Table 9-A-10 Criteria for Improvement of Energy Efficiency for each Entity

B: Partly Adopted, further study is necessary.
C: Recommendable, accompanied by small investment.
D: Recommedable, accompanied by rather large investment.

Categories		Main Theme	Methods	Hotel
Architectural Structure				
	Buildings			
		Thermal Insulation	1. Revamping Walls by Thermal Insulation	
			2. Revamping Roofs and Floors	C
			3. Introduction of Thermal Insulation of Glass Windows	
		Shelter from the Sun	4. Installation of Paper Screens and Sliding Shutters	
			5. Installation of Blinds and Curtains	C
			6. Installation of Louvers, Eaves and Penthouses	
			7. Revamping Glass Windows (Thermic Rays Absorption, Adjusting Films)	D
			8. Installation of Sprinklers and Water Storage on the Roofs	D
		Prevention from Draft	9. Revamping Front Doors (Automatic Door, Double Door, Rotating Doors)	B
			10. Introduction of Weather Strips and Airtight of Windows (None-Open)	
			11. Repair of Slits and Revamping of Weather Strips on the Walls	B
		Lighting	12. Installation of Reflecting Louvers and Eaves	
			13. Conversion to Light Coloring of Interior Finishing	
		Ventilation	14. Revamping of Sashes (None-Open) to make Open Windows	
		Passive Solar Function	15. Installation of Adjacent Greenhouses	
			16. Revamping around Windows to gather Heat	
Revamping & Expansion of Facilities				
	Air-conditioning			
		Waste Heat Recovery	17. Overall Air Heat Exchanger (Exhaust Air/Intake Air)	
			18. Installation of Waste Heat Recovery by Heat Pump	C
			19. Introduction of Waste Heat Recovery from Exhaust Gas and Waste Water	
			20. Introduction of Waste Heat Recovery from Cooling Water of Chillers	C
			21. Reutilization of Return Air from Air-conditioning	B
			22. Introduction of Heat Recovery of Solar Heat in Winter	
		Heat Source	23. Conversion to Regenerative Type	C
			24. Revamping Regenerative System	
			25. Alternation of Energy Source, Heat Source and Heat Sink	D
			26. Alternation of Type of Chillers	C
			27. Utilization of Electricity during Night	D
			28. Adoption of Solar Type Air-conditioning	
			29. Improvement of Operation-control System of Heat Source	C

Categories		Main Theme	Methods	Hotel
		Heat Conveying	30. Conversion to Variable Air Volume (VAV) System	C
			31. Conversion to Variable Water Volume (VWV) System	C
			32. Installation of Power Recovery Unit from Open Waterway	
			33. Reinforcement of Thermal Insulation of Ducts and Pipings	C
			34. Reducing Static Pressure of Fans by Revamping of Ducts	C
			35. Alternation of Efficient Fans and Pumps	C
			36. Increasing Temperature Difference and Decreasing Flow Rate	
		Space-conditioning	37. Reviewing of Zoning Condition and Increasing Number of Zoning Share	
			38. Alternation of Space-conditioning System	
			39. Introduction of Air Cooling during Intermediate Season (Spring / Autum)	
			40. Introduction of Control System for Suction Air	C
			41. Improvement of Air Distribution in the room	B
			42. Conversion to Efficient Speed Control System (Air Quantity)	C
			43. Improvement of Control System and Expansion of Control Zone	C
		Prevention of Draft	44. Prevention of Draft by Adjustment of Room Pressure	
	Hot Water Supply			
		Hot Water Supply	45. Improvement of Hot Water Supply System	C
			46. Reinforcement of Thermal Insulation Hot Water Supply System	
			47. Improvement of Water Supply, Drainage and Sanitation System	
	Lighting System			
		Optimum Lighting	48. Addition of Control for Illumination Intensity	C
		Restriction of Zone	49. Division of Wiring Circuit of Lighting System	
			50. Introduction of Automatic on-off System by Timer-switch	C
Revamping & Expansion of Facilities				
	Lighting System			
		Restriction of Zone	51 Setting of Individual Switches for Each Lighting Appliance	
		Efficient Lighting	52. Introduction of Sectional Lighting	
			53. Alternation of Efficient Lump	B
			54. Revamping or Alternation of Lighting Appliance	B
	Electricity			
		Power Factor Control	55. Introduction of Power Factor Control System	C
		Demand Control	56. Adoption of Demand Control System	
			57. Reduction of Contracted Capacity	
	Lift			
		Operation & Control Improvement	57.5 Adoption of Inverter Control	C

Categories		Main Theme	Methods	Hotel
Operation & Maintainance Management, Living Style and Others				
	Operation Management			
		Suction Air Control	58. Reduction of Suction Air Volume during Air-conditioning	C
			59. Abolition of Air Intake during Start-up of Air-conditioning	
			60. Adjustment of Suction Air Volume according to CO2 Content	C
			61. Adjustment of Suction Air Volume during Intermediate and Winter Seasons	
		Optimum Air-conditioning	62. Introduction of Frequent Manual Control for Air-conditioning	
			63. Introduction of Automatic Control for Air-conditioning	C
			64. Alternation of Setting Temperature for Water and Air Supply	C
		Temperature & Humidity	65. Alternation of Setting Temp. & Humid. in the Space-conditioned Rooms	C
			66. Adjustment or Introduction of Schedule Control of Atmospheric Air	C
			67. Calming-down of Temp. & Humid. Condition during Off Time	
		Prevention of Loss by Mixing & Parallel Operation	68. Abolition of Re-heating	
			69. Adjustment of Temperature of Cool/Hot Air in the Double Layered Ducts	
			70. Temperature Adjustment of Water & Air Supply to Perimetical Facilities	
		Restriction of Operation of Air-Conditioning	71. Stop of Air-conditioning for Unoccupied Rooms	
			72. Lessen of Operating Hours & Stop of Air-conditioning during Overtime	
			73. Restriction of Air-conditioning during Overtime	
			74. Introduction of Local Air-conditioning (Intensive Air-conditioned Area)	C
		Operation Management of Air-Conditioning	75. Adjustment of Setting Temperature & Pressure for Heat Source	C
			76. Adjustment of Operating Number of Heat Source	C
			77. Adjustment of Volume of Regenerative Vessel	
			78. Control & Adjustment of Operating Number of Fans and Pumps	C
		On-off Control of Lighting System	79. Reduction of Excess Lighting in Working Space	
			80. Lessoning & Restriction of Lighting Hours before Working Time	
		Hot Water Supply	81. Abolition of Hot Water Supply	
			82. Reduction & Restriction of Time and Scope of Hot Water Supply	
			83. Lowering of Temperature of Hot Water Supply	
			84. Cut-off of Boilers & Hot Water Vessels according to Water Temperature	
		Power System	85. Thinned-out Operation of Elevators & Escalators	
			86. Shift to Manual Operation of Front Doors during Intermediate Season	

Categories		Main Theme	Methods	Hotel
	Maintenance	Management		
		Maintenance	87. Inspection & Repair of Air-leakage in the Ducts	C
			88. Cleaning of Coils & Filters of Air-conditioner	C
			89. Cleaning of Condensers & Evaporators of Chillers	C
			90. Inspection & Repair of Automatic Control Instruments	C
			91. Repair & Exchange of Low Efficient Equipment	C
			92. Reinforcement of Monitoring System by Increasing Measuring Equipment	C
			93. Cleaning of Lighting Appliances and Exchange of Aged Lump	C
			94. Increasing Lighting Efficiency by Cleaning Inner Surface of Rooms	C
		Living Style	95. Putting out Lights & Thinned-out Lighting in Corridors & Halls	C
			96. Conduct On-off Operation of Lighting Switches	C
			97. Putting out Lights Around Windows	C
			98. Certain Execution of Open-close Management of Blinds	C
			99. Certain Execution of Close Management of Front & Stairs Doors	C
			100. Frequent Open-close Management of Windows	
			101. Publication and Requesting of Energy Conservation for Residents	C

Chapter 10 Shopping Complex

This shopping complex was founded in 1995, and consists of a 5 storey building with a total floor area of 191,752m^2, making it one of the largest and most modern shopping complexes in Malaysia. Energy consumption is mostly concentrated on electricity, and the study team conducted an intensive audit on electricity consumption.

10-1 Characteristics of Shopping Complex

10-1-1 Operation Mode of Shopping Complex Survey

Consumption of energy such as electricity, gas and chilling water was measured every morning using a computer system. The computer control system consisted of 3 major items: control (including scheduling), monitoring and measurement.

10-1-2 Maintenance Mode of Shopping Complex Survey

Normal equipment maintenance is periodically consigned to the companies who supply the equipment. Staff of the complex are responsible for daily maintenance work.

10-2 Outline of Shopping Complex

1.	Name of the Shopping Complex:	Bandra Utama Shopping Center
2.	Address:	1 Lebuh Bandar Utama 47800 Petaling Jaya Selangor Darul Ehsan Malaysia
	Telephone:	03-7166033
	Facsimile :	03-7166490
3.	President:	Bandar Utama GM S/B Date Dr Teo Soo Ching
4.	Engineering and energy manager:	Mr. Chow Yew Meng
5.	Type of shopping complex:	Private
6.	Organization chart:	Shown in Figure 10-1
7.	Number of employees (management staff of facilities):	110

8. Number of management staff (including energy-related staff)

Organization chart of the shopping complex:	Shown in Figure 10-2
Organization chart of Building Service Department:	Shown in Figure 10-3

9. Total area of the shopping complex, building, and others

Area of site, sqm:	374,883.66
Building area, sqm:	36,941.59
Total floor area, sqm:	191,751.53
Name of floors:	Lower ground, ground, 1st, 2nd, 3rd, roof, upper roof (7 floors)

10. Layout of buildings, equipment, facilities and major services:

Site of shopping complex:	Shown in Figure 10-4
Number of facilities on each floor:	Shown in Table 10-1
Individual area of Shopping Complex Service:	Shown in Table 10-2
Trends in annual sales (service) amounts of the shopping complex:	RM 550 Million

11. Year of establishment:	August, 15, 1995
12. Position in commercial sub-sector:	The largest shopping complex in Malaysia

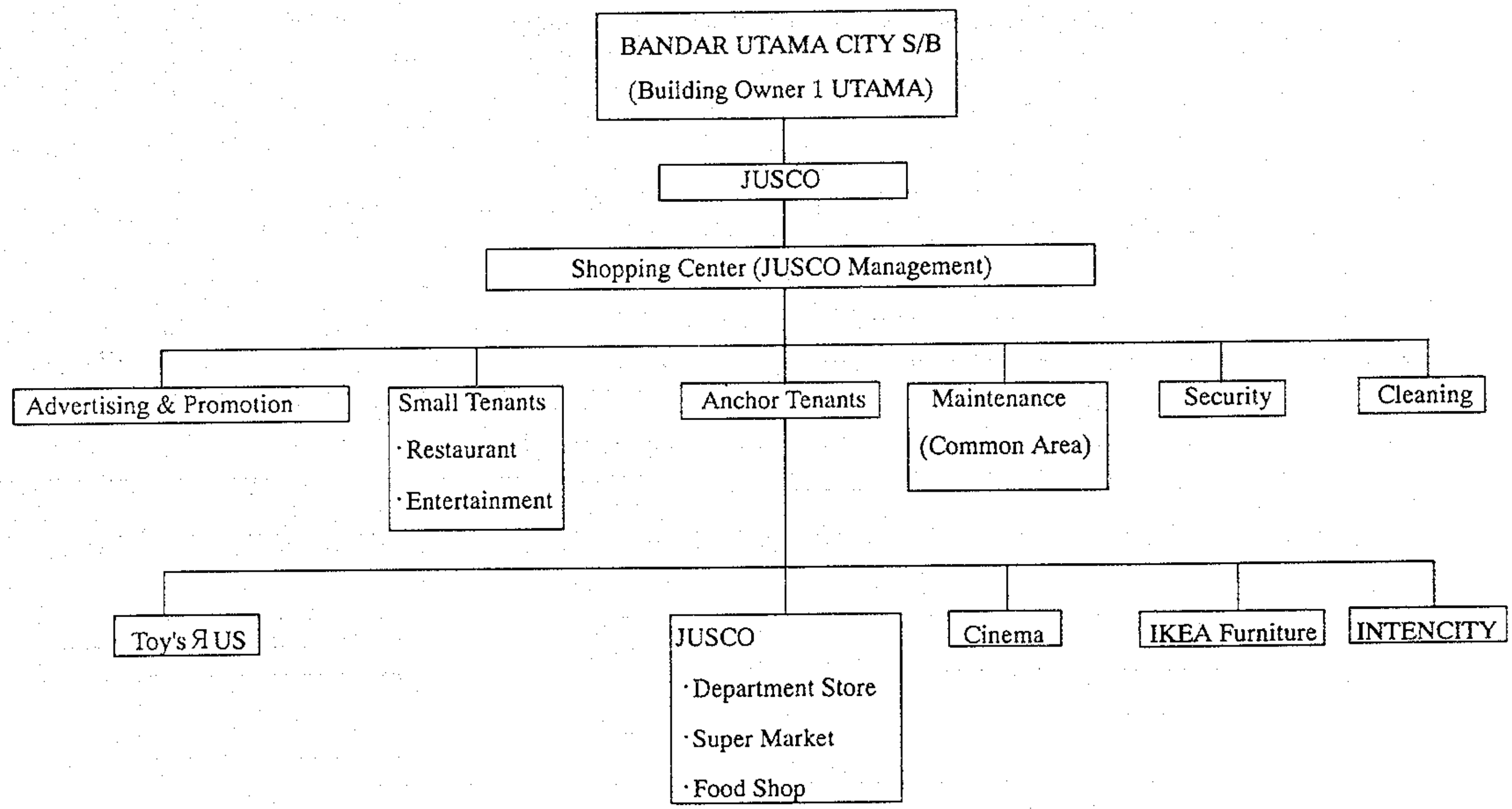


Figure 10-1 Organization Chart of Bandar Utama City S/B

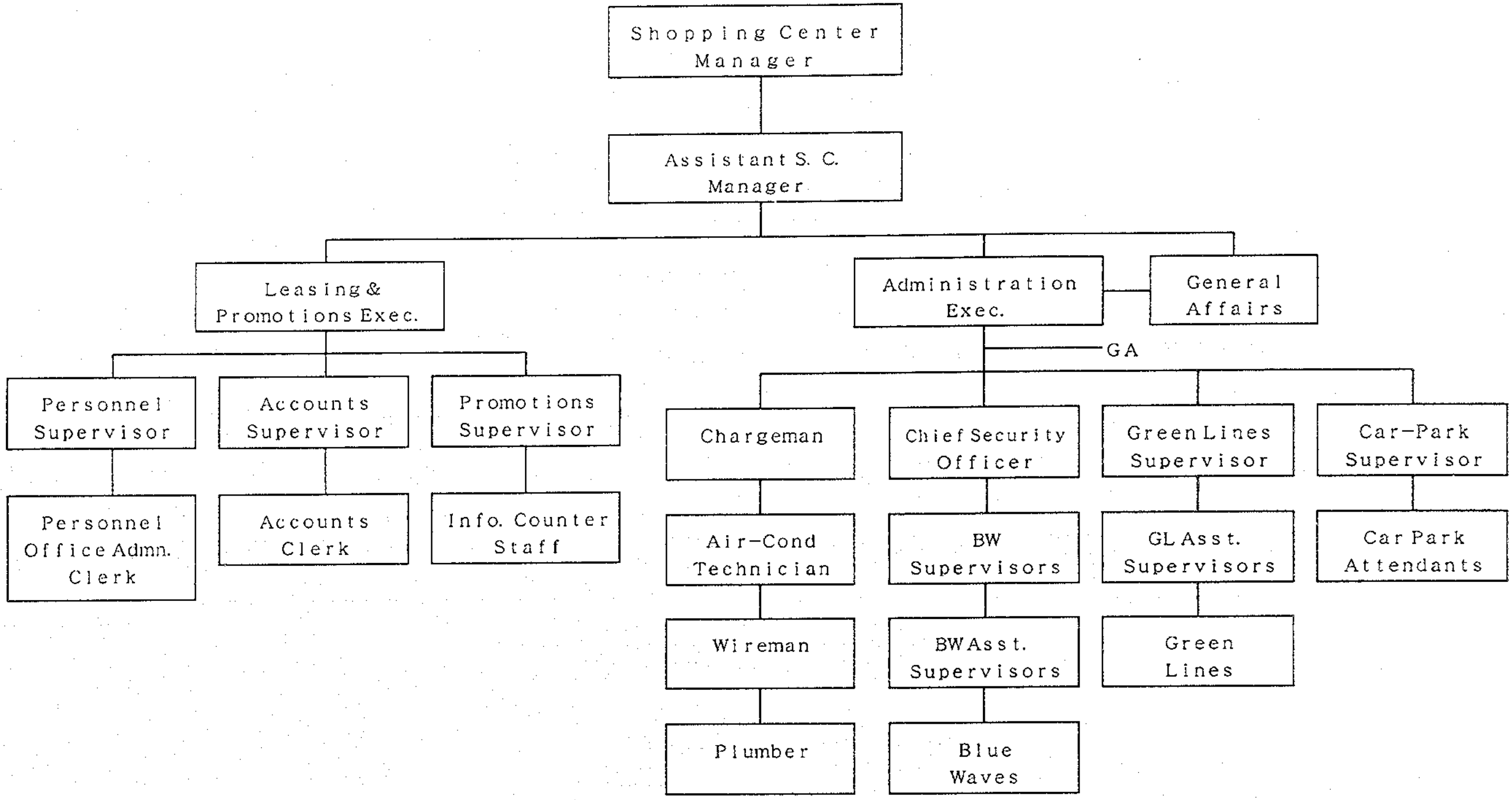


Figure 10-2 Organization Chart of The Shopping Center

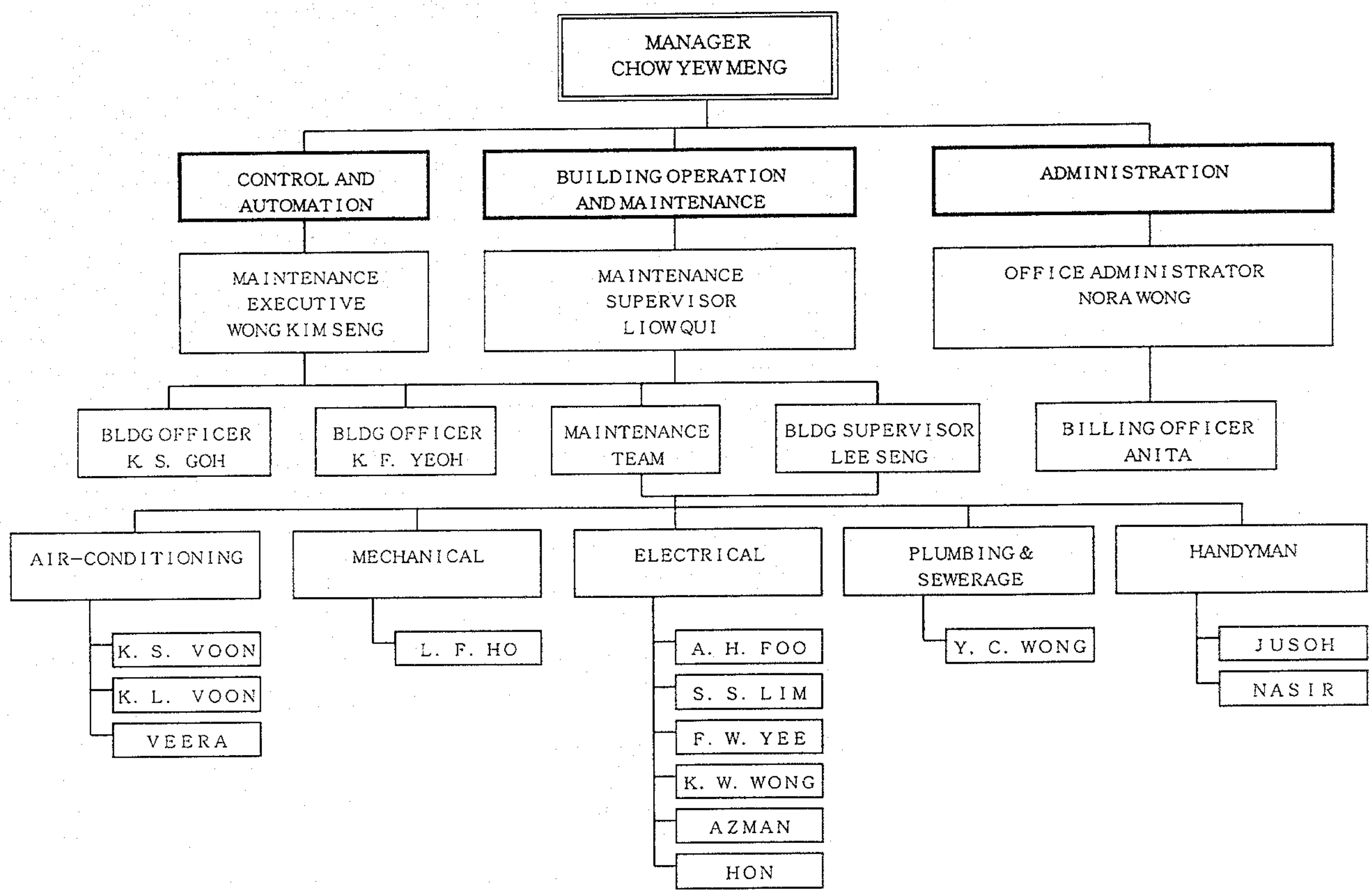


Figure 10-3 Organization Chart of Building Services Department 1997

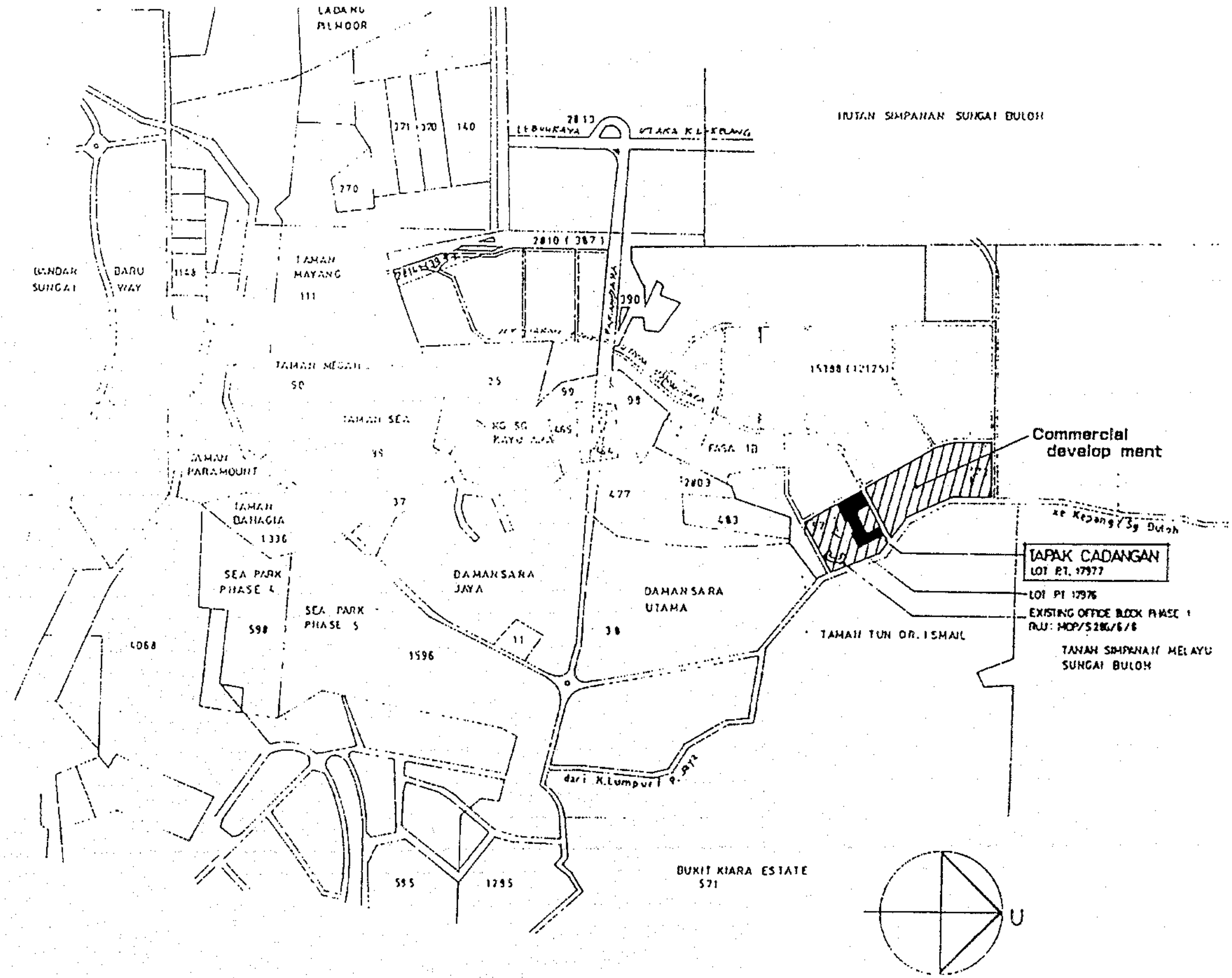


Figure 10-4 The Site of around Commercial Complex

Table 10-1 Number of Facilities and Equipment of Each Floor

		No.1~16 span	No.17~33 span
Upper Roof	Tank	1	
	Water storage tank Engr's detail	2	2
	BILLIK LIF MOTER ROOM	1	2
Roof	Water storage tank to Engr's detail	1	
3rd	BILIK LIF MOTOR ROOM	2	2
	AHU for 2F--1, CINEPLEX--1	2	
	Switch RM	1	
	BILIK AHU (2F)		2
2nd	BILIK AHU	1	2 (1F)
	Secondary chilled water PLANT ROOM	1	
	Transformer room	1	
	Switch room	1	
1st	BILIK AHU	3	
	BILIK AHU (1F)	1	1
	BILIK AHU (GF)	2	1
	BILIK AHU (GF&1F)	1	
	AHU (GF--2,1F--3)		5
	AHU (PENYEWA,UTAMA)		1
	BILIK SEMBAHYANG P'PUAN	1	
	BILIK SEMBAHYANG LELAKI	1	
Ground	BILIK AHU	1	
	AHU	3	
	TNB 33KV SWITCHING STATION		1
Lower	BILIK AHU	4	1
	Chiller, Ice storage	a set	
	SPRINKLER TANK		2
	Electrical receiving and distributing		a set
	MAINS WATER TANK		1
	Switch Room		1

Table 10-2 Individual Area of Commercial Complex Services (Sq.m)

	Lower Ground	Ground	1st	2nd	3rd	Roof	Upper Roof
Common Area	4,225.27	15,413.33	10,697.14	12,753.71	2,918.17	1,498.56	843.44
Car Parking	38,989.80				21,274.93		
Department Store		4,585.73	4,363.01	4,331.97			
Supermarket		1,354.00					
Restaurant	2,828.49	4,593.90		1,084.83			
Fast-food		751.84					
Tenant Shop		4,786.25	7,774.29	5,522.11			
IKEA Furniture	4,050.62	3,095.86					
Toy's Я us			1,950.43				
Marks r Spencer			1,523.02				
Fitness Centre			399.30				
Amusement				1,902.81			
Cinema				178.35	2,398.89		
Gallery			3,586.88				
Total	50,094.18	34,580.91	30,294.07	25,773.78	26,591.99	23,573.16	843.44

Site Area	374,883.66
Building Area	36,941.59
Total Floor Area	191,751.53

10-3 Service

1. Plan for increasing service capacity: An open space is available for future expansion of buildings and parking. A vacant space in the building is available for the addition of facilities and quipment to meet the future increase of utility requirements.

2. Service activities

Annual service hours, days and weeks: Opens throughout the year except during the New Year holiday period. Daily service hours are as follows.

Shopping center, karaoke, amusement, and arcade: From 10:00 to 22:00

Cinema: From 11:00 to 24:00

Working hours of employees

Operation staff (2 shifts): From 8:00 to 15:00
From 15:00 to 24:00

Others: From 9:00 to 17:30

3. Operation and management of the shopping complex

Staff for operation and management:

	Permanent Staff	Consignment (part timer)	Night duty
Management	21 (Utility), 25 (Jusco)		
Security management	32 (Jusco)		8 (Jusco)
Cleaning	20 (Jusco)	6	

Management of facilities: Working by maintenance manual and computer system

10-4 Energy Consumption and Trends

1. Trends in annual energy consumption by energy type

   Annual utilities consumption: Shown in Table 10-3

2. Variations in energy consumption by energy type

   Monthly variations in utilities consumption: Shown in the Table 10-4

10-5 Major Energy-consuming Facilities

Air conditioners, cooling storage, cooling fans, ventilation, air fans and lighting are the major equipment, which consume a large volume of energy.

