3.2 Present State and Development Plans of Tongonan Geothermal Energy

3.2.1 Background

Tongonan geothermal field is located on the southwestern slopes of the mountains of northwest Leyte and lies within the catchment area of the Upper Mahiao and the Sambaloran rivers. The production field is situated between elevations of 400 m and 700 m above sea level and has a minimum surface projected area of 4 km^2.

Exploration of the geothermal resources of the Leyte Island commenced in 1973 on the Tongonan field covering two areas, Bao Valley and Mahiao/Malitbog areas. The scientific studies and development of the Tongonan Geothermal Power Project has been carried out under the technical cooperation of the Government of New Zealand and the Tongonan geothermal project has been promoted by the joint efforts of three Government agencies of the Philippines i.e. NAPOCOR, PNOC and EDC.

On October 21, 1976, the first deep exploratory production well was drilled at the Mahiao area and in July 1977, the first 3 MW geothermal pilot plant started to supply the power to Ormoc city.

The construction of the 112.5 MW (= 3 units x 37.5 MW) geothermal power plant is now under way with completion expected in August 1982 for the plant No. 1, in November 1982 for the plant No. 2 and in February 1983 for the plant No. 3. The completion of these three plants is planned to coincide with the commissioning of the PASAR copper smelter project undertaken at Isabel in Leyte.

3.2.2 Technical and Economic Features of Tongonan Geothermal Power Project

(1) Current Development

The feasibility study together with preliminary design of the Tongonan Project was conducted in 1978 by a New Zealand consultnat in association with NAPOCOR, PNOC and EDC[1]. The said study had identified and proved the technical and economic feasibility of the first stage development of geothermal resources with the capacity of 112.5 MW.

According to NAPOCOR[2], the technical features of Tongonan 112.5 MW Project are as shown below.

(i) Area of geothermal field reservation: 107,625 ha

(ii) Heat energy: minimum 200°C

(iii) Steam wells:

Having been drilled to date: 17 wells

To be utilized for steam production for 112.5 MW : 11 "

Standby : 3 "

For re-injection : 3 "

(iv) Depth of steam wells: 3,700 - 6,600 ft.

(v) Power plant capacity: 112.5 MW (= 3 x 37.5 MW)

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[1] Tongonan Geothermal Power Station, Preliminary-Design Report, KRTA, October 1978

[2] Capsule Report, Tongonan Geothermal Power Project, NAPOCOR, 1979

(vi) Transmission lines:

Tongonan - Isabel (33.9 km): 138 kV (Double)
" - Tunga (43.9 km): 69 kV
" - Wright (110.0 km): 138 kV

The project cost for 112.5 MW installation is estimated at P 907.3 x 10^6 (\$121 x 10^6 equivalent) at 1981 price level. The above cost includes those of PNOC (EDC) and NAPOCOR and is composed of foreign currency portion of \$79.7 x 10^6 and local currency portion of P 309.6 x 10^6. The breakdown of the cost by project component is as shown in Table 3-9.

(2) Future Development

According to the most up-to-date information obtained from NAPOCOR the future development of Tongonan geothermal power is scheduled as shown below.

Tongonan Power Plant	Capacity	Year of Commission
No. 1 - No. 3	3 x 37.5 MW = 112.5 MW	1983 (Under construction)
No. 4 - No. 7	4 x 55 MW = 220 MW	1985
No. 8 - No. 11	4 x 55 MW = 220 MW	1986
No. 12 - No. 15	4 x 55 MW = 220 MW	1991
No. 16 - No. 19	4 x 55 MW = 220 MW	1992
No. 20 - No. 21	2 x 55 MW = 110 MW	1993
Total	1,102.5 MW	

The final exploitation of Tongonan geothermal energy is expected to amount to as much as 1,102.5 MW.

(3) Other Geothermal Energy Sources in Leyte

Since the Philippines lies on a high-heat flow region that is a part of the "Circumpacific Fire Belt", geothermal potential has long been identified as a viable economic source of energy. According to the Five-Year Energy Program 1981 - 85 prepared by the Ministry of Energy, twenty two sites are nominated as geothermal potential areas (Table 3-10). Tongonan is listed as one of the four "proven potential areas". In the Leyte Island, the three potential sites, other than Tongonan, are listed as "possible potential areas"; they include Biliran Island, Burawen in northern Leyte and Anahawan in southern Leyte. Their locations are shown in Fig. 3-1.

According to the newspaper/1, a team of geothermal scientists from New Zealand recommended immediate exploration of Burawen and Biliran fields after confirming them as the geothermal fields "with high potentials".

/1 "Bulletin Today" published in Manual on March 31, 1981

Table 3-9 Breakdown of Project Cost for Tongonan 112.5 MW
(At 1981 price)

	Foreign Currency ($10^6)	Local Currency (₱10^6)	Total (₱10^6)
I. EDC Cost /1			
(1) Steam Collection and Effluent-Disposal System	16.807	87.458	213.511
(2) Well Drilling Costs	15.544	13.481	130.061
(3) Site Expenses	-	16.560	16.560
(4) Head Office & Geoscientific Overhead	0.812	14.792	20.882
EDC Cost Total	33.163	132.291	381.014
II. NAPOCOR Cost			
(1) Civil Works	0.938	82.662	89.697
(2) Electro-Mechanical Works Equipment & Supply	22.943	1.376	173.448
(3) Balance-of-Plant Supply, Erec./Installation	3.000	52.500	75.000
(4) Housing Village	0.400	15.050	18.050
(5) Consulting Services	1.330	3.967	13.942
(6) Eng'g & Adm. Expenses	-	16.964	16.964
(7) General Plant	-	2.337	2.337
(8) Contingency	17.926	2.412	136.857
NAPOCOR Cost Total	46.537	177.268	526.295
III. Project Cost Total	79.700	309.559	907.309 (=$121.0x10^6)

Remarks: /1 Estimates based on the EDC data of 1980 price level.

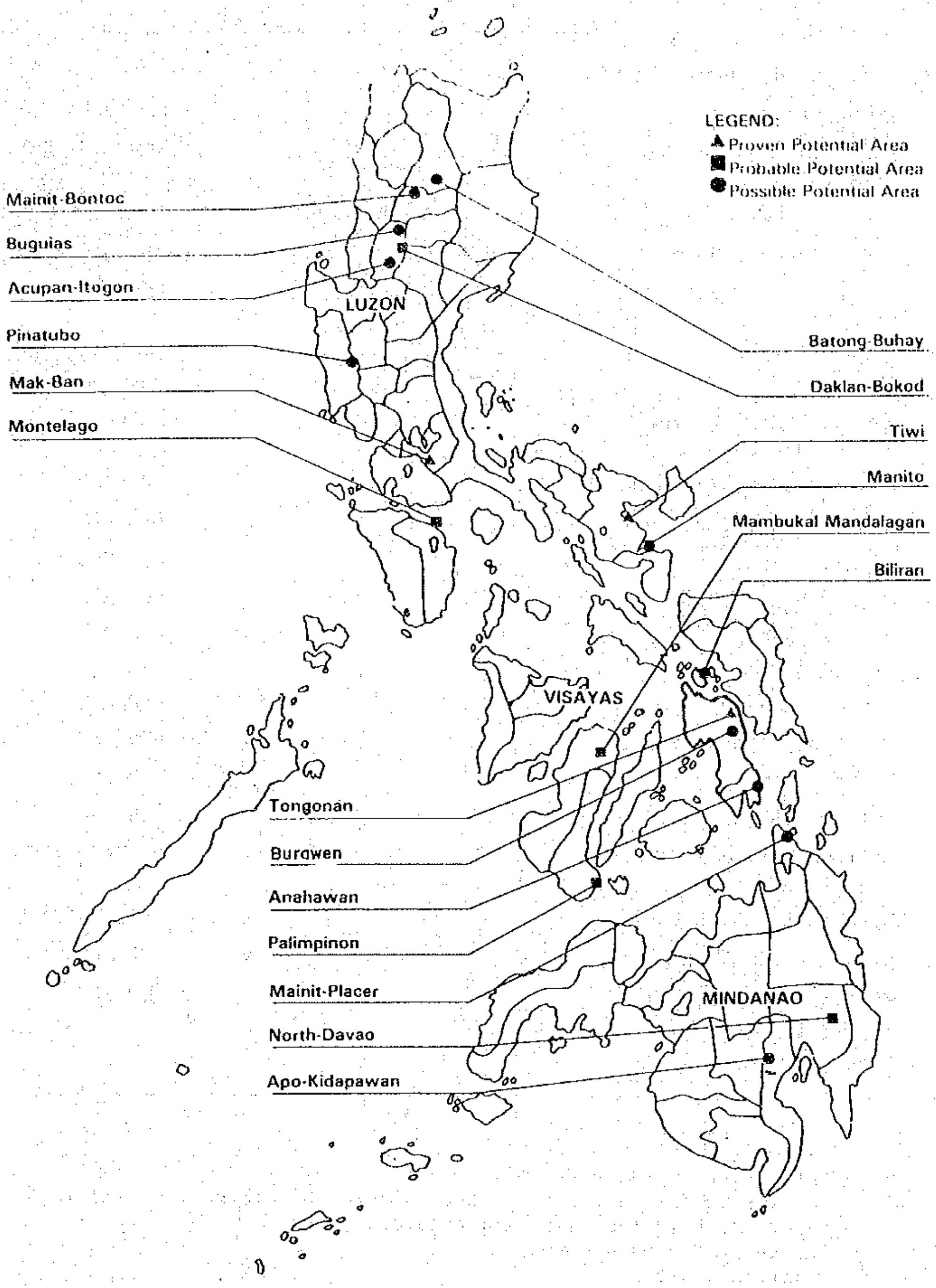
Table 3-10 Potential Geothermal Areas in the Philippines

Region	Geothermal area/location	Proven potential area	Probable potential area	Possible potential area	Entities involved
4	Makiling-Banahaw, Laguna	x			NPC/Union Oil (PGI)
5	Tiwi, Albay	x			NPC/Union Oil (PGI)
7	Palimpinon-Dauin, Negros Oriental	x			PNOC-EDC/KRTA
8	Tongonan Leyte	x			PNOC-EDC/KRTA/ NAPOCOR
1	Daklan-Bokod, Benguet		x		BED/ELC
4-A	Naujan-Montelago, Oriental Mindoro		x		BED/ELC
5	Manito, Albay		x		PNOC-EDC (under negociation by PGI)
6	Mambucal-Mandalagan, Negros Occidental		x		PNOC-EDC
11	Manat-Masara, North Davao		x		PNOC-EDC
1	Acupan-Itogon, Benguet			x	BED/ELC
1	Buguias, Benguet			x	BED/ELC
1	Mainit-Bontoc,Mt.Province			x	BED/ELC
2	Batong Buhay, Kalinga-Apayao			x	BED/ELC
2	Cagua, Cagayan			x	BED/ELC
3	Pinatubo, Zambales			x	BED/ELC
4	Mabini, Batangas			x	BED/ELC
5	Bulusan, Sorsogon			x	BED/ELC
8	Biliran Island Northern Leyte			x	PNOC-EDC/BED ELC
8	Burawen Northern Leyte			x	PNOC-EDC/KRTA
8	Anahawan Southern Leyte			x	BED/ELC
10	Mainit-Placer, Agusan Norte			x	BED/ELC
12	Apo-Kidapawan, North Cotabato			x	

NAPOCOR - National Power Corporation
PGI - Philippine Geothermal, Inc.
PNOC-EDC - Philippine National Oil Company - Energy Development Corporation
KRTA - Kingston, Reynolds, Thom and Allardice, Ltd.
BED - Bureau of Energy Development
ELC - Electroconsult
Proven - Sufficiently explored by drilling, thereby establishing certainty as to presence of economic geothermal potential
Probable - Sufficient exploratory and production well.
Possible - Geological reserves.

Source: Five-Year Energy Program 1981-85, MOE, July 1980.

Fig. 3-1 Potential Geothermal Areas



However, since there are still many uncertainties and since the gestation period is rather long, only Biliran in this is taken up study as the representative of these potential geothermal areas and is assumed to be commissioned from 1991.

3.3 Power System in the Philippines

3.3.1 Abstract

The power systems in the Philippines are divided into three blocks, that is, Luzon system in Luzon Island, Visayas system that is composed of Leyte Island, Samar Island and Cebu Island, etc., and Mindanao System in Mindanao Island. The following voltage classes are used at the present time in these systems.

Luzon system :	230 kV, 115 kV, 69 kV
Visayas system :	138 kV, 69 kV
Mindanao system:	138 kV, 69 kV

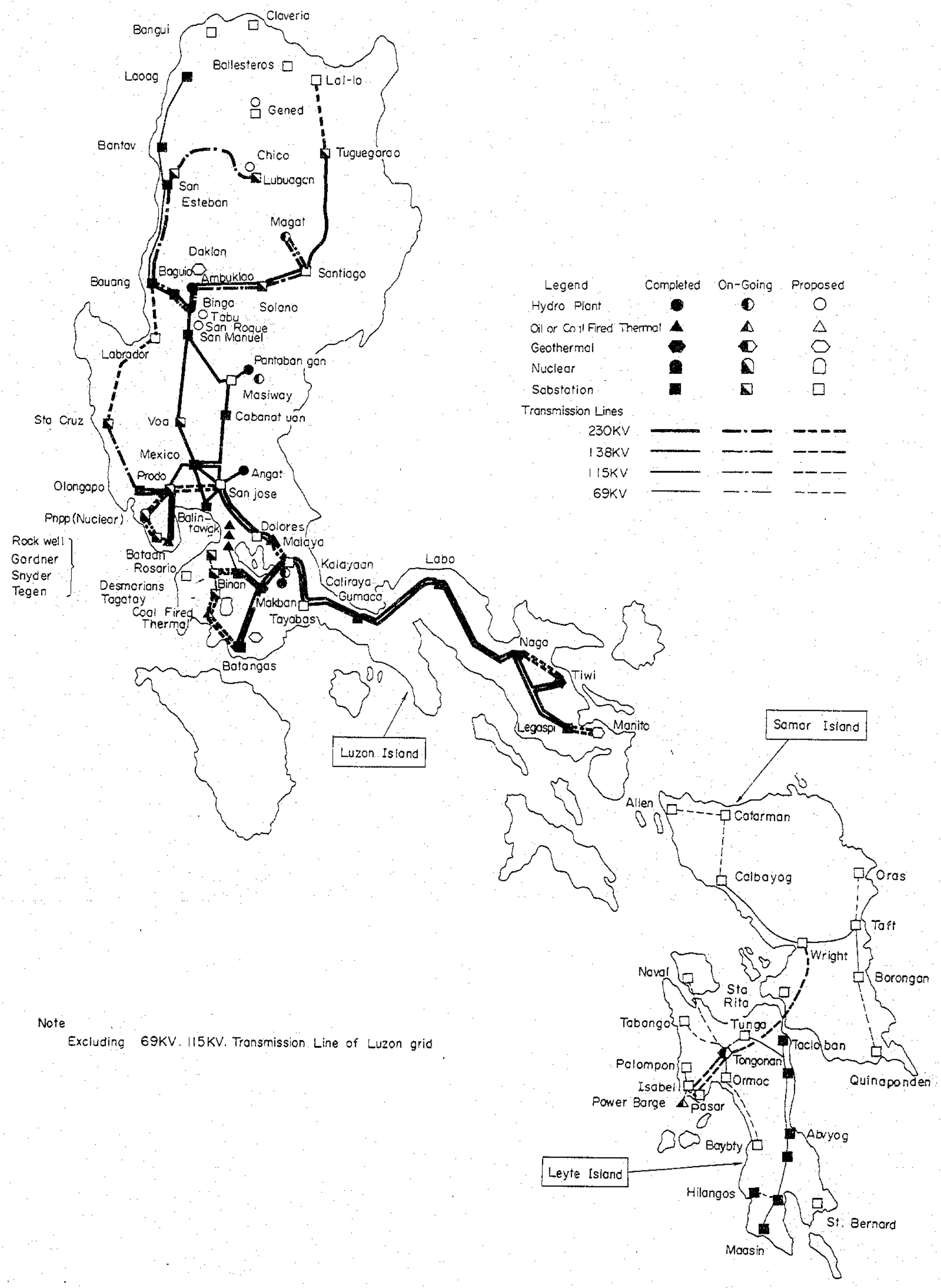
In the Luzon system, the 230 kV system was expanded in correspondence to the development of hydraulic power sources in the northern area and of geothermal power sources in the southern area, and transmission at 500 kV is also planned.

The Visayas system, on the other hand, is composed of the 138 kV system because the range of supply is small and the demand is also small.

In addition to the above, NAPOCOR plans construction of DC transmission lines (HVDC) related to this study for making effective use of the power generated by abundant geothermal energy in Leyte Island by transmitting it to the Luzon system.

The outline of the Luzon power system as well as of Leyte and Samar power system is described below. (Fig. 3-2)

Fig.3-2 ELECTRIC POWER SYSTEM (LEYTE, SAMAR AND LUZON) IN 1981



Note
Excluding 69KV. 115KV. Transmission Line of Luzon grid

3.3.2 Power System in Luzon

The population is concentrated in the Metro-Manila and many factories are located in and around this zone in Luzon Island. Accordingly, power is transmitted to Metro-Manila, which is a large place of demand for electric power, from power sources located in relatively long distances such as hydraulic power sources in the northern part of Luzon and geothermal power sources in the southern part, and in addition, power is also generated in the central area of the island with Manila as the nucleus, by mainly using oil thermal plants.

It is forecasted that the demand in Luzon Island will be expanded in the future with Manila as the center. Accordingly, transmission trunk systems, which spans the northern part and southern part of Luzon Island, are constituted by 230 kV transmission systems for transmitting power from hydraulic power sources in the northern part and for transmitting power from geothermal power sources in the southern part. These are used for transmitting power to Manila, for electrification of rural areas, and interconnection of various substations and generating plants such as nuclear, coal thermal and pumped storage hydraulic power plants under construction near the Metro-Manila area.

It is planned that the 230 kV trunk transmission system will be completed by about 1985, and construction of the new central load-dispatching center is going on for improving the reliability of these power systems linking north and south areas so that operation can be carried out at higher efficiency.

The 230 kV trunk transmission systems will be fully capable of coping up with increase of demand and development of power sources up to around 1985. However, the transmission capacity with is insufficient to a major extent for the geothermal power development in the southern part of Luzon (Tiwi, Manito) and for transmitting the power generated at Leyte geothermal power sources with the Luzon System. Under these circumstances, NAPOCOR conducted studies on the Southern Luzon system, based on which the plan to construct the 500 kV transmission lines (about 340 km) from San Jose to Kalayaan (both near Manila) to Naga (in the southern part) was conceived. These lines will be used to transmit the power generated at geothermal power sources in Southern Luzon as well in Leyte Island.

This plan for construction of 500 kV transmission lines is presently the detailed engineering stage.

3.3.3 Power Systems in Leyte Island and Samar Island

There are no outstanding large consumers in Leyte Island and Samar island at the present time, and the total demand on these islands is less than 1/100 of that on Luzon Island described earlier. (Table 3-11) Construction works are in progress in Isabel area located at a distance of about 30 km in the southwest of Tongonan with the schedule of commencement of operation of a copper smelting plant of 110,000 tons per year in 1982 and of commencement of a fertilizer plant in 1983. No that particularly large demand is presently considered in the forecast except the aforementioned plants.

To match the expected demand stated above, it is planned to commence operation of Tongonan #1 ∿ #3 (112.5 MW) in 1982 and to rapidly enforce electrification of Leyte Island and Samar Island by feeding adequate electric power generated by geothermal source in Tongonan by means of 138 kV transmission line crossing San Janico strait between Leyte and Samar Island in 1983.

At the crossing point on this strait, field surveys including surveying of steel tower positions and geological survey are going on at the present time.

