` embracing the Metro Manila area which corresponds to approximately 2.5% of the total land area of Luzon (104,000 km^2). However, the service area has the heaviest load density which consumes nearly two-thirds (2/3) of the total load in Luzon.

Fig. 3-6 EXISTING LUZON GRID OUTLINE

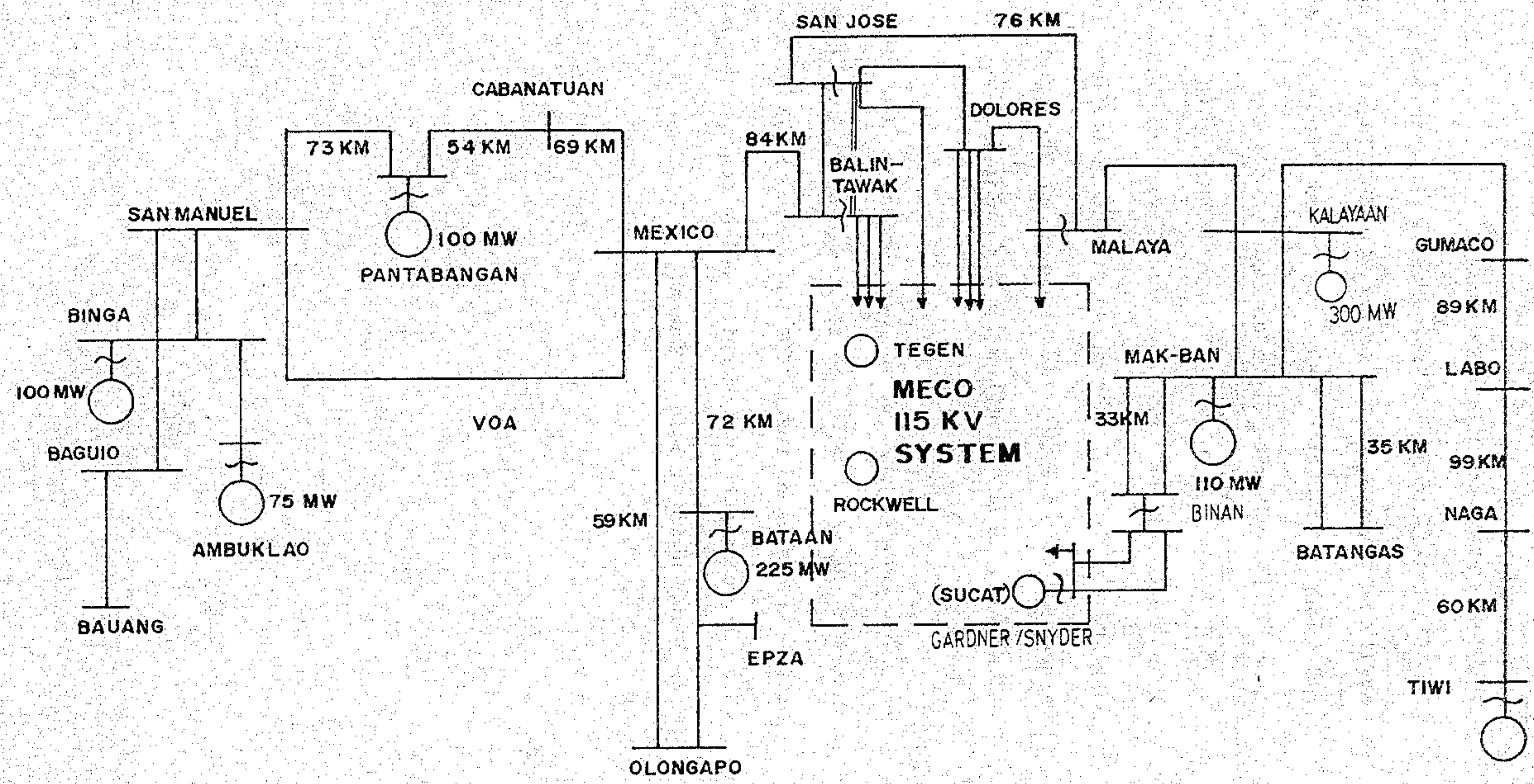
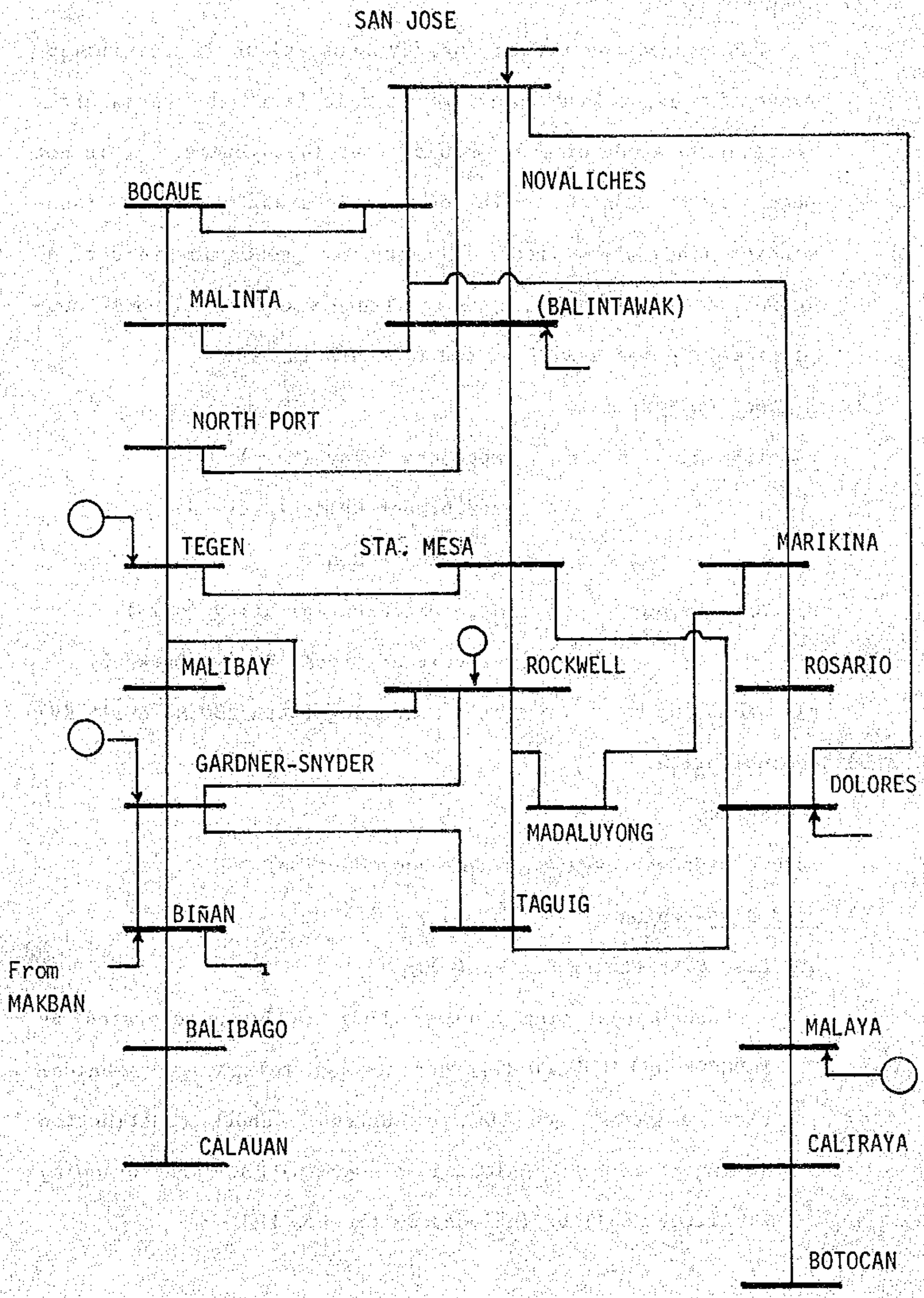


