Chapter 11 Hospital

11-1 Outline of Hospital

Hospital Seremban was founded in 1969, and has a T-shaped 9-storey tower block accommodating inpatients (800 beds), and a single-storey podium housing outpatients; and a Treatment and Diagnostic area. The hospital is owned by the Federal Government as a representative and general hospital in the State (Negeri Sembilan). There are several other hospitals designed similarly to this hospital in Malaysia, and this hospital is one of the typical hospitals in Malaysia. It has various kinds of energy-consuming facilities found in the commercial sector, such as facilities using electricity, fuel oil, chilled water, hot water and steam. Therefore, the study team conducted an audit of the various types of energy consumption.

In order to conduct an energy audit for the hospital, taking measurements was the first essential step and developing an energy balance the second. The results of the energy audit, including evaluation, analysis and recommendations for improvements of energy efficiency, are described in this chapter.

11-1-1 Outline of the Hospital

1. Name of Hospital:	Hospital Seremban
2. Address:	Jalan Dr. Muthu, off Jalan Rasah, 70300 Seremban,Nageri Sembilan Telephone: 06-723333, Facsimile: 06-7625771
3. Director:	Dr. T. Mahadevan
Hospital administrator:	Dr. K. Gunapusanam (Deputy Director)
Energy manager :	Tongkah Medivest Sdn. Bhd. Service Center, Hospital Seremban (privatized company)
4. Type of hospital:	Public (federal government-owned)
5. Annual expenditure:	RM 60 Million/year
6. Organization chart:	Shown in the Figure 11-1
7. Number of employees:	1,700 (permanent staff including clinical, non-clinical and supporting services) Doctors: 172, Nurses: 597

8. Number of energy-related managing staff:

Maintenance engineers: 4, Maintenance workers: 88

9. Total area of hospital, ha: 85 (new hospital: 26, old hospital: 59)

10. Total floor area, ha: 4 (new hospital: T-shaped 9-storey tower block accomodating inpatients with a single story podium housing outpatient as well as a Treatment and Diagnostic area)

11. Number of beds: 800

12. Layout of hospital: Shown in Figures 11-2, 11-3 and 11-4 (East site: new hospital)

13. Major services: Clinical: 14 disciplines, medical & clinical training: 12 courses, supporting services: 11 items

14. Trends in annual service amount:

Shown in Tables 11-1, 11-2 ,11-3 and 11-4

15. Year of establishment: 1969 (new hospital)

16. Position in hospital sub-sector:

There are several hospitals designed similarly as this hospital in Malaysia.

17. Financial information of hospital: Not available

11-1-2 Services and Energy Consumption

1. Capacity of major services: Capacity of major services is difficult to determine in the case of a hospital. (Number of beds is shown in Table 11-1 and 11-4)

1) Service Mode for Outpatients

Service days for outpatients in a week are 6 (six) and service hours are as follows:

Monday - Friday:	8:00 AM - 4:15 PM
Saturday:	8:00 AM - 12:45 PM
Sunday:	Holiday

2) Service Mode for Accident and Emergency

Service mode for accident and emergency is as follows:

Service days in a year, days: 365, Service hours in a day, hours: 24

2. Trends in number of patients: Shown in Tables 11-1, 11-2, 11-3 and 11-4

3. Kinds of fuels:

Light Fuel Oil: Fuel for horizontal & smoke tube-type boilers (3 units)

Diesel Oil: Fuel for emergency power generators (2 units) and the incinerator

4. Monthly energy consumption in 1997:

L.F.O, kl/month, RM/month: 85.7, 30,000

Electricity, MWh/month, RM/month: 571.4, 120,000

5. Outlines of major energy-consuming facilities:Shown in Table 11-5
   1) Boilers
   2) Chillers
6. Electric power receiving:
   1) Receiving Voltage, kV: 11
   2) Current demand, kW: 1,000
   3) Current Power Factor, %: 85
   4) Capacity of power generator for emergency, kVA: 750 & 819 (50% of normal demand)
7. Utilization of Steam and Electricity:
   1) Steam: Kitchen & laundry, hot water storage calorifiers, domestic hot water calorifiers, bed-pan washer's washing machines, sterilizers, humidifiers and re-heating coils of the air-handling units
   2) Electricity: All the power for air conditioning, lighting and others is received from TNB through the sub-station
8. Energy Management

A privatized supporting service company, named Tongkah Medivest Sdn. Bhd., is in charge of energy and maintenance management in this hospital.

The main Hospital complex was built in 1969 and some energy consuming facilities have been modified since then, for example the chillers.

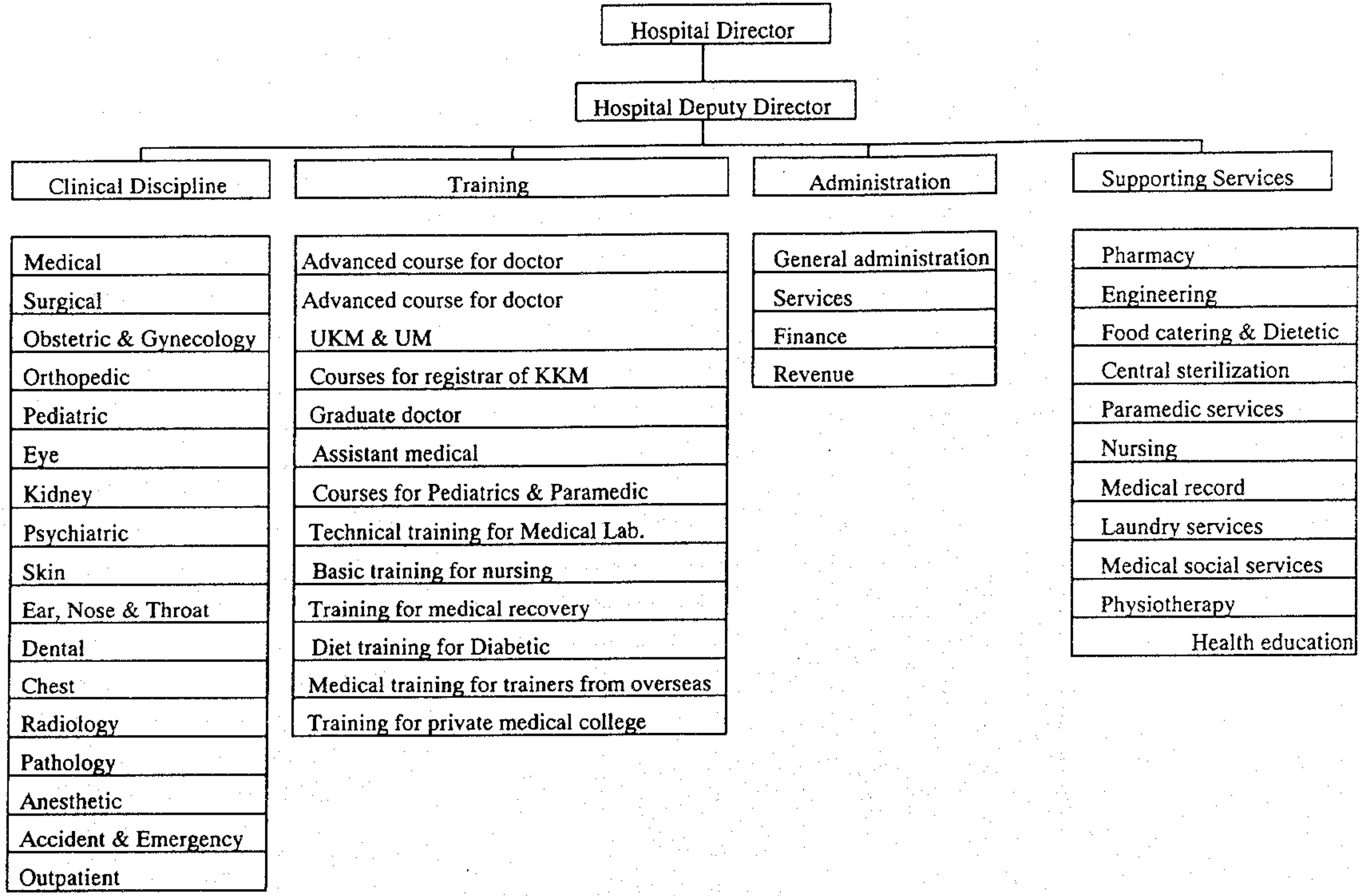


Figure 11-1 Hospital Organization Chart

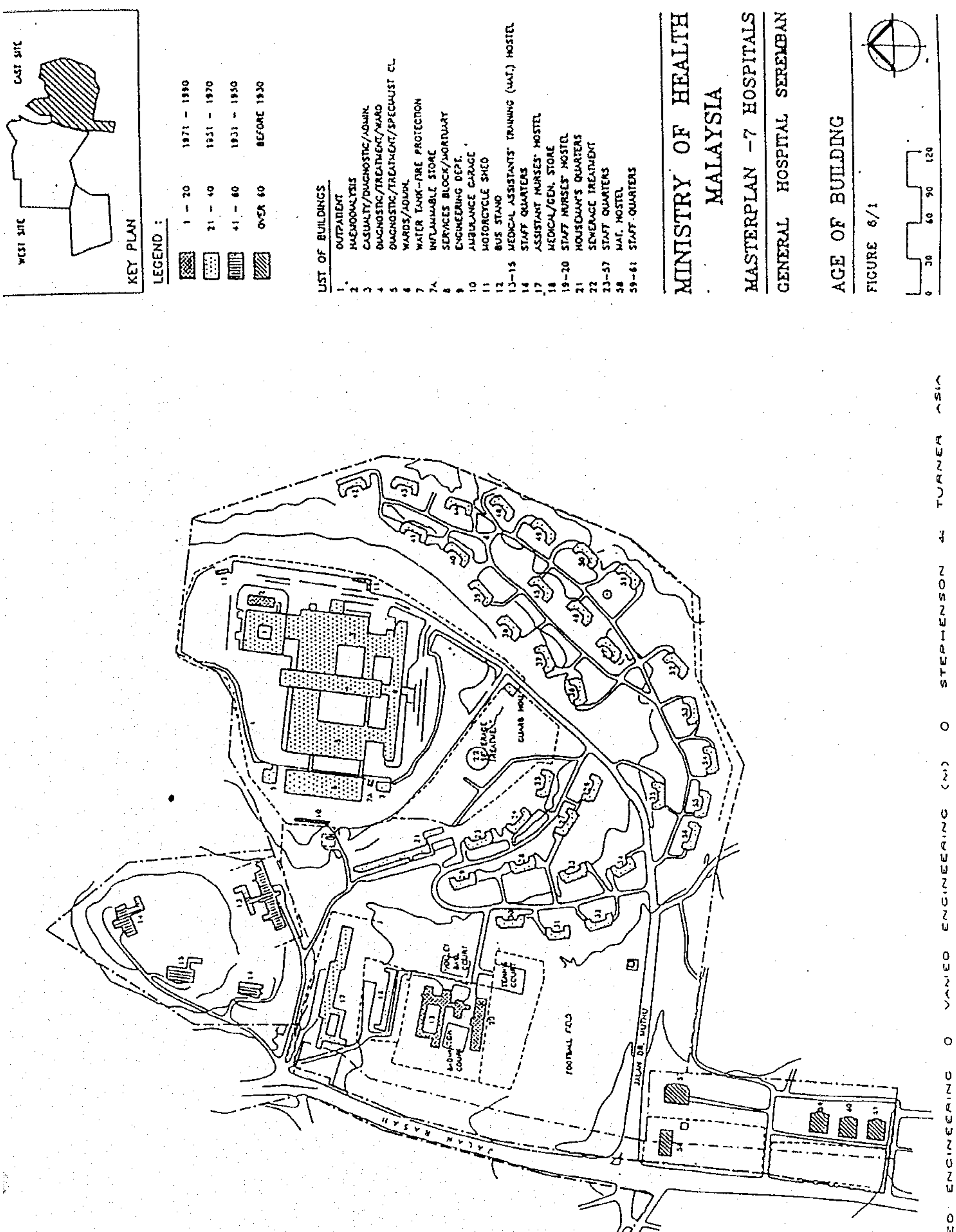


Figure 11-2 Layout of the Hospital

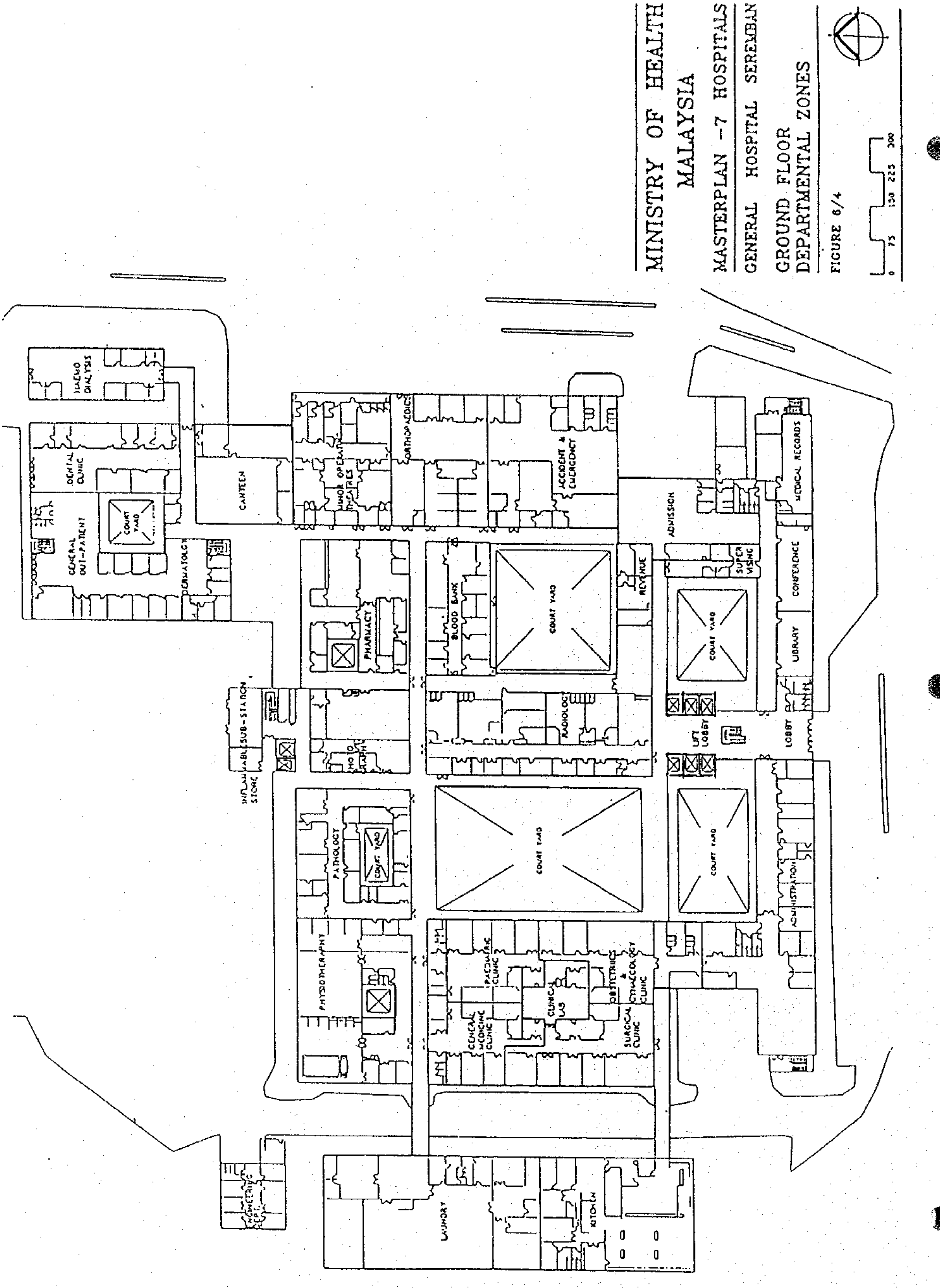


Figure 11-3 Layout of the Hospital (Ground Floor)

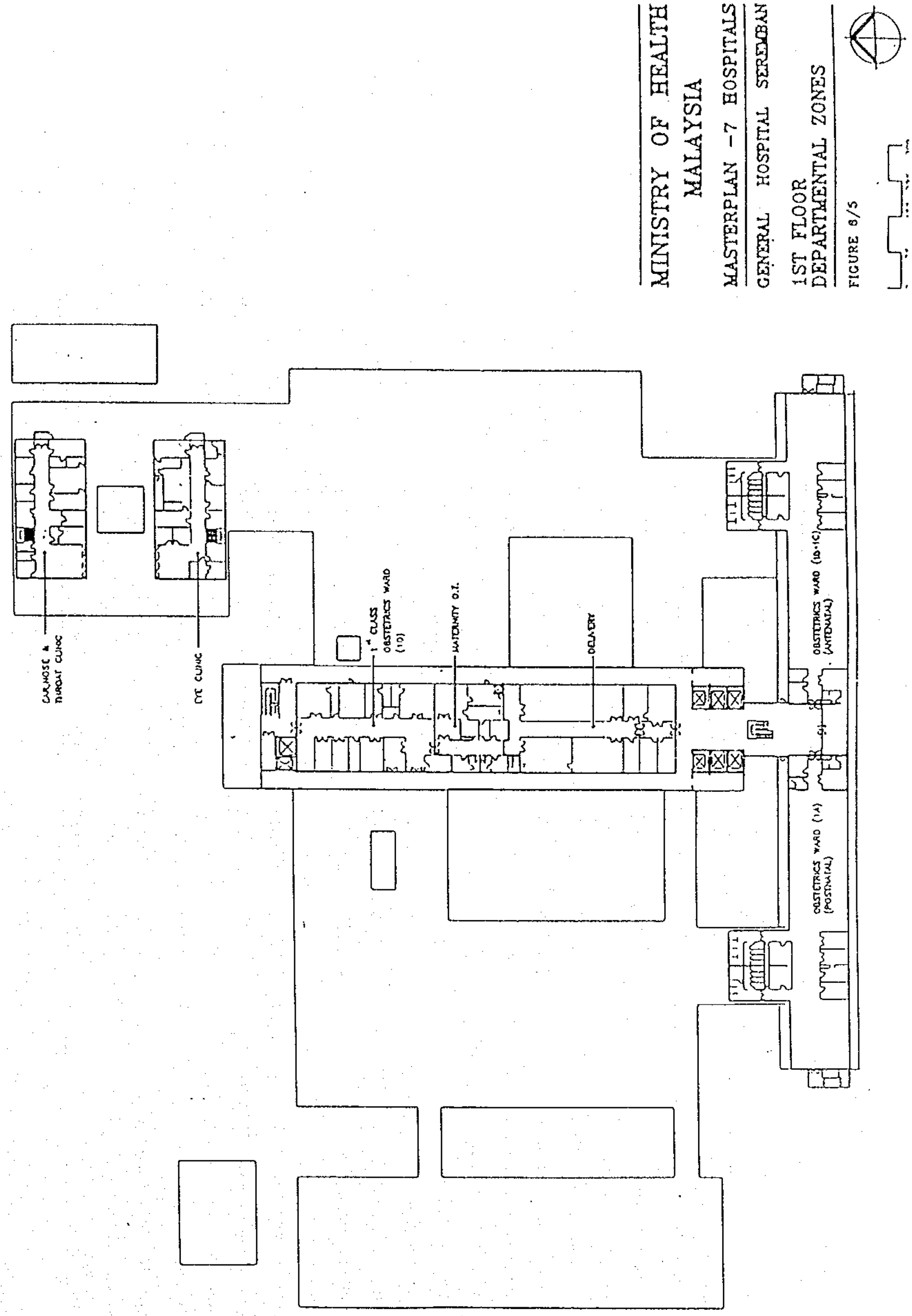


Figure 11-4 Layout of the Hospital (1st Floor: similar to the 2nd - 8th Floors)

Table 11-1 Patient Treatment According to Clinic Specialist

	1988	1989	1990	1991	1992	1993	1994	1995	1996
Number of beds	1,045	1,045	1,045	900	800	800	800	800	800
Number of admission	37,562	36,849	38,282	37,113	35,620	37,540	35,668	39,501	39,874
Average daily admission	102.90	100.96	104.88	101.68	97.32	102.85	97.72	108.22	109.24
Number of discharge	37,710	36,730	38,237	37,131	35,638	37,478	35,929	39,411	39,831
Average daily discharge	103.32	100.63	104.76	101.73	97.37	102.68	98.44	108	109.13
Number of daily inpatient	218,525	214,105	235,336	204,859	188,461	200,146	181,020	182,578	179,683
Average daily inpatient	598.70	586.59	644.76	561.26	514.26	548.35	495.95	500.21	492.28
Ratio of bed being occupied (BOR)	57.3%	56.1%	61.7%	62.36%	64.37%	68.54%	61.99%	62.53%	61.37%
Bed turnover (TOI)	4.3	4.6	3.8	3.33	2.93	2.45	3.09	2.78	2.84
Average duration of stay (ALOS)	5.8	5.8	6.2	5.52	5.29	5.34	5.04	4.63	4.51
Number of death	796	741	951	858	791	896	887	1,022	1,011
Number of outpatient	402,110	398,731	395,905	389,646	378,724	393,952	354,788	376,427	344,836
New outpatient	202,764	193,872	170,846	180,826	188,270	188,901	152,643	168,394	148,595
Repeated outpatient	199,346	204,859	225,059	208,820	190,454	205,051	202,145	208,033	196,241
Average daily number of outpatient	1,289	1,278	1,269	1,318	1,279	1,330.91	1,295.0	1,271.7	1,161.0
Clinic days						296	274	296	297
Operation (elective)	4,919	4,429	4,622	5,364	5,542	7,042	7,623	5,221	4,631
Operation (emergency)	7,085	7,389	6,738	6,565	8,645	8,336	7,779	9,108	10,603
Deliveries of baby	7,907	7,913	8,238	8,033	7,927	7,839	7,994	7,789	7,909
Birth of baby	7,984	7,982	8,325	8,143	7,974	7,897	8,087	7,834	8,004

Table 11-2 Attendance for Outpatient According to Discipline

Clinic	Outpatient Department			Polyclinc			Accident & Emergency			Specialist Clinic			Grand Total		
Year	New	Sub-Total	Clinic Days	New	Sub-Total	Clinic Days	New	Sub-Total	Clinic Days	New	Sub-Total	Daily Average	New	Sub-Total	Clinic Days
1988	65,530	115,180	308	31,079	80,171	308	53,169	56,359	365	51,986	150,400	1,757	201,764	402,110	308
1989	59,275	117,368	294	29,199	74,833	294	55,791	59,259	365	49,607	147,271	1,757	193,872	398,731	294
1990	59,580	126,486	295	29,446	62,241	295	56,400	60,350	365	45,420	146,828	1,762	170,846	395,905	295
1991	60,504	125,775	297	20,584	60,593	297	53,948	58,330	365	45,790	144,948	1,856	180,826	389,646	297
1992	57,080	114,822	296	39,598	57,272	296	50,064	55,132	366	41,528	151,498	2,117	188,270	378,724	296
1993	50,279	124,123	296	45,355	58,453	296	52,214	59,430	365	41,053	151,946	1,852	188,901	393,952	296
1994	53,268	129,530	296				58,886	64,857	365	40,489	160,401	1,172	152,643	354,788	274
1995	68,846	155,224	296				59,967	66,948	365	39,581	154,255	1,199	168,394	376,427	296
1996	54,128	128,156	297				55,930	63,571	365	38,537	153,109	1,838	148,595	344,836	297

Table 11-3 Outpatient Treatment According to Clinic Specialist

Clinic	1988	1989	1990	1991	1992	1993	1994	1995	1996
Medical	17,548	16,731	17,991	16,857	17,870	21,247	28,786	22,196	25,891
Surgical	14,438	11,746	11,086	13,041	12,610	12,564	13,889	12,906	12,761
Orthopedic	14,199	17,508	18,084	18,242	17,527	19,846	18,424	18,420	18,629
Pediatric	7,670	7,695	8,346	7,731	7,460	7,525	7,803	7,516	8,106
Obstetric & Gynecology	22,906	17,800	17,163	16,468	16,598	19,655	18,306	16,105	16,964
Ophthalmology	27,173	25,419	20,294	20,290	21,348	19,646	19,729	19,635	18,092
Ear, Nose & Throat	7,802	6,795	7,553	8,309	9,648	9,607	10,256	10,371	9,269
Dermatology	8,408	8,026	9,675	8,239	7,974	7,793	7,198	8,535	9,730
Tubercle Bacillus & Chest	10,378	11,313	9,612	8,935	10,959	9,233	8,406	10,401	10,659
Epidemic							193	149	173
Nephrology							4,574	7,229	6,500
Psychiatric							9,535	8,243	7,090
Dental							13,126	12,200	8,985
Plastic Surgery							176	349	260
Total	150,400	147,271	146,828	144,928	151,498	151,946	160,401	154,255	153,109