Tongonan #4 ∿ #21 (990 MW) geothermal power plants are also planned in addition to the above utilization of which is presently being studied to augment the power supply to Luzon Island, because the demand in Leyte-Samar grid is limited as described earlier. (Table 3-12)

Table 3-11 Forecast of Demand for Electric Power on Luzon Island, Leyte Island and Samar Island

Year	Luzon Island		Leyte Island + Samar Island	
	Max. Power (MW)	Demanded Electric Energy (GWh)	Max. Power (MW)	Demanded Electric Energy (GWh)
1981	2,240	13,750	20	40
1982	2,400	15,080	36	186
1983	2,565	16,140	80	434
1984	2,745	17,240	105	565
1985	2,940	18,420	108	773
1986	3,145	19,680	110	789
1987	3,365	21,030	113	804
1988	3,600	22,475	117	822
1989	3,850	24,020	120	841
1990	4,120	25,675	123	864
1991	4,390	27,320	126	883
1992	4,670	29,070	130	911
1993	4,975	30,930	133	932
1994	5,300	32,915	137	960
1995	5,645	35,030	141	988
1996	5,985	37,105	144	1,009
1997	6,340	39,310	148	1,037
1998	6,725	41,645	152	1,065
1999	7,125	44,120	156	1,093
2000	7,555	46,740	161	1,128

Table 3-12 Power Plant Expansion Program in Luzon Island, Leyte Island and Samar Island

(Rated MW is indicated)

Year	Luzon Island						Leyte Island + Samar Island		
	Hy-draulic	Geo-thermal	Coal	Nuclear	Petroleum	Total	Geo-thermal	Power barge	Total
1981	554	440	0	0	2,015	3,099	3	0	3
1985	1,214	770	300	620	1,925	4,157	115.5	32	147.5
1990	1,604	1,870	600	620	1,925	5,955	555.5	32	587.5
1995	2,551	2,530	900	620	1,925	7,516	1,105.5	32	1,137.5
2000	4,641	2,860	1,500	620	1,925	10,001	1,105.5	32	1,137.5

CHAPTER 4

POWER DEMAND FORECAST

CHAPTER 4 POWER DEMAND FORECAST

4.1 General

4.1.1 Objectives of Power Demand Forecast in the Present Study

The objectives of power demand forecast in this study lie in the followings:

a) To confirm the future power demand and supply in the Luzon power grid to ensure the needs of transmission of electric power from Leyte-Samar grid and

b) To confirm the future power surplus to arise in the Leyte-Samar power grid.

4.1.2 Methodology

(1) Luzon Grid

For Luzon power grid, the power demand forecast was carried out principally through projecting the GDP (Gross Domestic Product) elasticity of power demand which refers to the responsiveness of the power demand to changes in GDP. The procedure is briefly described below.

a) First, the historical values of the GDP elasticity of power demand were obtained based on the historical data on the GDP growth and the power consumption growth (both on the per capita bases).

b) The future GDP growth (per capita basis) was estimated independently.

c) The growth rate of future power consumption (energy requirement in GWh) was derived by applying the above elasticity to the estimated GDP growth rate.

d) The peak power demand was obtained based on the above estimated energy requirement taking into considerations such factors as the rate of energy loss and the load factor.

(2) Leyte-Samar Grid

The Leyte-Samar region is now at the initial stage of social and economic development. In the past, the power demand in this region has been small and met by local supply sources such as privately operated utilities and cooperatives. However, since the geothermal potentials have been identified and exploited in the Leyte Island, industrial development of the region is now programmed and incorporated in the Government's long-term plan. Hence, a big hike in the power demand is expected in the region in the near future.

The situation being as such, the projection of power demand in the Leyte-Samar grid was made taking into considerations the potentials of economic development of the region and the Government's plan of the industrial development in this region.

4.2 Power Demand in Luzon Grid

4.2.1 Historical Load Increase in Luzon

In Luzon, during the decade from 1970 to 1980, the energy generation increased annually at the rate of 7.5% and the energy sales increased annually at the rate of 8.8%. The peaking power demand nearly doubled from 1,111 MW in 1970 to 2,070 MW in 1980 with the annual increase rate of 6.4%.

The rate of system loss showed a prominent decrease from 18% in 1970 to 7% in 1980. The main reason of this low system loss is that many of the power plants are located near the Metro Manila area, the biggest load center in Luzon. However, this system loss covers only that of NAPOCOR and MECO and does not cover the distribution loss of cooperatives whose rate of loss is estimated to be bigger than the above figures.

The historical data on power generation, power sales, power demand, load factor and system loss in the Luzon power grid are shown in Table 4-1.

Table 4-1 Power Generation, Peak Demand and Power Sales in Luzon Grid - Historical and NAPOCOR Forecast

Year	Energy Generation (GWh)	Peak Demand (MW)	Load Factor (%)	Energy Sales (GWh)	System Loss (%)
Historical					
1955	785	128	70.0	628	20.0
1960	1,750	287	69.6	1,596	8.8
1965	3,381	569	67.8	3,122	7.7
1970	6,386	1,111	65.6	5,225	18.2
71	7,048	1,205	66.8	6,141	12.9
72	7,555	1,331	64.8	6,588	12.8
73	8,212	1,335	70.2	7,210	12.2
74	8,240	1,379	68.2	7,275	11.7
75	9,014	1,513	68.0	8,032	10.9
76	9,626	1,659	66.2	8,586	10.8
77	10,357	1,709	69.2	9,077	12.4
78	11,223	1,780	71.9	9,698	13.6
79	12,097	1,926	71.7	10,733	11.3
80	13,113	2,070	72.0	12,182	7.1
NAPOCOR Forecast					
1985	18,420	2,940	70.0	16,725	9.2
1990	25,675	4,120	70.0	21,919	14.6
1995	35,030	5,645	70.0	29,111	16.9
2000	46,740	7,555	70.0	38,592	17.4
Average Annual Growth Rate (%)					
Historical					
1965-70	13.6	14.3	-	10.8	-
1970-75	7.1	6.4	-	9.0	-
1975-80	7.8	6.5	-	8.7	-
NAPOCOR Forecast					
1980-85	7.0	7.0	-	7.0	-
1985-90	6.9	7.0	-	7.0	-
1990-95	6.4	6.5	-	6.3	-
1995-2000	5.9	6.0	-	6.0	-

Source: NAPOCOR, SPD-CORPLAN, March 19, 1981

4.2.2 Power Demand Projection in Luzon

(1) GDP Elasticity of Power Consumption

The GDP elasticity of power consumption indicates the responsiveness of the power demand to the changes in GDP values. The said elasticity can be derived by a proportionate change in the power consumption divided by a proportionate change in the GDP. The Table 4-2 shows the derivation of the historical GDP elasticity of power consumption both in per capita bases. In order to obtain a normal elasticity as possible, the period of seven years from 1972 to 1979 was chosen./1 Although the elasticity varies every year, the average value of 1.10 can be obtained for a long range values of elasticity.

In general, the GDP elasticity of power consumption has a declining trend in such countries whose major power plants are fossil fired thermal operated by imported fuel oil. Especially since the first world oil crisis in 1973, the forced saving energy movements have accelerated the improvement in oil productivity and resulted, in some countries, in a decline of the GDP elasticity of power consumption.

/1 The data of 1971 was omitted because its annual growth rate of per capita power consumption shows extraordinary high value. The data of 1980 was omitted because it is preliminary figure and still subject to change.

Table 4-2 GDP Elasticity of Power Consumption both in per capita bases

Year	(1) Per Capita/1 Power Consumption (kWh)	(2) Annual Growth Rate (%)		(3) Per Capita GDP (US$)	(4) Annual Growth Rate (%)		(5) GDP Elasticity of Power Consumption (1)/(3)	
1970	265	-		185	-		-	
71	303	14.3			2.1		6.9	
72	315	4.0	Average 3.9%	193	1.9	Average 3.6%	2.1	Average 1.10%
73	335	6.3		204	5.7		1.1	
74	329	-1.8		209	2.4		-0.8	
75	352	7.0		217	3.7		1.9	
76	364	3.4		225	3.7		0.9	
77	373	2.5		232	3.3		0.8	
78	385	3.2		239	3.1		1.0	
79	413	7.3		247	3.1		2.4	
80	453	9.7		256	3.7		2.6	

Remarks: /1 For Luzon grid

Note: Historical GDP at 1972 constant prices and population of the Philippines and of the Luzon Island are presented in Table 4-3.

Taking into consideration the above-mentioned general trend, the GDP elasticity of power consumption is, in projecting the power demand, assumed to decline to 1.0 in average during the period 1981 - 1990 and further to 0.9 in average for the period of 1991 - 2000.

(2) Per Capita GDP Growth

The historical growth rate of per capita GDP (at 1972 constant prices) shows 3.0% per annum for the period of 1970 - 1980. This value was adopted and applied in the power demand projection for the period of 1981 - 1990. For the period of 1991 - 2000, 3.5% of the annual growth rate of the per capita GDP was assumed taking into account of the expected GDP growth and of the declining trend of the Philippine population.

(3) Per Capita Power Consumption Growth

The growth rate of the per capita power consumption was derived by the growth rate of the per capita GDP multiplied by the GDP elasticity of power consumption (per capita bases). The growth rate of the per capita power consumption was derived at 3.0% per annum for the period of 1981 - 1990 and at 3.15% for the period of 1991 - 2000.

(4) Luzon Population Growth

The population of Luzon was projected by the "Ratio method". According to the population census made in 1960, 1970 and 1975, the ratio of the Luzon population toward the Philippine population shows a gradual increasing trend; the Luzon population corresponded to 51.9% of the total Philippine population in 1960, 53.7% in 1970 and 54.2% in 1975. Following this trend, the above ratio is estimated to have reached 54.7% in 1980. However, in projecting the future growth of the Luzon population, the ratio of 54.7% was assumed to be kept constant taking into consideration the Government's dispersion policy of population to Mindanao and Visayas regions.

Based on this assumption, the future growth of the Luzon population was estimated to decline gradually from 3.2% per annum in the period of 1975 - 1980 to 2.5% in the period of 1995 - 2000 (Table 4-3).

(5) Power Consumption Growth

Based on the aforementioned assumptions on the GDP elasticity of power consumption, the per capita GDP growth and the Luzon population growth, the power consumption growth was projected as shown in Table 4-4. The annual growth rate of power consumption was estimated at 6.0% in the period of 1980 - 1985, 5.9% in 1985 - 1990, 5.8% in 1990 - 1995 and 5.7% in 1995 - 2000.

Table 4-3 Historical and Projected Population and GDP

	(1)	(2)	(3)[7]	(4)	(5)[6]	(6)
	Population			GDP (at 1972 price)		
Year	Philippines (10^3)	Luzon (10^3)	Ratio(2)/(1)	GDP[3] (P10^6)	Per Capita (Peso)	Per Capita (US$)
Historical						
1970	36,684[1]	19,688[1]	0.537	51,014	1,391	185
71	37,703	20,284	0.538	53,526	1,420	189
72	38,751	20,887	0.539	56,075	1,447	193
73	39,827	21,507	0.540	60,931	1,530	204
74	40,934	22,145	0.541	64,139	1,567	209
75	42,071[1]	22,790[1]	0.542	68,361	1,625	217
76	43,398	23,565	0.543	72,962	1,681	224
77	44,767	24,353	0.544	77,363	1,728	230
78	46,178	25,167	0.545	81,859	1,773	236
79	47,635	26,009	0.546	86,539	1,817	242
80	49,137[2]	26,878	0.547	91,947[4]	1,871	249
Projected						
85	56,742[2]	31,038	0.547		2,169	289
90	65,041[2]	35,577	0.547		2,514	335
95	73,867[2]	40,405	0.547		2,986	398
2000	83,439[2]	45,641	0.547		3,547	473
Average Annual Growth Rate (%)						
Historical						
1970-75	2.8	3.0		6.0	3.2	3.2
1975-80	3.2	3.2		6.1	2.9	2.9
Projected						
1980-85	2.9	2.9			3.0	3.0
1985-90	2.8	2.8			3.0	3.0
1990-95	2.6	2.6			3.5	3.5
95-2000	2.5	2.5			3.5	3.5

Remarks:	/1	Population Census figures
	/2	Population Dimension of Planning II, NEDA, 1975
	/3	1980 Philippine Statistical Yearbook, NEDA
	/4	1980 Philippine Economy, NAPOCOR, Jan. 1981
	/5	Long-Term Philippine Development Plan up to the Year 2000, Cabinet Committee on the Development Plan, Sep. 1977.
	/6	(5) = (4)/(1)
	/7	For the period of 1981 onwards, the constant ratio of 0.547 in 1980 of Luzon population to Philippine population was assumed to estimate the Luzon population.

Table 4-4 Projection of Growth Rate of Power Consumption in Luzon

Year	(1) Per Capita GDP Growth Rate (%)	(2) GDP elasticity of Power consumpt (Per capita Bases)	(3) Per Capita Power Consumpt Growth Rate (%)	(4) Luzon Population Growth Rate (%)	(5) Power Consump Growth Rate (%)
1981	3.0	1.0	3.0	2.9	6.0
1982	3.0	1.0	3.0	2.9	6.0
1983	3.0	1.0	3.0	2.9	6.0
1984	3.0	1.0	3.0	2.9	6.0
1985	3.0	1.0	3.0	2.9	6.0
1986	3.0	1.0	3.0	2.8	5.9
1987	3.0	1.0	3.0	2.8	5.9
1988	3.0	1.0	3.0	2.8	5.9
1989	3.0	1.0	3.0	2.8	5.9
1990	3.0	1.0	3.0	2.8	5.9
1991	3.5	0.9	3.15	2.6	5.8
1992	3.5	0.9	3.15	2.6	5.8
1993	3.5	0.9	3.15	2.6	5.8
1994	3.5	0.9	3.15	2.6	5.8
1995	3.5	0.9	3.15	2.6	5.8
1996	3.5	0.9	3.15	2.5	5.7
1997	3.5	0.9	3.15	2.5	5.7
1998	3.5	0.9	3.15	2.5	5.7
1999	3.5	0.9	3.15	2.5	5.7
2000	3.5	0.9	3.15	2.5	5.7

Note : (3) = (1) x (2)
(5) = (3) x (4)

(6) Projection of Peak Demand in Luzon

The projection of the peak power demand in Luzon was made as shown in Table 4-5. The total system losses of 7.0% for the period of 1981 - 1990 and 6.5% for 1991 - 2000 were assumed. The load factor of 70% was also assumed for the period of 1981 onwards.

The peak demand in Luzon was projected to increase from 2,070 MW in 1980 to 6,634 MW in the year 2000 with the average growth rate of 6.0% per annum in the coming 20 years.

Meanwhile, the NAPOCOR projection of the peak demand in Luzon shows the growth rate of 6.7% per annum for the period of 1980 - 2000 reaching 7,555 MW in the year 2000. The difference between the two projections is deemed within the range of a reasonable allowance (about 12%). Taking into account the consistency required among the power demand projection, the future power development program and other related energy policy, the NAPOCOR projection of power demand in Luzon was adopted in the present study. The comparison of the two projections are shown in Table 4-5 and depicted in Fig. 4-1.

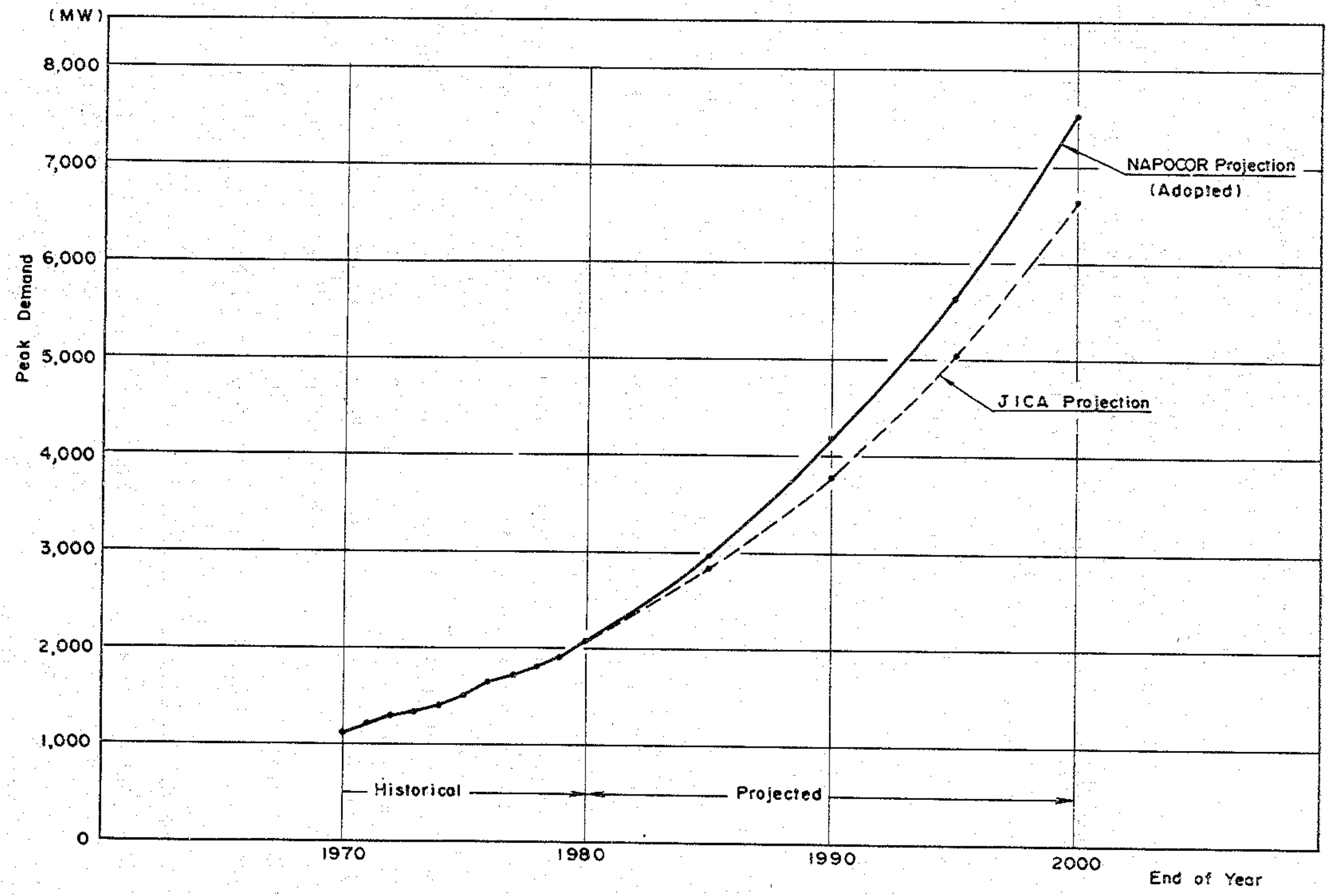
Table 4-5 Projection of Enrgy Production and Peak Power Demand in Luzon

Year	Power Sales	Total Loss	Energy Production	Load Factor	Peak Power Demand	NPC Estimate of Peak Power Demand
	(Gwh)	(%)	(Gwh)	(%)	(MW)	(MW)
1980	13,183	7.1	13,113	72.0	2,070	--
1981	12,911	7.0	13,883	70.0	2,264	2,240
1982	13,684	7.0	14,714	70.0	2,400	2,400
1983	14,503	7.0	15,595	70.0	2,543	2,565
1984	15,371	7.0	16,528	70.0	2,695	2,745
1985	16,291	7.0	17,517	70.0	2,857	2,940
1986	17,250	7.0	18,548	70.0	3,025	3,145
1987	18,265	7.0	19,640	70.0	3,203	3,365
1988	19,340	7.0	20,795	70.0	3,391	3,600
1989	20,478	7.0	22,019	70.0	3,591	3,850
1990	21,683	7.0	23,315	70.0	3,802	4,120
1991	22,948	6.5	24,543	70.0	4,002	4,390
1992	24,286	6.5	25,975	70.0	4,236	4,670
1993	25,702	6.5	27,489	70.0	4,483	4,975
1994	27,201	6.5	29,092	70.0	4,744	5,300
1995	28,787	6.5	30,789	70.0	5,021	5,645
1996	30,436	6.5	32,552	70.0	5,309	5,985
1997	32,180	6.5	34,417	70.0	5,713	6,340
1998	34,023	6.5	36,389	70.0	5,934	6,725
1999	35,973	6.5	38,474	70.0	5,274	7,125
2000	38,034	6.5	40,678	70.0	6,634	7,555

Average Annual Growth Rate (%)

1980 - 1985	6.0	6.0	6.7	7.3
1985 - 1990	5.9	5.9	5.9	7.0
1990 - 1995	5.8	5.7	5.7	6.5
1995 - 2000	5.7	5.7	5.7	6.0

Fig. 4-1 Projection of Peak Power Demand in Luzon Power Grid



4.3 Power Demand in Leyte-Samar Grid

4.3.1 Present Economy and Power Demand in Leyte-Samar Region

The Leyte and Samar Islands are designated administratively as the Eastern Visayas Region. At present, this region is one of the depressed regions in the Philippines.