List of energy related equipment Shown in Table 10-5

1. Air conditioning system:

   Conditioning type: Central air conditioning system with two cooling air supply ducts
   VAV (valuable air volume) by computer control is adopted for air conditioning.

   Air conditioning system: Shown in Figure 10-5

Table 10-3 Annual Utilities Consumption

NO	Name of Utility	Unit	Lake side building		1 UTAMA Shopping Center		Total	
			1996	1997	1996	1997	1996	1997
1	LPG (cooking gas)	m3	18,593	26,418	18,789	25,056	37,382	51,474
2	Electricity	kWh	1,944,644	4,521,286	20,005,656	20,718,945	21,950,300	25,240,231
3	City water	m3	44,073	59,898	148,541	168,437	192,614	228,335
4	Chilled water	kWh	3,403,473	4,317,940	36,992,201	41,228,720	40,395,674	45,546,660

Table 10-4 Monthly Change in Utilities Consumption

(Year1997)

N	Name of utility	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
1	LPG (cooking gas)	m3	2,619	2,249	2,557	2,037	2,212	2,262	2,051	2,114	2,206	2,180	1,831	2,100	26,418
			1,946	1,660	2,079	2,017	2,148	2,184	2,107	2,120	1,999	2,235	2,136	2,425	25,056
2	Electricity	kWh	411,778	361,911	386,666	356,934	388,231	389,252	377,495	385,554	361,008	373,391	355,902	373,164	4,521,286
			1,711,941	1,534,206	1,849,240	1,696,656	1,845,120	1,681,525	1,733,,238	1,755,081	1,671,965	1,747,902	1,703,385	1,788,686	20,718,945
3	City water	m3	4,716	4,487	4,823	4,154	4,663	4,800	4,397	5,108	5,343	5,629	5,447	6,331	59,898
			13,158	11,431	14,271	12,216	14,788	14,511	13,503	14,879	15,045	14,293	13,567	16,775	168,437
4	Chilled water	kWh	356,464	322,257	395,962	353,654	430,637	404,427	346,981	361,584	343,601	348,086	302,236	352,050	4,317,940
			3,046,698	2,835,538	3,423,845	3,349,431	3,677,297	3,683,017	3,480,659	3,620,791	3,303,635	3,558,567	3,620,834	3,628,408	41,228,720

Upper row : Lake side Building
Lowe row : 1 UTAMA Shopping Center

Table 10-5 List of Energy Related Equipment (1/2)

No	Name of Equipment	Quantity	Main Specification	Remarks
1	Transformers	2	33kV/11kV 15MVA	Chiller Plant
		2	11kV/3.3kV 5MVA	Chiller Plant
		2	11kV/433V 2,000kVA	Chiller Plant
		2	11kV/433V 2,000kVA	Shopping Complex
		2	11kV/433V 2,000kVA	Shopping Complex Phase II
		2	11kV/433V 1,500kVA	
2	Condenser	4	3×15kVar, 9×50kVar	
3	Chiller	5	1,100Rt	Future Plan
		2	550Rt	
4	AHU			
5	Ice Storage Tank	5	9[m]×12[m]×4[m] 5,000Rt·h×5=25,000Rt·h	Glycol (Set point 28%)
6	Emergency Generator (Emergency only)	4	415V 750kVA Diesel engine	Make use of Shopping Center (Lighting Fires Money check counter)

Table 10-5 List of Energy Related Equipment (2/2)

No	Name of Equipment	Quantity	Main Specification	Remarks
7	Primary Chiller water pump	5	Pump : 160ft 3,168USGPM 132kW	CHWP
		5	Motor: 132kW 1,476rpm 415V 229A	
8	Secondary Chiller water pump	5	Pump : 142ft 3,960USGPM 150kW	SCHWP
		5	Motor: 200HP 1,480rpm 415V 225A	
9	Ice pump	4	Pump : 138ft 3,770USGPM 132kW	
		4	Motor: 132kW 1,476rpm 415V 229A	
10	Condensing pump	5	Motor: 90kW 1,480rpm 415V 153A	
11	Chiller fun motor	5	Motor: 45kW 1,475rpm 415V 76A	
12	Shopping center fan	5	Motor: 75HP 1,483rpm 420V 89A	
13	Cooling tower	6		No.6 Spare
14	Heat-exchange	5		3 machines use to ice working

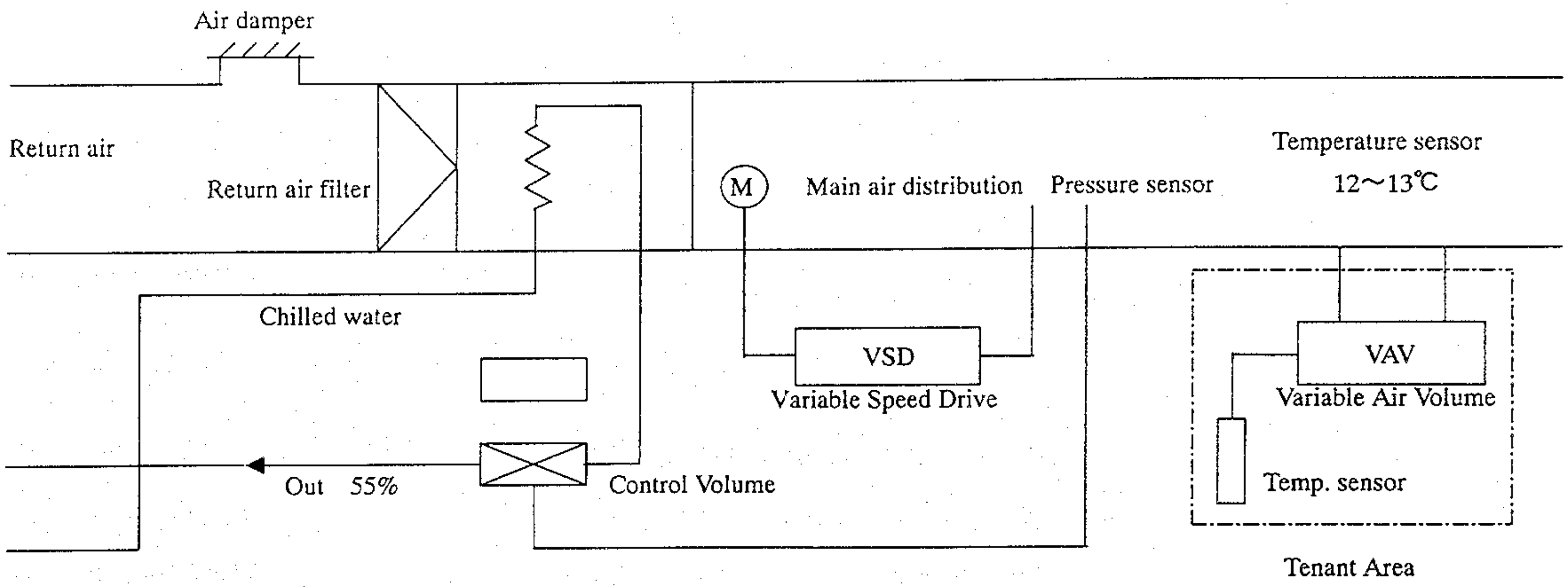
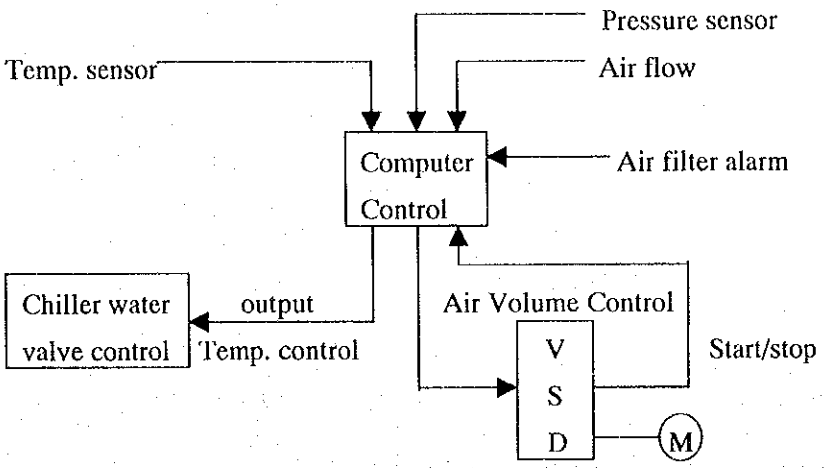


Figure 10-5 Air Conditioning System

Computer control system of chiller:



2. Thermal insulation condition of buildings

Method of thermal insulation:

Most of the equipment that generates heat is located in the south and west sides of the building.

The cinema and shopping center rooves are covered with rock wool of 2-inch thickness. However no measures are taken on flat concrete areas.

Solar shades are not provided. Swing doors are used to make sashes airtight.

3. Ventilation

Regulative standards:

By ASHRAE CODE

The car park and toilets have individual ventilation systems. For basement ventilation, one air control unit is operated under regular conditions and two units are operated under emergency conditions.

4. Chiller Control system:

Zoning for air conditioning: A two-zone system is applied for the suitable zoning of air conditioning.

5. Energy conveying system: Air ducts are covered with 2-inch thick glass fiber. 2-inch thick polyurethane with a steel cover is applied for insulation of chilled water pipes.

6. Lighting system

Fluorescent lights in use: 9W, 18W, 25W and 36W and 70W

Metal halide lamps in use: 70W, 100W, 150W and 175W

Specification, electricity consumption and efficiency of appliance:

Specification:	32W PHILIPS TLD 36N/75 made in Malaysia
Electric lamp:	70W PHOENIX MH70/EL JAPAN Q120 E-27 base
Type of appliance:	Electronic ballast (36W×2 type, 240V, 50/60 Hz, 0.35, PF 0.95 18/20×2, 18W type 240V, 0.41A, PF 0.49)

7. Water condition:

City water is exclusively utilized for facilities. The quality of city water is regulated by WHO standards. Septic tanks are not used, so discharge flows directly into city drainage and it is not reused.

Water supply system: Shown in Figure 10-6

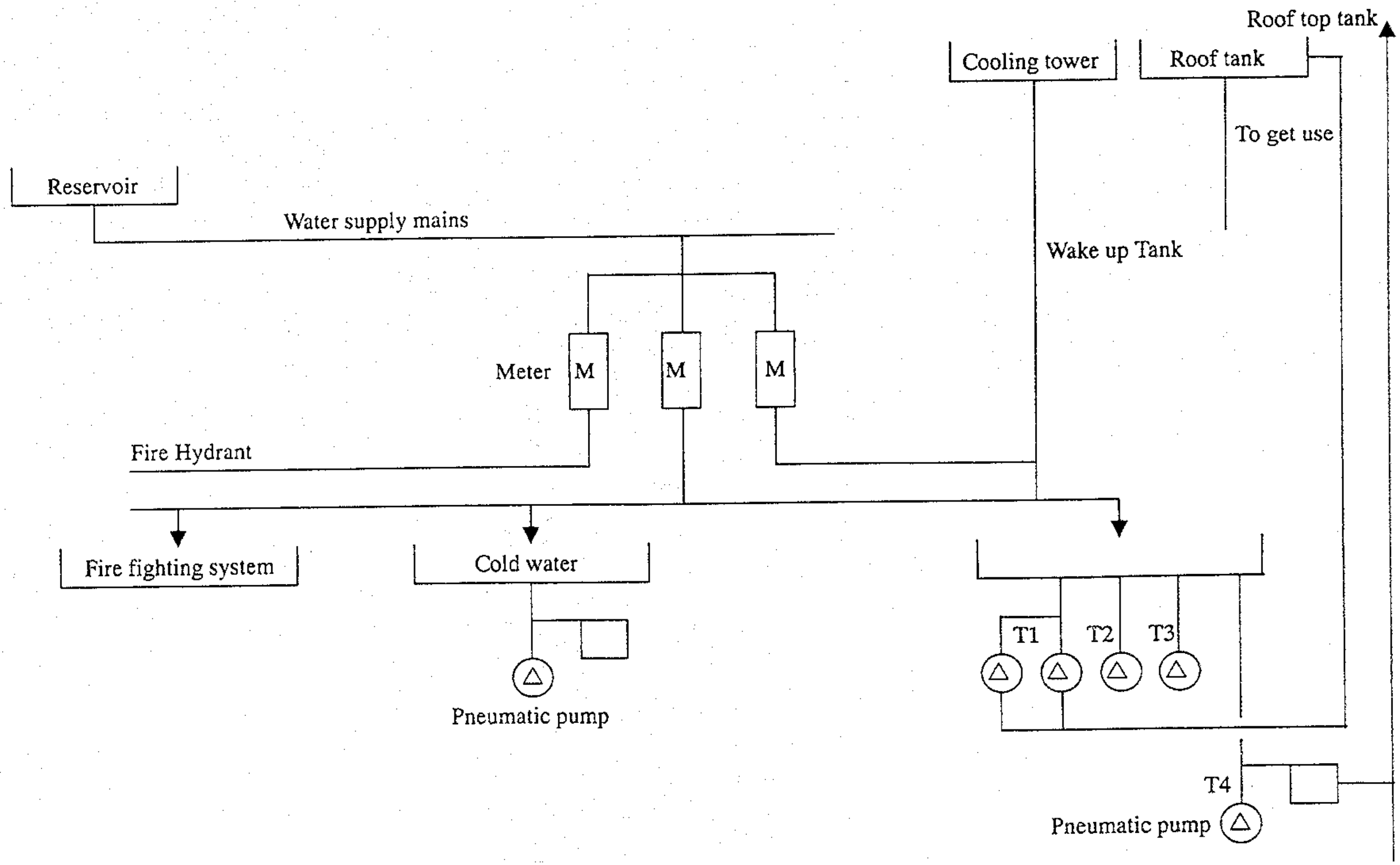


Figure 10-6 Water Supply System

8. Specification of elevators and escalators

Elevator:	Passenger , 1600 kg weights, 24 persons, 60 m/min. speed	
Number of stop floors:	Nos. P1, P2, P3, P4, P5 and P6	6 Stops
	Nos. G1, G2 and G3	3 Stops
	Nos. G4 and G5	4 Stops
	Nos. Lift	4 Stops
Escalator:	1200 Type	48 Units

9. Electrical power receiving facilities

Type and voltage of electrical power receiving:	Receiving type is double-line. Receiving voltage is 33kV.
Operating conditions	
Transformers (oil):	33/11 kV and 11kV/433 V
Demand factor of transformers:	25 %
Power factor:	About 0.90
Problems of harmonics:	Not available
Location of adjustment for factor:	Low voltage side
Imbalance among phases is indicated by computer system	
Regulation for fluctuation of supplying voltage and frequency:	410 V +5%, -5% 240 V +5%, -10% 50 Hz +1%, -1%
Low voltage distributor:	Installed on each floor.

10-6 Present Situation of Energy Management and Energy Efficiency Promotion

1. Establishment of target for energy efficiency:	
Demand control by computer system:	In the event of increased electric demand, some chiller machines stop working.
2. Systematic activities for energy management in the organization:	Special activities are not under taken currently.
3. Energy management utilizing data and records:	For energy management, monitoring items are water (tank level), chiller, and ice storage and pump operation. Control items are chiller, light, ventilator, demand, space conditioning and lift. Measurement items are voltage, amperage, temperature, humidity, flow meter and pressure.
4. Education, and training of employees for energy management:	Mainly by on-the-job training
5. Maintenance management of buildings and facilities:	Daily data check by permanent staff of electric meters, energy meters and chiller meters, and monthly data check of energy consumption by each tenant.
Item and frequency of equipment maintenance	
Cooling tower cleaning:	Monthly
Pump:	Semiannually
Electric inspection:	Monthly
Lift and escalator (HITACHI):	Monthly
6. Planned equipment for energy efficiency promotion:	The installation of co-generation has been planned. However, a solar generator has not been planned so far.

10-7 Method of Energy Audit

In order to conduct an energy audit of this shopping complex, the taking of 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 improved energy efficiency, are described in this chapter.

Major energy audit items for the shopping complex were as follows:

1. Electrical power receiving and distribution
2. Air-conditioning system
   (1) Mechanical performance
   (2) Air conditions
   (3) Electricity consumption
3. Lighting system
4. General energy consumption

10-7-1 Schedule of Energy Audit

The schedule for the energy audit for the shopping complex was from June 16 to 26 1998.
This included preparation for the measurements and preliminary discussion of measurement results.
The outline is as follows:

(1) Preparatory Stage

13 June (Sat.): Transportation of measuring equipment.

16 June (Tue.): Explanation, discussion and confirmation of the audit plan; preparation and confirmation of measurement

(2) Energy Audit

17 June (Wed.): Adjustment of measuring equipment
Confirmation of measurement points
Installation and adjustment of measuring equipment for electricity receiving

18 June (Thu.): Measurement of electricity consumption in transformers and distributors
Measurement around chillers and cooling towers

19 June (Fri.): Measurement of electricity consumption at distributors
Measurement of air conditions
Measurement around chillers and ice storage system

20 & 21 June (Sat. & Sun.): Analysis of the results

22 June (Mon.): Measurement of electricity consumption around chillers
Measurement around chillers and ice storage system
Measurement of air conditions

23 June (Tue.): Measurement of electrical current in sub-distribution room
Measurement of air conditions and illumination intensity
Measurement around chillers and ice storage system

24 June (Wed.): Measurement of electricity consumption in distributors
Measurement of air conditions (CO_2 content, illumination intensity, air flow and temperature)
Measurement of air and heat leakage at open doors
Measurement around cooling towers.

25 June (Thu.): General field survey of major energy consuming facilities
Measurement of air conditions
Removal of equipment for electricity consumption
Input of trend data and equipment list
Data analysis and evaluation
Reconfirmation of equipment specification
Preparation of report.

(3) Discussion of Preliminary Results and Transportation of the Measuring Equipment

26 June (Fri.): Preliminary evaluation of the results and recommendations for improvements in energy efficiency; repackaging of measuring equipment.

27 June (Sat.): Transportation of measuring equipment to the next audit location.

Table 10-6 shows a detailed schedule of measurement.

Table 10-6 (1) Detailed Schedule for Measurement (Shopping Complex)

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, Ampere & Power Factor)		x	x	x	x	x	x	x	
(2) HV Distributors (Voltage, Ampere & Power Factor)		x	x	x	x	x	x	x	
(3) LV Distributors (Voltage & Ampere)			x	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	x		
(2) Cooling Tower (Cooling Water: Inlet/Outlet Temp. & Flow rate)			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	
2-2 Space Condition (1) Area to be conditioned 1) Spaces (Temp., Humid., Air Flow & CO/CO_2)				x	x	x	x		
(2) Rooms to be conditioned 1) Rooms (Temp., Humid. & Direction of Air Flow)				x					
2-3 Electricity Consumption (1) Chillers, AHU, Blowers (Volt., Ampere & Power Factor)			x	x	x	x	x	x	
3. Lighting System (1) Main Part of Buildings Each Space & Room (Lux)						x	x	x	

Table 10-6 (2) Detailed Schedule for Measurement (Shopping Complex)

Measuring Items	Working Day								
	1	2	3	4	5	6	7	8	9
4. General Energy Consumption (1) Electricity (2) Chilled water		x	x	x	x	x	x	x	
5. Field Investigation (1) Preparation of Equipment List (2) Investigation of Drawings (3) Observation of Operating Condition		x	x	x	x	x	x	x	
6. Summarization & Reporting								x	
7. Review and Discussion									x

10-7-2 Outline of Measuring Items, Points and Measuring Equipment

To calculate and evaluate the current condition of energy consumption and to develop an energy balance, 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 distributors: voltage and current

(2) Air-conditioning System

1. Chillers and ice storage system: Inlet/outlet water temperature, water flow rate (primary and secondary), 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 and temperature of air, inlet/outlet temperature of chilled water
4. Air-conditioned area: temperature, humidity and CO_2 content
5. Air-conditioned rooms: temperature , humidity and CO_2 content
6. Outdoor conditions: temperature, humidity and CO_2 content

(3) Lighting System

1. Common space: Illumination intensity

(4) General Energy Consumption

1. Electricity consumption
2. Chilled water consumption

(5) Field Investigation

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

Details of measured items, points and equipment are shown in Tables 10-7.

Table 10-7 (1) **Outlines of Measurement for Energy Audit (Shopping Complex)**

Major Items of Energy Audit & Subject Items and Points	Measurement or Estimate	Available Equipment of Measurement			
		Required Equipment	Entity	JICA	Local Labo.
1. Electrical power receiving & distribution					
(1) HV Receivers (Sub-station)					
① Voltage	M	Clamp on power hitester, 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 hitester, 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 powermeter, control panel	x	x	
② Ampere	M	ditto	x	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	

Table 10-7 (2) Outlines of Measurement for Energy Audit (Shopping Complex)

Major Items of Energy Audit & Subject Items and Points	Measurement or Estimate	Available Equipment of Measurement			
		Required Equipment	Entity	JICA	Local Labo.
(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 powermeter		x	
2-2. Space condition					
(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 hitester, 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	
5. General energy consumption					
(1) Electricity	M	Clamp on power hitester	x	x	
(2) Chilled water	Trend data	Operation records & data	x		
6. Field investigation					
(1) Observation	Observation				
(2) Investigation of existing data	Review	Existing drawings and data	x		

10-8 Measurement Results

The measurement results are as follows.

10-8-1 Electricity

(1) Single Line Diagram (Figure 10-7 and 10-8)

There are two incoming lines from TNB. The measuring points are shown by numbers (① to ⑨) in Figure 10-7. Figure 10-8 shows the detailed load allocation of each branch.

(2) Electricity Consumption by Each Branch (Figure 10-9)

Figure 10-9 shows the consumption pattern of each branch at of 0 a.m. and 12 p.m. There is a considerable pattern difference between night and day.

(3) Incoming Electricity Data (No.1)

a) Frequency and voltage (Figure 10-10 and 10-11).

The stability of TNB supply influences these data. Compared to the electricity supply in Japan, the range of change is rather high in Malaysia.

b) Consumption (Figure 10-12)

This figure shows a big difference in electricity consumption between day and night. Power Factor shows reasonable values.

c) Current Balance (Figure 10-13)

There is no serious imbalance among each current phase.

(4) Incoming Electricity Data (No.2)

a) Consumption (Figure 10-14)

The difference between night and day is considerable. Power factor is very low, from 0.4 to 0.6.

b) Current Balance (Figure 10-15)

No serious imbalance is observed.

(5) Ring Feeder

a) No.1A: Consumption (Figure 10-16), current balance (Figure 10-17)

No problem was observed.

b) No.2B: Consumption (Figure 10-18)

Power Factor of No. 2B was so low (0.4 to 0.6) that it influenced the efficiency of the whole system.

c) No.2B: Current Balance (Figure 10-19)

No serious problem was observed.

(6) Chiller Plant Including Surrounding Facilities

Electricity consumption (Figure 10-20 and Figure 10-21): Equipment using electricity in the chiller system.

Power factor shows a low value caused by low operating rate.

(7) Chiller

a) Consumption (Figure 10-22 and Figure 10-23)

The 0.5 power factor in the TX-1 train is quite low compared to the TX-2 train.

b) Current Balance (Figure 10-24, Figure 10-25, Figure 10-26 and Figure 10-27)

There is no serious problem.

(8) Power Factor Comparison at the Incoming Supply of No.1 and No.2

(Figure 10-28 and Figure 10-29)

Because of the inefficient operation of the chiller plant (T1 and T3) and the chiller itself (TX-1), the power factor shows a low value.

10-8-2 Chiller System

(1) Operation Mode of Chiller and Pumps

(Figure 10-30, Figure 10-31 and Figure 10-32)

The chiller system is so complicated and advanced that the operating pattern changes quite drastically. These figures show a simplified pattern change. The dark colored equipment in Figure 10-31 and Figure 10-32 are the ones in operation.

(2) Temperature Pattern

(Table 10-8, Figure 10-33 and Figure 10-34)

Table 7-3 shows the data recorded by the computer.

Figures show the trend graph of temperature.

(3) Flow Rate Measurement

(Table 10-9 and Figure 10-35)

Table 10-9 shows the flow rate measured using an ultra-sonic flow meter.

Figure 10-35 shows the trend graph of the flow rate.

10-8-3 Air Conditions in Shopping Building

(1) Energy Loss from Building Entrance

(Table 10-10 and Figure 10-36)

A large amount of heat was found to be escaping from the front and back entrances.

(2) Temperature and Lighting Intensity

(Figure 10-37 and Figure 10-38)

These figures show the differences in values.

