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โครงการเร่งรัดพัฒนาไฟฟ้าชนบทระยะที่ ๒

FEASIBILITY STUDY
FOR
ACCELERATED RURAL ELECTRIFICATION PROJECT-SECOND STAGE

VOLUME I
MAIN REPORT

US. AID PROJECT DEVELOPMENT LOAN FUND

CONTRACT NO. 493-H-14(2)

สำนักงานโครงการเร่งรัดพัฒนาไฟฟ้าชนบท
OFFICE OF RURAL ELECTRIFICATION

การไฟฟ้าส่วนภูมิภาค
PROVINCIAL ELECTRICITY AUTHORITY

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SECTION I

INTRODUCTION

1.1 This report was prepared by the Office of Rural Electrification (ORE) of the Provincial Electricity Authority (PEA) during the years 1977-78 with the advisory assistance from Harza Engineering Company (HEC). The consultant was contracted by a loan from the Project Development Loan Fund No. 493-H-14 — an agreement between the Royal Thai Government (RTG) and the United States Agency for International Development (USAID) setting a special fund used for indentifying projects under the supervision of the National Economic and Social Development Board (NESDB).

1.2 This report — the fourth successive study done by PEA/ORE in development of Accelerated Rural Electrification (ARE) Project in Thailand — is a detail feasibility study for project implementation of the Second 5-Year ARE Program (ARE 2). The first report was done in 1970 for overall investigation purpose socalled ARE Reconnaissance Study and was approved in PRINCIPLE by the RTG in 1971. It was assisted by the USAID Specialists under a grant to PEA. The second report was done in 1972 for prefeasibility purpose socalled ARE National Plan Study and was approved in PLAN by the RTG in 1973. It was assisted by the Middle West Service Company contracted under a USAID grant to PEA. The third report was done in 1975 for ARE 1 Feasibility Study of the First 5-Year ARE Program (ARE 1) and was approved in PROJECT by the RTG in 1976. It was assisted by the R. W. Beck & Associates Company contracted under a loan from the USAID Project Development Loan Fund.

1.3 This ARE 2 Feasibility Study will be submitted to the RTG for PROJECT approval in 1979 in light of the following implemention in 5 years period of 1980-1984.

SECTION II

PROJECT BACKGROUND

SECTION II

PROJECT BACKGROUND

2.1 The Country

Thailand is located in the tropical monsoon zone of Southeast Asia. It has a population of 45 million in 1978, and an area of 514,000 sq.km. extending in latitude from 6° - 21° North and in longtitude from 97° - 106° East. The mainland lies within the central interior of the Indo-Chaina Peninsula. The country is bounded on the West by Burma, on the North by Burma and Laos, on the East by Laos and Cambodia, and on the South by Gulf of Thailand, Malaysia and Andaman Sea.

The topographic features of Thailand comprise 3 main types of land forms: highland, plain, and plateaus. Highland includes the several mountain ranges covered with forest extending from the Northern part to the Southern part through the entire Western bound, and the Eastern coast of the Gulf of Thailand. The Central part of the country is occupied by an extensive alluvial plain, while the Northeastern part is formed by the undulated plateaus.

2.2 The Economy

In 1976, the Per Capita GNP was US$ 380 based on population of 43.2 million with growth rate of 2.7% per annum. Economic growth was substantial in the 1960s with the increase in real GDP averaging 8.0% per year. The 1970s situation has been a difficult decade. The rate of growth of real GNP showed to 6.5% during 1970-74 largely due to a weak export demand in 1970-71, a drought in 1972 which severely restricted agricultural production, and a slowdown in economic activity following the world energy crisis and recession in 1974. The period of 1975-79 is expected to be improving even with the impact of another drought in 1977 and a flood in 1978. The rate of growth of real GNP rosed from 5.5% in 1975,

6.3% in 1976, to 7.0% in 1977. The 7.0% per annum is the target established in the RTG's Fourth National Plan (1977-1981).

Thailand is well endowed with land, water, and labor resources for agricultural and agro-industrial productions. Agriculture is the major economic activity, contributing about 29.9% of GDP, employing 75.7% of the labor force, and providing about 71.3% of merchandise export earnings in 1976. Industry as the minor economic activity contributed about 24.8% of GDP, 7.9% of labor force, and 14.3% of export earnings. Moderate development on tourism as a source of foreign exchange is also taking place. Significant development on rural infrastructure especially electricity has been emphasized under the Fourth Plan.

2.3 The Power Sector

The power sector of Thailand consistes of state-owned organizations: Electricity Generating Authority of Thailand (EGAT), Metropolitan Electricity Authority (MEA), and Provincial Electricity Authority (PEA).

A. The EGAT

EGAT was established in 1968 as a wholly-owned Government Corporation under the Office of Prime Minister responsible for electric generation and transmission systems and bulk supply to MEA and PEA. EGAT generated 91.4% (9,414 GWh) of all power in Thailand (10,295 GWh) in 1976, the balance of 8.6% was generated by PEA, private utilities and industries. EGAT's peak demand in 1976 was 1,652 MW, and has annual load factor of 65%.

B. The MEA

MEA was established in 1958 as a wholly-owned Government Corporation under the Ministry of Interior with the responsibility of supplying electricity to the Metropole area covering 3 provinces of Bangkok, Nonthaburi and Samut Prakan. MEA sold 5,285 GWh to 544,700 customers in 1976, and all power is purchased from EGAT. MEA's peak demand in 1976 was 958 MW, and has annual load factor of 67%.

C. The PEA

PEA was established in 1960, as a wholly-owned Government Corporation under the Ministry of Interior with the responsibility of providing and supplying electricity to all the Provincial area (outside the Metropole area of MEA) covering 69 provinces. PEA sold 2,617 GWh to 927,400 customers in 1976 — most of the power 95.9% is purchased from EGAT while the rest came from PEA's 310 diesel-generating plants located in the isolated areas throughout the country. PEA's peak demand in 1976 was 640 MW, and has annual load factor of 57%.

Sector growth rate has been considerable ; since 1968 GWh sales have grown from 2,520 GWh to 8,623 GWh in 1976, a growth rate of 16.6% per year.

Thailand's Per Capita Consumption of power in 1976 was 199 kWh, compared to 40 kWh of Indonesia, 300 kWh of Philippines, 480 kWh of Malaysia, and 565 kWh of Korea. It varies widely between PEA and MEA as follows:

Area	Population (000)	Consumption (GWh)	Per Capita (kWh)
MEA	5,638	5,371	593
PEA	37,576	3,252	87
Total	43,214	8,623	199

Imbalances also exist in term of the degree of electrification for MEA and PEA serving areas in 1976:

Area	Population (000)	Population Electrified (000)	Households (000)	Households Connected (000)	% of Electrification
MEA	5,638	3,986	804	568	70.7%
PEA	37,576	6,655	5,369	952	17.7%
Total	43,214	10,641	6,173	1,520	24.6%

The 1976 electrification coverages by regions also differ within PEA area as follows:

Region	Population (000)	Population Electrified (000)	% of Electrification
North	7,880	1,318	16.8%
Northeast	14,793	1,794	12.1%
Central (PEA)	9,574	2,461	25.7%
South	5,329	1,082	20.3%
Total	37,576	6,658	17.7%

Provision of power to the provincial areas began on the planned basis since the formation of PEA. Overall growth in the PEA area has been very rapid, an annual average growth rate for the past 10 years (1968-1977) of 24% for energy sales, 11% for number of customers, 22% for revenue from sales, and 7% for number of employees. The growth trends by year are as follows:

Category	1977	1976	1975	1974	1973	1972	1971	1970	1969	1968
Energy Sales (GWh)	3174	2617	2120	1779	1557	1211	924	769	602	458
(%)	21.3	23.4	19.2	14.2	28.6	31.1	20.1	27.8	31.4	33.2
No. of Customers (000)	1144	927	781	697	629	575	525	479	443	398
(%)	23.4	18.7	12.1	10.9	9.2	9.6	9.6	8.0	11.4	14.0
Revenue from Sales (MB)	2185	1739	1591	1223	936	762	623	527	444	361
(%)	25.7	9.3	30.1	30.7	22.7	22.5	18.0	18.8	23.1	13.7
No. of Employees (ea.)	8883	8028	7502	7305	6791	6327	5887	5648	5180	4661
(%)	10.7	7.0	2.7	7.6	7.3	7.5	4.2	9.0	11.1	6.7

PEA, by 1977, has 12 Region Electric Works, 69 Province Electric Work, 453 District Electric Works, and 313 Commune Electric Works. It has 14,000 circuit kilometers of high-voltage distribution lines by which 21% is 33 kV lines mostly in the South, 65% is 22 kV lines mostly in the Central and Northeast, 13% is 11 kV lines mostly in the North, and 1% of 3.5 kV lines scattered throughout the country with isolated diesel generations. It also has 1,545 MVA installed capacity of transformer out of which 13% is 33 kV class, 69% is 22 kV class, 15% is 11 kV class and 3% is 3.5 kV class. The sales of electricity has

mostly gone to business & industrial customers since 1976 and takes two-third of total sales in 1977, while only one-third goes to residential customers.

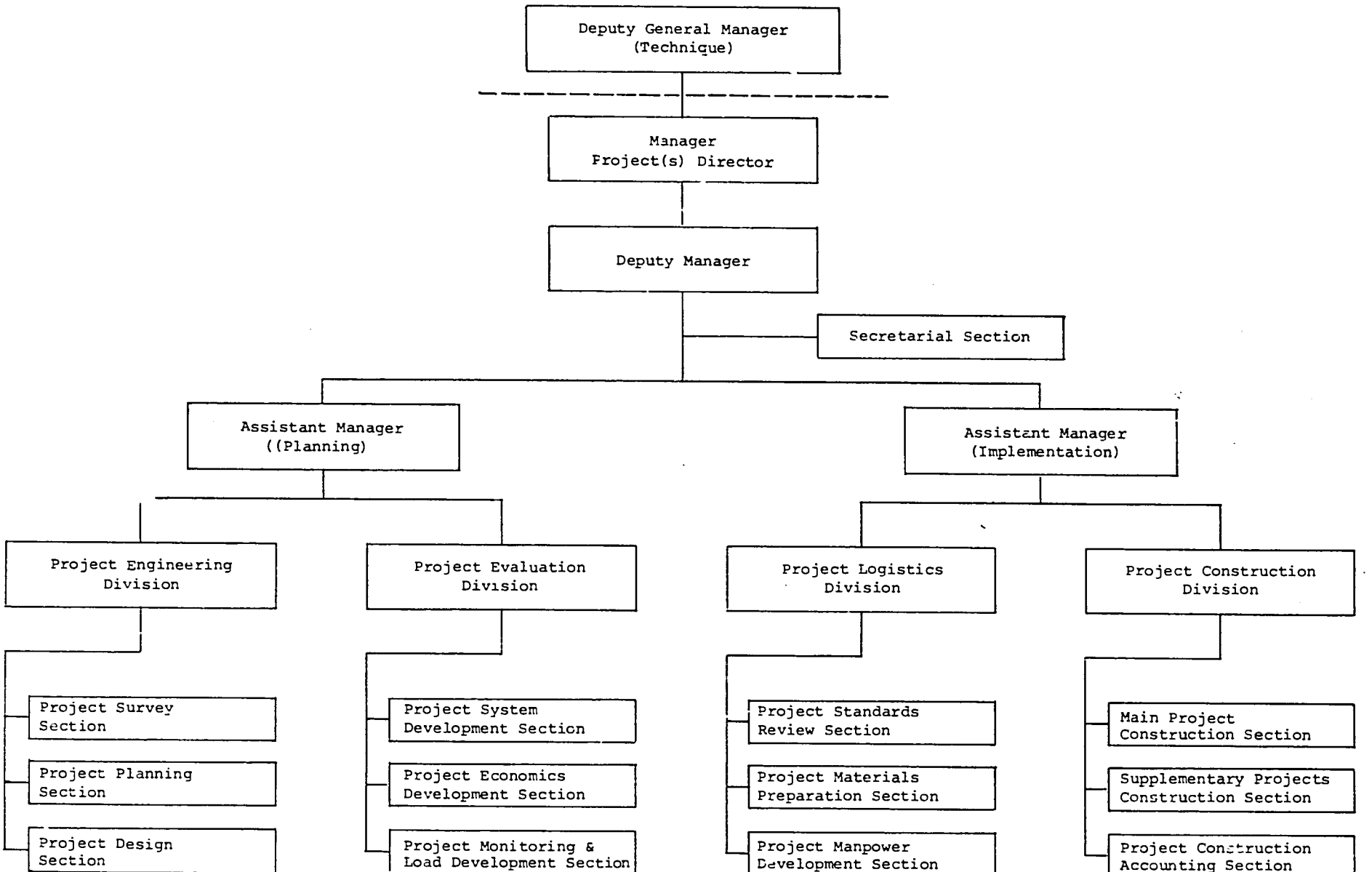
2.4 The ORE/PEA

By June 30, 1970, PEA decided to start a new approach to attack the problems of rural electrification by declaring the formation of the ARE Program taking an overview of the whole situation of rural Thailand. With successive development studies submitted to the RTG through NESDB, approvals have been granted to all proposals — in PRINCIPLE (Reconnaissance Study), in PLAN (Pre-Feasibility Study or Master Plan), in PROJECT (Feasibility Study for ARE 1). Therefore, by May 1, 1974, Office of Rural Electrification (ORE) was formally set up with the approval of the PEA Board of Directors. Its function is to plan and implement ARE Program as a package under single management — the Project Director who is also Manager of the ORE (see the following organization chart). In 1978, it has about 200 permanent employees and 1,000 workers. Most of these manpower task-forces are in the Line Organization working in the field (Project Construction Division) which account for 26 standard construction crews (approximate 56-man team for each crew, out of these 40 are labors and skill-labors). Minority of the ORE manpower, mostly professionals, work in the office as Staff Organization (Project Engineering Division, Project Evaluation Division, and Project Logistics Division). In addition, some 400 labors and skill-labors are working for the contractors on the project civil-work (poles hauling and pole setting) and another 600 skill-labors are working for the contractors on interior-wiring, in both cases not including some sizable amount of technicians who are the group leaders for such activities. In total, ORE/PEA can successfully support the government policy for reducing local unemployment by approximately 2,000 peoples.

ORGANIZATION CHART

OFFICE OF RURAL ELECTRIFICATION

PROVINCIAL ELECTRICITY AUTHORITY



2.5 The National Plan for ARE

Rural Electrification is regognized as a main component of rural infrastructure together with road and water. It is a means whereby the rural populace can increase their agricultural and agro-industrial productions not just to light up their homes. This, in turn, will result in increasing their incomes; raising their living standards; strengthening their communities' economic, social and political stabilities; and last but not least, reducing their birth rate and migration to towns and cities.

On August 28, 1973, the Council of Ministers gave approval in National Plan for Total Electrification of Thailand (ARE Program) as proposed by PEA's Pre-Feasibility Study and recommended by the Board of Rural Electrification, the Ministry of Interior, and the NESDB:

- Approval of 25-Year Long-Range Program (ARE),
- Approval of First 5-Year Short-Range Program (ARE 1) to be concentrated in the Northeast.

According to the Master Plan, the Long-Range Program was compressed to 15-Year instead of the original 25-Year, as per request of the RTG (Council of Ministers' resolution on June 5, 1975), by making 2 years overlapping of the 5 consecutive 5-Year Short-Range Programs as follows:

Short-Range Program	Project Villages		Concentrated Area
	In Program	Accumulated	
Stage I (FY 1977-1981)	5,200	5,200	Northeast
Stage II (FY 1980-1984)	8,000	13,200	South
Stage III (FY 1983-1987)	13,500	26,700	North
Stage IV (FY 1986-1990)	14,500	41,200	Central
Stage V (FY 1989-1991)	5,800	47,000	Contrywide

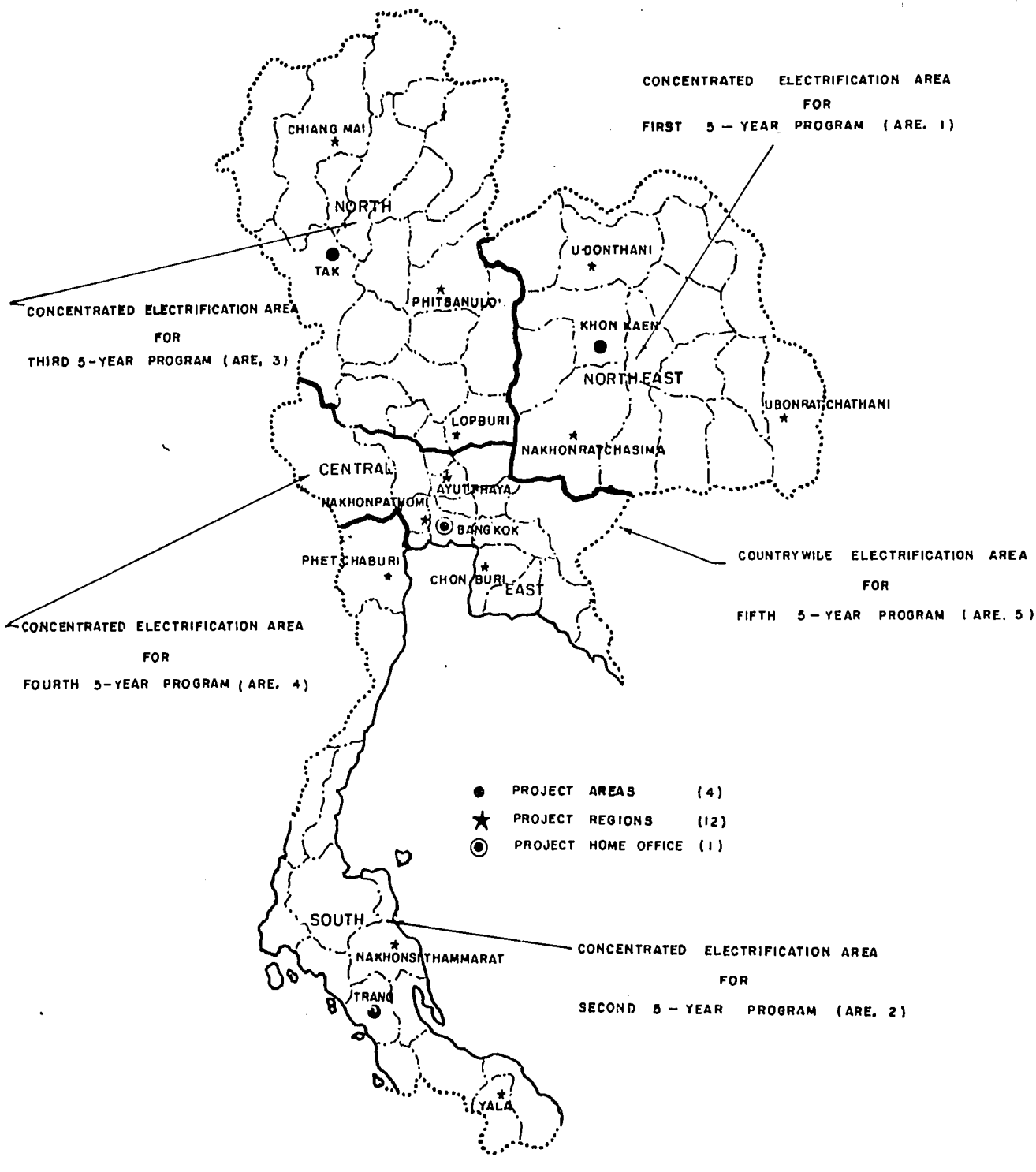
The following map, table and chart illustrate the 5 Subprogram(Stages 1,2,3,4,5) under the 3 National Economic & Social Development Plans (4th, 5th, 6th Plans).

RECOMMENDED

PROJECT SUBDIVISION FOR 69 PROVINCES

TOTAL 15-YEAR PROGRAM OF THAILAND ACCELERATED RURAL ELECTRIFICATION

(47,000 VILLAGES)

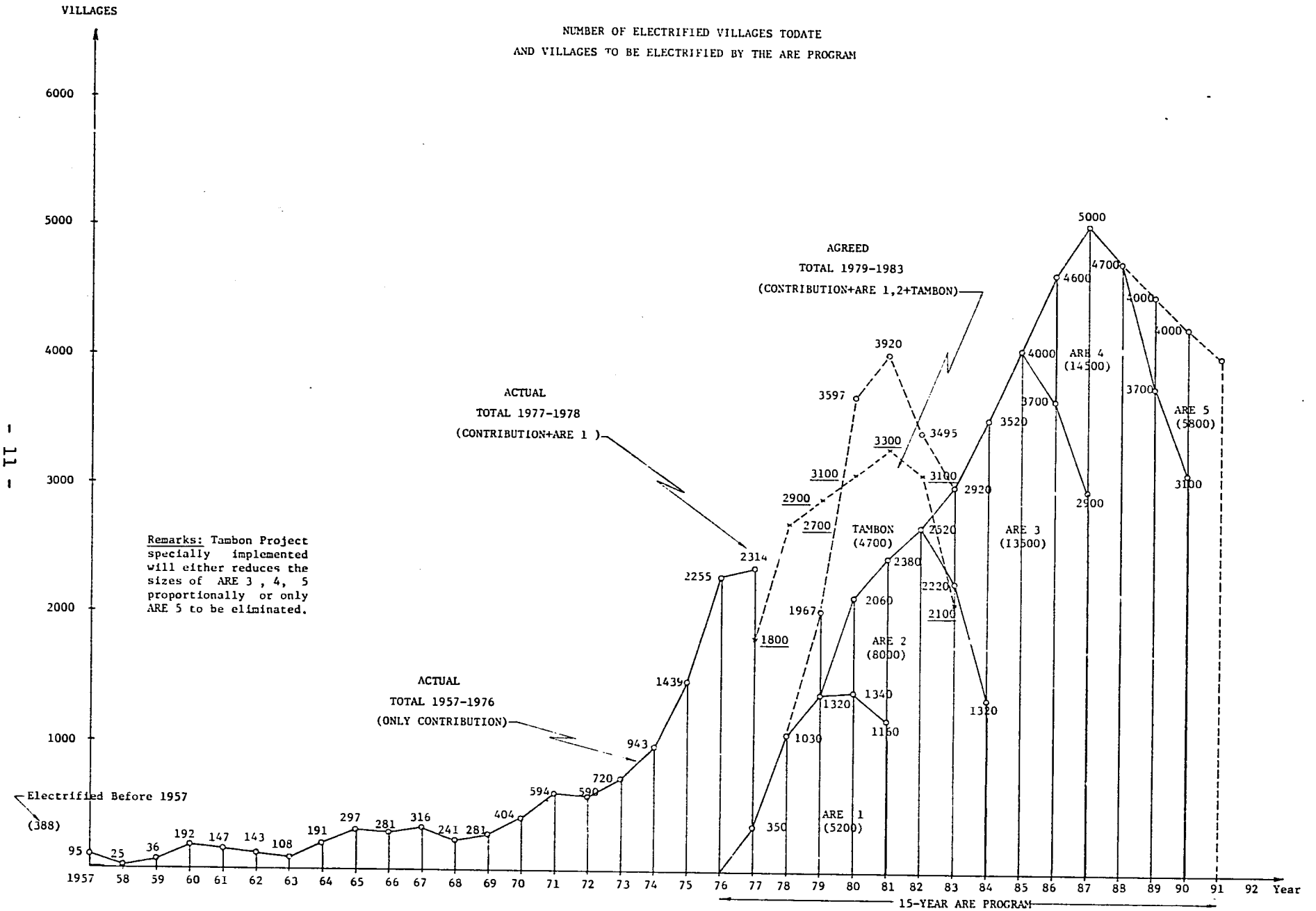


FORECASTED NUMBER OF VILLAGES TO BE ELECTRIFIED TO 1991
UNDER ARE PROGRAM (15 YEARS)

NO.	PROJECT	TOTAL	4th National Plan					5th National Plan					6th National Plan				
			1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	ARE 1	5,200	350	1,030	1,320	1,340	1,160	-	-	-	-	-	-	-	-	-	-
2	ARE 2	8,000	-	-	-	720	1,220	2,520	2,220	1,320	-	-	-	-	-	-	-
3	ARE 3	13,500	-	-	-	-	-	-	700	2,200	4,000	3,700	2,900	-	-	-	-
4	ARE 4	14,500	-	-	-	-	-	-	-	-	-	900	2,100	4,700	3,700	3,100	-
5	ARE 5	5,800	-	-	-	-	-	-	-	-	-	-	-	-	700	1,100	4,000
	ARE 1-5	47,000	350	1,030	1,320	2,060	2,380	2,520	2,920	3,520	4,000	4,600	5,000	4,700	4,400	4,200	4,000
	(ANNUAL)		(Subtotal 7,140)					(Subtotal 17,560)					(Subtotal 22,330)				
	ARE 1-5 (CUMUTATIVE)	47,000	350	1,380	2,700	4,760	7,140	9,660	12,580	16,100	20,100	24,700	29,700	34,400	38,800	43,000	47,000
ACCUMULATED TOTAL VILLAGES		BASE 35,000	35,700	36,414	37,142	37,885	38,643	39,415	40,204	41,008	41,828	42,664	43,518	44,388	45,276	46,181	47,000

REMARKS : (1) TOTAL VILLAGES BY 1977 WAS 47,000 BY WHICH 12,000 HAD BEEN ELECTRIFIED LEAVING 35,000 UNELECTRIFIED.

(2) AT 2% GROWTH RATE PER ANNUM, THE 35,000 UNELECTRIFIED VILLAGES WILL BE EXPANDED TO 47,000 IN 15 YEARS TIME-FRAME.


VILLAGES
NUMBER OF ELECTRIFIED VILLAGES TODATE
AND VILLAGES TO BE ELECTRIFIED BY THE ARE PROGRAM
6000
5000
4000
3000
2000
1000
AGREED
TOTAL 1979-1983
(CONTRIBUTION+ARE 1,2+TAMBON)
ACTUAL
TOTAL 1977-1978
(CONTRIBUTION+ARE 1)
ACTUAL
TOTAL 1957-1976
(ONLY CONTRIBUTION)
Remarks: Tambon Project specially implemented will either reduces the sizes of ARE 3 , 4, 5 proportionally or only ARE 5 to be eliminated.
Electrified Before 1957
(388)
95
25
36
192
147
143
108
191
297
281
316
241
281
404
594
590
720
943
1439
2255
2314
1800
350
1030
1967
1320
2060
2380
1340
1150
2220
2520
2100
2920
1320
3520
4000
4600
5000
3700
2900
4700
4000
3700
4000
3100
3920
3597
3495
3300
3100
2900
2700
ARE 1
(5200)
ARE 2
(8000)
TAMBON
(4700)
ARE 3
(13500)
ARE 4
(14500)
ARE 5
(5800)
1957
58
59
60
61
62
63
64
65
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91
92
Year
15-YEAR ARE PROGRAM

By September 17,1976 the World Bank's Report on "Thailand Power Sector Review" recommended a 20-Year Long-Range Program for the ARE. This 20-Year time frame is in principle not in conflicting with the 15-Year or 25-Year. The total electrification is still the underlined principle of all 3 alternate programs. With 20-Year Program, it just means there is only 1 year overlapping of the 5 Subprograms, and this may occur when there is a slippage on program implementation or a delay in financial arrangement. Hence, the 15-Year Program is still the most sensible program to be based on for successive development of ARE 2, 3, 4 and 5.

2.6 The Progress of ARE 1

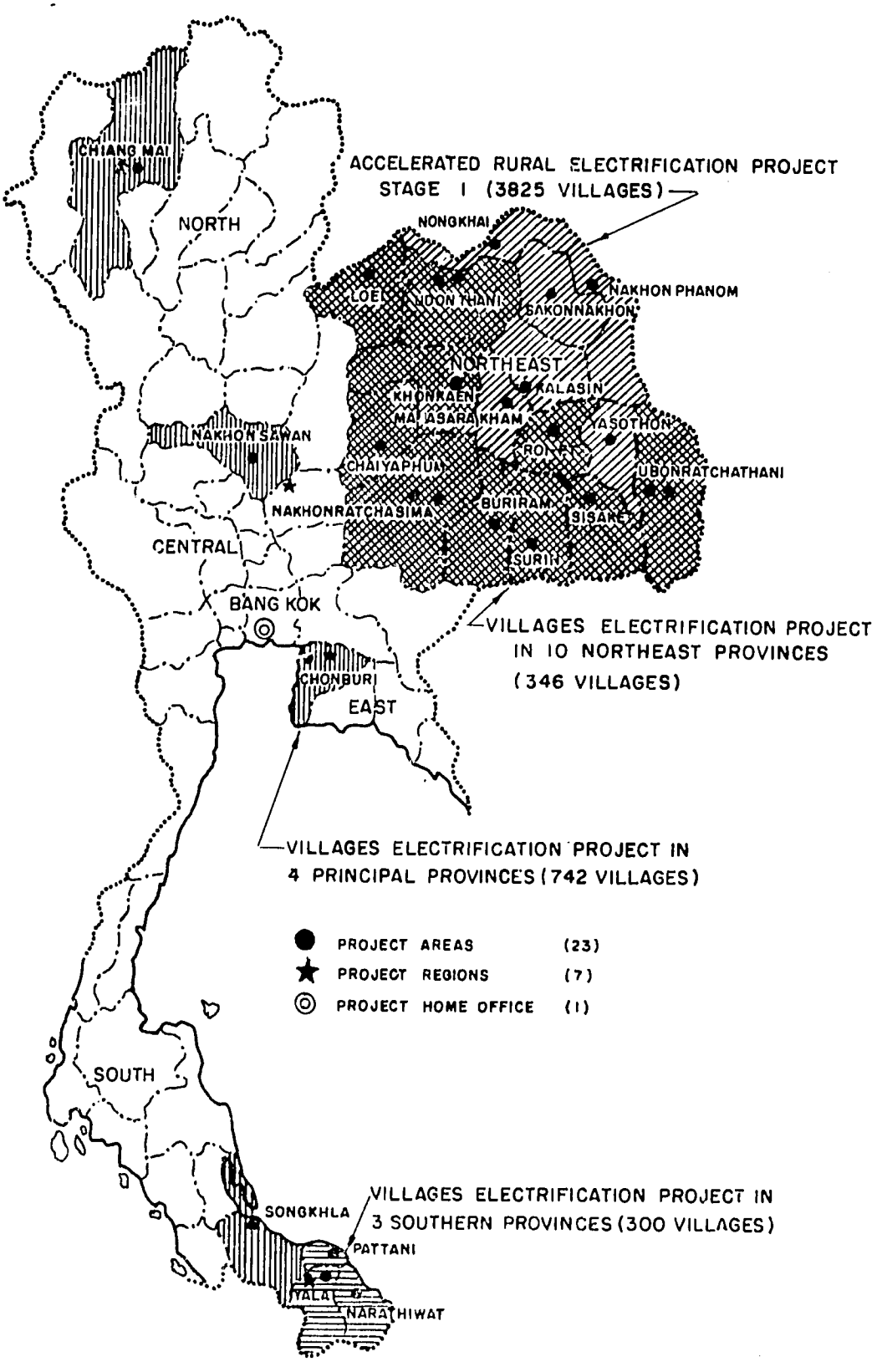
The First 5-Year Program (ARE 1) calls for electrification of 5,200 villages concentrating in 16 Northeast Highland provinces plus 7 provinces outside the Northeast (see the following project area map) with estimate of Baht 2,195 million investment by which Baht 1,254 million being capitalized by the government mainly through local loan suplemented by some national budget, and another Baht 941 million being loaned from aboard, scheduled for 5 years (FY 1977-1981) construction with 1 year (FY-1976) lead time for project preparation.

The estimated physical and financial magnitudes are as follows:

Significant Item	VENE 10	VES 3	VEP 4	ARE 1	ARE 1 Program
Project Approval Date (By RTG)	23 Sep. 75	28 Oct. 75	16 Mar. 76	12 Apr. 76	-
Provinces Electrified	10	3	4	16	23
Districts Electrified	39	19	41	176	236
Communes Electrified	108	76	250	1,037	1,363
Commune Councils Electrified	48	18	101	478	645
Villages Electrified	346	300	742	3,825	5,213
Customers Connected (Initial)	27,464	19,596	59,326	321,711	428,097
Population Served	300,000	200,000	739,000	3,676,000	4,915,000
Primary Distribution Lines (Km)	537	664	1,464	10,018	12,683
Secondary Distribution Lines (Km)	468	518	1,500	5,838	8,324
Installed Transformers (kVA)	9,110	5,450	22,260	114,750	151,570
Capital Investment (million Baht)	144	150	309	1,592	2,195
Source of Foreign Loan & Loan Signing Date	IBRD 3rd Window 3.6 M$ 27 Feb. 76	KFAED 1.0 MKØ 10 Apr. 76	OPEC 7.0 M$ 7 Oct. 77 + CIDA 10.0 MC$ 2 Mar. 78 + IBRD 25.0 M$ 9 Mar. 78		- - -

VENE 10: Villages Electrification Project in 10 Northeast Provinces (77-79)
VES 3: Villages Electrification Project in 3 Southern Provinces (77-79)
VEP 4: Villages Electrification Project in 4 Principal Provinces (77-80)
ARE 1: Accelerated Rural Electrification Project Stage 1 (78-81)
ARE 1 Program: First 5-Year ARE Program (77-81)

APPROVED
PROJECT AREAS (23 PROVINCES)
FOR
FIRST 5-YEAR PROGRAM OF THAILAND ACCELERATED RURAL ELECTRIFICATION
(5200 VILLAGES)



Upto the end of 1978, the percentage accomplishments of all 4 projects under the ARE 1 Program in the 4th Plan (1977-1981) are as summarized as follows:

No.	Project(s)	Accomplishment On Project Basis		Accomplishment On Program Basis	
		Actual Percentage	Project Villages Base	Equivalent Percentage	Project Villages Vase
1	VENE 10	97.88%	346	6.49%	5,213
2	VES 3	81.38%	300	4.68%	5,213
3	VEP 4	6.80%	742	0.97%	5,213
4	ARE 1	1.55%	3,825	1.07%	5,213
	ARE 1 Program	(13.21%)	5,213	13.21%	5,213

While the target is planned at 27.00%, it indicates that the actual cumulative accomplishment upto the year end 1978 is only a half — 13.21% as shown above.

In order to improve the speed of implementation, ORE decides to pool all construction task forces (26 standard 56-man crews altogether) until completion of ARE 1 before moving some crews to start-up ARE 2 as previously planned. However, ARE 2 still be able to be begun as scheduled by mobilizing new ORE crews and some available Regions crews. The following table gives the overall picture of how correction measures are set up:

No.	Item(s)	Fourth National Plan					Remarks
		1977	1978	1979	1980	1981	
1.	Target Villages Planned	363	1,030	1,320	1,340	1,160	Annual
		363	1,393	2,713	4,053	5,213	Cumulative
2	Target Percent Planned	7.0	20.0	25.0	26.0	22.0	Annual
		7.0	27.0	52.0	78.0	100.0	Cumulative
3	Actual Past & Future Revised	7.0	6.2	31.8	30.0	25.0	Annual
		7.0	13.2	45.0	75.0	100.0	Cumulative
		(Actual)		(Revised)			

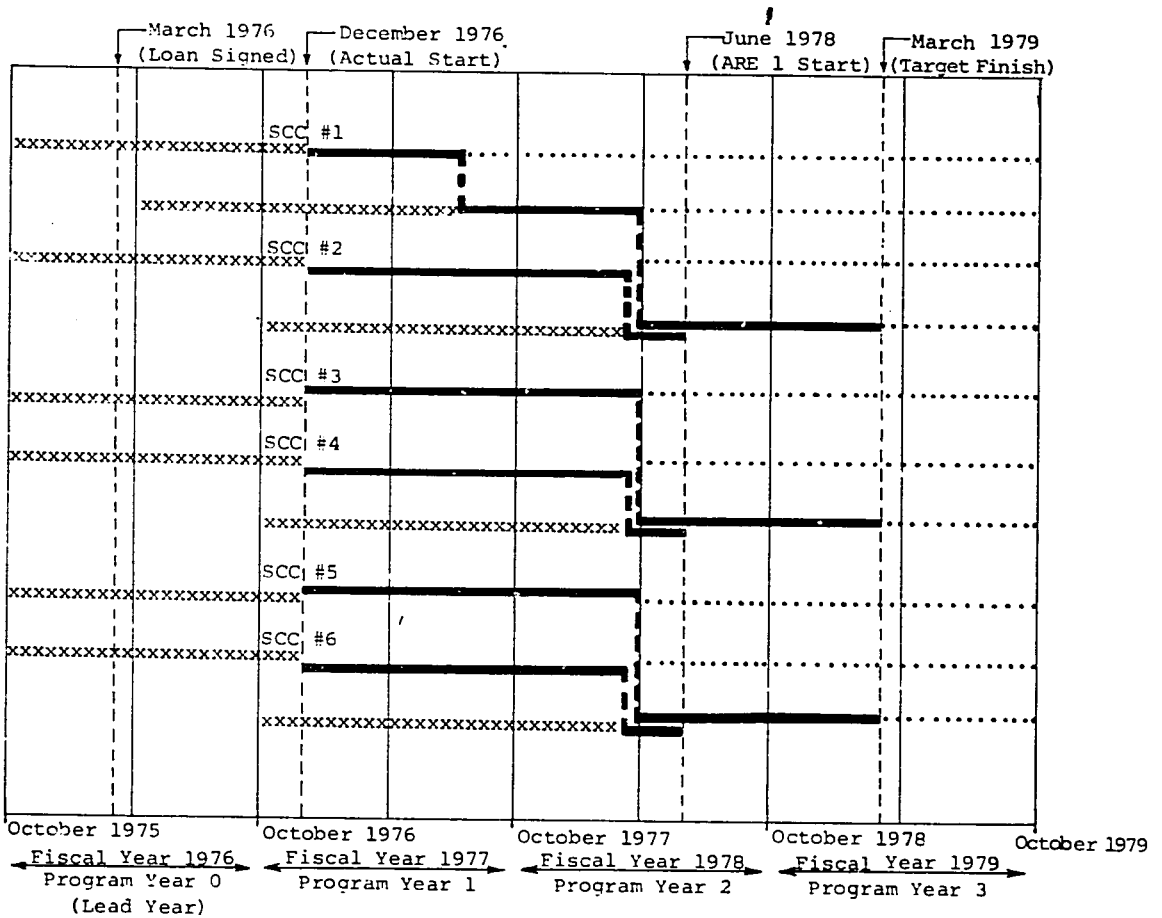
The following map, work schedules, construction charts show the scope of work and implementation capability of the ORE/PEA for ARE 1 Program.