Table 11-4 Patient Treatment According to Clinic Specialist in 1996

	Medical	Surgical	Pediatric	Orthopedic	Eye	Obstetric	Gynecology	Ear, Nose & Throat	Psychiatric	Tubercle Bacillus	Detoxification	Skin	Dental	Outpatient Department	Accident & Emergency
Number of beds	172	146	79	123	38	96	47	21	52	-	5	8	4	-	-
Number of admission	9,989	6,786	4,197	4,588	916	9,295	2,848	390	742	-	67	18	34	-	-
Average daily admission	27.37	18.59	11.50	12.57	2.51	25.47	7.80	1.07	2.03	-	0.18	0.05	0.09	-	-
Number of discharge	10,011	6,380	4,035	4,911	926	9,380	2,876	410	758	-	67	22	47	-	-
Average daily discharge	27.4	17.5	11	13.5	2.5	25.7	7.9	1.1	2.1	-	0.2	0.01	0.1	-	-
Number of daily inpatient	53,798	24,537	18,946	36,138	5,685	20,460	8,397	2,109	8,500	-	652	261	152	-	-
Average daily inpatient	147.4	67.2	51.9	99.0	15.6	56.1	23.0	5.8	23.8	-	1.8	0.7	0.4	-	-
Ratio of bed being occupied (BOR) (%)	85.7	45.92	65.53	80.27	40.88	58.23	48.81	27.44	44.66	-	35.63	8.91	10.38	-	-
Bed turnover (TOI)	0.55	4.53	2.47	1.81	8.88	1.56	3.06	13.60	13.89	-	17.58	121.23	27.91	-	-
Average duration of stay (ALOS)	5.37	3.85	4.70	7.36	6.14	2.18	2.92	5.14	11.21	-	9.73	11.86	3.23	-	-
Number of death	623	178	157	37	1	3	4	6	-	-	-	1	1	-	-
Number of outpatient	25,851	12,761	8,106	18,629	18,092	9,991	6,973	9,269	7,090	10,659	-	9,903	8,985	128,156	63,571
New outpatient	6,087	2,626	1,179	5,867	6,330	1,040	1,256	2,914	773	2,173	-	2,587	5,514	54,128	55,930
Repeated outpatient	19,804	10,135	6,927	12,762	11,762	8,951	5,717	6,355	6,317	8,486	-	7,316	3,471	74,028	7,641
Average daily number of outpatient	131.42	65.44	55.52	188.17	125.63	99.91	68.36	89.99	66.26	113.19	-	67.82	30.25	431.50	174.16
Clinic days	197	195	146	99	144	100	102	103	107	94	-	146	297	297	365
Operation (elective)	-	-	-	1,398	567	147	724	231	12	-	-	-	28	-	-
Operation (emergency)	-	-	-	3,788	147	1,074	748	63	-	-	-	-	42	-	400
Deliveries of babies	-	-	-	-	-	7,909	-	-	-	-	-	-	-	-	-
Birth of babies	-	-	-	-	-	8,004	-	-	-	-	-	-	-	-	-

Table 11-5 Outlines of Major Energy Consuming Facilities

Name	Type	Number	Manufacturer	Start-up	Rated Capacity	Remarks
Boilers						
Boiler - 1	Horizontal Smoke Tube	1	Multipac	1968	9 bar, 2950 kg/hour	in operation
Boiler - 2	ditto	1	ditto	ditto	ditto	broken
Boiler - 3	ditto	1	ditto	ditto	ditto	in operation
Air Conditioning System						
Chiller - 2	Centrifugal	1	Trane Hermetic	1969	185 tons	uneconomical
Chiller - 1	Vertical Rotary Screw	1	Dunham Bush	1988	250 tons	in operation
Chiller - 3	ditto	1	ditto	ditto	ditto	in operation
Cooling Tower	Louver with 2 Fans	1	Marley	1969	750 Tons	manual control
Chilled Water Pumps		3				
Cooling Water Pumps		3				
Air-Handling Units		53			290 tons in total	40% of buildings area

11-2 Schedule of Energy Audit

The schedule for the energy audit for the hospital was from 9 to 29 July, 1998. It included preparation for measurements and preliminary discussion of measurement results.
The outline is as follows:

(1) Preparatory Stage

27 June (Sat.): Transportation of measuring equipment.
29 June (Mon.): Explanation, discussion and confirmation of the audit plan,
Preparation of energy audit

(2) Energy Audit

30 June (Tue.): Adjustment of measuring equipment
Confirmation of measuring points
Installation and adjustment of measuring equipment for electricity receiving
Installation and adjustment of measuring equipment around chiller unit
1 July (Wed.): Measurement of electricity consumption at transformers and distributors
Measurement around chillers and cooling towers
2 July (Thu.): Measurement around chillers, measurement around Air Handling Units
Investigation of data and drawings about equipment
3 July (Fri.): Measurement around chillers, measurement of electricity consumption of lifts
4 July (Sat.): Preliminary meeting with director
Confirmation of measuring points around boilers
5 & 6 July (Sun. & Mon.): Analysis of the results
7 July (Tue.): Measurement around boilers
Measurement of space conditions
8 July (Wed.): Measurement of space conditions
Removal of measuring equipment at the electricity receiving point, main transformers and chillers
General field survey of major energy consuming facilities
Input of trend data and equipment list
Data analysis and evaluation
Preparation of preliminary report

(3) Discussion of Preliminary Results

9 July (Thu.): Preliminary evaluation of audit results and recommendations for improvements of energy efficiency

Repackaging of measuring equipment

10 July (Fri.): Transportation of measuring equipment

Table 11-6(1), (2) shows a detailed schedule of measurements.

Table 11-6 (1) Detailed Schedule for Measurement (Hospital)

Measuring Items	Working Day								
	1	2	3	4	5	6	7	8	9
0. Preparation & Discussion of the Plan	x								
1. Electrical Power Receiving and Distribution (1) HV Receivers (Voltage, Amperage & Power Factor)		x	x	x	x	x	x		
(2) HV Distributors (Voltage, Amperage & Power Factor)		x	x	x	x	x	x		
(3) LV Distributors (Voltage & Amperage)			x	x	x	x	x		
2. Air-conditioning System **2.1 Mechanical Performance** (1) Chillers (Chilled Water: Inlet/Outlet Temp.& Flow rate)			x	x	x				
(2) Cooling Tower (Cooling Water: Inlet/Outlet Temp. & Flow rate)		x	x	x	x				
(3) Air Handling Units 1) Suction Air (Temperature, & Flow Rate) 2) Delivery Air (Temperature)				x					
(4) Blowers and Fans 1) Suction or Delivery Air (Flow Rate)				x					
(5) Fan Coils 1) Delivery Air (Temperature & Humidity)				x					
2-2 Air Conditioning (1) Area to be conditioned 1) Spaces (Temp., Humid., Air Flow & CO/CO_2)							x	x	
(2) Rooms to be conditioned 1) Rooms (Temp., Humid. & Direction of Air Flow)							x	x	
2-3. Electricity Consumption (1) Chillers, AHU, Blowers (Volt., Ampere & Power Factor)			x	x	x	x	x		

Table 11-6 (2) Detailed Schedule for Measurement (Hospital)

Measuring Items	Working Day								
	1	2	3	4	5	6	7	8	9
3. Lighting System									
(1) Main Part of Buildings Each Space & Room (Lux)						x	x		
4. Heat Consuming Facilities									
(1) Steam Boiler							x	x	
1) Fuel Oil (Flow Rate & Properties)									
2) Boiler Feed Water (Flow Rate, Temperature)									
3) Generated Steam & Hot Water (Temperature & Pressure)									
4) Flue Gas (Temp., O_2, CO, CO_2)									
(2) Calorifiers							x	x	
1) Hot Water (Temperature)									
(3) Thermal Insulation (Surface Temp. of Steam Boilers)							x	x	
5. General Energy Consumption		x	x	x	x	x	x	x	x
(1) Electricity									
(2) Fuel									
6. Field Investigation		x	x	x	x	x	x	x	x
(1) Preparation of Equipment List									
(2) Investigation of Drawings									
(3) Observation of Operating Condition									
7. Summarization & Reporting								x	
8. Review and Discussion									x

11-3 Outline of Measuring Items, Points and Measuring Equipment

To calculate and evaluate the current condition of energy consumption and to develop an energy balance, the measurements described below for the main energy audit items were conducted according to the schedule.

(1) Electrical Power Receiving and Distribution

1. HV receivers: Trend data of voltage, current, kW and power factor
2. HV distributors: Trend data of voltage, current, kW and power factor
3. LV distributor: voltage and current

(2) Air-Conditioning System

1. Chillers: Inlet/outlet water temperature, flow rate of chilled water, voltage, current, kW and power factor
2. Cooling towers: Inlet/outlet water temperature, water flow rate
3. Air Handling Units(AHUs): voltage and current, flow rate & temperature of air
4. Blowers & fans: air flow rate, voltage, current
5. Air-conditioned area: temperature, humidity and CO_2 content
6. Air-conditioned rooms: temperature and humidity
7. Outdoor condition: temperature, humidity and CO_2 content

(3) Lighting System

1. Common space: Illumination intensity
2. Rooms: Illumination intensity

(4) Heat-Consuming Facilities

1. Steam boilers: Flow rate & properties of fuel oil; flow rate, temperature, electric conductivity and pH of BFW; temperature and pressure of generated steam; temperature, O_2, CO and CO_2 content of flue gas
2. Calorifiers: Temperature of hot water
3. Thermal insulation: Surface temperature of boilers

(5) General Energy Consumption

1. Electricity consumption
2. Fuel oil consumption

(6) Field Investigation

1. Review of equipment list
2. Investigation of drawings
3. Observation of operating conditions, equipment and facilities

Details of measured items, points and measuring equipment are shown in Tables 11-7(1), (2), (3).

Table 11-7 (1) Outlines of Measurement for Energy Audit (Hospital)

Major Items of Energy Audit & Subject Items and Points	Measurement or Estimate	Available Equipment of Measurement			
		Required Equipment	Hospital	JICA	Local Labo.
1. Electrical power receiving & distri- Bution					
(1) HV Receivers (Sub-station)					
① Voltage	M	Clamp on power hi tester, control panel	x	x	
② Ampere	M	Ditto	x	x	
③ Power factor	M	Ditto	x	x	
(2) HV Distributors (Main circuit)					
① Voltage	M	Clamp on power hi tester, control panel	x	x	
② Ampere	M	ditto	x	x	
③ Power factor	M	ditto	x	x	
(3) LV Distributors (Control unit)					
① Voltage	M	Clip-on AC power meter		x	
② Ampere	M	ditto		x	
2. Air-conditioning system					
2-1. Mechanical performance					
(1) Chillers					
① Water temperature (inlet/outlet)	M	Bar & Surface thermometer, T.G.	x	x	
② Water flow rate	M	Ultra-sonic flow meter		x	
(2) Cooling towers					
① Water temperature (inlet/outlet)	M	Bar & Surface thermometer, T.G.	x	x	
② Flow rate of water	M	Ultra-sonic flow meter		x	
(3) Air handling units (AHU)					
1) Suction air					
① Temperature	M	Surface thermometer, Anermometer		x	
② Flow rate	M	Hot wire anemometer		x	
2) Delivery air					
① Temperature	M	Surface thermometer, Anemometer		x	
(4) Blowers & fans					
① Flow rate	M	Hot wire anemometer		x	
② Temperature	M	Surface thermometer, Anemometer		x	
③ Electricity consumption	M	Clip-on AC power meter		x	

Table 11-7 (2) Outlines of Measurement for Energy Audit (Hospital)

Major Items of Energy Audit & Subject Items and Points	Measurement or Estimate	Available Equipment of Measurement			
		Required Equipment	Hospital	JICA	Local Labo.
(5) Fan coils					
1) Delivery air					
① Temperature	M	Temp.- humid. recorder		x	
② Humidity	M	ditto		x	
2-2. Air conditioning					
(1) Area to be conditioned					
1) Spaces					
① Temperature	M	Temp.-humid. recorder		x	
② Humidity	M	ditto		x	
③ Air flow	M	Hot wire anemometer		x	
④ CO/CO_2 contents	M	CO, CO_2 content meter		x	
2) Rooms					
① Temperature	M	Temp.- humid. meter		x	
② Humidity	M	ditto		x	
③ Direction of air flow	M	Observation			
2-3.Electricity consumption					
(1) Chillers, AHU, blowers					
① Voltage	M	Clamp on power hi tester, control panel	X	x	
② Ampere	M	ditto	X	x	
③ Power factor	M	ditto	X	x	
3. Lighting system					
(1) Main part of the building					
① Illumination intensity	M	Lux meter		x	
4. Heat consuming facilities					
(1) Calorifiers					
1) Hot water					
① Temperature	M	Surface thermometer & T.G.	x	x	

Table 11-7 (3) Outlines of Measurement for Energy Audit (Hospital)

Major items of Energy Audit &	Measurement	Available Equipment of Measurement			
Subject Items and Points	or Estimate	Required Equipment	Hospital	JICA	Local Labo.
(2) Steam boilers					
1) Fuel oil (LFO)					
① Flow rate	E				
② Properties	M	Sp.gr, Heating value, CHNS			x
2) Boiler feed water					
① Temperature	M	Surface thermometer & T.G.	x	x	
② Properties	M	Electric cond. meter & pH meter		x	
3) Generated steam					
① Temperature	M	Surface thermometer & T.G.	x	x	
② Pressure	M	Pressure gauges	x		
(4) Thermal insulation (Boilers)					
① Surface temperature	M	Surface thermometer		x	
5. General energy consumption					
(1) Electricity	M	Clamp on power hi tester		x	
(2) Fuel oil	Trend data	Operation records & data	x		
6. Field investigation					
(1) Observation	Observation				
(2) Investigation of existing data	Review	Existing drawings and data	x		

11-4 Measurement Results

The measurement results are as follows.

(1) Electrical Power Receiving and Distribution

A schematic diagram of the electrical power receiving and distribution system in the hospital is illustrated in Figure 11-5 'Electric Power Receiving and Distribution'. Figure 11-6 (1) and (2) 'Power Received from TNB' show hourly power consumption from 30 June to 7 July, 1998. There are considerable differences in pattern between night and day, weekdays and Sunday. Refer to the following sections for further discussion. The transformer and distribution system are also considered in the next section. Specifications for the transformer and emergency situations are shown in Table 11-8 'Incoming Transformer Specification' and Table 11-9 'Emergency Generator Specification'

(2) Air-conditioning System

The centralized chiller plant flow system is shown in Figure 11-7 'Chiller System' and the measuring points are plotted on it. Details on operating conditions and power consumption trends shall be discussed in section 11-5-3. The power factor figure is quite low for both chiller No.1 and No.3.

(3) Boiler System

A diagram of the boiler and its related facility is shown in Figure 11-8 'Boiler System'. Improvement of boiler exhaust gas content shall be discussed in section 11-6-2.

(4) Air Conditions in Hospital Building

Air condition data are shown in Table 11-10 'Temperature, Relative Humidity, CO-CO_2' and Table 11-11 'Illumination Intensity and Space Temperature'. A natural ventilation system is utilized in most parts of the hospital. An air conditioning system should be studied for future application.

Illumination intensity varies much by the measuring spot, ranging from 9 to 1,324 lux and these figures fit in the Japanese lighting standard applied for corridors, stairs of office building.

CO_2 content is also within the range of management standards of air conditions regulated by the Building Management Law.

(5) Electrical Data

Electrical measurement results and main motor/pump specifications are attached in Table 11-12 and Table 11-13, respectively.

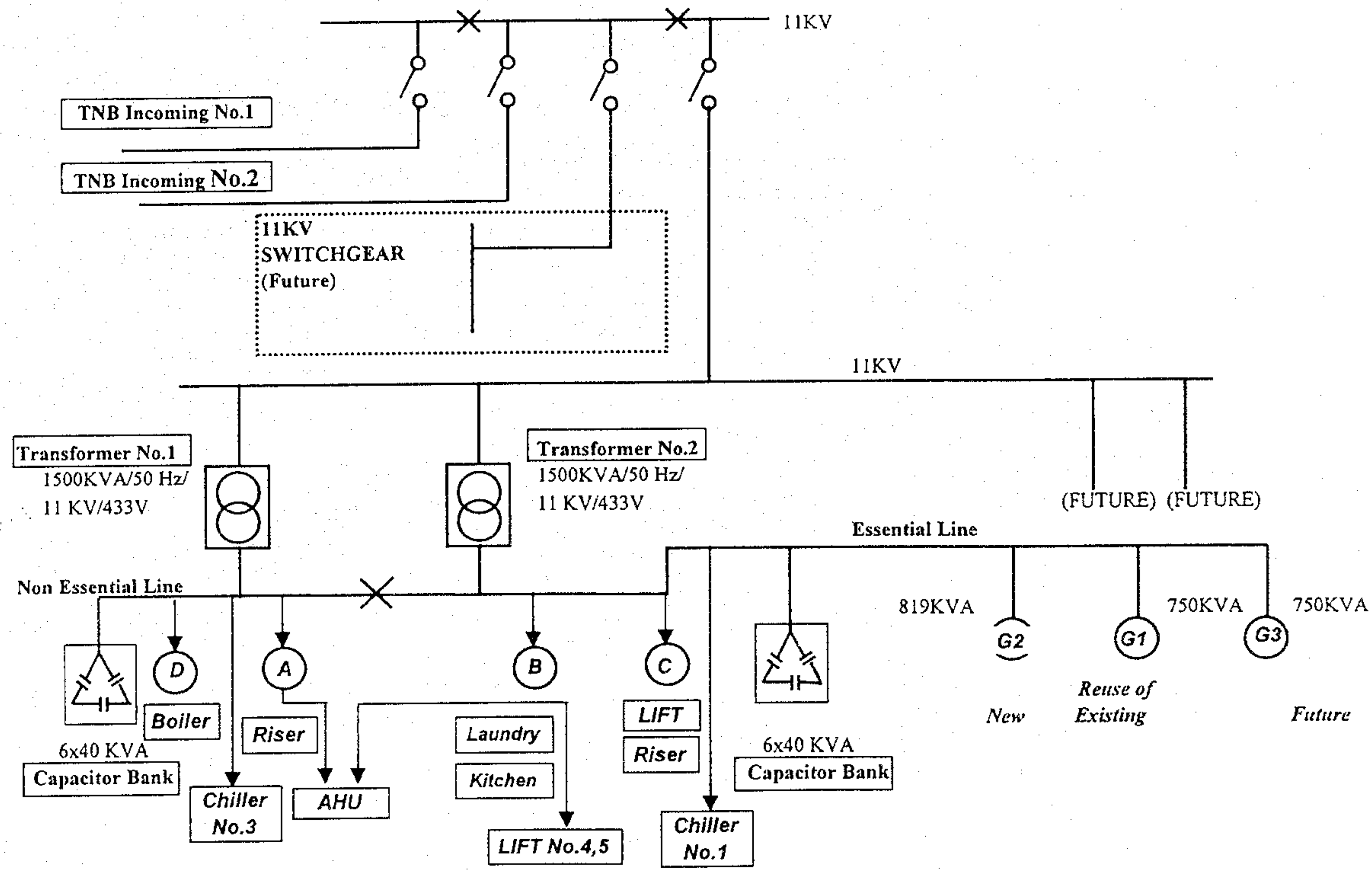


Figure 11-5 Electric Power Receiving and Distribution

Hospital Seremban

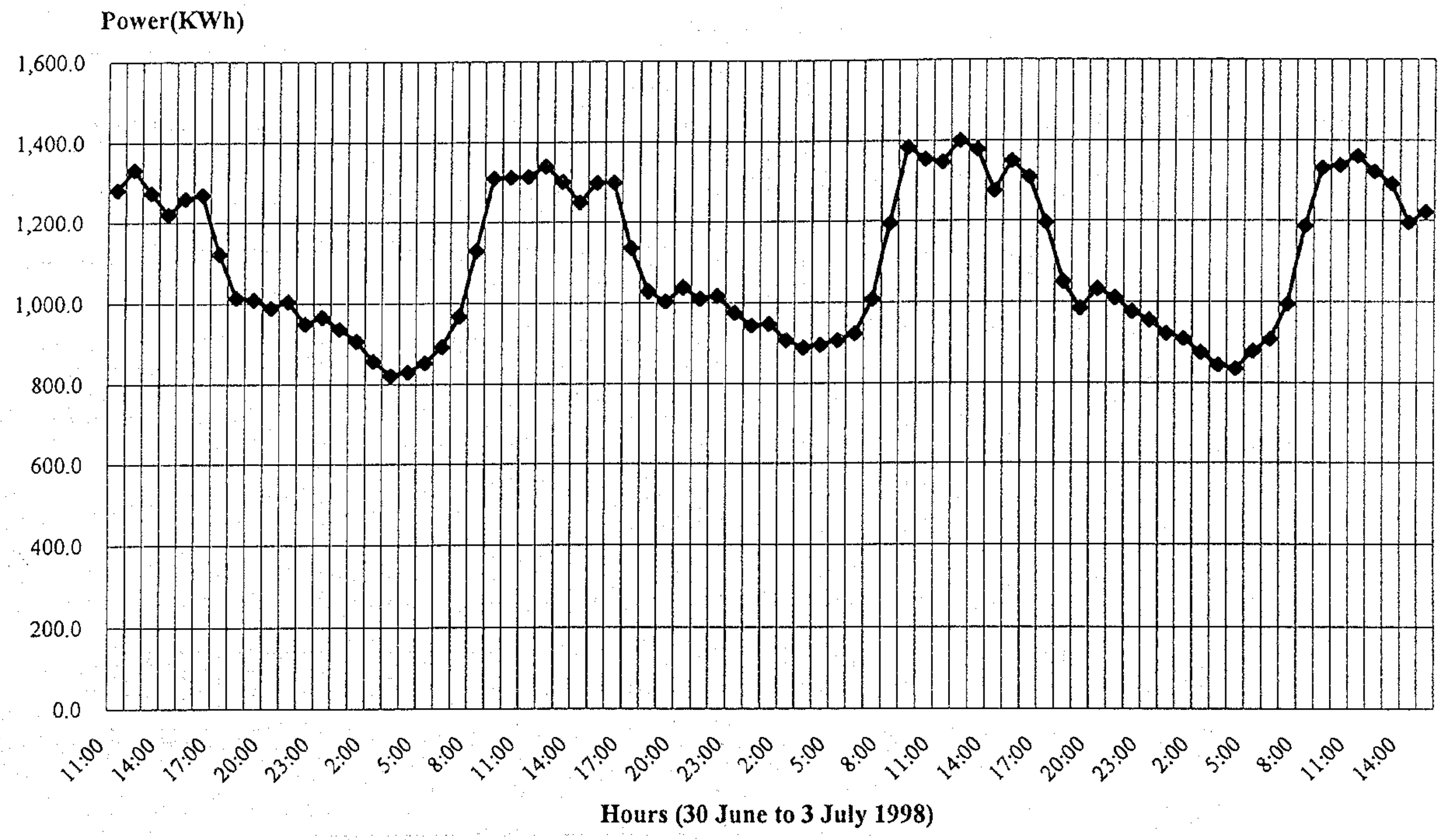


Figure 11-6 (1) Power Receiving from TNB

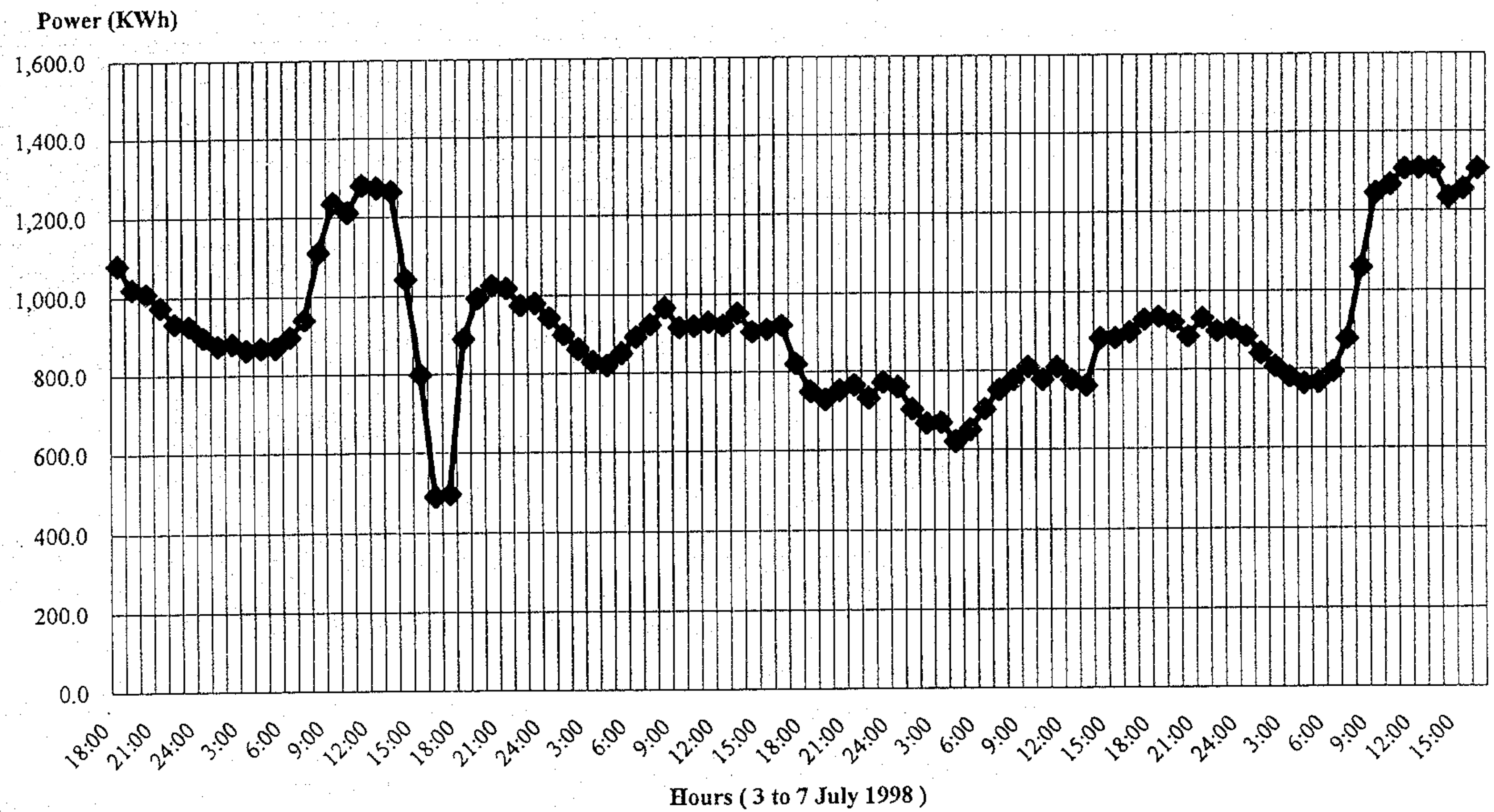


Figure 11-6 (2) Power Receiving from TNB

Table 11-8 Incoming Transformer Specification

No.1 for Non-Essential Line	1,500 kVA	50 Hz	11 kV / 433 V	Dry type (DYN II connected)
No.2 for Essential Line	1,500 kVA	50 Hz	11 kV / 433 V	Dry type (DYN II connected)

