国際協力事業団

エネルギー省
ヴィエトナム社会主義共和国

ヴィエトナム社会主義共和国

全国電力開発計画調査

最終報告書

付録 Vol. I

1995年9月

電源開発株式会社
(財)日本エネルギー経済研究所

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第 1 章　序　論

第1章 序 論

目 次

第1章　序 論

1.1 供与機材

1.1.1 ハードウェア

(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) I/F for Scanner

(d) Phone Net (GT-404P)

(2) Macintosh System

(a) Macintosh Centris 660AV
(17 "Color Display, Keyboard)

(b) HP Laser Jet 4

(c) Digitizer A3

(d) HP Scan Jet IIcx

1.1.2 ソフトウェア

(1) IBM System

(a) MS-Excel V 5.0 (E) for Windows

(b) MS-Word V 6.0 (E) for Windows

(c) MS-Access V 2.0 (E) for Windows

(d) Visual Basic Pro (E) for Windows

(e) Wordperfect V 6.0 (E) for Windows

(f) MS-Windows V 3.1

(g) Norton Utility (E) V8.0

(h) MS-Visual C++ Pro Windows

(i) MS Fortran Power Station

(j) XPRESS MP

(k) Micro TSP

(l) Desk Scan II

(m) Adobe Type Manager

(n) Type Reader

(o) DOS Printer Drivers for PH Laser Jet4, HP Explorer, Printing System

(p) DOS Drivers for HP Laser Jet 4L, HP Explorer, Printing System

(2) Mackintosh System

(a) Mackintosh System 7.1 (E)

(b) MS-Excel V 4.0 (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 書 籍

(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) Vietnam 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)

第3章　電気事業の現状

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 caliculated 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	Industry	Non-I.	Trans.	Agri.	House.	T.Sales	Import from PC1	PC2	Losses (%)	Generation
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

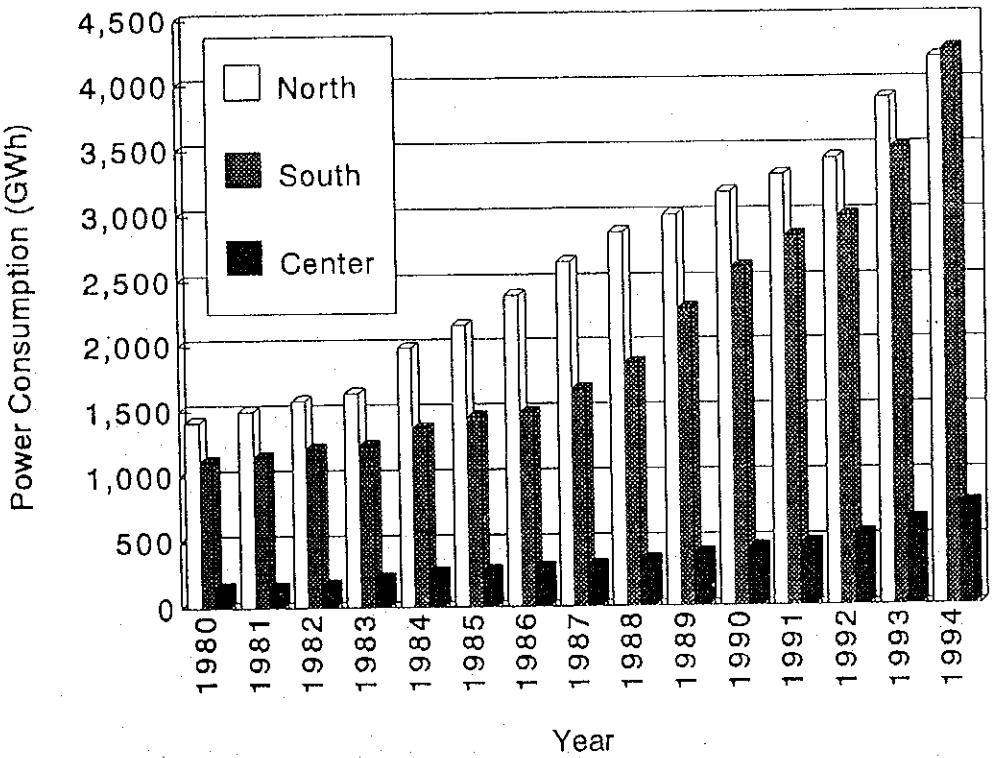


Table 3.4.1 EXISTING 220 KV TRANSMISSION SYSTEM FACILITIES
(As of end-December, 1994)

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

<u>Substations</u>

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.

第５章　電力需要予測

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 >

$$\mathrm{LOG(DI)} = -0.5787 + 0.4186*\mathrm{LOG(GDPi)} + 0.6642*\mathrm{LOG(DI(-1))}$$

(-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 >

$$\mathrm{LOG(DA)} = -0.8735 + 0.478*\mathrm{LOG(GDPa)} + 0.5323*\mathrm{LOG(DA(-1))} +$$

(-0.69) (2.44) (3.16)

$$0.1448*\mathrm{DUM80} - 0.2863*\mathrm{DUM}*82 - 0.2002*\mathrm{DUM83}$$

(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 >

$$\mathrm{LOG(DR)} = 0.5419 + 0.3582*\mathrm{LOG(USER)} + 0.8029*\mathrm{LOG(DR(-1))}$$

(1.05) (2.51) (6.97)

R-Squared = 0.97
Standard Error = 0.086
Durbin-Watoson Ratio = 1.64

$$\mathrm{USER} = \mathrm{ELECT}*\ \mathrm{POPULATION}$$

$$\mathrm{ELECT} = -1.2244 + 0.2795*\mathrm{LOG(GDP/CAPITA)}$$

(-15.69) (18.40)

R-Squared = 0.97
Standard Error = 0.006
Durbin-Watoson Ratio = 0.88

< Power demand for others, DO >

$$\mathrm{DO} = -5125.8 + 669.77*\mathrm{LOG(GDPo)} + 86.758*\mathrm{DUM88}$$

(-16.20) (17.13)

R-Squared = 0.98
Standard Error = 27.38
Durbin-Watoson Ratio = 1.55

< Total power demand, DT >

$$\mathrm{DT} = \mathrm{DI} + \mathrm{DA} + \mathrm{DR} + \mathrm{DI}$$

II. Northern, Central and Southern Regions

< Power demand for industrial use >

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

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

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

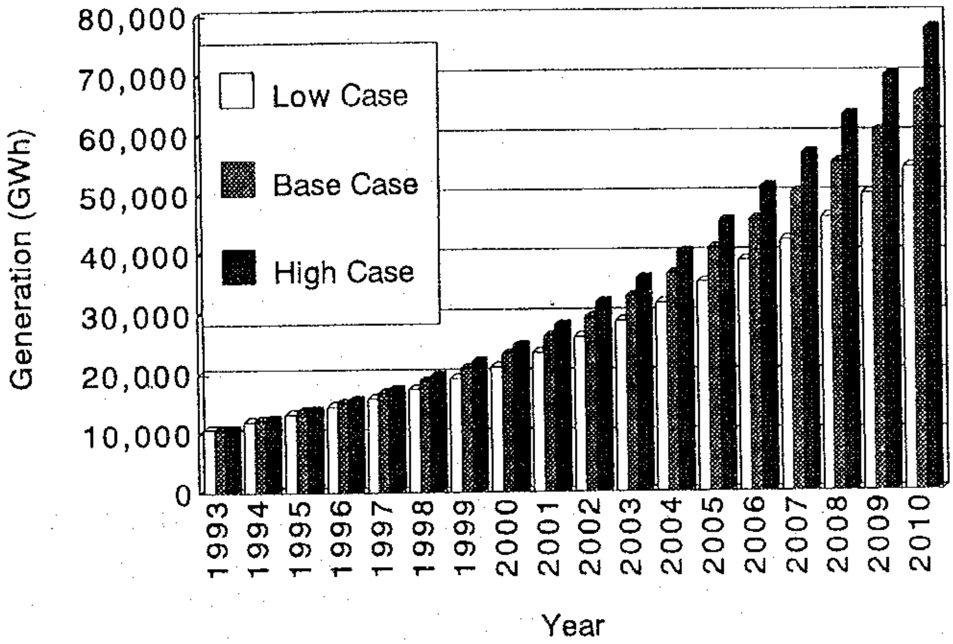


Figure 5.4-2 Peak Load Forecast Up to 2010

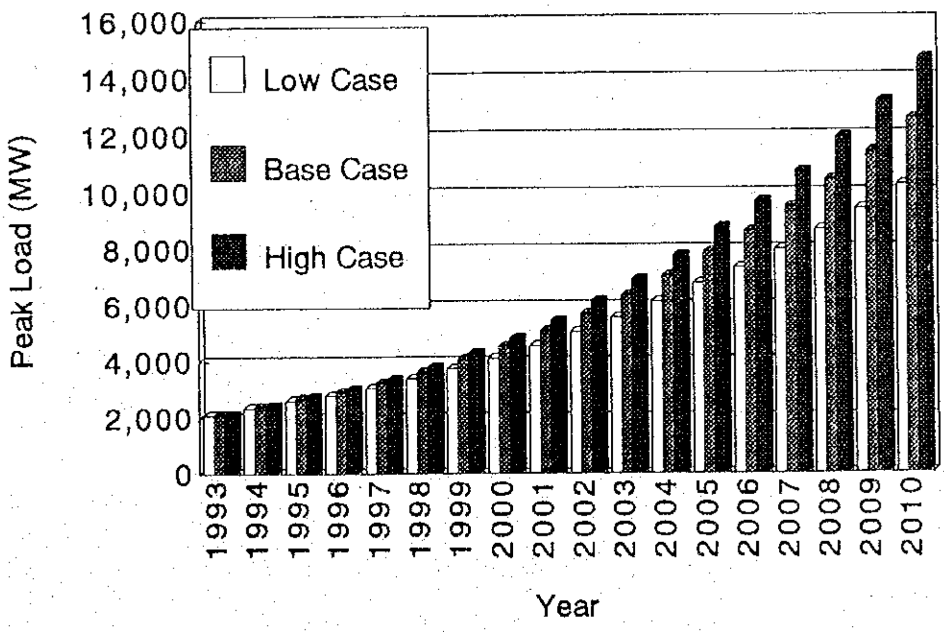


Table A1-1 Power Demand Forecast - Whole Country

Low case

Year	Regional Demand (GWh) Industry	Agriculture	Others	Residential	Total (GWh)	Losses (%)	Generation (GWh)	Load Factor (%)	Peak Load (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) Industry	Agriculture	Others	Residential	Total (GWh)	Losses (%)	Generation (GWh)	Load Factor (%)	Peak Load (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) Industry	Agriculture	Others	Residential	Total (GWh)	Losses (%)	Generation (GWh)	Load Factor (%)	Peak Load (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) Industry	Agriculture	Others	Residential	Total (GWh)	Losses (%)	Generation (GWh)	Load Factor (%)	Peak Load (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) Industry	Agriculture	Others	Residential	Total (GWh)	Losses (%)	Generation (GWh)	Load Factor (%)	Peak Load (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)				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	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)				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	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) 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	2,012.7	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) 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	2,061.4	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)

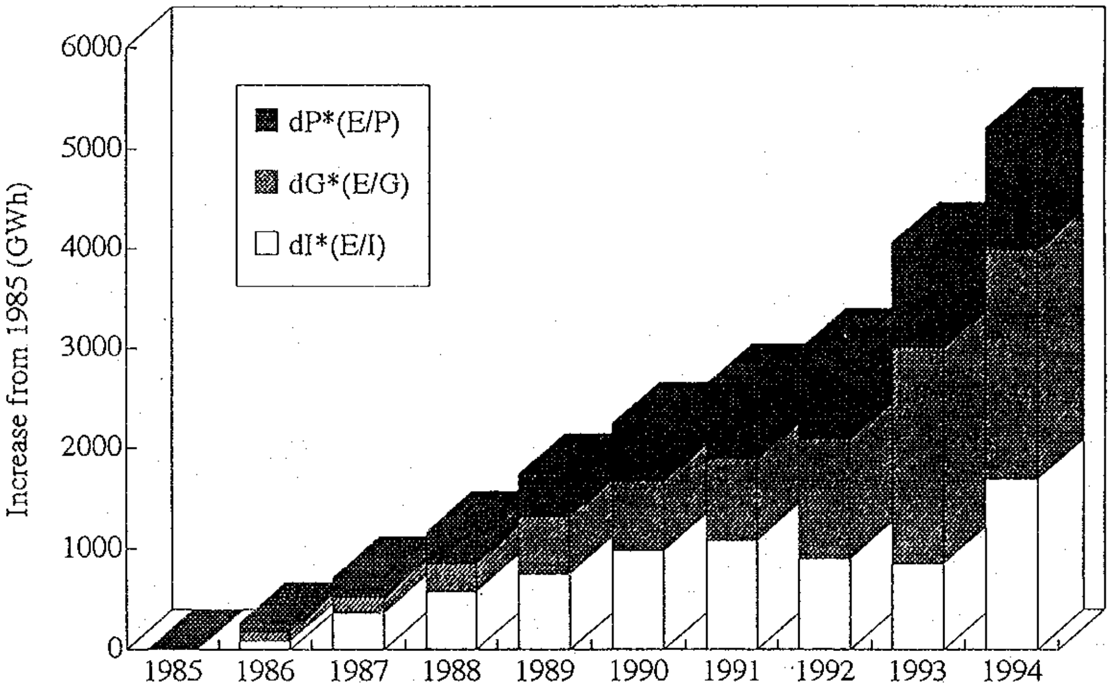


Figure 5.5-2 Factor Change in End-Use Consumption (Malaysia)

