表－60　ＰＬＮ販売電力量の推移

（単位:MWh）

年度	住宅用	%	オフィス・ビル用	%	公共照明用	%	商業用	%	工業用	%	合　計
1974／75	1,162,577	–	255,729	–	62,517	–	225,536	–	737,748	–	2,444,107
1975／76	1,290,212	10.98	278,442	8.80	74,721	19.52	280,023	24.16	880,214	19.31	2,803,613
1976／77	1,419,532	10.02	279,064	0.22	87,095	16.56	317,633	13.43	978,493	11.17	3,081,817
1977／78	1,609,499	13.38	309,451	10.88	103,931	19.33	362,552	14.14	1,141,670	16.68	3,527,103
1978／79	1,962,213	21.91	334,184	7.99	116,230	12.08	430,893	18.85	1,443,401	26.43	4,286,921
1979／80	2,427,611	23.72	352,556	5.49	134,643	15.84	518,695	20.38	1,909,901	32.32	5,343,406
1980／81	2,894,623	19.24	805,941	128.6	137,229	1.92	971,511	87.30	1,713,620	Δ(10.28)	6,522,924
1981／82	3,425,261	17.60	933,263	15.42	162,863	18.67	1,083,777	11.03	2,240,302	30.13	7,845,466
1982／83	3,932,797	14.81	1,018,387	9.26	179,207	10.04	953,477	Δ(12.02)	3,017,266	34.68	9,101,134

出典：ＰＬＮ

表－61　平均販売単価の推移

（単位:Rp/KWh）

年度	TARIFF'S GROUP					Revenues	COST
	住宅用	商業用	工業用	オフィス・ビル用	公共照明用	(KWH SOLD)	(KWH SOLD)
1974／75	14.76	31.80	14.65	15.54	13.12	16.36	20.30
1975／76	20.39	36.56	19.55	21.11	15.88	21.68	20.18
1976／77	26.23	42.08	24.28	26.72	19.94	27.12	24.70
1977／78	26.85	42.40	24.22	27.04	19.85	27.41	26.96
1978／79	27.36	42.43	23.61	26.77	20.15	27.37	25.86
1979／80	27.83	41.28	23.48	26.63	20.04	27.31	31.35
1980／81	41.82	56.12	27.33	52.33	34.28	41.19	36.51
1981／82	45.78	63.20	32.09	39.90	35.15	43.36	43.06
1982／83	60.63	90.79	42.46	52.94	44.79	56.58	57.90

Note:Figure for Revenues not included connection fee & other non operational revenues.

表−62 需要家数の推移

単位：口数

年度	住宅用	%	オフィス・ビル用	%	公共照明	%	商業用	%	工業用	%	合計	%
1974／75	964,362	−	27,528	−	980	−	86,407	−	6,828	−	1,086,105	6.12
1975／76	1,007,589	4.54	30,331	7.52	1,026	4.69	95,327	10.32	6,472	Δ(5.21)	1,140,745	5.03
1976／77	1,064,282	6.16	31,099	2.53	1,037	1.07	105,349	10.51	6,771	4.62	1,208,538	5.94
1977／78	1,249,521	17.40	35,777	15.02	1,226	18.23	120,119	14.02	7,212	6.51	1,413,855	16.99
1978／79	1,584,851	26.84	43,165	20.65	1,556	26.92	145,588	21.20	8,087	12.12	1,783,247	26.13
1979／80	2,012,855	27.01	52,143	20.80	1,779	14.33	170,946	17.42	8,934	10.49	2,246,657	25.99
1980／81	2,478,970	23.16	62,061	19.08	2,147	20.68	192,687	12.72	9,311	4.22	2,745,176	22.19
1981／82	2,936,326	18.45	72,700	17.08	2,360	9.92	210,072	9.02	10,617	14.03	3,232,075	17.74
1982／83	3,475,299	18.35	85,856	18.09	2,640	11.86	223,673	6.48	15,050	41.64	3,802,518	17.65

表－63 ＰＬＮ長期需要想定

年度	1983／84	1984／85	1985／86	1986／87	1987／88	1988／89	1989／90	1990／91	1991／92	1992／93	1993／94
電力需要 (GWh)											
住宅用	4,525	5,449	6,041	6,932	8,436	9,874	11,683	13,613	15,282	17,194	19,404
商業・サービス用	2,653	3,217	3,774	4,458	5,285	6,278	7,315	8,525	9,935	11,581	13,502
工業用	3,223	3,842	5,730	7,361	9,974	10,528	12,363	14,393	16,649	19,166	21,986
計 (GWh)	10,404	12,508	15,545	18,751	22,594	26,690	31,361	36,531	41,866	47,942	54,893
増加率 (%)	14	20	24	21	20	18	18	16	15	15	14
ロス (%)	21	20	20	19	18	17	16	15	15	15	15
発電電力量	13,162	15,704	19,442	23,161	27,709	32,154	37,335	42,978	49,254	56,402	64,580
負荷率 (%)	65	65	65	66	66	66	66	66	65	65	65
最大電力 (MW)	2,311	2,744	3,391	4,036	4,819	5,596	6,492	7,467	8,642	9,930	11,424

Source ：PLN

表－63によると1993年度までの負荷率が65～66%と比較的高く予測されているが，これは，工業用需要が引き続き増加するものと見込まれており，時間帯別料金によりピーク負荷のコントロールがある程度可能になるためである。

また，現在のピーク負荷は表－64の通り2,285.7MWであり，電力系統整備が遅れているため，結果的に負荷率が高い数値となっている。

表－64　最大電力・負荷率の推移

	最大電力 (MW)	平均電力 ※1 (MW)	負荷率 ※2 (%)
1973	507.1	334.7	66.0
1975	630.7	430.4	68.2
1978	1,039.6	653.3	62.8
1980	1,421.8	961.2	67.5
1982	2,285.7	1,352.3	59.2

※1平均電力は表－57より作成

※2負荷率は $\frac{\text{平均電力}}{\text{最大電力}} \times 100$ で算出

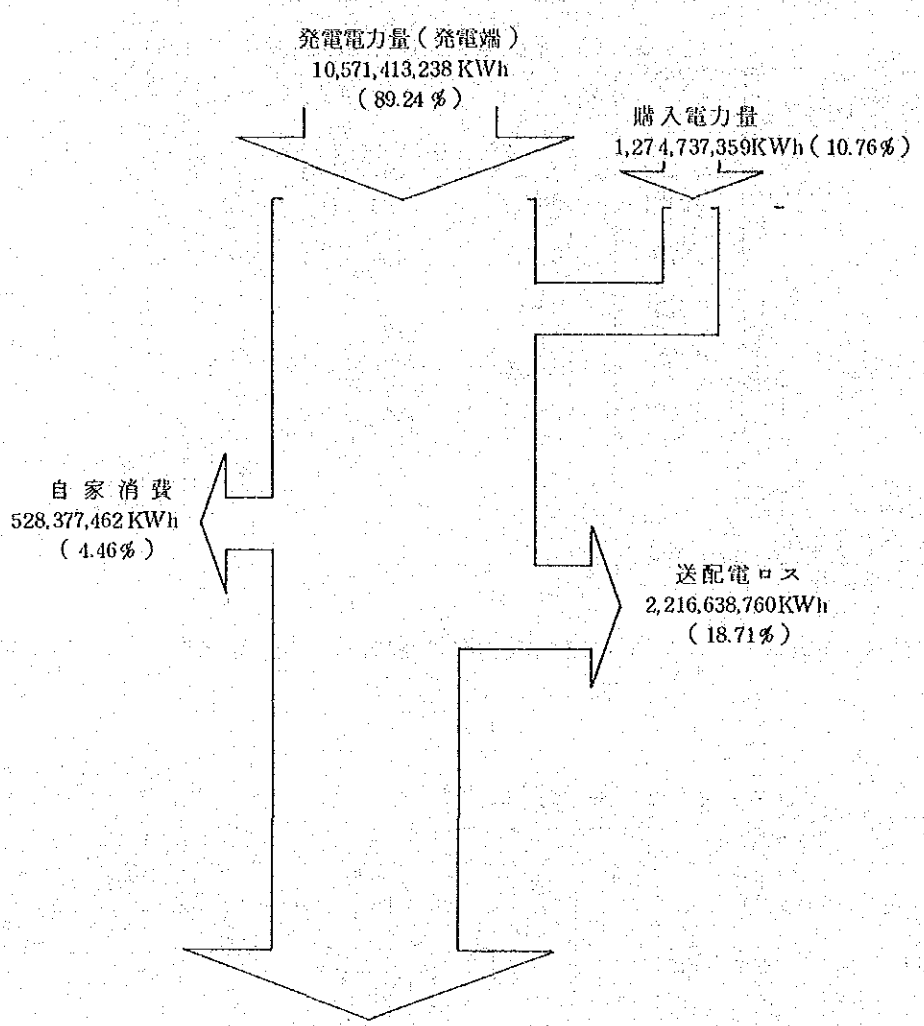
参考までにジャワ島とジャワ島以外の販売電力量の推移と，1982年度の需給バランス図を表－65，図－20に示す。

表－65　地域別販売電力量の推移

	ジャワ島						ジャワ島以外					
年度	家庭用	商業用	工業用	公共ビル等	公共照明	計	家庭用	商業用	工業用	公共ビル等	公共照明	計
1974／75	934	165	675	164	43	1,981	229	60	63	92	19	463
1975／76	1,041	207	783	177	51	2,259	249	73	97	102	24	545
1976／77	1,130	233	843	185	58	2,449	290	85	135	94	29	633
1977／78	1,266	263	1,035	203	70	2,837	343	100	107	106	34	690
1978／79	1,521	313	1,313	222	77	3,446	441	118	131	112	39	841
1979／80	1,837	362	1,729	227	87	4,242	590	157	181	125	48	1,101
1980／81	2,144	726	1,494	652	96	5,112	751	245	220	154	41	1,411
1981／82	2,561	814	2,008	723	103	6,209	864	270	232	210	60	1,636
1982／83	2,952	713	2,683	794	113	7,255	981	241	334	224	66	1,846

出典：ＰＬＮ

図－２０　電力需給バランス（１９８２／８３年）



＜電源開発＞

インドネシアにおける電力需要想定は前述した通り，1993年度には54,893GWHになると予想されているが，これに対してＰＬＮの電源開発計画は石油，火力，及びディーゼル発電所の低減に主眼が置かれ，石炭，水力，地熱等の発電所建設が予定されている。