(1) Population

The population of the Eastern Visayas Region was 2.6 million in 1975 according to the population census. The average growth rate of the population of the region in the period from 1960 to 1975 was 1.6% per annum, which was far below that of the whole country of 3.0% per annum for the same period. The ratio of the population of the region to the whole Philippines showed a decreasing trend from 7.5% in 1960 to 6.2% in 1975. Following this decreasing trend of the said ratio, the population of the region in 1980 is estimated at about 2.85 million (Table 4-6).

The population projection of the region was made as shown in Table 4-6. In projecting the future population of the region, it was assumed that the ratio of the population of the region to the Philippine population would decline until 1980 reaching 5.8% following the past decreasing trend and keep the constant rate for the next twenty years.

Table 4-6 Historical and Projected Population of Eastern Visayas Region

Year	(1) Total Philippines (10^3)	(2) Eastern Visayas (10^3)	(3) (2)/(1) (%)
Historical (Census)/1			
1948	19,234	1,764	9.17
1960	27,088	2,042	7.54
1970	36,684	2,381	6.49
1975	42,071	2,600	6.18
Projected			
1980	49,137	2,850	5.8
1985	56,742	3,290	5.8
1990	65,041	3,770	5.8
1995	73,867	4,280	5.8
2000	83,439	4,840	5.8
Average Annual Growth Rate (%)			
Historical			
1948- 60	2.89	1.23	
1960- 70	3.08	1.55	
1960- 75	2.98	1.62	
1970- 75	2.78	1.78	
Projected			
1975- 80	3.15	1.85	
1980- 85	2.92	2.92	
1985- 90	2.77	2.77	
1990- 95	2.58	2.58	
1995-2000	2.47	2.47	
1980-2000	2.68	2.68	

/1 Source: 1980 Philippine Statistical Yearbook, NEDA

This assumption was made taking into account the expected future industrial development of the region, which will be treated later in this chapter. According to this projection, the population of the region will reach 4.84 million in the year 2000 increasing at an average rate of 2.7% per annum in the period from 1980 to 2000.

(2) Gross Value Added of the Region

The gross value added in this region in 1977 amounted to P2.3 x 10^9, which occupied 3.0% of the whole country. The growth of gross value added in the region was so stagnant that the average increase rate was 3.6% per annum in the period from 1973 to 1977 while that of the whole country was 6.5% (Table 4-7).

The region's gross value added was composed of P1.5 x 10^9 from agriculture (occupying 6.4% of the country's agricultural gross value added), P0.5 x 10^9 from industry (2.3% of the country's industrial gross value added), and P0.3 x 10^9 (1.0% of the country's service sector gross value added) from services sectors. Of the above ratios of the region's gross value added to those of the whole country, only that of the region's agricultural sector (6.4%) was comparable to the ratio of the region's population to the whole country (6.2% in 1975). Meanwhile, the agricultural sector of the region made a growth in the period from 1973 to 1977 at the rate of 9.2% per annum, which was higher than the average

Table 4-7 Gross Value Added by Region
(1973 & 1977)

Unit: $Px10^6$

Region	1973				1977				Average Annual Growth (%)			
	Agri-culture	Industry	Services	Total	Agri-culture	Industry	Services	Total	Agri-culture	Industry	Services	Total
Luzon	7,013	14,032	16,612	37,658	10,291	16,553	23,217	50,061	10.1	4.2	8.7	7.4
Visayas	4,376	3,757	4,296	12,429	6,132	4,087	4,527	14,746	8.8	2.1	1.3	4.4
Eastern Visayas	1,039 (6.1)	416 (2.1)	563 (2.3)	2,018 (3.3)	1,477 (6.4)	532 (2.3)	313 (1.0)	2,322 (3.0)	9.2	6.3	-14.7	3.6
Mindanao	5,619	1,787	3,440	10,846	6,791	2,143	4,531	13,465	4.9	4.6	7.1	5.6
Philippines	17,008 (100.0)	19,576 (100.0)	24,349 (100.0)	60,933 (100.0)	23,214 (100.0)	22,783 (100.0)	32,275 (100.0)	78,272 (100.0)	8.1	3.9	7.3	6.5

Note: Figures in parentheses show percentages to Philippines total.

Source: Five-Year Philippine Development Plan, 1978-1982, Regional Development Framework, NEDA, Nov. 1977.

growth rate of the agricultural sector of the whole country (8.1%) in the same period. Hence, the region is characterized as an agricultural region in the country's economy (Table 4-7). Major agricultural products of the region were abaca, sugarcane and coconut and their shares in the country's production of each product were 21.5%, 13.0% and 4.6% respectively in 1975[/1].

Although the regional output was stagnant as stated above, as the increase in population was comparatively low, the per capita regional output increased by the average rate of 3.4% per annum, which was above the average of 3.2% in the whole country in the period of 1973 to 1977. The per capita output of the region in 1977 was as low as P935 ($125), which was 21% of Metro Manila's per capita output of P4,494 ($597) (Table 4-8).

(3) Present Power Demand

Electrification in the Leyte-Samar grid is still premature. The percentage of cities and municipalities equipped with electric services in 1977 was as low as 17.4%, which was the third lowest among the twelve regions and it was less than a half of the country's average of 35.8%.

/1 Five-Year Philippine Development Plan, 1978-1982, Regional Development Framework, NEDA, Nov. 1977

Table 4-8 Regional Per Capita Output (1973 & 1977)

Unit: Px10^3

	1973		1977		Annual increase rate (%)
	Per capita output	% to MMA/1	Per capita output	% to MMA	
Luzon	1,751	43.9	2,034	45.5	3.8
Metro Manila	3,988	100.0	4,474	100.0	2.9
Visayas	1,315	33.0	1,494	33.4	3.2
Eastern Visayas	818	20.5	935	20.9	3.4
Mindanao	1,206	30.2	1,273	28.5	1.4
Philippines	1,525	38.2	1,733	38.7	3.2

Remarks: /1 Metro Manila Area

Source: Five-Year Philippine Development Plan, 1978-1982, Regional Development Framework, NEDA, Nov. 1977

Since there exist no large scale industries in the region at present, which is attributed to the region's characteristics to have been an agricultural region, the power demand in the region has been comparatively low in the past.

The historical peak demand was recorded at 4.0MW at maximum for the period from 1968 to 1974 during which it increased with the average growth rate of 1.6% per annum. Thereafter, it increased at the average growth rate of 40% per annum reaching 13 MW in 1978.

The historical energy generation in the Leyte-Samar grid amounted to only 12.7 GWh in 1968 and it increased at a comparatively low growth rate of 2.6% per annum in the period from 1968 to 1974. Thereafter it increased at the average growth rate of 31% per annum reaching 43 GWh in 1978 (Table 4-9).

All the power demand in the region before 1977 has been met by the small scale diesel generators owned by private-run cooperatives. The supply capabilities of these cooperatives are as shown below.

Table 4-9 Historical Power Generation and Peak Demand in Leyte-Samar Grid

Year	Energy Generation (GWh)	Peak Demand (MW)	Load Factor (%)
1968	12.7	3.1	46.8
1969	15.8	3.7	48.7
1970	17.6	3.9	51.5
1971	18.1	4.0	51.7
1972	20.0	3.9	58.5
1973	13.9	3.2	49.6
1974	14.8	3.4	49.7
1975	23.9	5.8	47.0
1976	27.5	6.6	47.6
1977	28.9	6.9	47.8
1978	43.0	13.0	37.8
Average Annual Growth Rate (%)			
1968-74	2.6	1.6	
1974-78	30.6	39.8	

Source: Power Expansion Program (Revised Accelerated), NAPOCOR, Aug. 1980 (SPD-CORPLAN, 6-27-80)

Supply Capabilities of Cooperatives

(as of December 1980)

Name of Cooperatives	Installed Capacity (kW)	Peak Load (kW)
1. DORELCO (LEYCO I)	11,300	5,900
2. LEYCO II	7,670	4,293
3. LEYCO IV	390	179
4. LEYCO V	1,000	1,600/1
Sub-Total Leyte	20,360	
5. ESAMELCO	100	60
6. NORSAMELCO	100	70
7. SAMELCO I	1,100	716
8. SAMELCO II	6,306	1,950
9. SOLECO	1,065	700
Sub-Total Samar	8,671	
Total Leyte-Samar Grid	29,031	

/1 Estimated to be tapped from other system(s)

Source: NAPOCOR, CORPLAN, Mar. 1981

In July 1977, the 3 MW pilot plant of the Tongonan geothermal power station started commercial operation supplying power to Ormoc city. Having been reinforced by this geothermal power supply, the peak demand as well as energy generation in the grid has shown a big hike in 1978 (Table 4-9).

Meanwhile, according to NAPOCOR Ormoc Office, a number of factories have applied NAPOCOR for the provision of electric power, major of which are as shown below.

	Waiting Consumers	Peak Demand (kW)
1.	BIOPHIL (Chemicals)	2,500
2.	Ice Plant	2,000
3.	AZNAR (Wheat flour mill)	700
4.	HIDECO (Sugar mill)	610

From the data and information mentioned in this sub-section, it may be concluded that the region's power demand is, although the past power consumption has been stagnant, surpassing the supply capability. The future power demand will be mainly composed of demand for domestic use which will be subject to the speed of electrification, demand for small scale industries some of which are being listed already as waiting consumers and demand for big scale industries such as PASAR and PHILPHOS Projects which will be stated in sub-section 4.3.3.

4.3.2 Future Development Prospects in Leyte-Samar Region

In the on-going Five-year Philippine Development Plan (1978-1982)[/1], the development of Leyte-Samar region is expected to spur at the highest growth rate among the twelve regions in the whole country. According to the said plan, the per capita output of the region is planned to grow in the period from 1978 to 1987 at an average rate of 6.6% per annum, which is the highest among all twelve regions. (Table 4-10)

This accelerated growth is based on the fact that the region has substantial untapped resources such as arable lands, rich fishing grounds, forest resources and geothermal potentials. Especially, the geothermal power resources in the Leyte Island and the Biliran Island, as stated in the sub chapter 3.4, are expected to encourage industrialization of the region by supplying electric power to the industrial complex to be established in the Leyte Island.

A more detailed perspective of the industrialization of the region are described in the Regional Investment Program for the period of 1981 - 1985[/2] which was prepared by NEDA taking cognizance of the Regional Five-year Development Plan. According to the said program, seven projects among the Eleven Major Industrial Projects will be concentrated in the region as shown below.

[/1] Five-year Philippine Development Plan, 1978-1982, Regional Development Framework and Annexes, NEDA, Nov. 1977

[/2] Regional Development Investment's Program, 1981-1985, NEDA

Table 4-10 Projected Regional Per Capita Output (1978-1987)

Unit: Px10^3

	1978	1979	1980	1981	1982	1987	Annual increase rate for 1978-1987 (%)
Luzon	2,108	2,193	2,279	2,391	2,495	3,148	4.6
Visayas	1,569	1,663	1,751	1,841	1,938	2,523	5.4
Eastern Visayas	990	1,052	1,115	1,185	1,282	1,764	6.6
Mindanao	1,333	1,394	1,463	1,533	1,629	2,115	5.3
Total Philippines	1,804	1,885	1,967	2,064	2,163	2,756	4.8

Source: Five-year Philippine Development Plan, 1978-1982, Regional Development Framework, NEDA, Nov. 1977

Eleven Major Industrial Projects

To be established in the Leyte-Samar Region

1. Copper Smelter (under construction)
2. Phosphate Fertilizer (under land preparation stage)
3. Aluminum Smelter (under study)
4. Integrated Pulp and Paper Factory (under planning)
5. Alcogas Plant
6. Coconut-related Chemicals (under study)
7. Heavy machinery

To be established in other regions

8. Diesel Engine Factory
9. Integrated Steel Mill
10. Cement Factory
11. Petro-chemical Complex

These ambitious Eleven Major Industrial Projects were planned aiming at the modernization of industry of the Philippines by shifting from domestic-market-oriented light industry to export-oriented heavy industry. Some of the eleven projects are already being implemented.

In the abovementioned investment program, the investment requirement expected in the Leyte-Samar region is estimated to amount to P 18.8 billion (US$2.5 billion equivalent) for the period from 1981 to 1985. The breakdown of this investment requirement is shown in Table 4-11. Of the total investment requirement of the region for the period from 1981 to 1985, P 8.7 billion (US$1.2 billion equivalent) or 46% of the total requirement is expected to be invested for the industry in the Leyte region. But it is noted in the said program that such an industrialization shall be gradual and it would be heavily dependent on the raw materials to be found in the region.

Out of the seven major industrial projects to be established in the Leyte-Samar region, the copper smelter project and the phosphate fertilizer project are now already under way for implementation. The outlines of the two projects are described hereunder.

Copper Smelter Project (PASAR Project)

The main features of the copper smelter project are:

Project site	:	Isabel, Northern Leyte
Area (gross)	:	23 ha
Construction	:	Started on April 1980; to be completed on April 1983
Test run	:	April - December 1983
Commercial operation	:	Starting from Dec. 1983
Refining capacity	:	138,000 (Cathode) MTPA

By-products	: Sulhuric acid, Gold, Silver, Selenium and Sulhuris Nickel	
Project cost	: Capital cost:	US$306.2 x 10^6
	Plant & equipment	213.1 x 10^6
	Construction	57.5 x 10^6
	Interest during construction	14.4 x 10^6
	Infrastructure	21.1 x 10^6
Implementing agency	: Philippine Associated Smelting and Refining Corporation (PASAR)	
Employment	: 600 workers 200 staff	

The construction works are now (March 1981) under way at Isabel in Northern Leyte. The electric power required for the construction will be supplied through a diesel power plant (2 MW) to be installed at the project site and a power barge (8 MW x 4 = 32 MW) to be moored at the coast near Isabel. Tongonan geothermal power will be available to the project by April 1983 when the test operation of the smelter will start.

The power demand of the smelter is estimated at 33 MW under full capacity operation and the annual energy requirement at 246 GWh.

Phosphate Fertilizer Project (PHILPHOS Project)

This project was initially programmed as one of the Five ASEAN Projects which aimed at benefitting commonly all the ASEAN countries. But the capacity planned presently is the enlarged one, which is shown below.

Project site : Isabel, Northern Leyte (immediately adjacent to PASAR Project site)

Area (gro-s) : 180 ha

Present status : Land preparation is under way

Commissioning : Simultaneous commissioning with PASAR Project is expected

Supply of phosphate rock: Morocco, Nauru, USA and Jordan

Supply of sulfuric acid : 440×10^3 MTPA from PASAR
917×10^3 MTPA from domestic pyrites

Finished products : Ammonium sulfate: 153×10^3 MTPA

Granular NPK products:

15-15-15	72×10^3 MTPA
14-14-14	55×10^3 MTPA
16-20-0	126×10^3 MTPA
Monoammonium phosphate	169×10^3 MTPA
Diammonium phosphate	508×10^3 MTPA

Project cost	:	Capital cost:	US$342 x 10^6
		Plant & equipment	283.3 x 10^6
		Buildings & housing	8.9 x 10^6
		Other costs	21.2 x 10^6
		Financing costs (capitalized)	28.6 x 10^6
		Maintenance cost:	US$8.59 x 10^6
		(annual cost under full operation)	
		Working capital:	US$38 x 10^6
		(under full operation in 1986)	
Implementing agency	:	Philippine Phosphate Fertilizer Corporation (PHILPHOS)	
Employment	:	650 workers 70 staff	

The power barge (32 MW) to be moored at the coast near Isabel will also supply the electric power for the construction of the PHILPHOS Project. Since a part of the sulfuric acid required for the phosphate fertilizer plant will be supplied from the PASAR smelter plant, the PHILPHOS Project is required to start its operation simultaneously with the PASAR Project.

The power demand of the fertilizer plant is estimated at 30 MW under full capacity operation and the annual energy requirement at 236 GWh.

4.3.3 Power Demand Projection of Leyte-Samar Grid

The future power load of the Leyte-Samar grid is forecasted by NAPOCOR as shown in Table 4-12. The power load (at generation level) is forecasted to increase at as high growth rate as 73.8% per annum from 20 MW in 1981 to 105 MW in 1984. This is due to the expectation that the industrial projects such as PASAR, PHILPHOS and LSADA projects will start their operations in 1983 and 1984. Of the total power demand of 105 MW in 1984, the industrial power demand for these three big projects is projected to amount to 69 MW or 66% of the total demand. Thereafter until 1990, since no expansion in these three factories is scheduled, the industrial power demand is assumed to keep constant level without any increase, though the energy requirement (GWh) is projected to increase at a growth rate of 7.3% per annum. Meanwhile, the power demand of the utilities which include those of domestic use and small scale factories is projected to increase at a growth rate of 7.0% per annum for the period from 1984 to 1990.

This NAPOCOR projection is prepared until the year of 1990 as depicted in Fig. 4-2 for peak demand and in Fig. 4-3 for energy requirement.

In the present study, the abovementioned NAPOCOR forecast for the period of 1981-1990 was adopted after having been reviewed based on the data and information obtained through field survey and on the socio-economic study on the Leyte-Samar region. The industrial demand forecast is compatible with the on-going construction schedule of the PASAR, PHILPHOS and LSADA projects.