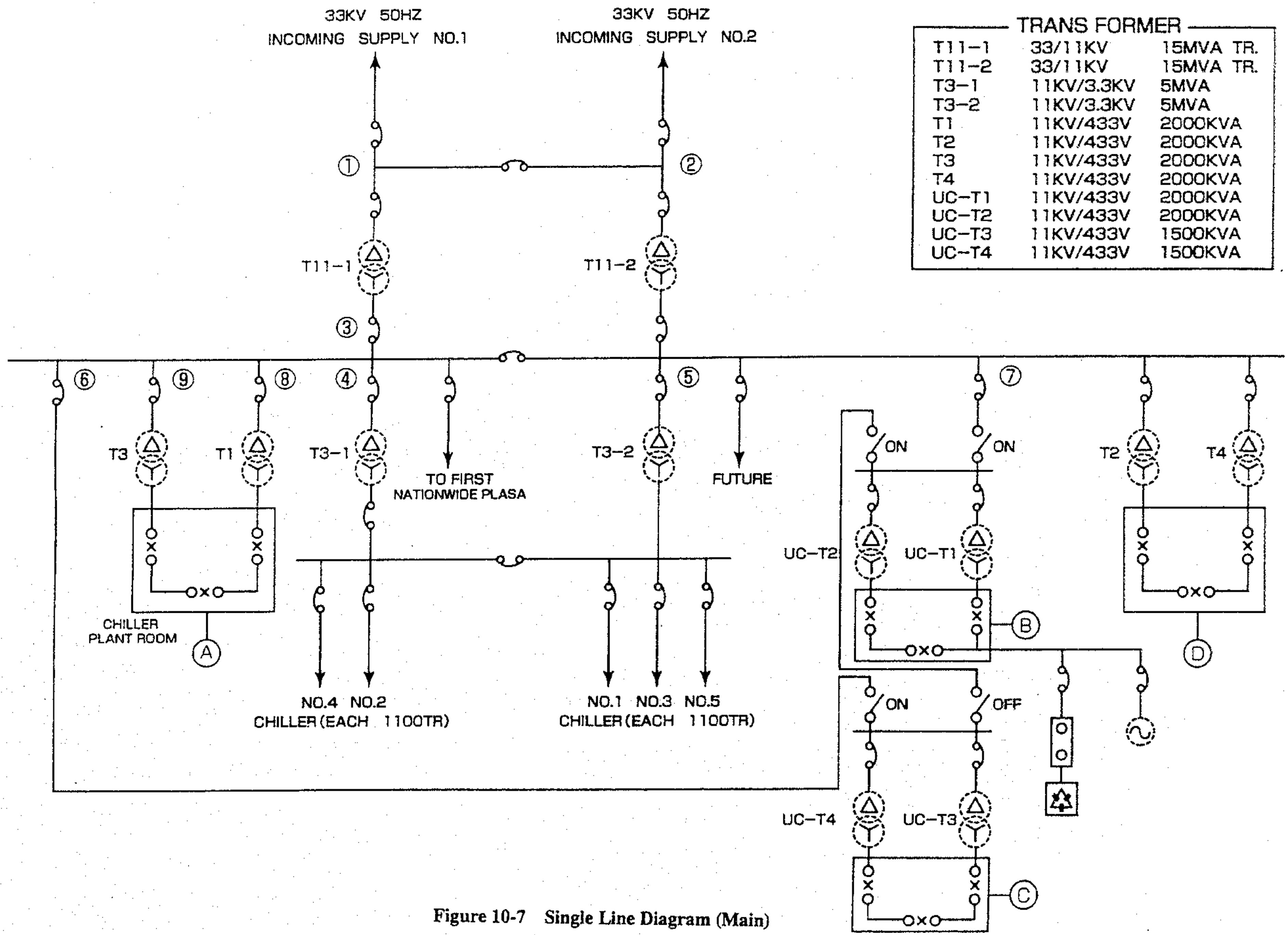


Figure 10-7 Single Line Diagram (Main)

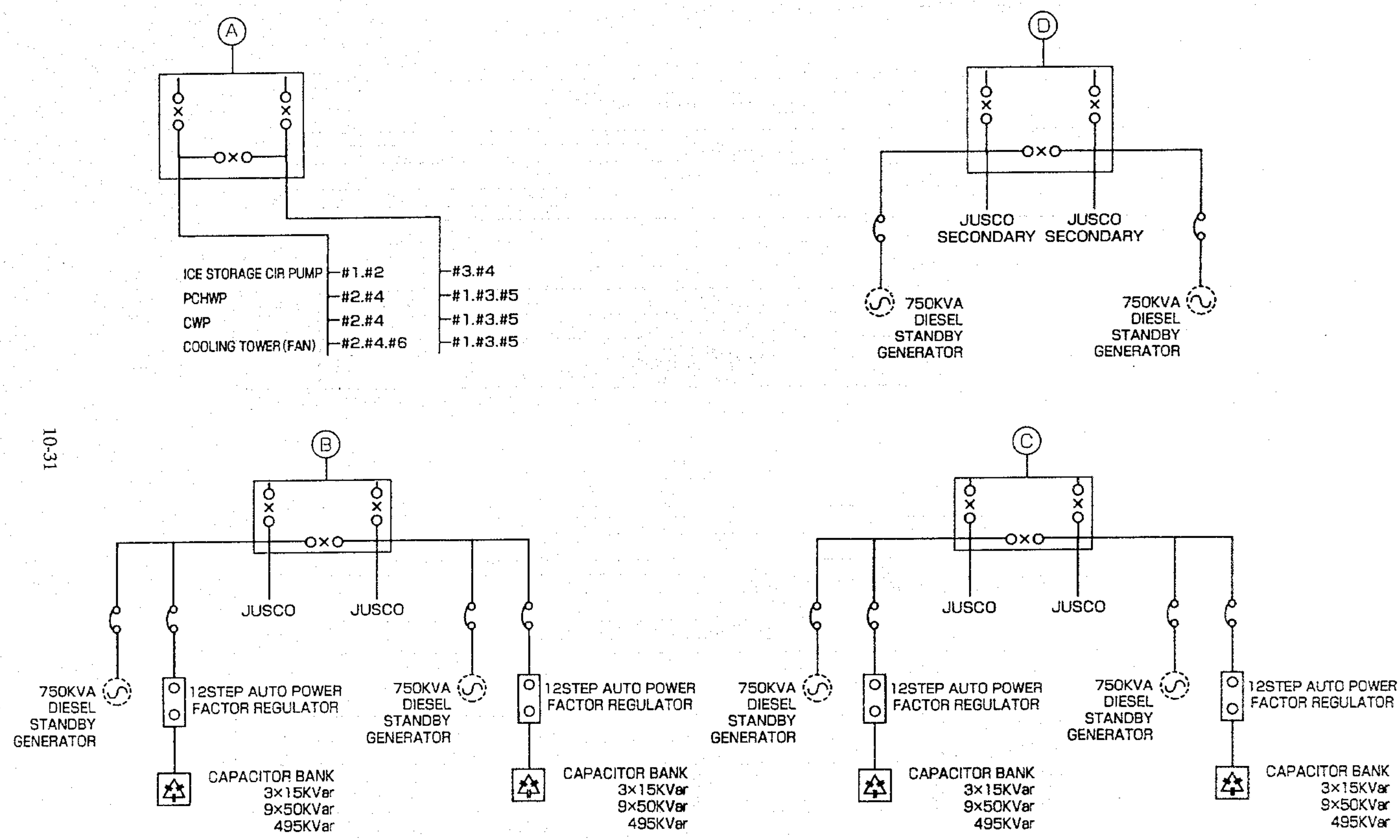
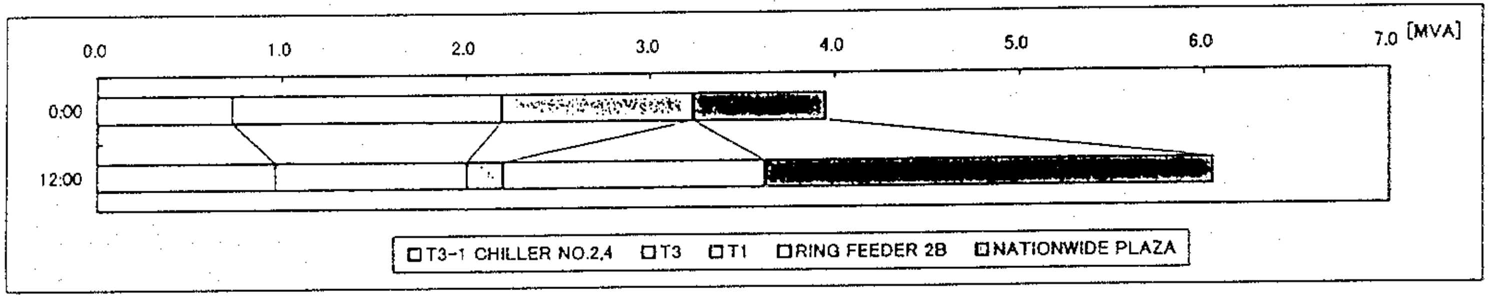


Figure 10-8 Single Line Diagram (Sub)

Electric Consumption Balance No.1 [MVA]

	T3-1 CHILLER NO.2,4	T3	T1	RING FEEDER 2B	[redacted]	Incoming Supply No.1
0:00	0.73	1.46	1.04	0.00	[redacted]	3.95
12:00	0.97	1.04	0.20	1.42	[redacted]	6.05



Electric Consumption Balance No.2 [MVA]

	T3-2 CHILLER NO.1,3,5	RING FEEDER 1A	T2,T4	Incoming Supply No.2
0:00	0.61	0.92	0.75	2.28
12:00	0.00.	3.05	1.27	4.32

