JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF ENERGY
THE SOCIALIST REPUBLIC OF VIET NAM

THE MASTER PLAN STUDY ON ELECTRIC POWER DEVELOPMENT IN THE SOCIALIST REPUBLIC OF VIET NAM

FINAL REPORT

APPENDIX Vol. I

SEPTEMBER 1995

ELECTRIC POWER DEVELOPMENT CO., LTD.
THE INSTITUTE OF ENERGY ECONOMICS, JAPAN

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CHAPTER 1

INTRODUCTION

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1.1 List of Equipment to be provided

1.1.1 Hardware

(1) **IBM System**

(a) ICL computer D4/66 (UK)
(CPU: Intel 80486DX, Clock 66MHz)
(RAM: 8MB, HDD: 340MB)
(14"SVGA Monitor, Keyboard)
(b) Laser Jet 4 C2001A
(c) L/F for Scanner
(d) Phone Net (GT-404P)

(2) **Macintosh System**

(a) Macintosh Centris 660 AV
(17" Color Display, Keyboard)
(b) HP Laser Jet 4
(c) Digitizer A3
(d) HP Scan Jet 1icx

1.1.2 Software

(1) **IBM System**

(a) MS-Excel V5.0 (E) for Windows
(b) MS-Word V6.0 (E) for Windows
(c) MS-Access V2.0 (E) for Windows
(d) Visual Basic Pro (E) for Windows
(e) Wordperfect V6.0 (E) for Windows
(f) MS-Windows V3.1
(g) Norton Utility (E) V8.0
(h) MS-visual C++Pro Windows
(i) MS Fortran Power Station
(j) XPRESS MP
(k) Micro TSP
(j) Desk Scan II
(k) Micro TSP
(l) Desk Scan II
(m) Adobe Type Manager

(n) Type Reader
(o) DOS Printer Drivers for HP Laser Jet4, HP Explorer, Printing System
(p) DOS Drivers for HP Laser Jet 4L, HP Explorer, Printing System

(2) Macintosh System

(a) Macintosh System 7.1 (E)
(b) MS-Excel V4.0 (E)
(c) File Maker Pro 2.0
(d) Delta Graph Professional
(e) MS-Word 5.1A
(f) Wordperfect 5.1A
(g) Mac Draw pro
(h) Micro TSP
(I) Power Print
(j) CD-Bus Driver
(k) Adobe Photoshop
(l) Desk Scan II

1.1.3 Publications

(1) Environmental control regulations in Japan, July 1990 (IPCAJ)
(2) Industrial pollution Control Air and Water (IPCAJ)
(3) Quality of the Environment in Japan 1992 (EPA, Japan)
(4) Electric Power industry in Japan (JEPIC)
(5) Coal Information 1991
(6) Electricity End-Use Efficiency
(7) Electricity Information
(8) Electricity Supply in OECD Countries
(9) Energy Efficiency and the Environment 1991
(10) Energy Policies of IEA Countries 1991
(11) Energy Technologies for Reducing Emissions of Greenhouse Gases
(12) Guidelines for the Economic Analysis of Renewable Energy Technology
(13) Proceedings of Seminar on Power Generation Management and Structure
(14) Advanced Technologies for Electric Demand-Side Management
(15) Demand-Side Management
(16) Energy Balances of OECD Countries 1960 - 1979
(17) Energy Balances of OECD Countries 1980 - 1989
(18) Energy Balances of OECD Countries 1989 - 1990
(19) energy Statistics and Balances in non-OECD Countries
(20) Energy Statistics of OECD Countries 1970 - 1979
(21) Energy Statistics of OECD Countries 1980 - 1989
(22) Energy Statistics of OECD countries 1989 - 1990
(23) Oil and Gas Information 1989 - 1991
(24) The Macro-economic Impact of Environmental Expenditure
(25) OECD Environmental Data 1991
(26) Competition and Economic Development
(27) Competition Policy in OECD Countries
(28) Consumer, Product Safety Standards and International Trade
(29) Viet Nam Oil and Gas Report (IBC Publishing)
(30) Long-Term Prospects for the World Economy

(31) Energy Balances and Electricity (United Nations)
(32) Energy Statistics Yearbook (United Nations)

CHAPTER 3

CURRENT STATUS OF ELECTRIC POWER SECTOR

Table 3.2-1 Historical trends of Power Consumption and Generation in Vietnam

Year	Demand (GWh)						Losses	Generation (GWh)					Share (%)			
		Industry	Non-I.	Trans.	Agri.	House.	(%)	Total	Thermal	Hydro	Diesel	G.T	Thermal	Hydro	Diesel	G.T
1976	2,218.4	1,117.7	116.2	27.7	218.1	738.7	25.2	2,964.6	1,854.9	831.0	275.6	3.1	62.57	28.03	9.30	0.10
1977	2,498.5	1,298.5	136.7	21.1	251.8	790.4	25.5	3,353.6	1,955.2	1,133.1	264.8	0.5	58.30	33.79	7.90	0.01
1978	2,740.1	1,481.0	152.2	24.8	290.6	791.5	26.1	3,705.7	2,083.8	1,330.8	289.9	1.2	56.23	35.91	7.82	0.03
1979	2,726.1	1,498.0	229.9	42.9	282.0	673.3	27.8	3,775.6	2,022.3	1,447.5	285.7	20.1	53.56	38.34	7.57	0.53
1980	2,670.3	1,401.9	237.0	31.9	337.8	661.7	25.0	3,559.0	1,740.7	1,488.2	316.0	14.2	48.91	41.81	8.88	0.40
1981	2,790.5	1,501.8	266.9	34.4	301.5	685.9	25.1	3,726.3	1,844.4	1,506.9	333.6	41.4	49.50	40.44	8.95	1.11
1982	2,957.2	1,644.1	317.7	40.2	236.8	718.4	25.6	3,974.4	1,981.6	1,559.6	331.6	101.6	49.86	39.24	8.34	2.56
1983	3,082.8	1,716.9	330.4	31.3	237.1	767.1	25.3	4,125.3	2,295.9	1,223.2	389.5	216.7	55.65	29.65	9.44	5.25
1984	3,599.8	2,020.4	381.7	38.5	305.2	854.0	24.7	4,778.5	2,616.1	1,599.0	373.4	190.0	54.75	33.46	7.81	3.98
1985	3,868.5	2,107.8	427.5	36.0	302.9	994.3	23.6	5,064.7	3,017.7	1,472.1	409.2	165.7	59.58	29.07	8.08	3.27
1986	4,146.0	2,197.0	482.3	40.1	332.2	1,094.4	25.0	5,526.7	3,627.1	1,401.9	394.6	103.1	65.63	25.37	7.14	1.87
1987	4,603.5	2,383.5	553.5	37.2	386.5	1,242.8	23.9	6,049.7	4,155.2	1,375.7	400.7	118.1	68.68	22.74	6.62	1.95
1988	5,063.2	2,589.3	637.0	39.4	441.2	1,356.3	25.4	6,783.2	4,432.9	1,785.5	425.6	139.3	65.35	26.32	6.27	2.05
1989	5,660.8	2,621.1	655.6	42.0	465.4	1,876.7	27.3	7,791.8	3,462.0	3,825.3	436.5	68.1	44.43	49.09	5.60	0.87
1990	6,187.1	2,846.7	665.8	51.5	586.7	2,036.4	28.7	8,678.5	2,841.1	5,368.7	410.7	58.0	32.74	61.86	4.73	0.67
1991	6,585.6	3,079.9	590.9	53.8	807.4	2,053.6	28.0	9,152.0	2,424.7	6,316.5	309.8	101.0	26.49	69.02	3.39	1.10
1992	6,925.4	3,192.6	550.4	55.5	974.1	2,152.8	28.2	9,652.1	1,887.4	7,228.1	318.6	218.0	19.55	74.89	3.30	2.26
*1993	8,006.8	3,644.7	632.4	63.8	429.5	3,236.4	25.4	10,728.9	1,776.3	7,965.0	360.7	626.9	16.56	74.24	3.36	5.84
*1994	9,198.0	4,058.7	742.1	81.5	515.6	3,800.1	24.6	12,195.0	2,248.0	8,872.0	272.0	808.0	18.43	72.72	2.23	6.62
Average of Annual Growth Rate (%)																
76-80	4.74	5.83	19.50	3.59		1.10		4.67								
80-85	7.70	8.50	12.52	2.45		5.35		7.31								
85-90	9.85	6.19	9.27	7.42		15.12		11.37								
90-93	8.97	8.59	-1.70	7.40		11.80		7.33								
93-94	14.88	11.36	17.35	27.74	20.05	17.42		13.66								
80-94	9.24	7.89	8.49	6.93		13.30		9.20								

Note : Losses (%) are caliculated by Eq. (Generation - Demand) / Generation * 100.
: Annual Growth rates in Household Include Agricultural Demand exept 1994.
: Agricultural datum since1993 is devided into columns of agriculture and household
: Industry = Demand for Industry, Non-I = Demand for Non-Industrial Sector,
: Trans.= Demand for Transportation & Others, Agri.= Demand for Agriculture,
: House = Demand for Household

Source : Institute of Energy, PC1 PC2 and PC3

Table 3.2-2 Historical Trends of Power Consumption and Generation in the Northern Region (PC1)

(Unit : GWh)

Year	R.Demand	Industry	Non-I.	Trans.	Agri.	House.	Export to PC3	Export to PC2	T. Sales	Losses (%)	Generation
1980	1,414.2	715.5	152.0	21.8	297.8	227.1	0.0	0.0	1,414.2	24.4	1,869.7
1981	1,495.1	792.0	170.1	24.5	250.7	257.8	0.0	0.0	1,495.1	25.1	1,995.9
1982	1,578.0	875.8	204.0	29.0	191.3	277.9	0.0	0.0	1,578.0	25.4	2,115.0
1983	1,633.9	923.0	208.7	16.7	187.0	298.5	0.0	0.0	1,633.9	25.7	2,197.9
1984	1,978.9	1,110.1	247.8	20.8	250.5	349.7	0.0	0.0	1,978.9	25.2	2,646.6
1985	2,150.1	1,136.7	293.6	18.5	238.1	463.2	0.0	0.0	2,150.1	24.5	2,848.9
1986	2,379.8	1,244.4	336.3	22.3	262.9	513.9	0.0	0.0	2,379.8	26.5	3,238.6
1987	2,637.3	1,343.7	355.4	21.0	307.5	609.7	0.0	0.0	2,637.3	25.4	3,537.3
1988	2,861.0	1,464.5	385.9	20.8	343.8	646.0	0.0	0.0	2,861.0	26.1	3,872.2
1989	2,992.3	1,384.7	354.7	24.5	354.6	873.8	0.0	0.0	2,992.3	31.3	4,358.6
1990	3,164.2	1,469.7	341.0	29.6	466.8	857.1	69.2	0.0	3,233.4	33.6	4,868.8
1991	3,292.1	1,444.6	261.0	27.0	672.8	886.7	260.8	0.0	3,552.9	30.6	5,121.5
1992	3,417.0	1,461.2	207.7	24.6	826.2	897.3	348.5	0.0	3,765.5	30.5	5,414.6
*1993	3,878.7	1,680.0	202.5	24.0	259.7	1,712.5	441.0	0.0	4,319.7	25.7	5,814.0
*1994	4,186.0	1,678.0	221.0	30.0	304.0	1,953.0	552.0	900.0	5,638.0	21.1	7,142.0
Average of Annual Growth Rate (%)											
80-85	8.74	9.70	14.07	-3.23		5.97			8.74		8.79
85-90	8.03	5.27	3.04	9.86		13.55			8.50		11.31
90-93	7.02	4.56	-15.95	-6.75		14.21			10.14		6.09
93-94	7.92	-0.12	9.14	25.00	17.06	14.04			30.52		22.84
80-94	8.06	6.28	2.71	2.31		16.61			10.38		10.05

Note : Losses (%) are caliculated by Eq. (Generation - T.Sale) / Generation * 100.

: Agricultural datum of 1993 is devided columns of into agriculture and household

: T.Sales (Total Sales Energy) = Regionnal Demand (R.Demand) + Export to PC3 + to PC2 (from 1994)

: Annual growth rates in household sector include agricultural demand exept 1994.

: Excluding 1993 value, agricultural demand includes rural household demand.

Source : Institute of Energy and PC1

Table 3.2-3 Historical Trends of Power Consumption and Generation in the Southern Region (PC2)

(Unit : GWh)

Year	R. Demand	Industry	Non-I.	Trans.	Agri.	House.	Export to PC3	Import from PC1	T. Sales	Losses (%)	Generation
1980	1,111.4	630.6	71.3	6.6	23.6	379.3	30.7	0.0	1,142.1	26.1	1,544.8
1981	1,141.8	650.3	81.4	6.9	32.5	370.7	31.4	0.0	1,173.2	25.5	1,575.5
1982	1,209.8	696.4	98.5	7.6	26.5	380.8	41.1	0.0	1,250.9	26.2	1,695.2
1983	1,230.3	693.9	100.6	9.8	26.5	399.5	67.3	0.0	1,297.6	25.1	1,732.9
1984	1,363.9	788.6	110.3	11.6	29.1	424.3	75.1	0.0	1,439.0	24.3	1,900.2
1985	1,444.4	841.8	110.0	11.1	32.6	448.9	78.1	0.0	1,522.5	22.6	1,966.4
1986	1,476.8	819.9	118.0	11.4	34.9	492.6	80.7	0.0	1,557.5	23.1	2,025.7
1987	1,656.8	894.9	169.6	10.6	41.7	540.0	91.6	0.0	1,748.4	21.7	2,233.9
1988	1,850.6	959.3	220.3	11.6	52.4	607.0	110.7	0.0	1,961.3	24.3	2,592.3
1989	2,270.6	1,054.8	267.1	11.0	69.0	868.7	120.1	0.0	2,390.7	22.1	3,068.7
1990	2,588.7	1,197.6	288.3	14.5	71.5	1,016.8	134.2	0.0	2,722.9	21.1	3,452.6
1991	2,824.4	1,448.1	286.2	18.9	79.2	992.0	141.2	0.0	2,965.6	21.8	3,793.1
1992	2,973.6	1,535.4	292.2	23.4	87.0	1,035.6	145.1	0.0	3,118.7	22.3	4,012.9
1993	3,490.5	1,739.9	359.8	31.8	95.6	1,263.4	161.1	0.0	3,651.6	21.8	4,667.9
1994	4,248.0	2,123.0	440.0	40.0	125.0	1,520.0	220.0	900.0	4,468.0	21.6	4,800.0
Average of Annual Growth Rate (%)											
80-85	5.38	5.95	9.06	10.96	6.67	3.43			5.92		4.94
85-90	12.38	7.31	21.25	5.49	17.01	17.77			12.33		11.92
90-93	10.48	13.26	7.66	29.92	10.17	7.51			10.28		10.58
93-94	21.70	22.02	22.29	25.79	30.75	20.31			22.36		2.83
80-94	10.05	9.06	13.88	13.73	12.65	10.42			10.23		8.43

Note : Losses (%) are calicultated by Eq. (Generation + Import - T.Sale) / (Generation +Import) * 100.
: T.Sales (Total Sales Energy) = Regionnal Demand (R.Demand) + Export to PC3

Source : Institute of Energy and PC2

Table 3.2-4 Historical Trends of Power Consumption and Generation in the Central Region (PC3)

(Unit : GWh)

Year	R.Demand						T.Sales	Import from		Losses	Generation
		Industry	Non-I.	Trans.	Agri.	House.		PC1	PC2	(%)	
1980	144.7	55.8	13.7	3.5	16.4	55.3	144.7	0.0	30.7	17.4	144.5
1981	153.6	59.5	15.4	3.0	18.3	57.4	153.6	0.0	31.4	17.6	154.9
1982	169.4	71.9	15.2	3.6	19.0	59.7	169.4	0.0	41.1	17.5	164.2
1983	218.6	100.0	21.1	4.8	23.6	69.1	218.6	0.0	67.3	16.5	194.5
1984	257.0	121.7	23.6	6.1	25.6	80.0	257.0	0.0	75.1	16.2	231.7
1985	274.0	129.3	23.9	6.4	32.2	82.2	274.0	0.0	78.1	16.3	249.4
1986	289.4	132.7	28.0	6.4	34.4	87.9	289.4	0.0	80.7	15.7	262.4
1987	309.4	144.9	28.5	5.6	37.3	93.1	309.4	0.0	91.6	16.4	278.5
1988	351.6	165.5	30.8	7.0	45.0	103.3	351.6	0.0	110.7	18.1	318.7
1989	397.9	181.6	33.8	6.5	41.8	134.2	397.9	0.0	120.1	17.9	364.5
1990	434.2	179.4	36.5	7.4	48.4	162.5	434.2	69.2	134.2	22.5	357.1
1991	469.1	187.2	43.7	7.9	55.4	174.9	469.1	260.8	141.2	26.6	237.4
1992	534.8	196.0	50.5	7.5	60.9	219.9	534.8	348.5	145.1	25.5	224.6
1993	637.6	224.8	70.1	8.0	74.2	260.5	637.6	441.0	161.1	24.9	247.0
1994	764.0	257.7	81.1	11.5	86.6	327.1	764.0	552.0	220.0	25.5	253.0
Average of Annual Growth Rate (%)											
80-85	13.62	18.30	11.77	12.83	14.45	8.25	13.62				11.53
85-90	9.64	6.77	8.84	2.95	8.49	14.60	9.64				7.44
90-93	13.66	7.81	24.30	2.63	15.31	17.04	13.66				-11.56
93-94	19.82	14.64	15.69	43.75	16.71	25.57	19.82				2.43
80-94	12.62	11.55	13.54	8.87	12.62	13.54	12.62				4.08

Note : Losses (%) are caliculated by Eq. (Generation + Import -T.Sales) / (Generation + Import) * 100.
: T.Sales (Total Sales Energy) = Regional Demand (R.Demand)
: R.Demand and Generation mean power demand and generation in the Region.

Source : Institute of Energy and PC3

Table 3.2-5 Historical Trends of Power Generation by Sorce in the Northern Region

Year	T.Generation (GWh)	Thermal (GWh)	Hydro. (GWh)	Diesel (GWh)	G.T (Oil) (GWh)	G.T(Gas) (GWh)	P.Load (MW)	L.Factor (%)
1980	1,869.8	1,420.7	373.8	61.5	13.8	0.0	390.0	54.7
1981	1,995.9	1,434.9	467.4	52.4	25.6	15.6	361.0	63.1
1982	2,115.0	1,522.5	459.5	32.8	64.0	36.2	348.0	69.4
1983	2,197.9	1,579.1	390.7	19.6	165.1	43.4	385.0	65.2
1984	2,646.6	2,016.0	436.2	6.2	110.6	77.6	446.0	67.7
1985	2,848.9	2,302.1	385.7	2.6	85.5	73.0	480.0	67.8
1986	3,238.6	2,656.0	477.9	7.7	30.6	66.4	591.0	62.6
1987	3,537.3	3,064.8	354.6	10.1	37.0	70.8	598.0	67.5
1988	3,872.2	3,438.7	293.1	11.3	65.1	64.0	707.0	62.5
1989	4,358.6	2,722.3	1,589.5	8.9	10.5	27.4	827.0	60.2
1990	4,868.8	2,000.5	2,856.6	6.1	5.6	0.0	878.0	63.3
1991	5,121.5	1,365.5	3,709.9	10.9	0.0	35.2	991.0	59.0
1992	5,414.6	851.4	4,548.8	8.9	0.0	5.5	1,080.0	57.2
1993	5,750.5	636.3	5,091.1	9.7	0.0	13.4	1,143.0	57.4
1994	7,147.0	1,288.0	5,834.0	12.0	0.0	13.0		

Note : T.Generation = Total Power Generation, G.T = Gas Turbine, P.Load = Peak Load
: L.Factor (Load Factor, %) = (T.Generation / 8.76) / (P.Load) * 100

Source : Institute of Energy, Vietnam

Table 3.2-6 Historical Trends of Power Generation by Source in the Southern Region

Year	T.Generation (GWh)	Thermal (GWh)	Hydro. (GWh)	Diesel (GWh)	G.T (Oil) (GWh)	G.T (Gas) (GWh)	P.Load (MW)	L.Factor (%)
1980	1,544.8	320.0	1,110.2	114.2	0.4	0.0	259.7	67.9
1981	1,575.5	409.5	1,035.5	130.3	0.2	0.0	264.8	67.9
1982	1,695.2	459.1	1,096.1	138.6	1.4	0.0	284.9	67.9
1983	1,732.9	716.8	828.8	179.1	8.2	0.0	291.3	67.9
1984	1,900.2	600.1	1,157.4	140.9	1.8	0.0	329.5	65.8
1985	1,966.4	715.6	1,081.3	162.3	7.2	0.0	331.0	67.8
1986	2,025.7	971.1	916.9	131.6	6.1	0.0	343.0	67.4
1987	2,233.9	1,090.4	1,015.5	117.7	10.3	0.0	368.0	69.3
1988	2,592.3	994.2	1,489.4	98.7	10.0	0.0	406.0	72.9
1989	3,068.7	739.7	2,226.4	76.3	26.3	0.0	560.0	62.6
1990	3,452.6	840.6	2,484.0	75.9	52.1	0.0	665.0	59.3
1991	3,793.1	1,059.2	2,550.0	118.1	65.8	0.0	711.0	60.9
1992	4,012.9	1,036.0	2,618.6	145.8	212.5	0.0	789.0	58.1
1993	4,667.9	1,139.5	2,789.5	126.0	612.9	0.0	816.6	65.3
1994	4,799.0	960.0	2,930.0	114.0	620.0	175		

Note : T.Generation = Total Power Generation, G.T = Gas Turbine, P.Load = Peak Load
: L.Factor (Load Factor, %) = (T.Generation / 8.76) / (P.Load) * 100

Source : Institute of Energy, Vietnam

Table 3.2-7 Installed Capacity and Power generation of Main Power Stations

		1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Northern region (PC1)															
H.P Thac Ba	MW	108	108	108	108	108	108	108	108	108	108	108	108	108	108
	GWh	458	447	375	421	370	478	355	293	295	457	386	345	327	405
H.P Hoa Binh	MW	0	0	0	0	0	0	0	0	480	480	960	1200	1680	1920
	GWh	0	0	0	0	0	0	0	0	1295	2400	3306	4188	4744	5660
T.P Uong Bi	MW	153	153	153	153	153	153	153	153	105	105	105	105	105	105
(Coal)	GWh	620	669	629	336	288	350	390	485	327	239	104	50	51	114
T.P Ninh Binh	MW	100	100	100	100	100	100	100	100	100	100	100	100	100	100
(Coal)	GWh	540	576	574	475	379	326	346	403	317	268	256	182	189	215
T.P Pha Lai	MW	0	0	0	220	440	440	440	440	440	440	440	440	440	440
(Coal)	GWh	0	0	0	942	1508	1904	2276	2551	2074	1493	1005	619	397	700
Southern region (PC2)															
H.P Da Nhim	MW	160	160	160	160	160	160	160	160	160	160	160	160	160	160
	GWh	1023	1080	816	1145	1068	903	998	841	781	774	800	918	958	1005
H.P Tri An	MW	0	0	0	0	0	0	0	200	400	400	400	400	400	400
	GWh	0	0	0	0	0	0	0	633	1437	1697	1738	1685	1832	1990
T.P Thu Duc	MW	165	165	165	165	165	165	165	165	165	165	165	165	165	165
(Oil)	GWh	315	342	552	428	509	765	835	789	584	665	852	794	928	864
T.P Tra Noc	MW	33	33	33	33	33	33	33	33	33	33	33	33	33	33
(Oil)	GWh						207	236	205	156	176	207	242	204	200
G.T Thu Duc	MW	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6	126	126
(DO/Gas)	GWh													292	340
G.T Ba Ria	MW	46.8	46.8	46.8	46.8	46.8	46.8	46.8	46.8	46.8	46.8	46.8	46.8	122	122
(DO/Gas)	GWh													296	350

Source : Institute of Energy, Vietnam

Figure 3.2-1 Historical Trends of Power Generation

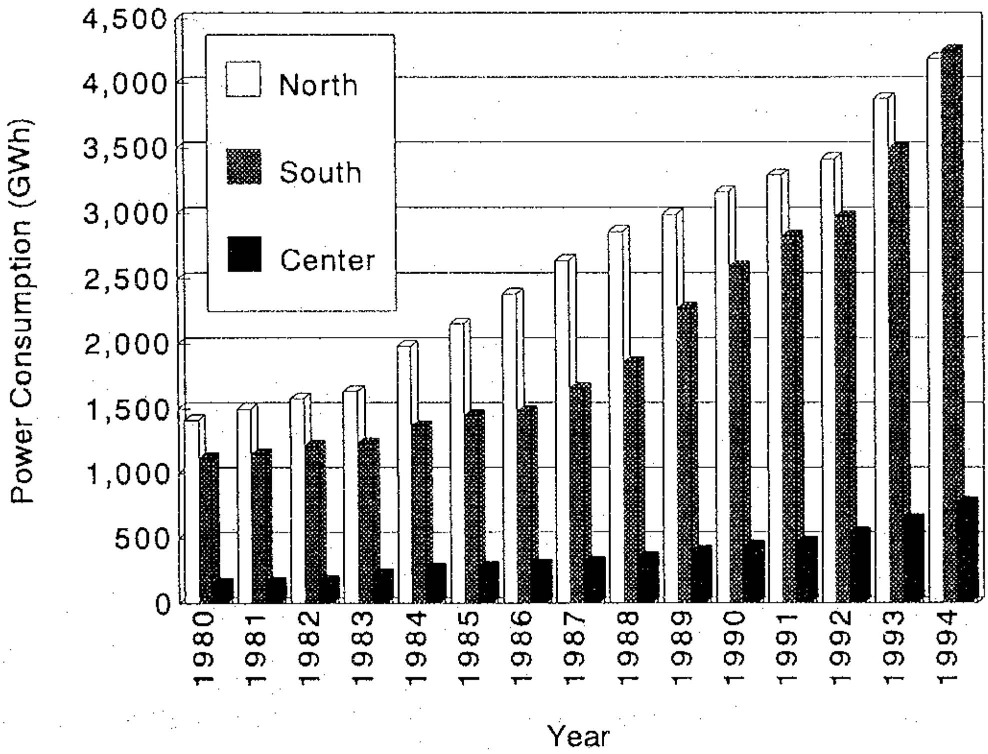


Table 3.4.1 EXISTING 220 KV TRANSMISSION SYSTEM FACILITIES
(As of end-December, 1994)

1. Northern Region

Transmission Lines

Section	Circuit	Length(km)
Hoa Binh-Ha Dong	2 x 55	110
Hoa Binh-Chem		64
Hoa Binh-Nho Quan	2 x 114	228
Nho Quan-Ninh Binh		20
Ha Dong-Chem		15
Ha Dong-Mai Dong		20
Ha Dong-Pha Lai		80
Ha Dong-Nho Quan		69
Mai Dong-Pha Lai		66
Pha Lai-Hai Phong		54
Nho Quan-Than Hoa		71
Thanh Hoa-Vinh		167
Total		964 km
2-cct lines	169 km	795 km

Substations

Substation	Transformer	Capacity(MVA)
Hoa Binh	2 x 63	126
Ha Dong	2 x 125	250
Chem	2 x 125	250
Mai Dong	2 x 125	250
Pha Lai	2 x 250	500
Hai Phong	2 x 125	250
Thanh Hoa		125
Vinh		125
Total 8 stations	14 sets	1,876 MVA

2. Southern Region

Transmission Lines

Section	Circuit	Length(km)
Da Nhim-Thu Duc		257
Thu Duc-Tra Noc		181
Tri An-Hoc Mon	2 x 52.5	105
Tri An-Long Binh		23
Long Binh-Ba Ria		67
Connection to Phu Lam	2 x 2	4
Hoc Mon-Phu Lam		20
Total		657 km
	2-cct lines 54 km	603 km

Substations

Substation	Transformer	Capacity(MVA)
Da Nhim		63
Bao Loc		25
Tri An		63
Long Binh		125
Thu Duc	2 x 3 x 28	168
Hoc Mon	2 x 125	250
Phu Lam		125
Cay Lai		125
Tra Noc	100 + 125	225
Total	9 stations 12 sets	1,169 MVA

3. Central Region

Transmission Lines

Section	Circuit	Length(km)
Vinh to Dong Hoi		203
Pleiku-Qui Nhon		146
Total		349 km

Substations

Substation	Transformer	Capacity(MVA)
Dong Hoi	2 x 63	126 MVA
Da Nang		125
Pleiku		125
Total	3 stations 4 sets	376 MVA

Table 3.4.2 EXISTING 110KV TRANSMISSION SYSTEM FACILITIES
(As of end-1994)

1. Northern Region

Transmission Lines

Section	Conductor	Circuit	Length(km)
Thac Ba-Yen Bai	AC185	2 x 20	40
Yen Bai-Lao Cai	AC185	2 x 137	274
Thac Ba-Tuyen Quang	AC185		30
Tuyen Quan-Thai Nguyen	AC185		60
Thai Nguyen-Bai Can	AC185		75
Bai Can-Cao Bang	AC185		90
Thac Ba-Bac Bang	AC185		57
Bac Bang-Lam Thao	AC120		10
Bai Bang-Viet Tri	AC185		16
Viet Tri-Vinh Yen	AC185		25
Vinh Yen-Donh Anh	AC185		27
Dong Anh-Go Dam	AC120		29
Go Dam-Thai Nguen	AC120	2 x 26	52
Dong Anh-Bac Ninh	AC150		23
Dong Anh-Pha Lai	AC150	2 x 60	120
Dong Anh-Gia Lam	AC150	2 x 11.5	23
Donh Anh-Chem	AC185	2 x 11	22
Chem-Ha Dong	AC185	2 x 17	34
Chem-Yen Phu	AC185	2 x 8	16
Branch-Nghia Do	AC185	2 x 2	4
Ha Dong-Mai Dong	AC120	2 x 17	34
Mai Dong-Tran Hung Dao	AC185	2 x 4	8
Mai Dong-Phuong Liet	AC185	2 x 5	10
Branch-Thuong Dinh	AC120	2 x 9	18
Thuong Dinh-Thanh Cong	AC120	2 x 5	10
Thanh Cong-Giam	AC120	2 x 2	4
Ha Dong-Son Tay	AC120		40
Ha Dong-Van Dinh	AC120		15
Pha Lai-Bac Giang	AC150		28
Bac Giang-Bac Ninh	AC150		9
Bac Giang-Dong Mo	AC120		65
Pha Lai-Uong Bi	AC150	2 x 54	104
Pha Lai-Hai Duong	AC150	2 x 21	42
Hai Duong-Pho Cao	AC120		30
Uong Bi-Mong Duong	AC120	2 x 65	130
Mong Duong-Tien Yen	AC120		40
Branch-Gieng Day	AC120	2 x 8	16
Branch-Ha Tu	AC120	2 x 22	44
Branch-Cam Pha	AC120	2 x 10	20
Mong Duong-Mong Duong(B)	AC120	2 x 12	
Mong Duong(B)-Ha Tu	AC120	2 x 22	44
Uong Bi-Hoang Thach(B)	AC150	2 x 16	
Hoang Thach(B)-H. Thach	AC150	2 x 5	10
Uong Bi-An Lac	AC150	2 x 65	130
Uong Bi-Thuy Nguyen(B)	AC150	2 x 49	

Thuy Nguen(B)-T. Nguyen	ACSR196	2 x 11	22
An Loc-Hai Phong	AC185	2 x 5	10
Hai Phong-Lach Tray	AC185	2 x 14	28
Lach Tray-Cua Cam	AC120	2 x 4	8
Hai Phong-Long Boi	AC150		55
Long Boi-Tien Hai	AC120		28
Long Boi-Thai Binh	AC150		10
Thai Binh-Nam Dinh	AC150		24
Nam Dinh-Trinh Xuyen	AC150		8
Trinh Xuyen-Ninh Binh	AC150		21
Ninh Binh-Bim Son	AC150	2 x 27	54
Bim Son-Nui Mot	AC150		37
Ninh Binh-Phu Ly	AC120		37
Phu Ly-Van Dinh	AC120		35
Thanh Hoa-Nui Mot	AC150		10
Thanh Hoa-Tho Xuan	AC120		30
Thanh Hoa-Nghia Dan	AC120	2 x 135	270
Nghia Dan-Quy Hop	AC120	2 x 35	70
Vinh-Ha Tinh	AC150		50
Total			2,685 circuit-km
2-cct lines:	818 km		1,867 km

Substations

Substation	Transformer Capacity(MVA)	
Yen Bai		20
Lao Cai (Apatit)	2 x 40	(80)
Tuyen Quang		16
Thai Nguyen	20 + 15	35
Bac Can		16
Cao Bang		25
Bai Bang		25
Lam Thao	2 x 16	32
Viet Tri		20
Vinh Yen		16
Dong Anh	2 x 25	50
Gia Sang	2 x 20	40
Go Dam		25
Pha Lai	2 x 6.3	13
Bac Ninh		16
Gia Lam		25
Chem		25
Ha Dong		25
Yen Phu	2 x 25	50
Nghia Do		25
Mai Dong	2 x 25	50
Van Dien		16
Tia		25
Tran Hung Dao	2 x 25	50
Phuong Liet	2 x 25	50
Thuong Dinh	3 x 25	75

Thanh Cong	2 x 25	50
Giam		40
Son Tay	16 + 25	41
Van Dinh		25
Bac Giang	2 x 20	40
Kinh Dap Cau	2 x 6.3	(13)
Dong Mo		16
Uong Bi	2 x 20	40
Hai Duong	2 x 25	50
Pho Cao	2 x 25	50
Gieng Day		16
Ha Tu		25
Cam Pha		16
Mong Duong	15 + 20	35
Tien Yen		16
Hoang Thach	2 x 16	32
An Lac	2 x 25	50
Thuy Nguyen		20
Haly		25
Lach Tray	2 x 16	32
Cua Cam		25
Long Boi	2 x 20	40
Tien Hai		25
Thai Binh		25
Nam Dinh		16
Trinh Xuyen	2 x 20	40
Ninh Binh	2 x 31.5	63
Bim Son	2 x 40	80
Nui Mot (Thanh Hoa)	2 x 20	40
Phu Ly-1	15 + 20	35
Phu Ly-2		25
Tho Xuan		16
Nghia Dan		16
Quy Hop	2 x25	50
Vinh	2 x 25	50
Ha Tinh		25
Hoa Binh	2 x 25	50
Total		
PC-1: 61 stations	91 sets	2,005 MVA
User's: 2 stations	4 sets	93 MVA

Note: Figures in parentheses show capacities of user's facilities.

