CHAPTER 9

POWER SYSTEM ANALYSIS, TRANSMISSION LINE AND TELECOMMUNICATION SYSTEM

CHAPTER 9. POWER SYSTEM ANALYSIS, TRANSMISSION LINE AND TELECOMMUNICATION SYSTEM

9.1 Power Transmission System

The Upper Quae Yai Project can be regarded to have an large effect on Regions 1 and 4 of EGAT's power system. The outline of the power system in these regions and the power system development plan in the future are shown on Fig. 9-1 and Fig. 9-2, respectively.

The power transmission system conceivable just before the Upper Quae Yai Project is incorporated was studied from the viewpoints of reliability, power flow and stability.

The following were confirmed:

- It is necessary to connect Srinagarind Switchyard with Ban Pong 2 Substation by a 230 kV, 4-cct transmission line (conductor used : ACSR 1272 MCM) and Ban Pong 2 Substation with Sai Noi Substation by a 230 kV, 3-cct transmission line (conductor used : ACSR 1272 MCM).
- It is also desirable from the standpoint of supply reliability, voltage and power flow aspects to construct a 230 kV, 1-cct transmission line (conductor used : ACSR 1272 MCM x 2) connecting Ang Thong Substation and Ang Thong 2 Substation.

The above strengthened system is considered as the system which is formed before the Upper Quae Yai Project is incorporated. The transmission system required to add for reinforcement for the Upper Quae Yai Project will be examined with this as the basis.

(1) Selection of Power Transmission Scheme

The following are the items considered in examining the transmission system required when the Upper Quae Yai Project is incorporated in the power system.

- The electric power generated by Nam Chon and Thi Khong Power Stations are to be transmitted to Bangkok, the load center.
- The transmission line is to be the most advantageous from a comprehensive viewpoint considering construction cost, convenience of maintenance and inspection, and transmission losses. Moreover, it is essential that power can be transmitted even during faulting outage of a single circuit.
- The power transmission system should be comprehensively advantageous considering the method of power transmission of the Quae Yai Pumped Storage Project (ultimate output 1,000 MW) which is planned to develop in the first half of the 1990's following the Upper Quae Yai Project.

The electric power generated by Nam Chon and Thi Khong Power Stations will have to be transmitted to Bangkok over a distance more than 270 km. It could not be sent by only a 230 kV, 2-cct transmission line with high reliability from the standpoint of stability.

Consequently, for transmission of the electric power generated at these plants, it is necessary either to adopt a 230 kV, 3-cct transmission system, or a 230 kV, 2-cct transmission system, to provide a switchyard at a midway point to Bangkok.

The three alternatives below were examined.

A. Schemes for Construction of 230 kV Transmission Lines Only

① Construction of a 230 kV, 2-cct transmission line (conductor used : ACSR 1272 MCM) from Nam Chon Power Station to Srinagarind Switchyard and to Ang Thong 2 Substation respectively.

② Construction of a 230 kV, 2-cct transmission line (conductor used : ACSR 1272 MCM x 2) from Nam Chon Power Station to Srinagarind Switchyard and strengthening of section between Srinagarind Switchyard and Sai Noi Substation with 230 kV transmission lines.

B. Scheme for Construction of 500 kV Transmission Line

Construction of a 230 kV, 2-cct transmission line (conductor used : ACSR 1272 MCM x 2) from Nam Chon Power Station to Srinagarind Switchyard and a 500 kV, 2-cct transmission line between Srinagarind Switchyard and Sai Noi Substation. The latter is planned to construct in advance aiming at transmission of the power of the Quae Yai Pumped Storage Project (scheduled to be developed in 1990 according to EGAT's Power Development Plan), and will be initially operated at 230 kV.

(a) Schemes for Construction of 230 kV Transmission Lines Only

The results of economic comparisons made for the various strengthening patterns under the A-① and A-② schemes are shown in Table 9-1.

A-(1) is free from problems regarding power flow and stability, but the construction cost is high, while there are also problems in maintenance of the transmission lines.

A-(2)-a is a scheme for construction of a 230 kV, 2-cct transmission line (conductor used : ACSR 1272 MCM x 2) between Nam Chon Power Station and Srinagarind Switchyard, and strengthening of the transmission line between Srinagarind Switchyard and Sai Noi Substation. The section between Srinagarind Switchyard and Ban Pong 2 Substation is formed by a 230 kV, 5-cct transmission line (conductor used : ACSR 1272 MCM), and the section between Ban Pong 2 Substation and Sai Noi Substation by a 230 kV, 4-cct transmission line (conductor used : 1272 MCM).

A-(2)-c is identical with A-(2)-a with regard to the transmission lines between Nam Chon Power Station and Srinagarind Switchyard, and between Ban Pong 2 Substation and Sai Noi Substation. However, between Srinagarind Switchyard and Ban Pong 2 Substation, a 230 kV, 2-cct transmission line (conductor used : ACSR 1272 MCM x 2) is to be added to the existing 230 kV, 4-cct transmission line.

A-(2)-b is a scheme for strengthening ranking between the preceding two.

A-(2)-a is the lowest in construction cost, and there are no problems in the aspects of power flow and stability. However, transmission loss will be the greatest.

Meanwhile, the scheme A-(2)-c is considerably improved with respect to transmission loss, but the construction cost is higher than the other schemes.

As for annual costs including transmission line losses, the scheme A-(1) costs most, followed by A-(2)-a, while A-(2)-c costs least.

When only energy loss is taken into account, the annual cost for the scheme A-(1) will be highest, followed by A-(2)-c, while the scheme A-(2)-a will cost least. If there will be sufficient reserve capacity in a power system, the transmission loss may be rather practically evaluated only by energy loss. In such a case, the scheme A-(2)-a will be advantageous at the present point in time.

However, it is quite conceivable that the cost of transmission loss will be increased by the continued sharp rises in petroleum prices in the future. Therefore, it is judged that the scheme A-(2)-c would ultimately be economically advantageous.

The outlines of the schemes A-(2)-c and A-(2)-a are as follows.

- Nam Chon Power Station and Srinagarind Power Station are to be connected by a 230 kV, 2-cct transmission line (conductor used : ACSR 1272 MCM x 2). As the present switchyard of Srinagarind Power Station has not such a large space that the equipment related to this line can be provided, it is necessary to enlarge it or to construct a new switchyard at a suitable place near Srinagarind Power Station.

- Thi Khong Power Station is to be connected with the above transmission line by a single-circuit T-branch (conductor used : ACSR 795 MCM).

- The new switchyard, if planned to construct, and the existing switchyard of Srinagarind Power Station are to be connected by a 230 kV, 2-cct transmission line (conductor used : ACSR 1272 MCM x 2). The transmission line for the Khao Laem Project will be usable for this purpose.

- A 230 kV, 2-cct transmission line (conductor used : ACSR 1272 MCM x 2) for the scheme A-(2)-c is to be constructed, or a 230 kV, 1-cct transmission line (conductor used : ACSR 1272 MCM) for the scheme A-(2)-a, between the switchyard of Srinagarind Power Station and Ban Pong 2 Substation.

- A 230 kV, 1-cct transmission line (conductor used : ACSR 1272 MCM) is to be constructed between Ban Pong 2 Substation and Sai Noi Substation.

In these schemes, a 500 kV transmission line for the Quae Yai Pumped Storage Project must be planned to construct when it is developed in the future.

The outline of the facilities to be constructed is shown in Table 9-2. The diagrams of these power transmission schemes are shown in Figs. 9-3 and 9-4.

(b) Scheme for Construction of 500 kV Transmission Line

The outline of this scheme is as follows.

- A new switchyard is to be constructed at a suitable location near Srinagarind Power Station.

  This switchyard, initially operated at 230 kV, will be upgraded to a 500 kV substation when the Quae Yai Pumped Storage Project is developed in the future.

- Nam Chon Power Station and the new switchyard of Srinagarind Power Station are to be connected by a 230 kV, 2-cct transmission line (conductor used : ACSR 1272 MCM x 2).

- Thi Khong Power Station is to be connected by a single-circuit T-branch (conductor used : ACSR 795 MCM) with the above transmission line.

- The existing switchyard and the new switchyard of Srinagarind Power Station are to be connected by a 230 kV, 2-cct transmission line (conductor used : ACSR 1272 MCM x 2).

The transmission line for the Khao Laem Project will be usable for this purpose like the schemes A-(2)-c and A-(2)-a.

- A 500 kV, 2-cct transmission line is to be constructed between the new switchyard of Srinagarind Power Station and Sai Noi Substation, and is to be connected to the 230 kV buses of them at first.

  The conductor used for the 500 kV transmission line is to be ACSR 1272 MCM x 3 which is more advantageous than ACSR 795 MCM x 4 from the aspect of transmission losses. A conductor of ACSR 1272 MCM is used most widely for 230 kV transmission lines in Thailand.

The 500 kV transmission line constructed between Srinagarind Power Station and Sai Noi Substation should be initially energized at 230 kV and should be upgraded to 500 kV by the 500 kV/230 kV transformers that are to be installed at both the new switchyard of Srinagarind Power Station and Sai Noi Substation when the Quae Yai Pumped Storage Project is developed. The 500 kV transmission line should be used in parallel with the existing 230 kV transmission system.

The outline of the facilities to be constructed is shown in Table 9-2. The power transmission system diagram when the Upper Quae Yai Project is incorporated is shown in Fig. 9-5.

(2) Power System Analysis

Power flow study and stability study on the schemes of A-(2)-a, A-(2)-c and B cleared that all three schemes will fulfill their functions satisfactorily.

The scheme A-(2)-a has the least load carrying capability of the schemes constructing 230 kV transmission lines only. Therefore, power system analysis was carried out chiefly on the scheme A-(2)-a.

Stability calculations for the scheme A-(2)-c were not carried out, since it was confirmed that the scheme A-(2)-a has no problems in stability.

(a) Examination from System Voltage and Power Flow Aspects

Power flow calculations were carried out based on EGAT's power development plan and load forecast for 1987. The results are indicated in Fig. 9-6 to Fig. 9-10. The reason why the reactive power required at Rangsit and Phitsanulok became fairly large is that the voltages of the 230 kV buses at both substations were settled at 102% of the nominal voltage.

The 230 kV bus voltages of the substations in the Bangkok Area will be maintained at 95% or higher, and the transmission voltages of the remote power stations will be under 105% on this condition. A considerable quantity of reactive power will be required to regulate the voltages of the whole power system in 1987. The voltage regulation of the entire power system should be thoroughly studied.

All three schemes will not have parts which will become overloaded even though there may be faulting and outage of one circuit of the transmission system between Nam Chon Power Station and Sai Noi Substation.

(b) Examination of Stability Aspect

Transient stability calculations on the two schemes of A-(2)-a and B were carried out for the power systems at the peak time in 1987. The study led to the conclusion that both schemes have no problems as to stability. Transient stability calculations for off-peak time in 1987 were not carried out, but there must be no problem at all in stability at off-peak time. Because the transient stability calculation for off-peak time in 1986 showed the stableness of the power system, and the power system in 1987 will be even more strengthened than that in 1986, stability must be further improved.

A change of an angular position of each rotor succeeding to a disturbance in the power system was calculated in the transient stability study. The result is shown as a function of time (swing curve).

A three-phase fault of a line with a fault-clearing time of 5 cycles was adopted as a disturbance.

Fault locations selected are shown below and thought to give the most severe effect to transient stability.

- Case of Scheme A-(2)-a

  The point near the 230 kV bus of Nam Chon Power Station for 230 kV Nam Chon - Srinagarind transmission line, and the point near the 230 kV bus of Srinagarind Power Station for 230 kV Srinagarind - Ban Pong 2 transmission line.

- Case of Scheme B

  The point near the 230 kV bus of Srinagarind Power Station for the 500 kV Srinagarind - Sai Noi transmission line.

  The swing curves are indicated in Figs. 9-11-a, b and 9-12.

(3) Economical Comparison

The construction costs of the transmission lines and equipment of the stations required for the Upper Quae Yai Project, annual costs and transmission line losses are estimated for the schemes of A-②-a, A-②-b, A-②-c and B.

Construction costs in 1987 will be approximately ฿880 million for the scheme A-②-a and approximately ฿1170 million for the scheme A-②-c, but with the scheme B, it will be approximately ฿2500 million, more than ฿1300 million higher than the scheme A-②-c. Regarding annual cost including transmission losses, the scheme B is the highest and approximately ฿140 million higher than the two other schemes.

(a) Schemes for Construction of 230 kV Transmission Lines Only (A-②-a, A-②-b and A-②-c)

	A-②-a	A-②-b	A-②-c
Construction cost of transmission lines and equipment in 1987	882 million฿	999 million฿	1169 million฿
Annual cost	107 "	121 "	141 "
Annual cost of transmission loss			
kW value	73 "	67 "	59 "
kWh value	128 "	115 "	102 "
Total Annual Cost	308 "	303 "	302 "
(Not including kW value)	(235) "	(236) "	(243) "

(b) Scheme for Construction of 500 kV Transmission Line (B)

		(million ₿)
Construction cost of transmission lines and equipment in 1987		2504
Annual cost		302
Annual cost of transmission loss		
	kW value	50
	kWh value	89
Total Annual Cost		441
(Not including kW value)		(391)

For the scheme A-②-a and A-②-c, a 500 kV transmission line only used for Quae Yai Pumped Storage Power Station should be constructed and be connected to Sai Noi Substation, when the power station is developed. The line will be approximately 166 km long.

While, for the scheme B, construction of a 500 kV transmission line of several kilometer length between this Pumped Storage Power Station and Srinagarind Power Station is sufficient when the power station is developed. However, with this scheme, the capacity of the 230 kV Srinagarind - Sai Noi transmission line is insufficient, so it must be used in parallel with the 500 kV transmission line with transformers (taken to be 400 MVA x 2 banks) installed at Srinagarind Substation. That will make the total construction cost, including the facility cost for the pumped storage, higher than the other two schemes.

Regarding the strengthening of the system accompanying development of Quae Yai Pumped Storage Power Station, economic studies including energy losses have resulted in the conclusion that if

Quae Yai Pumped Storage Power Station is developed in 1990, it is disadvantageous to construct a 500 kV transmission line at the time of development of the Upper Quae Yai Project in 1987.

(4) Conclusions

The following are recommended as measures for the necessary strengthening of the system accompanying development of the Upper Quae Yai Project.

(a) Construction of a 230 kV, 2-cct, ACSR 1272 MCM x 2 transmission line from Nam Chon Power Station to the Srinagarind Power Station.

(b) Connection of Thi Khong Power Station by a single-circuit T-branch (conductor used : ACSR 795 MCM) with the above transmission line.

(c) Since there is no open space left in the switchyard of Srinagarind Power Station, either expansion of the switchyard, or construction of a new switchyard at a suitable place in the neighborhood for leading in of the above-mentioned 230 kV, 2-cct transmission line coming from Nam Chon Power Station.

(d) Connection of the second switchyard of Srinagarind newly constructed and the existing switchyard by a 230 kV, 2-cct 1272 MCM x 2 transmission line. It is conceivable to use a part of the Khao Laem Transmission Line for this purpose.

(e) The 230 kV transmission system between Srinagarind Power Station and Sai Noi Substation is to be strengthened as below.

- Construction of a 230 kV, 2-cct transmission line (conductor used : ACSR 1272 MCM x 2) parallel to the existing (as of 1986) 230 kV, 4-cct transmission line (conductor used : ACSR 1272 MCM) between Srinagarind Power Station and Ban Pong 2 Substation for a total of 6 circuits.

- Strengthening of the existing (as of 1986) 230 kV, 3-cct transmission line between Ban Pong 2 Substation and Sai Noi Substation to form 230 kV, 4-cct transmission line (conductor used : ACSR 1272 MCM)

As for the scheme for construction of a 230 kV, 2-cct transmission line (conductor used : ACSR 1272 MCM) from Nam Chon Power Station to Srinagarind Power Station and to Ang Thong 2 Substation respectively, the annual cost will be higher than the above-mentioned scheme, and it will have problems in maintenance. Therefore, it cannot be recommended.

9.2 Construction and Maintenance of Transmission Line

As stated in the previous section, two alternatives are conceivable regarding the transmission line route from Upper Quae Yai Power Stations to substations in the outskirts of Bangkok. One alternative would be to lead from Nam Chon Power Station to Srinagarind Power Station along the access road for the Upper Quae Yai Project now being constructed at the right bank of Srinagarind Reservoir, after which the route would be the same as for the existing transmission line leading via Ban Pong 2 Substation to Sai Noi Substation, an outer-loop substation of Bangkok. The other alternative is to divide the power into two and transmit the power by separate routes. Of the two, one would be the above-mentioned route to Sai Noi Substation via Srinagarind Power Station, while the other transmission line route would run parallel with the former for approximately 11 km from Nam Chon Power Station after which it would branch east, cross the Quae Yai River, run through mountainous land along the Huai Hae Phhi to emerge at the plain area, then run further east to reach Ang Thong 2 Substation.

The pros and cons in construction and maintenance of these transmission line routes are as follows. The transmission line route connecting Nam Chon Power Station and Srinagarind Power Station can be selected along the access road for the Upper Quae Yai Project, while the section from Srinagarind Power Station to Sai Noi Substation via Ban Pong 2 Substation will be parallel to the existing transmission line of the Srinagarind Project, and both construction and maintenance will be easy.

In contrast, the section of approximatey 55 km of the transmission line route connecting from Nam Chon Power Station to Ang Thong 2 Substation where it crosses the Quae Yai River does not have roads, while especially, approximately 40 km of this goes through a mountainous area of very rugged terrain. Therefore, considerable expense will be required for construction of access roads for transmission line construction and for maintenance and administration of these roads for transmission line maintenance. Furthermore, this transmission line route is accompanied by the drawback that maintenance at Srinagarind Reservoir will be divided into two.

On consideration of the above conditions, as the transmission line route for transmission of the electric power generated with Upper Quae Yai Power Stations, the route from Nam Chon Power Station to Sai Noi Substation via Srinagarind Power Station and Ban Pong 2 Substation is recommended from the standpoints of construction and maintenance.

The construction cost of the transmission line and the economic analysis including losses are described in summary form in 9.1(a) and Table 9-1.

9.3 Telecommunication System

The telecommunication system required for this Project are to be designed based on the conditions below.

- Load dispatching orders to Nam Chon Power Station are to be issued from North Bangkok Substation.
- Offices for transmission line maintenance are to be provided at Nam Chon Power Station and Srinagarind Power Station.
- Interconnections with the existing system and the Khao Laem Project are to be considered.