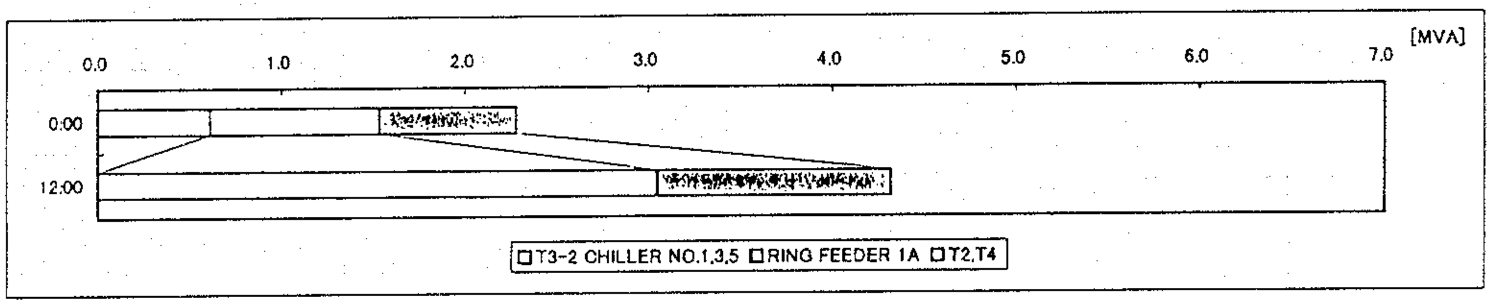


Figure 10-9 Electricity Consumption Pattern

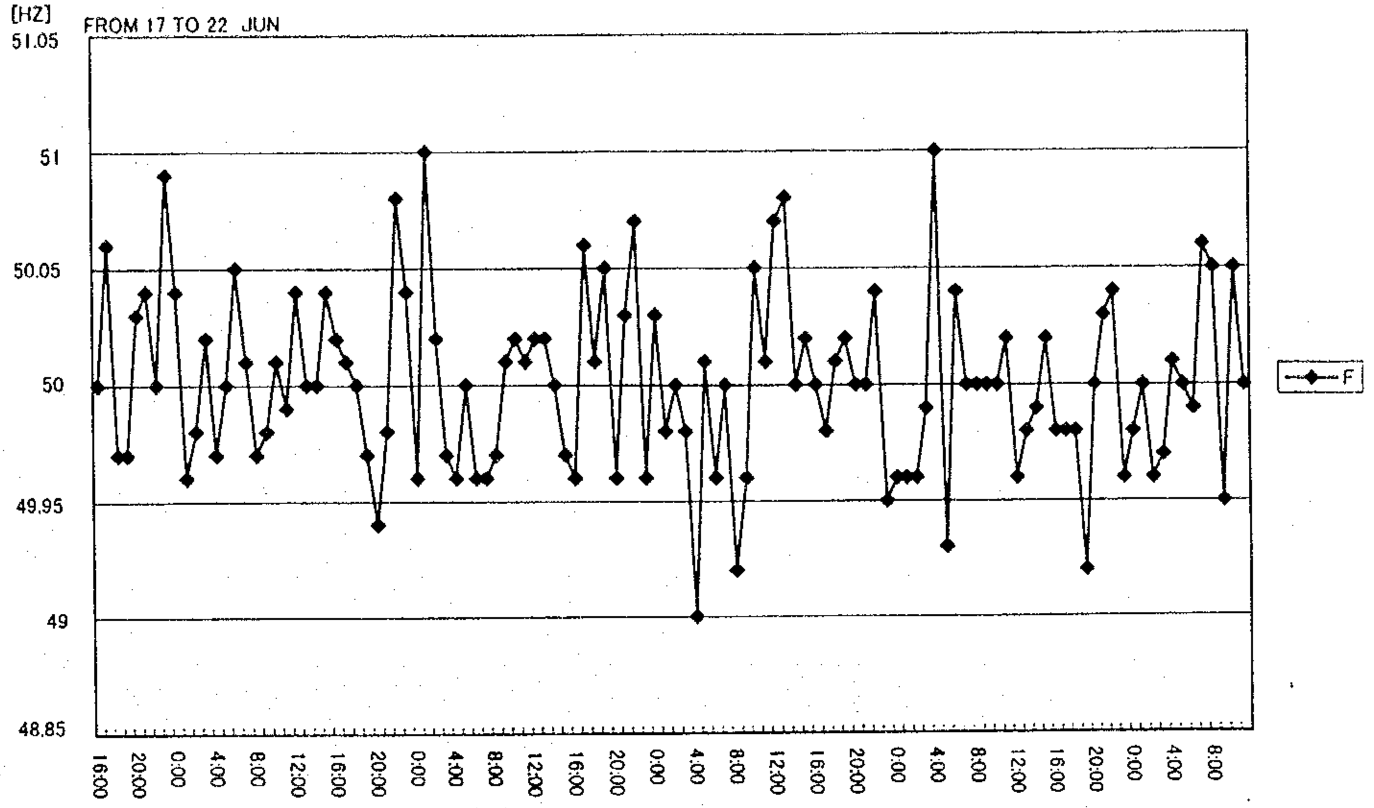


Figure 10-10 Frequency Trend at 33KV Incoming Supply No.1

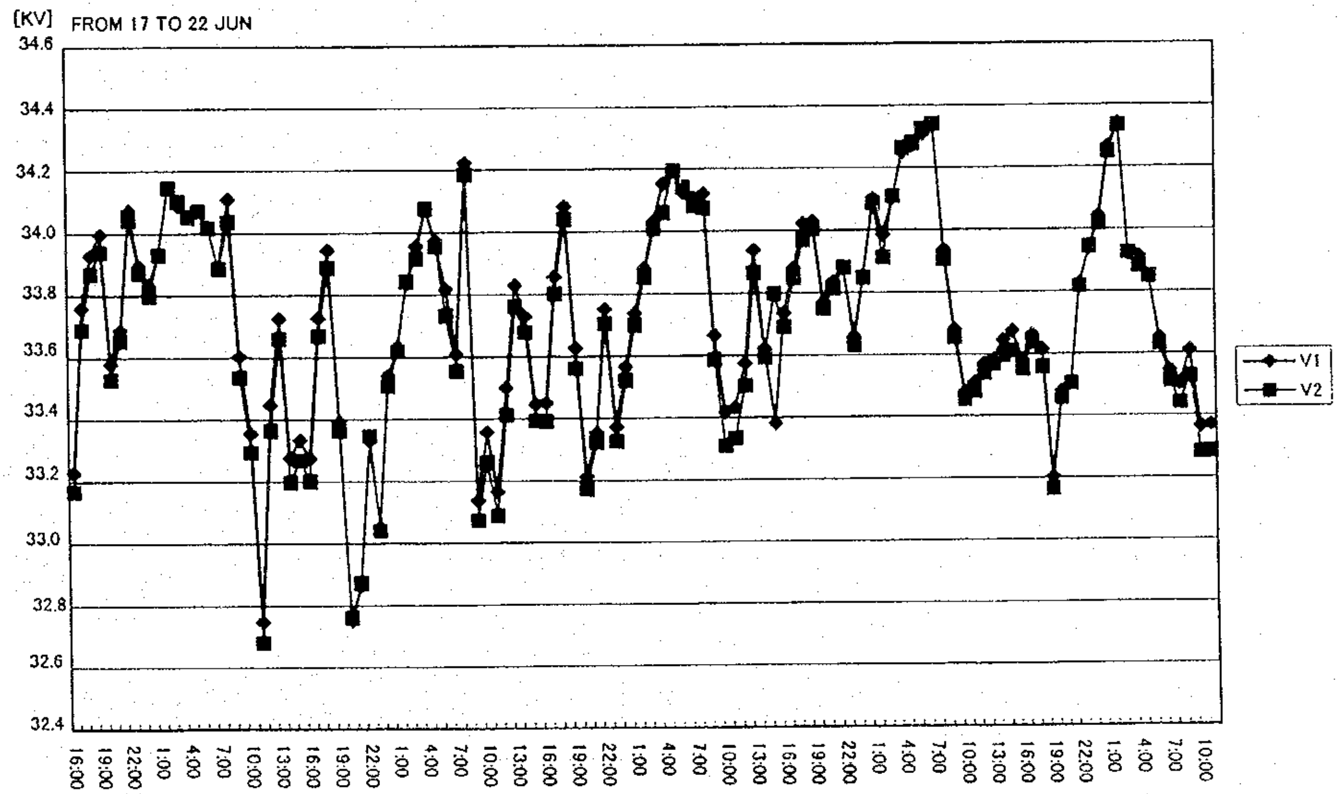


Figure 10-11 Electric Voltage at 33KV Incoming Supply No.1

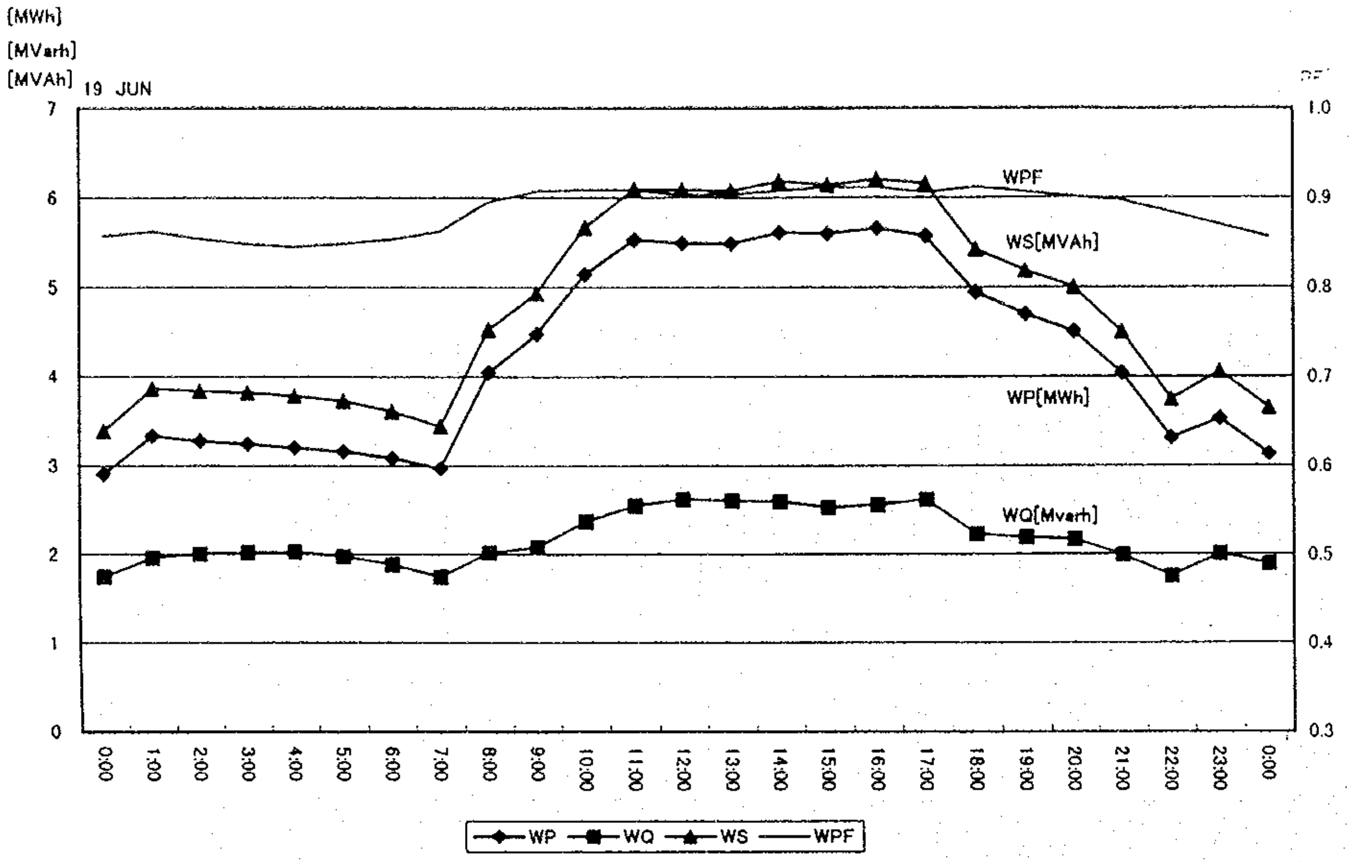


Figure 10-12 Electric Consumption at 33KV Incoming Supply No.1

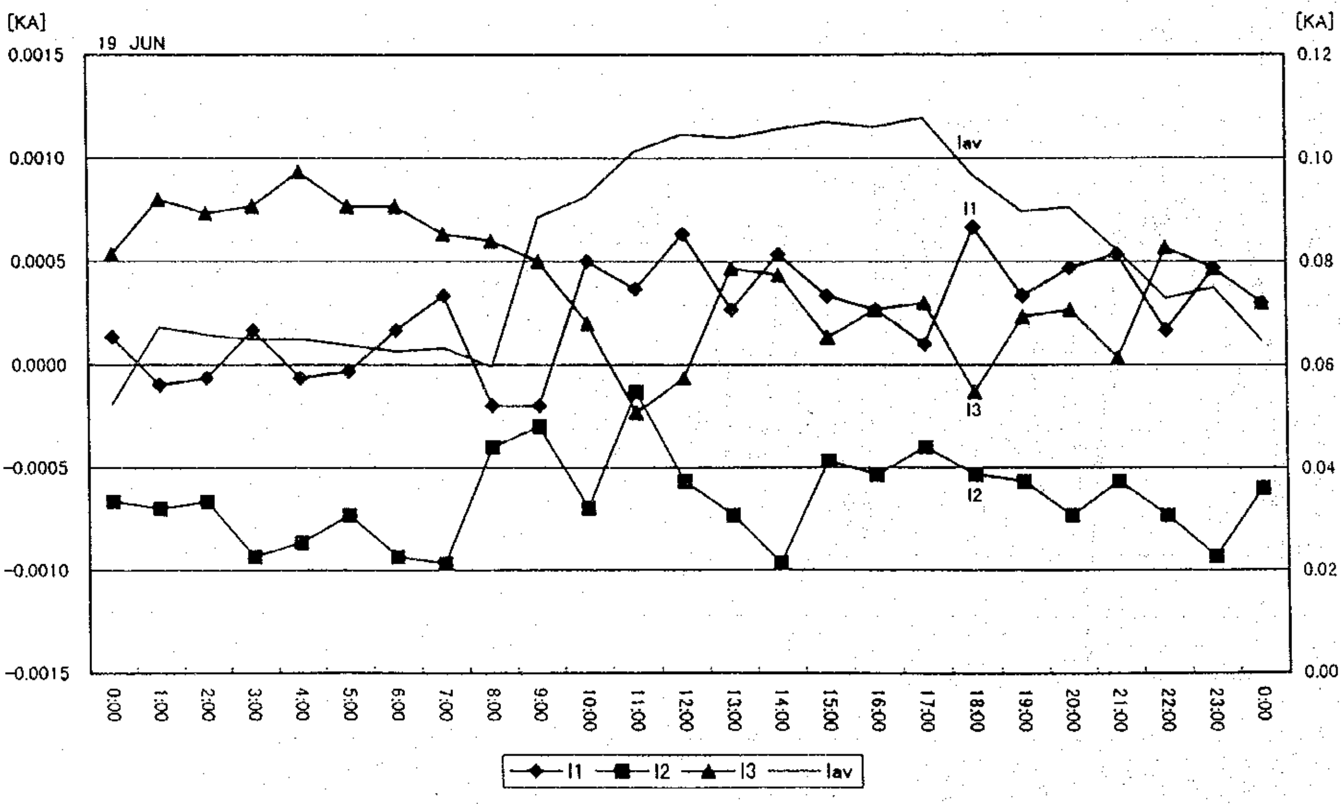


Figure 10-13 Electric Current Balance at 33KV Incoming Supply No.1

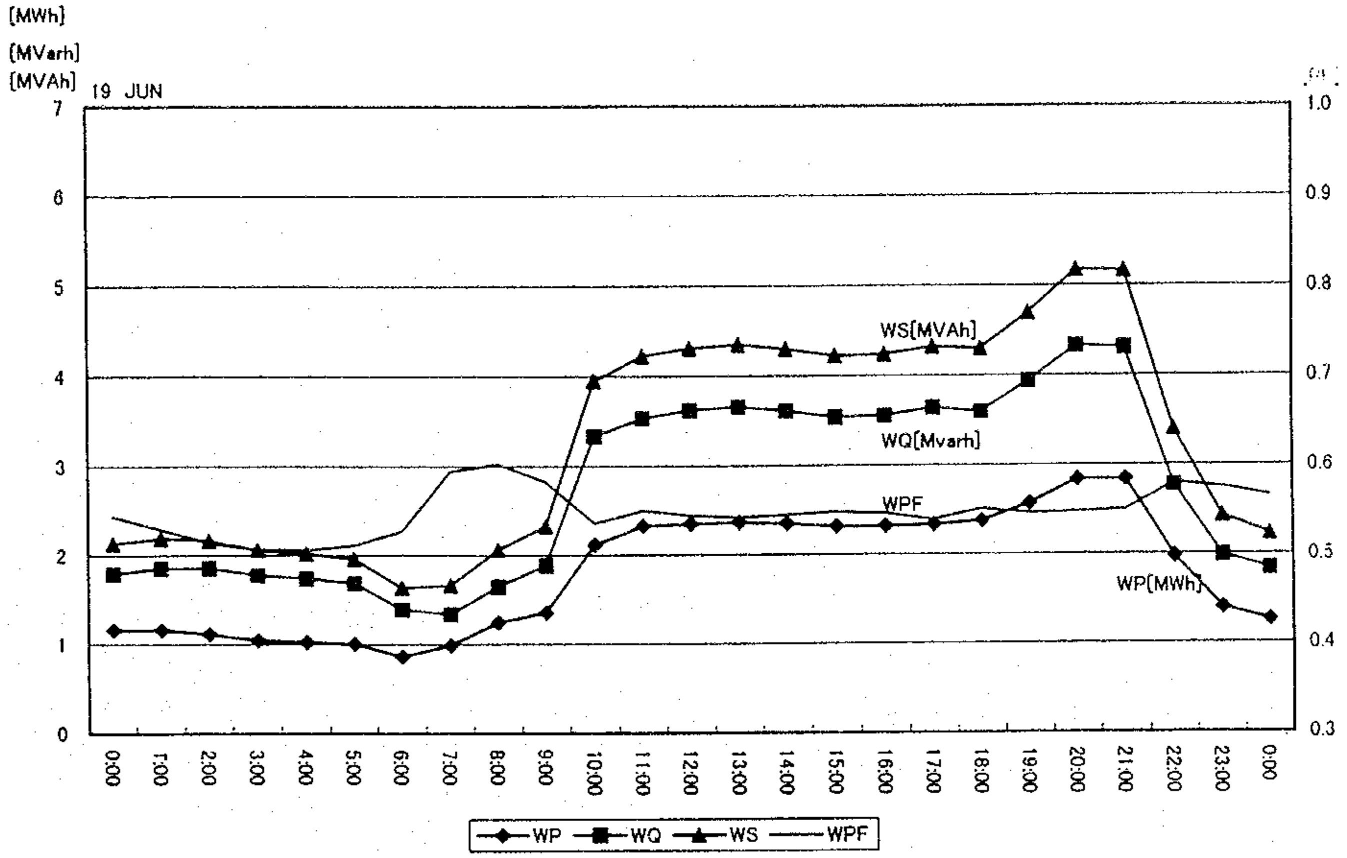


Figure 10-14 Electric Consumption at 33KV Incoming Supply No.2

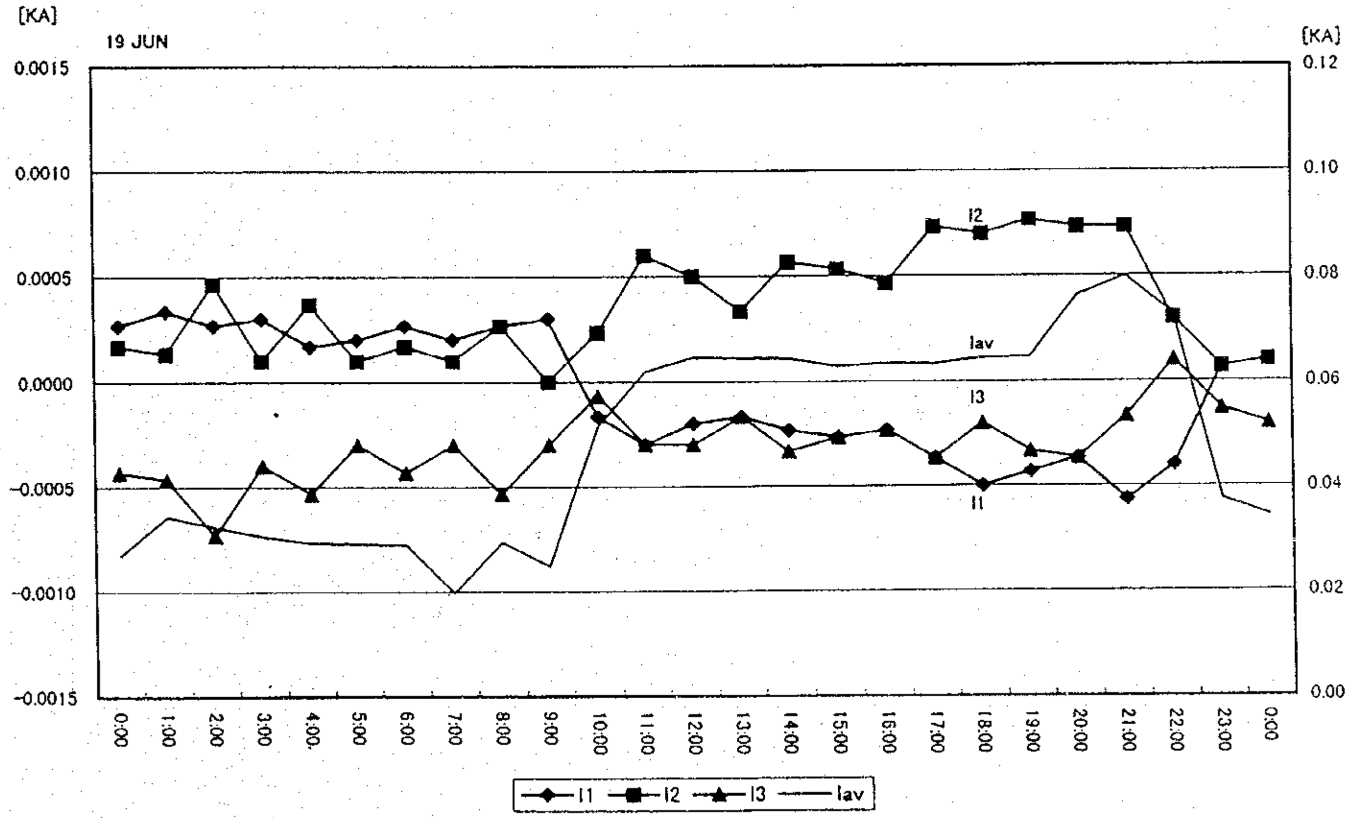


Figure 10-15 Electric Current Balance at 33KV Incoming Supply No.2

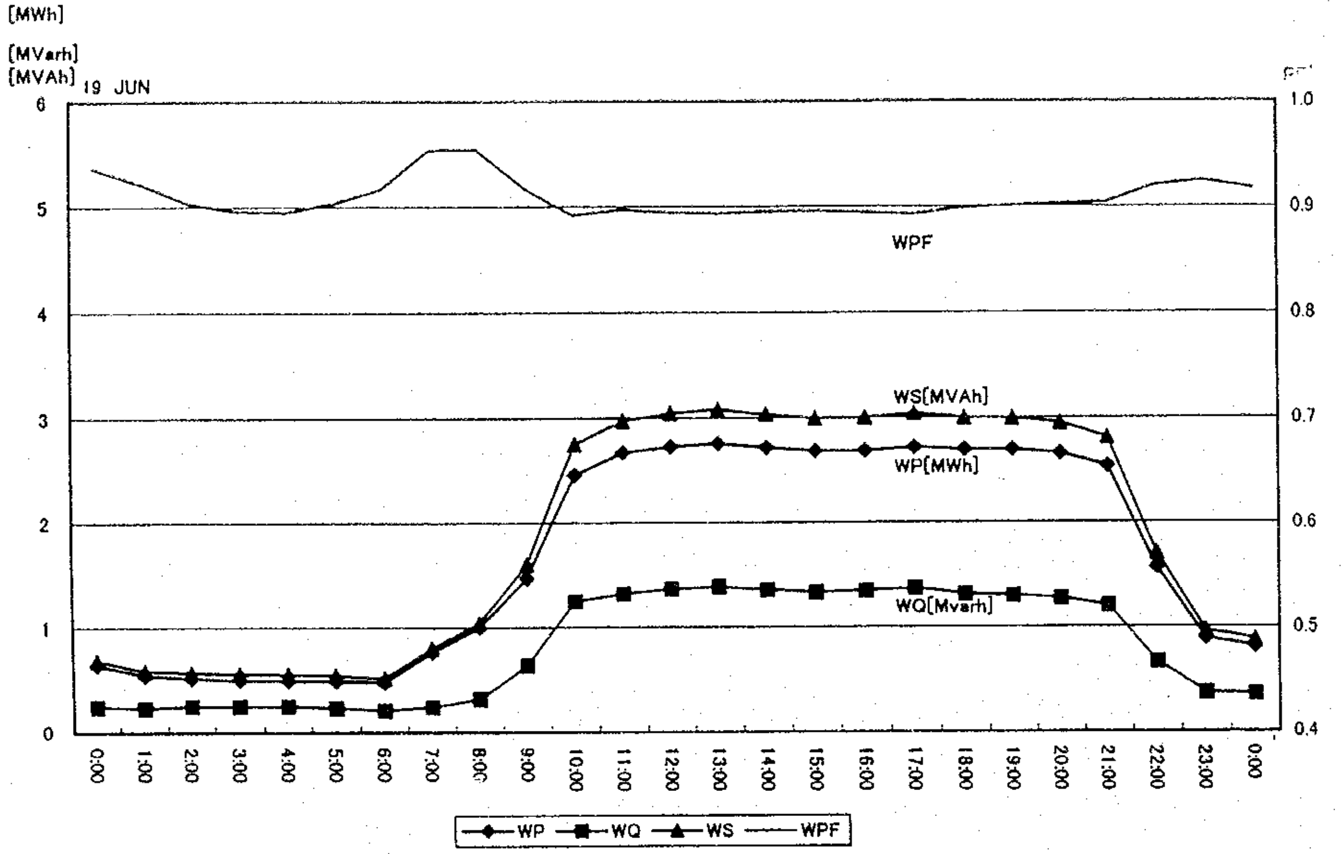


Figure 10-16 Electric Consumption at Ring Feeder No.1A

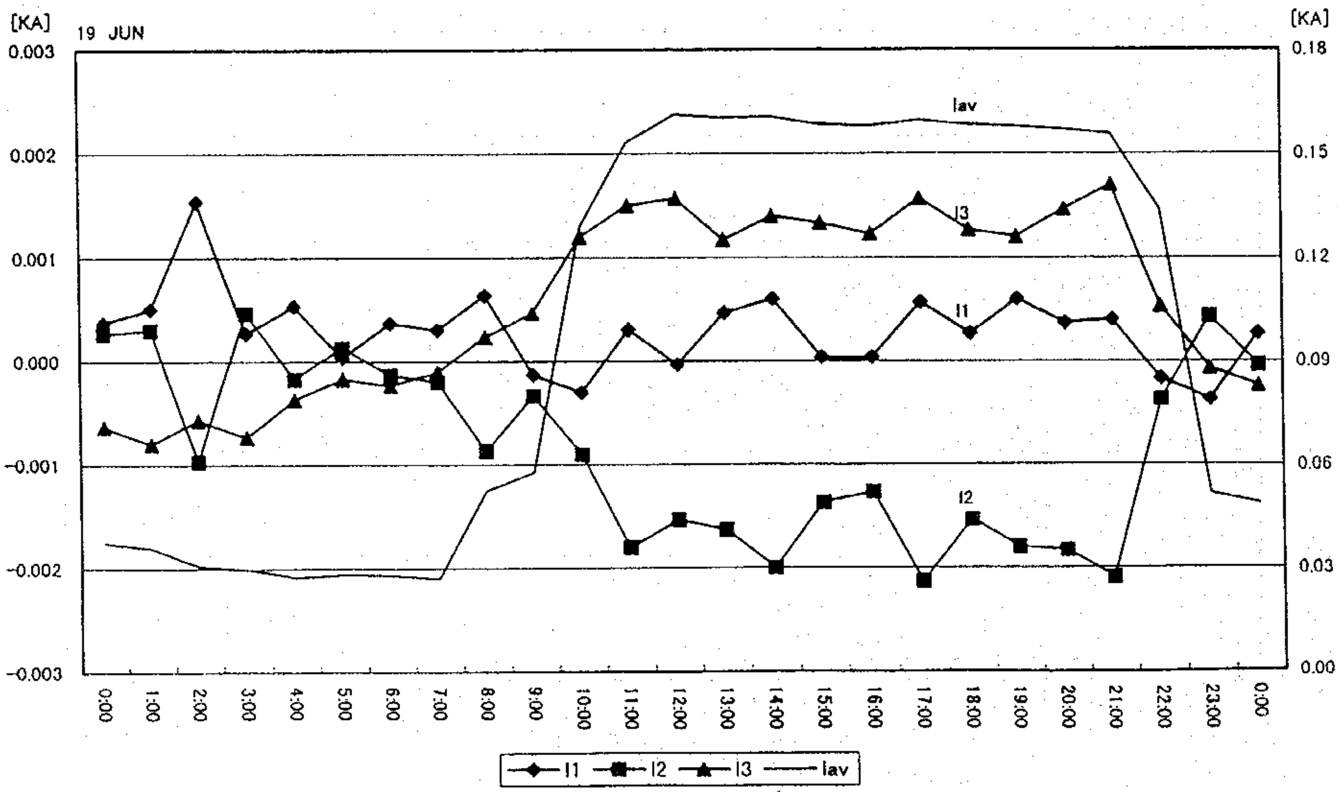


Figure 10-17 Electric Current Balance at Ring Feeder No.1A

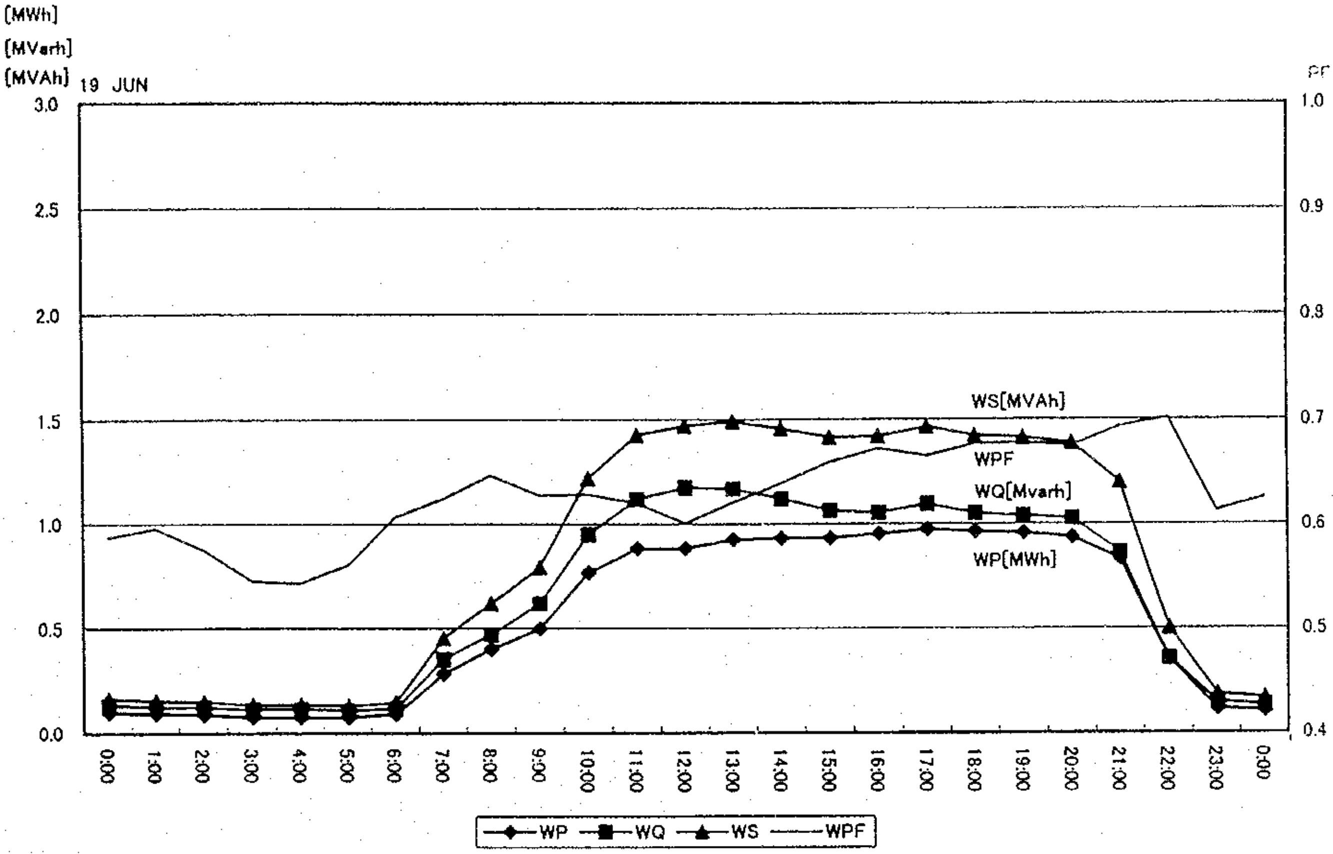


Figure 10-18 Electric Consumption at Ring Feeder No.2B

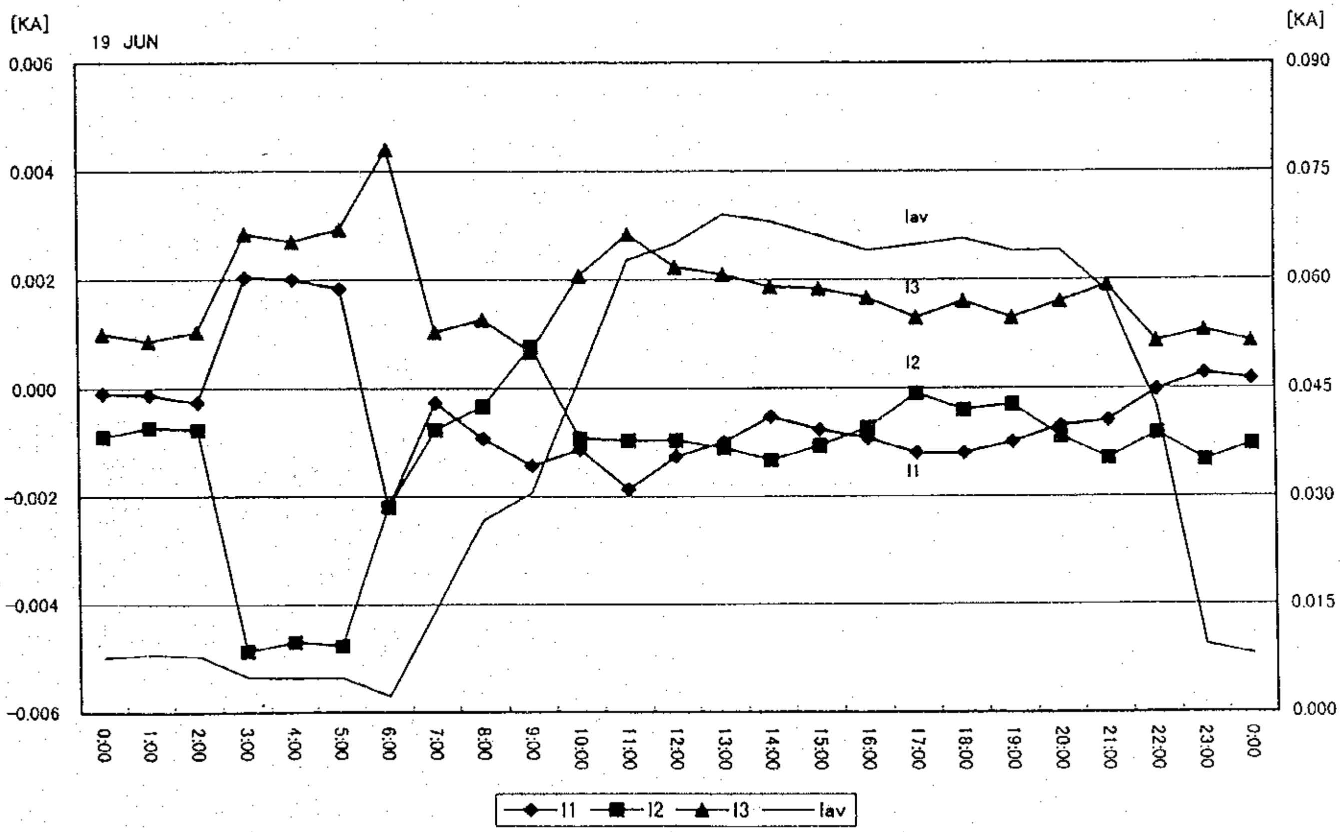


Figure 10-19 Electric Current Balanca at Ring Feeder No.2B

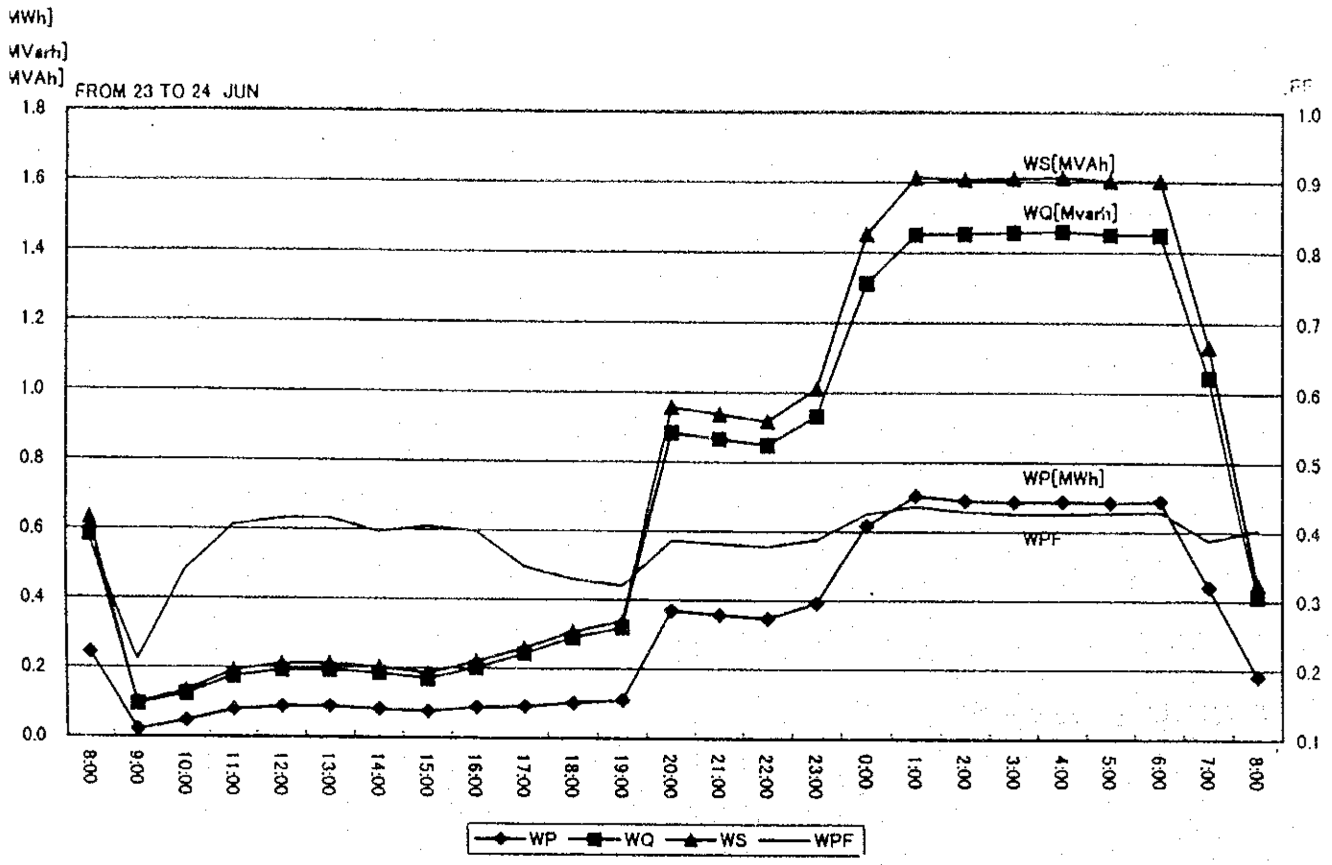


