THE GEOGRAPHY OF ELECTRIC POWER DEVELOPMENT IN THAILAND

Thesis for the Degree of M. A.

MICHIGAN STATE UNIVERSITY

Suwit Habanananda

1964

This is to certify that the

thesis entitled

THE GEOGRAPHY OF ELECTRIC POWER DEVELOPMENT IN THAILAND

presented by

Suwit Habanananda

has been accepted towards fulfillment
of the requirements for

M. A. degree in Geography

P. C. Morrison

Major professor

Date August 1964

O-169

ABSTRACT

THE GEOGRAPHY OF ELECTRIC POWER DEVELOPMENT IN THAILAND

By

Suwit Habanananda

This thesis is a discussion of electric power development in Thailand from a geographic point of view. Traditionally, charcoal, firewood and paddy husk have been the important sources of heat energy. However, depletion of forests resulting from heavy cutting for charcoal, along with other economic factors, have dictated that the government develop different sources of energy.

Lignite is now mined in the north at Mae Moh (45 million tons known reserves) and in the south at Krabi (4 million tons). It is mainly utilized for the thermal generation of electricity at both places, although some from Mae Moh is transported to Bangkok for use in power plants there.

Petroleum has been discovered at Mae Fang in the north, but it is of low quality and reserves are limited. Consequently, large importation has been necessary for the production of electricity by diesel engine and for other purposes.

Rivers, streams and waterfalls provide Thailand with an abundant renewable resource for power development, one that has as yet been little developed. The hydro-electric potential is estimated to be more than one million kilowatts in firm power. Some 80 per cent of this is located in the northern half of the country within economical distance of the main market in the Bangkok area. Favorable hydro-sites are found on tributaries of the Chaophraya, the Maekong, and other streams.

Electric power has become important in Thailand only in the last 25 years. Generating capacity in 1940 was only 32,000 kilowatts, which produced about 37.1 million kilowatt-hours of power during the year. Most of the capacity was located in Bangkok. Since the end of the Second World War there has been a continuing shortage of electric power. Although capacity to produce increased, so did demand. Production in 1952 was still under 150 million kilowatt-hours. But generating capacity has increased rapidly since then; it reached 264,470 kilowatts in 1961 when 601.82 million kilowatt-hours of electricity were produced. As a consequence per-capita consumption increased from 8.83 kilowatt-hours in 1956 to 17.76 in 1961. Presently, in 1964, generating capacity has reached some 500,000 kilowatts, and it promises to continue expanding rapidly.

The future power system is being independently developed region by region under the direction of the National

Energy Authority which was established in 1954. Several large hydroelectric projects are either being implemented, surveyed or actively considered. Of these, the Yanhee Project which will ultimately have 560,000 kilowatts capacity, located 260 miles from Bangkok on the Ping River, has already begun to transmit electricity to several provinces in the North and Central Regions, including Bangkok. Other schemes such as Nam Pong (32,000 kilowatts) and Nam Pung (10,000 kilowatts) in the Northeast, and Pattani River (30,000 kilowatts) in the South are being implemented. Eventually, the regional systems will be linked in a national grid.

The development of the hydroelectric industry is not without problems. The most important of these concerns administrative organization, financing, the provision of technical personnel and the establishment of long-term planning and co-ordination with industrial development. Unless these difficulties are effectively dealt with, development will be slowed.

The growth of demand for electric power, especially in Bangkok which consumes nearly 70 per cent of the country's output, is likely to continue at a high annual rate of 10 to 15 per cent for the rest of this decade, and at only a slightly lower rate thereafter to the end of the century. The total peak load increased from 79,966 kilowatts in 1956 to 203,800 in 1963, and it is estimated

it will increase to 275,000 in 1970.

The future supply will depend upon the extent and the speed with which local sources of power can be developed. It is possible that demand will increase so rapidly that nuclear energy as a supplementary source of power will become a reality in 1980's or 1990's. In any event, it is hoped that the rapid expansion of electric power supply, particularly from hydroelectric facilities, will both alleviate chronic shortages of the past and provide a stimulus for rapid industrialization, thus greatly improving the level of living of the people of Thailand.

THE GEOGRAPHY OF ELECTRIC POWER DEVELOPMENT IN THAILAND

By

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

Department of Geography

1964

Dedicated To

my

Father and Mother

ACKNOWLEDGMENTS

The writer wishes to express gratitude to the National Energy Authority of Thailand for letting him use the necessary materials pertinent to the thesis; to the writer's father, Mr. Swai Habanananda, through whose effort some of the information was expediently acquired; to Mrs. Paul Morrison for typing the preliminary manuscript; to Miss G. Aguilar for her help in general typing and editing; and above all, a special note of thanks is due Dr. Paul Cross Morrison whose advice and encouragement, understanding and patience made completion of this study possible.

East Lansing, Michigan — Suwit Habanananda

August 1964

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

TEXT TABLES

APPENDIX TABLES

LIST OF ILLUSTRATIONS

Chapter I

INTRODUCTION

Thailand is on the threshold of revolutionary changes in its electrical power industry. Not only will hydroelectric facilities now being built provide greatly increased amounts of energy to relieve the chronic shortages of recent years, but they promise to reduce to relative unimportance the thermoelectric plants which until now have produced practically all electricity used.

Generating capacity for the nation in 1961, excluding that of industrial companies producing power for their own use, was 264,000 kilowatts. That of Yanhee, the largest of several hydroelectric projects now under construction, will alone reach 560,000 kw. by 1970. This and other vast multipurpose schemes now being implemented, actively planned, or considered will have a tremendous impact on the life of every Thai in coming years. The purpose of this thesis, therefore, is to discuss the evolution, present character, and probable future of electric power generation in Thailand.

Chapter two is devoted to the discussion of existing and potential resources for power development and the advantages and disadvantages of each. The resources include wood, charcoal, lignite, oil, amount and distribution of rainfall, and streams and stream flow. The chapter ends with consideration of the possibilities of man developing

the water resource. It is an attempt to present in broad perspective what Thailand has or has not in terms of resources for power development.

The third chapter is concerned with the evolution of Thailand's electric power industry. Here, the past history is traced and the present nature of the industry is described and analyzed. Shortage of electricity has characterized Thailand since World War II. To understand the government's attempt to launch a program of expansion of electric power production it is necessary to know how the industry is coordinated and regulated. Thus, included in this chapter is a part dealing with the administrative organization of the industry.

Water power resources will play a significant role in the effort to alleviate power shortage in Thailand. A number of projects are now either under implementation, being actively planned, or considered. Expansion of hydroelectric power facilities is taking shape region by region. This regional development of projects, both actual and proposed, is discussed in the fourth chapter. The physical background of each region, and the features of and benefits expected from each project within the region are explained.

Chapter five deals with problems and prospects of the future of the electric power industry in Thailand. Not only are there many problems concerning organization, finance, technical personnel and long-term planning facing the industry, but there is the important question of what will be the re-

quirements (market) for power in the next ten years, twenty years, and beyond that. An estimate of such demands is attempted. Further, the role of atomic energy, as a possible source of alternative power, is also discussed.

In the sixth and last chapter the major findings of the study are summarized. Thus, the final touches are added to the picture, study of which should make the nature, the magnitude, and some of the problems of energy resources and electric power development in Thailand become fairly clear.

Sources of Information

Statistics concerning Thailand's electric power industry are fragmentary, while reliable estimates of resource potentials are still lacking. Such information as is available is scattered in various periodicals and journals. The difficulty the writer experienced in securing facts has many a time led to frustration. Nevertheless, the investigation was accomplished, the major sources used being: proceedings, reports and pamphlets published by the United Nation's Economic Commission of Asia and the Far East; the 1962 Report of the National Energy Authority of Thailand; and a book on Thailand by R. L. Pendleton. Other sources of value included articles in various geographic and economic periodicals and journals.

Past statistics are either incomplete or lacking. The National Energy Authority, for instance, has no complete data

concerning generation and distribution of electric power prior to 1954. Some essential data, if it does exist, is not readily available. Thus, the presentation of statistics in this paper leaves much to be desired, but it is believed that enough figures have been secured from various available sources to permit a fairly close approach to the truth.

Limitations of the Study

As indicated above, one of the limitations is either the lack of, or the inaccessibility of some of the essential information and reliable data. Another limitation was the difficulty of securing necessary materials from primary sources in Thailand in the time available. Moreover, the scope of the subject is a large one, and it was not possible here to attempt to cover every aspect of it. The writer hopes, however, that the picture presented has sufficient detail to bring to attention what a nation with an underdeveloped economy, like Thailand, can do to achieve better living standards through development of its power resources.