Fig. 3-7 EXISTING 115 KV NETWORK OF MERALCO



3.4 EFFECT ON THERMAL POWER PLANT BY ELECTRIC POWER SUPPLY SYSTEM

3.4.1 Power Supply System of NAPOCOR

1) Substation:

Bus connection system for EHV substations in the Philippines was determined to be 1ç circuit breakers system after comparative study of most popular four (4) systems. It is not necessary to stop the operation of main transformers or transmission lines when circuit breakers are opened in order to do inspection or maintenance work. There would be no power supply interruption even if a fault occurs in bus.

2) Protection System

a) Transmission Line	Impedance Relay (Main)
	Overcurrent Relay (Back-up)
	Reclosing - Non
b) Transformer	Ratio Differential Relay (Main)
	Overvoltage Ground Relay (Back-up)
c) Grounding	Solid Grounding (Both 230 KV & 115 KV)

3) Communication:

PLC System

Future Microwave system (under construction)

4) Load Dispatching:

a. Load Dispatching Center (LDC)

Load Dispatching Center (LDC) is being operated by NAPOCOR and MERALCO together through telephone communication, however, new LDC is currently under construction aiming at the commissioning in August 1983. The following facilities will be included in the new LDC:

- The data acquisition and remote control subsystem
- The process computer subsystem
- The man-machine interface subsystem
- The frequency control subsystem
- The communication system

b. Frequency Control

Frequency control is done by Tegen Power Station at night and hydro power station in day time. During the wet season, in particular from around August to October or November, some hydro power stations are generally operated at full capacity. As a result, these stations are not suitable for utilization as regulating plant during this season.

During system disturbances when the system frequency cannot be stabilized readily to normal, load shedding is taken by underfrequency relaying.

For automatic frequency control, total amount of regulating power available should be as large as possible. For this purpose as many power stations as possible should participate in frequency control. It has tentatively been assumed that the following power stations will be connected to the frequency control scheme: all hydraulic power stations except special ones; and the thermal power stations of Malaya-2, Tegen-1 and -2, and Bataan-2.

c. Voltage Regulation

The general principle adopted in the NAPOCOR system is that automatic voltage regulation is provided from on-load tap changers at the low voltage side of the 69/13.8 KV transformers installed at load center substations.