Figure 10-20 Electric Consumption at T1 2MVA 11KV/433V

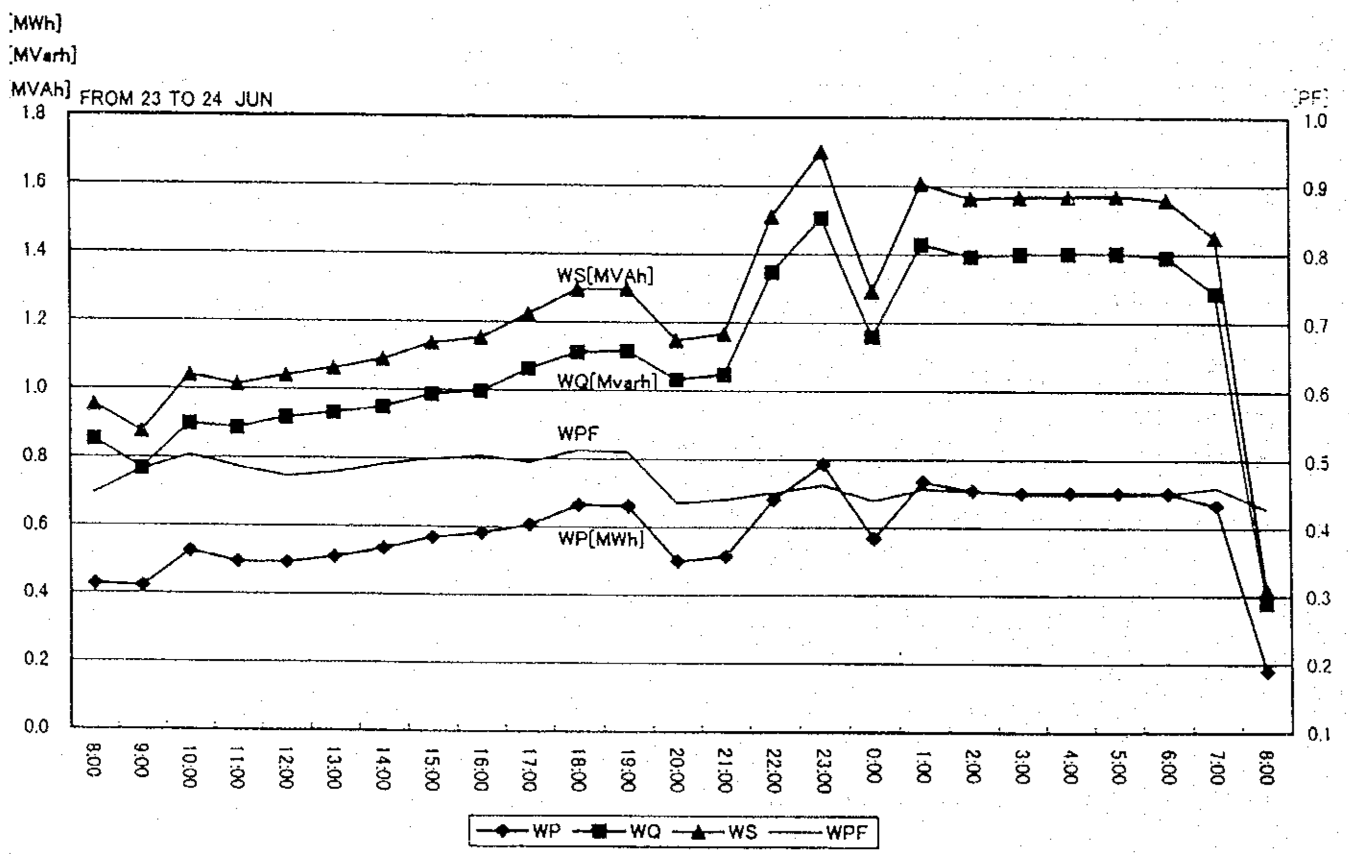


Figure 10-21 Electric Consumption at T3 2MVA 11KV/433V

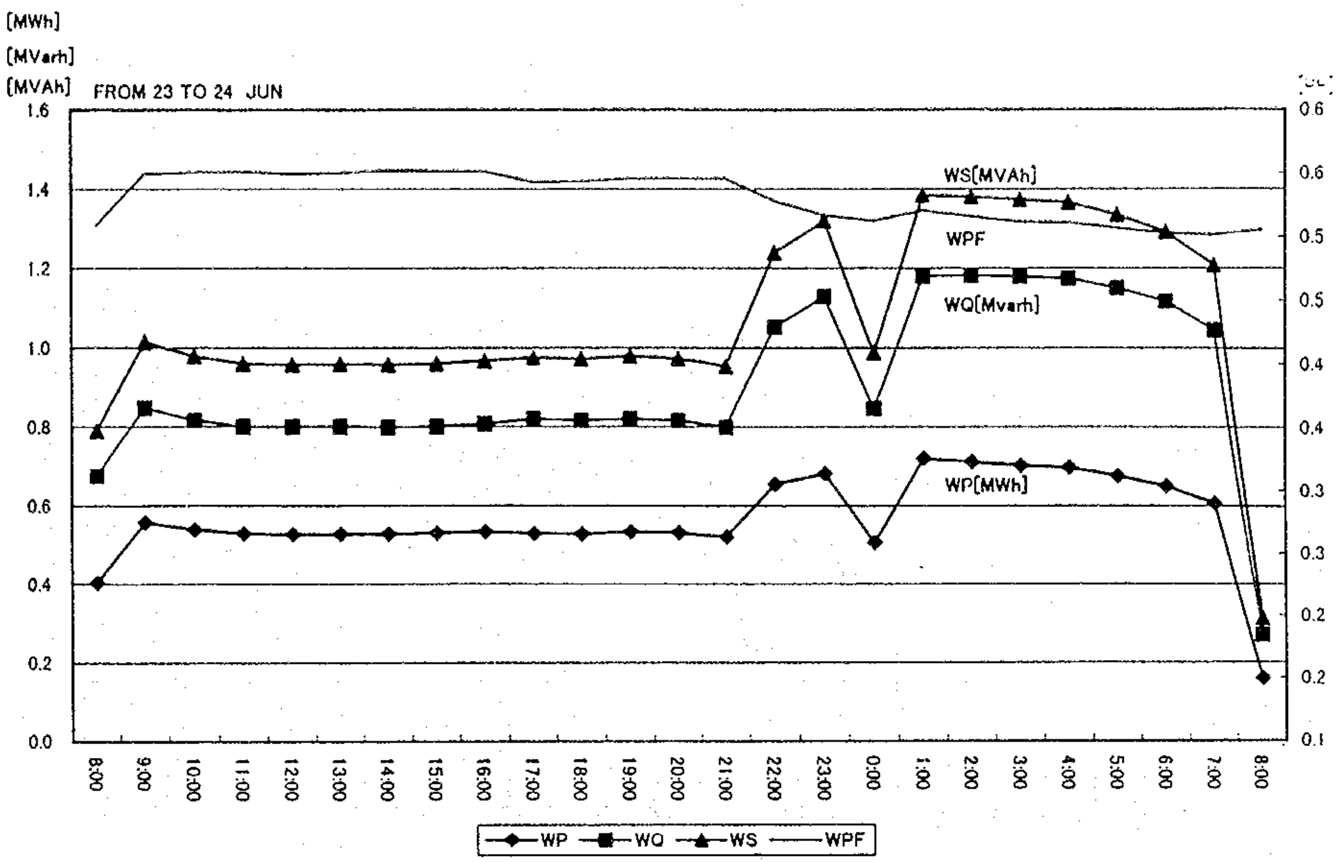


Figure 10-22 Electric Consumption at TX-1 5MVA 11KV/3.3KV

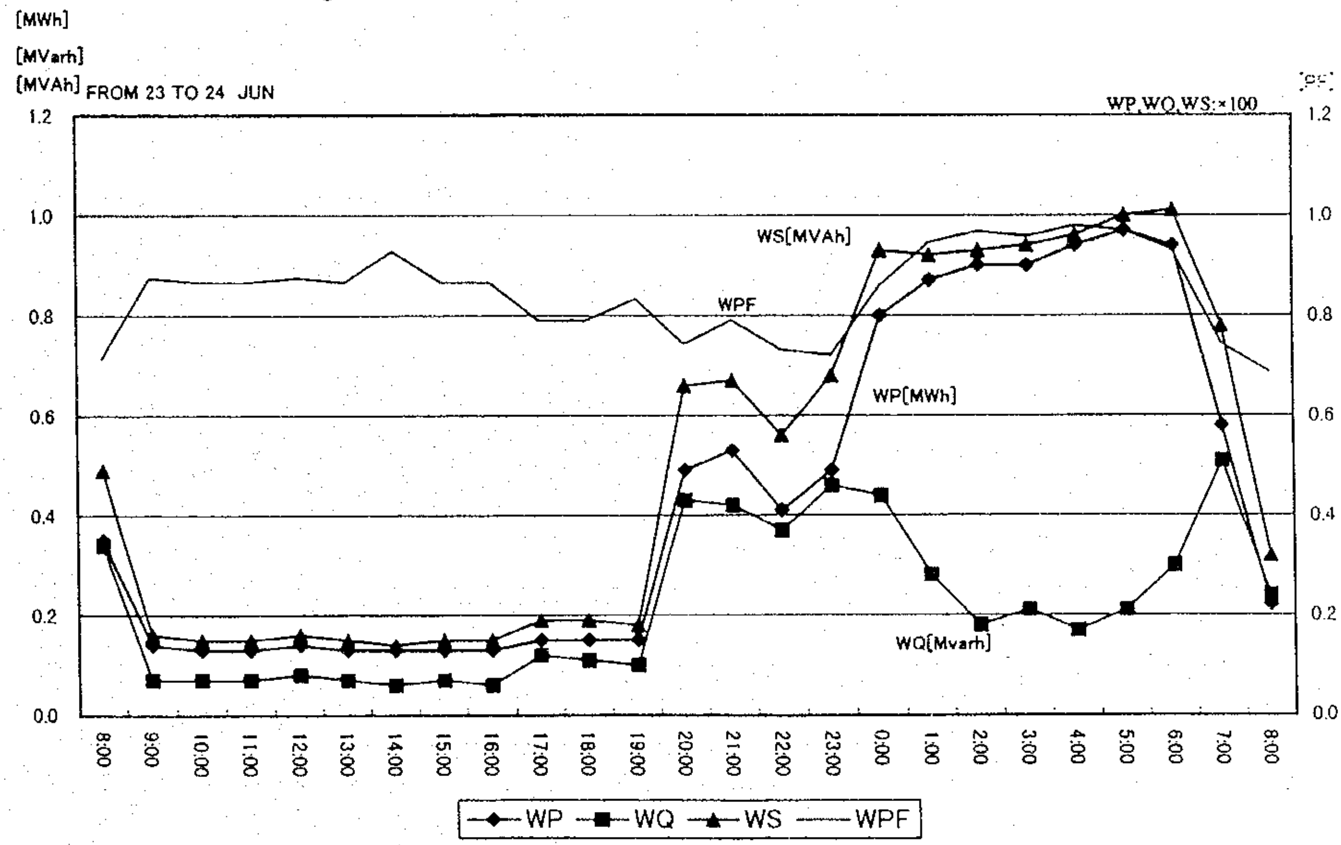


Figure 10-23 Electric Consumption at TX-2 5MVA 11KV/3.3KV

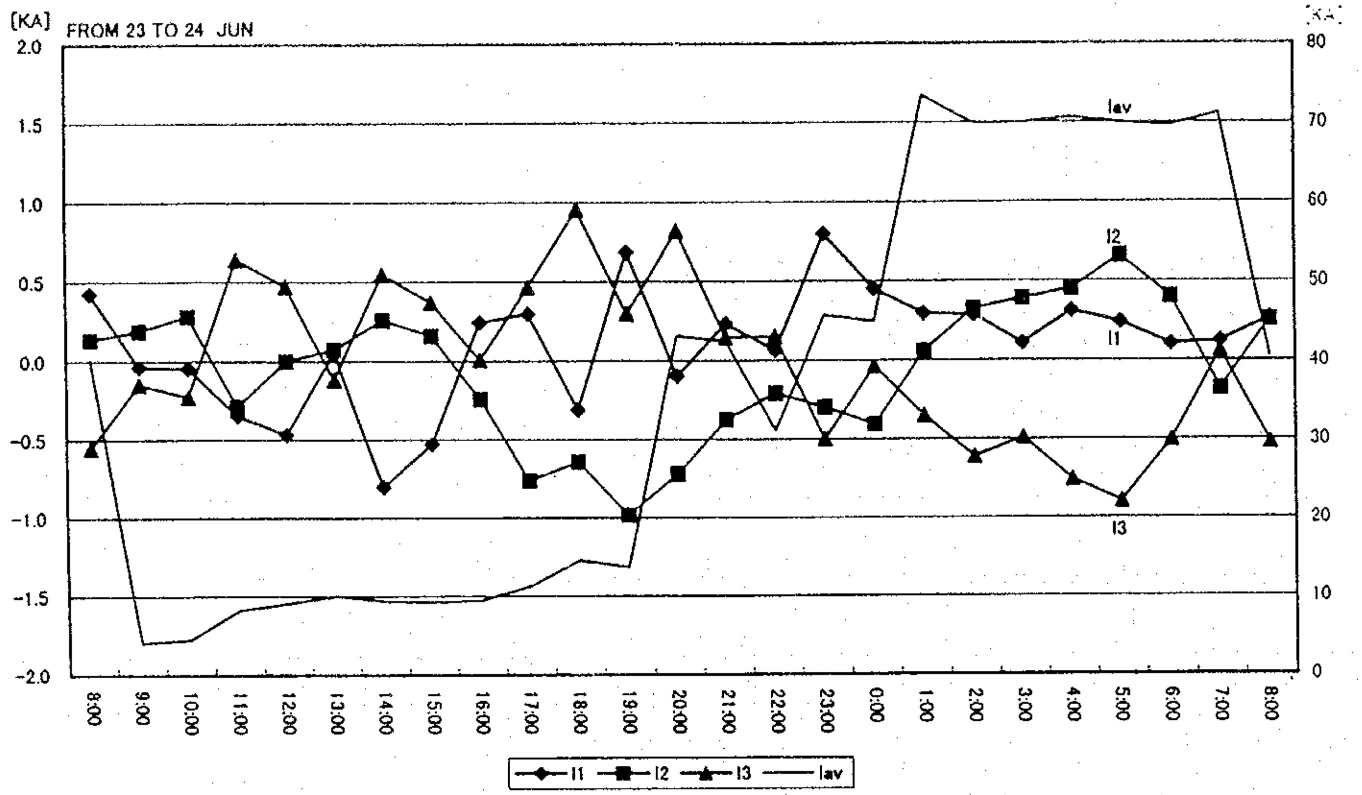


Figure 10-24 Electric Current Balance at T1 2MVA 11KV/433V

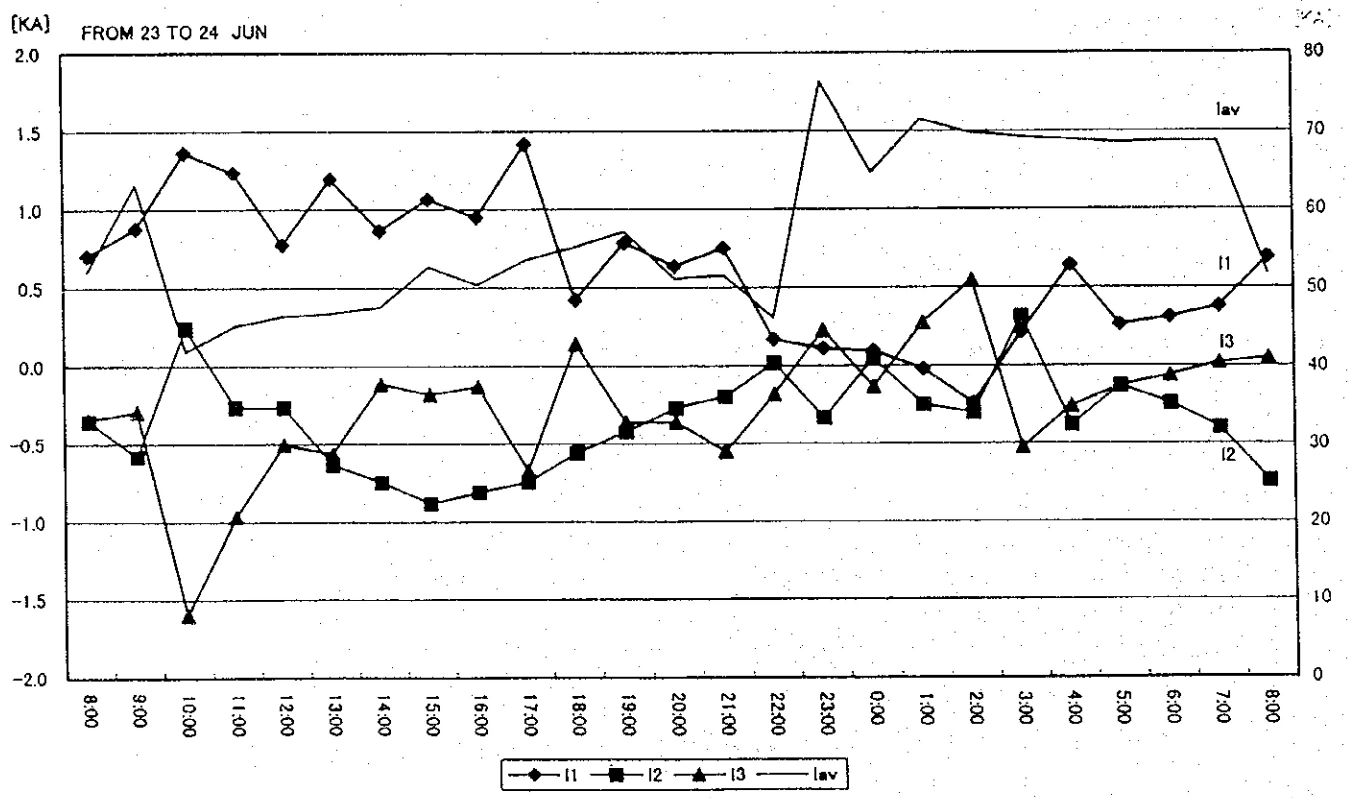


Figure 10-25 Electric Current Balance at T3 2MVA 11KV/433V

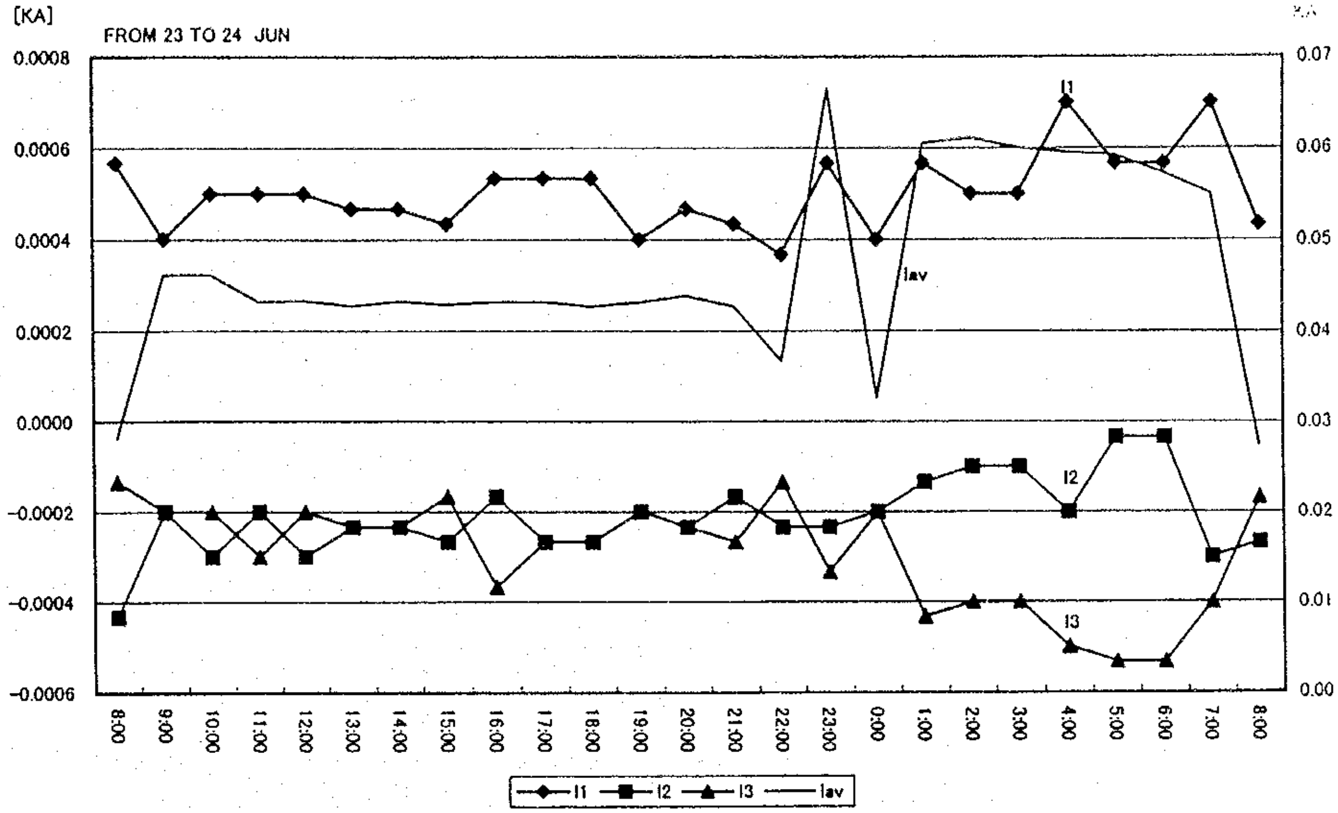


Figure 10-26 Electric Current Balance at TX-1 5MVA 11KV/3.3KV

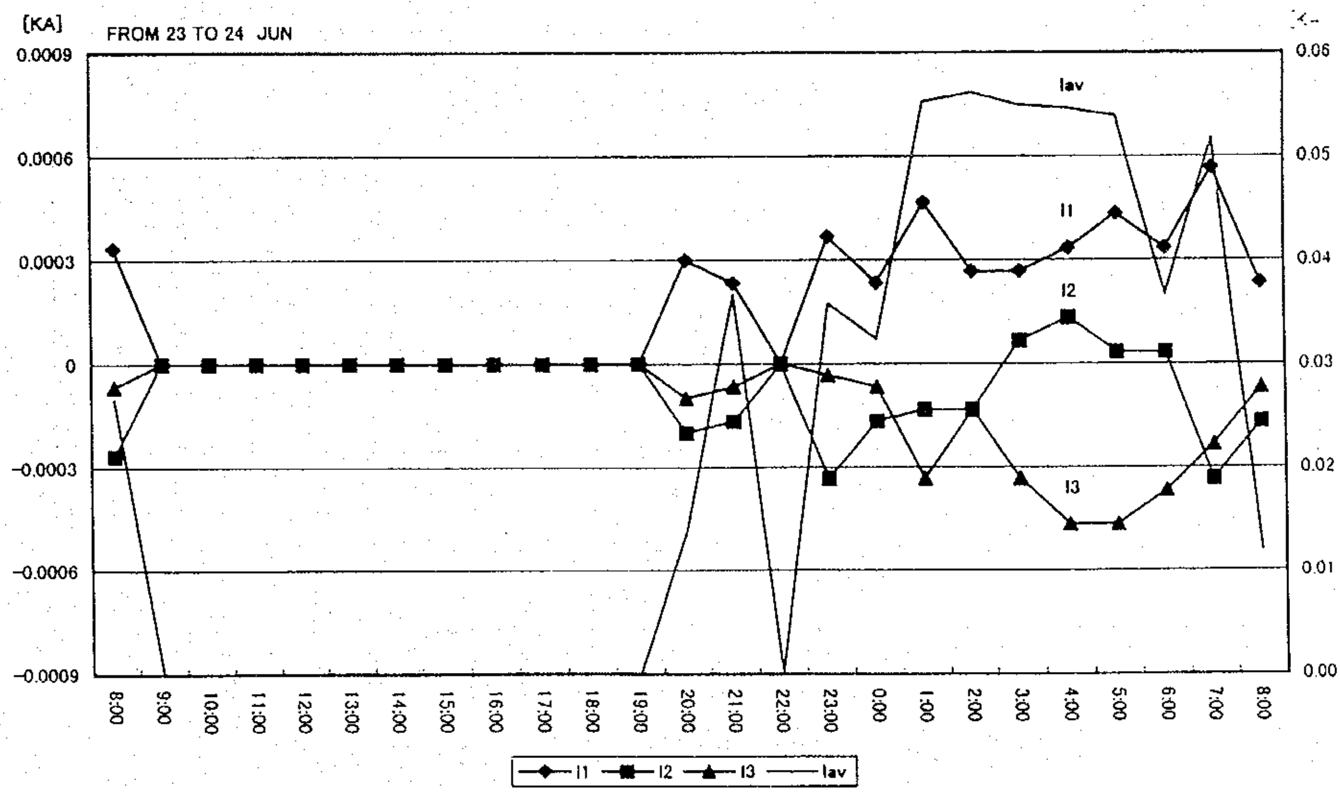


Figure 10-27 Electric Current Balance at TX-2 5MVA 11KV/3.3KV

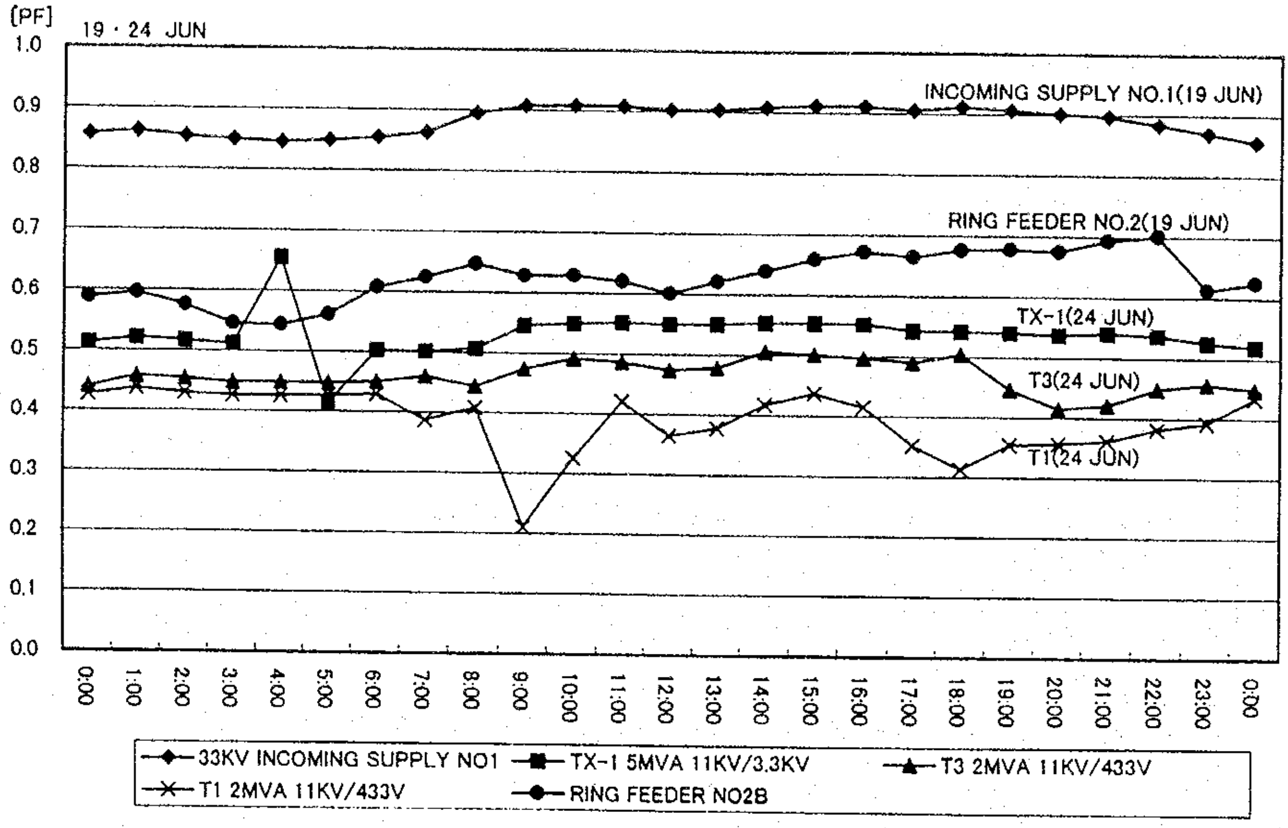


Figure 10-28 Power Factor at Incoming Supply No.1

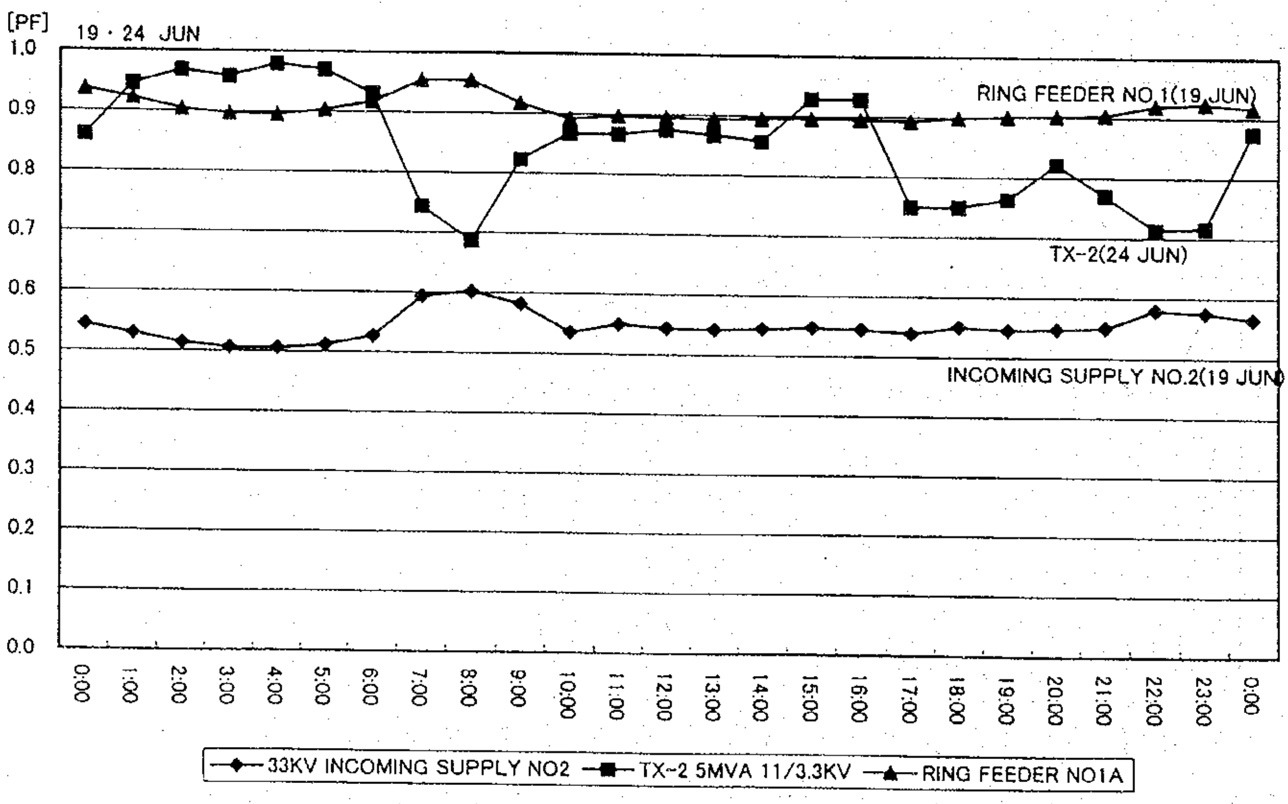


Figure 10-29 Power Factor at Incoming Supply No.2

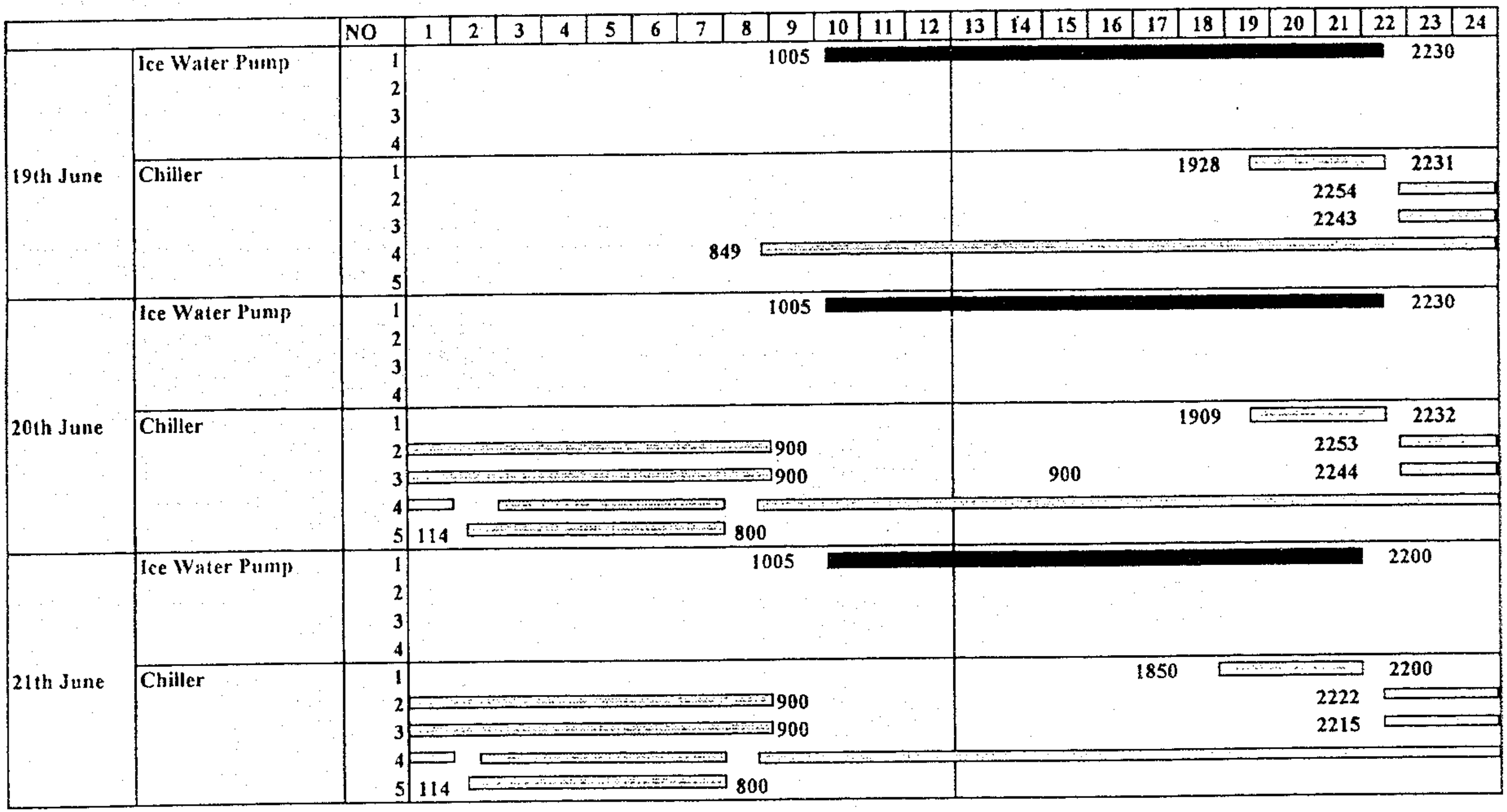


Figure 10-30 Operation Mode of Chillers and Pumps

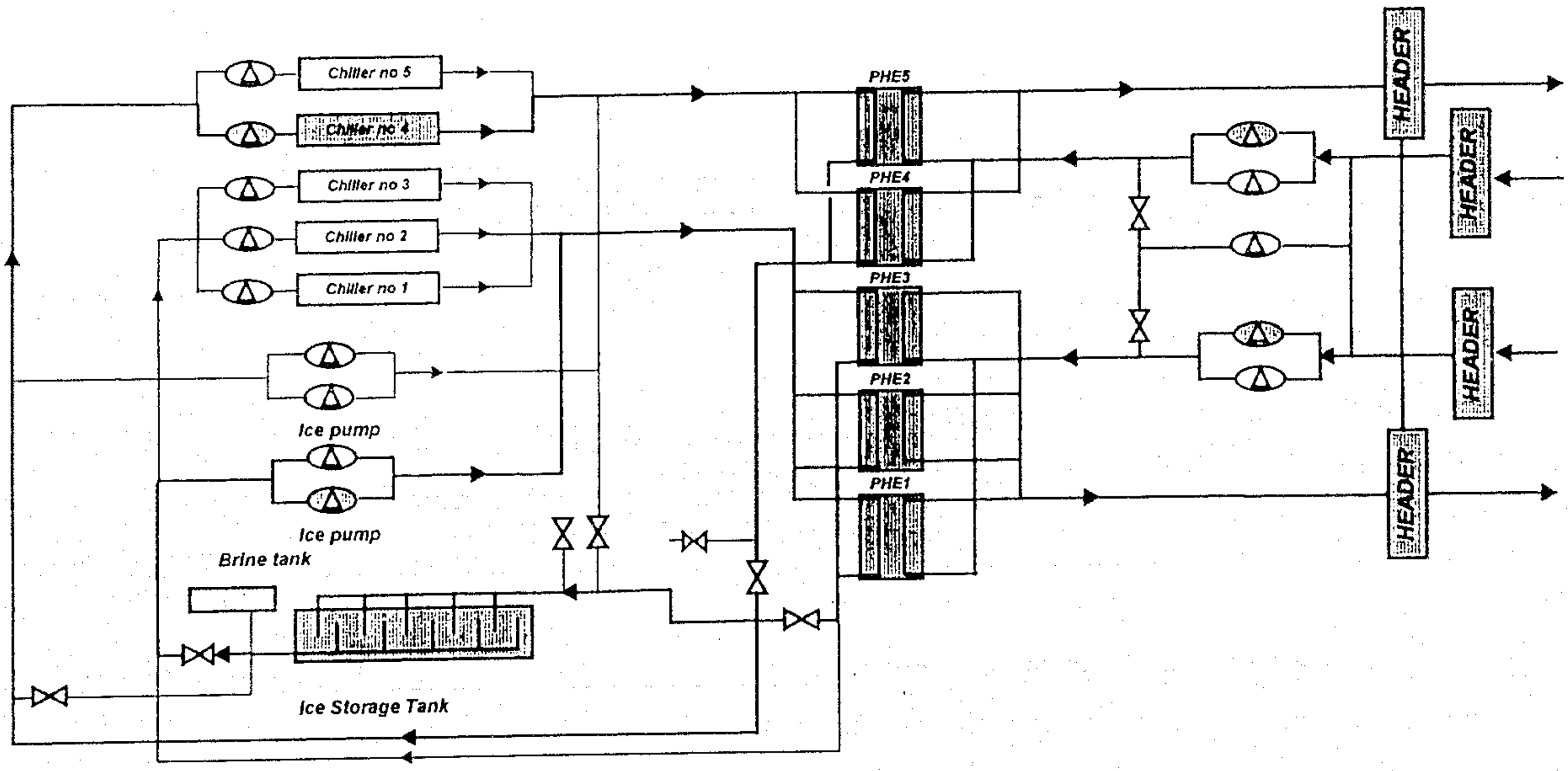


Figure 10-31 Brine / Chilled Water Loop (Daytime Operation)