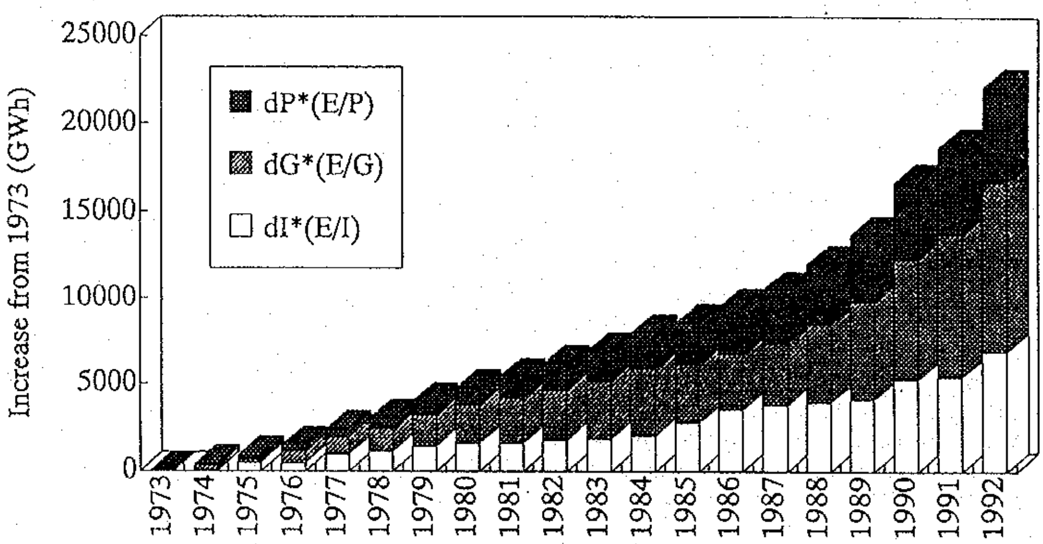


Figure 5.5-3 Factor Change in End-Use Consumption (Thailand)

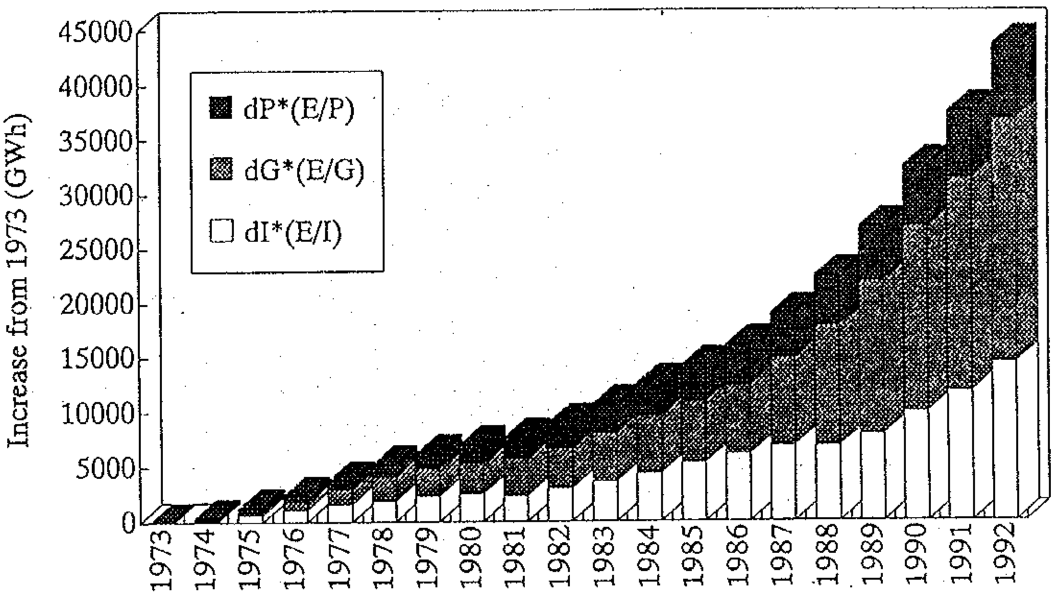


Figure 5.5-4 Factor Change in End-Use Consumption (S. Korea)

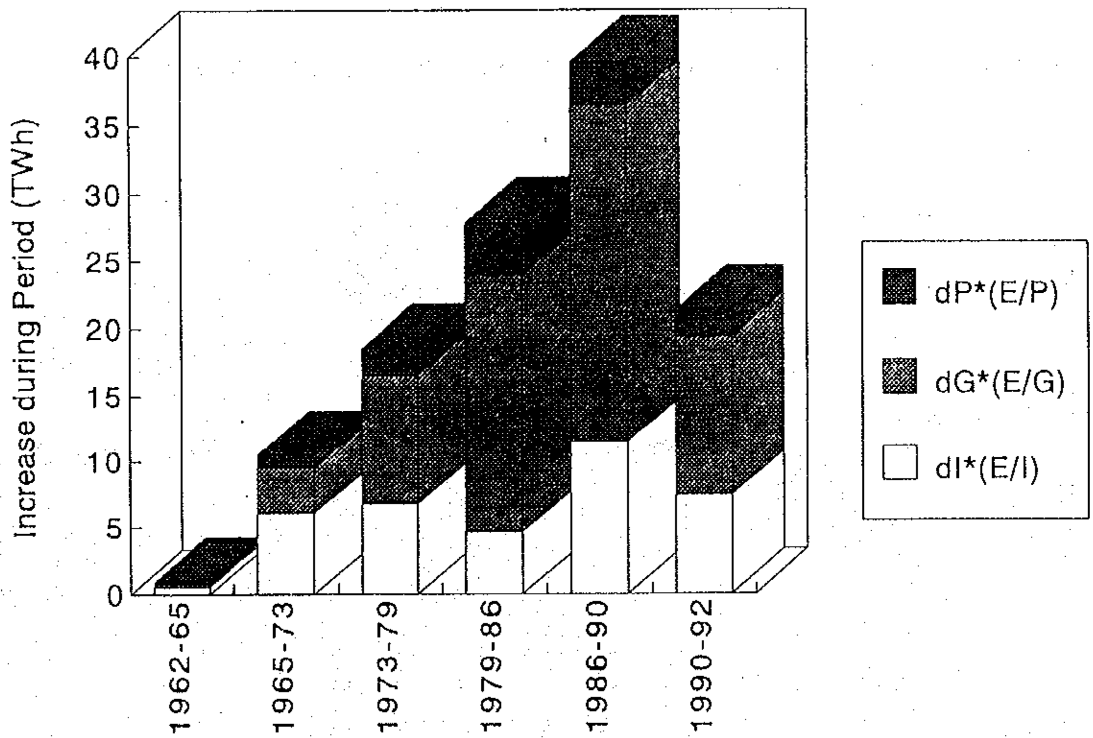


Figure 5.5-5 Factor Change in End-Use Consumption (Taiwan)

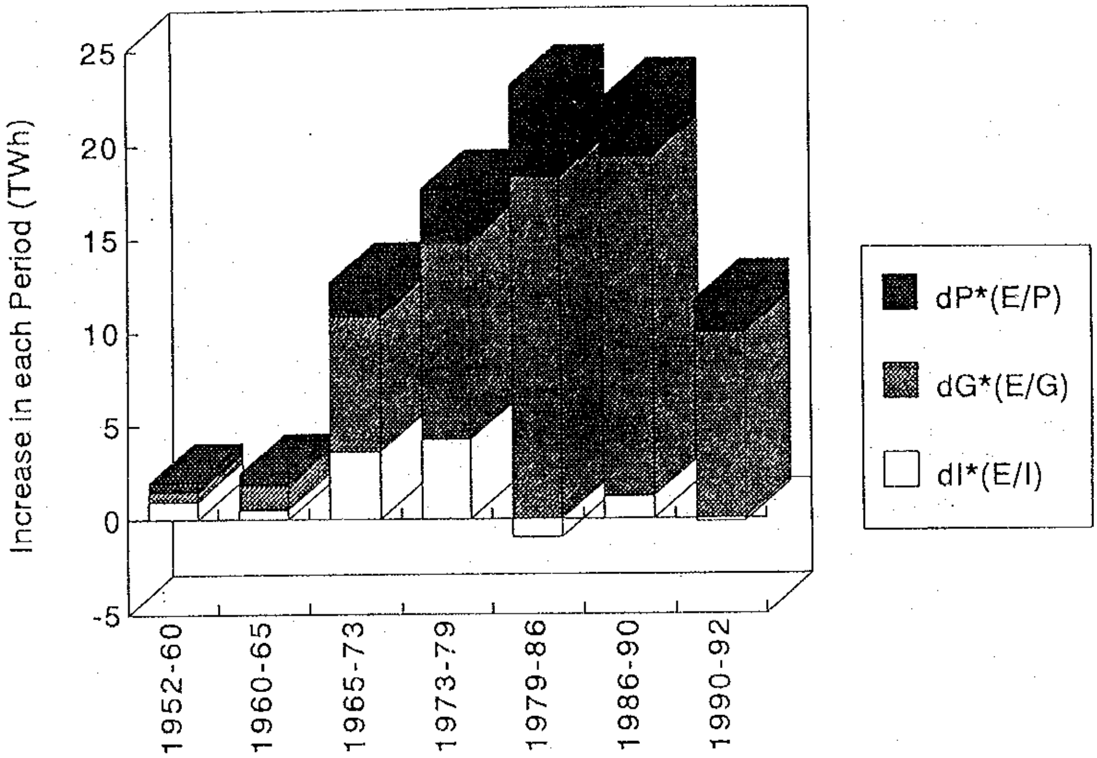
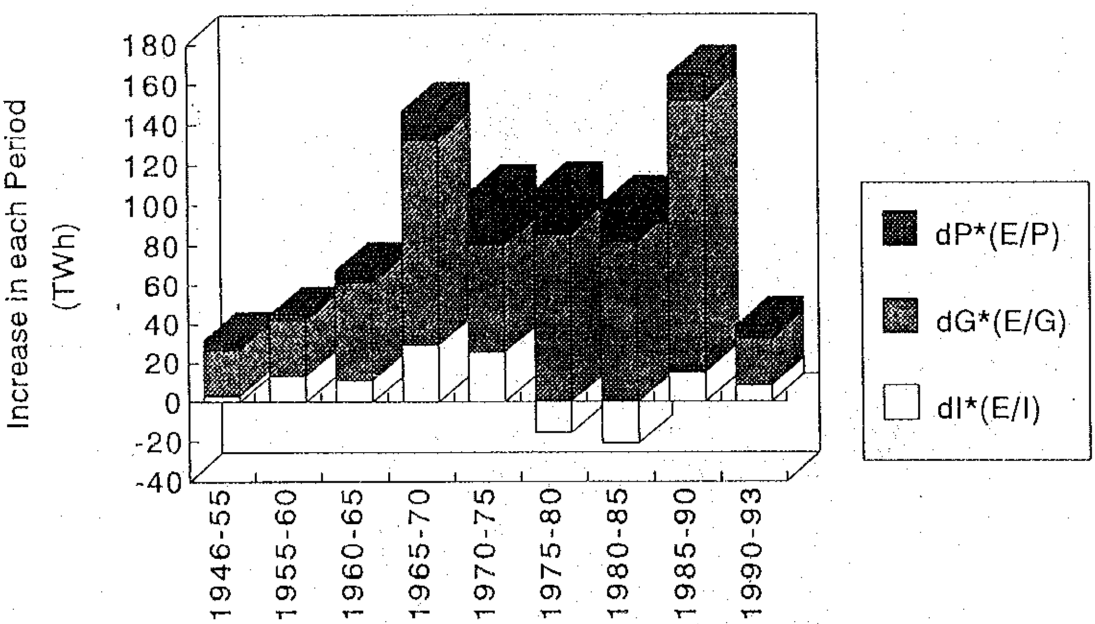


Figure 5.5-6 Factor Change in End-Use Consumption (Japan)



第６章　個別案件計画の見直しと評価

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目　次

頁

第６章　個別案件計画の見直しと評価

6.1　火力発電設備

6.1.1　電源開発計画地点

第３次電源開発計画（1992年から2000年までの期間が対象）に組み入れられている電力開発プロジェクトは次の通りである。

(1) 北部

(a) Pha Lai Ⅱ火力発電所拡張（２×300MW）

石炭火力発電設備（300MW）２基を既存のPha Lai火力発電所（石炭燃焼440MW）に隣接して追加建設する。これら新設備は、1999年中に就役の予定である。

(b) Quang Ninh火力計画（４×300MW）

1996年から1998年までの間に北部で予想される電力不足に対応するため、新石炭燃焼火力発電所をBOT方式で建設する。就役は1995年から1999年までの予定である。

(2) 南部

(a) Phu My火力計画（３×200MW＋２×300MW）

石油随伴ガスを燃料とする新火力発電所を、ホーチミン市の東約75kmのPhu Myに建設する。就役は1998年の計画である。さらに２×300MWの設備を2000年までに建設する計画である。

(b) Thu Duc火力発電所とBa Ria火力発電所のガスタービンの複合サイクルへの転換

Thu Duc火力発電所の２基のガスタービン設備とBa Ria火力発電所の５基の設備を複合サイクルシステムに転換する計画である。（それぞれ出力を 36.7MWと92.1MW（55.4＋36.7）づつ増強する。）これら複合サイクルシステムの就役は1996年頃の予定である。

(c) O Mon石炭火力計画（２×200MW＋２×200MW）

メコンデルタのO Mon建設地に石炭（または重油）燃焼火力発電所をBOT方式で建設する計画である。この開発は1995年から1999年までの間の予定である。

6.1.2 プロジェクト各論

(1) Pha Lai火力発電所

Pha Lai火力発電所はハノイの東約50kmのHai Hung省Pha Laiにあり、現在の総出力は 110MW設備4基、合計 440MWである。主な燃料は付近で採掘される品質N5の無煙炭である。