Fig. 3-8 COMMUNICATION SYSTEM IN LUZON GRID IN 1980

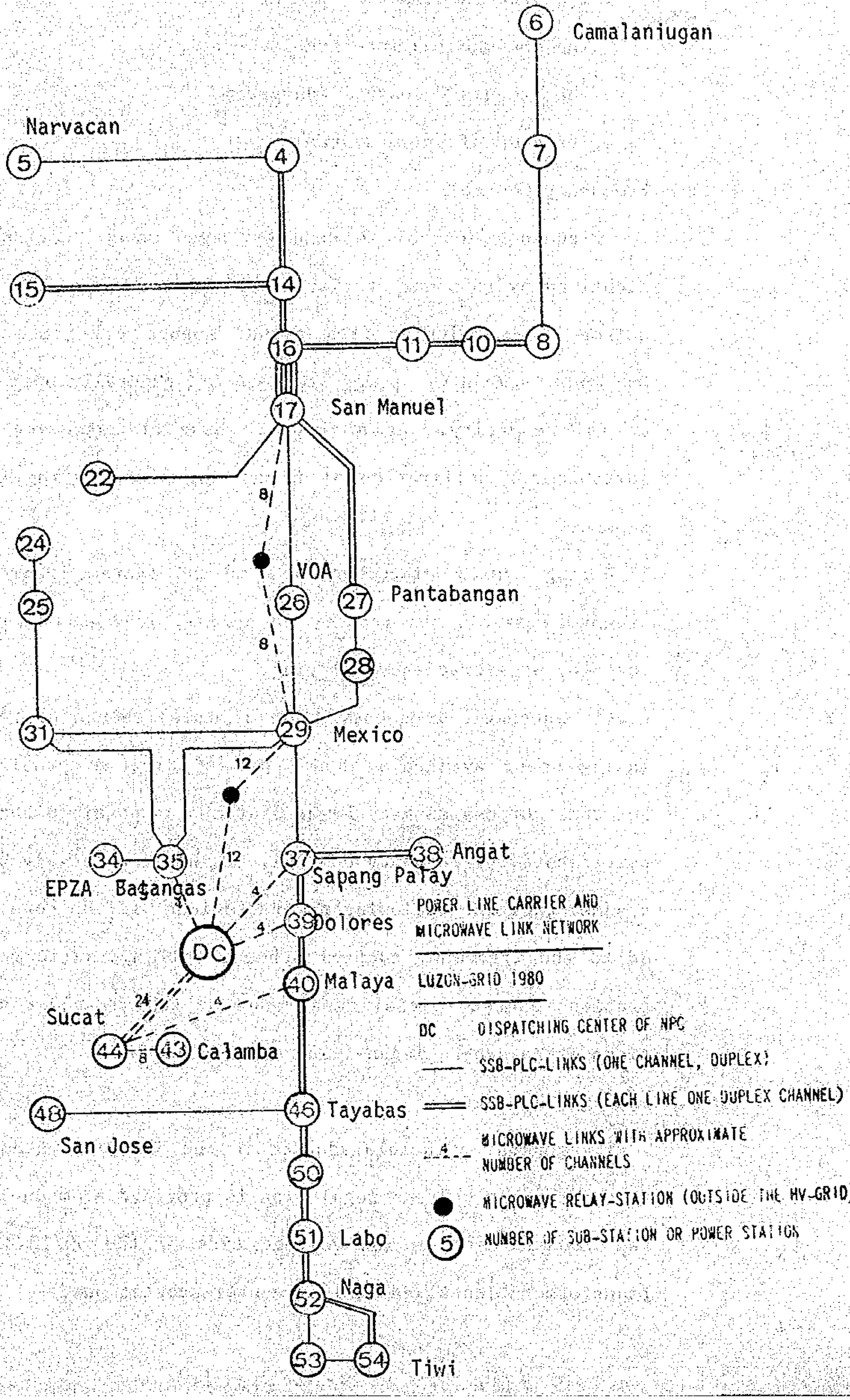
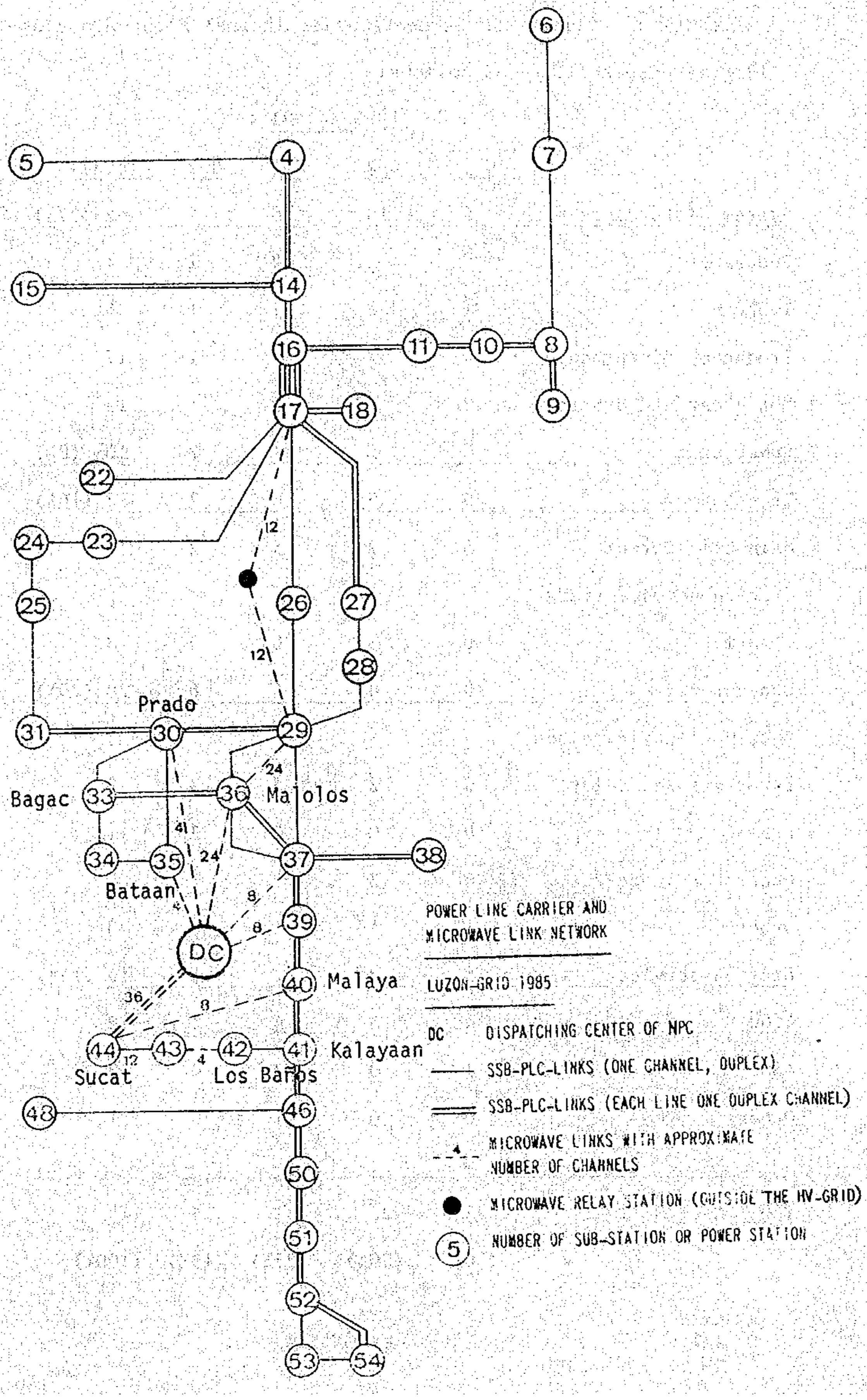