Table 10-8 Temperature Pattern of Chiller in and out

Primary Chilled Water

	Temperature														Flow	
	Chiller No.5		Chiller No.4		Chiller No.3		Chiller No.2		Chiller No.1		Chiller 1/2/3		Chiller 4/5		Chiller 4/5	Ice Storege
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	Out	Out
1630	31.3	30.8	44.3	37.9	31.2	29.7	31.6	29.7	42.5	36.7	33.95	45.28	38.14	40.23	990	0
1700	31.4	31.2	44.5	38	31.3	30	31.7	30	42.6	37	34.26	45.48	38.08	40.24	975	0
1730	31.4	31.4	44.7	38.3	31.5	30.3	31.8	30.2	42.7	37.2	34.29	45.67	38.09	40.53	987	0
1800	31.8	31.6	45	38.5	31.7	30.5	32	30.5	42.9	37.5	34.89	46.11	38.55	40.75	991	0
1830	32.1	31.8	44.8	38.4	31.8	30.7	32.1	30.7	43	37.7	35.07	45.86	38.82	40.66	996	0
1900	32.4	32	45.3	39.5	32	31	32.4	30.8	43.2	37.9	35.16	46.3	39.55	41.92	975	0
1930	32.7	32.3	45.4	39.5	32.3	31.2	32.7	31.2	43.3	38.1	35.57	46.45	40.48	41.97	969	0
2000	33	32.5	45.5	39.6	32.5	31.3	33.1	31.3	43.5	38.4	36.96	46.47	41.54	42.13	983	0
2030	33.2	32.8	45	38.5	32.7	31.4	33.4	31.5	43.6	38.6	38.1	46.04	42.56	40.74	971	0
2100	33.5	33.1	45.6	39.1	33	31.7	33.8	31.7	41.2	36.6	41.41	46.65	39.29	41.29	970	0
2130	33.8	33.4	44.2	37.9	33.1	31.8	34.1	31.8	41.5	36.2	41.82	45.16	38.72	40.17	981	0
2200	34.1	33.8	41.4	36	33.4	32	34.3	32	41.7	37	41.91	42.23	38.99	38.4	970	0
2230	34.3	34.1	41.2	36.2	37.3	31.7	37.5	31.9	41.5	41.2	37.45	42.1	48.5	38.55	946	0
2300	34.7	34.4	40.6	35.8	33.8	29.1	34.2	29.4	41.8	38.1	33.8	41.46	48.97	37.85	995	0
2330	34.9	34.8	40.1	35.8	31.8	27.3	32.1	27.4	42.1	36.2	31.72	40.91	48.18	38.13	984	0
2400	35.2	35.1	39.8	38.6	30.8	26.7	30.1	26	42.3	35	30.06	46.74	40.7	38.3	0	0
30	28.7	25.2	41.1	40.7	28.8	24.9	28.8	24.8	42.5	34.2	28.7	45.32	29.3	46.3	1508	0
100	28.3	24.3	28.5	23.6	28.3	24	28.5	24	42.8	33.3	28.42	44.06	29.02	45.61	1488	0
130	28.6	24.6	28.8	23.8	28.8	24.3	28.8	24.2	43	32.9	28.68	42.8	29.31	44.04	1514	0
200	28.5	24.6	28.6	23.7	28.8	24.4	28.7	24.2	43.1	32.6	28.68	42.04	29.16	42.67	1506	0
230	28.4	24.3	28.5	23.6	28.7	24.3	28.5	23.9	43.1	32.5	28.37	41.27	29.04	41.6	1519	0
300	28.3	24.2	28.3	23.5	28.5	24.2	28.4	23.8	43.2	32.3	28.29	40.86	28.84	40.56	1519	0
330	28.1	24.1	28.2	23.2	28.5	24.1	28.2	23.7	43.2	32.1	28.09	40.48	28.68	39.69	1487	0
400	27.8	23.8	27.9	23	28.3	23.9	28	23.3	43.2	32	27.86	40.07	28.4	39.27	1499	0
430	27.6	23.6	27.6	22.7	28	23.7	27.7	23.2	43.1	31.7	27.57	39.64	28.11	38.83	1514	0
500	27.2	23.3	27.3	22.5	27.7	23.5	27.3	23	43	31.5	27.17	39.3	27.7	38.12	1499	0
530	26.6	22.8	26.7	22	27.3	23.2	26.7	22.4	42.9	31.2	26.6	38.95	27.14	38.11	1493	0
600	25.9	22.2	25.9	21.5	26.8	22.8	26	22	42.7	30.8	25.87	38.53	26.39	37.71	1525	0
630	25.6	25.8	25.7	21.7	26.4	22.4	25.8	22	42.5	30.4	25.59	38.33	26.17	37.35	886	0
700	26.1	25.2	24.9	21.2	25.6	21.9	25	21.4	42.4	30.3	24.7	38.04	25.39	37.08	878	0
730	26.5	24.7	25.4	25.2	25.2	21.8	25.8	22.3	42.2	30.3	25.63	37.71	27.16	36.72	0	0
800	26.6	25.4	25.9	25.5	25.3	22	25.7	21.6	42	30.3	37.21	27.25	36.21	36.21	0	0
830	25.4	25.5	25.5	25.3	24.7	21.4	25.2	21.4	41.7	30.1	24.41	37.21	26.76	36.23	0	0
900	26	25.8	58.5	48.3	26	26	26.4	22.7	41.6	30	25.76	36.36	59.74	53.19	989	0
930	26.5	26.1	50.5	43.2	26.1	26.2	27.7	26.4	42	33.1	26.81	37.4	51.44	45.64	989	0
1000	27	26.4	49.8	42.6	26.5	26.4	27.9	26.7	41.9	32.7	27.23	37.68	50.91	44.85	1004	0
1030	27.3	26.8	43.9	37.7	27.1	26.7	28.2	27	41.6	32.7	30.38	34.13	44.88	39.64	1008	0
1100	27.8	27.1	44.6	38.3	27.5	27	28.6	27.1	41.4	32.8	30.99	34.3	45.54	40.12	992	0
1130	28.2	27.5	44.9	38.5	27.9	27.1	28.9	27.3	41.3	33	30.99	34.57	45.82	40.56	981	0
1200	28.6	27.8	44.7	38.3	28.2	27.3	29.2	27.7	41.2	33.3	31.67	34.82	45.64	40.32	968	0
1230	28.9	28.2	44.7	38.3	28.6	27.7	29.6	27.8	41.2	33.7	31.84	34.97	45.69	40.25	984	0
1300	29.3	28.5	44.6	38.2	29	27.9	29.9	28.1	41.2	34.2	32.23	35.14	45.62	40.17	992	0
1330	29.6	28.8	44.7	38.4	29.3	28.2	30.2	28.3	41.3	34.7	32.63	35.43	45.84	40.39	0	0
1400	29.9	29.2	44.7	38.4	29.7	28.5	30.5	28.6	41.3	35	32.76	35.67	45.81	40.38	0	0
1430	30.2	29.5	44.5	38.2	30	28.6	30.7	28.9	41.4	35.3	32.96	35.95	45.5	40.16	0	0
1500	30.5	29.7	44.3	38.1	30.3	28.9	31	29.2	41.5	35.6	32.97	37.25	45.35	40.13	0	0
1530	30.7	30.1	44.5	38.2	30.5	29.2	31.3	29.4	41.7	35.9	33.24	37.42	45.38	40.19	0	0
1600	31	30.3	44.5	38.2	30.7	29.5	31.4	29.7	41.8	36.1	34.91	37.54	45.48	40.21	0	0

	Primary Chilled Water						Secondary Chilled Water								Condensing Water		
	Temperature						Temperature						Tons		Temperature		Flow
	Ice Storage Tank						PHE 1/2/3			PHE 4/5			PHE 1/2/3	PHE 4/5	Cooling Tower		
	Out	In (1)	In (2)	In (3)	In (4)	In (5)	In	Out	Main	In	Out	Main	In	Out	In	Out	Out
1630	34.71	50.58	50.71	50.84	49.36	50.08	52.13	47.45	0	50.79	45.03	44.46	0	0	0	0	0
1700	34.8	50.65	50.8	50.95	49.45	50.1	52.24	47.56	0	51.11	45	44.55	0	0	0	0	0
1730	35.34	50.39	50.53	50.69	49.23	49.92	52.26	47.01	0	51.04	45.38	44.25	0	0	0	0	0
1800	35.94	50.42	50.56	50.76	49.31	49.95	52.42	46.67	0	51.58	45.49	44.42	0	0	0	0	0
1830	36.58	50.19	50.33	50.47	49.15	49.79	52.19	46.32	0	51.13	45.49	44.19	0	0	0	0	0
1900	37.8	49.6	49.68	49.82	48.64	49.25	52	45.35	0	51.05	46.26	44.06	0	0	0	0	0
1930	38.9	49.52	49.65	49.82	48.64	49.32	52.04	45.42	0	51.27	46.17	44.21	0	0	0	0	0
2000	40.02	49.98	50.11	50.3	49.18	49.83	52.41	46	0	51.33	46.34	44.67	0	0	0	0	0
2030	41.11	50.4	50.54	50.7	49.6	50.25	52.63	46.75	0	51.58	45.82	44.85	0	0	0	0	0
2100	41.64	50.31	50.31	50.47	49.42	50.04	52.55	46.92	0	52.31	46.11	44.18	0	0	0	0	0
2130	41.98	48.97	49.05	49.24	48.01	48.68	51.23	44.83	0	50.27	44.84	43.12	0	0	0	0	0
2200	42.21	43.79	43.48	43.67	43.21	43.68	44.28	43.3	0	46.21	44.12	40.67	0	0	0	0	0
2230	37.6	32.88	32.83	32.99	32.51	33.13	45.27	46.06	0	46.14	41.88	42.62	0	0	0	0	0
2300	34.07	30	30.05	30.22	29.59	30.29	44.59	45.76	0	45.3	41.51	42.07	0	0	0	0	0
2330	31.98	28.26	28.26	28.39	27.83	28.53	43.87	44.92	0	44.16	41.1	41.57	0	0	0	0	0
2400	30.21	26.83	26.91	27.11	26.47	27.24	42.98	44.18	0	43.59	40.95	41.15	0	0	0	0	0
30	29	26	26.06	25.74	25.1	25.81	46.93	46.82	0	47.08	46.78	46.64	0	0	0	0	0
100	28.68	24.91	25.01	25.05	24.28	25.03	50.42	50.43	0	50.53	50.54	50.14	0	0	0	0	0
130	29.03	25.09	25.21	25.24	24.43	25.16	53.33	53.5	0	53.42	53.57	53.06	0	0	0	0	0
200	28.88	25.03	25.13	25.14	24.38	25.13	55.78	56.13	0	55.32	56.1	55.28	0	0	0	0	0
230	28.71	24.78	24.93	24.98	24.15	24.95	57.47	58.02	0	57.07	57.71	57.01	0	0	0	0	0
300	28.57	24.68	24.79	24.88	24.09	24.87	59.08	59.52	0	58.78	59.2	58.51	0	0	0	0	0
330	28.34	24.52	24.59	24.62	23.88	24.57	60.43	60.88	0	60.09	60.5	59.78	0	0	0	0	0
400	28.13	24.24	24.33	24.35	23.57	24.32	61.66	62.2	0	61.36	61.87	61.04	0	0	0	0	0
430	27.83	23.99	24.09	24.09	23.3	24.06	62.82	63.4	0	62.5	63.13	62.17	0	0	0	0	0
500	27.42	23.7	23.81	23.87	23.08	23.79	63.92	64.55	0	63.6	64.26	63.24	0	0	0	0	0
530	26.88	23.22	23.36	23.37	22.58	23.31	65	65.63	0	64.61	65.35	64.29	0	0	0	0	0
600	26.07	22.71	22.82	22.83	22	22.76	65.95	66.65	0	65.66	66.37	65.2	0	0	0	0	0
630	25.91	22.47	22.57	22.93	22.16	22.96	66.86	67.58	0	66.51	67.34	66.16	0	0	0	0	0
700	25.05	21.99	22.02	22.24	21.5	22.26	67.72	68.44	0	67.35	68.21	67.05	0	0	0	0	0
730	25.86	23	23.05	23.23	22.53	23.3	68.56	69.35	0	68.23	69.1	67.92	0	0	0	0	0
800	25.26	22.49	22.84	22.77	22.05	22.79	67.84	70.25	0	61.13	70.01	64.72	0	0	0	0	0
830	24.59	21.99	22.09	22.3	21.57	22.3	66.76	67.48	0	66.43	67.24	66.33	0	0	0	0	0
900	26	23.61	24.78	25.08	23.39	24.77	63.82	68.78	0	64.81	60.59	60.2	0	0	0	0	0
930	26.75	26.92	27.27	27.51	26.78	27.65	59.04	59.64	0	56.98	51.27	53.46	0	0	0	0	0
1000	27.26	27.18	27.72	27.73	26.97	28.07	61.17	61.36	0	56.93	49.53	55.23	0	0	0	0	0
1030	32.29	51.23	51.39	51.57	49.86	50.54	52.48	48.29	0	50.2	44.09	44.92	0	0	0	0	0
1100	32.55	50.53	50.69	50.88	49.11	49.74	52.01	47.73	0	51.21	44.67	44.67	0	0	0	0	0
1130	32.96	50.53	50.67	50.78	49.15	49.84	52.26	47.19	0	51.14	45.28	44.31	0	0	0	0	0
1200	33.18	50.63	50.74	50.85	49.29	49.98	52.36	47.39	0	50.98	45.23	44.21	0	0	0	0	0
1230	33.39	50.69	50.81	50.99	49.38	50.04	52.45	47.36	0	51.24	45.02	44.42	0	0	0	0	0
1300	33.57	50.71	50.78	50.93	49.29	50	52.41	47.24	0	50.89	44.96	44.4	0	0	0	0	0
1330	33.81	50.57	50.74	50.87	49.33	49.96	52.4	47.18	0	51.35	45.3	44.35	0	0	0	0	0
1400	34.08	50.59	50.71	50.87	49.28	49.96	52.33	46.92	0	51.24	45.03	44.35	0	0	0	0	1054
1430	34.37	50.56	50.61	50.77	49.27	49.94	52.27	47.06	0	50.79	45.17	44.29	0	0	0	0	1173
1500	35.94	49.4	49.49	49.64	48.31	49	51.94	44.68	0	50.58	45.18	43.99	0	0	0	0	1164
1530	35.96	49.5	49.63	49.74	48.35	49.06	51.83	45.08	0	50.83	45.06	44.1	0	0	0	0	1170
1600	36.06	49.7	49.81	49.98	48.6	49.29	52.07	45.27	0	50.91	44.99	44.23	0	0	0	0	1090

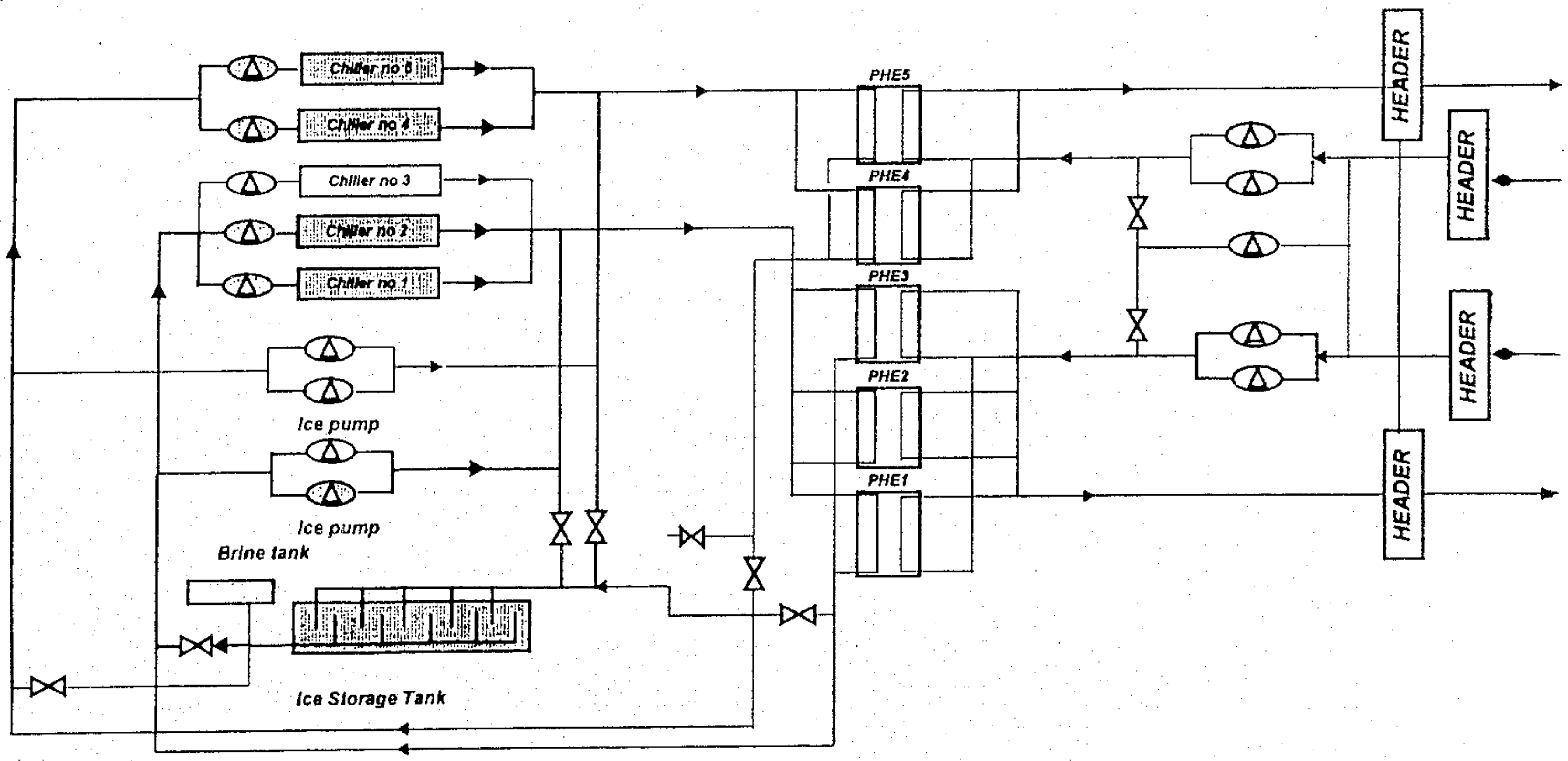


Figure 10-32 Brine / Chilled Water Loop (Nighttime Operation)

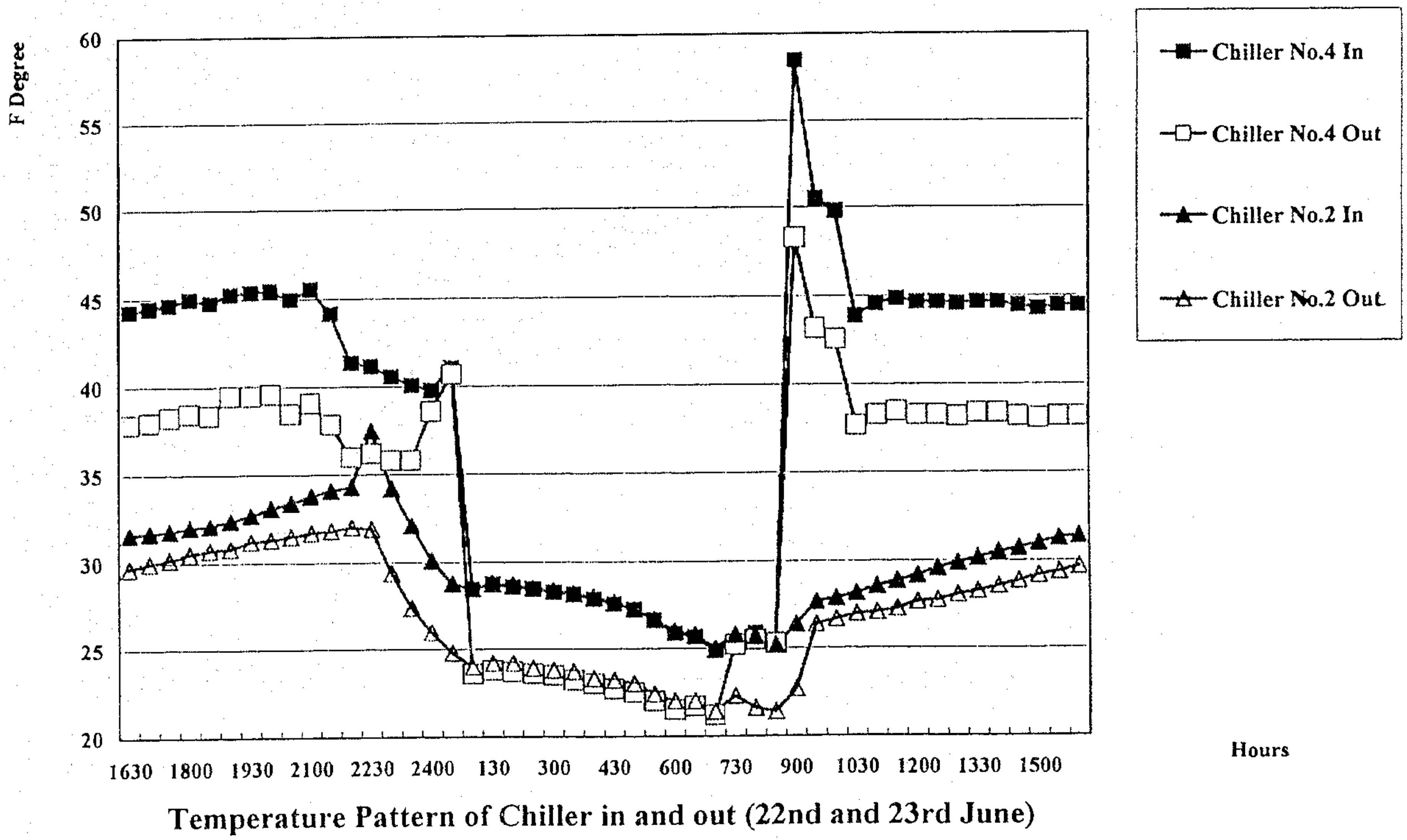


Figure 10-33 Temperature Pattern of Chiller in and out

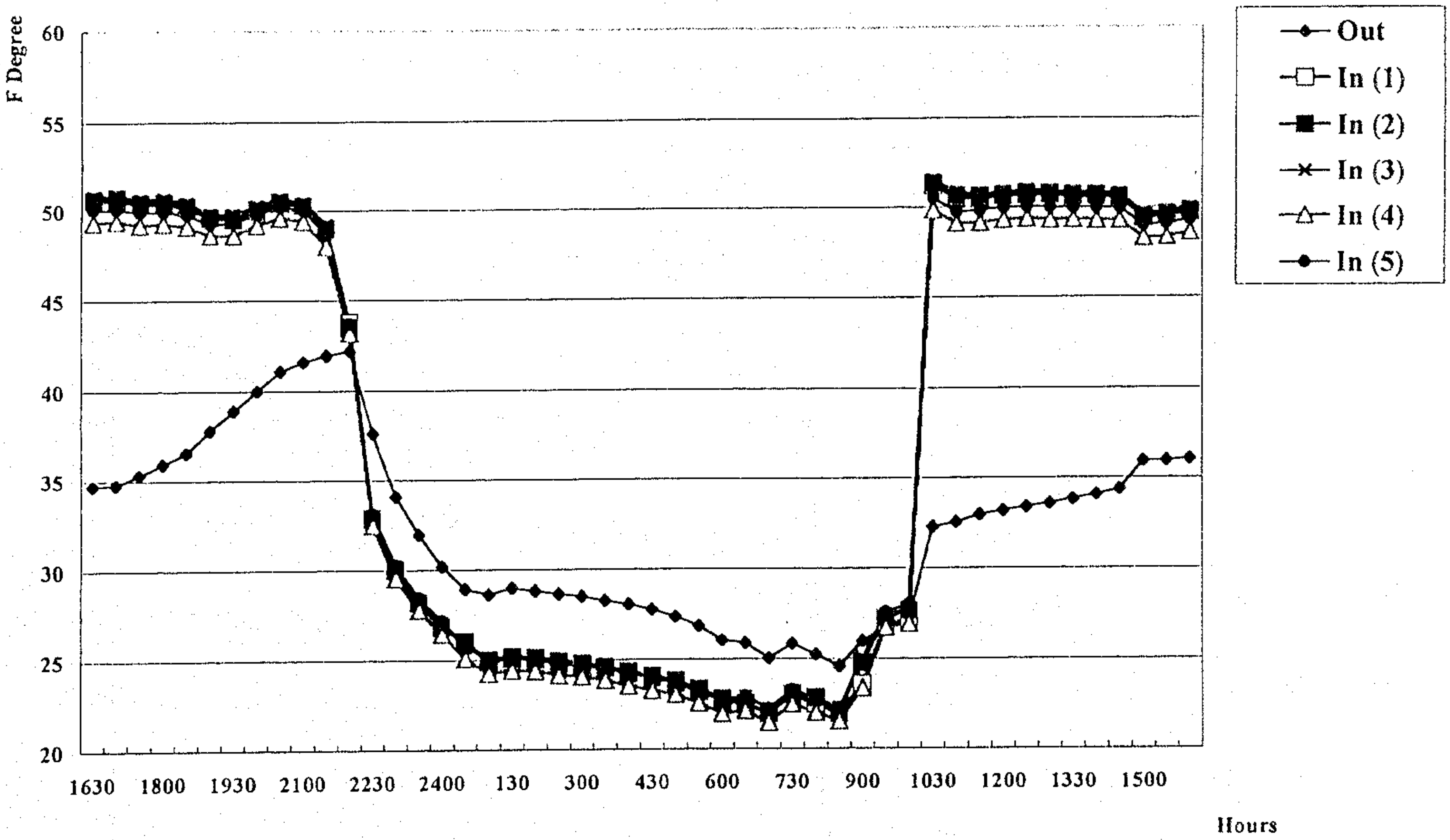


Figure 10-34 Temperature Pattern of Ice Storage

Table 10-9 Measured Flowrate and Temperature around Chillers

	Flow (Ton/Hour)							Temperature (F Degree)	
Date	6/19	6/20	6/21	6/22		6/23	6/24	6/20	
Item	Ice Storage	Ice Storage	Ice Storage	Chiller 4/5	Ice Storage	Chiller 4/5	Condense Water	Cooling tower in	Cooling tower out
800	0	2446	2507	0	1708	0	0	86.1	82.3
830	0	1678	1700	0	1700	0	0	83.7	82.3
900	0	1785	1786	0	1793	989	0	94.5	83.3
930	0	0	0	0	0	989	0	97.3	87.1
1000	0	0	0	0	0	1004	0	97.7	87
1030	0	909	980	983	0	1008	0	96.8	87.5
1100	0	678	633	973	0	992	0	96	86.9
1130	0	694	697	986	0	981	0	96.4	87.2
1200	0	757	688	996	0	968	0	96.7	87.6
1230	0	825	755	990	0	984	0	96.4	87.3
1300	0	832	719	984	0	992	0	96.5	87.3
1330	798	804	766	996	0	0	0	96.8	87.5
1400	806	841	861	973	0	0	1054	96.6	87.5
1430	880	896	844	963	0	0	1173	97.1	87.9
1500	924	962	929	986	0	0	1164	97.7	88.5
1530	846	989	911	998	0	0	1170	97.3	88.3
1600	908	966	842	990	0	0	1090	97.3	88.2
1630	883	1010	864	990	0	0	1193	97.3	88.3
1700	1013	1031	857	975	0	0	1082	97.3	88.2
1730	1078	1123	1065	987	0	0	1096	97.7	88.3
1800	1117	1095	1097	991	0	0	1076	97.8	88.3
1830	1133	1096	1098	996	0	0	1190	98	88.5
1900	1130	1075	911	975	0	0	1205	98	88.4
1930	912	934	913	969	0	0	1211	97.7	88.4
2000	924	886	942	983	0	0	1073	97.3	88.3
2030	920	894	908	971	0	0	1188	97.1	88.1
2100	919	926	928	970	0	0	1170	97.5	88.3
2130	940	915	926	981	0	0	1028	97	88
2200	924	917	947	970	0	0	1121	96.7	87.6
2230	948	914	1755	946	0	0	1099	96.1	87.3
2300	1800	1783	1746	995	0	0	978	92.4	85.7
2330	1765	1737	1739	984	0	0	1208	89.6	84.1
2400	1745	1789	1782	0	0	0	751	86.3	83.9
30	1770	1757	2446	1508	0	0	941	86.4	84.1
100	1741	1772	2575	1488	0	0	1471	86.4	84.1
130	2477	2771	2575	1514	0	0	1400	85.8	81
200	2575	2493	2575	1506	0	0	1435	87	82.4
230	2575	2493	2575	1519	0	0	1446	87.5	82.8
300	2575	2493	2575	1519	0	0	1445	87.3	82.6
330	2575	2493	2575	1487	0	0	1437	87.3	82.7
400	2575	2493	2575	1499	0	0	1417	87.3	82.8
430	2575	2493	2575	1514	0	0	1428	86.8	82.2
500	2575	2493	2575	1499	0	0	1423	86.7	82.1
530	2575	2493	2575	1493	0	0	1418	86.6	82.1
600	2575	2493	2575	1525	0	0	1422	86.7	82.3
630	2575	2493	2575	886	0	0	1460	86.6	82.3
700	2575	2493	2466	878	0	0	1425	86	82
730	2458	2493	2450	0	0	0	512	81.4	81.5