The outlines of the telecommunication system are as described below.

(1) Multi-channel Radio Link System

Multiplex radio channels are to be structured between Nam Chon Power Station and North Bangkok Substation and between Nam Chon Power Station and Srinagarind Power Station after comparison studies from the standpoints of economy and operation. And, these are to be used as telephone channels for the load dispatching and maintenance of Nam Chon Power Station.

For this purpose, the existing UHF multiplex radio channels between North Bangkok Substation and Srinagarind Power Station are to be increased and the existing UHF Radio Link is to be extended to Nam Chon Relay Station.

(2) Power Line Carrier System

Power line carrier channels are to be structured utilizing the transmission lines constructed under this Project. The sections and the purposes of these channels are as described below.

- Nam Chon Power Station - Thi Khong Power Station
  Used for load dispatching, maintenance and data transmission required for operation of Thi Khong Power Station.
- Nam Chon Power Station - Srinagarind Power Station
  Used as reserve channels for the multiplex radio channels in this section.

(3) Carrier Protective Relaying System

For protection of transmission lines constructed in this Project, power line carrier protective relaying equipment is to be provided at the sections below.

- Nam Chon Power Station - Thi Khong Power Station - Srinagarind Power Station
  Three-terminal type power line carrier protective relaying system is to be used at this section.
- Srinagarind Power Station - Ban Pong 2 Substation
- Ban Pong 2 Substation - Sai Noi Substation

(4) Transmission Line Fault Locating System

In order to aim for rapid restoration of faults of transmission lines to be constructed under this Project, fault locating equipment of the pulse radar type is to be installed at Srinagarind Power Station and Ban Pong 2 Substation and used for fault locating of the two sections below.

- Srinagarind Power Station - Nam Chon Power Station

  Since Thi Khong Power Station will be T-branched midway, the fault locating range will be to the branching point.

- Srinagarind Power Station - Ban Pong 2 Substation

- Ban Pong 2 Substation - Sai Noi Substation

(5) Mobile Radio Telecommunication System

VHF mobile radio channels are to be structured and controlled from Nam Chon Power Station and Srinagarind Power Station to make possible communication with maintenance personnel working along the transmission line in this section.

For this purpose, a VHF base station is to be installed at the Huai Mun Sae Relay Station in UHF radio link, and together with the existing Ban Takian Duan Base Station, the service area along the entire transmission line route is to be secured.

(6) Data acquisition and Control System

(a) A terminal apparatus for EGAT's data acquisition and control system (REDAC) is to be installed at Nam Chon Power Station, and a data transmission channel is to be structured using the multiplex radio channels described in (1).

(b) Data transmission apparatus of the cyclic digital telemetering type are to be installed at Nam Chon Power Station and Thi Khong Power Station, and a data transmission channel necessary for operation of Thi Khong Power Station is to be structured at this section.

(7) Other Telecommunication System

Private Automatic Exchanger (PAX) and paging equipment are to be provided at Nam Chon Power Station and Thi Khong Power Station and are to be used for telephone communications for intrastation work and maintenance.

Further, with regard to PAX, a tie line telephone network in EGAT is to be formed through the multiplex radio channels.

Fig. 9-1 Electric Power System of Main Part of Thailand

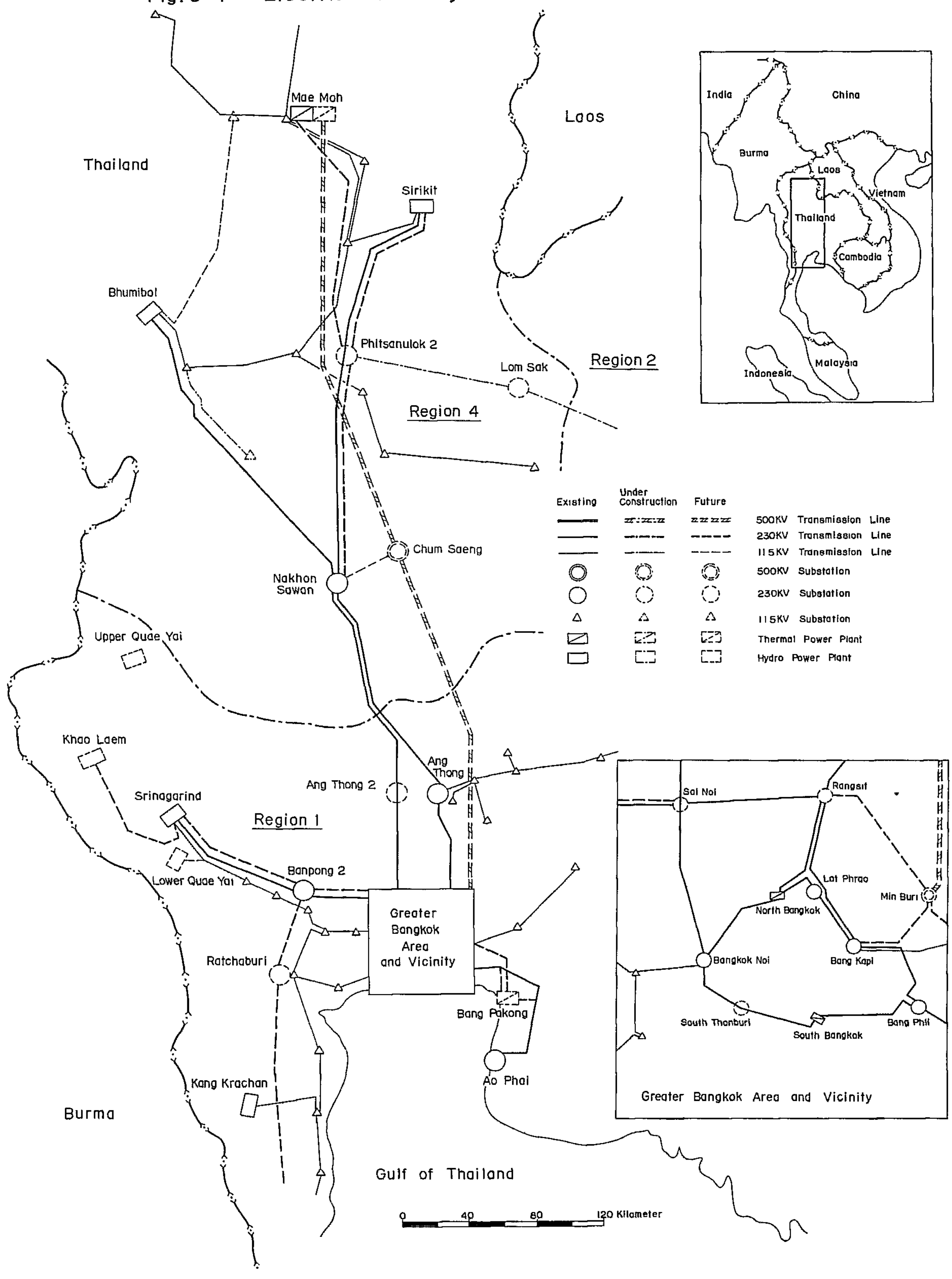


Fig. 9-2 EGAT's Power System Development Plan (1979-1995)

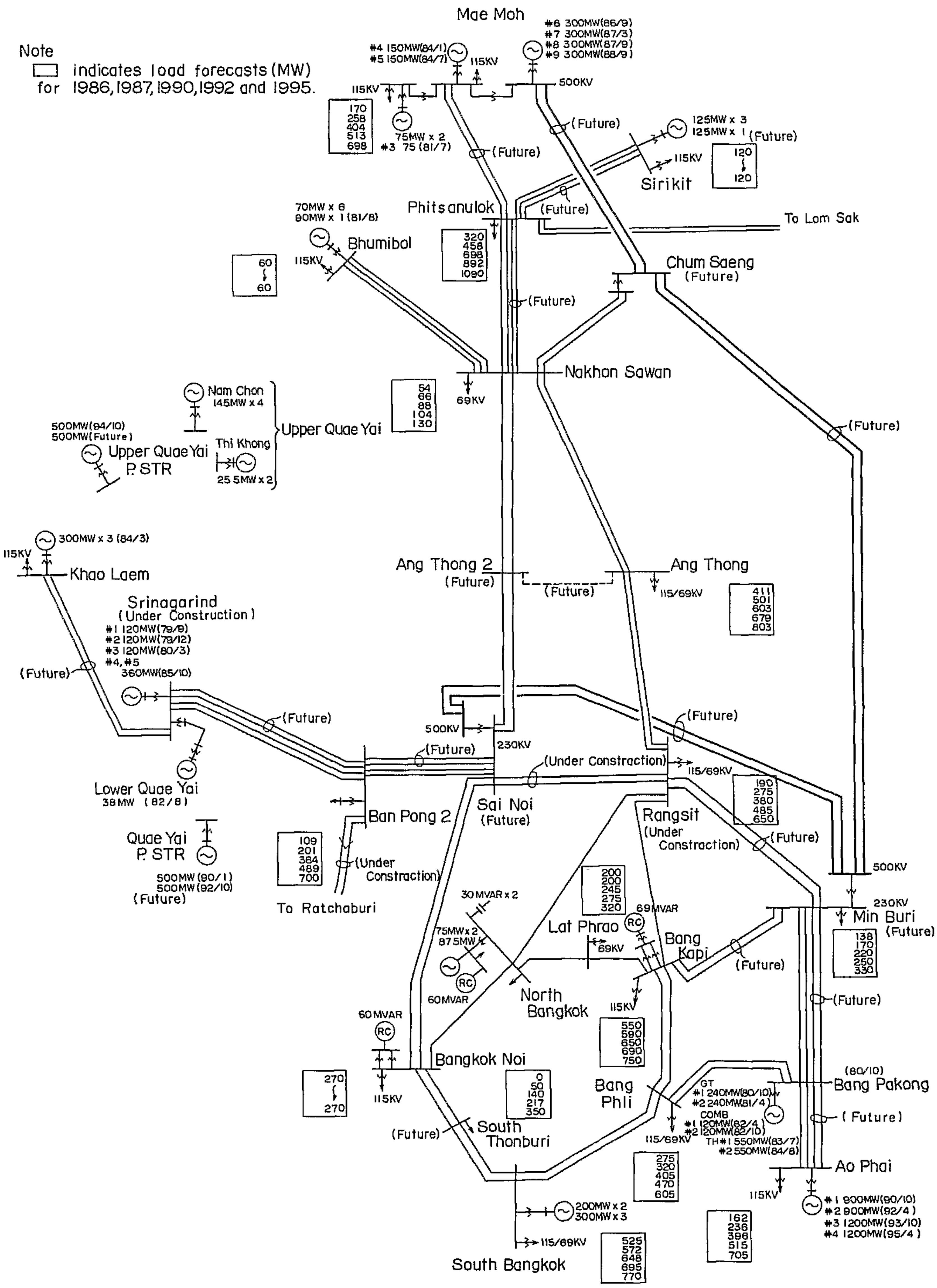


Fig. 9-3 Transmission System for Upper Quae Yai Project

Scheme A-②-a

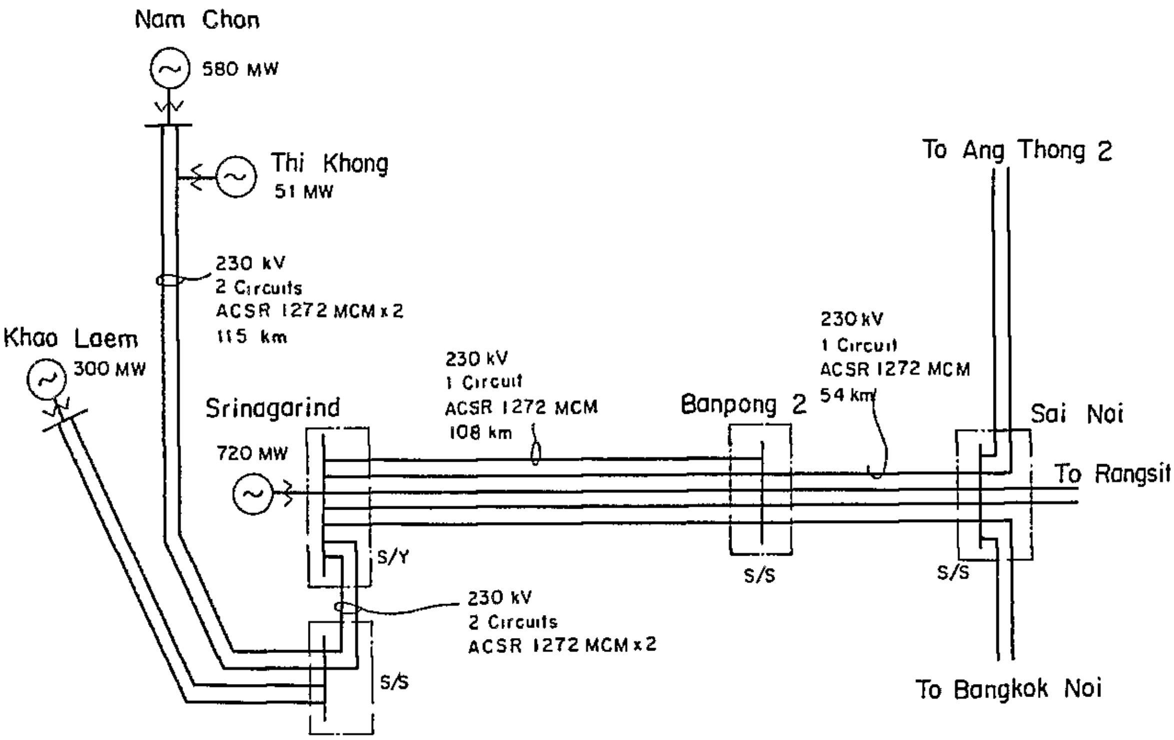


Fig. 9-4 Transmission System for Upper Quae Yai Project

Scheme A-②-c

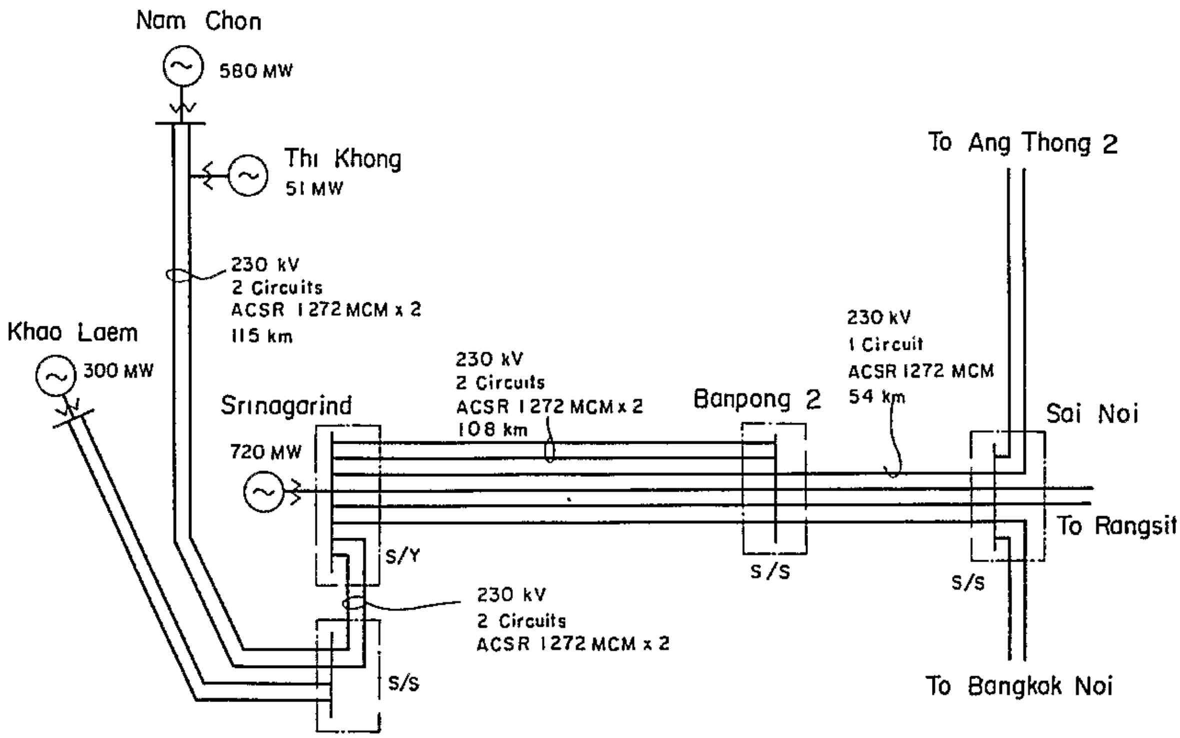


Fig. 9-5 Transmission System for Upper Quae Yai Project

Scheme B

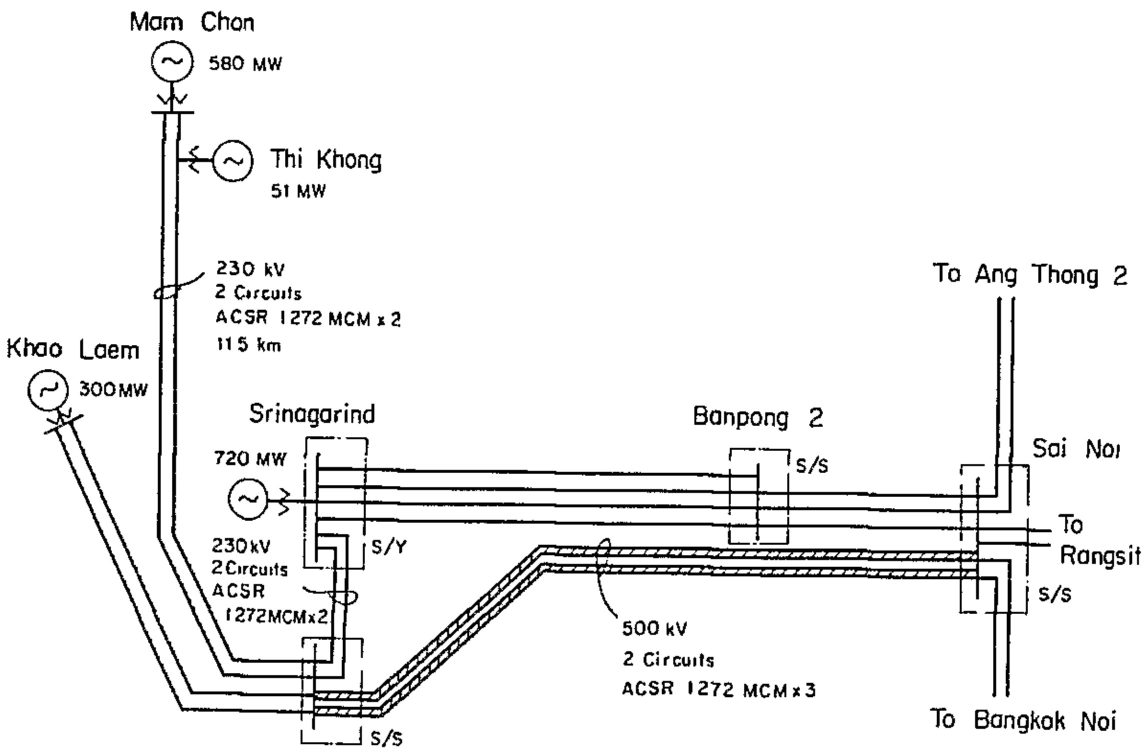


Fig. 9-6 Power Flow - Peak Time in Sept., 1987

Scheme A - ② - a

Note

P+jQ ; Active Power (MW) and Reactive Power (MVAR)