Fig. 3-9 COMMUNICATION SYSTEM IN LUZON IN 1985



3.4.2 System Trouble

Electrical troubles in Gardner/Snyder Thermal Plant are classified by each facility as follows:

1970 - 1981

	G-1	G-2	S-1	S-2	Total
System disturbance	9	19	10	4	42 (37%)
Feeder trip	2	2	2	1	1
Typhoon	1	2	1	1	5
Frequency disturbance	4	7	5	1	17
Not clear and others	2	8	2	1	13
Substation	5	2	1	2	10 (8%)
Transformer	5	5	6	2	18 (16%)
Main transformer	5	2	5	2	15
Station service transformer	0	3	0	0	3
Generator	10	6	6	6	28 (25%)
Back-up relay (include reverse power relay)	0	2	4	3	9
AVR	9	0	0	2	11
Generator & exciter	0	3	1	1	5
Others	1	1	1	0	3
Station service	5	3	7	1	16 (14%)
4160 V	4	3	4	1	12
480 V	1	0	2	0	3
Others	0	0	1	0	1
T O T A L	34 (30%)	35 (30%)	31 (27%)	15 (13%)	114 (100%)

The most frequently occurred troubles are caused by system disturbance, occupying the share of about 40% of total trippings and generator troubles share 25% of the total. However, the greater part of generator troubles due to actuation of the reverse power relay are conceivable to be caused by boiler or turbine troubles, not by the troubles of generator proper.

Transformer trouble has a share of 16% of the total, station service 14% and substation 8%.