拡張計画は1994年に完成したヴィエトナム 500kV送電線により南部の電力不足に対応するよう計画された。

1999年に 300MWの設備2基を追加し、この発電所の総出力を 1,040MWにする。

F/Sの報告では、使用する予定の石炭は灰の含有量の多い高燃料比無煙炭の特性をもつため、重油30%を混合する予定になっている。この混合燃料燃焼計画は、燃焼試験完了後に再検討される。

この発電所は、既存のPha Lai発電所に隣接する計画であるが、この計画は近隣の炭坑の産炭規模と輸送の問題を考慮してさらに研究しなければならない。

このプロジェクトは、1993年6月にOECFのSAPROFチームが調査した。Pha LaiⅡ火力発電所の運転を始めることにより、石炭部門の開発に寄与するのみでなく、500kVの送電線の能力を活用して全国電力網の安定電力供給を強化する。

Pha LaiⅡ火力発電所は、1989年以降、中水位の年にはT_{max}=5,300時間／年で、また低水位の年はT_{max}=6,500時間／年に対する予備エネルギーで電力系統の電力バランスに寄与する。この発電所はまた周波数制御と電力系統の事故の場合と予備容量強化に寄与する。さらにNinh BinhやUong bi火力発電所等の古くからある発電施設を逐次置換していく。

(2) Phu My火力発電所

これは南部で予想される供給電力不足に対応するためのPC2の事業計画である。

当初この計画では、1998年までに 200MWの設備を3基就役させ、次に適切な時期（2000年頃）に追加の 300MW設備を2基就役させ、最終的に合計出力 1,200MWを開発する計画であった。

事業地域はホーチミン市の東約75kmにあり、道路条件は極めて良い。この用地は国道51号線から西に約3km離れた民家がほとんどない場所である。建築物その他の構造物に対する基礎条件がよく、また地所から 1.5kmのところに深い入江があって

冷却水設備や専用港湾設備の建設は容易である。

2005年頃まではVung Tau沖に噴出している石油随伴ガスを使用し、その後燃料を重油に転換することが計画されている。Petro Viet Nam社がVung TauからThu Duc火力発電所までの140kmのガスパイプラインを建設することが決定されている。Phu My火力発電所へはこのパイプラインから分岐してガスを供給することができる。

石油ガスの生産が枯渇する2005年に、燃料ガスから重油に切り換えるためボイラーを改造する計画である。また期待通りにガスが供給されないばあいは、重油を使用することが予定されている。

このプロジェクトは、1993年6月にOECFのSAPROFチームが調査研究した。南部系統No.2の電力需要は、第3次マスタープランで予想した量に向かって増大しつつある。ここに水力発電電源と並行して国の電力系統の構成単位として火力発電所を1基建設し、500kV送電線により全国規模の一次エネルギーバランスを確保することが必要である。この電源は、年間を通じて電力とエネルギーのバランスに組み入れられる。水の不足する年にはその運転時間は年間約 6,500時間となる。これとは別に、この電源は電力の品質を改善し電力系統No.2の既存の電源の経済的効果を増すための予備電源となる。

Phu Myの600MWの火力発電所はすべての需要を賄う能力がある。これは1997年末までに発電を開始し1998年末までに完成する計画である。この需要開発シナリオにもとづいて、発電能力は1999年から2000年の間に倍増（1,200MW）もありえる。

Phu My火力発電所の予定主燃料は、1997年から2007年までの最初の11年間は随伴ガスであり、予備燃料は重油である。もし2007年後に追加ガス量が供給されないときは、発電所は重油燃焼発電所に転換される。詳細な計算によればこの燃料転換は可能であり財政経済的見通しも優れている。

燃料供給と負荷配分と候補用地の比較研究と代案の財政分析にもとづいて、Phu Myの立地は火力発電所用地として最も適切であるとして選定された。

(3) O Mon火力発電所

ヴィエトナム南部の西部地域は13省からなり、ここは全国最大の米の産地であるCuu Longデルタである。Cuu Longデルタはエネルギー源から遠く離れ、従来電力は主としてThuduc- Cantho 220kV送電線から供給を受け、供給電力は容量も品質も不

十分であった。そのためここに発電所を建設して電力系統No.2の品質を改善し、西部領域の電力供給を強化する必要がある。

電力負荷の増大に対応し、予備電源を確保し、西部電力網と電力系統No.2の電力供給品質と技術目標を向上するため、西部火力発電所の建設は必要である。発電所容量の 400MWという規模は予想負荷の最高値とベース値に対して充分なものであり、この運転開始の適時は1999年から2003年の間である。発電所は2005年以降 800MWに拡張することができる。この西部火力発電所の燃料は、北部から輸送する無煙炭とする。補助燃料は重油とする。この発電所の石炭需要は、将来の適切な利用計画に対する総合的な石炭部門開発計画の中に組み入れるべきである。

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/cm²)	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/cm²)	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/cm²)	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: Types	Gas Turbine: Capacity (MW)	Gas Turbine: Numbers	Gas Turbine: Turbine Inlet Pressure (kg/cm²)	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	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: Types	Steam Turbine: Capacity (MW)	Steam Turbine: Number	Steam Turbine: Turbine Inlet Pressure (kg/cm²)	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 (MVA)	Transformer: Number	Transformer: Voltage (kV)	Transformer: Manufacturer	Year and Month of Commission	Remarks
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.

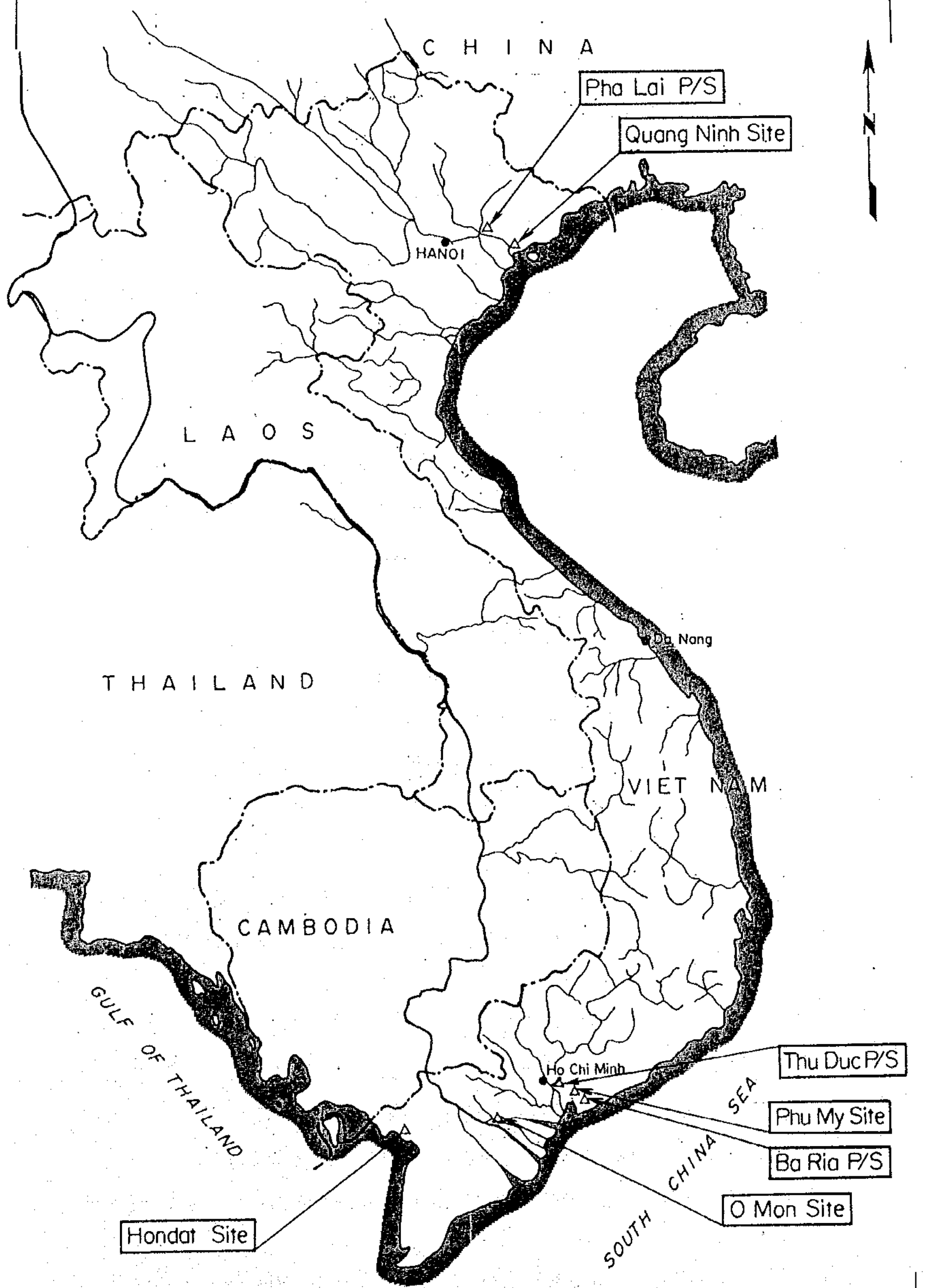


Figure 6.1.2: LOCATION of THERMAL POWER PLANT PROJECT

6.1.3 火力発電方式

(1) 無煙炭焚火力発電方式

(a) 無煙炭の特徴

無煙炭は石炭のうちでも最も炭化が進んだものであり、高炭素分という、いわゆる低揮発分（10%以下）、高燃料比（固定炭素／揮発分＝4.0以上）の特性を持つ石炭である。

従って無煙炭の燃焼は、高い着火・燃焼温度による長時間燃焼という特徴を持つことになり、発電事業用微粉炭ボイラのような急速燃焼には、もともと不向きな性状である。

(b) ヴィエトナム無煙炭の成分分析

ヴィエトナム無煙炭は、「ホンゲイ（Hon Gai）炭」の名称で日本国内に最近は年間約30万t輸入されているが、そのうちCam Pha炭鉱の８号炭及び９号炭（いずれも粉炭）について石炭の成分を分析されている。

この分析結果によると

- 燃料比（固定炭素／揮発分）： 7.8～ 8.1
- 揮発分（無水無灰ベース） ：10.9～11.4
- 固定炭素（無水無灰ベース）：88.6～89.1

となっており、国際規格においても無煙炭に近いデータを示しており、一般的に無煙炭（Anthracite：アンスラサイト）と呼べる性状を有している。

(c) ヴィエトナム無煙炭の温度特性

前項で分析を実施した石炭の温度特性は、揮発分による火炎発生燃焼がなく、固定炭素によるチャー燃焼が見られるだけであり前項の成分分析特性を裏付ける結果となっている。

(d) 無煙炭と瀝青炭の温度特性比較

ヴィエトナム無煙炭（８＆９号炭）と瀝青炭（ブレアソール炭）の温度特性について比較すると、瀝青炭は、300℃付近で揮発分による発熱が見られ、更に高温領域において470℃付近で炭素分による発熱のピークが見られる。

一方、無煙炭は揮発分による発熱が全く見られず530℃付近において炭素分燃焼による発熱ピークが見られるだけである。

これは、瀝青炭が先ず揮発分燃焼から始まり、続いて炭素燃焼に移る特性を示

すのに対し、無煙炭は揮発分燃焼がなく、いきなり炭素燃焼から始まり、それも瀝青炭よりも一層高温度雰囲気が必要なことを示している。

従って、ヴィエトナム無煙炭は瀝青炭の着火・燃焼特性と大幅に異なる性状を有しているため、その着火性及び燃焼安定性について格別の配慮が必要であり、微粉炭ボイラでの燃焼においては、ボイラ構造・バーナ型式・微粉粒度等、瀝青炭とは別の新たな設計・運転が要求されることになる。

(e) 無煙炭の燃焼方式

無煙炭は、これまで述べた通り揮発分が少なく炭素分が多い石炭であるため、

- 着火が容易ではない。
- 長い燃焼時間が必要である。
- 高い燃焼温度が必要である。

という特性を有しており、従来の瀝青炭焚ボイラのような水平吹込による急速燃焼方式では十分な燃焼性を得ることができない。

そのため、無煙炭焚ボイラでは一般的に垂直下方吹込として、バーナ火炎を長くすることによって比較的長い燃焼時間をかせぎ、かつバーナゾーンを耐火材で覆うことによってボイラチューブへの吸熱を防止し、高い燃焼温度を確保する方式（W形火炎炉）としている。また、バーナは微粉炭機において従来以上に細かな微粉粒度とするとともに、数多くのバーナを設置し微粉と燃焼用空気の混合性・接触性の改善を図り、良好な燃焼性を確保することも重要なファクターとなる。

(f) 200MW級無煙炭焚ボイラの概要

以上のような条件をベースに日本国内の代表的なボイラメーカであるＡ社、Ｂ社およびＣ社の200MW級無煙炭焚ボイラの概念設計によると、Ａ社およびＢ社は前項に示した通り、垂直下方バーナのW型火炎炉としているが、Ｃ社は斜め下方向（15°）吹込として、タンジェンシャル・ファイアリングによりファイアボールを形成して燃焼させる CUF (Circular Ushaped Flame) ボイラを開発しており、これにより無煙炭を専焼することが可能としている。〔Figure 6.1.3-1 参照〕

ボイラメーカの200MWクラス無煙炭焚ボイラの主要な仕様は以下の通り。

○ボイラサイズ	ボイラ建屋　高さ	約50m
	ボイラ建屋　奥行き	約30m
	ボイラ建屋　幅	約40m

この建屋内に、ボイラ本体及び補機を納めることが可能。

○性能

- 燃焼効率　約95～97%
- ボイラ効率　約84～88%

無煙炭は燃えにくい性質を有しているために、未燃カーボンの発生により、燃焼効率は瀝青炭焚ボイラに比べて低下し、ボイラ効率も90%を下廻る効率となる。また、無煙炭の燃焼性を安定させるためには、微粉度が細かい高微粉炭として燃焼させる必要があり、そのために、チューブミル（数多くの小さなミルボールにより石炭を粉砕するもの）の採用及び微粉セパレータの改良等により高微粉炭を石炭バーナへ供給し、更に、比較的小容量のバーナを多数設置することにより、空気との混合性・接触性を良好にして、無煙炭を微粉炭燃焼させる。