2. Southern Region

The secondary transmission system of the southern system includes old 66kV facilities. Most of 66kV lines are insulated for 132kV use. Voltage level is noted for the substations.

Transmission Lines

Section	Conductor	Circuit	Length(km)
Da Nhim-Dalat	ACSR336MCM		33
Da Nhim-Thap Cham	ACSR336MCM		49
Thap Cham-Phang Ri	AC185		80
Phan Ri-Phan Thiet	AC185		57
Tri An-Dong Xoai	AC185		61
Dong Xoai-Thac Mo	AC185		45
Long Binh-Xuan Loc	AC150		45
Long Binh-Long Thanh(B)	ACSR196		39
Long Thanh(B)-L. Thanh	AC120		2
Long Thanh(B)-Ba Ria	ACSR196		29
Ba Ria-Vung Tau	ACSR196		17
Long Binh-Bien Hoa	AC240	2 x 6.5	13
Thu Duc-Bien Hoa	AC182		16
Thu Duc-Dong Nai	ACSR200		16
Dong Nai-Visca	ACSR147		1
Dong Nai-Bien Hoa			
Dong Nai-Tan Mai	AC182		6
Thu Duc-Go Dau	ACSR397.5MCM		22
Go Dau-Phu Hoa Dong	ACSR397.5MCM		12
Phu Hoa Dong-Trang Bang	ACSR397.5MCM		23
Trang Bang-Thai Ninh	AC185		46
Thu Duc-Binh Trieu	AC240		7
Thu Duc-Xa Lo	ACSR795MCM	9 + 14	23
Thu Duc-Viet Thanh	ACSR795MCM		11
Hoc Mon-Hoa Xa	AC24015	2 x	30
Hoa Xa-Binh Trieu	AC240		1
Hoa Xa-Cholon	ACSR795MCM		8
Hoc Mon-Phu Lam	AC240	2 x 18	36
Branch-Ba Queo	AC240	2 x 4.5	9
Phu Lam-Cholon	ACSR795MCM		5
Xa Lo-Hung Vuong	ACSR795MCM		6
Hung Vuong-Cholon 66	ACSR795MCM		3
Viet Thanh-An Nghia	AC120		25
Viet Thanh-Chanh Hung	ACSR795MCM		4
Chanh Hung-Cholon 66	ACSR795MCM		7
Cholon 66-Binh Chanh			
Binh Chanh-Long An	ACSR147		39
Long An-My Tho	ACSR147		28
My Tho-Go Cong	ACSR147		35
My Tho-Ben Tre	AC150		18
Cay Lai-My Tho	AC120		25
Cay Lai-My Thuan	AC120		30
Tra Noc-Can Tho	ACSR160		15
Tra Noc-Sa Dec	ACSR160		32
Sa Dec-Vinh Long	ACSR160		23

Vinh Long-Trạ Vinh	AC182	64
Sa Dec-My Thuan	ACSR412	3
My Thuan-Cao Lanh	AC150	36
Cao Lanh-Hong Ngu	AC150	47
Tra Noc-Soc Trang	AC182	78
Soc Trang-Bac Lieu	ACSR397.5MCM	55
Bac Lieu-Ca Mau	AC150	70
Tra Noc-Thot Not	ACSR160	50
Thot Not-Long Xuyen	ACSR160	13
Long Xuyen-Cha Doc	AC150	54
Thot Not-Rach Gia	ACSR160	59
Rach Gia-Kien Luong	AC182	69
Total		1,630 cct-km

2-cct lines: 44 km 1,586 km

Substations

Substation	Transformer Capacity(MVA)	
Dalat (66)		12
Ninh Son (66)		1
Thap Cham (66)	18 + 15	33
Phan Ri (66)	2 x 2	4
Phan Thiet (66)		10
Tri An (110)	2 x 6.3	13
Dong Xoai (110)		16
Long Binh (110)		40
Xuan Loc (110)		16
Vedan	3 x 15	(45)
Long Thanh (110)		10
Vung Tau (110)		40
Bien Hoa (110)		40
(66)		20
Dong Nai (66)		20
Tạn Mai (66)	20 + 25	45
Vicasa (66)		(12.5)
Thu Duc (66)	2 x 20	40
Vi Kimco (66)	3 x 2	(6)
Go Dau (66)		20
Phu Hoa Dong (66)		10
Trang Bang (66)		10
Tay Ninh (66)		15
Binh Trieu (110)		40
Xa Lo (66)	20 + 33	53
Ben Thanh (66)		33
Hung Vuong (66)		33
Viet Thanh (66)		33
Hoc Mon (110)		40
Ha Xa (110)	2 x 40	80
Phu Lam (110)		40
Ba Queo (110)	2 x 40	80
Cholon (110)	2 x 40	80
An Nghia (66)		2

Chanh Hung (66)	2 x 30	60
Binh Chanh (66)		5
Ben Luc (66)		6.3
Long An (66)		12
My Tho (66)		20
Go Cong (66)	2 x 2	4
Ben Tre (66)		10
Thoi Son (66)		0.5
Cay Lai (66)		10
Tra Noc (66)		6
Can Tho (66)		20
Sa Dec (66)		15
Vinh Long (66)		20
Tra Vinh (66)		6
My Thuan (66)		2
Cao Lanh (66)		10
Hong Ngu (An Long) (66)		6.3
Soc Trang (110)		16
Bac Lieu (110)		16
Ca Mau (110)		16
Long Xuyen (110)	2 x 12	24
Chau Doc (110)		16
Chung Su (110)		20
Rach Gia (110)		12
Kien Luong (110)	2 x 30	60
Total		
PC-2: 56 stations	69 sets	1,322 MVA
User's: 3 stations	6 sets	63 MVA

Note:

(1) 110 and 66 in parenthesis of substation name show the voltage class of the substation.

(2) Transformer capacities in parenthesis show capacities of user's facilities.

3. Central Region

Transmission Lines

Section	Conductor	Circuit	Length(km)
Dong Hoi-Dong Hoi 110	AC185		2
Dong Hoi-Dong Ha	ACSR196		106
Dong Ha-Hue	ACSR196		68
Hue-Soi Hue	AC185		5
Hue-Xuan Ha(B)	AC185	2 x 91	182
Xuan Ha(B)-Xuan Ha	AC185	2 x 4	8
Xuan Ha(B)-Cau Do	AC185	2 x 7	14
Da Nang-Cau Do	AC300	2 x 3	6
Da Nang-Tam Ky	AC185		70
Tam Ky-Quang Ngai	AC185		60
Quang Ngai-Vinh Son	AC185		130
Vinh Son-Qui Nhon	AC185		95
Qui Nhon 220-Qui Nhon	AC240	2 x 2	4
Pleiku 500-Pleiku	AC185		8
Qui Nhon-Tuy Hoa	AC185		86
Tuy Hoa-Nha Trang	AC185		138
Nha Trang-Cam Ranh	ACSR196		46
Nha Trang-Soi Nha Trang	AC185		12
Da Nhim-Cam Ranh	AC150		92
Total			1,132 circuit-km
	2-cct lines:	107 km	1,025 km

Substations

Substation	Transformer	Capacity(MVA)
Dong Hoi 110		16
Dong Ha		16
Hue		25
Soi Hue		(16)
Xuan Ha	2 x 25	50
Cau Do		25
Tam Ky		16
Quan Ngai		25
Qui Nhon		25
Pleiku		25
Tuy Hoa		16
Nha Trang		25
Soi Nha Trang		(16)
Cam Ranh (66)		6

Total			
PC-3:	12 stations	13 sets	286 MVA
User's:	2 stations	2 sets	32 MVA

Note: Figures in parenthesis are those of user's.

CHAPTER 5

ELECTRIC POWER DEMAND FORECAST

CHAPTER 5 ELECTRIC POWER DEMAND FORECAST

Table 5.2-1 Gross Domestic Product by Sector (at constant prices of 1989, million dongs)

	Agriculture Forestory	Industry	Construct.	Other Material	Trade	Transport Communicat	Finance Insurance	Service Private	Total
1976	6333091	2719708	774511	122026	2045742	431932	832897	1115325	14375232
1977	6263417	3037914	789226	113240	2062108	440346	867046	1167169	14740466
1978	6056724	3323478	778967	123092	2206455	484214	896525	1207493	15076948
1979	6153632	3173333	764166	119153	2096132	491961	917145	1246540	14962062
1980	6541311	2750917	729015	125707	2035345	383730	929986	1277265	14773276
1981	6722588	2767686	696209	133375	2037380	418650	986946	1342212	15105046
1982	7115960	2940818	591082	144045	2163690	437988	1036456	1429279	15859318
1983	7799090	3150550	673242	160634	2219955	467685	1129075	1529630	17129861
1984	8126650	3560829	758744	169140	2555167	457306	1224685	1694767	18547288
1985	8565480	3966080	826272	166401	2440595	504508	1305143	1849570	19624049
1986	8890547	4128520	824620	195094	2586596	548401	1378232	1997463	20549473
1987	8850021	4605944	868300	200164	2692647	596112	1452657	2129461	21395306
1988	9201827	4758038	841127	211192	2829972	597900	1538364	2518415	22496835
1989	9841079	4567717	872273	215205	2995275	599096	1956799	3260147	24307591
1990	9986985	4681910	913270	223167	3152982	627852	2193571	3756090	25535827
1991	10126805	5014325	958933	229192	3288560	673685	2369056	4097894	26758450
1992	10501493	5585958	987700	236296	3387216	700630	2925784	4601934	28927011
Annual Growth Rate (%)									
(76-80)	0.81	0.29	-1.50	0.75	-0.13	-2.91	2.79	3.45	0.69
(80-85)	5.54	7.59	2.54	5.77	3.70	5.63	7.01	7.69	5.84
(85-90)	3.12	3.37	2.02	6.05	5.26	4.47	10.94	15.22	5.41
(90-92)	2.54	9.23	4.00	2.90	3.65	5.64	15.49	10.69	6.43

Source : Institute of Energy, Vietnam

Table 5.2-2 Scenario of GDP Growth Rate(%)

			1990-1995	1996-2000	2001-2005	2006-2010
Northern Region	Industry	Low Case	6.50	8.50	10.00	10.00
		Base Case	7.00	9.00	11.00	11.00
		High Case	7.50	10.00	12.00	12.00
	Agriculture	Low Case	1.93	3.60	3.60	3.75
		Base Case	1.93	4.00	4.00	4.00
		High Case	1.93	4.00	4.00	4.00
	Others	Low Case	5.88	9.00	10.00	9.00
		Base Case	8.08	10.00	11.00	10.00
		High Case	8.87	11.00	12.00	11.00
	Total	Low Case	4.20	6.76	7.85	7.78
		Base Case	5.17	7.56	8.82	8.72
		High Case	5.59	8.26	9.67	9.66
Central Region	Industry	Low Case	5.00	6.00	8.00	9.00
		Base Case	7.46	6.84	9.00	10.00
		High Case	8.04	8.39	10.00	11.00
	Agriculture	Low Case	3.42	4.00	4.00	4.05
		Base Case	3.42	5.18	4.00	4.05
		High Case	3.42	5.18	4.00	4.05
	Others	Low Case	6.00	8.00	8.50	9.00
		Base Case	7.00	9.00	9.50	10.00
		High Case	8.00	10.00	10.50	11.00
	Total	Low Case	4.58	5.86	6.56	7.21
		Base Case	5.35	6.95	7.24	8.01
		High Case	5.81	7.67	8.01	8.91
Southern Region	Industry	Low Case	11.75	12.00	10.00	8.00
		Base Case	13.36	13.50	11.00	9.00
		High Case	14.16	14.50	12.00	10.00
	Agriculture	Low Case	5.27	4.50	4.00	3.20
		Base Case	5.51	5.00	5.00	5.00
		High Case	5.51	5.00	5.00	5.00
	Others	Low Case	9.30	9.00	8.00	7.00
		Base Case	10.50	11.00	9.50	8.00
		High Case	12.00	11.50	11.00	9.00
	Total	Low Case	8.54	8.54	7.68	6.59
		Base Case	9.54	10.10	9.01	7.79
		High Case	10.43	10.68	10.15	8.71
Whole Nation	Industry	Low Case	9.79	10.79	9.90	8.52
		Base Case	11.17	12.04	10.89	9.49
		High Case	11.88	13.08	11.89	10.48
	Agriculture	Low Case	3.76	4.12	3.86	3.50
		Base Case	3.88	4.67	4.53	4.55
		High Case	3.88	4.67	4.53	4.55
	Others	Low Case	8.02	8.92	8.61	7.76
		Base Case	9.49	10.57	9.93	8.74
		High Case	10.75	11.25	11.25	9.73
	Total	Low Case	6.74	7.77	7.63	6.99
		Base Case	7.72	9.08	8.81	8.07
		High Case	8.42	9.72	9.84	8.99

Table 5.2-3 GDP based on Scenario

			GDP (million US$ at 1989 constant price)				
			1990	1995	2000	2005	2010
Northern Region	Industry	Low Case	771.78	1,057.40	1,589.96	2,560.65	4,123.96
		Base Case	771.78	1,082.45	1,665.49	2,806.45	4,729.03
		High Case	771.78	1,107.98	1,784.42	3,144.75	5,542.13
	Agriculture	Low Case	2,255.26	2,481.46	2,961.46	3,534.31	4,248.60
		Base Case	2,255.26	2,481.46	3,019.08	3,673.17	4,468.97
		High Case	2,255.26	2,481.46	3,019.08	3,673.17	4,468.97
	Others	Low Case	1,765.14	2,348.82	3,613.94	5,820.29	8,955.24
		Base Case	1,765.14	2,603.19	4,192.46	7,064.54	11,377.52
		High Case	1,765.14	2,699.73	4,549.20	8,017.25	13,509.53
	Total	Low Case	4,792.18	5,887.67	8,165.37	11,915.26	17,327.80
		Base Case	4,792.18	6,167.11	8,877.03	13,544.16	20,575.52
		High Case	4,792.18	6,289.17	9,352.70	14,835.17	23,520.63
Central Region	Industry	Low Case	222.30	283.71	379.67	557.87	858.35
		Base Case	222.30	318.54	443.44	682.29	1,098.84
		High Case	222.30	327.23	489.56	788.44	1,328.57
	Agriculture	Low Case	723.94	856.49	1,042.05	1,267.81	1,546.20
		Base Case	723.94	856.49	1,102.52	1,341.39	1,635.93
		High Case	723.94	856.49	1,102.52	1,341.39	1,635.93
	Others	Low Case	500.32	669.54	983.78	1,479.26	2,276.03
		Base Case	500.32	701.73	1,079.69	1,699.69	2,737.37
		High Case	500.32	735.14	1,183.94	1,950.48	3,286.68
	Total	Low Case	1,446.55	1,809.75	2,405.50	3,304.94	4,680.58
		Base Case	1,446.55	1,876.76	2,625.66	3,723.38	5,472.15
		High Case	1,446.55	1,918.86	2,776.03	4,080.31	6,251.18
Southern Region	Industry	Low Case	1,652.43	2,879.79	5,075.18	8,173.63	12,009.74
		Base Case	1,652.43	3,093.31	5,826.42	9,817.86	15,106.00
		High Case	1,652.43	3,204.01	6,305.52	11,112.48	17,896.76
	Agriculture	Low Case	2,719.78	3,516.07	4,381.66	5,330.96	6,240.28
		Base Case	2,719.78	3,556.33	4,538.88	5,792.89	7,393.36
		High Case	2,719.78	3,556.33	4,538.88	5,792.89	7,393.36
	Others	Low Case	3,518.13	5,487.98	8,443.94	12,406.91	17,401.34
		Base Case	3,518.13	5,795.93	9,766.48	15,374.77	22,590.58
		High Case	3,518.13	6,200.14	10,685.04	18,004.91	27,702.79
	Total	Low Case	7,890.34	11,883.84	17,900.78	25,911.50	35,651.35
		Base Case	7,890.34	12,445.57	20,131.78	30,985.52	45,089.94
		High Case	7,890.34	12,960.48	21,529.44	34,910.28	52,992.91
Whole Nation	Industry	Low Case	2,646.51	4,220.91	7,044.82	11,292.15	16,992.04
		Base Case	2,646.51	4,494.30	7,935.36	13,306.61	20,933.87
		High Case	2,646.51	4,639.22	8,579.49	15,045.67	24,767.45
	Agriculture	Low Case	5,698.98	6,854.02	8,385.18	10,133.09	12,035.08
		Base Case	5,698.98	6,894.28	8,660.48	10,807.45	13,498.26
		High Case	5,698.98	6,894.28	8,660.48	10,807.45	13,498.26
	Others	Low Case	5,783.59	8,506.34	13,041.66	19,706.47	28,632.61
		Base Case	5,783.59	9,100.84	15,038.63	24,139.00	36,705.47
		High Case	5,783.59	9,635.01	16,418.18	27,972.64	44,498.99
	Total	Low Case	14,129.08	19,581.26	28,471.65	41,131.70	57,659.73
		Base Case	14,129.08	20,489.43	31,634.47	48,253.06	71,137.60
		High Case	14,129.08	21,168.52	33,658.16	53,825.76	82,764.71

Table 5.2-4 GDP per capita Projected

	1990	1995	2000	2005	2010
Population					
	30.8	34.81	37.8	40.34	42.68
GDP/Capita					
Low Case	155.59	169.14	216.02	295.37	405.99
Base Case	155.59	177.16	234.84	335.75	482.09
High Case	155.59	180.67	247.43	367.75	551.09

Central Region

	1990	1995	2000	2005	2010
Population					
	9.5	11.59	13.1	14.44	15.67
GDP/Capita					
Low Case	152.27	156.15	183.63	228.87	298.70
Base Case	152.27	161.93	200.43	257.85	349.21
High Case	152.27	165.56	211.91	282.57	398.93

Southern Region

	1990	1995	2000	2005	2010
Population					
	25.2	28.23	31.19	33.75	36.03
GDP/Capita					
Low Case	313.11	420.96	573.93	767.75	989.49
Base Case	313.11	440.86	645.46	918.09	1251.46
High Case	313.11	459.10	690.27	1034.38	1470.80

Whole Nation

	1990	1995	2000	2005	2010
Population					
	65.5	74.63	82.1	88.5	94.38
GDP/Capita					
Low Case	215.71	262.38	346.79	464.77	610.93
Base Case	215.71	274.55	385.32	545.23	753.74
High Case	215.71	283.65	409.97	608.20	876.93

Table 5.2-5(1) **Energy indicators for Selected Asian Countries (1992)**

	Bangladesh	Brunei	China	Hong Kong	India	Indonesia	Malaysia	Myanmar
Total Primary Energy Supply (Mtoe)	6.52	2.08	709.57	12.59	205.63	58.86	28.02	1.74
Oil Requiremqent (Mtoe)	2.08	0.45	132.74	6.73	64.05	40.18	14.84	0.78
Electricity Consumption (TWh)	8.89	1.63	757.05	29.95	329.34	42.94	29.93	2.67
Population (Millions)	112.75	0.27	1167.00	5.81	882.95	184.04	18.61	43.73
GDP (Billion 1987 $US)	21.24	2.90	437.25	59.29	333.28	103.86	48.89	11.41
GDP / Capita (1987$US per Capita)	188	10741	375	10205	377	564	2627	261
TPES / GDP (Toe / 000$US)	0.31	0.72	1.62	0.21	0.62	0.57	0.57	0.15
TPES / Pop. (Toe per Capita)	0.06	7.65	0.61	2.17	0.23	0.32	1.51	0.04
Oil Req. / GDP (Toe / 000$US)	0.10	0.15	0.30	0.11	0.19	0.39	0.30	0.07
Oil Req. / Pop. (Toe per Capita)	0.02	1.64	0.11	1.16	0.07	0.22	0.80	0.02
Elec. con. / GDP (kWh / $US)	0.42	0.56	1.73	0.51	0.99	0.41	0.61	0.23
Elec. con. / Pop. (kWh per Capita)	79	5974	649	5155	373	233	1608	61

	Nepal	Pakistan	Philippines	Singapore	South Korea	Sri Lanka	Taiwan	Thailand
Total Primary Energy Supply (Mtoe)	0.44	26.48	20.26	14.51	113.84	1.94	53.73	35.50
Oil Requiremqent (Mtoe)	0.31	11.90	13.78	14.50	70.45	1.69	26.88	23.82
Electricity Consumption (TWh)	0.90	51.97	26.56	17.54	130.96	3.54	98.46	57.54
Population (Millions)	19.88	119.22	64.08	2.81	43.65	17.41	20.66	57.96
GDP (Billion 1987 $US)	3.51	44.70	38.20	30.05	193.22	8.25	156.24	79.53
GDP / Capita (1987$US per Capita)	177	375	596	10694	4427	474	7562	1372
TPES / GDP (Toe / 000$US)	0.13	0.59	0.53	0.48	0.59	0.24	0.34	0.45
TPES / Pop. (Toe per Capita)	0.02	0.22	0.32	5.17	2.61	0.11	2.60	0.61
Oil Req. / GDP (Toe / 000$US)	0.09	0.27	0.36	0.48	0.36	0.20	0.17	0.30
Oil Req. / Pop. (Toe per Capita)	0.02	0.10	0.21	5.16	1.61	0.10	1.30	0.41
Elec. con. / GDP (kWh / $US)	0.26	1.16	0.70	0.58	0.68	0.43	0.63	0.72
Elec. con. / Pop. (kWh per Capita)	45	436	415	6250	3000	203	4767	993

Souecs : IEA, "Energy Statistics and Balances of Non-OECD Countries 1991-1992"

Table 5.2-5(2) Energy indicators for Selected Asian Countries (1990)

	Bangladesh	China	Hong Kong	India	Indonesia	Malaysia	Nepal
Primary Energy Requrement (Mtoe)	7.212	700.678	10.044	195.564	53.758	18.338	0.453
Final Energy Consumption (Mtoe)	4.843	536.457	5.630	128.883	40.559	13.146	0.319
GDP at current market price (mn $US)	21,709	300,426	70,106	254,945	107,294	42,509	2,793
GDP per Capita (current $US)	192	266	12,087	308	599	2,394	148
Population (Millions)	113.01	1,128.50	5.80	827.05	179.14	17.76	18.92
Per Capita Energy Consumption (toe)	0.064	0.621	1.732	0.236	0.300	1.033	0.024
Urbanization ratio (%)	13.6	21.4	93.1	28.0	28.8	42.3	9.6
Industrialization ratio (%)	8.6	46.5		19.5	14.1	26.6	5.4
Energy Intensity (toe / 000$US)	0.321	0.793	0.198	0.671	0.402	0.423	0.150
Oil Intensity (toe / 000$US)	0.096	0.222	0.069	0.205	0.225	0.248	0.074
National Energy Conversion losses (%)	32.8	23.4	43.9	34.1	24.6	28.3	29.6
Electricity Share in primary Energy (%)	33.6	31.5	66.5	40.8	16.7	33.1	34.3
Net Energy Import Dependency (%)	33.5	-4.2	100.0	13.5	-129.2	-147.7	62.7
Net Oil Import dependency (%)	28.1	-3.4	100.0	12.7	-69.6	-107.9	48.0

	Pakistan	Philippines	South Korea	Sri Lanka	Taiwan	Thailand	Viet Nam
Primary Energy Requrement (Mtoe)	29.393	15.106	89.395	2.069	49.929	29.179	6.980
Final Energy Consumption (Mtoe)	20.125	10.707	72.495	1.481	33.559	21.682	3.786
GDP at current market price (mn $US)	35,578	46,465	239,773	7,905	156,234	81,388	17,500
GDP per Capita (current $US)	318	766	5,603	465	7,734	1,445	260
Population (Millions)	112.05	60.68	42.79	16.99	20.20	56.34	67.20
Per Capita Energy Consumption (toe)	0.262	0.249	2.089	0.122	2.472	0.518	0.104
Urbanization ratio (%)	32.00	42.40	71.10	21.90	78.50	22.60	20.00
Industrialization ratio (%)	17.40	24.70	29.20	17.60	34.10	25.00	n.a
Energy Intensity (toe / 000$US)	0.674	0.361	0.586	0.335	0.573	0.430	n.a
Oil Intensity (toe / 000$US)	0.234	0.267	0.318	0.213	0.248	0.289	n.a
National Energy Conversion losses (%)	31.5	29.1	18.9	28.4	32.8	25.7	45.8
Electricity Share in primary Energy (%)	35.8	37.2	29.2	36.2	38.8	32.5	53.6
Net Energy Import Dependency (%)	28.3	60.2	78.5	69.3	94.9	62.0	4.1
Net Oil Import dependency (%)	26.1	58.2	61.6	69.3	57.1	60.8	8.5

Note : Energy / Oil Intensity is measured by Primary Energy requrement / Oil Consumption per thousand U.S.dollars of real GDP at 1980 constant price.