ＰＬＮの計画は表－66の通りであり，予定通り電源開発が進めば1993年度には64,580GWh，2003年度には181,933GWhが発電可能となる。また，2003年度の燃料別発電電力量の比率は，水力14.4%，石炭71.5%，地熱3.7%，ディーゼル7.2%，ガス・タービン0.8%及び石油2.4%であり，非石油燃料（水力，石炭，地熱）からの発電電力量の割合が89.6%，となっており，急速に石油代替エネルギーの開発が進展すると思われる。このため，将来的には，石炭火力をベース負荷用に，石油火力，ガス・タービンはピーク負荷用に使用することが予想される。（表－67に発電燃料の消費予想を示す）

また，ＰＬＮの事業経営の改善・強化が指摘されており，送配電ロスの低減，供給の安定確保と信頼度の向上及び合理的料金制の設定が予定されている。この電源開発計画を実行するため表－68の様な予算が組まれている。

表－66　ＰＬＮの発電計画

	1984/85		1985/86		1986/87		1987/88		1988/89	
	GWh	%	GWh	%	GWh	%	GWh	%	GWh	%
石油以外	2,990	19.0	6,891	35.4	10,366	44.8	12,645	45.6	15,359	47.8
水　力	2,780	17.7	3,206	16.5	4,866	21.0	5,497	19.8	6,907	21.5
石炭火力	-	-	3,475	17.9	5,290	22.8	6,199	22.4	7,471	23.2
地　熱	210	1.3	210	1.0	210	1.0	949	3.4	981	3.1
石油系	12,714	81.0	12,551	64.6	12,795	55.2	15,064	54.4	16,795	52.2
ディーゼル	1,911	12.2	2,762	14.2	3,126	13.5	3,390	12.2	3,983	12.4
ガス・タービン	1,608	10.2	1,472	7.6	1,411	6.1	2,372	8.6	2,967	9.2
石油火力	9,195	58.6	8,317	42.8	8,258	35.6	9,302	33.6	9,845	30.6
計	15,704	100.0	19,442	100.0	23,161	100.0	27,709	100.0	32,154	100.0

Source: PLN

	1989/90		1990/91		1991/92		1992/93		1993/94	
	GWh	%	GWh	%	GWh	%	GWh	%	GWh	%
石油以外	19,511	52.3	25,415	59.2	33,178	67.4	40,145	71.2	51,783	80.2
水　　力	7,169	19.3	8,033	18.7	10,273	20.9	11,761	20.8	13,946	21.6
石炭火力	11,361	30.4	16,401	38.2	19,997	40.6	24,149	42.8	31,290	48.5
地　　熱	981	2.6	981	2.3	2,908	5.9	4,235	7.6	6,547	10.1
石　油　系	17,824	47.7	17,563	40.8	16,076	32.6	16,257	28.8	12,797	19.8
ディーゼル	4,521	12.1	4,977	11.6	4,258	8.6	3,702	6.6	3,232	5.0
ガス・タービン	3,069	8.2	2,895	6.7	2,699	5.5	3,655	6.5	2,119	3.3
石油火力	10,234	27.4	9,691	22.5	9,119	18.5	8,900	15.7	7,446	11.5
計	37,335	100.0	42,978	100.0	49,254	100.0	56,402	100.0	64,580	100.0

	1994/95		1995/96		1998/99		2000/01		2003/04	
	GWh	%	GWh	%	GWh	%	GWh	%	GWh	%
石油以外	62,134	54.6	70,382	83.0	105,112	87.5	134,890	89.0	162,984	89.6
水　　力	15,336	13.5	16,376	19.3	21,782	18.1	24,234	16.0	26,180	14.4
石炭火力	40,179	35.3	47,387	55.9	76,711	63.8	104,037	68.7	130,185	71.5
地　　熱	6,619	5.8	6,619	7.8	6,619	5.6	6,619	4.3	6,619	3.7
石　油　系	51,752	45.4	14,386	17.0	15,044	12.5	16,585	11.0	18,949	10.4
ディーゼル	6,355	5.6	7,930	9.3	9,071	7.5	10,552	7.0	13,091	7.2
ガス・タービン	81	0.1	288	0.3	552	0.4	1,241	0.8	1,482	0.8
石油火力	45,316	39.7	6,168	7.4	5,421	4.6	4,792	3.2	4,376	2.4
計	113,886	100.0	84,768	100.0	120,156	100.0	151,475	100.0	181,933	100.0

表−67　P L N 発 電 用 燃 料 計 画

	ジャワ島			ジャワ島以外			合　計		
	HSD/IDO (10^3 Kl)	MFO (10^3 Kl)	Coal Req. (10^3 Ton)	HSD/IDO (10^3 Kl)	MFO (10^3 Kl)	Coal Req. (10^3 Ton)	HSD/IDO (10^3 Kl)	MFO (10^3 Kl)	Coal Req. (10^3 Ton)
1984／85	945	2,437	-	716	183	-	1,661	2,656	-
1985／86	526	2,198	1,737	796	252	-	1,322	2,450	1,737
1986／87	492	2,308	2,453	894	294	160	1,386	2,602	2,613
1987／88	961	2,508	2,453	979	222	492	1,940	2,730	2,945
1988／89	1,312	2,563	3,066	1,181	333	654	2,493	2,896	3,720
1989／90	1,329	2,558	4,896	1,254	444	784	2,583	3,002	5,680
1990／91	1,294	2,418	7,206	1,254	420	934	2,548	2,838	8,140
1991／92	1,249	2,304	8,956	1,175	393	1,042	2,424	2,697	9,998
1992／93	1,669	2,272	10,669	1,068	397	1,405	2,737	2,669	12,074
1993／94	977	1,952	13,678	1,094	331	1,967	2,071	2,283	15,645
1995／96	413	1,272	18,533	2,187	568	2,132	2,600	1,840	20,665
2000／01	1,236	1,093	37,756	2,668	289	7,974	3,904	1,382	45,730
2003／04	2,355	1,050	52,305	2,727	206	16,770	5,082	1,256	69,075

Source ： PLN

表−68　P L N 予 算 計 画

(billion rlpiah)

	1984／85		1985／86		1986／87		1987／88		1988／89		Total 1984／85−1988／89		合　計
	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	
発電設備	544,1	350,9	770,5	256,0	664,6	262,5	830,6	315,3	749,3	290,7	3559,1	1475,4	5034,5
送変電設備													
送　電	72,9	58,4	71,5	55,3	48,1	34,4	28,0	20,2	42,5	34,1	263,0	202,4	465,4
変　電	97,7	32,1	88,5	25,9	64,9	16,4	45,3	14,1	51,3	19,9	347,7	108,4	456,1
配電設備	205,6	48,8	230,6	54,8	259,0	61,5	290,7	69,1	326,3	77,5	1312,2	311,7	1623,9
地方電化	-	142,7	-	159,6	-	188,4	-	206,0	-	208,4	-	905,0	905,0
研究開発	5,4	1,6	5,4	1,6	7,2	2,1	9,0	2,6	9,0	2,6	36,0	10,4	46,4
資源調査	17,9	19,4	13,5	18,4	12,2	16,6	13,0	18,4	13,0	17,5	69,6	90,3	159,9
情報管理システムその他	1,0	44,8	1,0	49,3	1,0	60,0	0,0	51,8	0,0	55,5	2,9	261,4	264,3
教育・訓練	1,4	1,8	2,6	2,0	1,6	2,1	2,2	2,6	2,3	2,1	10,1	10,6	20,7
計	946,0	700,5	1183,6	622,9	1058,6	644,0	1218,8	700,1	1193,7	708,3	5600,6	3375,6	8976,2

FC＝外資
LC＝内資
1983年４月現在価格
Source: PLN

＜発電設備＞

将来の電力需要増に備え，ＰＬＮでは2003年度までに送設備容量を48,364MWに増強しようとしているが，これは1983年度実績（3,917.7MW）の12.3倍に当る（表－69）。ＰＬＮでは，現在建設及び計画中の石油火力以外は石油火力を建設しない方針であり，火力発電所の建設はほとんど石炭火力になる見込みである。そのため，2003年度には石炭火力の割合が約60％になり，反対に石油火力は老朽，発電所の廃棄等により約５％にまで低減させる予定である。また，1993年までに地熱発電所の建設が進み，現在の30MWから830MW（27.7倍）にまで達する見込みである。

図－21に1993年度までのエネルギーバランスを示す。

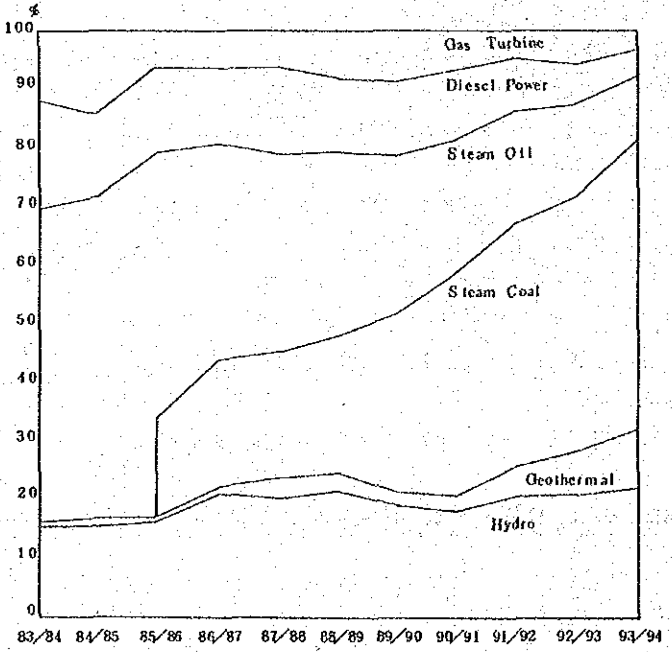
表－69　ＰＬＮ電源開発計画

(MW)

年度	水力	ディーゼル	ガス・タービン	地熱	石炭火力	石油火力	原子力	計
1983／84	536,4 (13,7)	767,1 (19,6)	1027,9 (26,2)	30,0 (0,8)	－	1556,3 (39,7)	－	3917,7 (100)
1988／89	2011,4 (21,9)	1884,4 (20,5)	1027,9 (11,2)	250,0 (2,7)	1830,0 (19,9)	2186,3 (23,8)	－	9190,0 (100)
1990／91	2596,0 (25,2)	1527,0 (14,8)	650,0 (6,3)	360,0 (3,5)	2770,0 (26,8)	2410,0 (23,4)	－	10,313,0 (100)
1993／94	4284,0 (27,4)	1904,0 (12,2)	340,0 (2,2)	830,0 (5,3)	5835,0 (37,4)	2410,0 (15,5)	－	15603,0 (100)
1998／99	5209,0 (18,6)	2584,0 (9,2)	2750,0 (9,8)	830,0 (3,0)	14385,0 (51,3)	2260,0 (8,1)	－	28018,0 (100)
2003／04	5848,0 (12,1)	2691,0 (5,6)	8250,0 (17,0)	830,0 (1,2)	28685,0 (59,3)	2060,0 (4,8)	－	48364,0 (100)