○環境諸元（ボイラ出口）

- ＳＯｘ　400 ～　500 ppm
- ＮＯｘ　500 ～ 1,000 ppm
- ばい塵　30 g/m^{3}N

SOxは、無煙炭の含有硫黄分（Ｓ分）によって決定されるが、ヴィエトナム無煙炭の場合、Ｓ分は最大0.5%と硫黄含有量が低いため、ボイラ出口SOxも400～500ppm程度の比較的低い数値となる。

NOxは無煙炭の含有窒素分（Ｎ分）が１%以下（0.9%程度）と低いため、フュエル（Fuel）NOx発生量は少ない。一方、サーマル（Thermal）NOxは、前述の石炭分析が示す通り、揮発分が少なく固定炭素分燃焼のみとなるため、瀝青炭と比べて60℃程度高い着火温度となることから、比較的高い燃焼温度が必要とされ、サーマルNOxは瀝青炭に比べ発生量は多くなる。従って、トータルNOx発生量（ﾌｭｴﾙ NOx＋ｻｰﾏﾙ NOx）は瀝青炭より多くなり、ボイラ出口NOxは500～1,000ppmの範囲と予想される。

ボイラNOx発生量は低NOxバーナや２段燃焼方式の採用により、サーマルNOxの低減が可能であるが、設備コストの上昇に結びつくことから、環境規制、対設備コストの関係から、低NOx燃焼方式の採用について、排出規制値を考慮しながら決定することが必要である。

ばい塵については、ボイラ出口で30～50g/m^{3}Nであり、電気集塵器（EP）の設

置より煙突出口で300～500mg/m³N以下（集塵効率99％以上）という数値が可能であると判断される。

なお、Vang Danh炭は灰溶融温度が他のヴィエトナム産無煙炭に比べて低く、ボイラのクリンカトラブルが心配されるので、ボイラ設計炭として考慮する場合には、今後慎重な取扱いが必要となる。

(g) 循環流動層燃焼技術

燃焼方式には、大きく分けて固定床燃焼、噴流床燃焼及び流動床燃焼に分類できる。さらに、流動床燃焼方式はバブリング方式と循環方式に分類される。これらの原理、特徴を Figure 6.1.3-2 に示す。

この中で、流動床燃焼方式は一般的に下記の特徴を有するといえる。

- 灰が溶融せず、灰トラブルがないため、炭種の制約が少ない。
- 流動媒体を有するため、失火の懸念がない。
- 粗粒炭を燃焼するので、石炭の破砕性に制限がない。
- 炉内で脱硫が可能で、また、発生NOxも少ない。
- 粒子濃度が非常に高く、炉内伝熱管の磨耗対策が必要である。

さらに、循環流動層方式では、下記の特徴が加わる。

- 粒子を循環するため、炉内での滞留時間が長く、燃焼性の悪い石炭でも比較的効率的に燃焼できる。
- 循環粒子濃度が非常に高濃度であるため、炉内伝熱管の磨耗対策が重要である。

無煙炭を燃焼しようとする場合、石炭の着火性が悪い、燃焼完結時間が長い、未燃分を減らすには高温での燃焼が必要等の性質に配慮が必要である。循環流動床燃焼方式では、この無煙炭の性質に対して、下記のように対応可能である。

無煙炭の性質	循環流動床方式の特徴
着火性が悪い	流動媒体を有するため失火の懸念がない。 着火性の制限も少ない。
燃焼完結時間が長い	粒子を循環するため炉内での滞留時間が長く、燃焼性の悪い石炭でも比較的効率的に燃焼できる。
未燃分を減らすには高温での燃焼が必要	粒子を循環するため炉内での滞留時間が長く、燃焼性の悪い石炭でも比較的効率的に燃焼できる。

このように、無煙炭を燃料とする場合、循環流動床方式が適しているといえ、各国にて無煙炭やオイルコークスを燃料とした循環流動床ボイラが実用化されている。

一方、循環流動床方式では下記の課題もある。

- 大型化する上で、サイクロンの技術的制約、炉内の均一化の維持等に課題があり、現状では200MWクラスの計画が最大である。
- 炉内伝熱管の磨耗対策に十分配慮する必要がある。

循環流動床方式には幾つかの方式があり、参考として、これを Figure 6.1.3-3 に示す。

(2) ガス火力発電所

Figure 6.1.3-4 に、一般的な油焚のシステム図を示す。

ガス火力発電所は、従来型の石炭、油焚火力と同様にボイラ、タービン、発電機等で構成されている。ボイラは石炭焚より小さく、油火力とほぼ同程度である。従って、油焚とガス焚は燃料供給装置とバーナを併設しておくことによって、燃料を自由に選択することができる。ガス焚火力の環境特性は非常に良好であるが、油併用で計画する場合にはEPを設置する必要がある。ガス専焼の場合には、図のタンク、ガス再循環ファン、EPが不要となる。

名目の熱効率は燃料種別によって大差ないが、正味の熱効率で比較すると、燃料前処理設備、灰処理設備、環境保全設備の所内動力の差によって、Gas＞Oil ＞ Coalの順に効率は高くなる。

近年日本においては、更なる効率向上を目的としてガス生焚の新設火力計画はなく、すべてコンバインドサイクルが採用されている。

(3) コンバインドサイクル発電

コンバインドサイクル発電は、汽力発電サイクル（ランキンサイクル）とガスタービン発電サイクル（ブレイトンサイクル）を Figure 6.1.3-5 のように組み合わせることにより、ガスタービンの最高利用温度が高いという利点と、蒸気タービンのサイクル最低利用温度が低いという利点を悦用したものである。すなわち、この二つのサイクルを組合わせることによって、汽力発電の高温化に対する制約は軽

減され、一方、ガスタービンの排ガス余熱によるエネルギーロスも低減される。

コンバインドサイクル発電の熱効率向上策としては、ガスタービン入口ガス温度の上昇が主なものであり、前述のごとく、現在の 1,100℃級のガスタービンによる場合、その熱効率は43％（LNG焚：高位発熱量基準）程度であるが、各方面で研究開発中の 1,300℃級のガスタービンによる場合は47％（同様）、さらに 1,500℃級のガスタービンによれば50％（同様）前後の熱効率が見込まれている。

(a) コンバインドサイクル発電方式の種類

コンバインドサイクル発電方式には Figure 6.1.3-6 に示す５種類があり、各方式には各々特徴があるため、その選択にあたっては、プラントの出力、燃料の種類、スペース等の設置条件あるいは運用条件などを考慮して最適な方式が選ばれる。

(b) コンバインドサイクル発電の特徴

近年の主流である排熱回収式コンバインドサイクル発電について、主な特徴をさらに詳述すると以下の通りである。

1）熱効率が高い

コンバインドサイクル発電の設計熱効率は、前述のとおり、従来の汽力発電の約40％に対し、現在の 1,100℃級ガスタービンを用いたもので43％（どちらもLNG焚：高位発熱量基準）程度に達し、後述の部分負荷効率が高いこと、起動停止時間が短く、その損失が少ないことなどの特長と相乗し、従来の汽力発電に比べ約１割の燃料節約を可能としてる。Figure 6.1.3-7 に汽力発電およびコンバインドサイクル発電の代表的な熱精算図を示す。

2）部分負荷における熱効率の低下が少ない

コンバインドサイクル発電プラントは、比較的小容量の単位機を組合せて大容量プラントが構成される。このため、出力の増減を、この単位機の運転台数の増減で行うことにより、広い出力範囲にわたり、定格出力のときと同等の高い熱効率を維持することができる。Figure 6.1.3-8 に、汽力発電およびコンバインドサイクル発電両プラントの部分負荷における熱効率の変化を示す。

3）起動停止時間が短い

前項と同様に、小容量機の組合せとなるため、負荷変化率が大きくとれ、また、短時間での起動停止が可能である。従来の汽力発電プラントが600MW級で

最短でも2時間半程度であるのに対し、コンバインドサイクル発電プラントでは、その起動時間は一軸型の場合で約1時間程度である（いずれも8時間停止後、定格出力に達するまでの起動時間）。Figure 6.1.3-9 に、一軸型排熱回収式コンバインドサイクル発電プラントの起動曲線を示す。

4）最大出力が外気温度によって変化する

コンバインドサイクル発電は、ガスタービンを主体に構成されるため、その最大出力は、外気温度により大きく変化し、外気温度が低いほど大きい。これは以下の理由によるためである。ガスタービンは、その翼の高温域における耐久性の観点から、ガスタービン第1段入口燃焼ガス温度の上限を定めて運転される。一方、コンプレッサの吸込可能な空気容積はほぼ一定であるため、大気温度が下がって空気密度が増加すると、吸込可能空気重量は増大することとなる。また、この場合、吸込温度の低下によって圧縮後の空気の温度も低下するため、ガスタービン入口燃焼ガス温度の上限値までの加熱代が大きくなり、吸込空気量の増加と相まって、多くの燃料を投入することが可能となる結果、ガスタービンの最大出力は増大する。

蒸気タービンについては、大気温度の低下に伴うガスタービン排ガス量の増大により、排熱回収ボイラの発生蒸気量が若干増大し、その分、最大出力が増加する。

以上により、コンバインドサイクル発電の最大出力は、大気温度の低下に伴い増大することとなる。

5）温排水量が少ない

コンバインドサイクル発電プラントの蒸気タービンは、その入口蒸気条件は汽力発電プラントに比べ悪いものとなるが、分担する出力はプラント全体の3分の1と小さいため、コンバインドサイクル発電プラントの温排水量は、同容量の汽力発電プラントの6～8割程度少なくなる。

6）使用燃料による性能等の変化が大きい

コンバインドサイクル発電プラント、なかでも排熱回収式の場合には、その優れた特性を効果的に発揮させるためには現状の技術レベルではクリーンな燃料の使用を要する。

現在、我が国で運転あるいは建設・計画中の排熱回収式コンバインドサイク

ル発電プラントにおける使用燃料は、LNG, LPG等のクリーンガス燃料、あるいは、上質で硫黄分の極めて少ない灯油に限られている。この主な理由としては以下が挙げられる。

a）ガスタービン動静翼の腐食防止のための設備の増加と熱効率の低下

重質油中の重金属、アルカリ金属、あるいは硫黄分などは、特に高温下にさらされるガスタービンの燃焼器あるいは動静翼の腐食の大きな要因となるため、燃料の前処理装置等の設置が必要となるとともに、それらの耐食性の観点から、ガスタービン入口燃焼ガス温度を低下させる必要も生じてくる。このため、設備費の増加や熱効率の低下をもたらすこととなる。

b）ガスタービン動静翼あるいは排熱回収ボイラチューブの未燃分等の付着による熱効率の低下

燃焼中の未燃分等がガスタービンの動静翼に付着し、その熱効率を低下させるとともに、NOx低減のためにガスタービン排気中に混入されるアンモニアと燃料中の硫黄分によって発生する酸化硫黄分により、硫安等が生成されやすく、排熱回収ボイラにおける熱回収を低下させる。

c）排熱回収ボイラチューブの低温腐食防止による熱効率の低下

コンバインドサイクル発電プラントには、従来の汽力発電における空気予熱器がなく、排熱回収ボイラチューブの硫黄分による低温腐食を防止するためにガスタービン排ガスの持つ余熱の利用が比較的高温域の範囲にとどまるので、総合熱効率の低下を招くこととなる。

d）環境対策

ガスタービンによる燃料の燃焼においては、燃焼器内の熱負荷が高く、過剰空気量が多いなどの理由により、特に窒素分を多く含む燃料を使用した場合には、そのNOx発生量が増大することとなり、また一方、排ガス量も同出力の汽力発電プラントに比べ多くなる。このため、脱硝装置あるいは煤塵処理装置が大規模なものとなる。

重質油等の使用にあたっては、現状では以上のような問題点があるが、今後の技術開発により、経済性を損なうことなく、環境性能あるいは耐久性の向上をはかることにより、コンバインドサイクル発電への適用燃料の範囲が一層広まることが期待される。