Source : ADB July 1992, "Energy Indicators of Developing Member Countries of ADB"

5.3 Electric Power Demand forecasting Models

I. Nationwide

< Power demand for industrial use, DI >

LOG(DI) = -0.5787 + 0.4186*LOG(GDPi) + 0.6642*LOG(DI(-1))

(-1.34) (2.99) (6.25)

R-Squared = 0.98

Standard Error = 0.045

Durbin-Watoson Ratio = 1.69

< Power demand for agricultural use, DA >

LOG(DA) = -0.8735 + 0.478*LOG(GDPa) + 0.5323*LOG(DA(-1)) +

(-0.69) (2.44) (3.16)

0.1448*DUM80 - 0.2863*DUM*82 - 0.2002*DUM83

(1.60) (-3.26) (-2.08)

R-Squared = 0.91

Standard Error = 0.082

Durbin-Watoson Ratio = 1.73

< Power demand for residential use, DR >

LOG(DR) = 0.5419 + 0.3582*LOG(USER) + 0.8029*LOG(DR(-1))

(1.05) (2.51) (6.97)

R-Squared = 0.97

Standard Error = 0.086

Durbin-Watoson Ratio = 1.64

USER = ELECT* POPULATION

ELECT = -1.2244 + 0.2795*LOG(GDP/CAPITA)

(-15.69) (18.40)

R-Squared = 0.97

Standard Error = 0.006

Durbin-Watoson Ratio = 0.88

< Power demand for others, DO >

DO = -5125.8 + 669.77*LOG(GDPo) + 86.758*DUM88

(-16.20) (17.13)

R-Squared = 0.98

Standard Error = 27.38

Durbin-Watoson Ratio = 1.55

< Total power demand, DT >

DT = DI + DA + DR + DI

II. Northern, Central and Southern Regions

< Power demand for industrial use >

North : $DI(t)_N = (Ei(t)*(GDPi(t)_N / GDPi(t-1)_N - 1) + 1)*DI(t-1)_N$

Center : $DI(t)_C = ((Ei(t)+ei(t))*(GDPi(t)_C / GDPi(t-1)_C - 1) + 1)*DI(t-1)_C$

South : $DI(t)_S = (Ei(t)*(GDPi(t)_S / GDPi(t-1)_S - 1) + 1)*DI(t-1)_S$

< Power demand for agricultural use >
North : $DA(t)_N = (Ea(t)*(GDPa(t)_N / GDPa(t-1)_N - 1) + 1)*DA(t-1)_N$
Center : $DA(t)_C = ((Ea(t)+ea(t))*(GDPa(t)_C / GDPa(t-1)_C - 1) + 1)*DA(t-1)_C$
South : $DA(t)_S = (Ea(t)*(GDPa(t)_S / GDPa(t-1)_S - 1) + 1)*DA(t-1)_S$

< Power demand for residential use >
North : $DR(t)_N = (Er(t)*(USER(t)_N / USER(t-1)_N - 1) + 1)*DR(t-1)_N$
Center : $DR(t)_C = ((Er(t)+er(t))*(USER(t)_C / USER(t-1)_C - 1) + 1)*DR(t-1)_C$
South : $DR(t)_S = (Er(t)*(USER(t)_S / USER(t-1)_S - 1) + 1)*DR(t-1)_S$

Where,
$USER(t)_N = (Eu(t)*(GDP(t)_N / GDP(t-1)_N - 1) + 1)*USER(t-1)_N$
$USER(t)_C = ((Eu(t)+eu(t))*(GDP(t)_C / GDP(t-1)_C - 1) + 1)*USER(t-1)_C$
$USER(t)_S = (Eu(t)*(GDP(t)_S / GDP(t-1)_S - 1) + 1)*USER(t-1)_S$

< Power demand for others >
North : $DO(t)_N = (Eo(t)*(GDPo(t)_N / GDPo(t-1)_N - 1) + 1)*DO(t-1)_N$
Center : $DO(t)_C = ((Eo(t)+eo(t))*(GDPo(t)_C / GDPo(t-1)_C - 1) + 1)*DO(t-1)_C$
South : $DO(t)_S = (Eo(t)*(GDPo(t)_S / GDPo(t-1)_S - 1) + 1)*DO(t-1)_S$

< Total power demand >
North : $DT(t)_N = DI(t)_N + DA(t)_N + DR(t)_N + DO(t)_N$
Center : $DT(t)_C = DI(t)_C + DA(t)_C + DR(t)_C + DO(t)_C$
South : $DT(t)_S = DI(t)_S + DA(t)_S + DR(t)_S + DO(t)_S$

And above system of equations subject to ;

$$DT(t)_N + DT(t)_S + DT(t)_C = DT(t)$$
$$DI(t)_N + DI(t)_S + DI(t)_C = DI(t)$$
$$DA(t)_N + DA(t)_S + DA(t)_C = DA(t)$$
$$DR(t)_N + DR(t)_S + DR(t)_C = DR(t)$$
$$DO(t)_N + DO(t)_S + DO(t)_C = DO(t)$$
$$GDP(t)_N + GDP(t)_S + GDP(t)_C = GDP(t)$$
$$GDPi(t)_N + GDPi(t)_S + GDPi(t)_C = GDPi(t)$$
$$GDPa(t)_N + GDPa(t)_S + GDPa(t)_C = GDPa(t)$$
$$GDPo(t)_N + GDPo(t)_S + GDPo(t)_C = GDPo(t)$$

Where,
DI(t), GDPi(t) : industrial demand and Industrial GDP at year t
DA(t), GDPa(t) : agricultural demand and agricultural GDP at year t
DR(t), GDP(t) : residential demand and total GDP at year t
DO(t), GDPo(t): other demand and GDP of other sector at year t
USER : number of electricity using people
Ei(t), Ea(t), Er(t), Eo(t), Eu(t) : elasticities in equations at year t
ei(t), ea(t), er(t), eo(t), eu(t) : adjustment factors in equations at year t
Suffix $_N$, $_C$ and $_S$ mean Northern, Central and Southern Region.

III. Prefecture

< Northern Region >

$Dp(1995) = Dp(1993) + (DT_N(1995) - DT_N(1993))*(VAp(1995)/VA_N(1995))$

$Dp(2000) = Dp(1995) + (DT_N(2000) - DT_N(1995))*(VAp(2000)/VA_N(2000))$

$Dp(2005) = Dp(2000) + (DT_N(2005) - DT_N(2000))*(VAp(2005)/VA_N(2005))$

$Dp(2010) = Dp(2005) + (DT_N(2010) - DT_N(2005))*(VAp(2010)/VA_N(2010))$

< Central Region >

$Dp(1995) = Dp(1993) + (DT_C(1995) - DT_C(1993))*(VAp(1995)/VA_C(1995))$

$Dp(2000) = Dp(1995) + (DT_C(2000) - DT_C(1995))*(VAp(2000)/VA_C(2000))$

$Dp(2005) = Dp(2000) + (DT_C(2005) - DT_C(2000))*(VAp(2005)/VA_C(2005))$

$Dp(2010) = Dp(2005) + (DT_C(2010) - DT_C(2005))*(VAp(2010)/VA_C(2010))$

< Southern Region >

$Dp(1995) = Dp(1993) + (DT_S(1995) - DT_S(1993))*(VAp(1995)/VA_S(1995))$

$Dp(2000) = Dp(1995) + (DT_S(2000) - DT_S(1995))*(VAp(2000)/VA_S(2000))$

$Dp(2005) = Dp(2000) + (DT_S(2005) - DT_S(2000))*(VAp(2005)/VA_S(2005))$

$Dp(2010) = Dp(2005) + (DT_S(2010) - DT_S(2005))*(VAp(2010)/VA_S(2010))$

Where, $Dp(t)$: Power demand in each province at year t

$DT_{N,C,S}(t)$: Total demand in the Regions at year t

$VAp(t)$: Capacity of transformer in each province at year t

$VA_{N,C,S}(t)$: Total capacity of transformer in the Region at year t

Table 5.4-1 Power Demand - Average Annual Growth Rate (%) 1993 - 2010

		Industry	Agriculture	Others	Residence	Total	Generation	Peak Load
Low Case	PC1	11.72	4.50	5.65	9.15	10.06	9.00	8.46
	PC2	13.05	6.12	6.04	10.13	11.39	10.94	11.25
	PC3	14.43	7.31	5.56	13.62	11.59	10.79	9.96
Base Case	PC1	12.87	4.74	6.25	9.85	10.98	9.92	9.38
	PC2	14.78	7.13	6.59	11.35	12.90	12.44	12.76
	PC3	17.10	7.49	5.88	12.36	13.73	12.91	12.06
High Case	PC1	14.08	4.78	6.53	10.40	11.89	10.82	10.28
	PC2	16.05	7.13	7.01	12.04	13.95	13.49	13.81
	PC3	18.56	8.49	6.48	13.38	14.93	14.10	13.24

Table 5.4-2 Summary on Power Demand for PC1, PC2 and PC3

(Unit : GWH)

			Industry	Agriculture	Others	Residence	Total
Low Case	2000	PC1	3,266	376	389	2,908	6,939
		PC2	4,640	181	776	2,611	8,208
		PC3	793	167	142	653	1,755
	2005	PC1	6,016	453	486	4,789	11,744
		PC2	8,546	223	929	4,304	14,002
		PC3	1,352	308	169	978	2,707
	2010	PC1	11,060	549	577	7,590	19,776
		PC2	13,991	263	1,062	6,519	21,834
		PC3	2,225	246	196	1,449	4,116
Base Case	2000	PC1	3,447	381	426	3,069	7,322
		PC2	5,327	186	829	2,869	9,210
		PC3	1,022	176	148	751	2,098
	2005	PC1	6,758	467	534	5,222	12,980
		PC2	10,444	240	1,008	4,989	16,682
		PC3	1,864	229	178	1,208	3,479
	2010	PC1	13,155	571	635	8,452	22,813
		PC2	18,128	308	1,159	7,859	27,454
		PC3	3,290	296	206	1,889	5,682
High Case	2000	PC1	3,695	381	440	3,200	7,716
		PC2	5,736	186	864	2,998	9,784
		PC3	1,127	176	157	817	2,278
	2005	PC1	7,661	457	556	5,560	14,244
		PC2	11,894	240	1,070	5,403	18,607
		PC3	2,180	229	194	1,368	3,971
	2010	PC1	15,767	571	664	9,206	26,207
		PC2	21,857	308	1,239	8,730	32,133
		PC3	4,063	296	227	2,202	6,788

Figure 5.4-1 Power Generation Forecast Up to 2010

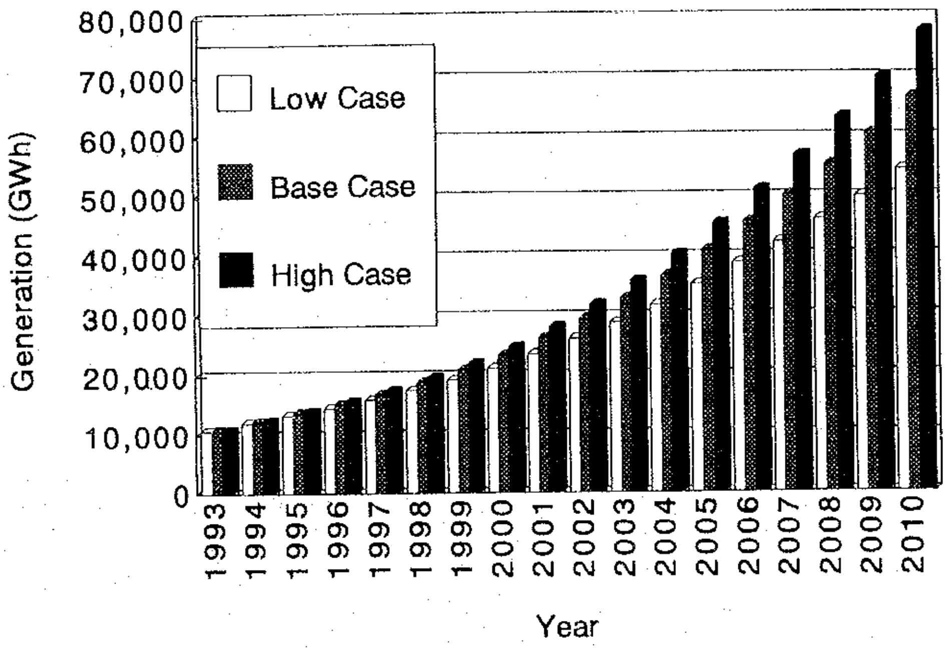


Figure 5.4-2 Peak Load Forecast Up to 2010

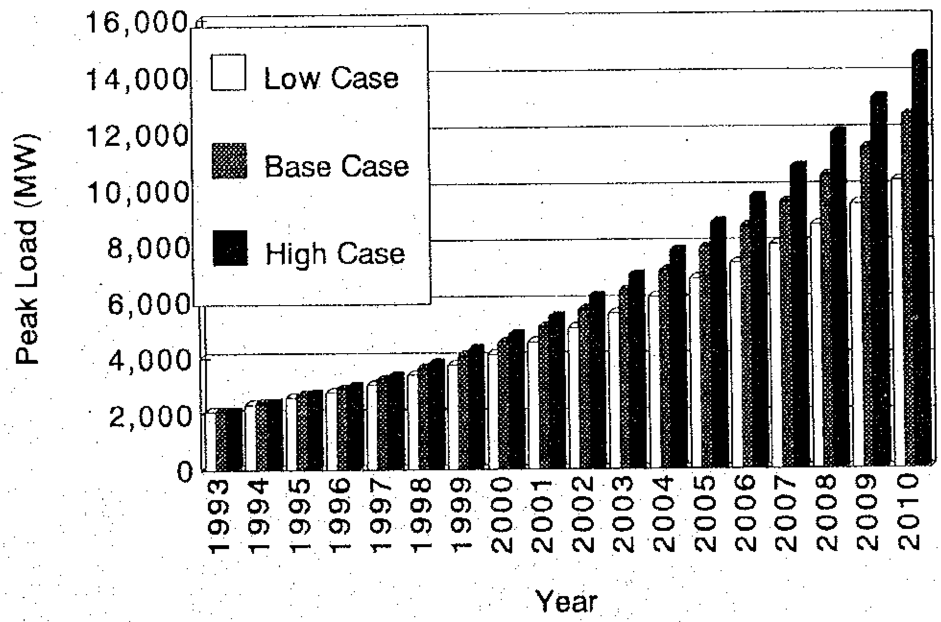


Table A1-1 Power Demand Forecast - Whole Country

Annex 1

Low case

Year	Regional Demand (GWh)				Total	Losses	Generation	Load Factor	Peak Load
	Industry	Agriculture	Others	Residential	(GWh)	(%)	(GWh)	(%)	(MW)
1993	3,644.7	429.5	696.2	3,236.4	8,006.8	25.4	10,728.9	58.8	2,082.7
1994	4,120.8	500.7	969.6	3,497.1	9,088.2	24.6	12,051.7	58.9	2,337.3
1995	4,649.1	553.0	1,021.3	3,802.4	10,025.8	24.5	13,272.7	58.5	2,590.7
1996	5,257.7	594.4	1,078.5	4,161.1	11,091.7	23.5	14,506.3	59.6	2,780.7
1997	5,955.3	629.7	1,135.8	4,574.7	12,295.5	22.5	15,872.1	59.6	3,042.6
1998	6,752.7	662.0	1,193.0	5,045.7	13,653.4	21.9	17,482.2	59.1	3,375.0
1999	7,662.1	693.1	1,250.2	5,577.3	15,182.8	21.0	19,218.7	58.8	3,731.7
2000	8,698.0	724.1	1,307.4	6,172.9	16,902.5	20.0	21,128.2	58.8	4,102.9
2001	9,843.8	754.7	1,362.8	6,825.7	18,787.0	20.0	23,483.7	59.0	4,540.5
2002	11,117.8	785.6	1,418.1	7,538.5	20,860.0	20.0	26,075.0	59.1	5,040.8
2003	12,539.7	817.2	1,473.4	8,314.7	23,145.1	19.5	28,749.1	59.2	5,545.9
2004	14,130.8	849.8	1,528.7	9,157.7	25,667.0	19.0	31,687.6	59.2	6,112.6
2005	15,914.2	883.6	1,584.0	10,070.9	28,452.7	19.0	35,126.8	59.3	6,763.4
2006	17,821.1	917.0	1,634.1	11,040.5	31,412.7	19.0	38,781.1	60.5	7,316.6
2007	19,881.2	950.8	1,684.1	12,070.1	34,586.3	18.1	42,228.1	60.5	7,966.4
2008	22,123.9	985.4	1,734.2	13,163.7	38,007.2	17.5	46,061.1	60.6	8,672.7
2009	24,578.7	1,021.0	1,784.3	14,325.1	41,709.0	16.5	49,940.5	60.6	9,401.3
2010	27,275.6	1,057.7	1,834.3	15,558.5	45,726.0	16.0	54,414.3	60.7	10,241.8
AGR(%)	12.57	5.44	5.86	9.68	10.79		10.02		9.82

Base Case

Year	Regional Demand (GWh)				Total	Losses	Generation	Load Factor	Peak Load
	Industry	Agriculture	Others	Residential	(GWh)	(%)	(GWh)	(%)	(MW)
1993	3,644.7	429.5	696.2	3,236.4	8,006.8	25.4	10,728.9	58.8	2,082.7
1994	4,207.8	501.8	1,005.8	3,535.8	9,251.3	24.6	12,267.2	58.9	2,379.3
1995	4,839.0	555.2	1,066.6	3,887.8	10,348.6	24.5	13,698.0	58.5	2,674.1
1996	5,568.5	598.8	1,133.9	4,304.4	11,605.5	23.5	15,177.8	59.5	2,910.5
1997	6,410.7	637.1	1,201.2	4,788.5	13,037.5	22.5	16,829.0	59.5	3,227.7
1998	7,382.5	673.1	1,268.5	5,344.1	14,668.1	21.9	18,779.8	59.1	3,628.0
1999	8,503.2	708.3	1,335.8	5,975.7	16,522.9	21.0	20,915.1	58.7	4,064.2
2000	9,795.3	743.8	1,403.1	6,688.5	18,630.8	20.0	23,288.5	58.7	4,526.2
2001	11,236.1	779.8	1,466.5	7,473.5	20,955.9	20.0	26,194.8	59.0	5,067.2
2002	12,852.6	816.8	1,529.9	8,334.5	23,533.9	20.0	29,417.3	59.0	5,689.7
2003	14,674.3	855.1	1,593.3	9,276.0	26,398.7	19.5	32,794.7	59.2	6,328.4
2004	16,733.4	895.0	1,656.7	10,302.4	29,587.5	19.0	36,527.7	59.2	7,048.7
2005	19,065.7	936.6	1,720.1	11,418.4	33,140.7	19.0	40,914.5	59.3	7,879.0
2006	21,596.0	980.1	1,776.2	12,608.4	36,960.8	19.0	45,630.6	60.4	8,619.7
2007	24,367.0	1,025.7	1,832.3	13,876.9	41,101.9	18.1	50,189.8	60.4	9,480.8
2008	27,422.5	1,073.4	1,888.5	15,228.3	45,612.7	17.5	55,286.6	60.6	10,421.6
2009	30,808.2	1,123.4	1,944.6	16,667.5	50,543.7	16.5	60,528.1	60.6	11,407.7
2010	34,572.3	1,175.6	2,000.7	18,199.6	55,948.3	16.0	66,599.8	60.6	12,550.3
AGR(%)	14.15	6.10	6.41	10.69	12.12		11.34		11.14

High Case

Year	Regional Demand (GWh)				Total	Losses	Generation	Load Factor	Peak Load
	Industry	Agriculture	Others	Residential	(GWh)	(%)	(GWh)	(%)	(MW)
1993	3,644.7	429.5	696.2	3,236.4	8,006.8	25.4	10,728.9	58.8	2,082.7
1994	4,252.9	501.8	1,036.5	3,563.1	9,354.4	24.6	12,403.0	58.9	2,405.5
1995	4,938.7	555.2	1,104.9	3,948.8	10,547.6	24.4	13,959.8	58.5	2,725.2
1996	5,742.3	598.8	1,176.3	4,403.9	11,921.4	23.5	15,590.5	59.5	2,990.0
1997	6,682.2	637.1	1,247.7	4,932.8	13,499.8	22.5	17,425.5	59.5	3,342.7
1998	7,780.3	673.1	1,319.1	5,540.2	15,312.6	21.9	19,604.5	59.1	3,788.2
1999	9,062.1	708.3	1,390.5	6,232.0	17,392.9	21.0	22,016.3	58.7	4,279.3
2000	10,557.6	743.8	1,461.9	7,014.6	19,777.9	20.0	24,722.4	58.7	4,806.3
2001	12,247.6	779.8	1,533.3	7,883.4	22,444.2	20.0	28,055.2	59.0	5,428.0
2002	14,167.9	816.8	1,604.7	8,844.0	25,433.4	20.0	31,791.7	59.0	6,150.0
2003	16,358.5	855.1	1,676.1	9,901.6	28,791.3	19.5	35,767.6	59.1	6,903.0
2004	18,864.2	895.0	1,747.5	11,062.1	32,568.8	19.0	40,208.4	59.2	7,759.9
2005	21,735.6	936.6	1,818.9	12,331.4	36,822.5	19.0	45,459.9	59.3	8,755.0
2006	24,897.8	980.1	1,881.1	13,690.8	41,449.8	19.0	51,172.6	60.4	9,669.6
2007	28,409.3	1,025.7	1,943.3	15,145.4	46,523.6	18.1	56,812.3	60.4	10,735.1
2008	32,332.3	1,073.4	2,005.5	16,700.8	52,111.9	17.5	63,166.1	60.5	11,910.1
2009	36,733.8	1,123.4	2,067.7	18,362.8	58,287.7	16.5	69,804.0	60.6	13,159.4
2010	41,687.1	1,175.6	2,129.9	20,137.6	65,130.1	16.0	77,534.6	60.6	14,614.8
AGR(%)	15.41	6.10	6.80	11.35	13.12		12.34		12.14

Table A2-1 Power Demand Forecast - Northern Region

Low Case

	1993-1995	1996-2000	2001-2005	2005-2010		
GDP Growth Rate (%)	4.20	6.76	7.85	7.78		
Industry	6.50	8.50	10.00	10.00		
Agriculture	1.93	3.60	3.60	3.75		
Others	5.88	9.00	10.00	9.00		
Population Growth Rate (%)	2.00	1.70	1.20	1.20	Pop. 1993	33.5
Urban	4.80	4.80	3.10	3.10	(million)	4.9
Rural	1.50	1.00	0.80	0.80		28.6 (Ratio 85.4%)

Year	Regional Demand (GWh)				Total	Losses	Generation	Load Factor	Peak Load
	Industry	Agriculture	Others	Residential	(GWh)	(%)	(GWh)	(%)	(MW)
1993	1,680.0	259.7	226.5	1,712.5	3,878.7	28.0	5,374.0	57.0	1,076.3
1994	1,825.7	281.8	291.7	1,802.2	4,201.4	26.0	5,677.6	57.0	1,137.1
1995	1,981.1	296.9	303.1	1,902.8	4,483.9	26.0	6,059.3	57.0	1,213.5
1996	2,185.4	316.3	320.3	2,058.6	4,880.6	24.0	6,421.9	59.0	1,242.5
1997	2,413.8	332.7	337.4	2,236.5	5,320.5	23.0	6,909.7	59.0	1,336.9
1998	2,668.4	347.7	354.6	2,436.8	5,807.5	22.0	7,445.5	59.0	1,440.6
1999	2,951.5	361.9	371.7	2,660.4	6,345.5	21.0	8,032.3	59.0	1,554.1
2000	3,265.9	376.1	388.9	2,907.9	6,938.8	20.0	8,673.4	59.0	1,678.2
2001	3,701.9	390.9	408.0	3,221.4	7,722.3	20.0	9,652.9	59.0	1,867.7
2002	4,187.0	405.8	427.3	3,564.4	8,584.6	20.0	10,730.7	59.0	2,076.2
2003	4,728.7	421.1	446.7	3,938.7	9,535.2	19.0	11,771.9	59.0	2,277.7
2004	5,335.4	436.7	466.3	4,346.1	10,584.6	19.0	13,067.4	59.0	2,528.3
2005	6,016.0	452.9	486.0	4,788.7	11,743.6	19.0	14,498.3	59.0	2,805.2
2006	6,814.5	471.3	504.0	5,276.1	13,065.9	19.0	16,130.7	62.0	2,970.0
2007	7,703.7	489.9	522.0	5,797.6	14,513.3	18.0	17,699.1	62.0	3,258.8
2008	8,697.4	509.0	540.2	6,355.6	16,102.2	17.0	19,400.2	62.0	3,572.0
2009	9,810.7	528.7	558.5	6,952.3	17,850.1	16.0	21,250.1	62.0	3,912.6
2010	11,060.0	549.0	576.8	7,590.1	19,776.0	15.0	23,265.8	62.0	4,283.7
AGR(%)	11.72	4.50	5.65	9.15	10.06		9.00		8.46

Base Case

	1993-1995	1996-2000	2001-2005	2006-2010		
GDP Growth Rate (%)	5.17	7.56	8.82	8.72		
Industry	7.00	9.00	11.00	11.00		
Agriculture	1.93	4.00	4.00	4.00		
Others	8.08	10.00	11.00	10.00		
Population Growth Rate (%)	2.00	1.70	1.20	1.20	Pop. 1993	33.5
Urban	4.80	4.80	3.10	3.10	(million)	4.9
Rural	1.50	1.00	0.80	0.80		28.6 (Ratio 85.4%)

Year	Regional Demand (GWh)				Total	Losses	Generation	Load Factor	Peak Load
	Industry	Agriculture	Others	Residential	(GWh)	(%)	(GWh)	(%)	(MW)
1993	1,680.0	259.7	226.5	1,712.5	3,878.7	28.0	5,374.0	57.0	1,076.3
1994	1,842.7	281.5	312.3	1,817.4	4,253.8	26.0	5,748.3	57.0	1,151.2
1995	2,015.9	296.3	328.3	1,942.0	4,582.6	26.0	6,192.7	57.0	1,240.2
1996	2,243.0	316.3	347.9	2,115.7	5,022.9	24.0	6,609.1	59.0	1,278.8
1997	2,496.6	333.6	367.5	2,314.4	5,512.1	23.0	7,158.6	59.0	1,385.1
1998	2,779.5	349.7	386.9	2,538.9	6,055.1	22.0	7,763.0	59.0	1,502.0
1999	3,095.0	365.4	406.4	2,790.0	6,656.8	21.0	8,426.3	59.0	1,630.3
2000	3,446.5	381.1	425.7	3,068.8	7,322.2	20.0	9,152.7	59.0	1,770.9
2001	3,960.2	397.4	447.1	3,425.9	8,230.5	20.0	10,288.2	59.0	1,990.6
2002	4,536.9	414.0	468.5	3,817.5	9,237.0	20.0	11,546.2	59.0	2,234.0
2003	5,187.3	431.2	490.1	4,245.8	10,354.5	19.0	12,783.3	59.0	2,473.4
2004	5,923.2	448.9	511.8	4,713.1	11,597.1	19.0	14,317.4	59.0	2,770.2
2005	6,757.7	467.4	533.7	5,221.5	12,980.2	19.0	16,024.9	59.0	3,100.6
2006	7,743.9	486.5	553.7	5,780.8	14,564.9	19.0	17,981.3	62.0	3,310.7
2007	8,855.4	506.4	573.9	6,380.9	16,316.6	18.0	19,898.3	62.0	3,663.7
2008	10,112.4	527.1	594.2	7,024.4	18,258.0	17.0	21,997.6	62.0	4,050.2
2009	11,537.2	548.6	614.5	7,713.8	20,414.1	16.0	24,302.5	62.0	4,474.6
2010	13,154.5	571.1	635.0	8,452.0	22,812.6	15.0	26,838.4	62.0	4,941.5
AGR(%)	12.87	4.74	6.25	9.85	10.98		9.92		9.38

Table A2-1 Power Demand Forecast - Northern Region (continue)

High Case	1993-1995	1996-2000	2001-2005	2006-2010		
GDP Growth Rate (%)	5.59	8.26	9.67	9.66		
Industry	7.50	10.00	12.00	12.00		
Agriculture	1.93	4.00	4.00	4.00		
Others	8.87	11.00	12.00	11.00		
Population Growth Rate (%)	2.00	1.70	1.20	1.20	Pop. 1993	33.5
Urban	4.80	4.80	3.10	3.10	(million)	4.9
Rural	1.50	1.00	0.80	0.80		28.6 (Ratio 85.4%)

Year	Regional Demand (GWh)				Total	Losses	Generation	Load Factor	Peak Load
	Industry	Agriculture	Others	Residential	(GWh)	(%)	(GWh)	(%)	(MW)
1993	1,680.0	259.7	226.5	1,712.5	3,878.7	28.0	5,374.0	57.0	1,076.3
1994	1,857.0	281.5	317.9	1,824.2	4,280.5	26.0	5,784.5	57.0	1,158.5
1995	2,046.0	296.3	335.2	1,959.0	4,636.6	26.0	6,265.6	57.0	1,254.8
1996	2,300.6	316.3	356.3	2,149.1	5,122.2	24.0	6,739.8	59.0	1,304.0
1997	2,588.4	333.6	377.4	2,367.0	5,666.5	23.0	7,359.0	59.0	1,423.9
1998	2,913.6	349.7	398.4	2,613.8	6,275.6	22.0	8,045.7	59.0	1,556.7
1999	3,280.6	365.4	419.4	2,890.9	6,956.3	21.0	8,805.4	59.0	1,703.7
2000	3,694.5	381.1	440.3	3,199.6	7,715.6	20.0	9,644.4	59.0	1,866.0
2001	4,293.1	397.4	463.2	3,587.1	8,740.8	20.0	10,925.9	59.0	2,114.0
2002	4,973.8	414.0	486.1	4,014.3	9,888.2	20.0	12,360.3	59.0	2,391.5
2003	5,750.9	431.2	509.2	4,483.8	11,175.0	19.0	13,796.4	59.0	2,669.4
2004	6,640.7	448.9	532.3	4,998.1	12,620.0	19.0	15,580.3	59.0	3,014.5
2005	7,661.4	467.4	555.5	5,560.0	14,244.2	19.0	17,585.4	59.0	3,402.5
2006	8,877.5	486.5	577.0	6,187.2	16,128.1	19.0	19,911.2	62.0	3,666.1
2007	10,265.2	506.4	598.6	6,862.3	18,232.6	18.0	22,234.8	62.0	4,093.9
2008	11,853.7	527.1	620.3	7,588.4	20,589.5	17.0	24,806.6	62.0	4,567.4
2009	13,675.4	548.6	642.2	8,368.5	23,234.7	16.0	27,660.3	62.0	5,092.9
2010	15,767.4	571.1	664.1	9,206.0	26,208.6	15.0	30,833.6	62.0	5,677.1
AGR(%)	14.08	4.74	6.53	10.40	11.89		10.82		10.28

Table A3-1 Power Demand Forecast - Central Region

Low Case	1993-1995	1996-2000	2001-2005	2006-2010		
GDP Growth Rate (%)	4.58	5.86	6.56	7.21		
Industry	5.00	6.00	8.00	9.00		
Agriculture	3.42	4.00	4.00	4.05		
Others	6.00	8.00	8.50	9.00		
Population Growth Rate (%)	2.80	2.50	1.80	1.80	Pop. 1993	11.0
Urban	4.60	3.80	3.00	3.00	(millon)	2.7
Rural	2.20	2.00	1.30	1.30		8.3 (Ratio 75.8%)