Table 11-9 Emergency Generator Specification

Generator No.1 (reuse of existing)	750 kVA	415 V
Generator No.2 (new)	819 kVA	415 V
Generator No.3 (future)	750 kVA	415 V

Under Ground Reinforced Concrete Fuel Storage Tank : 3 m x 2.4 m x 2.4 m

Table 11-10 Temperature, Relative Humidity, CO-CO_2

Date: 7 July 1998
At: TONGKAH MEDIVEST SDN BHD office 1st Floor Lobby

Time	Relative Humidity (%)	Temperature (℃)	CO_2 (%)	CO (%)	Time	RH (%)	Temp. (℃)	CO_2 (%)
12:00	68	29	0.048		14:45	62	32	0.017
14:00	64	32	0.010	-0.500	15:00	62	32	0.045
14:15	62	32	0.052	0.810				
14:30	62	32	0.111	-0.500				

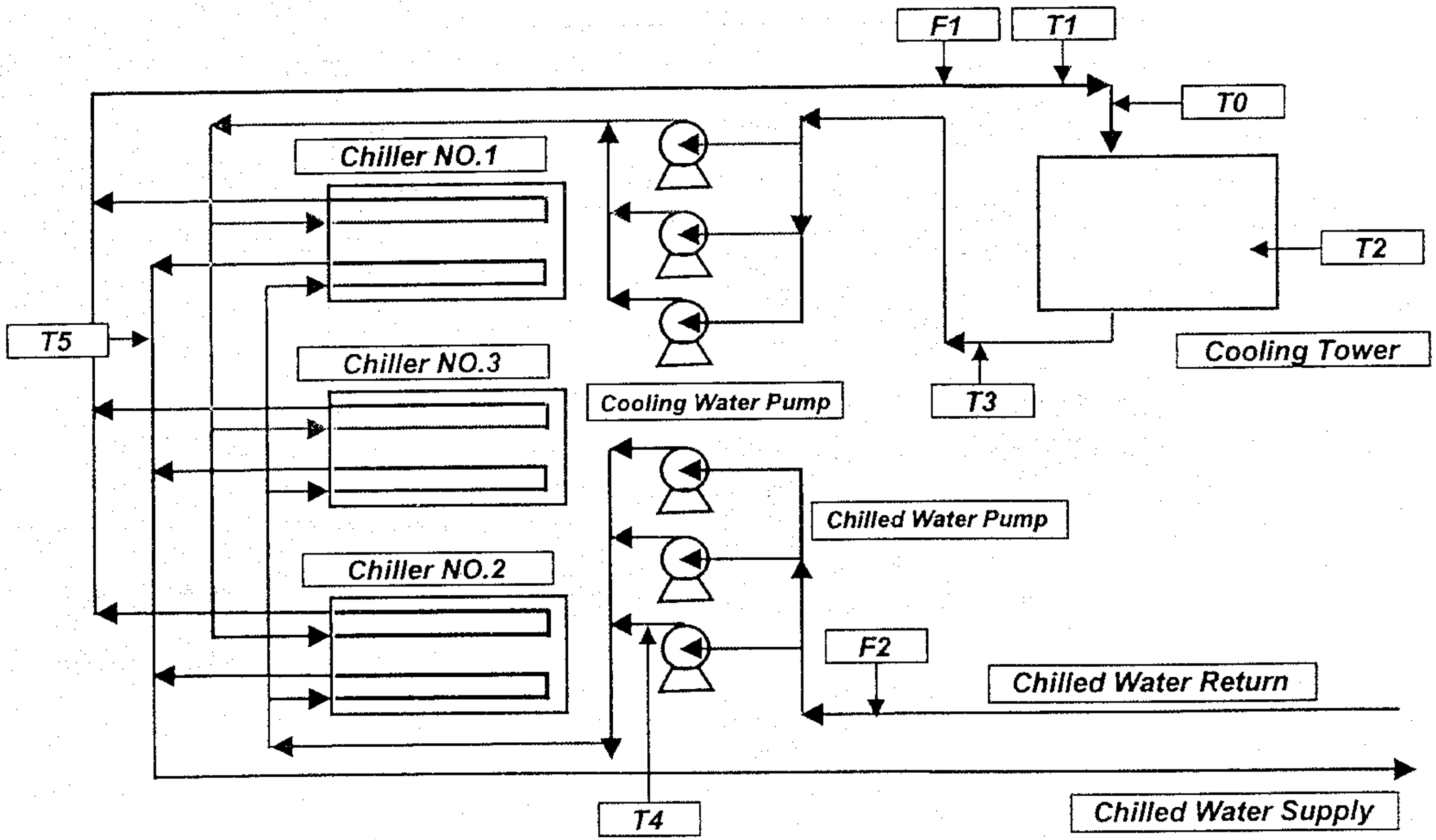


Figure 11-7 Chiller System

<u>Hospital Seremban</u>

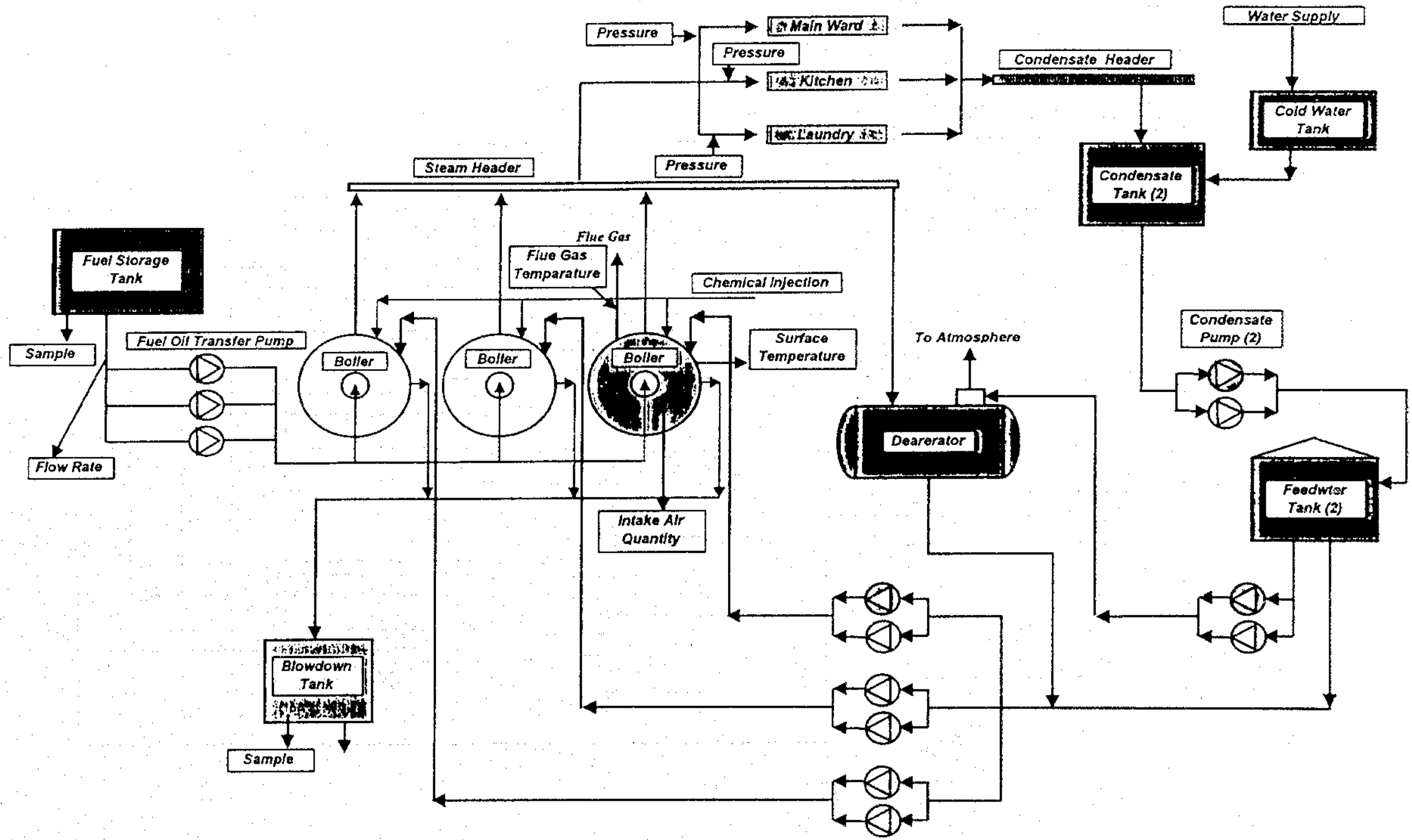


Figure 11-8 Boiler System __Hospital Seremban__

Table 11-11 Illumination Intensity and Space Temperature

Hospital Building Ground Floor								
Spot	Temperature (℃)	Illumination Intensity (lux)	Spot	Temperature (℃)	Illumination Intensity (lux)	Spot	Temperature (℃)	Illumination Intensity (lux)
1	27	180	16	29	162	31	25	77
2	28	81	17	27	56	32	24	58
3	27	48	18	28	311	33	24	80
4	27	93	19	28	50	34	28	35
5	27	9	20	28	513	35	29	240
6	27	59	21	27	520	36	29	230
7	27	168	22	27	320	37	29	92
8	27	281	23	25	140	38	29	221
9	27	1324	24		22	39	29	190
10	27	623	25	23	44	40	29	90
11	28	250	26	28	122	41	29	120
12	28	70	27	27	164			
13	28	28	28	27	430			
14	29	114	29	27	55			
15	29	198	30	27	47			

1st Floor			2nd Floor			8th Floor		
Spot	Temperature (℃)	Illumination Intensity (lux)	Spot	Temperature (℃)	Illumination Intensity (lux)	Spot	Temperature (℃)	Illumination Intensity (lux)
1	28	146	1	27	119	1	28	268
2	28	92	2	27	138	2	28	703
3	28	64	3	27	105	3	28	618
4	26	109	4	27	113	4	28	143
			5	27	253	5	28	238
			6	27	411	6	28	653
			8	27	74			
			9	27	243			
			10	28	90			

Table 11-12 Electrical Measured Data

Service	Voltage (V)	Ampere (A)	Power (kW)	C/T ratio	Power (kW)calculated
Chilled water pump / motor No.2	412	2.03/1.87	0.83/0.79	100:5	32 (0.83+0.79)x20
Cooling water pump / motor No.2	412	22.5/22.4	0.01/0.01 /0.01	1:1	16
Chiller system total ammeter	412/414	4.82/4.72	1.96/1.95	500:5	391 (196+195)
Chiller water pump / motor No.1	–	35	–	–	–
Cooling water pump / motor No.3	–	22	–	–	–
Cooling tower fan No. 1	–	10	–	–	–
Cooling tower fan No.2	–	17.5	–	–	–
Chiller compressor No.1	–	110	–	–	–
Boiler air intake Blower / motor	427	0.59/0.08	0.10/0.11	1:1	0.21 (0.10+0.11)
Boiler fuel pump / motor	–	14.7	–	–	7.5

Table 11-13 Motor/Pump Specification Data

Service	Voltage (V)	Ampere (A)	Power (kW)	Power Factor	Manufacturer
Chiller No.1&3 compressor motor	400	302	–	–	Dunhamburg-Bush, Inc.
Chilled water Motor	400	59	29.4	0.875	Brown Boveri
Pump	370 GPM	1,505 feet TDH	2,900 RPM		Worthington Simpson
Cooling water Motor	400	32.3	16.2	0.855	Brown Boveri
Pump	470 GPM	68 feet TDH	1,450 RPM		Worthington Simpson
Boiler fuel pump motor	–	14.7	7.5	0.9	Enco Engineering SDN BHD

11-5 Results of Energy Audit

11-5-1 Power Received from TNB

The hospital obtains its electrical supply from TNB using incoming line No.1 or No.2. Electrical power demand per hour varies considerably on weekdays, showing high demand in the day time and low demand at night, while it varies little on Sunday. These statistics are shown in Figure 11-9 (1) and Figure 11-9 (2).

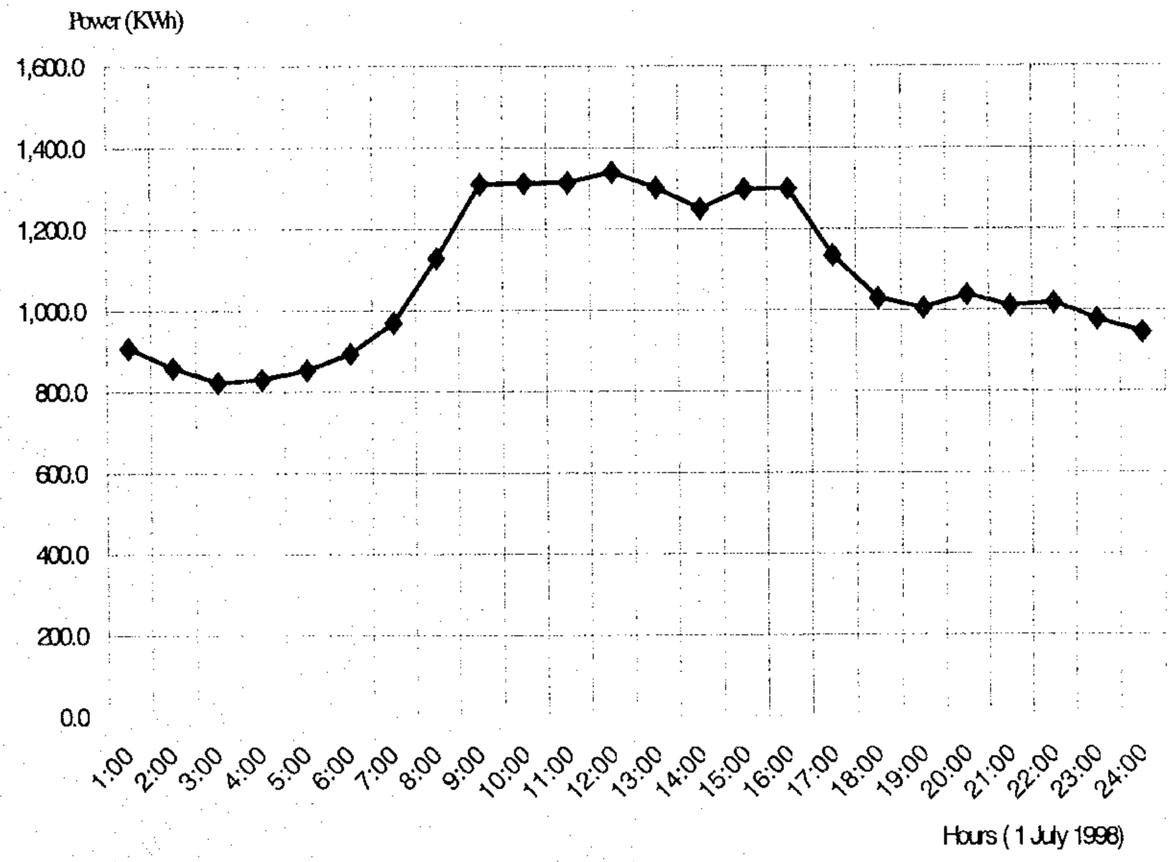


Figure 11-9 (1) Power Receiving TNB

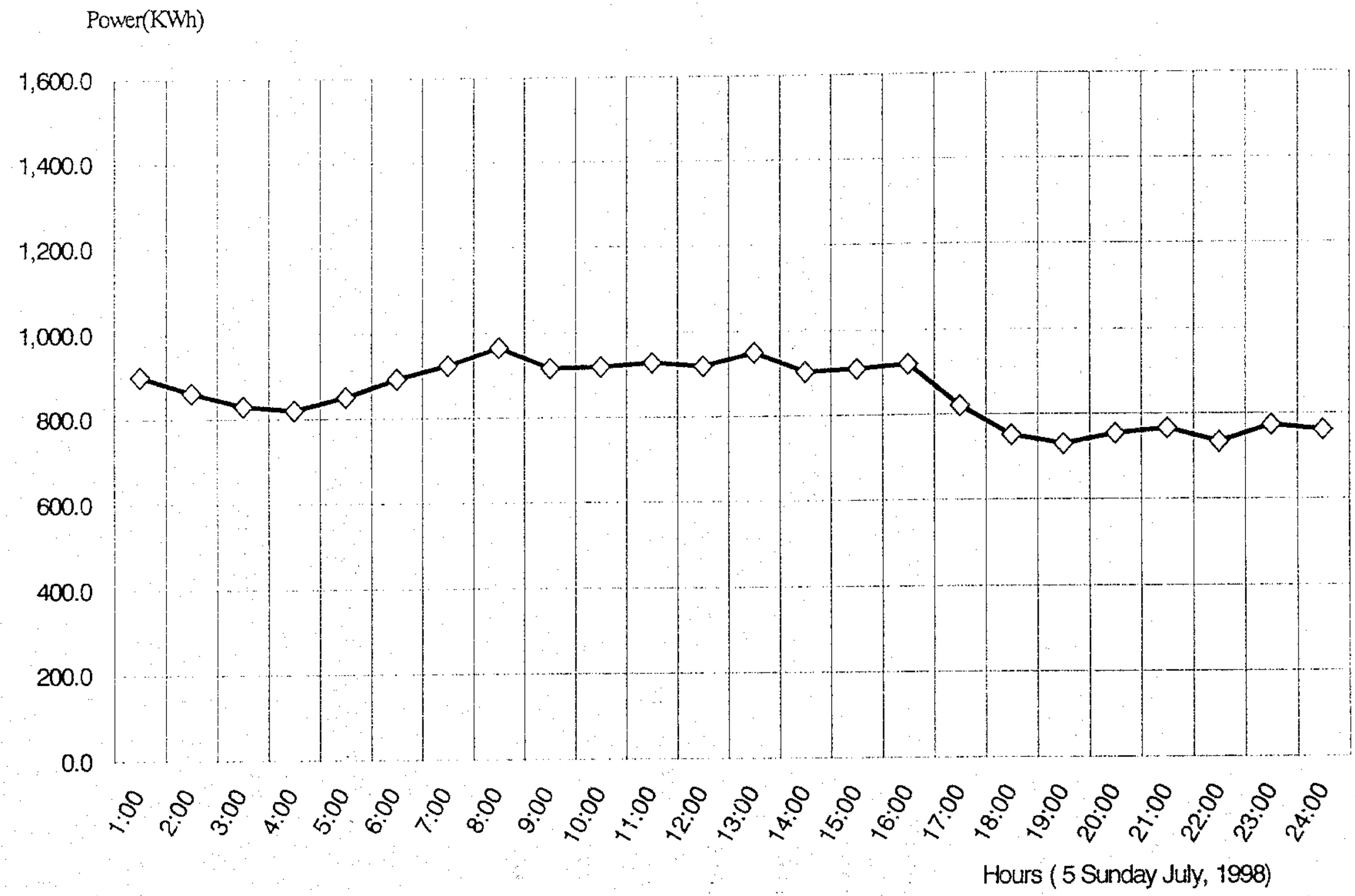


Figure 11-9 (2) Power Receiving TNB

11-5-2 Power Distribution at Incoming Transformer

There are two transformers that supply low voltage power. Transformer No.1 is connected to the non-essential line, while No.2 is connected to the essential line equipped with emergency generators. Power trends and power factor at each transformer are illustrated in Figures 11-10 (1) through 11-10 (4).

- Power Factor: No.1 = 0.733 – 0.679 No.2 = 0.807 – 0.752
- Load: No.1 = 30 – 49 per cent No.2 = 26 – 44 percent

The load figures for both No.1 and No.2 transformers are very low and it might be necessary to take some measures to compensate for the fixed power loss of the transformer.