Chapter II

ENERGY RESOURCES, ACTUAL AND POTENTIAL

Inanimate sources of power probably satisfy no more than one-fifth to one-third of Thailand's present total requirements. The remainder is supplied by men and their draft animals, from which the United States, by contrast, draws no more than three per cent of its energy needs.[1] Animals and humans are the almost exclusive sources of power in rural Thailand, and are major power factors in urban centers.

In transport alone perhaps 80 to 90 per cent of the power used is derived from these two agents. Because of the scarcity of motorable roads, motor vehicles, and railroads, most goods are moved in river boats, by bullock carts and other animal or human-propelled vehicles, and on pack animals and human backs. In agriculture almost every power need is met by human and animal muscle. The same is largely true in mineral exploitation and in manufacturing where mechanization has barely begun; the number of persons engaged in cottage and small workshop industries still far exceeds

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[1] U.S., Department of Agriculture, Office of International Trade, Investment in India (Washington: 1953), p. 73, as quoted in R. L. Pendleton, Thailand, Aspects of Landscape and Life (New York: Duell, Sloan and Pearce, First Edition, 1962), p. 257. The latter is an American Geographical Society Handbook.

the total of mill and factory employees.

Firewood, paddy husk and charcoal have long been traditional fuels for Thailand. They still play an important role where they cannot be suitably substituted by other energy resources. In recent years, however, the importance of these as sources of power has relatively declined. Utilization of coal, oil and electric power has gradually taken their place, and these sources have come to largely fulfill the country's energy needs.

Further exploration and experimentation must be made before Thailand's fuel and power resources can be assessed at all accurately. On the basis of present knowledge, however, the best prospects for providing future power appear to lie in the development of hydroelectric potentials in Northern Thailand, in the Northeastern region along the Maekong and its tributaries, along the Southeast Coast where waterfalls abound, and in the Southern Peninsula. Some coal and petroleum have been produced in commercial quantities in recent years, but known reserves of both these mineral fuels do not appear now to be of sufficient quantity or the high quality required for most industrial uses. The coal is mostly lignitic; none suitable for coking has been discovered. The petroleum has a heavy napthalene base, and deposits are probably very limited in size.

Wood

Until recently, charcoal, firewood and paddy husk were the only sources of heat energy used in Thailand. Charcoal

was used exclusively for household purposes. Firewood and paddy husk were consumed mainly for production of steam to propel prime movers as well as to generate electricity. As industry has grown, with development of the country and its population, paddy husk has lost most of its relative importance as an energy supplier due to its limited availability. Firewood and charcoal, however, are still very significant sources, while rice stalks are an important fuel for some uses. Probably the most prized of the charcoal woods is mangrove, which therefore demands a very high price. Average production of wood and charcoal during the years 1947 to 1956 was 1,347,000 and 649,000 cubic meters respectively, although the 1956 output was down to 1,030,000 and 570,000 cubic meters.[2]

Wood and charcoal are the major cooking fuels of rural Thailand and their constant production for a growing population has brought serious depletion of forests near heavily populated areas. Forests on or near densely settled rice plains, especially those of the Central Plain, have been completely destroyed.[3] In addition, wood is used by the railroads for locomotive fuels. It is noted that most of the wood cut in the provinces of Prachuabkirikhan, Ranong, Phangnga, Krabi, Trang, Satool and Narathiwas is probably

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[2] International Bank of Reconstruction and Development, A Public Development Program For Thailand (Baltimore: 1959), p. 106.

[3] Pendleton, R. L., Thailand, Aspects of Landscape and Life (New York: Duell, Sloan and Pearce, First Edition, 1962), p. 216. An American Geographical Society Handbook.

sold to the railroads (Fig. 1).[4]

Firewood and wood cut for charcoal together amounted to about 70 per cent of the timber removed from all Thai government forests in 1954.[5] It is estimated that 7,000,000 cubic meters of wood are cut from government forests and private lands each year for charcoal purposes, and reserves are threatened with exhaustion.[6] Thus, although wood is still a very important source of energy, the country's forests have been depleted to such an extent that cutting of trees for firewood has had to be curtailed. Other sources of energy should be sought to replace this type of fuel.

In view of the situation, the government of Thailand had directed increasing effort to the search for coal, oil, hydro-power, and other energy resources. Meanwhile, the country's demand has expanded so that coal and fuel oil have been imported in increasing amounts for industrial as well as domestic power generation. Certainly, factories, power stations, and railroads can be switched to these substitutes with relative ease and probably to their considerable benefit, as the present fuels are not particularly satisfactory. A suitable fuel substitute for domestic cooking purposes, however, is not so easily found. Among those suggested are:[7] charcoal manufactured from coconut husks; solar cooking stoves

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[4] Ibid., p. 217.
[5] Ibid., p. 258.
[6] United Nations, Economic Commission for Asia and the Far East, Lignite Resources of Asia and the Far East, Their Exploration, Exploitation and Utilization, Mineral Resources Development Series No. 7 (E/CN.11/438), (New York: 1956), p.9.
[7] Pendleton, op. cit., p. 258.


THAILAND
PROVINCES BY
NATIONAL ENERGY AUTHORITY
ZONES
NORTHERN
1 PICHIT
2 PITSANULOKE
3 PETCHABOON
4 SUKHOTHAI
5 UTARADIT
6 PHRAE
7 NAN
8 LAMPANG
9 LAMPOON
10 CHIENGMAI
11 CHIENGRAI
12 MAE - HONG - SORN
13 TAK
14 KAMPANGPET
NORTHEASTERN
1 NAKHONRASRIMA
2 BURIRUM
3 SURIN
4 SISAKET
5 UBOLRAJADHANI
6 ROI - ET
7 MAHASARAKAM
8 KALASIN
9 SAKOLNAKHON
10 NAKHONPHANOM
11 NONGKAI
12 UDONTHANI
13 KHONKAN
14 CHAIYAPHOOM
15 LOEI
CENTRAL
1 BANGKOK
2 THONBURI
3 NONTBURI
4 PATUMTHANI
5 AYUDTHAYA
6 ANGTHONG
7 SUPHANBURI
8 SARABURI
9 LOPBURI
10 SINGHABURI
11 CHAINAT
12 UTHAITANI
13 NAKHONSAWAN
14 SAMUTPRAKARN
15 SAMUTSAKHON
16 SAMUTSONGKRAM
17 NAKHONPATHOM
18 KANCHANABURI
19 RATBURI
20 PETCHABURI
21 PRACHUABKIRIKHAN
22 NAKHONAYOK
23 PRACHINBURI
24 CHACHOENGSAO
25 CHOLBURI
26 RAYONG
27 CHANTABURI
28 TRAD
SOUTHERN
1 CHUMPORN
2 SURATTANI
3 NAKHONSRITHAMRAT
4 PATTALUNG
5 SONGKLA
6 SATOOL
7 YALA
8 NARATHIWAS
9 RANONG
10 PHANG - NGA
11 KRABI
12 PHUKET
13 TRANG
14 PATTANI
0
125
MILES
13
101
S.H. 1964

Figure 1

utilizing sun power, like those recently developed by the National Physical Laboratory in India and at New York University; inexpensive hydroelectricity; fuel alcohol manufactured from molasses; oil from the yang forests; lignite briquets or lignitic coke drawn from the several known lignite reserves; and windmill generated electricity.

It is interesting to note that windmill generation of electricity as a by-product of irrigation projects has been suggested for the Far East by a Commission of the United Nations. Windmills have already proved successful in several sections of Thailand for direct pumping of irrigation water from canals and rivers, although they have not, as far as is known, been used to generate electricity. The aim of the government in searching for coal, oil, hydro-power and other energy resources available within the country is to reduce the expenditure of foreign currency credits as well as to develop the country's natural resources.

Lignite

Deposits of lignite are known in eight of the seventy-one changwads (political subdivisions) of Thailand shown in Figure 1). Deposits in northern Thailand are of Tertiary age, brown, woody and of low calorie content. Those of the Peninsula area in the south are denser, blacker, and analyze by calorie content as sub-bituminous, or even bituminous in quality.[8] In general, the lignite of the northern basins usually has high water and ash content and

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[8] Pendleton, ibid., p. 259.

no coking properties; the sulphur content is also very high.[9] Hence, it is suitable for direct use in thermal power stations, but not for metallurgical or domestic fuel purposes without expensive pre-treatment.