Source:PLN
Notes :- Number in parentheses are percentages of the total

図－21　エネルギーバランス



現在建設中の発電所は以下の様に水力７カ所，火力５カ所，地熱１カ所であり，その合計出力は2,246MWである。

建設中の発電所

					運開年
水力	1．Saguling	1-2	2×175 MW		1985年度
	2．Saguling	3-4	2×175 MW		1985年度
	3．Tanggari Ｉ	1-2	2×8.5 MW		1986年度
	4．Bakura	1-2	2×62 MW		1987年度
	5．Wadaslintag		2×8 MW		1987年度
	6．Sengguruh		1×29 MW		1987年度
	7．Mrica	1-3	3×60 MW		1989年度
	計		1,066 MW		
火力	1．Suralaya	1	400 MW	（石炭）	1984年度
	2．Suralaya	2	400 MW	（石炭）	1984年度
	3．B.Asam	1-2	2×65 MW	（石炭）	1986年度
	4．Belawan	1-2	2×65 MW	（石油）	1989年度
	5．B.Asam	3	65 MW	（石炭）	1992年度
	計		1,125 MW		
地熱	1．Salak	1	55 MW		1988年度
	計		55 MW		
	合　計		2,246 MW		

また，表－70に今後の主要発電プロジェクト（現在建設中を含む）を示す。

表－７０　今後の主要発電プロジェクト

ジャワ島

水　力

No.	Name of Project	Location	Type	*Status	Cap. (MW)	Completion
1.	Wadaslintang	C. Java	Hydro	U.C	2x 8	1987/88
2.	Saguling #1-2	W. Java	Hydro	U.C	2x175	1985/86
3.	Saguling #3-4	W. Java	Hydro	U.C	2x175	1985/86
4.	Mrica #1-3	C. Java	Hydro	U.C	3x 60	1989/90
5.	Maung #1-2	C. Java	Hydro	E.D	2x 95	1992/93*)
6.	Sengguruh	E. Java	Hydro	U.C	1x 29	1987/88
7.	Kesamben	E. Java	Hydro	P	1x 33	1989/90
8.	Curug	W. Java	Hydro	E.D	2x3.1	1989/90
9.	Cirata I #1-2	W. Java	Hydro	E.D	2x125	1988/89
10.	Cirata II #3-4	W. Java	Hydro	E.D	2x125	1988/89
11.	Jatigede	W. Java	Hydro	F.S	175	1993/94
12.	Cirata II	W. Java	Hydro	－	250	1991/92

*) Economics under further review.

Source: PLN

火　力

No.	Name of Project	Location	Type	*Status	Cap. (MW)	Completion
1.	Gresik #3	E. Java	Steam	E.D	200	1986/87
2.	Suralaya #1	W. Java	Steam Coal	U.C	400	1984/85
3.	Suralaya #2	W. Java	"	U.C	400	1984/85
4.	Suralaya #3	W. Java	"	E.D	400	1988/89
5.	Suralaya #4	W. Java	"	P	400	1988/89
6.	Suralaya #5	W. Java	"	P	600	1991/92
7.	Suralaya #6	W. Java	"	P	600	1993/94
8.	Paiton #1	E. Java	"	E.D	400	1988/89
9.	Paiton #2	E. Java	"	E.D	400	1989/90
10.	Paiton #3	E. Java	"	P	600	1992/93
11.	Paiton #4	E. Java	"	P	600	1993/94
12.	C. Java #1	C. Java	"	P	600	1991/92
13.	Kamojang #2	W. Java	Geothermal	E.D	55	1986/87
14.	Kamojang #3	W. Java	"	E.D	55	1986/87
15.	Salak #1	W. Java	"	U.C	1x 55	1988/89
16.	Salak #2,3,4	W. Java	"	P	3x 55	1989/90
17.	Drajat #1,2	W. Java	"	P	2x 55	1989/90
18.	Cisolok #1-2	W. Java	"	P	2x 55	1989/90
19.	Dieng #1	C. Java	"	P	1x 55	1988/89
20.	Dieng #2	C. Java	"	P	1x 55	1989/90
21.	Dieng #3	C. Java	"	P	1x 55	1990/91
22.	Dieng #4	C. Java	"	P	1x 55	1990/91
23.	Banten #1-2	W. Java	"	P	2x 55	1993/94
24.	Gresik #4	E. Java	Steam	E.D	200	1987/88
25.	Combined Cycle	W. Java			100	1986/87

Source: PLN

* U.C ＝ 建設中　　Pre F.S ＝ 予備調査中
E.D ＝ 設計中　　P ＝ 計画中
F.S ＝ 事前調査中

ジャワ島以外

水　力

No.	Name of Project	Location	Type	*Status	Cap. (MW)	Completion
1.	Peusangan	Aceh	Hydro	F.S	50	1993/94
2.	Asahan I #1-2	N. Sumatera	Hydro	F.S	2x 90	1990/91
3.	Asahan III #1-2	"	Hydro	F.S	2x 75	1992/93
4.	Asahan III #3-4	"	Hydro	F.S	2x 75	1992/93
5.	Renun	"	Hydro	P	90	1994/95
6.	Singkarak #1-3	"	Hydro	F.S	3x 80	1991/92
7.	Koto Panjang	W. Sumatra	Hydro	F.S	3x 37	1993/94
8.	TES I #1-4	Bengkulu	Hydro	E.D	4x 4	1988/89
9.	TES II #1-2	Bengkulu	Hydro	Pre F.S	2x8.5	1993/94
10.	Batutegi #1-2	Lampung	Hydro	Pre F.S	2x 12	1992/93
11.	So. Jaya (Besai)	Lampung	Hydro	F.S	2x 10	1992/93
12.	P. Kembayung #1	W. Kalimant.	Hydro	F.S	1x 10	1988/89
13.	P. Kembayung #2-3	W. Kalimant.	Hydro		2x 10	1989/90
14.	Riam Kiwa #1-2	S. Kalimant.	Hydro	F.S	2x 21	1991/92
15.	Tanggari I #1-2	N. Sulawesi	Hydro	U.C	2x8.5	1986/87
16.	Tanggari II #1-2	N. Sulawesi	Hydro	E.D	2x7.6	1991/92
17.	Bakaru #1-2	S. Sulawesi	Hydro	U.C	2x 62	1987/88
18.	Bakaru #3	S. Sulawesi	Hydro	P	63	1993/94
19.	Bakaru #4	S. Sulawesi	Hydro	P	63	1994/94
20.	Sentani I #1-2	Irian Jaya	Hydro	E.D	2x6.5	1988/89
21.	Sentani II #1-2	Irian Jaya	Hydro	P	2x6.5	1992/93

Source: PLN

火　力

No.	Name of Project	Location	Type	*Status	Cap. (MW)	Completion
1.	Belawan #1-2	N. Sumatra	石油	U.C	2x 65	1989/90
2.	Belawan #3-4	N. Sumatra	〃	E.D	2x 65	1989/90
3.	Jambi #1-2	Jambi	〃	P	2x 25	1992/93
4.	Pontianak #1	W. Kalimantan	〃	P	25	1993/94
5.	Pontianak #2	W. Kalimantan	〃	P	25	1993/94
6.	B. Papan #1-2	E. Kalimantan	〃	P	2x 50	1993/94
7.	B. Masin #1-2	S. Kalimantan	〃	P	2x 30	1992/93
8.	Ombilin #1	W. Sumatra	石炭	F.S	1x 50	1987/88
9.	Ombilin #2	W. Sumatra	〃	P	1x 50	1988/89
10.	B. Asam #1-2	S. Sumatra	〃	U.C	2x 65	1986x87
11.	B. Asam #3	S. Sumatra	〃	U.C	65	1992x93
12.	Tarahan #1	Lampung	〃	P	50	1989x90
13.	Tarahan #2	Lampung	〃	P	50	1990x91
14.	Loa Kulu #1	E. Kalimantan	〃	P	50	1993/94
15.	Loa Kulu #2	E. Kalimantan	〃	P	50	1993/94
16.	Lubendong #1-2	N. Sulawesi	Geo.	P	2x 15	1993/94

Source: PLN

表－70からも分かる様に，今後の水力プロジェクトについてはジャワ島以外のプロジェクトが多く，前述したスマトラのアサハン水力同様，代替エネルギー開発と産業，住民の地域分散が計られている。しかし，電力需要の中心地であるジャワ島とそれ以外の地域は系統で結ばれているため豊富な水力資源を生かした大規模水力の開発は行われず，Asahan 水力等を除き，小水力主体となっている。

火力プロジェクトについては石炭を中心に行われているが，石炭の輸送システムが確立されておらず，輸送設備の整備が急がれている。

また，地熱プロジェクトも多数予定されており，計画が予定通り行われ，インドネシアは一躍地熱発電大国となろう。

参考までに表－71に火力発電所（地熱を含む）の1983年４月時点の建設コストを示す。

表－71 建 設 コ ス ト
(constant April 1983 Prices)

Type of Power Plant	Total Cost US$/KW	FC %	LC %
1．Gas Turbine	254	85	15
2．Steam Oil	561	77	23
3．Coal			
． 400 KW	704	77	23
． 600 KW	631	77	23
4．Geothermal	770	89	11
5．Diesel			
． 250- 400 KW	1,029	77	23
． 401- 750 KW	808	77	23
． 751- 2000 KW	624	83	17
．2001- 3500 KW	523	85	15
．3501- 6000 KW	541	79	21
．6001- 8000 KW	512	77	23
．8001-12500 KW	533	85	15

Source:PLN
FC＝外資
LC＝内資

＜送配電計画＞

ＰＬＮの電力開発計画の基本方針にもある様に，送電連系の拡充と送配電ロスの低減はＰＬＮの緊急課題であり，電力系統整備がジャワ島を中心に行われる予定である。

現在ジャワ島においても送電系統が分断されているため，送配電ロス率が非常に高く，同時に供給信頼度が低くなっており，その対策として150KV＜70KVの送電線建設に加え500KV系統の開発も計画されている。

なお，将来構想として，西部ジャワのスララヤ火力からサグリン水力を経て，中部ジャワのウンガラを結ぶ計画と西ジャワのスララヤ火力から南スマトラのブキットアッサム火力，西スマトラのオンビリンを経て，北スマトラのアサハン水力を結ぶスマトラ縦断直流送電計画があり，これが完成するとジャワ島とスマトラ島が連系されることとなり，将来的にはマレーシアとも連系が可能となりうる。