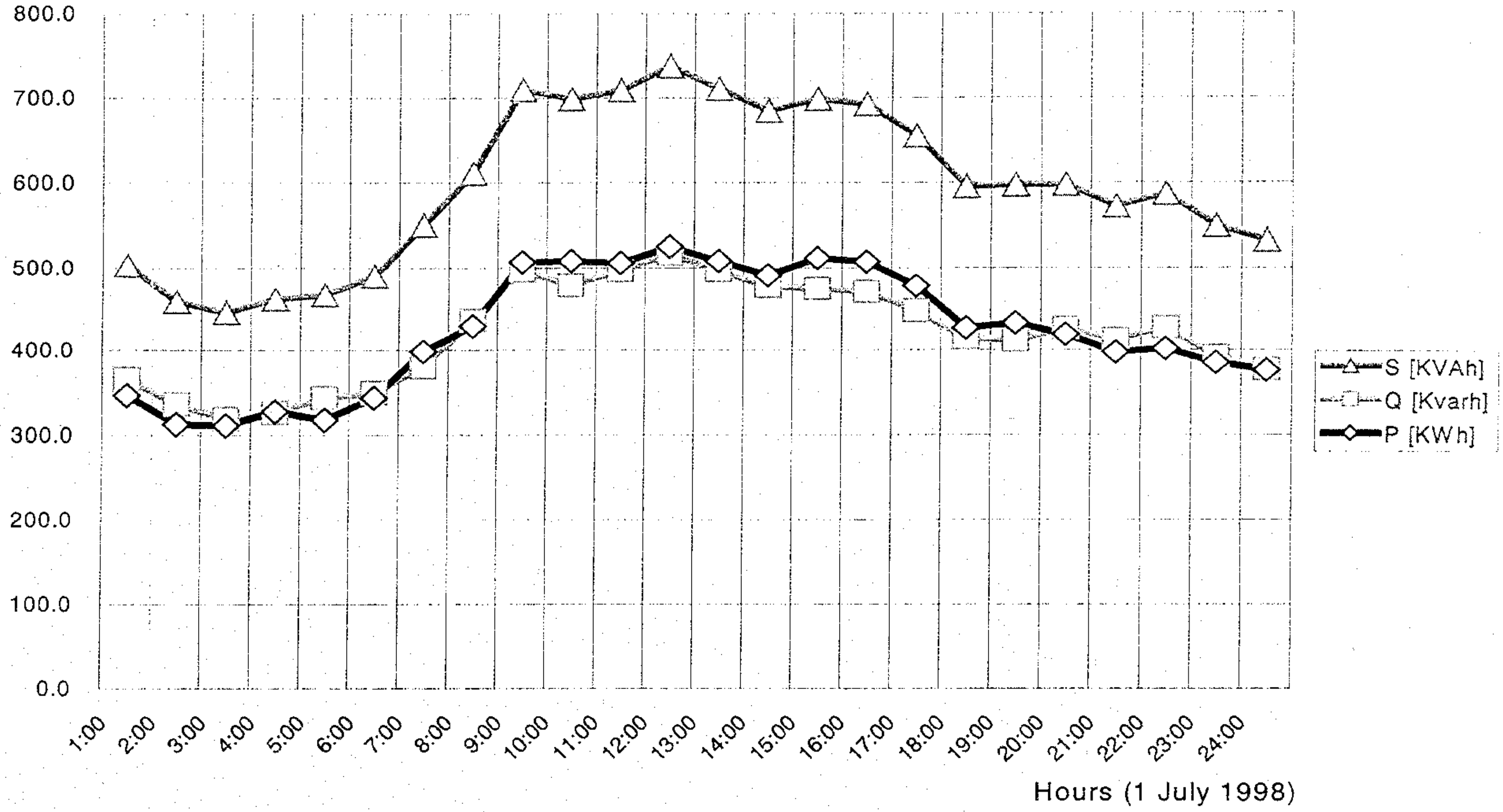


Figure 11-10 (1) Power Trend at Main Incoming Transformer No.1

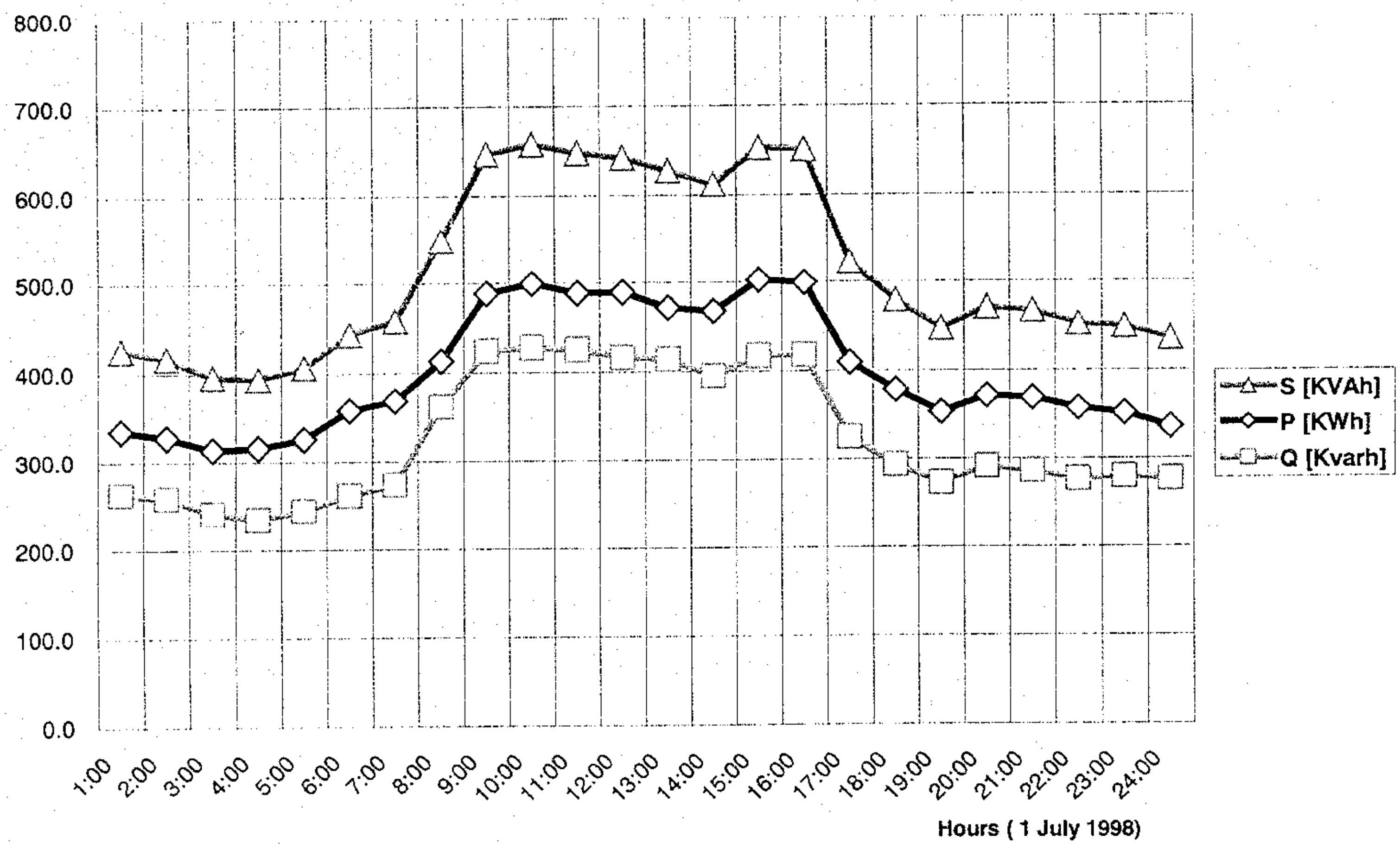


Figure 11-10 (2) Power Trend at Main Incoming Transformer No.2

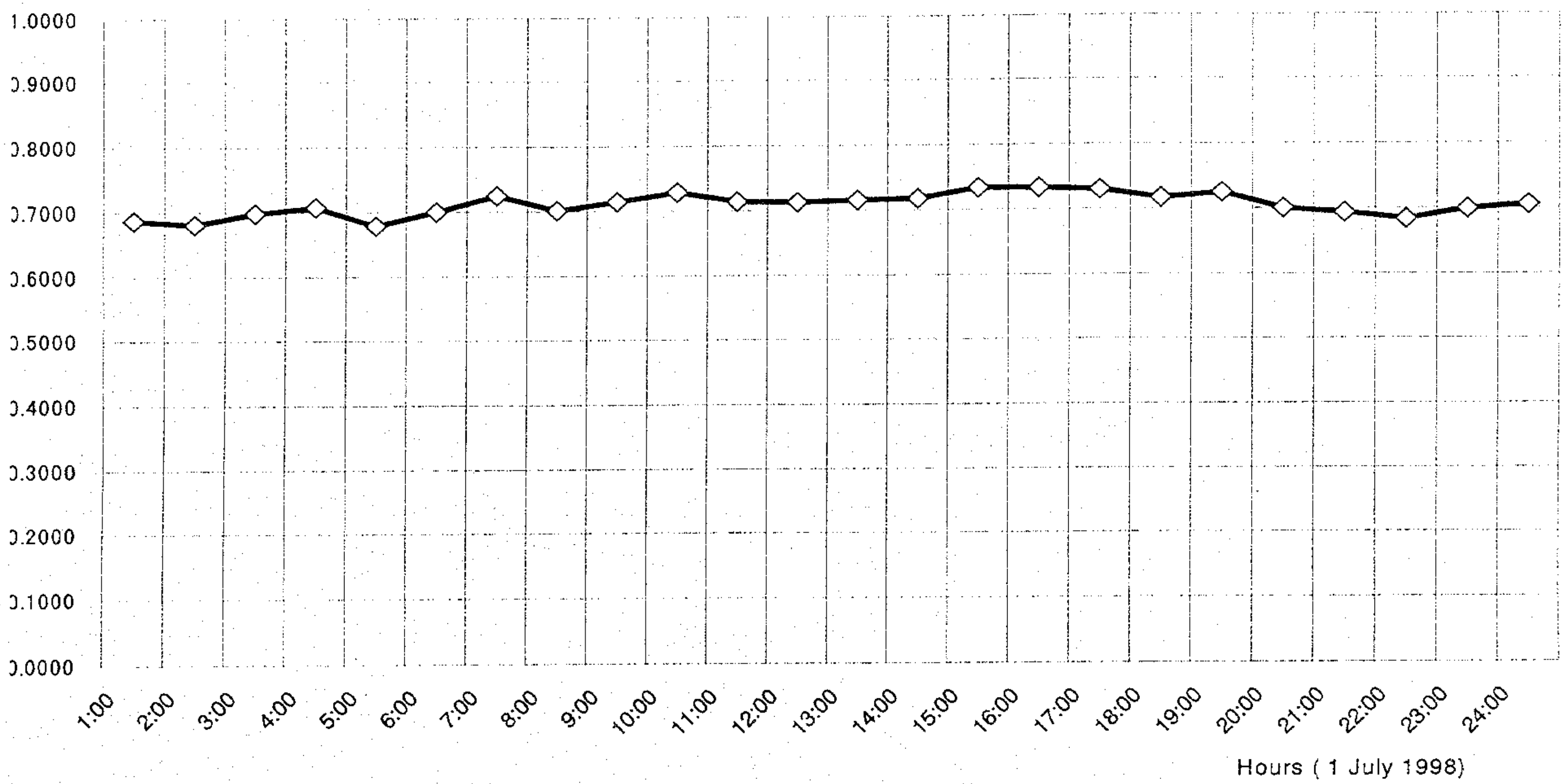


Figure 11-10 (3) Power Factor Trend at Main Incoming Transformer No.1

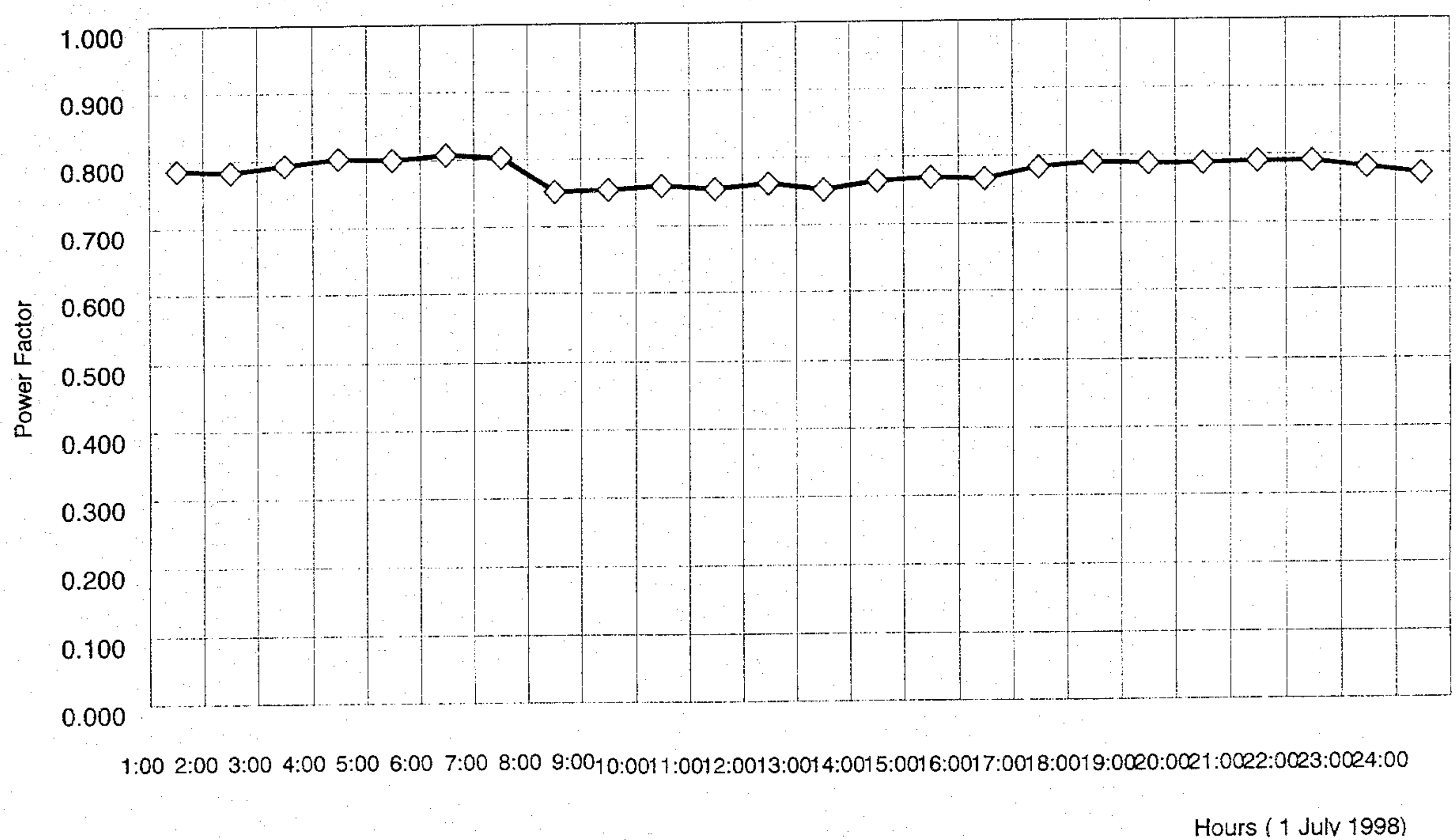


Figure 11-10 (4) Power Factor Trend at Main Incoming Transformer No.2

11-5-3 Chilled Water System

(1) Operation Performance

Chilled water inlet/outlet temperature and cooling tower water inlet/outlet temperature are shown in Table 11-14 and Figure 11-11.

Table 11-14 Temperature around Chiller System

Unit: ℃

	Condensed Water Return (Surface M.)	Condensed Water Return (Bar M.)	Cooling Tower Basin	Condensed Water Supply	Chilled Water Return	Chilled Water Supply
10:00	40.0	38.0	34.0	36.0	20.0	8.0
11:00	40.5	38.5	34.5	37.0	19.0	9.0
12:00	40.5	39.0	34.5	36.5	20.0	9.0
14:00	40.5	39.0	34.5	37.0	22.0	10.0
15:00	40.5	39.5	34.5	37.0	22.0	10.0
16:00	40.5	39.0	34.0	37.0	22.0	10.0

Flow rate (measured by ultrasonic flow meter on July 3) unit: m^3/h

Time	Chilled water return	Condensed water supply
10:30	245.9	229.3
11:00	237.1	231.6
11:30	242.7	231.1
12:00	248.1	231.1
14:00	248.1	231.1
15:00	239.7	231.1
15:30	241.2	231.1
16:00	245.3	253.3
16:30	241.4	236.0

Rough calculations based on the measured data;

Chiller load = 240(m^3/h) x 1,000 (kcal/kg deg.) x 10 (deg.)

= 2,400 x 10^3 (kcal/h)

= 790 USRT

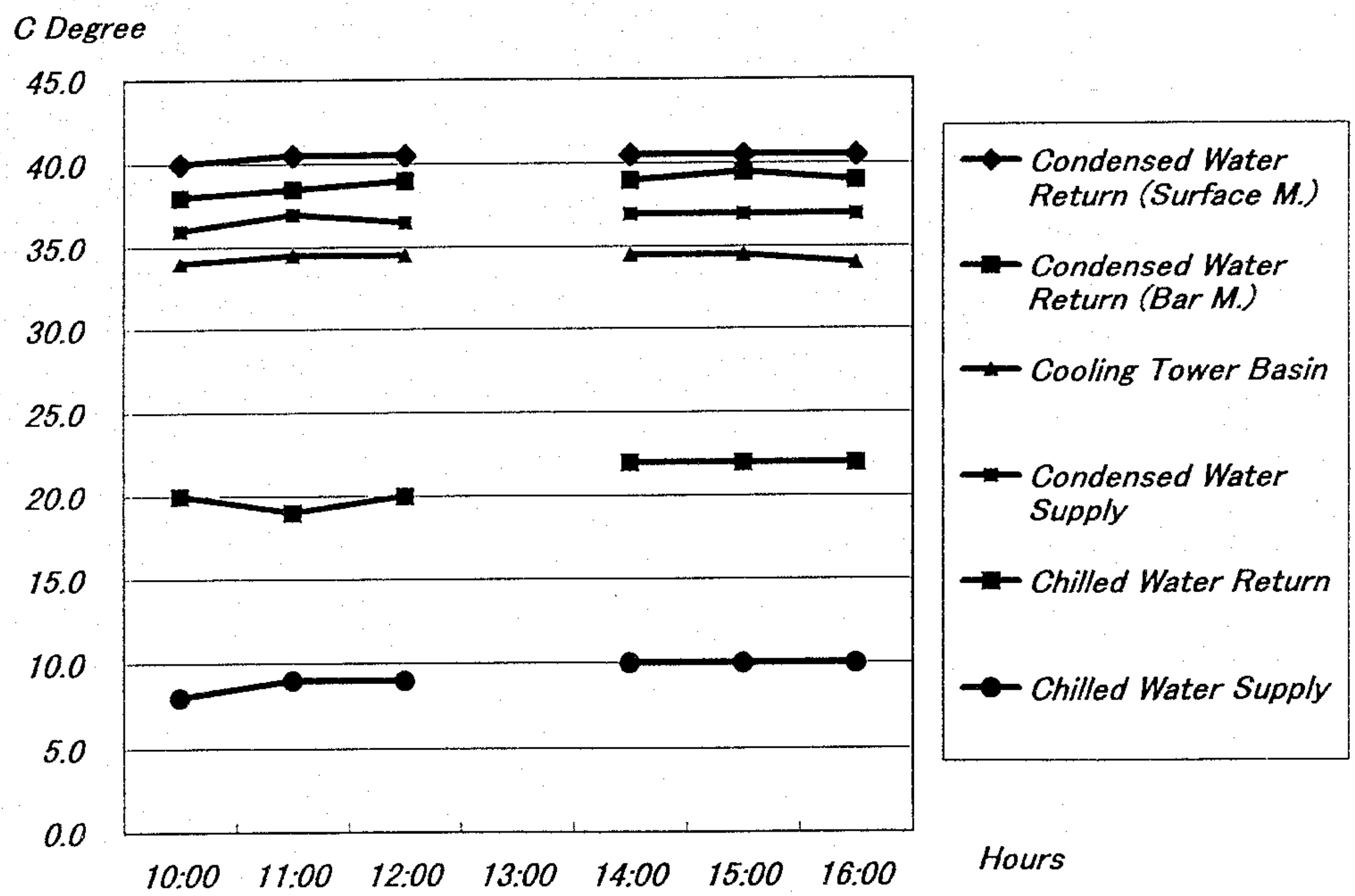


Figure 11-11 Temperature Pattern around Chiller System Hospital Seremban

(2) Electricity Consumption

With reference to Figure 11-12 for Chiller No.1, Chiller No.3 has almost the same power consumption profile by hours as No.1.

- Chiller No.1 : Power Consumption kWh : 63.8 – 119.3
  Power Factor : 0.30 – 0.49
- Chiller No.3 : Power Consumption kWh : 82.0 – 105.3
  Power Factor : 0.37 – 0.48

These figures show that the power factor is too low and the chiller system has a frequent over-current trip problem. The details and solution are discussed in the following section 11-6-3.

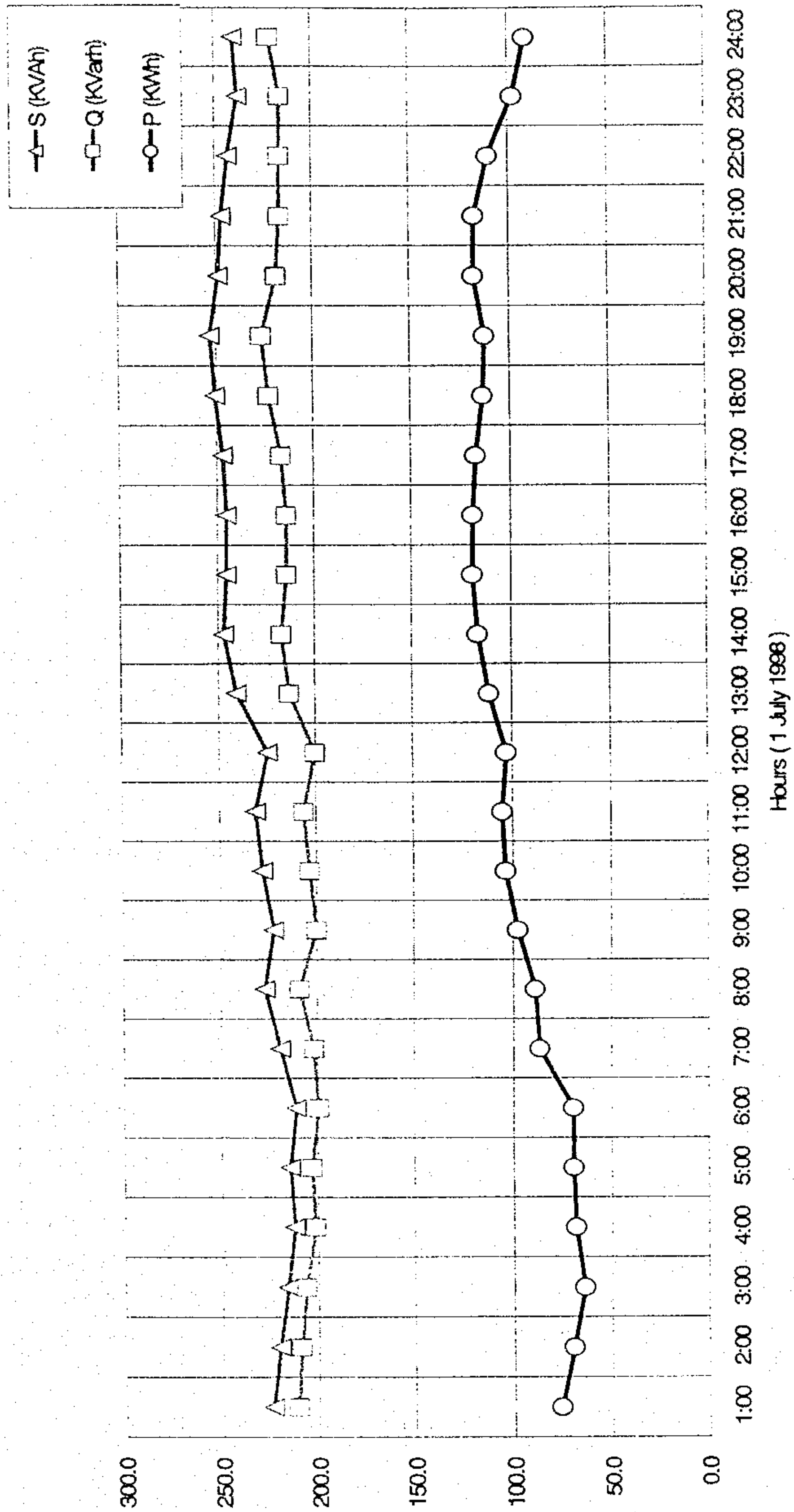


Figure 11-12 Electricity Trend at Chiller No.1

11-5-4 Boiler System

(1) Operation Performance

Table 11-15 shows boiler operation data such as fuel oil flow rate and intake air velocity. Table 11-16 shows boiler specifications.

Table 11-15 Boiler Operation Data

Date	Time	Fuel Oil Flow (l/h)	Fuel Oil Temp. ℃	Intake Air Temp. ℃	Intake Air Velocity (m/s)	Steam Main Header	To Main Ward	To Kitchen	To Laundry
6 July	11:00	166.1	32.0	–	–	–	–	–	–
	12:00	166,1	32.0	–	–	–	–	–	–
	14:00	166.1	31.4	–	–	170.0	6.3/4.0	8.5/1.65	6.4/5.3
	15:00	174.0	31.0	33.8	4.50	174.0	6.4/4.0	8.8/1.63	7.2/5.7
	16:20	174.0	31.0	33.1	8.03	172.0	6.7/4.0	8.8/1.65	6.6/5.4
	17:00	174.0	31.0	32.5	8.23	174.0	6.6/4.0	9.2/1.70	7.0/5.4

Table 11-16 Boiler Specifications at Hospital Seremban

Unit:	3
Boiler Type:	TDC 7 (Serial No. 1026/TDC 7)
Manufacturer:	ENCO ENGINEERING SDN BHD
Manufacturing Date:	1995
Design Code:	TRD
Inspection Authority:	LLOYDS
Design Pressure:	12.3 bar
Max. Working Pressure:	12.3 bar
Test Pressure:	16.0 bar
JKKP Approval No.:	KB-BD 2800/2596
Hydrostatic Test Date:	19-4-95 YKL
Operating Water Volume:	8,600 Litre

Table 11-17 shows boiler flue gas content measured on July 8.

Table 11-17 Boiler Flue Gas Content and Intake Air Condition

Instrument: HODAKA HT-2000							
Parameter (Fuel Type):			"Diesel Oil"		"Heavy oil (C)"		
Time:			10:45		14:30		
Flue Gas Content							
Oxygen (%)			7.3 - 7.6		7.2		
Carbon dioxide (%)			9.9		10.5		
Carbon monoxide (%)			7		8		
Nitrogen oxide (ppm)			98 - 102		111		
TG (degree Celcius)			165.0 - 186.1		195.3		
TA (degree Celcius)			33.7 - 33.9		34.9		
DIOX							
hPa			-0.97 to -1.12		-1.24		
Intake air		0.4497	(Nm^3/s)				
Velocity;		9.04	(m/s)	(8.49, 8.88, 9.06, 9.73)			
Temperature;		30.1 degree Celcius					
Suction Area;		0.0552	(m^2)	(235mm x 235mm)			

Ambient Air Condition Date: July 8, 1998 Time : 15:00 Instrument : ANNEMOMETER

Oxygen, percent ; 20.9
Carbon dioxide, percent ; 0
Carbon monoxide, percent ; 0
Nitrogen oxide, ppm ; 8

11-5-5 Lift

(1) Power Trend

Figure 11-14 shows the electricity consumption over a 24 hour period for Lift No.4 and No.5, operated for general hospital usage by a duplex collective control method. The introduction of a VVVF power supply system instead of the VVGD-CL system is recommended in the case of lift facility modification as discussed later. About a 30-40 percent power reduction can be anticipated after the substitution.

11-5-6 Energy Flow in Hospital

(1) Power Demand Profile

Overall power consumption over a 24 hour period at the hospital is shown in Figure 11-15. And total power energy consumption balance during the daytime is roughly illustrated in Figure 11-13. It can be seen that air conditioning is responsible for the largest part of consumption.

Unit: percent

Air Conditioning sub total (42.1)

Chiller 19.9
Water Pump 3.4
Others 0.6

Receiving Power Total ((100.0))

Split A/C 18.2

Riser, Lighting, Lift, Boiler, Others (35.3)

Loss & balance (22.6)

Figure 11-13 Power Energy Consumption Balance

(2) Overall Energy Flow

Various types of energy consisting of electrical power, light fuel oil and diesel oil were used in the major facilities in the hospital as Table 11-18 shows. Their percentages show the features of energy flow in the hospital. The main energy source was electrical power, which accounted for about 56 percent of the total primary energy. Overall energy flow in the hospital is shown in Figure 11-16.