Year	Regional Demand (GWh) Industry	Agriculture	Others	Residential	Total (GWh)	Losses (%)	Generation (GWh)	Load Factor (%)	Peak Load (MW)
1993	224.8	74.2	78.1	260.5	637.6	24.8	848.1	51.0	189.8
1994	282.4	101.1	108.0	305.3	796.7	25.0	1,062.3	51.0	237.8
1995	345.6	121.0	113.0	358.5	938.1	24.0	1,234.4	51.0	276.3
1996	411.8	132.0	118.9	402.1	1,064.7	24.0	1,401.0	52.0	307.6
1997	488.4	141.4	124.7	452.9	1,207.4	23.0	1,568.1	52.0	344.2
1998	576.5	150.0	130.6	511.4	1,368.6	21.0	1,732.4	52.0	380.3
1999	677.5	158.5	136.4	578.2	1,550.5	21.0	1,962.7	53.0	422.7
2000	792.6	166.9	142.2	653.7	1,755.4	20.0	2,194.2	53.0	472.6
2001	882.9	174.7	147.8	709.3	1,914.7	20.0	2,393.3	55.0	496.7
2002	982.8	182.7	153.3	769.5	2,088.2	20.0	2,610.3	55.0	541.8
2003	1,093.4	190.8	158.7	834.4	2,277.3	19.0	2,811.5	56.0	573.1
2004	1,216.0	199.3	164.0	903.9	2,483.2	19.0	3,065.7	56.0	624.9
2005	1,351.9	208.0	169.2	978.1	2,707.3	19.0	3,342.3	57.0	669.4
2006	1,552.7	215.4	174.7	1,067.0	3,009.8	19.0	3,715.8	57.0	744.2
2007	1,736.8	222.8	180.1	1,158.4	3,298.1	19.0	4,071.7	57.0	815.5
2008	1,908.5	230.4	185.4	1,252.4	3,576.7	17.0	4,309.3	58.0	848.1
2009	2,070.5	238.2	190.7	1,349.3	3,848.6	16.0	4,581.7	58.0	901.8
2010	2,224.5	246.2	195.9	1,449.2	4,115.8	15.0	4,842.1	58.0	953.0
AGR(%)	14.43	7.31	5.56	10.62	11.59		10.79		9.96

Base Case	1993-1995	1996-2000	2001-2005	2006-2010		
GDP Growth Rate (%)	5.35	6.95	7.24	8.01		
Industry	7.46	6.84	9.00	10.00		
Agriculture	3.42	5.18	4.00	4.05		
Others	7.00	9.00	9.50	10.00		
Population Growth Rate (%)	2.80	2.50	1.80	1.80	Pop. 1993	11.0
Urban	4.60	3.80	3.00	3.00	(million)	2.7
Rural	2.20	2.00	1.30	1.30		8.3 (Ratio 75.8%)

Year	Regional Demand (GWh) Industry	Agriculture	Others	Residential	Total (GWh)	Losses (%)	Generation (GWh)	Load Factor (%)	Peak Load (MW)
1993	224.8	74.2	78.1	260.5	637.6	24.8	848.1	51.0	189.8
1994	303.7	101.9	109.3	309.6	824.5	25.0	1,099.3	51.0	246.1
1995	391.8	122.5	114.9	366.0	995.2	24.0	1,309.5	51.0	293.1
1996	483.2	134.7	121.7	421.4	1,161.0	24.0	1,527.6	52.0	335.4
1997	589.8	145.6	128.4	486.8	1,350.6	23.0	1,754.0	52.0	385.0
1998	713.7	155.8	135.1	562.9	1,567.5	21.0	1,984.2	52.0	435.6
1999	857.0	166.0	141.8	650.6	1,815.3	21.0	2,297.9	53.0	494.9
2000	1,022.1	176.3	148.4	750.9	2,097.7	20.0	2,622.1	53.0	564.8
2001	1,155.3	186.1	154.6	827.6	2,323.5	20.0	2,904.4	55.0	602.8
2002	1,303.8	196.2	160.7	911.4	2,572.0	20.0	3,215.0	55.0	667.3
2003	1,469.7	206.6	166.6	1,002.6	2,845.6	19.0	3,513.1	56.0	716.1
2004	1,655.5	217.6	172.5	1,101.3	3,146.9	19.0	3,885.0	56.0	792.0
2005	1,863.8	229.0	178.3	1,207.6	3,478.6	19.0	4,294.6	57.0	860.1
2006	2,160.8	241.2	184.0	1,332.8	3,918.9	19.0	4,838.1	57.0	968.9
2007	2,447.2	254.0	189.7	1,463.3	4,354.3	19.0	5,375.6	57.0	1,076.6
2008	2,728.4	267.4	195.4	1,599.3	4,790.5	17.0	5,771.7	58.0	1,136.0
2009	3,008.5	281.5	200.9	1,741.0	5,231.9	16.0	6,228.5	58.0	1,225.9
2010	3,289.9	296.4	206.4	1,888.8	5,681.5	15.0	6,684.1	58.0	1,315.6
AGR(%)	17.10	8.49	5.88	12.36	13.73		12.91		12.06

Table A3-1 Power Demand Forecast - Central Region (continue)

High Case	1993-1995	1996-2000	2001-2005	2006-2010		
GDP Growth Rate (%)	5.81	7.67	8.01	8.91		
Industry	8.04	8.39	10.00	11.00		
Agriculture	3.42	5.18	4.00	4.05		
Others	8.00	10.00	10.50	11.00		
Population Growth Rate (%)	2.80	2.50	1.80	1.80	Pop. 1993	11.0
Urban	4.60	3.80	3.00	3.00	(million)	2.7
Rural	2.20	2.00	1.30	1.30		8.3 (Ratio 75.8%)

Year	Regional Demand (GWh)				Total	Losses	Generation	Load Factor	Peak Load
	Industry	Agriculture	Others	Residential	(GWh)	(%)	(GWh)	(%)	(MW)
1993	224.8	74.2	78.1	260.5	637.6	24.8	848.1	51.0	189.8
1994	310.0	101.9	113.4	315.7	840.9	25.0	1,121.2	51.0	251.0
1995	405.8	122.5	119.9	378.7	1,026.9	24.0	1,351.2	51.0	302.4
1996	506.3	134.7	127.3	442.3	1,210.5	24.0	1,592.8	52.0	349.7
1997	625.6	145.6	134.7	516.7	1,422.7	23.0	1,847.6	52.0	405.6
1998	766.7	155.8	142.2	603.2	1,668.0	21.0	2,111.4	52.0	463.5
1999	932.8	166.0	149.8	702.8	1,951.4	21.0	2,470.1	53.0	532.0
2000	1,127.3	176.3	157.4	816.9	2,278.0	20.0	2,847.4	53.0	613.3
2001	1,289.4	186.1	164.9	906.1	2,546.5	20.0	3,183.1	55.0	660.7
2002	1,472.4	196.2	172.3	1,005.4	2,846.2	20.0	3,557.8	55.0	738.4
2003	1,679.4	206.6	179.5	1,115.3	3,180.8	19.0	3,926.9	56.0	800.5
2004	1,913.9	217.6	186.7	1,236.1	3,554.3	19.0	4,388.0	56.0	894.5
2005	2,180.0	229.0	193.8	1,368.2	3,971.0	19.0	4,902.5	57.0	981.8
2006	2,552.9	241.2	200.6	1,518.5	4,513.1	19.0	5,571.8	57.0	1,115.9
2007	2,922.1	254.0	207.3	1,676.7	5,060.0	19.0	6,246.9	57.0	1,251.1
2008	3,293.8	267.4	214.0	1,843.0	5,618.2	17.0	6,768.9	58.0	1,332.3
2009	3,672.9	281.5	220.6	2,018.0	6,193.0	16.0	7,372.6	58.0	1,451.1
2010	4,062.6	296.4	227.1	2,202.0	6,788.2	15.0	7,986.1	58.0	1,571.8
AGR(%)	18.56	8.49	6.48	13.38	14.93		14.10		13.24

Table A4-1 Power Demand Forecast - Southern Region

Low Case

	1993-1995	1996-2000	2001-2005	2006-2010		
GDP Growth Rate (%)	8.54	8.54	7.68	6.59		
Industry	11.75	12.00	10.00	8.00		
Agriculture	5.27	4.50	4.00	3.20		
Others	9.30	9.00	8.00	7.00		
Population Growth Rate (%)	2.30	2.00	1.50	1.50	Pop. 1993	27.0
Urban	3.50	2.90	2.40	2.40	(million)	7.6
Rural	1.80	1.60	1.00	1.00		19.4 (Ratio 72.0%)

Year	Regional Demand (GWh)				Total	Losses	Generation	Load Factor	Peak Load
	Industry	Agriculture	Others	Residential	(GWh)	(%)	(GWh)	(%)	(MW)
1993	1,739.9	95.6	391.6	1,263.4	3,490.5	22.6	4,506.8	63.0	816.6
1994	2,012.7	117.8	569.9	1,389.7	4,090.1	23.0	5,311.8	63.0	962.5
1995	2,322.4	135.1	605.2	1,541.2	4,603.8	23.0	5,979.0	62.0	1,100.9
1996	2,660.5	146.1	639.4	1,700.4	5,146.3	23.0	6,683.5	62.0	1,230.6
1997	3,053.1	155.6	673.6	1,885.3	5,767.5	22.0	7,394.3	62.0	1,361.4
1998	3,507.7	164.3	707.9	2,097.5	6,477.3	22.0	8,304.2	61.0	1,554.1
1999	4,033.1	172.7	742.1	2,338.8	7,286.7	21.0	9,223.7	60.0	1,754.9
2000	4,639.5	181.2	776.4	2,611.3	8,208.4	20.0	10,260.5	60.0	1,952.1
2001	5,258.9	189.1	807.0	2,895.0	9,150.0	20.0	11,437.5	60.0	2,176.1
2002	5,948.0	197.1	837.5	3,204.6	10,187.2	20.0	12,734.0	60.0	2,422.8
2003	6,717.6	205.4	867.9	3,541.6	11,332.5	20.0	14,165.6	60.0	2,695.1
2004	7,579.4	213.8	898.4	3,907.6	12,599.2	19.0	15,554.6	60.0	2,959.4
2005	8,546.3	222.6	928.8	4,304.1	14,001.8	19.0	17,286.2	60.0	3,288.8
2006	9,453.8	230.3	955.4	4,697.4	15,337.0	19.0	18,934.5	60.0	3,602.5
2007	10,440.6	238.1	982.0	5,114.1	16,774.9	18.0	20,457.2	60.0	3,892.2
2008	11,518.0	246.0	1,008.6	5,555.7	18,328.3	18.0	22,351.6	60.0	4,252.6
2009	12,697.5	254.1	1,035.1	6,023.5	20,010.3	17.0	24,108.7	60.0	4,586.9
2010	13,991.0	262.5	1,061.6	6,519.2	21,834.3	17.0	26,306.4	60.0	5,005.0
AGR(%)	13.05	6.12	6.04	10.13	11.39		10.94		11.25

Base Case

	1993-1995	1996-2000	2001-2005	2006-2010		
GDP Growth Rate (%)	9.54	10.10	9.01	7.79		
Industry	13.36	13.50	11.00	9.00		
Agriculture	5.51	5.00	5.00	5.00		
Others	10.50	11.00	9.50	8.00		
Population Growth Rate (%)	2.30	2.00	1.50	1.50	Pop. 1993	27.0
Urban	3.50	2.90	2.40	2.40	(million)	7.6
Rural	1.80	1.60	1.00	1.00		19.4 (Ratio 72.0%)

Year	Regional Demand (GWh)				Total	Losses	Generation	Load Factor	Peak Load
	Industry	Agriculture	Others	Residential	(GWh)	(%)	(GWh)	(%)	(MW)
1993	1,739.9	95.6	391.6	1,263.4	3,490.5	22.6	4,506.8	63.0	816.6
1994	2,061.4	118.5	584.3	1,408.8	4,173.0	23.0	5,419.5	63.0	982.0
1995	2,431.3	136.4	623.3	1,579.8	4,770.8	23.0	6,195.8	62.0	1,140.8
1996	2,842.2	147.8	664.3	1,767.3	5,421.6	23.0	7,041.1	62.0	1,296.4
1997	3,324.2	158.0	705.3	1,987.3	6,174.8	22.0	7,916.4	62.0	1,457.6
1998	3,889.3	167.5	746.4	2,242.3	7,045.4	22.0	9,032.6	61.0	1,690.4
1999	4,551.3	176.9	787.6	2,535.0	8,050.8	21.0	10,190.9	60.0	1,938.9
2000	5,326.7	186.4	828.9	2,868.9	9,210.9	20.0	11,513.6	60.0	2,190.6
2001	6,120.6	196.3	864.8	3,220.0	10,401.8	20.0	13,002.3	60.0	2,473.8
2002	7,012.0	206.6	900.7	3,605.6	11,724.8	20.0	14,656.1	60.0	2,788.4
2003	8,017.2	217.3	936.5	4,027.6	13,198.6	20.0	16,498.3	60.0	3,138.9
2004	9,154.6	228.5	972.4	4,488.1	14,843.5	19.0	18,325.3	60.0	3,486.6
2005	10,444.2	240.2	1,008.2	4,989.3	16,681.9	19.0	20,595.0	60.0	3,918.4
2006	11,691.3	252.5	1,038.5	5,494.7	18,477.0	19.0	22,811.1	60.0	4,340.0
2007	13,064.4	265.4	1,068.7	6,032.6	20,431.1	18.0	24,915.9	60.0	4,740.5
2008	14,581.7	278.9	1,098.9	6,604.6	22,564.2	18.0	27,517.3	60.0	5,235.4
2009	16,262.6	293.2	1,129.1	7,212.7	24,897.6	17.0	29,997.1	60.0	5,707.2
2010	18,127.9	308.2	1,159.2	7,858.9	27,454.2	17.0	33,077.3	60.0	6,293.3
AGR(%)	14.78	7.13	6.59	11.35	12.90		12.44		12.76

Table A4-1 Power Demand Forecast - Southern Region (continue)

High Case		1993-1995	1996-2000	2001-2005	2006-2010		
GDP Growth Rate (%)		10.43	10.68	10.15	8.71		
	Industry	14.16	14.50	12.00	10.00		
	Agriculture	5.51	5.00	5.00	5.00		
	Others	12.00	11.50	11.00	9.00		
Population Growth Rate (%)		2.30	2.00	1.50	1.50	Pop. 1993	27.0
	Urban	3.50	2.90	2.40	2.40	(million)	7.6
	Rural	1.80	1.60	1.00	1.00		19.4 (Ratio 72.0%)

Year	Regional Industry	Agriculture	Others	Residential	Total (GWh)	Losses (%)	Generation (GWh)	Load Factor (%)	Peak Load (MW)
1993	1,739.9	95.6	391.6	1,263.4	3,490.5	22.6	4,506.8	63.0	816.6
1994	2,086.0	118.5	605.3	1,423.2	4,232.9	23.0	5,497.3	63.0	996.1
1995	2,486.9	136.4	649.8	1,611.0	4,884.1	23.0	6,343.0	62.0	1,167.9
1996	2,935.5	147.8	692.7	1,812.6	5,588.6	23.0	7,257.9	62.0	1,336.3
1997	3,468.1	158.0	735.6	2,049.0	6,410.7	22.0	8,218.8	62.0	1,513.3
1998	4,099.9	167.5	778.5	2,323.2	7,369.0	22.0	9,447.5	61.0	1,768.0
1999	4,848.7	176.9	821.3	2,638.4	8,485.2	21.0	10,740.8	60.0	2,043.5
2000	5,735.7	186.4	864.2	2,998.1	9,784.4	20.0	12,230.5	60.0	2,327.0
2001	6,665.0	196.3	905.2	3,390.3	11,156.9	20.0	13,946.1	60.0	2,653.4
2002	7,721.7	206.6	946.3	3,824.2	12,698.9	20.0	15,873.6	60.0	3,020.1
2003	8,928.2	217.3	987.4	4,302.5	14,435.4	20.0	18,044.3	60.0	3,433.1
2004	10,309.6	228.5	1,028.6	4,827.9	16,394.5	19.0	20,240.1	60.0	3,850.9
2005	11,894.2	240.2	1,069.7	5,403.2	18,607.3	19.0	22,972.0	60.0	4,370.6
2006	13,467.5	252.5	1,103.5	5,985.0	20,808.6	19.0	25,689.6	60.0	4,887.7
2007	15,222.0	265.4	1,137.4	6,606.4	23,231.1	18.0	28,330.6	60.0	5,390.1
2008	17,184.8	278.9	1,171.2	7,269.3	25,904.2	18.0	31,590.5	60.0	6,010.4
2009	19,385.6	293.2	1,204.9	7,976.3	28,860.0	17.0	34,771.1	60.0	6,615.5
2010	21,857.0	308.2	1,238.6	8,729.6	32,133.4	17.0	38,714.9	60.0	7,365.8
AGR(%)	16.05	7.13	7.01	12.04	13.95		13.49		13.81

Table A5-1 Power Demand by Province (Low Case)

	1993		1995		2000		2005		2010		AGR
	GWh	Share(%)	GWh	Share(%)	GWh	Share(%)	GWh	Share(%)	GWh	Share(%)	93-10(%)
Northern Region	3,878.7	100.0	4,483.9	100.0	6,938.8	100.0	11,743.6	100.0	19,776.0	100.0	10.06
1. Tuyen Quang	28.3	0.73	32.5	0.72	41.3	0.59	65.2	0.56	105.2	0.53	8.03
2. Ha Giang	5.0	0.13	6.6	0.15	13.8	0.20	28.7	0.24	53.7	0.27	14.93
3. Cao Bang	11.2	0.29	14.5	0.32	21.4	0.31	39.1	0.33	68.7	0.35	11.23
4. Lang Son	31.0	0.80	37.4	0.83	59.2	0.85	110.4	0.94	195.8	0.99	11.45
5. Lai Chau	6.6	0.17	7.4	0.16	20.3	0.29	37.9	0.32	67.2	0.34	14.64
6. Yen Bai	26.0	0.67	32.4	0.72	45.9	0.66	76.3	0.65	127.0	0.64	9.78
7. Lao Kay	10.5	0.27	20.9	0.47	61.7	0.89	117.2	1.00	209.9	1.06	19.29
8. Bac Thai	283.5	7.31	313.7	7.00	463.9	6.68	691.9	5.89	1,073.1	5.43	8.14
9. Son La	8.5	0.22	8.5	0.19	22.6	0.33	49.7	0.42	95.1	0.48	15.23
10. Ha Tay	197.0	5.08	227.2	5.07	322.4	4.65	494.3	4.21	781.8	3.95	8.44
11. Hoa Binh	52.4	1.35	65.4	1.46	101.7	1.47	151.0	1.29	233.5	1.18	9.19
12. Quang Ninh	180.4	4.65	214.2	4.78	316.9	4.57	541.8	4.61	917.8	4.64	10.04
13. Vinh Phu	288.6	7.44	323.5	7.21	405.9	5.85	560.7	4.77	819.5	4.14	6.33
14. Ha Bac	223.0	5.75	240.9	5.37	347.3	5.01	534.7	4.55	847.9	4.29	8.17
15. Hanoi	1,044.1	26.92	1,207.1	26.92	1,824.1	26.29	3,029.4	25.80	5,044.2	25.51	9.71
16. Hai Phong	419.3	10.81	492.7	10.99	939.2	13.54	1,950.1	16.61	3,640.0	18.41	13.56
17. Hai Hung	256.4	6.61	295.4	6.59	410.9	5.92	730.9	6.22	1,265.9	6.40	9.85
18. Thai Binh	90.4	2.33	113.8	2.54	194.6	2.81	316.5	2.70	520.2	2.63	10.84
19. Nam Ha	222.6	5.74	268.1	5.98	417.5	6.02	662.5	5.64	1,072.1	5.42	9.69
20. Ninh Binh	64.0	1.65	73.1	1.63	119.9	1.73	226.0	1.92	403.5	2.04	11.44
21. Thanh Hoa	283.1	7.30	310.7	6.93	462.5	6.67	741.4	6.31	1,207.6	6.11	8.91
22. Ha Tinh	29.9	0.77	33.1	0.74	81.2	1.17	188.5	1.61	367.9	1.86	15.92
23. Nghe An	116.7	3.01	144.6	3.23	244.7	3.53	399.5	3.40	658.2	3.33	10.71
Central Region	637.6	100.00	938.1	100.00	1,755.4	100.00	2,707.3	100.00	4,115.8	100.00	11.59
24. Quang Binh	27.9	4.37	47.8	5.09	77.0	4.39	120.3	4.44	184.2	4.48	11.75
25. Quang Tri	20.3	3.18	30.2	3.22	55.8	3.18	92.3	3.41	146.3	3.55	12.33
26. Thua Thien Hue	63.8	10.00	107.1	11.42	208.2	11.86	315.3	11.65	473.8	11.51	12.52
27. Quang Nam Da Nang	179.4	28.13	257.2	27.42	491.2	27.98	780.3	28.82	1,208.1	29.35	11.87
28. Quang Ngai	37.2	5.83	52.7	5.62	113.1	6.44	179.3	6.62	277.2	6.74	12.55
29. Binh Dinh	71.1	11.15	102.2	10.90	200.0	11.39	310.8	11.48	474.7	11.53	11.82
30. Phu Yen	21.9	3.43	31.8	3.39	75.7	4.31	118.9	4.39	182.9	4.44	13.31
31. Khanh Hoa	143.9	22.57	208.7	22.24	355.8	20.27	505.8	18.68	727.7	17.68	10.00
32. Gia Lai	23.9	3.75	33.3	3.54	56.1	3.20	107.4	3.97	183.4	4.46	12.73
33. Kon Tum	8.0	1.25	17.3	1.85	31.0	1.77	41.2	1.52	56.1	1.36	12.17
34. Dac Lak	40.4	6.34	49.8	5.30	91.4	5.21	135.8	5.01	201.3	4.89	9.90
Southern Region	3,490.5	99.98	4,603.8	99.98	8,208.4	99.99	14,001.8	100.00	21,834.3	100.00	11.39
35. Binh Thuan	25.1	0.72	29.8	0.65	65.4	0.80	140.4	1.00	242.0	1.11	14.25
36. Ninh Thuan	27.6	0.79	41.2	0.90	71.2	0.87	118.9	0.85	183.4	0.84	11.79
37. Lam Dong	46.1	1.32	60.1	1.31	130.4	1.59	289.1	2.06	503.7	2.31	15.11
38. Ho Chi Minh	1,988.9	56.98	2,515.0	54.63	4,126.0	50.27	6,538.2	46.70	9,799.5	44.88	9.83
39. Song Be	62.8	1.80	90.1	1.96	147.0	1.79	268.2	1.92	432.1	1.98	12.01
40. Tay Ninh	40.1	1.15	65.1	1.41	134.6	1.64	251.9	1.80	410.5	1.88	14.66
41. Dong Nai	436.0	12.49	613.8	13.33	1,227.5	14.95	2,156.6	15.40	3,412.6	15.63	12.87
42. Vung Tau	119.0	3.41	158.3	3.44	433.5	5.28	909.9	6.50	1,554.0	7.12	16.32
43. Long An	67.0	1.92	93.5	2.03	133.1	1.62	230.8	1.65	362.8	1.66	10.44
44. Dong Thap	60.4	1.73	92.1	2.00	162.0	1.97	289.7	2.07	462.4	2.12	12.72
45. An Giang	88.0	2.52	104.0	2.26	169.1	2.06	299.8	2.14	476.6	2.18	10.45
46. Tien Giang	83.8	2.40	120.3	2.61	210.0	2.56	332.2	2.37	497.3	2.28	11.05
47. Ben Tre	31.1	0.89	50.0	1.09	100.9	1.23	178.2	1.27	282.7	1.29	13.87
48. Vinh Long	35.3	1.01	62.5	1.36	103.4	1.26	171.6	1.23	263.9	1.21	12.57
49. Tra Vinh	18.5	0.53	44.4	0.97	83.3	1.01	149.2	1.07	238.4	1.09	16.23
50. Can tho	125.7	3.60	153.7	3.34	332.0	4.04	639.7	4.57	1,055.8	4.84	13.34
51. Soc trang	31.1	0.89	48.4	1.05	124.5	1.52	224.0	1.60	358.6	1.64	15.47
52. kien Giang	155.0	4.44	191.9	4.17	343.6	4.19	584.8	4.18	910.9	4.17	10.98
53. Minh Hai	48.5	1.39	68.8	1.49	110.3	1.34	227.8	1.63	386.5	1.77	12.98

Table A5-1 Power Demand by Province (Base Case)

	1993		1995		2000		2005		2010		AGR
	GWh	Share(%)	GWh	Share(%)	GWh	Share(%)	GWh	Share(%)	GWh	Share(%)	93-10(%)
Northern Region	3,878.7	100.0	4,582.6	100.0	7,322.2	100.0	12,980.2	100.0	22,812.6	100.0	10.98
1. Tuyen Quang	28.3	0.73	33.2	0.72	43.0	0.59	71.2	0.55	120.1	0.53	8.87
2. Ha Giang	5.0	0.13	6.9	0.15	14.8	0.20	32.4	0.25	63.0	0.28	16.02
3. Cao Bang	11.2	0.29	15.0	0.33	22.7	0.31	43.6	0.34	79.8	0.35	12.22
4. Lang Son	31.0	0.80	38.5	0.84	62.8	0.86	123.0	0.95	227.7	1.00	12.44
5. Lai Chau	6.6	0.17	7.5	0.16	21.9	0.30	42.6	0.33	78.6	0.34	15.69
6. Yen Bai	26.0	0.67	33.4	0.73	48.5	0.66	84.3	0.65	146.4	0.64	10.70
7. Lao Kay	10.5	0.27	22.6	0.49	68.1	0.93	133.4	1.03	247.0	1.08	20.43
8. Bac Thai	283.5	7.31	318.7	6.95	486.2	6.64	754.7	5.81	1,221.4	5.35	8.97
9. Son La	8.5	0.22	8.5	0.19	24.2	0.33	56.1	0.43	111.7	0.49	16.33
10. Ha Tay	197.0	5.08	232.2	5.07	338.3	4.62	540.8	4.17	892.7	3.91	9.29
11. Hoa Binh	52.4	1.35	67.5	1.47	108.0	1.48	166.1	1.28	267.1	1.17	10.06
12. Quang Ninh	180.4	4.65	219.7	4.79	334.3	4.57	599.1	4.62	1,059.4	4.64	10.98
13. Vinh Phu	288.6	7.44	329.2	7.18	421.2	5.75	603.5	4.65	920.2	4.03	7.06
14. Ha Bac	223.0	5.75	243.8	5.32	362.6	4.95	583.2	4.49	966.7	4.24	9.01
15. Hanoi	1,044.1	26.92	1,233.7	26.92	1,922.2	26.25	3,341.5	25.74	5,807.9	25.46	10.62
16. Hai Phong	419.3	10.81	504.7	11.01	1,003.0	13.70	2,193.3	16.90	4,261.9	18.68	14.61
17. Hai Hung	256.4	6.61	301.8	6.59	430.7	5.88	807.5	6.22	1,462.4	6.41	10.78
18. Thai Binh	90.4	2.33	117.6	2.57	207.8	2.84	351.3	2.71	600.7	2.63	11.79
19. Nam Ha	222.6	5.74	275.5	6.01	442.3	6.04	730.8	5.63	1,232.2	5.40	10.59
20. Ninh Binh	64.0	1.65	74.6	1.63	126.8	1.73	251.8	1.94	469.0	2.06	12.43
21. Thanh Hoa	283.1	7.30	315.2	6.88	484.6	6.62	813.0	6.26	1,383.7	6.07	9.78
22. Ha Tinh	29.9	0.77	33.7	0.73	87.3	1.19	213.7	1.65	433.2	1.90	17.04
23. Nghe An	116.7	3.01	149.2	3.25	260.8	3.56	443.1	3.41	759.8	3.33	11.65
Central Region	637.6	100.00	995.2	100.00	2,097.7	100.00	3,478.6	100.00	5,681.5	100.00	13.73
24. Quang Binh	27.9	4.37	51.6	5.18	91.0	4.34	153.7	4.42	253.8	4.47	13.88
25. Quang Tri	20.3	3.18	32.1	3.23	66.7	3.18	119.6	3.44	204.0	3.59	14.55
26. Thua Thien Hue	63.8	10.00	115.3	11.59	251.7	12.00	407.1	11.70	655.0	11.53	14.69
27. Quang Nam Da Nang	179.4	28.13	272.0	27.33	587.6	28.01	1,007.0	28.95	1,676.1	29.50	14.05
28. Quang Ngai	37.2	5.83	55.7	5.60	137.1	6.53	233.1	6.70	386.3	6.80	14.76
29. Binh Dinh	71.1	11.15	108.1	10.87	240.1	11.44	400.8	11.52	657.1	11.57	13.98
30. Phu Yen	21.9	3.43	33.7	3.39	92.9	4.43	155.6	4.47	255.7	4.50	15.56
31. Khanh Hoa	143.9	22.57	221.0	22.20	419.5	20.00	637.0	18.31	984.1	17.32	11.97
32. Gia Lai	23.9	3.75	35.0	3.52	65.8	3.14	140.3	4.03	259.1	4.56	15.05
33. Kon Tum	8.0	1.25	19.1	1.92	37.6	1.79	52.3	1.50	75.7	1.33	14.16
34. Dac Lak	40.4	6.34	51.5	5.18	107.8	5.14	172.0	4.95	274.6	4.83	11.93
Southern Region	3,490.5	100.00	4,770.8	100.00	9,210.9	100.00	16,681.9	100.00	27,454.2	100.00	12.90
35. Binh Thuan	25.2	0.72	30.5	0.64	74.3	0.81	171.1	1.03	310.8	1.13	15.94
36. Ninh Thuan	27.7	0.79	43.4	0.91	80.4	0.87	141.8	0.85	230.5	0.84	13.28
37. Lam Dong	46.1	1.32	62.3	1.30	148.8	1.62	353.5	2.12	648.7	2.36	16.83
38. Ho Chi Minh	1,988.8	56.98	2,593.8	54.37	4,578.2	49.70	7,689.0	46.09	12,174.3	44.34	11.25
39. Song Be	62.9	1.80	94.2	1.98	164.3	1.78	320.7	1.92	546.1	1.99	13.56
40. Tay Ninh	40.2	1.15	69.0	1.45	154.6	1.68	305.9	1.83	524.0	1.91	16.30
41. Dong Nai	436.0	12.49	640.5	13.42	1,396.5	15.16	2,594.6	15.55	4,322.0	15.74	14.45
42. Vung Tau	119.1	3.41	164.3	3.44	503.2	5.46	1,117.6	6.70	2,003.4	7.30	18.06
43. Long An	67.1	1.92	97.5	2.04	146.4	1.59	272.3	1.63	453.8	1.65	11.90
44. Dong Thap	60.4	1.73	96.8	2.03	182.9	1.99	347.6	2.08	585.1	2.13	14.29
45. An Giang	88.0	2.52	106.5	2.23	186.7	2.03	355.2	2.13	598.3	2.18	11.93
46. Tien Giang	83.8	2.40	125.8	2.64	236.3	2.57	393.9	2.36	621.0	2.26	12.50
47. Ben Tre	31.0	0.89	52.9	1.11	115.5	1.25	215.2	1.29	358.9	1.31	15.49
48. Vinh Long	35.2	1.01	66.6	1.40	116.9	1.27	204.9	1.23	331.8	1.21	14.11
49. Tra Vinh	18.4	0.53	48.3	1.01	96.1	1.04	181.2	1.09	303.8	1.11	17.91
50. Can tho	125.8	3.60	158.1	3.31	377.6	4.10	774.4	4.64	1,346.7	4.91	14.97
51. Soc trang	31.0	0.89	51.0	1.07	144.7	1.57	273.1	1.64	458.1	1.67	17.16
52. kien Giang	155.1	4.44	197.5	4.14	384.4	4.17	695.5	4.17	1,144.0	4.17	12.47
53. Minh Hai	48.6	1.39	71.9	1.51	123.1	1.34	274.5	1.65	492.9	1.80	14.60