PROJECT WORK-SCHEDULE

FOR

VILLAGES ELECTRIFICATION PROJECT IN 10 NORTHEAST PROVINCES (VENE 10)

REGIONS	PROVINCES	VILLAGES
REGION NORTHEAST 1 (114)	LOEI	13
	CHAIYAPHUM	20
	KHON KAEN	42
	UDON THANI	39
REGION NORTHEAST 2 (114)	ROI-ET	40
	SISAKET	34
	UBON RATCHATHANI	40
REGION NORTHEAST 3 (118)	SURIN	34
	BURIRUM	40
	NAKHON RATCHASIMA	40
	TOTAL	346
	(Average Per Province	35)



REMARK: (a) Abbreviation for SCC = Standard Construction Crew(Approximate 56-man team).

(b) Half of 6 SCC of VENE 10 Project will be moved to form the 12 SCC of ARE 1 Project by mid-FY 1978 and the rest will reinforce ARE 1 by mid-FY 1979.

SYMBOL: xxxxxxxxxx PRE - CONSTRUCTION ACTIVITIES (Design, Procurement, Etc.)

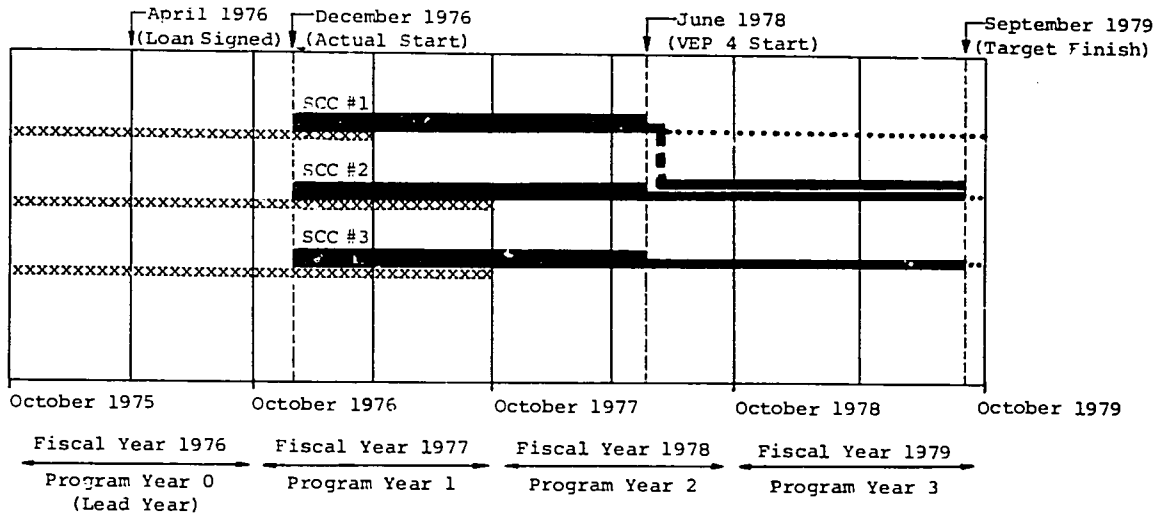
▬▬▬ CONSTRUCTION ACTIVITIES (Work Orders, Erection, Etc.)

..... POST - CONSTRUCTION ACTIVITIES (Operation, Load Promotion, Etc.)

PROJECT WORK-SCHEDULE
FOR

VILLAGES ELECTRIFICATION PROJECT IN 3 SOUTHERN PROVINCES (VES 3)

REGION	PROVINCES	VILLAGES
REGION SOUTH 3 (300)	YALA	50
	PATTANI	150
	NARATHIWAT	100
	TOTAL (Average Per Province 100)	300



SYMBOL: xxxxxxxxxx PRE - CONSTRUCTION ACTIVITIES (Design, Procurement, Etc.)
▬▬▬▬ CONSTRUCTION ACTIVITIES (Work Orders, Erection, Etc.)
..... POST - CONSTRUCTION ACTIVITIES (Operation, Load Promotion, Etc.)

REMARK: (a) Abbreviation for SCC = Standard Construction Crew (Approximate 56-man team).

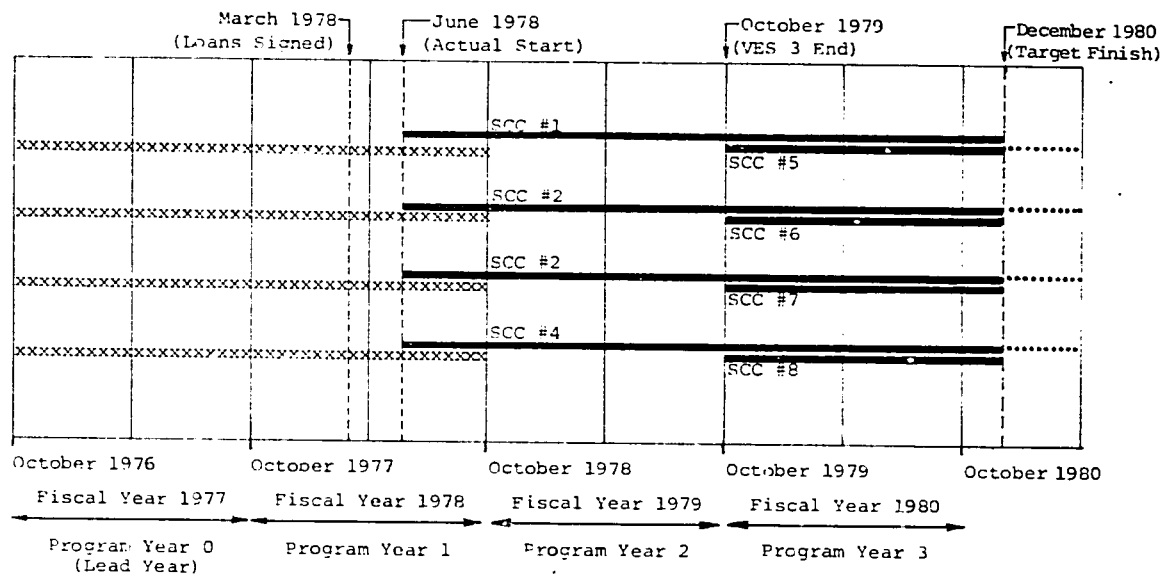
(b) Half of 3 SCC of VES 3 Project will be moved to form the 4 SCC of VEP 4 Project by mid-FY 1978 and the rest will reinforce VEP 4 by end-FY 1979.

PROJECT WORK-SCHEDULE

FOR

VILLAGES ELECTRIFICATION PROJECT IN 4 PRINCIPAL PROVINCES (VEP 4)

REGIONS		PROVINCES	VILLAGES
REGION NORTH 1	—	CHIANG MAI	210
REGION NORTH 3	—	NAKHON SAWAN	189
REGION CENTRAL 2	—	CHONBURI	163
REGION SOUTH 3	—	SONGKHLA	180
		TOTAL	742
		(Average Per Province	186)



SYMBOL: xxxxxxxxxxxxxxxxxxxx PRE - CONSTRUCTION ACTIVITIES (Design, Procurement, Etc.)

CONSTRUCTION ACTIVITIES (Work Orders, Erection, Etc.)

POST-CONSTRUCTION ACTIVITIES (Operation, Load Promotion, Etc.)

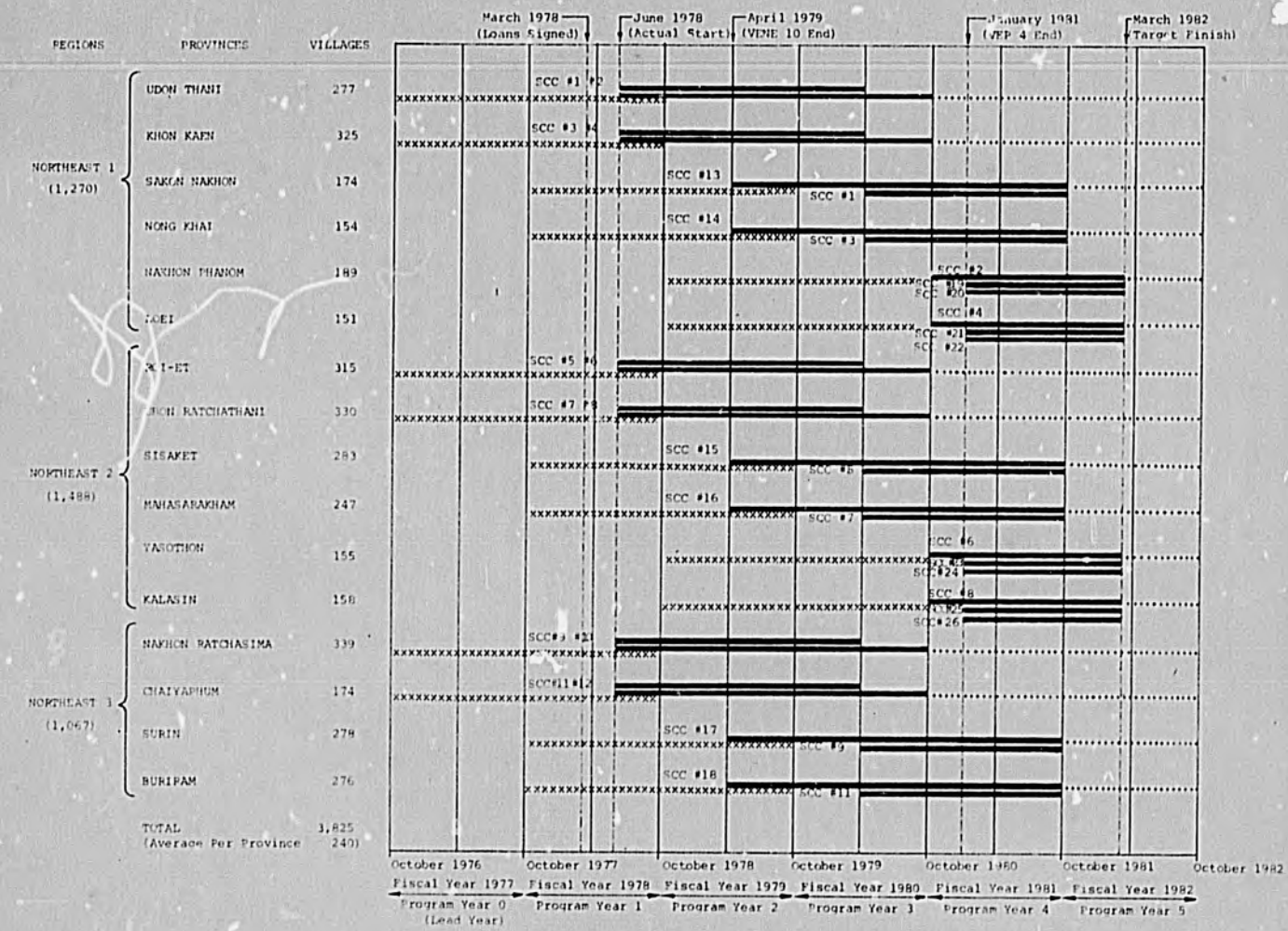
REMARK: (a) Abbreviation for SCC = Standard Construction Crew (Approximate 56-man team).

(b) 4 SCC of VEP 4 Project will be reimforced by 4 SCC of VES 3 Project by beginning-FY 1979.

PROJECT WORK-SCHEDULE

FOR

ACCELERATED RURAL ELECTRIFICATION PROJECT — FIRST STAGE (ARE 1)



SYMBOL: xxxxxxxxxxxxxxxx PRE - CONSTRUCTION ACTIVITIES (Design, Procurement, Etc.)

CONSTRUCTION ACTIVITIES (Work Orders, Erection, Etc.)

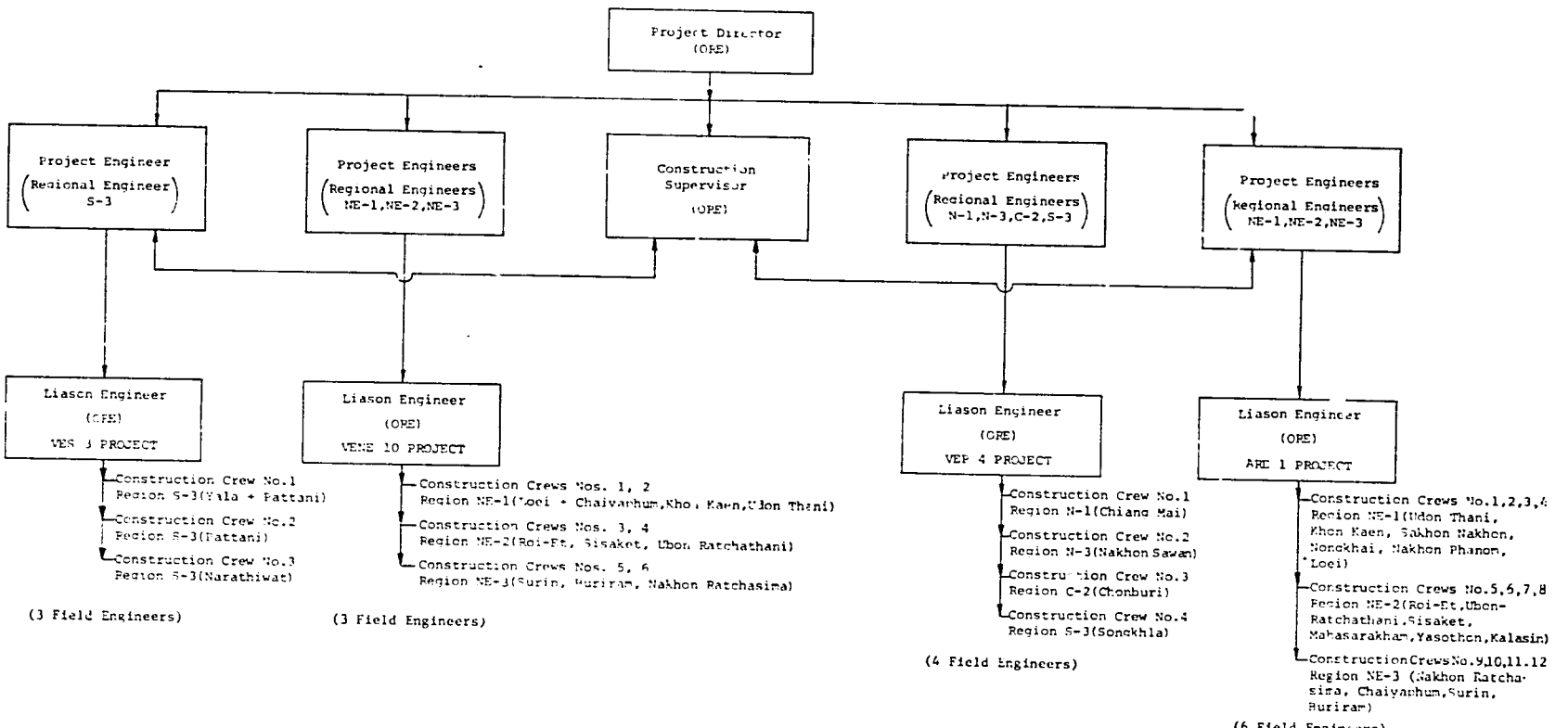
•••••••••••••••••• POST-CONSTRUCTION ACTIVITIES (Operation, Load Promotion, Etc.)

REMARK: (a) Abbreviation for SCC = Standard Construction Crew (Approximate 56-man team)

(b) ARE 1 Project was started first 6 provinces with 12 SCC, then by mid-FY 1979 it will be reinforced by another 6 SCC from VENE 10 Project implementing the next 6 provinces, and finally another 8 SCC from VEP 4 Project by early-FY 1981 completing the last 4 provinces by mid-FY 1982.

(c) By end-FY 1980 another 2 spare crews (SCC #10, #12) will be on stand-by ready to assist the active 24 crews to be able to complete the ARE 1 in time. If not required, these 2 extra crews will be moved to start up ARE 2 by beginning-FY 1981.

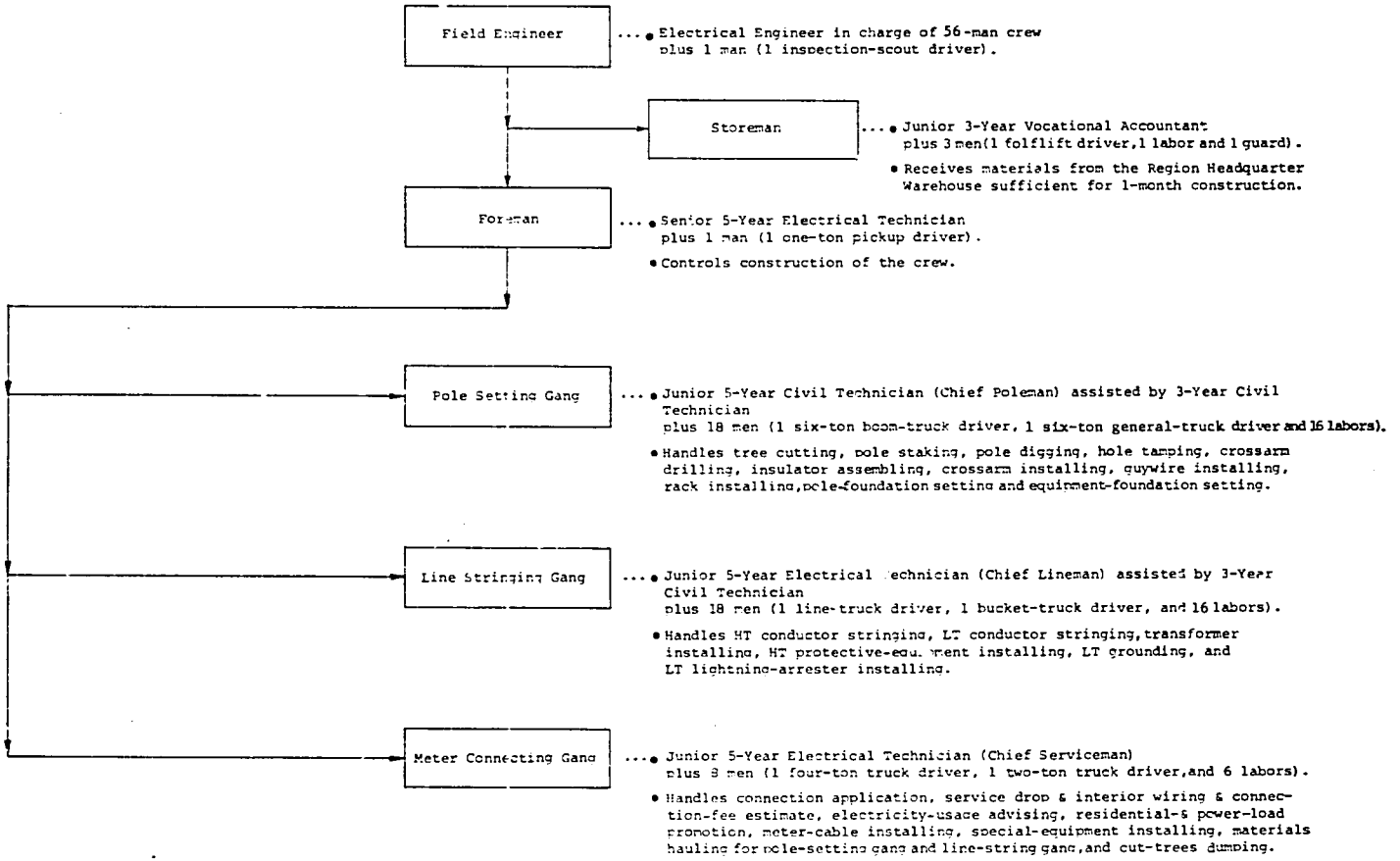
ORGANIZATION CHART
FOR
OPE PROJECT CONSTRUCTION SUPERVISION
OF
FIRST 5-YEAR PROGRAM
THAILAND ACCELERATED RURAL ELECTRIFICATION



Remarks

1. Project Engineers and Construction Crews for VES 3 Project, VENE 10 Project, VEP 4 Project are all Regions' personnel.
2. Construction Crews for ARE 1 Project shall be all OPE's personnel.
3. Construction Supervisor, Liason Engineers, Field Engineers are all OPE's personnel.
4. Construction Crews for VES 3 Project and VENE 10 Project have already been set up and operated.
5. Construction Crews for VEP 4 Project and ARE 1 Project have already been set up and operated.
6. Field Engineers are the engineers attached to each Construction Crew or group of Construction Crews in each region.
7. One Construction Crew (56-man crew included foreman, skillmen, drivers and labors) is designed to be capable of constructing 1 village per week.

ORGANIZATION CHART
FOR
STANDARD CONSTRUCTION CREW (SCC)
OF
FIRST 5-YEAR PROGRAM
THAILAND ACCELERATED RURAL ELECTRIFICATION



Remarks

1. For VES 3 Project and VENE 10 Project, addition of 1 digger truck per project instead of per construction crew attached to the Pole Setting Gang was approved by PEA.
2. For VEP 4 Project, addition of 1 digger truck per construction crew was approved by PEA.
3. For ARE 1 Project,addition of 1 digger truck per construction crew was approved by PEA.
4. Each SCC (capability of 1 village per week) shall electrify 52 villages per year.
5. With 3 SCC, VES 3 Project shall be completed in 3 years(considering the 3 clustered project provinces in 1 administrative region).
6. With 6 SCC, VENE 10 Project shall also be completed in 2 years(considering the 10 diversified project provinces in 3 administrative regions).
7. For VEP 4 Project, the first year will be carried out by their own 4 SCC. Then another 3 SCC from VES 3 Project will be moved in to assist completing the project in the third year.
8. For ARE 1 Project, the first year will be carried out by their own 12SCC. Then another 6 SCC from VENE 10 Project will be moved in to assist in the second year. In the last 2 years, 3 SCC from VES 3 Project and 4 SCC from VEP 4 Project will join in completing the project well within 5 years.
9. Maximum implementation time for ARE 1 Project is 5 years as indicated. This time-frame is expected to reduce to 4 years because ORE have succeeded in contracting the domestic construction contractors for certain jobs of the distribution system construction, for example, pole hauling, pole setting, pole assembling and hardware installing.

SECTION III

SCOPE OF ARE 2

SECTION III

SCOPE OF ARE 2

3.1 Scope of Feasibility Study

ARE 2 representing the Second 5-Year Program for 1980-1984 was proposed by PEA with confirmation by NESDB in 1977 (see the following letter and map) as follows:

- Approving the proposed Southern Peninsula as the concentrated area for rural electrification under ARE 2 in conformance with the 4th and 5th National Economic and Social Development Plans.
- Recommending the additional areas to be included in ARE 2 for the reasons of economic strengthening (Central Plain) and political stability (Northern Corridor).

Thus ARE 2 consists of 27 project provinces (as shown in the follow-map) — 16 southern provinces, 6 Central provinces and 5 Northern provinces — covering 9 PEA's operating regions (Regions North 1,2,3 Central 1,2,3 and South 1,2,3).

In the 27 project provinces, there are 14,141 total villages of which 21% (about 3,017 villages) are electrified. Of the remaining 11,124 unelectrified villages, 71% (about 7,878 villages) are to be electrified under ARE 2. The following table lists the number of communes, villages, households, and population of all 27 project provinces.

3.2 Methodology for Feasibility Study

The feasibility study is conducted in steps which can be classified into 4 principal operations:

- Preliminary Review and Analysis

  This part of preliminary investigation includes the following:

  . Appraisal of the existing electrical system,

ที่ สร.๐๔๐๘/๑๖๖๔

สำนักงานคณะกรรมการ
พัฒนาการเศรษฐกิจและสังคมแห่งชาติ

๑ เมษายน ๒๕๒๐

เรื่อง ขอบเขตการศึกษาความเหมาะสมก่อนการลงทุนโครงการเร่งรัดพัฒนาไฟฟ้าชนบทระยะที่ ๒

เรียน ผู้ว่าการการไฟฟ้าส่วนภูมิภาค

อ้างถึง หนังสือการไฟฟ้าส่วนภูมิภาคที่ มท.๑๔๐๐/ฟข. ๑๐ ลงวันที่ ๘ กุมภาพันธ์ ๒๕๒๐

ตามหนังสือที่อ้างถึง การไฟฟ้าส่วนภูมิภาคได้ขอให้สำนักงานคณะกรรมการพัฒนาการเศรษฐกิจและสังคมแห่งชาติพิจารณาให้ความเห็นว่า นอกจากจังหวัดภาคใต้ ๑๖ จังหวัดซึ่งจัดอยู่ในโครงการเร่งรัดพัฒนาไฟฟ้าชนบทระยะที่ ๒ แล้ว ยังจะมีจังหวัดใดบ้างที่สมควรพิจารณาจัดรวมเข้าโครงการเร่งรัดพัฒนาไฟฟ้าชนบทระยะที่ ๒ ความแจ้งแล้ว นั้น

สำนักงานคณะกรรมการพัฒนาการเศรษฐกิจและสังคมแห่งชาติได้พิจารณาเกี่ยวกับเรื่องนี้แล้วมีความเห็นเพิ่มเติมว่า

๑. ในเขตพื้นที่ภาคใต้ทั้ง ๑๖ จังหวัด ซึ่งจัดอยู่ในโครงการเร่งรัดพัฒนาไฟฟ้าชนบทระยะที่ ๒ แล้วนั้น เห็นควรให้การไฟฟ้าฯได้พิจารณาเน้นหนักเป็นกรณีพิเศษในเขตพื้นที่จังหวัดพัทลุง สุราษฎร์ธานี นครศรีธรรมราช สตูล ยะลา ปัตตานี และนราธิวาส เพราะเป็นพื้นที่ที่มีความสำคัญต่อการพัฒนาเศรษฐกิจ สังคม และการเมืองในภาคใต้

๒. สำหรับแผนงานส่วนที่เหลือซึ่งกำหนดจะกระจายการพัฒนาไฟฟ้าออกไปยังภาคอื่น ๆ อีกรวม ๑๑ จังหวัด โดยจำแนกเป็นภาคเหนือ ๕ จังหวัด และภาคกลาง ๖ จังหวัดนั้น สำนักงานคณะกรรมการพัฒนาการเศรษฐกิจและสังคมแห่งชาติพิจารณาแล้วเห็นชอบด้วย นอกจากนี้สมควรให้การไฟฟ้าฯได้พิจารณารวมพื้นที่ดังต่อไปนี้เข้าไว้ในแผนงานด้วยคือ

๒.๑ พื้นที่บริเวณ Sugar Cane Belt คือจังหวัดกาญจนบุรีและสุพรรณบุรี ซึ่งเป็นพื้นที่ที่มีแนวโน้มในการพัฒนาเป็นเขตปลูกอ้อยและอุตสาหกรรมน้ำตาล

๒.๒ เขตพื้นที่ที่มีปัญหาด้านการปกครองและการเมืองซึ่งมีผู้ก่อการร้ายปฏิบัติการรุนแรงตามรายชื่อที่แนบมาพร้อมนี้

จึงเรียนมาเพื่อโปรดทราบและพิจารณาดำเนินการตามที่เห็นสมควรต่อไป.

ขอแสดงความนับถืออย่างสูง

(ลงชื่อ) นายประกอบ จ่วงพานิช

(นายประกอบ จ่วงพานิช)

รองเลขาธิการฯ รักษาราชการแทนเลขาธิการ

คณะกรรมการพัฒนาการเศรษฐกิจและสังคมแห่งชาติ

กองโครงการพื้นฐานเศรษฐกิจ
โทร. ๒๘๑๖๓๒๗-๘

เจริญ/คัด
ภ.ฉ./ทาน

เขตพื้นที่พัฒนาเพื่อความมั่นคง (เขต พ.ม.)

แบ่งออกเป็นเขตต่าง ๆ ได้ดังนี้

เขต พ.ม. ๑	จังหวัดเชียงราย	ประกอบด้วยอำเภอเชียงแสน เชียงของ แม่จัน เทิง เชียงคำ ปง เชียงม่วน
	จังหวัดน่าน	ประกอบด้วยอำเภอทุ่งช้าง เชียงกลาง ปัว ท่าวังผา อ.เมือง กิ่งแม่จริม สา นาน้อย
เขต พ.ม. ๒	จังหวัดพิษณุโลก	ประกอบด้วยอำเภอนครไทย วังทอง ชาติตระการ
	จังหวัดเพชรบูรณ์	ประกอบด้วยอำเภอหล่มเก่า หล่มสัก ชนแดน อ.เมือง
	จังหวัดเลย	ประกอบด้วยอำเภอด่านซ้าย กิ่งนาแห้ว ภูเรือ ท่าลี่ เชียงคาน ปากชม วังสะพุง ภูกระดึง อ.เมือง
เขต พ.ม. ๓	จังหวัดอุดรธานี	ประกอบด้วยอำเภอน้ำโสม นากลาง บ้านผือ เพ็ญ บ้านดุง กิ่งกุดจับ อ.เมือง หนองหาร ศรีบุญเรือง หนองบัวลำภู หนองวัวซอ โนนสัง กุมภวาปี กิ่งศรีธาตุ กิ่งโนนสะอาด กิ่งสุวรรณคูหา
	จังหวัดสกลนคร	ประกอบด้วยอำเภอบ้านม่วง สว่างแดนดิน วานรนิวาส อากาศอำนวย พังโคน กิ่งส่องดาว วาริชภูมิ พรรณานิคม กุสุมาลย์ กุดบาก อ.เมือง กิ่งนิคมน้ำอูน
	จังหวัดกาฬสินธุ์	ประกอบด้วยอำเภอสมเด็จ สหัสขันธุ์ กิ่งคำม่วง เขาวง กุฉินารายณ์ ท่าคันโท กิ่งหนองกุงศรี กิ่งนามน
	จังหวัดนครพนม	ประกอบด้วยอำเภอเมือง ปลาปาก เรณูนคร ธาตุพนม นาแก คำชะอี มุกดาหาร ดอนตาล
เขต พ.ม. ๔	จังหวัดอุบลราชธานี	ประกอบด้วยอำเภอบุณฑริก กิ่งนาจะหลวย เดชอุดม กิ่งน้ำยืน
	จังหวัดศรีสะเกษ	ประกอบด้วยอำเภอกันทรลักษ ขุนหาญ ขุขันธุ์ กิ่งไพรบึง
	จังหวัดสุรินทร์	ประกอบด้วยอำเภอสังขะ ปราสาท กิ่งกาบเชิง ศรีขรภูมิ
	จังหวัดบุรีรัมย์	ประกอบด้วยอำเภอบ้านกรวด ละหานทราย นางรอง ประโคนชัย
	จังหวัดนครราชสีมา	ประกอบด้วยอำเภอครบุรี
เขต พ.ม. ๕	จังหวัดปราจีนบุรี	ประกอบด้วยอำเภอตาพระยา วัฒนานคร สระแก้ว กบินทร์บุร กิ่งนาดี
เขต พ.ม. ๖	จังหวัดราชบุรี	ประกอบด้วยอำเภอปากท่อ จอมบึง กิ่งสวนผึ้ง
	จังหวัดเพชรบุรี	ประกอบด้วยอำเภอเขาย้อย บ้านลาด ชะอำ ท่ายาง กิ่งหนองหญ้าปล้อง
	จังหวัดประจวบคีรีขันธ์	ประกอบด้วยอำเภอหัวหิน ปราณบุรี กุยบุรี อ.เมือง ทับสะแก บางสะพาน
เขต พ.ม. ๗	จังหวัดสุราษฎร์ธานี	ประกอบด้วยอำเภอดอนสัก กาญจนดิษฐ์ บ้านนาสาร เวียงสระ เคียนซา พระแสง พนม คีรีรัฐนิคม พุนพิน
	จังหวัดนครศรีธรรมราช	ประกอบด้วยอำเภอท่าศาลา กิ่งพิปูน ฉวาง ลานสกา ทุ่งสง ร่อนพิบูลย์ เชียรใหญ่ ชะอวด
	จังหวัดพัทลุง	ประกอบด้วยอำเภอควนขนุน อ.เมือง เขาชัยสน ปากพยูน
เขต พ.ม. ๘	จังหวัดปัตตานี	ประกอบด้วยอำเภอเมือง หนองจิก โคกโพธิ์ ยะรัง ยะหริ่ง มายอ ปานาเระ สายบุรี
	จังหวัดนราธิวาส	ประกอบด้วยอำเภอบาเจาะ รือเสาะ ระแงะ แว้ง สุไหงปาดี ยี่งอ ตากใบ อ.เมือง กิ่งศรีสาคร

จังหวัดยะลา ประกอบด้วยอำเภอเมือง บันนังสตา เบตง ยะหา รามัน

<u>หมายเหตุ</u> อำเภอในภาคเหนือและภาคตะวันออกเฉียงเหนือที่ควรจะได้รับการพิจารณาเป็นพิเศษคือ

<u>ภาคเหนือ</u>

ขอให้พิจารณาจัดไฟฟ้าเข้าหมู่บ้านเป็นกรณีพิเศษที่เส้นทางแค้มป์สน-ทุ่งสมอ อ.หล่มสัก เพราะเป็นหมู่บ้านทางยุทธศาสตร์ มีประชากรประมาณ ๑๘,๐๐๐ คน สภาพการเกษตรสมบูรณ์

<u>ภาคตะวันออกเฉียงเหนือ</u>

อ.ละหานทราย จ.บุรีรัมย์ โดยเฉพาะหมู่บ้านโนนดินแดง เป็นหมู่บ้านที่เกิดใหม่และเป็นหมู่บ้านทางยุทธศาสตร์ มีประชากร ๒๐,๐๐๐ คน พื้นดินอุดมสมบูรณ์เหมาะแก่การเพาะปลูก

สรุปเขตพื้นที่โครงการ รฟช.๒

ภาคใต้ (พัฒนาเน้นหนัก)

แผนพัฒนา :
๑. ยะลา
๒. ปัตตานี
๓. นราธิวาส
๔. สงขลา
๕. สตูล
๖. พัทลุง
๗. นครศรีธรรมราช
๘. สุราษฎร์ธานี
๙. พังงา
๑๐. ตรัง
๑๑. กระบี่
๑๒. ภูเก็ต
๑๓. เพชรบุรี
๑๔. ราชบุรี
๑๕. ประจวบคีรีขันธ์
๑๖. ชุมพร

ภาคเหนือ&ภาคกลาง (เศรษฐกิจ&ความมั่นคง)

เศรษฐกิจ :
๑๗. ระนอง
๑๘. นครปฐม
๑๙. กาญจนบุรี
๒๐. สุพรรณบุรี
๒๑. จันทบุรี
๒๒. ปราจีนบุรี

ความมั่นคง :
๒๓. เพชรบูรณ์
๒๔. พิษณุโลก
๒๕. น่าน
๒๖. เชียงราย
๒๗. พะเยา

Summary of ARE 2 Project Areas

Southern Peninsula
(Concentrated Development)