V/θ ; Bus Voltage (%) and Leading Angle (deg)

—— ; Line 500 kV

—— ; Line 230 kV

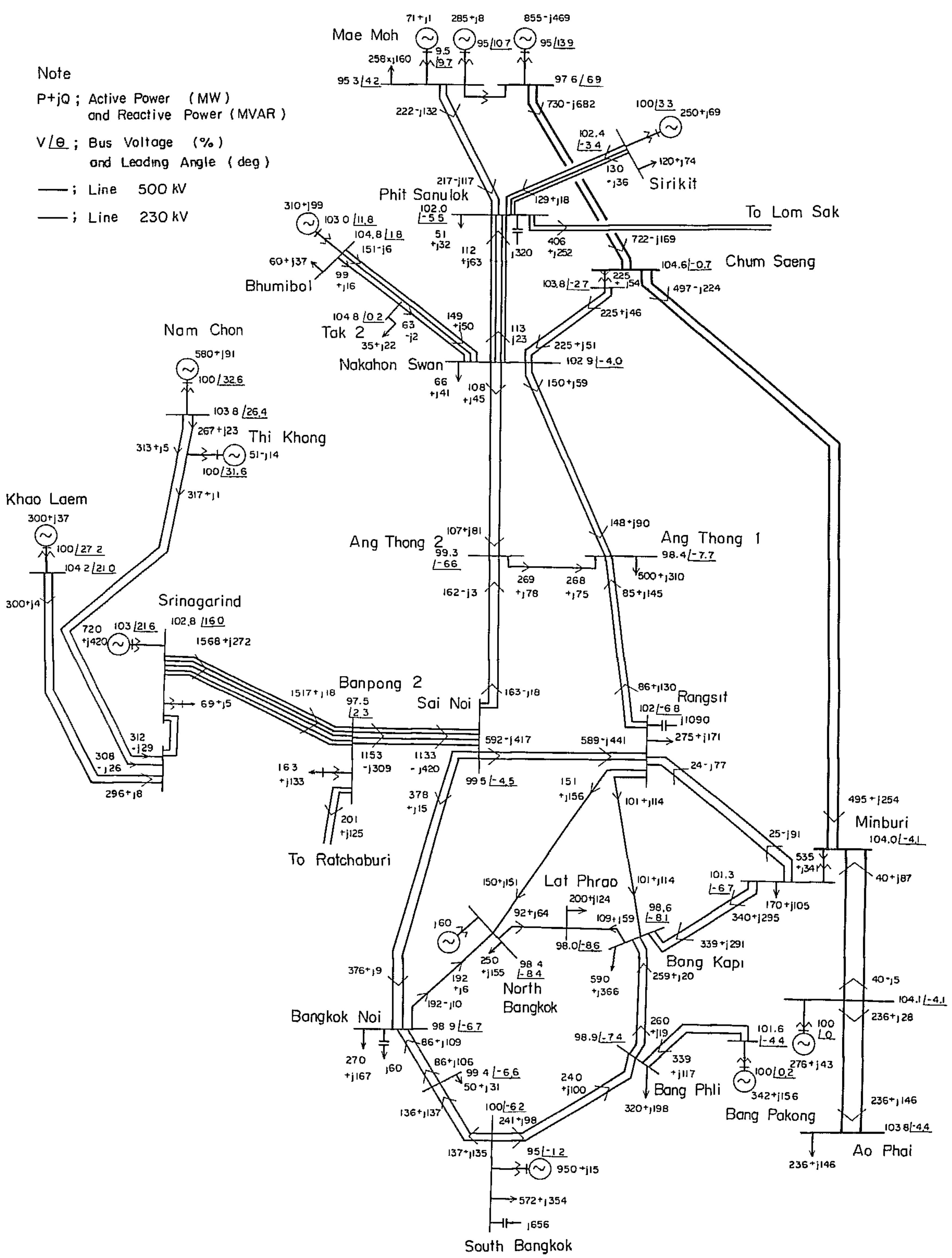


Fig. 9-7 Power Flow-Peak Time in Sept., 1987

Scheme A-②-c

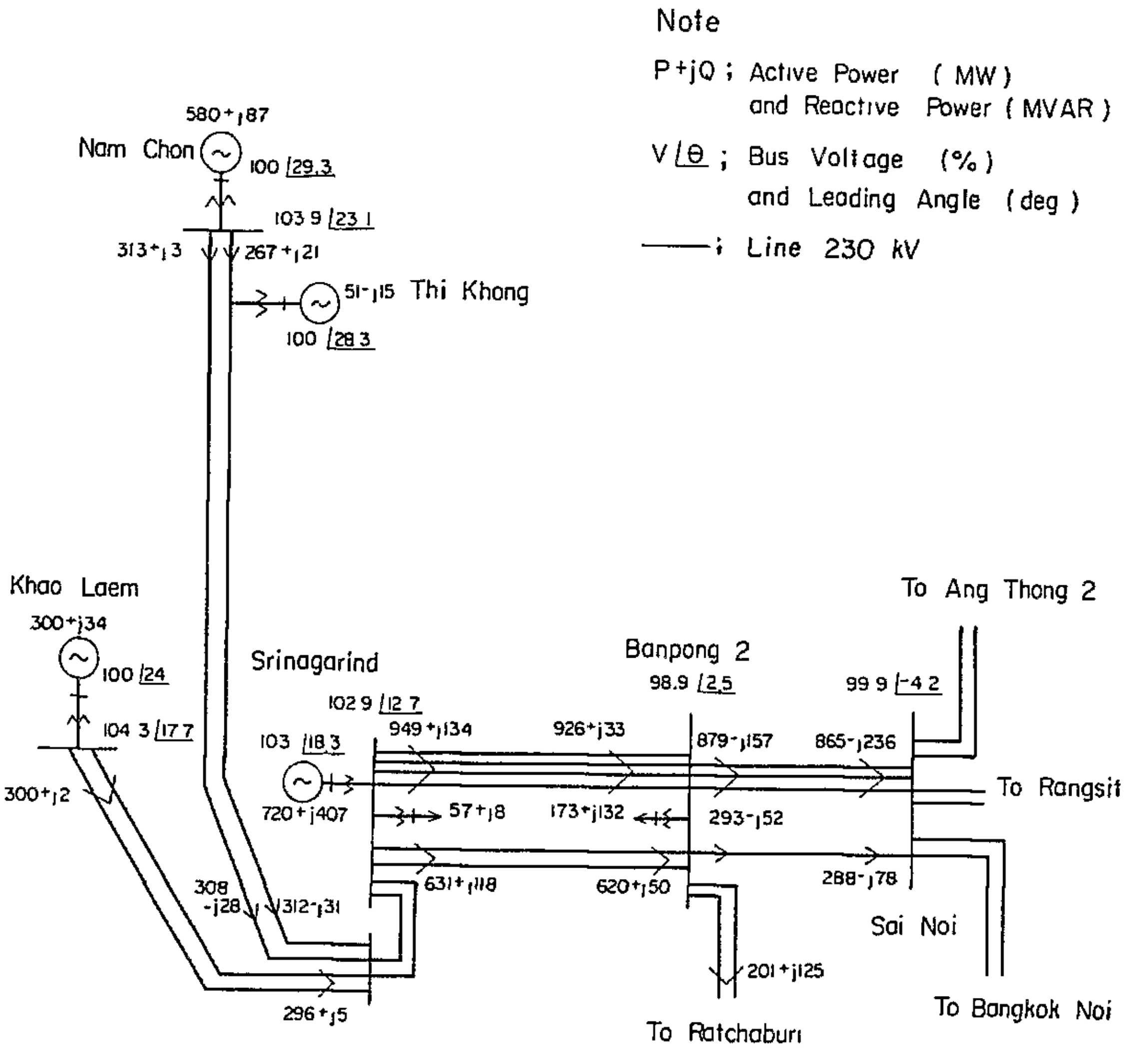


Fig. 9-8 Power Flow - Peak Time in Sept., 1987

Scheme B

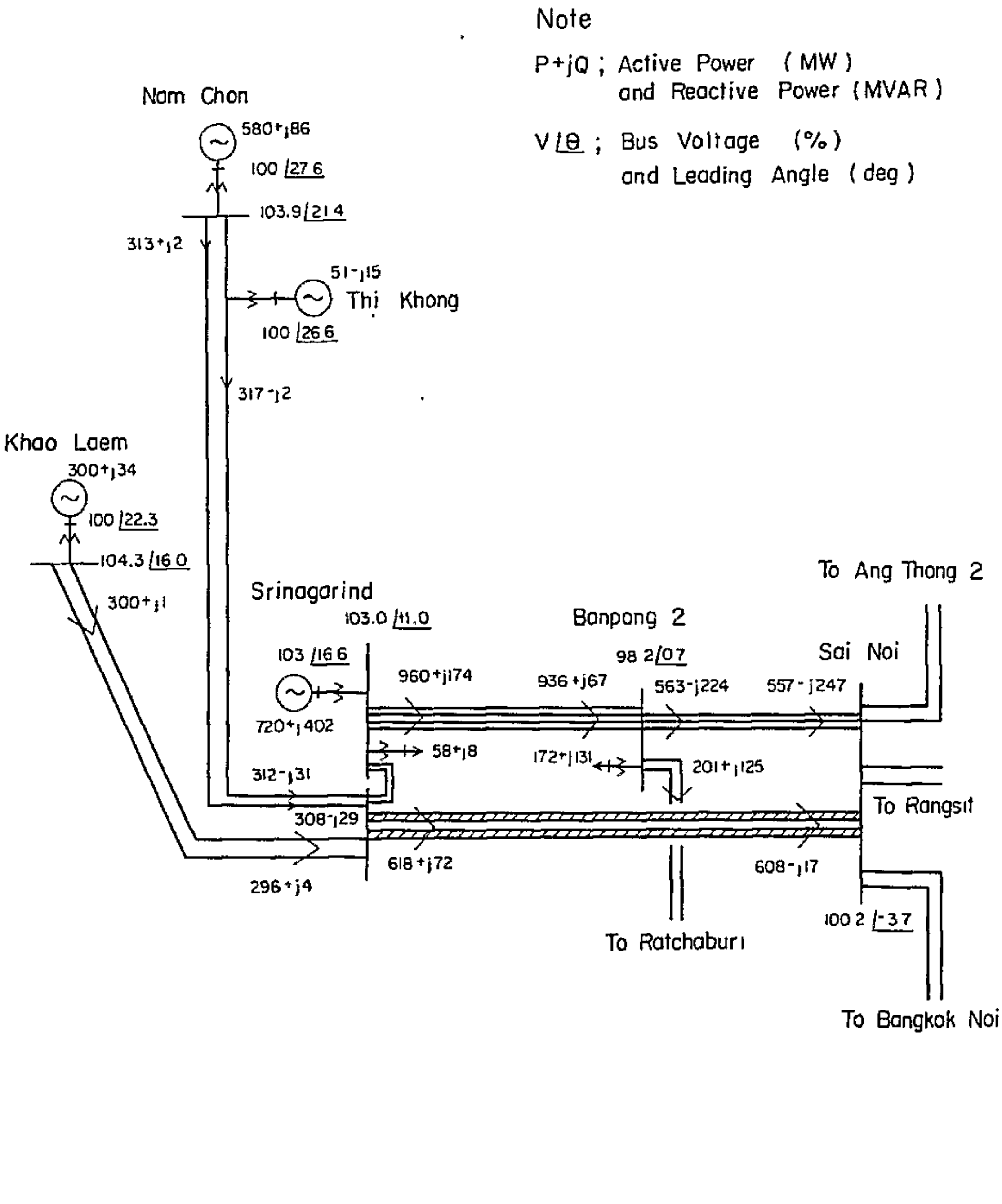


Fig. 9-9 Power Flow-Off-peak Time in Sept., 1987

Scheme A - ② - a

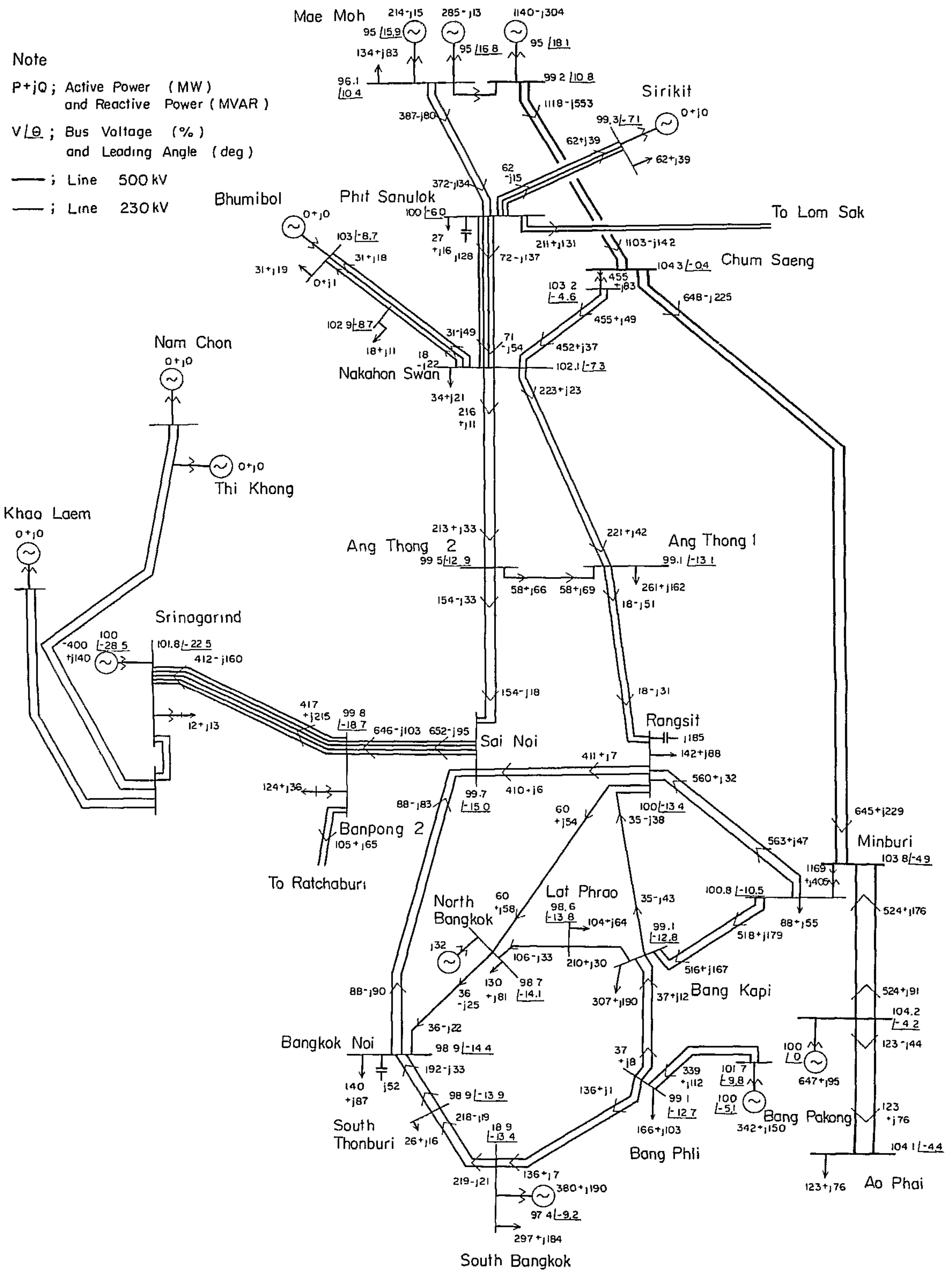


Fig. 9-10 Power Flow - Off - peak Time in Sept., 1987

Scheme B

Note

P+jQ ; Active Power (MW) and Reactive Power (MVAR)

V/θ ; Bus Voltage (%) and Leading Angle (deg)