Table A5-1 Power Demand by Province (High Case)

	1993		1995		2000		2005		2010		AGR
	GWh	Share(%)	GWh	Share(%)	GWh	Share(%)	GWh	Share(%)	GWh	Share(%)	93-10(%)
Northern Region	3,878.7	100.0	4,636.6	100.0	7,715.6	100.0	14,244.2	100.0	26,208.6	100.0	11.89
1. Tuyen Quang	28.3	0.73	33.5	0.72	44.6	0.58	77.1	0.54	136.7	0.52	9.70
2. Ha Giang	5.0	0.13	7.0	0.15	16.0	0.21	36.3	0.25	73.5	0.28	17.07
3. Cao Bang	11.2	0.29	15.3	0.33	23.9	0.31	48.0	0.34	92.1	0.35	13.17
4. Lang Son	31.0	0.80	39.1	0.84	66.4	0.86	135.9	0.95	263.2	1.00	13.40
5. Lai Chau	6.6	0.17	7.6	0.16	23.8	0.31	47.7	0.33	91.4	0.35	16.73
6. Yen Bai	26.0	0.67	34.0	0.73	51.0	0.66	92.2	0.65	167.8	0.64	11.60
7. Lao Kay	10.5	0.27	23.5	0.51	74.7	0.97	150.1	1.05	288.2	1.10	21.53
8. Bac Thai	283.5	7.31	321.4	6.93	509.6	6.61	819.5	5.75	1,387.3	5.29	9.79
9. Son La	8.5	0.22	8.5	0.18	26.1	0.34	63.0	0.44	130.6	0.50	17.41
10. Ha Tay	197.0	5.08	234.9	5.07	354.2	4.59	587.8	4.13	1,016.0	3.88	10.13
11. Hoa Binh	52.4	1.35	68.7	1.48	114.2	1.48	181.2	1.27	304.1	1.16	10.90
12. Quang Ninh	180.4	4.65	222.7	4.80	351.5	4.56	657.1	4.61	1,217.1	4.64	11.89
13. Vinh Phu	288.6	7.44	332.3	7.17	435.7	5.65	646.0	4.54	1,031.4	3.94	7.78
14. Ha Bac	223.0	5.75	245.4	5.29	378.9	4.91	633.5	4.45	1,100.1	4.20	9.84
15. Hanoi	1,044.1	26.92	1,248.3	26.92	2,022.1	26.21	3,659.7	25.69	6,660.9	25.42	11.52
16. Hai Phong	419.3	10.81	511.2	11.03	1,071.2	13.88	2,444.8	17.16	4,961.9	18.93	15.64
17. Hai Hung	256.4	6.61	305.3	6.58	450.1	5.83	884.9	6.21	1,681.8	6.42	11.70
18. Thai Binh	90.4	2.33	119.7	2.58	221.1	2.87	386.7	2.71	690.2	2.63	12.70
19. Nam Ha	222.6	5.74	279.6	6.03	467.0	6.05	799.9	5.62	1,410.0	5.38	11.47
20. Ninh Binh	64.0	1.65	75.4	1.63	134.0	1.74	278.3	1.95	542.7	2.07	13.40
21. Thanh Hoa	283.1	7.30	317.7	6.85	508.1	6.58	887.0	6.23	1,581.4	6.03	10.65
22. Ha Tinh	29.9	0.77	33.9	0.73	94.3	1.22	240.1	1.69	507.2	1.94	18.13
23. Nghe An	116.7	3.01	151.6	3.27	277.2	3.59	487.5	3.42	872.8	3.33	12.56
Central Region	637.6	100.00	1,026.9	100.00	2,278.0	100.00	3,971.0	100.00	6,788.2	100.00	14.93
24. Quang Binh	27.9	4.37	53.7	5.23	98.4	4.32	175.3	4.42	303.3	4.47	15.08
25. Quang Tri	20.3	3.18	33.2	3.23	72.4	3.18	137.2	3.46	245.2	3.61	15.79
26. Thua Thien Hue	63.8	10.00	119.9	11.68	274.6	12.06	465.2	11.71	782.3	11.52	15.89
27. Quang Nam Da Nang	179.4	28.13	280.2	27.29	638.4	28.02	1,152.6	29.02	2,008.2	29.58	15.27
28. Quang Ngai	37.2	5.83	57.3	5.58	149.7	6.57	267.4	6.73	463.3	6.83	16.00
29. Binh Dinh	71.1	11.15	111.4	10.85	261.1	11.46	458.2	11.54	786.0	11.58	15.18
30. Phu Yen	21.9	3.43	34.8	3.39	101.9	4.47	178.8	4.50	306.8	4.52	16.81
31. Khanh Hoa	143.9	22.57	227.8	22.18	453.1	19.89	719.8	18.13	1,163.6	17.14	13.08
32. Gia Lai	23.9	3.75	36.0	3.51	71.0	3.12	162.3	4.09	314.2	4.63	16.36
33. Kon Tum	8.0	1.25	20.1	1.95	41.1	1.80	59.1	1.49	89.1	1.31	15.26
34. Dac Lak	40.4	6.34	52.5	5.11	116.3	5.11	195.1	4.91	326.3	4.81	13.07
Southern Region	3,490.5	100.00	4,884.1	100.00	9,784.4	100.00	18,607.3	100.00	32,133.4	100.00	13.95
35. Binh Thuan	25.2	0.72	31.0	0.63	79.3	0.81	193.7	1.04	369.0	1.15	17.11
36. Ninh Thuan	27.7	0.79	44.7	0.92	85.6	0.87	158.2	0.85	269.5	0.84	14.33
37. Lam Dong	46.1	1.32	63.7	1.30	159.2	1.63	401.0	2.15	771.6	2.40	18.02
38. Ho Chi Minh	1,988.8	56.98	2,647.3	54.20	4,837.4	49.44	8,511.1	45.74	14,143.0	44.01	12.23
39. Song Be	62.9	1.80	97.0	1.99	174.3	1.78	359.0	1.93	642.1	2.00	14.65
40. Tay Ninh	40.2	1.15	71.5	1.46	166.0	1.70	344.7	1.85	618.6	1.92	17.44
41. Dong Nai	436.0	12.49	658.6	13.48	1,493.0	15.26	2,907.8	15.63	5,076.8	15.80	15.53
42. Vung Tau	119.1	3.41	168.3	3.45	542.3	5.54	1,267.9	6.81	2,380.2	7.41	19.27
43. Long An	67.1	1.92	100.2	2.05	154.1	1.58	302.8	1.63	530.8	1.65	12.94
44. Dong Thap	60.4	1.73	100.0	2.05	195.0	1.99	389.6	2.09	687.8	2.14	15.39
45. An Giang	88.0	2.52	108.1	2.21	196.6	2.01	395.7	2.13	700.9	2.18	12.98
46. Tien Giang	83.8	2.40	129.5	2.65	251.5	2.57	437.6	2.35	722.8	2.25	13.51
47. Ben Tre	31.0	0.89	54.8	1.12	123.9	1.27	241.6	1.30	422.1	1.31	16.60
48. Vinh Long	35.2	1.01	69.4	1.42	124.9	1.28	228.8	1.23	388.2	1.21	15.16
49. Tra Vinh	18.4	0.53	50.9	1.04	103.7	1.06	204.2	1.10	358.1	1.11	19.06
50. Can tho	125.8	3.60	160.9	3.29	403.2	4.12	871.9	4.69	1,590.4	4.95	16.10
51. Soc trang	31.0	0.89	52.8	1.08	156.2	1.60	307.8	1.65	540.1	1.68	18.30
52. kien Giang	155.1	4.44	201.3	4.12	407.5	4.16	774.9	4.16	1,338.1	4.16	13.51
53. Minh Hai	48.6	1.39	74.0	1.51	130.5	1.33	309.3	1.66	583.5	1.82	15.74

Table 5.5-1 Main Electricity Indicators in Selected Asian Countries

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Indonesia																				
*E End-Use consumption (GWh)	5521	6543	7582	8350	9114	10171	11472	12811	13819	15249	16691	26564	27328	31090	31229	33010	37810	40260	44689	49604
Electricity Generated (GWh)	6135	7270	8424	9278	10127	11301	12747	14234	15354	16584	20012	29152	30564	34541	34810	37010	41810	44260	49129	54533
*P Population (Millions)	126.41	129.5	132.59	135.9	139.1	142.2	145.26	148.3	151.31	154.25	157.16	160.08	163.04	166.02	168.99	171.99	175.06	178.23	181.31	184.04
GDP (Billion 1987$US)	32.96	35.49	37.27	39.84	43.42	46.77	49.65	53.59	57.57	57.37	62.42	66.66	68.43	72.4	75.93	80.34	86.28	92.28	98.17	103.86
End-Use consumption / Pop. (kwh/capita)	43.7	50.5	57.2	61.4	65.5	71.5	79.0	86.4	91.3	98.9	106.2	165.9	167.6	187.3	184.8	191.9	216.0	225.9	246.5	269.5
Electricity Generated/ Pop. (kwh/capita)	48.5	56.1	63.5	68.3	72.8	79.5	87.8	96.0	101.5	107.5	127.3	182.1	187.5	208.1	206.0	215.2	238.8	248.3	271.0	296.3
*G GDP /Pop. (1987 $US/Capita)	260.7	274.1	281.1	293.2	312.1	328.9	341.8	361.4	380.5	371.9	397.2	416.4	419.7	436.1	449.3	467.1	492.9	517.8	541.4	564.3
*I End-Use consumption / GDP (wh/$US)	167.5	184.4	203.4	209.6	209.9	217.5	231.1	239.1	240.0	265.8	267.4	398.5	399.4	429.4	411.3	410.9	438.2	436.3	455.2	477.6
Malaysia																				
*E End-Use consumption (GWh)	4347	4752	5229	5819	6790	7437	8468	9252	9903	10687	11461	12551	13103	14056	15096	16643	18378	21465	23508	27145
Electricity Generated (GWh)	4783	5308	5788	6446	7520	8241	9159	10030	10772	11759	12733	13721	14554	15682	16986	18735	20799	23728	27255	29950
*P Population (Millions)	11.69	11.97	12.26	12.55	12.84	13.14	13.44	13.76	14.13	14.51	14.89	15.27	15.68	16.11	16.53	16.94	17.35	17.76	18.18	18.61
GDP (Billion 1987$US)	13.98	15.13	15.25	17.04	18.36	19.6	21.46	23.06	24.64	26.11	27.78	29.97	29.61	29.98	31.6	34.47	37.68	41.39	45.02	48.89
End-Use consumption / Pop. (kwh/capita)	371.9	397.0	426.5	463.7	528.8	566.0	630.1	672.4	700.8	736.5	769.7	821.9	835.7	872.5	913.2	982.5	1,059.3	1,208.6	1,293.1	1,458.6
Electricity Generated/ Pop. (kwh/capita)	409.2	443.4	472.1	513.6	585.7	627.2	681.5	728.9	762.3	810.4	855.1	898.6	928.2	973.4	1,027.6	1,106.0	1,198.8	1,336.0	1,499.2	1,609.3
*G GDP /Pop. (1987 $US/Capita)	1195.9	1264.0	1243.9	1357.8	1429.9	1491.6	1596.7	1675.9	1743.8	1799.4	1865.7	1962.7	1888.4	1861.0	1911.7	2034.8	2171.8	2330.5	2476.3	2627.1
*I End-Use consumption / GDP (wh/$US)	310.9	314.1	342.9	341.5	369.8	379.4	394.6	401.2	401.9	409.3	412.6	418.8	442.5	468.8	477.7	482.8	487.7	518.6	522.2	555.2
Philippiens																				
*E End-Use consumption (GWh)	12562	12422	12986	13979	14326	14740	15927	17703	16238	17434	18638	17220	18030	16814	17909	19789	21142	22378	23464	23245
Electricity Generated (GWh)	13186	13047	13670	14716	15080	15542	16677	18009	18446	19910	21442	20353	21776	20802	22644	24196	25537	27492	26646	26564
*P Population (Millions)	40.9	42.01	43.1	44.14	45.15	46.16	47.21	48.32	49.54	50.8	52.06	53.35	54.7	56	57.36	58.72	60.1	61.48	62.87	64.08
GDP (Billion 1987$US)	22.45	23.21	24.48	26.63	28.1	29.55	31.19	32.8	33.91	35.13	35.77	33.14	30.73	31.79	33.31	35.41	37.54	38.51	38.19	38.2
End-Use consumption / Pop. (kwh/capita)	307.1	295.7	301.3	316.7	317.3	319.3	337.4	366.4	327.8	343.2	358.0	322.8	329.6	300.3	312.2	337.0	351.8	364.0	373.2	362.7
Electricity Generated/ Pop. (kwh/capita)	322.4	310.6	317.2	333.4	334.0	336.7	353.3	372.7	372.3	391.9	411.9	381.5	398.1	371.5	394.8	412.1	424.9	447.2	423.8	414.5
*G GDP /Pop. (1987 $US/Capita)	548.9	552.5	568.0	603.3	622.4	640.2	660.7	678.8	684.5	691.5	687.1	621.2	561.8	567.7	580.7	603.0	624.6	626.4	607.4	596.1
*I End-Use consumption / GDP (wh/$US)	559.6	535.2	530.5	524.9	509.8	498.8	510.6	539.7	478.9	496.3	521.1	519.6	586.7	528.9	537.6	558.9	563.2	581.1	614.4	608.5
Thailand																				
*E End-Use consumption (GWh)	6485	6839	7782	8969	10414	11857	12903	13759	14358	15671	17458	19456	21117	23047	26085	29560	34298	40130	45334	51647
Electricity Generated (GWh)	6971	7395	8440	9826	11175	12637	13443	14426	15369	16620	18857	21024	23074	24717	28652	32464	37406	44176	50186	57098
*P Population (Millions)	39.14	40.26	41.36	42.45	43.53	44.6	45.66	46.7	47.73	48.74	49.74	50.72	51.68	52.65	53.61	54.54	55.45	56.3	57.15	57.96
GDP (Billion 1987$US)	20.24	21.11	22.12	24.19	26.53	29.33	30.8	32.24	34.26	35.64	38.19	40.93	42.31	44.45	48.72	55.26	62.03	68.42	73.9	79.53
End-Use consumption / Pop. (kwh/capita)	165.7	169.9	188.2	211.3	239.2	265.9	282.6	294.6	300.8	321.5	351.0	383.6	408.6	437.7	486.6	542.0	618.5	712.8	793.2	891.1
Electricity Generated/ Pop. (kwh/capita)	178.1	183.7	204.1	231.5	256.7	283.3	294.4	308.9	322.0	341.0	379.1	414.5	446.5	469.5	534.5	595.2	674.6	784.7	878.1	985.1
*G GDP /Pop. (1987 $US/Capita)	517.1	524.3	534.8	569.8	609.5	657.6	674.6	690.4	717.8	731.2	767.8	807.0	818.7	844.3	908.8	1013.2	1118.7	1215.3	1293.1	1372.2
*I End-Use consumption / GDP (wh/$US)	320.4	324.0	351.8	370.8	392.5	404.3	418.9	426.8	419.1	439.7	457.1	475.3	499.1	518.5	535.4	534.9	552.9	586.5	613.5	649.4
Bangladesh																				
*E End-Use consumption (GWh)	1042	1178	1211	1261	1367	1651	1661	1521	1861	2174	2537	2866	3365	3859	4091	4500	5092	5135	5224	6021
Electricity Generated (GWh)	1404	1549	1627	1769	1934	2219	2402	2353	2661	3036	3433	3966	4870	5125	5570	6546	7114	7732	8270	8894

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
*P Population (Millions)	72.43	74.47	76.58	78.67	80.73	82.76	84.75	86.7	88.69	90.73	92.8	94.93	97.1	99.29	101.51	103.74	106	108.28	110.56	112.75
GDP (Billion 1987$US)	9.19	10.42	10.29	10.75	10.86	11.65	12.35	12.52	13.71	14.22	14.88	15.59	16.2	16.91	17.6	18.1	18.55	19.78	20.45	21.24
End-Use consumption / Pop. (kwh/capita)	14.4	15.8	15.8	16.0	16.9	19.9	19.6	17.5	21.0	24.0	27.3	30.2	34.7	38.9	40.3	43.4	48.0	47.4	47.3	53.4
Electricity Generated/ Pop. (kwh/capita)	19.4	20.8	21.2	22.5	24.0	26.8	28.3	27.1	30.0	33.5	37.0	41.8	50.2	51.6	54.9	63.1	67.1	71.4	74.8	78.9
*G GDP /Pop. (1987 $US/Capita)	126.9	139.9	134.4	136.6	134.5	140.8	145.7	144.4	154.6	156.7	160.3	164.2	166.8	170.3	173.4	174.5	175.0	182.7	185.0	188.4
*I End-Use consumption / GDP (wh/$US)	113.4	113.1	117.7	117.3	125.9	141.7	134.5	121.5	135.7	152.9	170.5	183.8	207.7	228.2	232.4	248.6	274.5	259.6	255.5	283.5
Pakistan																				
*E End-Use consumption (GWh)	7686	8486	8908	8888	9592	11005	12954	13487	14782	16172	17757	19939	22864	24980	27226	31446	33335	35928	39160	42972
Electricity Generated (GWh)	9674	10585	11419	11780	12599	14467	16562	17842	18925	20570	22697	25428	27531	30171	33475	38618	40284	43878	47334	51972
*P Population (Millions)	66.71	68.85	71.03	73.25	75.49	77.78	80.14	82.58	85.11	87.74	90.45	93.27	96.18	99.2	102.32	105.56	108.9	112.35	116.84	119.22
GDP (Billion 1987$US)	14.68	15.18	15.81	16.64	17.3	18.7	19.38	21.4	23.1	24.6	26.26	27.61	29.7	31.33	33.35	35.95	37.68	39.3	41.47	44.7
End-Use consumption / Pop. (kwh/capita)	115.2	123.3	125.4	121.3	127.1	141.5	161.6	163.3	173.7	184.3	196.3	213.8	237.7	251.8	266.1	297.9	306.1	319.8	335.2	360.4
Electricity Generated/ Pop. (kwh/capita)	145.0	153.7	160.8	160.8	166.9	186.0	206.7	216.1	222.4	234.4	250.9	272.6	286.2	304.1	327.2	365.8	369.9	390.5	405.1	435.9
*G GDP /Pop. (1987 $US/Capita)	220.1	220.5	222.6	227.2	229.2	240.4	241.8	259.1	271.4	280.4	290.3	296.0	308.8	315.8	325.9	340.6	346.0	349.8	354.9	374.9
*I End-Use consumption / GDP (wh/$US)	523.6	559.0	563.4	534.1	554.5	588.5	668.4	630.2	639.9	657.4	676.2	722.2	769.8	797.3	816.4	874.7	884.7	914.2	944.3	961.3
South Korea																				
*E End-Use consumption (GWh)	13698	15947	17716	20818	24249	28993	33076	34891	37681	40447	45976	50621	54831	61186	69886	80924	89152	102050	112421	123898
Electricity Generated (GWh)	14825	16835	19837	23117	26587	31510	35600	37239	40207	43122	48850	53808	58007	64695	73992	85462	94472	107670	118619	130962
*P Population (Millions)	33.94	34.61	35.28	35.85	36.41	36.97	37.53	38.12	38.72	39.33	39.91	40.41	40.81	41.18	41.58	41.98	42.38	42.87	43.27	43.65
GDP (Billion 1987$US)	41.07	44.72	48.14	54.64	60.65	67.28	72.29	69.92	74.72	80.22	89.89	98.18	104.98	117.86	131.82	146.91	155.92	170.02	184.29	193.22
End-Use consumption / Pop. (kwh/capita)	403.6	460.8	502.2	580.7	666.0	784.2	881.3	915.3	973.2	1,028.4	1,152.0	1,252.7	1,343.6	1,485.8	1,680.8	1,927.7	2,103.6	2,380.5	2,598.1	2,838.4
Electricity Generated/ Pop. (kwh/capita)	436.8	486.4	562.3	644.8	730.2	852.3	948.6	976.9	1,038.4	1,096.4	1,224.0	1,331.6	1,421.4	1,571.0	1,779.5	2,035.8	2,229.2	2,511.5	2,741.4	3,000.3
*G GDP /Pop. (1987 $US/Capita)	1210.1	1292.1	1364.5	1524.1	1665.8	1819.9	1926.2	1834.2	1929.8	2039.7	2252.3	2429.6	2572.4	2862.1	3170.3	3499.5	3679.1	3965.9	4259.1	4426.6
*I End-Use consumption / GDP (wh/$US)	333.5	356.6	368.0	381.0	399.8	430.9	457.5	499.0	504.3	504.2	511.5	515.6	522.3	519.1	530.2	550.8	571.8	600.2	610.0	641.2
Taiwan																				
*E End-Use consumption (GWh)	18914	19869	22289	25883	28907	33346	37045	39822	39308	40778	45196	49019	52680	59393	65475	72372	76864	81914	89213	93561
Electricity Generated (GWh)	20735	21479	23914	27961	30968	35846	39547	42607	41928	43432	48294	52213	55554	62329	69176	76258	81676	86991	94458	98464
*P Population (Millions)	15.43	15.71	16	16.33	16.66	16.97	17.31	17.64	17.97	18.3	18.6	18.87	19.14	19.36	19.56	19.79	20.01	20.23	20.46	20.66
GDP (Billion 1987$US)	37.04	37.47	39.32	44.77	49.33	56.04	60.62	65.05	69.05	71.51	77.55	85.77	90.01	100.49	112.89	121.18	130.35	136.69	146.58	156.24
End-Use consumption / Pop. (kwh/capita)	1,225.8	1,264.7	1,393.1	1,585.0	1,735.1	1,965.0	2,140.1	2,257.5	2,187.4	2,228.3	2,429.9	2,597.7	2,752.4	3,067.8	3,347.4	3,657.0	3,841.3	4,049.1	4,360.4	4,528.6
Electricity Generated/ Pop. (kwh/capita)	1,343.8	1,367.2	1,494.6	1,712.2	1,858.8	2,112.3	2,284.6	2,415.4	2,333.2	2,373.3	2,596.5	2,767.0	2,902.5	3,219.5	3,536.6	3,853.4	4,081.8	4,300.1	4,616.7	4,765.9
*G GDP /Pop. (1987 $US/Capita)	2400.5	2385.1	2457.5	2741.6	2961.0	3302.3	3502.0	3687.6	3842.5	3907.7	4169.4	4545.3	4702.7	5190.6	5771.5	6123.3	6514.2	6756.8	7164.2	7562.4
*I End-Use consumption / GDP (wh/$US)	510.6	530.3	566.9	578.1	586.0	595.0	611.1	612.2	569.3	570.2	582.8	571.5	585.3	591.0	580.0	597.2	589.7	599.3	608.6	598.8

Source : IEA/OECD, Energy Statistics and Balances of Non-OECD Countries, 1989-1990,1990-1991, 1991-1992

South Korea	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
*E End-Use consumption (GWh)	1470	1696	2043	2464	3008	3903	4850	6358	7740	8884	9992
Electricity Generated (GWh)	1979	2236	2700	3250	3886	4913	6026	7700	9167	10540	11839
*P Population (Millions)	26.15	26.90	27.68	28.33	28.96	30.13	30.84	31.54	32.24	32.88	33.51

GDP (Billion 1987$US)	15.36	16.76	18.38	19.43	21.80	23.09	25.70	29.26	31.83	34.75	36.82
End-Use consumption / Pop. (kwh/capita)	56.2	63.0	73.8	87.0	103.9	129.5	157.3	201.6	240.1	270.2	298.2
Electricity Generated/ Pop. (kwh/capita)	75.7	83.1	97.5	114.7	134.2	163.1	195.4	244.1	284.3	320.5	353.4
*G GDP /Pop. (1987 $US/Capita)	587.2	623.0	664.0	686.0	752.8	766.3	833.5	927.7	987.2	1056.9	1099.0
*I End-Use consumption / GDP (wh/$US)	95.7	101.2	111.2	126.8	138.0	169.0	188.7	217.3	243.2	255.6	271.4

Source : Ministry of Trade, Industry and Energy, Korea Energy Economics Institute, "Yearbook of Energy Statistics 1987"
Source : International Monetary Fund "International Financial Statistics Yearbook 1992"

Taiwan	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
*E End-Use consumption (GWh)	1,076	1,225	1,402	1,497	1,770	2,084	2,416	2,770	3,136	3,528	4,066	4,367	5,185	5,672	6,481	7,470	8,762	10,051	11,964	13,836	16,081
Electricity Generated (GWh)	1,420	1,564	1,805	1,966	2,250	2,555	2,880	3,213	3,628	4,084	4,693	5,019	5,914	6,455	7,340	8,412	9,802	11,119	13,213	15,171	17,449
*P Population (Millions)	8.13	8.44	8.75	9.08	9.39	9.69	10.04	10.43	10.79	11.15	11.51	11.88	12.26	12.63	12.99	13.30	13.65	14.34	14.68	15.00	15.29
GDP (Billion 1987$US)	5.71	6.24	6.91	7.39	7.79	8.37	8.93	9.61	10.22	10.92	11.78	12.89	14.46	16.07	17.50	19.38	21.15	23.05	25.67	28.98	32.83
End-Use consumption / Pop. (kwh/capita)	132.4	145.2	160.2	164.9	188.5	215.1	240.7	265.6	290.6	316.4	353.2	367.5	423.0	449.2	498.8	561.8	641.9	701.2	815.2	922.7	1051.8
Electricity Generated/ Pop. (kwh/capita)	174.7	185.4	206.3	216.6	239.6	263.7	286.9	308.0	336.2	366.3	407.7	422.3	482.5	511.2	564.9	632.6	718.1	775.7	900.3	1011.7	1141.3
*G GDP /Pop. (1987 $US/Capita)	702.0	739.0	789.8	813.8	829.7	863.4	889.5	921.4	946.9	979.6	1023.7	1084.4	1179.7	1272.5	1347.0	1457.2	1549.7	1607.7	1748.9	1932.4	2147.6
*I End-Use consumption / GDP (wh/$US)	188.6	196.5	202.9	202.6	227.2	249.1	270.6	288.2	306.9	323.0	345.0	338.9	358.6	353.0	370.3	385.5	414.2	436.1	466.1	477.5	489.8

Source : Council for Economic Planning and Development, Republic of China, "Taiwan Statistical Data Book, 1987, 1992"

Vietnam	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
*E End-Use consumption (GWh)	2670	2791	2957	3083	3600	3869	4146	4604	5063	5661	6187	6586	6925	8007	9198
Electricity Generated (GWh)	3559	3726.3	3974.4	4125.3	4778.5	5064.7	5526.7	6049.7	6783.2	7791.8	8678.5	9152	9652.1	10728.9	12195
*P Population (Millions)	53.722	54.722	55.687	56.655	57.692	58.868	60.249	61.75	63.263	64.744	66.47	68.31	69.83	71.39	72.99
GDP (Billion 1989 $US)	7.727	7.9	8.295	8.959	9.7	10.264	10.748	11.19	11.766	12.713	13.356	13.995	15.129	17.616	18.325
End-Use consumption / Pop. (kwh/capita)	49.7	51.0	53.1	54.4	62.4	65.7	68.8	74.6	80.0	87.4	93.1	96.4	99.2	112.2	126.0
Electricity Generated/ Pop. (kwh/capita)	66.2	68.1	71.4	72.8	82.8	86.0	91.7	98.0	107.2	120.3	130.6	134.0	138.2	150.3	167.1
*G GDP /Pop. (1989 $US/Capita)	143.8	144.4	149.0	158.1	168.1	174.4	178.4	181.2	186.0	196.4	200.9	204.9	216.7	246.8	251.1
*I End-Use consumption / GDP (wh/$US)	345.5	353.3	356.5	344.1	371.1	376.9	385.7	411.4	430.3	445.3	463.2	470.6	457.7	454.5	501.9

Vietnam (Forecast-Base Case)	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
*E End-Use consumption (GWh)	8007	9251	10349	11606	13038	14668	16523	18631	20956	23534	26399	29588	33141	36961	41102	45613	50544	55948
Electricity Generated (GWh)	10729	12267	13698	15178	16829	18780	20915	23289	26195	29417	32795	36528	40915	45631	50190	55287	60528	66600
*P Population (Millions)	71.39	72.99	74.62	76.06	77.54	79.04	80.58	82.14	83.30	84.47	85.66	86.87	88.10	89.34	90.60	91.98	93.18	94.50
GDP (Billion 1989 $US)	17.60	18.98	20.49	22.31	24.31	26.52	28.95	31.63	34.38	37.39	40.69	44.30	48.25	52.11	56.30	60.84	65.78	71.14
End-Use consumption / Pop. (kwh/capita)	112.2	126.7	138.7	152.6	168.1	185.6	205.0	226.8	251.6	278.6	308.2	340.6	376.2	413.7	453.7	495.9	542.4	592.0
Electricity Generated/ Pop. (kwh/capita)	150.3	168.1	183.6	199.6	217.0	237.6	259.6	283.5	314.5	348.3	382.8	420.5	464.4	510.8	554.0	601.1	649.6	704.8
*G GDP /Pop. (1989 $US/Capita)	246.5	260.0	274.6	293.3	313.5	335.5	359.3	385.1	412.7	442.6	475.0	509.9	547.7	583.3	621.4	661.5	705.9	752.8
*I End-Use consumption / GDP (wh/$US)	454.9	487.4	505.1	520.2	536.3	553.1	570.7	588.9	609.5	629.4	648.9	667.9	686.8	709.3	730.1	749.7	768.4	786.5