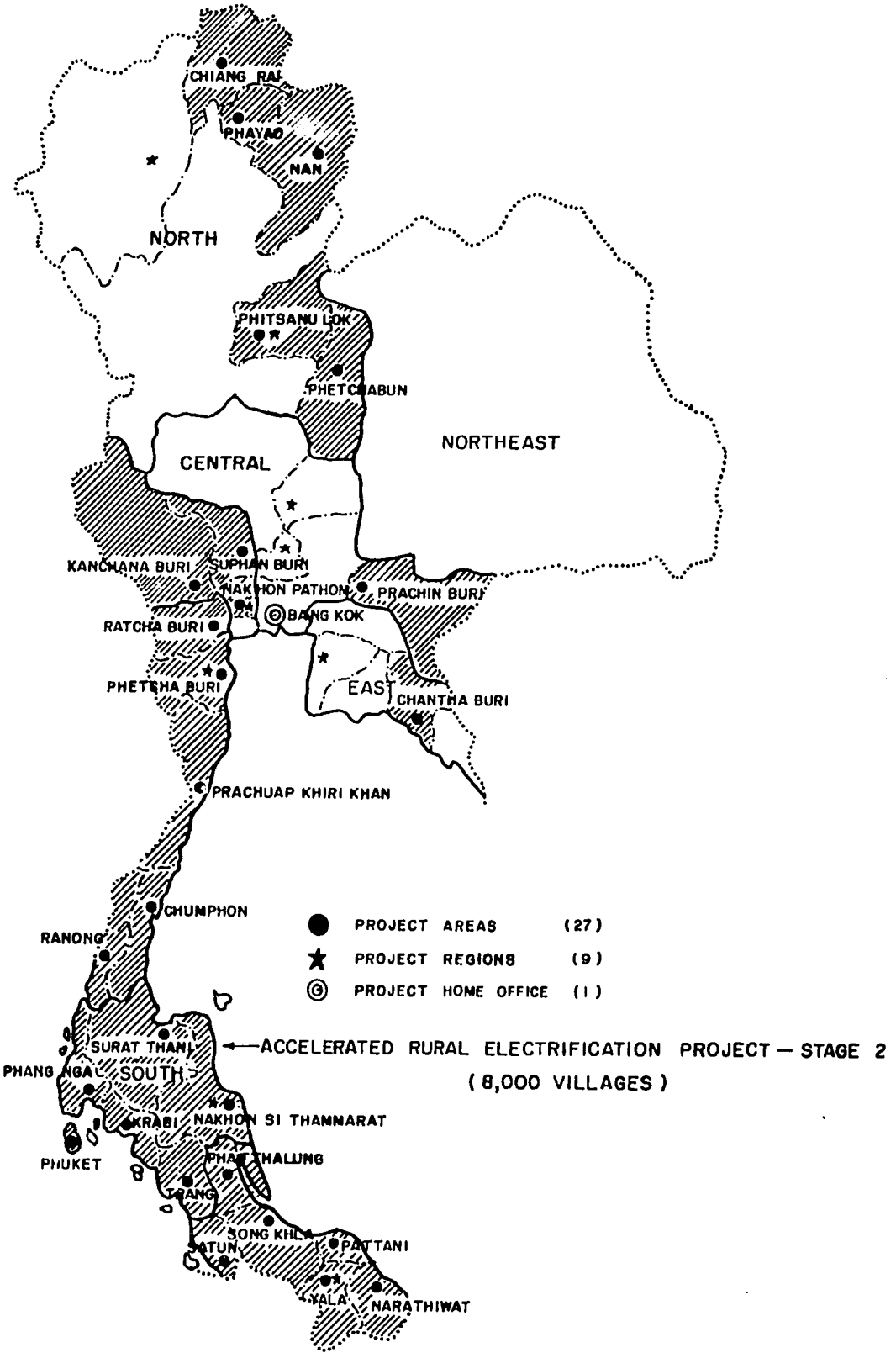
Development:
1. Yala
2. Pattani
3. Narathiwat
4. Songkhla
5. Satun
6. Phatthalung
7. Nakhonsithammarat
8. Suratthani
9. Phangnga
10. Trang
11. Krabi
12. Phuket
13. Phetchaburi
14. Ratchaburi
15. Prachuap Khirikhan
16. Chumphon

Central Plain & Northern Corridor
(Economic Strengthening & Political Stability)

Economic :
17. Ranong
18. Nakhon Pathom
19. Kanchanaburi
20. Suphanburi
21. Chanthaburi
22. Prachinburi

Political :
23. Phetchabun
24. Phitsanulok
25. Nan
26. Chiang Rai
27. Phayao

PROPOSED
PROJECT AREAS (27 PROVINCES)
FOR
SECOND 5-YEARS PROGRAM OF THAILAND ACCELERATED RURAL ELECTRIFICATION
(8000 VILLAGES)



NUMBER OF COMMUNES, VILLAGES, HOUSEHOLDS AND POPULATION
OF 27 PROJECT PROVINCES UNDER ARE 2

No.	Project Province	Number of						
		Communes		Villages			Households	Population
		Total	Elec-trified	Total	Elec-trified	Unelec-trified	Total (000)	Total (000)
	Southern Peninsula (16 Provinces)							
1	Yala	45	13	248	93	155	31	174
2	Pattani	103	24	551	243	308	60	353
3	Narathiwat	60	13	341	152	189	57	330
4	Songkhla	111	19	866	277	589	97	610
5	Satun	26	6	204	21	183	24	117
6	Patthalung	47	16	435	78	357	62	318
7	Nakhon Sithammarat	125	21	1,008	124	884	159	944
8	Suratthani	101	22	675	74	601	82	428
9	Phang-Nga	44	11	268	50	218	26	131
10	Trang	77	13	463	42	421	52	281
11	Krabi	38	6	267	21	246	30	156
12	Phuket	15	10	90	55	35	13	68
13	Phetchaburi	73	30	536	202	334	52	300
14	Prachuab Khirikhan	30	7	252	29	223	50	264
15	Chumphon	56	18	465	86	379	48	244
16	Ranong	24	9	120	20	100	12	58
	Subtotal	975	238	6,789	1,567	5,222	885	4,776
	Central Plain (6 Provinces)							
17	Ratchaburi	92	38	781	232	549	78	465
18	Nakhon Pathom	96	40	767	289	478	68	490
19	Kanchanaburi	75	26	468	95	373	68	365
20	Suphanburi	93	29	670	142	528	102	641
21	Chantaburi	54	21	501	115	386	37	229
22	Prachinburi	80	24	812	128	684	80	510
	Subtotal	490	178	3,999	1,001	2,998	433	2,700
	Northern Corridor (5 Provinces)							
23	Phetchabun	73	21	713	120	593	109	613
24	Phitsanulok	74	17	684	88	596	87	513
25	Nan	63	14	571	56	515	53	323
26	Chiang Rai	74	17	921	125	796	154	838
27	Phayao	41	11	464	60	404	68	368
	Subtotal	325	80	3,353	449	2,904	471	2,655
	Total	1,790	496	14,141	3,017	11,124	1,789	10,131

- Load forecast for the area where the proposed project will be developed,
- Plans to satisfy future rural load requirement including complete review of EGAT's adequate supply.

- Technical Analysis

The first phase of the technical feasibility of the proposed implementation program is the planning of the proposed facilities which should be installed to satisfy not only the early requirements of the rural customers, but also those derived from their increased demand and those of newer customers added in the proposed project area, throughout the project time-frame. This part of technical analysis includes the following considerations:

- Complete planning for selected electric system,
- Preliminary design for the electric system,
- Review of technical standards and specifications,
- Logistics of materials, equipment and construction labor,
- Solution of construction problems,
- Management of the project,
- Overall technical feasibility of the project.

- Financial Analysis

In the cost evaluation of the project, the financial feasibility aspect covers the following steps forecasted for 30 years:

- Cost estimate of proposed distribution system and forecasted system investment,
- Annual costs of proposed distribution system,
- Annual revenues and financial projections including forecasted financial position, statement of operation, cash flow, and balance sheet,
- Financial analysis to be performed under certain assumption of interest rate(s),
- Overall financial feasibility of the project, including a complete justification for subsidy requirement, if any,
- Financial internal rates of return and benefit-cost ratios to be calculated for individual sub-projects and the overall combined project.

- Economic Analysis

This part of analysis treats with those tangible and intangible economic benefits that implementation of the program will represent for the rural areas covered by the project in particular, and to the whole country in general. In the discussion the following matters are considered:

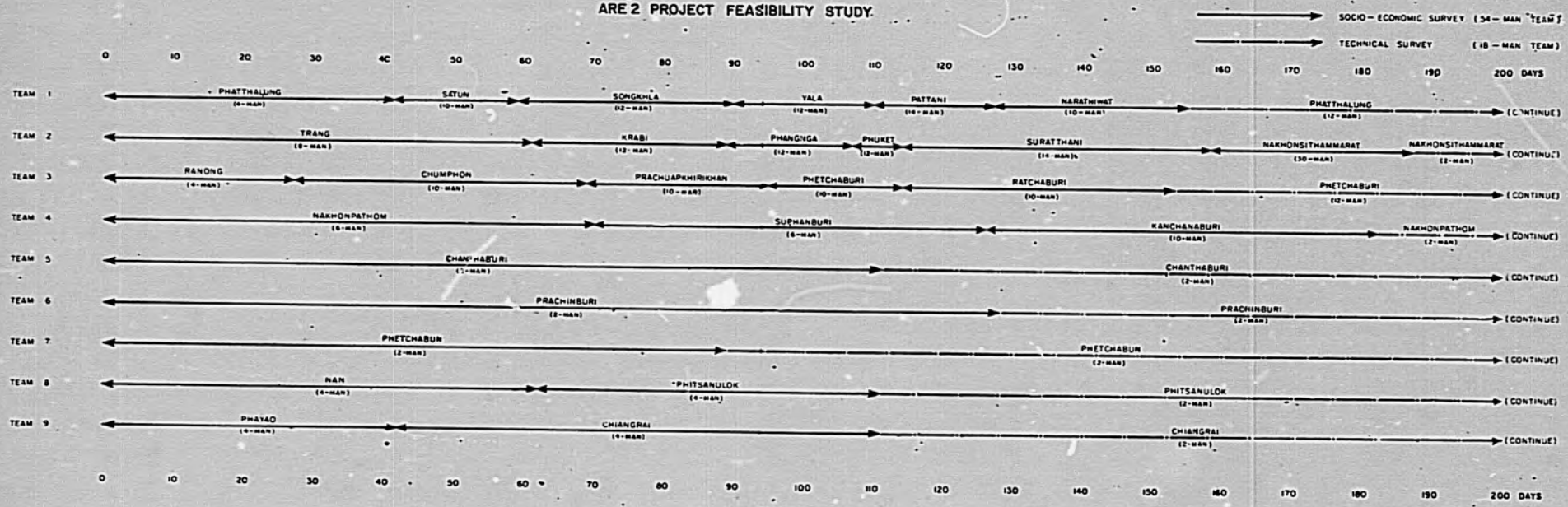
- More effective and fuller utilization of labor, from job opportunity point-of-view,
- Such benefits to the rural villagers as may be generated by the subsidized tariff rates to maximize income,
- Benefits from agro-industrial development in the rural villages including cottage industries, food processing, fish industry, rubber plantation, rice mills, etc. The feasibility of the electric rice mills is an important aspect to the project,
- Benefits from increased agricultural and natural reasource productions due to installation of electric water pumps for irrigation and mining. Proper government departments to be consulted to establish data for availability of ground-and surface-water and the feasibility of this water pumping in the project areas.
- Benefits from training of personnel for future electrification programs including the operation, maintenance and management of other rural distribution systems.
- Benefit/cost analysis to be made on a 30 years projection basis. Income of the project as a whole under each alternative (i.e. benefits) to be figured year by year for 30 years, discounted to present worth and compared with discounted annual and total costs. This analysis to be extended by adding other possible benefits in monetary terms, where feasible, in comparison with the overall cost to the national economy, i.e. economic costs.
- Economic internal rates of return to be calculated for individual sub-projects and the overall combined project.

3.3 Procedures for Villages Survey

The following chart shows the socio-economic survey plan by ORE's 54-man team for 6-month period during the course of conducting ARE 2 Feasibility Study. The next table shows the volume of such extensive and comprehensive survey which is divided into 2 parts, the first part is the socalled Main Survey for unelectrified villages having 3 kinds of survey (Forms A, B, C), the second part is the socalled Supplementary Survey for electrified villages having 2 kinds of survey (Forms D, E):

- Survey A (Unelectrified Village): This is done on a sampling basis of 6 villages per district in all districts of the 27 project provinces. The purpose is to estimate the villages incomes, expenditures, etc. to be compared with Survey D (Electrified Village) to provide date for Regression Model developed by analyzing Survey D.
- Survey B (Unelectrified Household): This is also done on a sampling basis of 10 households per village in all unelectrified villages of the 27 project provinces. The purpose is to estimate the kWh consumption, income elasticity, etc.
- Survey C (Power Load Potential): This is done to all unelectrified villages in the 27 project provinces. The purpose is three-fold:
  . Selection of the project villages,
  . Preliminary Design of the distribution system, and
  . Load Forecasting of the project provinces, project regions and the overall project area.
- Survey D (Electrified Village): This is done on a sampling basis of 2 villages per district in the 27 project provinces. The purpose is to estimate the connection rate, household consumption, load growth, benefits of electricity availability, etc.
- Survey E (Electrified Household): This is also done on a sampling basis of 10 households per village in the 27 project provinces. The purpose is to estimate the household lighting and appliances loads by relating such consumption with the economic situation, etc.

SURVEY PLAN
FOR
ARE 2 PROJECT FEASIBILITY STUDY



SURVEY VOLUME

FOR

ARE 2 PROJECT FEASIBILITY STUDY

SURVEY ORDER	PROJECT PROVINCE		AMOUNT OF QUESTIONAIRES: MAIN SURVEY FOR UNELECTRIFIED VILLAGES			SUPPLEMENTARY SURVEY FOR ELECTRIFIED VILLAGES		DAYS OF SURVEY
			FORM A	FORM B	FORM C	FORM D	FORM E	
1	Patthalung	TEAM 1 (Region S.3)	24	120	357	8	80	12
2	Satun		25	120	183	6	60	7
3	Songkhla		54	270	589	18	180	25
4	Yala		30	150	155	10	100	8
5	Pattani		48	240	308	16	160	16
6	Narathiwat		54	270	189	18	180	13
			235	1,170	1,781	76	760	81
1	Trang	TEAM 2 (Region S.2)	30	150	421	-	-	14
2	Krabi		30	150	246	10	100	10
3	Phang-Nga		42	210	218	14	140	8
4	Phuket		25	120	35	4	40	4
5	Suratthani		90	450	601	30	300	24
6	Nakhon Si T.		90	450	884	30	300	32
			307	1,530	2,405	88	880	92
1	Ranong	TEAM 3 (Region S.1)	25	120	100	6	60	7
2	Chumphon		36	180	379	12	120	18
3	Prachuab K.		36	180	223	12	120	12
4	Phetchaburi		36	180	334	12	120	15
5	Ratchaburi		48	240	549	16	160	23
			181	900	1,585	58	580	75
1	Nakhon Pathom	TEAM 4 (RegionC.3)	30	150	478	10	100	32
2	Suphanburi		48	240	528	16	160	38
3	Kanchanaburi		54	270	373	18	180	30
			132	660	1,379	44	440	100
1	Chanthaburi	TEAM 5 (Region C.2)	30	150	386	10	100	80
			30	150	386	10	100	80
1	Prachinburi	TEAM 6 (Region C.1)	60	300	684	20	200	144
			60	300	684	20	200	144
1	Phetchabun	TEAM 7 (Region N.3)	42	210	593	14	140	120
			42	210	593	14	140	120
1	Nan	TEAM 8 (Region N.2)	48	240	515	16	160	55
2	Phitsanulok		48	240	596	16	160	62
			96	480	1,111	32	320	117
1	Phayao	TEAM 9 (Region N.1)	36	180	404	12	120	43
2	Chiang Rai		60	300	796	20	200	82
			96	480	1,200	32	320	125
			1,179	5,880	11,124	374	3,740	187 (All together)

3.4 Methodology for Villages Allocation to the Project Province

Within the framework of the Master Plan, all 16 Southern Peninsula provinces plus 11 Central Plain and Northern Corridor provinces are included in the scope of the ARE 2. Thus, the 8,000 project villages will have to distributed among the total of 27 project provinces. The project villages represent about 71% of the 11,124 unelectrified villages in these provinces. Having defined the scope of the ARE 2, in formulation of the Project a methodology is required for allocating the number of project villages for each project province, allocating the number of project villages for each district of the project province, and the final selection of unelectrified villages within the districts for inclusion in the Project.

The province and district quota allocations and villages selection methodology must be based on the several considerations of maximizing economic impact, minimizing implementation cost, maximizing potential benefits, integrating electrification with other components of rural development, and giving due regard to social and political requirements at the village level, district level, provincial level, and regional level.

Available information for decision-making include some 30 parameters of socio-economic conditions at the provincial level derived from the 1970 Population and Housing Census and the more up-to-date Changwat Statistical Data Books complied by the NSO (National Statistical Office) based on information supplied by the various ministries and agencies of the RTG. A detailed survey has currently been conducted in all project provinces by the ORE/PEA gathering the vital socio-economic information on a district-based random sampling and the necessary data for preliminary engineering design for all unelectrified villages. These 3 levels of provincial, district, and village data provide an adequate basis for the evolution of a procedure for allocation and selection that will serve the purpose of ensuring project viability and meeting the national needs of rural electrification.

The provincial quota of unelectrified villages to be included in ARE 2 are based on standard score for each province derived from a range of the 30 socio-economic indicators. These indicators include percentage of rural households with access to public well, private well, electric lighting, radio, television, sewing machine, refrigerator, electric fan, water pump for agricultural use; percentage of households using charcoal, gas, other modern fuels; percentage of dwellings constructed in the past 5 years; rural population density; population birth rate and growth rate; ratio of students in upper elementary schools to lower elementary schools, lower secondary school enrollment to upper elementary school enrollment, upper secondary school enrollment to lower secondary school enrollment; number of population seved by each physician; percentage of gross area in agricultural use; percentage of arable land in rice cultivation, percentage of arable land in field crop and tree crop cultivation; electricity consumption in villages already electrified; percentage of households already electrified; average households size and average village size. Most of these indicators are parameters of good prospects for electrification. This range of parameters provides an extremely useful profile of each project province. (See the following list and table tabulating indicator names and values).

The transformation of each parameter into a standard score (z-score, where mean = 0 and standard deviation = 1) for the province sums to a Composite Score to reflect the degree of advancement in the province. These Composite Scores range from + 28.40 for Phuket to -13.20 for Nan (See Column No. 3 of the next table). This quantitative measurement of the project provinces tallies well with qualitative assessments derived from field experience. Given that a larger proportion of villages to be electrified should first be achieved under the Project in the more advanced provinces which could derive greater benefits from electrification than the others, this range of Composite Scores can form the basis of allocation of project villages, on a degree of electrification basis. Assuming that the target is to achieve total electrification in the most advanced project province, namely Phuket, the maximum degree of electrification within the scope of electrifying 9,000 villages under the ARE 2 relative to the degree of advancement expressed by the range of socio-economic indicators, can readily be calculated for each of the project provinces (See Column No. 4 of the next table).

IDENTIFICATION OF SOCIO-ECONOMIC VARIABLES
USED IN ALLOCATING 9,000 PROJECT VILLAGES TO
THE 27 PROJECT PROVINCES

No.	Indicator
1	Number of non-municipal village households built in the last 5 years (prior to census).
2	Percent of non-municipal village households with a public well source of water supply.
3	Percent of non-municipal village households with a private well source of water supply.
4	Percent of non-municipal village households with electric lightning.
5	Percent of non-municipal village households with radios.
6	Percent of non-municipal village households with televisions.
7	Percent of non-municipal village households with sewing machines.
8	Percent of non-municipal village households with refrigerators.
9	Percent of non-municipal village households with electric fans.
10	Percent of non-municipal village households with agricultural use water pumps.
11	Percent of non-municipal village households using charcoal as a cooking fuel.
12	Percent of non-municipal village households using wood as a cooking fuel.
13	Percent of non-municipal village households using gas as a cooking fuel.
14	Percent of non-municipal village households using other types of cooking fuels.
15	Rural population (1976) per total rural area (Square Kilometer).
16	Province birth rate per thousand population, 1974.

(Continued)

No.	Indicator
17	Province birth rate minus death rate plus net migration rate per thousand population, 1974.
18	Upper elementary enrollments divided by lower elementary enrollments, 1974.
19	Lower secondary enrollments divided by upper elementary enrollments, 1974.
20	Upper secondary enrollments divided by lower secondary enrollments, 1974.
21	Number of province population per physician, 1973.
22	Percent of total province land area held for use, 1971.
23	Percent of total land use area in paddy land use, 1971.
24	Percent of total land use area under field crops, 1971.
25	Percent of total land use area under fruit trees and tree crops, 1971.
26	Electricity MWh sold to consumers per consumer, 1974.
27	Number of electricity consumers, 1974, divided by total number of dwellings, 1974.
28	Percentage of villages electrified in 1976.
29	Average province household size, 1976.
30	Average province village population size, 1976.

Source of Data:

Variables 1-14: 1970 Population and Housing Census, National Statistics Office, Office of the Prime Minister, Thailand.

Variables 16-27: Statistical Reports of Changwat, National Statistics Office, Office of the Prime Minister, Thailand.

Variables 28-30: 1976 Rural Villages Directory, Office of Rural Electrification, PEA.

Variable 15: Statistical Reports of Changwat and 1976 Rural Villages Directory.

SOCIO-ECONOMIC VARIABLES USED IN ALLOCATING 9,000 PROJECT VILLAGES TO THE 27 PROJECT PROVINCES

No.	Project Province	Value to Each Socio-Economic Indicator Number									
		1	2	3	4	5	6	7	8	9	10
		11	12	13	14	15	16	17	18	19	20
		21	22	23	24	25	26	27	28	29	30
1	Phatthalung	207.00	128.00	754.00	13.00	529.00	1.00	87.00	1.00	1.00	4.00
		303.00	690.00	4.00	0.00	97.51	39.93	34.58	30.19	58.11	9.07
		42,821.00	43.76	71.83	1.46	20.64	696.14	8.00	17.93	5.16	732.12
2	Satun	361.00	124.00	781.00	34.00	540.00	3.00	111.00	6.00	6.00	10.00
		251.00	738.00	4.00	1.00	43.92	30.44	26.05	25.42	48.14	4.18
		41,834.00	11.37	39.28	0.23	49.34	727.50	11.80	10.29	4.89	574.38
3	Songkhla	180.00	242.00	655.00	29.00	600.00	5.00	116.00	4.00	4.00	14.00
		184.00	804.00	6.00	1.00	84.48	35.78	30.64	33.61	66.76	12.45
		14,151.00	38.51	32.83	0.35	59.62	3,222.85	13.24	11.42	6.27	704.68
4	Yala	247.00	119.00	718.00	41.00	444.00	1.00	112.00	3.00	2.00	7.00
		63.00	920.00	8.00	1.00	37.00	31.71	24.68	34.52	60.48	10.75
		18,212.00	25.00	16.78	0.07	79.50	1,052.14	20.33	17.34	5.54	700.84
5	Pattani	149.00	186.00	764.00	26.00	383.00	4.00	96.00	2.00	1.00	11.00
		55.00	929.00	7.00	1.00	168.26	25.68	16.68	25.94	49.89	11.48
		27,703.00	46.30	36.08	0.37	55.43	375.13	6.99	16.88	5.87	640.35
6	Narathiwat	213.00	177.00	776.00	26.00	406.00	3.00	117.00	1.00	3.00	3.00
		33.00	948.00	7.00	1.00	78.52	28.20	16.18	23.40	48.19	9.09
		28,610.00	22.28	30.67	1.38	61.11	742.55	10.99	15.84	5.75	968.09
7	Trang	219.00	59.00	881.00	16.00	527.00	1.00	121.00	3.00	2.00	4.00
		69.00	920.00	6.00	1.00	53.86	35.15	27.15	26.83	59.14	9.45
		19,374.00	41.09	27.69	0.22	59.00	2,356.72	13.83	9.07	5.39	605.88
8	Krabi	328.00	76.00	824.00	29.00	517.00	1.00	88.00	10.00	8.00	6.00
		270.00	705.00	5.00	16.00	33.77	39.78	34.19	23.66	46.52	3.21
		23,928.00	14.03	25.07	2.06	57.07	876.81	9.39	7.87	5.17	582.91
9	Phang-Nga	394.00	104.00	775.00	88.00	578.00	1.00	181.00	18.00	12.00	9.00
		133.00	847.00	9.00	3.00	25.70	31.20	25.52	34.16	41.22	5.16
		13.219.00	17.38	21.85	0.10	68.91	3,424.02	21.03	18.66	4.98	488.92

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PROVINCIAL ALLOCATION OF PROJECT VILLAGES

No.	Project Province	Composite Score	Degree of* Electrification	Allocation Of Project Villages
1	Yala	-3.20	0.806	125
2	Pattani	-8.40	0.778	240
3	Narathiwat	-8.60	0.777	147
4	Songkhla	-1.30	0.816	481
5	Satun	-7.20	0.785	144
6	Phatthalung	-6.30	0.789	301
7	Nakhon Sithammarat	-3.90	0.802	709
8	Suratthani	-2.10	0.812	482
9	Phang-Nga	4.00	0.844	184
10	Trang	-5.90	0.792	325
11	Krabi	-7.70	0.782	190
12	Phuket	28.40	0.975	34
13	Phetchaburi	7.90	0.865	289
14	Ratchaburi	8.10	0.866	476
15	Prachuap Khirikhan	5.60	0.853	190
16	Chumphon	1.50	0.831	322
17	Ranong	14.80	0.902	90
18	Nakhon Pathom	20.80	0.934	306
19	Kanchanaburi	1.90	0.833	311
20	Suphanburi	2.20	0.835	441
21	Chanthaburi	5.50	0.852	329
22	Prachinburi	5.00	0.792	545
23	Phetchabun	-3.60	0.804	477
24	Phitsanulok	1.90	0.833	497
25	Nan	-13.20	0.752	388
26	Chiang Rai	-5.00	0.796	634
27	Phayao	-5.00	0.796	322
	Average	0.60	0.826	333
	Total	-	-	8,985

*The computer program ensures that these percentages will generate a total number of project villages compatible with the size and scope of the ARE 2:

$$(Si - Sm) \times \left[\frac{0.975 - Dm}{Sx - Sm}\right] + Dm = Di \quad \ldots\ldots\ldots\ldots (1)$$

$$\sum_{i=1}^{27} (Di \times Vi) = 9{,}000 \pm 50 \quad \ldots (2)$$

Si = Composite Score for Province;
Vi = Unelectrified Villages in Province i;
Di = Degree of Electrification under Project in Province i;
Sx, Sm = Maximum & Minimum Scores;
Dm = Minimum Degree of Electrification Achievable within Project Scope.

This method of quota allocation, of course, favours the more advanced provinces, but from the Project's point of view, 2 very important factors must be borne in mine. Firstly, it is the objective of the Project to reach the largest possible number of beneficiaries within the constraints of the Project which limits its size of 9,000 villages. It is generally true that the less developed a province, the smaller the proportion of the population who are willing or can afford to be connected and thereby increase considerably the project cost of providing electricity to the households that can meaningfully increase their productivity through electrification. Secondly, electrification is one of the many components of rural development strategy, and unless other favourable developmental factors are present, the incremental effect brought by electrification will be somewhat reduced. A pro rota distribution of the project villages amongst the provinces would inevitably reduce the impact of the Project, at least in the short term.

3.5 Methodology for Villages Allocation to the Districts within the Project Province

The allocation of the project villages among the districts within each province is based on the forecast of electricity consumption per average prospective customer in each of the districts. Ideally, the forecast consumption at the time of electrification would consider all the three components of domestic, commercial, and agro-industrial usage. As the survey data from the sample of electrified villages have shown, there is a significant relationship between domestic and commercial levels of consumption and that the present agro-industrial utilization of electricity is insufficient to form a basis for differentiating one district from another. A relatively simpler forecast model on an average household basis is considered adequate for reflecting the differences on expected level of rural electricity usage among the districts.

The forecast model is developed by establishing the relationship between the annual consumption of households and the following 16 socio-economic factors:

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In order to satisfy all these criteria on which the selection of the project villages is to be based, the procedure will involve 2 stages: a priority ranking of all unelectrified villages in each district on the basis of some of the quantitative data collected by the Load Potential Survey (Survey C) conducted in each and every village (this Section 3.6); and then, if necessary, a modification of the priority ranking on consideration of technical feasibility and other special factors (next Section 3.7).

The priority ranking for each unelectrified village in each district is based on the total score of 7 components:

- Proximity to distribution system;
- Proximity to highway or road;
- Size of the settlement;
- Number of expected initial consumers;
- Kilowatts equivalent of existing machines and other power sources;
- Number of commercial establishments;
- Number of existing infrastructural facilities.

The first component is obviously an important consideration as the incremental cost of electrifying a village that is near to a distribution line or a electrified village is obviously less than that which does not share the same advantage.

The second component is also a cost consideration in that a village that is near to either a national or provincial highway or road will require a lower cost for the transport element, site accessibility, and the time requirement for project implementation.

The third component of village size is a reflection of the fact that there are generally more potential customers in larger village than in a smaller one, and the share of the distribution system cost per consumer will therefore be lower than otherwise the case. It is also true that the larger villages are the more important local centers and should therefore merit a higher priority for electrification.

The fourth component, the number of expected initial consumers, is intended to reflect the residential load, at least in the first couple of years of implementation. Unlike the third component which is primarily a cost consideration, this component contributes towards maximizing the benefits and impact of the earlier years of the project and thereby increasing the economic viability.

The fifth component, the Kilowatts equivalent of power load potential of the village, is of considerable importance to the Project. It is not only that under favourable conditions, electricity consumption by rural industries will be significantly larger in quantities than its use for domestic lighting and household appliances, but also that industrial usage of electricity will increase productivity and generate more income for the rural population. At the present, most villages do already have an diesel engine driven rice mill, along with a range of powered tools for such activities as water pumping and house building. In many other villages, some industries requiring a source of power are flourishing. Given the present differences in the cost of energy, electrification will most likely prompt rapid conversion from diesel engines to electric motors and lead to an expansion of the enterprises. Yet, many more rural industries that are considered not viable at high fuel cost will also be developed.

The sixth component, number of commercial establishments, is another important consideration. Past experience has shown that not only are the establishments like general purpose commercial shops, tailoring establishments, and barber shops the more heavier consumers of electricity, but also, almost without exception, these are among the initial consumers in the electrified villagers. Besides, the number of commercial establishments in a village is also an indication of the relative importance of the settlement in the hierarchy of the system of villages in the vicinity.

The seventh component, the number of public infrastructural facilities located in the village, is also an indication of the importance of the village in the overall rural development strategy.

The presence of a health clinic, for example, suggests that the village enjoys a position of centrality in the spatial distribution of settlements in the area — through not necessarily the largest in the area, it would certainly be the most convenient location for serving the population in the vicinity. The location of various grades of schools, potable water supply systems and the like can similarly be interpreted as centers of rural development influence. The supply of electricity to these villages will enhance the impact of these infrastructural facilities already in existence and electrification would render them greater utility as well. The incremental benefits due to electrification cannot, of course, be directly quantified and must therefore remain intangible, but their existence must certainly be counted.

It should be noted that the last 3 components are the key aspects of the direct benefits of the Project, and all the 7 components can be measured in physical quantities in terms of numbers and these items of information have been collected for every village by the survey. An overall index number is calculated for each village by summing all seven component indices. Equal weighting is attributed to each of these components in the preliminary ranking.

3.7 Final Adjustments for Project Villages Selection

The final number and list of project villages derived by the foregoing methodologies should be reviewed in the light of the quantifiable information such as those villages lately included in Tambon Project and Contribution Scheme, and the non-quantifiable information such as map locations and village sketches of the potential project villages.

At this stage, the preliminary listed project villages which present technical problems that will involve considerably higher than average cost to surmount, or those village settlements that have a highly dispersed layout, demanding uneconomical costs for reaching the potential consumers, may have to be excluded. On the other hand, lower

priority villages not included in the preliminary list but laying along the direct path of the distribution line to reach a project village, or those villages located near project villages which could be served with a relatively small incremental investment, may finally be added.

Special consideration will finally be given to the unlikely event that a few villages which fail to qualify for inclusion on the standard selection procedure but nevertheless have some outstanding developmental merit such as villages that have local importances for administrative, security, and socio-political reasons and villages that are located in the impact area of development projects sponsored by other RTG institutions, may also be included in the Project on consultation with the NESDB and other responsible agencies.

The following table concludes 4 sets of number of potential villages beginning from the total unelectrified of 11,124; then out of these, the Load Survey reduces the number down to 9,807; then by villages allocation criteria, it was further reduced to 8,985(for simplicity, in few occasions referred to as 9,000);and finally with the villages selection criteria, it ended up with 7,878(rounded off to 8,000 for convenient reference)for ARE 2.

The majority of the first round of writing off 1,317 villages are the remoted villages located in Off-Shore Islands in the Gulf of Thailand and Andaman Sea and the hilltribe villages located in the High Mountains in the Northern and Western areas which can only be served by isolated diesel-generators (The policy of ARE 2 is to concentrate on villages served by grid system only). The majority of the last round of writing off 1,107 villages are the villages finally included in the Tambon Project and Contribution Scheme.

NUMBER OF ARE 2 PROJECT VILLAGES

No.	Project Province	Number of Villages			
		Unelectrified	Surveyed	Allocated	Selected
1	Yala	155	149	125	121
2	Pattani	308	291	240	202
3	Narathiwat	189	182	147	155
4	Songkhla	589	583	481	462
5	Satun	183	184	144	139
6	Phatthalung	357	346	301	301
7	Nakhon Sithammarat	884	835	709	668
8	Suratthani	601	587	488	475
9	Phang-Nga	218	212	184	147
10	Trang	421	410	325	294
11	Krabi	246	243	190	177
12	Phuket	35	29	34	19
13	Phetchaburi	334	271	289	219
14	Ratchaburi	549	340	476	268
15	Prachuap Khirikhan	223	191	190	162
16	Chumphon	379	387	322	311
17	Ranong	100	100	90	73
18	Nakhon Pathom	478	327	306	260
19	Kanchanaburi	373	317	311	227
20	Suphanburi	528	383	441	342
21	Chanthaburi	386	297	329	231
22	Prachinburi	684	617	545	539
23	Phetchabun	593	515	477	439
24	Phitsanulok	596	539	497	454
25	Nan	515	487	398	387
26	Chiang Rai	796	646	634	526
27	Phayao	404	339	322	280
	Total	11,124	9,807	8,985	7,878

To give the picture of regional spread of the project villges under ARE 2, the following tabulation shows such distribution:

Area	Villages Total	Villages Electrified	Villages Unelectrified	Villages Project	Percent Electrification
South Subtotal	6,789	1,567	5,222	3,925	75%
Non-South — Central	3,999	1,001	2,998	1,867	62%
— North	3,353	449	2,904	2,086	72%
Non-South Subtotal	7,352	1,450	5,902	3,953	67%
Total	14,141	3,017	11,124	7,878	71%

In the villages selected for inclusion in the project, the total number of rural households were approximately 1¼ million.

SECTION IV

TECHNICAL ANALYSIS

SECTION IV

TECHNICAL ANALYSIS

4.1 Project Customers

In the 27 project provinces, the following number of districts, communes, villages, households, people are covered in the project area:

Level	Number Covered By Project Area		
	Total	Coverage	Percent
Districts	220	217	99%
Communes	1,787	1,578	88%
Villages	14,141	7,878	56%
Households	1,789,000	882,235	49%
People	10,131,000	4,996,044	49%

Out of 882,235 potential households, if all 7,878 project villages are electrified at the same time, the initial households connected would be 500,758 or 57% (See Table A1-1, Annex A-1).

If the 7,878 project villages are to be phased in the program year-by-year according to the 5 years implementation schedule, 1,228,663 households (with population growth rates of 2.50% down to 2.35% from Year 1 to Year 5) will be covered by the project network. Out of these potential households, 753,953 are the customers (61%) classified as Residence (including Social Facility) by the 5th program year.

In addition, 5 more groups of customers are categorized under the Project, namely, Commercial Shop, Potable Pump, Rice Mill, Power Tool and Agricultural Pump. The overall 5th program year customers are as follows (See Table A2-1):

Type	Customer	5th Year Connection
Single-Phase	Residence (& Social Facility)	753,953
	Shop	57,670
	Pump (Potable)	11,871
	Total Customers, 1-ø	823,494
Three-Phase	Rice Mill	1,675
	Power Tool	6,644
	Pump (Agricultural)	2,094
	Total Customers, 3-ø	10,413
	Total Customers	833,907

Under the assumption that the population growth rate would be declined by the RTG's active program of birth control, the growth rate is forecasted to be 2.0% by the 30th year and the total customers shall be 2,350,397 (all categories together) which is almost three-fold that of 5-year program.