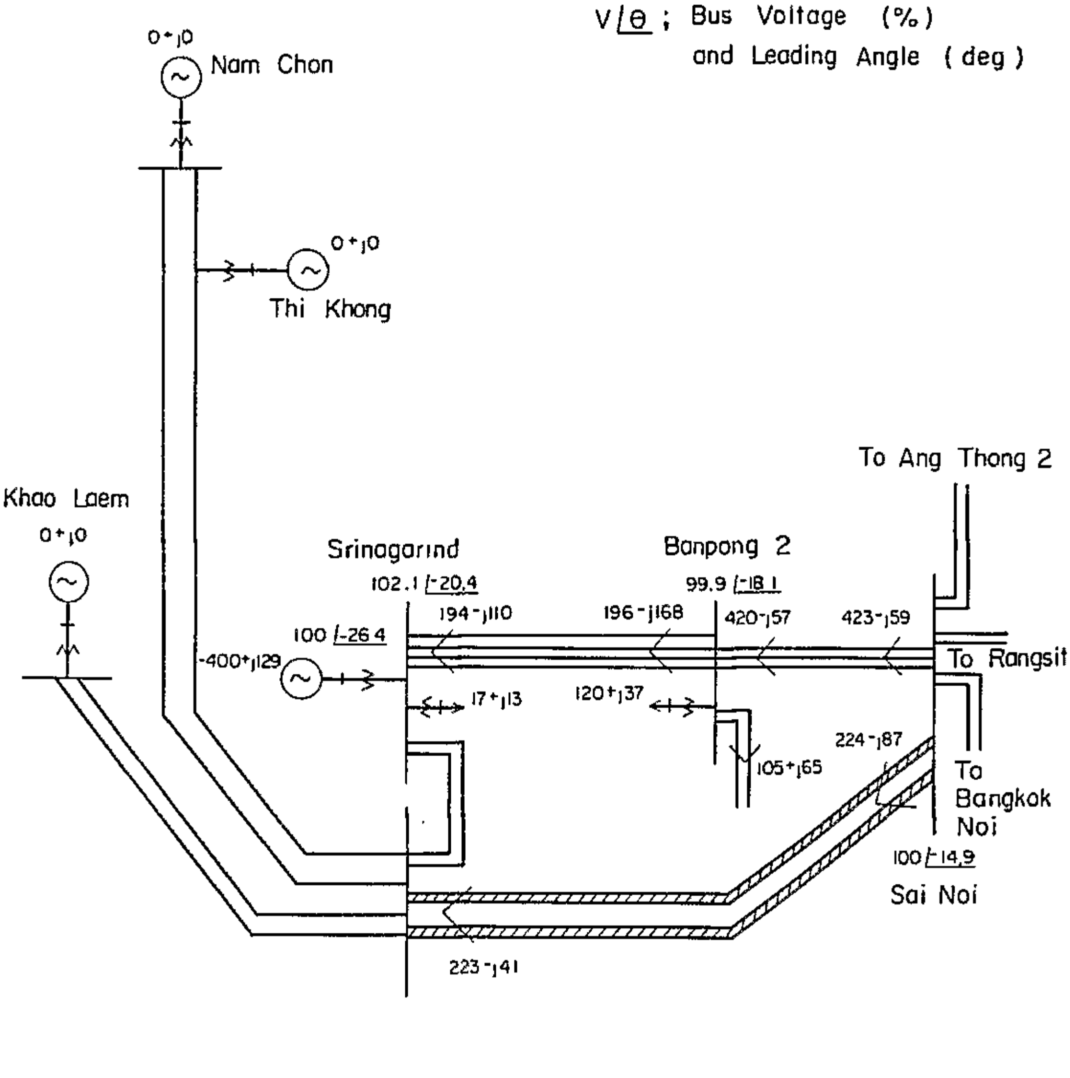
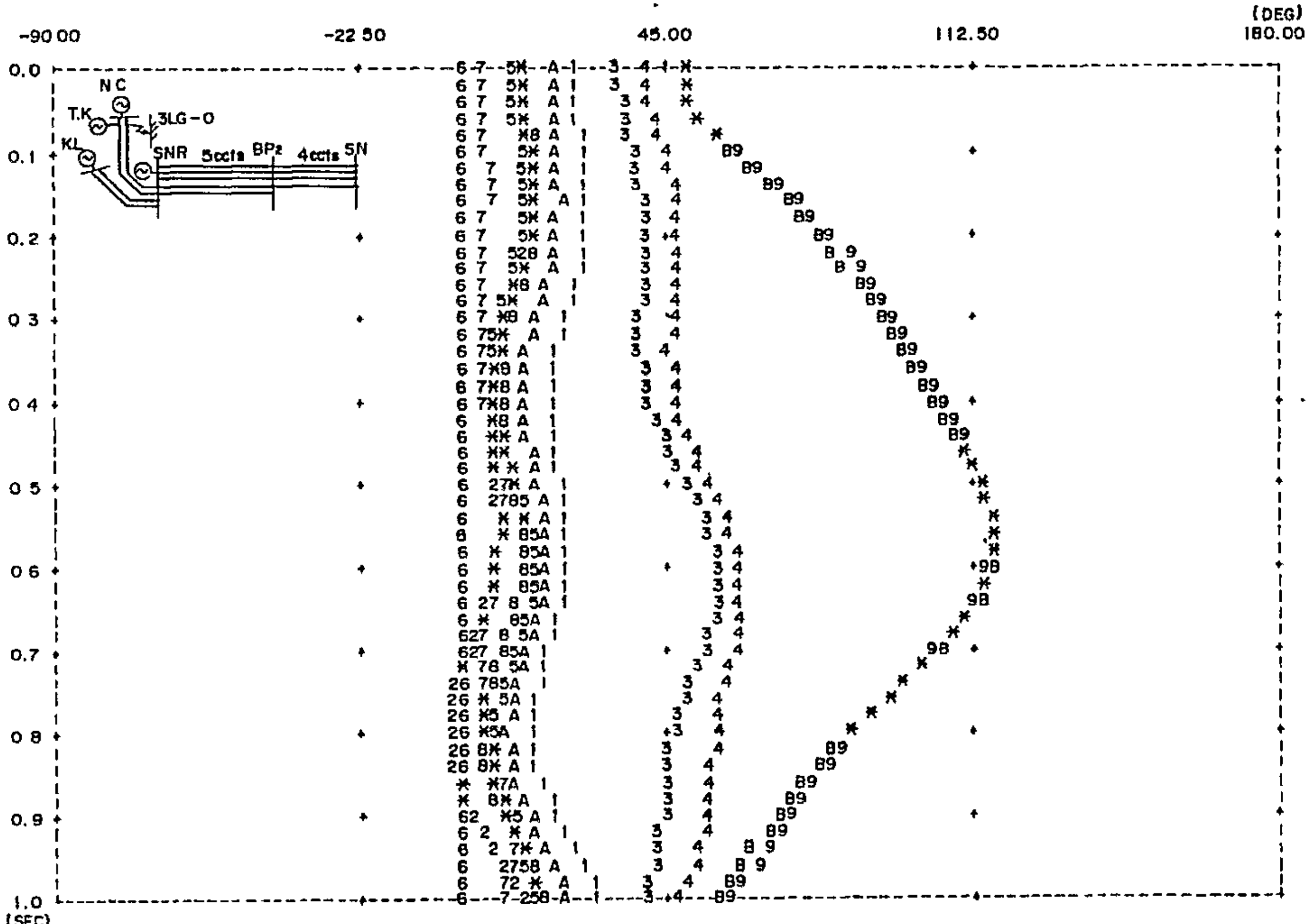


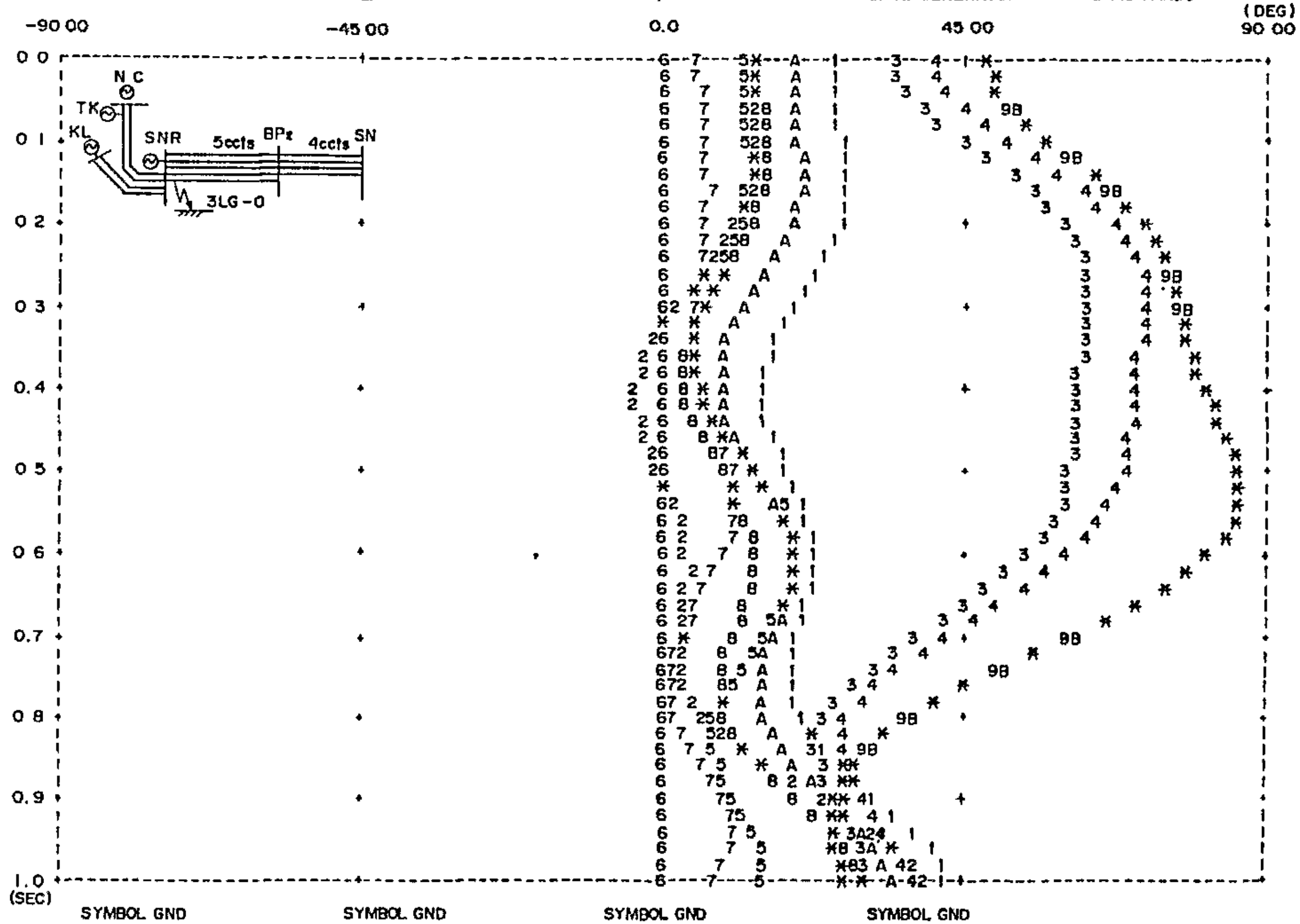
Fig. 9-11-a Transient Stability Study for Upper Quae Yai - Bangkok Transmission System
Scheme A-②-a

THAILAND 1987 PEAK 3LG-O BASE GENERATOR= 26 BANG PAKOG



SYMBOL	GND	SYMBOL	GND	SYMBOL	GND	SYMBOL	GND
1=	21 BHUMIBOL	2=	22 SIRIKIT	3=	23 SRINAGRIND	4=	24 KHAO LAEM
5=	25 SOUTH BANK	6=	26 BANG PAKOG(G&T)	7=	32 BANG PAKONG(G#-1)	8=	45 MAE MOH(#1-3)
9=	48 NAM CHON	A=	52 MAE MOH(#6-9)	B=	59 THI KHONG		

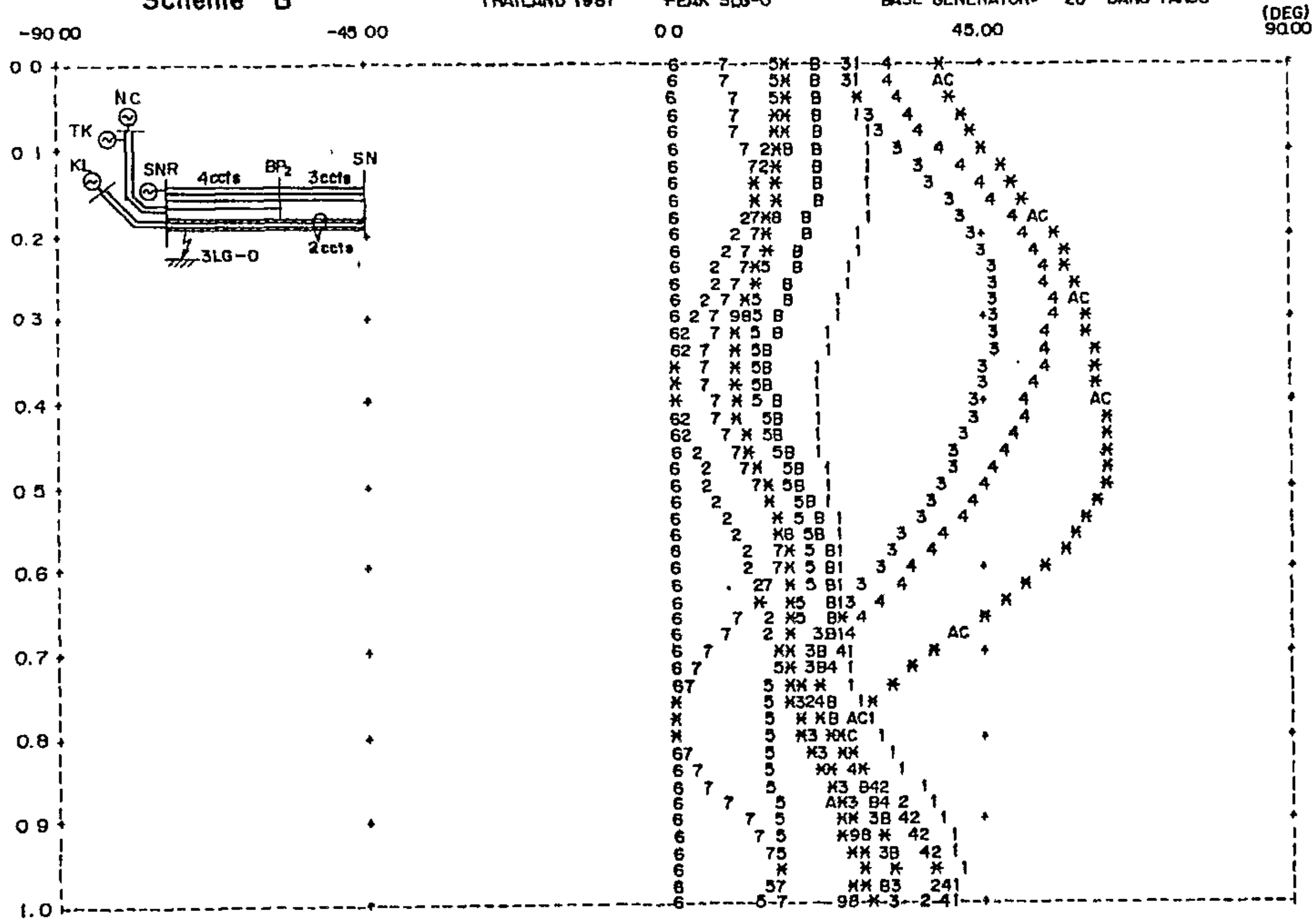
Fig. 9-11-b Transient Stability Study for Upper Quae Yai - Bangkok Transmission System
Scheme A-②-a THAILAND 1987 PEAK 3LG-0 BASE GENERATOR= 26 BANG PAKOG



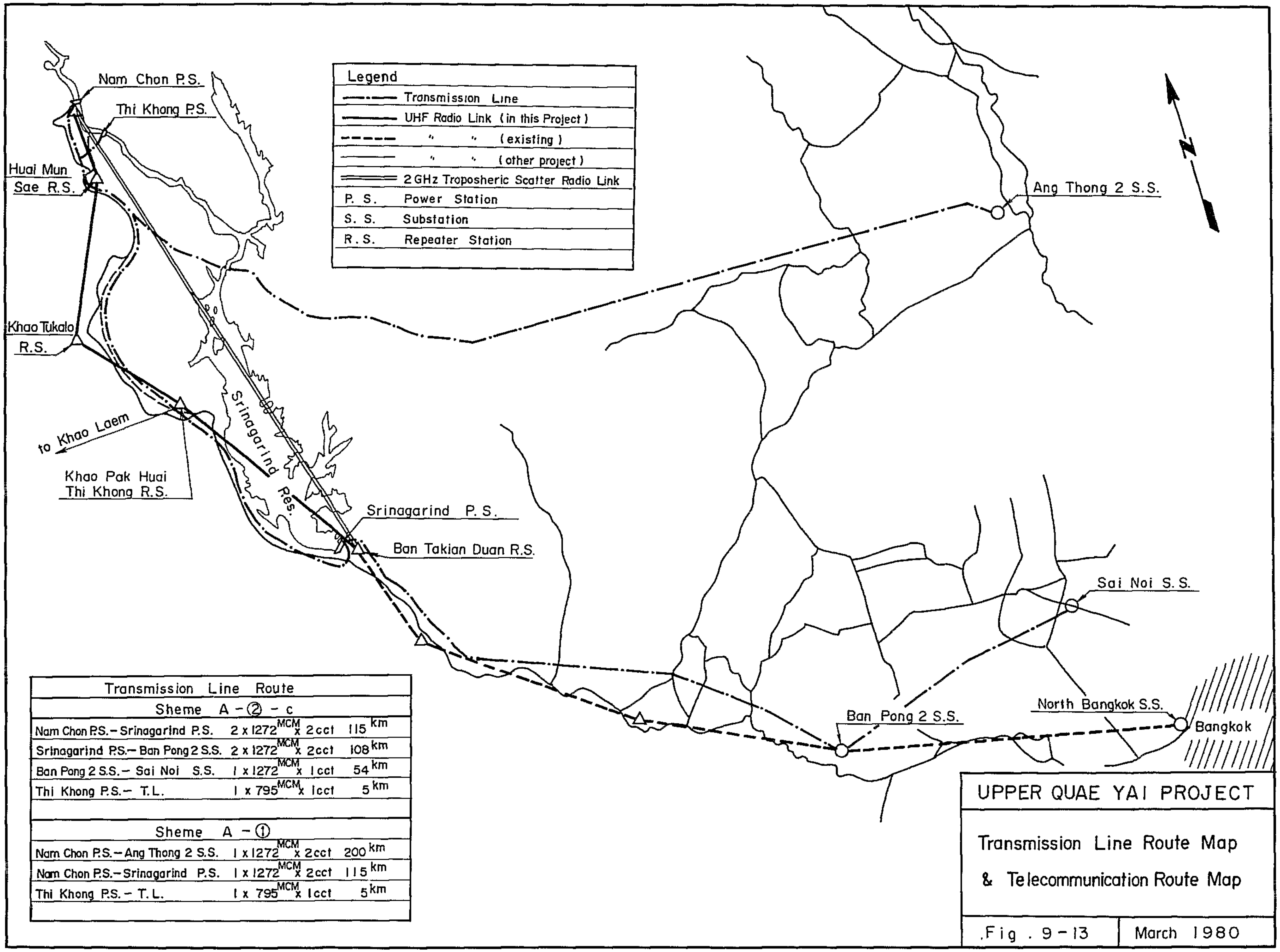
SYMBOL	GND	SYMBOL	GND	SYMBOL	GND	SYMBOL	GND
1=	21 BHUMIBOL	2=	22 SIRIKIT	3=	23 SRINAGRIND	4=	24 KHAO LAEM
5=	25 SOUTH BANK	6=	26 BANG PAKOG (GBT)	7=	32 BANG PAKONG (G#1)	8=	45 MAE MOH (#1-3)
9	48 NAM CHON	A=	52 MAE MOH (PG-9)	B=	59 THI KHONG		