As yet, only two or three areas have been surveyed by the Department of Mines in the Ministry of Industry, aided by technical and financial aid from the United States Foreign Operation Administration. Only one, that at Mae Moh, 35 kilometers east of Lampang, is being extensively exploited (Fig. 2 A). Reserves here may be as much as 80,000,000 tons. The most promising reserves besides those at Mae Moh totaling some 4,000,000 tons, are at Ban Pudam in Krabi in the southern peninsula. Amounts at Kiansa in Surathani and at Kantang in Trang are insignificant. Except for Mae Moh, the deposits have the disadvantage of being in sections of the country far from centers of consumption. Those at Ban Pudam and Kiansa have been commercially mined at times, but operations have failed because of their poor location and other factors. Nevertheless, the construction of a thermo-power station at Krabi in 1961, utilizing the Ban Pudam lignite deposit, has reactivated the mining operation there under the direction of the Lignite Power Authority.

The deposit at Mae Moh is being actively developed with the equipment obtained through United States government

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[9] International Bank of Reconstruction and Development, op. cit., p. 107.

assistance. Mines were opened in the early fifties. The deposit is located in a Tertiary basin about 310 miles north of Bangkok and 62 miles south of Chiengmai.[10] Proven reserves are presently about 45 million tons, but exploration is continuting and total reserves are expected to be nearly twice this amount. Mining by open-cast method began in 1954. Production in 1955 amounted to between 30,000 and 35,000 tons; rose to about 80,000 and 130,000 tons in 1957 and 1958 respectively; was 140,000 tons in 1960; and was expected to be increased to 450,000 tons annually after June 1962. The total national production was recorded at 109,000 and 149,432 tons in 1959 and 1960 respectively.[11]

The main consumers of lignite are thermo-power stations in Bangkok. These utilize about 200,000 tons a year, but other uses are contemplated by both the government and private industry. A substantial amount of the Mae Moh output is also being burned in a mine-based electric station generating inexpensive electricity for the towns in the area and to supply power for the Yanhee dam construction. The low cost of pro-

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[10] Information about the Mae Moh deposit is from United Nations, Commission for Asia and Far East, op. cit., p. 7-9; International Bank for Reconstruction and Development, op. cit., pp. 107-108; and United Nations Economic Commission for Asia and the Far East, "Development of Lignite Resources in Thailand" in Proceedings of the Regional Seminar on Energy Resources and Electric Power Development, (E/CN.11/595) (New York: 1962), pp. 149-150.

[11] United Nations Economic Commission for Asia and the Far East, Mining Development in Asia and the Far East, 1960, Mineral Resource Development Series, No. 16 (Bangkok: 1962), p. 5.

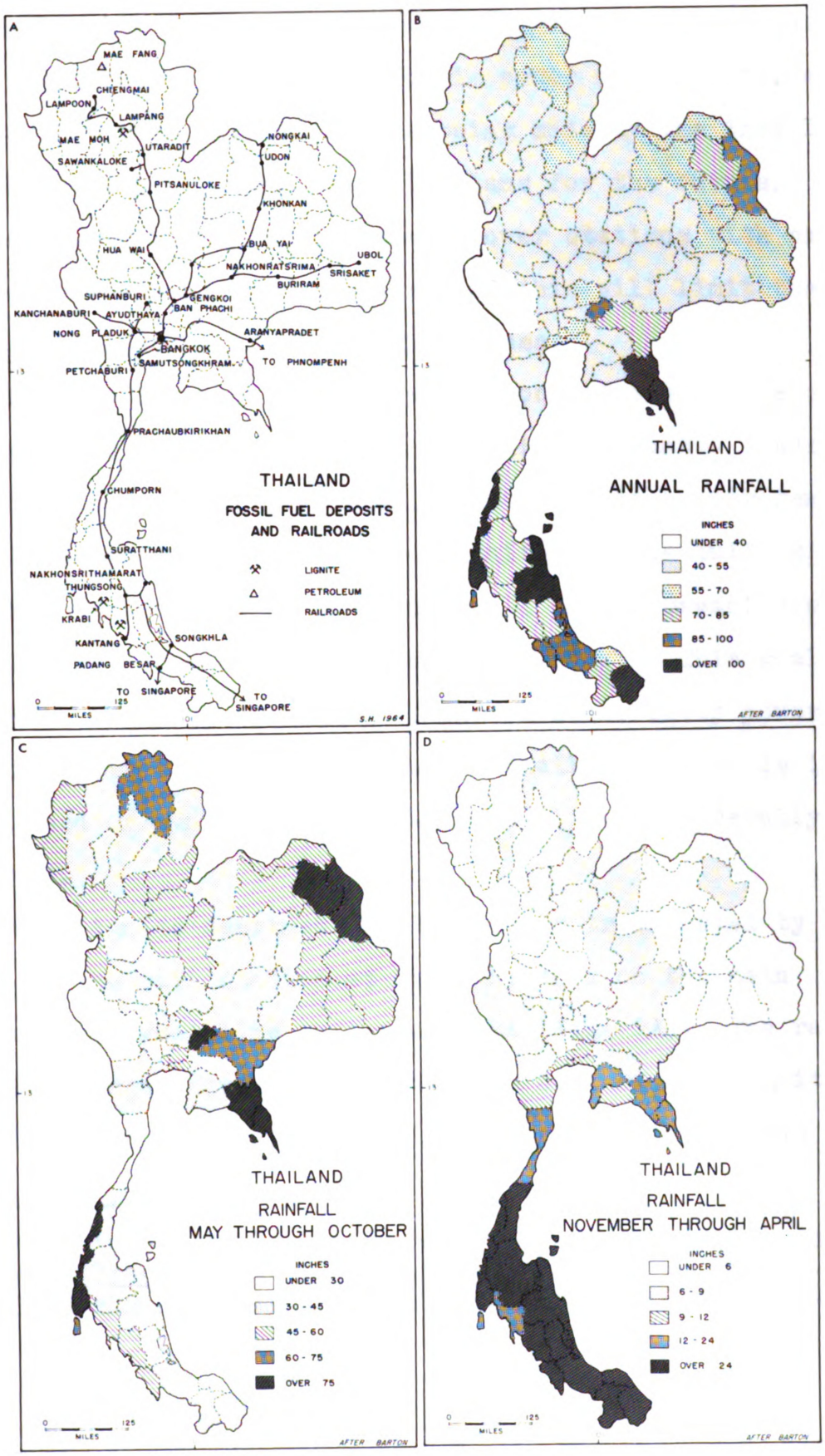
A
MAE FANG
CHIENGMAI
LAMPOON
LAMPANG
MAE MOH
UTARADIT
SAWANKALOKE
PITSANULOKE
NONGKAI
UDON
KHONKAN
BUA YAI
UBOL
HUA WAI
NAKHONRATSRIMA
SRISAKET
BURIRAM
SUPHANBURI
BENGKOI
BAN PHACHI
KANCHANABURI
AYUDTHAYA
NONG PLADUK
ARANYAPRADET
BANGKOK
SAMUTSONGKHRAM
TO PHNOMPENH
PETCHABURI
PRACHAUBKIRIKHAN
CHUMPORN
SURATTHANI
NAKHONSRITHAMARAT
THUNGSONG
KRABI
KANTANG
SONGKHLA
PADANG BESAR
TO SINGAPORE
TO SINGAPORE
MILES
S.H. 1964
THAILAND
FOSSIL FUEL DEPOSITS
AND RAILROADS
LIGNITE
PETROLEUM
RAILROADS
B
THAILAND
ANNUAL RAINFALL
INCHES
UNDER 40
40 - 55
55 - 70
70 - 85
85 - 100
OVER 100
MILES
AFTER BARTON
C
THAILAND
RAINFALL
MAY THROUGH OCTOBER
INCHES
UNDER 30
30 - 45
45 - 60
60 - 75
OVER 75
MILES
AFTER BARTON
D
THAILAND
RAINFALL
NOVEMBER THROUGH APRIL
INCHES
UNDER 6
6 - 9
9 - 12
12 - 24
OVER 24
MILES
AFTER BARTON

Figure 2

ducing lignite from open-cuts at US$ 3.00 per ton or less, allows generation of cheap electric power on the site, and full use of this possibility is being made by the Thai Lignite Authority. In the over-all plans for the future, however, integration of the steam power stations with projected hydro-sources is included and this will limit the geographical scope of lignite power use.