1) Unit Trip Due to System Disturbance:

The unit trip due to system disturbance caused 42 times (37%) for years of 1970 to 1981. However, since the first cause of the trip was not clarified thoroughly, it is very difficult to establish the measures to be taken.

For example, when the unit trip occurred not only the phenomena but also the first cause of the trip should be recorded in order not to repeat the same trouble.

The influences of system disturbance on power plants as follows:

a. In case of the other unit trip:

In case of unit trip other than Gardner/Snyder power generating unit, the system frequency decreases about one (1) Hz/140 MW in Luzon Grid. Low frequency operation of steam turbine gives serious damages to the turbine blades.

b. <u>In case of feeder line trip:</u>

In case of feeder line trip, system frequency increases, power station copes with output decrease accompanying with high frequency. To avoid increases in system frequency, load shedding relays are provided at G-2, S-1, S-2 and M-1. However, according to trouble records, unit trips due to system disturbances and frequency disturbances occurred many times. As a result of survey, these load shedding relays could not operate adequately.

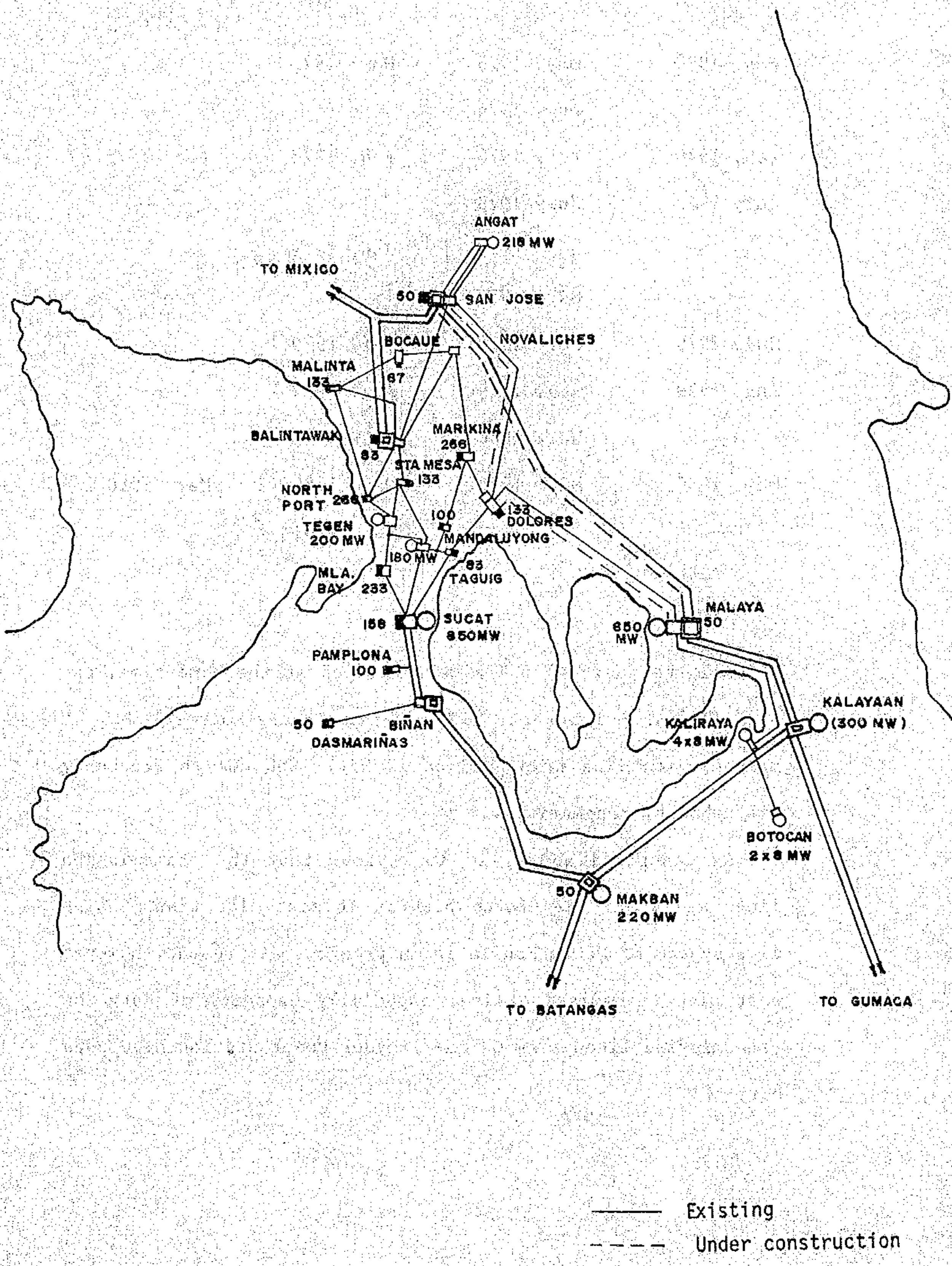
Unit Trip Due to Transmission Line Trip and Frequency Disturbance