Fig. 9-12 Transient Stability Study for Upper Quae Yai - Bangkok Transmission System Scheme B

THAILAND 1987 PEAK 3LG-O BASE GENERATOR= 26 BANG PAKOG



SYMBOL	GNO		SYMBOL	GNO		SYMBOL	GNO		SYMBOL	GNO	
1=	21	BHUMIBOL	2=	22	SIRIKIT	3=	23	SRINAGRIND	4=	24	KHAO LAEM
5=	25	SOUTH BANK	6=	26	BANG PAKOG(GST)	7=	32	BANG PAKONG(G#1)	8=	44	MAE MOH(#1-3)
9=	45	MAE MOH(#1-3)	A=	48	NAM CHON	B=	52	MAE MOH(#6-9)	C=	59	THI KHONG

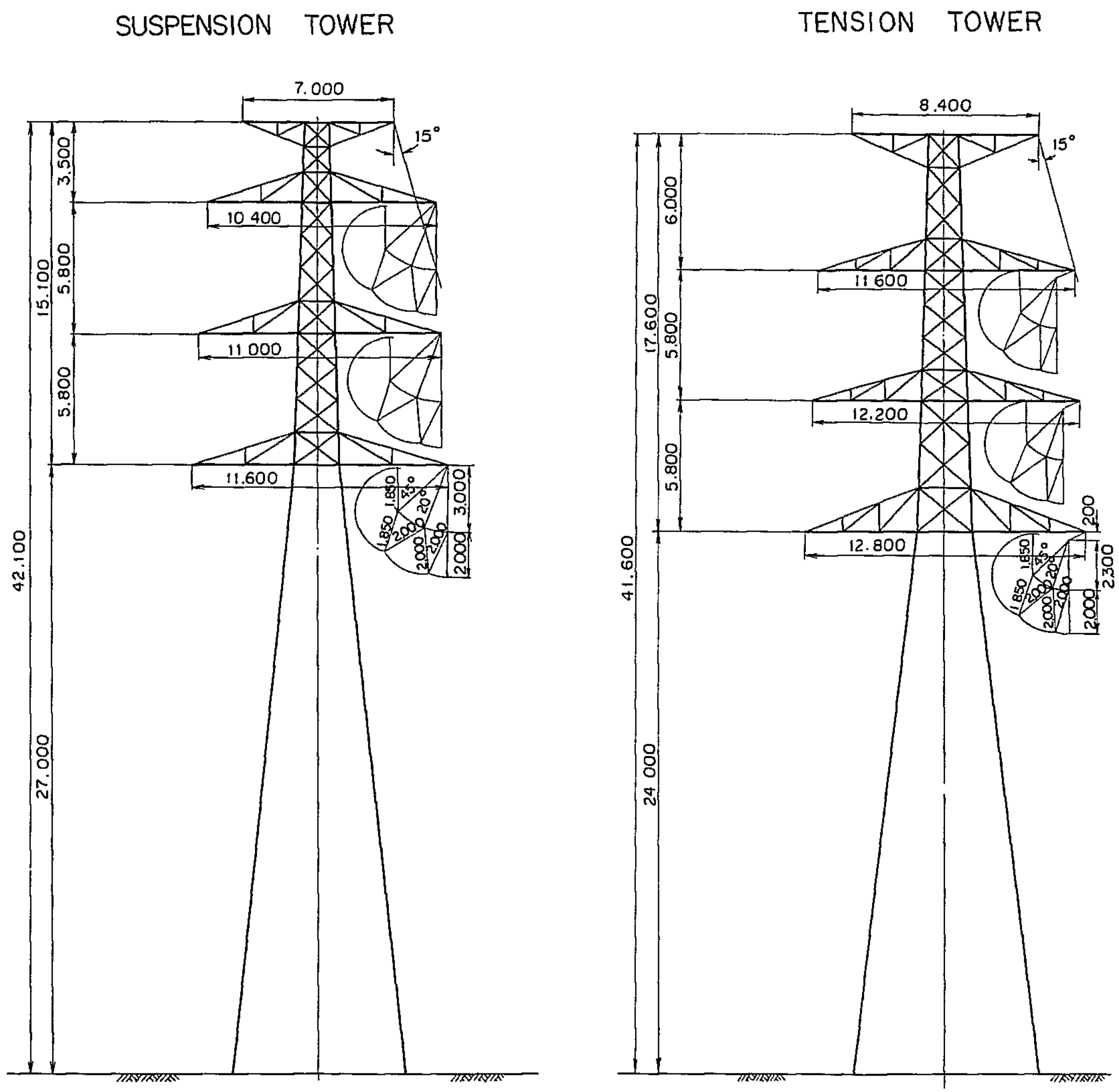


Transmission Line Route		
Sheme A - ② - c		
Nam Chon P.S.- Srinagarind P.S.	$2 \times 1272^{MCM} \times$ 2cct	115^{km}
Srinagarind P.S.- Ban Pong 2 S.S.	$2 \times 1272^{MCM} \times$ 2cct	108^{km}
Ban Pong 2 S.S.- Sai Noi S.S.	$1 \times 1272^{MCM} \times$ 1cct	54^{km}
Thi Khong P.S.- T.L.	$1 \times 795^{MCM} \times$ 1cct	5^{km}
Sheme A - ①		
Nam Chon P.S.- Ang Thong 2 S.S.	$1 \times 1272^{MCM} \times$ 2cct	200^{km}
Nam Chon P.S.- Srinagarind P.S.	$1 \times 1272^{MCM} \times$ 2cct	115^{km}
Thi Khong P.S.- T.L.	$1 \times 795^{MCM} \times$ 1cct	5^{km}