Table 11-18 Energy Flowchart of the Hospital

(1997)

Item	Electricity	Light Fuel Oil	Diesel Oil	Total
Amount of consumption	(kWh) 4,501,099	(kl) 786,240	(kl) 13.63	
Primary energy, 10^6 kcal	10,127.5 (56.2 percent)	7,783.8 (43.2 percent)	122.7 (0.6 percent)	18,034 (100.0 percent)
Energy consuming facility				
(1) Power for Air conditioning	4,263.7	-	-	4,263.7 (23.6 percent)
(2) Power for Lighting, Lift, Boiler	3,575.0	-	-	3,575.0 (19.8 percent)
(3) Power for Others	2,288.8	-	-	2,288.8 (12.7 percent)
(4) Steam for Calorifier, Laundry, Kitchen, Others	-	7,783.8	-	7,783.3 (43.2 percent)
(5) Emergency generator	-	-	122.7	122.7 (0.6 percent)
Total				18,034 (100.0 percent)

Note 1: Conversion factor of electric power to primary energy is 2,250 kcal/kWh
Note 2: Low heating value of light fuel oil is 9,900 kcal/kl
Note 3: Low heating value of diesel oil is 9,000 kcal/kl

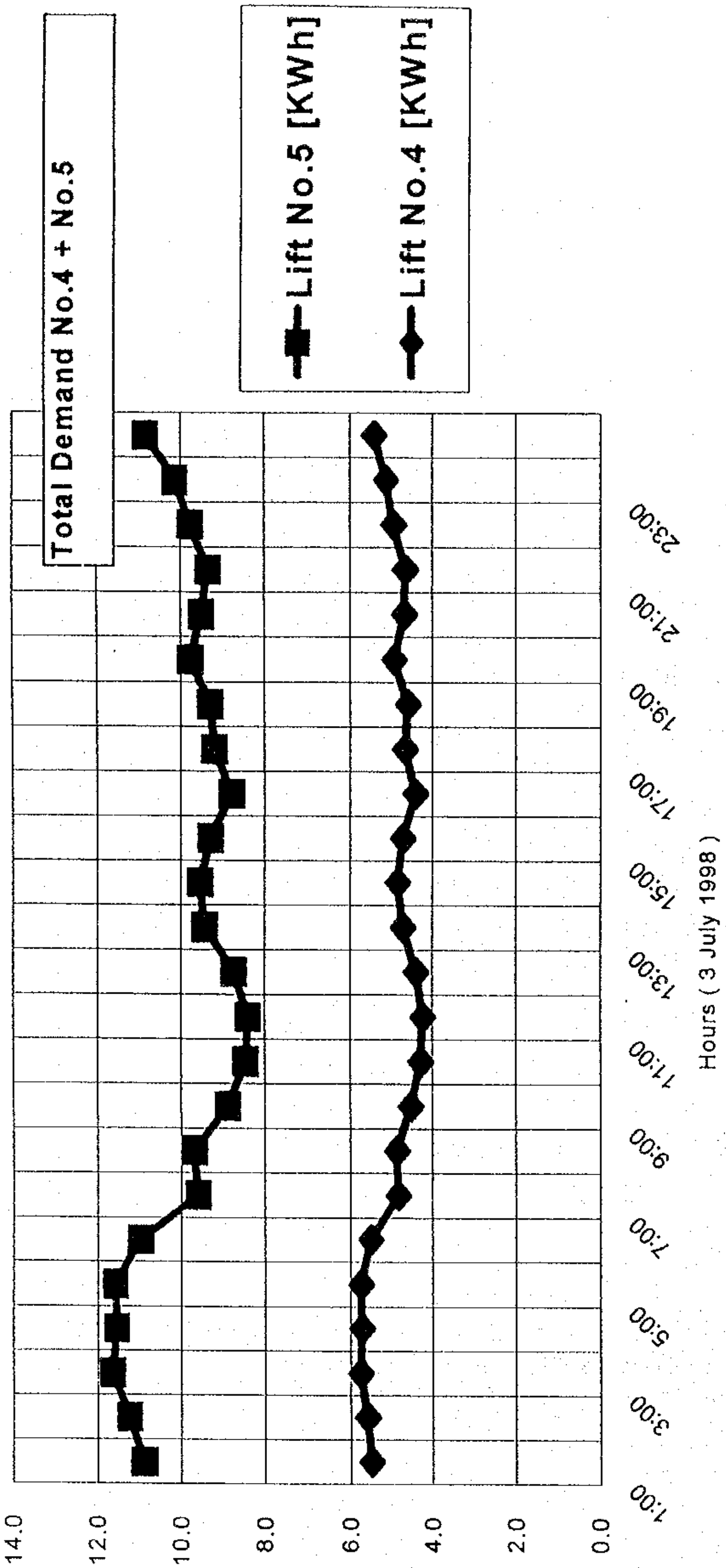


Figure 11-14 Power Trend at Lift No.4 & 5

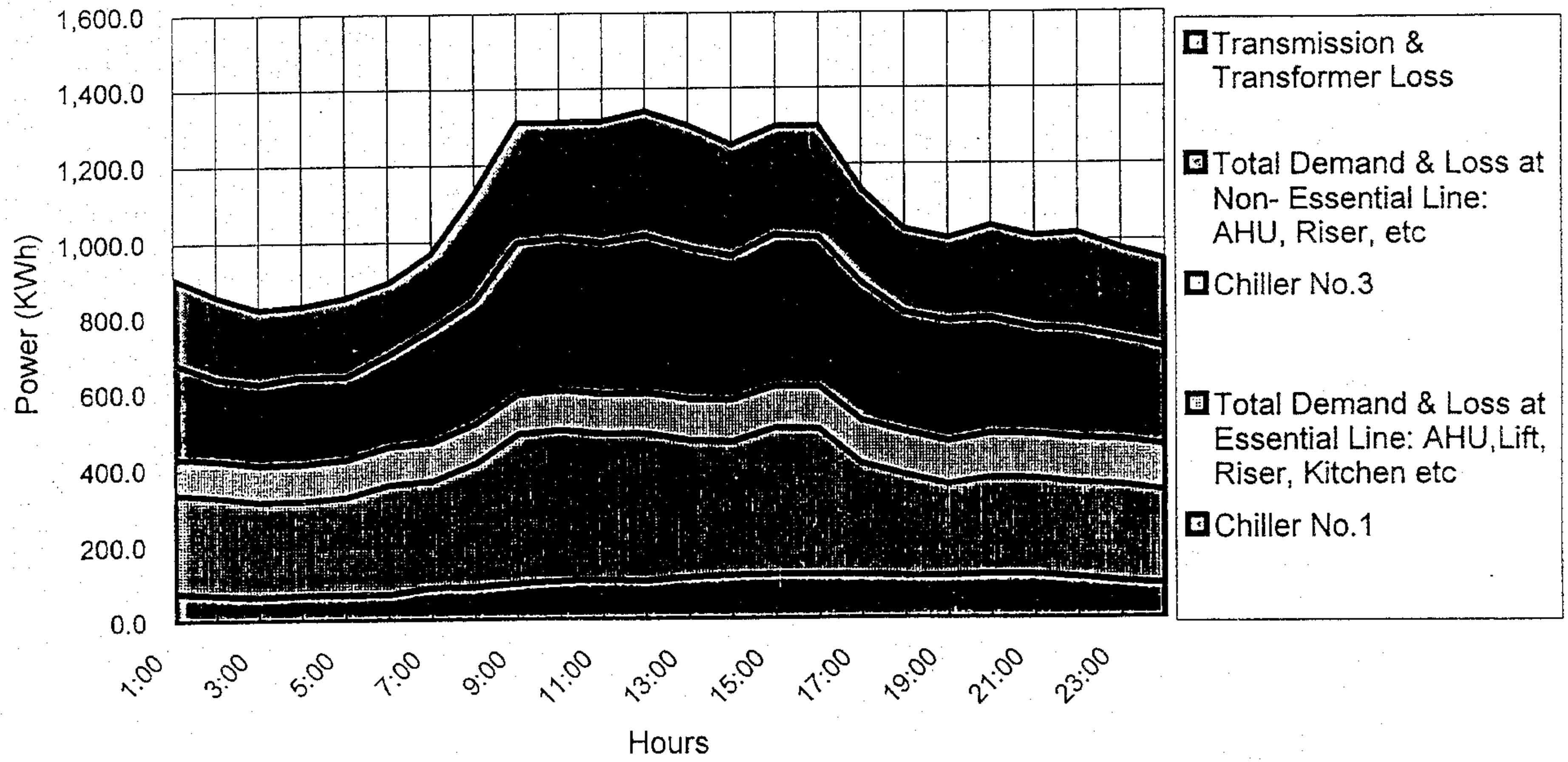


Figure 11-15 Power Demand Profile at Hospital Seremban

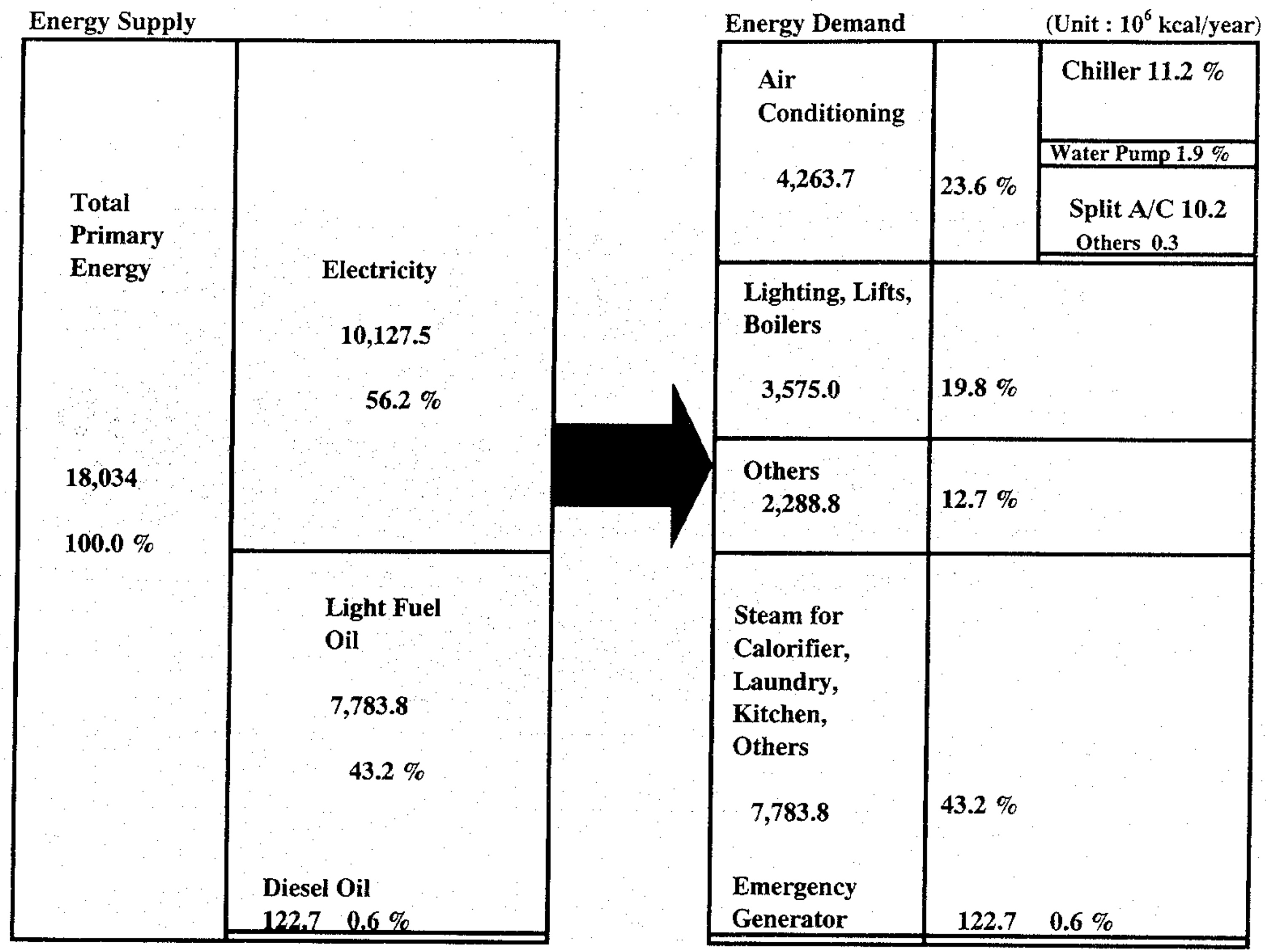


Figure 11-16 Overall Energy Flow in the Hospital

11-5-7 Unit Energy Consumption

454,600 kcal/m^2/yr

(Note-1) Energy Consumption Amount

Energy	Consumption	Unit Calorific Value	Energy Consumption Amount
Light Fuel Oil	786,240 kl/yr	9,900 kcal/l	7,783.8 x 10^6 kcal/yr
Diesel Oil	13.63 kl/yr	9,000 kcal/l	122.7 x 10^6 kcal/yr
Electric Power	4,501,099 kWh/yr	2,250 kcal/kWh	10,127.5 x 10^6 kcal/yr
TOTAL			18,034.0 x 10^6 kcal/yr

(Note-2) Total Floor Area

Floor	1	2	3	4	5	6	8	TOTAL
Area, m^2	1,920	270	3,750	14,300	2,600	14,200	2,630	39,670

The study team looked for a similar-sized hospital in Japan to investigate the specific conditions of the hospital in Malaysia. As Table 11-19 shows, major differences exist in the low figures of unit energy consumption for Hospital Seremban. Hospital Seremban is more energy-efficient thanks to: 1) applying a more natural ventilation system for air conditioning and dedicating it to cooling (no heating function needed) for air-conditioning

2) Introduction of energy-saving management such as careful control of lighting and rational operation of lifts.

Table 11-19 Hospital Energy Management Comparison

Item	Malaysia National Hospital SEREMBAN	A Tokyo Metropolitan Hospital
1. Establishment	1969(year)	1974(year)
2. Floors	9 (building A) 9 (building B)	14 (building A) 14 (building B)
3. Total floor area	40,000(m^2)	65,238(m^2)
4. Beds	800	801
5. Electricity Consumption Power receiving Voltage	4,501(MW/year) 11 kV	13,995(MW/year) 22 kV
6. Fuel Consumption (1) Fuel Oil (2) City Gas (3) Others	 786 kl/yr – 14 kl/yr (emergency use)	 2 kl/yr (emergency use) 2,182,027 Nm^3/yr -
7. Boiler (1) Capacity x Unit (2) Steam Pressure	 3 (t/h) x 3 9 (kg/cm^2)	 8.4 (t/h) x 3 7 (kg/cm^2)
8. Chiller (1) Capacity x Unit (2) Type (3) Air-Conditioning Unit	 250 RT x 3 Turbo x 3 AHU x 53 Window x 120 Package x 10	 1,000 USRT x 1 350 USRT x 4 Turbo x 4 Absorption x 1 FCU x 461 (Main building) x 126 (Annex building) Package x 31
9. Water Consumption	Not available	273,133 m^3/yr
Unit Energy Consumption (National average)	**454,600 kcal/m^2/yr** ---	**810,700 kcal/m^2/yr** (586,100 kcal/m^2/yr)

11-5-8 Present Situation of Energy Management and Energy Efficiency Promotion

The main hospital complex was built in 1969 and some of the facilities have become out-dated. Features of the hospital energy efficiency problem are as follows.

1) Open-type building

- Utilizing natural ventilation system to maximum extent
- Model facility of old type energy-efficient building
- Coexistence of open and closed zones

2) High energy-saving awareness

- Controlling illumination density at minimum level
- Lift operation control system
- Separation of air conditioning zones for localized cooling
- Power factor management

3) Electricity management

- Old type of lift power control system
- Frequent over-current trip in chiller system

4) Heat management

- Boiler on/off operation control
- Future expansion of air-conditioning system

11-6 Measures for Energy Efficiency Promotion

The measurement results for the hospital audit were analyzed and processed in the previous section. In accordance with the hospital energy audit results, recommended measures for energy efficiency improvements are described and discussed in this section. The major items are as follows:

1. Introduction of an inverter control system for the lift power supply
2. Improvement of boiler exhaust gas oxygen content and temperature
3. Solution to the frequent over-current trip problem and low power factor operation in chiller system
4. Improvement of TNB power receiving system
5. Improvement of air-conditioning system and introduction of energy storage system for the future

11-6-1 Introduction of Inverter Control System for the Lift Power Supply

This hospital has eight lift units whose specifications are as follows:

Table 11-20 Lift Specification at Hospital Seremban

Control System	VVGD-CL	Working status Lift #1 : operating for goods Lift #2,3: stand by Lift #4,5: operating for general usage Lift #6 : operating for patient Lift #7,8: operating for bed/ passengers
Capacity	23 persons	
Stops	9 stops	
Speed	Lift #1,6,7,8 : 90 m/min. Lift #2,3,4,5 :105 m/min.	
Operation	Lift #1,6,7,8 : 1C-2BC Lift #2,3,4,5 : 2C-2BC	

Although the main lift bank of 6 lifts is old and the control system is based on relays, all lifts are in good working order and have been well maintained. The introduction of the Variable Voltage Variable Frequency (VVVF) power supply system in the event of future lift renovation is recommended, in order to achieve both improved energy efficiency and transportation amenability. The power saved is estimated to be approximately 30-40 percent of the total consumption; that is 51-68 kWh per day for No.4 plus No.5 lift.

Table 11-21 shows a comparison of performance between the installed Ward-Leonard System (VVGD), VVVF and the AC feedback control system (DIAGLIDE).

Table 11-21 Performance Comparison of Power Supply Control System

	VVGD (Ward-Leonard system)	VVVF (variable voltage variable frequency)	DIAGLIDE (AC feedback control system)
Riding Comfort	Good Simple feedback control without tacho-meter	Excellent Perfect continuous torque control and complete feedback control with pulse generator	Very Good Complete feedback control with tacho-meter. However, discontinuous torque control between motoring and braking
Landing Accuracy	Excellent	Excellent	Excellent
Noise	Large Starting noise of M-G set	Quiet Sine wave current controlled by PWM (Pulse Width Modulation)	Small Motor noise caused by thyrister controlled current
Power Consumption	Large Large consumption caused by M-G set	Very Small, about half of DIAGLIDE Voltage and frequency control for induction motor at high efficiency	Small Static voltage control, but fixed frequency
Space for Machine Room	Large Large DC motor and M-G set	Very Small Small sized single-winding AC motor and control panel	Small Small-sized reconnect AC motor
Weight of Machine Room Apparatus	Large	Very Small	Small
Reliability	Good Wear and tear of brushes and commutator of DC motor and M-G set	Excellent, superior to DIAGLIDE Solid state digital control by micro processor	Very Good Solid state control by analog devices
Response	Bad Time lag to start due to starting time of M-G set	Excellent No time lag to start	Excellent No time lag to start
Maintenance-ability	Bad Required complex "compound adjustment"	Excellent No special adjustment	Very Good No complex adjustment

11-6-2 Improvement of Boiler Exhaust Gas Oxygen Content and Temperature

The study team tried to estimate the actual air ratio figure of the boiler based on the measurement data. The O_2 and CO_2 content in the boiler flue gas are around 7.2 and 10.5 percent, respectively. High oxygen content means excess air in the boiler chamber and low carbon dioxide indicates imperfect combustion. Referring to the general technical chart of flue gas content vs. air ratio, the air ratio could easily be read as 1.45-1.5.

The specific air volume, A, introduced to the boiler was 9.82 Nm^3/kg (intake air volume is 1,620 Nm^3/hr, fuel oil flow rate is 165 kg/hr). Theoretical air volume necessary to burn 1 kg of fuel oil, A_0, can be calculated as 6.54 Nm^3/kg, by consulting the fuel oil chemical elementary analysis data. Then the air ratio is calculated to be 1.5 ($= A/A_0$).

The automatic on/off operation of the boiler may be the reason for the rather high air ratio. Firing on/off in the boiler is rather frequent and operation time is short. This means that it is difficult for the boiler to maintain a steady state of operation for long periods, and boiler efficiency may not be always high enough because of imperfect combustion.

The Japanese judgement criteria are published so as to promote appropriate and rational use of energy at factories. For reference purposes, some of the criteria for small sized boilers are extracted below in Table 11-22.

Table 11-22 Japanese Guidelines for Boiler Operation Conditions (Reference)

Equipment	Air Ratio		Exhaust Gas Temperature	
	(Standard Value)	(Desired Value)	(Standard Value)	(Desired Value)
Steam Boiler Size: less than 5 ton/hr Fuel: Liquid Fuel Load:50-100 %	1.3	1.2-1.3	250 degrees centigrade	220 degrees centigrade

Few measuring instruments are installed around the boilers. Exhaust gas sampling will be necessary in order to improve the air ratio by controlling the Forced Draft Fan (FDF) damper or RPM of the fan motor. Care should be taken to avoid air pollution caused by the lack of air or imperfect combustion, and to improve energy efficiency through combustion control.
Exhaust gas temperature fluctuated from 165 to 195.3 degrees centigrade, as described in Table 11-17, and this figure is below the desired Japanese guideline value.

11-6-3 Solution to Frequent Over-Current Trip Problem and Low Power Factor Operation in Chiller System

Chiller No.1 and No.3 are being operated 24 hours continuously at approximately full capacity to supply chilled water to about 40 percent of the main building's areas. This system often stops because of the over-current trip problem.

As Figure 11-17 and 11-18 show, this system has two problems: extraordinarily low PF (power factor) and high current quite close to the trip set value of 300 amperes. These problems are also found in chiller No.3 system.

The following measures should be investigated.

(1) Clarifying the cause of low PF

(2) Increasing the fuse from 300 A to 350 A

(3) Installation of capacitor

(4) Replacing distribution line cable with larger size

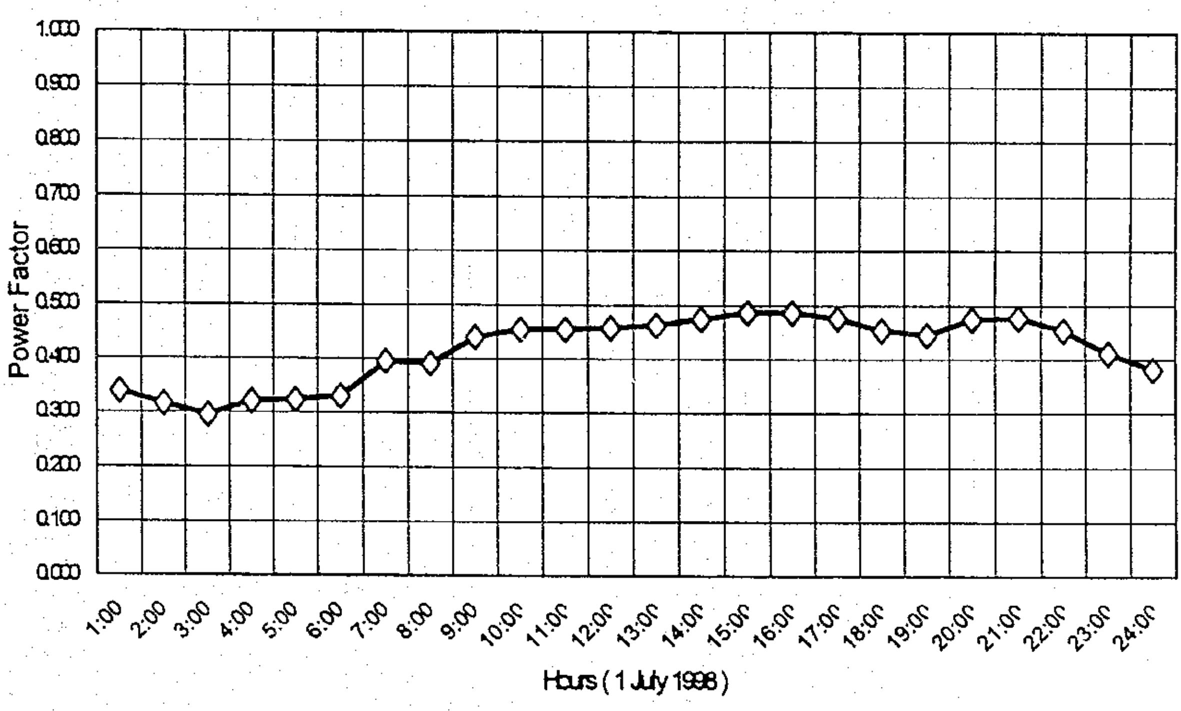


Figure 11-17 Power Factor Trend for Chiller No.1

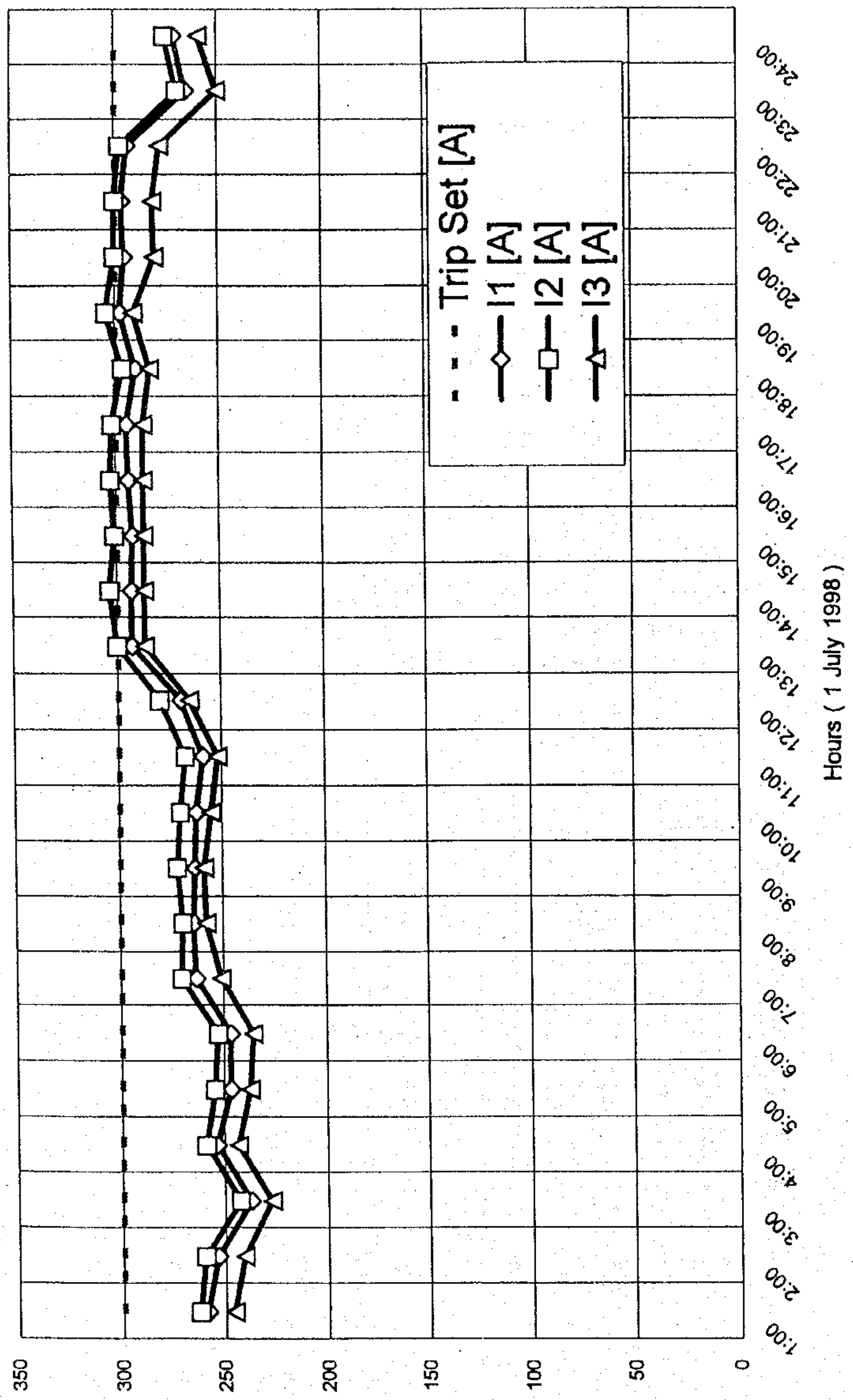


Figure 11-18 Ampere Trend at Chiller No.1

11-6-4 Improvement of TNB Power Receiving System

Since renewing the capacitor or power factor reformer, the hospital has been obtaining the highest power factor possible from TNB. No supplementary charges have been added since then to the bill.

A detailed observation of power receiving data shows that the reactive power is negative and the power factor is approximately -0.96 (leading), as illustrated Figure 11-19 and Figure 11-20.

Some adjustment of the automatic control system of the capacitor bank is needed.