Lignite is also being tried on locomotives of the state railways and in sugar refining and tobacco plants. Near Mae Moh, a gypsum deposit has been discovered and a nitrogen fertilizer plant using gasified lignite will be built with aid from West Germany. The plant will have a capacity of 120,000 tons of ammonium sulphate per year.[12] This goal should be achieved without difficulty, since cheap power and fuel is available. The agronomy of Thailand, which is in great need of synthetic fertilizer, will be considerably improved.

The lignite destined for Bangkok is transported by truck to the rail station at Mae Moh, then on the main Bangkok-Chiengmai line to the capital (Fig. 2A). The rail freight charges exceed the production cost of the lignite. In 1959 the cost of lignite at the mine is said to have been

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[12] United Nations, Economic Commission for Asia and the Far East, Proceedings of the Regional Seminar on Energy Resources and Electric Power Development, op. cit., p. 150.

70-80 baht (US$ 3.50-4.00) per ton. Addition to this of the freight charges although levied at a special reduced rate, raised prices at the Bangkok power stations to 180-200 baht per ton. The cost of fuel oil at the same time was 650 baht per ton.[13] Thus, final costs of lignite to the consumer in Bangkok depend more on transport costs than on those at the mine. This being true, a low grade fuel such as lignite is severely handicapped.

Its price in Bangkok is fixed on a level slightly below the equivalent heat unit costs in the form of fuel oil. Naturally, the danger exists that the lignite industry could be subjected to severe competition from fuel oil supplied below present price levels fixed by the government. Nevertheless, lignite may continue to be competitive on a calorific basis with fuel oil, if the costs of mining and of transportation do not substantially increase. Given the saving of foreign exchange which the use of lignite permits, it probably would be justified to continue its use even if the costs were slightly in excess of those of imported fuel oil. Indeed, it may be that the economic cost is already higher than the quoted price in Bangkok, since the State Railways find the lignite haul unprofitable at existing rates.

Exploitation of lignite deposits other than those at Mae

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13 International Bank of Reconstruction and Development, op. cit., p. 108.

Noh can only be regarded as a long-term prospect inseparable from Thailand's power problem as a whole. By its very nature, lignite cannot compete effectively with other fuels unless it can be utilized at or near the mine. Presently, other conditions are not favorable for industrial development at these points, so the only practicable solution is to generate electrical energy on the spot and then transmit it over long distances for use by agricultural and domestic, as well as industrial consumers. Thus the new thermal power station at Krabi might eventually become the focal point of an integrated power supply incorporating small hydroelectric stations, to serve most of Southern Thailand.

Oil

The search for oil has been carried on throughout Thailand by the Department of Mines, but deposits of commercial size and quality have not been found. The limited reserves of natural asphalt and oil that have been discovered are in the Mae Fang basin in the northern changwad of Chiengmai, adjoining the Burmese border in upper Thailand (Fig. 2 A). According to the rock from the borings in this basin these deposits have no connection with those in Burma. The latter occur in Tertiary marine formations unknown in Thailand. It appears more probable that the asphalt has been formed in the basin alluvium from lignite strata.[14]

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[14] The geological material pertaining to oil is from the United States Geological Survey, Geologic Reconnaissance of the Mineral Deposits of Thailand, Geological Survey Bulletin 984, (Washington: 1951), p. 155.

Test wells were sunk at Mae Fang, as early as 1923, but no success was achieved until 1942 when a well sunk by the highway department struck oil-saturated sand. The well produced a total of 300 barrels of oil with a maximum yield of five barrels in one day. Early in the 1950's a small field of high-viscosity, heavy-naphthalene base oil was found at a depth of some 500 feet. Exploration has been very slow owing to the limited equipment and personnel available, but proven reserves are estimated at 1.5 million barrels and the total possible reserves may reach 5 million barrels.[15] In 1956 the government decided to erect a refinery with a capacity of 1,000 barrels a day at a cost of 84 million bahts (about US$ 6.8 million). Since the refinery is too small to have any hope of being profitable, it seems clear that strategic considerations have prevailed over economic arguments and doubts about total reserves.

The only other known possible source of petroleum in Thailand is oil shale. This has been found both in the intermontane basin around Mae Sod in Tak near the Burmese frontier, and along a tidal estuary near Krabi in the Peninsula. Information about the shale in the Peninsula is not available. Reserves at Mae Sod, where study began in 1935, are estimated to exceed 2 billion tons with a hydrocarbon content of up to 35 per cent on the best samples.[16]

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[15] International Bank of Reconstruction and Development, op. cit., p. 109.

[16] Ibid., p. 109.

Further exploration has been hampered and prevented by inaccessibility to this heavily forested and rugged hill country, but possibilities of development seem to be worth additional study.

Consumption of oil products in Thailand has rapidly increased from about 300,000 tons in 1950, to 903,000 tons in 1957, and 1.3 million tons in 1963.[17] Fuel and diesel oil in 1959 amounted to about 4 per cent of total import value and gasoline accounted for another 4 per cent. These together increased to 10.7 per cent of this value in 1960.[18] The increasing demand for petroleum products resulted in the construction of a refinery to process imported crude oil. Erection of this facility, with an operating capacity of 36,000 barrels per day, at Sriracha located about 70 miles east of Bangkok on the Gulf of Thailand, began in June 1962. The project is by far the largest single private enterprise ever promoted by the Board of Investment.[19] It will cost 600 million bahts (about US$ 20 million) and will be run by the government owned Thai Oil Refinery Company, with technical and financial support from the Shell Oil Company. British, French, United States and West Germany companies are also participating. Construction is progressing well

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17 United Nations, Economic Commission for Asia and the Far East, Mining Development in Asia and Far East, 1960, op. cit., Table 4, p. 7.

18 ibid., p. 7.

19 The Economist Intelligence Unit Ltd., Three-Monthly Economic Review, Continental S.E. Asia, (London: September, 1962), p. 8.

and the plant should be able to begin operation before the scheduled date of September 1964.[20]

Another refinery, with a capacity of 5,000 barrels per day, owned by the Defense Ministry and located at Bangchak (near Bangkok), has been leased to the Time Oil Company of America for ten years. It has been a subject of long controversy within the government whether to make this installation state operated, hiring foreign technicians necessary for the first five years, or whether to lease it to a foreign company. Time Oil will pay the government back the 400 million bahts it originally invested in the refinery and will also pay rentals and taxes. However, it was reported recently that some difficulties have arisen regarding the leasing; the main reason for this seems to be the high price at which the product will eventually be delivered to the Defense Ministry's Oil Fuel Organization.

Although the government conducts retail marketing of oil, foreign petroleum companies also compete directly for the market. They have their own storage and distributing facilities in Bangkok. With increasing consumption of petroleum products, the country has to rely more and more upon importation. Thus the government may well save some foreign exchange by importing crude oil to be processed at the newly built refinery. Increasing utilization of lignite in power stations and the beginning of hydro-power development at Yanhee and elsewhere, may further reduce the cost of import-

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20 Ibid., October, 1963, p. 8.

ing oil through substitution of these for generation of needed power.

A Potential Source of Energy-Hydroelectricity

The inadequacy and inefficiency of firewood and charcoal and the uncertainty regarding local lignite and petroleum deposits, has prompted Thailand to search for other source of energy which can provide sufficient power to satisfy the public needs, as well as to serve as a basis for rapid economic development. Thus, the government has turned attention to harnessing power from the numerous rivers and waterfalls.

Prime factors in exploitation of hydroelectric force are two which are susceptible to combination in a variety of ways. These are water and slope.[21] Thus, other factors being equal, the most favorable conditions for a hydroelectric industry will be realized in a country of pronounced slopes, or mountainous regions, which at the same time is well watered because of humid climate. As far as Thailand is concerned, strong relief is found in the north and the west, and the country as a whole is well watered (Fig. 2 B).

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21 See Blanchard, Raoul, "Geographical Conditions of Water Power Development," Geographical Review, Vol. XIV, (January, 1924), pp. 88-100. His discussion includes physical conditions, circumstances in non-glaciated regions, economic factors, significance of power transmission, and competition with coal.

Another important factor that has to be taken into consideration is the regularity of stream regimen. A river with marked seasonal variation in flow is of inferior value, for utilization must be based on minimum flow or power production will be irregular. Thus, a storage reservoir is necessary to correct irregularity. In middle latitudes rivers rising from non-glaciated mountains are marked by lack of uniform flow, usually being low in late summer. In low latitude regions, however, especially those with a monsoon climate, the streams flood during the rainy months which are usually the summer months. They carry the least water just before the heavy rains begin, ending the dry season. Most rivers in Thailand have this pattern of flow, the low water stage being during the spring of the northern hemisphere.