UPPER QUAE YAI PROJECT

Transmission Line Route Map & Telecommunication Route Map

Fig. 9-13 March 1980

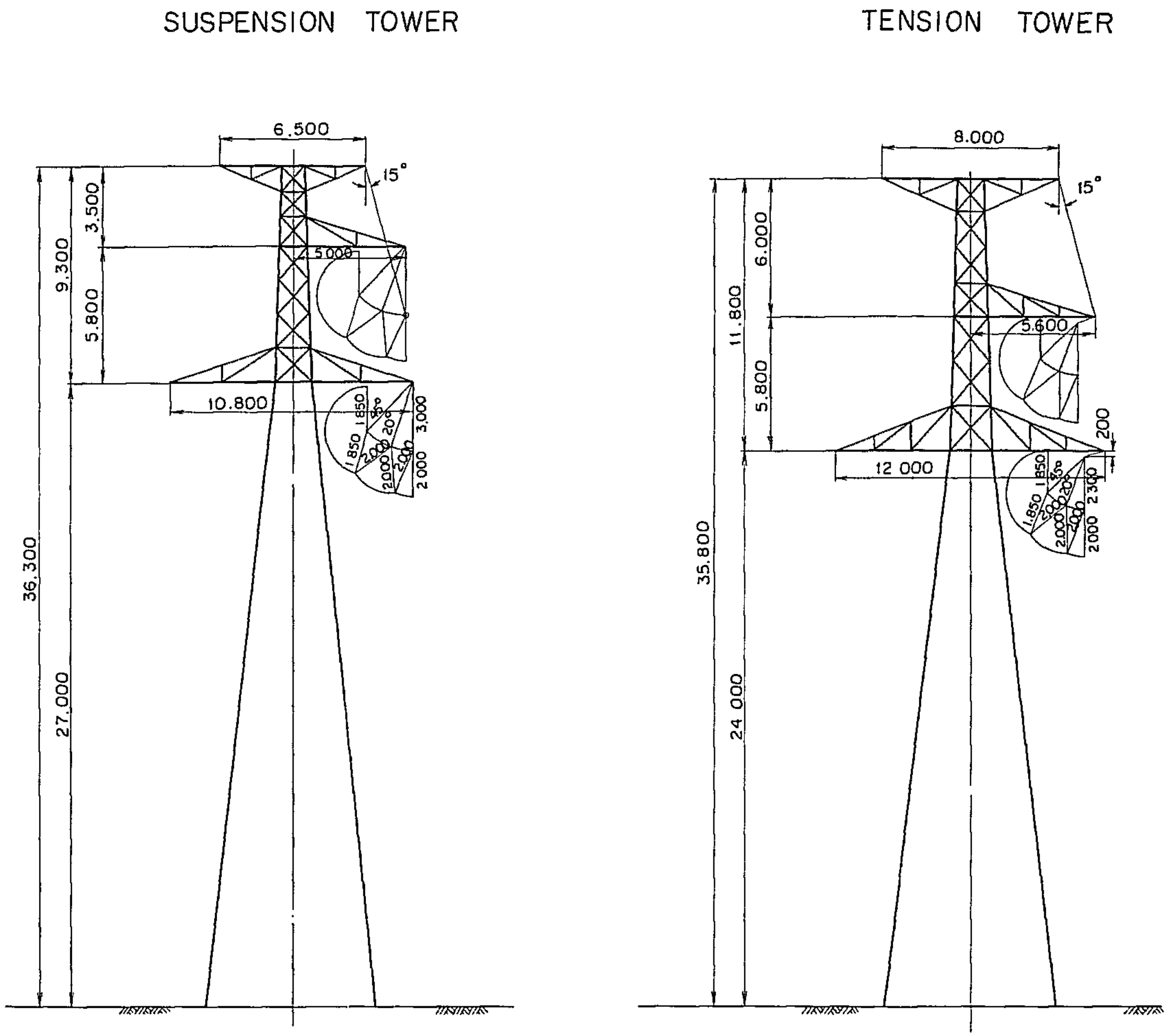


Unit : mm
Scale : 1/200

UPPER QUAE YAI PROJECT

230kV TRANSMISSION LINE
TOWER FOR 1272 MCM x 2

Fig. 9 - 14 | March 1980



Unit . mm

Scale : 1/200

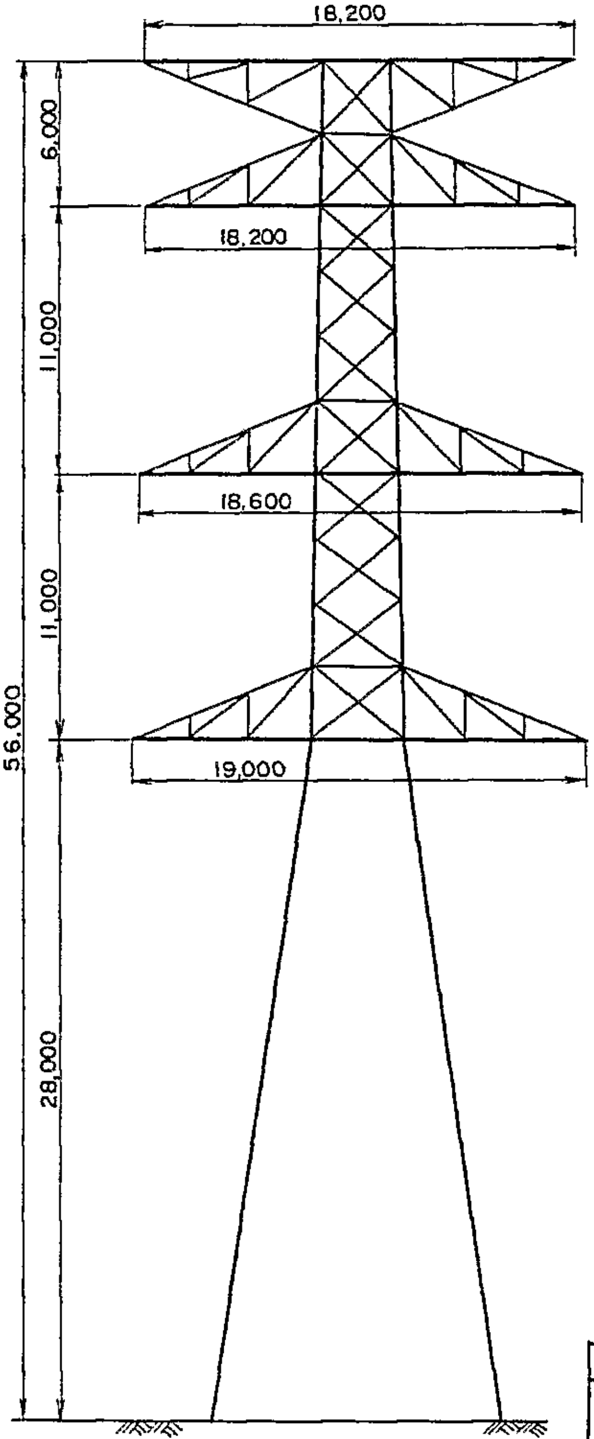
UPPER QUAE YAI PROJECT

230kV TRANSMISSION LINE

TOWER FOR 1272 MCM x 1

Fig. 9 - 15 | March 1980

SUSPENSION TOWER



Unit mm

Scale . 1/200

UPPER QUAE YAI PROJECT

500kV TRANSMISSION LINE
TOWER FOR 1272MCM x 2

Fig. 9 - 16 March 1980

Fig. 9 - 17 Telecommunication System Diagram

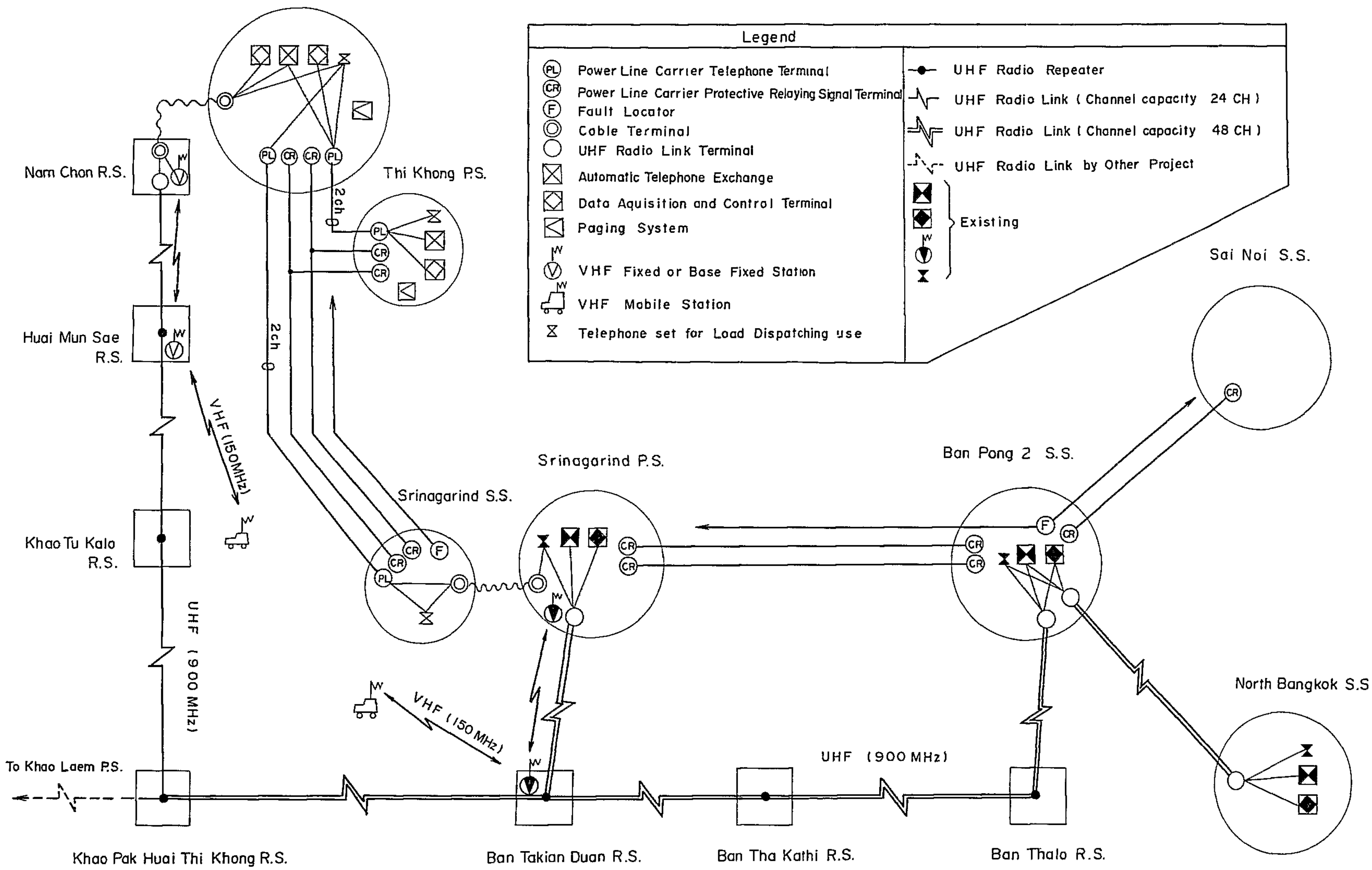


Fig. 9-18 UHF Radio Link System Diagram

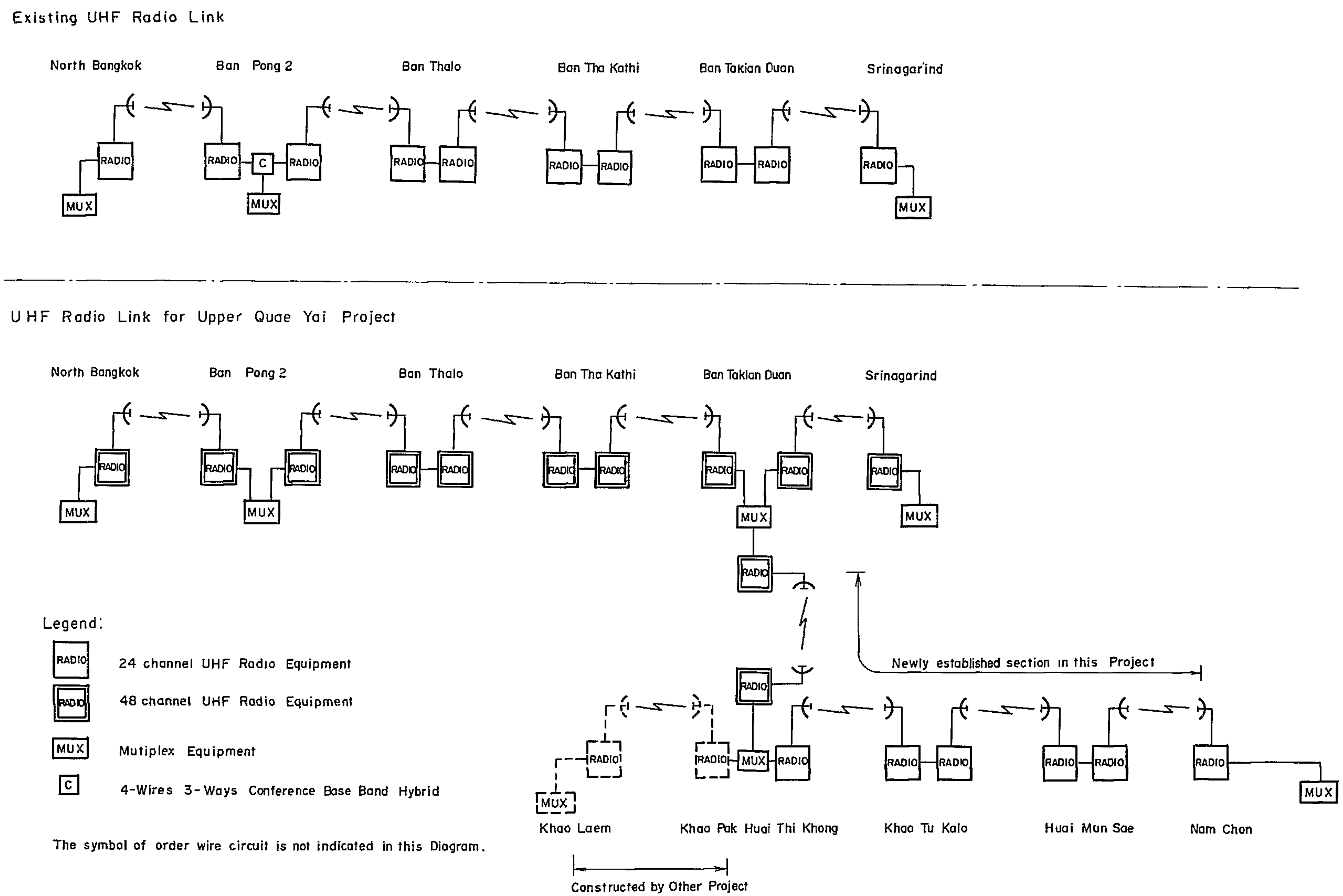
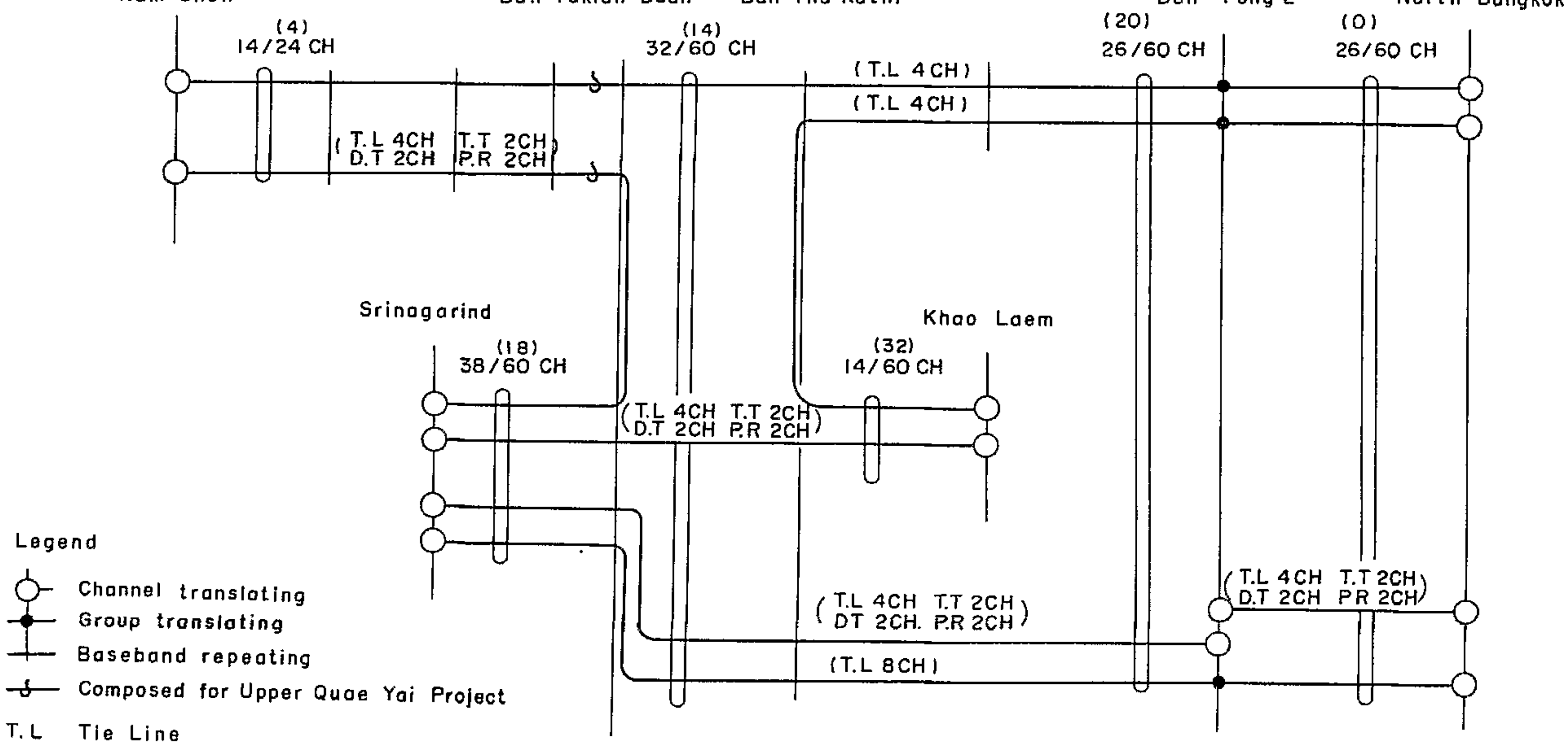


Fig. 9 - 19 UHF Radio Link Channel Plan



Legend

- Channel translating
- Group translating
- Baseband repeating
- Composed for Upper Quae Yai Project

T.L Tie Line
T.T Tele Type
D.T Data Transmission
P.R Party Line
Y/X Number of channel / Channel capacity
(Z) Number of ineffective channel

Fig.9-20 Baseband Frequency Allocation of UHF Radio Link

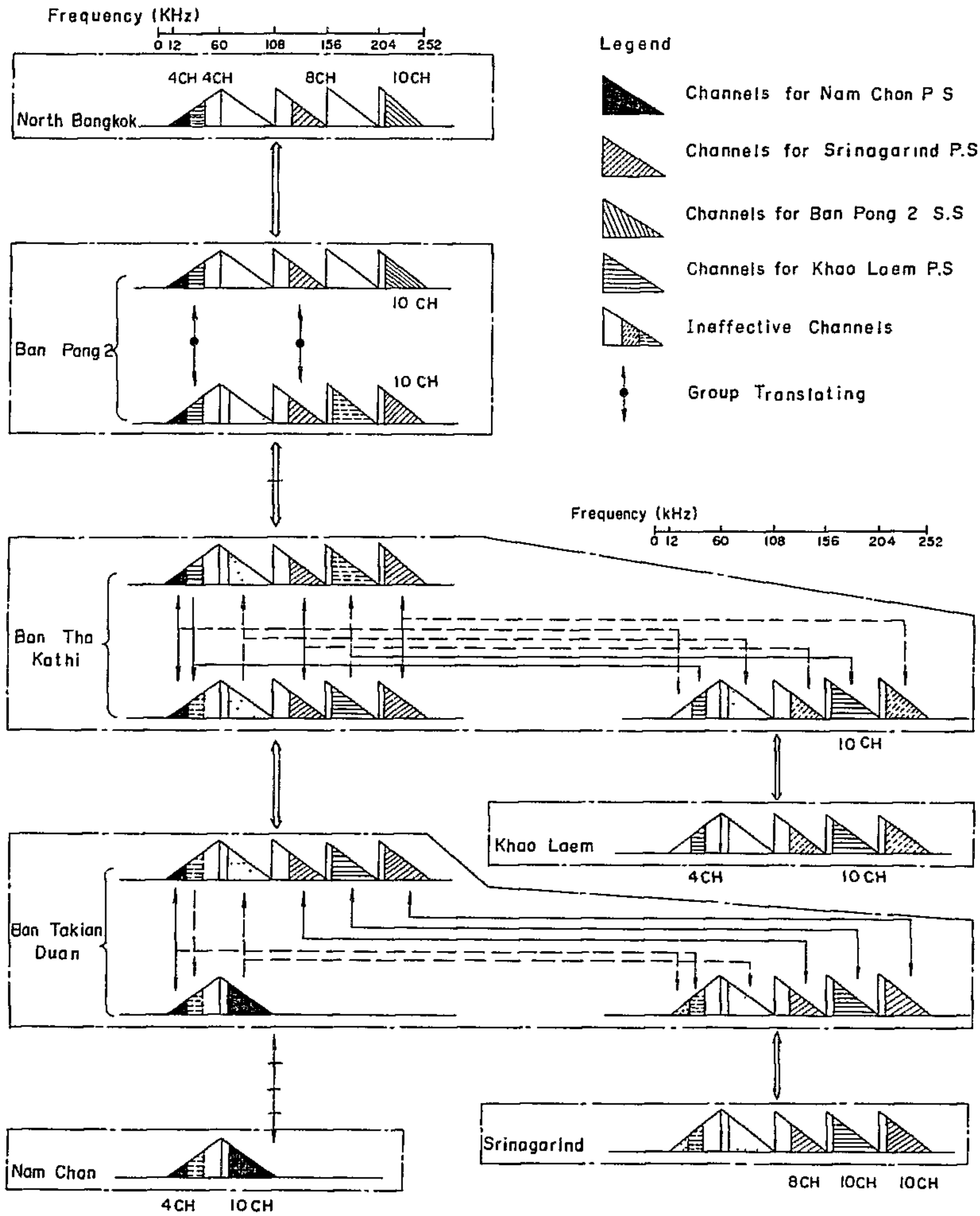
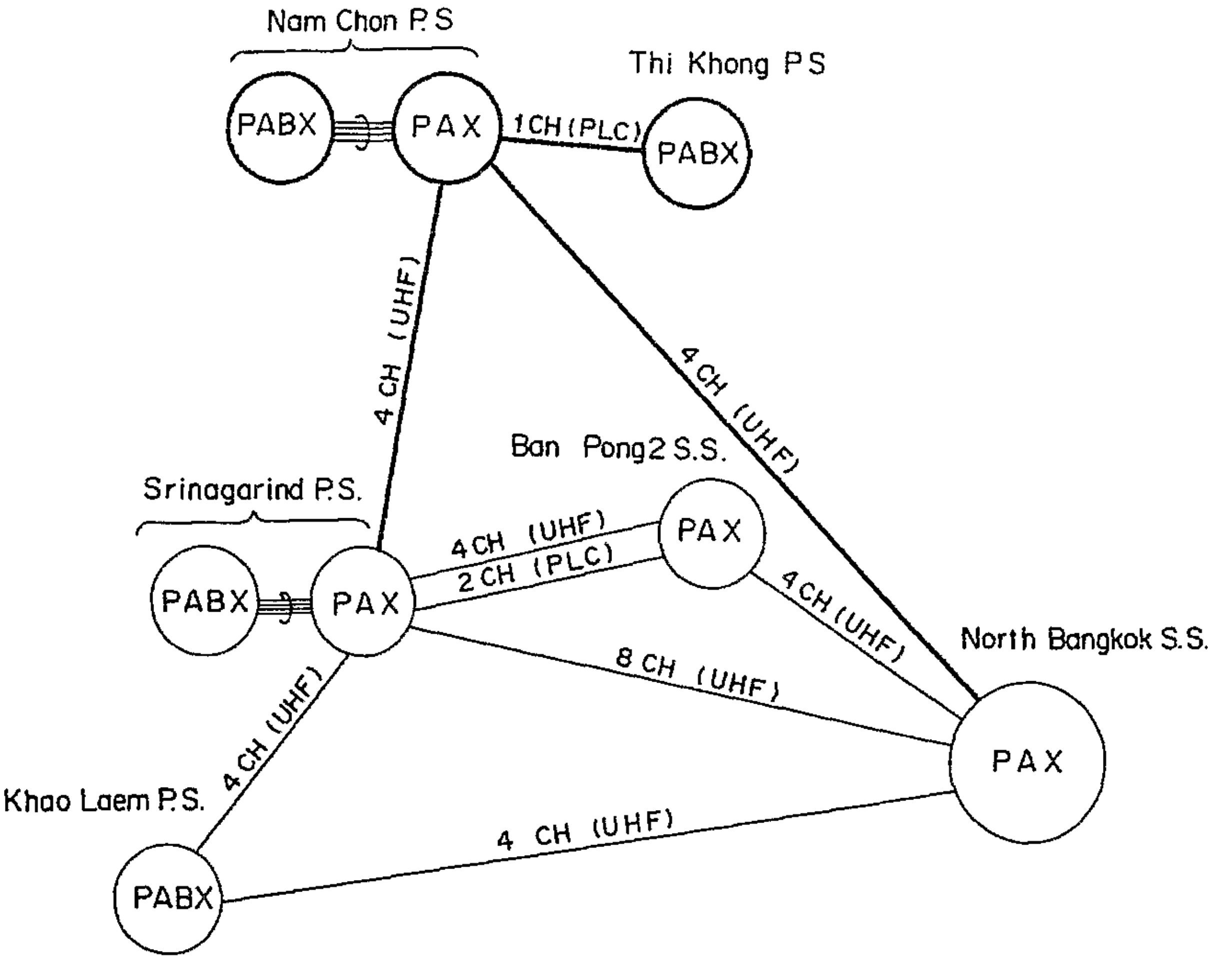


Fig. 9 - 21 Tie Line Telephone Network



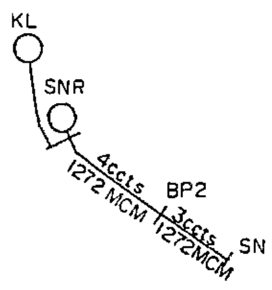
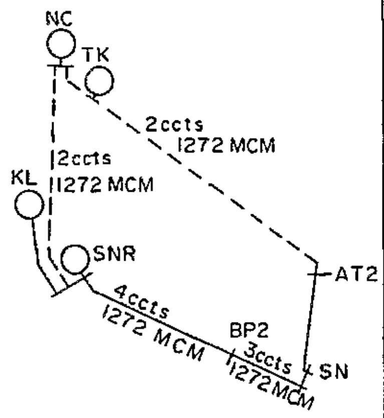
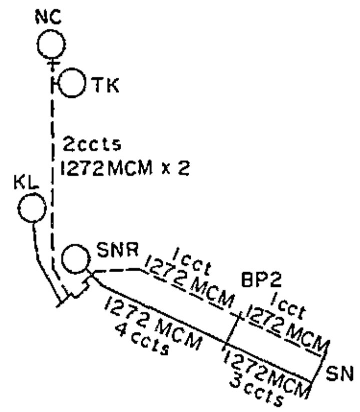
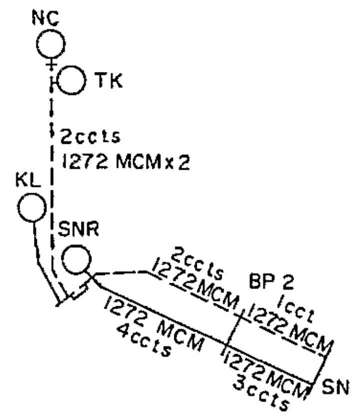
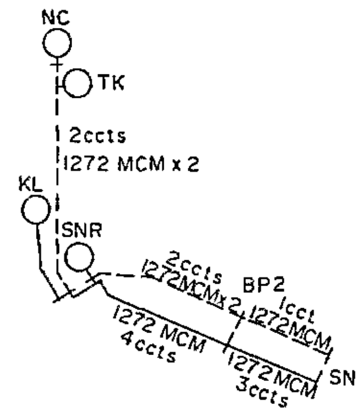
Legend :

PAX : Private Automatic Toll Exchange

PABX : Private Automatic Branch Exchange

By Upper Quae Yai Project

Table 9-1 Economic Comparison for the Selection of 230 kV Power System for Upper Quae Yai Project

Number / Power System Diagram / Items	———	A - ①	A - ② - a	A - ② - b	A - ② - c
Power System Diagram	Before 1987 				
(1) Construction Cost (M฿)					
1 Lines		889*	648	731	901
2 Equipments of Stations		184	234	268	268
3 Total		1,073	882	999	1,169
(2) Annual Cost (M฿)		149	107	121	141
(3) Line Losses in 1987					
1 Power (MW)	16.4	47	60	55	48
2 Annual Energy (GWH)	52.6	107	126	114	101
(4) Cost of Losses (M฿)					
1 Power	20	58	73	67	59
2 Annual Energy	53	108	128	115	102
3 Total	73	166	201	182	161
(5) Total Annual Cost Including Line Losses (M฿)					
(2) + (4).3		315	308	303	302
(2) + (4).2		257	235	236	243

Note: 1. * Including 139 M฿ for road construction
2. ---- Planed transmission line for Upper Quae Yai
3. Annual Cost Factor 0.2638 for roads
0.1173 for lines
0.1302 for equipments
4. Construction Cost includes the cost for the line bays of NC and TK.
5. Cost of Losses 1.224 M฿/MW, 1.013 ฿/KWH

Table 9-2 Transmission Lines and Main Equipments of the Power System for Upper Quae Yai Project

Scheme / Item	A - ② - a	A - ② - c	B
Transmission Lines	Nam Chon-Srinagarind 1 double-circuit line 115 km 230 kV, 2 x ACSR 1272 MCM Thi Khong-Transmission Line 1 single-circuit line 5 km 230 kV, ACSR 795 MCM Srinagarind-Banpong 2 1 single-circuit line 108 km 230 kV, ACSR 1272 MCM Banpong 2-Sai Noi 1 single-circuit line 54 km 230 kV, ACSR 1272 MCM	Nam Chon-Srinagarind 1 double-circuit line 115 km 230 kV, 2 x ACSR 1272 MCM Thi Khong-Transmission Line 1 single-circuit line 5 km 230 kV, ACSR 795 MCM Srinagarind-Banpong 2 1 double-circuit line 108 km 230 kV, 2 x ACSR 1272 MCM Banpong 2-Sai Noi 1 single-circuit line 54 km 230 kV, ACSR 1272 MCM	Nam Chon-Srinagarind 1 double-circuit line 115 km 230 kV, 2 x ACSR 1272 MCM Thi Khong-Transmission Line 1 single-circuit line 5 km 230 kV, ACSR 795 MCM Srinagarind-Sai Noi 1 double-circuit line 162 km 500 kV, 3 x ACSR 1272 MCM
Main Equipments of Substations	Srinagarind 7 230 kV line bays Banpong 2 2 230 kV line bays Sai Noi 1 230 kV line bay	Srinagarind 8 230 kV line bays Banpong 2 3 230 kV line bays Sai Noi 1 230 kV line bay	Srinagarind 2 500 kV line bays 6 230 kV line bays Sai Noi 2 500 kV line bays

CHAPTER 10

CONSTRUCTION SCHEDULE
AND
PROCEDURE

CHAPTER 10 CONSTRUCTION SCHEDULE AND PROCEDURE

10.1 Nam Chon Project

The construction schedule with the start of operation of Nam Chon Power Station planned in October 1987 determined from the demand and supply balance described in Chapter 2, is shown in Fig. 10-1.