Table 5.5-2 Historical Trends of Main Electricity Indicators in Japan

Year	GNP/GDP(87) (10**12 yen)	AGR(%)	Population (thousand)	AGR(%)	Electricity Consumption (GWh)	AGR(%)	(kWh/Capita)	Intensity wh/(1987US$)	GDP/Capita (1987US$)
1945	n.a		72,200		16,419		227		
1946	18.448		75,750	4.9	20,805	26.7	275	156.14	1,759.0
1947	20.300	10.0	78,101	3.1	23,204	11.5	297	158.26	1,877.3
1948	23.617	16.3	80,002	2.4	26,863	15.8	336	157.48	2,132.2
1949	24.546	3.9	81,773	2.2	29,867	11.2	365	168.46	2,168.1
1950	27.551	12.2	83,200	1.7	33,888	13.5	407	170.30	2,391.7
1951	31.266	13.5	84,541	1.6	36,844	8.7	436	163.15	2,671.3
1952	35.335	13.0	85,808	1.5	40,182	9.1	468	157.44	2,974.3
1953	38.141	7.9	86,581	0.9	45,216	12.5	522	164.13	3,181.9
1954	39.030	2.3	88,239	1.9	48,004	6.2	544	170.29	3,194.8
1955	43.478	11.4	89,276	1.2	53,144	10.7	595	169.23	3,517.6
1956	46.201	6.3	90,172	1.0	60,967	14.7	676	182.70	3,700.7
1957	50.308	8.9	90,928	0.8	68,035	11.6	748	187.24	3,996.2
1958	53.768	6.9	91,767	0.9	72,104	6.0	786	185.66	4,232.0
1959	59.765	11.2	92,641	1.0	84,501	17.2	912	195.75	4,659.6
1960	67.239	12.5	93,419	0.8	99,411	17.6	1,064	204.70	5,198.7
1961	75.184	11.8	94,187	0.8	114,575	15.3	1,216	210.99	5,765.5
1962	80.968	7.7	95,181	1.1	121,800	6.3	1,280	208.27	6,144.3
1963	89.122	10.1	96,156	1.0	139,513	14.5	1,451	216.73	6,694.5
1964	97.987	9.9	97,186	1.1	157,208	12.7	1,618	222.13	7,282.4
1965	104.524	6.7	98,275	1.1	168,821	7.4	1,718	223.62	7,682.1
1966	116.209	11.2	99,036	0.8	190,296	12.7	1,921	226.72	8,475.2
1967	128.851	10.9	100,196	1.2	218,092	14.6	2,177	234.34	9,288.5
1968	145.400	12.8	101,331	1.1	241,860	10.9	2,387	230.30	10,364.1
1969	162.922	12.1	102,536	1.2	279,842	15.7	2,729	237.81	11,476.5
1970	175.957	8.0	104,665	2.1	319,701	14.2	3,055	251.55	12,142.6
1971	184.872	5.1	106,100	1.4	345,832	8.2	3,259	258.99	12,585.3
1972	201.180	8.8	107,595	1.4	384,473	11.2	3,573	264.59	13,505.2
1973	210.909	4.8	109,104	1.4	421,768	9.7	3,866	276.87	13,962.4
1974	210.847	0.0	110,573	1.3	415,936	-1.4	3,762	273.12	13,772.9
1975	219.074	3.9	111,940	1.2	428,335	3.0	3,826	270.70	14,135.5
1976	227.863	4.0	113,094	1.0	459,467	7.3	4,063	279.17	14,552.6
1977	238.592	4.7	114,165	0.9	478,752	4.2	4,194	277.81	15,094.9
1978	250.539	5.0	115,190	0.9	504,255	5.3	4,378	278.66	15,709.7
1979	264.306	5.5	116,155	0.8	529,070	4.9	4,555	277.14	16,435.2
1980	273.043	3.3	117,060	0.8	520,251	-1.7	4,444	263.80	16,847.3
1981	282.018	3.3	117,902	0.7	522,662	0.5	4,433	256.59	17,276.8
1982	291.329	3.3	118,728	0.7	521,731	-0.2	4,394	247.94	17,723.0
1983	299.784	2.9	119,536	0.7	553,052	6.0	4,627	255.42	18,114.1
1984	313.110	4.4	120,305	0.6	580,750	5.0	4,827	256.79	18,798.4
1985	327.575	4.6	121,049	0.6	599,306	3.2	4,951	253.30	19,545.9
1986	336.964	2.9	121,672	0.5	601,808	0.4	4,946	247.27	20,003.2
1987	347.535	3.1	122,264	0.5	638,128	6.0	5,219	254.22	20,530.9
1988	362.929	4.4	122,783	0.4	672,317	5.4	5,476	256.48	21,349.6
1989	378.486	4.3	123,255	0.4	713,918	6.2	5,792	261.15	22,179.6
1990	398.606	5.3	123,611	0.3	765,602	7.2	6,194	265.92	23,291.3
1991	412.867	3.6	124,043	0.3	789,888	3.2	6,368	264.88	24,040.6
1992	414.660	0.4	124,452	0.3	797,752	1.0	6,410	266.36	24,065.6
1993	414.792	0.0	124,762	0.2	804,695	0.9	6,450	268.59	24,013.5

Source : The Energy Data and Modelling Center, IEEJ "Energy and Economics Statistics"
: MITI, "Outline of Electric Power Demand and Supply"

Note : GNP values are adopted in 1946-1964, GDP 1965-1993, at 1987 constant price (by deflator)
: Exchange rate = 138.45 yen/US dollar

Figure 5.5-1 Factor Change in End-Use Consumption (Viet Nam)

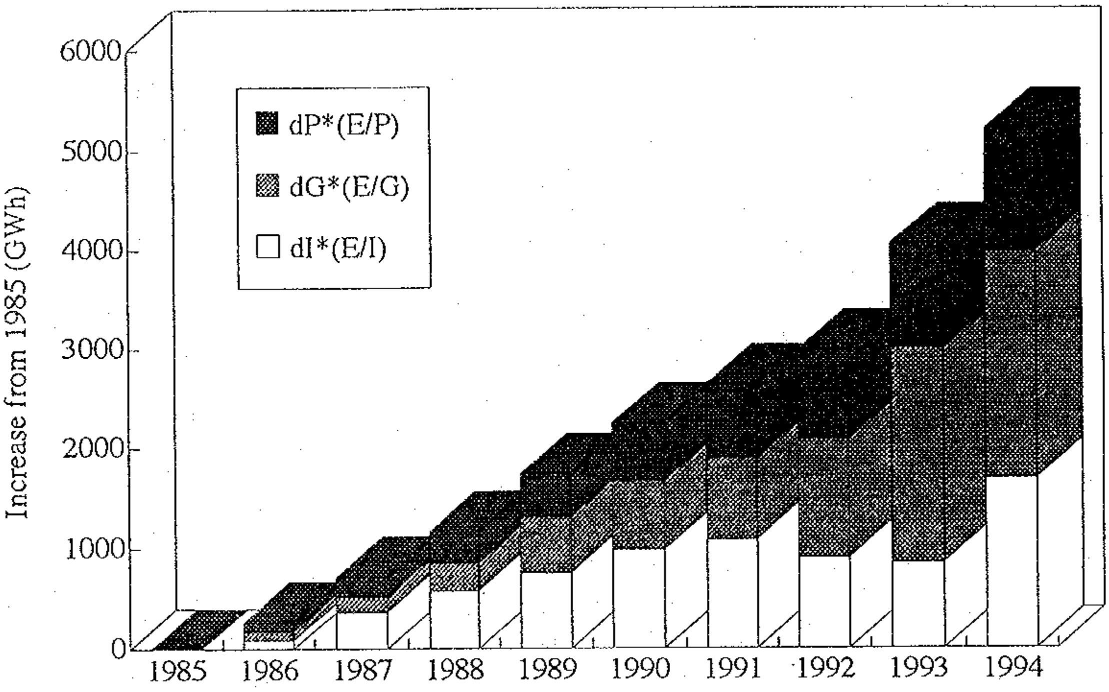


Figure 5.5-2 Factor Change in End-Use Consumption (Malaysia)

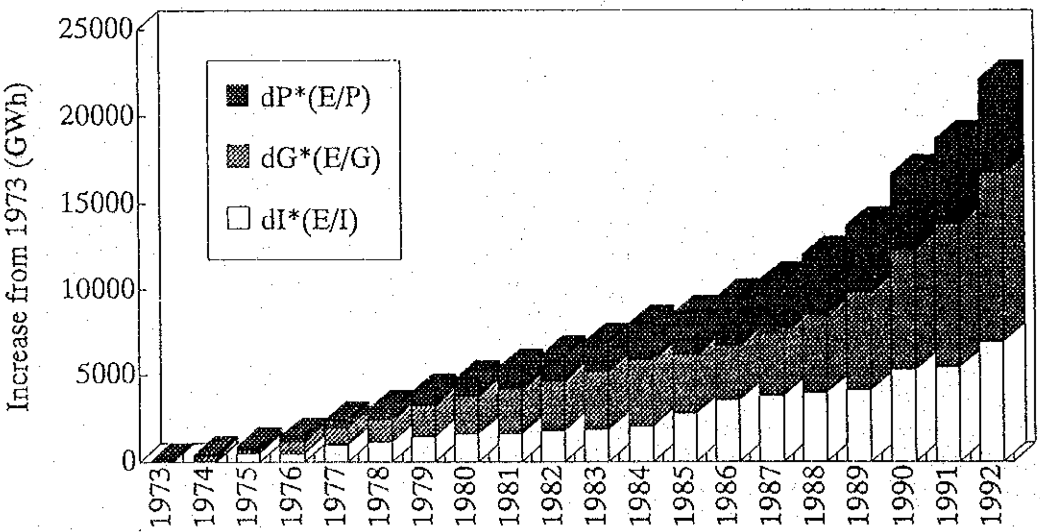


Figure 5.5-3 Factor Change in End-Use Consumption (Thailand)

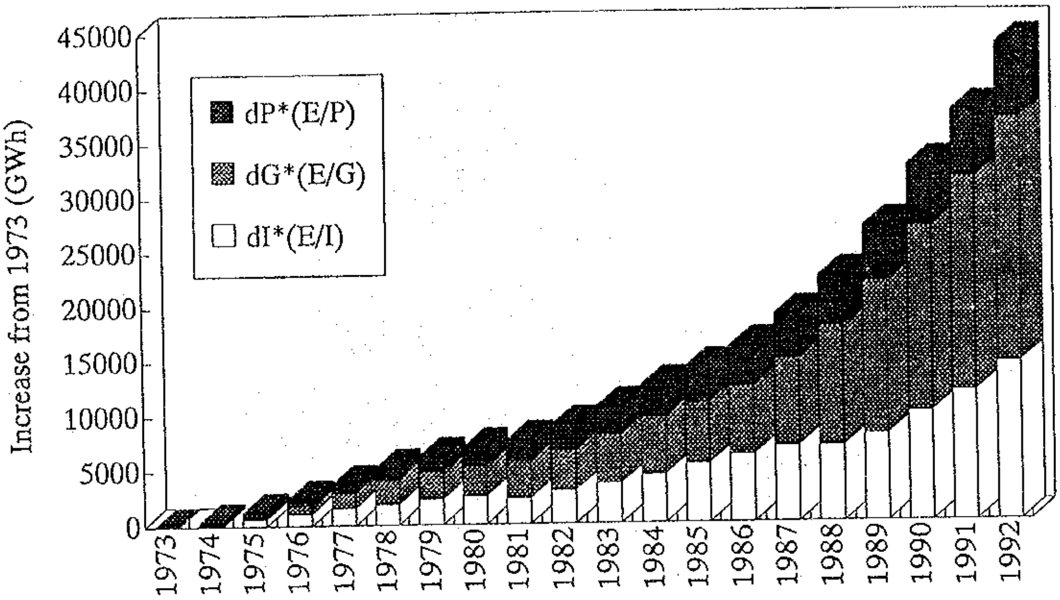


Figure 5.5-4 Factor Change in End-Use Consumption (S. Korea)

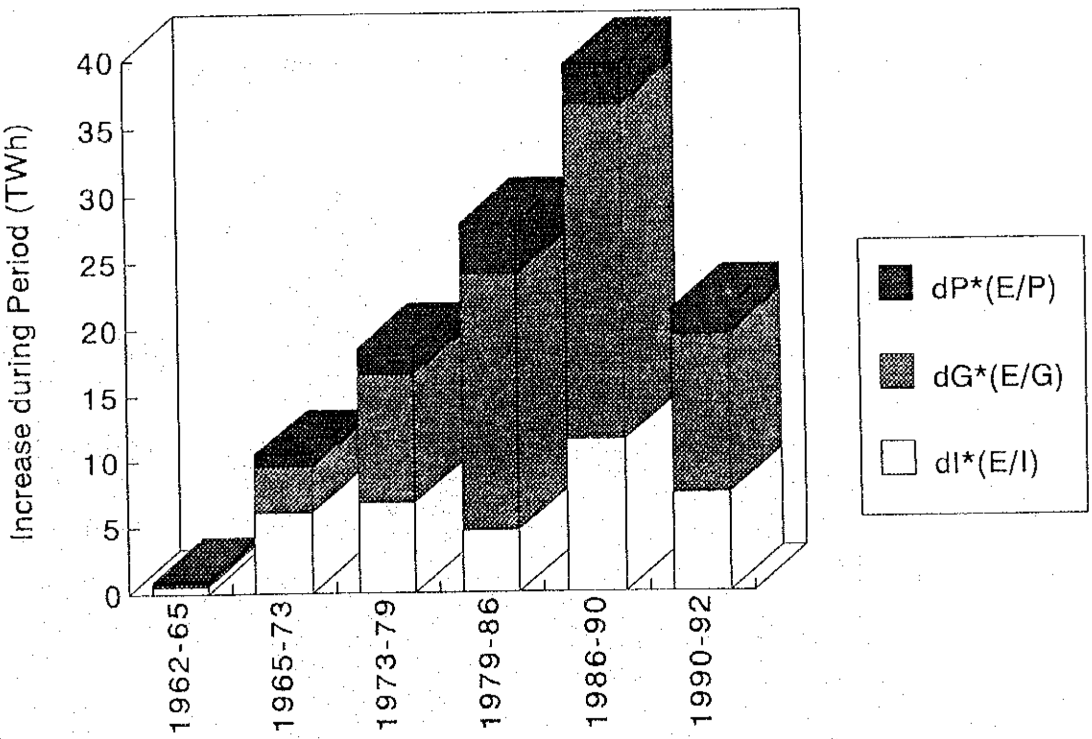


Figure 5.5-5 Factor Change in End-Use Consumption (Taiwan)

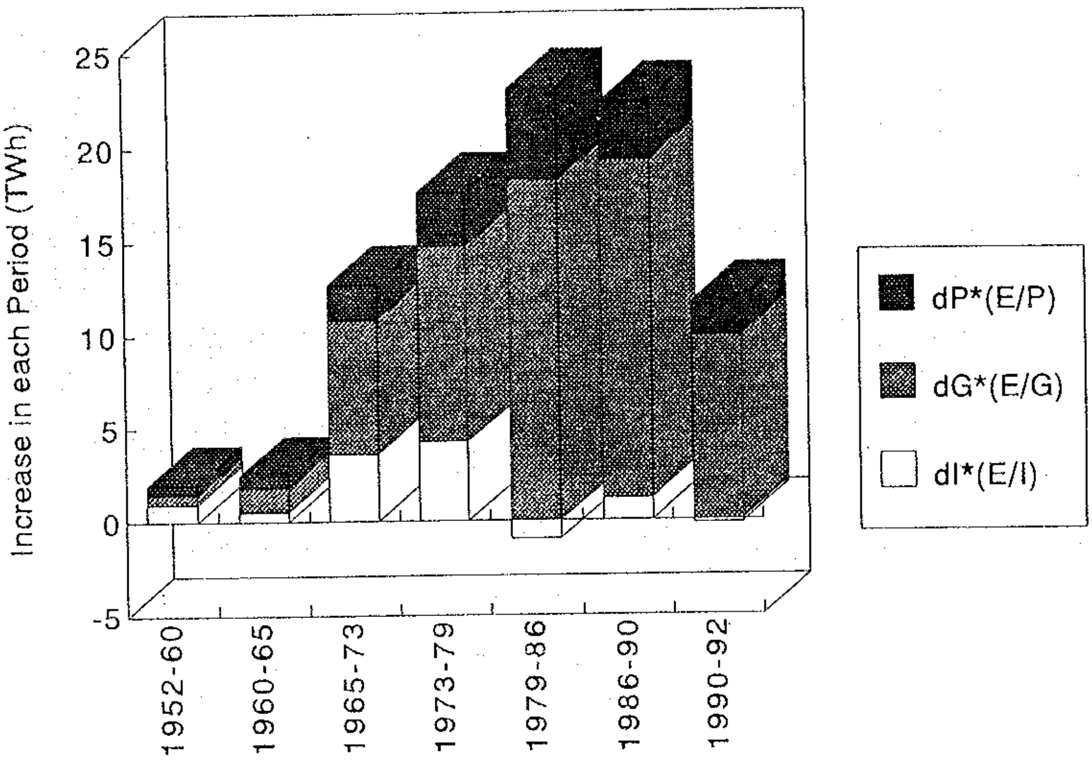
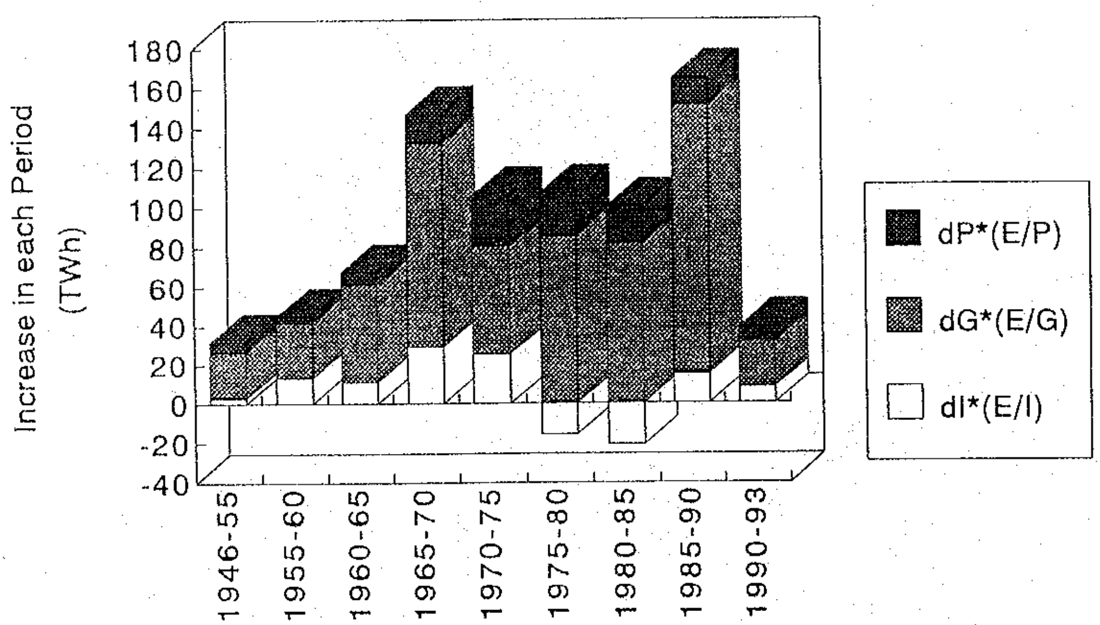


Figure 5.5-6 Factor Change in End-Use Consumption (Japan)



CHAPTER 6

REVIEW AND ASSESSMENT OF POWER DEVELOPMENT PROJECTS

CHAPTER 6 REVIEW AND ASSESSMENT OF POWER DEVELOPMENT PROJECTS

6.1 Thermal Power Generation Facilities

6.1.1 Electric Power Development Sites

The electric power development projects which are incorporated into the Third Electric Power Development Plan (covering the period from 1992 to 2000) are as presented below.

(1) **Northern Region**

(a) Pha Lai II Thermal Power Plant Expansion (2 x 300 MW)

Two, 300 MW coal fired units will be additionally constructed adjacent to the existing Pha Lai thermal power plant (coal fired, 440 MW). The new units are scheduled for commissioning in 1999.

(b) Quang Ninh Thermal Power Project (4 x 300 MW)

In order to deal with the projected power shortage in Northern Region for the period from 1996 to 1998, a new coal fired thermal power plant will be constructed under a BOT scheme. The commissioning is scheduled for 1995 through 1999.

(2) **Southern Region**

(a) Phu My Thermal Power Project (3 x 200 MW + 2 x 300 MW)

A new thermal power plant burning associated gas will be constructed at Phu My, approximately 75 km to the east of Ho Chi Minh City. Commissioning is scheduled for 1998. It is also being contemplated to construct additional 2 x 300 MW units before year 2000.

(b) Conversion of Gas Turbine to Combined Cycle for Thu Duc & Ba Ria Thermal Power Plant

It is being planned to convert the two gas turbine units at Thu Duc thermal power plant and five units at Ba Ria thermal Power Plant to C/C (to extend their output by 36.7 MW and 92.1 MW (55.4 + 36.7) respectively. The commissioning of these C/C systems are scheduled for around 1996, respectively.

(c) O Mon Thermal Power Project (2 x 200 MW + 2 x 200 MW)

Construction of a coal (or oil) fired thermal power plant at O Mon site on Mekong Delta under BOT scheme is being planned. The development is scheduled for the period from 1995 to 1999.

6.1.2 Individual Project

(1) Pha Lai Thermal Power Plant

Pha Lai Coal Fired thermal power plant is located at Pha Lai of Hai Hung Province approximately 50 km to the east of Hanoi, and its current total output is 440 MW, consisting of four 110 MW units. The major fuel source is the anthracite of grade N5 which is produced in the vicinity.

The expansion plan is designed to deal with the power shortage in the Southern Region by means of the Viet Nam 500 kV line which has been completed in 1994.

Two 300 MW units will be added in 1999, to make the total output of the power plant 1,040 MW.

In the Feasibility Study Report, it has been planned to mix 30% of fuel oil, because the coal to be used has the characteristic of high fuel ratio anthracite with high ash content. This mixed fuel burning plan will be reviewed after the combustion test is completed.

Although this power plant is planned adjacent to existing Pha Lai Power Plant, the plan must be further studied in relation to the scale of coal production at nearby coal mines and the problem of transportation.

This project has been studied by the SAPROF TEAM of OECF in June, 1993.

Putting Pha Lai thermal power plant II into operation not only contributes development of coal sector but also rationally exploits ability of 500 kV transmission line and reinforces stable electric supply to national electric network.

Pha Lai thermal power plant II will participate to balance Electric Power in Power System from the year of 1989 with Tmax = 5300 hours/year in medium water level years and reserves energy for low water level years with Tmax = 6500 hours/year. It also increases reserve capacity in cases of frequency control and accident of power system. It gradually replaces the previous power generation facilities such as Ninh Binh and Uong Bi thermal power plants.

(2) Phu My Thermal Power Plant

This is a project plan of PC2 designed to deal with the anticipated power supply shortage in the Southern Region.

Originally, it was planned to commission three, 200 MW units by 1998, and then commission additional two, 300 MW units at an appropriate time (year 2000 or so), to develop finally the output of 1,200 MW in all.

The project site is at a location which is approximately 75 km to the east of Ho Chi Minh City, and the road condition is excellent. This site is approximately 3 km to the west away from national highway 51, where there are few houses. The foundation conditions for building and other structure are good. As a deep inlet is located at 1.5 km from the site, the cooling water facility and a private harbor can be constructed easily.

It has been planned to use the associated gas which gushes off Vung Tau until year 2005 or so, and then convert the fuel to oil. It has been decided to have Petro Viet Nam construct a gas pipeline extending for 140 km from Vung Tau to Thu Duc Thermal Power Plant. The gas can be supplied to Phu My thermal power plant by branching this pipeline.

It is planned to retrofit the boilers in order to convert the fuel from gas to oil by 2005 when the associated gas production will be exhausted. It is being contemplated to use fuel oil if the gas supply is not produced as expected.

This project has been studied by the SAPROF TEAM of OECF in June, 1993.

Power demand of South system No. 2 is growing up to the amount forecasted in the Master Plan Stage III. It is necessary to build one thermal power source here together with development of hydropower sources, national power systems unite and keeping balance of primary energy on the state size by 500 kV line. This power source gets into the balance in terms of power and energy in all seasons of the year.

In the year inadequate of water, its operational time is about 6,500 hours per year. Apart from that it is as reserve source for power system in order to improve electricity quality, raise economic effects of existing power sources in the power system No. 2.

600 MW TPP Phu My is realizable for all demand alternatives. It is proposed to begin generating power by the end of 1997 and completed by the end of 1998. Based on the demand development scenario it would be doubled (1,200 MW) in the 1999-2000 period.

Proposed main fuel for TPP Phu My is associated gas in the first 11 years from 1997 to 2007. Stand by fuel is fuel oil (FO). If after 2007, there will be no more added gas volume supplied, the plant would be converted into the oil fired power plant. Detail calculations showed that this fuel alternative is available and it has good finance economy indication.

Based on fuel supply, load distribution, comparative study on conditions of the possible sites, finance analyzing of alternatives, the site Phu My has been selected as the most suitable site for TPP.

(3) O Mon Thermal Power Plant

Western region in the South of Viet Nam consists of 13 provinces. It's a Cuu Long delta, the biggest rice field of the whole country. Cuu Long delta is far from energy source, up to now being supplied electricity mainly by 220 kV Thuduc-Cantho transmission line, so the capacity and quality of electric supply are restricted. That's why the construction of power plant in this region is necessary to improve the quality of power system No. 2 and supply electricity to Western region.

The construction of Western thermal power plant is necessary to meet load growth, to create reserve source, to improve supplying electricity quality and technical target of Western network and Power system No. 2.

The scale of the plant capacity 400 MW is surely for both high and base cases of load forecast. The reasonable time to put it into operation is 1999-2003. Plant can be extended up to 800 MW after 2005.

The fuel for Western thermal power plant will be anthracite coal, transported from the North. Back-up fuel will be fuel oil (FO). The coal demand for the plant should be taken in the General Scheme of Coal Sector Development for the suitable exploration plan in the future.

Table 6.1.2-1 Outline of Power Plants under Planning (1/2)

Basic Specifications of Thermal Power Plants

Power Company	Power Station	Province	Station Output (MW)	Boiler: Unit Number	Boiler: Types	Boiler: Capacity (t/h)	Boiler: Fuel	Boiler: Manu-facturer	Stack Height (m) (Concentric)	Turbine: Unit Number	Turbine: Types	Turbine: Capacity (MW)	Turbine: Pressure (kg/cm^2)	Turbine: Temp-rature (°C)	Turbine: Manu-facturer	Generator: Capacity (MVA)	Generator: Voltage (kV)	Generator: Cooling Method: Stator	Generator: Cooling Method: Roter	Generator: Manu-facturer	Transformer: Capacity (MVA)	Transformer: Voltage (kV)	Transformer: Manu-facturer	Year and Month of Commission
PC1	Pha Lai	Hai Hung	600	2	* N	930	Coal		200	2	* T	300	169	538		335	18 - 22	H_2O	H_2		322	/220		99/99
PC2	Phu My	Ba Ria-Vung Tau	1,200	3	N	640	GAS*-DO		180	3	T	200	128	538		235	13.8	H_2	H_2		250	13.8/220		98/98/98
				2	N		GAS-DO		200	2	T	300												
	O Mon	Can Tho	400	2	N	670	Coal		180	2	T	200	140	543		235	13.8	H_2	H_2		250	13.8/220		

* N: natural circulation * DO: distillate oil * T: tandem compound

Basic Specifications of Combined Steam and Gas Turbine Power Plants

(New combined cycle)

HP: High pressure
LP: Low pressure

Power Company	Power Station	Province	Station Output (MW)	Unit Number	Gas Turbine: Types	Gas Turbine: Capacity (MW)	Gas Turbine: Numbers	Gas Turbine: Turbine Inlet Pressure (kg/cm^2)	Gas Turbine: Turbine Inlet Temperature (°C)	Gas Turbine: Fuel	Gas Turbine: Manufacturer	Exhaust Heat Recovery Boiler: Types	Exhaust Heat Recovery Boiler: Capacity (t/h)	Exhaust Heat Recovery Boiler: Number	Exhaust Heat Recovery Boiler: Manufacturer	Stack Height (m)
PC2	Phu My	Ba Ria-Vung Tau	300	1		123.4	2	12.1	1,105	GAS-DO			HP: dual LP: pressurer	1		100 (concentric)
			300	1		123.4	2	12.1	1,105	GAS-DO			HP: dual LP: pressure	1		

HP: High pressure
LP: Low pressure

Steam Turbine: Types	Steam Turbine: Capacity (MW)	Steam Turbine: Number	Steam Turbine: Turbine Inlet Pressure (kg/cm^2)	Steam Turbine: Turbine Inlet Temperature (°C)	Steam Turbine: Manufacturer	Generator: Capacity (MVA)	Generator: Number	Generator: Voltage (kV)	Generator: Cooling Method: Stator	Generator: Cooling Method: Rotor	Generator: Manufacturer	Transformer: Capacity (kVA)	Transformer: Number	Transformer: Voltage (kV)	Transformer: Manufacturer	Year and Month of Commission	Remarks
T	100	1	HP: dual LP: pressure	HP: LP:		GT ST	3	13.8 - 15	H_2	H_2			3	13.8 - 15/220			1st GT must be completed before 1997
T	100	1	HP: dual LP: pressure	HP: LP:		GT ST	3	13.8 - 15	H_2	H_2			3	13.8 - 15/220			

Table 6.1.2-1 Outline of Power Plants under Planning (2/2)

Basic Specifications of Combined Steam and Gas Turbine Power Plants

(Convert existing gas turbine into combined cycle)

HP: High pressure
LP: Low pressure

Power Company	Power Station	Province	Station Output (MW)	Unit Number	Gas Turbine							Exhaust Heat Recovery Boiler				Stack Height (m)
					Types	Capacity (MW)	Numbers	Turbine Inlet Pressure (kg/cm^2)	Turbine Inlet Temperature (°C)	Fuel	Manufacturer	Types	Capacity (t/h)	Number	Manufacturer	
PC2	Ba Ria	Ba Ria-Vung Tau	(112.5) & 55.4	1	#5, #6, #7 (existing)							N	HP: 64.2 LP: dual pressure	3		(Concentric)
			(75) & 36.7	1	#3, #4 (existing)							N	HP: 64.2 LP: dual pressure	2		
	Thu Duc	Ho Chi Minh	(75) & 36.7	1	#4, #5 (existing)							N	HP: 64.2 LP: dual pressure	2		

(existing GT)