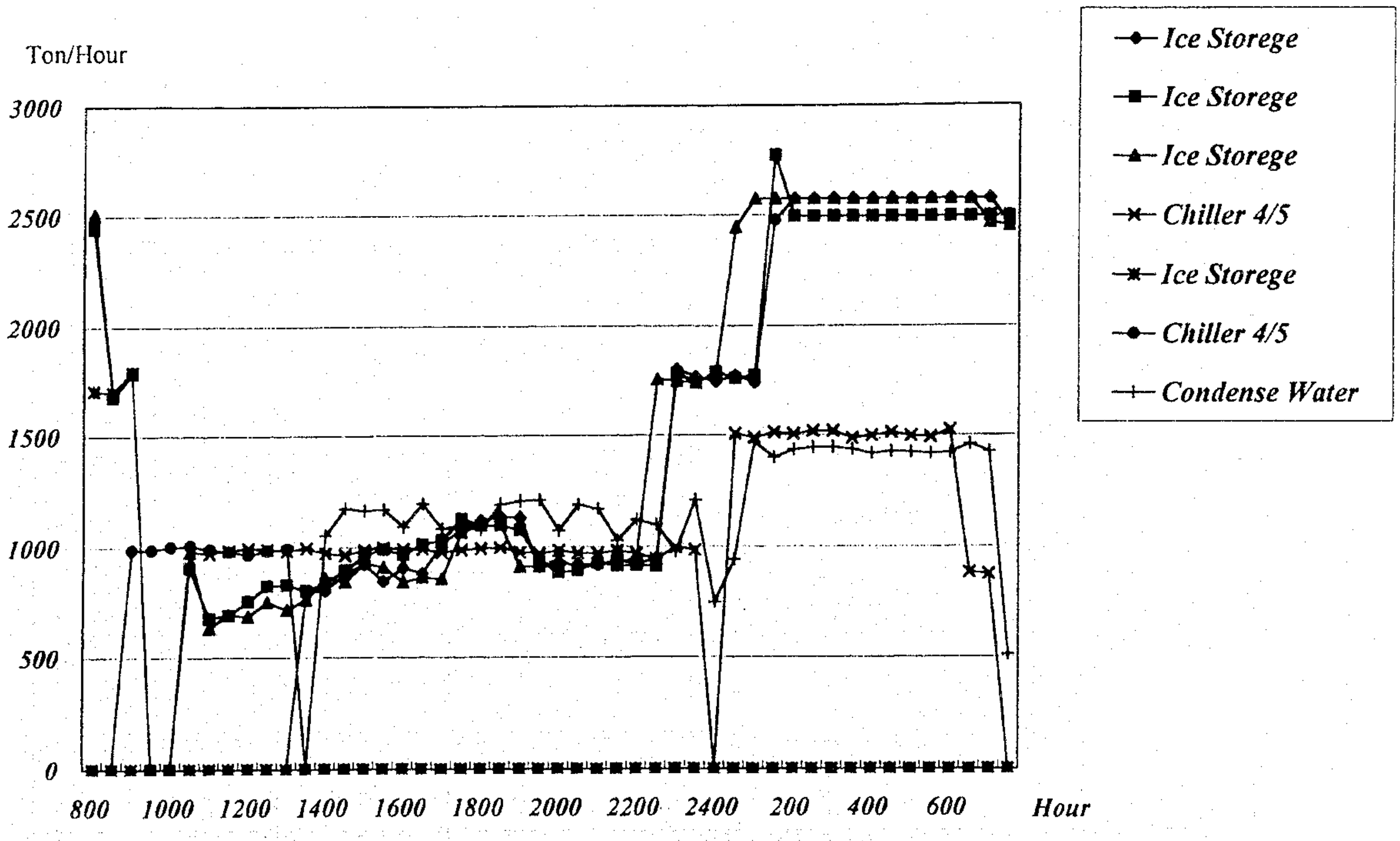


Figure 10-35 Flowrate around Chillers

Table 10-10 (Air Condition) Heat Loss from Entrance

No	Average Velocity * m/s	Temp Inside °C	Temp Outside °C	Width m	Height m	Area m^2	Comments	Heat Release Rate (kcal/hr)
1	1.086	21	30	1.7	2.05	3.485		38053
2	1.024	24	28	2	1.71	3.42		15649
3	-0.9	25	31	2.37	2.1	4.977	Auto Door 6 Sec	30024
4	-0.86	26	30	2.37	1.76	4.1712		16030
5	1.7	22	25	2.37	1.76	4.1712	Auto Door /Broken	23765
6	1.57	22	27	2.37	1.76	4.1712	Auto	36580
7	1.6	20	30	2.33	1.76	4.1008		73299
8	-0.84	20	30	2.34	1.73	4.0482	Auto/Broken	37989
9	1.8	22	28	1.8	2.1	3.78		45607
10	2	23	30	1.77	2.1	3.717		58134
11	1.46	23	30	0.86	2.1	1.806		20620
12	1.53	24	31	1.77	2.1	3.717		44473
20	1.35	24	28	0.9	2.34	2.106		12705
Total								452,928

* Note: Negative value of average velocity means out-going air flow.

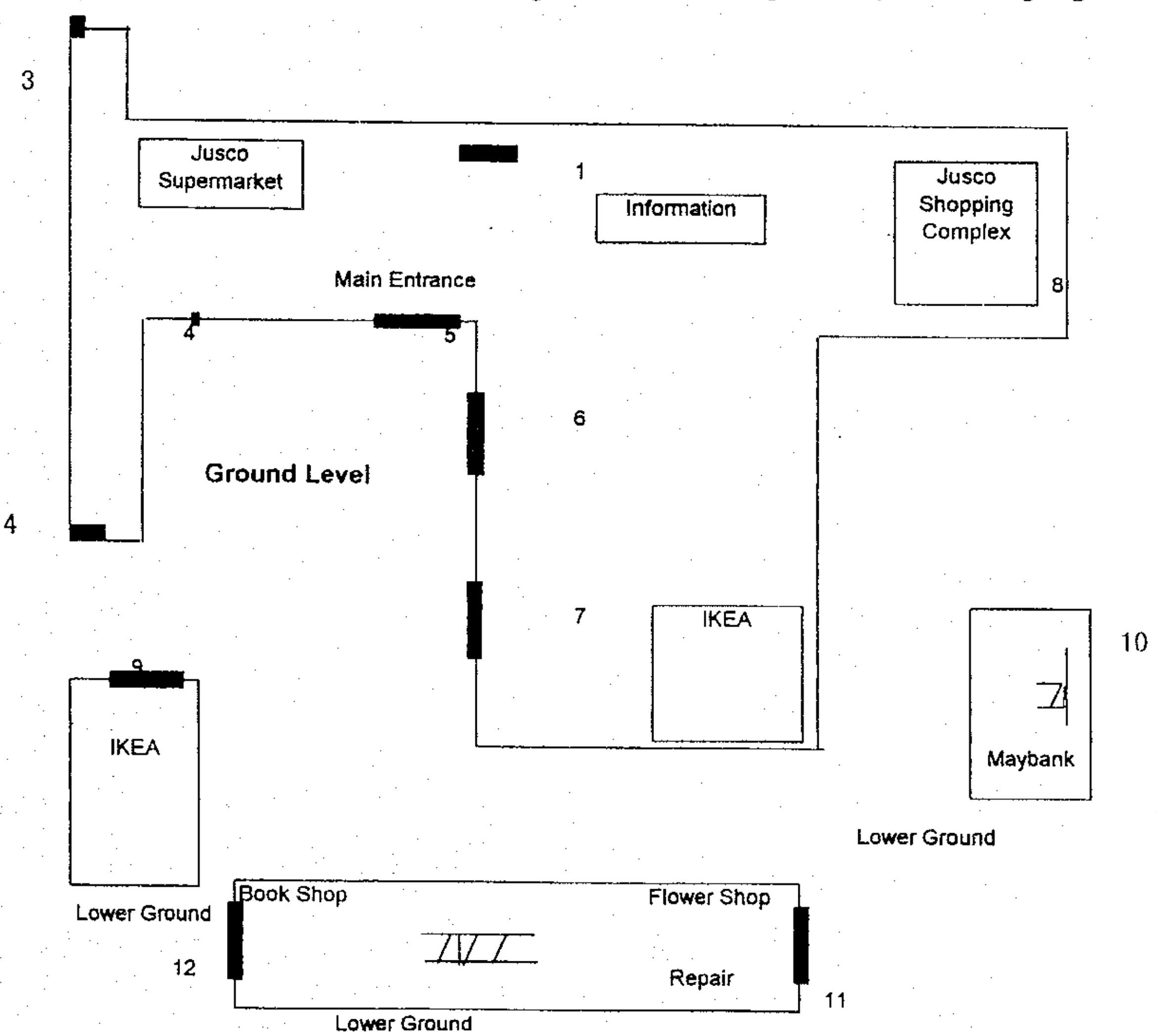


Figure 10-36 Measuring Points of Heat Loss

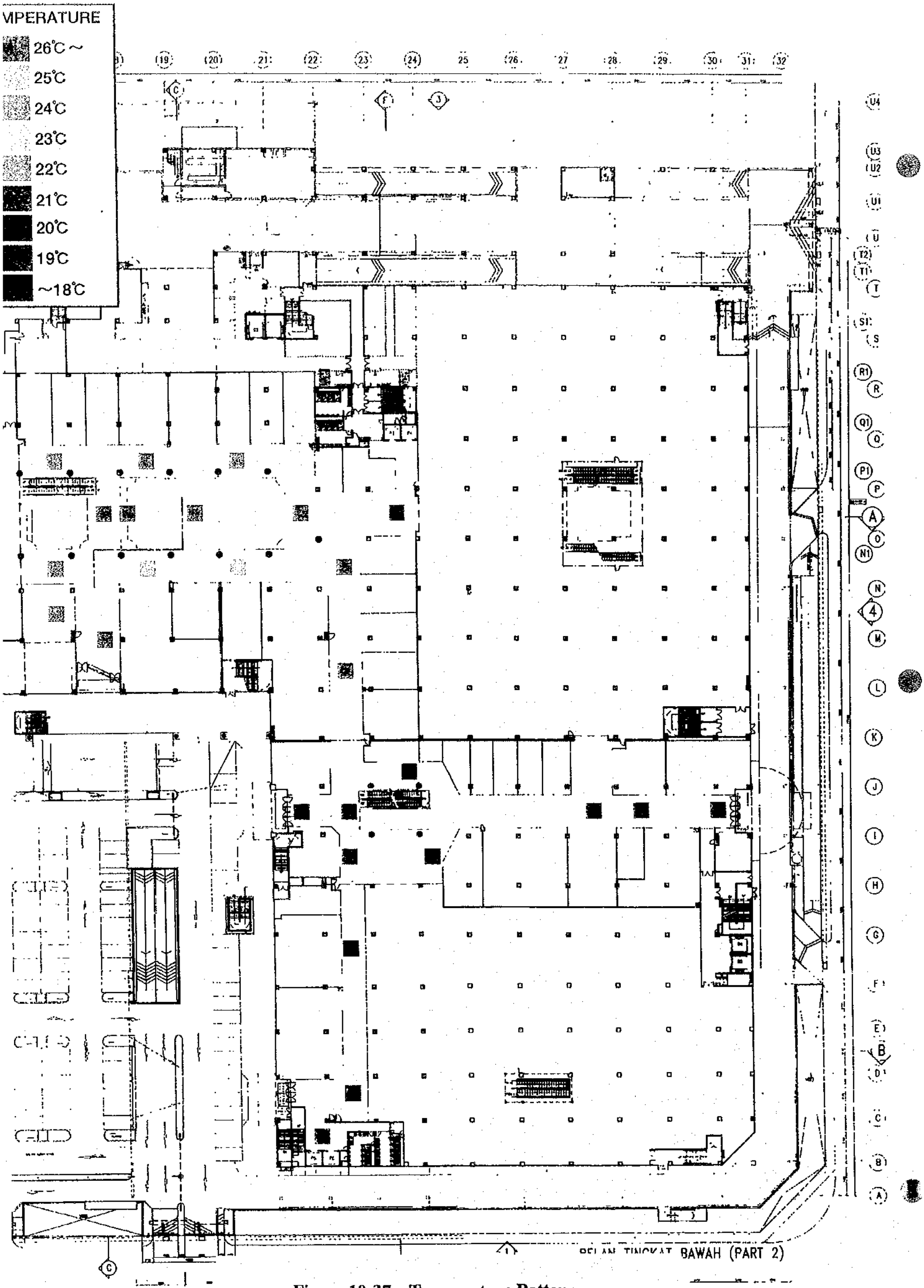


Figure 10-37 Temperature Pattern

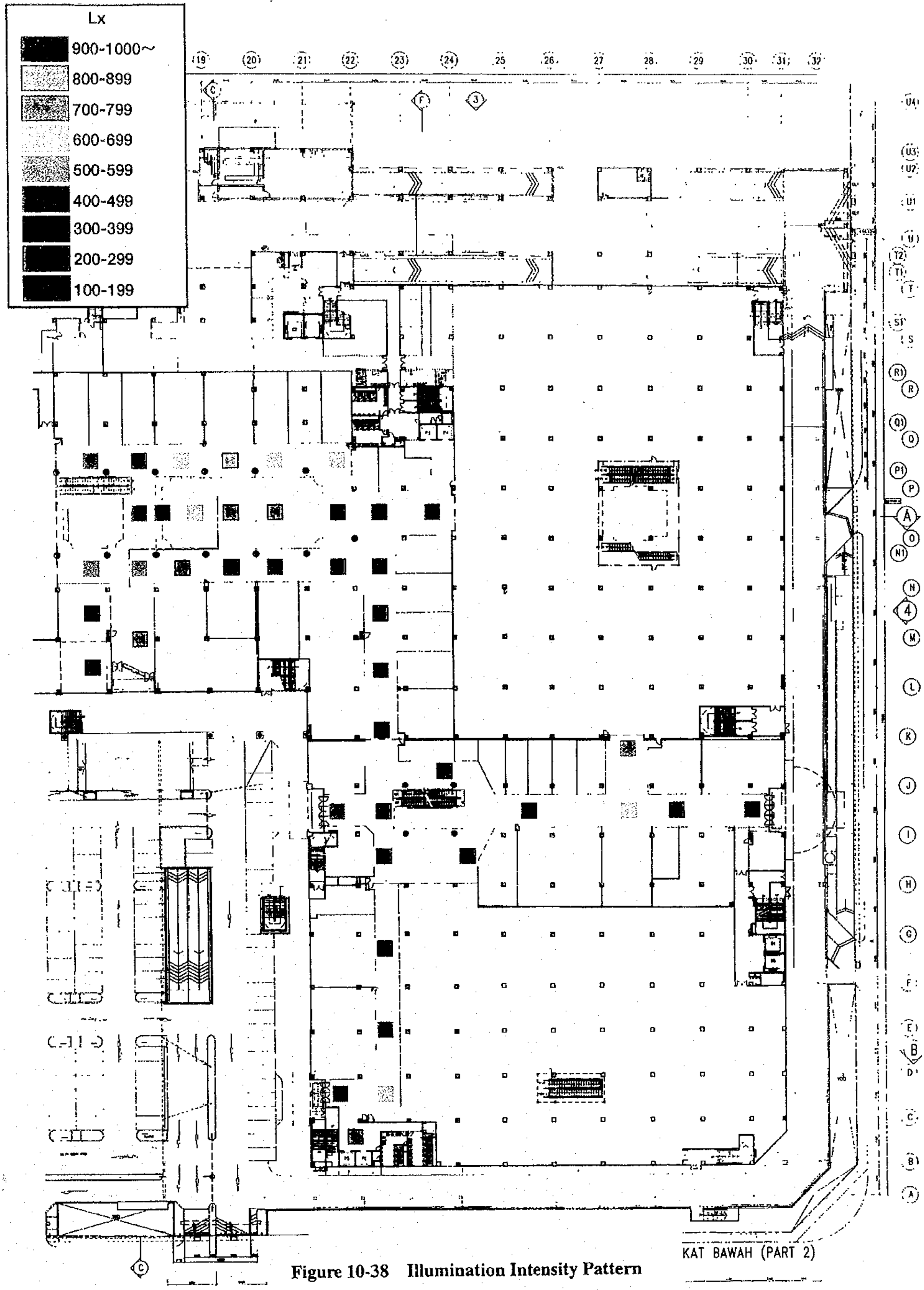


Figure 10-38 Illumination Intensity Pattern

10-9 Energy Efficiency Promotion Checklist

Using a checklist of 101 energy efficiency promotion items, we found the following list of energy efficiency promotion items in this shopping complex.

10-9-1 Architectural Structure

(1) Installation of Blinds and Curtains

Around the back side of the building (service and office area), some windows have no blinds or curtains to shelter the rooms from sunshine.

(2) Renovating Glass Windows (Thermic Ray Absorption, Adjusting Films)

To shelter the building from sunshine, renovating the glass windows by adopting thermic ray absorption films would also be effective.

(3) Repair to Slits Weathering on the Walls

Slits and weathering causing air leakage should be repaired or renovated.

10-9-2 Renovation and Expansion of Facilities

(1) Air Conditioning

(a) Overall Air Heat Exchanger (Exhaust Air/Intake Air)

At present, fresh air to the building comes mainly from the entrances of the building.

The concentration of carbon dioxide in the building shows around 200 ppm, far below the maximum allowable contents of 1000 ppm. Therefore, it is not necessary to increase the intake air volume by opening the air damper of the air transferring room. And return air of the air conditioning system is reclycled to the air blower suction, providing the most effective method of energy efficiency promotion (direct use of cold energy).

However, in future when the occupancy rate and number of customers increase, the installation of an overall air heat exchanger is highly recommended.

The ratio of intake air to reclycle air should be adjusted by the concentration of carbon dioxide.

(b) Renovation of Regenerative System

This measure is being studied in detail as a recommended improvement.

(c) Alternation of Energy Source, Heat Source and Heat Sink

In this shopping complex, electricity is the main energy source. But in future, if LPG becomes available it is useful to study the adoption of a co-generation system.

(d) Adoption of Variable Air Volume (VAV) System / Variable Water Volume (VWV) System

This system (VAV) is already adoped in part. However the installation of an additional VAV system would be more effective when some energy efficiency promotion measures are adopted.

(e) Review of Zoning Conditions and Increasing Number of Zones

This shopping complex has quite a sophisticated and well designed air-conditioning system. However, the control of temperature is conducted by manual adjustment of air dampers at end users. Consequently, the temperature pattern in the building shows quite uneven data. This measure does not need big investment, but would be quite effective.

We studied this in detail in the following section.

(f) Prevention of Draft by Adjustment of Room Pressure

Room pressure of the building depends on the discharge pressure of air blowers and the air tightness of the building. In this building, air flows from the main entrance to back entrance quite freely. After under taking some steps, re-measurement should be conducted to avoid unnecessary high pressure. A large pressure defference between outside and inside the building causes a waste of energy.

(2) Lighting System

(a) The illumination intensity of the building shows quite eneven values. This is one of the items listed in this report for detailed study.

(b) Introduction of Power Factor Control System

The power factor of No.2 incoming supply shows a very low value. The cause of this low power factor is from the low operation load of chiller.

The introduction of a power factor control system would probably be an effective improvement. But in this study, the ice storage system was renovated.

10-9-3 Operation, Maitainance Management, Living Style and others (Air Conditioning)

(a) Reduction of Suction Air Volume during Air-conditioning

Judging from the carbon dioxide concentration and room temperature of the building, it is possible to decrease the suction air from the entrances.

This measure is one effective method for energy efficiency promotion.

(b) Adjustment of Suction Air Volume according to CO_2 Content

This is another effective method, together with the installation of a carbon dioxide detector.

(c) Introduction of Automatic Control for Air-conditioning

The operation of the air-conditioning system is conducted by computer-control, installed in the control room of Bandar Utama City Corporation. However the shopping complex itself is unter the management of JASCO. The information exchange between JASCO and Bandar Utama City Corporation appears to be in sufficient to achieve the common target of attaining higher energy efficiency. Before the introduction of an automatic control system for air-conditioning, some rules should be established between both parties to enable mutual enjoyment of cost reductions by higher energy efficiency.

(d) Other Recommended Items

Inspection & Repair of Air-leakage in the Ducts
Cleaning of Coils & Filters of Air-conditioner
Clean Condensers & Evaporators of Chillers
Reinforcement of Monitoring System by Increasing Measuring Equipment
Clean Lighting Appliances and Replacement of Old Lamps
Increase Lighting Efficiency by Cleaning Inner Surfaces of Rooms
Extinguishing Lights Around Windows
Regular opening/closing of Blinds
Reliable closing of Front & Stair well Doors
Frequent opening/closing of Windows
Publication and Request to residents for Energy Efficiency Promotion

10-10 Results of Energy Audit

10-10-1 Electrical Power Receiving and Distribution

The single line diagram and distributing network are shown in Figures 10-7 and 10-8 in Section 10-8.

(1) Demand Ratio of Transformers

Table 10-11 Demand Ratio of Transformers

(Maximum Electricity / Facility Capacity × 100)

Name of Transformer	Capacity MVA	Max. EL MVA	Demand Ratio %
T11-1	15	6.3	42.0
T11-2	15	5.4	36.0
T3-1(TX-1)	5	1.737	34.7
T3-2(TX-2)	5	4.018	80.4*
T1	2	1.736	86.8*
T3	2	1.768	88.8*
UC-T4(Ring Feeder 2B)	1.5	1.535	102.3*
UC-T3	1.5		
UC-T2	2		
UC-T1	2	3.148	157.4*

The Demand Ratio of Electricity should be kept at around sixty percent (60%) to achieve high energy efficiency.

(2) Electric Power Balance

During the day time, Ring Feeder 2B and Nationwide Plaza of the No.1 System consume a considerable amount of electricity. Ring Feeder 1A of the No.2 System also consumes a large amount. Electricity to Chiller No.1/3/5 is only used during night time. Accordingly, the load of No.1 System is bigger than that of No.2 System.

(3) Incoming Voltage

The incoming voltage constantly exceeds 33 kV. The highest value shows 34.35 kV (104.1 %) at night during the measurement period. Higher incoming voltage, which makes the voltage of the downstream side higher, will cause the following effects.

Electricity consumption increase in resistance load (fluorescent light) and rotation load (motor).

Reduction in the life span of fluorescent lights (for example).

(4) Frequency

The stability of electricity frequency depends mainly on the supplier's conditions. The deviation of frequency was within the allowable range between 49.5 and 50.5 V during almost all the measurement period; however it sometimes shot up to 49 to 51 V instantaneously. The rise and fall of the electricity's frequency leads to the electricity loss of rotating machines (lowers the efficiency).

(5) Electricity Consumption Trend

The difference in electricity consumption between day and night is as follows.

No.1 System: 3.2/5.5 kWh=58%

No.2 System: 1/2.5 kWh=40%

(6) Power Factor

The incoming supply No.1 is of a reasonable value, at over 0.85. The incoming supply No.2 is between 0.5 to 0.6, which is regarded as too low.

10-10-2 Air-conditioning System

(1) Chillers

The following is the simplified energy balance around the chiller system.

a) Number of chillers: 5

b) Capacity of chillers: AHU utilization 1000RT(Refrigeration Ton) / unit (high temperature)

Ice making 700RT/unit (low temperature)

(Electricity consumption: 1,000kw/Unit)

c) Daytime operation (14 hours):

One unit operation 1,000RT/Hours × 10Hours=10,000RT

Utilization of stored ice 4 × 700RT × 10Hours=28,000RT

Total 38,000 RT/day required

d) Ice making operation (10 hours):

4 × 700RT × 10Hours=28,000RT

Capacity of ice tank: around 5,000 to 6,000 (×5=25,000 to 30,000)

(2) **Cooling Towers**

There are six cooling towers in the chiller circuits. The number of operating towers changes depending on the mode of operation by remote control, to achieve effective energy management. Judging from the appearance of cooling towers, there is no serious maintenance problem.

10-10-3 Lighting System and Air Conditions

The following tables show the illumination intensity and the room temperature of each floor.

Table 10-12 Illumination Intensity (Lx)

	Average	Max	Min
Ground	518	2168	129
First Floor	368	1580	89
Second Floor	496	1081	89

Table 10-13 Room Temperature (℃)

	Average	Max	Min
Ground	21.7	26	18
First Floor	21.4	23	19
Second Floor	22.5	24	19

a) Wind velocity is not a problem in most areas as it is below 0.5m/s.

b) As the average illumination intensity is a rather high value, a decreased value would contribute to considerable energy savings.

c) There are considerable differences in intensity between different areas.

d) Room temperature is rather low.

e) There are also big differences in temperature.

f) Front and back entrances are always open, which causes considerable heat loss.

10-11 Total Energy Balance of the Shopping Complex

Table 10-14 Total Energy Balance of the Shopping Complex

Energy Type	Utilization	Energy Consumption		Lake Side Building	
		Basic Unit	kcal / h*10^3	Basic Unit	kcal / h*10^3
Electricity	Chiller	4700 kWh/h	10575	490 kWh/h	1100
	Lighting	1870 kWh/h	4207	520 kWh/h	1170
	Lifts	300 kWh/h	675		
	Others	200 kWh/h	450		
LPG	Cooking	2.86 m^3/h	68	3.01 m^3/h	71
City Water	Kitchens / Toilets	12.23 m^3/h	-	6.84 m^3/h	-
Total			15907		

Energy Calculation Rate : (EL) 2250 kcal / kWh, (LPG) 23,640 kcal / Nm^3

Energy Consumption Pattern and Maximum Demand :

Peak Consumption : 70%

Off-Peak Consumption : 30%

Maximum Demand : 9380 kW

a) Heat released from Cooling Tower

Total Condense Water: 24,700 Ton/Day

Temperature Difference: 3.78℃

Heat Transferred: 93,300$\times 10^3$ kcal/Day

b) Total Area of the shopping Complex: 191,751 m^2

c) Energy Consumption per Area: 1,990 kcal / m^2/Day

717$\times 10^3$ kcal / m^2/Year

Compared to Japanese energy consumption level, this shopping complex shows rather high value because of ice-storage system. (1996 Data of Japanese Department Store and Supermarket: 345 $\times 10^3$ kcal / m^2/Year)

Figure 10-39 illustrates energy flow of the shopping complex.