Table 4-12 Leyte-Samar Sub-Grid-Load Pick-Up Forecast

	PHILPHOS		PASAR		LSADA		TOTAL INDUSTRIES		TOTAL MISC.		TOTAL UTILITIES		GRAND TOTAL (SALES LEVEL)		GRAND TOTAL (GENERATION LEVEL)	
	MW	GWH	MW	GWH	MW	GWH	MW	GWH	MW	GWH	MW	GWH	MW	GWH	MW	GWH
1981	0.5	1	4	2	3	4	7.5	7	0.7	1	14	29	22	37	20	40
1982	3	8	7	26	6	32	16	66	1	3	23	102	40	171	36	186
1983	7	22	33	175	6	32	46	229	3	10	37	160	86	399	80	434
1984	30	59	33	246	6	32	69	337	3	10	40	173	112	520	105	565
1985	30	236	33	246	6	32	69	514	3	11	43	186	115	711	108	773
1986	30	236	33	246	6	32	69	514	3	11	46	201	118	726	110	789
1987	30	236	33	246	6	32	69	514	3	11	49	215	121	740	113	804
1988	30	236	33	246	6	32	69	514	3	12	53	230	125	756	117	822
1989	30	236	33	246	6	32	69	514	3	12	56	248	128	774	120	841
1990	30	236	33	246	6	32	69	514	3	13	60	268	132	795	123	864
Average Growth Rate (%)																
1981-1984							109.5	263.8	62.4	115.4	41.9	81.4	72.0	141.3	73.8	141.7
1984-1990							0.0	7.3	0.0	4.5	7.0	7.6	2.8	7.3	2.7	7.3
1981-1990							28.0	61.2	17.6	33.0	17.6	28.0	22.0	40.6	22.4	40.7

NOTES:

1981 MW Generation Level = MW Sales Level ÷ 1.12

1982 MW Generation Level = MW Sales Level ÷ 1.10

1983-1990 Mw Generation Level = MW Sales Level ÷ 1.07

GWH Generation Level = GWH Sales Level ÷ 0.92

PASAR:	Philippine Associated Smelting and Refining Corporation
PHILPHOS:	Philippine Phosphate Fertilizer Corporation
LSADA:	Leyte Sub-A Development Authority

Source: NAPOCOR, Aug. 1981

Fig. 4-2 Leyte-Samar kW Balance

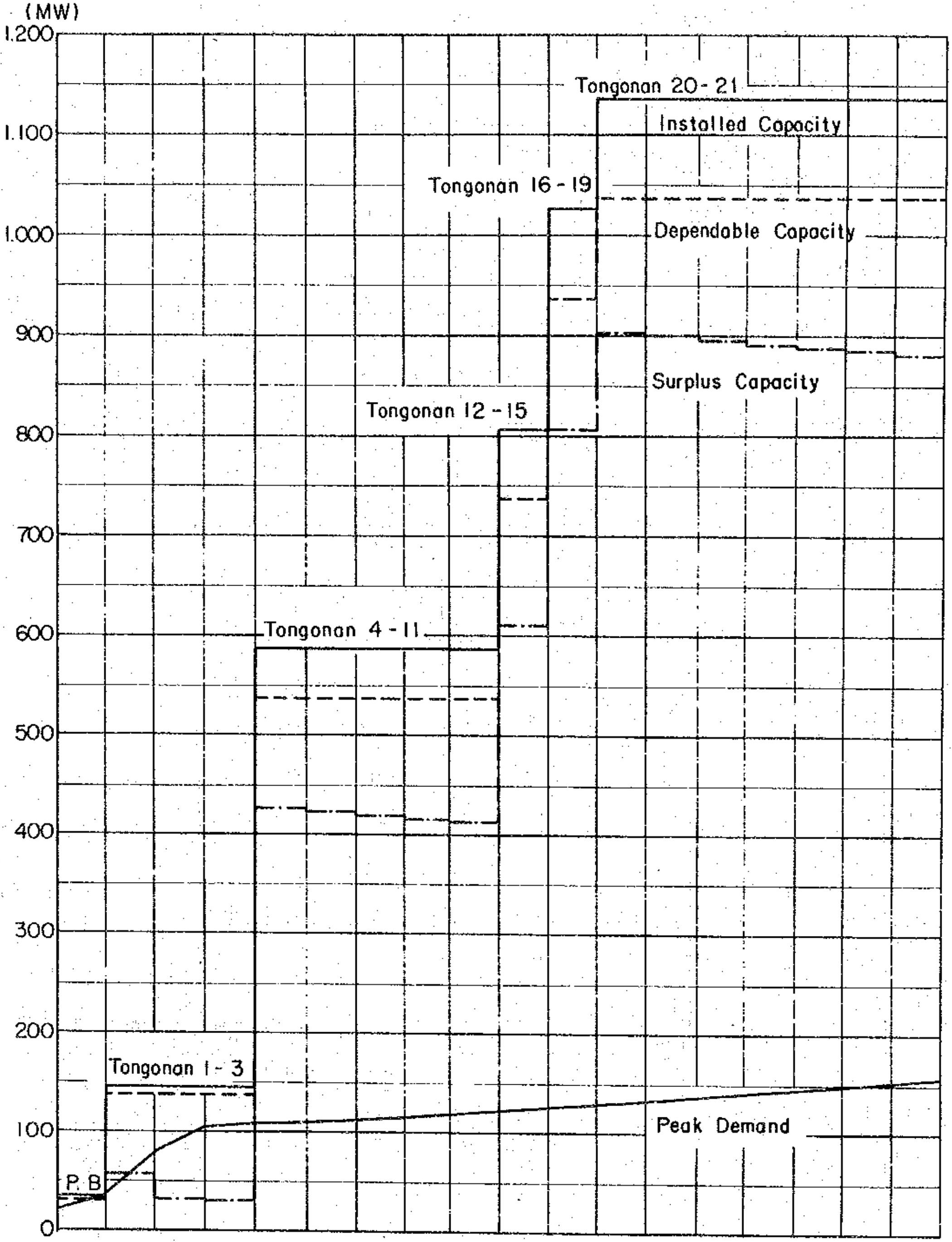
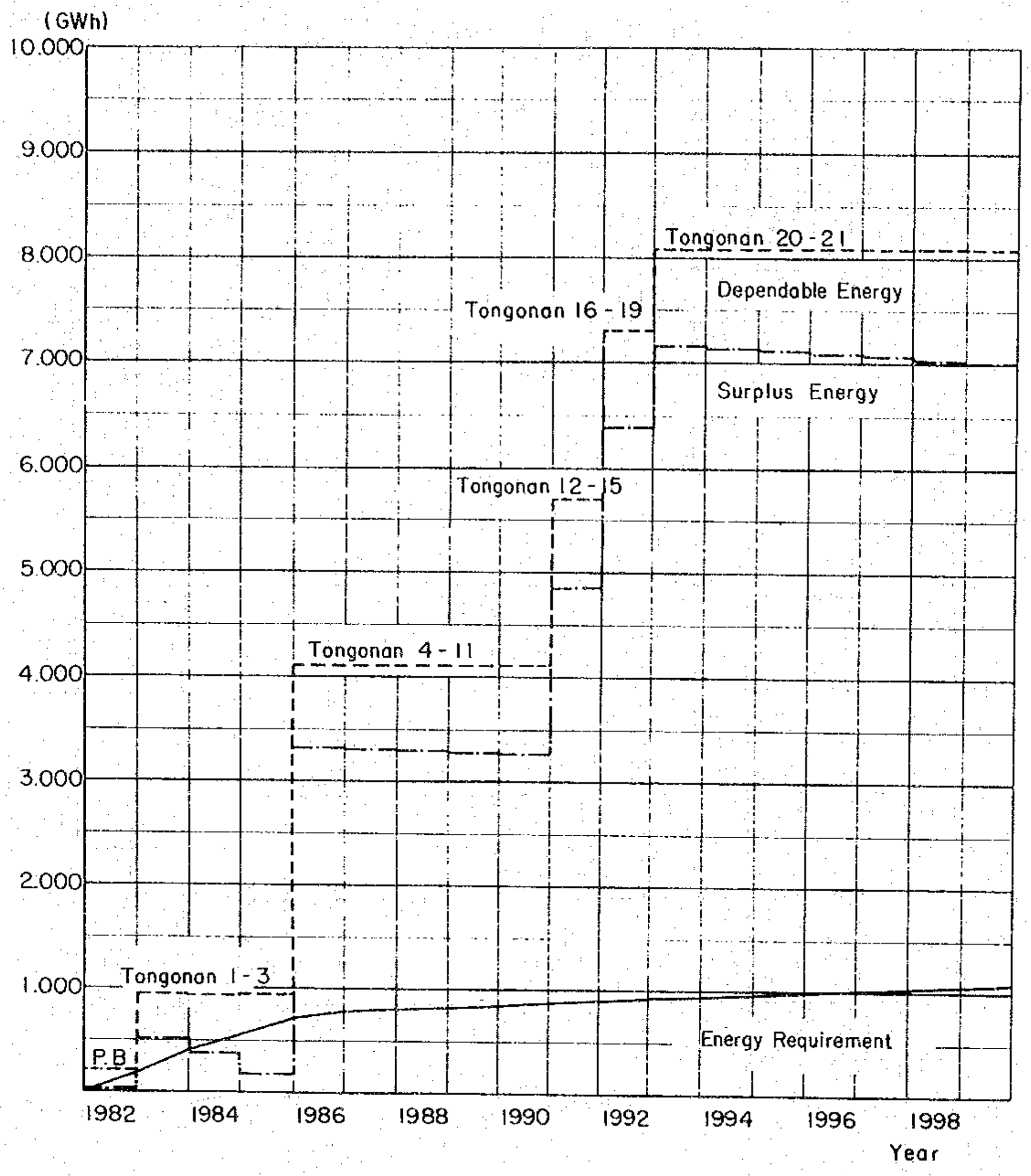


Fig. 4-3 Leyte-Samar kwh Balance



The power demand of the whole utilities is projected in the NAPOCOR forecast to grow at the rate of 7.0% per annum for the period from 1984 to 1990. This growth rate is comparable to the growth rate of per capita output (6.6% per annum) of the Leyte-Samar region stipulated in the long term development plan for the Leyte-Samar region for the period of 1978-1987 (Ref. sub-section 4.3.2).

The NAPOCOR forecast until 1990 was in the present study extrapolated until the year of 2000. The above extrapolation was made with the following considerations:

a) The Leyte-Samar region is now at the initial stage of a rapid social and economic development. Therefore, a long term forecast, over ten years for example, cannot be a reliable basis with which a power transmission plan can be made.

b) Since the economy of the Leyte-Samar region is characterized as the agriculture-base economy, a rapid increase in power demand would be triggered mainly by large scale industries. Although such large scale industrial projects are stipulated in the investment program of the region as stated in sub-section 4.3.2, these projects are still so premature and subject to change that locations, scale, financing and implementation timing are not definite yet.

The present situation being as stated above, the power demand projection was made in the present study based on a simple extrapolation of NAPOCOR forecast. Namely, the total power demand was projected to increase until 2000 at the same growth rate (2.7% per annum) as projected in NAPOCOR forecast for the period of 1984-1990. In other words, the power demand of total utilities including domestic use, commercial use and small scale factories was projected to increase at the growth rate of 7% per annum, while other power demands of big scale industries and miscellaneous use were projected to remain at the constant level.

The load forecast of the Leyte-Samar grid until the year of 2000 is presented in Table 4-13 and depicted in Fig. 4-2 and 4-3. The peak power demand in 2000 is projected to reach 161 MW at generation level. The energy requirement was also projected to amount to 1,128 GWh in 2000 by assuming the load factor of 80% for the period of 1991-2000.

4.3.4 Surplus Power Expected in Leyte-Samar Grid

According to the most up-to-date power development program prepared by NAPOCOR, the development of geothermal power in the Leyte and Biliran Islands is scheduled as shown in the forgoing subsection 3.4.2 (2) Table 4-14. In the present study, however, Tongonan geothermal is assumed to be exploited by installing eleven power plants with the total installed capacity of 552.5 MW by 1986 and the geothermal power of Biliran. Burawen and Anahawan are assumed to be exploited by installing ten power plants with the total installed capacity of 550 MW by 1993.

Table 4-13 Load Forecast and kW/kWh Balance

Leyte-Samar Grid

	Power Supply			Load			
		Dependable		Generation Level		Surplus	
Year	Installed (MW)	MW	GWh	MW	GWh (L.F.%)	MW	GWh
1981	35	30.5	216	20	40 (23)	-	176
1982	35	30.5	216	36	186 (59)	-	30
1983	147.5	137	951	80	434 (62)	57	517
1984	147.5	137	951	105	565 (61)	32	386
1985	147.5	137	951	108	577 (61)	29	374
1986	587.5	537	4,127	110	789 (82)	427	3,338
1987	587.5	537	4,127	113	804 (81)	424	3,323
1988	587.5	537	4,127	117	822 (80)	420	3,305
1989	587.5	537	4,127	120	841 (80)	417	3,286
1990	587.5	537	4,127	123	864 (80)	414	3,263
1991	807.5	737	5,715	126	883 (80)	611	4,832
1992	1,027.5	937	7,303	130	911 (80)	807	6,392
1993	1,137.5	1,037	8,097	133	932 (80)	904	7,165
1994	1,137.5	1,037	8,097	137	960 (80)	900	7,137
1995	1,137.5	1,037	8,097	141	988 (80)	896	7,109
1996	1,137.5	1,037	8,097	144	1,009 (80)	893	7,088
1997	1,137.5	1,037	8,097	148	1,037 (80)	889	7,060
1998	1,137.5	1,037	8,097	152	1,065 (80)	885	7,032
1999	1,137.5	1,037	8,097	156	1,093 (80)	881	7,004
2000	1,137.5	1,037	8,097	161	1,128 (80)	876	6,969

Average Annual Growth Rate (%)

1981-1984	73.8	141.7
1981-2000	11.6	19.2
1984-1990	2.7	7.3
1984-2000	2.7	4.4

Note: (1) Load forecast was made by NAPOCOR for 1981-1990 and by JICA for 1991-2000.

(2) Estimate of energy requirement (GWh) for 1991-2000 was made by JICA by assuming the load factor of 80%.

Table 4-14 Development Schedule of Power Supply
Leyte-Samar Grid

Year of Commission	Power Plant	Installed Capacity	
		MW	Accumulated
1977 (July)	Tongonan Pilot Plant	3	3
To be scheduled			
1981	Power Barge	32	35
1983	Tongonan #1-#3	112.5	147.5
1986	Tongonan #4-#11 /1	440	587.5
1991	Biliran & Others #1-#4	220	807,5
1992	Biliran & Others #5-#8	220	1,027.5
1993	Biliran & Others #9-#10	110	1,137.5

Remarks: /1 tentatively assumed as Biliran, Burawen and Anahawan geothermal

Source: NAPOCOR

Based on this development program and the demand projection made in the foregoing sub-section 4.3.3, a bulk of surplus power exceeding the demand is expected to be produced in the Leyte-Samar grid. The kilowatt balance and kilowatt-hour balance are computed by the dependable supply deducted by the projected load at generation level as shown in Table 4-13.

In 1986 when the eleventh power plant of Tongonan geothermal is commissioned, the power surplus will amount to 427 MW, which will gradually decrease along with the increase of intra-grid demand of the Leyte-Samar grid. From 1991 when the four units of Biliran geothermal (or other geothermal in the Leyte Island) power plants are commissioned, the power surplus will begin to increase and reach its maximum of 904 MW in 1993.

Therefore, in the present study, the power transmissible to the other power grid was determined to be 450 MW from 1986 and 900 MW from 1991 taking into consideration some capacity allowances and possible change of power demand in the Leyte-Samar grid.

CHAPTER 5

LEYTE POWER TRANSMISSION PROJECT

CHAPTER 5 LEYTE POWER TRANSMISSION PROJECT

5.1 Transmission Power for Leyte Project

5.1.1 Demand and Supply Balance in Luzon Grid

The power development plan made by the Government of Philippines (NAPOCOR) for the Luzon grid, together with its demand and supply balance, is as shown in Table 5-1, Fig.5-1-2,respectively.

The power development plan is based primarily upon the political needs to develop any other energy resources available as alternative to oil. Suppose if this plan encourages development of nuclear power, coal-fired thermal power, geothermal power and hydro power, it is anticipated that almost all of the existing oil-fired power plants could be utilized as the system reserve capacity. If such is the future circumstance, those oil-fired power plants would only be operated as reserve power for scheduled maintenance outage of non-oil-fired power plants, forced outage or power failure in emergency and rapid load increase beyond the forecast. After comprehensive study on their operating characteristic and economy, these plants would assume different roles in the system as cold reserve, hot reserve and spinning reserve, as the case maybe.

Although it is estimated that total supply capacity throughout the system, even excluding oil-fired power plants, may be nearly

Table 5-1 Luzon Grid Generation Expansion Program On-Going, Firm and Probable Project

Year of Comm.	Plant Addition	Installed Capacity (MW)						Dep. Cap.	Peak Demand	Res. Cap.	Res.	Available Energy (GWh)	Energy Capability and Requirement (GWh)							
		Hydro	Geo.	Coal Ther.	Nuc.	Oil Ther.	Total						System Capability						Generation Level	Surplus (Dep.)
													Hydro	Geo.	Coal Ther.	Nuc.	Oil Ther.	Total		
1980	Existing	542	440			2,230	3,212	2,880	2,070	470	23	19,097	2,050	2,283			13,871	18,204	13,113	5,091
1981	Masiway (1 x 12)	554	440			2,105	3,099	2,816	2,240	235	11	48	2,098	3,176			13,297	18,571	13,750	4,821
1982/7	Tiwi Geo 5-6 (110)	854	550			1,925	3,329	3,066	2,400	325	14	794	2,248	3,672			13,510	19,430	15,080	4,350
1982/5	Kalayaan 1 (150)											150								
1982/8	Kalavaan 2 (150)											150								
1983/9	Magat 1-4 (360)	1,214	605			1,925	3,744	3,387	2,565	482	19	1,103	3,042	4,036			13,510	20,588	16,140	4,448
1983/11	Mak-Ban Geo 5 (55)											397								
1984/2	Mak-Ban Geo 6 (55)	1,214	660	300		1,925	4,099	3,707	2,745	622	23	397	3,501	4,731	830		13,510	22,572	17,240	5,332
1984/8	Coal Ther. I (300)											1,989								
1985	PNPP 1 (620)	1,214	770	300	620	1,925	4,829	4,157	2,940	1,067	36	3,910	3,501	5,558	1,989	1,684	13,510	26,242	18,420	7,822
	Tiwi Geo 7-8 (110)											794								
1986	Coal Ther. II (300)	1,214	1,265	600	620	1,925	5,624	4,927	3,145	1,382	44	1,989	3,501	9,131	3,978	3,367	13,510	33,487	19,680	13,807
	Tongonan 4-11 (440)											3,176								
	Daklan 1 (55)											397								
1987	Manito Geo 1-2 (110)	1,214	1,375	600	620	1,925	5,734	5,127	3,365	1,262	38	794	3,501	9,925	3,978	3,639	13,510	34,553	21,030	13,323
1988	Tiwi Geo 9-10 (110)	1,214	1,540	600	620	1,925	5,899	5,327	3,600	1,177	33	794	3,501	11,116	3,978	3,356	13,510	35,961	22,475	13,486
	Daklan 2 (55)											397								
1989	San Rogue (390)	1,604	1,650	600	620	1,925	6,399	5,755	3,850	1,315	34	1,153	4,654	11,910	3,978	3,910	13,510	37,962	24,020	13,942
	Tiwi Geo 11-12 (110)											794								
1990	Manito 3 & 4 (110)	1,604	1,870	600	620	1,925	6,619	5,955	4,120	1,245	30	794	4,654	13,498	3,978	3,910	13,510	39,550	25,675	13,875
	Mak-Ban 7 & 8 (110)											794								
1991	Tongonan 12-15 (220)	1,647	2,090	600	620	1,925	6,882	6,177	4,390	1,175	27	1,588	4,853	15,086	3,978	3,910	13,510	41,337	27,320	14,017
	Bonga (43)											199								
1992	Tongonan 16-19 (220)	1,646	2,310	600	620	1,925	7,101	6,377	4,670	1,117	24	1,588	4,853	16,674	3,978	3,910	13,510	42,925	29,070	13,855
1993	Mak-Ban 9-10 (110)	1,756	2,530	600	620	1,925	7,431	6,654	4,975	1,089	22	794	5,373	18,262	3,978	3,910	13,510	45,033	30,930	14,103
	Tongonan 20-21 (110)											794								
	Tabu (110)											520								
1994	Magat 5-6 (180)	2,251	2,530	900	620	1,925	8,226	7,419	5,300	1,529	29	-	6,330	18,262	5,967	3,910	13,510	47,979	32,915	15,064
	Diduyon (345)											957								
	Luzon Coal III (300)											1,989								
1995	Abra III-B (300)	2,551	2,530	900	620	1,925	8,526	7,516	5,645	1,281	23	825	7,155	18,262	5,967	3,910	13,510	48,804	35,030	13,774
1996	Gened (600)	3,711	2,530	900	620	1,925	9,686	8,434	5,985	1,859	31	1,153	9,642	18,262	5,967	3,910	13,510	51,291	37,105	14,186
	Abra II (200)											530								
	Chico IV (360)											804								
1997	Chico II (250)	3,961	2,640	900	620	1,925	10,046	8,731	6,340	1,801	28	1,050	10,692	19,056	5,967	3,910	13,510	53,135	39,310	13,825
	Batangas Geo 1-2 (110)											794								
1998	Luzon Coal IV (300)	3,961	2,750	1,200	620	1,925	10,456	9,101	6,725	1,786	26	1,989	10,692	19,850	7,956	3,910	13,510	55,918	41,645	14,273
	Zamcales Geo 1-2 (110)											794								
1999	Cagayan Geo 1-2 (110)	4,641	2,860	1,200	620	1,925	11,246	9,731	7,125	2,016	28	794	12,242	20,644	7,956	3,910	13,510	58,262	44,120	14,142
	Agos Kanan (280)											875								
	Agbulu (400)											675								
2000	(300)	4,641	2,860	1,500	620	1,925	11,546	10,001	7,555	1,856	25	1,989	12,242	20,644	9,945	3,910	13,510	60,251	46,740	13,511