HP: High pressure
LP: Low pressure

Steam Turbine						Generator						Transformer				Year and Month of Commission	Remarks
Types	Capacity (MW)	Number	Turbine Inlet Pressure (kg/cm^2)	Turbine Inlet Temperature (°C)	Manufacturer	Capacity (MVA)	Number	Voltage (kV)	Cooling Method: Stator	Cooling Method: Rotor	Manufacturer	Capacity (MVA)	Number	Voltage (kV)	Manufacturer		
T		1	HP: LP: 40.6*	HP: LP: 497*		GT	#5, #6, #7 (existing)					#5, #6, #7 (existing)					
						ST 55.4 (MW)	1	11	Air	Air		75	1	11/220			
T		1	HP: LP: 40.6*	HP: LP: 497*		GT	#3, #4 (existing)					#3, #4 (existing)					
						ST 36.7 (MW)	1	11	Air	Air		50	1	11/110			
T		1	HP: LP: 40.6*	HP:* LP: 497		GT	#4, #5 (existing)					#4, #5 (existing)					
						ST 36.7 (MW)	1	11	Air	Air		50	1	11/110			

*: boiler steam condition

Source: IEV, PC1, PC2, PC3

Table 6.1.2-2a Pha Lai Thermal Power Plant 2 Project

(1)	Name of plant	:	Pha Lai Thermal Power Plant 2
(2)	Plant site	:	Hai Hung province
(3)	Plant capacity	:	600 MW (2 x 300 MW)
(4)	Construction area	:	Inside the plant Outside the plant Ash disposal area
(5)	Main equipment		
	Boiler	:	Outdoor, single drum natural circulation reheat
	Turbine	:	Impulse tandem compound double flow exhaust reheat condensing
	Generator	:	Total-enclose hydrogen-cooled three phase synchronous
	Transformer	:	N.A.
	Substation	:	N.A.
	Stack	:	200 m
(6)	Station efficiency	:	N.A.
(7)	Annual availability	:	Base load and middle load In the low water level years, 6,500 hours/year In the medium water level years, 5,300 hours/year
(8)	Investment cost	:	Estimation by OECF 9,886.5 billions Dong for Power Plant 354 billions Dong for Transmission Lines Estimation by Reference in Asian Region: 9,686.6 billions Dong for Power Plant 354 billions Dong for Transmission Lines Estimation by Interior Tariff: 9,404.95 billions Dong for Power Plant 288 billions Dong for Transmission Lines
(9)	Investment cost per installed capacity	:	N.A.
(10)	Fuel		
	Kind	:	Coal
	Consumption	:	N.A.
	Auxiliary combustion	:	N.A.
(11)	Construction schedule	:	36 months
	Construction start	:	January 1997
	Start up unit No. 1	:	June 1999
	Start up unit No. 2	:	December 1999
(12)	Economic indicators of the project		
	Energy price	:	N.A.
	EIRR	:	15.44%
	NPV	:	89.2 million US$
	B/C	:	1.1

Table 6.1.2-2b Phu My Thermal Power Plant Project

(1)	Name of plant	:	Phu My Thermal Power Plant
(2)	Plant site	:	Phu My village, Chau Thanh district, Ba Ria-Vung Tau province Longitude: 106°30' East longitude (Latitude: 10°30' North latitude)
(3)	Plant capacity	:	1st stage 600 MW (3 x 200 MW) 2nd stage 600 MW (2 x 300 MW)
(4)	Construction area	:	Inside the plant Outside the plant
(5)	Main equipment		
	Boiler	:	Outdoor, single drum, radiant reheat natural circulation
	Turbine	:	Inside, tandem compound single flow exhaust reheat condensing
	Generator	:	Inside, three phase synchronous, horizontal axle
	Transformer	:	Auto transformers 3 voltage 220/110/13.8 kV
	Substation	:	Two busbar system with switch gear
	Stack	:	180 m
(6)	Station efficiency	:	N.A.
(7)	Annual availability	:	6,500 hours per year (in the year inadequate of water)
(8)	Investment cost	:	97,367 million yen Foreign currency 73,991 million yen (Local currency 23,376 million yen)
(9)	Investment cost per installed capacity	:	N.A.
(10)	Fuel		
	Kind	:	Associated gas (1997 - 2008 : 12 years) Fuel oil (2008 -)
	Consumption	:	Gas 904 million m^3/year Oil 792,000 tons/year (in case of oil fired only)
	Auxiliary combustion	:	N.A.
(11)	Construction schedule	:	44 months
	Construction start	:	May 1995
	Start up unit No. 1	:	April 1998
	Start up unit No. 2	:	August 1998
	Start up unit No. 3	:	January 1999
(12)	Economic indicators of the project		
	Energy price	:	Gas 84.33 US$/10^3 m^3 Oil 115.00 US$/ton
	EIRR	:	15.35%
	NPV	:	78.44 million US$
	B/C	:	1.0637

Table 6.1.2-2c O Mon Thermal Power Plant Project

(1)	Name of plant	:	O Mon Thermal Power Plant
(2)	Plant site	:	Phuoc Thoi village, O Mon district, CanTho province
(3)	Plant capacity	:	+1st stage 400 MW (2 x 200 MW) +2nd stage 400 MW (2 x 200 MW)
(4)	Construction area	:	Inside the plant 19.58 ha Outside the plant 8 ha (+1st stage) Ash disposal area 26.42 ha (1st stage)
(5)	Main equipment		
	Boiler	:	High pressure, single reheat
	Turbine	:	Pure-condensed type
	Generator	:	Synchronic, three phases
	Transformer	:	3 x 1 phase, 3 wind
	Stack	:	200 m
	Diagram of 220 kV & 110 kV bus bar systems	:	Two bus bar systems with by-pass switch disconnector
(6)	Station efficiency	:	31%
(7)	Annual availability	:	2400 - 2600 GWh (base load operating)
(8)	Investment cost	:	US$515.85 million Foreign currency US$417.7 million (Local currency 103.2 million US$)
(9)	Investment cost per installed capacity	:	1289.63 US$/kW
(10)	Fuel		
	Kind	:	Vietnamese anthracite grade coal No. 4
	Consumption	:	1,118,000 tonnes per year (+1st stage)
	Auxiliary combustion	:	Heavy oil is necessary at boiler start-up and partial load regimes
(11)	Construction schedule	:	48 months
	Construction start	:	January, 1997
	In service	:	Middle of the year 2000
(12)	Economic indicators of the project		
	Energy price	:	6.45 US¢/kWh (all taxes, interest 8% year, payment period 15 years)
	EIRR	:	15.50%
	NPV	:	87.22 mill. US$
	B/C	:	1.120

Table 6.1.2-2d Thu Duc Power Plant (repowering by combined cycle gas turbine)

(1)	Name of plant	:	Thu Duc Power Plant (or Site)
(2)	Plant site	:	Ho Chi Minh City
(3)	Plant capacity	:	111.7 MW (GT 37.5 MW x 2 + ST 36.7 MW)
(4)	Construction area	:	Inside the plant Outside the plant Ash disposal area
(5)	Main equipment (existing)		
	Gas turbine	:	Outdoor packaged, simple cycle heavy duty, industrial type, GE Frame-6
	Generator	:	Open ventilated air cooled synchronous
	Step-up transformers	:	Outdoor oil immersed, ONAN/ONAF cooling 50 MVA x 2 u, 11 kV/121 kV
	110 kV substation stack	:	Single bus bar system
	(new)		
	Heat recover steam generator	:	Unfired, dual pressure, natural circulation horizontal arrangement (2 units)
	Steam turbine	:	Single flow, single pressure condensing unit
	Generator	:	Open ventilated air cooled synchronous, 2 poles, 3,000 rpm
	Step-up transformer	:	Three phase, ONAN/ONAF cooling, 50 MVA x 1 u, 11 kV/110 kV
(6)	Station efficiency	:	N.A.
(7)	Annual availability	:	N.A.
(8)	Investment cost	:	647.215 billion Don. Foreign currency 5,945 million yen (Local currency 46.77 billion Don)
(9)	Investment cost per installed capacity	:	N.A.
(10)	Fuel		
	Kind	:	Coal
	Consumption	:	N.A.
	Auxiliary combustion	:	N.A.
(11)	Construction schedule		
	Construction start	:	N.A.
(12)	Economic indicators of the project	:	N.A.

Table 6.1.2-2e Ba Ria Power Plant - Block-1 (repowering by combined cycle gas turbine)

(1)	Name of plant	:	Ba Ria Site - Block-1
(2)	Plant site	:	Ba Ria - Vung Tau province
(3)	Plant capacity	:	167.9 MW (GT 37.5 MW x 3 + ST 55.4 MW)
(4)	Construction area	:	Inside the plant Outside the plant
(5)	Main equipment (existing)		
	Gas turbine	:	Outdoor packaged, simple cycle heavy duty, industrial type, GE Frame-6
	Generator	:	Open ventilated air cooled synchronous
	Step-up transformer	:	Outdoor oil immersed, ONAN/ONAF cooling 50 MVA x 3 u, 11.5 kV/230 kV
	220 kV substation stack	:	Single bus bar system
	(new)		
	Heat recovery steam generator	:	Unfired, dual pressure, natural circulation horizontal arrangement (3 units)
	Steam turbine	:	Single flow, single pressure condensing unit
	Generator	:	Open ventilated air cooled synchronous 2 poles, 3,000 rpm
	Step-up transformer	:	Three phase transformer, ONAN/ONAF cooling 75 MVA x 1 u, 11 kV/220 kV
(6)	Station efficiency	:	N.A.
(7)	Annual availability	:	N.A.
(8)	Investment cost	:	837.145 billion Don (Foreign Currency 7.735 million yen, local currency 55.91 billion Dong)
(9)	Investment cost per installed capacity	:	N.A.
(10)	Fuel		
	Kind	:	Distillate oil (LNG available)
	Consumption	:	N.A.
	Auxiliary combustion	:	N.A.
(11)	Construction schedule	:	N.A.
	Construction start	:	N.A.
(12)	Economic indicators of the project	:	N.A.

Table 6.1.2-2f Ba Ria Power Plant - Block-2 (repowering by combined cycle gas turbine)

(1)	Name of plant	:	Ba Ria Site - Block-2
(2)	Plant site	:	Ba Ria - Vung Tau province
(3)	Plant capacity	:	111.7 MW (GT 37.5 MW x 2 + ST 36.7 MW)
(4)	Construction area	:	Inside the plant Outside the plant
(5)	Main equipment (existing)		
	Gas turbine	:	Outdoor packaged, simple cycle heavy duty, industrial type, GE Frame-6
	Generator	:	Open ventilated air cooled synchronous
	Step-up transformer	:	Outdoor oil immersed, ONAN/ONAF cooling 50 MVA x 2 u, 11 kV/121 kV
	220 kV substation	:	Single bus bar system
	stack		
	(new)		
	Heat recovery steam generator	:	Unfired, dual pressure, natural circulation horizontal arrangement (2 units)
	Steam turbine	:	Single flow, single pressure condensing unit
	Generator	:	Open ventilated air cooled synchronous 2 poles, 3,000 rpm
	Step-up transformer	:	Three phase transformer, ONAN/ONAF cooling 50 MVA x 1 u, 11 kV/110 kV
(6)	Station efficiency	:	N.A.
(7)	Annual availability	:	N.A.
(8)	Investment cost	:	N.A.
(9)	Investment cost per installed capacity	:	N.A.
(10)	Fuel		
	Kind	:	Distillate oil (LNG available)
	Consumption	:	N.A.
	Auxiliary combustion	:	N.A.
(11)	Construction schedule	:	N.A.
	Construction start	:	N.A.
(12)	Economic indicators of the project	:	N.A.

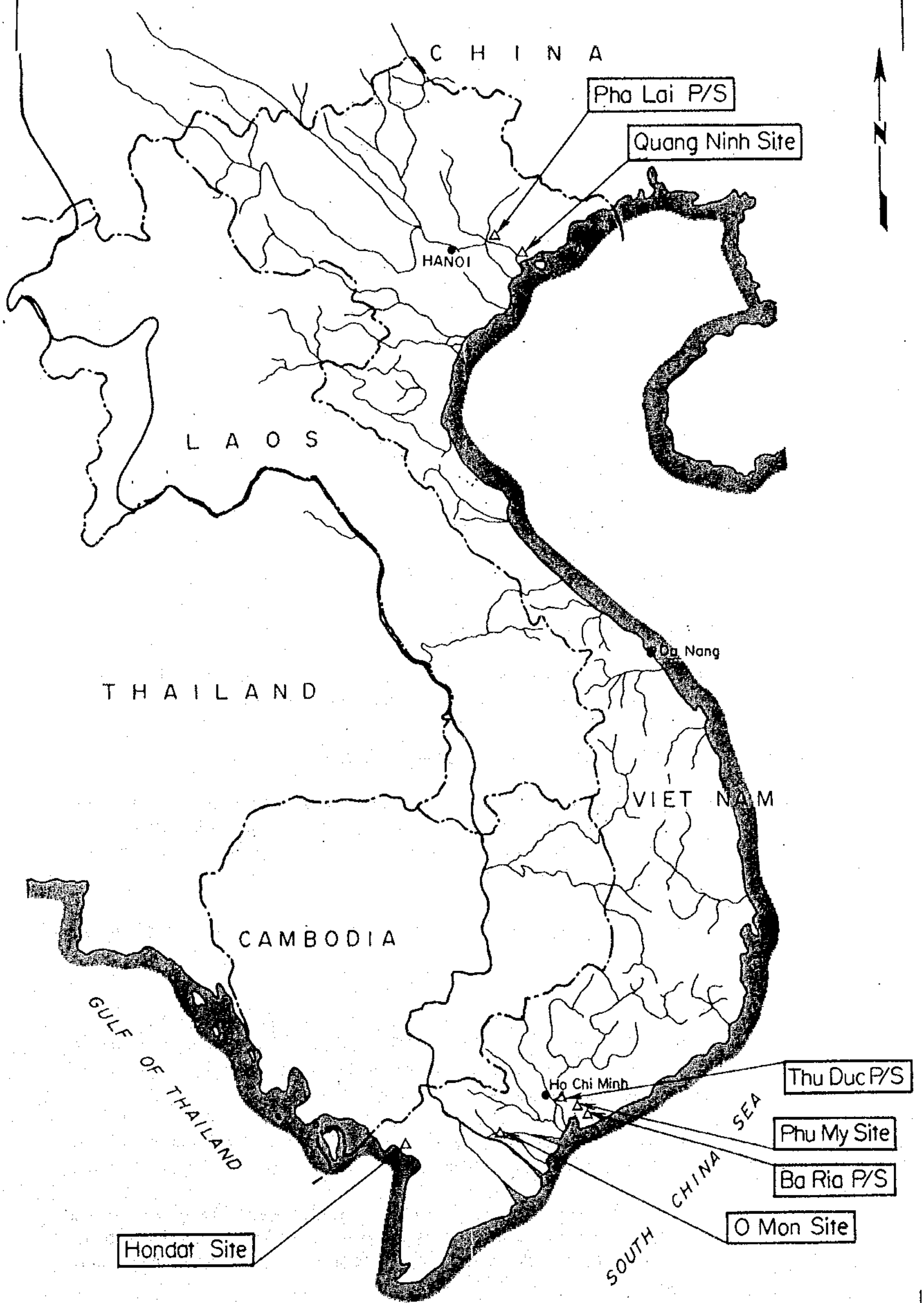


Figure 6.1.2 LOCATION of THERMAL POWER PLANT PROJECT

6.1.3 Thermal Power Generation Systems

(1) Anthracite Fired Thermal Power Generation

(a) Features of Anthracite

Of all the coals, anthracite is the most carbonized. Anthracite features a high carbon content or so-called low volatile content (max. 10%) and a fuel ratio (fixed carbon/volatile content = min. 4.0). Consequently, as anthracite provides a high inanition/combustion temperature and long combustion, it is inappropriate for fast combustion in pulverized coal boilers used in power generation.

(b) Component Analysis of Vietnamese Anthracite

Vietnamese anthracite is called 'Hon Gai coal'. Approx. 300,000 tons is exported to Japan yearly. The components of Nos. 8 and 9 (both pulverized) from the Cam Pha Mine have been analyzed.

According to the analysis:

- Fuel ratio (Fixed carbon/volatile content) : 7.8 - 8.1
- Volatile content (dry ash-free basis) : 10.9 - 11.4
- Fixed carbon (dry ash-free basis) : 88.6 - 89.1

This data indicates that its component is close to the anthracite of international standards and is, therefore, qualified as an anthracite in general.

(c) Temperature Characteristic of Vietnamese Anthracite

The temperature characteristic of the previously analyzed coal indicates no fire development combustion due to its volatile content. Only char combustion due to the fixed carbon is indicated, thereby proving the results of the previously described component analysis.

(d) Comparison of Temperature Characteristics between Anthracite and Bituminous Coal

When comparing the temperature characteristics of Vietnamese anthracite (Nos. 8 and 9) and bituminous coal (Blair athol), due to a volatile content at approx. 300°C, the bituminous coal indicates a heat generation. The heat peak due to the carbon content is indicated at approx. 470°C.

Contrarily, anthracite does not generate heat due to the volatile content and only indicates a heat peak due to carbon combustion at approx. 530°C.

Bituminous coal combustion starts with the volatile content, changing to carbon combustion. Anthracite combustion starts with the carbon combustion with no combustion of the volatile content. Also, anthracite requires a higher temperature atmosphere than bituminous coal.

Since the ignitability and combustion characteristic of Vietnamese anthracite are significantly different from those of bituminous coal, special consideration is required for its ignitability and combustion stability. When using a pulverized coal boiler, therefore, the design and operation system including the boiler structure, burner type and pulverizing level must be totally different from those for bituminous coal.

(e) Anthracite Combustion Method

As previously described, with a lesser volatile content and higher carbon content anthracite provides the following characteristics;

- Difficult to ignite.
- Requires a long combustion time.
- Requires a high combustion temperature.

Does not provide satisfactory combustibility with a fast combustion method by horizontal blow such as a conventional bituminous coal boiler. Generally, therefore, the vertical bottom blow method is used for anthracite boilers to acquire a long burner flame thus gaining a relatively long combustion time.

Also, the fireproof coating on the burner zone prevents heat absorption to the boiler tubes and ensures a high combustion temperature (W-type flame boiler).

Another important factor is to ensure good combustibility. For this, the pulverizer must provide finer pulverized coal to the burner. Also, many burners are required to improve the mixture and contact between the coal dust and the combustion air.

(f) Outline of 200 MW Class anthracite Boiler

The most renowned Japanese boiler manufacturers, A, B, and C provided a schematic design of a 200 MW class anthracite boiler based on the previously described conditions.

A and B applied a W-type flame boiler with a vertical bottom blow burner as described previously.

Against this, C developed a Circular U-shaped Frame Boiler (CUF) by which the diagonal bottom blow (15°) forms a fireball by tangential firing. This system enables single fuel combustion with anthracite. (See Figure 6.1.3-1)

The major specifications of a 200 MW class anthracite boiler are described below.

- Boiler dimensions (Boiler building)

Height	:	Approx. 50m
Depth	:	Approx. 30m
Width	:	Approx. 40m

The boiler main unit and auxiliaries can be stored in this building.

• Performance

Combustion efficiency	:	Approx. 95% - 97%
Boiler efficiency	:	Approx. 84% - 88%

Anthracite is difficult to burn. Unburned carbon generation lowers its combustion efficiency compared to the bituminous coal boiler. Boiler efficiency also falls to less than 90%. Also, ultra fine pulverized coal is required for its stable combustibility. Therefore, anthracite requires a tube mill to crush the coal by many small mill balls. It is also necessary to improve the dust separator to supply ultra fine coal dust to the coal burner. To achieve good combustion, anthracite also requires many relatively small capacity burners so that the air and coal dust are well mixed and contacted.

• Environmental Specifications (boiler outlet)

SOx	:	400 - 500ppm
NOx	:	500 - 1,000ppm
Coal dust	:	30g/m^{3}N

SOx content is determined by the sulfur content (S) of the anthracite. Since Vietnamese anthracite has a low sulfur content (max. 0.5%), the SOx at the boiler outlet is relatively low at approx. 400 - 500 ppm.

Since the nitrogen content (N) in anthracite is as low at max. 1% (approx. 0.9%), its fuel NOx generation is also low. Contrarily, the thermal NOx generation is higher than that of bituminous coal because its volatile content is low and, as previously described, only fixed carbon combustion is conducted. This requires an approx. 60°C higher ignition temperature and a relatively high combustion temperature.

Consequently, the total NOx generation (fuel NOx + thermal NOx) is higher than that of bituminous coal. NOx at the boiler outlet is expected to remain within 500 - 1,000 ppm.

Although the thermal NOx in the boiler NOx can be reduced by using a low NOx burner and 2-stage combustion method, it increases the facility cost. Due to the cost balance between the environmental restrictions and facility cost, it is, therefore, necessary to consider the exhaust restriction value when considering installation of a low NOx combustion system.

The coal dust is 30 - 50 g/m^{3}N at the boiler outlet. Max. 300 - 500mg/m^{3}N (min. 99% dust collection efficiency) can be achieved at the stack outlet by installing an electric precipitator (EP).

Vang Danh coal provides a lower ash melting temperature than other Vietnamese anthracite coal, thus creating clinker problems in the boiler. When considering using this coal, careful handling is required in the future.

(g) Circulating Fluidized Bed Combustion Technology

The combustion method is mainly classified into fixed bed combustion, entrained combustion and fluidized bed combustion. Fluidized bed combustion is classified further to the bubbling method and the circulating method.

The fluidized bed combustion method has the following characteristics in general. (Refer to Figure 6.1.3-2)

- Provides less restrictions in coal type because the ash does not melt and therefore creates no ash problems.
- Provides no problem with accidental miss fire due to a fluidized medium.
- Does not restrict coal crush performance because it burns coarse coal.
- Enables desulfurization in the furnace and generates minimal NOx.
- Requires countermeasures against heat exchanger tube wear in the furnace due to extremely high particle concentration.

The following specifications are added to the circulating fluidized bed method.

- A long stay time in the furnace due to particle circulation enables relatively efficient combustion regardless of poor combustibility coals.
- Requires countermeasures against heat exchanger tube wear in the furnace due to a high concentration of circulating particles.

When using anthracite, it is necessary to consider its characteristics such as poor coal ignitibility, long combustion completion time, and its requiring high temperature combustion to reduce the unburned content. The circulating fluidized bed method provides the following countermeasures against the characteristics of anthracite.

Anthracite characteristics	Features of circulating fluidized bed method
Poor ignitibility	No accidental miss fire due to fluidized medium
Long combustion completion time	Long stay time in furnace due to particle circulation enables relatively efficient combustion regardless of poor coal combustibility.
High temperature combustion to reduce the unburned content	Long stay time in furnace due to particle circulation enables relatively efficient combustion regardless of poor coal combustibility.

Although the circulating fluidized bed method is appropriate for anthracite, a circulating fluidized bed boiler using anthracite and oil coke has been used in many countries.

On the other hand, the circulating fluidized bed method provides the following problems;

- Technological restrictions of cyclone and retaining even internal condition of the furnace are problems when developing a large system. Currently, the 200 MW class is the largest available.

- Countermeasures against heat exchanger tube wear in the furnace must be fully considered.

There are several systems in the circulating fluidized bed method.

These are described in Figure 6.1.3-3.

(2) **Gas Fired Power Generation**

Figure 6.1.3-4 shows the system diagram of a general oil fired power plant.

A gas fired power plant consists of a boiler, turbine, generator and other components similar to that in conventional coal-fired or oil-fired power plants.

Its boiler is smaller than that of a coal-fired power plant, being almost equivalent to that of an oil-fired power plant.

Therefore, in either an oil fired or gas fired power plant, the fuel can be selected flexibly by installing a fuel supply system and a burner together.

The environmental characteristics provided by the gas fired power plant are very good. However, EP is necessary when planning the use of oil together with gas. When only gas is used, no tank, gas mixing fan and EP are not required.

There is very minimal difference between the fuels in their gross thermal efficiency. When the net thermal efficiency is compared, however, the efficiency of gas fired power generation is the highest followed by oil fired and then by coal fired as the lowest in efficiency. The difference is caused by the auxiliary power difference including the fuel preparation equipment, ash treatment equipment, environmental control equipment, etc.

In Japan, no new gas fired power developments have been planned. The combined cycle is applied to all new projects for achieving further efficiency.

(3) **Combined Cycle Power Generation**

In the combined cycle power generation, the steam turbine generation (Rankine cycle) cycle and the gas turbine generation (Brayton cycle) cycle are combined as illustrated in Figure A6.1.3-5 to make the best use of the high temperature of the gas turbine cycle and the low temperature of the steam turbine cycle. That is, by combining these two cycles, the constraint on the high temperature operation of steam turbine is reduced, and at the same time, the energy loss of the gas turbine cycle arising from its exhaust gas can also be reduced.

The way of improving the thermal efficiency of a combined cycle power generation is the adoption of higher temperature of the gas turbine inlet., and as discussed before, although the currently available gas turbine unit of 1,100 °C class has a thermal efficiency of 43% or so (LNG fired, high calorific value base), but an efficiency of 47% (the same base) will be attained by the gas turbine unit of 1,300 °C class which is being developed by various manufactures. An expected thermal efficiency as high as 50% (the same base) is expected with a more sophisticated, 1,500 °C class gas turbine unit.

(a) Type of Combined Cycle Power Generation System

There are 5 types of combined cycle power generation systems, as illustrated in Figure 6.1.3-6, each having its particular features. Therefore, the optimal system must be selected in reference to the plant output, fuel type, available installation space, or operating conditions.

(b) Features of Combined Cycle Power Generation.

The exhaust heat recovery type combined cycle power generation, which is the leading technology in recent years, are described in terms of its features.

1) High Thermal Efficiency

The design thermal efficiency of a combined cycle power generation can reach, as discussed before, 43% with a 1,100 °C gas turbine unit, as against 40% or so of conventional steam turbine cycle power plant (LNG fired, high calorific value base). In addition, as to be discussed later, there are such features as the high plant efficiency under partial load, the time required to startup and shutdown is short, and fuel saving of 10% or so is possible as compared to the conventional steam turbine cycle plant. The typical heat balance diagrams of a steam turbine cycle and a combined cycle plants are shown in Figure 6.1.3-7.

2) Good Thermal Efficiency at Partial Load

A combined cycle power plant of large capacity is constituted by a combination of relatively small capacity units. For this reason, a thermal efficiency as high as at the rated output can be realized in a wide range of output by reducing or increasing the number of units being operated. The change of thermal efficiency under partial load is illustrated in Figure 6.1.3-8 for a steam turbine cycle plant and a combined cycle plant.

3) Short Startup/Shutdown Time

Since the combined cycle plant consists of smaller units, as discussed above, it can deal with a wide load change rate, and the plant can be started up and shut down in a shorter time. While a conventional steam turbine cycle plant of 600 MW class takes 2 and a half hours for start up at the shortest, a combined cycle plant with single shaft type can start up in approximately 1 hour. (In both cases, the startup time is measured to reach the rated output after daily stop.) In Figure 6.1.3-9, the startup curve of a single shaft exhaust heat recovery type combined cycle generation plant is presented.

4) Change of Maximum Output with Atmospheric Temperature

As a combined cycle power plant is mainly composed of gas turbines, its maximum output changes substantially with the atmospheric temperature, and the output is larger as the temperature is low. This is due to the following reasons. A gas turbine is operated with limitation of the highest temperature at the first stage inlet of gas turbine fixed to a certain value, in view of the durability of the turbine blades under high temperature operation. On the other hand, as the volume of air which can be inhaled by the compressor is almost constant, the mass of the intake air increases with the increased atmospheric air density at lower temperature. Under these circumstances, as the intake air temperature decreases, the temperature of the compressed air also decreases, then the turbine inlet gas temperature can be raised to larger extent. Together with the increased mass of the inlet air, more fuel can be injected, and the maximum output of the gas turbine is increased.

Concerning the steam turbine, the steam generated by the exhaust heat recovery boiler is somewhat increased as the gas turbine exhaust gas volume is increased, with corresponding increase of the maximum output.

As discussed above, the maximum output of a combined cycle power plant is increased with the decrease of atmospheric temperature.

5) Smaller Discharge of Condenser Cooling Water

Although the steam condition of a steam turbine in a combined cycle plant is poorer than in a conventional steam turbine plant, the discharge of condenser cooling water is from 60 to 80% of a steam turbine plant having same capacity, as the proportion of the output of the steam turbine in combined cycle plant is only 1/3 (one third) of the total capacity.

6) Large Fluctuation of Performance by Type of Fuel

A combined cycle power generation plant, especially an exhaust heat recovery plant, needs clean fuel if we want to have its superior performance fully exhibited at the current technology level.

The fuels used in the exhaust heat recovery type combined cycle power plants which are being operated, constructed or planned are limited to clean gas fuels such as LNG and LPG, or high grade kerosine having very low sulfur content. The reasons for this situation are explained below.

a) Additional Facilities Required and Reduction of Efficiency for Prevention of Corrosion of Moving/Stationary Blades

The heavy metals, alkali metals and sulfur contents contained in heavy oil causes substantial corrosion of gas turbine combustors, moving blades and stationary blades which are exposed to high temperature. For the reason, the fuel pre-treatment facility and other facilities must be installed, and the turbine inlet gas temperature may have to be decreased to withstand corrosion. These measures increase the capital cost and decrease the thermal efficiency.

b) Reduction of Thermal Efficiency by Adhesion of Unburnt Carbon to Gas Turbine Moving/Stationary Blades or Exhaust Heat Recovery Boiler Tube

The unburnt carbon in the combustion may adhere to the gas turbine moving/stationary blades to reduce the thermal efficiency. Also, the sulfur oxide components which are generated burning the fuel with sulfur and the ammonia injected in the gas turbine exhaust for reduction of NOx tends to produce ammonia sulfate, thereby reducing the heat recovery in the exhaust heat recovery boiler.

c) Reduction of Thermal Efficiency Due to Prevention of Low Temperature Corrosion of Exhaust Heat Recovery Boiler Tubes

As a combined cycle power plant does not have the air preheater like conventional steam cycle plants, and the residual heat in the gas turbine exhaust gas is utilized only at relatively high temperature in order to prevent the low temperature corrosion of exhaust heat recovery boiler tubes with sulfur oxide components. This reduces the overall thermal efficiency.

d) Environmental Measures

The NOx generation in combustion of fuel with gas turbine tends to be larger as the thermal load in the combustor is higher and contains more excess air, particularly when fuels having high nitrogen content are used. The volume of exhaust gas is also larger than in a steam cycle plant of same capacity. For these reasons, the denitration system and the dust collector are larger in capacity.

Although the above problems exist when heavy oil, etc. is used, it is expected that the range of fuels usable in combined cycle power plants will be extended if the environmental performance and durability are further enhanced without reducing the economy by means of future technology development.