Amount and Distribution of Rainfall

None of the watersheds in Thailand are snow-fed; thus the regularity of regimen depends to a great extent upon the distribution of rainfall through the year. This is particularly significant since practically all parts of the kingdom receive fairly large amounts of precipitation, although the heaviest concentrations are in the southern part of the Peninsula, in the Southeast, and in provinces of the Northeast along the Maekong River (Fig. 2 B).

From the point of view of power development the seasonal character of Thailand's rainfall is therefore highly significant. Figures 2C and 2D indicate this difference. Most of the country receives the bulk of its moisture during the period

of the Southwest Monsoon, May through October. The notable exception is in the Peninsula East Coast area. Thus, all 57 provinces north of the province of Chumporn (Fig. 1) receive 86 per cent or more of their moisture during the summer monsoon.[22] Moreover, eight of the remaining 14 provinces in the south receive more than half of their precipitation during these months (Fig. 2C). From November to April the country, except the Southeast and the Peninsula areas, is relatively dry; but these are the months the Northeast Monsoon brings heavy rain to the Peninsula East Coast (Fig. 2D).

The quantity of rainfall decreases with increased distance from the sea. The average annual rainfall in the Central Plain is about 50 inches, gradually becoming less from south to north. Bangkok has an average of 59 inches, Lopburi has 54 inches, and Nakhonsawan in the Upper Plain has 42 inches.[23] Towards the northern end of the Upper

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[22] Statistical information obtained from: Barton, Thomas Frank, "Thailand Rainfall Distribution by Geographic Regions," Journal of Geography, Vol. 61, No. 3, (March, 1962), pp. 110-118; and Pendleton, op. cit., pp. 116-119. In Barton"s discussion, Thailand is divided into five geographic regions after the Thailand Economic Farm Survey, 1953. They are the North, Northeast, Central Plain, Southeast, South, and West South-West. See Appendix 1 for a complete listing of provinces of each of these regions. According to Pendleton Bangkok receives 86 per cent of its annual rainfall during these six months; Chiengmai in the North, 88 per cent; Udon in the Northeast, 85 per cent; Takuapa on the Peninsula West Coast, 83 per cent.

[23] Pendleton, op. cit., p. 118.

Plain, however, rainfall increases as a result of the orographic effect of the northern mountains.

Within these mountains the precipitation diminishes inland and away from the plains. Thus, in the mountains of Northern Thailand the average rainfall is less than 70 inches annually. Inhabited valley areas generally have much less than this; Chiengmai receives 40 inches and Nan about 50 inches. The overall average in the North is about 51 inches (Fig. 2B).

The Northeast receives a fairly large amount of rain. The annual average gradually increases as one moves eastward, being heaviest in the provinces along the Maekong River, where in some areas it reaches between 70 to 100 inches (Fig. 2B). The fall occurs mostly in the May-October period. Precipitation during these six months accounts for 90 per cent of the total.[24] On the other hand, during November to April when the Northeast Monsoon prevails, the average for much of the area is only about 7 inches. Contrary to some beliefs, Northeast Thailand does not have the least amount of rain among the regions of the nation, but it does have one of the most pronounced differences between wet season and dry season. The average annual precipitation in this area is about 57 inches.

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24 Barton, op. cit., Table 1, p. 116.

The Southeast, which consists of the provinces of Cholburi, Chantaburi, Rayong and Trad, has very heavy rain.[25] The annual amount reaches 96 inches, with the heaviest fall occurring during the May to October period, and amounting to some 82 inches.[26] The months between November and April have a much lighter total, averaging about 14 inches.

Along the Peninsula, in the province of Chumporn and southward, rain occurs at all seasons, but even here there are differences in seasonal distribution at different places.[27] Several mountain ranges receive rain from the Southwest as well as the Northeast Monsoon. The provinces on the west coast receive more precipitation than those on the east coast. Takuapa on the west coast, for instance, receives 166 inches a year, and one year it had 260.1 inches.[28] The largest quantities fall along the west coast from May to October, during the summer monsoon, and along the east coast from October to January, during the winter monsoon. According to Barton, the South, which includes all but a few provinces on the Peninsula West Coast, has an annual precipitation of 84 inches, with more rain falling during the November to April period.

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25 Both Barton and Pendleton recognize the Southeast as a distinct region.

26 Barton, ibid., Table 1, p. 116.

27 Barton noted that the northern boundary of Chumporn, or near there, is one of the most significant rainfall boundaries in Thailand (ibid., p. 117).

28 Pendleton, op. cit., p. 119.

In the West South-West, which includes the provinces of Kanchanaburi to the west of the Central Plain and Chumporn, Ranong, Phangnga, Krabi, Satool and Narathiwas, the annual rainfall averages 95 inches, with 67 inches coming between May and October.

Thus, there are large seasonal rainfall differences in all of the major regions of Thailand. Since the amount of rain received during the dryer part of the year is the principal factor determining minimum stream flow, and this in turn sets a limit on the amount of water power regularly available without use of reservoirs, the nation's leading problem areas for production of hydroelectricity would be those with the least precipitation during the dry months. Study of Figures 2C and 2D shows the Northeast, or Korat Plateau, and the North to rank first and second respectively in this regard. Much of the surface of both areas receives under six inches of rainfall during the dryest half of the year. On the other extreme, the precipitation during this period is least limiting in the South as a whole, and only a little more so in the four provinces comprising the Southeast. In the South most provinces have over 24 inches during the dryer six months; in the Southeast between 12 and 24 inches (Fig. 2D). The Central Plain occupies a position between the Northeast and North on the one hand, and the South and Southeast on the other.

It can be concluded that in the South and Southeast the terrain is suitable, and the volume of stream flow sufficient

even during the dry season, to provide a considerable potential for generating hydroelectricity. Even here the potential can be expanded, but to a vastly greater amount in less favored regions, by the construction of reservoirs. These manmade lakes will in addition, be particularly valuable in the areas having a marked dry season for storing water to irrigate agricultural land. Under such conditions construction costs can be spread over more than one use, thereby facilitating development.

Watersheds and Streams

Thailand is blessed with several large rivers and numerous lesser streams. Three main rivers and their tributaries provide most of the drainage system of the country (Fig. 3A). The Chaophraya River and its four principal branches, the Ping, Wang, Yom and Nan Rivers, drain the northern mountains and the great Central Plain. The Chaophraya flows through Bangkok and enters the Gulf of Thailand at Samutprakarn; its main distributary, the Nakhonchaisi, enters the Gulf just to the west. In the western part of the country the Kwae Yai and the Kwae Noi flow out of the Western Mountains and meet to form the second major stream, the Maeklong, at Karnchanaburi. This drains the area between the Salaween in Burma and the Chaophraya in Thailand. The northeastern and the eastern parts of Thailand lie in the drainage basin of the Maekong, the "great river" of Southeast Asia. The major tributaries which flow into the Maekong are the Mune and the Chee. Other rivers independent of the Mune-Chee system also

flow into the Maekong along the Thai-Laos boundary. There are no large rivers or drainage basins along the Southeast Coast or in the Peninsula. Only small rivers and streams tap inland mountainous areas and enter the Gulf of Thailand along the Southeast Coast and the Peninsula East Coast, and the Adaman Sea and the Strait of Malacca along the Peninsula West Coast.

Like most rivers of the tropical region, the Choaphraya has much water well maintained throughout the year, and a large volume of water has permitted it to rapidly approach base level. This low gradient in its lower course, along with the amount of alluvium carried, militates against utilization for power generation. However, the four main tributaries of the Choaphraya possess desirable conditions as they flow through mountainous area in the north. Recently, one hydro-plant, the Yanhee, on the Ping River began to generate electricity. Possibilities for further development on the other tributaries are under investigation.

Suitable conditions for hydro-power installations also exist on smaller rivers such as Nam Pong and Nam Pung in the northeast, and the Pattani in the south. Consequently, they have been designated for immediate development; in fact projects on all three are now under implementation.