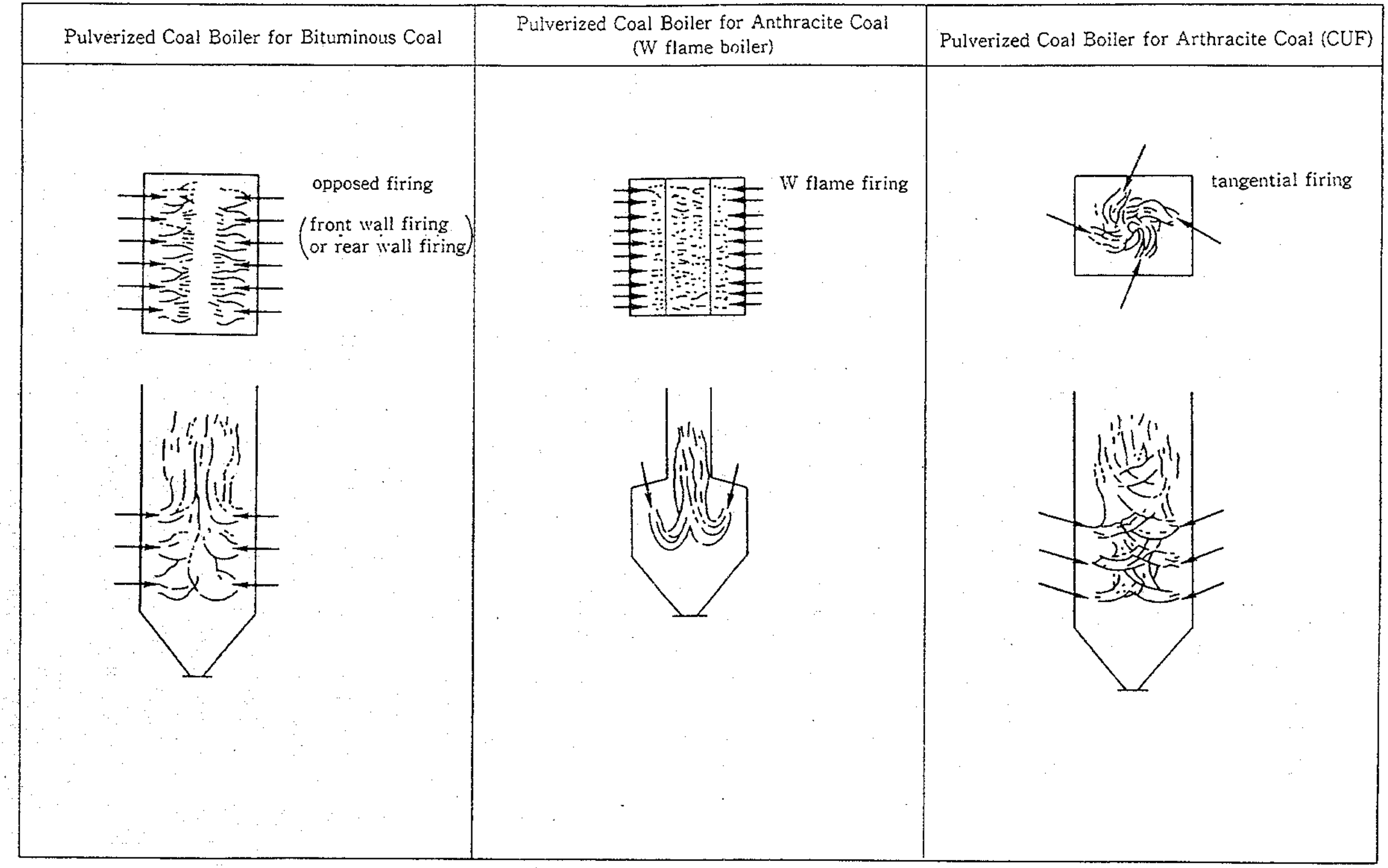


Figure 6.1.3-1 Combustion System for Bituminous Coal and Anthracite Coal

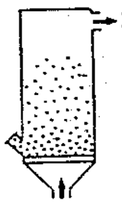
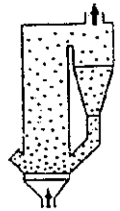
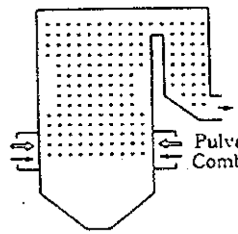
		Bubbling Type Atomuspheric FBC Builer	Circulgting Type Atomospheric FBC Boiler	(Reference) Pulverized Coal Boiler
Principle		 The gas flow speed in the combustion furnace is relatively low (1 to 2m/s), and the air bubbles rise through the dense particle layer of coal having relatively large diameter (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

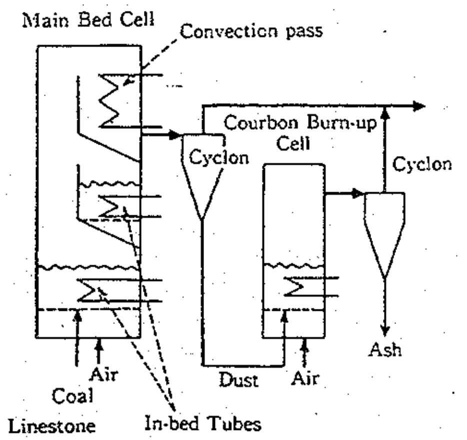
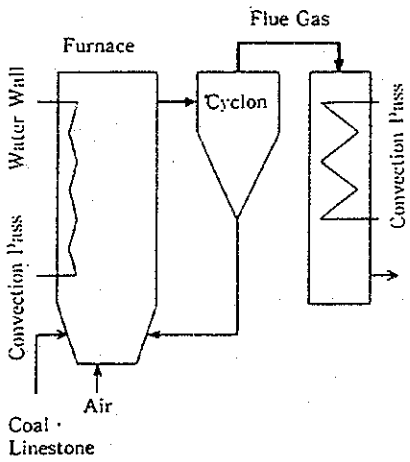
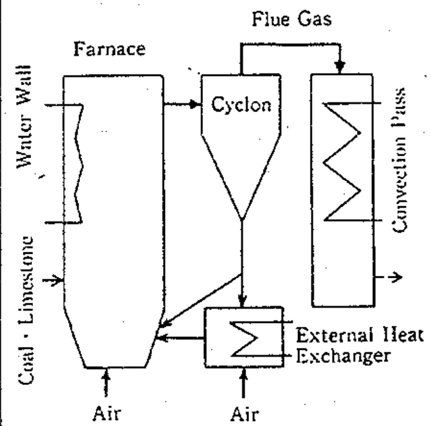
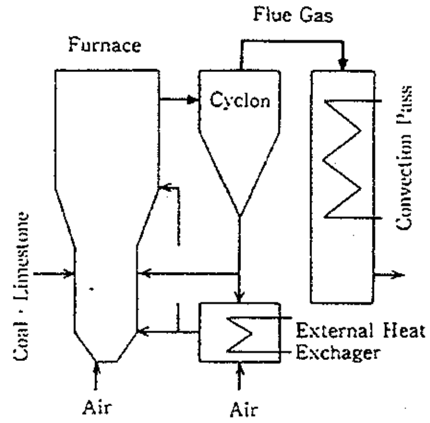
Bubbling Type Atmospheric FBC Boiler	Circulating Type Atmospheric FBC Boiler		
	Ahlstrom Type	Lurgi Type	Battel Type
			
Gas Velocity: 1~2m/sec Combustion: Main Bed Cell and Curbon Burn-up Cell Heat Surface: In-bed tubes, Water wall, and convection Pass	Gas Velocity: 4~5m/sec Combustion: In Furnace Heat Surface: Water wall, Panell SH/RH, and Convection Pass Temperature Control: Inventry Control by adjustment of air distribution	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	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

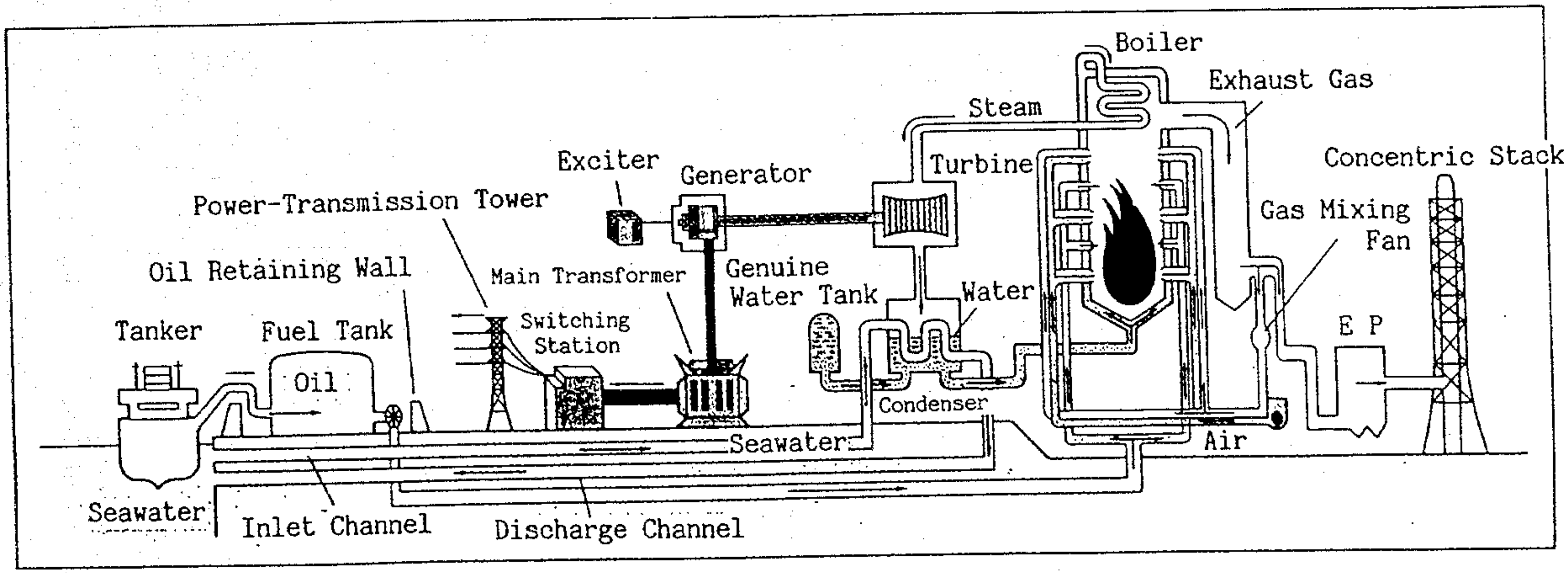


Figure 6.1.3-4 General Oil Fired Power Plant System Diagram

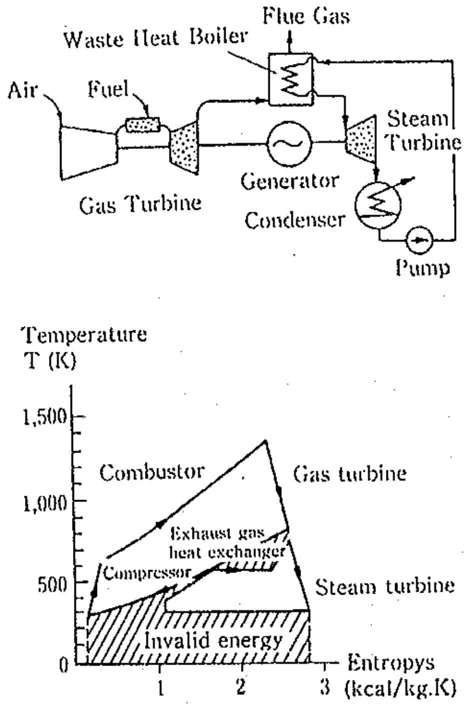


Figure 6.1.3-5 Combined Cycle

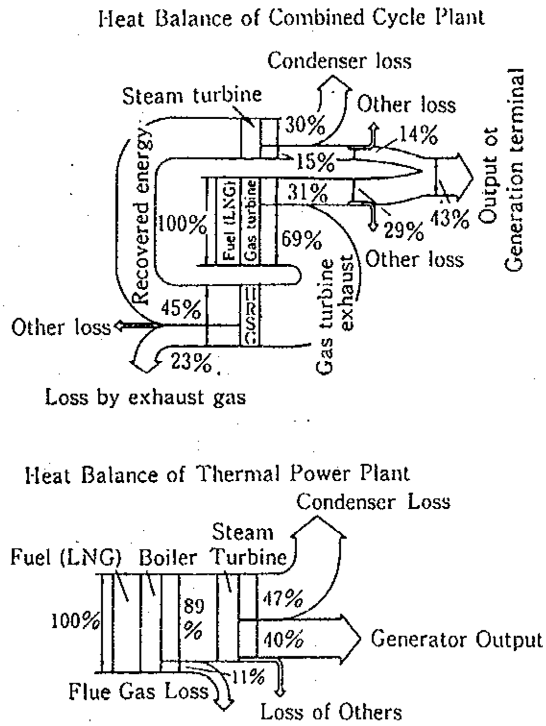


Figure 6.1.3-7 Heat Balance

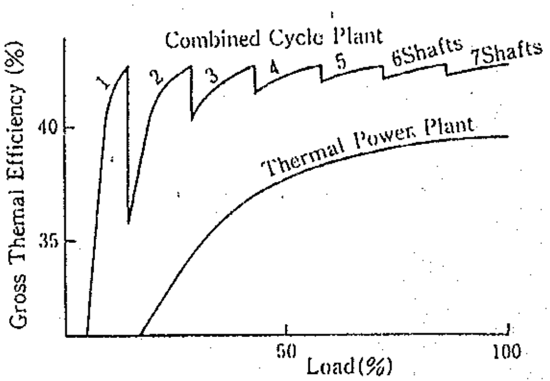


Figure 6.1.3-8 Thermal Efficiency

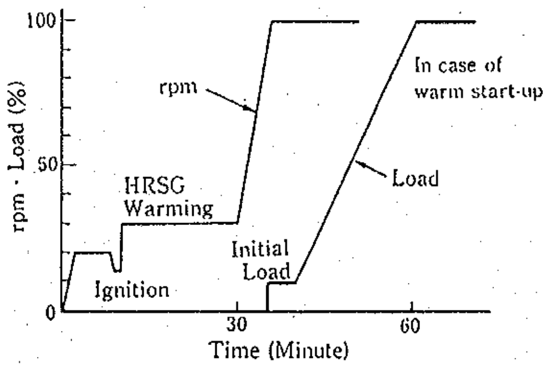
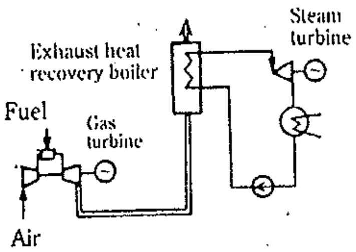
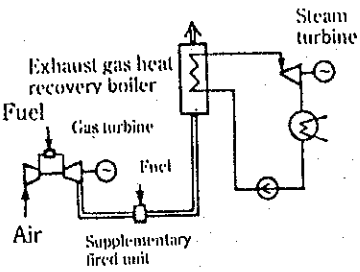
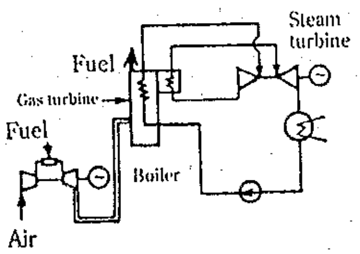
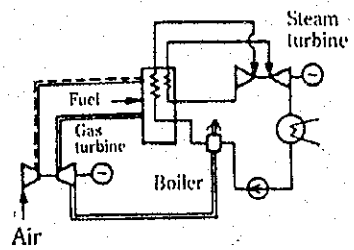
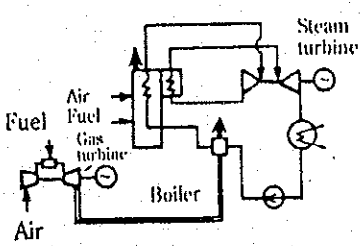