Fig. 5.1 Luzon Grid Power Balance (kW Balance)

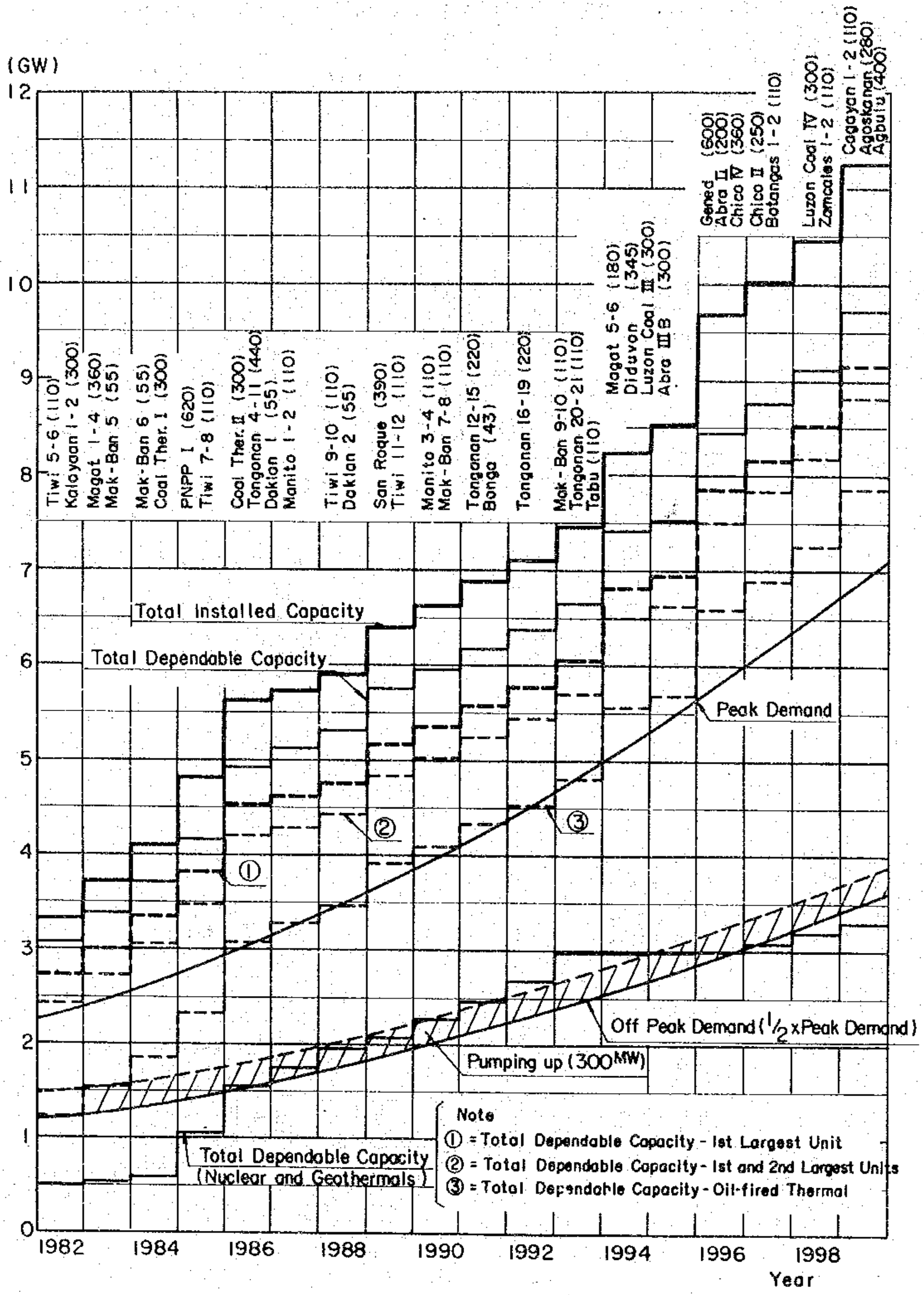
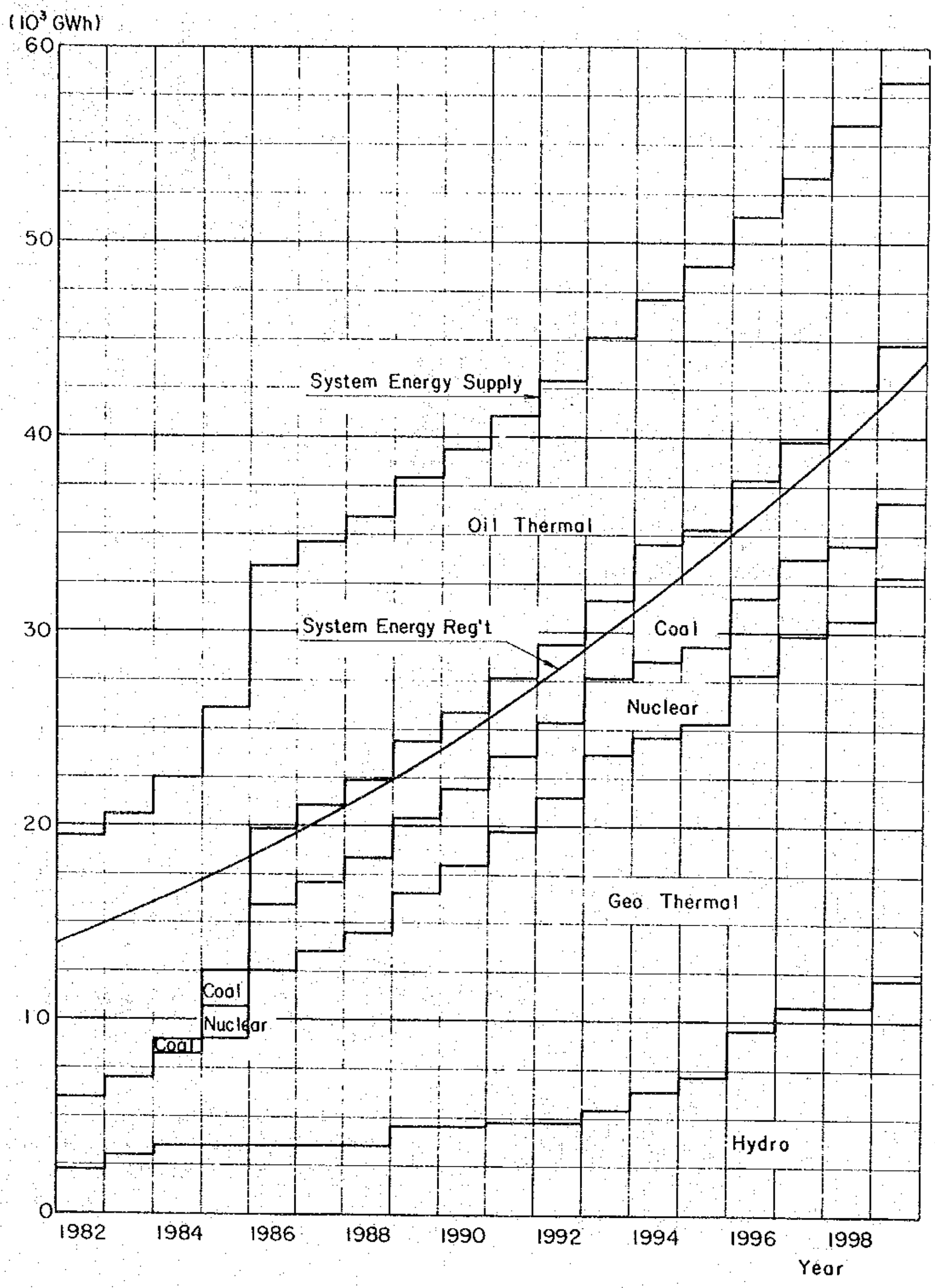


Fig. 5. 2 Luzon Grid Energy Balance (kWh Balance)



balanced with total system demand, it would still be necessary to put 2 or 3 oil-fired thermal power units into operation because of needs to satisfy power demand completely and also to control voltage and power flow of the system.

In view of the energy balance, it is obvious as shown in Fig. 5-2 that the power system has enough energy supply capability against probable energy demand throughout the system.

Although during off-peak load time energy demand can be met only by nuclear and geothermal power plants, it is still advisable to promote economic operation of the whole power system by effective integration of all available non-oil power generating sources such as nuclear power, geothermal power, coal-fired power and pumped-storage hydro power.

5.1.2 Leyte Geothermal Power Development Plan

According to the development plan made by NAPOCOR, it is planned that by 1986 eight (8) geothermal generating units (440 MW) will be developed with future additions of four (4) units of 220 MW by 1991 and six (6) units of 330 MW during the period of 1992 to 1993. Energy production from those geothermal units will be transmitted to the Luzon grid, the major consuming areas.

5.1.3 Transmission Power of Leyte Power Transmission Project

According to the NAPOCOR's power development plan, total installed capacity of power generating units for power transmission from Leyte to Luzon is as follows:

Year	No. of Units	Installed Capacity (MW)
1986	8	440
1991	12	660
1992	16	880
1993	18	990 (final)

Furthermore, total power generating capacity within the Leyte-Samar grid system may be increased as follows inclusive of No. 1 to No. 3 unit of Tongonan, a pilot plant and a power barge in addition to those cited above:

Year	Installed Capacity (MW)
1986	587.5
1991	807.5
1992	1,027.5
1993	1,137.5

Surplus power within the Leyte-Samar grid may then be estimated as follows from the balance after substraction of power demand within the said grid from total installed capacity:

Year	Surplus Power within Leyte-Samar (MW)
1986 ∿ 1990	414 ∿ 427
1991	611
1992	807
1993 ∿ 2000	876 ∿ 904

Further details are as shown in Table 5-2, Table 5-3 and Fig. 5-3.

It is well conceivable that the operation of the oil-fired power units in Luzon could be reduced to some extent if such surplus power in the Leyte-Samar grid is fed into the Luzon grid as much as available for effective utilization of indigenous energy resources.

For the reason mentioned above, the required capacity for the Leyte - Luzon power transmission project should correspond to such surplus power.

Table 5-2 Load Forecast and kW/kWh Balance

Leyte-Samar Grid

	Power Supply			Load		Surplus	
		Dependable		Generation Level			
Year	Installed (MW)	MW	GWh	MW	GWh (L.F.%)	MW	GWh
1981	35	30.5	216	20	40 (23)	-	176
1982	35	30.5	216	36	186 (59)	-	30
1983	147.5	137	951	80	434 (62)	57	517
1984	147.5	137	951	105	565 (61)	32	386
1985	147.5	137	951	108	577 (61)	29	374
1986	587.5	537	4,127	110	789 (82)	427	3,338
1987	587.5	537	4,127	113	804 (81)	424	3,323
1988	587.5	537	4,127	117	822 (80)	420	3,305
1989	587.5	537	4,127	120	841 (80)	417	3,286
1990	587.5	537	4,127	123	864 (80)	414	3,263
1991	807.5	737	5,715	126	883 (80)	611	4,832
1992	1,027.5	937	7,303	130	911 (80)	807	6,392
1993	1,137.5	1,037	8,097	133	932 (80)	904	7,165
1994	1,137.5	1,037	8,097	137	960 (80)	900	7,137
1995	1,137.5	1,037	8,097	141	988 (80)	896	7,109
1996	1,137.5	1,037	8,097	144	1,009 (80)	893	7,088
1997	1,137.5	1,037	8,097	148	1,037 (80)	889	7,060
1998	1,137.5	1,037	8,097	152	1,065 (80)	885	7,032
1999	1,137.5	1,037	8,097	156	1,093 (80)	881	7,004
2000	1,137.5	1,037	8,097	161	1,128 (80)	876	6,969

Average Annual Growth Rate (%)

1981-1984	73.8	141.7
1981-2000	11.6	19.2
1984-1990	2.7	7.3
1984-2000	2.7	4.4

Note: (1) Load forecast was made by NAPOCOR for 1981-1990 and by JICA for 1991-2000.

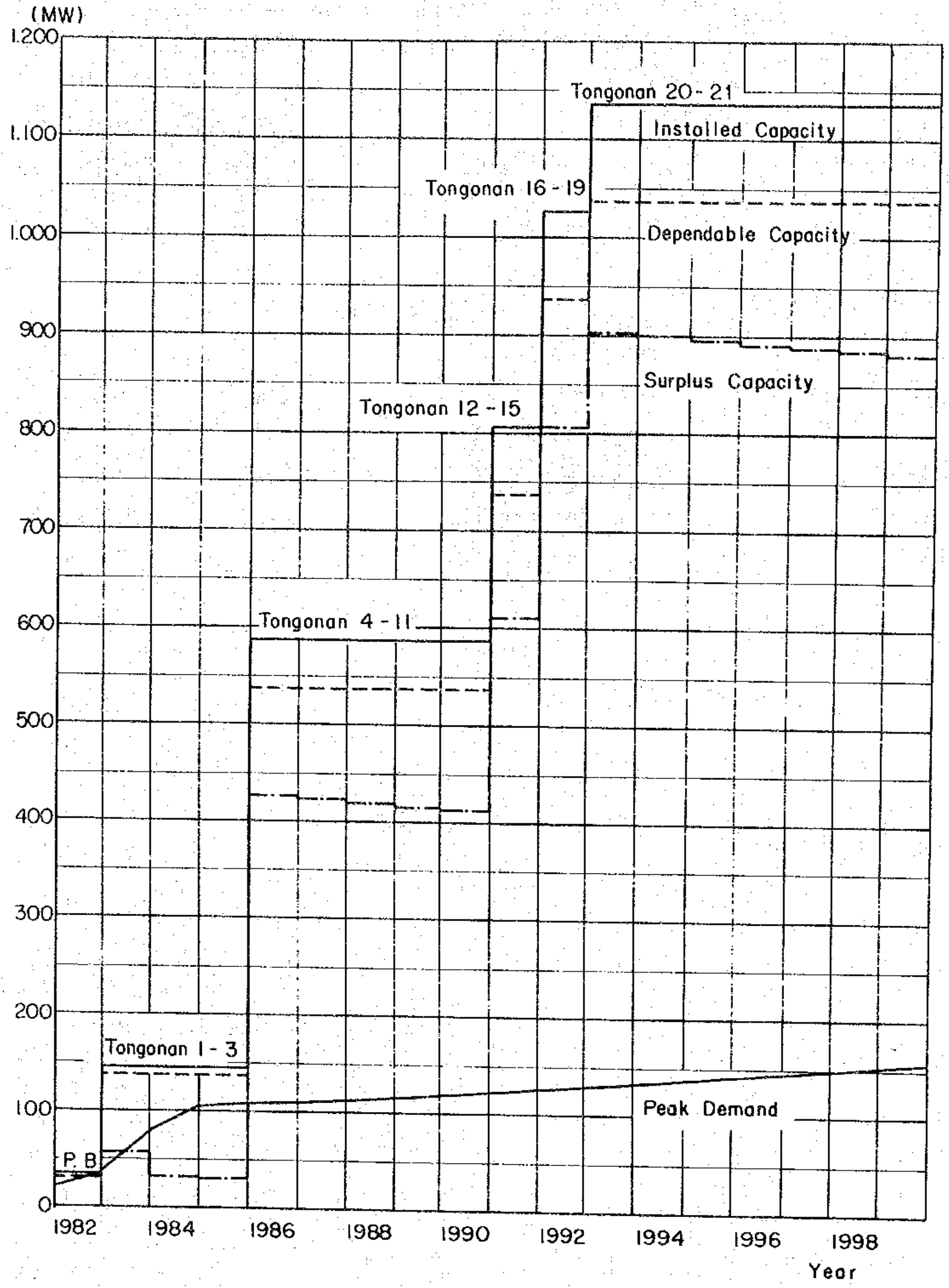
(2) Estimate of energy requirement (GWh) for 1991-2000 was made by JICA by assuming the load factor of 80%.

Table 5-3 Development Schedule for Power Supply Leyte-Samar Grid

Year of Commission	Power Plant	Installed Capacity	
		MW	Accumulated
1977 (July)	Tongonan Pilot Plant	3	3
To be scheduled			
1981	Power Barge	32	35
1983	Tongonan #1-#3	112.5	147.5
1986	Tongonan #4-#11	440	587.5
1991	Tongonan #12-#15	220	807.5
1992	Tongonan #16-#19	220	1,027.5
1993	Tongonan #20-#21	110	1,137.5

Source: NAPOCOR

Fig. 5-3 Leyte-Samar kW Balance



5.2 Timing for Implementation of Leyte Power Transmission Project

Construction of the Leyte-Luzon transmission system should be divided into two stages if due consideration is given to initial and ultimate installed capacity and required construction period of Tongonan Geothermal Power Plant. It is therefore recommended that the first stage should aim at 50 percent completion of the total ultimate installed capacity and the second stage should complete the remaining half to the ultimate capacity.

The target year for the start of operation of the proposed transmission line should be scheduled for 1986 if it is coordinated with the scheduled timing for construction of Tongonan Geothermal Power Plant. Therefore, the time schedule for construction of the said transmission line can be set as follows:

	Year	Installed Capacity (MW)
First stage	1986	450
Second stage (final)	1991	900

5.3 Power Transmission Plan

5.3.1 AC Transmission versus DC Transmission

The Leyte transmission line aiming at power transmission from Tongonan Geothermal Power Plant must be completed to the terminal substation of the 500 KV transmission line being proposed in the southern Luzon region. This transmission system includes submarine cable of about 23 km between Luzon and Samar.

Power to be generated from the said Geothermal Power Plant, together with power from Tiwi Geothermal Power Plant and Manito Geothermal Power Plant in the southern Luzon region, will be transmitted further to Kalayaan and San Jose Substations which are situated in the center of the large consuming area.

Therefore, the plan calls for the construction of a long-distance transmission line over about 800 km starting from Leyte and ending at the consuming centers at Kalayaan and San Jose.

Generally speaking, the required capacity for AC transmission may be determined from whichever is smaller by comparison of the following two alternative conditions:

a) Transmission capacity to be determined by allowable current of conductors (thermal capacity)

b) Transmission capacity to be determined by system stability

The rough criteria for such determination may be that if the overhead transmission line does not exceed 100 km in total length transmission capacity can be determined by allowable current of the conductors and, if it exceeds 100 km in length, capacity can be determined by other factors such as system stability. An example of calculation for transmission capacity as may be determined by stability of the 500 kV, 2-circuits transmission line is shown in Fig. 5-4. It can be noted from the figure that transmission capacity will be reduced in inverse proportion to increased length of transmission line.