G-1	G-2	S-1	S-2
May 1970	May 1975	May 1973	---
---	Aug. 1976	---	---
Feb. 1978	Feb. 1978	Feb. 1978	Feb. 1978
July 1978	July 1978	---	---
---	Jan. 1979	Jan. 1979	---
---	Mar. 1979	---	---
July 1979	July 1979	July 1979	---
Aug. 1979	Aug. 1979	Aug. 1979	---
---	Mar. 1980	---	---
May 1980	May 1980	May 1980	May 1980
---	---	May 1981	---

All the four (4) units were tripped at the same time, especially on 7 Feburary, 1978 due to Taguig-Rockwell 115 KV transmission line trip, and on 12 May, 1980 due to frequency disturbance, respectively.

As described above, it is obvious that the transmission lines are weak. Reinforce program of east side transmission line system of Metro Manila is in progress at present, however west side transmission line, especially capacity of outgoing transmission lines from Gardner/Snyder Power Station have capacity of:

Fig. 3-10 Transmission Line Near Metro Manila



Gardner/Snyder - Taguig ; 343 MVA

Gardner/Snyder - Rockwell; 343 MVA

Gardner/Snyder - Malibay ; 343 MVA

115KV/34.5KV transformer ; 133 MVA

115KV/34.5KV transformer ; 25 MVA

Therefore, when the Gardner/Snyder power station delivers the power of rated output of 850 MW, it is very difficult to supply power to Metro Manila with high reliability. Moreover, taking the future additional power development in south side (Mak-Ban geothermal and Batangas coal-fired thermal power plants) and power demand increase in Metro Manila into consideration, the problem becomes acute in the future.

RECOMMENDATIONS:

(1) Frequency Control

Automatic frequency control should be installed to cope with load adjustment accompanying to frequent decreases in the event of unit trip. At present, frequency relays to protect low frequency operation are provided at S-1 and S-2 units. However, if these relays are placed into service continuous operation of S-1 and S-2 units is not possible even in the event of Kalayaan Pump Hydro power station start-up at present situation of Luzon Grid. Selective load shedding by the Central Load Dispatching Center should be urgently needed to keep the frequency constant.

(2) Additional Transmission Line

Construction of only one transmission line from Gardner/Snyder P/S to Binan S/S cannot cope with the future situation, therefore it is recommendable that one additional transmission line from Gardner/Snyder to Rockwell should be installed.

(3) Application of Automatic Oscillograph

In order to analyze the system disturbance and relay activations, automatic oscillograph should be installed at important stations/plants.

(4) Application of High Speed Reclosing System

In order to improve system reliability on the 230 KV system, single phase reclosing scheme which shall cover approximately 80% of line faults is recommendable.

(5) Relaying Equipment Coordination

The relaying equipment for station service shall be coordinated with T/L protection relaying equipment. Some relaying equipment shall be tested immediately.

(6) Analysis of Accident Cause

The cause of accidents should be classified, identified and it should be fed back to maintenance for repair/checking on the equipment and all similar types of equipment.