Water-Power Potential

The hydroelectric potential of Thailand from its rivers and waterfalls has been estimated at 1,160,000 kilowatts, of which about 80 per cent is located in the northern half of the

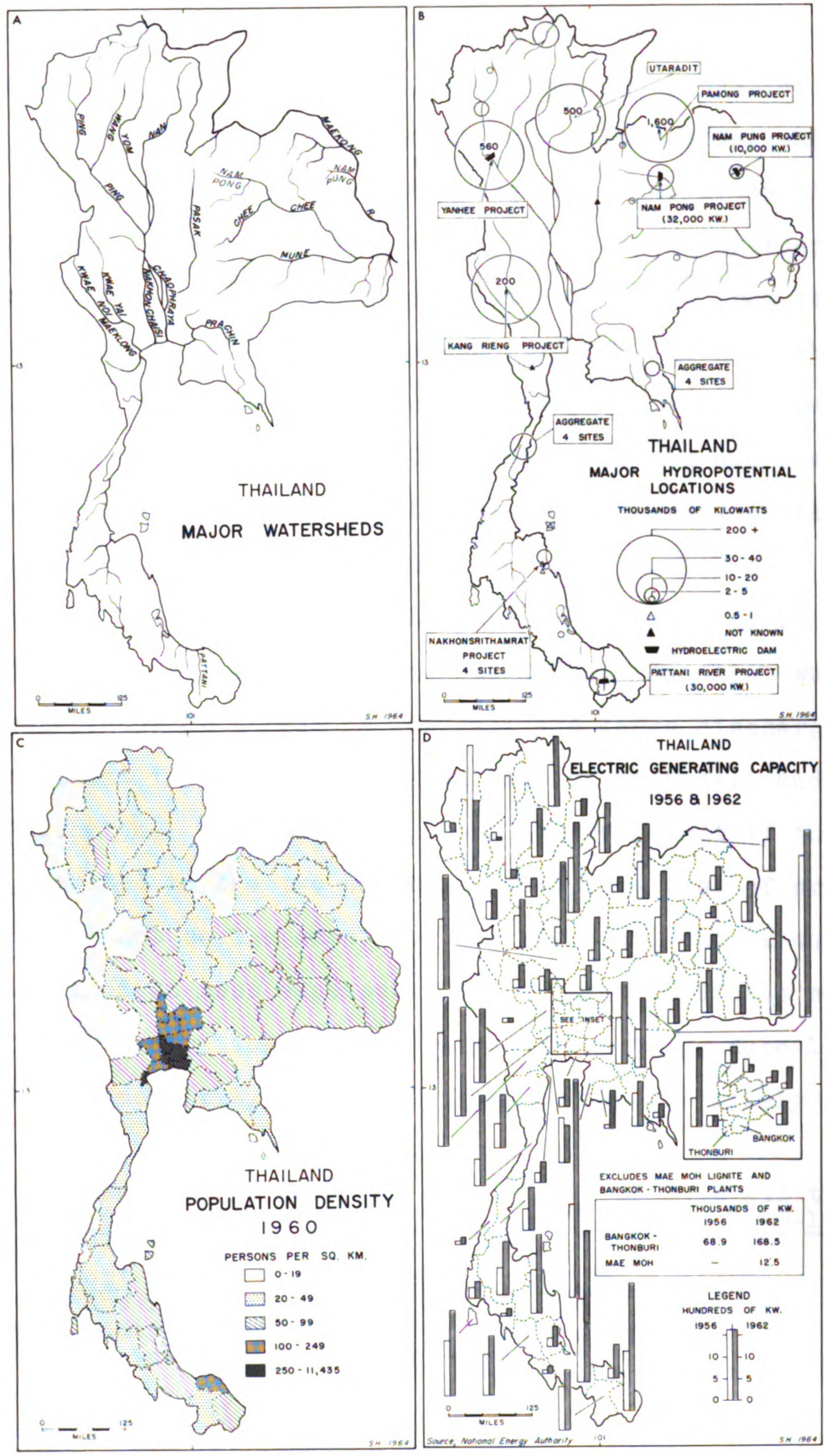
A
PING
WANG
YOM
NAN
NAM PONG
NAM PUNG
MAE KONG
CHEE
MUN
PASAK
CHAO PHRAYA
KWAE YAI
KWAE NOI
MAE KLONG
PRACHIN
THAILAND
MAJOR WATERSHEDS
MILES
S.H. 1964
B
UTARADIT
PAMONG PROJECT
500
1,600
560
NAM PUNG PROJECT (10,000 KW.)
YANHEE PROJECT
NAM PONG PROJECT (32,000 KW.)
200
KANG RIENG PROJECT
AGGREGATE 4 SITES
AGGREGATE 4 SITES
THAILAND
MAJOR HYDROPOTENTIAL LOCATIONS
THOUSANDS OF KILOWATTS
200 +
30 - 40
10 - 20
2 - 5
0.5 - 1
NOT KNOWN
HYDROELECTRIC DAM
NAKHONSRITHAMRAT PROJECT 4 SITES
PATTANI RIVER PROJECT (30,000 KW.)
MILES
S.H. 1964
C
THAILAND
POPULATION DENSITY
1960
PERSONS PER SQ. KM.
0 - 19
20 - 49
50 - 99
100 - 249
250 - 11,435
MILES
S.H. 1964
D
THAILAND
ELECTRIC GENERATING CAPACITY
1956 & 1962
SEE INSET
BANGKOK
THONBURI
EXCLUDES MAE MOH LIGNITE AND BANGKOK - THONBURI PLANTS
THOUSANDS OF KW.
1956
1962
BANGKOK - THONBURI
68.9
168.5
MAE MOH
—
12.5
LEGEND
HUNDREDS OF KW.
1956
1962
10
5
0
MILES
Source, National Energy Authority
S.H. 1964

Figure 3

country.[29] Only a very small percentage, however, is from waterfalls. Another source indicates that the potential may exceed this estimate. The National Energy Authority, which has conducted surveys of some 32 hydro-potential sites since 1954, reports nearly a million kilowatt of latent hydro-power in these alone.[30] This amount excludes the power from Yanhee project (560,000 kw.) and the Pamong (1.6 million kw.) which is part of an inter-national scheme--the Lower Maekong Basin Project. There are still more than thirty rivers and their tributaries and several waterfalls to be surveyed and their capacities estimated in the future.

Most of the hydro-potential power is expected to be derived from rivers and not from waterfalls. In other words, the power-producing stream of low fall and large discharge is more prominent in the planning than that of high fall and small discharge. It should be noted, however, that if the power generated in the two cases is equal, the cost of production will not be the same, for the high fall can be equipped and maintained at less expense. Most of the waterfalls surveyed for power generation are not large enough to produce large amounts of electricity. None of them, so far, is likely to

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[29] United Nations Economic Commission for Asia and the Far East, Electric Power in Asia and the Far East, 1956-1960 (E/CN. 11/597) (New York: 1962), p. 240.

[30] Report of the National Energy Authority, 1962, (Office of the Prime Minister, Bangkok: 1963), pp. 60-61. The report indicated only 28 sites were surveyed up to 1961; the rest were investigated after 1961.

be able to generate more than 15,000 kilowatts.

Major hydro-potential locations are shown in Figure 3B. Only four of these sites have a capacity over 100,000 kw. namely, Pamong (1.6 million kw.), Yanhee (560,000 kw.), Utaradit (500,000 kw.) and Kang Rieng (200,000 kw.). Of these only Yanhee is being actively exploited as yet and it recently began to transmit some electricity. Others remain in the planning stage, except Kang Rieng, which is designated as a first priority program to be implemented in the near future.

Besides these four of large potentials, others range from a mere 300 kw. to as much as 40,000 kw. They are located in smaller tributaries, streams and waterfalls, such as Mae Kok in the north, Nam Pung and Nam Pong in the northeast, tributaries of the Mune River in the east and the Pattani and other rivers in the south (Fig. 3A). Power from high-head type of stream could be realized from waterfalls in the province of Chantaburi in the southeast where aggregate potential of four sites may possibly reach about 14,500 kw.; and elsewhere especially in the Peninsula such as those in the provinces of Nakhonsrithamarat and Sogkla.

It is unlikely that all of these potentials will be developed in the foreseeable future. Economic, political and other factors may prevent effective exploitation. Nevertheless, several significant projects are already under implementation or are actively planned, and when they are completed they should satisfy the country's need of electric

power for a number of years to come.

Location of Energy Resources to Consuming Area

As noted earlier, firewood, wood and charcoal are generally consumed locally, though some amounts are moved over considerable distance for use by railroads and for other heating purposes. Riverboats, bullock carts, trucks, and railroads are the means of transporting such supplies.