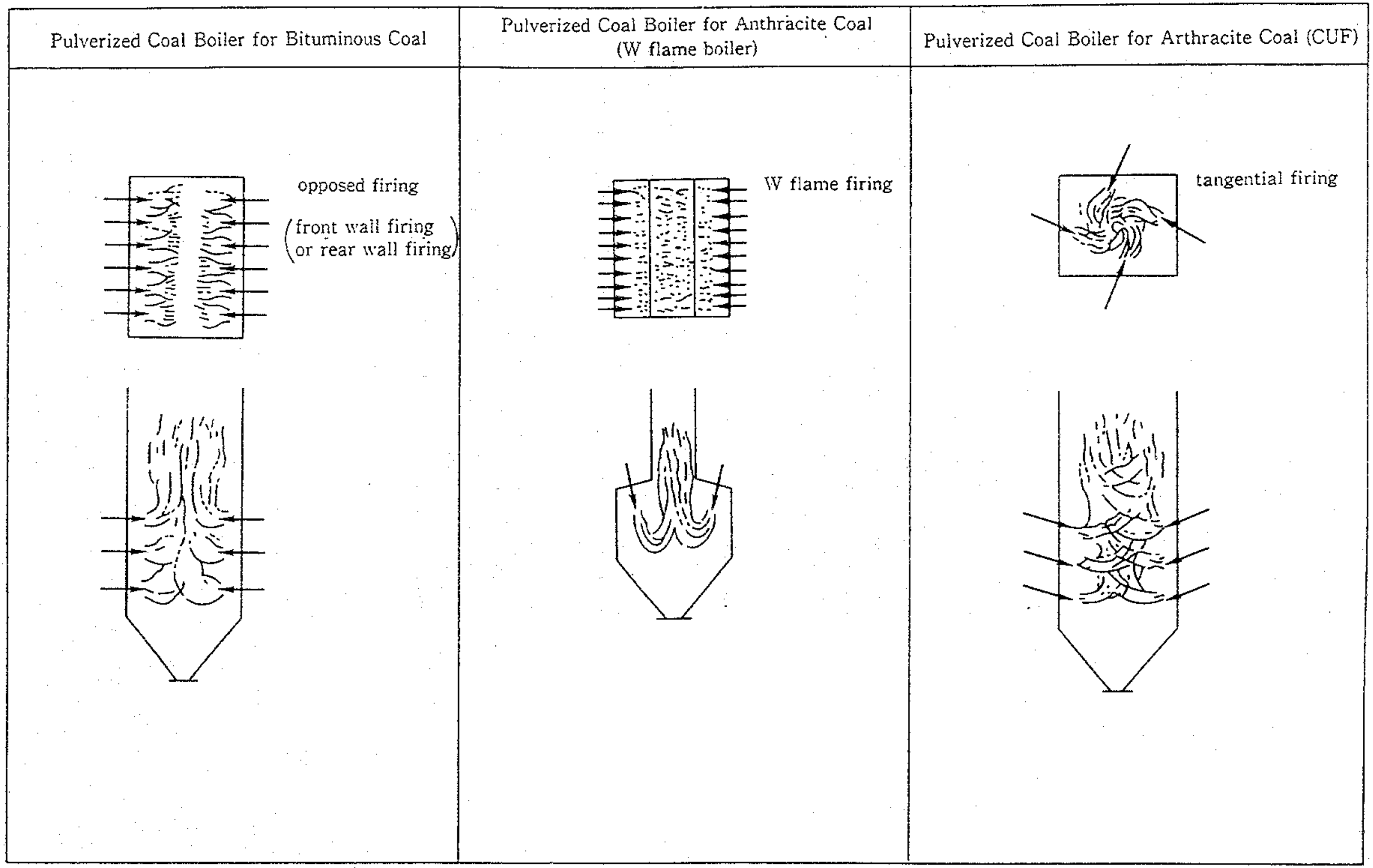


Figure 6.1.3-1 Combustion System for Bituminous Coal and Anthracite Coal

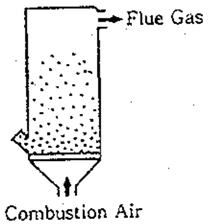
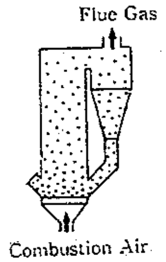
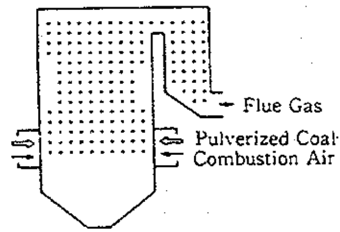
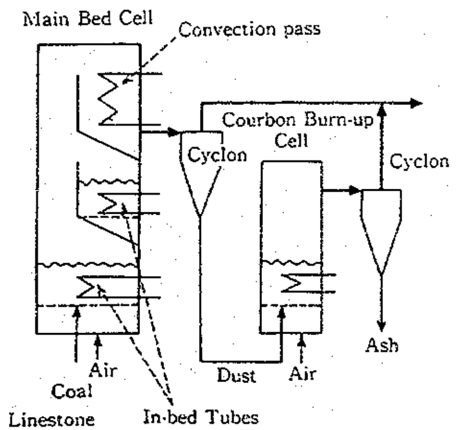
		Bubbling Type Atomuspheric FBC Builer	Circulgting Type Atomospheric FBC Boiler	(Reference) Pulverized Coal Boiler
Principle		 The gas flow speed in the combustion furnace is relatively low (1 to 2m/s), and the air bubbles rise through the dense particle layer of coal having relatively large diameter (600 to 900μm) and ash. The particles are fluidized with the rise of bubbling air, thereby enabling combustion at low temperature (approximately 850℃).	 The gas flow velocity in the combustion furnace is relatively high (4 to 8m/s) and coal of medium sized particle (100 to 200μm) ash, etc. are fluidized by the air flow. The low temperature combustion (approximately 850℃) is made possible by capturing the particles dispersed to the outside of the combustion furnace and recirculating them into the furnace.	 The gas flow speed inside the combustion furnace is relatively fast (11 to 15m/s), and the coal particles of small diameter (under 80μm) are dispersed with combustion air and burnt. For this reason, the combustion temperature is high (1400 to 1500℃).
Features	System Combustion Characteristics	· There is no constraint on coal brand, as no ash trouble without ash melting. · There is no constraint on pulverized coal as coarse coal particles are used. · High boiler efficiency is obtained by the heat transfer tubes in fluidized bed. · The combustion efficiency of low grade coal is high, although the combustion efficiency of high fuel ratio coal is reduced.	· There is no constraint on coal brand, as no ash trouble without ash melting. · There is constraint on pulverized coal as coarse coal particles are used. · The provision for expansion of heat transfer area is a problem in assuring boiler efficiency. · The combustion efficiency is high for large variety of fuels.	· Although the combustion efficiency is high, the coal brands are limited as the ash melts and cause troubles. · There is constraint on the coal pulverization performance of the mill.
	Operability	· The boiler can be operated in a wide loading renge, from 25 to 100%. · Quick load change ratio is possible, such as 3 to 5%/min.	· The boiler can be operated in a wide loading range, from 25 to 100%. · Quick load change ratio is possible, such as 3 to 5%/min.	· The boiler loading range is normal, being 30 to 100%. · The load change ratio is also normal, being 2~4%/min, due to operational condition of coal pulverizer.
	Maintainability	· Countermeasure is required against erosion of heat transfer tubes in the fluidized bed.	· The countermeasure against erosion of furnace heat transfer tubes is required because the concentration of recirculating particles is very high (500 to 600 times the bubbling type), and the gas flow velocity is high, being 4 to 8m/s.	
	Environmental Impact	· Desulfurization effitiency of 90% or more is possible. · NOx concentration is 100 to 200 ppm.	· Desulfurization efficiency of 90% or more is possible. · NOx concentration is 100 to 200 ppm.	· A desulfurizing eauipment having desulfurization efficiency of 90% is required on the downstream. · The NOx concentration is 200 to 250%. ppm.
	Feasibility of Large Facility	· The facility size can be expanded to 500 MWe, although there are such restrictions as the increase of coal feeding nozzles as the fluidized bed area is increased.	· As there is limit to the size of the cyclone, the boiler layout must be designed with particular effort, and a corresponding space is required. · A 110 MWe plant is currently in a demonstration test, and we must see how it turns out.	· Proven up to 1300 MWe.

Figure 6.1.3-2 Characteristics of Fluidized-bed Combustion (FBC) Boiler

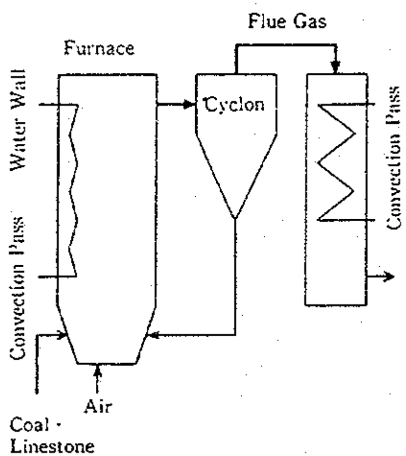
Bubbling Type Atmospheric FBC Boiler



Gas Velocity: 1~2m/sec
Combustion: Main Bed Cell and Curbon Burn-up Cell
Heat Surface: In-bed tubes, Water wall, and convection Pass

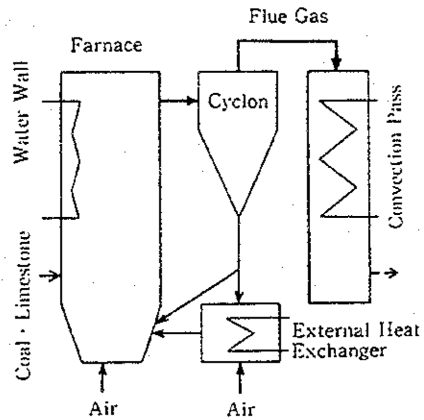
Circulating Type Atmospheric FBC Boiler

Ahlstrom Type



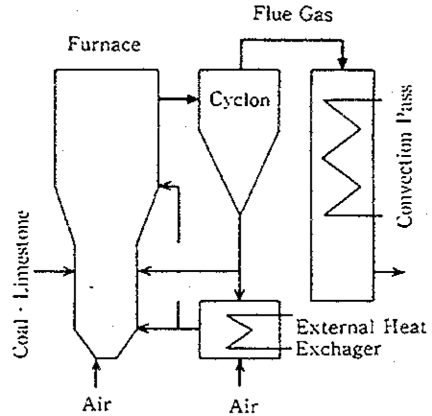
Gas Velocity: 4~5m/sec
Combustion: In Furnace
Heat Surface: Water wall, Panell SH/RH, and Convection Pass
Temperature Control: Inventry Control by adjustment of air distribution

Lurgi Type



Gas Velocity: 6~7m/sec
Combustion: In-Furnace
Heat Surface: External Heat Exchanger, Water Wall, and Convection Pass
Temperature Control : Mass flow control of external heat exchanger

Battel Type



Gas Velocity: 8~10m/sec
Combustion: In Furnace
Heat Surface: External Heat Exchanger, and Convection Pass
Temperature Control: Mass flow control of external heat exchanger

Figure 6.1.3-3 Systems of Circulating FBC Boiler

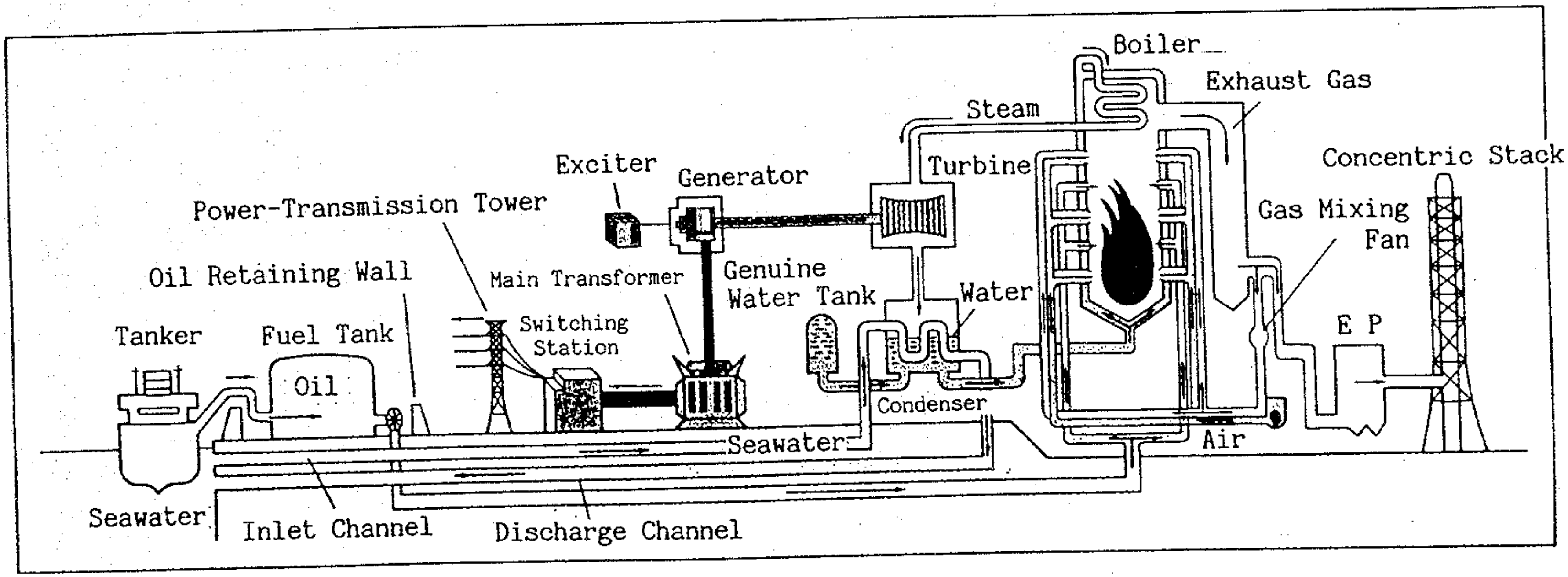


Figure 6.1.3-4 General Oil Fired Power Plant System Diagram

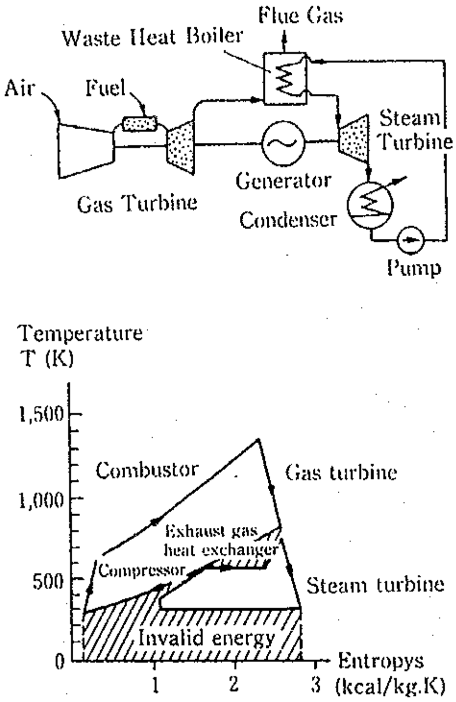


Figure 6.1.3-5 Combined Cycle

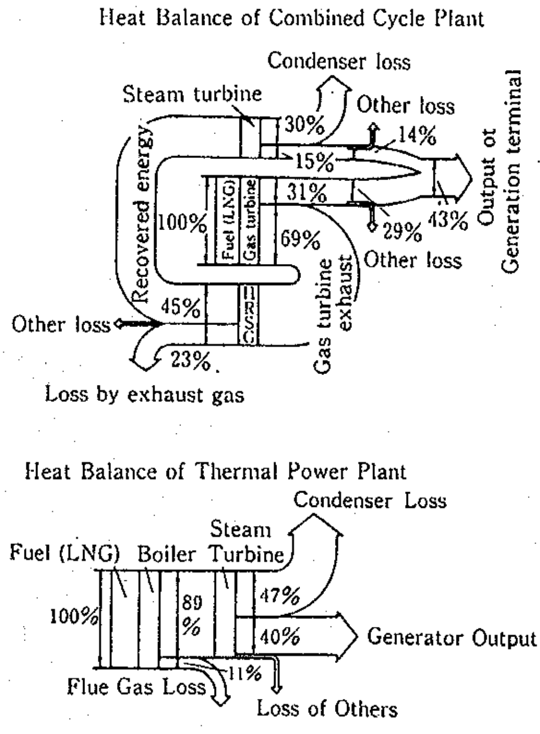


Figure 6.1.3-7 Heat Balance

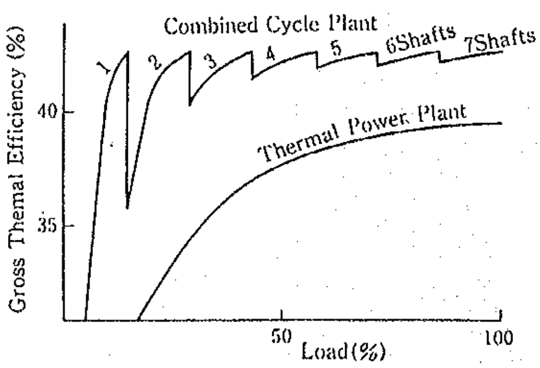


Figure 6.1.3-8 Thermal Efficiency

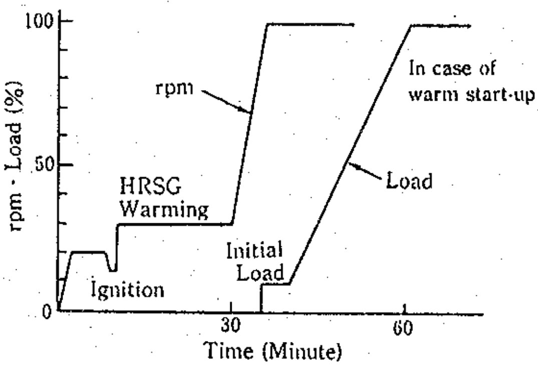
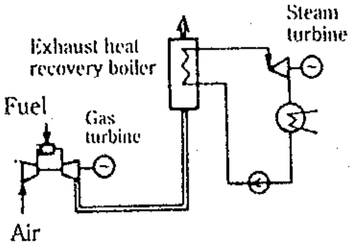
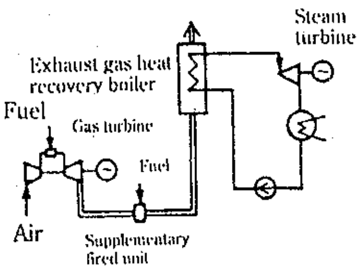
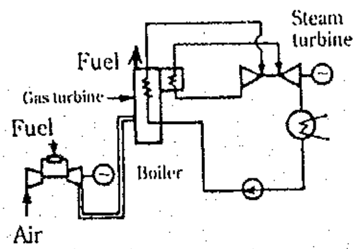
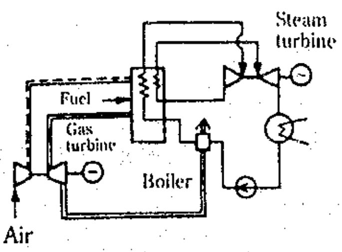
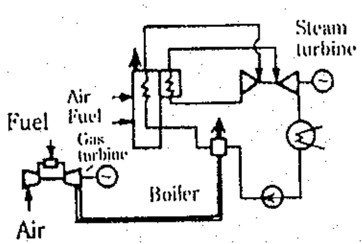


Figure 6.1.3-9 Start - up Schedule

Figure 6.1.3-6 Combined Cycle Power Generating Systems

Types	Systems	Features
Exhaust heat recovery		1. The system is simple. 2. The output ratio of gas turbine is large 3. The increase of plant thermal efficiency is greater as the gas turbine temperature is increased. 4. The start-up time is short. 5. Independent operation of steam turbine is not possible. 6. The condenser cooling water discharge per plant is less. 7. Suitable for replacement of existing plant.
Supplementary fuel to exhaust gas		1. The steam turbine output ratio is larger as the supplement fire is large. 2. The optimal supplement fire is determined by the gas turbine exhaust gas temperature, and the optimal supplement fire becomes smaller as the gas turbine temperature is higher. 3. The startup time is a little longer than the exhaust gas recovery system. 4. Independent operation of steam turbine is not possible. 5. The condenser cooling water discharge becomes larger as the supplement fire is increased. 6. Can be adopted as the replacement system of existing plant.
Exhaust gas refiring		1. The plant control system is complicated. 2. The steam turbine output ratio is large. 3. The fuel for boiler can be selected independently from the gas turbine. 4. The thermal efficiency becomes highest when the steam turbine capacity is so selected that the gas turbine exhaust gas is utilized to the maximum extent. However, as the excess oxygen in the gas turbine exhaust becomes little according to higher temperature of gas turbine, it is required to supplement the combustion air of the boiler with forced draft fan. 5. Independent operation of steam turbine is possible (when 100% capacity forced draft fan is installed). 6. The condenser cooling water discharge is a little less than conventional plant. 7. It is difficult to apply this system to replace existing plant.
Supercharged boiler		1. The steam turbine output ratio is a little larger. 2. The gas turbine inlet gas temperature can be reduced (but this is an obsolete technology because 1,100℃ class gas turbines are practically used). 3. The fuel for boiler is constrained by the gas turbine. 4. The steam turbine can not be operated independently. 5. It is not possible to apply this system to replace existing plant.
Feed water heating		1. The system is simple. 2. The improvement of thermal efficiency is little unless the steam turbine capacity is made large. 3. The fuel for boiler can be selected independently from steam turbine. 4. Used as the repowering of existing plant.

6.1.4 Estimation of Smoke Density

(1) Conditions of Calculation

- Fuel Anthracite (5,500 kcal/kg, Sulfur oxide 0.5%)
- Plant Capacity 300 MW x 1u
  300 MW x 2u
  300 MW x 1u + 300 MW x 2u
  300 MW x 2u + 300 MW x 2u
  One stack for two units. Plant efficiency is assumed to be 34%.
- SOx volume is calculated from sulfur contents in the coal.
- NOx volume is estimated on the assumption of 600 ppm at the stack outlet.

(2) Calculation Equation

Bosanque-Sutton equation: the same meteorological conditions are used as those in Japan except ambient temperature 25°C adopted in Viet Nam.

(3) Results of Estimation

(a) Maximum Value

Table 6.1.4-1 Maximum Value

(Unit: ppb)

	Stock Height	300 MW x 1u	300 MW x 2u	300 MW x 1u 300 MW x 2u	300 MW x 2u 300 MW x 2u
SOx	150 m	12.5	8.5	21.0	17.0
	180 m	10.0	7.1	17.1	14.2
NOx	150 m	20.4	13.9	34.3	27.8
	180 m	16.4	11.6	28.0	23.2

(b) Daily Average

Table 6.1.4-2 Daily Average

(Unit: ppb)

		300 MW x 1u	300 MW x 2u	300 MW x 1u 300 MW x 2u	300 MW x 2u 300 MW x 2u
SOx	150 m	7.4	5.0	12.4	10.0
	180 m	5.9	4.2	10.1	8.4
NO	150 m	12.0	8.2	20.2	16.4
	180 m	9.7	6.8	16.5	13.6

(c) Most Concentrated Point

Table 6.1.4-3 Most Concentrated Point

(Unit: km)

Stack Height	300 MW x 1u	300 MW x 2u
150 m	12.0	14.9
180 m	13.6	16.5

(d) Vietnamese Environmental Criteria

Table 6.1.4-4 Environmental Criteria

(Unit: ppb)

	Max. Value	Daily Average
SOx	175	17.5
NOx	41.4	41.4

Max. Concentration = 1.72 x (emission volume)/He^2

Most concentration point = 20.8 x $He^{1.143}$ x 10^{-3} (km)

[Example of Calculation] 300 MW x 2u

(a) Effective Stack Height

Hm = 106 Ht = 148 (J = 10)

$$He = \begin{pmatrix}150\\180\end{pmatrix} + 0.65\ (106 + 148)$$

$$= \begin{pmatrix}approx.\ 315\\approx.\ 345\end{pmatrix}$$

(b) Most Concentrated Value

1) SOx max. value = $\begin{pmatrix}8.5\ ppb\\7.1\ ppb\end{pmatrix}$ for $\begin{pmatrix}150\ m\\180\ m\end{pmatrix}$

SOx daily average= $\begin{pmatrix}5.0\ ppb\\4.2\ ppb\end{pmatrix}$ for $\begin{pmatrix}150\ m\\180\ m\end{pmatrix}$

2) NOx max. value= $\begin{pmatrix}13.9\ ppb\\11.6\ ppb\end{pmatrix}$ for $\begin{pmatrix}150\ m\\180\ m\end{pmatrix}$

NOx max. value= $\begin{pmatrix}8.2\ ppb\\6.8\ ppb\end{pmatrix}$ for $\begin{pmatrix}150\ m\\180\ m\end{pmatrix}$

(c) Most Concentrated Point

14.9 km for 150 m
16.5 km for 180 m

[Bosquat-Sutton's Equation]

$$\text{Fuel Consumption} = \frac{Load\ (MW)\ x\ 860\ (kcal\ /\ kWh)}{Calorific\ Rage\ (kcal\ /\ kg)\ x\ Plant\ Efficiency}$$

$$= \frac{300\ (MW)\ x\ 860\ (kcal\ /\ kWh)}{5{,}500\ (kcal\ /\ kg)\ x\ 0.34}$$

= 140 (ton/h)

SOx Emission = 7 x Coal Consumption (t/h) x Sulfur Contents
⇒ approx. 490 (Nm^3/h)

NOx Emission (600 ppm) ⇒ approx. 800 (Nm^3/h)

Effective Stack Height : He

He = Ho + 0.65 (Hm + Ht)

where,

Ho : Stack height (150/180 m)
Hm: Momentum lifting height
Ht: Lifting height by buoyant

$$\begin{cases} Hm = 0.795\sqrt{Qt \bullet V}\ /\ (1 + \frac{258}{V}) \\ Ht = 2.01\ x\ 10-3\ x\ Qt\ x\ (T-298)\ (2.3\ \log J + \frac{1}{J} - 1) \end{cases}$$

where,

$$J = \left(1\ /\ \sqrt{Qt \bullet V}\right)\ \{1{,}460 - 296V\ /\ (T-298)\} + 1$$

V: Emitting speed (approx. 30 m/sec)
T: Flue gas temperature 373°K
Qt: Emission volume at 25°C (350 m^3/sec)

6.1.5 Economy of Thermal Power Plants

Generating unit cost of each type of thermal power plants are tentatively estimated with assumptions of related parameters in the table. (See Table 6.1.5)

As reference, example of generating cost in the developed country is shown in Figure 6.1.5.

Figure 6.1.5 Cost Estimation of Electricity by OECD/ENA (1992)

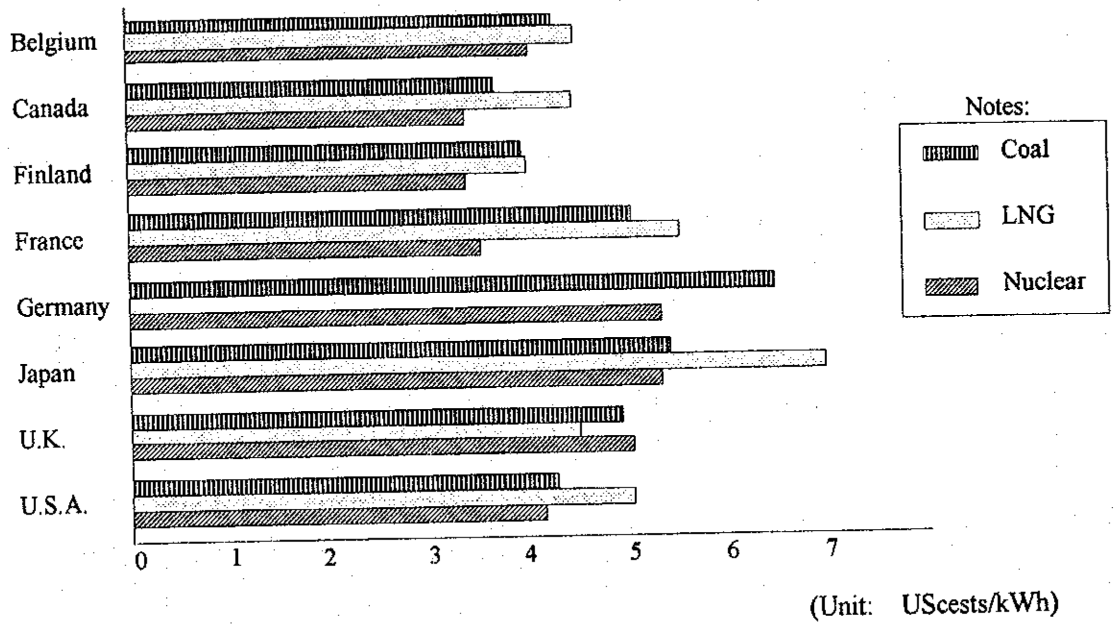


Table 6.1.5 Tentative Estimation of Thermal Power Plants

Item	Coal		Gas	Combined Cycle		
Output MW	2 x 300		2 x 300	2 x 300		
Unit Cost $/kW	1,250		1,100	800		
Annual Energy GWh (Load factor 60%)	3,150		3,150	12,830*		
Life (yr.)	25		25	20		
Station Service (%)	6		3	1.5		
FOR (%)	8		8	6		
Max. Efficiency (%)	34		38	40		
Heat Rate (kcal/kWh)	2,520		2,260	2,150		
Heat Value	5,500 kcal/kg		10,500 kcal/m^3	10,500 kcal/m^3		
OM Cost (%)	5.0		5.0	5.0		
CRF (i = 10%)	0.11017		0.11017	$0.11746 \times \frac{1}{0.9}$ *1		
Fuel Cost Unit Cost (cent/kWh)	24 $/t	34 $/T	2.5 $/MBTU (104.17 $/$m^3$)	2.0 $/MBTU (83.33 $/$m^3$)	2.5 $/MBTU (104.17 $/$m^3$)	3.0 $/MBTU (125.00 $/$m^3$)
Captal Cost ($/kW)	137.7	137.7	121.2	122.8	122.8	122.8
OM Cost ($/kW)	62.5	62.5	55.0	40.0	40.0	40.0
Fixed Cost	@3.806	@3.806	@3.350	@3.095	@3.095	@3.095
*1 Fuel Cost	@1.100	@1.558	@2.242	@1.706	@2.133	@2.560
Unit Cost	@4.906	@5.364	@5.592	@4.801	@5.228	@5.655

*1 Output is decreased in 10% due to higher ambient temperature.
*2 (Unit price) x (Heat Rate) x 1/(Heat Value)