In the case of submarine cable, as compared with overhead transmission line, decrease of such transmission capacity, which is inversely proportional to line distance, will be greater because of charging current flow through cable. Fig. 5-5 shows the outline of this relationship.

The result of comparative study concludes finally that the AC long-distance transmission line including submarine cable should require, as compared with the short-distance transmission line of equivalent capacity, larger scale of transmission facilities including increased number of routes and boosting-up of transmission voltage, in the consequence of which is that the construction cost for the transmission line would be increased significantly.

Fig. 5-4 Example of limit of Transmission Power due to Transient Stability

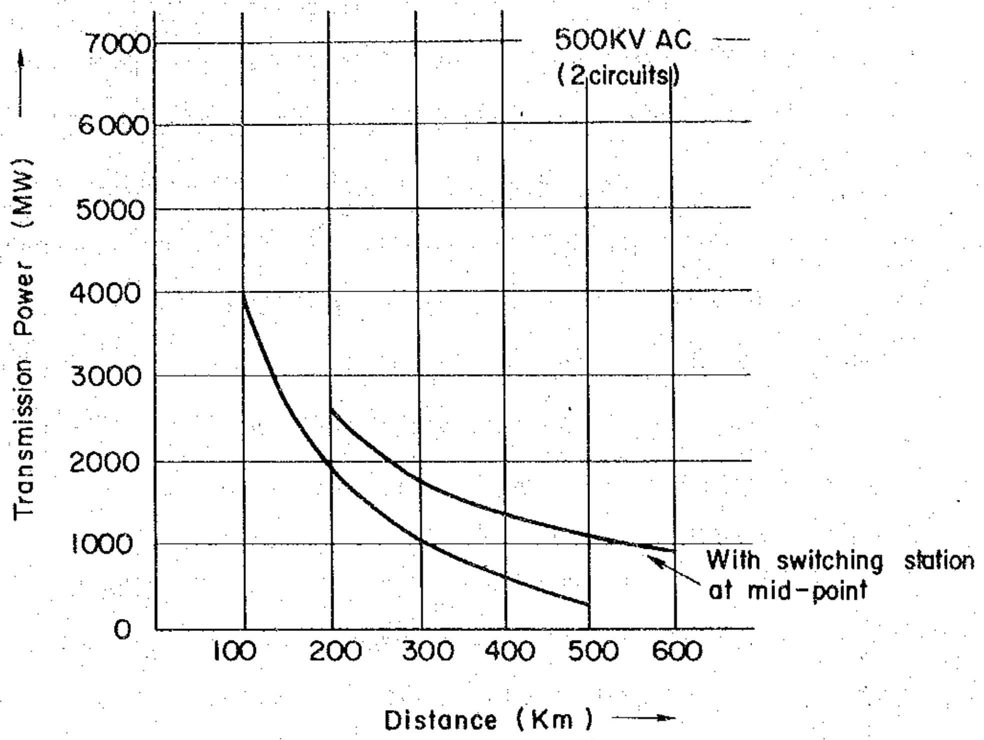
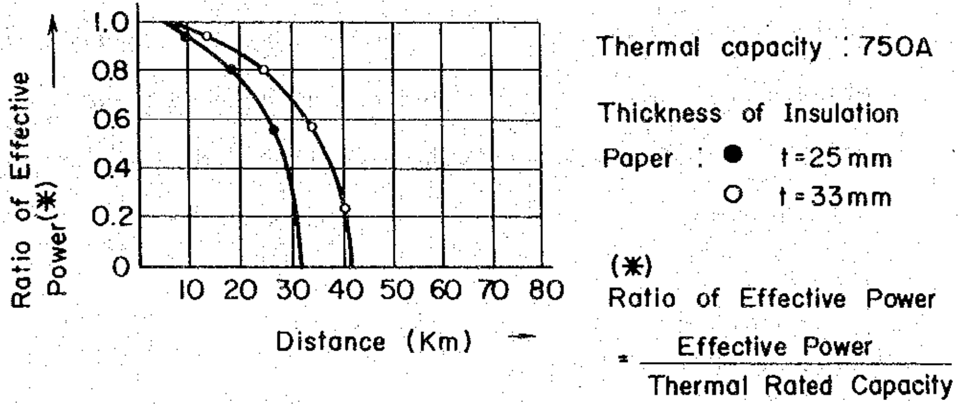


Fig. 5-5 Relationship between Transmission Distance and Effective Power (A.C.500KV OF Cable)



On the other hand, since the DC transmission line is, by nature, not affected by any such factors as system stability and charging current, its transmission capacity can only be determined by allowable current of the conductor. Therefore, even the long-distance transmission line of DC system can ensure nearly stabilized power transmission at its constant capacity, regardless of whether long or short in the transmission distance.

In the case of the DC transmission system, it should necessarily require large investment for construction of the AC/DC converter station. However, such investment cost can be offset by lower construction costs for transmission lines including long-distance lines and submarine cable, which is one of the marked advantage of DC transmission over AC transmission.

With the aforementioned view in mind, comparison has been made to evaluate the two alternatives of both AC and DC transmission for the Leyte Power Transmission Project. AC transmission is studied with two voltage ratings, i.e., 500 kV and 230 kV while DC transmission study is based on the rating of ±350 kV as selected from both technical and economic aspects. Full particulars are stated later in this Report.

The conventional method applicable to the development pattern of HVDC is to adopt the bipolar composition from the initial stage and, at the second stage of construction, to double transmission capacity by additional installation in series of the converter with the same capacity. Therefore, this pattern has been taken up for study.

(1) AC 500 kV transmission

- a) Proposed power of 400 MW for the first stage of construction can be transmitted from Tongonan to Naga through a single-circuit 500 kV transmission line. The EHV transmission line from Naga to San Jose will be operated at a rated voltage of 500 kV.
- b) Ultimate power of 900 MW can be transmitted by additional installation of one more circuit to the existing 500 kV line between Tongonan and Naga.
- c) This plan would require very high construction cost. Besides that, there is no 500 kV submarine power cable has yet been used at present. Therefore, technical research and development should further be required so as to ensure adaptability for submarine cable.

(2) AC 230 kV transmission

- a) Construction at the first stage for 400 MW transmission will need 230 kV 2-circuit transmission line in two (2) routes, that means four (4) circuits in total, between Tongonan and Naga. The EHV transmission line from Naga to San Jose will be operated at 500 kV.

b) Transmission of 900 MW in the final stage will require additional installation of two 230 kV transmission lines, from four (4) to six (6) circuits, between Tongonan and Naga.

c) In comparison with the AC 500 kV transmission plan, this plan is much more advantageous based on savings on construction cost. However, since the 230 kV transmission line will finally be three (3) routes, this plan may have some difficulties in a providing necessary rights-of-way for the lines.

(3) HVDC ±350 kV transmission

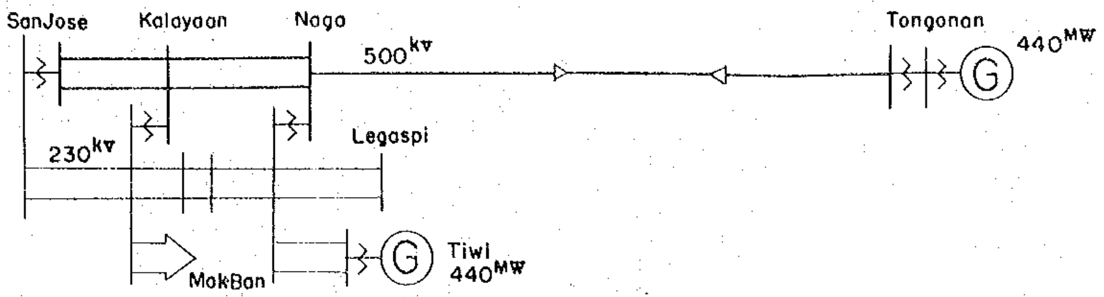
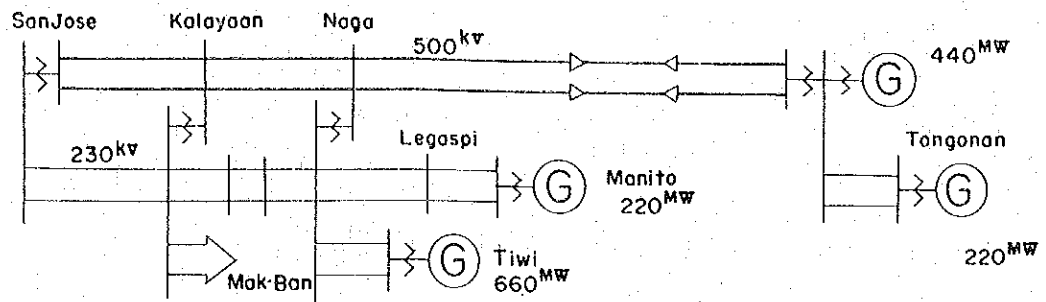
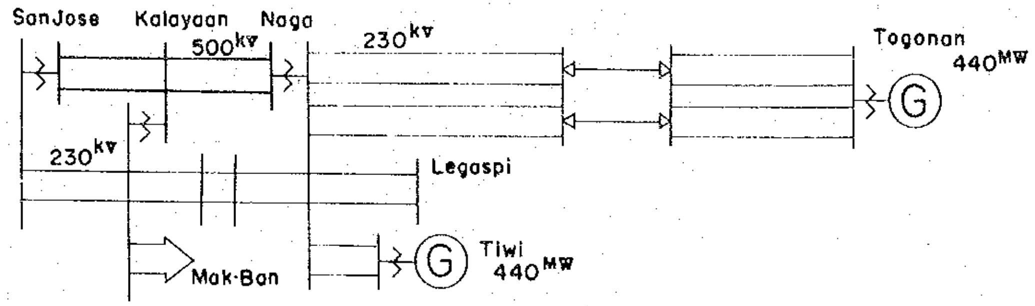
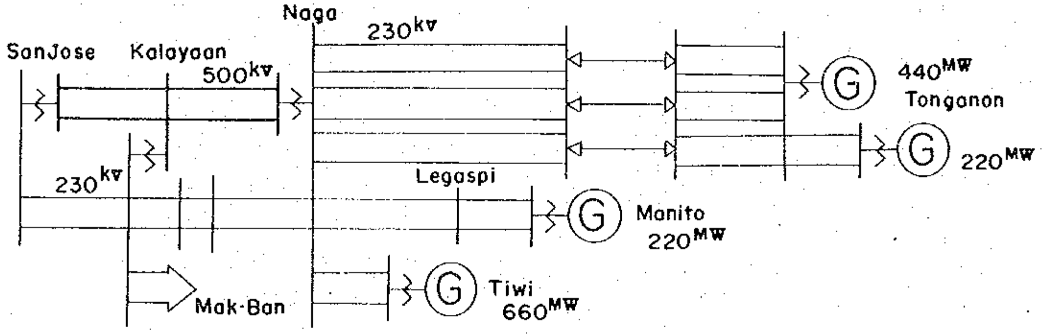
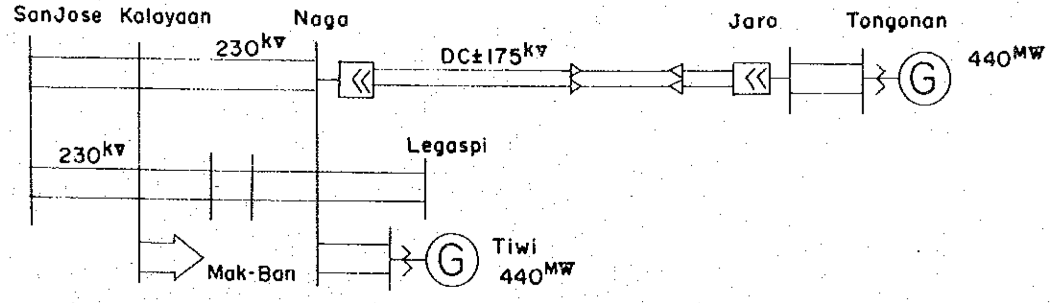
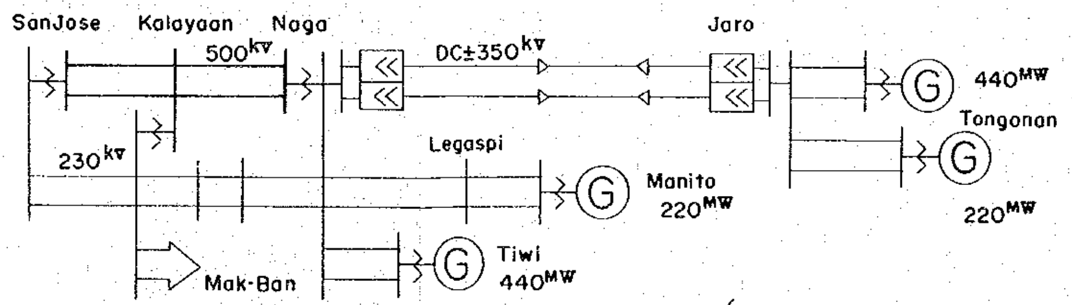
a) The HVDC transmission system will constitute a single bipolar circuit of ±175 kV when completed at its first stage for 400 MW transmission. AC/DC converter stations will be constructed at Jaro in Leyte and at Naga in Luzon.

The EHV transmission line will be operated at 230 kV from Naga to San Jose. Power generated in the geothermal power plant will be transmitted from Tongonan to Jaro Converter Station by way of the 138 kV 2-circuit transmission line.

b) The HVDC system at the final stage will be composed of a single bipolar circuit of ±350 kV by additional installation in series of converters at each station. Total future power transmission from the southern part of Luzon into Kalayaan and San Jose would reach about 1,200 MW including power from Tiwi and Manito and it is considered necessary that the EHV transmission system should be operated at 500 kV between Naga and San Jose to ensure stabilized supply from Tiwi and Manito Geothermal Power Plants in the southern part of Luzon.

c) This plan shows clearly the excellent point of the long-distance HVDC transmission system including submarine cable. Construction cost for the transmission line between Tongonan and Naga, including construction of converter stations, is lower than the costs to be required for AC 500 kV and AC 230 kV transmission plans. Also, since the EHV transmission line of Luzon grid can be operated at 230 kV during the period of 400 MW transmission, there will be a significant length of time lag until the subsequent stepping-up of the voltage from 230 kV to 500 kV for the EHV transmission line. Such being the circumstance, the HVDC transmission plan may supercede any other alternatives, as shown in Table 5-4, in terms of construction costs including expenses to be required for stepping-up of the voltage.

TABLE 5 - 4 AC · DC ECONOMICAL COMPARISON (DIRECT COST)

PLAN	1ST STAGE (1986)	2ND STAGE (1991)	Total Construction Cost ⊿1
AC 500kV	 Construction Cost US\$ 419×10^6 ◦ Tongonan~Naga 500^{kV} T/L 1/2cct (including submarine cable) ◦ SanJose, Kalayaan, Naga, 230^{kV}→ 500^{kV} step up cost	 Construction Cost US\$ 133×10^6 ⊿1 ◦ Tongonan~Naga 500^{kV} T/L 1/2cct (including submarine cable) ◦ Tongonan 138^{kV} T/L 2cct 80^{km}	US \$ 552 ×10^6
AC 230kV	 Construction Cost US\$ 307×10^6 ◦ Tongonan~Naga 230^{kV} T/L 2cct×2route (including submarine cable) ◦ SanJose, Kalayaan, Naga 230^{kV}→ 500^{kV} step up cost	 Construction Cost US\$ 103×10^6 ⊿1 ◦ Tongonan~Naga 230^{kV} T/L 2cct (including submarine cable) ◦ Tongonan 230^{kV} T/L 2cct 80^{km}	US \$ 410 ×10^6
HVDC ±350kV	 Construction Cost US\$ 213×10^6 ◦ Jaro~Naga HVDC±175^{kV} bipolar system (including submarine cable) ◦ Tongonan Jaro 138^{kV} T/L 2cct 26^{km}	 Construction Cost US\$ 107×10^6 ⊿1 ◦ Jaro~Naga HVDC System DC Voltage ±175^{kV}→ ±350^{kV} • Tongonan 138^{kV} T/L 2cct 80^{km} • SanJose, Kalayyaan, Naga 230^{kV}→500^{kV} step up cost	US \$ 320 ×10^6

Note ⊿1 Price in year 1986, Discount rate 10%/year, NO Price escalation.

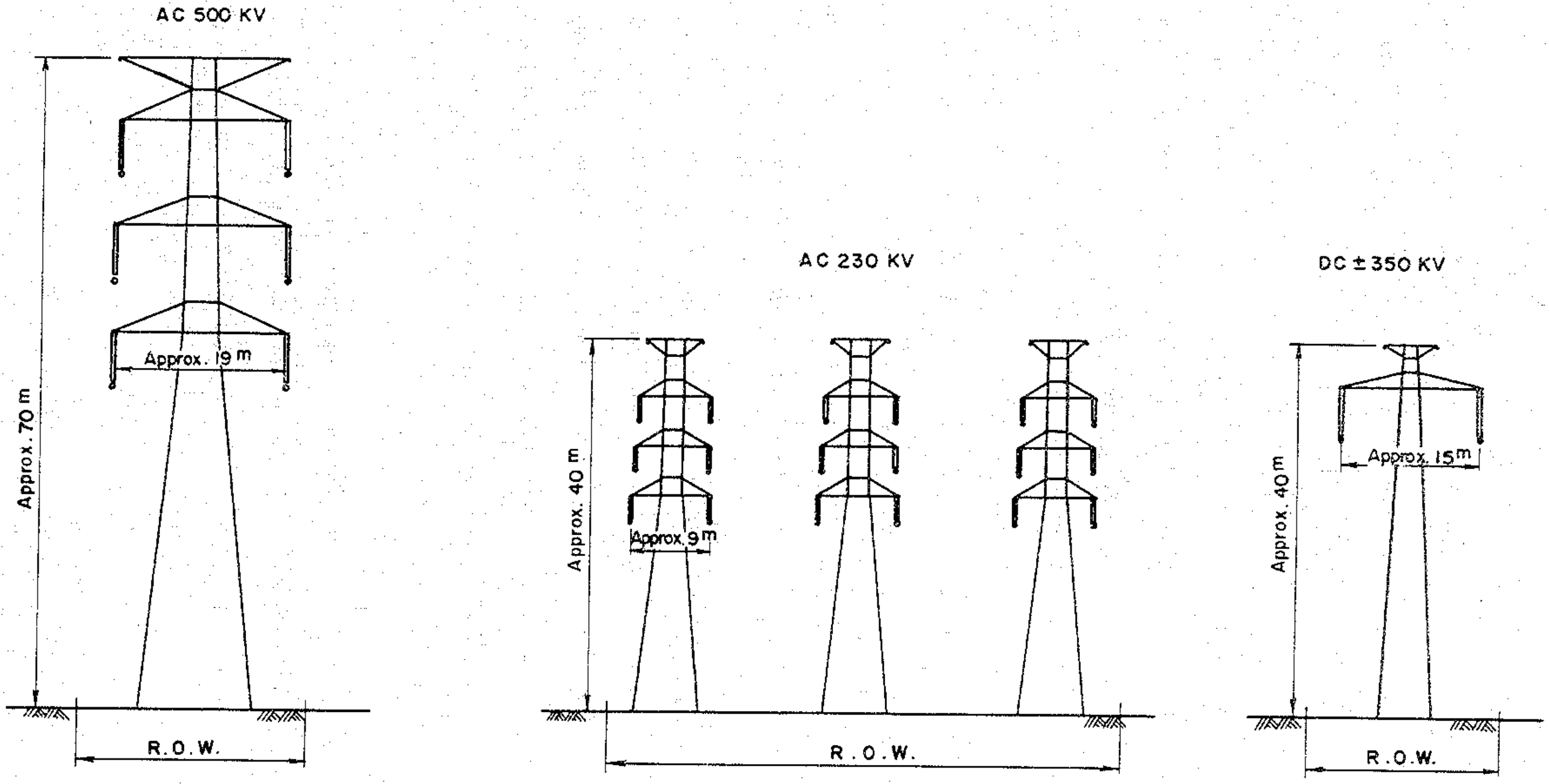
Aside from its economy in costs, as compared with the AC transmission pattern, the size of tower structure and the width of right-of-way for the overhead line can be reduced to a considerable extent, thus being more readily acceptable to the community environment. Tower size and width of the right-of-way are roughly compared for each plan in Fig. 5-6.