Lignite is being exploited at or near the colliery mainly for production of electricity. From Mae Moh, in the north, however, much is moved by truck to a railroad station where it is loaded for carrying to power plants in the Bangkok area. At Krabi in the south, so far as it is known, lignite is utilized on the spot to generate electricity. If demand for lignite in other parts of the country rises it is conceivable that the supply may come from either or both of these mines. Because lignite has a low-value and high-weight ratio the distance it has to be moved is a significant factor. Without subsidy, it cannot hope to compete effectively against other sources of fuel if it has to be transported very far to market.

Thailand has come to rely upon a large importation of oil as a source of power. Deposits at Mae Fang in the north are inadequate for domestic needs. Oil and its products are distributed from Bangkok, mostly by means of railroads. Thus, the cost of petroleum in areas outside of Bangkok is apt to be higher--depending on the transportation costs that must be paid.

Power from hydro sources unlike charcoal, lignite and oil,

must be transported over transmission lines to consuming areas. Ideally, it would be advantageous to utilize the power generated on the spot, or as near the generating plant as practicable. The possibility of electric power transmission modifies somewhat the earlier controls of water power sites on the location of industry. Now it is possible to transmit power to great distances in the form of high voltage and low intensity currents through the use of transformers. But power still cannot be transported efficiently beyond a certain limit. The problem is one of cost. Transmission involves a loss of 10 to 20 per cent of the power and erection and maintenance of line is expensive. Thus, a point can be reached where costs of transmission exceed the value of power delivered.

The potential water power sites of Thailand, in most cases are located fairly close to consuming centers. The distances are generally not so great as to hinder economical and effective development. Presently, the main market for hydro-power is the Bangkok-Thonburi area and the surrounding provinces. Figure 3 C showing population density by provinces in 1960, indicates that the greatest concentration of people is in and around the provinces of Bangkok and Thonburi in the Central Plain. A major hydroelectric project, the Yanhee, is to serve this area, as well as other provinces in the Central Plain and Northern Regions. In the Northeast and the South separate programs are being

implemented to supply power to major urban and rural markets in these regions. Future inter-connection on a nation-wide basis will be possible when economic and other conditions call for such development.

Chapter III

EVOLUTION AND PRESENT CHARACTER OF THE ELECTRIC POWER INDUSTRY

Although electric energy has been used on a limited basis in Thailand for many years, it has been during only the last twenty to twenty-five years that the average citizen has become aware of its many potentials. Between 1929 and 1940 there was practically no change in the amount of installed generating capacity in the country. In 1940 this totaled only 32,000 kilowatts, and the production for the entire kingdom was recorded at 37.1 million kilowatt-hours[1] (see Appendix 2 for data on installed capacity and production from 1929 to 1961). The actual peak load served by this capacity is not accurately known, but in the Bangkok area alone, for which more information is available, the 1940 peak demand was approximately 12,000 kilowatts.[2]

During the Japanese occupation in World War II the

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[1] Statistical Yearbook, 1949-50, (United Nations, New York: 1952), p. 278; p. 250.

[2] U. S. Department of Interior, Bureau of Reclamation, "Report on Yanhee Multiple Purpose Project - Thailand," (Denver: 1955), p. 6. (Mimeographed).

generating capacity was reduced to zero by Allied bombing. In spite of this setback and the difficulties of reconstruction, a peak load of upwards of 22,000 kilowatts was served in Bangkok in 1950.

The demand has stayed considerably ahead of the ability to supply since the end of the war. Consequently, a number of extraordinary measures have been effected to maintain system loads at maximum generation and distribution capabilities. Direct measures to this end include blackouts on part of the system, limitation of motor loads during periods of peak demand, restriction of adding new loads, and the intentional lowering of voltage to reduce load. Because of these actions, especially the latter, and the inadequate distribution facilities, service provided by the system has been less than satisfactory.

In addition, the very structure of the power rate schedule has been an effective deterrent to increase of loads. This has allowed use of the first 50 kilowatt-hours per month at a rate of 0.65 baht per kilowatt-hour (about 3 cents), but increased the cost to 1.00 baht per kilowatt-hour for additional energy consumed. Thus, it is seen that what appeared to be a relatively large increase in generating capacity between 1940-1950 was still woefully inadequate to meet the growing requirements. The same can be said for the years since 1950.

Present Capacity

The growth of electrical generating capacity in Thailand between 1951 and 1961 is shown in Table 1 and Fig. 4A; also the type of power plants established. The capacity increased from 32,334 kilowatts in 1950[3] to 264,470 in 1961.[4] All of it was thermoelectric; no hydroelectric facilities existed. Over half of the 1961 total was located in Bangkok. This is evidented by the fact that in 1961 the Bangkok-Thonburi area accounted for 73.7 per cent of the total 466.54 million kilowatt-hours electric energy sales; also for 46.4 per cent of the 445,568 customers in the nation.[5]

The total generating capacity has risen rapidly since 1950. During the 1951 to 1955 period it increased by 152 per cent, while total production rose from 104.8 million kilowatt-hours to 288.5 million, or 175 per cent in four years. Between 1960 and 1961 there was a spectacular increment in generating capacity of nearly 50 per cent--from 177,610 kilowatts to 264,470. The same year total production increased about 21 per cent, rising from 501.5 million

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[3] Pendleton, op. cit., p. 261.

[4] Report of the National Energy Authority, 1962, op. cit., Table 2, p. 106.

[5] Ibid., Table 1, p. 105; Table 3, p. 107; p. 118. The total production of 611.88 million kilowatt-hours in 1961 was divided into 466.54 million sold, 106.89 million lost in transmission, and 38.45 million consumed within the generating plants.

kilowatt-hours to 611.9 million. This was largely because of additions of a large steam thermal plant in northern Bangkok and the Mae Moh lignite plant in northern Thailand.

These new power plants, it should be noted, reversed the 1950's trend of increasing relative importance of the generating capacity of diesel units. In 1959 these accounted for a peak 68.3 per cent of the total, but dropped to 48.9 per cent in 1961 (Table 1). The latter year electric energy generated by and purchased from steam plants accounted for 64.8 per cent of the total supply.

Not included in the above, is a substantial amount of generating capacity in the hands of industrial establishments, who have found it necessary to install facilities to meet their own needs in the absence of sufficient supplies from the public systems. Major plants, including only the Siam Cement Co. Ltd., the Royal State Railways Machine Tool Shop, the Port Authority, and the Thai Pulp and Paper Mill, had an installed capacity of 16,750 kilowatts with production of 92.38 million kilowatt-hours in 1960.[6] Surplus electricity is sold to outside agencies. This amounted to 13.82 million kilowatt-hours in 1960. No other detailed information concerning the private-owned plants is available, except that practically all are small, high-cost diesel units. Even so the cost of the power is not materially greater than

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[6] United Nations, Economic Commission for Asia and the Far East, Electric Power in Asia and the Far East, 1956-1960, op. cit., Table 2, p. 102; Table 12, p. 116.

Table 1

ELECTRICAL GENERATING CAPACITY BY

TYPE OF POWER PLANT, 1951-1961

Year	Total Capacity[a] (1000 kw)	TYPE OF POWER PLANT*			
		Steam Plant		Diesel Plant	
		1000 kw	Per Cent	1000 kw	Per Cent
1951	42.7[b]	n.a.	n.a.	n.a.	n.a
1952	48.3	27.3	56.5	21.0	43.5
1953	68.3	35.6	52.1	32.7	47.9
1954	81.5	22.6	39.9	48.9	60.1
1955	107.6	51.05	47.4	56.55	52.6
1956	135.68	53.05	39.10	82.63	60.90
1957	141.69	53.0	37.41	88.69	62.59
1958	150.38	53.63	35.66	96.75	64.34
1959	160.34	50.78	31.67	109.56	68.33
1960	177.61	61.00	34.34	116.61	65.66
1961	264.47	135.00	51.05	129.47	48.95

* There were no hydro-plants operating during the years covered.

a Excludes all industry-owned plants. In 1961, out of 264,470 kilowatts capacity, 250,850 were in government-owned plants and 13,620 in privately-owned units.

b Originally not in the Report, but inserted by the author. (Taken from United Nations, Economic Commission for Asia and the Far East, Electric Power in Asia and the Far East, 1951-1955 (E/CN.11/458), (Bangkok: 1957), p. 17).

Source: Report of the National Energy Authority, 1962 (Bangkok: 1963), Table 2, p. 106.