今後の送配電計画を表－72に示す。

表－72 送配電計画

Item	1983／84	1984／85	1985／86	1986／87	1987／88	1988／89	1989／90	1990／91	1991／92	1992／93	1993／94
送電設備											
.500KV（回線－km）	－	741	－	536	145	240	－	918	－	－	－
.150KV（回線－km）	900	739	1,544	1,571	965	1,246	269	1,317	1,196	450	420
. 70KV（回線－km）	152	345	233	256	334	434	215	464	34	130	10
変電設備											
（MVA）	573	4,152	1,114	3,661	627	1,516	1,462	2,657	460	1,765	180
配電設備											
. 20KV（回線－km）	3,690	4,289	4,992	5,499	6,035	6,983	6,839	7,131	8,352	10,096	11,075
.220V （回線－km）	7,380	8,577	9,983	10,998	12,070	13,966	13,678	14,261	16,704	20,193	22,149
配電用変電設備											
（MVA）	615	660	768	846	928	1,074	1,140	1,188	1,392	1,683	1,846

Source:PLN

表－72の送配網整備のため，かなりの予算が投じられているが（電源開発の項　表－68を参照），これに要する建設コストは1983年現在で表－73～75の通りになっている。

表－73　送電コスト
(constant April 1983 Price)

Voltage Grade	Type	US$/Km
1．500KV-（架空線）	2 Circuits	289.000
	2 x 1 CCT	331.500
	1 Circuit	165.750
	1st CCT	253.300
	2nd CCT	43.120
2．150KV-（架空線）	2 Circuits	86.756
	1st CCT	70.930
	2nd	19.360
3．70KV-（架空線）	2 Circuits	74.456

Source:PLN

表－74　変電コスト
(constant April 1983 Price)

Substation	Capital Cost
1．変圧器	
-500/150KV	US$ 8.7/KVA
-150/ 70KV	US$10.6/KVA
-150/ 20KV	US$12.1/KVA
- 70/ 20KV	US$18.8/KVA
-220/150KV	US$ 8.8/KVA
-500KV Reactor	US$10.5/KV
2．リアクター関連費用	
-500KV	US$ 4 785 968/bay
-275KV	US$ 1 509 464/bay
-150KV	US$ 270 456/bay
- 70KV	US$ 209 432/bay
3．開閉設備　20KV	US$ 31 324/unit

Source:PLN

表－75　配電コスト
(constant April 1983 Prices)

Items	Total Cost
中圧架空線	US$ 15 980/Km
中圧地中線	US$ 50 760/Km
低圧架空線	US$ 8 178/Km
低圧地中線	US$ 25 380/KM

Source:PLN

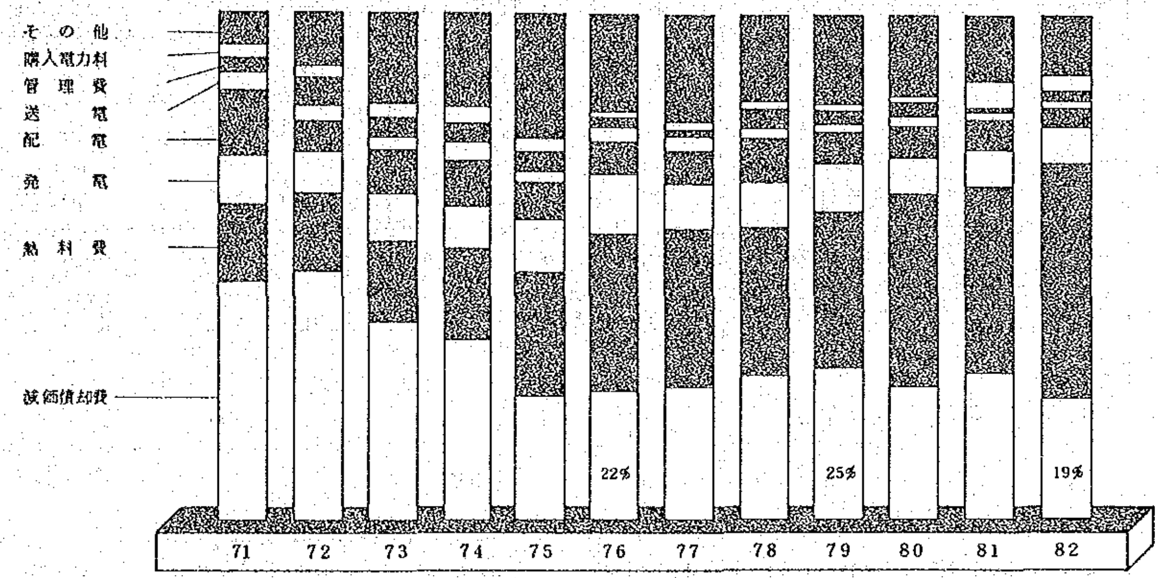
<電気料金>

1973年から1980年までの７年間ＰＬＮの電気料金は据え置かれていたが，石油，天然ガスの国内価格上昇の影響を受け，1980年新料金に変更した。その後もＰＬＮの支出額に占める燃料費の割合が増加してきたため（図－22），1982年に平均17.9%，1983年に平均34.5%の値上げを実施した。

さらに，1984年３月には，支出額に占める燃料費の割合が50～60%となり国内石油価格が上昇してきたため，平均31.6%の料金値上げが行われた。

なお，1982年度までの平均販売単価を見ると（表－76）工業用の値上げ率は低く抑えてあるが，これは工業化促進のための価格政策によるものである。表－77に1984年４月の電気料金を示す。

図－22　ＰＬＮの科目別支出額の割合



表－76　平均販売単価の推移

(in:Rupiah KWH)

年度	料金種別					Revenues	COST
	住宅用	商業用	工業用	オフィス・ビル用	公共照明用	(KWH SOLD)	(KWH SOLD)
1974/75	14.76	31.80	14.65	15.54	13.12	16.36	20.30
1975/76	20.39	36.56	19.55	21.11	15.88	21.68	20.18
1976/77	26.23	42.08	24.28	26.72	19.94	27.12	24.70
1977/78	26.85	42.40	24.22	27.04	19.85	27.41	26.96
1978/79	27.36	42.43	23.61	26.77	20.15	27.37	25.86
1979/80	27.83	41.28	23.48	26.63	20.04	27.31	31.35
1980/81	41.62	56.12	27.33	52.33	34.28	41.19	36.51
1981/82	45.78	63.20	32.09	39.90	35.15	43.36	43.06
1982/83	60.63	90.79	42.46	52.94	44.79	56.58	57.90

Note:Figure for Revenues not included connection fee & other non operational revenues.

表－７７　電気料金表

１９８４年４月

US.$ 1 = Rp. 998.-

No.	Code of Tariff		Contracted Power	Demand Charge Rp/kVA	Energy Charge Rp/kWh	Projected Average Revenue Rp/kWh
1.	S_1	低圧　小口	to 200 VA	*)		
2.	S_2	低圧　公共施設等	250 VA to 200 kVA	2,100	43.50	60.57
3.	R_1	低圧　住宅用１	250 VA to 500 VA	2,100	70.50	85.19
4.	R_2	低圧　住宅用２	501 VA to 2200 VA	2,100	84.50	98.41
5.	R_3	低圧　住宅用３	2201 VA to 6600 VA	3,080	126.50	156.42
6.	R_4	低圧　住宅用４	6601 VA to over	3,680	158.00	184.10
7.	U_1	低圧　商業用１	250 VA to 2200 VA	3,680	134	160.10
8.	U_2	低圧　商業用２	2200 VA to 200 kVA	3,680	150	185.73
9.	U_3/MV	中圧　商業用３	201 kVA & over	2,300	P =158 OP= 99	123.17
10.	U_4	低圧　臨時電力	-	-	307	307
11.	I_1	低圧　工業・ホテル用１	to 99 kVA	2,300	P =106 OP= 66	93.97
12.	I_2	低圧　工業・ホテル用２	100 kVA to 200 kVA	2,300	P =100 OP=62.50	85.51
13.	I_3/MV	中圧　工業・ホテル用３	201 kVA & Over	2,100	P =96.50 OP=60.50	75.88
14.	I_4/HV	高圧　工業用	5000 kVA & Over	1,970	P =81.50 OP=52	61.13
15.	G_1	低圧　ビル用１	250 VA to 200 kVA	3,680	96	120.86
16.	G_2/MV	中圧　ビル用２	201 kVA & Over	1,970	P =99 OP=65	84.92
17.	J	低圧　公共照明用	-		76.50	76.50
		Average				98.315

*) Tariff S_1: 100 VA = Rp.2.510,-/month
150 VA = Rp.3,765,-/month
200 VA = Rp.5,025,-/month

Note: P = Peak Hours (18:00 - 22:00)
OP = Off Peak Hours (22:00 - 18:00)

Jakarta, March,1, 1984

＜おわりに＞

インドネシアは，石油・天然ガスの輸出により経済開発が行われてきたが，近年，資源輸入諸国では石油代替化が進み，ＯＰＥＣを中心に石油価格の値下げが実施されたため，インドネシアの外貨獲得に大きな影響を及ぼしている。そのため，石油・天然ガス以外の国内資源有効利用が計られているが，インドネシアの代替エネルギー開発は始められたばかりであり，現在までのところあまり進行はしていない。

しかし，代替エネルギー開発は緊急課題であり各地で石炭火力，水力を中心とした開発が行われている。

遠隔地にある石炭火力水力の開発が進むにつれ，インフラの整備も行われ，首都圏に集中していた産業人口が各地に分散することも考えられ，地域開発という点からも代替エネルギー開発に対する期待は大きい。