4.2 Phased Program for Project Implementation

The following criteria are applied to phase the project provinces into construction:

- To start up the first 2 years mostly in the Non-South Area, then bring construction in South Area by the 3rd year when EGAT shall be able to sufficiently supply the power demand there,
- To commence construction in as many Operating Regions of the PEA as possible (The Project covers 9 Regions — 3 in the South, 3 in the Central, and 3 in the North),
- To spread construction over the 5 years program as smoothly as possible,
- To select provinces in the Project Area with the highest expected energy sales and economic benefits to be implemented before the others,

- To select districts in the Project Province with such economic priority for implementation,
- To allow some training of the newly recruited construction crews in the first year by a relatively smaller workload,
- To allow some lead time for materials procurement and logistic preparation in the first year by such a smaller workload.

The following table gives the 5-year phased program (sequence and number) of implementing villages by year. It can be transformed into an implementing schedule as follows:

Program Year	Entering Provinces	Project Villages	South Villages	Percent South
1	7 Provinces: Chiangrai, Phitsanulok Phetchabun, Prachinburi, Chanthaburi, Nakhon Phathom, Petchaburi	1,470	118	1.5%
2	4 Provinces: Phayao, Nan, Kanchanaburi, Ratchaburi	1,643	101	1.3%
3	5 Provinces: Suphanburi, Prachuab Kirikhan, Chumphon, Nakhon Si Thamarat, Phattalung	1,547	672	8.5%
4	6 Provinces: Ranong, Phang-Nga, Krabi, Songkhla, Satun, Narathiwat	1,605	1,421	18.0%
5	5 Provinces: Suratthani, Phuket, Trang, Yala, Pattani	1,613	1,613	20.5%
	Total	7,878	3,925	49.8%

SEQUENCE AND NUMBER OF IMPLEMENTING VILLAGES BY YEAR

No.	Project Province	Sequence and Number of Implementing Village by Year					
		Program Year 1 (7 Provinces Entered)	Program Year 2 (4 Provinces Entered)	Program Year 3 (5 Provinces Entered)	Program Year 4 (6 Provinces Entered)	Program Year 5 (5 Provinces Entered)	Total Villages
1	Yala					121	121
2	Pattani					202	202
3	Narathiwat				90	65	155
4	Songkhla				257	205	462
5	Satun				79	60	139
6	Phatthalung			141	160		301
7	Nakhon Si Thammarat			313	355		668
8	Suratthani					475	475
9	Phang-Nga				82	65	147
10	Trang					294	294
11	Krabi				102	75	177
12	Phuket					19	19
13	Phetchaburi	118	101				219
14	Ratchaburi		101*	167 *			268*
15	Prachuap Khirikhan			73	89		162
16	Chumphon			145	166		311
17	Ranong				41	32	73
18	Nakhon Pathom	138 *	122 *				260*
19	Kanchanaburi		87 *	140 *			227*
20	Suphanburi			158 *	184 *		342*
21	Chanthaburi	130 *	101 *				231*
22	Prachinburi	305 *	234 *				539*
23	Phetchabun	246 *	193 *				439*
24	Phitsanulok	250 *	204 *				454*
25	Nan		150 *	237 *			387*
26	Chiang Rai	283 *	243 *				526*
27	Phayao		107 *	173 *			280*
	Subtotal South	118	101	672	1,421	1,613	3,925
	Subtotal Non-South *	1,352*	1,542*	875*	184*	-	3,953*
	Total Project	1,470	1,643	1,547	1,605	1,613	7,878

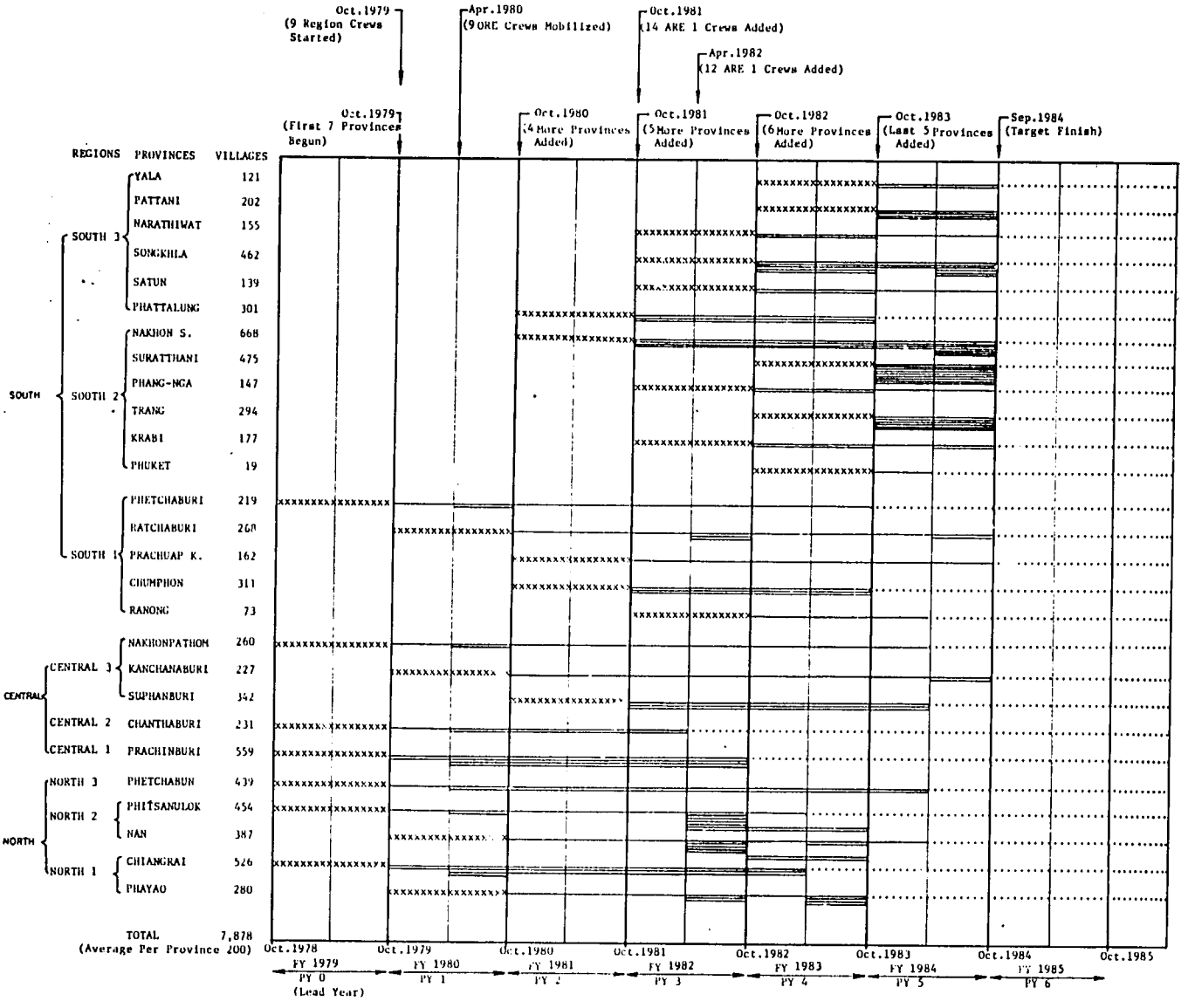
The detailed project work-schedule is shown in the following chart. The Project shall be started off in the first 7 provinces with 9 Region Construction Crews equipped and upgraded by the ORE in the beginning of FY 1980. Then it shall be supplemented by the newly mobilized 9 ORE Crews in mid-Fy 1980, also taking care of another 4 provinces. By end-FY 1981 it shall be reinforced by another 14 ORE Crews from ARE 1 implementing the next 5 provinces, and finally another 12 ORE Crews also from ARE 1 shall join in by mid-FY 1982 implementing the next 6 provinces. The rest of 5 provinces shall be implemented by all 44 ORE and Region Crews completing the Project with FY 1984 as planned.

The next organization chart shows the administration and supervision of ARE 2 project implementation, which is similar to that of ARE 1. It should be noted that along with ARE 2 as the main project for the Second 5-Year ARE Program, the Minihydro Project in the North is also planned to be implemented — according to the Government policy of concentrating utilization of Thailand's own natural resource — as a special supplementary project in the 4th & 5th National Plans.

4.3 Existing Facilities

The following table shows the survey of the existing distribution system serving the 27 project provinces. PEA has 77 feeders of high-voltages lines (22 kV & 33 kV) taken from 38 substations all-together. Out of these, 31 substations are EGAT's delivery points integrated to the National Grid System, and 7 substations are PEA's supply points isolated as Local Diesel-Generating Plants. These 7 PEA's supply points serving 8 provinces are Chiangrai, Nan, Prachuab Khirikhan, Chumphon, Satun, Yala, and Narathiwat (Pattani is normally served both directions from Yala and Narathiwat). Out of these, 4 provinces are completely served by PEA's own power (Nan, Prachuab Khirikhan, Chumphon, and Satun), and 4 provinces are served by both PEA's power and EGAT's power (Chiangrai, Yala, Pattani, and Narathiwat).

PROJECT WORK-SCHEDULE
FOR
ACCELERATED RURAL ELECTRIFICATION PROJECT - SECOND STAGE (ARE 2)



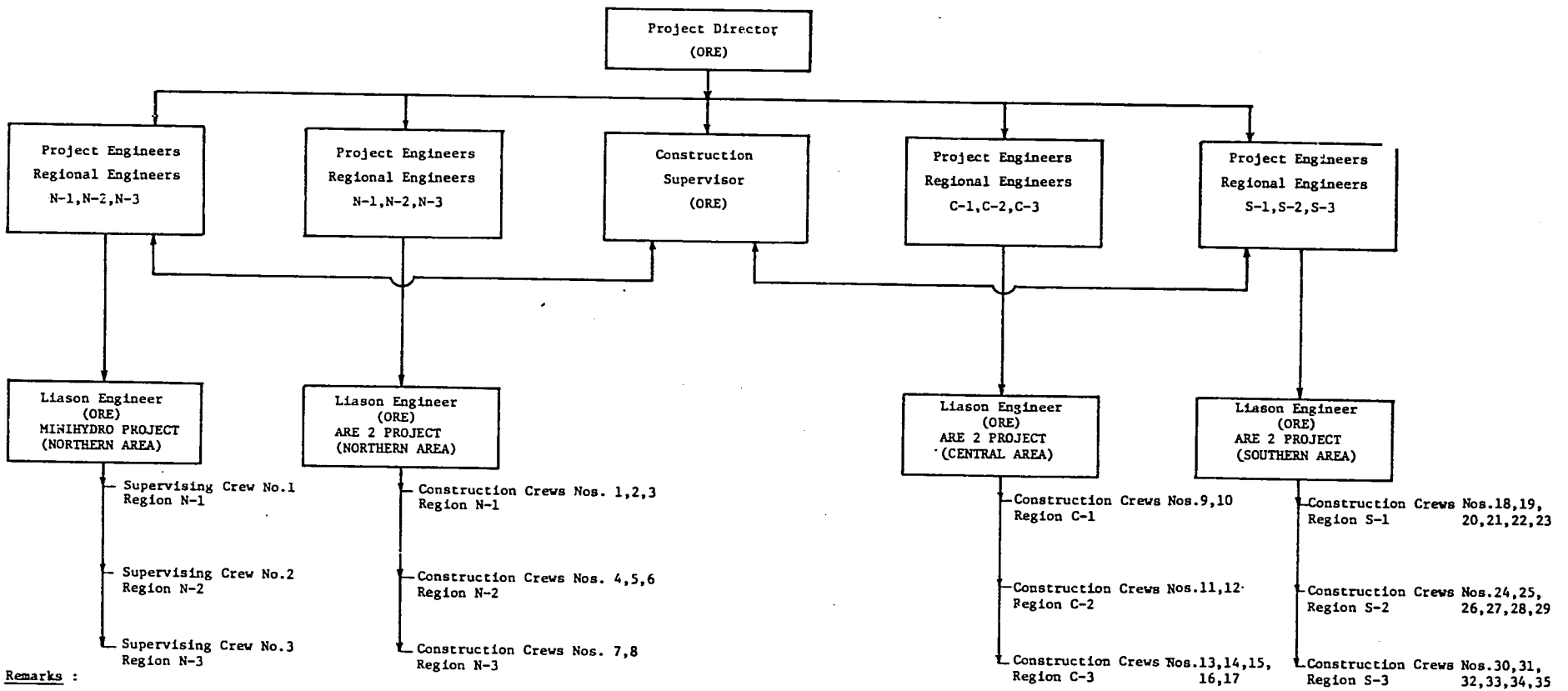
SYMBOL: xxxxxxxxxxxxxxxxxx PRE - CONSTRUCTION ACTIVITIES (Design, Take-Off Materials, Procurement, Etc.)
——————— CONSTRUCTION ACTIVITIES (Work Orders, Erection, Energization, Etc.)
..... POST-CONSTRUCTION ACTIVITIES (Operation, Load Promotion, Electrification Monitoring, Etc.)

REMARK: (a) Abbreviation: SCC = Standard Construction Crew (Approximate 56-man team), FY = Fiscal Year, PY = Program Year

(b) ARE 2 Project to be started off in first 7 provinces with 9 Region SCC by beginning FY 1980, supplemented by newly mobilized 9 ORE SCC in mid-FY 1980. Then by end-FY 1981 it will be reinforced by another 14 ORE SCC from ARE 1 Project implementing the next 5 provinces, and finally another 12 ORE SCC from ARE 1 Project by mid-FY 1982 implementing the next 6 provinces. The rest of 5 provinces will be implemented by all 44 Region and ORE SCC completing the Project within FY 1984 as planned.

(c) By beginning-FY 1985, the 9 Regions Crews and the 35 ORE Crews will be continued to start up ARE 3 Project.

ORGANIZATION CHART
FOR
ORE PROJECT CONSTRUCTION SUPERVISION
OF
SECOND 5-YEAR PROGRAM
THAILAND ACCELERATED RURAL ELECTRIFICATION



Remarks :

1. Project Engineers for ARE 2 Project are all Regions' personnel (Regional Engineers or formally titled Chief of Regional Technical Sector).
2. Construction Crews for ARE 2 Project shall be mainly ORE's personnel (approximate 35 crews) assisted by some Regions' personnel (approximate 9 crews).
3. Construction Supervisor, Liason Engineers, Field Engineers are all ORE's personnel.
4. Twenty six (26) ORE Construction Crews are to be transferred from ARE 1 Project.
5. Another 9 ORE's Construction Crews are to be mobilized in addition,for initial implementation before ARE 1 crews move in.
6. Nine (9) Regions' Construction Crews are existing crews in each Project Region assisting implementation from the first year of ARE 2.
7. Field Engineers are the engineers attached to a group of Construction Crews in each region.
8. One Construction Crew (56-man team included foreman, skillmen, drivers and labors) is designed to be capable of constructing 1 village in 1 week (or 50 villages in 1 year).
9. Supervising Crews for the special project of Minihydro are special task force to supervise and inspect the work done by contractors.

SURVEY OF THE EXISTING SYSTEM

No.	Region	Substation	Province	Owner	No.Of Feeders	Remarks
						(P = PEA,E = EGAT)
		Northern Region 1, 2, 3				
1	N1	Chiangrai	Chiangrai	P	3	
2	N1	Payao	Payao	E	3	
3	N2	Nan	Nan	P	2	
4	N2	Phitsanulok	Phitsanulok	E	4	
5	N2	Phichit	Phichit	E	1	To Phitsanulok
6	N3	Phetchabun	Phetchabun	E	2	
				4E+2P	15	
		Central Region 1, 2, 3				
1	C1	Prachinburi	Prachinburi	E	3	
2	C2	Chanthaburi	Chanthaburi	E	2	
3	C3	Suphanburi	Suphanburi	E	3	
4	C3	Khanchanaburi	Khanchanaburi	E	3	
5	C3	Thamuang	Khanchanaburi	E	2	
6	C3	Nakhonchaisi	Nakhon Pathom	E	3	To Ratchaburi
7	C3	Samphran	Nakhon Pathom	E	1	
8	C3	Kamphangsan	Nakhon Pathom	E	1	
				8E	15	
		Southern Region 1				
1	S1	Ratchaburi	Ratchaburi	E	3	
2	S1	Banpong 1	Ratchaburi	E	3	
3	S1	Banpong 2	Ratchaburi	E	3	
4	S1	Prachuab Khirikhan	Prachaub Khirikhan	P	2	
5	S1	Phetchaburi	Phetchaburi	E	2	
6	S1	Cha-Am	Phetchaburi	E	1	To Phetchaburi
7	S1	Pranburi	Prachuab Khirikhan	E	1	
8	S1	Chumphon	Chumphon	P	2	
9	S1	Ranong	Ranong	E	1	
				7E+2P	21	
		Southern Region 2				
1	S2	Lampoora	Trung	E	2	
2	S2	Krabi	Krabi	E	1	
3	S2	Phang-Nga	Phang-Nga	E	2	
4	S2	Phuket	Phuket	E	3	
5	S2	Suratthani	Suratthani	E	3	
6	S2	Phunphin	Suratthani	E	1	
7	S2	Nakhon Si Thammarat	Nakhon Si Thammarat	E	2	
8	S2	Thungsong	Nakhon Si Thammarat	E	1	
9	S2	Takuapa	Phang-Nga	E	1	
				9E	16	
		Southern Region 3				
1	S3	Phatthalung	Phatthalung	E	2	
2	S3	Satun	Satun	P	1	
3	S3	Hat Yai	Songkhla	E	4	
4	S3	Yala	Yala	E	3	
5	S3	Yala	Yala	P		
	S3	-	Pattani	-		
6	S3	Narathiwat	Narathiwat	P		
				3E+3P	10	
Total		38 Substations	27 Provinces	31E+7P	77	

The total capacity of the 31 EGAT's substations is approximately 500 MVA by the end of 1977 while the total peak demand in the areas served by these substations is approximately 250 MW (See the following table summarizing the existing & proposed EGAT delivery points). In addition, there is another existing demand of approximately 30 MW in the areas of 27 project provinces beyond the areas served by the 31 EGAT's substations. Therefore, the total peak demand of approximate 280 MW has already existed in the 27 provinces dominated for ARE 2.

The next table shows the physical quantity of existing distribution system by provinces. The combined system has 8,099 circuit km. of high-voltage 22 kV & 33/19 kV lines, 6,769 circuit km. of low-voltage 400/230 V lines, and 685 MVA of installed transformer capacity. While the overall area of the 27 project provinces is 199 thousand square km., the table gives the average density values as follows:

- High-Tension Lines = 41.0 cct. meter/km^2
- Low-Tension Lines = 30.5 cct. meter/km^2
- Transformer Capacity = 3.5 kVA/km^2

4.4 Load Forecast

For ARE 2 Project,7 justifiable groups of customer are categorized for the load forecast and demand growth as follows:

- Residential Household
- Commercial Shop
- Rice Mills
- Power Tool
- Potable Pumps
- Agricultural Pumps
- Social Facility

4.4.1 Residential Households

An ordinary least squares Stepwise Multiple Regression (SMR) computer program is used to project initial rural household energy demands.

SUMMARY OF EXISTING AND PROPOSED EGAT DELIVERY POINTS

EGAT SUBSTATION	EXISTING CAPACITY (KVA) BY 1977	EXISTING DEMAND (KW) BY 1977	NUMBER OF VILLAGES TO BE ADDED BY 1984	CONNECTED LOAD FOR* VILLAGES ADDED (KVA)
EXISTING SUBSTATIONS IN NORTHERN PROJECT PROVINCES				
1. Phayao	6,000	9,100	356	6,847
2. Phitsanulok	25,000	11,340	375	7,213
3. Phetchabun 1 (North)	12,500	4,750	229	3,135
4. Phichit	12,500	4,000	126	2,424
Subtotal - For Existing Substations	56,000	29,190	1,086	19,619
EXISTING SUBSTATIONS IN CENTRAL PROJECT PROVINCES				
1. Prachinburi	12,500	7,300	336	6,468
2. Chanthaburi	12,500	3,900	231	4,444
3. Kanchanaburi	13,330	7,800	157	3,020
4. Thamuang (Kanchanaburi Province)	13,330	5,400	60	1,154
5. Suphanburi	7,500	5,500	342	6,578
6. Kamphangsan (Nakhonpathom Province)	12,500	4,100	138	2,654
7. Sampran (Nakhonpathom Province)	25,800	15,200	5	96
8. Nakhonchaisi (Nakhonpathom Province)	50,000	22,600	44	846
Subtotal - For Existing Substations	147,460	71,800	1,313	25,260
EXISTING SUBSTATIONS IN SOUTHERN PROJECT PROVINCES				
1. Ratchaburi	37,500	7,300	172	3,308
2. Banpong 1 (Ratchaburi Province)	25,000	14,600	169	3,770
3. Banpong 2 (Ratchaburi Province)	38,330	20,200	10	192
4. Phetchaburi	12,500	6,800	144	2,770
5. Cha-Am (Phetchaburi Province)	25,000	17,600	88	1,693
6. Pranburi (Prachuap Khirikhan Province)	12,500	1,500	68	1,308
7. Ranong	13,000	5,600	59	1,135
8. Phunphin (Suratthani Province)	12,000	8,200	475	9,137
9. Phang-Nga	6,000	1,900	100	1,923
10. Takuapa (Phang-Nga Province)	6,000	1,400	47	904
11. Phuket	22,500	12,000	19	366
12. Krabi	3,000	1,200	177	3,405
13. Nakhon Sithammarat	13,000	7,250	356	6,848
14. Thung Song (Nakhon Sithammarat Province)	20,500	4,600	273	5,252
15. Lumphula (Trang Province)	12,000	6,200	317	6,097
16. Hat Yai (Songkhla Province)	26,000	21,000	300	5,770
17. Phatthalung	3,000	2,080	301	5,790
18. Yala	15,000	10,400	350	6,732
Subtotal - For Existing Substations	302,830	149,830	3,425	66,400
PROPOSED SUBSTATIONS FOR THE WHOLE PROJECT AREA				
1. Chiang Rai	-	9,200	450	8,655
2. Nan	-	4,000	387	7,444
3. Phetchabun 2 (South)	-	2,700	163	3,135
4. Aranyaprathet (Prachinburi Province)	-	2,700	203	3,905
5. Prachuap Khirikhan	-	1,800	81	1,558
6. Chumphon	-	4,000	325	6,251
7. Ranot (Songkhla Province)	-	2,500	174	3,346
8. Sadao (Songkhla Province)	-	900	64	1,231
9. Narathiwat	-	2,100	207	3,982
Subtotal - For Proposed Substations	-	29,900	2,054	39,507
Total - For 27 Project Provinces	506,290	280,720	7,878	150,786

*Fifth Year Demand = 128.0 MW (From Table A3-1, Annex A-1)
Average Demand Per Village = 16.3 KW
Power Factor Used = 0.85

EXISTING ELECTRIFICATION DENSITY
BY END - 1977

NO.	PROJECT PROVINCES	HIGH TENSION LINES (CCT. KM.)	LOW TENSION LINES (CCT. KM.)	TRANSFORMER CAPACITY (KVA)	AREA OF PROVINCE (KM^2)	HIGH TENSION CCT. KM. PER KM^2	LOW TENSION CCT. KM. PER KM^2	TRANSFORMER KVA PER KM^2
1	Yala	266.00	120.00	25,422	4,715.85	0.0564	0.0255	5.3908
2	Pattani	290.00	155.00	16,132	2,109.63	0.1375	0.0735	7.6469
3	Narathiwat	390.00	150.00	14,785	4,227.75	0.0923	0.0355	3.4978
4	Songkhla	360.00	200.00	42,136	7,321.99	0.0492	0.0273	5.7548
5	Satun	140.00	45.00	3,887	2,669.06	0.0525	0.0169	1.4564
6	Phatthalung	140.00	65.00	6,350	3,269.53	0.0429	0.0199	1.9422
7	Nakhon Si Thammarat	300.00	341.00	32,420	11,211.44	0.0268	0.0305	2.8917
8	Suratthani	386.00	232.00	24,705	19,163.68	0.0202	0.0121	1.2892
9	Phangnga	204.00	96.00	13,040	5,108.77	0.0400	0.0188	2.5525
10	Trang	228.00	130.00	23,975	5,106.00	0.0447	0.0255	4.6955
11	Krabi	150.00	58.00	5,120	4,624.31	0.0325	0.0126	1.1072
12	Phuket	197.00	231.00	44,056	538.72	0.3657	0.4288	81.7791
13	Phetchaburi	470.00	450.00	22,190	6,357.19	0.0740	0.0708	3.4906
14	Ratchaburi	190.00	523.00	91,364	5,093.54	0.0373	0.1027	17.9373
15	Prachuap Khirikhan	447.00	182.00	21,315	8,225.00	0.0544	0.0222	2.5915
16	Chumphon	250.00	150.00	7,265	5,745.00	0.0436	0.0261	1.2646
17	Ranong	79.50	50.00	22,315	3,425.60	0.0232	0.0146	6.5142
18	Nakhon Pathom	471.68	598.97	110,130	2,080.32	0.2268	0.2880	52.9390
19	Kanchanaburi	329.46	417.23	27,297	19,486.07	0.0169	0.0215	1.4009
20	Suphanburi	333.67	501.61	30,480	5,348.39	0.0624	0.0938	5.6990
21	Chanthaburi	317.00	188.00	24,520	6,052.27	0.0524	0.0311	4.0514
22	Prachinburi	406.00	315.00	1,782	11,794.94	0.0345	0.0267	0.1511
23	Phetchabun	354.38	353.00	14,850	13,660.00	0.0260	0.0259	1.0872
24	Phitsanulok	289.40	282.06	15,750	9,701.09	0.0299	0.0291	1.6236
25	Nan	261.23	145.87	9,510	11,694.51	0.0224	0.0125	0.8132
26	Chiang Rai	542.00	550.00	23,650	12,302.54	0.0441	0.0447	1.9224
27	Phayao	307.00	239.00	10,300	7,767.00	0.0396	0.0308	1.3262
	Total 27 Project Provinces	8,099.00	6,769.00	684,746	198,800.00	0.0407	0.0340	3.4444

For each province, household annual kWh energy demand, as the dependent variable, is regressed on independent explainatory economic variables so as to maximise the predictive value of the equation.

Data used to develop these regression coefficients are taken from the Survey B & E (Unelectrified & Electrified Households). Corresponding data for the independent economic variables are subsituted into the derived regression equations to predict initial rural household kWh energy demands at the district level.

The above derived kWh energy demands correspond with average rural household energy consumption in the nth year of village electrification, where n is the average number of years the households were electrified in each village as calculated from the Survey E. The independent variables identified in the SMR model of annual rural household kWh energy demand are presented in Table C6 of Annex C. The actual coefficients derived from the model are shown in the following table along with projected project household annual kWh energy demand for the year n.

A simple Oridinary Least Squares (OLS) regression is used to estimate household income elasticity of demand for electricity. Rural household annual kWh consumption is regressed on annual total household cash income. Income elasticities are calculated at the mean values of the independent variables.

For example, in the province of Trang, an income elasticity of 0.87 is estimated. These calculated "income" elasticities are considered conservative for they only account for cash income and ignore the fact that a great deal of rural real income is often in a noncash form. Thus for Trang, it is assumed that the rural household annual kWh real income elasticity of demand is approximately 1.0.

Projected annual growth of real per capita income along with the above estimated income elasticities are used to project annual increases in rural household kWh energy demand. Between 1967, Thailand

TREND OF KWH CONSUMPTION

FOR RESIDENTIAL CUSTOMERS

No.	Province	Intercept	Slope	* Average Annual Total HH. Cash Income in Electrified Villages (000)Baht	** Average Annual Total HH. Cash Income in Unelectrified Villages (000)Baht	Project Average Annual HH.KWH (SMR Method)	Year n	KWH Trend	Remarks
1	Yala	197.1	0.7	30.6	28.0	218	5	163	
2	Pattani	138.2	1.9	30.6	23.4	236	5	204	
3	Narathiwat	123.6	2.4	29.5	22.1	236	6	198	
4	Songkhla	222.6	2.6	29.6	17.4	268	6	240	
5	Satun	335.0	2.0	38.2	19.7	259	4	132	
6	Phatthalung	260.7	2.5	36.3	20.7	334	4	228	
7	Nakhon Si Thammarat	172.4	1.9	29.6	23.2	230	6	137	
8	Suratthani	168.1	1.1	31.2	23.0	210	6	252	
9	Phang-Nga	259.6	1.5	32.3	27.4	356	5	288	
10	Trang	190.0	5.3	30.0	18.6	254	6	254	
11	Krabi	238.0	2.7	31.8	22.7	259	4	216	
12	Phuket	326.0	2.2	38.3	28.8	268	7	252	
13	Phetchaburi	210.7	2.4	33.7	26.1	370	6	204	
14	Ratchaburi	284.1	1.8	29.0	31.3	415	5	180	
15	Prachuap Khirikhan	231.1	0.9	44.1	34.0	251	7	264	
16	Chumpon	216.2	0.6	42.6	37.5	212	5	173	
17	Ranong	212.8	3.9	32.8	20.8	237	4	204	
18	Nakhon Pathom	-0.7	15.2	62.4	87.5	621	7	396	
19	Kanchanaburi	221.6	3.2	32.8	28.8	326	7	240	
20	Suphanburi	184.0	1.5	38.8	45.7	254	6	216	
21	Chanthaburi	180.6	1.8	47.1	38.0	396	5	259	
22	Prachinburi	205.4	1.3	29.5	28.4	269	6	206	
23	Phetchabun	150.9	0.6	38.3	39.3	212	4	204	
24	Phitsanulok	122.3	2.7	25.0	22.0	301	4	194	
25	Nan	122.4	1.0	22.6	17.5	183	5	190	
26	Chiang Rai	169.3	1.4	22.6	21.0	242	7	216	
27	Phayao	135.1	4.8	22.5	22.0	276	6	160	

* From 1977 ORE Survey E (Electrified Households).
** From 1977 ORE Survey B (Unelectrified Households).

Gross Domestic Product (GDP), in 1962 market prices, increased at an average annual rate of 7.0% (See the following table). During this same time period, Thailand Per Capita GDP, in 1962 market prices, increased at an average annual rate of 3.6%. The Fourth (1977-1981) National Development Plan's target rates of annual growth for population, real GDP, and real GDP per capita are 2.1, 7.0, and 4.9 percent, respectively.

TRENDS OF THAILAND GROSS DOMESTIC PRODUCT

Year	Population Growth Rate (%)	GDP Growth Rate (at 1962 Market Price) (%)	Per Capita GDP (at 1962 Market Price) (Baht)
1967	3.2	7.8	2,913
1968	3.2	8.5	3,067
1969	3.2	7.5	3,195
1970	3.2	6.9	3,311
1971	3.2	8.2	3,466
1972	3.1	4.3	3,502
1973	3.1	10.3	3,745
1974	3.1	4.6	3,804
1975	3.1	5.5	3,891
1976	3.1	6.2	4,011

Source: Key Indicators of Developing Member Countries of ADB, Economic Office, Asian Development Bank, April 1977.

Thus for a province with a household annual kWh income elasticity of approximately 1.0 and an annual growth of real per capita income of approximately 5.0%, rural household annual energy demand is projected to increase approximately 5.0% (1.0 x 5.0) a year for the first 15 years following province household electrification in year n. After year n + 15, rural household annual kWh energy demand is assumed to

increase approximately 3.5% (0.68 x 5.0) as household lighting and basic appliance demand becomes saturated, assuming an appliance kWh income elasticity of 0.68. After the 20th year of province household electrification (Year n + 20) this rate of growth is assumed to decline to 1.5% until project year 30 (the last forecasted year).

Between 1966 and 1975, total MWh energy sales in Thailand increased at an annual average rate of 19.5%. Lighting and power energy sales increased at average annual rate of 16.1 and 21.9% respectively (See the following table).

TRENDS OF THAILAND ELECTRICAL ENERGY SALES

Year	Energy Sales (MWh)			Annual % Change		
	Light	Power	Total	Light	Power	Total
1966	686.3	809.9	1,496.2	26.58	48.58	37.61
1967	818.6	1,136.9	1,955.5	19.28	40.38	30.70
1968	961.4	1,555.5	2,516.9	17.44	36.82	28.71
1969	1,164.5	1,914.9	3,079.4	21.13	23.11	22.35
1970	1,345.7	2,459.2	3,804.9	15.56	28.39	23.54
1971	1,484.5	2,937.5	4,422.0	10.31	19.45	16.22
1972	1,662.8	2,653.5	5,316.3	12.01	24.37	20.22
1973	2,191.0	2,998.8	6,189.8	31.77	9.45	16.43
1974	2,257.5	4,267.9	6,525.4	2.52	7.01	5.42
1975	2,631.5	4,836.5	7,468.0	16.58	13.32	14.44

Source: Electric Power in Thailand, 1975. National Energy Administration, Office of the Prime Minister.

Assuming that residential customers increased approximately 10.4% (See the following table) a year during this same time period, then household energy consumption (which is primarily a lighting load) conservatively increased approximately 5.7% (16.1-10.4)

during this time period. Thus the above income elasticity of demand methodology used to project annual rates of growth of household kWh energy demand is conservatively in agreement with historical precedent.

PEA CUSTOMERS

Year	Total Number of Customers	Residential Customers	Small Business
1966	321,189	-	-
1967	349,371	-	-
1968	398,224	-	-
1969	443,423	-	-
1970	478,940	-	-
1971	524,869	515,554	5,567
1972	575,464	565,378	5,966
1973	628,662	618,506	6,573
1974	697,369	685,828	6,927
1975	781,472	768,160	8,455

Source: Provincial Electricity Authority Annual Reports

This study assumes that the rural household connection rate, under a moderate load promotion program, will increase on the average of 15% a year from the initial electrification connection rate, until reaching 95%, then remaining constant.

The initial village electrification connection rate for each province is estimated from data from the Survey D (Electrified Villages) and the Survey A (Unelectrified Villages) The Survey D provides information on the actual connection rate of electrified villages. The Survey A asks the Unelectrified Village Headman what they expect the initial village connection rate to be. The Village

Headman's response is based upon his initmate knowledge of local household's preferences and effective demand. The lower of the above 2 estimated connection rates is assumed as a village average for each province. Average rural village connection rates for the 27 project provinces are presented in the following table.

For example, in the Province of Trang, a connection rate of 36.0% is calculated from the census of Village Headmen in Unelectrified Villages in Survey A. The actual connection rate for similar sampled electrified villages is 33.0% as calculated from the collected data of Electrified Villages in Survey D. This 33.0% is an average connection rate for villages electrified on the average of 6 years. Thus for Trang, it is assumed that there is an average connection rate of 33.0% at the end of the fifth project year and that this rate grows at 15% per year until reaching 95% in the 13th project year. The same methodology is applied to the other provinces.

Number of project households in based on population growth rate of 2% per annum and effect on the household size.

4.4.2 Commercial Shops

A simple Ordinary Least Squares (OLS) regression is used to estimate electrified annual shop kWh energy demand. Shop annual kWh consumption is regressed on annual total shop income. Data used to develop these regression coefficients are taken from the Survey E(Electrified Households & Shops). Corresponding data for the independent variable, total shop cash income, is substituted into the derived regression equations to predict initial rural shop kWh energy demands at the district level. The above derived kWh energy demands correspond with average rural shop energy consumption in the nth year of village electrification. The actual coefficients derived from this model are summarized in the following table along with projected shop annual kWh energy demand for year n.

AVERAGE RURAL VILLAGE CONNECTION RATES

IN 27 PROJECT PROVINCES

NO.	Project Province	Expected Initial Connection Rate (%)*	Actual Average Connection **	
			Connection Rate (%)	Years Electrified
1	Yala	65.6	35.0	6
2	Pattani	69.3	49.0	5
3	Narathiwat	63.6	23.0	7
4	Songkhla	69.5	46.0	8
5	Satun	59.3	31.0	8
6	Phatthalung	53.8	24.0	4
7	Nakhon Si Thammarat	53.0	33.0	8
8	Suratthani	52.4	40.0	6
9	Phang-Nga	56.5	55.0	6
10	Trang	36.0	33.0	6
11	Krabi	50.9	32.0	5
12	Phuket	62.9	61.0	10
13	Phetchaburi	63.5	67.0	10
14	Ratchaburi	63.2	60.0	7
15	Prachuap Khirikhan	49.4	45.0	11
16	Chumphon	51.5	50.0	7
17	Ranong	49.0	74.0	4
18	Nakhon Pathom	80.0	80.0	8
19	Kanchanaburi	74.0	55.0	8
20	Suphanburi	82.1	59.0	7
21	Chanthaburi	57.1	46.0	7
22	Prachinburi	61.4	36.0	8
23	Phetchabun	45.1	36.0	5
24	Phitsanulok	56.2	45.0	5
25	Nan	58.8	51.0	9
26	Chiang Rai	41.3	50.0	7
27	Phayao	54.9	46.0	8

* From 1977 ORE Survey A (Unelectrified Villages).