Figure 6.1.3-9 Start - up Schedule

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　煤煙拡散計算

(1)　計算条件

- 使用燃料　　無煙炭（発熱量：5,500kcal/kg、硫黄分：0.5%）
- 発電出力　（プラント定格効率：34%）

　— 300MW×１u

　— 300MW×２u（煙突は２缶集合）

　— 300MW×１u＋300MW×２u＝　900MW

　— 300MW×２u＋300MW×２u＝ 1,200MW

の４ケース指定

- 煤煙量　　SOx　：石炭中硫黄分より排出量を産出

　　　　　　NOx　：煙突出口濃度を600ppmとし排出量を算出

(2)　拡散計算式

ボサンケ・サットン式（気象条件は気温のみヴィエトナムの年平均25℃とし大気安定度の条件は日本で用いられる値を採用した。）

(3)　検討結果

(a)　最大値

Table 6.1.4-1　SOx, NOx 排出最大値

単位 ppb

	煙突高さ	300MW×1u	300MW×2u	300MW×1u 300MW×2u	300MW×2u 300MW×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)　1日平均値

Table 6.1.4-2　SOx, NOx 排出1日平均値

単位 ppb

	煙突高さ	300MW×1u	300MW×2u	300MW×1u 300MW×2u	300MW×2u 300MW×2u
SOx	150 m	7.4	5.0	12.4	10.0
	180 m	5.9	4.2	10.1	8.4
NOx	150 m	12.0	8.2	20.2	16.4
	180 m	9.7	6.8	16.5	13.6

(c)　最大着地濃度　出現地点　X_{max}

Table 6.1.4-3　最大着地濃度

単位 km

煙突高さ	300MW×1u	300MW×2u
150 m	12.0	14.9
180 m	13.6	16.5

(d)　ヴィエトナム国　環境基準

Table 6.1.4-4　環境基準

単位 ppb

	1時間値	1日平均
SOx	175	17.5
NOx	41.4	41.4

$$\text{最大着地濃度} = 1.72 \times \frac{\text{排出量}}{He^2}$$

$$\text{最大着地濃度出現地点} = 20.8 \times He^{1.143} \times 10^{-3}(\text{km})$$

[計算例] 300MW　2基

(a)　有効煙突高さ

Hm＝106　　Ht＝148　　(J＝10)

$$He = \begin{pmatrix} 150 \\ 180 \end{pmatrix} + 0.65\ (106+148) = \begin{pmatrix} \text{約 } 315 \\ \text{約 } 345 \end{pmatrix}$$

(b) 最大着地濃度1時間値（24時間値）

1）SOx

Ho＝ 150m ⇒ 8.5 ppb (5.0 ppb)

Ho＝ 180m ⇒ 7.1 ppb (4.2 ppb)

2）NOx

Ho＝ 150m ⇒ 13.9 ppb (8.2 ppb)

Ho＝ 180m ⇒ 11.6 ppb (6.8 ppb)

(c) 最大着地濃度出現地点

Ho＝ 150m ⇒ 14.9 km

Ho＝ 180m ⇒ 16.5 km

[ボサンケーサットンの式]

$$\text{燃料消費量} = \frac{\text{出力 (MW)} \times 860\ \text{(kcal/kWh)}}{\text{発熱量 (kcal/kg)} \times \text{プラント効率}}$$

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

$$= 140\ \text{(ton/h)}$$

SOx 排出量 ＝ 7×石炭消費量×S分含有量

NOx 排量量（600ppm）⇒約 800（N㎥/h）

有効煙突高：He

He＝Ho＋ 0.65（Hm＋Ht）

Ho：煙突地上高さ

Hm：排ガスのモーメンタムによる上昇高さ

Ht：排ガスの温度による浮力上昇高さ

$$Hm = 0.795\sqrt{Qt \cdot V} \,/\, \left(1 + \frac{258}{V}\right)$$

$$Ht = 2.01 \times 10 - 3 \times Qt \times (T - 298)\left(2.3 \log J + \frac{1}{J} - 1\right)$$

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

V：排ガスの排出速度

T：排ガス温度

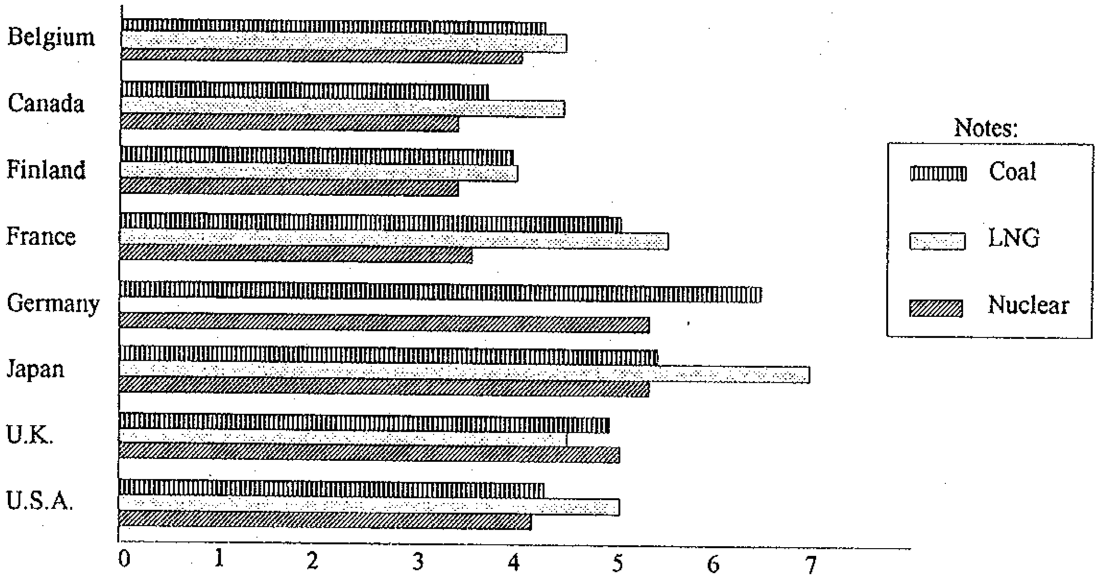
Qt：排ガス量

6.1.5　経済性評価

6.1.3項で述べた3種類の発電方法について諸種の経済・技術指標を想定して、平均発電単価を試算した結果は Table 6.1.5 のとおりである。

また、参考として欧米諸国の電気料金の概要についても Figure 6.1.5 に示す。

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



(Unit:　UScests/kWh)

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	$0.11746 x \frac{1}{0.9}$ *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)

6.2　水力発電設備

6.2.1　電力量見直し手順

見直しは以下の手順で行った。

(1)　計画地点の流入量によるマスカーブの作成

(2)　マスカーブと貯水池有効容量により保証流量(Qf)を算出

(3)　Qfに基づいて年間発生電力量が最大となるような貯水池運用ルールを作成（コンピューターにより自動的に決定される。）

(4)　流量資料保有期間中の月別出力、電力量の算定

(5)　保証出力の算定（本検討においては、計算期間中、95%以上発生可能な出力を保証出力と定義している。）

Appendix 6.2-1 Reviewed Projects and used discharge data and calculation term

Project	The Name of G/S	C.A. of G/S (km^2)	Start of Calculation	End of Calculation	Remarks
Hoa Binh	Hoa Binh	51,700	Jan,1961	Dec,1991	Along the Da river
Son La	Ta Bu	45,700	Jan,1961	Dec,1991	
Huoi Quan	N0.60.	2,930	Jan,1961	Dec,1991	
Yaly	Tuyen Dap	7,455	Jan,1961	Dec,1990	Along the Sesan river
Plei Krung	Tuyen Dap	7,455	Jan,1961	Dec,1990	
Thuong Kontum	Tuyen Dap	7,455	Jan,1961	Dec,1990	
Sesan 3	Tuyen Dap	7,455	Jan,1961	Dec,1990	
Sesan 4	Tuyen Dap	7,455	Jan,1961	Dec,1990	
Tri An	Cay Gao	14,800	Jan,1979	Dec,1986	Along the Dong Nai river
Ham Thuan	Cay Gao	14,800	Jan,1979	Dec,1986	
Da Mi	Cay Gao	14,800	Jan,1979	Dec,1986	
Dai Ninh	Cay Gao	14,800	Jan,1979	Dec,1986	
Dong Nai 8	Cay Gao	14,800	Jan,1979	Dec,1986	
Dong Nai 4	Cay Gao	14,800	Jan,1979	Dec,1986	

Appendix 6.2-1 Monthly Dischage (unit:CMS) at HUOI QUANG Dam Site No.60 gauging station 20 km upstream from dam site

Year	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Average	Total	Max	Min
1961	352.27	503.69	385.82	247.15	91.14	49.88	49.09	34.44	47.98	48.31	72.91	81.86	163.71	2,128.25	503.69	34.44
1962	287.41	299.71	580.41	236.41	146.50	82.64	62.40	62.63	40.60	29.86	48.98	98.64	164.68	2,140.87	580.41	29.86
1963	441.74	435.03	335.50	135.32	79.62	43.61	28.07	24.71	22.03	29.86	21.92	49.88	137.27	1,784.56	441.74	21.92
1964	183.40	421.61	309.77	176.69	127.49	192.35	70.79	42.83	32.32	31.09	44.62	89.02	143.50	1,865.48	421.61	31.09
1965	390.29	619.55	324.31	161.04	178.93	75.82	56.25	39.81	38.36	31.09	54.69	66.65	169.73	2,206.52	619.55	31.09
1966	488.71	498.77	367.93	138.67	183.40	139.79	78.95	52.90	37.02	26.62	33.10	46.97	174.40	2,267.23	498.77	26.62
1967	495.42	798.48	374.64	211.36	98.52	60.72	41.49	34.78	33.77	23.71	35.45	73.92	190.19	2,472.45	798.48	23.71
1968	167.75	297.47	493.18	176.69	82.20	54.80	46.30	33.55	36.79	31.87	69.11	100.98	132.56	1,723.25	493.18	31.87
1969	366.81	613.96	427.20	242.68	144.26	117.42	52.11	35.45	26.76	22.93	30.64	149.85	185.84	2,415.91	613.96	22.93
1970	295.24	479.76	885.71	148.74	75.15	84.55	41.83	43.17	36.68	23.82	44.17	266.16	202.08	2,627.06	885.71	23.82
1971	248.27	1,063.52	287.41	277.34	105.79	56.25	73.59	37.69	41.71	25.39	53.68	117.42	199.01	2,587.07	1,063.52	25.39
1972	413.78	521.14	726.91	229.26	91.37	51.67	36.90	36.46	26.84	25.16	45.18	119.66	193.69	2,518.02	726.91	25.16
1973	207.63	572.58	322.08	216.95	169.98	89.24	62.63	41.71	45.96	55.02	102.66	208.01	174.54	2,268.99	572.58	41.71
1974	390.29	421.61	441.74	295.24	107.14	55.80	37.35	28.29	22.70	22.81	35.45	99.98	163.20	2,121.60	441.74	22.70
1975	499.89	691.12	281.82	418.26	189.00	60.39	39.36	45.18	27.85	25.72	65.53	187.88	211.00	2,743.00	691.12	25.72
1976	384.70	338.85	199.06	187.88	119.66	116.31	57.26	40.04	49.99	32.65	61.62	216.95	150.41	1,955.38	384.70	32.65
1977	366.81	357.86	362.34	194.59	108.25	93.60	45.29	40.04	30.87	24.94	63.86	73.36	146.82	1,908.63	366.81	24.94
1978	275.11	674.35	347.80	128.61	121.90	66.88	49.88	61.28	37.46	27.18	26.50	206.89	168.65	2,192.49	674.35	26.50
1979	375.76	324.31	350.03	288.53	114.07	52.90	37.13	33.44	42.50	27.51	36.68	73.70	146.38	1,902.94	375.76	27.51
1980	265.04	365.69	588.24	450.68	88.24	45.18	30.98	23.71	24.38	20.80	27.06	81.53	167.63	2,179.16	588.24	20.80
1981	148.74	454.04	413.78	216.95	74.70	40.82	36.68	46.30	27.62	26.50	48.54	176.69	142.61	1,853.97	454.04	26.50
1982	315.37	509.95	490.94	269.52	135.32	118.54	54.13	36.90	40.71	24.27	56.59	61.28	176.13	2,289.65	509.95	24.27
1983	211.36	339.97	458.51	238.20	125.25	92.60	54.24	37.13	31.31	41.38	22.93	58.82	142.64	1,854.34	458.51	22.93
1984	162.16	284.05	362.34	313.13	138.67	100.65	43.61	33.44	26.17	20.80	66.09	209.13	146.69	1,906.93	362.34	20.80
1985	501.01	451.80	258.33	225.90	191.23	57.82	37.35	31.87	27.40	26.06	42.16	72.47	160.28	2,083.68	501.01	26.06
1986	296.35	339.97	374.64	281.82	78.73	127.49	53.01	33.77	24.60	20.13	90.81	194.59	159.66	2,075.57	374.64	20.13
1987	380.23	644.15	184.52	171.10	92.82	51.22	35.23	34.22	23.82	21.36	25.83	36.57	141.76	1,842.83	644.15	21.36
1988	156.56	376.87	306.42	149.85	138.67	83.09	40.26	34.89	31.42	24.49	38.82	165.51	128.90	1,675.75	376.87	24.49
1989	179.59	474.17	380.23	307.54	107.36	48.76	38.47	31.42	27.62	29.08	44.73	120.78	149.15	1,938.90	474.17	27.62
Ave.	318.89	488.76	400.75	232.28	120.87	79.68	47.95	38.35	33.22	28.29	48.63	120.87				
Max	501.01	1,063.52	885.71	450.68	191.23	192.35	78.95	62.63	49.99	55.02	102.66	266.16				
Min	148.74	284.05	184.52	128.61	74.70	40.82	28.07	23.71	22.03	20.13	21.92	36.57				