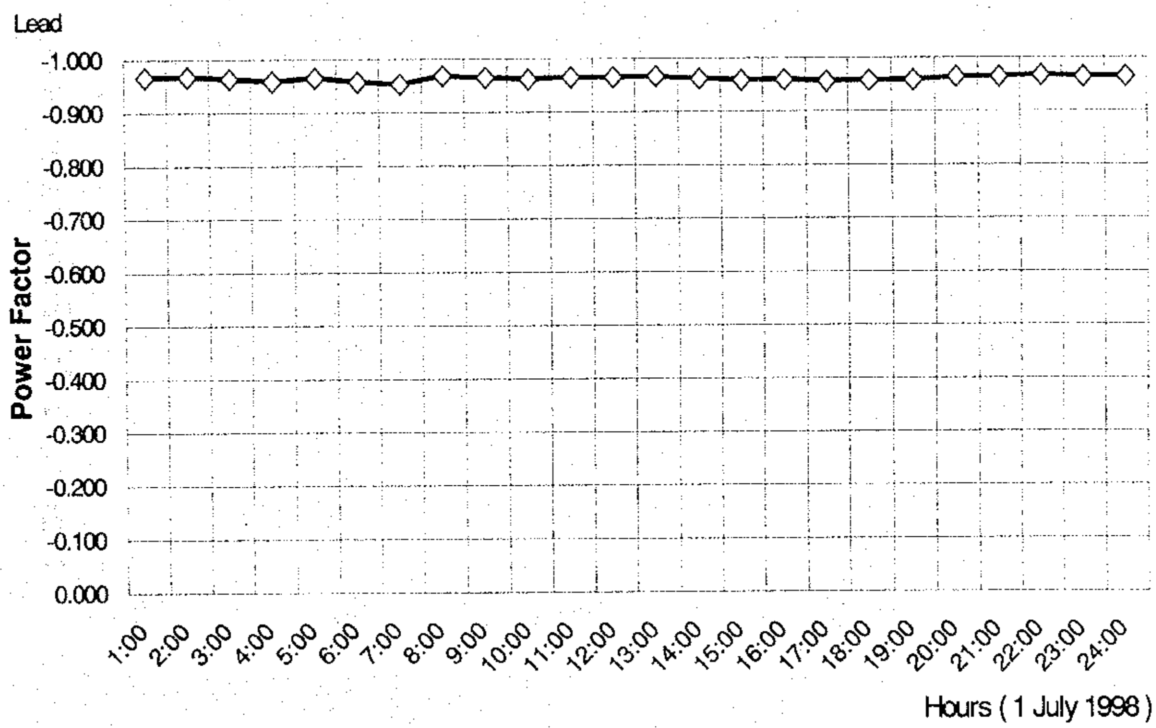


Figure 11-19 Power Factor

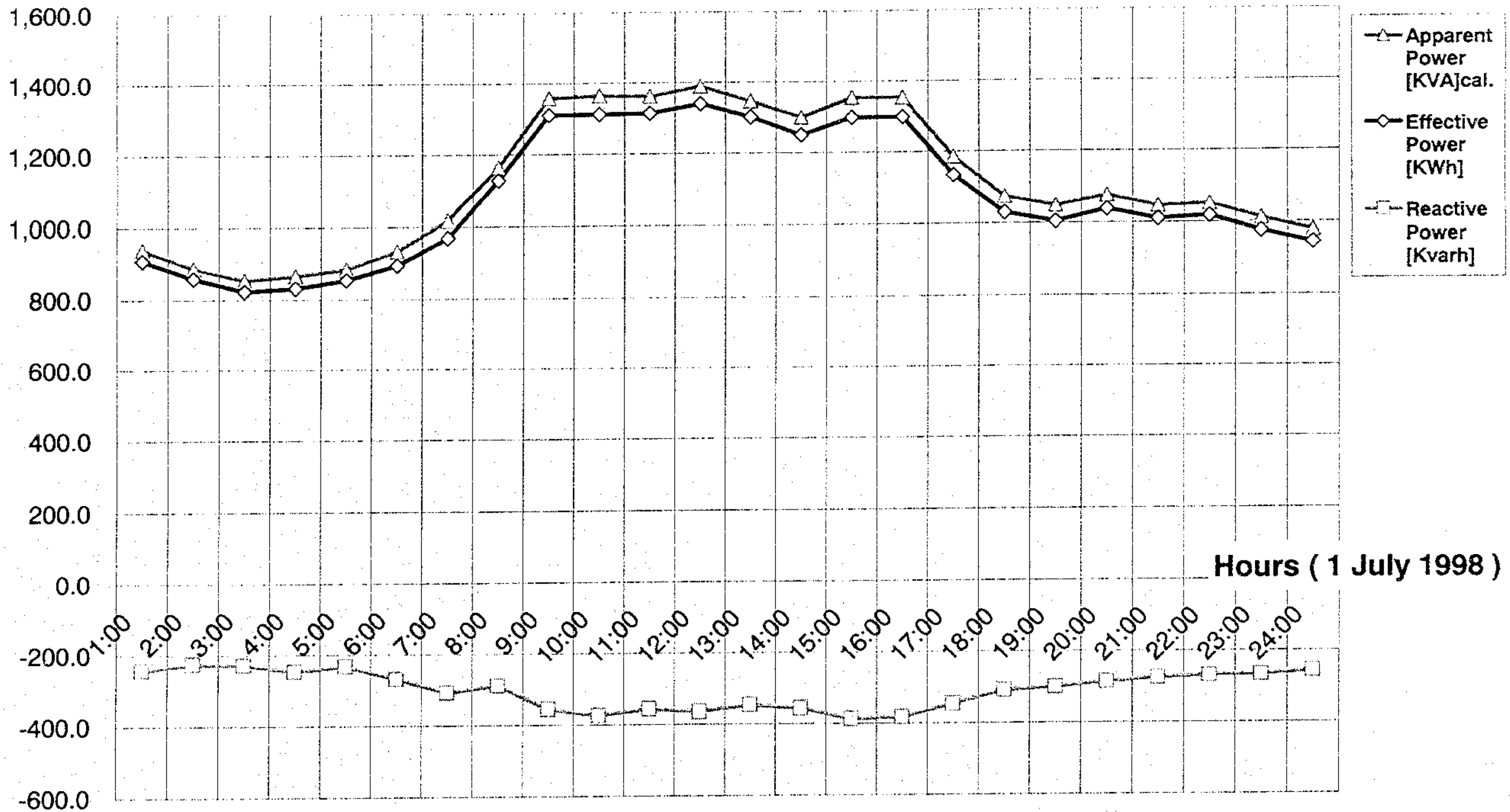


Figure 11-20 Power Receiving

11-6-5 Improvement of Air-Conditioning System and Introduction of Energy Storage System for the Future

As the next section describes, Japanese hospitals mainly use a centralized air heating and cooling system equipped with both turbo and absorption-type chillers and supplementary local package-type air conditioners. Hospital Seremban uses a combination of natural ventilation, mechanical ventilation and a centralized and local air cooling system, and approximately 40 percent of the main building's areas are cooled by the centralized system.

In the near future, the demand for air cooling, instead of natural or mechanical ventilation, will become inevitable. In this regard, the following should be studied.

(1) Reform the chiller system and select an economical mechanical model.
Absorption chiller: fixed load
Turbo chiller: variable load

(2) Introduce a latent heat storage facility attached to the centralized chiller system
Advantages:
- Effective peak load saving, shifting peak time demand to off-peak period
- Reduction of demand electricity amount
- Investment cost saving by reducing chiller design capacity

A schematic flow diagram for a future chiller system with a latent heat storage facility is shown in Figure 11-21.

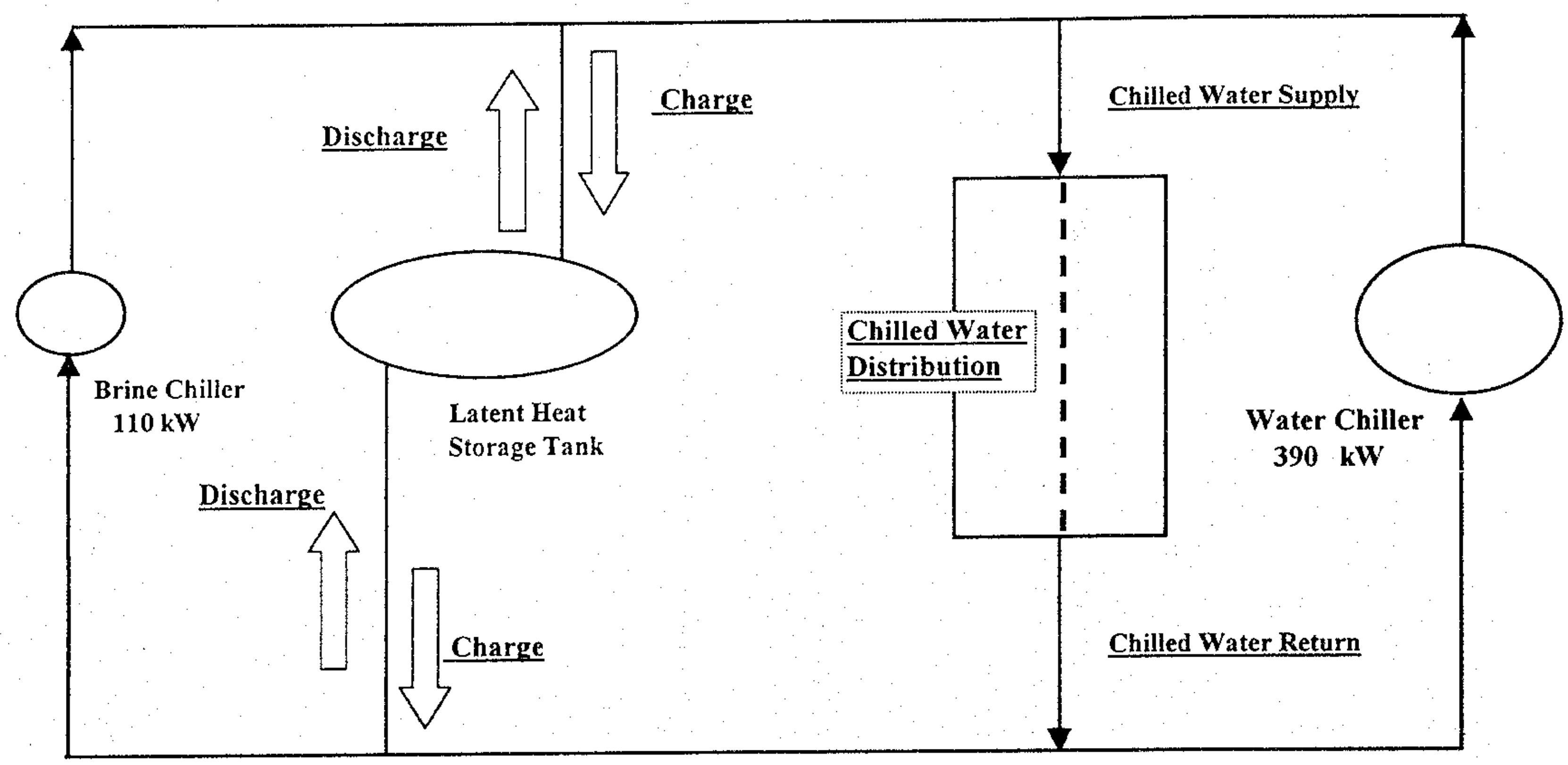


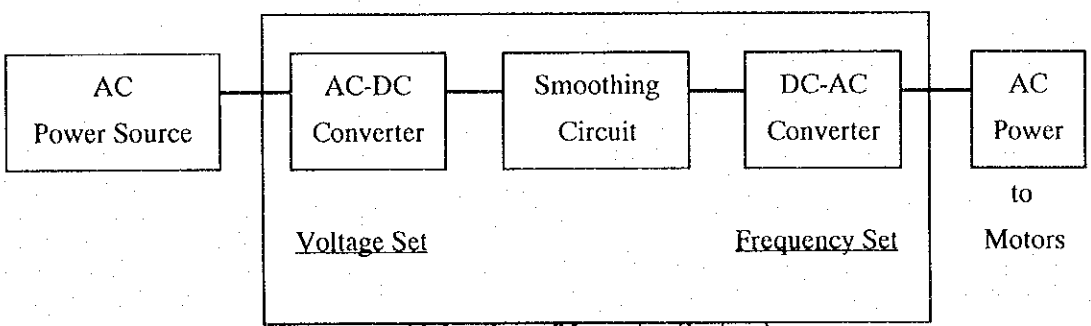
Figure 11-21 Schematic Flow for Latent Heat Storage System

11-7 Selection of Energy Efficiency Promotion Technology

Based on recommended measures to improve energy efficiency described in section 11-6, applicable and related technologies are discussed in this section.

(1) Inverter Control System

The VVVF inverter can control the speed of the AC motor by supplying the motor with a particular frequency and voltage. An outline of the inverter controlling system structure is shown below.



(Adoption of Inverter System)

A performance comparison of the installed VVGD and VVVF, DIAGLIDE is illustrated in Table 11-21, shown previously.

(2) Combustion Control Equations

As there was excess air in the boiler, a more appropriate air ratio is recommended for combustion using the following equations.

1) Theoretical Air Volume, A_0 : Air volume necessary to burn 1 kg of solid or liquid fuel

$A_0 = 1/0.21 \times \{22.4/12 \times c + 22.4/4 \times (h\text{-}o/8) + 22.4/32 \times s$

$= 8.89 \times c + 26.7 \times (h\text{-}o/8) + 3.33 \times s$ [Nm3/kg]

c: Carbon content in 1 kg of fuel *h:* Hydrogen content in 1 kg of fuel

o: Oxygen content in 1 kg of fuel *s:* Sulfur content in 1 kg of fuel

2) Theoretical air ratio, m: Ratio of theoretical air volume (A_0) and real air volume (A)

$$m = 1 + \frac{(O_2) - 0.5 \times (CO)}{\{1.867 \times c + 5.6 \times (h\text{-}o/8) + 0.7 \times s\} \times \{(CO_2) + (CO)\}/\{1.867 \times c + 0.7 \times s\}}$$

(O_2) , (CO_2), (CO) : Exhaust gas content

or $m = A_0 / A$

(3) Power Factor Correction Capacitor

Calculation of capacitor size : Q_c

$$Q_c = P \times PF_1 \times \{(1/(PF_1)^2 - 1)^{1/2} - (1/(PF_2)^2 - 1)^{1/2}\}$$

P : Load [kVA]

PF_1 : power factor before correction PF_2 : power factor corrected

Currency reduction ratio : α

$$\alpha = I_2/I_1 = PF_1/PF_2$$

I_1 : currency before correction I_2 : currency after correction

(4) Automatic Control of Capacitor Bank

1) Advantages of power factor correction
- High efficiency operation of load
- Reduction of voltage drop in power line
- Reduction of power loss
- Reduction of power amount

2) Disadvantages of leading current
- Shortened facility life-time
- Facility power loss

3) High-efficiency operation of transformer

$$\eta = \frac{\text{Effective Power [kW]}}{\text{Effective Power [kW]} + W_i + W_{cu}}$$

W_i [kW] : Iron loss W_{cu} [kW] : Copper loss Maximum efficiency : at $W_i = W_{cu}$

(5) Air-Conditioning System

For reference purposes, air-conditioning systems are compared.

Zone Control	Cooling Medium	Cooling Load Control System	Energy Saving	Remarks
Centralized Chiller Controlling	Air	Constant flow rate	good	-Temperature total control - Common operation hour - Central machine room - Energy saving
		Variable flow rate	good	
	Water	Constant flow rate	good	
		Variable flow rate	excellent	
Localized Chiller Controlling	Air	Temperature control	good	- Temperature local control ability
	Water			

11-8 Cost of Measures for Energy Efficiency Promotion

Budget-type costs were estimated for two recommended modification works (1) power saving in lift system (2) solution to frequent over-current trip problem and (3) introduction of latent heat storage system. Note that item (3) is only for reference, applicable after future chiller expansion.

Cost is not required for "Improvement of boiler exhaust gas oxygen content and temperature" and "Improvement of TNB power receiving system" since these two measures are taken by reinforcement of operation management.

(1) Introduction of inverter control system for lift power supply

	RM
1. Lift replacement (L# 1, 6, 7, 8)	1,550,400
2. Lift replacement (L# 2, 3, 4, 5)	1,594,400
(Inverter controller installation: L# 1,2,3,4,5,6,7,8)	(314,480)
TOTAL	3,144,800

(2) Solution to frequent over-current trip problem

	10^3 Yen
1. Capacitor (25 kVar x 7 unit = 175 kVar)	3,220
2. Installation work (2 man-day)	100
TOTAL	3,320

(3) Introduction of latent heat storage system

	10^3 Yen
1. Water chiller (capacity: 390 kW)	19,500
2. Brine chiller (capacity: 110 kW)	9,000
3. Phase change material and tank (tank : carbon steel, 70 m^3)	10,500
4. Installation work	6,000
TOTAL	45,000

11-9 Potential of Energy Efficiency Promotion

Based on the discussion on applicable technology for improved energy efficiency in sections 11-6 and 11-7, energy efficiency promotion potential is discussed in this section.

"Improvement of TNB power receiving system" is excluded from the energy efficiency promotion potential estimation, since its expected value is extremely small.

(1) Power Saving by Introduction of Inverter Controller

Eight lifts are being operated already in an energy-saving manner. Some lifts are working continuously while others operate intermittently or are on stand-by. Unloaded operation is avoided.

By introducing the 'VVVF' inverter controller to replace 'VVGD' for the lift power supply system, the power saved is estimated of approximately 30-40 percent of the power consumption per lift.

Lift No.	Working Status	Expected Power	Remarks
# 1	Continuous operation	25-34	Estimated
# 2,3	Stand by	5-6	Estimated
# 4,5	Continuous operation	51-68	Based on measured data
# 6	Continuous operation	25-34	Estimated
# 7,8	Continuous operation	51-68	Estimated
Total		157-210 kWh/day	

(2) Combustion Air Control at Boiler

Based on the equations mentioned in section 11-7 (2), characteristic figures on boiler combustion are estimated as follows.

Theoretical air volume necessary to burn 1 kg of fuel oil, A_0 : 6.54 Nm^3/kg

Measured intake air volume to burn 1 kg of fuel oil, A : 9.82 Nm^3/kg

Air ratio, m : 1.5

(3) Power Factor Correction Capacitor in Chiller System

Capacitor size and current after installation are estimated as follows.

Capacitor size : $Qc = 250 \times 0.45 \times \{(1/(0.45)^2 - 1)^{1/2} - (1/(0.90)^2 - 1)^{1/2}\}$

$= 170$ [kVA]

Current after capacitor installation : $I_2 = 300 \times 0.5$

$= 150$ [Ampere]

(4) Energy Storage System

In the near future, the demand for air-cooling will increase instead of natural mechanical ventilation, which is now utilized in at most parts of the hospital building.

The introduction of a latent heat storage facility attached to the expanded chiller system is advised. The latent heat storage facility would aid 1) investment cost saving of the chiller and 2) reduction of demand power amount.

Supposing that future air cooling demand increases by 1.2 times of the split-type air-conditioning now in operation, the basic parameters are roughly as follows.

1) Power demand profile: Figure 11-22
2) Peak instantaneous demand : 650 kW
3) Energy charge

   peak period : 500 kW x 14 hr (08:00 to 22:00) = 7,000 kWh per day

   off-peak period : 500 kW x 10 hr (22:00 to 08:00) = 5,000 kWh per day
4) Total chiller design capacity : 500 kW
   - Water chiller 390 kW
   - Brine chiller 110 kW
5) Phase change material tank : 70 m^3 carbon steel

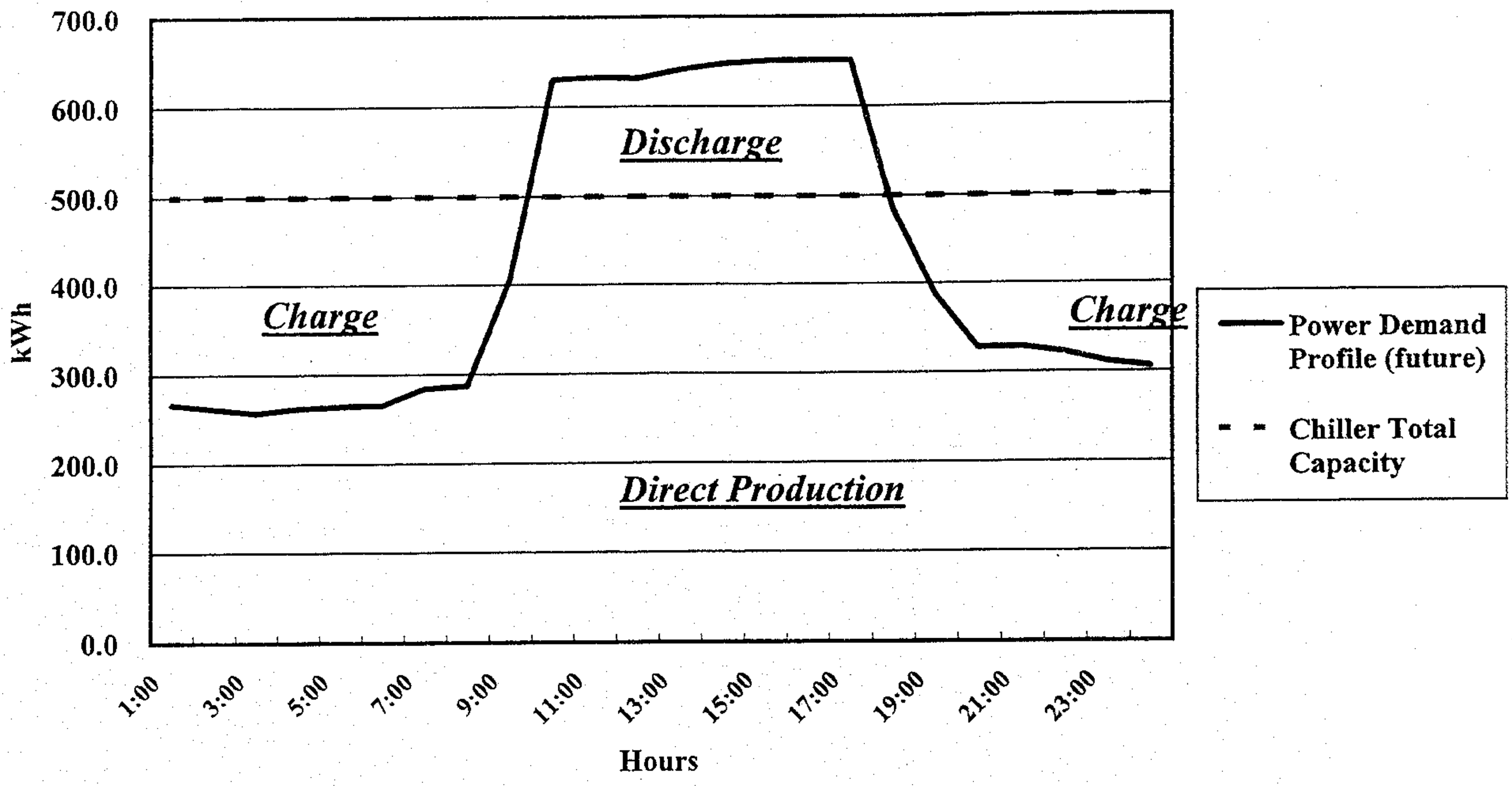


Figure 11-22 Air Conditioning Power Demand Profile (After Future Expansion)

11-10 Effectiveness of Energy Efficiency Promotion

The energy saving effect is summarized in this section.

(1) Power Saving in Lift System

1) Operation Management Control	Avoiding empty car operation already adopted
2) Introduction of Inverter Control System for the Lift Power Supply	157-210 kWh/day

(2) Improvement of Boiler Combustion Conditions

1) Improvement of Air Ratio	Hard to control strictly because of automatic on/off operation
2) Reduction of Exhaust Gas Temperature	Standard value already achieved (no exact standard data available for on/off boilers)

(3) Solution for Frequent Over-Current Trip Problem

Installation of Capacitor	Stable chiller operation would be achieved after installation of 170 kVA capacitor for chiller #1 and #3 power supply

(4) Improvement of TNB Power Receiving System

Adjustment of Automatic Capacitor Control Set-up	Avoid problems due to leading current: Facility life time, power loss

(5) Introduction of Latent Heat Storage System (available only after future chiller expansion)

Reduction of Demand Power Charge	150 kW / month
Reduction of Energy Charge peak period off-peak period	 1,400 kWh per day -2,000 kWh per day
Reduction of Chiller Design Capacity	650 to 500 kW

11-11 Benefit of Measures for Energy Efficiency Promotion

In this section, benefits are estimated of the measures for energy efficiency promotion based on the current price of energy in Malaysia. This estimation is made for two measures, "Introduction of Inverter Control System for the Lift Power Supply" and "Introduction of Latent Heat Storage System" for which numerical effectiveness of energy efficiency improvements have been obtained in the previous section.

11-11-1 Current Price of Energy in Malaysia

Electric power could be saved by all the recommended measures for iproved energy efficiency. The current price of electric power conforms to category C2 of TENAGA NASIONAL's tariff, effective from 1 May, 1997, in the case of Hospital Seremban. The following rates are applied, according to this category of tariff.

- Peak load rate (between 800 and 2200 hours): 0.208 RM/kWh;
- Off-peak load rate(between 2200 and 800 hours): 0.128 RM/ kWh
- Maximum demand charge: 25.7RM/kW/month

11-11-2 Benefits of Measures

(1) Introduction of Inverter Control System for the Lift Power Supply

The benefit derived from this measure is estimated at 20,569 RM/year by the calculations shown in Table 11-23 below.