** From 1977 ORE Survey D (Electrified Villages).

After year n of province household electrification, annual rural shop kWh evergy demand is assumed to increase 3.5% until the 20th year of the project and then 1.5% thereafter.

Average shop coefficients per total number of village households for each project province are presented in Table C3 and C6 of Annex C. The average ratio of unelectrified village shops to total number of unelectrified village households and the average ratio of electrified village shops to total number of households in electrified villages are estimated from the from the Survey C (Power Load Potential) and the Survey D (Electrified Rural Villages) respectively. Survey data (See the next table) indicates that shops have close to a 95% initial connection rate when a village is electrified.

The coefficients of average number of unelectrified village households per unelectrified shop are used to project the average number of shops for each project year. By the end of the first year of project village electrification, a 75% shop connection rate is assumed. This conversion rate is then assumed to increase 5% a year until reaching 100% in the fifth year of project village electrification.

4.4.3 Rice Mills

Load forecast for rice mills is made on a per capita consumption basis utilizing the size of rice mill required by the average village multiplied by the number of villages in each province. The "average village" rice mill is developed from the size rice mill required to mill sufficient paddy to supply the average project village (of approximate 700 population) with 165 kg. of white rice consumed per person annually. The population growth rate is assumed to increase at 2.50% per annum for the first program year, down to 2.35% by 5th year and to 2.00% by the 25th year and thereafter.

Average rice mill coefficients per total number of village households for each project province are shown in the following table.

TREND OF KWH CONSUMPTION

FOR COMMERCIAL CUSTOMERS

No.	Province	Intercept	Slope	Average Annual* Total Shop Cash Income in Electrified Villages (000) Baht	Average Annual** Total Shop Cash Income in Unelectrified Villages (000) Baht	Projected Average Annual Shop kWh	Year n
1	Yala	485.5	0.3	38.6	65.7	505	5
2	Pattani	203.9	11.7	41.1	21.1	451	5
3	Narathiwat	551.2	1.6	37.3	33.8	605	6
4	Songkhla	466.9	6.3	68.1	22.9	611	6
5	Satun	391.3	2.6	32.2	29.1	467	4
6	Phatthalung	335.9	5.7	23.6	25.1	479	4
7	Nakhon Si Thammarat	449.7	3.7	38.9	29.4	558	6
8	Suratthani	397.6	2.4	40.8	26.8	462	6
9	Phang-Nga	299.4	6.9	37.1	37.4	557	5
10	Trang	551.2	1.6	37.3	33.8	605	6
11	Krabi	487.8	-2.5	40.7	35.7	467	4
12	Phuket	158.3	7.9	43.0	32.5	611	7
13	Phetchaburi	462.7	2.2	41.4	43.6	559	6
14	Ratchaburi	441.1	12.1	43.7	32.6	836	5
15	Prachuap Khirikhan	674.4	-0.04	51.0	44.7	672	7
16	Chumphon	440.2	0.4	72.1	47.4	459	5
17	Ranong	197.1	5.9	54.6	45.8	467	4
18	Nakhon Pathom	441.1	12.1	43.7	32.6	836	5
19	Kanchanaburi	800.8	2.4	32.8	40.4	898	7
20	Suphanburi	719.9	3.0	48.6	67.6	923	6
21	Chanthaburi	28.5	10.2	55.3	39.5	431	5
22	Prachinburi	523.9	3.1	35.9	35.9	635	6
23	Phetchabun	96.1	4.7	61.7	51.7	243	4
24	Phitsanulok	173.9	7.2	31.8	26.3	363	4
25	Nan	143.2	4.2	36.2	25.5	250	5
26	Chiangrai	95.3	8.9	28.1	32.2	382	7
27	Phayao	217.7	3.1	28.8	45.9	360	6

* From 1977 ORE Survey E (Electrified Households & Shops)
**From 1977 ORE Survey B (Unelectrified Households & Shops)

AVERAGE NUMBER OF RURAL VILLAGE HOUSEHOLDS PER SHOP

No.	Province	Average Number of Households in Unelectrified Village per Unelectrified Shop*	Average Number of Households in Electrified Village per Shop**	Shop Connection Rate (%)
1	Yala	18	20	90
2	Pattani	25	15	92
3	Narathiwat	17	19	70
4	Songkhla	15	11	91
5	Satun	15	12	95
6	Phatthalung	13	18	94
7	Nakhon Si Thammarat	18	24	92
8	Suratthani	24	10	98
9	Phang-Nga	17	9	78
10	Trang	18	11	94
11	Krabi	22	10	98
12	Phuket	18	24	92
13	Phetchaburi	22	12	86
14	Ratchaburi	19	12	96
15	Prachuap Khirikhan	19	9	96
16	Chumphon	16	7	98
17	Ranong	22	5	52
18	Nakhon Pathom	21	3.5	100
19	Kanchanaburi	22	9	100
20	Suphanburi	20	6	96
21	Chanthaburi	20	9	97
22	Prachinburi	23	23	80
23	Phetchabun	22	12	86
24	Phitsanulok	28	28	97
25	Nan	39	31	99
26	Chiang Rai	35	33	98
27	Phayao	37	37	90

* From 1977 ORE Survey B (Unelectrified Households & Shops) and Survey C (Power Load Potential).

** From 1977 ORE Survey D (Electrified Villages) and Survey E (Electrified Households).

AVERAGE NUMBER OF RURAL VILLAGE HOUSEHOLDS PER RICE MILL
IN 27 PROJECT PROVINCES

No.	Project Province	Average Number of Unelectrified Households Per Rice Mill*
1	Yala	200
2	Pattani	98
3	Narathiwat	108
4	Songkhla	81
5	Satun	97
6	Phatthalung	46
7	Nakhon Si Thammarat	65
8	Suratthani	56
9	Phang-Nga	130
10	Trang	95
11	Krabi	69
12	Phuket	640
13	Phetchaburi	97
14	Ratchaburi	254
15	Prachuap Khirikhan	356
16	Chumphon	66
17	Ranong	67
18	Nakhon Pathom	280
19	Kanchanaburi	393
20	Suphanburi	430
21	Chanthaburi	143
22	Prachinburi	62
23	Phetchabun	122
24	Phitsanulok	75
25	Nan	41
26	Chiang Rai	100
27	Phayao	78
	Total Average	120

* From 1977 ORE Survey C (Power Load Potential).

These coefficients are derived from the Survey C (Power Load Potential) and are used to project the total number of rice mills for each project year. From the Survey C, the total number of rice mills in the 7,878 project villages is 10,248 mills and the total size is 94,981 HP giving the average of 1.3 mill per village and 12.1 HP per mill. Typically the mills are oversized by diesel - or gasoline - driven prime movers from 50%-100%; therefore, if electric motor are used as the prime movers, the 5-10 HP would be the adequate size for replacement.

The conversion assumptions used with respect to the electrification of diesel rice mills are presented in the next table. These assumptions are based on the remaining life of present diesel engines and the rate of increasing percentage of 3-phase in the system.

The conversion rate begins 8% by the first program year, then up to 15% by the 5th year, to 70% by the 15th year, and to 95% by the 25th year and thereafter. These conversion rates are well covered by the available 3-phase system (high-voltage 22 kV or 33 kV) which starts with 25% by the first year, 50% by the 5th year, 75% by the 15th year, and 100% by the 30th year.

In case the conversion rate is even higher than expected, or there is a requirement of 3-phase where the 1-phase system is available, the solution by using a phase converter is proved to be more economical than bringing the 3rd phase in. For example, the average village which requires approximately 2 km. of high-voltage lines gives the alternative cost comparison as follows:

Case	Cost (Baht) 22 kV	Cost (Baht) 33 kV
1. Primary 3-ø, 50 mm^2	145,948	172,176
plus 50 kVA Transformer	62,096	83,494
	208,044	255,670
2. Primary 1-ø, 50 mm^2	119,866	128,260
plus 30 kVA Transformer	30,346	31,793
plus Phase Converter	32,342	32,342
	182,554	192,395

DIESEL RICE MILL CONVERSION ASSUMPTIONS

Project Year	Percent Of Rice Mills Electrified If 3-ϕ Available	Percent Of Available 3-ϕ Of The Total System	Percent Of Rice Mills Electrified
1	10	25	8
2	12	31	9
3	15	37	11
4	20	43	13
5	25	50	15
6	30	52	18
7	35	54	23
8	40	56	28
9	45	58	36
10	50	60	44
11	55	63	51
12	60	66	57
13	65	69	65
14	70	72	68
15	75	75	70
16	80	80	74
17	82	82	78
18	85	85	82
19	87	87	86
20	90	90	90
25	95	95	95
30	95	100	95

It can be seen that the 1-phase system with the phase converter is approximately 12% and 25% cheaper than the 3-phase system for 22 kV and 33 kV respectively.

The average electrified rural rice mill is assumed to have 7.5 HP and to operate 869 hours per year (Assuming 75% of average unelectrified rice mills' hours of milling operation). Thus, each electrified rice mill is assumed to consume 4.86 MWh per year [(7.5 hp) (0.746 kW/hp) (869 hr/yr) (0.001 Wh/kWh)].

4.4.4 Power Tools

Electrified portable power tools include 1-phase drills, saws, sanders, planers, routers, grinders,etc. of the 1-2 HP range. Field Survey C & D (Power Load Potential & Electrified Villages) to the unelectrified and electrified rural villages provided informations that support the following assumptions.

It is assumed that by the end of the first year of village electrification, 1.5% of electrified rural households will own a portable power tool. This assumption is roughly equivalent to assuming at least 1 portable power tool in each electrified blacksmith or repair shop. The 1977 ORE Survey D (Electrified Villages) shows that approximately 50% of the electrified villages have an electrified blacksmith or repair shop. By the 25th year of village electrification, it is assumed that 5% of electrified rural households own a portable power tool.

The average rural electrified portable power tool is assumed to have 1.0 HP and to operate 180 hours per year [(90 days/year) (2 hours/day)]. Thus, each electrified rural power tool is assumed to use 0.13 MWh per year [(1.0 HP) (0.746 kW/HP) (280 hours/year) (0.001 Wh/kWh)].

4.4.5 Potable Pumps

Electric private potable water pumps are driven by small 1-phase motors of generally less than 1.0 HP. This category of "private"

potable water pumps includes those used in rural households, shops, schools, and temples. Average electrified private potable water pump coefficients per electrified village household for each project province are presented in the following table. These coefficients are derived from the ORE Survey D (Electrified Villages) and are used to project the total number of electrified potable water pumps for the nth year of village electrification, where n is the average number of years the households were electrified in each village as calculated from the survey.

For example, in the province of Trang, there is an average of 1 electrified private potable water pump per 16 electrified rural households after 6 years of village electrification (The coefficient is roughly equivalent to assuming only 1 electrified private potable water pump per 2 electrified shops). This coefficient is conservatively assumed to reduce 1 electrified household per year until reaching 1 electric private potable water pump per 10 electrified households and remaining constant thereafter.

The average electrified rural private potable water pump is assumed to have 0.5 HP and to operate 365 hours a year [(1 hour/day)(365 days/year)]. The private pump is assumed to operate at least 3 times a day and is used in the homes for bathing and cooking, and for washing and cooking in the shops. Thus, each electrified rural private potable water pump is assumed to use 0.136 MWh per year [(0.5 hp)(0.746 kW/hp)(365 hours/year)(0.001 Wh/kWh)].

4.4.6 Agricultural Pumps

The majority of rural agricultural water pumps are portable ones and are used to pump surface water. Most of these pumps are presently powered by small benzine engines in the 2-3 HP range. Average private agricultural water pump coefficients per village household (both electrified and unelectrified) are presented in the following table. These coefficients are derived from the Survey A & C

ELECTRIFIED RURAL VILLAGE HOUSEHOLDS

PER ELECTRIFIED PRIVATE POTABLE WATER PUMPS

No.	Project Province	Average Number of Electrified Village Households per Electrified Private Potable Water Pump*	Village Electrification Years
1	Yala	50	5
2	Pattani	78	5
3	Narathiwat	45	6
4	Songkhla	31	6
5	Satun	108	4
6	Phattalung	20	4
7	Nakhon Si Thammarat	115	6
8	Suratthani	115	6
9	Phang-Nga	85	5
10	Trang	16	6
11	Krabi	93	4
12	Phuket	90	7
13	Phetchaburi	45	6
14	Ratchaburi	27	5
15	Prachuap Khirikhan	14	7
16	Chumphon	13	5
17	Ranong	24	4
18	Nakhon Pathom	44	7
19	Kanchanaburi	115	7
20	Suphanburi	85	6
21	Chanthaburi	10	5
22	Prachinburi	19	6
23	Phetchabun	34	4
24	Phitsanulok	115	4
25	Nan	62	5
26	Chiang Rai	115	7
27	Phayao	100	6

* From 1977 ORE Survey D (Electrified Villages).

AVERAGE NUMBER OF VILLAGE HOUSEHOLDS PER AGRICULTURAL PUMP

No.	Project Province	Average Number of Village Households per Unelectrified Agricultural Pump*
1	Yala	64
2	Pattani	89
3	Narathiwat	100
4	Songkhla	40
5	Satun	99
6	Phatthalung	45
7	Nakhon Si Thammarat	73
8	Suratthani	34
9	Phang-Nga	81
10	Trang	66
11	Krabi	80
12	Phuket	50
13	Phetchaburi	6
14	Ratchaburi	9
15	Prachuap Khirikhan	25
16	Chumphon	40
17	Ranong	39
18	Nakhon Pathom	2
19	Kanchanaburi	15
20	Suphanburi	3
21	Chanthaburi	3
22	Prachinburi	9
23	Phetchabun	14
24	Phitsanulok	11
25	Nan	78
26	Chiang Rai	93
27	Phayao	32

* From 1977 ORE Survey A (Unelectrified Villages) & Survey C (Power Load Potential).

(Unelectrified Villages & Power Load Potential) are used along with conversion assumptions to project the total number of electrified private agricultural water pumps as follows:

Project Year	Conversion Assumption (%)
5	3.0
6	4.2
7	4.8
8	6.0
9	7.2
10	7.8
11	9.0
12	10.2
13	10.8
14	12.0
15	13.2
16	13.8
17	15.0
18	16.2
19	16.8
20	18.0
21	18.0
22	18.0
23	18.0
24	18.0
25	18.0
26	18.0
27	18.0
28	18.0
29	18.0
30	18.0

The average electrified private agricultural water pump is assumed to have 2.5 HP and to operate 2 hours per day for 120 days per year during the dry season. Thus, each electrified private agricultural water pump is assumed to use 0.447 MWh per year [(2.5 hp)(0.746 kW/hp)(2 hr/day)(120 days/year)(0.001 Wh/kWh)].

4.4.7 Social Facilities

Load forecasts for social facilities are based on 3 important facilities in the village namely, Street Lighting, Temples (or

Mosques), and Schools (Few others are yet not taken into account, for example, Health Centers, Coop Centers, etc.).

From Survey A & D (Unelectrified Villages & Electrified Villages), all villagers including the headmen, the priests, the teachers, the polices and other local administrators expressed the desire for street lightings for community security and night gathering. Therefore, it is assumed that each project village will have a system of street lighting installed and consume 2.88 MWh annually [(20 Units) (40 Watt) (10 Hours) (360 Days)].

From the same Survey A & D, the total temples and mosques in 7,878 project villages are 4,885 or about 3 religious facilities for every 5 villages.

It is then ansumed that one-third of the temples and mosques will have electricity or consumes equivalently 0.24 MWh annually per village [(1/3 Temples) (5 Units) (100 Watt) (4 Hours) (360 Days)].

Also from the same Survey A & D, the total number of schools is 5,394 or about 2 schools for every 3 villages. Therefore, it is assumed that one-third of the schools will have electricity consuming equivalently 0.072 MWh annually per village [(1/3 Schools) (4 Units) (100 Watt) (3 Hours) (180 Days)].

Hence, the total consumption for social facilities per village is approximately 3.2 MWh per year.

4.5 Peak Power Demand

One theory for determining peak load demand is that the load factor (LF) tends to approach 65% over time. As the LF approaches this number, for long-range prediction, energy-usage in GWh can be converted into MW power demand by multiplying a factor of 17.50%.

The annual LF for Thailand has been increasing from 51.50% for 1966 to 64.97% for 1975 (see the following table).

THAILAND ANNUAL LOAD FACTORS

Year	Gross Peak Demand (MW)	Gross Energy Generation (GWh)	Annual Load Factor(%)
1966	399	1,800	51.50
1967	544	2,332	48.94
1968	639	2,980	53.24
1969	782	3,660	53.43
1970	954	4,405	52.71
1971	983	5,083	59.04
1972	1,118	5,975	61.01
1973	1,236	6,971	64.41
1974	1,291	7,395	65.40
1975	1,483	8,440	64.97

Source: National Energy Administration, Office of The Prime Minister. Electric Power in Thailand, 1975.

PEA System LF in 1978 was 45.00%. Hence, it is estimated that the LF for the project villages will begin with 20%, increasing at 3.00% per annum until Year 20, thereafter increasing 1.50% per annum until reaching 43.00% by Year 30. These LF's correspond with multiplying factors of approximately 30% to 20% as presented in the next table. These factors are similar to factors found for rural electrification projects in other developing countries.

ASSUMED MULTIPLIER FACTORS
TO CONVERT NET GWH ENERGY REQUIREMENTS PER YEAR
TO NET MW PEAK POWER DEMANDS

Year of Project	Multiplier Factor (%)
0 - 5	30
6 - 10	28
11 - 15	26
16 - 20	24
21 - 25	22
25 - 30	20

The following energy and power demands are forecasted for the project (See Table A3-1, Annex A-1):

Program Year	GWH/Year	MW	LF
1	32	18	20.00
2	74	42	20.00
3	123	68	20.59
4	178	98	20.66
5	238	128	21.21
10	438	196	25.54
15	681	255	30.45
20	904	291	35.43
25	1,152	327	38.96
30	1,313	357	41.95

Hence by the end of 1984 (completing ARE 2 Project), the power requirement of 128 MW is not great but substantial, approximately half of this is added in the South Area which has already been critical in term of EGAT's supply capability at present.

To solve the problem of supply adequacy in the Southern Peninsula, NESDB and EGAT has come up with a plan to add generation capacity of 437 MW by the end of 1984 on top of the present 198 MW installed capacity by adding Gas Turbine Units by 1979, interconnecting to Central Grid System and Malaysian Grid System by 1980, commissioning Barge Thermal Plant and Pattani Dam by 1981, interconnecting another Tie Line by 1982, and commissioning Lang Suan Dam by 1984 (See the following table and map).

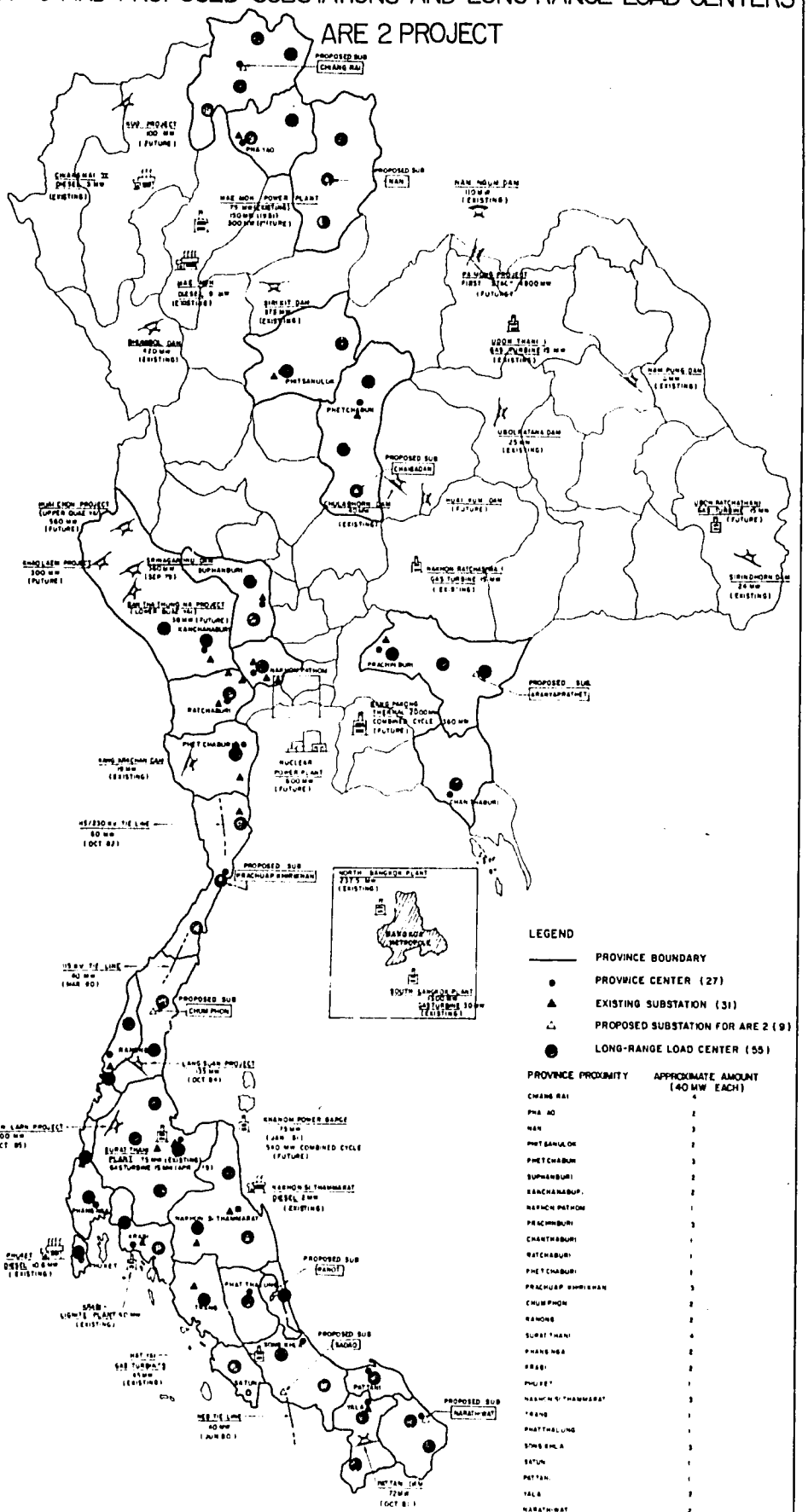
By this EGAT supply arrangement, ARE 2 can come back to the South Area by 1982 after spending the first 2 years (1980-1981) in the Project Non-South Area (North & Central Areas).

EGAT'S SUPPLY PLAN FOR SOUTHERN AREA

No.	Date	Supply Plan	Installed Capacity (MW)	Cumulative Total (MW)
1	Oct.1978	Existing	198	198
2	Apr.1979	Gas Turbine (Surat Thani)	15	213
3	Mar.1980	115 kV Tie Line (Central-South)	40	253
4	Jun.1980	NEB Tie Line (Sadao)	40	293
5	Jan.1981	Barge Thermal (Nakhon Si Thammarat)	75	368
6	Oct.1981	Pattani Dam (Yala)	72	440
7	Oct.1982	115/230 kV Tie Line (Prachuab Khirikhan)	60	500
8	Oct.1984	Lang Suan Dam (Chumpon)	135	635
9	Oct.1985	Chiew Lan Dam (Surat Thani)	100	735
10	Oct.1985	R 3 Thermal (1) (180 MW) Retired Gas Turbines (105 MW)	75	840
11	Jul.1990	R 3 Thermal (2) (180 MW) Retired Krabi Plant (60 MW)	120	960

EXISTING AND PROPOSED SUBSTATIONS AND LONG-RANGE LOAD CENTERS

ARE 2 PROJECT



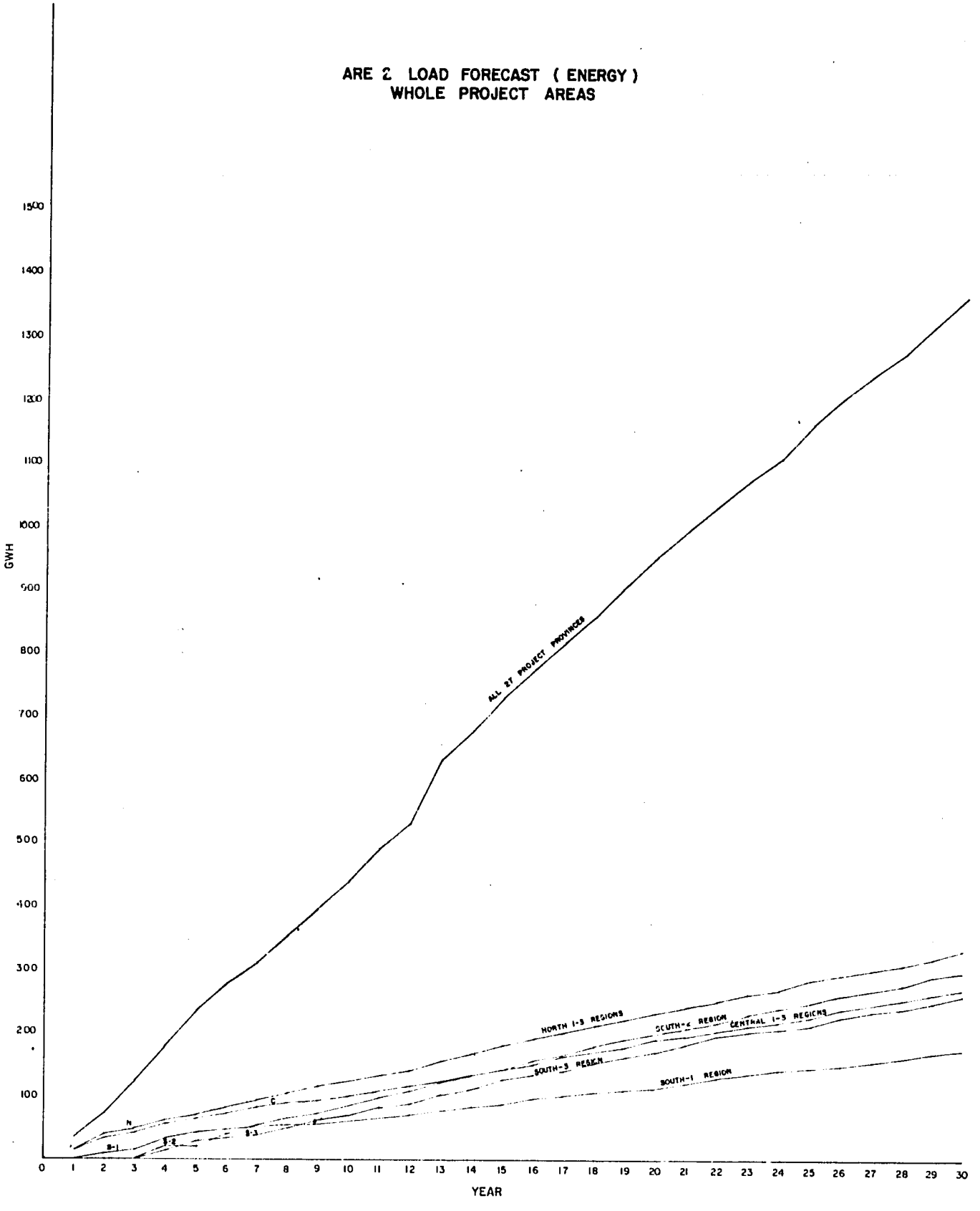
With the demand of 128 MW by the 5 years of project time-frame (the average demand per village is 16.3 kW) the total project villages connected load estimated at 150 MVA (using a power factor of 0.85) on top of the existing demand of approximately 280 MW requires the addition of 9 new EGAT's delivery points (substations) at the following locations dictated by the formation of new load centers and long distance delivery of power:

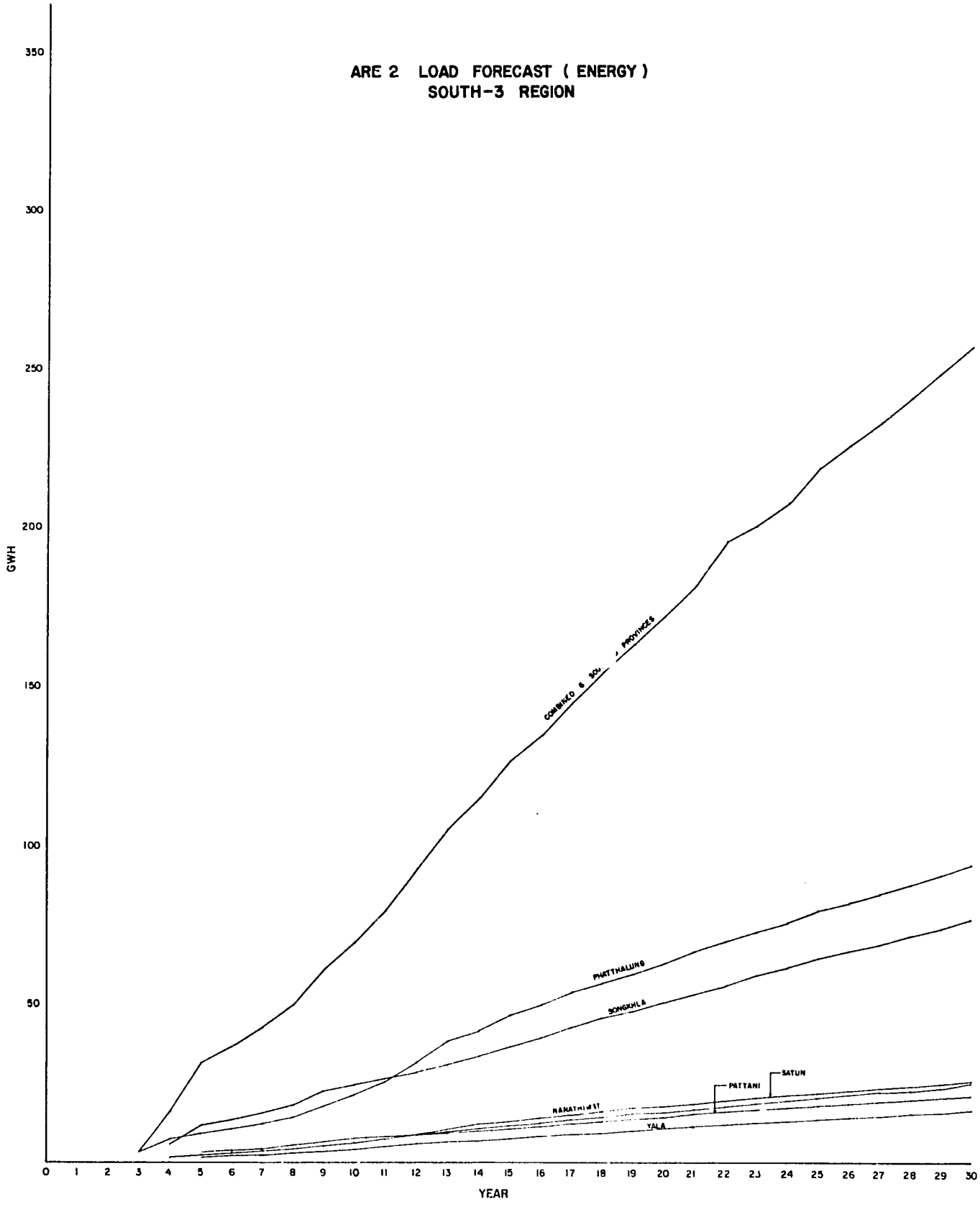
- Chiangrai
- Nan
- Chaibadan (South Petchabun)
- Aranyaprathet (East Prachinburi)
- Prachuab Khirikhan
- Chumpon
- Ranot (North Songkhla)
- Sadao (South Songkhla)
- Narathiwat

All of the 9 new substations are already in the EGAT's Transmission Plan to be completed simultaneously with the ARE 2 Project before 1984. In addition to the short-range (5 years) load centers of 9 on top of existing 31, the preliminary investigation of the long-range (30 years) load requirement of 1,313 GWh/year and 357 MW identifies another 55 load centers in the 27 project provinces. This information would be an useful guideline for EGAT's and PEA's planning in the future. The following 12 charts show the trends for energy and power demands, over the 30 years time-period, for each project province , project region, and the whole project area.