Appendix 6.2-1 Monthly Dischage (unit:CMS) at SON LA, Dam Site, River G.S. No.61 locating 6 km downstream from dam site

Year	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Average	Total	Max	Min
1961	2,424.0	2,856.0	5,632.0	2,434.0	1,730.0	1,086.0	776.0	692.0	504.0	350.0	350.0	692.0	1,627.2	19,526.0	5,632.0	350.0
1962	3,238.0	3,902.0	3,791.0	1,579.0	1,157.0	686.0	438.0	362.0	300.0	293.0	236.0	292.0	1,356.2	16,274.0	3,902.0	236.0
1963	1,076.0	2,876.0	3,329.0	1,619.0	1,488.0	1,740.0	720.0	516.0	406.0	338.0	325.0	682.0	1,259.6	15,115.0	3,329.0	325.0
1964	2,102.0	5,491.0	3,570.0	2,635.0	1,519.0	1,026.0	760.0	517.0	417.0	323.0	365.0	414.0	1,594.9	19,139.0	5,491.0	323.0
1965	2,223.0	3,621.0	3,168.0	1,428.0	2,032.0	1,921.0	991.0	690.0	484.0	357.0	336.0	487.0	1,478.2	17,738.0	3,621.0	336.0
1966	3,138.0	5,632.0	4,495.0	3,470.0	2,182.0	1,126.0	714.0	543.0	409.0	319.0	360.0	449.0	1,903.1	22,837.0	5,632.0	319.0
1967	1,066.0	2,866.0	4,365.0	2,132.0	1,348.0	1,086.0	724.0	648.0	523.0	408.0	586.0	788.0	1,378.3	16,540.0	4,365.0	408.0
1968	1,861.0	4,948.0	4,043.0	2,846.0	2,102.0	1,388.0	697.0	495.0	356.0	280.0	264.0	543.0	1,651.9	19,823.0	4,948.0	264.0
1969	1,569.0	3,208.0	7,130.0	2,072.0	1,096.0	831.0	530.0	436.0	358.0	268.0	312.0	1,177.0	1,582.3	18,987.0	7,130.0	268.0
1970	1,951.0	6,970.0	3,590.0	2,384.0	1,167.0	774.0	1,267.0	554.0	456.0	333.0	148.0	726.0	1,693.3	20,320.0	6,970.0	148.0
1971	2,715.0	4,224.0	8,005.0	3,389.0	1,408.0	883.0	547.0	457.0	338.0	285.0	357.0	547.0	1,929.6	23,155.0	8,005.0	285.0
1972	1,659.0	4,335.0	3,138.0	2,233.0	1,951.0	1,468.0	1,247.0	569.0	436.0	474.0	512.0	1,046.0	1,589.0	19,068.0	4,335.0	436.0
1973	2,404.0	3,399.0	3,993.0	2,665.0	1,458.0	1,227.0	680.0	494.0	375.0	316.0	363.0	593.0	1,497.3	17,967.0	3,993.0	316.0
1974	1,901.0	3,781.0	3,560.0	3,832.0	1,680.0	861.0	587.0	537.0	390.0	289.0	440.0	881.0	1,561.6	18,739.0	3,832.0	289.0
1975	2,534.0	2,967.0	2,223.0	1,881.0	1,307.0	1,056.0	689.0	501.0	555.0	358.0	390.0	1,197.0	1,304.8	15,658.0	2,967.0	358.0
1976	2,202.0	3,460.0	4,817.0	2,554.0	1,448.0	1,197.0	750.0	530.0	433.0	336.0	448.0	525.0	1,558.3	18,700.0	4,817.0	336.0
1977	1,368.0	5,049.0	3,791.0	1,589.0	1,589.0	965.0	602.0	659.0	396.0	291.0	262.0	1,096.0	1,471.4	17,657.0	5,049.0	262.0
1978	2,725.0	3,017.0	3,208.0	2,353.0	1,056.0	600.0	387.0	318.0	317.0	239.0	240.0	319.0	1,231.6	14,779.0	3,208.0	239.0
1979	1,207.0	2,524.0	4,073.0	4,304.0	1,378.0	625.0	449.0	325.0	313.0	243.0	225.0	350.0	1,334.7	16,016.0	4,304.0	225.0
1980	774.0	2,766.0	3,550.0	1,961.0	1,297.0	619.0	471.0	397.0	302.0	234.0	291.0	1,167.0	1,152.4	13,829.0	3,550.0	234.0
1981	2,444.0	3,631.0	4,184.0	2,957.0	1,629.0	1,770.0	863.0	596.0	485.0	299.0	478.0	344.0	1,640.0	19,680.0	4,184.0	299.0
1982	1,509.0	3,128.0	4,787.0	2,343.0	1,931.0	1,106.0	724.0	530.0	397.0	433.0	237.0	343.0	1,455.7	17,468.0	4,787.0	237.0
1983	911.0	1,619.0	4,214.0	3,631.0	1,519.0	1,951.0	891.0	614.0	405.0	285.0	297.0	945.0	1,440.2	17,282.0	4,214.0	285.0
1984	2,444.0	4,174.0	2,474.0	2,625.0	2,072.0	848.0	548.0	439.0	361.0	268.0	370.0	625.0	1,437.3	17,248.0	4,174.0	268.0
1985	2,213.0	3,409.0	3,471.0	3,258.0	1,227.0	1,760.0	861.0	527.0	381.0	296.0	472.0	1,016.0	1,574.3	18,891.0	3,471.0	296.0
1986	1,981.0	4,978.0	3,098.0	2,524.0	1,911.0	954.0	592.0	478.0	372.0	302.0	274.0	261.0	1,477.1	17,725.0	4,978.0	261.0
1987	939.0	3,118.0	3,007.0	2,394.0	1,659.0	1,227.0	654.0	447.0	383.0	285.0	300.0	901.0	1,276.2	15,314.0	3,118.0	285.0
1988	844.0	3,570.0	3,721.0	3,359.0	1,287.0	655.0	480.0	370.0	324.0	322.0	327.0	656.0	1,326.3	15,915.0	3,721.0	322.0
1989	2,011.0	2,816.0	1,730.0	1,649.0	1,307.0	749.0	461.0	344.0	320.0	494.0	430.0	1,569.0	1,156.7	13,880.0	2,816.0	320.0
Ave.	1,911.5	3,735.7	3,936.4	2,555.2	1,549.5	1,109.8	693.1	502.9	396.4	321.3	344.7	711.4				
Max	3,238.0	6,970.0	8,005.0	4,304.0	2,182.0	1,951.0	1,267.0	692.0	555.0	494.0	586.0	1,569.0				
Min	774.0	1,619.0	1,730.0	1,428.0	1,056.0	600.0	387.0	318.0	300.0	234.0	148.0	261.0				

Appendix 6.2-1 Monthly Average River Runoff at Hoa Binh Gauging Station

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average	Total	Max	Min
1961	526.0	498.0	396.0	432.0	456.0	2,583.0	2,853.0	6,527.0	3,073.0	2,192.0	1,391.0	963.0	1,824.2	21,890.0	6,527.0	396.0
1962	861.0	607.0	428.0	402.0	800.0	3,792.0	4,790.0	4,480.0	2,235.0	1,477.0	837.0	538.0	1,770.6	21,247.0	4,790.0	402.0
1963	411.0	334.0	322.0	258.0	325.0	1,141.0	3,284.0	3,825.0	2,203.0	1,702.0	1,972.0	837.0	1,384.5	16,614.0	3,825.0	258.0
1964	563.0	417.0	350.0	346.0	759.0	2,237.0	6,233.0	4,125.0	3,226.0	2,147.0	1,229.0	832.0	1,872.0	22,464.0	6,233.0	346.0
1965	566.0	435.0	332.0	384.0	453.0	2,558.0	4,027.0	3,378.0	1,779.0	2,188.0	2,118.0	1,039.0	1,604.8	19,257.0	4,027.0	332.0
1966	735.0	509.0	363.0	336.0	530.0	3,347.0	6,244.0	4,945.0	3,976.0	2,308.0	1,239.0	761.0	2,107.8	25,293.0	6,244.0	336.0
1967	560.0	430.0	319.0	363.0	468.0	1,190.0	3,070.0	5,040.0	2,570.0	1,520.0	1,210.0	781.0	1,460.1	17,521.0	5,040.0	319.0
1968	730.0	580.0	440.0	600.0	868.0	1,890.0	5,061.0	4,461.0	3,441.0	2,330.0	1,600.0	764.0	1,897.1	22,765.0	5,061.0	440.0
1969	525.0	390.0	295.0	279.0	563.0	1,648.0	3,407.0	7,562.0	2,168.0	1,169.0	879.0	569.0	1,621.2	19,454.0	7,562.0	279.0
1970	490.0	400.0	290.0	340.0	1,239.0	2,051.0	7,425.0	4,243.0	2,932.0	1,431.0	834.0	1,401.0	1,923.0	23,076.0	7,425.0	290.0
1971	597.0	514.0	377.0	488.0	867.0	2,854.0	4,721.0	8,413.0	3,723.0	1,647.0	1,048.0	630.0	2,156.6	25,879.0	8,413.0	377.0
1972	497.0	380.0	302.0	376.0	609.0	1,757.0	4,444.0	3,844.0	2,786.0	2,237.0	1,538.0	1,348.0	1,676.5	20,118.0	4,444.0	302.0
1973	648.0	539.0	539.0	611.0	1,308.0	2,923.0	4,244.0	4,885.0	3,583.0	1,652.0	1,331.0	722.0	1,915.4	22,985.0	4,885.0	539.0
1974	537.0	399.0	328.0	375.0	621.0	2,152.0	4,144.0	4,044.0	4,465.0	2,082.0	1,041.0	670.0	1,738.2	20,858.0	4,465.0	328.0
1975	577.0	387.0	286.0	478.0	913.0	2,982.0	3,202.0	2,772.0	2,982.0	1,611.0	1,201.0	731.0	1,510.2	18,122.0	3,202.0	286.0
1976	558.0	599.0	393.0	417.0	1,151.0	2,233.0	3,574.0	5,126.0	2,763.0	1,602.0	1,402.0	811.0	1,719.1	20,629.0	5,126.0	393.0
1977	587.0	459.0	357.0	465.0	541.0	1,565.0	5,352.0	4,252.0	2,094.0	1,809.0	1,163.0	736.0	1,615.0	19,380.0	5,352.0	357.0
1978	716.0	480.0	363.0	304.0	1,206.0	2,822.0	3,202.0	3,672.0	2,942.0	1,471.0	755.0	506.0	1,536.6	18,439.0	3,672.0	304.0
1979	411.0	363.0	271.0	257.0	367.0	1,383.0	2,746.0	4,329.0	4,670.0	1,583.0	739.0	517.0	1,469.7	17,636.0	4,670.0	257.0
1980	382.0	314.0	247.0	233.0	379.0	800.0	3,248.0	3,997.0	2,718.0	1,459.0	721.0	528.0	1,252.2	15,026.0	3,997.0	233.0
1981	442.0	347.0	295.0	357.0	1,289.0	2,700.0	4,030.0	4,970.0	3,480.0	2,070.0	2,040.0	997.0	1,918.1	23,017.0	4,970.0	295.0
1982	615.0	498.0	374.0	502.0	405.0	1,695.0	3,246.0	5,076.0	3,081.0	2,233.0	1,251.0	853.0	1,652.4	19,829.0	5,076.0	374.0
1983	643.0	502.0	530.0	356.0	455.0	1,010.0	1,690.0	4,439.0	3,969.0	2,109.0	2,039.0	970.0	1,559.3	18,712.0	4,439.0	356.0
1984	751.0	506.0	380.0	378.0	1,200.0	2,992.0	4,924.0	2,782.0	2,882.0	2,502.0	1,041.0	606.0	1,745.3	20,944.0	4,924.0	378.0
1985	453.0	381.0	306.0	386.0	663.0	2,304.0	3,447.0	3,797.0	3,918.0	1,463.0	1,783.0	862.0	1,646.9	19,763.0	3,918.0	306.0
1986	661.0	437.0	329.0	567.0	1,313.0	2,280.0	5,200.0	3,550.0	2,830.0	2,040.0	1,080.0	643.0	1,744.2	20,930.0	5,200.0	329.0
1987	509.0	387.0	295.0	266.0	273.0	995.0	2,990.0	3,690.0	2,690.0	1,840.0	1,260.0	650.0	1,320.4	15,845.0	3,690.0	266.0
1988	448.0	368.0	269.0	259.0	938.0	746.0	3,450.0	3,900.0	3,790.0	1,680.0	287.0	105.0	1,353.3	16,240.0	3,900.0	105.0
1989	390.0	400.0	361.0	432.0	816.0	2,670.0	3,190.0	1,820.0	1,740.0	1,610.0	848.0	547.0	1,235.3	14,824.0	3,190.0	361.0
Ave.	565.1	443.4	349.6	387.8	750.9	2,113.8	4,049.6	4,411.9	3,058.9	1,833.2	1,237.1	755.8				
Max	861.0	607.0	539.0	611.0	1,313.0	3,792.0	7,425.0	8,413.0	4,670.0	2,502.0	2,118.0	1,401.0				
Min	382.0	314.0	247.0	233.0	273.0	746.0	1,690.0	1,820.0	1,740.0	1,169.0	287.0	105.0				