This schedule was prepared considering the project scale, work execution method, and conditions of structures and the site. The major points in this construction schedule are as follows:

Before starting on the Project, it is necessary for an access road from the Srinagarind to Nam Chon, and the camps in the vicinity of the Nam Chon site, etc. to be built and completed as soon as possible.

Regarding electric power for construction purposes, it will be necessary for diesel generators to be used since the site is far from the Srinagarind.

Driving of the diversion tunnels is to be started in the dry season of 1981 and diversion into these tunnels is scheduled to be completed before the rainy season of 1983.

Embankment and foundation treatment of the dam is to be started in 1983, and these works are to be done in parallel. Foundation treatment is to be completed by May 1985 when impoundment is to be started. Embankment work is scheduled to be finished in the first half of 1987.

Outlet works are to be started in 1983, and installation of valves for discharge downstream during impounding should be completed before the start of impoundment.

Since installation of electrical equipment such as turbines and generators will be from 1985, the powerhouse works should be executed from 1982.

Works on the spillway, intake, headrace tunnels, surge tanks and penstocks are scheduled to be carried out between 1983 and 1986.

The excavation material from the various works is to be used for dam embankment as much as possible.

Transmission line work would be performed from 1984 with all work completed in the first half of 1987 and operation scheduled to be started in October 1987.

10.2 Thi Khong Project

The construction schedule with the start of operation of Thi Khong Power Station planned in March 1989 determined from the demand and supply balance described in Chapter 2, is shown in Fig. 10-2. This construction schedule was prepared considering factors such as construction scale, construction method, conditions of the structure, and the site, etc.

The essential points of this construction schedule are as described below. The access road from Nam Chon to Thi Khong should be completed before starting on the Project. The camp should be prepared in the vicinity of Thi Khong site.

Electric power for construction purposes should be supplied by diesel generators as in the case of Nam Chon Project.

For reasons of economy, the electric power for the camp and construction purposes is to be that for the Nam Chon Project as much as possible.

On this Project, it will be necessary for civil main works to be started on the diversion channel, that is the right half of the river flow, from May 1985 when impoundment of Nam Chon Reservoir will be started.

Diverting the flow to this diversion channel, work on the dam and the spillway is to be done from the latter half of 1985 to the first half of 1987. After these works have been completed and the river flow switched to the former channel, works such as on the intake and the powerhouse at the right bank side are scheduled to be performed by the end of 1988. Excavation material from the various works is expected as concrete aggregate.

Installation of electrical equipment such as turbines and generators is to be started in 1987, and operation is to begin in March 1989.

Fig. 10-1 Construction Schedule of Nam Chon Project

Description	Item	Unit	Quantity	Notes
Preparation Works		L.S.	1	
Construction Facilities		L.S.	1	
Clearing		L.S.	1	
Care of River		L.S.	1	
Diversion Tunnel No. 1	Ex.	m^3	239,000	
Diversion Tunnel No. 2	Con.	m^3	72,500	
Dam	Ex.	m^3	901,700	
	Gro.	m^3	60,000	
	Em.	m^3	12,700,000	
Spillway	Ex.	m^3	840,000	Ex. : Excavation Con. : Concrete
	Con.	m^3	62,100	Em. : Embankment
	Gate	L.S.	1	Gro. : Grout Injection
Intake	Ex.	m^3	160,000	Incl. In. : Inclined Shaft
	Con.	m^3	39,000	A.T. : Access Tunnel
	Gate	L.S.	1	O. Ex. : Open Excavation
Outlet Works	Ex.	m^3	10,300	
	Con.	m^3	11,400	Tra. : Trashrack
	Gate	L.S.	1	V. : Valve
Headrace	Ex.	m^3	65,000	
	Con.	m^3	21,600	
	Gro.	L.S.	1	
Surge Tank	Ex.	m^3	38,000	
	Con.	m^3	14,000	
	Gro.	L.S.	1	
Penstock	Ex.	m^3	32,000	
	Con.	m^3	10,800	
	S.P.	L.S.	1	S.P. : Steel Pipe
Powerhouse	Ex.	m^3	261,000	
	Con.	m^3	70,000	
	Con.(S.S.)	m^3	40,000	S.S. : Super Structure
Tailrace	Ex.	m^3	243,000	
	Con.	m^3	34,500	
	Gate	L.S.	1	
Electrical Equipment		L.S.	1	
Transmission Line		L.S.	1	
Switchyard Equipment		L.S.	1	

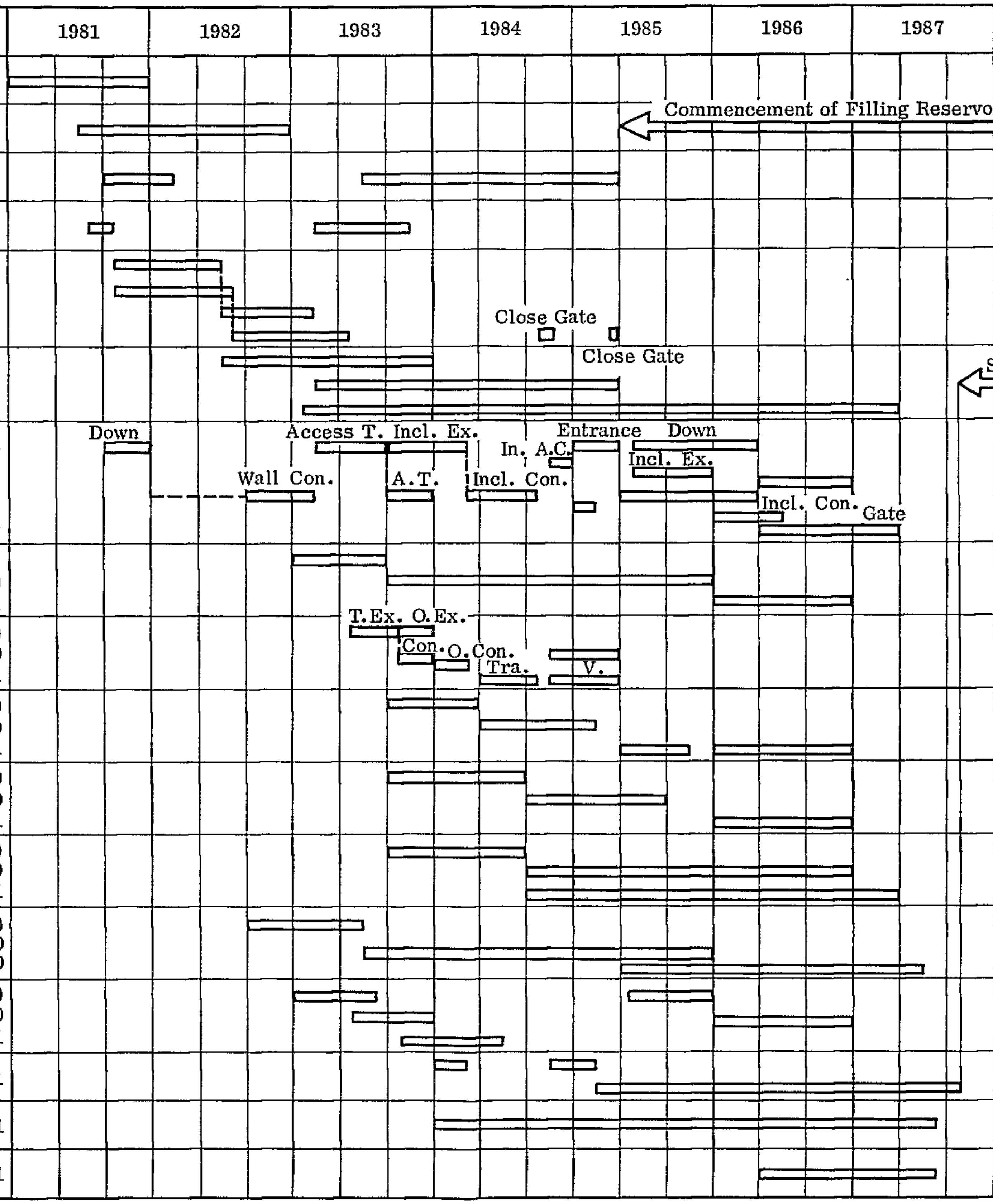


Fig. 10-2 Construction Schedule of Thi Khong Project

Description	Unit	Quantity	1985	1986	1987	1988	1989
Preparation Works	L.S.	1					
Construction Facilities	L.S.	1					
Clearing	L.S.	1					
Care of River	L.S.	1					Start of Operation
Excavation	m^3	720,000					
Concrete (Dam & Spillway)	m^3	46,000					
Concrete (Intake)	m^3	24,000					
Concrete (Powerhouse)	m^3	35,000					
Concrete (Tailrace)	m^3	10,000					
Gate (Spillway)	L.S.	1					
Gate (Intake)	L.S.	1					
Gate (Tailrace)	L.S.	1					
Switchyard	L.S.	1					
Electrical Equipment	L.S.	1					
Transmission Line	L.S.	1					

CHAPTER 11

CONSTRUCTION COST
AND
FINANCIAL PROGRAM

CHAPTER 11 CONSTRUCTION COST AND FINANCIAL PROGRAM

11.1 Construction Cost

The construction costs of Nam Chon Project and Thi Khong Project are shown in Tables 11-1 and 11-2. The summary of construction costs is as shown below. The construction costs were estimated by the price level as of October 1979, and were increased by 15% to obtain 1980 prices. Of wages, materials and machinery costs required for the works, those procurable in Thailand were estimated in local currency and the rest in foreign currency.

(1) Nam Chon Project

Project Cost	(million US$)	(million ฿)
Local currency	344.8	(7,069)
Foreign currency	225.6	4,625
Total	570.4	(11,694)

Note: 1US$ = 20.5฿

(2) Thi Khong Project

Project Cost	(million US$)	(million ฿)
Local currency	31.7	(650)
Foreign currency	24.7	506
Total	56.4	(1,156)

Note: 1US$ = 20.5฿

11.2 Financial Program

The annual financial programs were made based on the construction schedules, and these are indicated in Tables 11-3 and 11-4.

Table 11-1 Nam Chon Project Construction Cost

Item	Currency US$ (Million)		Total US$ (Million)
	Foreign	Local	
Preparation Works			
Camp, Road, Compensation and Contingency	14.2	45.7	59.9
Civil Works			
Diversion, Outlet Works and Care of River	6.1	20.1	26.2
Dam	59.5	45.8	105.3
Spillway	5.9	15.5	21.4
Intake, Headrace, Surge Tank and Penstock	4.1	17.0	21.1
Powerhouse and Tailrace	3.4	17.1	20.5
Miscellaneous	2.4	3.5	5.9
Contingency	7.9	11.6	19.5
Sub-total	89.3	130.6	219.9
Hydraulic Equipment			
Spillway Gates	1.5	0.3	1.8
Outlet Valve	1.1	0.3	1.4
Intake Gates	2.0	0.3	2.3
Penstock	6.9	2.3	9.2
Draft Gates	0.8	0.1	0.9
Contingency	0.8	0.8	1.6
Sub-total	13.1	4.1	17.2
Electrical Equipment	56.7	10.0	66.7
Transmission Line and Telecommunication	40.2	16.5	56.7
Engineering Fee	12.1	8.1	20.2
Total	225.6	215.0	440.6
Interest During Construction	-	107.9	107.9
Import Duties	-	21.9	21.9
Total Project Cost (Million US$)	225.6	344.8	570.4
(Million Bahts)	4,625	7,069	11,694

Table 11-2 Thi Khong Project Construction Cost

Item	Currency US$ (Million) Foreign	Currency US$ (Million) Local	Total US$ (Million)
Preparation Works			
Camp, Road, Compensation and Contingency	0.9	2.3	3.2
Civil Works			
Dam and Spillway	1.0	4.3	5.3
Intake, Powerhouse, Tailrace and Switchyard	3.2	9.7	12.9
Care of River	0.2	0.2	0.4
Miscellaneous	0.1	0.4	0.5
Contingency	0.5	1.4	1.9
Sub-total	5.0	16.0	21.0
Hydraulic Equipment			
Spillway Gates	1.4	0.3	1.7
Intake Gate, Trashrack and Draft Gate	1.6	0.3	1.9
Contingency	0.1	-	0.1
Sub-total	2.1	0.6	3.7
Electrical Equipment	14.3	2.5	16.8
Engineering Fee	1.4	0.9	2.3
Total	24.7	22.3	47.0
Interest During Construction	-	6.8	6.8
Import Duties	-	2.6	2.6
Total Project Cost (Million US$)	24.7	31.7	56.4
(Million Bahts)	506	650	1,156

Table 11-3 Financial Program of Nam Chon Project

Unit: Million US$ (Million ฿)

Year	Foreign Currency	Local Currency	Total
1981	10.9 (223)	23.2 (477)	34.1 (700)
1982	18.3 (376)	45.3 (928)	63.6 (1,304)
1983	22.5 (462)	51.0 (1,044)	73.5 (1,506)
1984	38.6 (791)	46.7 (957)	85.3 (1,748)
1985	54.4 (1,115)	64.4 (1,320)	118.8 (2,435)
1986	47.7 (977)	57.1 (1,172)	104.8 (2,149)
1987	33.2 (681)	57.1 (1,171)	90.3 (1,852)
Total	225.6 (4,625)	344.8 (7,069)	570.4 (11,694)

Notes: * These prices are based on the level as of 1980.

* 1US$ = 20.5฿

Table 11-4 Financial Program of Thi Khong Project

Unit: Million US$ (Million ฿)

Year	Foreign Currency	Local Currency	Total
1985	1.9 (39)	4.3 (88)	6.2 (127)
1986	2.9 (59)	5.2 (108)	8.1 (167)
1987	6.1 (125)	9.4 (192)	15.5 (317)
1988	12.3 (253)	10.6 (217)	22.9 (470)
1989	1.5 (30)	2.2 (45)	3.7 (75)
Total	24.7 (506)	31.7 (650)	56.4 (1,156)

Notes: * These prices are based on the level as of 1980.

* 1US$ = 20.5฿

CHAPTER 12

ECONMIC JUSTIFICATION

CHAPTER 12 ECONOMIC JUSTIFICATION

12.1 Scope of Economic Analysis

The economic analysis of an electric power generating project is made in the form of comparison with an alternative project providing equal service with the project contemplated. In the case of a hydroelectric power generating project, the technique recognized throughout the world is to select thermal power generating facilities as alternative project and compare the cost of the objective hydroelectric power station with those of the alternative thermal power station. Accordingly, the economic analysis of this project was made by this manner.

Since the character of this hydroelectric power project is that of a peaking station, in order that the alternative thermal power station would match this power generating character, combinations of gas turbine power plant, which has the capability of quickly responding to peak loads, and oil-fired thermal power plant were considered, and the combination with the cheapest power generating cost was selected and this was considered as the alternative power station.

Economic analyses were made for the two cases of Nam Chon Power Station developed alone, and Nam Chon Power Station and Thi Khong Power Station constructed simultaneously as a two-stage development project. Since development of Thi Khong Power Station alone is obviously not practical as a hydroelectric power generating project both technically and economically, this case was not taking this economical study into consideration. To start construction of Thi Khong Power Station after completion of Nam Chon Power Station would mean an enormous expense for construction of a diversion waterway to construct Thi Khong Power Station and this is not realistic.

The economic analysis was made by the discounted cash flow method with the cost of the alternative power station substituted as the benefit of this hydroelectric power project. Base case of the economic justification is a case in consideration of Shadow Price Factor in accordance with EGAT's consent.

Since it is very difficult to foresee the fuel prices and discount rate, influences on the project economy were examined by sensitive analysis concerning fuel price increase and changing the discount rate.

Basic criteria for the economic study is shown in Table 12-1.

12.2 Selection of Alternative Power Generating Facility

The electric power produced by this hydroelectric power project is to be supplied to meet the peak load of the whole power system of Thailand, therefore, the alternative thermal power station is considered to be installed near Bangkok area. As the alternative thermal power project, economical conbination of several units of 60 MW gas turbine power plant and oil-fired thermal power plant were studied taking the generating cost into consideration. The result is summerized in Table 12-2. In this study, the annual available energy of the alternative plants is considered to be 1,160 x 10^6kWh (in the case of the project with Thi Khong Power Station) at Bangkok area which is the same amount of that of the Upper Quae Yai Project. In addition, annual plant factors of gas turbine and oil-fired thermal power plants were restricted to be not less than 5% and within 80%, respectively.

In the study of the scale of development of the project, unit kW and kWh benefits and unit surplus kWh benefit were estimated basing on the combination of six units of 60 MW gas turbine power plant and a 200 MW oil-fired thermal power plant with referring to the above study. The details are shown in Table 12-3.

Economic analysis of the selected project by the preliminary study is based on a suitable combination of the thermal power plants in consideration of the study result shown in Table 12-2.

Accordingly, the alternative power project to be considered for the Upper Quae Yai Project with Thi Khong Power Station was selected to be eight units of 60 MW gas turbine power plant and a 170 MW oil-fired thermal power plant (Refer to Table 12-4).

12.3 Project Cost

As described in Chapter 11, the total construction cost of this hydroelectric power generation project in case of simultaneous development of Thi Khong Power Station was estimated to be US$626.8 million.

The period considered for the economic analysis was taken to be 57 years, and the total amount of the equipment investment cost and operation and maintenance costs of each year during this period was taken as the annual cost of the Project and converted to present value, and the total for the 57 years was taken as the cost of the Project. A discount rate of 10% was employed for conversion ot present value.