4.6 System Physical Requirement

Together with the exact locations of the 7,878 project villages (as shown in the Project Maps, Annex A-2, having the scale of 1:150,000), the existing EGAT's transmission and PEA's distribution facilities can be expanded to accommodate the new facilities serving the project load demand. The following table shows the physical requirement of the project, composing of approximate 71 main items. Out of those, 4 important items can be summarized as follows:


ARE 2 LOAD FORECAST (ENERGY)
WHOLE PROJECT AREAS
GWH
YEAR
ALL 27 PROJECT PROVINCES
NORTH 1-5 REGIONS
SOUTH-4 REGION
CENTRAL 1-5 REGIONS
SOUTH-3 REGION
SOUTH-1 REGION


ARE 2 LOAD FORECAST (ENERGY)
SOUTH-3 REGION
GWH
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
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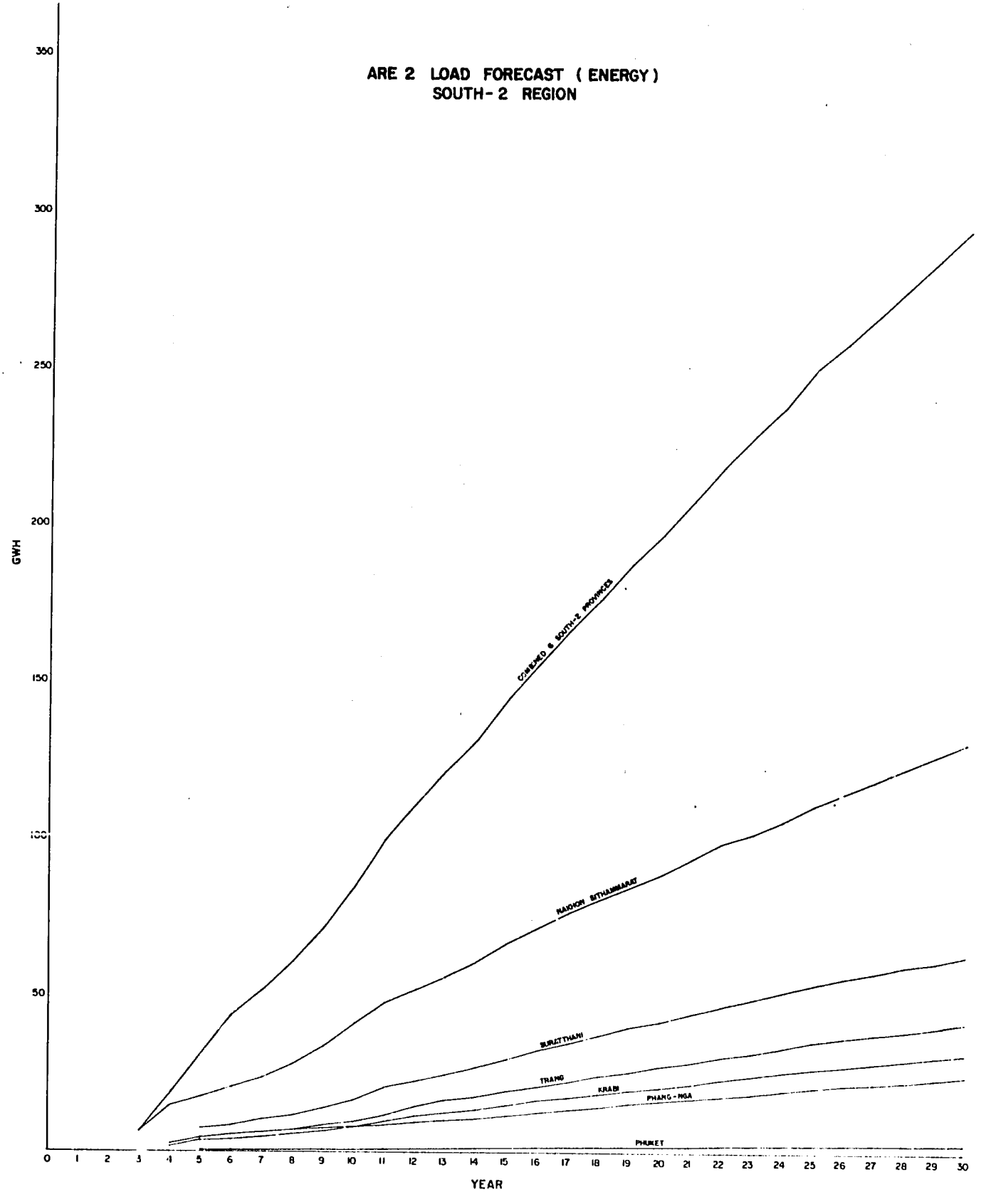
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
YEAR
COMBINED 6 SOU. PROVINCES
PHATTHALUNG
SONGKHLA
PATTANI
SATUN
NARATHIWAT
YALA


ARE 2 LOAD FORECAST (ENERGY)
SOUTH- 2 REGION
GWH
350
300
250
200
150
100
50
0
1
2
3
4
5
6
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8
9
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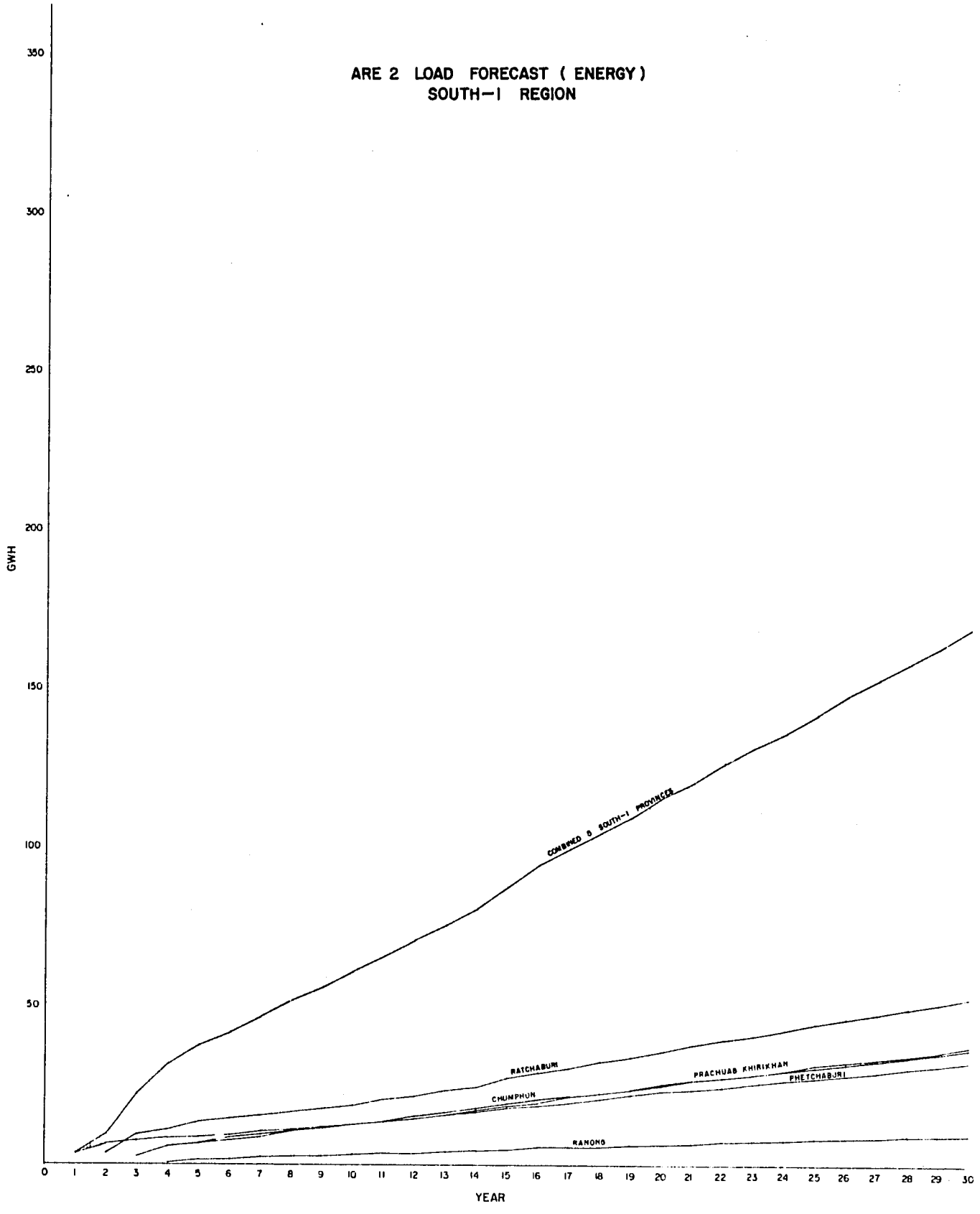
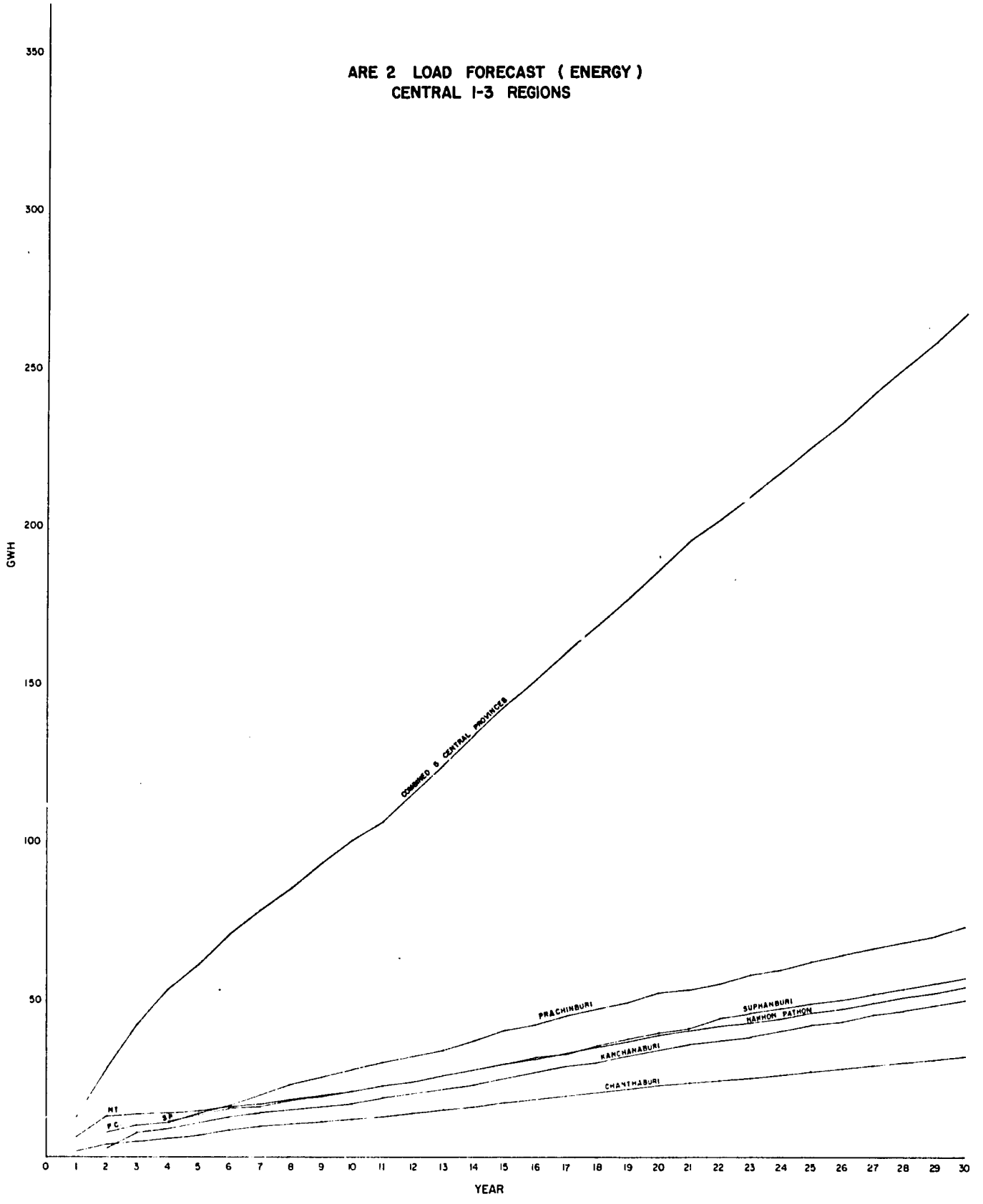
26
27
28
29
30
YEAR
COMBINED 6 SOUTH-2 PROVINCES
NAKHON SITHAMMARAT
SURAT THANI
TRANG
KRABI
PHANG-NGA
PHUKET


ARE 2 LOAD FORECAST (ENERGY)
SOUTH-I REGION
GWH
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
YEAR
COMBINED 6 SOUTH-I PROVINCES
RATCHABURI
PRACHUAB KHIRIKHAN
PHETCHABURI
CHUMPHON
RANONG


ARE 2 LOAD FORECAST (ENERGY)
CENTRAL I-3 REGIONS
GWH
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
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16
17
18
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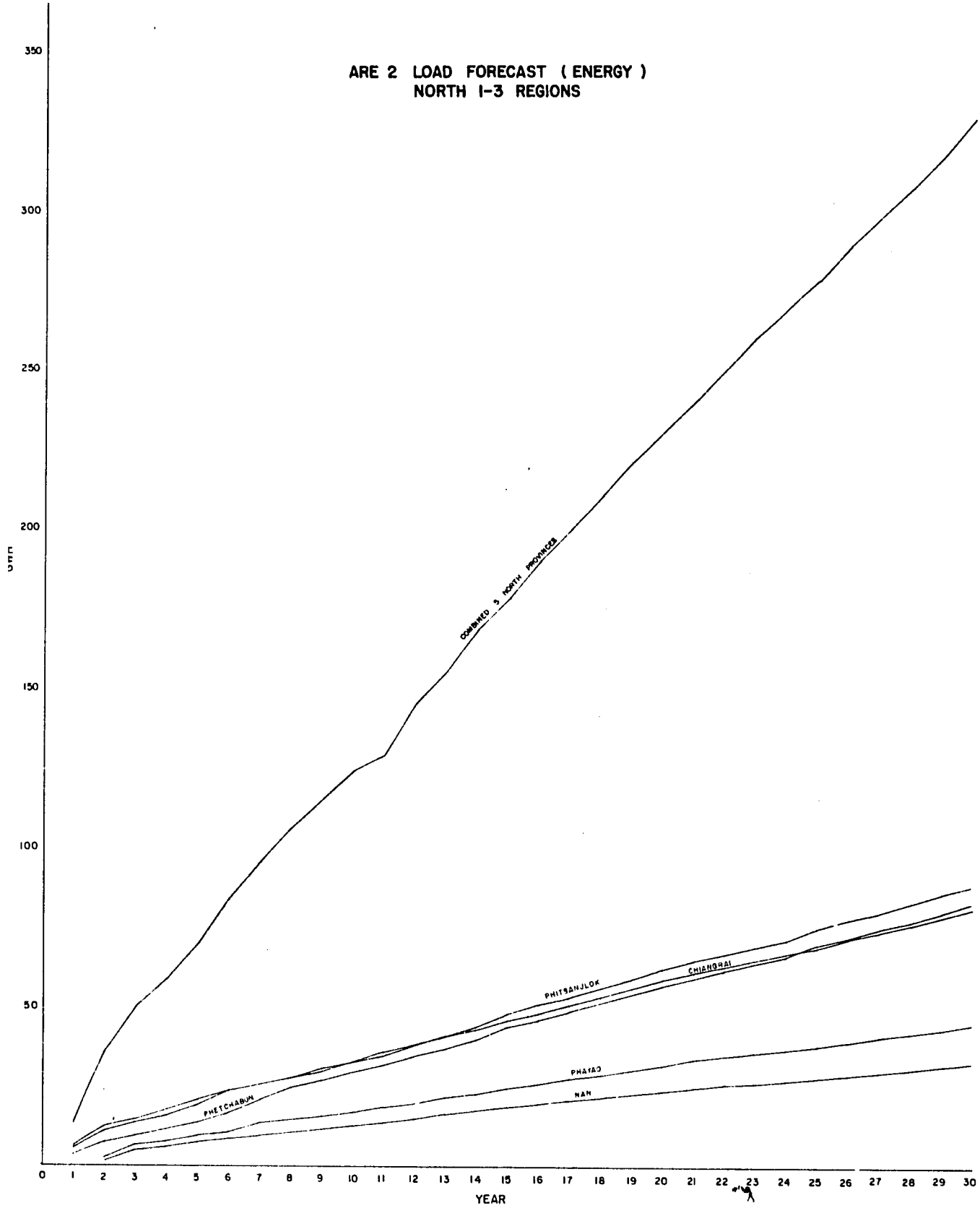
22
23
24
25
26
27
28
29
30
YEAR
COMBINED 8 CENTRAL PROVINCES
PRACHINBURI
SUPHANBURI
NAKHON PATHOM
KANCHANABURI
CHANTHABURI
NT
SP
PC


ARE 2 LOAD FORECAST (ENERGY)
NORTH 1-3 REGIONS
GWH
350
300
250
200
150
100
50
0
1
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3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
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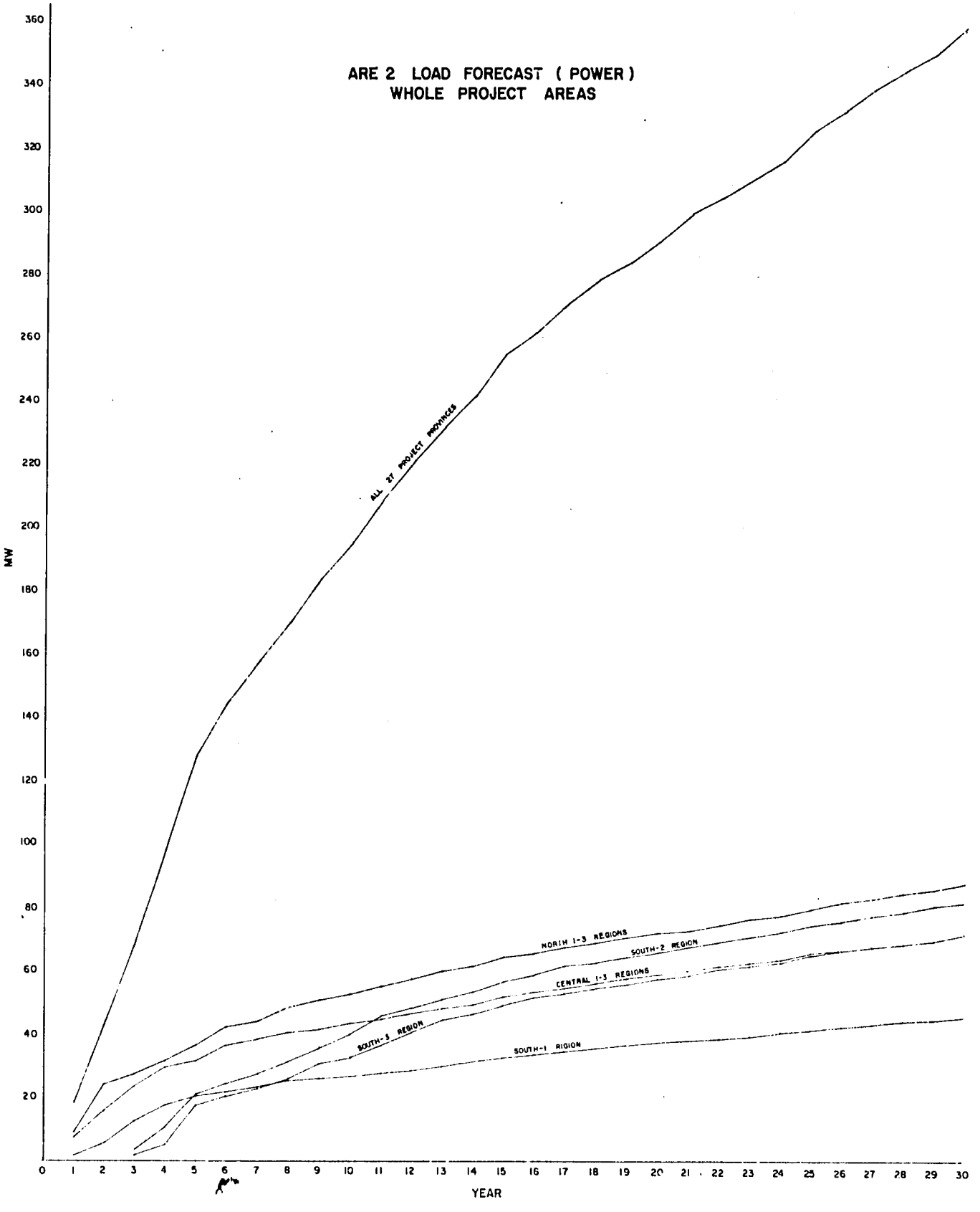
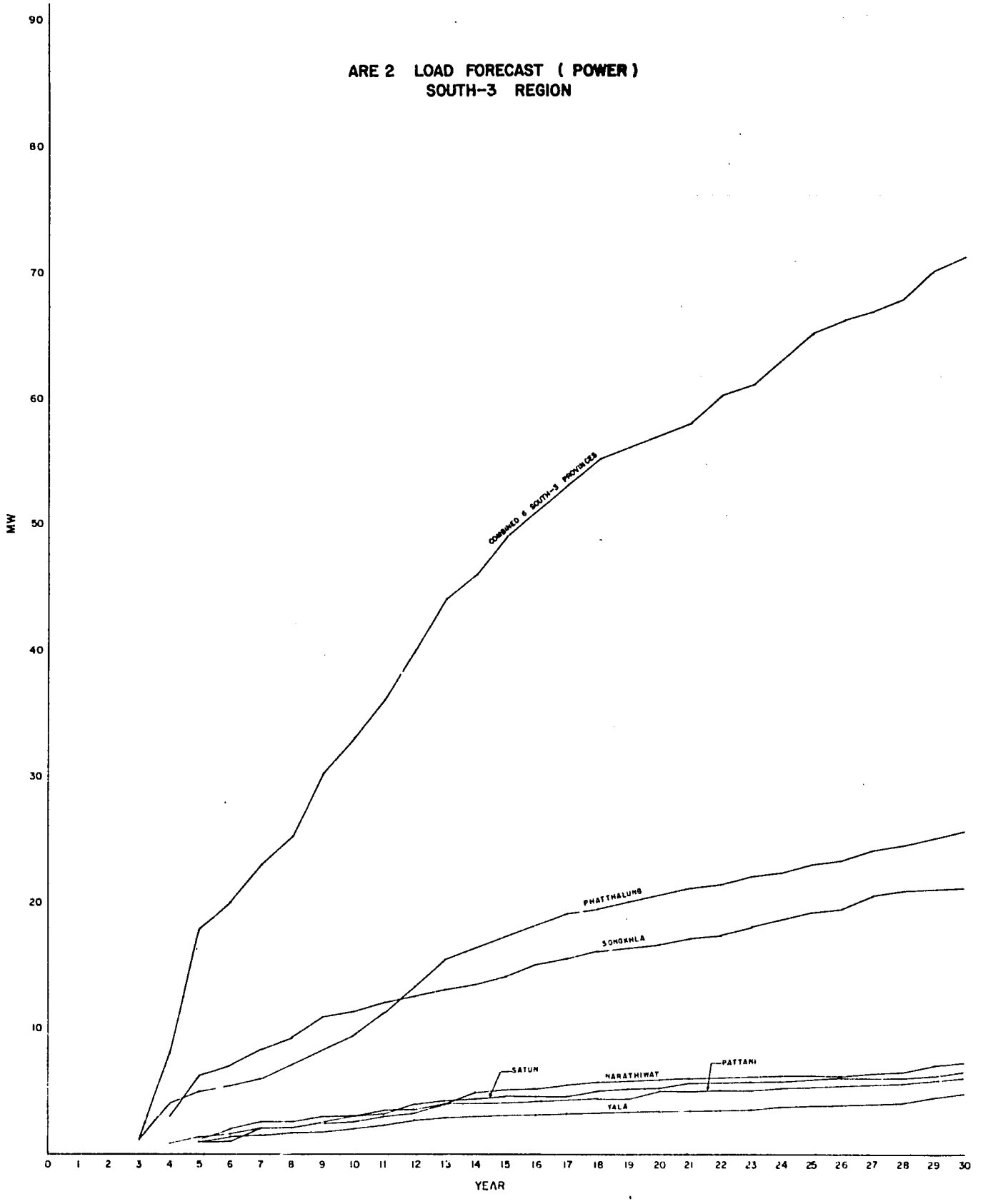
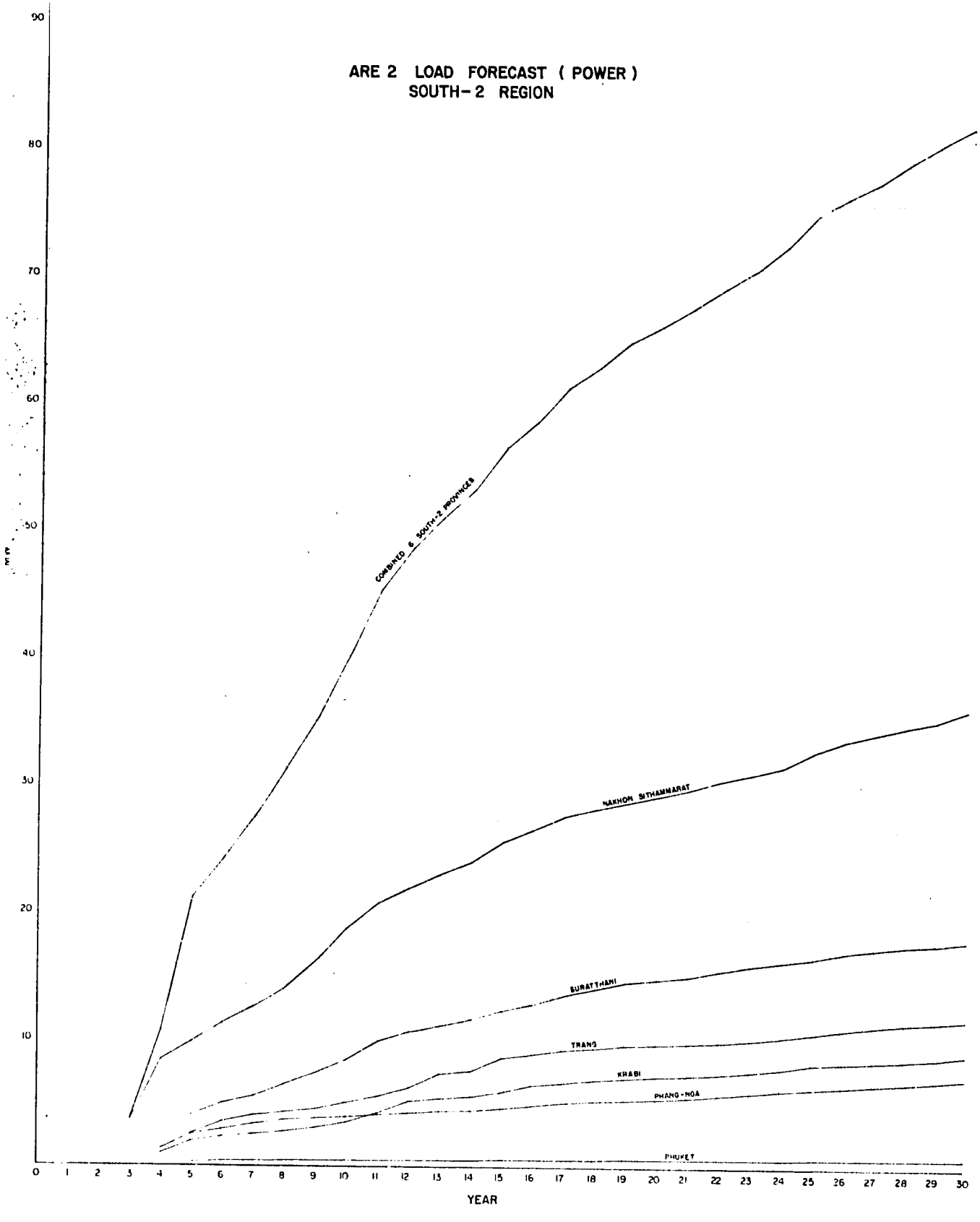
24
25
26
27
28
29
30
YEAR
COMBINED 3 NORTH PROVINCES
PHITSANJLOK
CHIANGRAI
PHATAO
NAN
PHETCHABUN


ARE 2 LOAD FORECAST (POWER)
WHOLE PROJECT AREAS
MW
YEAR
ALL 27 PROJECT PROVINCES
NORTH 1-3 REGIONS
SOUTH-2 REGION
CENTRAL 1-3 REGIONS
SOUTH-3 REGION
SOUTH-1 RIGION


ARE 2 LOAD FORECAST (POWER)
SOUTH-3 REGION
MW
YEAR
COMBINED 6 SOUTH-3 PROVINCES
PHATTHALUNG
SONGKHLA
SATUN
NARATHIWAT
PATTANI
YALA


ARE 2 LOAD FORECAST (POWER)
SOUTH-2 REGION
MW
YEAR
COMBINED 6 SOUTH-2 PROVINCES
NAKHON SITHAMMARAT
SURATTHANI
TRANG
KRABI
PHANG-NGA
PHUKET
0
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70
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90
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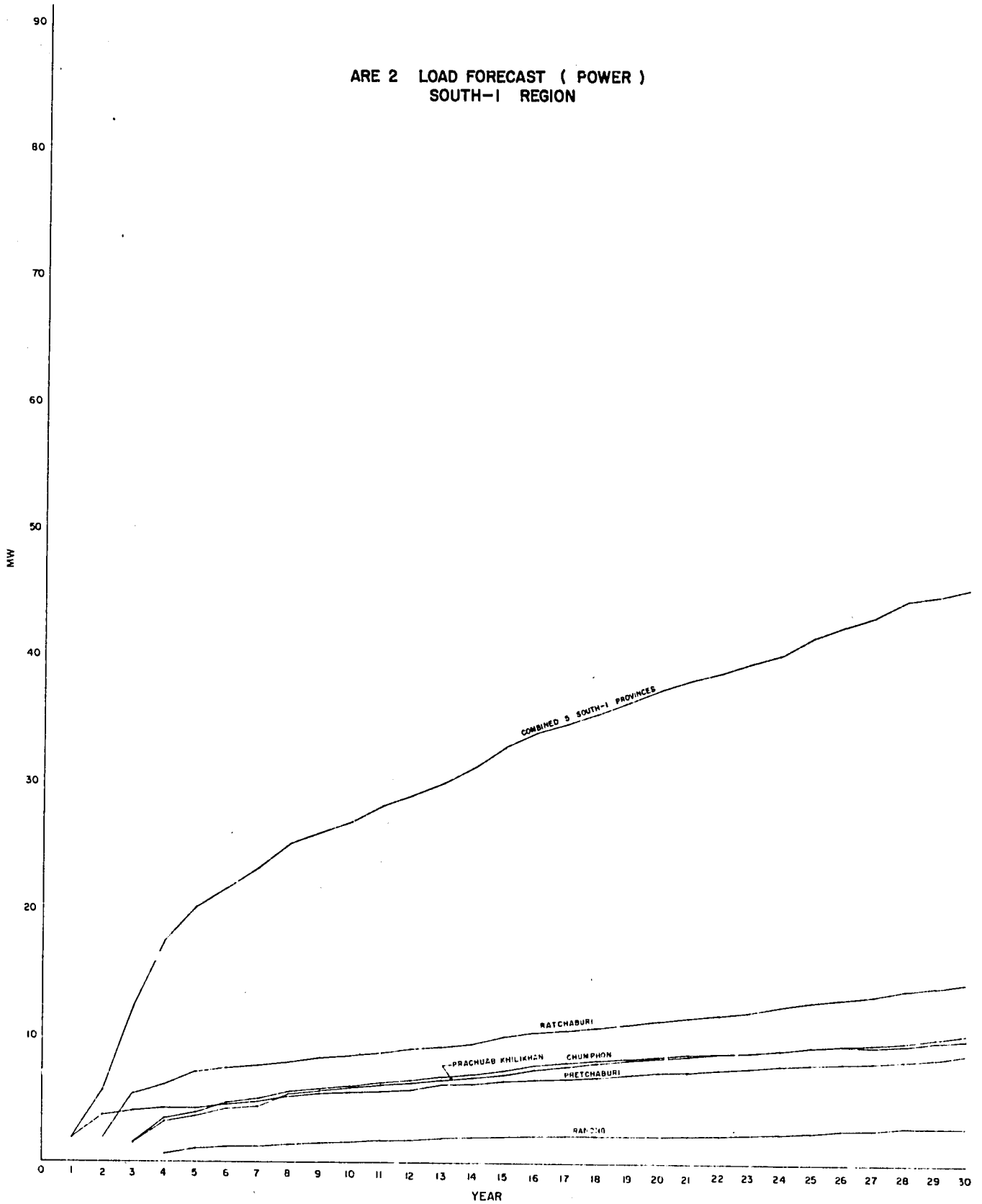
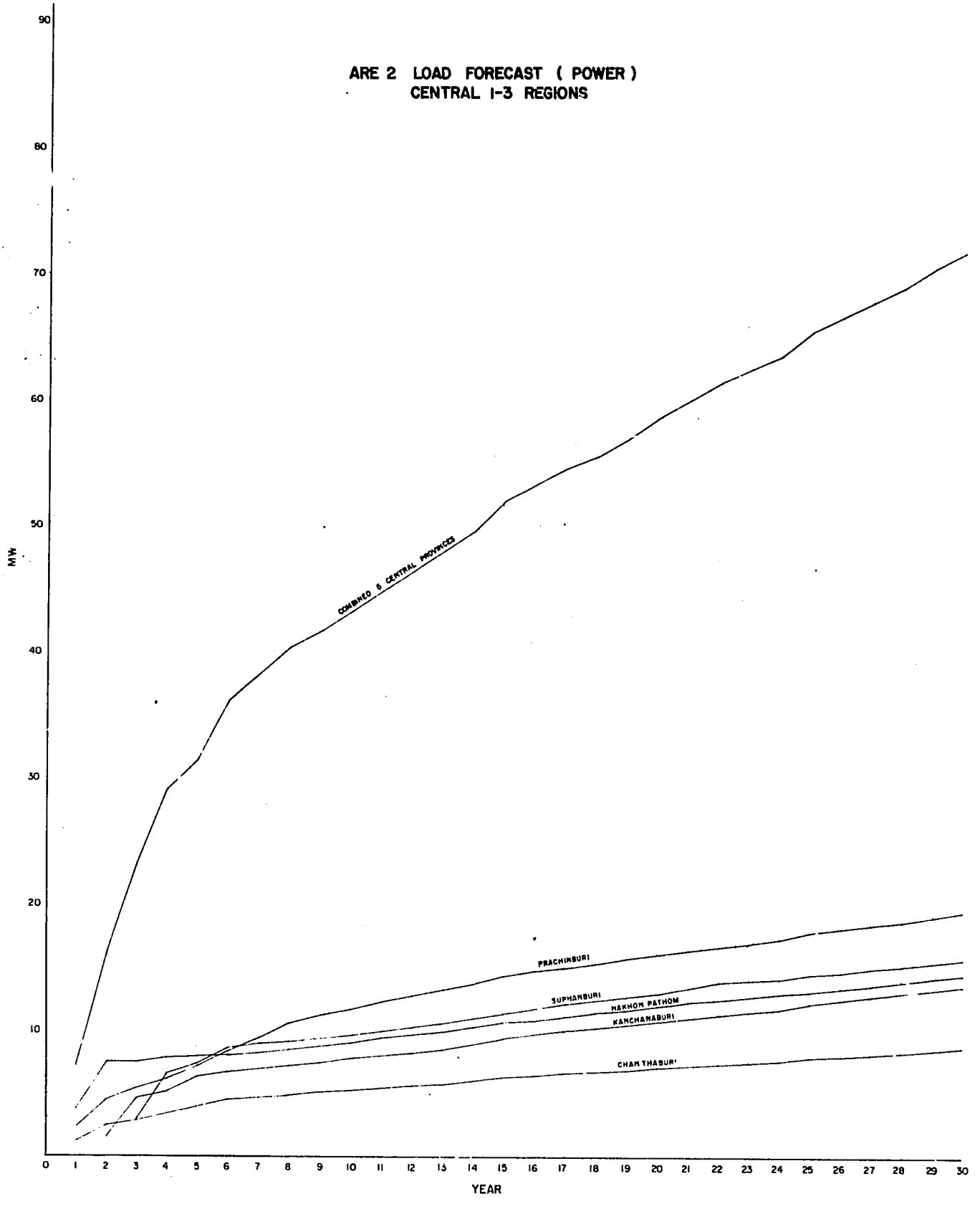

ARE 2 LOAD FORECAST (POWER)
SOUTH-I REGION
MW
YEAR
COMBINED 5 SOUTH-I PROVINCES
RATCHABURI
PRACHUAB KHILIKHAN
CHUMPHON
PHETCHABURI
RANONG


ARE 2 LOAD FORECAST (POWER)
CENTRAL 1-3 REGIONS
MW
YEAR
COMBINED 6 CENTRAL PROVINCES
PRACHINBURI
SUPHANBURI
NAKHON PATHOM
KANCHANABURI
CHANTHABURI
90
80
70
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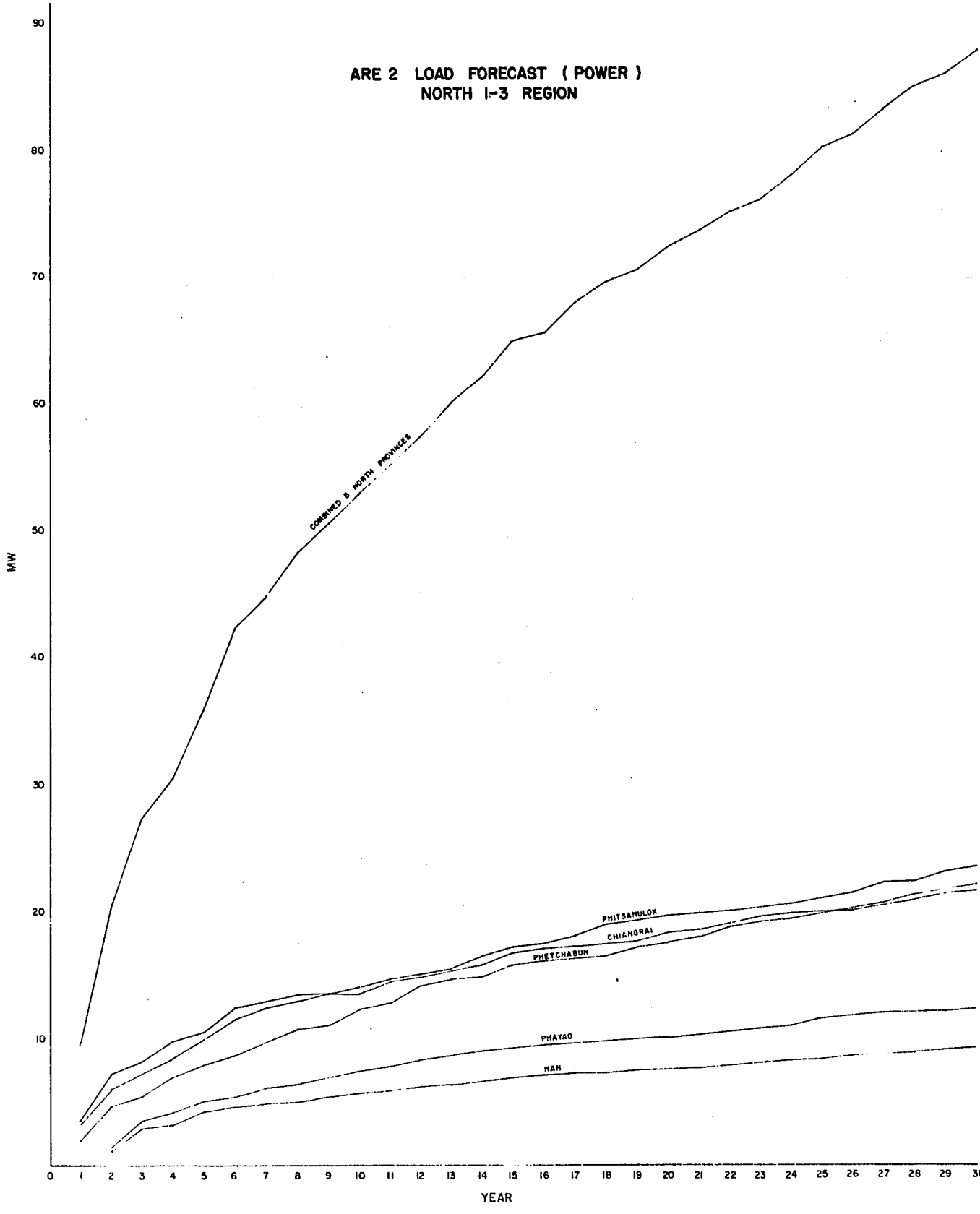
ARE 2 LOAD FORECAST (POWER)
NORTH I-3 REGION
MW
YEAR
COMBINED 8 NORTH PROVINCES
PHITSANULOK
CHIANGRAI
PHETCHABUN
PHAYAO
NAN
0
10
20
30
40
50
60
70
80
90
1
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3
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SUMMARY OF THE PROJECT PHYSICAL REQUIREMENT