以　上

別　添　資　料

昭和59年度　水力コース研修日程

月	火	水	木	金	土
4/30	5/1	5/2	5/3 来日	5/4	5/5
5/7 ←──	5/8	5/9 オリエンテーション （JICA）	5/10	5/11 ──→	5/12
5/14 • 日程説明会（海外電力） • 日本の電気事業の現状（公益）	5/15 • 電力供給計画需要想定 • 電源開発計画（公益）	5/16 • 日本の送配電系統（公益） • 中央給電連絡指令所（海外電力）	5/17 • 日本の火力発電所 • 日本の水力発電所（公益）	5/18 • 日本の原子力発電所（公益） • ゴミ発電（海外電力）	5/19
5/21 ―見 学― • 富士電機 川崎工場 （海外電力）	5/22 ―見 学― • 三菱重工横浜造船所 （海外電力）	5/23 ―見 学― • 昭和電線 相模原工場 （海外電力）	5/24 ―見 学― • 明電舎 沼津工場 （海外電力）	5/25 ―見 学― • 日本電気 横浜工場 （海外電力）	5/26
5/28（～7/6まで電発） • 日程打合せ • 建設工事記録映画	5/29 ―見 学― • 中央通信指令所 • 中央給電指令所	5/30 • 電発の現況と展望 • 水力開発地点の経済評価	5/31 • 水力開発地点の調査	6/1 • 水力開発地点の計画	6/2
6/4 • 水力開発地点の地質調査	6/5 • 原子力発電の概要	6/6 ―見 学― • 広野火力発電所	6/7 ―見 学― • 福島第二原子力発電所 • BWR訓練センター	6/8 ―見 学― • 鬼首地熱発電所	6/9 仙台→東京
6/11 •（土木班）コンクリートダムの設計施工 •（電気班）電力系統計画	6/12 •（土木班）コンクリートダムの設計施工 •（電気班）発電所電気設備の設計施工	6/13 •（土木班）ロックフィルダムの設計施工 •（電気班）発電所電気設備の設計施工	6/14 •（土木班）ロックフィルダムの設計施工 •（電気班）送電設備の設計施工	6/15 •（土木班）発電所及び水路 •（電気班）変電設備の設計施工	6/16
6/18 ―見 学― • 下郷発電所建設現場	6/19 ―見 学― • 同　左	6/20 移 動 日	6/21 ―見 学― • 沼原揚水式発電所	6/22 ―見 学― • 同　左	6/23
6/25 • 通信設備の設計施工	6/26 • 発電所建築設備の設計施工	6/27 • 水力発電所の運転保守（土木班） • 水力発電所の運転保守（電気班）	6/28 ―見 学― • 土木試験所	6/29 ―見 学― • 西東京変電所	6/30
7/2 ―見 学― • 南横浜火力発電所 • 磯子火力発電所	7/3 ―見 学― • 船明・佐久間発電所	7/4 ―見 学― • 新豊根発電所・ダム	7/5 ―見 学― • 早木戸水力建設所	7/6 ―見 学― • 佐久間第2発電所・F・C	7/7
7/9 ―見 学― • 湯浅電池（海外電力）	7/10 ―見 学― • 日新電機（海外電力）	7/11 ―見 学― • 川鉄鉄構，播磨工場 （海外電力）	7/12 移 動 日	7/13 ―見 学― • 竹原火力発電所 （海外電力）	7/14 広島→東京
7/16	7/17 • 懇談会（海外電力） • 閉講式（JICA）	7/18	7/19	7/20	7/21

昭和５９年度　火力コース研修日程

月	火	水	木	金	土
4/30	5/1	5/2	5/3 来　日	5/4	5/5
5/7 ←	5/8	5/9 オリエンテーション （ＪＩＣＡ）	5/10	5/11 →	5/12
5/14 •日程説明会（海外電力） •日本の電気事業の現状（公益）	5/15 •電力供給計画・需要想定 •電源開発計画（公益）	5/16 •日本の送配電系統（公益） •中央給電連絡指令所（海外電力）	5/17 •日本の火力発電所 •日本の水力発電所（公益）	5/18 •日本の原子力発電所（公益） •ゴミ発電（海外電力）	5/19
5/21　－見　学－ •富士電機　川崎工場 （海外電力）	5/22　－見　学－ •三菱重工　横浜造船所 （海外電力）	5/23　－見　学－ •昭和電線　相模原工場 （海外電力）	5/24　－見　学－ •明電舎　沼津工場 （海外電力）	5/25　－見　学－ •日本電気　横浜工場 （海外電力）	5/26
5/28（～7/6まで東電） •オリエンテーション •会社概要	5/29 •研修参加国の電力事情報告会及び意見交換	5/30 •電源計画の考え方 •流通設備計画の考え方	5/31 •電力系統運用について •中央給電指令所見学	6/1 •変電設備の概要 •都内地下式変電所の見学	6/2
6/4 •送電設備の概要　運用・保守等 •配電設備の概要　系統運用等	6/5 •原子力発電の概要	6/6　－見　学－ •広野火力発電所	6/7　－見　学－ •福島第２原子力発電所 •ＢＷＲ訓練センター	6/8　－見　学－ •鬼首地熱発電所	6/9 仙台→東京
6/11 •火力発電所の設計	6/12 •火力発電所の計装設計 •火力発電所の建設	6/13 •主機器据付け工法	6/14 •火力発電所の運転と運転体制	6/15 •ＬＮＧ火力の設計 •火力発電所の保守・点検	6/16
6/18 •火力運転シミュレーター実習	6/19 同　左	6/20 同　左	6/21 同　左	6/22　－見　学－ •省エネルギービル大塚支社	6/23
6/25 •火力発電所の環境対策 •火力発電所の熱効率管理	6/26 •火力発電設備購入契約 •揚水発電の概要	6/27　－見　学－ •新高瀬川水力発電所	6/28　－見　学－ •梓川水力総合制御所	6/29　－見　学－ •新信濃周波数変換設備	6/30
7/2　－見　学－ •南横浜火力発電所 •磯子火力発電所	7/3 •発電の新技術開発状況	7/4 •発電の新技術開発状況（技開研） •火力発電用燃料対策	7/5　－見　学－ •送変電建設現場	7/6 •総括質疑 •終了懇談会	7/7
7/9　－見　学－ •湯浅電池（海外電力）	7/10　－見　学－ •日新電機（海外電力）	7/11　－見　学－ •川鉄鉄構　播磨工場 （海外電力）	7/12 移　動　日	7/13　－見　学－ •竹原火力発電所 （海外電力）	7/14 広島→東京
7/16	7/17 •懇談会（海外電力） •閉講式（ＪＩＣＡ）	7/18	7/19	7/20	7/21

昭和59年度　電気事業経営コース研修日程

月	火	水	木	金	土
8/20	8/21	8/22	8/23 来　日	8/24	8/25
8/27 ←	8/28	8/29 オリエンテーション （JICA）	8/30	8/31 →	9/1
9/3 • 日程説明会（海外電力） • 日本の電気事業の現状（公益）	9/4 • 電力供給計画・需要想定 • 電源開発計画（公益）	9/5　—見学— • 古河電工　千葉工場	9/6 • 日本の送配電系統（公益） • 中央給電連絡指令所（海外電力）	9/7　—見学— • 富士通　川崎工場	9/8
9/10（〜10/5まで中電） • オリエンテーション • 会社概要	9/11 • 労務の概要 • 電力供給計画	9/12 • 電源開発計画 • 中央給電指令所	9/13 • 電力系統運用 • 中央通信所・名古屋地方制御所	9/14　—見学— • 知多火力発電所	9/15
9/17 • 発送変電設備の保守管理	9/18 • 発送配電設備の保守管理 • 情報システム　見学	9/19　—見学— • 奥矢作揚水発電所	9/20 • 電力流通設備の近代化 • 電力系統計画	9/21 • 送変電設備計画 • 日本碍子(株)　見学	9/22
9/24（祭日）—見学— • 伊勢営業所	9/25　—見学— • 伊勢営業所	9/26　—見学— • 超高圧送変電設備工事現場	9/27 • 営業の概要	9/28 • 配電の概要	9/29
10/1　—見学— • 浜岡原子力発電所	10/2　—見学— • 総合技術研究所	10/3 • 個別研修	10/4 • 個別研修	10/5　—見学— • 能力開発センター見学 • トヨタ自工見学	10/6
10/8　—見学— • 新日鉄　名古屋工場	10/9　—見学— • 高岳製作所　名古屋工場	10/10 祭　日	10/11—見学— • 三菱電機　神戸製作所	10/12—見学— • 新興金属工業所	10/13
10/15	10/16 • 懇談会（海外電力）	10/17	10/18	10/19	10/20

昭和59年度　配電技術コース　研修日程

月	火	水	木	金	土
9/3	9/4	9/5	9/6 来　日	9/7	9/8
9/10 ←	9/11	9/12 オリエンテーション （ＪＩＣＡ）	9/13	9/14 →	9/15 祭　日
9/17 • 日程説明会（海外電力） • 日本の電気事業の現状（公益）	9/18 • 電力供給計画・需要想定 • 電源開発計画（公益）	9/19 • 日本の送配電系統（公益） • 中央給電連絡指令所（海外電力）	9/20 —見　学— • 大井電気	9/21 —見　学— • 日本碍子　小牧工場	9/22
9/24 祭　日	9/25（~11/9まで関電） • オリエンテーション • 当社の概要	9/26 • 営業部門の概要 • 支店・営業所の見学	9/27 • 講師と研修員との懇談会 • 関西電力学園の見学	9/28 • 系統計画の概要	9/29
10/1 • 配電用変電所	10/2 • 需給計画　電力系統運用技術 • 電力系統保護技術	10/3 —見　学— • 中央給電指令所 • 新曽根崎制御所	10/4 • 配電部門の概要 • 配電線の設備計画	10/5 • 配電における安全対策 • 配電線の電圧管理	10/6
10/8 • 配電線の停電対策	10/9 —見　学— • 避雷器の製造工程	10/10 祭　日	10/11 • 配電線の自動機器	10/12 —見　学— • 配電用変圧器製造工場 • 開閉器製造工場	10/13
10/15 —見　学— • 天ケ瀬水力発電所 • 喜撰山揚水発電所	10/16 • 架空配電線の工事・保守	10/17 —見　学— • 架空配電線工事現場 • 碍子製造工場の見学	10/18 • 配電の業務機械化 • 第1計算センター見学	10/19 —見　学— • 堺港火力発電所	10/20
10/22 • 架空配電線の設計	10/23 —見　学— • コンクリート柱製造工場	10/24 —見　学— • 鋼管柱製造工場	10/25 • 地中配電線の設計・工事保守	10/26 —見　学— • 電線ケーブル製造工場 • ケーブル接続箱製造工場	10/27
10/29 • 引込線・計器の設計・工事	10/30 —見　学— • 地中配電線工事現場 • 架空配電線・引込線工事現場	10/31 —見　学— • 計器修理工場・計器検定所 • 配電用機械受入試験	11/1 • 質疑応答	11/2 —見　学— • 美浜原子力発電所	11/3 祭　日
11/5 • 新しい配電設備と業務の概要	11/6 —見　学— • 新しい配電設備の見学	11/7 —見　学— • 主任技能コンクール • 電気機器製造工場	11/8 • 配電線設備計画の実際	11/9 • 質疑応答最終懇談会	11/10
11/12 —見　学— • 京都セラミック	11/13 —見　学— • 湯浅電池	11/14 —見　学— • 三菱電機　伊丹製作所	11/15 —見　学— • 石川島播磨重工　相生工場	11/16 —見　学— • 中国電力新広島変電所	11/17 広島—東京
11/19	11/20 • 閉校式（ＪＩＣＡ）	11/21	11/22	11/23	11/24

別添－1 セミナー原稿

「Electric Power Industry in Japan」

I am Hiraoka, an official of the Ministry of International Trade & Industry (MITI), who has had the honor of being introduced to you. I am in charge of the whole range of administration in respect to electric power engineering in Thermal Electric Power Division, the Public Utility Department, the Agency of Natural Resources & Energy.