If compared by required number of submarine cables, the AC transmission system should require six (6) cable lines of two (2) circuits at 500 kV and nine (9) cable lines of three (3) circuits at 230 kV rating while the HVDC system would not require any more than three (3) cable lines, if spare cable is provided.

After comparative study on the foregoing three (3) alternatives, conclusion has been reached that the Leyte Transmission Project should adopt the HVDC transmission system which may be considered most beneficial from the view point of economy, technical feasibility and environmental acceptability (for land acquisition).

On this basis, further comparison is made in the following alternative patterns of the DC transmission system so that the most appropriate plan for HVDC can be prepared for the Project.

Fig.5-6 COMPARISON OF R.O.W. OF OVERHEAD TRANSMISSION LINES



5.3.2 DC Power Transmission Patterns

The 3 alternatives described below are compared, by taking into consideration the steps referring to the transmission of power from the Leyte geothermal power plants to the Luzon grid. (Table 5-5)

Pattern 1 :

At the time of the 400 MW power transmission in 1986 the system will be operated with the bipolar 450 MW transmission capacity, and in 1991 it will be graded up to a bipolar 900 MW system, by expansion of the AC/DC converter station.

Pattern 2 :

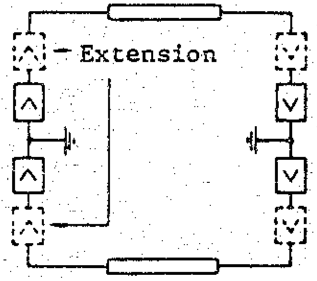
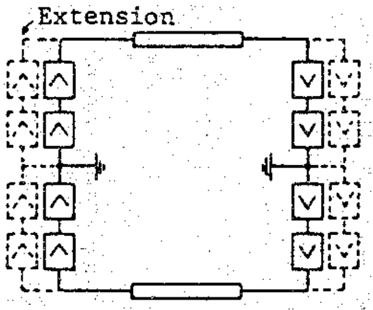
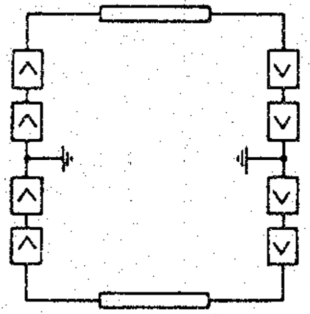
A 450 MW bipolar transmission line will be constructed in 1986, and in 1991 a 450 MW additional transmission line will be constructed in parallel with the former one.

Pattern 3 :

A bipolar transmission line having the final power transmission capacity of 900 MW will be constructed from the beginning in 1986.

The above-mentioned patterns each will have a bipolar system at the initial stage so that power transmission during one pole stoppage due to ground fault of the DC transmission line can be maintained upto 50% of the rated capacity of the

Table 5 - 5 Comparison of HVDC Patterns

Pattern	HVDC Schemes	Technical Items	Total Construction Cost △1 (%)
1		∘ This extension is common method in the world. ∘ Operates in 6-pulse during the other pole's failure.	100
2		∘ Parallel extension means new technology of multi-terminal HVDC System, and can be adopted for this project.	115
3		∘ No additional work	110

Note: △1 Price in year 1986. Discount rate 10%. No price escalation.

system and the increase of the rotor speed could be lessened to the allowable extent.

Table 5-5 shows the comparison of the three patterns. Pattern 1 has the cheapest construction cost with no technical problems anticipated. Therefore, this pattern is recommended for adoption.

5.4 System of AC-DC Converter System

5.4.1 Outline of Leyte Power Transmission Project

(1) Transmission Section (Refer to Fig. 5-7)

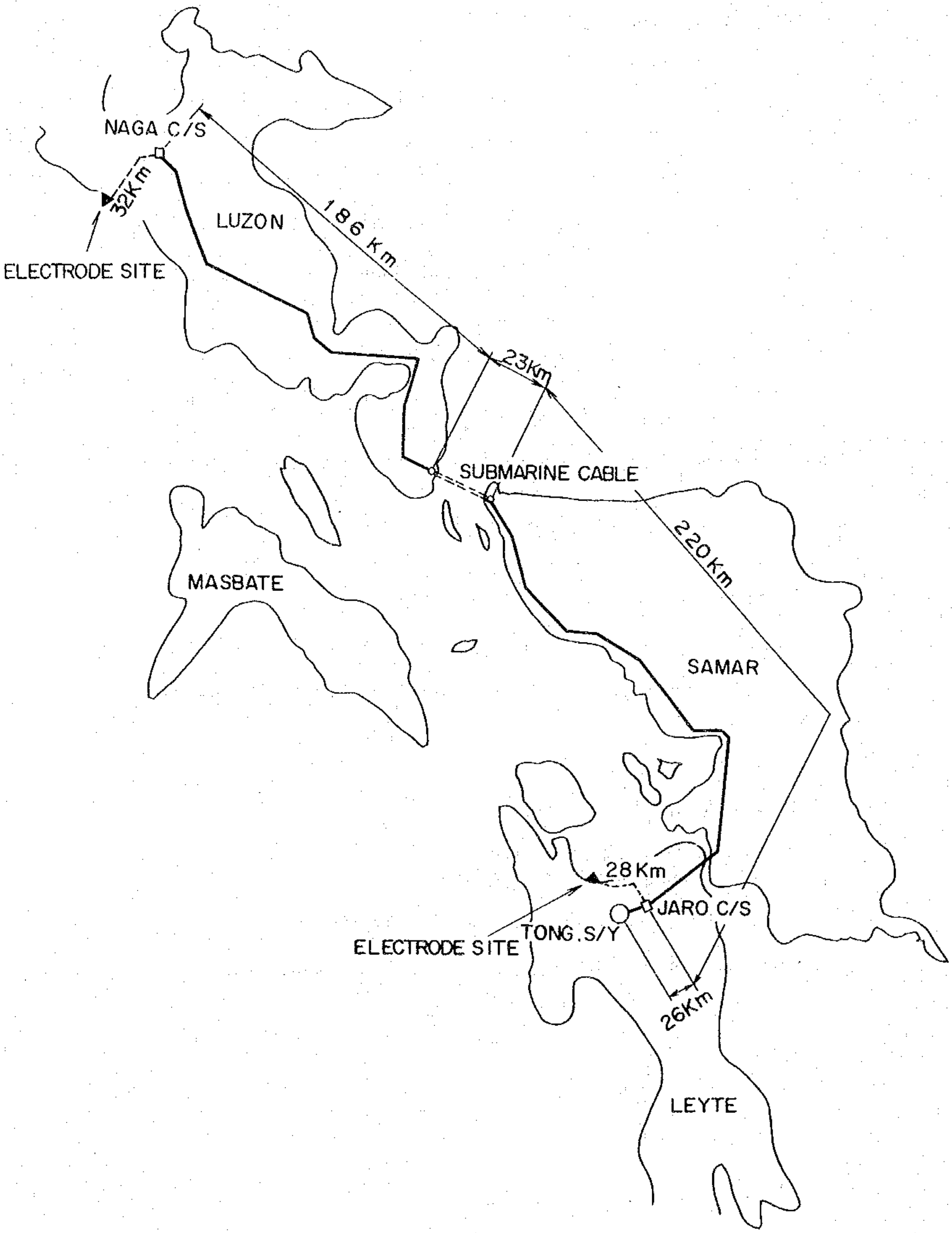
a) Transmission Line

Transmission Section	Voltage rating	Length (km)
Tongonan S/Y - Jaro C/S	AC 138 kV Overhead line	26
Jaro C/S - Cable Head in Samar	DC ±350 kV Overhead line	220
San Bernardino Strait	DC ±350 kV Submarine Cable	23
Cable Head in Luzon - Naga C/S	DC ±350 kV Overhead Line	186
Naga C/S - Naga S/S	AC 230 kV Bus	Short Distance (Same place)
Total Line Length (km)		455

b) Electrode Line

Section	Length (km)
Jaro C/S - Managasnas Electrode	28
Naga C/S - Pasacao Electrode	32
Total Line Length (km)	60

Fig. 5-7 LENGTH OF TRANSMISSION LINE AND ELECTRODE LINE (PRELIMINARY)



(2) Transmitting Capacity

Transmission Section	Voltage	Transmitting Capacity
Tongonan S/Y - Jaro C/S	AC, 138 kV	440 MW
Jaro C/S - Naga C/S	First Stage DC±175 kV	450 MW
	Final Stage DC±350 kV	900 MW

(3) Transmission Method

a)	Tongonan S/Y - Jaro C/S	AC, 2 cct, Transmission
b)	Jaro C/S - Naga C/S	Bipolar, 1 cct, Transmission

(4) Main Circuit Diagram (Refer to Fig. 5-8)

(5) Method of Grounding Main Circuit

a)	AC system	Neutral point directly earthed
b)	DC system	Both neutral points earthed through electrode lines

(6) Transmission Line

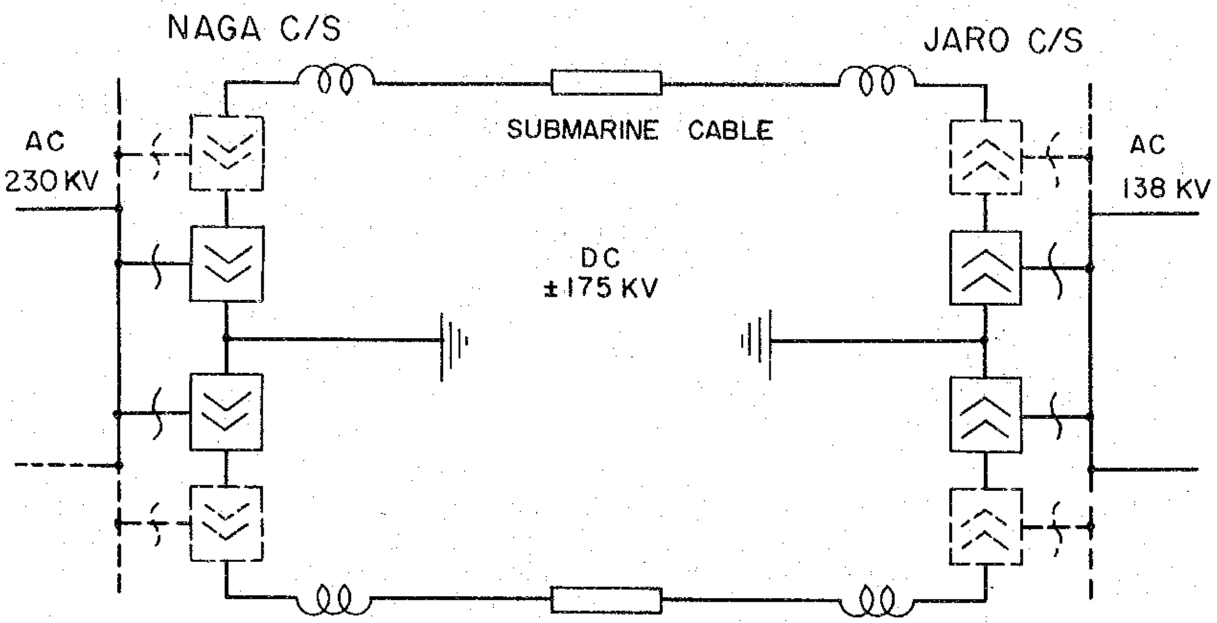
a) AC Transmission line
(Tongonan S/Y - Jaro C/S)

Voltage, frequency: AC 138 kV, 60 Hz

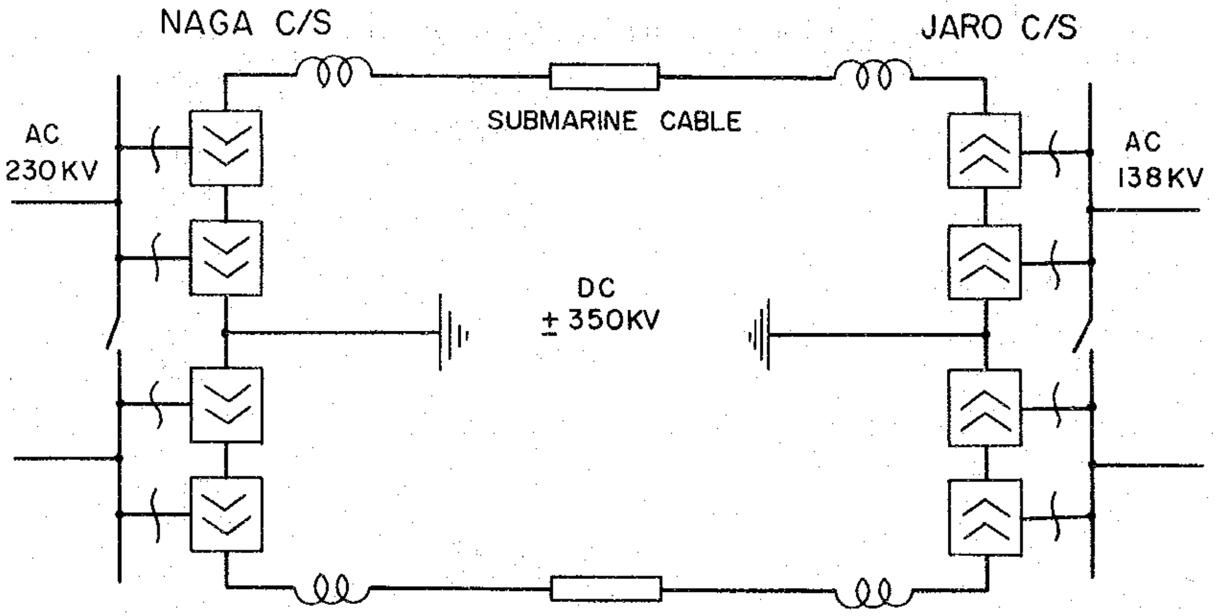
Overhead line : ACSR 610 mm^2 x 2, 2 cct.

Fig. 5-8 MAIN CIRCUIT DIAGRAM (PRELIMINARY)

(a) FIRST STAGE (450MW)



(b) FINAL STAGE (900MW)



b) DC Transmission line
(Jaro C/S - Naga C/S)

Voltage	:	First Stage	DC ±175 kV
		Final Stage	DC ±350 kV

Overhead line : Main Conductor, ACSR 810 mm^2 x 2, and AACSR 520 mm^2 x 2 for the Sun Juanico strait crossing

Electrode line ACSR 410 mm^2 x 2

Submarine cable: OF 1000 m^2, 2 cables

(7) Converter Station

a) Thyristor valve

First Stage : DC±175 kV, 450 MW, 225 MW × 2

Final Stage : DC±350 kV, 900 MW, 225 MW × 4

b) Reactive power supply method

Jaro converter station:	Supply of reactive power by means of Tongonan generators and AC filters.
Naga converter station:	Supply of reactive power by means of AC filters and var compensators.

5.4.2 Selection of DC Voltage and Conductor Size

The voltage and the conductor size are factors which have considerable influence upon the economy of the power transmission project, and accordingly, their selection is an important element of the power transmission project itself.

There are many comparative parameters for the selection of the voltage and conductor size, but in the Leyte Power Transmission Project the minimum cost method will be adopted as basic criterion. The voltage and conductor size will be determined by making a comparison of the overall expenses (expense of facilities - power loss expenses).

(1) Premises

a) Transmission method

Bipolar single circuit transmission (both neutral points directly grounded).

b) Capacity of the facilities and power to be transmitted.

Capacity of the facilities:	First stage (1986)	450 MW
	Final stage (1991)	900 MW
Power to be transmitted :	1986 - 1990	400 MW
	1991	600 MW
	1992	800 MW
	on and after 1993	900 MW

c) Construction cost of the HVDC facilities

The construction costs are calculated in terms of prices prevailing in March 1981, and refer to the direct construction costs of the facilities listed below:-

Transmission section : Jaro C/S - Naga C/S

Outline of the facilities :

Converter station	2 stations
Transmission line	429 km
Electrode	2 sites
Electrode line	60 km

d) Annual expense rate of the HVDC facilities

Converter station	13.6%
Overhead transmission line	12.6%
Cable	10.6%
Electrodes, electrode lines	13.6%

e) Power loss expenses

Power loss : Total of converter station power loss and transmission line power loss.

Average load factor : 80%

KWH loss cost : Oil fuel cost (US$ 32/bbl) is used as a base for calculation of the KWH power cost.

f) Evaluation period

The overall expenses are compared for a period of 30 years and based on 1986 prices.

g) Voltage and conductor size

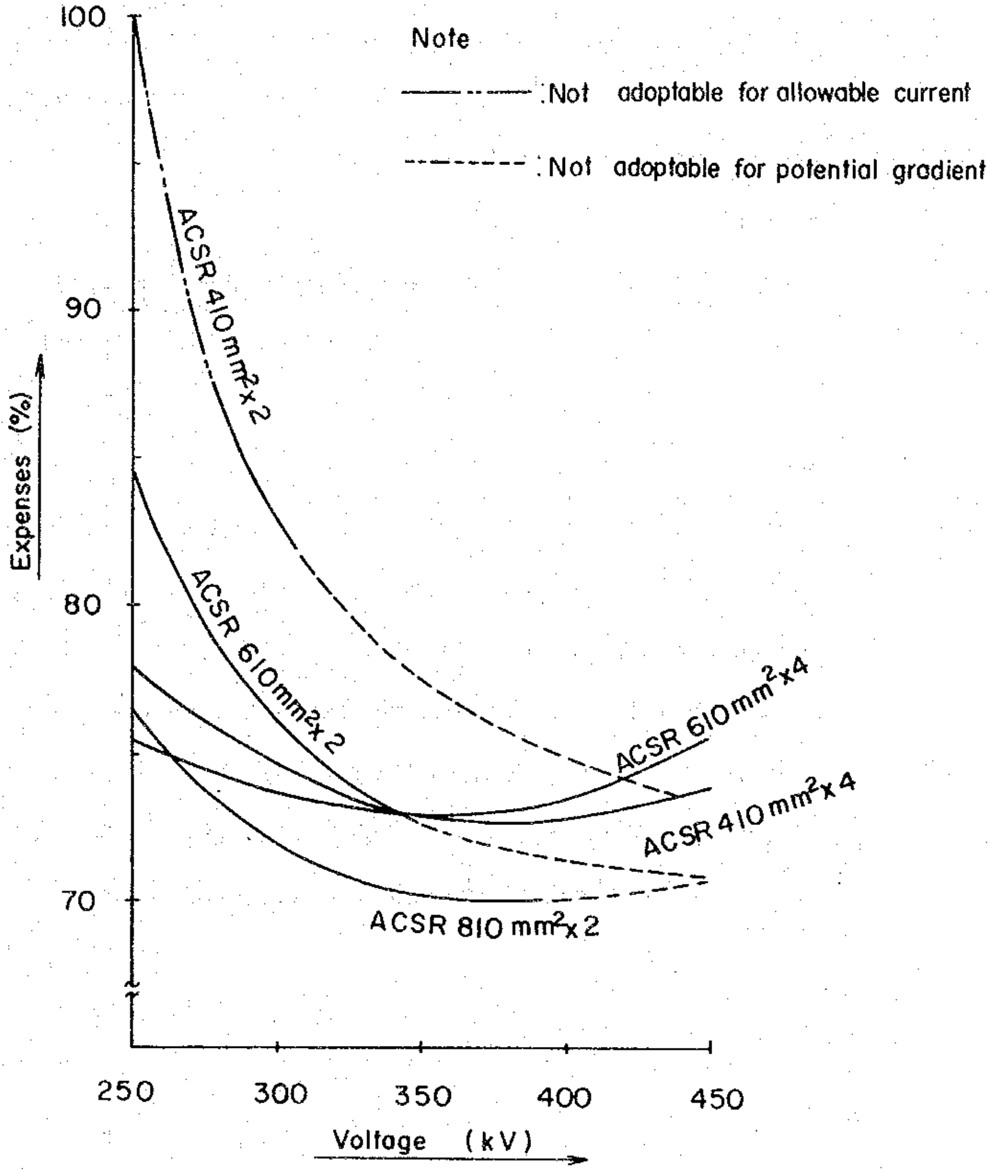
The voltage and conductor size are selected based upon factors like power transmission capacity, thyristor rating and electrical characteristics of the conductor and the following are examined.