NO.	DESCRIPTION	QUANTITY
1	MAIN PRIMARY LINE, 22 KV, 3-PHASE, 120 SQ.MM. ALUMINUM CONDUCTOR	777.15 KM.
2	MAIN PRIMARY LINE, 33/19 KV, 120 SQ.MM.ALUMINUM CONDUCTOR.....	454.60 KM.
3	MAIN PRIMARY LINE, 22 KV, 3-PHASE, 95 SQ.MM.ALUMINUM CONDUCTOR..	389.25 KM.
4	MAIN PRIMARY LINE, 33/19 KV, 95 SQ.MM.ALUMINUM CONDUCTOR.....	204.80 KM.
5	MAIN PRIMARY LINE, 22 KV, 3-PHASE, 70 SQ.MM.ACSR CONDUCTOR.....	0.00 KM.
6	MAIN PRIMARY LINE, 33/19 KV, 70 SQ.MM.A-A CONDUCTOR.....	0.00 KM.
7	MAIN PRIMARY LINE, 33/19 KV, 70 SQ.MM.ACSR CONDUCTOR.....	0.00 KM.
8	MAIN PRIMARY LINE, 22 KV, 3-PHASE, 50 SQ.MM.ACSR CONDUCTOR.....	1051.25 KM.
9	MAIN PRIMARY LINE, 33/19 KV, 50 SQ.MM. A-A CONDUCTOR.....	866.20 KM.
10	MAIN PRIMARY LINE, 33/19 KV, 50 SQ.MM. ACSR CONDUCTOR.....	275.50 KM.
11	PRIMARY LINE, 22 KV, 1-PHASE, 50 SQ.MM.ACSR CONDUCTOR.....	490.80 KM.
12	PRIMARY LINE, 19 KV, 1-PHASE, 50 SQ.MM. A-A CONDUCTOR.....	278.00 KM.
13	PRIMARY LINE, 19 KV, 1-PHASE, 50 SQ.MM.ACSR CONDUCTOR.....	160.50 KM.
14	PRIMARY LINE, 22 KV, 1-PHASE, 35 SQ.MM.ACSR CONDUCTOR.....	5450.90 KM.
15	PRIMARY LINE, 19 KV, 1-PHASE, 35 SQ.MM.A-A CONDUCTOR.....	4433.80 KM.
16	PRIMARY LINE, 19 KV, 1-PHASE, 35 SQ.MM.ACSR CONDUCTOR.....	651.00 KM.
17	ADDITIONAL SECOND PHASE, 22 KV, 50 SQ.MM.ACSR CONDUCTOR.....	0.00 KM.
18	ADDITIONAL SECOND PHASE, 33/19 KV, 50 SQ.MM. A-A CONDUCTOR.....	55.70 KM.
19	ADDITIONAL SECOND PHASE, 33/19 KV, 50 SQ.MM.ACSR CONDUCTOR.....	0.00 KM.
20	ADDITIONAL THIRD PHASE, 22 KV, 50 SQ.MM.ACSR CONDUCTOR.....	104.75 KM.
21	ADDITIONAL THIRD PHASE, 33/19 KV, 50 SQ.MM. A-A CONDUCTOR.....	55.70 KM.
22	ADDITIONAL THIRD PHASE, 33/19 KV, 50 SQ.MM.ACSR CONDUCTOR.....	0.00 KM.
23	ADDITIONAL SECOND PHASE,22 KV, 35 SQ.MM.ACSR CONDUCTOR.....	0.00 KM.
24	ADDITIONAL SECOND PHASE, 33/19 KV, 35 SQ.MM. A-A CONDUCTOR.....	16.50 KM.
25	ADDITIONAL SECOND PHASE, 33/19 KV, 35 SQ.MM. ACSR CONDUCTOR.....	0.00 KM.
26	ADDITIONAL THIRD PHASE, 22 KV, 35 SQ.MM.ACSR CONDUCTOR.....	0.00 KM.
27	ADDITIONAL THIRD PHASE, 33/19 KV, 35 SQ.MM. A-A CONDUCTOR.....	12.00 KM.
28	ADDITIONAL THIRD PHASE, 33/19 KV, 35 SQ.MM.ACSR CONDUCTOR.....	0.00 KM.
29	RECONDUCTOR, 3-PHASE, 22 KV, 120 SQ.MM.ALUMINUM CONDUCTOR.....	375.25 KM.
30	RECONDUCTOR, 3-PHASE, 33/19 KV, 120 SQ.MM. ALUMINUM CONDUCTOR...	624.00 KM.
31	ADDITIONAL OF NEUTRAL CONDUCTOR 70 SQ.MM.....	0.00 EA.
32	ISOLATING TRANSFORMER 100 KVA, 22 KV.....	0.00 EA.
33	ISOLATING TRANSFORMER 100 KVA, 33 KV.....	0.00 EA.
34	RECLOSER, 3-PHASE, 400 AMP, 22 KV.....	27.00 EA.
35	RECLOSER, 3-PHASE, 400 AMP, 33 KV.....	36.00 EA.
36	FUSE, 3-PHASE, 40 AMP, 22 KV.....	133.00 EA.
37	FUSE, 3-PHASE, 40 AMP, 33 KV.....	235.00 EA.
38	FUSE, 1-PHASE, 40 AMP, 22 KV.....	1087.00 EA.
39	FUSE, 1-PHASE, 40 AMP, 33 KV.....	932.00 EA.
40	TRIPPLE POLE AIR BREAK SWITCH 22 KV, 3-PHASE,400 AMP.....	51.00 EA.
41	TRIPPLE POLE AIR BREAK SWITCH 33 KV, 3-PHASE, 400 AMP.....	36.00 EA.
42	ISOLATING SWITCH, 1-PHASE, 600 AMP, 22 KV.....	1.00 EA.
43	ISOLATLNG SWITCH, 1-PHASE, 600 AMP, 33 KV.....	0.00 EA.
44	ISOLATLNG SWITCH, 1-PHASE, 600 AMP, 33 KV.....	0.00 EA.
45	CAPACITOR, 3-PHASE, 300 KVAR, 22 KV.....	145.00 EA.
46	CAPACITOR, 3-PHASE, 300 KVAR, 33 KV.....	142.00 EA.
47	BULK OIL CIRCUIT BREAKER, 22 KV, 600 AMP.....	36.00 EA.
48	BULK OIL CIRCUIT BREAKER, 33 KV, 600 AMP.....	24.00 EA.

SUMMARY OF THE PROJECT PHYSICAL REQUIREMENT
(CONTINUED)

NO.	DESCRIPTION	QUANTITY
49	VOLTAGE REGULATOR, 3-PHASE, 200 AMP, 22 KV.....	17.00 EA.
50	VOLTAGE REGULATOR, 3-PHASE, 150 AMP, 33 KV.....	13.00 EA.
51	SECONDARY LINE, 400/230 VOLT, 70 SQ.MM.ALUMINUM CONDUCTOR.....	147.67 KM.
52	SECONDARY LINE, 400/230 VOLT, 50 SQ.MM.ALUMINUM CONDUCTOR.....	769.68 KM.
53	SECONDARY LINE, 400/230 VOLT, 35 SQ.MM.ALUMINUM CONDUCTOR.....	108.65 KM.
54	SECONDARY LINE, 460/230 VOLT, 50 SQ.MM.ALUMINUM CONDUCTOR.....	2325.63 KM.
55	SECONDARY LINE, 460/230 VOLT, 35 SQ.MM.ALUMINUM CONDUCTOR.....	12231.72 KM.
56	SECONDARY LINE, 230 VOLT, 35 SQ.MM.ALUMINUM CONDUCTOR.....	994.79 KM.
57	TRANSFORMER RATED AT 10 KVA, 1-PHASE, 22 KV-460/230 VOLT.....	2298.00 EA.
58	TRANSFORMER RATED AT 10 KVA, 1-PHASE, 33 KV-460/230 VOLT.....	2685.00 EA.
59	TRANSFORMER RATED AT 20 KVA, 1-PHASE, 22 KV-460/230 VOLT.....	1676.00 EA.
60	TRANSFORMER RATED AT 20 KVA, 1-PHASE, 33 KV-460/230 VOLT.....	1662.00 EA.
61	TRANSFORMER RATED AT 30 KVA, 1-PHASE, 22 KV-460/230 VOLT.....	1036.00 EA.
62	TRANSFORMER RATED AT 30 KVA, 1-PHASE, 33 KV-460/230 VOLT.....	772.00 EA.
63	TRANSFORMER RATED AT 50 KVA, 3-PHASE, 22 KV-400/230 VOLT.....	261.00 EA.
64	TRANSFORMER RATED AT 50 KVA, 3-PHASE, 33 KV-400/230 VOLT.....	262.00 EA.
65	TRANSFORMER RATED AT 100 KVA, 3-PHASE, 22 KV-400/230 VOLT.....	58.00 EA.
66	TRANSFORMER RATED AT 100 KVA, 3-PHASE, 33 KV-400/230 VOLT.....	48.00 EA.
67	METER KWH RATED AT 3 AMP, 220 VOLT, 1-PHASE, 2 WIRE.....	519515.31 EA.
68	STREET LIGHT STREET LIGHTING LUMINAIRES,LAMP INCANDESCENT.....	101609.00 EA.
69	LIGHTNING ARRESTER RATED AT 250 VOLT, 5 KA.....	48986.00 EA.
70	STREET LIGHTING ACCESSORIES & CONDUCTOR RATED AT 220 VOLT.....	10492.36 KM.
71	GROUNDING SET.....	48708.00 EA.

No.	Item	Physical Requriement	
1	Primary Main, 22 kV, 3ø	2,218	ckm.
	Primary Main, 33 kV, 3ø	1,801	ckm.
	Primary Tap, 22 kV, 1ø	5,942	ckm.
	Primary Tap, 19 kV, 1ø	5,523	ckm.
	Subtotal New Primary	15,484	ckm.
	Primary add-Phase, 22 kV, 3ø	105	ckm.
	Primary add-Phase, 33 kV, 3ø	140	ckm.
	Primary Reconductor, 22 kV, 3ø	375	ckm.
	Primary Reconductor, 33 kV, 3ø	624	ckm.
	Subtotal Revamped Primary	1,244	ckm.
	Total Primary	16,728	ckm.
2	Secondary, 400/230 V, 3ø	15,583	ckm.
	Secondary, 230 V, 1ø	995	ckm.
	Total Secondary	16,578	ckm.
3	Transformer, 22 kV, 3ø	18,850	kVA.
	Transformer, 33 kV, 3ø	17,900	kVA.
	Transformer, 22 kV, 1ø	87,580	kVA.
	Transformer, 19 kV, 1ø	83,250	kVA.
	Total Transformer	207,580	kVA.
4	Meter, 400/230 V, 3ø	10,413	Set
	Meter, 230 V, 1ø	823,494	Set
	Total Meter	833,907	Set

With the total area of 198,800 square km. for the whole 27 project provinces, the following 2 tables give the Electrification Densities for High-Tension Lines, Low-Tension Lines and Transformer Capacity per square km. for ARE 2 alone and combined existing and ARE 2.

The existing, the ARE 2 and the combination can be summarized as follow:

ARE 2 ELECTRIFICATION DENSITY

BY END - 1977

NO.	PROJECT PROVINCES	HIGH TENSION LINES (CCT. KM.)	LOW TENSION LINES (CCT. KM.)	TRANSFORMER CAPACITY (KVA)	AREA OF PROVINCE (KM^2)	HIGH TENSION CCT. KM. PER KM^2	LOW TENSION CCT. KM. PER KM^2	TRANSFORMER KVA PER KM^2
1	Yala	215.30	265.74	3,160	4,715.85	0.0457	0.0563	0.6701
2	Pattani	313.30	335.93	4,680	2,109.63	0.1485	0.1593	2.2184
3	Narathiwat	339.50	355.22	4,790	4,227.75	0.0803	0.0841	1.1330
4	Songkhla	727.10	751.58	11,670	7,321.99	0.0993	0.1027	1.5939
5	Satun	264.00	305.06	3,580	2,669.06	0.0990	0.1143	1.3413
6	Phatthalung	382.50	445.21	9,840	3,269.53	0.1170	0.1362	3.0096
7	Nakhon Si Thammarat	1,327.00	1,823.54	15,800	11,211.44	0.1184	0.1627	1.4093
8	Suratthani	915.00	1,416.18	10,760	19,163.68	0.0478	0.0739	0.5615
9	Phangnga	319.00	316.38	2,960	5,108.77	0.0616	0.0611	0.5714
10	Trang	580.00	588.95	5,870	5,106.00	0.1124	0.1142	1.1376
11	Krabi	491.10	476.54	3,580	4,624.31	0.1062	0.1031	0.7742
12	Phuket	29.60	46.45	380	538.72	0.0550	0.0863	0.7054
13	Phetchaburi	352.00	390.92	5,590	6,357.19	0.0554	0.0615	0.8794
14	Ratchaburi	454.50	495.25	6,730	5,093.54	0.0893	0.0973	1.3213
15	Prachuap Khirikhan	361.00	493.25	4,530	8,225.00	0.0439	0.0600	0.5508
16	Chumphon	583.00	779.74	7,270	5,745.00	0.1015	0.1358	1.2655
17	Ranong	106.00	168.98	1,550	3,425.00	0.0310	0.0494	0.4526
18	Nakhon Pathom	266.00	524.05	7,690	2,080.32	0.1279	0.2519	3.6966
19	Kanchanaburi	591.00	606.91	7,440	19,486.07	0.0304	0.0312	0.3819
20	Suphanburi	847.20	1,012.41	14,320	5,348.39	0.1584	0.1893	2.6775
21	Chanthaburi	450.00	498.96	5,560	6,052.27	0.0744	0.0825	0.9187
22	Prachinburi	1,065.00	857.93	13,810	11,794.94	0.0903	0.0728	1.1709
23	Phetchabun	1,249.40	904.24	13,130	13,660.00	0.0915	0.0662	0.9612
24	Phitsanulok	963.00	772.95	11,930	9,701.09	0.0992	0.0796	1.2287
25	Nan	977.25	465.31	8,430	11,694.51	0.0836	0.0398	0.7209
26	Chiang Rai	811.50	1,003.67	14,250	12,302.54	0.0660	0.0816	1.1583
27	Phayao	303.50	471.12	8,280	7,767.00	0.0391	0.0607	1.0661
	Total 27 Project Provinces	15,484.00	16,578.00	207,580	198,800.00	0.0779	0.0834	1.0442

EXISTING AND ARE 2 ELECTRIFICATION DENSITY
BY END - 1977

NO.	PROJECT PROVINCES	HIGH TENSION LINES (CCT. KM.)	LOW TENSION LINES (CCT. KM.)	TRANSFORMER CAPACITY (KVA)	AREA OF PROVINCE (KM^2)	HIGH TENSION CCT. KM. PER KM^2	LOW TENSION CCT. KM. PER KM^2	TRANSFORMER KVA PER KM^2
1	Yala	481.30	385.74	28,582	4,715.85	0.1021	0.0818	6.0608
2	Pattani	603.30	490.93	20,812	2,109.63	0.2860	0.2327	9.8652
3	Narathiwat	729.50	505.22	19,575	4,227.75	0.1726	0.1195	4.6301
4	Songkhla	1,087.10	951.58	53,806	7,321.99	0.1485	0.1300	7.3485
5	Satun	404.00	350.06	7,467	2,669.06	0.1514	0.1312	2.7976
6	Phatthalung	522.50	510.21	16,190	3,269.53	0.1598	0.1560	4.9518
7	Nakhon Si Thammarat	1,627.00	2,164.54	48,220	11,211.44	0.1451	0.1931	4.3010
8	Suratthani	1,301.00	1,648.18	35,465	19,163.68	0.0679	0.0860	1.8506
9	Phangnga	523.00	412.38	16,000	5,108.77	0.1024	0.0807	3.1319
10	Trang	808.00	718.95	29,845	5,106.00	0.1582	0.1408	5.8451
11	Krabi	641.10	534.54	8,700	4,624.31	0.1386	0.1156	1.8814
12	Phuket	226.60	277.45	44,436	538.72	0.4206	0.5150	82.4844
13	Phetchaburi	822.00	840.92	27,780	6,357.19	0.1293	0.1323	4.3699
14	Ratchaburi	644.50	1,018.25	98,094	5,093.54	0.1265	0.1999	19.2585
15	Prachuap Khirikhan	808.00	675.25	25,845	8,225.00	0.0982	0.0821	3.1422
16	Chumphon	833.00	929.74	14,535	5,745.00	0.1450	0.1618	2.5300
17	Ranong	185.50	218.98	23,865	3,425.60	0.0542	0.0639	6.9667
18	Nakhon Pathom	737.68	1,123.02	117,820	2,080.32	0.3546	0.5398	56.6355
19	Kanchanaburi	920.46	1,024.14	34,737	19,486.07	0.0472	0.0526	1.7827
20	Suphanburi	1,180.87	1,514.02	44,800	5,348.39	0.2208	0.2831	8.3764
21	Chanthaburi	767.00	686.96	30,080	6,052.27	0.1267	0.1135	4.9700
22	Prachinburi	1,471.00	1,172.93	15,592	11,794.94	0.1247	0.0994	1.3219
23	Phetchabun	1,603.78	1,257.24	27,980	13,660.00	0.1174	0.0920	2.0483
24	Phitsanulok	1,252.40	1,055.01	27,680	9,701.09	0.1291	0.1088	2.8533
25	Nan	1,238.48	611.18	17,940	11,694.51	0.1059	0.0523	1.5341
26	Chiang Rai	1,353.50	1,553.67	37,900	12,302.54	0.1100	0.1263	3.0807
27	Phayao	610.50	710.12	18,580	7,767.00	0.0786	0.0914	2.3922
	Total 27 Project Provinces	23,583.00	23,347.00	892,326	198,800.00	0.1186	0.1174	4.4386

No.	Description	Absolute Amount			Electrification Density		
		HT Lines (000) ckm	LT Lines (000) ckm	Tx Capacity (000) kVA	HT Lines ckm/km^2	LT Lines ckm/km^2	Tx Capacity kVA/km^2
1	Existing	8.1	6.8	684.7	0.041	0.034	3.445
2	ARE 2	15.5	16.5	207.6	0.078	0.083	1.044
3	Combination	23.6	23.3	892.3	0.119	0.117	4.439

It can be seen that while the physical network (high-tension and low-tension lines) for ARE 2 system is about twice as much over the existing system, the load demand (transformer capacity) is only one-third that of the existing system. This characterizes the project of this kind — rural electrification — which is typical throughout the world.

4.7 System Financial Requirement

Application of Unit Aggregated Cost from Table A4, Annex A-1 (40 groupwise items for each of the 22 kV and 33 kV system) to the system physical requirement of the project gives the system financial requirement as shown in Table B1, Annex B. It can be transformed into individual project provinces financial requirement for distribution system investment as shown in the following table. The overall investment cost can be summarized as follows:

No.	Description	Investment	
1	Construction	3,031.7	M₱
	Facility	54.7	M₱
	Vehicle	118.3	M₱
	Service Addition	320.6	M₱
	Total System Investment	3,525.3	M₱
2	First-Year Investment	650.1	M₱
	Second-Year Investment	678.9	M₱
	Third-Year Investment	730.5	M₱
	Fourth-Year Investment	768.4	M₱
	Fifth-Year Investment	697.4	M₱
	Total System Investment	3,525.3	M₱

SUMMARY OF THE PROJECT FINANCIAL REQUIREMENT

No.	Project Province	Cost Estimate (Million Baht)				
		Direct Foreign	Indirect Foreign	Combined Foreign	Direct Local	Total Estimate
1	Yala	15.021	9.319	24.340	35.289	59.629
2	Pattani	19.614	11.975	31.589	48.077	79.666
3	Narathiwat	22.274	13.017	35.291	53.760	89.051
4	Songkhla	44.338	25.291	69.629	113.209	182.838
5	Satun	15.601	10.003	25.604	38.302	63.906
6	Phatthalung	26.551	16.063	42.614	67.548	110.162
7	Nakhon Si Thammarat	54.503	52.363	106.866	211.837	318.703
8	Suratthani	43.957	36.617	80.574	151.409	231.983
9	Phang-Nga	14.948	11.182	26.130	41.346	67.476
10	Trang	24.643	19.873	44.516	77.669	122.185
11	Krabi	17.274	17.233	34.507	62.013	96.520
12	Phuket	5.879	2.553	8.432	5.396	13.828
13	Phetchaburi	15.536	12.630	28.166	47.632	75.798
14	Ratchaburi	20.048	15.587	35.635	61.854	97.489
15	Prachuap Khirikhan	17.157	14.130	31.287	54.556	85.843
16	Chumphon	26.434	21.651	48.085	87.619	135.704
17	Ranong	9.462	5.511	14.973	18.011	32.984
18	Nakhon Pathom	19.850	13.544	33.394	55.015	88.409
19	Kanchanaburi	27.726	20.376	48.102	83.938	132.040
20	Suphanburi	43.053	32.793	75.846	138.551	214.397
21	Chanthaburi	18.861	15.017	33.878	58.556	92.434
22	Prachinburi	44.319	33.098	77.417	138.854	216.271
23	Phetchabun	43.596	36.947	80.543	150.810	231.353
24	Phitsanulok	35.771	29.195	64.966	119.377	184.343
25	Nan	29.217	24.323	53.540	95.838	149.378
26	Chiangrai	41.357	35.876	77.233	147.987	225.220
27	Phayao	30.928	18.341	49.269	78.266	127.535
	Total	727.918	554.508	1,282.426	2,242.719	3,525.245

SECTION V

FINANCIAL ANALYSIS

SECTION V

FINANCIAL ANALYSIS

Assumptions and Criteria for Financial Forecast

The following assumptions and criteria are considered for the ARE 2 Feasibility Study's financial projections:

- Increases in project customers and electric loads are given in Table A-2 & A-3, Annex A-1.
- Revenues are based on existing PEA tariff rates applied to each category of the forecasted loads as given in Table A-5, Annex A-1.
- Power cost is based on average charge of 0.4737 Baht per kWh (See Table A-5, Annex A-1). It is assumed to be constant throughout. This is actually a very conservative estimate as the rate of energy cost would be lower as the load factor increases.
- Operation expense is calculated on the basis of 0.75% of the average investment in system each year.
- Maintenance expense is also related to the average investment in system but in increasing levels from 0.50% to a maximum of 1.00% during the study period.
- Customer accounting is applied initially at the existing level of 50 Baht per customer per year but decreasing in the study period to 32 Baht.
- Administration and general expenses are treated in the same manner as the customer accounting.
- Renewals and replacements are assumed as 3.00% of electric system investment existing each year.
- Assuming 5% for Miscellaneous, 5% for Contingency, 8% for Overhead & Indirect Cost, 8% for Engineering & Supervision Cost (of the materials & labor costs).
- Assuming 4% for Transportation Cost, 6% for Store Cost (of the materials cost).

- Alternative financial arrangements are justified by the following 2 combinations, applying 4% present worth discount rate:

Case		Arrangement
I	Foreign Borrowing:	30 years term, 10 years grace, 4% interest per annum,
	Local Borrowing:	6 years term, 3 years grace, 4% interest per annum.
II	Foreign Borrowing:	same as Case I,
	Local Borrowing:	none, assuming all the Baht fund is granted by the RTG from national budget.

The justification on terms of foreign borrowing is based on the past borrowing of ARE 1 which required about US$ 50 million and came from 5 sources of fund as follows:

. IBRD:	Terms 20 - 5 - 7.45%
. IBRD(3rd Window):	Terms 22 - 7 - 4.50%
. KFAED:	Terms 25 - 5 - 3.50%
. OPEC(Special Fund):	Terms 20 - 5 - 0 %
. CIDA:	Terms 50 - 10 - 0 %

- The combination resulted in a blended loan for 30 years term, 10 years grace and 4.00% effective rate.
- Direct Foreign Component is the cost of equipment manufactured aboard using foreign raw materials & foreign labors, and Indirect Foreign Component is the cost of equipment manufactured locally using foreign raw materials & local labors.
- The proportion of foreign and local components is approximately 36% - 64%. The foreign component is based on foreign currency required for imported materials on CIF basis. The local component is based on local currency (Baht) required for domestic materials, duty & taxes, inland transportation, labor cost, engineering & supervision, miscellaneous & contingencies, etc.

5.2 Financial Forecasts

Ten computer runs for financial forecasts are available in Annex B as follows:

- System Investment Cost (Table B1, B3, B7)
- Revenues & Energy Cost (Table B2)

- Change in Financial Position, 2 Cases (Table B4, B6)
- Pro-Forma Results, 2 Cases (Table B5)
- Annual Cost, 2 Cases (Table B8)
- Statement of Operation, Cash Flow, Balance Sheets (Table B9)
- Financial Rate of Return (Table B10)

5.3 Investment Cost

From Section IV Technical Analysis, the total financial requirement for distribution system investment is Baht 3,525.3 million. Consider Case I (100% borrowings for both foreign and local funds), the IDC (Interest During Construction) for foreign loan is Baht 122.9 million and Baht 203.4 million for local loan, therefore, the overall financing can be categorized in 4 different ways as follows

No.	Item	Investment
1	Construction	3,031.7 MB
	Facility	54.7 MB
	Vehicle	118.3 MB
	Service Addition	320.6 MB
	Interest During Construction	326.3 MB
	Total Project	3,851.6 MB
2	Foreign Component Borrowing	1,282.4 MB
	Foreign Component IDC	122.9 MB
	Total Foreign	1,405.3 MB
		(or 70.3 M$)
	Local Component Borrowing	2,242.7 MB
	Local Component IDC	203.4 MB
	Total Local	2,446.1 MB
	Total Project	3,851.6 MB
3	First-Year Investment	650.1 MB
	Second-Year Investment	678.9 MB
	Third-Year Investment	730.5 MB
	Fourth-Year Investment	768.4 MB
	Fifth-Year Investment	697.4 MB
	Total Investment	3,525.3 MB
	Interest During Construction	326.3 MB
	Total Project	3,851.6 MB

No.		Foreign	Local	Combined
4	First-Year Finance	345.9	561.3	907.2 MB
	Second-Year Finance	267.9	467.9	735.8 MB
	Third-Year Finance	283.1	504.1	787.2 MB
	Fourth-Year Finance	325.3	548.6	873.9 MB
	Fifth-Year Finance	183.1	364.4	547.5 MB
	Total Project	1,405.3	2,446.3	3,851.6 MB

It can be seen that the foreign currency required for the Project is approximately US$ 70 million. PEA expects to obtain financial assistance from both bilateral and multilateral lending agencies including those who participated in ARE 1 Project and the new sources of fund, for example, the SFFD (Saudi Fund For Development). The aim is to blend the loan concessional to the level that is suitable for the Project and acceptable by the PEA.

5.4 Operating Revenues and Power Cost

During the 5 years Project period, the operating revenues from sales of electricity goes up from Baht 24.1 million to Baht 180.8 million, while the power cost purchased from EGAT increases from Baht 15.0 million to Baht 112.6 million resulting the net revenues of Baht 9.1 million upto Baht 68.2 million. This net revenues climb up to Baht 447 million by the 30th year.

The percent distribution of gross revenues by different categories of customers is as follows:

Year	Lighting (%)			Non-Lighting (%)					
	House-hold	Social Facility	Combined	Shop	Rice Mill	Power Tool	Potable Pump	Agri. Pump	Combined
5	75.1	5.2	80.3	12.9	5.1	0.4	0.8	0.5	19.7
10	75.5	3.6	79.1	8.0	10.5	0.6	0.8	1.0	20.9
20	77.0	1.8	78.8	7.4	11.0	0.5	0.8	1.5	21.2
30	78.9	1.3	80.2	7.6	9.8	0.3	0.8	1.3	19.8

It can be seen that the proportion of lighting revenues and non-lighting revenues remain almost the same throughout the 30 years period (approximately 80% - 20%), and the revenue from lighting loads still be the dominant income for PEA under this project.

The annual cost breakdown by 5th year is given in percentage as follows:

No.	Cost	Percent
1	Power	18.8%
2	Operation	3.8%
	Maintenance	2.5%
	Accounting	4.9%
	Administration	4.9%
	Total OMA	16.1%
3	Interest - Foreign	7.6%
	Interest - Local	12.6%
	Total Interest	20.2%
4	Principle - Foreign	0.0%
	Principle - Local	30.8%
		30.8%
5	Renew & Replacement	14.1%
	Total 5th Year Cost	100.0%

It may be seen that the repayment of loan and interest (local and foreign under Case I) is about a half of the total expenses by the completion year of the Project, while the cost of purchased power is only one-fifth of the total expenses.

5.5 Internal Financial Rate of Return (IFRR)

The calculations of IFRR for each project province and for the whole project is shown in Table B10, Annex B.

The cost stream is derived from 3 costs, i.e., system investment cost,OMA cost, purchased energy cost, while the benefit stream is derived from gross revenue of energy sales (See the following table).

Only 3 provinces (Phattalung, Ratchaburi and Nakhon Pathom) have a possitive IFRR while the other 24 provinces all have a negative IFRR. The overall project has a negative IFRR of -2.46 (See the next table).

Although the Project IFRR shows only -2.46%,this is inevitable because of the high degree of electrification requiring higher investment costs particularly in the earlier years. However, this will provide the foundation for very much increased sales of energy beyond the life of the project. Rural electrification should conceptually be considered in longer terms than other more conventional projects.

SUMMARY OF COST STREAM AND BENEFIT STREAM

FOR PROJECT IFRR CALCULATION

Year	Financial Cost Stream (M฿)	Financial Benefit Stream (M฿)
0	31.379	0
1	612.346	24.140
5	906.511	180.782
10	480.500	340.402
15	547.561	544.797
20	650.138	730.982
25	817.696	905.180
30	- 658.856	1,069.098

Cost Stream = Investment + OMA + Purchased Power

Benefit Stream = Gross Revenue from Power Sales

See Table B10-[illegible], Annex B

SUMMARY OF PROJECT IFRR
(INTERNAL FINANCIAL RATE OF RETURN)

No.	Project Province	IFRR
1	Yala	- 4.99
2	Pattani	- 3.96
3	Narathiwat	- 4.11
4	Songkhla	- 1.46
5	Satun	- 2.31
6	Phatthalung	+ 3.40
7	Nakhon Si Thammarat	- 1.64
8	Suratthani	- 3.16
9	Phang-Nga	- 1.41
10	Trang	- 2.06
11	Krabi	- 2.16
12	Phuket	- 46.01
13	Phetchaburi	- 0.76
14	Ratchaburi	+ 1.34
15	Prachuap Khirikhan	- 2.74
16	Chumphon	- 3.86
17	Ranong	- 5.41
18	Nakhon Pathom	+ 3.55
19	Kanchanaburi	- 1.81
20	Suphanburi	- 3.61
21	Chanthaburi	- 1.46
22	Prachinburi	- 2.46
23	Phetchabun	- 3.81
24	Phisanulok	- 0.61
25	Nan	- 5.21
26	Chiang Rai	- 3.96
27	Payao	- 3.21
	ARE 2 Project	- 2.46

SECTION VI

ECONOMIC ANALYSIS

SECTION VI

ECONOMIC ANALYSIS

6.1 Conceptual Framework

In evaluating the IERR (Internal Economic Rate of Return) and the B/C Ratio (Benefit-To-Cost Ratio), the cost savings between electricity and alternative fuels are emphasized. There are many Indirect (Tangible) Benefits that can be quantified but being conservative only those items that have been confirmed by field enquiries are included in this project justification. Therefore, the Economic Benefits are derived from Direct Benefits (revenue from energy sales) plus Tangible (Quantifiable) Indirect Benefits (electricity usages for residential households, commercial shops, rice mills, power tools, potable pumps, and agricultural pumps). The Intangible (Non-Quantifiable) Indirect Benefits are qualitatively presented in order to give the complete spectrum of social and economic impacts by making availability of electric power to the rural areas.

In terms of full cost savings, comparison is made between the present diesel fuel cost and electric tariff rates. The trend is for the difference to be even larger than those assumed in this study because

- The price of diesel fuel will increase more rapidly than electric tariff,
- Increased electricity consumption will be charged at lower rates according to the sliding scales.

The fuel cost savings which constitute the bulk of the Indirect Benefits are therefore conservatively estimated.

6.2 Direct Benefits

The direct benefits are derived only from direct sales of electric energy (Table B2, Annex B) less taxes of 0.011 Baht per kWh.

6.3 Quantifiable Indirect Benefits

The tangibel (quantifiable) benefits are derived from:

- Residential Household: Cost saving from lighting and cooking fuels; Increased productivity; expansion of household handicrafts for domestic needs and occasional sales.
- Commercial Shop: Cost saving from lighting and cooking fuels; competitive margin due to refrigeration and other electrical facilities.
- Rice Mill: Cost saving from fuel consumption (about 75%) and improved recovery rate (about 25%).
- Power Tool: Comparative operations with manual implements for similar work and quantities.
- Potable Pump: Comparative operations with manual bucketing from wells by a certain carrying distance.
- Agricultural Pump: Cost saving from replacing diesel pump with electric pump.

6.3.1 Economic Benefits from Rural Household Electrification

Indirect tangible (quantifiable) economic benefits from rural household electrification include lighting benefits and cooking savings benefits. These benefits are in excess of the amounts paid for electricity, the direct benefits. Field visits of electrified and unelectrified village households were made to develop case studies of rural residential electrification benefits to supplement survey data. Lighting benefits may be subdivided into lighting savings, peak agricultural season labor savings, and cottage industry benefits.

Household's lighting savings benefits are due to costs saved by not using kerosene. A synthesized case study of representative average economic costs and benefits of rural household electrification is presented in the following table. Average annual savings in lighting costs are estimated at ₦ 28 per electrified household.

RURAL HOUSEHOLD LIGHTING BUDGET

Item (Average 1978 Price)	Lighting Source (Baht)	
	Unelectrified (Kerosene)	Electrified
- Connection Cost:		
. Blue-Wire Connection (by PEA)	-	50
. Meter Deposit (by PEA)	-	120
. Inspection Fee (by PEA)	-	40
. House Wiring with Light Fixtures & Receptacles (by Private Contractor)	-	1,340
Total Connection Cost	-	1,550
- Annual Fuel Cost	325 (1)	105 (2)
- Annual Connection Recovery Cost	-	192 (3)
Total Annual Lighting Cost	325	297

Average Savings in Annual Lighting Cost per Electrified Household = ฿ 28

(1) Average kerosene fuel expenditures per unelectrified residential household, Trang Province (Survey B: Unelectrified Households). This fuel expenditure figure was found to vary somewhat between province, with wide variation among households within the provinces. For example, Trang Province had an average kerosene expenditure per unelectrified residential household of ฿ 325 with a standard deviation of ฿ 330. Ranong Province had an average of ฿ 251 with a standard deviation of ฿ 358.

(2) Assumes 3 Fluorescent Tubes that use 40 W each and burn 3 hours a day for 365 days per year at ฿ 0.80 per kWh.

(3) Assumes a 12% opportunity cost of capital and a 30 years connection life.

It should be noted that these estimated lighting savings benefits are conservative because they neglect quality difference between light sources. The above case study only considers changes in the quanity value of light consumed following electrification. Electric light, however, is often preferred to subsitutes even if it costs more. It is in other words superior in quality. Also, the lighting savings benefits do not consider the value of extra electric light taken on account of its higher quality and/or reduced cost.

Household's agricultural labor savings benefits from electrified lighting are attributable to additional labor input available during the peak agricultural labor season. Field interviews of households in electrified and unelectrified villages revealed that households in electrified villages have additional productive daylight time. Because of electrification of lights, farmers can leave for work earlier in the morning and come home later at night. Farm families are more likely to do housework, cook and eat food during morning and evening non-daylight hours under electric lights than under kerosene illumination. A nonelectrified farm family would be more likely to do many of these activities during daylight hours leaving less daylight time for agricultural activities. The ensuing agricultural labor savings generate benefits in the form of additional agricultural labor productivity and/or reduced agricultural labor costs.

The above argument implicitly assumes a positive marginal value product of agricultural labor during the peak agricultural season. One of the most severe problems in Thailand's agricultural economy is the peak labor problem. Certain operations in the crop cycle, such as transplanting rice, harvesting, and threshing demand much more labor in a brief period than is ordinarily required for most of the year. The problem is particularly acute in those parts of Thailand where only one crops is grown a year. Rural electrification can help reduce peak labor demands.

A synthesized case study of representative average economic benefits from peak agricultural season labor savings is presented in the following table.

RURAL ELECTRIFIED HOUSEHOLD PEAK AGRICULTURAL SEASON LABOR SAVINGS

Item (Average 1978 Price)	Assumption	Unit
Peak Agricultural Labor Season	30	Days/Year
Additional Agricultural Labor Available During the Peak Season	1.5	Hours/Day
Marginal Value Product of Agricultural Labor During the Peak Season	20	฿/8 Hour-Day
Percent of Village Households Whose Major Occupation is Agriculture	79 (1)	Percent

Average Annual Rural Electrified Household Peak Agricultural Season Labor Savings (2) = ฿ 88

$$\left[\frac{(30)(1.5)}{(8)}\right](20)(0.79) = 88$$

(1) For example, in 1970, 61,660 out of 79,208 economically active males 11 years of age and over were engaged in agriculture as their major accupation in the Province of Trang.
Source: NSO, 1970 Population and Housing Census.