It is a great pleasure for me to have an opportunity of delivering a speech in the presence of all of you here today. I am going to speak about the situation of electric power in Japan. I suppose the circumstances have considerably changed as compared with the time when you visited Japan, and I hope my speech will be somewhat informative for you.

At first, I will talk about the recent trend of demand and supply of energy in our country. Since the Second Oil Crisis demand for energy in our country had shown a decrease for three consecutive years from (fiscal) 1980. It was caused by the change of the industrial structure, the promotion of the energy saving and the stagnation in business. But an increase of 5.3% was shown in (fiscal) 1983 due to the improvement in business and the climatic factors, namely the fierce heat in summer and the severe cold in winter, which are both unusual. It kept on increasing in (fiscal) 1984.

As for supply of energy, petroleum showed a sharp decrease in ratio, accounting for 62% in 1983 as against 72% in 1979. As the substitutive energy for petroleum, the ratio of nuclear power tremendously increased from 4.2% in 1979 to 7.2% in1983, and also natural gas, from 5.2% to 7.5%, coal from 13.9% to 17.7% and hysraulic power, from 5.0% to 5.4%.

	1979	1983	1995
Demand for Energy	443 million kl	414 million kl	530 million kl
Petroleum	71.6%	61.9%	48%
Nuclear Power	4.2	7.2	14
Natural Gas	5.2	7.5	12
Coal	13.9	17.7	18
Hydraulic Power	5.0	5.0	5
Demand for Electricity	529.1 billion kwh	553.1 billion kwh	768.0 billion kwh
Nuclear Power	14.95 million kw	18.28 million kw	48.0 million kw
LNG Thermal Power	18.63	23.38	43.5
Coal Thermal Power	4.41	8.23	21.0
Hydraulic Power	27.21	32.40	42.0
Petrolium Thermal Power	58.23	60.09	49.0
(%, kwh)	(51%)	(36%)	

Next, I would like to make mention of the trend of demand and supply of electicity. In spite of the tendency to decrease in demand for energy, demand for electricity favorably increased to 553.1 billion kwh in 1983 as against 529.1 billion kwh in 1979. In terms of the installed capacity of generation of electric powe, njclear power tremendously increased from 14.95 million kw in 1979 to 18.28 kw in 1983, LNG thermal power from 18.63 million kw to 23. 38 million kw, coal thermal power from 4.41 million kw to 8.23 million kw and hydraulic power from 27.21 million kw to 32.4 million kw. Thus it can be said that the substitutive power sou ce for petroleum has been steadily developed. As for the petroleum thermal power, ratio of its output in total output sharply decreased from 51% to 36%, although its installed capacity slightly increased from 58.23 million kw to 60.09 million kw.

As I have explained so far, substitutive energy for petroleum has been favorably introduced into our country for both energy supply and electric power supply, and we are certainly getting rid of dependence upon petroleum.

Now, let me talk about our outlook on the future demand for energy.

In November, 1983, our Government issued "The long-termed Outlook on Demand and Supply of Energy", which has been the guideline for the Government's policy as to energy.

It is estimated there that the demand for energy will reach 530 million kl in 1995 with annual increase by per cent. And the supply in 1995 is forecast to show the increase in nuclear power by 14 per cent, natural gas by 12 per cent, coals by 18 per cent and hydraulic electric power by 5 per cent.

In other word, most of the future increase in the demand for energy will be covered by the substitutes for petroleum. Eventually, we forecast that the future supply of petroleum will hardly be able to increase in its volume and that the ratio of dependence on petroleum in energy supply will further lessen to 48 per cent in 1995.

In this connection, I hereby wish to make a little comment on what we call "new energy", such as solar energy, biomass-alcohol, etc. We estimate the supply of new energy will expand to 19 million kl in 1995, 4 per cent of total demand for energy, as much as 19 times bigger than supply of 1 million kl in 1983 with merely 0.2 per cent coverage.

Now, you may be aware of how positively our Government will proceed with research and development of new energy, while it seems very difficult to achieve the figures in our estimate entirely as forecast.

Next, I will take up our estimate of demand for electricity.

We estimate that the demand for electricity will be totaled to 768 billion kw at tempo of estimated annual increase of 2.8 per cent, which is based on our estimate that the expansion of electricity demand for home-use is remarkable and that for industrial use is comparatively slight.

It is also estimated that supply of nuclear power shows a big increase with 48 million kw, coal thermal power with 21 million kw, LNG thermal power with 43.5 million and hydraulic power with 4200 kw, while the supply of petro-thermal power is estimated to sharply decrease to 49 million kw.

The ratio of electric power output by petro-thermal power is estimated to decrease to 14 per cent of total power output.

I have been talking about our outlook on future demand and supply of energy in our country. There seem to be some points I would like to raise for you, which were actually taken into consideration in making outlook:-

Firstly, the demand and supply of petroleum is currently in weakening tendency, but will certainly turn to be tightened again, for the long run, with high possibility of soaring-up of the oil price in 1990's.

Secondly, the well-planned and steady development and introduction of the substitue energy for petroleum will minimize our current dependence on petroleum so that it may assure the maintenance of security.

Thirdly, we will have to make every possible effort to realize cost-down of energy so as to increase supply of such energy with high economical efficiency as nuclear power, coal thermal power, etc.

The outlook you have been listening to was made through consideration of these three (3) points that I have mentioned. I hope you now have an idea the status quo and outlook of the demand and supply of energy in Japan.

Now, let me switch over to speak roughly about the trend of electric power en gineering in our country, taking up four (4) subjects on powe generation engineering.

Firstly, about the operation of nuclear power station.
In our country, we have made efforts toward research and development of nuclear power and in act the rate of operation of nuclear power stations has recently been improved quite a deal, showing 74 per cent in 1984 as against 50 per cent in 1980.

This is because troubles have been remarkably eliminated through fully developed technology and also the period of periodical inspections hane been made considerably shorter.

Secondly, about the thermal power by LNG combined cycle.
Recently, LNG combined cycle power facilities have been being build in our country. The combined cycle power, incorporated with gas-turbine and boiler, is capable of producing high thermal efficiency.

There are now four (4) stations in operation and under planning.

Thirdly, about co-generation system.

A number of organizations and authorities are now carefully checking and studying the co-generations which are installed in buildings and/or factories by end-users themselves.

MITI is shortly expected to conclude the guideline to the connection of the co-generation with service cables of electric power company.

Fourthly let me talk about the new power source. We have been taking a great interest in research and develpment on fuel cells and solar heated generation as the new power source. We have been confronted with an obstacle in economical efficiency at present but believe that intruduction for practical use will be gradually promoted in the near future.

As for the hydraulic power generation, Mr. Ogawa will go into details after my speech.

Next, I would like to present two subjects in the field of power transmiision. Firstly about the transmission voltage. In our country the power cables with 500 thousand volts A.C. are widely installed as a key system. But the Tokyo Electric Power Company has recently announced the construction plan for the power cables with 1 million volts A.C. it was decided as the result of making experiments for years, and construction work is planned to be launched around 1988.

Let me drift to the second subject, the direct current power transmission. Research and development has been conducted with the Electric Power Development Company as leader and we assume that we have the sufficient technical ability now. But there found few places for application within the country, therefore we are looking for an oppotunity to use our ability in foreign countries.

As concerns the facilities for transformation, the considerable progress in the remote control system in substations is highly noticeable. More than 95% of the whole substations have already become unmanned. Such automation is being promoted on the basis of the idea that the reliability in supply shall never be reduced.

Then next, let me turn on the topic in the field of power distribution. There are two subjects here. First one is the installation of underground distribution lines. There are a large number of utility poles in urban areas in Japan at present as against very few in Europe and America. Therefore the removal of utility poles is requested by the self-governing bodies and residents from the aesthetic point of view. But the electric power companies offered opposition because laying subterranean lines costs a great deal. Then MITI decided a policy to lay approximately 1,000 km subterranean line during the next decade, and the electric power companies agreed to it and are putting it into practice.

The second one is automation of power distribution. We found the cases that the remote control system of break and make switches installed in power distribution routes is introduced are increasing. It is implemented by respective electirc power companies under the policy of minimizing the power failure time and its diffusion is h ghly expected from now on.

So far I have explanined, in general, the recent situation of electric power in Japan. I should be pleased if my speech could be instructive for you.

Well, I would like to close my presentation now. If you havé any questions, please do not hesitate to ask me.

	1979	1983	1995	/ YEAR
ENERGY DEMAND	4.43	4.14	5.30	/ 100 million KL
OIL	71.6%	61.9%	48.0%	
NUCLEAR	4.2%	7.2%	14.0%	
LNG	5.2%	7.5%	12.0%	
COAL	13.9%	17.7%	18.0%	
HYDRO	5.0%	5.4%	5.0%	
NEW ENERGY	0.1%	0.2%	4.0%	

	1979	1983	1995	/ YEAR
POWER DEMAND	529	553	768	/ 1000million KWH
NUCLEAR	14950	18280	48000	/ MW
LNG FIRED	18630	23380	43500	"
COAL FIRED	4410	8230	21000	"
HYDRO	27210	32400	42000	"
OIL FIRED (%, KWH)	58230 (51.0%)	60090 (36.0%)	49000 (14.0%)	"

NEW HYDRAULIC GENERATING TECHNOLOGY IN JAPAN

Aug. 1980
JICA
SUMIO OGAWA

1. MODEL PLANT TESTS for SEA WATER PUMP-TURBINE
2. VARIABLE SPEED HYDRAULIC TURBINE & GENERATOR

I. Introduction

I am an electrical engineer specializing in hydro-electric power. So today, I would like to talk about hydraulic power.

Recently, in Japan, from the technical point of view, very interesting studies have been in progress. And I would like to introduce two subjects which I think may be of interesting to you.

These are:

1. Model plant test for Sea Water Pump-Turbine
2. Variable speed hydraulic turbine & generator

These Study has just started for each of them, so we do not yet have a practical solution. However, we will continue to do our best to realize a prototype power station.

II. Model Plant Tests for Sea Water Pump-Turbine

1. Background

Large capacity thermal power plants have increased in number and so have the number of atomic power plants, and recently atomic power plants are running at a high operating factor.

In order to utilyze surplus power during the light load hours in the night time and in order to provide quick response peak supply power plant, in the day time, many pumped-storage hydro power plants (combined with base load thermal and atomic power plants) have been installed in the power system.

- o JAPAN is surrounded by sea and more than 50% of coast line is a steep topography. Therefore, there are many sites where a high head can be utilized with a short water way.
- o Large capacity thermal and atomic power stations constructed on the coast line which supply electric power for base load. In combination with them, sea water pumped-storage power station can be installed near the thermal and atomic Power Station.