The annual operation and maintenance costs of the electric power facilities of this Project, with the concurrence of EGAT, were obtained as follows:

Facilities	Operation & Maintenance Cost
Dam & Reservoir	1.0%
Power Station	2.0%
Substation	2.0%
Transmission Line	1.5%

12.4 Project Benefit

12.4.1 Alternative Thermal Power Generating Facility

The outline of the alternative thermal power generating facility selected as the basis for economic analysis is as indicated below.

(1) The location is to be near the Bangkok Metropolice.

(2) The construction cost is to be calculated referring to unit construction costs of similar thermal power station contracts recently awarded by EGAT upon international bidding.

(3) The scale of the alternative thermal power generating facility is to be equal in electricity output to this hydroelectric power generating facility.

(4) Relation between Installed Capacity and Dependable Capacity

For the thermal power plants in the EGAT's system, records of operations in FY. 1975 ∿ 1978 showed that there are several occasions that the thermal plants are not able to generate up to full rated capacity. Therefore, dependable capacity of thermal power plants including gas turbines should be used for the following criteria for planning:

Average figure of dependable capacity of thermal plants (oil/gas/ lignite) is 95 percent in which the diversity of the rated installed capacity of several power plants were taken into account. Therefore, total installed capacity of gas turbines and oil fired thermal plants are:

$$\text{Total installed capacity} = \frac{\text{Dependable capacity}}{0.95}$$

The details of the alternative thermal power generating facilities considered based on the above conditions are given in Table 12-4.

12.4.2 Fuel Cost of Alternative Thermal Power Plant

Fuel prices in this study were estimated taking those for 550 MW oil-fired thermal power unit and 60 MW gas turbine power unit in EGAT's Ban Pakong Thermal Power Plant into consideration.

Following to the OPEC's decision of export crude oil price-up to 16 $\sim$ 18 US$/barrel in June 1979, the further price increase was agreed by OPEC at Caracas in Venezuera in December 1979.

In the study for determination of the scale of development of the project, the fuel prices in 1980 were estimated to be 2.62฿/ℓ and 3.80 ฿/ℓ for heavy oil and diesel oil, respectively. Estimation of benefits of the Upper Quae Yai Project was made based on the 20% higher prices than the above price taking rapid escalation of oil prices into consideration.

Judging from these matters, prices of fuel oil are not stable and nobody guesses how much price would be increased by the time when this report is completed. Therefore, the economic analysis on the selected case of the project was made based on the fuel prices suggested by EGAT

January 1980, i.e. 3.48฿/ℓ for heavy oil and 4.68฿/ℓ for diesel oil. In addition to this study, the similar economic analysis based on the 5% to 150% higher fuel price than the above prices for examining the influence of fuel price increase against the project economy, what is called sensitivity analysis, was made.

Further study based on the different fuel prices will not be made even the fuel prices be changed during preparation of this report because this sensitivity analysis cover all cases concerning fuel price changing.

12.5 Annual Available Energy

The annual available energy of the Upper Quae Yai Project was estimated taking the following matters into consideration:

(1) Energy decrease at the downstream power plants by storing water in Nam Chon Reservoir in 1985 and 1986.

(2) Power and energy increases at the downstream power plants after completion of the Upper Quae Yai Project.

(3) Transmission line loss from the power stations to the 230 kV outer-ring transmission line in Bangkok (Refer to Chapter 9)

12.6 Economic Justification

The results of economic analysis made by the discounted cash flow rate method are shown in Table 12-5 and Table 12-6. As seen in these tables, the internal rate of return (IRR) of this Project in case of simultaneous development of Nam Chon Power Station and Thi Khong Power Station will be 15.2%, while the benefit-cost ratio (B/C) in case of a discount rate of 10% will be 1.45, and it is judged that this Project is worth implementing from an economic viewpoint. It is similarly judged that the Project will still be economical in the case that Thi Khong Power Station is not developed.

Studies were made of the effects on the economics of the Project when discount rates were varied, and when the unit fuel costs of the alternative thermal power generating facilities were increased, and the results are indicated in Fig. 12-1, Fig. 12-2, Fig. 12-3, and Fig. 12-4.

Fig. 12 - 1 Sensitivity Analysis (1A)

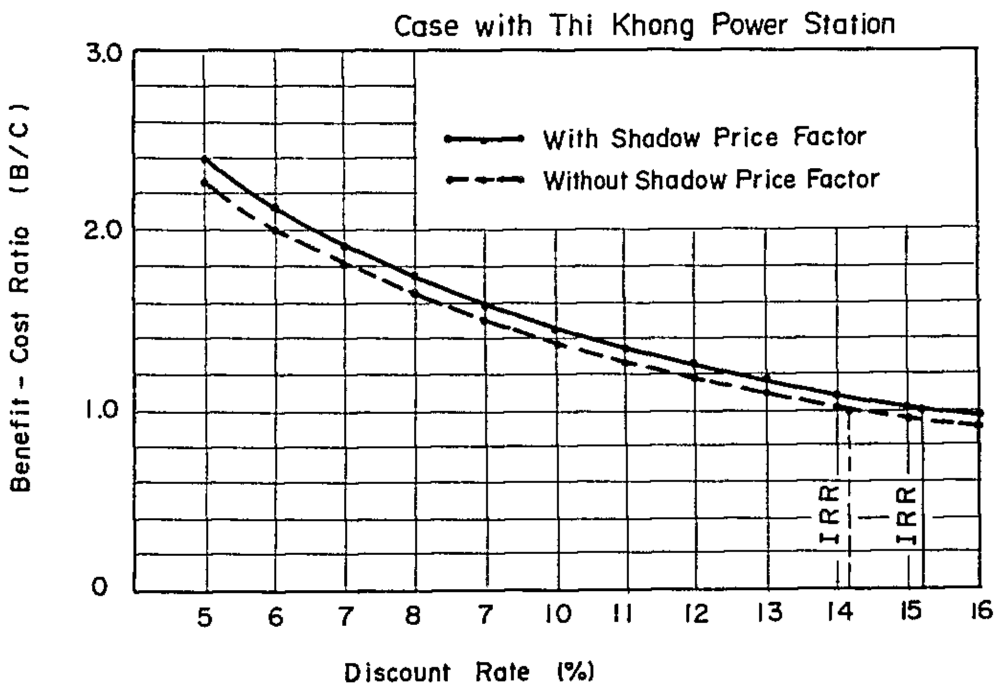


Fig. 12 - 2 Sensitivity Analysis (1 B)

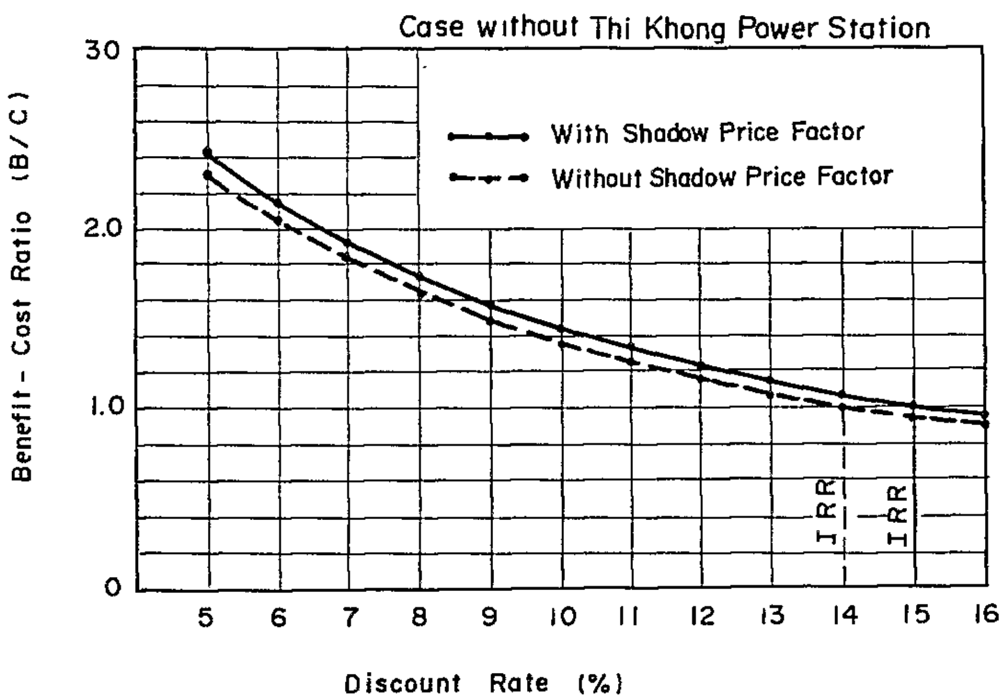


Fig. 12 - 3 Sensitivity Analysis (2 A)

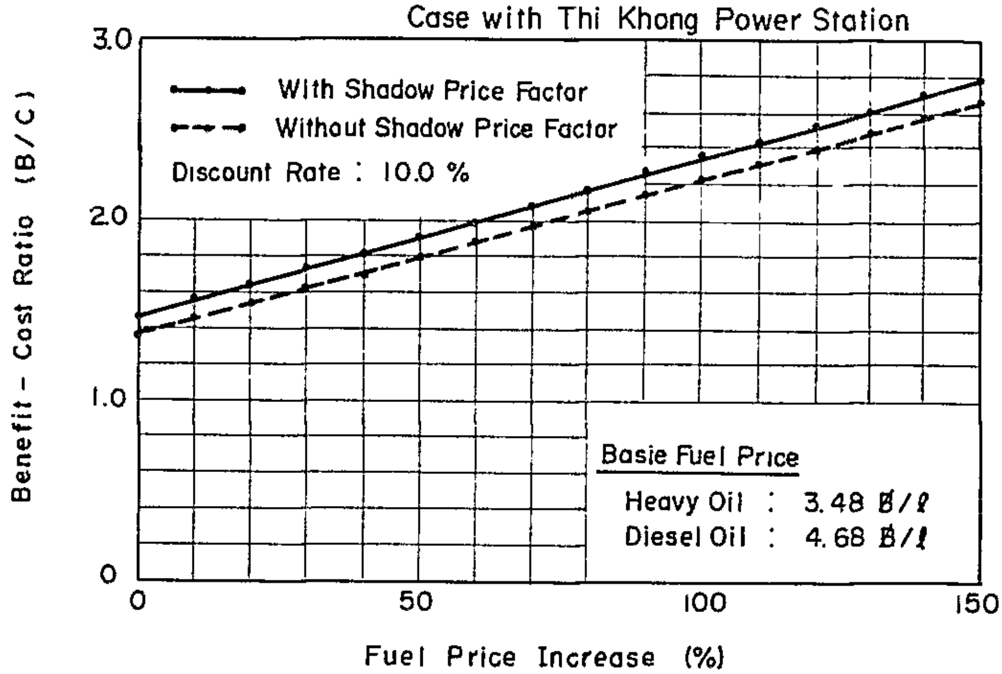


Fig. 12 - 4 Sensitivity Analysis (2 B)

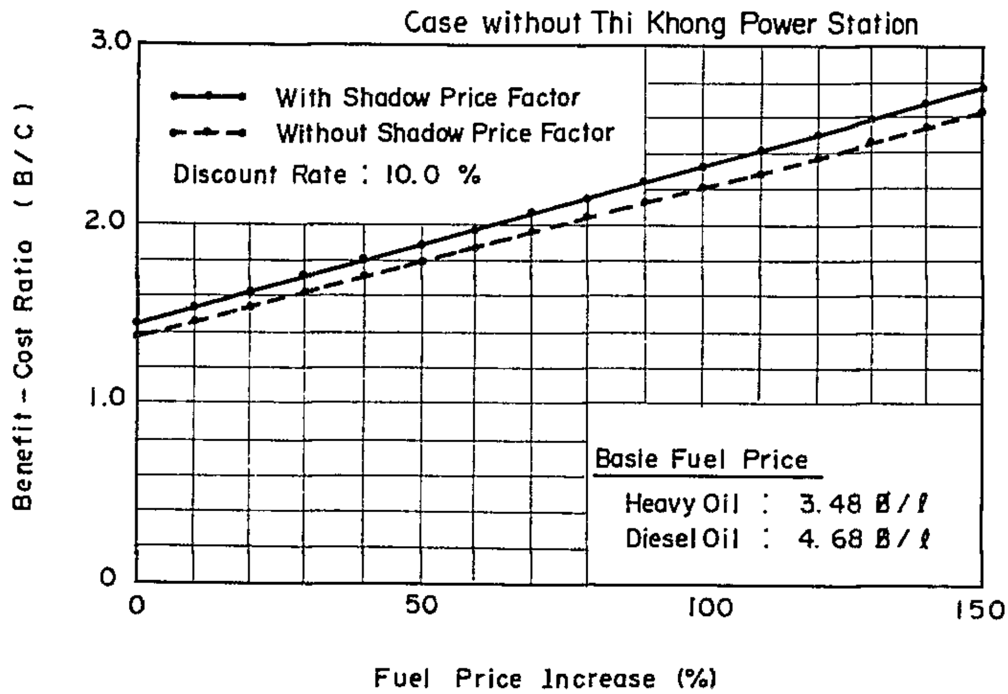


Table 12-1 BASIC CRITERIA FOR ECONOMIC STUDY

Method of Analysis:	Discounted Cash Flow Method
Study Priod:	57 years (1981 - 2012)
Discount Rate:	10%
Escalation:	Not considered
Shadow Price Factor:	
Foreign Currency	1.10
Local Currency for Hydro	0.85
Local Currency for Thermal	0.95
Fuel Price	1.0
Service Life of Facilities:	
Dam & Reservoir	50 years
Hydro Power Plant	25 years
Oil Fired Thermal Plant	25 years
Gas Turbine Plant	20 years
Substation	25 years
Transmission Line	40 years
Conversion Rate of Currency:	US$1.00 = ฿20.5

Table 12-2 GENERATING COST RATIO OF ALTERNATIVE THERMAL PLANT

No. of 60 MW Gas Turbine Unit	Total Installed Capacity of Thermal Power Plants				
	650 MW	600 MW	550 MW	500 MW	450 MW
3	-	-	-	-	94
4	-	-	-	98	94
5	-	-	101	97	95
6	-	104	100	100	-
7	107	103	106	-	-
8	106	111	-	-	-
9	117	-	-	-	-

Note: Annual Available Energy: 1,060 GWh (sending end)

Unit Construction Cost:

Gas Turbine Plant	240$/kW
Oil-fired Thermal	495$/kW

Fuel Cost Per Litre:

Gas Turbine	0.2283$ (4.68฿)
Oil-fired Thermal	0.1698$ (3.48฿)

Fuel Consumption Rate:

Gas Turbine	0.3977 ℓ/kWh
Oil-fired Thermal	0.252 ℓ/kWh

Table 12-3 ALTERNATIVE THERMAL POWER PLANT FOR STUDYING OPTIMUM SCALE OF DEVELOPMENT

Interest Rate: 0.100
1980 Price Level

		Gas Turbine	Oil Fired	Line
Installed Capacity		6 x 60 MW	1 x 200 MW	560 MW
Dependable Capacity	(MW)	342	188	-
Annual Plant Factor	(%)	5	59	22.6
Annual Energy Production	(10^6kWh)	158	1,026	-
Station Service Use	(%)	2	7	-
Annual Available Energy	(10^6kWh)	155	954	1,109
Unit Construction Cost	(US$/kW)	278	574	35
Construction Cost	(10^6US$)	100.1	114.8	19.6
Service Life	(Year)	20	25	40
Capital Recovery Factor	(p.u.)	0.11746	0.11016	0.10226
O & M Cost Rate w/o Fuel	(%)	3.0	2.5	1.5
Fuel Consumption Rate	(1/kWh)	0.3977	0.252	-
Unit Fuel Cost	(US$/1)	0.1854	0.1278	-
Annual Cost	(10^6US$)			
Capital		11.76	12.65	2.00
Fixed O & M cost		2.40	2.30	0.53
Fuel cost		11.65	33.04	-
Variable O & M cost w/o fuel		0.60	0.57	-
Combined Cost (Benefit of hydro project)				
kW cost	(US$/kW)	59.70 (= 1,224฿/kW)		
kWh cost	(US$/kWh)	0.04135 (= 0.848฿/kWh)		
2ry kWh benefit	(US$/kWh)	0.03523 (= 0.722฿/kWh)		
Combined Cost (Fuel 20% up)				
kW cost	(US$/kW)	59.70 (= 1,224฿/kW)		
kWh cost	(US$/kWh)	0.04941 (= 1.013฿/kWh)		
2ry kWh benefit	(US$/kWh)	0.04216 (= 0.864฿/kWh)		

Note:
- Interest during construction is included in the unit construction costs.
- Net construction costs are 240$/kW and 495$/kW for gas turbine and oil-fired thermal power plants, respectively.
- Benefit of secondary energy of hydro is evaluated by the variable cost of oil-fired thermal plant.
- Costs of Fuel 20% up case are used for evalution of the hydro taking the present oil crisis into consideration.

Table 12-4 ALTERNATIVE THERMAL POWER PLANT FOR STUDYING ECONOMIC JUSTIFICATION

Item	Unit	Gas Turbine	Oil-fired Thermal
Installed Capacity	(MW)	480	170
Unit Capacity	(MW)	60	170
Dependable Capacity	(MW)	456	160
Annual Plant Factor	(%)	5	70
Annual Energy Production	(10^6kWh)	200	1,036
Station Service Power Use	(%)	2	7
Annual Available Energy	(10^6kWh)	196	963
Fuel Consumption Rate	(ℓ/kWh)	0.3977	0.252
Unit Fuel Price	(฿/kWh)	4.68	3.48
Construction Cost	(10^6US$)	115.2	84.2
Unit Construction Cost	(US$/kW)	240	495

Table 12-5 ECONOMY OF PROJECT (1)

- with Thi Khong Power Plant -

	Discount Rate (%)	Base Case (with shadow price factor)	Alternative Case (without shadow price factor)
B/C	10	1.45	1.37
B-C	10	152.9 x 10^6US$ (3,134 x 10^6Baht)	129.4 x 10^6US$ (2,653 x 10^6Baht)
IRR	--	15.2%	14.1%

Table 12-6 ECONOMY OF PROJECT (2)

- without Thi Khong Power Plant -

	Discount Rate (%)	Base Case (with shadow price factor)	Alternative Case (without shadow price factor)
B/C	10	1.45	1.36
B-C	10	140.9 x 10^6US$ (2,888 x 10^6Baht)	119.0 x 10^6US$ (2,440 x 10^6Baht)
IRR	--	15.0%	14.0%

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