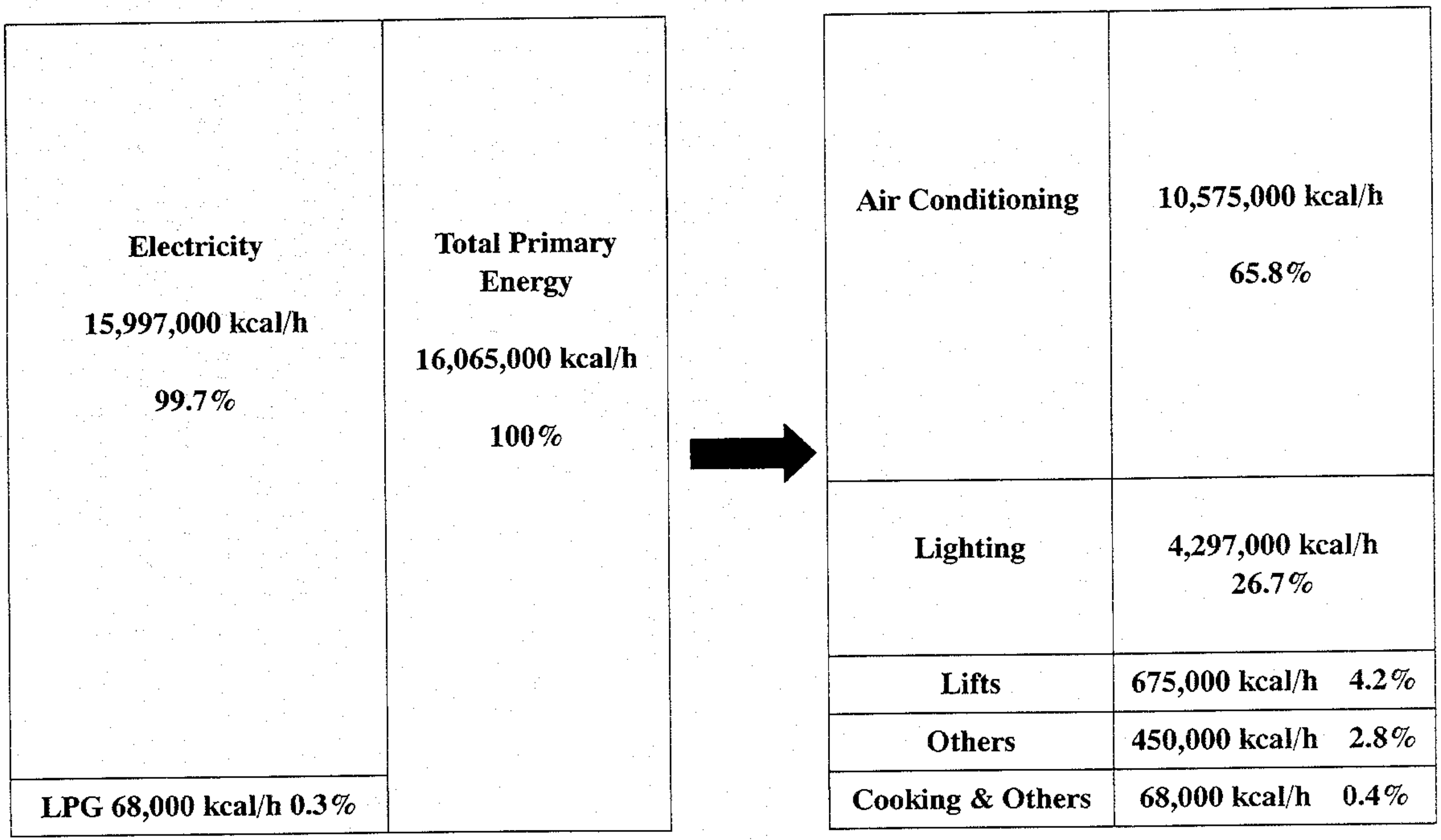


Figure 10-39 Energy Flow of Shopping Complex

10-12 Measures for Energy Efficiency Promotion

10-12-1 Improvement of Electric Power Receiving and Distribution

(1) Demand Ratio of Transformers

It is recommended that in order to adjust the allocation of electricity load to each transformer, the maximum demand ratio should be kept under eighty percent (80%).

(2) Electric Power Balance

As the transformers are operating at below capacity, load imbalance poses no serious problem for the time being. However, further increase in load requires a study of the electric power balance together with the efficiency of transformers in future.

(3) Incoming Voltage

Tap adjustment of the transformer or adoption of an automatic voltage controller is recommended.

(4) Frequency

There is no regulation regarding acceptable frequency deviation in Japan. But a Japanese power supplier would keep it between 49.8 and 50.2 Hz in the case of a 50 Hz region for example. It is recommended that the operating conditions be observed constantly as a measure.

(5) Electricity Consumption Trend

It is preferable to keep the value at around seventy percent (70%) by improving the ice storage system for example.

(6) Power Factor

The following measures should be taken to improve the low power factor up to 0.5 to 0.6.

a) Improve the operating method (including ice storage system), as the operating load is low judging from the power factor of 0.5 in the Chiller TX-1 circuit.

b) Most circuits except Ring Feeder No.1A show below 0.6. It is recommended that the uneven current of each phase be studied and the connection load adjusted.

c) In order to improve the power factor, it is necessary to review the condenser capacity and the automatic circuit of power factor adjustment.

10-12-2 Improvement of Air-conditioning System

(1) Chillers

Further energy savings could be attained by changing the current operating method to an improved one.

Present: one unit / daytime, four units / nighttime

Improved mode: zero unit / daytime, five units / nighttime

(No chiller operation during daytime)

This change could contribute to a reduction in the maximum demand and take advantage of the difference in electricity prices between night and day to the maximum extent. However, ice-making by the five chillers during night time will not be able to supply enough heat to the system, and additional ice-storage tanks will be required.

Unit operation for ice making:

700 × 5units × 10 Hours =35,000

A capacity increase of the chillers or an energy saving of 3,000 RT is required.

10,000 RT ice storage tanks are necessary.

From the above calculations, it is strongly recommended that new ice-storage tanks be installed by utilizing the existing spare tanks to the maximum. It is also recommended that a study be conducted on ice-storage expansion method tanks, since new effective energy-saving technology (energy regenerative system) is quite commonly used in Japan, such as plastic ice balls (latent heat storage).

To reduce the electricity consumption of pump motors, a variable water volume system (VWV) would be effective.

In Malaysia, the utilization of natural gas has become quite common and cost-effective. In the event of future expansion of this shopping complex, utilization of natural gas should be studied together with co-generation systems, absorption type chillers and so on.

The brine of this chiller system is ethylene glycols in water. And the concentration of ethylene glycols is 28% (35% is maximum concentration). Increasing the concentration of EG would lower the melting point and make the temperature difference greater. Consequently the chiller capacity could be increased.

(2) Air Handling Units

Maintenance of AHU is strongly recommended, especially for the leakage of ducts, cleaning of filters and removal of blocking materials. By careful maintenance of these, pressure drops through the system would decrease and electricity consumption could be saved together with air-quantity control. Installation of a heat exchanger for intake-air and recycling-air (overall type or partial exchangers) is recommended. Co-operation and collaboration between Bandar Utama City Corporation and JUSCO is essential to achieve effective energy use.

(3) Other Facilities

The building itself is quite new and built airtight. However, the following would further improve energy saving.

Install blinds and curtains (especially management area)
Renovate glass windows by adopting thermic ray absorption-adjusting film
Repair of slits and weather strips on the walls.

10-12-3 Improvement of Lighting System and Air Conditions

a) As the lighting intensity of each shop is rather high, decreasing the lighting intensity of common areas would highlight the interior of the shops better.

b) To normalize the lighting intensity, the following measures should be studied.

Reduction of number of lights one switch covers
Utilization of outside light (sun shine)
Adoption of automatic on-off switch
Control system for lighting intensity

c) Decreasing the air volume of the AHU could increase the average temperature, leading to energy efficiency. In addition, the adoption of an inverter control for the AHU fan, which depends on heat requirements, would also contribute to further energy efficiency. The variable air volume (VAV) system should be studied for controlling air volume.

d) The installation of temperature censors at critical locations provides an effective energy saving method. And the cost of censors is quite cheap.

e) Front and back entrances are always open, which results in a large heat loss.

10-13 Selection of Energy Efficiency Promotion Technology

10-13-1 Electric Power Receiving and Distribution

(1) Demand Ratio of Transformers

Among the various electrical equipment, the transformer is highly efficient but still experiences energy loss. There are two kind of losses in the transformer, non-load loss ("Iron Loss") and load loss ("Copper Loss"). To decrease the loss, it is important to use low-loss materials and to optimize the transformer use. Specific examples of the latter are optimization of transformer capacity, high efficiency-operation (60 – 80%) and stoppage of unnecessary transformers.

In the case of this shopping complex, the second item should be studied.

T3-1/T3-2:	Change of load allocation
T1/T3, UCT1, UCT1:	Installation of new transformer

(2) Electric Power Balance

This shopping complex has adopted the advanced chiller system. However, the design of the system does not fully utilize the merits of the freezing system, as there is still one chiller operating during the day time. By changing to non-chiller operation, this electric power balance could be normalized.

(3) Incoming Voltage

Tap adjustment of the transformer could be done without any investment as a minor improvement.

Adoption of an automatic voltage controller is recommended for major improvement.

(4) Power Factor

It is probable that the automatic power factor controller is not properly functioning judging from the data. (TX-1, Ring feeder)

Modification of the chiller operation method would improve the power factor.

10-13-2 Air-conditioning System

(1) Chillers

The adoption of Stockage par Chaleur Latente system (STL) is highly recommended. STL is illustrated in Figure 10-40.

a) This system is characterized by its larger heat capacity compared to the water (ice) heat storing system.

b) It would contribute to highly economical operation of the chiller system. And also the space for the tank is smaller compared to existing facilities.

c) Either the utilization of existing spare tanks or new installation is possible.

d) In the case of new installation, either vertical, horizontal or panel type can be adopted.

e) As heat storage agents, there are several candidates to improve the chiller efficiency, such as NaCl, NH_3Cl, KCl and $NaCO_3$ solution for a lower temperature system.

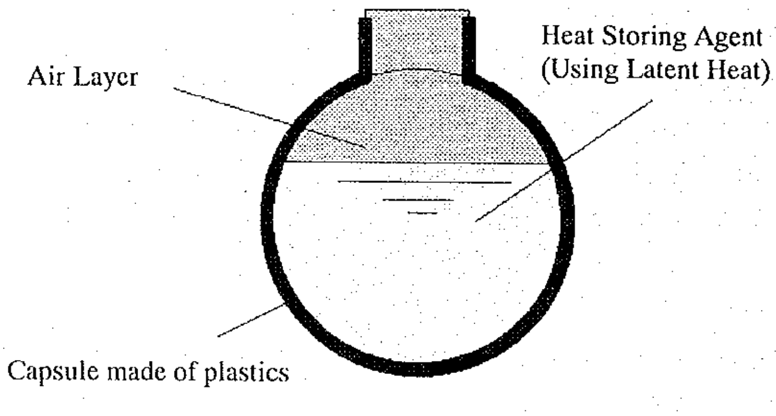


Figure 10-40 Stockage par Chaleur Latente

f) During storage and release of heat, the heat transfer agent (water) circulates the outer side of the ball and exchanges heat with the heat storing agent through the plastic layer.

(2) Air Handling Units

In this shopping complex, a large amount of cold air is released from the entrances of the building. By making the system air-tight, it would be possible to use recycled air as a cold air source.

10-13-3 Lighting System and Air Conditions

(1) Lighting

It is preferable to adopt lamps of higher efficiency. Table 10-15 shows that the efficiency of a high pressure sodium lamp is about twice that of an incandescent bulb.

Table 10-15 Lighting Source and Efficiency

	Lamp Efficiency (lm/W)	Total Efficiency (lm/W)	Heat Generated (kcal/h/1000lm)	Average Life (hours)
Incandescent Bulb	15	15	57	1,000
Halogen Bulb	21	21	41	2,000
Fluorescence Lighting(40W)	81	65	13	10,000
Fluorescence Lighting(100W)	86	79	11	10,000
High Pressure Mercury Lamp	55	52	17	12,000
Metal Halide Lamp	76	72	12	9,000
High Pressure Sodium Lamp	119	108	8	12,000

(2) Air Conditions

Table 10-16 shows the characteristics of air leakage through three kinds of doors. As (area (A)×flow factor (α)) shows the degree of air-leakage, the rotating door is the best one among the three. However, a rotating door without an air-tight structure is less effective.

Table 10-16 Door Characteristics by Type Difference

Type of Door	Position	Area (m^2)(A)	Flow Factor (α)	A× α (m^2)
1. Single Layer Door	Close	0.100	0.7	0.070
	Open	4	0.5	2.000
2. Double Layer Door	Close/Close	Two single layer doors are connected in series.		0.049
	Open/Close	Ditto		0.070
3. Rotating Door (Air Tight Structure)	Close			0.016
	Open	0.03	0.7	0.021

10-14 Potential of Energy Efficiency Promotion

The following are the potentials of energy efficiency promotion.

a) The stoppage of incoming transformer:	20 kW
b) Decreasing the illumination intensity:	24 kW
c) Increasing the temperature of building area by 2℃:	940 kW
20% reduction in electric energy for chiller	
d) Prevention of heat loss from entrances:	75 kW
80% reduction in entrance loss (452,000 kcal/h)	
e) Utilization of off-peak electricity:	940kW-100 kW

Decreased electricity: 20+24+940+75-100= 959kW	(23,000kW/D)
Converted electricity from daytime to night: 940kW	(22,560kW/D)
Current Daily Consumption: 7,070kW	(169,700 kW/D)

Rate of Decrease: 13.5%

Convert Ratio: 13.3%

These ratios are quite high, and further studies are necessary to total the economic aspects.

10-15 Cost of Energy Efficiency Promotion

The following is a summary of the cost of energy efficiency promotion.

(1) Stoppage of incoming transformer

The transformer (T-11-1) could be stopped, since the transformer's total load is rather small.

Consequently, only the transformer (T-11-2) would operate.

Manual cut-off operation could be conducted.

Cost : Zero

(2) Decreasing the illumination intensity

a) Extinguishing unnecessary lights : 100W*100 (10 kW) Cost : Zero

b) Replacing incandescent bulbs (100W) with fluorescent lighting (60W) : 40W*100 (4kW).

As the life of fluorescent lighting is about ten times longer (10000hrs) than an incandescent bulb (1000hrs), the cost difference could be neglected.

Incandescent bulb (100W), ¥300/Piece ; Fluorescent lighting (60W), ¥1,440/Piece

Cost : Zero

c) Automatic on-off system activated by lighting intensity : 100W*100 (10kW)

Material Cost, ¥166,000 ; Renovation Cost, ¥100,000

Cost : ¥266,000

(3) Increasing the temperature of building area by 2℃

Cost : Zero

(4) Prevention of heat loss from entrances

80% reduction in entrance loss

a) Air Curtain Cost : ¥126,000

b) Rotating Door Cost : ¥8,000,000

(5) Utilization of off-peak electricity

a) Ice Strorage : ¥68,000,000

b) Brine and chilled water exchanger/ brine tank/ pumps : ¥10,000,000

c) Instrument : ¥8,000,000

d) Piping : ¥21,200,000

Cost : ¥107,200,000

10-16 Benefit of Measures for Energy Efficiency Promotion

In this section, benefits are estimated of the five measures for energy efficiency promotion for which energy-saving potentials have been estimated, based on the current price of energy in Malaysia.

10-16-1 Current Price of Energy in Malaysia

Electric power could be saved by all the recommended measures for improved 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 Bandar Utama Shopping Center. 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

10-16-2 Benefits of Measures

(1) Stoppage of Incoming Transformer

The benefit derived from this measure is estimated at 36,770 RM/year by the calculations shown in Table 10-17 below.

Table 10-17 Estimation of Benefit from the "Stoppage of Incoming Transformer" Measure

No.	Item	Estimated Value	Remarks
Electricity Saving			
①	Effectiveness	20 kW	
②	Electricity saving at peak time	102,200 kWh/year	① x 14 h/d x 365 d/y
③	Electricity saving at off-peak time	73,000 kWh/year	① x 10 h/d x 365 d/y
④	Saving in max. demand	20 kW/month	①
Saving in Electricity Bill			
⑤	Electricity saving at peak time	21,258 RM/year	② x 0.208 RM/kWh
⑥	Electricity saving at off-peak time	9,344 RM/year	③ x 0.128 RM/kWh
⑦	Saving in max. demand charge	6,168 RM/year	④ x 25.7 RM/kW/m x 12 m/y
⑧	Saving in Electricity Bill	36,770 RM/year	⑤ + ⑥ + ⑦

(2) Decreasing the Illumination Intensity

A 58,533 RM/year benefit is estimated from this measure by the calculations shown in Table 10-18, assuming that effectiveness of this measure is concentrated in the twelve hours of business.

Table 10-18 Estimation of Benefit from the "Decreasing the Illumination Intensity" Measure

No.	Item	Estimated Value	Remarks
Electricity Saving			
①	Effectiveness	24 kW	
②	Electricity saving at peak time	210,240 kWh/year	① x 24 h/d x 365 d/y
③	Electricity saving at off-peak time	none	
④	Saving in max. demand	48 kW/month	① x 24 / 12
Saving in Electricity Bill			
⑤	Electricity saving at peak time	43,730 RM/year	② x 0.208 RM/kWh
⑥	Electricity saving at off-peak time	0 RM/year	③ x 0.128 RM/kWh
⑦	Saving in max. demand charge	14,803 RM/year	④ x 25.7 RM/kW/m x 12 m/y
⑧	Saving in Electricity Bill	58,533 RM/year	⑤ + ⑥ + ⑦

(3) Increasing the Temperature of Building Area by 2℃

Table 10-19 Estimation of Benefit by the Measure "Decreasing the Temperature of Building Area by 2℃"

No.	Item	Estimated Value	Remarks
Electricity Saving			
①	Effectiveness	940 kW	
②	Electricity saving at peak time	8,234,400 kWh/year	① x 24 h/d x 365 d/y
③	Electricity saving at off-peak time	-	
④	Saving in max. demand	1,611 kW/month	① x 24 / 14
Saving in Electricity Bill			
⑤	Electricity saving at peak time	1,712,755 RM/year	② x 0.208 RM/kWh
⑥	Electricity saving at off-peak time	0 RM/year	③ x 0.128 RM/kWh
⑦	Saving in max. demand charge	496,965 RM/year	④ x 25.7 RM/kW/m x 12 m/y
⑧	Saving in Electricity Bill	2,209,720 RM/year	⑤ + ⑥ + ⑦

The benefit of this measure is estimated at 2,209,720 RM/year, which is the largest among those of the recommended measures for Bandar Utama Shopping Center. The estimation is made as shown on Table 10-19, assuming that effectiveness is concentrated in the fourteen peak-time hours.

(4) Prevention of Heat Loss From Entrances

A 182,916 RM/year benefit is estimated from this measure by the calculations shown in Table 10-20, assuming that effectiveness of this measure is concentrated in the twelve hours of business.

Table 10-20 Estimation of Benefit from the "Prevention of Heat Loss From Entrances" Measure

No.	Item	Estimated Value	Remarks
Electricity Saving			
①	Effectiveness	75 kW	
②	Electricity saving at peak time	657,000 kWh/year	① x 24 h/d x 365 d/y
③	Electricity saving at off-peak time	none	
④	Saving in max. demand	150 kW/month	① x 24 / 12
Saving in Electricity Bill			
⑤	Electricity saving at peak time	136,656 RM/year	② x 0.208 RM/kWh
⑥	Electricity saving at off-peak time	0 RM/year	③ x 0.128 RM/kWh
⑦	Saving in max. demand charge	46,260 RM/year	④ x 25.7 RM/kW/m x 12 m/y
⑧	Saving in Electricity Bill	182,916 RM/year	⑤ + ⑥ + ⑦

(5) Utilization of Off-peak Electricity

A 836,520 RM/year benefit is estimated from this measure by the calculations shown in Table 10-21. By this measure, part of the peak electricity demand is able to be shifted into the off-peak period in order to use electricity at a lower rate.

Table 10-21 Estimation of Benefit from the "Utilization of Off-peak Electricity" Measure

No.	Item	Estimated Value	Remarks
Electricity Saving			
①	Effectiveness	940 kW	
②	Electricity saving at peak time	8,234,400 kWh/year	① x 24 h/d x 365 d/y
③	Electricity saving at off-peak time	- 9,110,400kWh/year	- (① + 100) x 24 h/d x 365 d/y
④	Saving in max. demand	940 kW/month	①
Saving in Electricity Bill			
⑤	Electricity saving at peak time	1,712,755 RM/year	② x 0.208 RM/kWh
⑥	Electricity saving at off-peak time	-1,166,131 RM/year	③ x 0.128 RM/kWh
⑦	Saving in max. demand charge	289,896 RM/year	④ x 25.7 RM/kW/m x 12 m/y
⑧	Saving in Electricity Bill	836,520 RM/year	⑤ + ⑥ + ⑦

10-17 Financial Evaluation of Measures

In this section, financial evaluations are made of the following measures involving investment in order to find out the financial feasibility of the measures.

- Decreasing the illumination intensity
- Prevention of heat loss from entrances
- Utilization of off-peak electricity

Financial evaluation is not conducted for two measures with benefits, "Stoppage of Incoming Transformer" and "Increase the Temperature of Building Area by 2℃", since they do not require investment.

10-17-1 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 improved energy efficiency, 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 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 changes in 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).

10-17-2 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: 35 percent

4) Depreciation: The straight-line method is applied. Depreciation rate is 7.5% per annum for the plant and machinery.

5) Fixed investment: The fixed investment cost shown in Table 10-22 in Malaysian Dollars, converted from Japanese Yen value in the section 10-15, is used for the financial evaluation.

Table 10-22 Fixed Investment for Measures

Measures	Fixed Investment, RM
Decreasing the illumination intensity	8,566
Prevention of heat loss from entrances	261,685
Utilization of off-peak electricity	3,452,203

10-17-3 Results of Financial Evaluation

Table 10-23 shows FIRROI before tax, FIRROI after tax and payback period for the three measures. Estimated cash flow tables for these measures are presented in Tables 10-24 through 10-26.

Table 10-23 Results of Financial Evaluation

Measures	FIRROI before tax	FIRROI after tax	Payback Period
Decreasing the illumination intensity	683.3%	446.8%	0.2 years
Prevention of heat loss from entrances	69.9%	47.9%	2.1 years
Utilization of off-peak electricity	23.2%	16.4%	5.4 years

10-17-4 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 regarded as an indication of the opportunity cost of capital in Malaysia.

For all three measures, FIRROIs calculated exceed this rate. In addition, the first two measures, "Decreasing the illumination intensity" and "Prevention of heat loss from entrances", have good payback periods, and the last measure "Utilization of off-peak electricity" has a reasonable payback period duration. It is concluded that all three measures can be regarded as financially feasible under the conditions of this study.

Table 10-24 Cash Flow Table (Measure: Decreasing the Illumination Intensity)

Unit: RM

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Less: Fixed investment	8,566															
Plus: Reduction in operating cost	0	58,533	58,533	58,533	58,533	58,533	58,533	58,533	58,533	58,533	58,533	58,533	58,533	58,533	58,533	58,533
Less: Corporate tax increased	0	20,262	20,262	20,262	20,262	20,262	20,262	20,262	20,262	20,262	20,262	20,262	20,262	20,262	20,412	20,487
Incremental Cash Flow (before Tax	-8,566	58,533	58,533	58,533	58,533	58,533	58,533	58,533	58,533	58,533	58,533	58,533	58,533	58,533	58,533	58,533
Incremental Cash Flow (After Tax)	-8,566	38,271	38,271	38,271	38,271	38,271	38,271	38,271	38,271	38,271	38,271	38,271	38,271	38,271	38,121	38,047
Cumulative net cash flow	-8,566	29,705	67,977	106,248	144,519	182,791	221,062	259,334	297,605	335,876	374,148	412,419	450,691	488,962	527,083	565,130
Depreciation		642	642	642	642	642	642	642	642	642	642	642	642	642	214	0

Table 10-25 Cash Flow Table (Measure: Prevention of Heat Loss from Entrances)

Unit: RM

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Less: Fixed investment	261,685															
Plus: Reduction in operating cost	0	182,916	182,916	182,916	182,916	182,916	182,916	182,916	182,916	182,916	182,916	182,916	182,916	182,916	182,916	182,916
Less: Corporate tax increased	0	57,151	57,151	57,151	57,151	57,151	57,151	57,151	57,151	57,151	57,151	57,151	57,151	57,151	61,731	64,021
Incremental Cash Flow (before Tax	-261,685	182,916	182,916	182,916	182,916	182,916	182,916	182,916	182,916	182,916	182,916	182,916	182,916	182,916	182,916	182,916
Incremental Cash Flow (After Tax)	-261,685	125,765	125,765	125,765	125,765	125,765	125,765	125,765	125,765	125,765	125,765	125,765	125,765	125,765	121,185	118,895
Cumulative net cash flow	-261,685	-135,920	-10,155	115,609	241,374	367,138	492,903	618,668	744,432	870,197	995,962	1,121,726	1,247,491	1,373,255	1,494,441	1,613,336
Depreciation		19,626	19,626	19,626	19,626	19,626	19,626	19,626	19,626	19,626	19,626	19,626	19,626	19,626	6,542	0

Table 10-26 Cash Flow Table (Measure: Utilization of Off-peak Electricity)

Unit: RM

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Less: Fixed investment	3,452,203															
Plus: Reduction in operating cost	0	836,520	836,520	836,520	836,520	836,520	836,520	836,520	836,520	836,520	836,520	836,520	836,520	836,520	836,520	836,520
Less: Corporate tax increased	0	202,162	202,162	202,162	202,162	202,162	202,162	202,162	202,162	202,162	202,162	202,162	202,162	202,162	262,575	292,782
Incremental Cash Flow (before Tax	-3,452,203	836,520	836,520	836,520	836,520	836,520	836,520	836,520	836,520	836,520	836,520	836,520	836,520	836,520	836,520	836,520
Incremental Cash Flow (After Tax)	-3,452,203	634,358	634,358	634,358	634,358	634,358	634,358	634,358	634,358	634,358	634,358	634,358	634,358	634,358	573,945	543,738
Cumulative net cash flow	-3,452,203	-2,817,845	-2,183,487	-1,549,128	-914,770	-280,412	353,947	988,305	1,622,663	2,257,022	2,891,380	3,525,738	4,160,097	4,794,455	5,368,400	5,912,138
Depreciation	0	258,915	258,915	258,915	258,915	258,915	258,915	258,915	258,915	258,915	258,915	258,915	258,915	258,915	86,305	0

10-18 Recommendations for Energy Efficiency Promotion

Based on the energy audit and subsequent study for Bandar Utama Shopping Center, the following measures are recommended for improving its energy efficiency.

(1) Measures Requiring Investment

(a) The following are recommended: decrease the illumination intensity by installing an automatic on-off system activated by lighting intensity; replace incandescent bulbs with fluorescent lights; and extinguish unnecessary lights. This investment measure can be regarded as financially feasible based on the financial evaluation.

(b) It is recommended that heat loss from entrances be prevented by installation of a rotating doors and air curtains. The investment for this measure appears financially feasible.

(c) It is recommend that off-peak electricity be utilized by expanding the ice storage system. The investment can be said to be financially feasible as well.

(2) Measures Not Requiring Investment

(a) Stoppage of the incoming transformer, T-11-1, is recommended. This measure will enable an RM37,000 annual saving in the electricity bill without any investment.

(b) It is recommend that the temperature of building areas be increased by 2℃. By this measure, an RM 2.2 million annual saving in the electricity bill is expected. This is the largest benefit among the recommended measures.

(3) Other Recommendations

Other recommendations are listed in Table 10-27.

Table 10-27 Other Recommendations

Category		Recommendations
Architectural Structure	(a)	To install blinds and curtains on windows to shelter rooms from sunshine
	(b)	To renovate glass windows by adopting thermic ray absorption film
	(c)	To repair slits and replace weather strips on the walls
Renovation and Expansion of Air-conditioning	(a)	To install an overall air heat exchanger in future when the number of customers increases
	(b)	To make a study on the co-generation system if LPG becomes available as a heat source in future
	(c)	To install an additional Variable Air Volume (VAV) system
	(d)	To adjust the room pressure to prevent excess draft
Operation, Maintenance, Management, Living Style and Others	(a)	To reduce suction air volume from entrances
	(b)	To adjust suction air volume by installation of carbon dioxide detectors
	(c)	To establish rules of air-conditioning system operation between Bandar Utama City Corporation and JUSCO before introducing an automatic control system for the air-conditioning system
	(d)	To inspect and repair air leakage from the ducts
	(e)	To clean coils and filters of air-conditioners
	(f)	To clean condensers and evaporators of chillers
	(g)	To reinforce the monitoring system by increasing the number of measuring equipment pieces
	(h)	To clean lighting appliances and exchange aged lamps
	(i)	To increase lighting efficiency by cleaning the inner surfaces of rooms
	(j)	To extinguish lights around windows
	(k)	To regularly open/close blinds
	(l)	To regularly close front & stairwell doors
	(m)	To frequently open/close windows