  So there is a saving in the cost of transmission line. In addition, isolated power system (for example isolated island) where conventional hydro Power Plant can not be constructed. Sea Water Pumped-Storage-Power Plant is useful from the view point of quick response frequency control.
- o Compared with conventional pumped-storage plants using river water, there is no basic difference in sea water pumped-storage plant, except that the water is sea water for which various technical problems must be solved.

  Ministry of International Trade and Industry of our government entrusted EPDC (Electric Power Development Co., Ltd.) to conduct the 1st stage study on sea water pumped-storage power plant.

From 1981 to 1984, EPDC studied the following problem: –

(1) Countermeasures against sea life

(2) Investigation of materials for turbine, perticularly in respect of corrosion caused by sea water

(3) Investigation of materials suited to prevent seepage of sea water into the ground from the water way and upper reservoir.

(4) Geological investigation of probable sites for sea water pump storage plant

As the 2nd stage study which started this year, EPDC started model plant tests for pumped-turbine on the island of OKINAWA where is one of the probable sites of Japan.

The study will continue for 5 years. Running test of model pump turbine started this April, and after 3 months of testing, the model was disassemble to inspect the influence to runner and other parts submerged in sea water.

I would introduce this study.

2. Characteristics of Sea Water Pumped-Storage Power Plant

(1) LOWER RESERVOIR . . . . . . SEA

⇒ LOWER RESERVOIR COST : ZERO (0)

The lower reservoir will be the sea, and therefore, the cost of lower reservoir is zero.

(2) EXTENSIVE AREA for UPPER RESERVOIR

⇒ LARGE CAPACITY POWER STATION

If an extensive area can be obtained for the upper reservoir, a large capacity station can be constructed.

(3) THERMAL & ATOMIC POWER STATION . . . .COAST LINE

SEA WATER PUMP STORAGE POWER STATION . . . . COAST LINE

⇒ SHORT DISTANCE TRANSMISSION LINE

⇒ LOW COST

EASY POWER FLOW CONTROL

The power for pumping up sea water will be supplied from thermal and atomic power plant located on the coast line. Because sea water pump storage power plnats can be constructed on the coast line near the thermal and atomic plant, there will be great savings on the cost of transmission line and facilitate operation of power flow control.

(4) ADDITIONAL COST for PREVENTION of CORROSION
STICKING of MARINE LIFE
UNDESIRABLE EFFECT to PLANTS
CAUSED by OSMOTIC ACTION of SEA WATER

The following countermeasures will require additional costs compared to pump-storage plants using river water.

That is; Countermeasures to prevent

Corrosion of machine

Marine life adhering to
the water conveyance structure and machine

Adverse effect to plants by
seepage of sea water into the ground in and arround the upper reservoir

(5) SEA WATER IN UPPER RESERVOIR

Strong winds by typhoon are apt to cause spraying of sea water stored in upper reservoir to plants in the surrounding area causing salt polution.

(6) SPILLWAY to DISCHARGE WATER into SEA

Overflowing of water from upper reservoir caused by foods or heavy rain will cause salt polution.

In order to prevent this adverse effect, a spillway should be constructed to discharge water from the reservoir directly into the sea.

3. Problems to be solved

Sea water pumped storage plants have some advantages over river water pumped-storage plants but there are various technical problems which must be solved because sea water is used.

(1) CORROSION of MATERIALS by SEA WATER
(ESPECIALLY RUNNER MATERIAL)

At present, there are materials that are corrosion resisting against sea water, but as the pump turbine is required to operate under high head and high velocity flow and other severe conditions there is the need to develop materials which can satisfy these requirements and easy maintenance.

(2) STICKING of MARINE LIFE

Solving of the problem of the environment which cause sticking of marine life and preventative measures.

(3) PENSTOCK MATERIAL

For anti-corrosion, FRP (Fibre Reinforced Plastic) lining is desirable.

(4) PREVENTION of SEEPAGE and SPRAYING of SEA WATER

Prevention of seepage of sea water into the ground in and near the upper reservoir, and spraying of sea water.

(5) INFLUENCE by INTAKE and DISCHARGE of SEA WATER

At the Tailrace (intake for pumping), the discharge through the turbine is 100 to 300 m^3/s causes substantial turbalence at the tailrace outlet.
This will cause suction and discharge of sand into the tailrace, movement of sea bed sand deposit, environmental changes to marine life, influence to fishing and changes in sea current flow.

4. Purposes of the Tests

Model pump-turbine (of such design so that the discharge, head revolving speed and draft head can be adjusted) is to be manufactured, and installed on the island of OKINAWA where characteristics of the sea water, temperature and marine life are similar to the site where one if the probable sites of Japan.

Purposes of the tests are as follows: –

(1) ANTI-CORROSION CHARACTERISTICS of MATERIALS

(2) CATHODIC PROTECTION EFFECT

(3) ANTI-CORROSION PAINT RESULTS

(4) ANTI-CORROSION CHARACTERISTICS of SENSORS

(5) STICKING CONDITIONS of MARINE LIFE

These results will be used as indicators in the design and manufacture and operation of prototype plant.

5. General Features of the Tests

(1) In order to test runner materials having desirable and undesirable characteristics and to test different anti-corrosion methods, 3 model runner are to be manufactured and tested in turn.

(2) In order to reduce running cost of pump-turbine, runner is to be mounted on each end of a common shaft. (Fig. 1)
One runner will operate as a turbine, and the other runner will operate as a pump. By this arrangement the total system loss is to be compensated by a moter mounted

in the center of the shaft.

That is, motor supply power total system loss only.

(3) Each day, the direction of rotation of the runners are to be changed, and the operating hours per day is to be 8 hours.

6. Items to be confirmed

(1) The operation characteristics of sea water pump-turbine are same as those of river water pump turbine.

Therefore, the purposes of the tests are to be confirmed

Head

Draft head

Revolving speed

Discharge

(2) Effect of cathodic protection and anti-corrosion paint

(3) Condition of corrosion in gap between connection by structural arrangement

(4) Condition of cavitation

(5) Check of anti-corrosion characteristics of various sensors

(6) Analysis of stricking condition of marine life

III. VARIABLE SPEED HYDRAULIC TURBINE & GENERATOR

1. Background

From many years ago, in order to achieve high efficiency of runner at different operating range, variable pitch runner vane, such as Kaplan and Dariaz turbines have been developed.

However, these type of turbine are of complicated structure, and recently Research and Development are underway to achieve high efficiency at a wide range of head with a Francis turbine which is of simple construction, by adopting variable speed hydraulic turbine and generator. I would like to brief comment on this Research and Development.

2. Outline

In recent years, DC transmission technology has developed remarkably in our country.

SCR (Silicon Controlled Rectifier) has been developed and put into practical use, replacing the conventional Mercury rectifier.

Field Tests of water cooled directly light triggered SCR, have been successfully performed, and as a result, it is possible to manufacture a compact SCR.

Variable Speed System is to employ frequency convertor device using newly developed water cooled directly light triggered SCR in combination with recent electronics control system for turbine & generator. (Fig.2)

By this system, it is possible to achieve high efficiency at actual operating head by applying optimum revolution of turbine & generator.

In other words, the revolution of turbine & generator can be selected with no relation to transmission frequency, and therefore, high efficiency can be achieved for a wide range of operating head, and as a result greater energy production can be expected.

Compared with conventional turbine & generator, variable speed method requires converter and inverter as frequency converter.

In order to judge whether this new method can be economically put into practical application, the critical point would be whether the additional costs for these equipment would be equal to or better than the increment in energy production due to higher efficiency.

3. Development of AC/DC Converter Equipment

Before, touching on the subject of characteristics between revolution and efficiency and sites where this new method can be applied, I would like to show you SLIDES giving the development from mercury rectifier to the newly developed water cooled directly light triggered SCR.

SLIDES

(1) General view of SAKUMA frequency converter station

(2) General view of HOKKAIDO-HONSHU DC Interconnection AC/DC converter station

(3) Mercury rectifier in SAKUMA frequency converter station

(4) Air cooled SCR in SAKUMA TEST PLANT

(5) Oil cooled SCR in SHIN SHINANO frequency converter station

(6) Air cooled indirectly light triggered SCR in HOKKAIDO-HONSHU DC Interconnection AC/DC converter station (HITACHI)

(7) Water cooled directly light triggered SCR in SAKUMA frequency converter station at field test

(8) Element of SCR triggered by electric signal

(9) Element of light triggered SCR

(10) One module of air cooled indirectly light triggered SCR

(11) One module of water cooled directly light triggered SCR

(12) One module of Air Cooled Indirectly light triggered SCR

(13) One module of Water Cooled Directly light triggered SCR

4. Efficiency of Hydraulic Turbine

This slide shows the typical efficiency characteristics of a Francis Turbine. (Fig.3)

In a conventional Francis Turbine, runner is designed so that the best efficiency point is achieved at normal effective head which is in the range of 80～90% of maximum discharge, and based on this criteria, the revolving speed is determined.

Therefore, variation in head will cause deviation of the best efficiency point resulting lower efficiency.

Compared with the conventional design, in the variable speed design, runner revoluting speed can be adjusted corresponding to $\sqrt{H}$ when there is a fluctuation of head, and this results in incremental energy production.

The more incremental energy production would be beneficial. For this reason, sites where head fluctuation is great, are most suited for variable speed method.

In addition, an important factor would be that the frequency converter could be manufactured at low cost.

From the point of cost, the application of converter to small and midium hydro which do not require a large capacity converter, is the subject of our study which has just started.

As stated earlier, variable speed method is most suited to sites where head fluctuation is great, and studies have been initiated to determine the sites where this method could be applied fiesibily from a technical standpoint.

The studies also include estimation of incremental energy production.