Table 11-23 Estimation of Benefit from the "Introduction of Inverter Control System for the Lift Power Supply" Measure

No.	Item	Estimated Value	Remarks
	Electricity Saving		
①	Electricity saving at peak time	76,650 kWh/year	= 210 kWh/day x 365 day/year (from Section 11-10)
②	Electricity saving at off-peak time	none	
③	Saving in max. demand	15 kW/month	= 210 kWh/day / 14 h/day
	Saving in Electricity Bill		
④	Electricity saving at peak time	15,943 RM/year	①x 0.208 RM/kWh
⑤	Electricity saving at off-peak time	0 RM/year	②x 0.128 RM/kWh
⑥	Saving in max. demand charge	4,626 RM/year	③x 25.7 RM/kW/m x 12 m/y
⑦	Saving in Electricity Bill	20,569 RM/year	④ + ⑤ + ⑥

(2) Introduction of Latent Heat Storage System

A 59,108 RM/year of benefit is estimated for this measure by the calculations shown in Table 11-24 below.

Table11-24 Estimation of Benefit by the Measure "Introduction of Latent Heat Storage System"

No.	Item	Estimated Value	Remarks
	Electricity Saving		
①	Peak instantaneous demand before installation of the system	650 kW	12 hours/day at peak
②	Lower demand before installation of the system	300 kW	2 hours/day at peak, and 10 hours/day at off-peak
③	Demand after installation of the system	500 kW	24 hours/day
④	Electricity saving at peak time	1,400 kWh/day	= ①x12+②x2-③x14
⑤	Electricity saving at off-peak time	-2,000 kWh/day	= - (③x 10-②x10)
⑥	Saving in max. demand	150 kW/month	① - ③
	Saving in Electricity Bill		
⑦	Electricity saving at peak time	91,104 RM/year	④x 365x 6/7x0.208 RM/kWh
⑧	Electricity saving at off-peak time	- 80,091 RM/year	⑤x 365x6/7x0.128 RM/kWh
⑨	Saving in max. demand charge	46,260 RM/year	⑥x 25.7 RM/kW/m x 12 m/y
⑩	Saving in Electricity Bill	57,273 RM/year	⑦ + ⑧ + ⑨

11-12 Financial Evaluation of Measures

In this section, financial evaluations are made for the following measures requiring investment in order to know the financial feasibility of the measures.

- Introduction of Inverter Control System for the Lift Power Supply
- Introduction of Latent Heat Storage System

The financial evaluation for the first measure is made under the assumption that the measures would be taken at a time when overage lifts were to be replaced by new lifts. As for the second measure, the financial evaluation is made assuming that the latent heat storage system is introduced into the hospital at the time of chiller system expansion. Under such conditions, only the amount of money that will be used for energy saving equipment is considered as fixed investment in order to obtain the energy saving benefit. The remaining invested money is regarded as a cost that is necessary, regardless of energy saving.

In fact, for the first measure, only the cost related to inverters is counted as the fixed investment for the purpose of the financial evaluation, assuming VVVF system lifts with inverters are introduced at the time of lift replacement. As for the second measure, the fixed investment cost for the financial evaluation is defined as the difference between the fixed investment in the case that latent heat storage is installed and that in which latent heat storage is not installed.

The financial evaluation is not conducted for the measure "Solution for frequent over-current trip problem" which requires investment, since numerical estimation of benefits is difficult for the measure.

11-12-1 Method of Financial Evaluation

(1) Applied Method

Two different methods, both widely used and accepted for financial evaluation of the investment projects, are applied in the study. The first method is the payback period method to calculate the payback period, defined as the period required to recover the investment outlay through the accumulated net cash flows earned by the project. The second method is the internal rate of return (IRR) method on discounted cash flow basis. Financial Internal Rate of Return on Investment (FIRROI) is defined the discount rate for which the present value of net receipts from the project is equal to the present value of the investment.

(2) Payback Period

Net cash flow is defined as follows:

1) Increased Sales Revenue
2) Less: Fixed Investment
3) Less: Pre-production Expenditure
4) Less: Increase in Net Working Capital
5) Less: Increased Operating Costs

6) Less: Increased Marketing Costs
7) Less: Increase in Corporate Tax Paid

In the case of the investment for energy efficiency improvement, the change in sales revenue and marketing cost should be zero. The changes in net working capital and pre-production expenditure are negligible in the case of projects for improved energy efficiency. Fixed investment was estimated in the previous section. Changes in operating costs, which mainly include the changes in utility bills such as electricity and fuel, were also estimated. Corporate tax change is calculated based on the change in taxable profit due to change of operating costs, in consideration of the country's tax rate, and depreciation system.

When calculating the payback period, a cash flow table starting from the construction period to the operating period is created. Accumulated net cash flow is negative during construction due to fixed investment and pre-production expenditure, however it will increase by the recovery of capital and become zero in a certain year. The payback period is defined as the period from the start of operation until the year when the cumulative net cash flow is zero.

(3) Internal Rate of Return (IRR)

The calculation procedure begins with the preparation of a cash flow table in the same way as the payback period method. Then, the discount rate when the cumulative net cash flow of the project becomes zero is obtained by trial-and-error. The thus discounted rate obtained is the Financial Internal Rate of Return on Investment (FIRROI).

11-12-2 Premises for Financial Evaluation

Financial evaluations are made on the following premises.

1) Exchange rate: US$ 1 = RM 3.8 ; US$ 1 = JY 118

2) Project life: 15 years from the start of operation

3) Corporate tax rate: No tax is imposed on Hospital Seremban, as it is a government organization.

4) Depreciation: none

5) Fixed investment: Fixed investment cost is shown in Table 11-25 in Malaysian Dollars. For the latent heat storage system, only the inverter controller installation is counted. As for the second measure, the fixed investment cost was obtained by subtracting the cost of a 650 kW-water chiller (32.5 million Japanese Yen) from the cost listed in section 11-8 (45.0 million Japanese Yen), and converting it to Malaysian Dollars.

Table 11-25 Fixed Investment for Measures

Measures	Fixed Investment, RM
Introduction of Inverter Control System for the Lift Power Supply	314,000
Introduction of Latent Heat Storage System	402,542

11-12-3 Results of Financial Evaluation

Table 11-26 shows FIRROI before tax, FIRROI after tax and payback period for the two measures. Estimated cash flow tables for these measures are presented in Table 11-27 and Table 11-28.

Table 11-26 Results of Financial Evaluation

Measures	FIRROI before tax	FIRROI after tax	Payback Period
Introduction of Inverter Control System for the Lift Power Supply	-0.2%	-0.2%	15.3 years
Introduction of Latent Heat Storage System	11.4%	11.4%	7.0 years

In addition to the above, three kinds of indicators are calculated for the two measures on the assumption that electricity tariff rises to the rate shown in Table 11-29, which is considered to be the current level in Japan. This calculation is made in order to find out the effect of electricity tariff on the financial feasibility of those measures.

Table 11-27 Cash Flow Table (Measure: Introducing of Inverter Control System for the Lift Power Supply)

Unit: RM

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Less: Fixed investment	314,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plus: Reduction in operating cost	0	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569
Less: Corporate tax increased	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Incremental Cash Flow (before Tax)	-314,000	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569
Incremental Cash Flow (After Tax)	-314,000	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569	20,569
Cumulative net cash flow	-314,000	-293,431	-272,862	-252,292	-231,723	-211,154	-190,585	-170,016	-149,446	-128,877	-108,308	-87,739	-67,170	-46,600	-26,031	-5,462
Depreciation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 11-28 Cash Flow Table (Measure: Introduction of Latent Heat Storage System)

Unit: RM

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Less: Fixed investment	402,542	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plus: Reduction in operating cost	0	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273
Less: Corporate tax increased	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Incremental Cash Flow (before Tax)	-402,542	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273
Incremental Cash Flow (After Tax)	-402,542	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273	57,273
Cumulative net cash flow	-402,542	-345,270	-287,997	-230,725	-173,452	-116,180	-58,907	-1,634	55,638	112,911	170,183	227,456	284,728	342,001	399,274	456,546
Depreciation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 11-29 Assumed Rise in Electricity Rate for Study

	Assumed Electricity Rate for Study		Reference (C2 tariff)
Peak Load Rate	0.483 RM/kWh	(15 JY/kWh)	0.208 RM/kWh
Off-peak Load Rate	0.113 RM/kWh	(3.5 JY/kWh)	0.128 RM/kWh
Max. Demand Charge	49.9 RM/kW/month	(1,550 JY/kWh/month)	25.7 RM/kW/month

Table 11-30 shows the results of the evaluation at the electricity rate assumed in Table 11-29. FIRROI before tax and after tax increased by about 12% for the first measure and 46% for the second. The payback periods were shortened by 8.5 years and by 5.3 years for the first and second measures, respectively.

Table 11-30 Results of Financial Evaluation at Assumed Increased Electricity Rate

Measures	FIRROI before tax	FIRROI after tax	Payback Period
Introduction of Inverter Control System for the Lift Power Supply	12.0%	12.0%	6.8 years
(Difference from the base)	(+12.2%)	(+12.2%)	(-8.5 years)
Introduction of Latent Heat Storage System	57.3%	57.3%	1.7 years
(Difference from the base)	(+45.9%)	(+45.9%)	(-5.3 years)

11-12-4 Conclusion of Financial Evaluation

According to the information obtained during the field survey, the lending rate in Malaysia has been ranging from 12 to 14% per annum recently. This rate could be taken as an indication of the opportunity cost of capital in Malaysia.

The measure of installing an inverter control system in the lift power supply is not financially feasible, assuming an inverter system is installed together with lift replacement. Currently, the hospital consumes electricity at a relatively low rate in the lift system, because of the low frequency of lift operation. Therefore, no large effect is expected by the installation of an inverter control system. Another reason for low feasibility is due to the low electricity tariff in Malaysia. If the electricity tariff increases to the current Japanese level, its financial feasibility will be improved to the marginal levels shown in Table 11-30.

The latent heat storage system measure is evaluated under the assumption that it is installed at the time of chiller expansion, as mentioned before. It is concluded that the measure is at the marginal level of financially feasibility under the conditions of the study. Its FIRROI is 11.4% and the payback period is 7 years. However, it is said that the measure will become financially feasible if electricity tariff increases to the current Japanese level, judging from the indicators shown in Table 11-30. It is recommended that the introduction of latent heat storage be investigated at the time of chiller expansion.

11-13 Recommendations for Energy Efficiency Promotion

Based on the energy audit and subsequent study for Hospital Seremban, the following measures are recommended for improving its energy efficiency.

(a) For space cooling, Hospital Seremban currently uses a combination of natural ventilation, mechanical ventilation, centralized air-conditioning and local air-conditioning systems. Approximately forty percent of main building areas are cooled by the centralized system. In the near future, expansion of air-conditioning will become inevitable instead of natural ventilation and mechanical ventilation. In the event of such air-conditioning system expansion, it is recommended that the introduction of latent heat storage be investigated. This technology will enable effective peak load saving and reduction in maximum demand by shifting peak demand into off-peak demand. As a result of the financial evaluation, we conclude that this measure has a marginal level of financial feasibility under the conditions set for the study.

(b) The chiller system often stops because of the over-current trip problem. According to the investigation by the study team during the energy audit, this system has two problems: extraordinarily low power factor and high current quite close to the trip set value of 300 amperes. The following measures should be investigated.

- Clarifying the cause of low power factor
- Increasing the fuse from 300 ampere to 350 ampere

- Installation of capacitor
- Replacing distribution line cable with a larger size

(c) Negative power factor values were observed at the power receiving system from TNB during the energy audit by the study team. It is recommended the automatic control system of the capacitor bank be adjusted.

(d) The air ratio of boiler exhaust gas exceeds the Japanese guideline. Improvement is desired by reinforcement of operation management from an energy efficiency point of view, although the current air ratio may be affected by the on-off operation of boilers.

Chapter 12 Cement

At APMC's Rawang Works, one of the works targeted for an energy audit in this time, a new 5-stage, twin-string SF precalciner plant, the latest type of cement burning facility, was erected and commissioned by IHI Japan early in 1981, instead of 2 sets of wet kilns.
This 4,000 t/day SF precalciner was modified to a 5,000 t/day, 5-stage NSF precalciner plant in 1992, and has been operating to the present day.

A factory survey for the energy audit was carried out through interviews and plant observations based on questionnaires and data sheets prepared by the Study Team. As for these results, high figures were recorded for power consumption and also heat consumption at this factory, in spite of the latest facilities. For the investigation, the study team carried out an energy audit concerning the energy consumption of facilities and equipment, instrumental and control equipment, and operations.

To conduct an energy audit of these cement works, field investigations such as an analysis of operation data is the first essential step, followed by many kinds of measurements. The results of the energy audit, including an evaluation of the results and recommendations for energy efficiency, are described in this chapter.

Major items and types of energy audits in cement works are as follows.

1. Heat consumption of the burning department
2. Electricity consumption of the raw material grinding department
3. Electricity consumption of the coal drying and grinding department
4. Electricity consumption of the cement grinding department
5. Others

12-1 Outline of Cement Industry in Malaysia

The first commercial cement plant was established in 1953, in Rawang, Selangor, by Malayan Cement Limited. Subsequently, Malaya Industrial and Mining Corporation began operations in 1958, also in Selangor, followed by Tasek Cement Limited and Pan Malaysia Cement Works, Ltd., in Perak in 1964. Between the 70's and 80's, several cement manufacturers, including the two cement grinding plants, one each in Sabah and Sarawak, were established to augment supply.

There were ten cement manufacturers operating in Malaysia in 1995 (six integrated plants and four cement grinding plants all ensuring a regular supply of high quality cement to meet the nation's growing needs).

Key data of the cement industry for 1996 follows. (Data Source: Cement & Concrete Association)

Total clinker production :	9.29	million tons
Total cement production :	12.71	million tons
Total cement consumption :	15.19	million tons
Average cement price :	198.00	MR/tons (9.90 MR/50kg Bag)
Per capita consumption :	717.0	kg

In March 1967, Malayan Cement and Pan Malaysia Cement Works merged their manufacturing operations to form Associated Pan Malaysia Sdn Berhad (APMC). Since then, APMC has invested huge sums to expand and modernize both factories. Upon completion of an upgrading exercise in 1993, its rated production capacity stood at 2.8 million tons of clinker per annum. Another 1.8 million tons of clinker production capacity at Kanthan is expected to be on-stream in 1997.

APMC produces ordinary portland cement, masonry cement and portland pulverized fuel ash cement, all in compliance with Malaysian and equivalent British standards. It is also able to produce other special cements depending on market demand.

12-2 Outline of Factory, Facilities and Operation

12-2-1 Outline of Factory

1) Name of Factory : Associated Pan Malaysia Cement Sdn, Berhad. Rawang Works

2) Address :

Head Office : Wisma APMC : No 2. Jaran Kilang 46050 Petaling Jaya Selangor Darul Ehsan
Tel : 03-7918344 Fax : 03-7917309 / 7942518

Rawang Plant : Rawang Works : 48000 Rawang Selangor Darul Ehsan
Tel : 03-6916711 / 4 Fax : 03-6919361

Kanthan Plant : Kanthan Works : 13 ½ Miles , Jaran Kuala Kangsar 31200 Chemor Perak Darul Riduan.
Tel : 05-2011202 / 4 Fax : 05-2012103

3) President (Name) : Mr. Saw Zwe Seng

4) Factory Manager (Plant Manager) : Mr. Chen Choon Siong

5) Energy Manager (Engineering Manager) : Mr. Tan Chek Luck
(Operations Manager) : Mr. R. Jaya Kumaran

6) Type of Industry : Cement manufacturing industry (private company)

7) Capital : Not available

8) Organization Chart : See Figure 12-1

9) Number of Employees / Number of Engineers : Total 560 persons

	Managers	Staff / Engineers	Workers	Sub-Total
Administrative Department	9	14	3	26
Production Department	56	123	294	473
Mining Department	4	5	52	61
Total	69	142	349	560

(* Not Include Plant Manager 1)

10) Number of Energy-Related Engineers : 13 persons
General Manager (Plant Manager): 1 person
Fuel-Related Engineers : 5 persons
Electricity-Related Engineers : 7 persons

11) General Layout drawing of Cement Factory : See received drawing Figure 12-2.
— Factory Area : 183,805 (m^2) — Utility Facility Area : 740 (m^2)
— Building Area : 37,390 (m^2) — Future Extension Area : 77,510 (m^2)

12) General Factory Layout drawing : See received drawing (Fig. 12-2).

13) Flow sheet of Cement Production Department : See attached flow sheet
(Fig. 12-3, Fig. 12-4, Fig. 12-5, Fig. 12-6, Fig. 12-7, Fig. 12-8.)

14) Major Products (Type of Cement) :
(a) Ordinary Portland Cement .
(b) Masonary Cement (Walcrete) .
(c) Portland Pulverized Fuel Ash Cement (Mascrete) .

15) Trend of annual sales amount : See Table 12-1.

16) History of Factory :

Malayan Cement Berhad(MCB) was established as the country's first major cement plant in Malaysia at Rawang, Selangor, in 1953. It is a member of Blue Circle Group(UK), one of world's largest cement producers. Two wet kilns and associated crushers, mills, etc., were constructed and operated until 1981 but are not operating at present.

The new 5-stage, twin-string SF precalciner plant was erected and commissioned by IHI Japan early in 1981. This 4,000 t/day SF precalciner was modified to a 5,200 t/day, 5-stage NSF precalciner plant in 1992.

17) Share and Position in Industrial Sub-sector

APMC is the No. 1 cement company in Malaysia and its market share is about 33 Percent.

18) Plant Capacity (Designed & Actual) :

Designed Capacity : 1,500,000 t-clinker/year

Actual Capacity : 1,600,000 t-clinker/year (1,860,000 t-cement/year)

19) Financial Information of Industry.

(a) Balance Sheet : Not available

(b) Statement of Profit and Loss : Not available

20) Employment and Training

For newly hired employees, operations training through on-the-job training (OJT) and safety education are carried out for a certain period inside the factory. However, energy efficiency promotion training for employees is not executed directly. Details of operations training and safety education were not available.

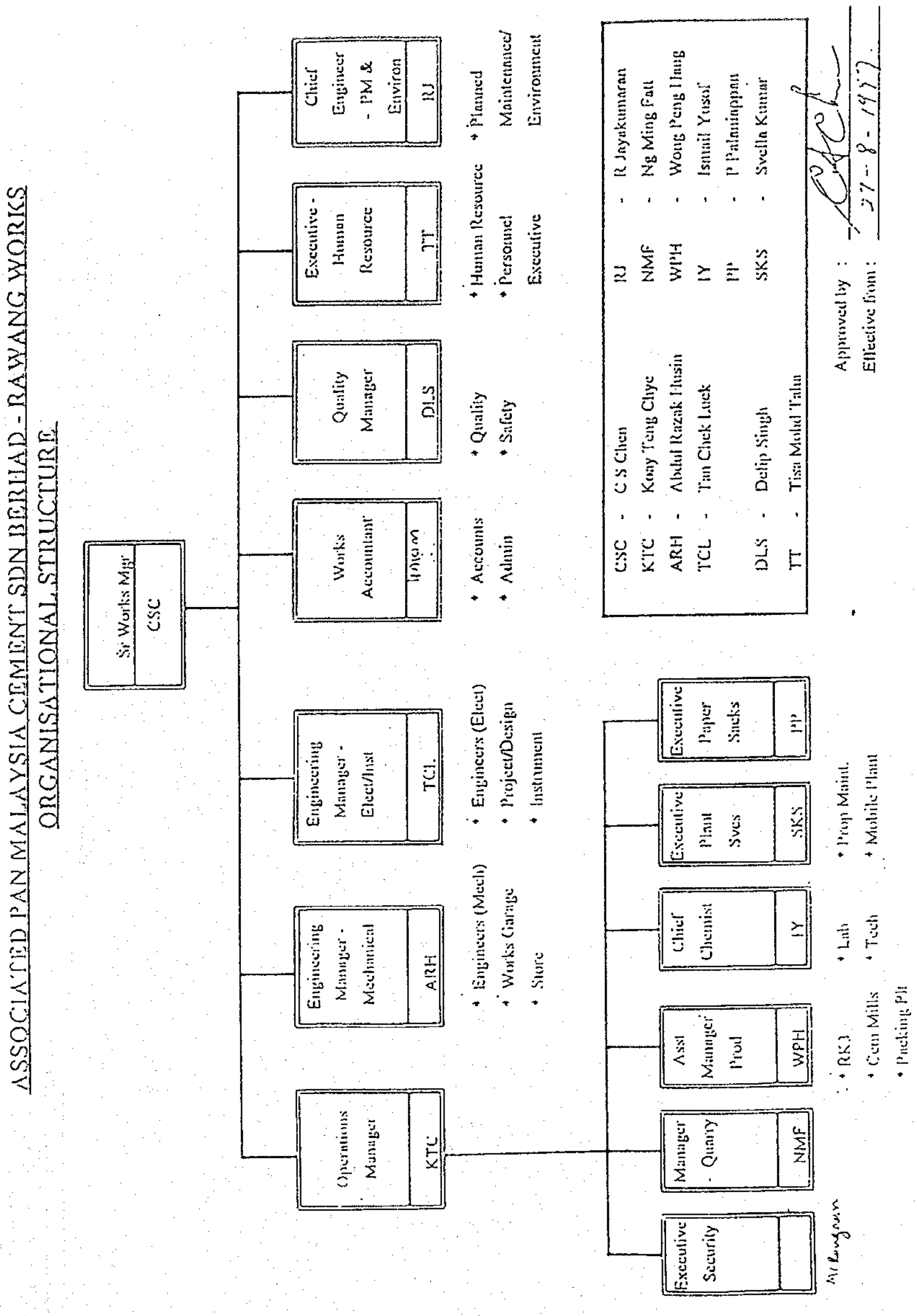


Fig. 12-1 Organization Chart

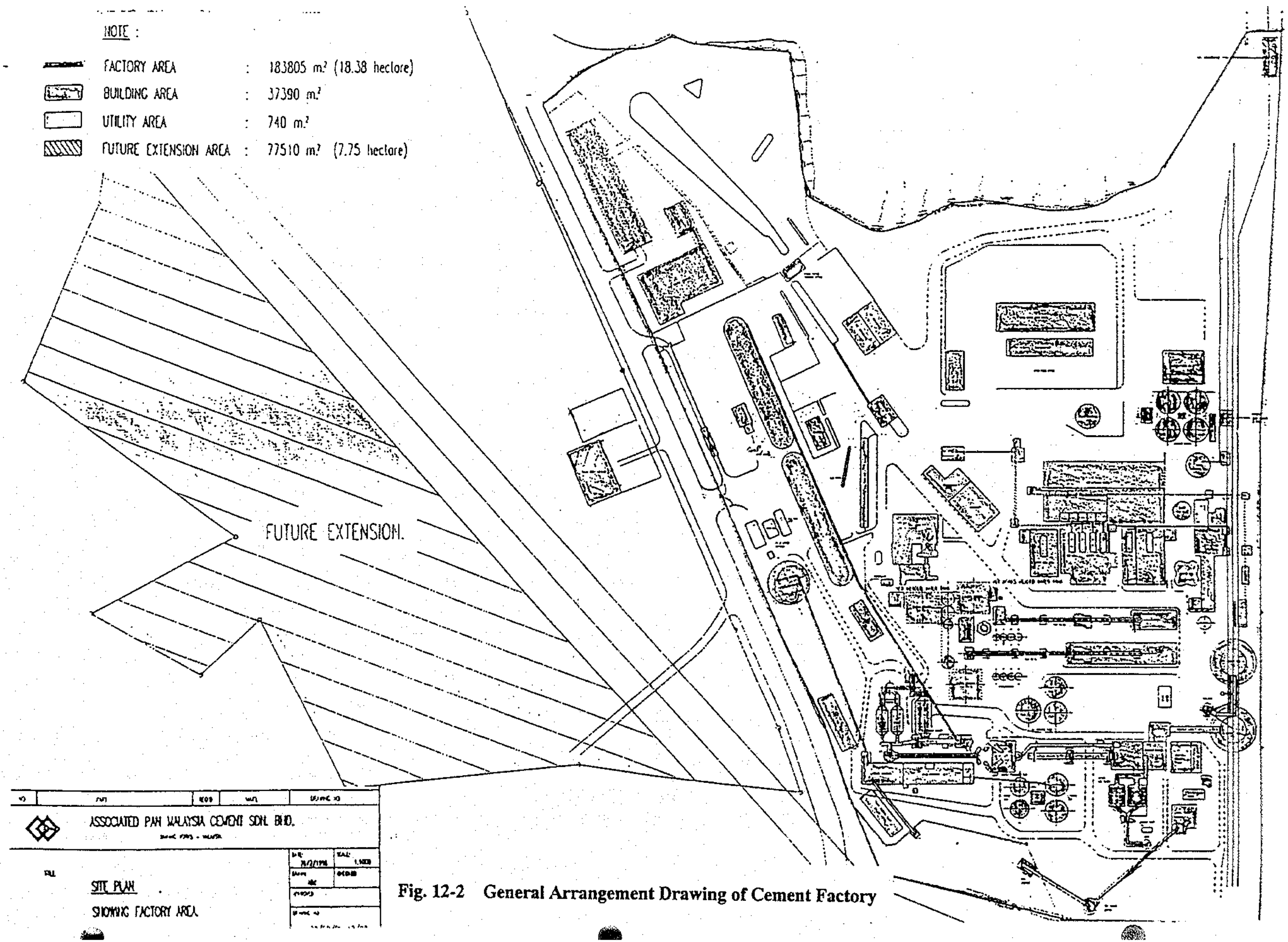


Fig. 12-2 General Arrangement Drawing of Cement Factory

12-2-2 Utility Facilities

Specifications of major facilities and equipment of factory are as follows.