Appendix 6.2-1 Monthly Dischage (unit:CMS)at TUYEN DAP YALY Dam Site

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Average	Total	Max	Min
1960	300.1	671.0	581.8	904.6	551.6	330.7	207.5	142.5	118.8	108.2	201.8	479.1	383.1	4597.7	904.6	108.2
1961	495.1	605.6	514.1	696.1	380.5	191.5	154.1	111.5	80.3	76.0	90.7	165.6	296.8	3561.1	696.1	76.0
1962	246.2	373.9	390.4	402.0	222.1	143.7	96.9	71.4	56.0	42.6	48.7	111.2	183.8	2205.1	402.0	42.6
1963	139.3	377.7	696.8	417.4	187.6	133.9	84.6	72.8	46.6	41.5	99.3	200.7	208.2	2498.2	696.8	41.5
1964	260.2	387.6	838.0	542.2	841.4	323.4	124.2	76.3	62.7	54.7	99.8	150.1	313.4	3760.6	841.4	54.7
1965	262.6	456.1	586.8	331.8	207.0	135.4	65.1	57.9	46.5	42.1	142.1	71.9	200.4	2405.3	586.8	42.1
1966	311.3	389.7	536.2	295.2	170.9	200.2	166.6	102.7	64.7	56.5	99.6	370.6	230.4	2764.2	536.2	56.5
1967	236.4	688.6	799.1	554.2	293.3	216.2	141.1	78.7	43.3	32.1	29.8	36.0	262.4	3148.8	799.1	29.8
1968	81.4	525.3	531.8	408.4	281.9	167.8	96.6	75.5	61.5	61.8	86.7	119.5	208.2	2498.2	531.8	61.5
1969	231.2	389.4	337.1	254.3	163.9	111.1	66.9	59.1	56.8	55.0	130.2	324.1	181.6	2179.1	389.4	55.0
1970	381.3	467.0	416.4	508.2	654.6	234.8	193.8	117.3	101.1	92.0	154.6	465.7	315.6	3786.8	654.6	92.0
1971	311.3	870.2	590.0	553.7	345.7	274.0	179.7	109.3	94.1	85.9	143.0	429.0	332.2	3985.9	870.2	85.9
1972	295.2	825.6	558.6	529.6	329.0	259.7	223.6	135.5	116.7	106.0	180.6	545.9	342.2	4106.0	825.6	106.0
1973	345.5	965.1	657.7	607.2	379.0	303.0	126.8	99.4	82.3	98.0	86.3	235.9	332.2	3986.2	965.1	82.3
1974	154.4	569.1	431.9	360.3	475.6	243.6	115.8	71.4	58.5	51.4	92.8	139.2	230.3	2764.0	569.1	51.4
1975	248.7	432.8	553.9	316.4	196.8	128.7	106.8	65.8	53.7	47.1	85.7	129.0	197.1	2365.4	553.9	47.1
1976	244.0	422.6	545.6	309.1	191.8	125.8	87.6	71.8	60.6	59.8	59.5	67.8	187.2	2246.0	545.6	59.5
1977	134.0	206.7	413.1	221.0	234.9	102.9	73.6	47.7	51.5	54.2	69.3	118.6	144.0	1727.5	413.1	47.7
1978	241.1	637.6	706.6	451.6	303.0	207.2	140.6	101.8	75.6	76.3	157.2	436.1	294.6	3534.7	706.6	75.6
1979	515.0	905.2	526.1	517.4	322.9	201.7	139.8	102.4	78.5	74.0	168.4	236.2	315.6	3787.6	905.2	74.0
1980	351.0	316.7	574.1	568.5	623.8	267.4	179.1	127.8	112.7	115.2	142.3	541.3	326.7	3919.9	623.8	112.7
1981	373.3	654.7	351.7	657.5	641.0	350.3	204.3	141.3	105.2	105.2	96.7	305.5	332.2	3986.7	657.5	96.7
1982	480.2	438.3	692.8	345.9	225.7	150.9	107.3	79.2	60.0	50.5	85.2	154.5	239.2	2870.5	692.8	50.5
1983	165.3	378.8	297.9	652.5	463.2	214.7	150.8	108.6	81.5	114.0	122.1	399.7	262.4	3149.1	652.5	81.5
1984	219.0	696.7	643.1	487.9	469.9	266.3	174.9	129.7	98.4	104.9	116.2	340.4	312.3	3747.4	696.7	98.4
1985	327.8	602.3	543.5	416.3	287.8	214.8	141.3	101.9	79.1	74.3	262.2	177.8	269.1	3229.1	602.3	74.3
1986	280.6	508.5	545.5	513.9	307.7	332.7	161.1	115.9	85.2	69.4	74.3	128.3	260.3	3123.1	545.5	69.4
1987	246.1	393.2	438.6	227.3	285.3	156.8	122.8	103.2	93.4	85.9	152.6	259.4	213.7	2564.6	438.6	85.9
1988	222.1	339.3	211.1	580.3	282.9	187.9	149.2	122.7	117.2	116.1	233.2	242.1	233.7	2804.1	580.3	116.1
1989	368.8	643.3	605.6	384.3	230.3	172.8	124.0	99.4	86.4	82.5	152.8	265.8	268.0	3216.0	643.3	82.5
1990	274.2	396.8	507.4	722.7	485.8	259.8	163.3	123.1	106.5	85.0	90.5	173.5	282.4	3388.6	722.7	85.0
Ave.	282.0	533.4	536.2	475.4	356.0	213.2	137.7	97.5	78.6	74.8	121.1	252.3				
Max	515.0	965.1	838.0	904.6	841.4	350.3	223.6	142.5	118.8	116.1	262.2	545.9				
Min	81.4	206.7	211.1	221.0	163.9	102.9	65.1	47.7	43.3	32.1	29.8	36.0				

Appendix 6.2-1 Dischage at <Cay Gao> G/S on Dong Nai R CA=14800km2

Average Dischage <Unit :M3/S>

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Total	Max	Min
1978	72.6	36.6	30.9	37.6	99.6	244.0	523.0	1,510.0	1,860.0	1,600.0	516.0	196.0	560.5	6,726.3	1,860.0	30.9
1979	97.4	59.6	47.6	55.6	140.0	466.0	1,490.0	1,710.0	820.0	1,296.0	593.0	211.0	582.2	6,986.2	1,710.0	47.6
1980	97.4	71.6	49.5	48.9	134.0	570.0	646.0	794.0	1,600.0	1,270.0	817.0	284.0	531.9	6,382.4	1,600.0	48.9
1981	123.0	92.1	55.0	46.7	91.3	600.0	564.0	1,480.0	1,000.0	1,090.0	595.0	257.0	499.5	5,994.1	1,480.0	46.7
1982	103.0	63.8	50.8	89.2	95.7	241.0	903.0	974.0	1,850.0	916.0	504.0	207.0	499.8	5,997.5	1,850.0	50.8
1983	92.7	57.4	41.7	38.4	50.5	230.0	621.0	1,280.0	815.0	1,639.0	750.0	238.0	487.8	5,853.7	1,639.0	38.4
1984	127.0	78.8	50.7	66.2	161.0	451.0	673.0	2,110.0	1,569.0	1,270.0	449.0	241.0	603.9	7,246.7	2,110.0	50.7
1985	104.0	66.6	52.1	91.9	242.0	516.0	568.0	882.0	1,020.0	1,150.0	530.0	307.0	460.8	5,529.6	1,150.0	52.1
1986	133.0	74.4	44.4	44.6	214.0	346.0	731.0	2,040.0	1,620.0	1,430.0	779.0	336.0	649.4	7,792.4	2,040.0	44.4
1987	147.0	77.2	48.6	92.0	56.5	437.0	1,000.0	1,200.0	1,390.0	1,013.0	547.0	264.0	522.7	6,272.3	1,390.0	48.6
1988	137.0	85.8	59.9	71.4	96.9	356.0	491.0	617.0	677.0	1,194.0	710.0	216.0	392.7	4,712.0	1,194.0	59.9
1989	109.0	62.4	78.6	95.3	277.0	500.0	1,033.0	1,237.0	1,487.0	1,125.0	397.0	174.0	547.9	6,575.3	1,487.0	62.4
Ave	111.9	68.9	50.8	64.8	138.2	413.1	770.3	1,319.5	1,309.0	1,249.4	598.9	244.3				
Max	147.0	92.1	78.6	95.3	277.0	600.0	1,490.0	2,110.0	1,860.0	1,639.0	817.0	336.0				
Min	72.6	36.6	30.9	37.6	50.5	230.0	491.0	617.0	677.0	916.0	397.0	174.0				

Appendix 6.2-1 Input Data for Review of Projects

Project Name	Catchment Area (km^2)	HWL EL-m	LWL EL-m	Active Capacity 10^6 m^3	IWL EL-m	TWL EL-m	He Design m	Q_{max} m^3/s
Da River								
Hoa Binh	51,700	115	80	5,650	105	17	88	2,400
Hoa Binh (S)	51,700	115	90	2,160	107	17	88	2,400
Hoa Binh (L)	51,700	115	105	2,160	112	17	88	2,400
Son La (S)	45,730	215	180	19,162	203	107	83	3,177
Son La (L)	45,730	265	215	7,410	248	112	129	3,060
Huoi Quang	2,930	440	410	1,067	430	203	220	368
Se San River								
Yaly	25,250	515	490	779	507	303	189	420
Plei Krong	3,224	585	560	1,292	577	507	60	208
Thuong Kontun*	350	1,194	1,150	357	1,179	310	800	33
Se San 3	8,009	305	305	0	305	250	53	516
Se San 4	10,920	235	225	1,315	232	165	62	734
Dong Nai River								
Da Nhim	7,555	1,042	1,018	150	1,018	242	706	26
Tri An	15,250	64	50	2,547	59	4	52	888
Da Mi	1,360	325	323	18	324	173	142	136
Ham Thuan	1,280	605	575	523	595	324	250	136
Dai Ninh	1,933	880	860	252	873	210	611	57
Dong Nai 4	4,530	480	430	262	463	285	167	133
Dong Nai 8	9,047	120	110	847	117	60	49	492

* As loss is so large, electricity values are 10% increased in assessment of the project.

Appendix 6.2-1 H-V curve Data of Reservoir1

Volume(10^6m^3)

Hoa Binh		Son La (Ban Pau)		Huoi Quan							
E.L.(m)	Volume	E.L.(m)	Volume	E.L.(m)	Volume	E.L.(m)	Volume	E.L.(m)	Volume	E.L.(m)	Volume
25	322	100	0	300	0						
50	1222	110	9.6	320	4.47						
75	3215	120	80.2	340	39.87						
90	5089	130	252.5	360	149.34						
100	6634	140	540.5	380	353.27						
115	9450	150	1035.6	400	677.3						
125	11526	160	1805.3	420	1204.4						
135	14077	170	2814.1	440	2007.9						
150	19005	180	4068.3	460	3173.4						
		190	5599.6	480	4805.8						
		200	7465.5	500	7114.5						
		210	9676.4								
		220	12239.2								
		230	15193.1								
		240	18559.1								
		250	22412.7								
		260	26828.2								
		270	31755.5								

Appendix 6.2-1 H-V curve Data of Reservoir 2

Volume(10^6m^3)

Yaly		Plei Krung		Thoung Kontum		Sesan 3		Sesan 4			
E.L.(m)	Volume	E.L.(m)	Volume	E.L.(m)	Volume	E.L.(m)	Volume	E.L.(m)	Volume	E.L.(m)	Volume
455	0	508	0	1002	0	235.7	0	162	0		
460	2.6	520	15	1120	4.55	245	1.71	165	1.38		
465	12.2	530	59.8	1140	34.87	255	18.1	175	20.4		
470	32.3	540	153.9	1160	107.03	265	48.85	185	56.23		
475	66.6	550	320.9	1180	249.4	275	93.5	195	125.23		
480	114.6	560	578.9	1200	506.68	285	154.8	205	279.4		
485	179	570	958.9			295	233.4	215	589.9		
490	258.1	580	1508.6			305	331.03	225	1131.4		
495	349.2	590	2306.3			315	448.5	235	1974.4		
500	461.4	600	3422.8			325	587.2				
505	598.9					335	749.9				
510	776					345	938.55				
515	1037.1					355	1149.98				
520	1442.5					360	1263.1				
525	2002.7										

Appendix 6.2-1 H-V curve Data of Reservoir 3

Volume($10^6 m^3$)

Tri Anh		Da Mi		Ham Thuan		Dong Nai 4		Dong Nai 8		Dai Nhim	
E.L.(m)	Volume	E.L.(m)	Volume	E.L.(m)	Volume	E.L.(m)	Volume	E.L.(m)	Volume	E.L.(m)	Volume
40	0	260	0	518.68	0	349.5	0	80	0	835	0
42	10	265	0.08	530	1.19	360	0.3	105	277.8	840	1.2
44	28.48	270	0.6	535	3.76	370	4	110	480.1	850	17.2
46	62.64	275	1.87	540	8.68	380	8.9	120	1327.2	860	58.5
48	120.6	280	4.73	545	16.65	390	15.7			865	92.7
50	218.03	285	10.08	550	29.27	400	24.6			870	139.5
52	306.39	290	17.29	555	45.92	410	40			875	201.7
54	397.86	295	26.05	560	66.66	420	57.2			880	276.7
56	1108.26	300	36.71	565	93.57	430	83.6				
58	1594.25	305	50.06	570	128.43	440	117.5				
60	2147.77	310	66.78	575	172.73	450	159				
62	2764.73	315	87.1	580	227.54	460	210.1				
64	3440.92	320	111.72	585	293.5	470	271.6				
66	4177.3	325	140.78	590	372.55	480	345.4				
		330	175.47	595	465.26	490	433.5				
		335	263.59	600	574.55	500	544.2				
		340	316.38	605	695.23						
				610	828.63						
				615	976.55						