Voltage	250 kV - 450 kV
Conductor	ACSR 410 mm^2 x 2, ACSR 610 mm^2 x 2, ACSR 810 mm^2 x 2, ACSR 410 mm^2 x 4 and ACSR 610 mm^2 x 4.

h) Results

The results of the economical comparison are summarized in Fig. 5-9. As can be seen from the said figure, the conductor size of ACSR 810 mm^2 x 2 and the voltage of 350 kV will involve minimum expenses, which is therefore the most economic value for this project. Accordingly, the voltage of 350 kV and the conductor size of ACSR 810 mm^2 x 2 conductors are adopted.

Fig. 5-9 Comparison of Expenses on Voltages and Conductors



5.5 Communication System

For the HVDC transmission system operation, large quantities of various information will be transmitted and high-speed will be needed for control and protection of the HVDC System between Jaro C/S - Naga C/S as well as Jaro C/S - Tongonan S/Y. In addition, telephone communication for power system maintenance between the above stations and other related stations as well as telephone communication for power transmission line maintenance will be required.

The total length between Naga C/S - Jaro C/S - Tongonan S/Y is very long approximately 500 km. The most appropriate communication system to assure correct and stable transmission of important data and information will be the microwave radio link system which enables the speedy transmission of such large quantity of data and information, and is also the most advantageous system from the economical point of view.

Therefore, the microwave system will be adopted in the composition of the communication circuits of the Leyte HVDC Project.
(Fig. 5-10, Fig. 5-11)

Fig.5-10 MICRO WAVE RADIO LINK ROUTE (Preliminary)

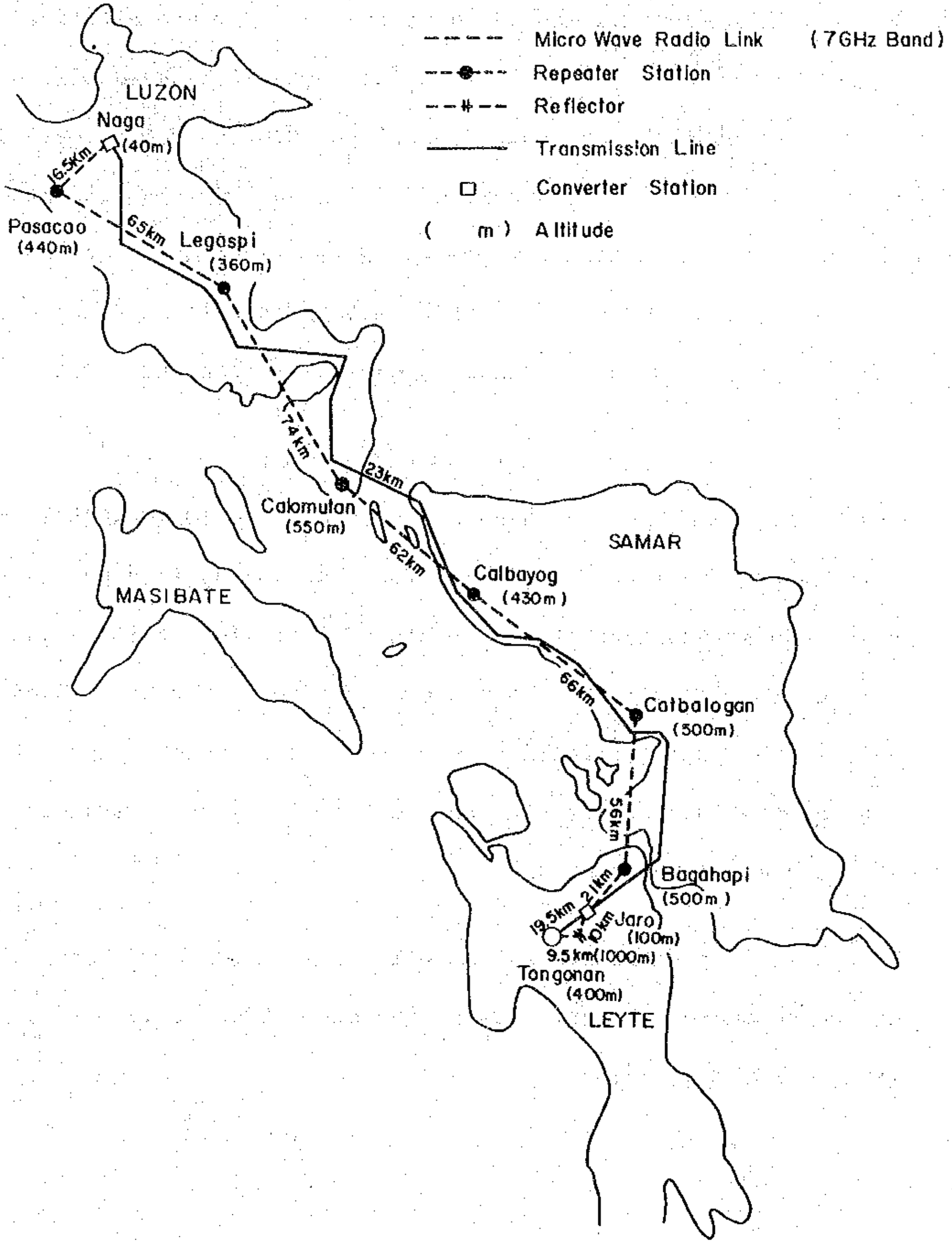
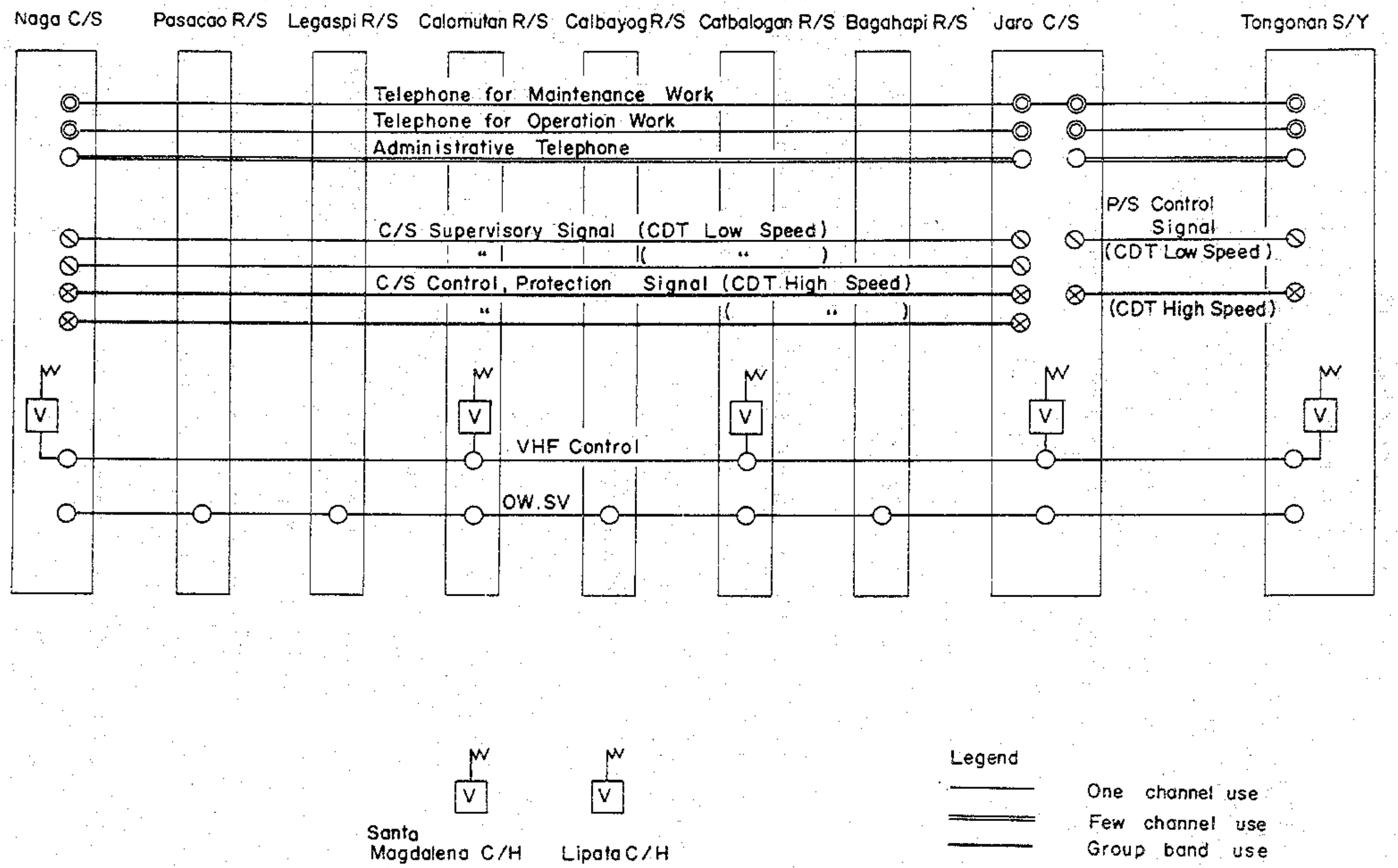


Fig. 5-11 TELECOMMUNICATION CIRCUIT (Preliminary)



5.5.1 Configuration of Communication Circuits

The required communication system for the Project will consist of the microwave radio circuit composed by microwave relay system (6 relay stations and 3 terminal stations at frequency of 7 GHz) between Naga C/S and Tongonan S/Y.

Required circuits for the proposed communication system are as follows:

(1) Naga C/S ∿ Jaro C/S

- a) Information transmission circuit for the converter station of converter facilities (for high speed use)
- b) Information transmission circuit for monitoring of converter facilities (for low speed use)
- c) Telephone circuit for security
- d) Telephone circuit for load dispatching

(2) Jaro C/S ∿ Tongonan S/Y

- a) Information transmission circuit for Tongonan S/Y control (for high speed use)
- b) Information transmission circuit for supervising of Tongonan S/Y
- c) Telephone circuit for maintenance and operation
- d) Telephone circuit for load dispatching

(3) Mobile radio telephone system for power transmission line maintenance

5.5.2 Outline of Communication Equipment

(1) Micro wave radio system

The micro wave radio system will be composed of six (6) relay stations and two (2) plane reflectors on the way between Naga C/S, Jaro C/S and Tongonan S/Y.

(2) Information transmission equipment for control and protection

a) Information transmission equipment will be installed at Naga C/S and Jaro C/S for transmission of necessary data for control and protection between both converter stations.

b) Information transmission equipment will be provided at Tongonan S/Y and Jaro C/S for transmission of necessary data for control of Tongonan Switch Yard.

(3) Information transmission equipment for supervisory

Information transmission equipment will be installed wherever required between Naga C/S and Jaro C/S and between Jaro C/S and Tongonan S/Y for mutual transmission of necessary data for supervisory of the operating conditions at converter stations and Tongonan S/Y.

(4) Telephone system for maintenance and administration

The telephone communication system will be established between Naga C/S, Jaro C/S and Tongonan S/Y for maintenance and administration of the HVDC transmission system.

(5) Transmission line fault locator

The fault locator for the overhead transmission line section will be installed to locate the fault point to help speedy recovery from the line failure.

(6) Oil pressure supervising equipment of submarine cable

The oil pressure supervising equipment will be provided for submarine cable maintenance to monitor the condition of the oil pressure of the cable.

(7) Mobile radio telephone system for line maintenance

The VHF base station will be provided for power transmission line maintenance between Tongonan S/Y and Naga C/S so as to constitute the mobile radio telephone circuit serving the proposed area for construction of the transmission line between Tongonan S/Y and Naga C/S.

The said VHF base stations will be located in the microwave radio relay station and remote-controlled from Naga C/S, Jaro C/S and Tongonan S/Y.

(8) Power supply set for communication

a) The power supply set for communication equipment at each station will be of direct current, uninterruptible power system by use of the floating charging method and will consist of battery charger and storage battery.

b) The power supply set to be provided at each relay station will consist of both solar photovoltaic cell and storage battery.

(9) Telecommunication system for load dispatching

In order to superintend at all times the balance between demand and supply moved with the load variation and to keep the safe and stable operation of the power system, the appropriate commands or exchange of information are necessary from time to time, between each station and relating offices.

To meet such need, the exclusive telephone system for load dispatching will be established in order to make efficient operation of the HVDC transmission system and also to deal with any possible line failure with promptness.

Furthermore, this system may require new installation of the load dispatching data transmission system for load dispatching service between Central Dispatching centre and each local control station. It should be noted, however, that this system is excluded from the plan for the Project because there still remains much to be coordinated with the central load dispatching system now under planning separately by NAPOCOR.

It is added, however, that the necessary channel for constitution of the said system will be readily available by use of the mirowave radio circuit as proposed for this Project.

CHAPTER 6

PRELIMINARY DESIGN

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6.1 Principles of Preliminary Design

6.1.1 System Composition at 1st Stage

Transmitting power under the proposed project plays an important role in the base-load power generating source throughout the whole system in Luzon, taking significant weight in the power balance.

Under such circumstance, therefore, the HVDC design consideration should fully reflect the following points in order to secure bulk power transmission over a long distance:

① Assurance of high service reliability
② No unfavorable effect to the connected AC equipment
③ Continued power service during scheduled maintenance and check

With the above three points taken into consideration, comparison has been made as shown in the following Table 6-1 between monopolar and bipolar systems at the first stage.

Table 6-1 Comparison of Main Circuit Composition

Compared items	Monopole	Bipole
Service reliability (in case of fault in one pole)	Total power stoppage until recovery from failure	Power service can continue at 1/2 load through the other pole in good condition
Influence upon AC equipment (influence to be exerted upon generator at sending end in case of failure on DC transmission line)	It is impossible to avoid significant speed increase of generator because of transmission power-off for time interval from stop to restart of converter. This would give grave consequence to service-life of equipment.	Speed increase of generator can be restrained to minimum if the pole in good condition can be used for appropriate control for time interval from stop to restart of the pole in trouble.
Scheduled maintenance and check (in case of regular checking)	Total power stoppage is required during maintenance.	Power service can be ensured at 1/2 load operation if maintenance is made by shifting from one pole to the other.

After comparative study as aforestated, the bipolar system has been adopted because of its advantages in respect of service reliability, influence upon AC equipment and maintainability.

6.1.2 Methods for Expansion

This Project aims at the installed capacity of 450 MW at the first stage and 900 MW (450 MW addition) at the second stage. The following alternative methods of expansion can be adopted for the system designed for the bipolar composition from the beginning.

(1) Series Expansion:

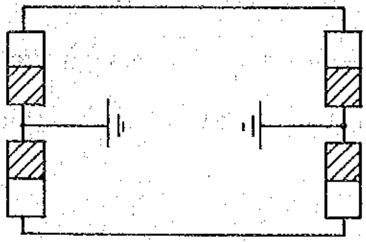
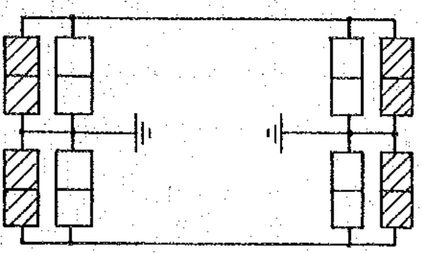
The system at the first stage will be operated at 1/2 of rated voltage and at rated current by single pole, six-pulses on both poles. At the second stage, the 6-pulse valves will be installed additionally in series.

(2) Parallel Expansion

The system will be operated, from its beginning at the first stage, by 12 pulses on both poles at rated voltage and 1/2 of rated current. At the second stage, the 12-pulse valves will be installed additionally in parallel.

The two alternative methods above may be compared as shown in the following Table 6-2.

Table 6-2 Comparison of Alternative Expansion Methods

Compared items	Series expansion	Parallel expansion
Expansion steps (▨ : 1st stage □ : 2nd stage)		
Maintenance	Relatively easy maintenance as compared with parallel arrangement because of its final composition with 2 systems.	Complicated maintenance as compared with series arrangement because of its final composition with 4 systems.
Expansion	° Total system adjustment can be completed at 1st stage. ° Easy test and adjustment at 2nd stage, which may be required only for valves and transformers.	° 2 more systems to be further added at 2nd stage. ° Considerable time period to be required for test and adjustment.
Line loss	Larger increase of line loss at 1st stage than parallel arrangement because of rated full current from the begining.	Line loss may be reduced because of its initial current at 1/2 of rated capacity.
Construction cost	Relatively higher in cost because of 6-phase operation as compared with 12 phases on single pole. However, much lower cost than in parallel arrangement.	Total cost is relatively higher because of nearly double in the total number of equipment than in series arrangement, though less in filter cost for reason of 12-pulse operation.

From the foregoing result of comparative study, the series expansion method has been adopted for the proposed Project because of easy maintenance and expansion at final formation of system linkage and lower construction cost.

Namely,

1st stage: 450 MW (±175 kV, 1290 A)
2nd stage: 900 MW (±350 kV, 1290 A)

6.1.3 Scope of Construction Work at 1st and 2nd Stages

(1) DC Transmission Line, Electrode and its Line

All the works will be completed at the first stage because the bipolar constitution is proposed from the beginning.

(2) Converter Station

a) 1st stage

Converters, DC main circuit equipment (DCR, DCF, Arr and DCPCT) and control board to be required for the bipolar composition will be included in the scope of work to be executed at the first stage of construction.

b) 2nd stage

Valves, transformers and filters for converter and Var compensators will be installed additionally.

Stoppage for about one month per pole will be needed to test the additional equipment. But, during this period, the other pole can be operated at 1/2 power of the rated system capacity.

(3) Communication System

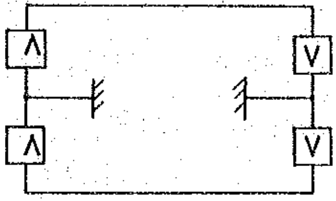
All the works will be completed to meet the requirement of bipolar constitution from the beginning.

6.1.4 Operation Pattern of HVDC System

Operation patterns for both 1st and 2nd stages are planned as illustrated hereunder.

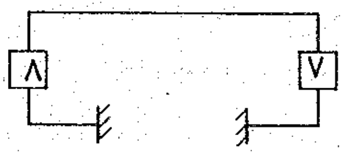
(1) 1st stage (at 450 MW)

a) Normal operation (12-pulse operation)



450 MW

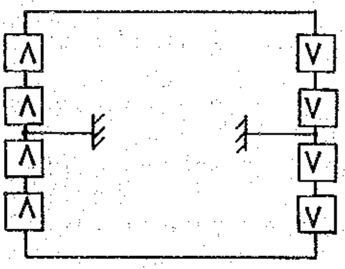
b) In case of failure in one pole or scheduled maintenance (6-pulse operation)



225 MW

(2) 2nd Stage (at 900 MW)

c) Normal operation (12-pulse operation)



900 MW