Plant Section	Equipment	Description / Size	Installed Capacity
Raw Materials Quarrying	Drilling Equipment	Hydraulic Drill Model Tamrock DH800	4,000 t/8h-day unit
		Atlas Copco Hydraulic Drill	900 t/8h-day unit
	Loading Machine	Cat 245MEH / 325HP	3.25 m^3 Bucket
		Cat 988B / 375HP	5.00 m^3 Bucket
		Cat 235C / 250HP	2.40 m^3 Bucket
	Dump Tracks	Aveling Barford	10 x 30 t Payload
Raw Material Preparation			
Limestone Preparation	Limestone Crusher	Compound Double-Roll Impactor	650 t/h
	Limestone Storage Silo	Reinforced Concrete Silo 30 m (D) x 27 m (H)	26,500 t
Shale Preparation	Shale Crusher	Double-Roll Crusher	330 t/h (max)
	Shale Stockpile & Reclaimer	Covered Storage Hall & Bridge Mounted Scraper	8,000 t 140 t/h (max)
	Shale Dryer	Uniflow Rotary Dryer 4.0m(D) x 28.0m(L),	70 t/h
Limestone Grinding			
Limestone Grinding / Storage	Limestone Grinding Mill	2 Compartment Closed-Circuit Tube Mill	265 t/h
		Drive motors	2 x 2,100 kW
		Mill speed 14.5rpm	
	Roller Press	Double Roller 1.2 m (D) x 1.2 m (W)	100 t/h
		Roller press motor	2 x 600 kW
		Speed : 1,500 rpm	
	Homogenizing & Storage Silos	Claudius Peters RC Silos 15 m(D) x 46.5 m(H)	2 x 5,700 t
Shale Grinding & Storage	Shale Grinding Mill	2 compartment Closed-Circuit Tube Mill	85 t/h
		Drive motor	2,250 kW
		Mill speed : 15.7 rpm	
	Homogenizing & Storage silos	Claudius Peters RC silos 12 m(D) x 20 m(H)	2 x 1,750 t

Plant Section	Equipment	Description / Size	Installed Capacity
Coal Grinding	Vertical Roller Mill	UBE-Loesche LM 15.20 D	12.0 t/h
Clinker Burning	Limestone kiln Feeders Kiln feed shale	Weigh feeder, Air slide and bucket elevator Loss-in -weigh system & FK pump transport	
	Preheater	2-String , 5-Stage Cyclone preheater and Flash Furnace (NSP)	5,000 t/day
	Rotary Kiln	4.7 m(D) x 74 m(L) 3-Pier, kiln slope 1 : 25 Speed : 0.6 - 3 rpm Motor : 400 kW Main drive : 750 rpm Auxiliary drive: 1,500 rpm	5,000 t/day
	Grate Cooler	3-Stage Horizontal Grate cooler 1st Grate-Retrofit CFG 2nd Grate-FB3-40 Babcock 3rd Grate-FB3-40 Babcock	5,000 t/day
	Clinker storage silo	Reinforced concrete 30 m(D) x 41.7 m(H)	2 x 26,500 t
Cement Grinding	Cement mills	2-Compartment Closed-Circuit Tube Mill Drive motor : 900 kW Mill speed : 17.5 rpm	3 x 28 t/h
		2-Compartment Closed-Circuit Tube Mill Drive motor : 2,250 kW Mill speed : 15.7 rpm	2 x 70 t/h
		2-Compartment Open-Circuit Tube Mill Drive motor : 590 kW Mill speed : 21.02 rpm	1 x 15 t/h
	Cement storage silos	Reinforced concrete silo	4 x 1,100 t 6 x 5,000 t
Packing Distribution	Packing Plant	1) 4-Spout on line packer 2) Rotary packer 3) Road bulk lording plant 4) Rail bulk lording plant	40 t/h 2 x 100 t/h 100 t/h 170 t/h

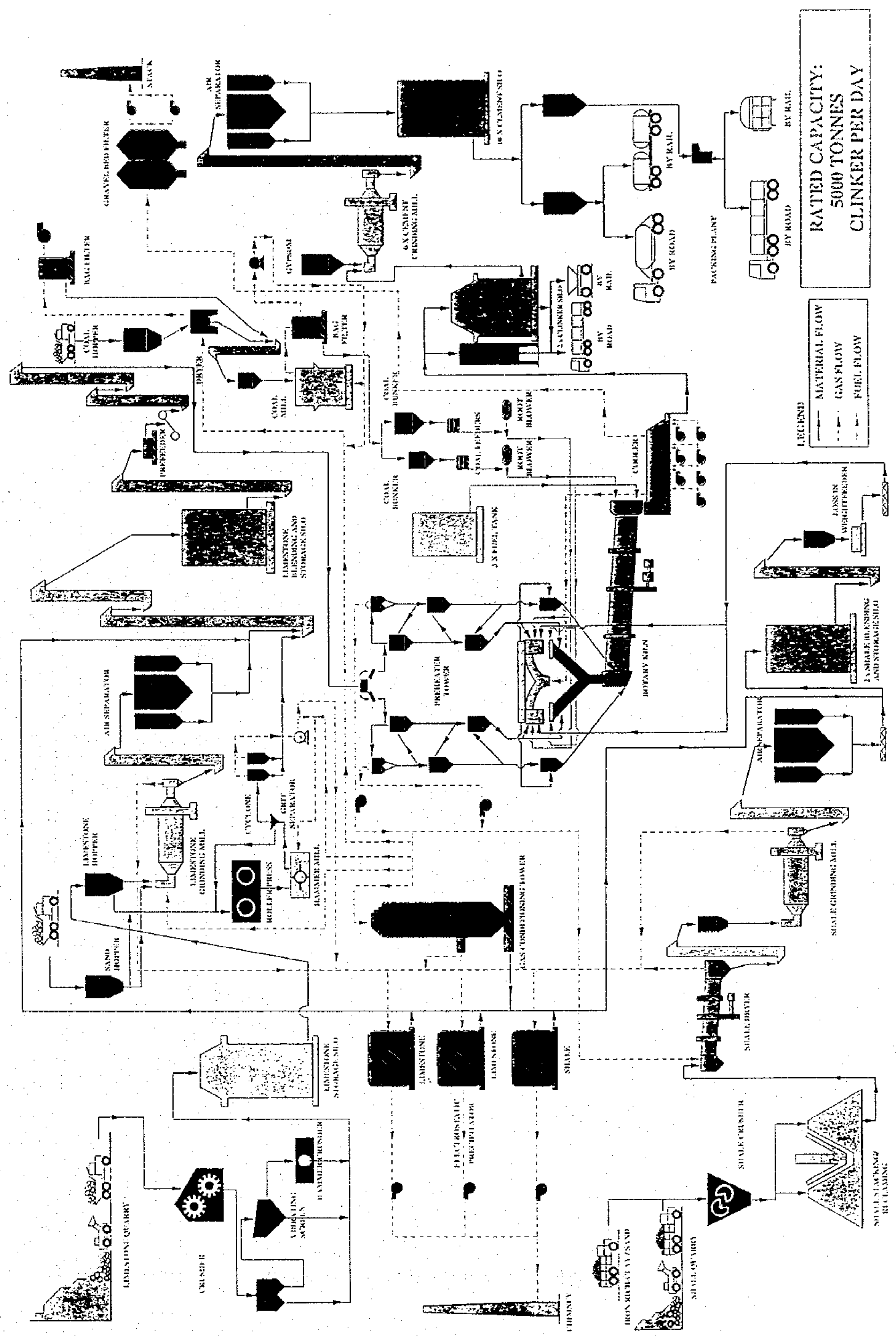


Fig. 12-3 APMC Rawang Works Dry-Process Flow Chart

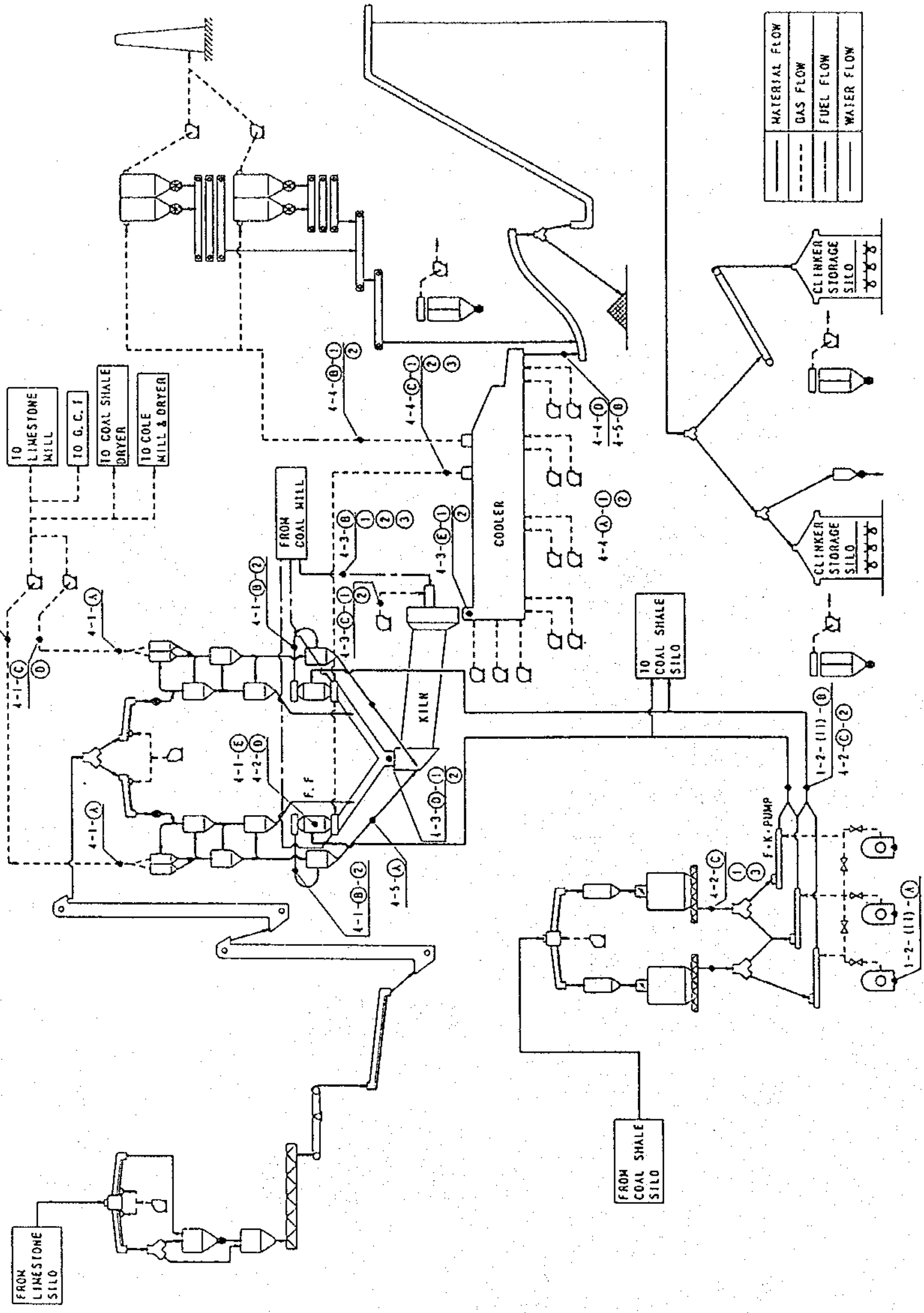


Fig. 12-4 Flow Sheet-1 (Burning Department)

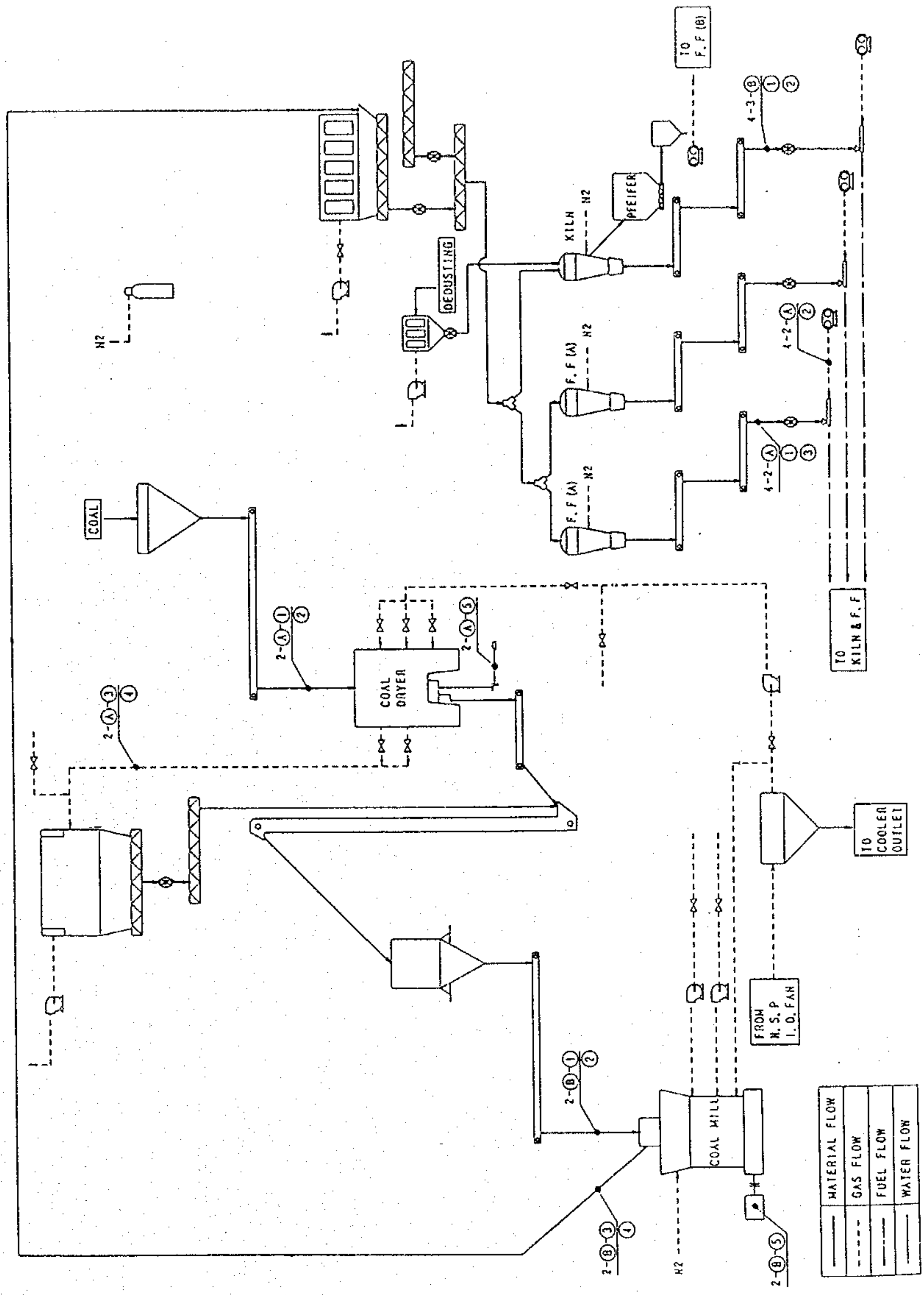


Fig. 12-5 Flow Sheet-2 (Coal Drying and Grinding Department)

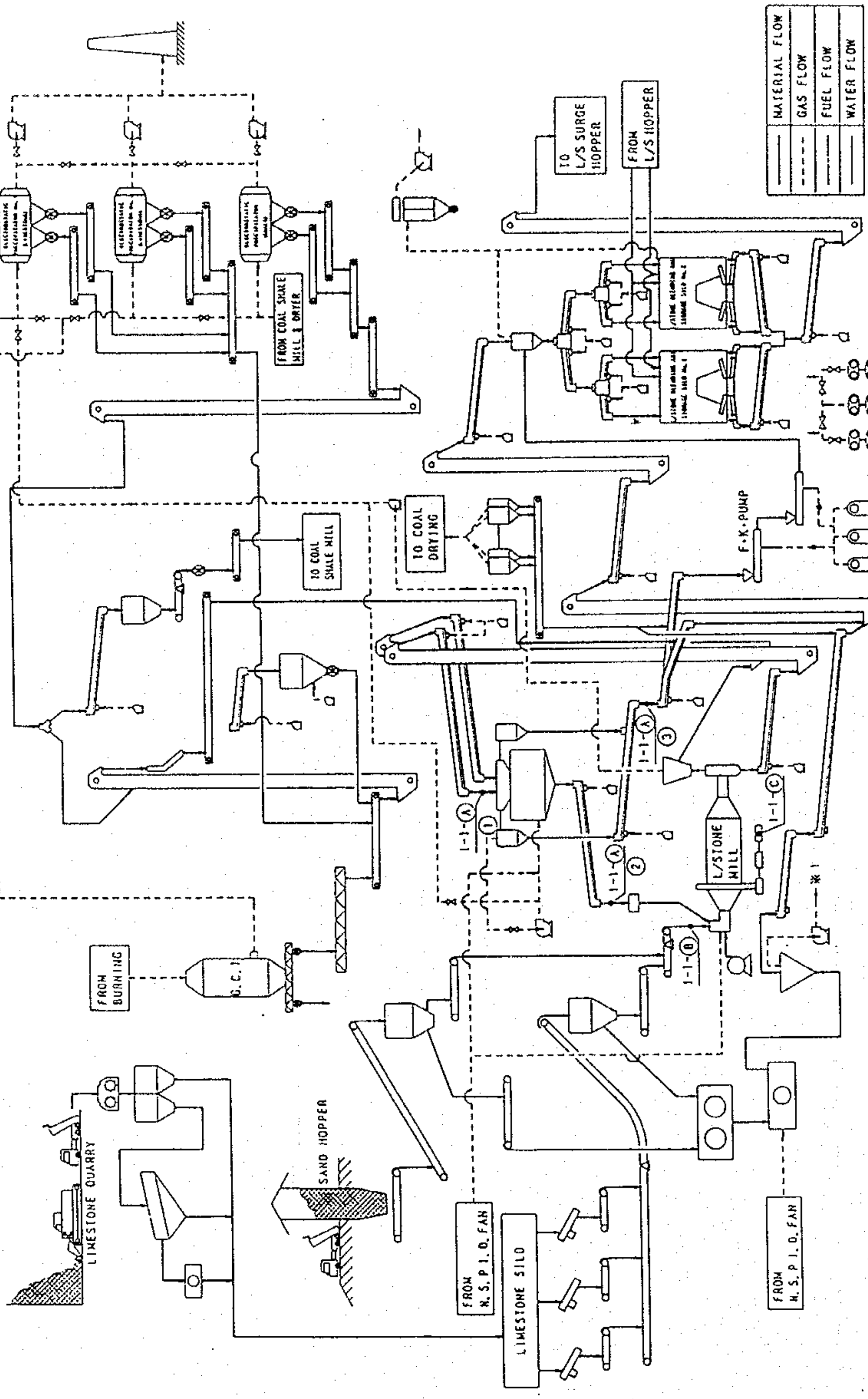


Fig. 12-6 Flow Sheet-3 (Limestone Drying and Grinding Department)

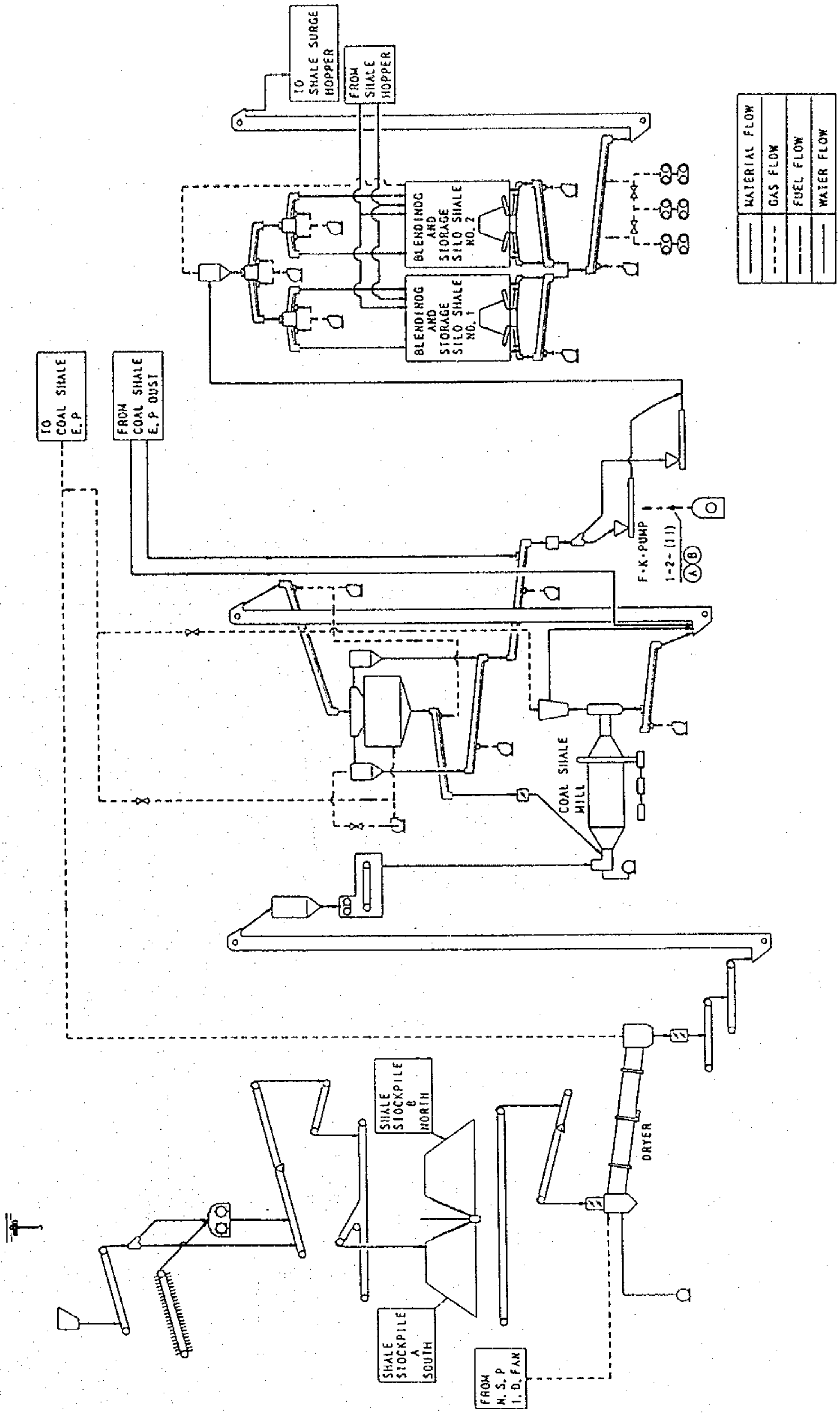


Fig. 12-7 Flow Sheet-4 (Coal Shale Drying and Grinding Department)

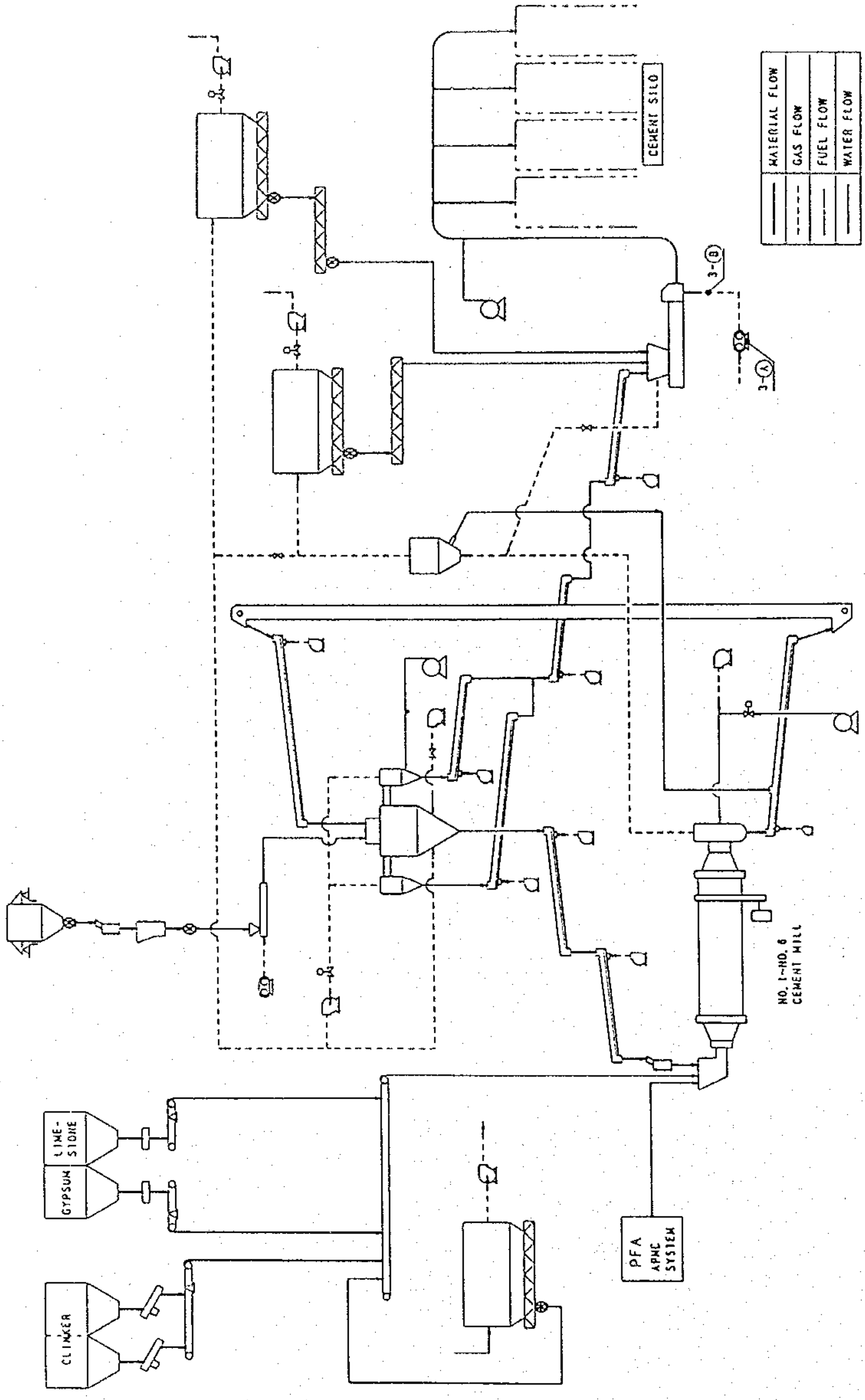


Fig. 12-8 Flow Sheet-5 (Cement Grinding Department)