(2) Annual light tube, electricity, and connection cost are covered in the Lighting Budget (previous table).

Average annual rural electrified household peak agricultural season labor savings are conservatively estimated at ฿ 88.

Household's lighting benefits from cottage industry activities are attributable to productive labor input available during the evening non-daylight hours. Again, field interviews of households in electrified and unelectrified villages revealed that households in electrified villages have additional productive non-daylight evening time to devote to cottage industry activities. Because of superior quality electric lights, an electrified rural household can increase its productive hours awake by effectively utilizing former non-productive, non-daylight evening time.

Representative case studies of avarage economic lighting benefits from cottage industry activities are presented in the following table. Synthesized average annual rural electrified household lighting benefits from cottage industry activities are estimated at ฿ 58 as summarized in the same table.

Household's cooking saving benefits are due to costs saved by not having to buy or gather fuel for cooking. Cooking is the main domestic use of fuel for people in rural Thailand. An enormous amount of rural labor is now invested in the collection of firewood. Each year, wood fuel is becoming more and more difficult to obtain. Whereas previously wood fuel was just outside the door, now many rural Thai households have to search further from home for thier required cooking fuel. A synthesized case study of representative average economic cost and benefits of electrified and nonelectrified cooking is presented in the following table. Average annual rural electrified household cooking benefits are estimated at ฿ 24.

In summary, total average indirect tangible economic benefits per rural electrified household are estimated at ฿ 228 per year. Of this total, 12% (฿ 28) is due to lighting savings benefits, 39% (฿ 88) is due to peak agricultural season labor savings benefits, 25% (฿ 58) is due to cottage industry benefits, 24% (฿ 54) is due to cooking savings benefits.

SUMMARY OF RURAL ELECTRIFIED HOUSEHOLD LIGHTING BENEFITS FROM COTTAGE INDUSTRY ACTIVITIES

Case Study	Average Annual Benefits per Household	Weight	Weighted Annual Benefits per Household
(1)	฿ 720	1/6	฿ 120
(2)	฿ 480	2/6	฿ 160
(3)	฿ 80	3/6	฿ 40

Weighted average annual benefits per household involved in cottage industry activities = ฿ 320

Percentage of households having people working in nonagriculture fields.(4) 18%

(1) Case 1: Basket Making (Village of Tachamung, Province of Songkhla)

- Without electrification: 2 families engaged in a rattan basket cottage industry together used to work until 19.00 or 20.00 hours making baskets.
- With electrification: The same 2 families now work until 22.00 hours because of high quality electric lighting. Given 2 productive workers per family, each family now makes 2 extra baskets per day. The families sell the baskets for ฿ 8 each and each family makes a profit of ฿ 3 per basket.
- Annual benefits = [(฿ 6 / Day) (120 Days)] = ฿ 720.

(2) Case 2: Silk Weaving (Village of Phumriang, Province of Surat Thani)

- Without electrification: a farm family engaged in silk weaving partime did not work in the non-daylight evening hours.
- With electrification: The same farm family can now productively work an extra 2 hours each night because of high quality electric lighting. The family is able to make 1.6 extra meters of silk per day. The family sells the silk for ฿ 40 per meter and makes a profit of ฿ 2.5 per meter.
- Annual benefits = [(฿ 4 / Day) (120 Days)] = ฿ 480.

(3) Case 3: Mat Making and Pillow Making (Village of Bantum, Province of Kalasin)

- Without electrification: A farm family undertakes on cottage industry activities.
- With electrification: The same farm family makes straw mats and stuffed pillows at night because of high quality electric lighting. The family makes a profit of ฿ 20 per month with these cottage industry activities.
- Annual benefits = [(฿ 20 / Month) (4 Months / Year)] = ฿ 80.

(4) For example, in the Province of Trang, 30 households out of 159 electrified households had people working in nonagriculture fields.
Source: 1977, ORE Survey D (Electrified Villages).

RURAL HOUSEHOLD COOKING BUDGET

Item (Average 1978 Price)	Cooking Source (Baht)	
	Unelectrified	Electrified
Rice Cooker	-	850 (1)
Annual Fuel Cost	305 (2)	110 (3)
Equipment Recovery Cost	30	171 (4)
Total Annual Cooking Costs	335	281 (5)

Average Savings in Annual Cooking Costs per Electrified Household = ฿ 54

(1) Assumes a 750 W, 1.8 liter rice cooker.

(2) Average of North, Central, and Southern Thailand average household consumption expenditures for charcoal and firewood, 1972-1973,
Source: NSO, Thailand Socio-Economic Survey, 1971-1973.

(3) Assumes the 750 W rice cooker is used for 5 hours per day for 365 days per year at ฿ 0.8 per kWh.

(4) Assumes a 12% opportunity cost of capital and an 8 years life.

(5) Annual connection cost are covered in the Lighting Budget (previous).

6.3.2 Economic Benefits from Rural Shop Electrification

Indirect, tangible (quantifiable) economic benefits from rural shop Electrification include cost savings benefits, increased productivity benefits, new activity benefits, and competitive profit margin benefits. Field visits of electrified and unelectrified village shops were made to develop case studies of rural commercial shop electrification benefits to supplement survey data.

- Case Study 1 (Tailor Shop): demonstrates cost-savings benefits in a rural tailor shop from subsituting an electric iron for a charcoal iron. These cost-savings benefits for electric irons do not include the additional benefits due to the value of the difference in quality and the extra productivity resulting from the electrified activity. Increased tangible productivity benefits are domonstrated by the case study of adaption of an electric motor to a treadle sewing machine. The tangible rural shop benefits here consist of the net value of extra shirts produced due to electrification.

- Case Study 2 (Food Shop): demonstrates new activity benefits from rural shop refrigeration electrification. In rural Thailand, except for ice boxes, there are generally few subsitutes for rural electrified refrigeration. Few actual cases of kerosene or gas refrigeration are found in rural Thailand. Case Study 2 demonstrates new activity benefits that consist of the net value of ice produced due to rural shop electrification. These new activity benefits do not include the additional possible cost-savings benefits from subsituting electric for say kerosene refrigeration.

- Case Study 3 (Composite Shop): demonstrates competitive profit margin benefits from rural commercial shop electrification. Competitive profit margin benefits are a composite variant of new activity benefits. In a newly electrified village, commercial shops are always the first to electrify because of the great new activity benefits they derive from electrification. For example, rural commercial shop electrification makes possible lighting, fan, and television new activities which increase the shop's competitive margin over a similar non-electrified commercial shop.

CASE STUDY OF RURAL ELECTRIFIED SHOP BENEFITS

CASE 1: TAILOR SHOP

- Electrified Sewing Shop, Village of Muang Lot, Province of Nakhon Si Thammarat.
- Without electrification: The shop owner worked 8 hours per day making shirts. One fourth of each day involved the use of a treadle sewing machine. The shop owner also used a charcoal iron and paid ฿ 1 per day for charcoal. The owner makes ฿ 15 per shirt profit.
- With electrification: The shop owner adapted an electric motor to the sewing machine. The sewing machine could now make shirts two times faster than without electrification. The shop owner could now make 3 shirts a day. The shop owner subsituted an electric iron for the charcoal iron.

Item	Unelectrified	Electrified	Unit
Shirts per Day	2.625 (1)	3	Shirts
Profit per Shirt per Day	15	15	฿
Profit per Year (2)	9,450	10,800	฿
Electric Iron Recovery Cost	-	30 (3)	฿/Year
Iron Fuel Cost	240	157 (4)	฿/Year

Average Annual Increase in Shop Profits Due to Electrification = ฿ 1,350

Average Annual Savings in Shop Ironing Costs = ฿ 53

Average Annual Tailor Shop Benefits Due to Electrification (Less Connection Costs) = ฿ 1,403

(1) (3 Shirts/Day) (0.25 Machine Time) = 0.75 Shirts/Machine Time/Day
(0.75 Shirts/Machine Time/Day) (0.5) = 0.375 Shirts/Machine Time/Day without Electricity.
(0.375 Shirts) + (3 Shirts/Day) (0.75 Time) = 2.625 Shirts/Day Without Electricity.

(2) Assumes 240 Working Days/Year.

(3) Assumes a 12% opportunity cost of capital and an 8 years life for a 650-800 W electric iron with an initial cost of ฿ 150.

(4) (0.725 kW) (1 Hour/Day) (240 Days) (0.9 ฿ / kWh) = ฿ 157.

CASE STUDY OF RURAL ELECTRIFIED SHOP BENEFITS

CASE 2: FOOD SHOP

. Electrified Food Shop, Village of Bango, Province of Yala.

. Without electrification: The shop owner is not able to make or sell ice.

. With electrification: The shop owner bought an 8 cubic-foot refrigerator and now sells ฿ 20 worth of ice per day.

Item	Unelectrified	Electrified	Unit
Profit from Ice Sales per Day	-	15	฿
Profit from Ice Sales per Year	-	3,600 (1)	฿
Electric Refrigerator Recovery Cost	-	2,214 (2)	฿/Year
Electric Refrigerator Fuel Cost	-	90 (3)	฿/Year

Average Annual Food Shop Benefits with Electric Regrigeration (Less Connection Costs) = ฿ 1,296

(1) Assumes 140 Ice-sales Days/Year.

(2) Assumes a 12% opportunity cost of capital and an 8 years life for an 8 cubic-feet refrigerator with an initial cost of ฿ 11,000.

(3) [(100 kWh/Year) (0.9 ฿/kWh)] = ฿ 90.

CASE STUDY OF RURAL ELECTRIFIED SHOP BENEFITS

CASE 3: COMPOSITE SHOP

Electrified Composite (Commercial General Goods) Shop, Province of Trang[1]

Item	Unelectrified	Electrified	Unit
Total Average Annual Cash Income	29,927	39,115	฿
Total Average Annual Variable Expenditures	273	263	฿
Total Average Annual Fixed Expenditures	10,628	15,098	฿
Total Average Annual Wage Expenditures	235	948	฿

Annual Average Profit Margin Between Electrified and Unelectrified Composite Shop	=	฿ 4,015
Competitive Margin Due to Electrification between Electrified and Unelectrified Shop	=	25%
Average Annual Composite Shop Benefits due to Electrification (Less Connection Costs)	=	฿ 1,003

(1) Source of Data for All Rural Village Shops Surveyed in Trang Province: 1977 ORE Survey D (Unelectrified Households & Shops), and 1977 ORE Survey E (Electrified Households & Shops)

In summary, total average indirect tangible economic benefits per rural electrified shop are estimated at ฿ 966 per year (See the following summary table).

6.3.3 Economic Benefits from Rural Rice Mill Electrification

Rice mill data from field surveys are tabulated for the different project provinces in the following table. This survey date was supplemented by information from field visits to several rural rice mills. Most of the rice mills covered by the 1977 ORE Surveys are presently powered by diesel engines generally in the range of 10-20 BHP. The average age of the diesel engines is generally in the range of 5-10 years rendering good opportunities for conversion to electric motors as a power source within a few years of village electrification.

Field visits of electrified rural rice mills were made in Northeast Thailand to develop case studies of actual rural rice mill electrification. All of the electrified rice mills observed in the Northeast were in 3-phase electrified villages under ARE 1 Project. Almost all the electrified rural rice mills observed in these non-ARE 2 project provinces were in villages that were given a minimum amount of load promotion treatment by PEA. The 3 electrified rural rice mills observed in the Northeast Provinces of Udon Thani and Mahasarakham had 3-phase motors that varied from 10-20 HP. All the rural electrified rice mills observed were in villages that had been electrified from 4-6 years. A rural electrified rice mill was also observed in the ARE 2 Northern Project Province of Phitsanulok.

Economic benefits from rice mill electrification are considered a major contributor to potential electrification benefits in rural Thailand. The next table presents a synthesized case study of representative average economic benefits and costs of rural rice mill electrification. Total average annual surplus economic benefits(not including electricity revenues) per electrified rice mill are conservatively estimated at ฿16,646.

Rice mill electrification increases the annual fuel cost sligthly (with new August 1977 rates) and substantially reduces the annual maintenance and capital recovery costs. The net effect is to reduce the average total annual operating cost to the rice mill owner by approximately 48%.

SUMMARY OF RURAL ELECTRIFIED SHOP BENEFITS

Case Study	Average Annual Benefits Per Shop (Less Connection Cost)	Average Percentage of Shops Per Village (1)	Weighted Annual Benefits Per Shop
1	฿ 1,403	10%	฿ 140
2	฿ 1,296	25%	฿ 324
3	฿ 1,003	65%	฿ 652

Weighted Average Annual Benefits per Shop (Less Connection Cost)	฿ 1,116
Annual Connection Recovery Cost	฿ 150
Representative Average Annual Rural Electrified Shop Benefits	฿ 966

(1) From the 1977 ORE Survey D (Electrified Villages), 25% of all shops were food shops and 75% were other commercial shops in the Province of Trang. From the 1977 ORE Survey A (Unelectrified Villages), 8% of all shops in the same province were tailor shops.

RICE MILL DATA FOR ARE 2 PROJECT VILLAGES

No.	Project Province	Average Number of Rice Mills per Project Village (1)	Average Size of Rice Mills per Project Village (HP) (1)	Average Residential Cash Expenses for Household Milling Rice (฿) (2)
1	Yala	0.5	4.8	24.5
2	Pattani	0.9	9.0	82.6
3	Narathiwat	1.2	10.0	92.7
4	Songkhla	1.1	10.9	84.4
5	Satun	1.2	9.7	78.8
6	Phatthalung	2.9	21.4	149.0
7	Nakhon Si Thammarat	2.1	17.2	53.9
8	Suratthani	1.9	12.6	39.7
9	Phang-Nga	0.7	5.1	41.7
10	Trang	1.2	8.7	74.4
11	Krabi	1.4	9.2	121.3
12	Phuket	0.1	0.5	8.7
13	Phetchaburi	0.7	6.7	18.3
14	Ratchaburi	0.3	4.3	4.2
15	Prachuap Khirikhan	0.4	3.5	7.1
16	Chumphon	1.7	13.4	62.9
17	Ranong	1.2	6.6	106.5
18	Nakhon Pathom	0.3	3.4	0.0
19	Kanchanaburi	0.3	3.2	4.9
20	Suphanburi	0.3	4.0	5.2
21	Chanthaburi	0.5	4.2	6.1
22	Prachinburi	1.5	12.7	16.1
23	Phetchabun	1.1	15.3	20.6
24	Phitsanulok	1.4	15.7	57.6
25	Nan	2.2	14.2	243.3
26	Chiang Rai	1.5	20.9	234.6
27	Phayao	1.7	24.4	152.8
	ARE 2 Project	1.3	12.1	67.4

(1) From 1977 ORE Survey C (Power Load Potential).
(2) From 1977 ORE Survey B (Unelectrified Households).

RURAL RICE MILL ECONOMIC BUDGET

Item (Average 1978 Price)	Rice Mill		
	Unelectrified	Electrified	Unit
Horsepower	15 (1)	7.5	HP.
Capital Cost	25,500 (2)	6,300 (3)	฿
Life Expectance	10	15	Years
Hours of Operation per Year	1,159 (1)	869 (4)	Hours
Consumption of Fuel per Hour	1.8 (1)	5.6 (5)	Liters/kW
Annual Fuel Cost	4,882 (6)	5,450 (7)	฿
Annual Maintenance Cost	3,609 (1)	315 (8)	฿
Annual Capital Recovery Cost (9)	4,512	925	฿
Annual Connection Recovery Cost	-	467 (10)	฿
Total Annual Operayion Cost	13,003	7,157	฿
Paddy-Rice Conversion Ratio	60.0	60.5 (11)	Percent
Paddy Requirement per Capita (12)	275	273	Kilograms
Cost of Paddy to Consumer (13)	688	682	฿
Cost of Paddy per Rice Mill Service Area (14)	412,800	409,200	฿
Savings in Annual Costs to Operator			฿ 5,846
Savings in Annual Rice Costs to Society			฿ 3,600
Total Average Annual Surplus Economic Benefits			฿ 9,446

RURAL RICE MILL ECONOMIC BUDGET

(Continued)

(1) Average coefficient from rice mill survey of ARE 1 (16 Northeast provinces and 4 Principle provinces), 1975.

(2) Average 1978 cost for 15 HP diesel equals ₱ 30,000, including a 15% duty & taxes.

(3) Average 1978 retail cost for 7.5 HP 3-phase motor equals ₱ 5,500 and for starter equals ₱ 3,500, both costs include a 30% duty & taxes.

(4) Equals 75% of average unelectrified rice mills' hours of operation.

(5) One HP equals 0.746 kW.

(6) Average 1978 diesel fuel cost of ₱ 2.66 per liter including a 8.3% excise tax and a 4% business tax.

(7) Average 1978 cost of ₱ 1.12 per kWh, based on average 405 kWh per month (August 1977 Small Business Rates).

(8) Equals 5% of capital cost.

(9) Assumes a 12% opportunity cost of capital and the stated life expectance with zero salvage value.

(10) Assumes a 12% opportunity cost of capital and a ₱ 3,760 connection cost spread over 30 years. The 3-phase transformer share cost is included in project cost.

(11) A 1974 ORE Survey of electrified and unelectrified rice mills found a 60.5% recovery rate of white rice.

(12) Assumes 165 kilograms of rice per capita.

(13) Assumes a 1978 average price of ₱ 2.5 per kilogram.

(14) Assumes an average rice mill serves approximately 600 persons.

Electrification of rice mills also greatly improves the efficiency of white rice recovery from paddy resulting in substantial benefits to all the village households. Households realize benefits of not having to mill as much paddy as was previously required for subsistence.
A substantial rise in the average recovery rate results from a smoother running electric motor. Also frequent breakdowns of diesel engines also contribute to unsatisfactory recovery rates in unelectrified rice mills. All electrified rice mill owners interviewed agreed that their milling recovery rate was greatly improved by electric motors that increased the efficiency of their machinery.

6.3.4. Economic Benefits from Rural Power Tool Electrification

Indirect, tangible (quantifiable) economic benefits from rural power tool electrification include cost-savings benefits and increased productivity benefits. Field visits to present electrified rural villages were made to observe the use of power tools. The case study in the following table demonstrates cost-savings benefits for a rural private house builder from subsituting a power planer for additional hired labor.

The actual quantified benefits of this case study do not include the additional increased tangible productivity benefits resulting from the subsitution of electric power for human labor. It is assumed that the average small rural sawyer, furniture maker, or blacksmith will have a net cash income of approximately ₱ 22,000 per year in a rural electrified village. If it is assumed that the competitive profit margin due to electrification cost-savings and productivity benefits is approximately 15%, then total average annual cost-savings and productivity indirect tangible economic benefits per power tool are estimated at ₱ 3,300. This compares with an average annual portable power tool cost-savings benefit of ₱ 2,935 estimated in the case study.

6.3.5 Economic Benefits from Rural Potable Pump Electrification

Most rural electrified private potable water wells are generally 20-50 feet deep and depend on rising and falling water tables, though some depend on reqular aquifers. Usually the quanity of water from these wells is sufficient only for domestic use though there are some minor irrigation uses from these wells for household garden plots. Ground water where

CASE STUDY OF RURAL PORTABLE POWER TOOL BENEFITS

Case 1: Wood Planing

- Electrified Village of Lubosawo, Province of Narathiwat.
- Without electrification: A contractor pays ฿ 100 per day to 4 men to plane boards.
- With electrification: The same contractor hires 1 man at ฿ 35 per day to plane boards with the contractor's 1 HP, 3" planer. More wood is planed by this 1 man with a power tool than was previously planed by the 4 men.

Item (Average 1978 Price)	Unelectrified	Electrified	Unit
Wood Planing Labor Cost	฿ 100.00	฿ 35.00 (1)	฿/day
Portable Power Tool Recovery Cost	-	3.40 (2)	฿/day
Fuel Cost	-	1.30	฿/day
Connection Recovery Cost	-	1.70 (3)	฿/day
Total Cost	฿ 100.00	฿ 41.40	

Average Annual Portable Power Tool Cost-Savings Benefits = ฿ 2,935 (4)

(1) Assumes a 12% opportunity cost of capital and an 8 years life for a 1 HP, 3" electric planer with an initial cost of ฿ 2,000.

(2) [(0.9 ฿/kWh) (2 hours/day) (1 HP) (0.746 kW/HP)].

(3) [(฿ 150/year) / (90 days/year)].

(4) [(฿ 100) - (฿ 41.40) (50 days/year)].

feasible, is now being increasingly preferred as a source for rural domestic water supply, even where surface water is available.

Indirect, tangible (quantifiable) economic benefits from electrified private potable water pumps include opportunity cost-savings benefits from subsituting electrified water pumping for hand pumping (either by bucket or hand water pumping). The time required each day to obtain drinking water and water for sanitation requirements will be saved by each household. These man-hours will allow additional hours for agricultural production, cottage industry activities, cooking, laundry, repair, and social functions.

A case study of economic benefits from electrified private potable water pumps is presented in the following table. Average annual cost-savings benefits from electrified private potable water pumps are estimated at ฿ 116.

6.3.6 Economic Benefits from Rural Agricultural Pump Electrification

Since Thailand is an agricultural country and agricultural products constitute the largest component of national income, the optimum development of water resources for agriculture is of paramount importance to the future economic and social well being of the country. Thai people have deverted stream flows into their rice farming areas by means of canals for many centuries. Small benzine powered pumps are commonly used to pump water from the canals to the rice paddies and to irrigate small plots of fruits and vegetables.

Ground water, however, has played a small roll in the solution of Thailand's irrigation needs. An attempt to provide ground water for agricultural use is undertaken by the Royal Irrigation Department. The Department of Mineral Resources has been assigned ground water resource investigation, evaluation, and development. The ground water investigation programme was started in 1955. The result of the investigation has been complied in the hydrogeological map of Northeastern Thailand recently published and in draft hydrogeological

CASE STUDY OF RURAL ELECTRIFIED

PRIVATE POTABLE WATER PUMP BENEFITS

Item (Average 1978 Prive)	Water Pumping Source		Unit
	Gasoline	Electrified	
Fuel Cost per Day	3.45 (1)	0.33 (3)	฿
Fuel Cost per Year	1259 (2)	120	฿
Annual Capital Recovery Cost	372 (4)	220 (5)	฿
Total Annual Cost	1631 (6)	340 (7)	฿
Average Annual Cost-Savings Benefits Per Electrified Private Potable Water Pump	฿ 116		

(1) Average 1978 benzine fuel cost of ฿ 3.93 per liter including a 8.3% excise tax and a 4% business tax.

(2) Assume ฿ 20 minimum wage for an 8 hour-day. Assume an economic marginal value product of labor of 50% of the wage rate or ฿ 10 per day.

(3) Average 1978 cost of ฿ 0.90 per kWh, [(0.746 kW/hp)(0.5 hp)(1 hr)(฿0.9/kWh)]

(4) Average 1978 cost for 2 HP engine equals ฿ 1,500.
Average 1978 cost for water pump equals ฿ 600. Assume a 12% opportunity cost of capital and a 10 years life expectance with a zero salvage value.

(5) Average 1978 cost for 0.5 HP 1-phase electric motor equals ฿ 900.
Average 1978 cost for water pump equals ฿ 600. Assume a 12% opportunity cost of capital and a 15 years life expectance with a zero salvage value.

(6) Assume no annual maintenance cost.

(7) Assume no annual maintenance cost and that annual connection costs are covered in the Lighting Budget (previous table).

maps of Northern, Western, Central, and Eastern Thailand completed in 1976. Another hydrogeological map devoted to Southern Thailand is under preparation. The above investigations for rural provinces are mostly preliminary and actual systematic investigations leading to the aquifer system analysis have not yet been initiated.

The primary use of ground water at present is for domestic supplies in rural communities (See Economic Benefits from Electrified Private Potable Water Pumps). The present general concensus of experts in the RTG is that development of Thailand's ground water for large-scale agriculture is not considered economically justified.*

A case study of economic benefits from electrified private agricultural water pumps is presented in the following table. Average annual cost-savings benefits per electrified private agricultural water pumps are estimated at ฿ 1,018.

6.4 Non-Quantifiable Indirect-Benefits

Indirect benefits obtained from ARE 2 Project electrification that are considered intangible (non-quantifiable) or difficult to quantify — if not all impossible — can be summarized as follows:

Benefits to the PEA: An extensive distribution network capable of future expansion & future development at a relatively small incremental cost.

- Benifits to the General Public:
  - Improvement of general rural standard of living and a quality of life,
  - Better utilization of development facilities, for example public education, health clinics, etc.
  - Availability of mass media — educational radio-television program — to promote literacy, farm development techniques, etc.
  - Increase in security and ease of movement in the hours of darkness.
  - Reduction in difference between urban and rural mode of living which would have beneficial effects on reducing migration to town, birth rate, etc.

*Ministry of Agriculture and Cooperatives, Thailand Country Report, United Nations Water Conference, ESCAP Regional Preparatory Meeting, 27 July - 2 August, 14 May 1976, p. 10.

CASE STUDY OF RURAL ELECTRIFIED
PRIVATE AGRICULTURAL WATER PUMPS

Item (Average 1978 Price)	Water Pumping Source		Unit
	Unelectrified	Electrified	
Fuel Cost per Year	600 (1)	200 (2)	฿/Year
Annual Capital Recovery Cost	354 (3)	259 (4)	฿/Year
Annual Connection Recovery Cost	-	150	฿/Year
Total Annual Cost	2,030	1,012	฿/Year
Average Annual Cost-Savings Benefits Per Electrified Private Agricultural Water Pump	฿ 1,018 (5)		

(1) Average 1978 benzine cost of ฿ 3.93 per liter including an 8.3% excise tax and a 4% business tax, [(2 hr/day)(120 days/year)(1.3 liter/hr)(฿ 3.45/liter)].

(2) Average 1978 cost of ฿ 0.90/kWh, [(฿ 0.9/kWh)(2.5 hp)(0.746 kW/hp)(2 hr/day)(120 days/year)].

(3) Average 1978 cost for a 3.5 HP engine equals ฿ 2,000. Average 1978 cost for water pump equals ฿ 600. Assume a 12% opportunity cost of capital and a 10 years life expectance with a zero salvage value.

(4) Average 1978 cost for a 2.5HP 1-phase electric motor equals ฿1,765. Average 1978 cost for water pump equals ฿600. Assume a 12% opportunity cost of capital and a 15 years life expectance with a zero salvage value.

(5) Assume that maintenance cost-savings due to electrification are offset by a annual connection recovery cost.

6.5 Economic Benefits Stream

Table C7, Annex C gives the details of 30 years economic benefits stream which can be summarized as shown in the following table. The Indirect Benefits — even though having been conservatively eatimated — is substantial, significant and comparable to that obtained from the Direct Benefits, as seen from the following comparison:

Year	Direct Benefits	Indirect Benefits
0	0%	0%
1	44%	56%
5	40%	60%
10	43%	57%
15	47%	53%
20	51%	49%
25	53%	47%
30	55%	45%

In the Stream of Direct Benefits which is derived from revenue from energy sales, the fuel tax of 0.011 Baht per kWh has been deducted.

6.6 Economic Cost Stream

Table C8, Annex C gives the details of 30 years economic cost stream which is derived from 3 financial costs (investment, OMA and energy purchase) with taxes deducted. The following comparision shows the impact of purchased energy in the cost stream:

Year	Energy Stream	Construction & OMA Stream
0	0%	100%
1	3%	97%
5	14%	86%
10	47%	53%
15	62%	38%
20	69%	31%
25	67%	33%
30	71%	29%

CATEGORIZED ECONOMIC BENEFIT STREAM

FOR IERR CALCULATION

Year	Total Benefit	Direct Benefit (Gross Revenue) (M฿)	Indirect (Tangigle) Benefit (M฿)							
			Households	Shops	Rice Mills	Power Tools	Potable Pumps	Agri. Pumps	Social Facility	Total
0	0	0	0	0	0	0	0	0	0	0
1	55.096	24.132	22.621	5.471	1.587	1.089	0.047	0.146	0	30.964
5	447.923	180.729	172.653	55.710	15.820	19.501	1.379	2.131	0	267.196
10	794.151	340.300	280.049	62.738	48.192	52.541	3.515	6.810	0	453.847
15	1,154.775	544.639	342.551	71.774	111.330	65.857	5.321	13.303	0	610.138
20	1,432.787	730.774	381.681	80.054	138.678	73.386	7.287	20.928	0	702.016
25	1,699.369	904.923	430.698	90.506	156.738	82.804	8.965	24.734	0	794.445
30	1,946.984	1,068.798	475.523	99.926	173.081	91.426	10.917	27.315	0	878.189

The following tax deductions are applied individual items of the cost stream:

Cost Stream	Sub-Item	Tax Deduction
Investment	Construction	9.0%
	Facilities	4.0%
	Vehicles	20.0%
	Service To New Customers	7.0%
	Additional Primary	7.5%
	Additional Secondary	6.6%
	Additional Transformer	19.0%
OMA	Operation Expense	10.0%
	Maintenance Expense	10.0%
	Customer Accounting	10.0%
	General Administration	10.0%
Energy	EGAT Bulk Supply	0.011 ฿/kWh (Fuel Tax)

6.7 Benefit-To-Cost Ratio

B/C Ratios are derived from Table C8, Annex C at 2 discount rates (4% for the PEA, 12% for the market) for individual project provinces and the whole ARE 2 Project, as shown in the following 2 tables. Obviously, the B/C Ratio is low for this kind of project, but the result is quite impressive as follows:

Discount Rate	Project B/C Ratio
4%	1.5581 : 1
12%	1.1485 : 1

6.8 Internal Economic Rate of Return

Table C8, Annex C gives the IERR for individual project provinces and the overall ARE 2 Project which are summarized in the following 2 tables.

Six provinces are on top of the list, they are Patthalung (22.32%), Phuket (18.26%), Nakhon Pathom (17.28%), Prachuab Khirikhan (17.15%),

PROJECT BENEFIT-TO-COST RATIO

AT 4% DISCOUNT RATE

No.	Project Province	Benefit (000) Baht	Cost (000) Baht	B/C Ratio
1	Yala	171,846	125,603	1.3672:1
2	Pattani	246,487	166,037	1.4845:1
3	Narathiwat	278,078	189,629	1.4664:1
4	Songkhla	847,440	499,000	1.6983:1
5	Satun	249,235	165,831	1.5029:1
6	Patthalung	875,973	502,223	1.7442:1
7	Nakhon Si Thammarat	1,544,422	973,631	1.5862:1
8	Suratthani	762,844	493,455	1.5459:1
9	Phang-Nga	233,989	168,471	1.3889:1
10	Trang	440,390	268,687	1.6390:1
11	Krabi	326,805	222,801	1.4668:1
12	Phuket	32,705	24,307	1.3455:1
13	Phetchaburi	384,084	247,588	1.5513:1
14	Ratchaburi	508,621	344,841	1.4749:1
15	Prachuap Khirikhan	436,304	268,408	1.6255:1
16	Chumphon	484,191	313,317	1.5454:1
17	Ranong	131,137	75,148	1.5055:1
18	Nakhon Pathom	505,058	332,180	1.5204:1
19	Kanchanaburi	538,409	374,353	1.4382:1
20	Suphanburi	696,194	503,245	1.3834:1
21	Chanthaburi	352,627	250,718	1.4065:1
22	Prachinburi	918,089	605,280	1.5168:1
23	Phetchabun	1,030,172	689,419	1.4943:1
24	Phisanulok	1,027,647	646,237	1.5902:1
25	Nan	497,193	336,223	1.4788:1
26	Chiangrai	1,132,556	744,048	1.5222:1
27	Phayao	553,845	383,090	1.4457:1
	ARE 2 Project	15,051,365	9,659,892	1.5581:1

PROJECT BENEFIT-TO-COST RATIO

AT 12% DISCOUNT RATE

No.	Project Province	Benefit (000) Baht	Cost (000) Baht	B/C Ratio
1	Yala	46,839	47,613	0.9837:1
2	Pattani	67,555	66,160	1.0211:1
3	Narathiwat	74,552	76,439	0.9753:1
4	Songkhla	222,907	195,751	1.1387:1
5	Satun	66,474	63,728	1.0431:1
6	Patthalung	235,839	168,975	1.3957:1
7	Nakhon Si Thammarat	441,468	357,977	1.2332:1
8	Suratthani	199,400	186,645	1.0683:1
9	Phang-nga	67,769	65,489	1.0348:1
10	Trang	110,541	107,329	1.0299:1
11	Krabi	93,724	86,022	1.0895:1
12	Phuket	9,261	8,667	1.0685:1
13	Phetchaburi	129,222	112,883	1.1447:1
14	Ratchaburi	158,684	141,169	1.1241:1
15	Prachuap Khirikhan	129,425	106,353	1.2169:1
16	Chumphon	140,591	132,255	1.0630:1
17	Ranong	31,348	29,804	1.0518:1
18	Nakhon Pathom	183,454	151,031	1.2147:1
19	Kanchanaburi	166,968	165,905	1.0064:1
20	Suphanburi	208,685	216,411	0.9643:1
21	Chanthaburi	110,949	117,170	0.9469:1
22	Prachinburi	283,223	278,628	1.0165:1
23	Phetchabun	315,467	317,317	0.9942:1
24	Phisanulok	325,575	283,247	1.1494:1
25	Nan	152,736	156,231	0.9776:1
26	Chiang Rai	353,849	307,147	1.1521:1
27	Phayao	188,328	162,735	1.1573:1
	ARE 2 Project	4,756,662	4,141,550	1.1485:1

SUMMARY OF COST STREAM AND BENEFIT STREAM

FOR PROJECT IERR CALCULATION

Year	Economic Cost Stream (M฿)	Economic Benefit Stream (M฿)
0	25.699	0
1	511.180	55.095
5	780.041	447.922
10	440.867	794.146
15	521.240	1,154.773
20	624.911	1,432.783
25	784.122	1,699.366
30	880.476	1,946.978

Cost Stream = Investment + OMA + Purchased Power (Taxes Deducted)

Benefit Stream = Direct Benefit (Gross Revenue from Power Sales, Taxes Deducted)

+Indirect (Tangible) Benefit (From Power Usages in Household, Shop, Rice Mill, Power Tool, Potable Pump, Agricultural Pump and Social Facility)

See Table C 8-1, Annex C

SUMMARY OF PROJECT IERR
(INTERNAL ECONOMIC RATE OF RETURN)

No.	Project Province	IERR
1	Yala	12.04
2	Pattani	13.05
3	Narathiwat	11.60
4	Songkhla	16.74
5	Satun	14.57
6	Patthalung	22.32
7	Nakhon Si Thammarat	15.77
8	Suratthani	13.00
9	Phang-Nga	14.48
10	Trang	13.26
11	Krabi	12.31
12	Phuket	18.26
13	Phetchaburi	15.17
14	Ratchaburi	16.06
15	Prachuap Khirikhan	17.15
16	Chumphon	12.57
17	Ranong	14.54
18	Nakhon Pathom	17.28
19	Kanchanaburi	12.73
20	Suphanburi	10.82
21	Chanthaburi	10.21
22	Prachinburi	11.65
23	Phetchabun	11.39
24	Phisanulok	14.34
25	Nan	11.45
26	Chiangrai	14.07
27	Phayao	13.05
	ARE 2 Project	13.29

Songkhla (16.74%) and Ratchaburi (16.06%). The lowest two are Chanthaburi (10.21%) and Suphanburi (10.82%). The ARE 2 project has an impressive IERR of 13.29% compared with 12.00% for ARE 1 Project as justified by the IBRD 1976 Appraisal. It is seen that the 13.29% project IERR is above the opportunity cost. As the method of calculation is conservatively based, the rate of return should be much higher. Future trends in fuel costs and rural development promoting rural industrialization from presently small power consumption will most likely improve on the rate presented here.

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5	Phetchabun	11,12,13,14*,15
6	Kanchanaburi	16,17,18,19,20,21*,22,23
7	Suphanburi	17,18,21*
8	Nakhon Phathom	21,23*
9	Ratchaburi	22,23*,29,30
10	Phetchaburi	22,23,29,30*
11	Prachinburi	24*,25,26,27
12	Chanthaburi	27,28*
13	Prachup Khirikhan	29,30,31*,32,33
14	Chumphon	32,33*,34
15	Ranong	33,34*,35
16	Suratthani	34,35,36*,37,38,39
17	Phang-nga	35,38*,41
18	Nakhon Sithammarat	36,37,39,40*,42,43
19	Krabi	38*,39,42
20	Phuket	38,41*
21	Trang	42*,43,44,45
22	Phatthalung	43*,45
23	Songkhla	43,45,46*,48
24	Satun	44,45*
25	Pattani	46,47*
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Remarks: *Indicates Page No. by which the Province Center is located.

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