In the studies the following factors are taken into consideration:

Head

Range of head fluctuation

Turbine discharge

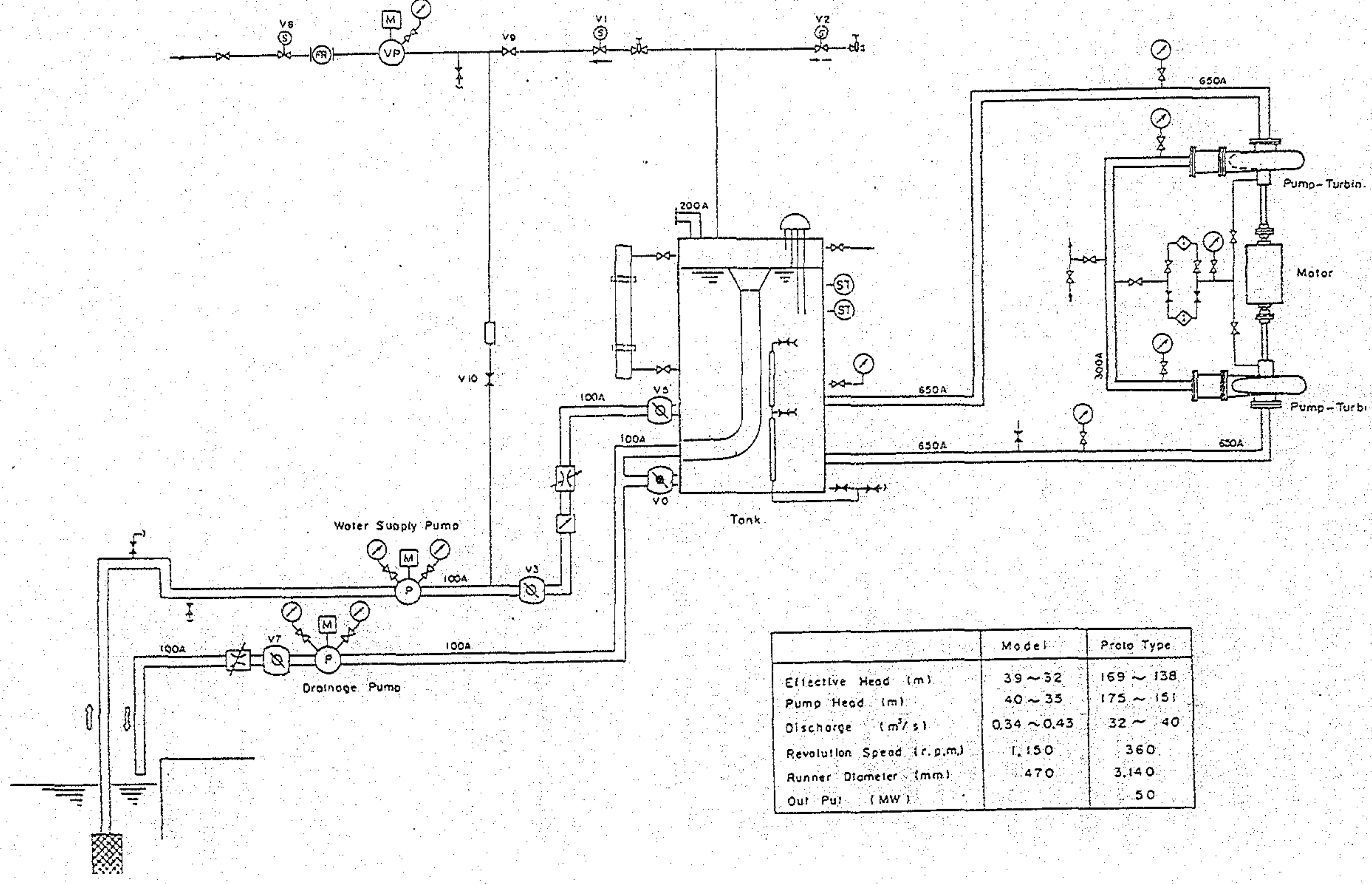
Power plant output

Annual runoff trend

This has been a very brief presentation, but I hope that you were able to get a general idea of Research and Development on Variable Speed Turbine and Generator which we are now performing.

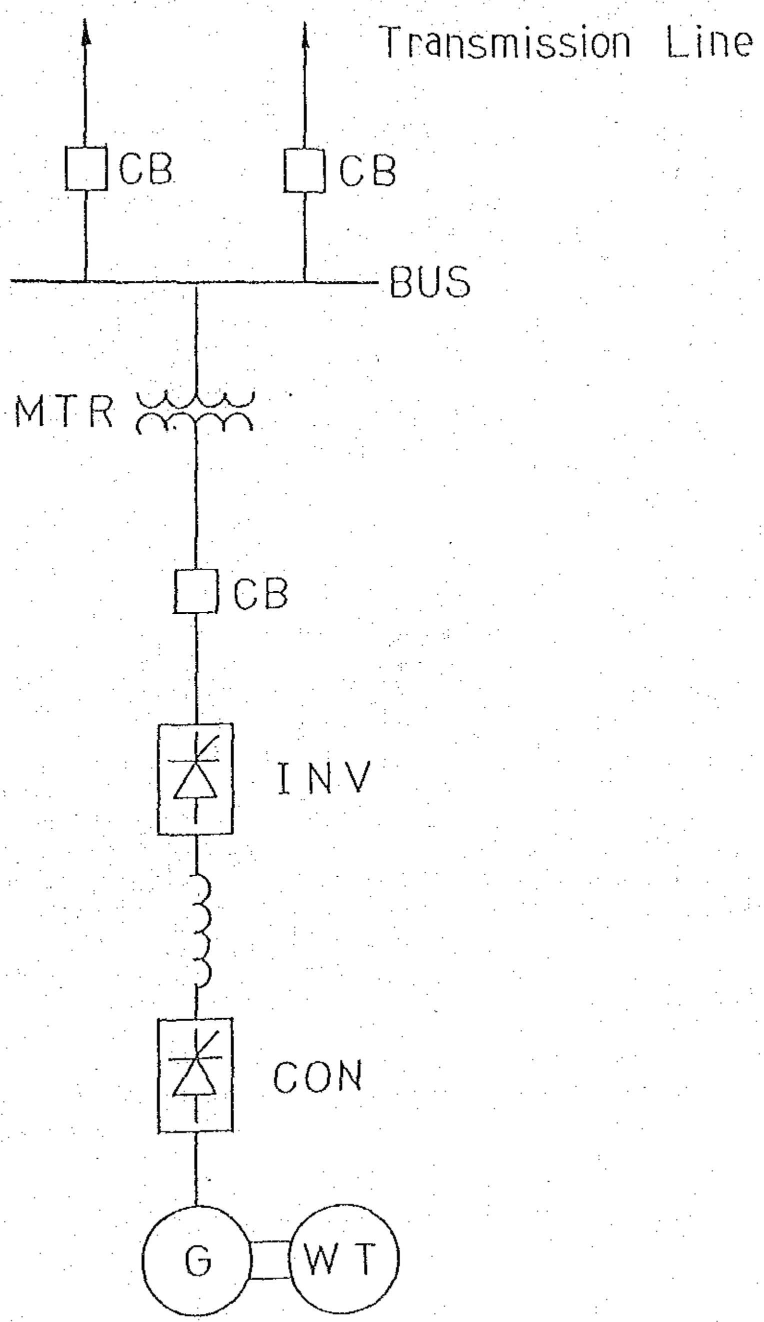
Thank you.

Fig. 1 SCHEMATIC WATER SYSTEM OF MODEL TEST PLANT FOR SEA WATER PUMP - TURBINE



	Model	Proto Type
Effective Head (m)	39 ~ 32	169 ~ 138
Pump Head (m)	40 ~ 35	175 ~ 151
Discharge (m^3/s)	0.34 ~ 0.43	32 ~ 40
Revolution Speed (r.p.m.)	1,150	360
Runner Diameter (mm)	470	3,140
Out Put (MW)		50

Fig.2 One Method of Variable Speed Turbine And Generator



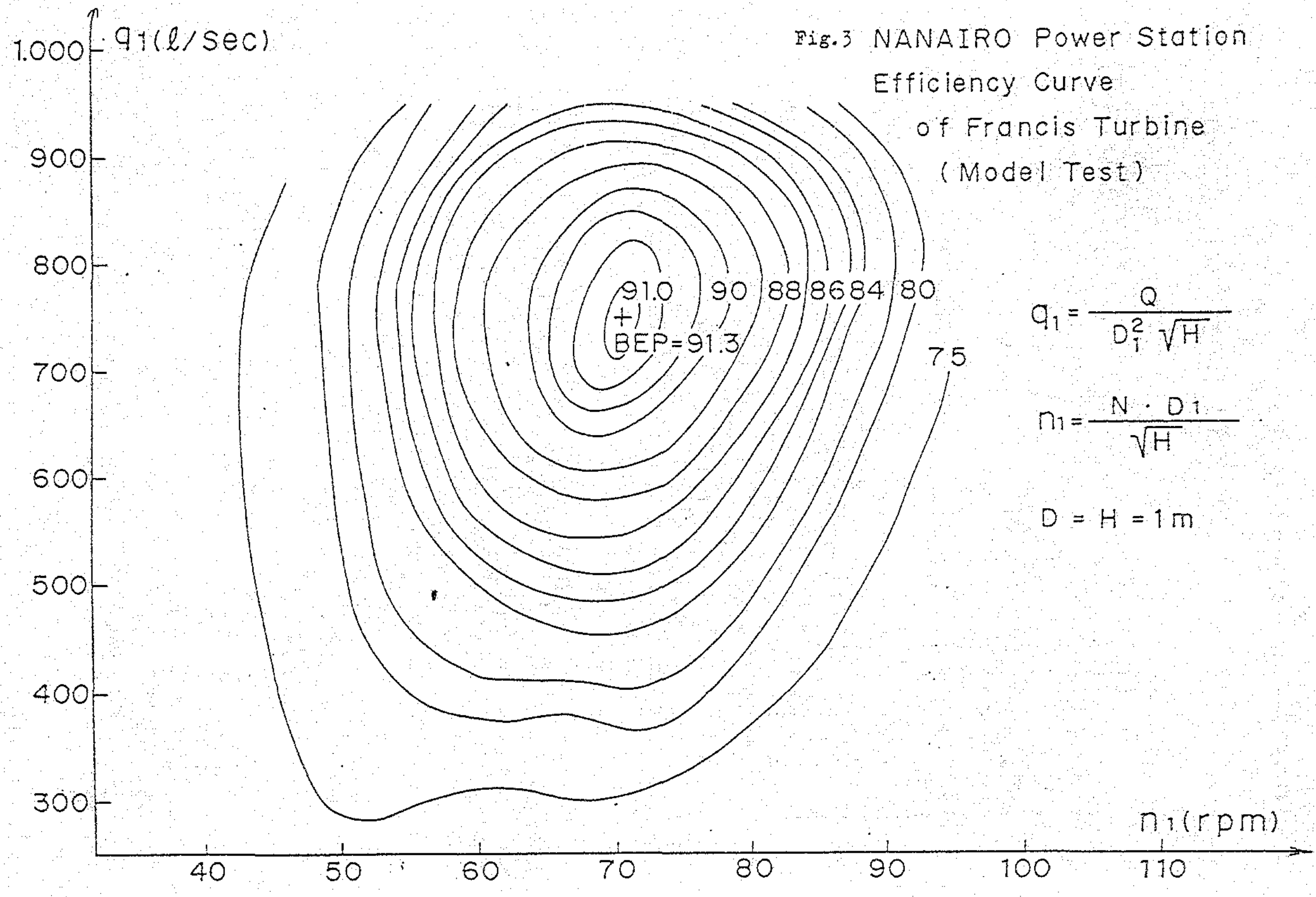


Fig.3 NANAIRO Power Station
Efficiency Curve
of Francis Turbine
(Model Test)