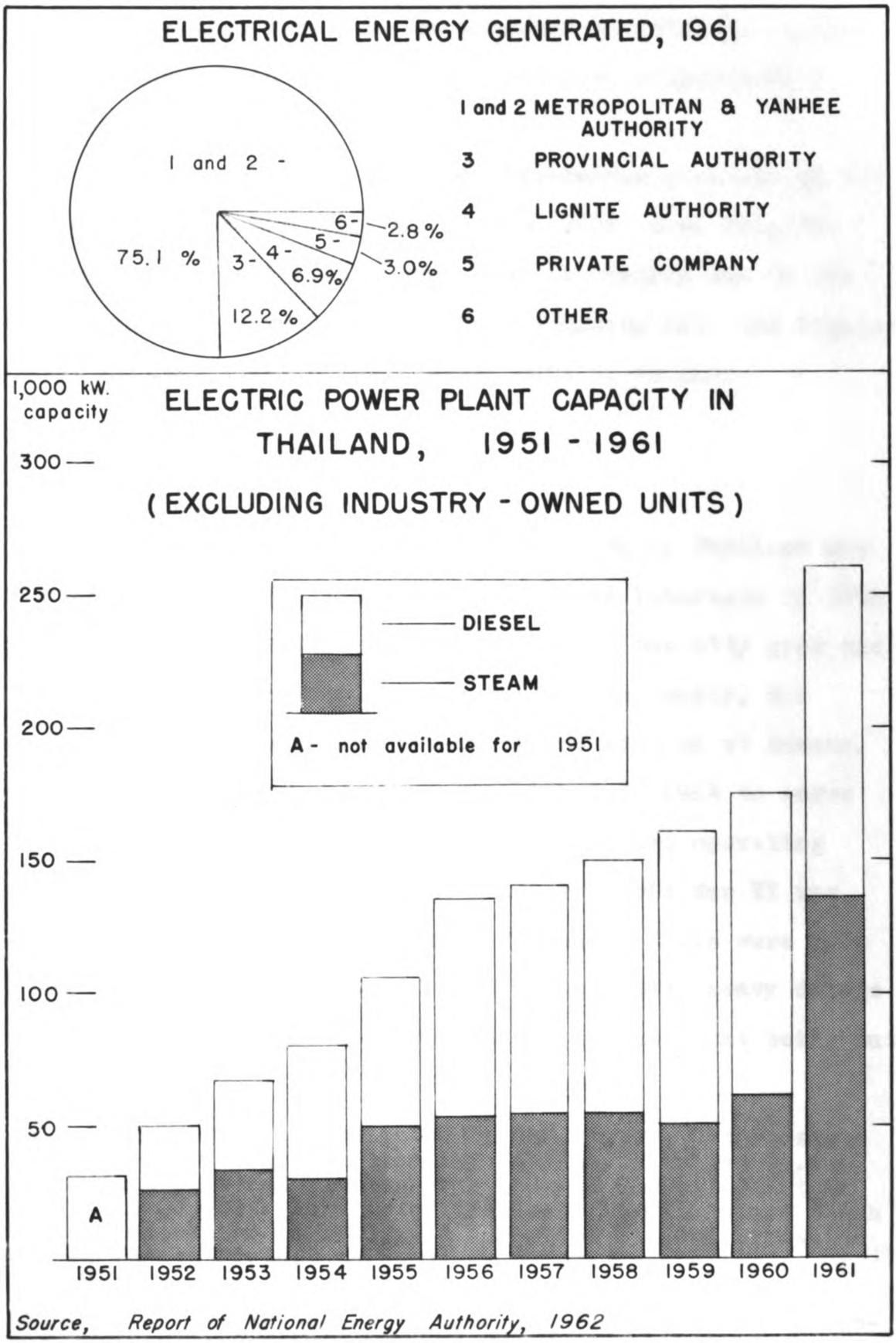
ELECTRICAL ENERGY GENERATED, 1961
1 and 2 - 75.1 %
3 - 12.2 %
4 - 6.9%
5 - 3.0%
6 - 2.8 %
1 and 2 METROPOLITAN & YANHEE AUTHORITY
3 PROVINCIAL AUTHORITY
4 LIGNITE AUTHORITY
5 PRIVATE COMPANY
6 OTHER
1,000 kW. capacity
ELECTRIC POWER PLANT CAPACITY IN THAILAND, 1951 - 1961
(EXCLUDING INDUSTRY - OWNED UNITS)
DIESEL
STEAM
A - not available for 1951
300
250
200
150
100
50
A
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
Source, Report of National Energy Authority, 1962

Figure 4

if the companies were able to purchase it from the facilities of the public system which also have comparatively high operating charges.

Presently (1964), the total generating capacity of the nation has probably reached, or soon will, some 500,000 kilowatts.[7] The increase over 1961 is largely due to the beginning of operation of the Yanhee Hydroplant, the lignite plant at Krabi, and a new thermal unit in Bangkok.

Bangkok-Thonburi Area

Generating Capacities

The first permanent electric facility in Thailand was a steam-generating plant built by Belgian interests in 1890 at Wat Liep in Bangkok. Subsequently, as the city grew and the demand for electric power exceeded the supply, the government built a second steam-powered station at Samsen, a suburb of Bangkok. It was established in 1914 to serve the northern parts of the city. The combined operating capacity of these two stations prior to World War II was no more than 22,000 kilowatts.[8] The major fuels were rice straw and firewood. Both facilities sustained heavy damage during the war, which resulted in the Samsen plant being out

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[7] The figure is estimated by the writer. It consists of the 264,470 kilowatt capacity in 1961, plus the 75,000 kilowatt unit added in the North Bangkok Thermal Plant in 1963, the 20,000 kilowatts of the Krabi lignite plant which started operation in 1963, and the first 140,000 kilowatts of the Yanhee Project which began generating in 1964.

[8] The precise figure cannot be obtained; this is an estimate by the writer based upon the facts given in Economic Commission for Asia and the Far East, 1951-1955, op. cit., p. 17.

of operation entirely from 1944 to 1948.

After the war the government purchased the Belgian franchise and repaired the Wat Lieb plant and also the one at Samsen. However, electricity available in the Bangkok area was grossly inadequate. According to one source the 1950 capacity of the Bangkok Electric Works (Wat Lieb) was 22,000 kilowatts and of the Samsen plant 3,000 kilowatts; and these two plants were supposed to serve an urban area of well over a million people.[9] Consequently, a severe power shortage existed in Bangkok as early as 1950, and since then it has been getting worse.

Another source indicates that in 1950 only the Wat Lieb station, with a capacity of 14,000 kilowatts, was operating.[10] A new 7,000 kilowatt generator was added to this plant in 1953 raising its capacity to 21,000 kilowatts. The Samsen Steam Plant was rehabilitated in 1952. Its operating capacity was then 9,000 kilowatts, but in 1955 two new units of 8,750 kilowatts each were added, raising the total to 26,500. With United States aid small diesel generating plants were installed from 1951 to 1953 in the outlying sections of the city to supplement the existing steam stations. These had a total capacity of 21,400 kilowatts. Thus, by 1955 the aggregate installed capacity for

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[9] Central Statistical Office, National Economic Council, Thailand, Statistical Yearbook, Thailand, 1952, New Series, Vol. 1 (Bangkok: 1953), p. 360, as cited by Pendleton, op.cit. p. 262.

[10] Statistical Information presented here is from Economic Commission for Asia and the Far East, 1951-1955, op.cit.,p.17.

supplying electricity in Bangkok-Thonburi area was 68,900 kilowatts. The furnaces of some of the existing boilers were modified in 1955-1956. These and new boilers that have been installed since are designed to burn domestic lignite, which was mined for this purpose the first time at Mae Moh in 1960.

The total capacity of the power stations feeding the Bangkok-Thonburi area remained at 68,900 kilowatts in 1956.[11] There was no significant change in 1957, but in 1958, an old unit of 7,130 kilowatts was taken out of commission, and ten 1,000 kilowatt diesel units were added in the diesel electric stations.[12]

The installation of the several diesel generating plants has temporarily helped to alleviate the acute power shortage, but permanent improvement will be obtained only with the completion and commissioning of the Yanhee hydroelectric plant in 1964. Another part of this comprehensive project is the North Bangkok thermal plant, which has an initial capacity of 75,000 kilowatts. It was constructed at a cost of 18 million dollars, with financial help from Export-Import Bank of the United States, and began to operate in March 1961. This new station is the largest and most efficient steam-operated unit ever established in Thailand. It is

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[11] United Nations, Economic Commission for Asia and the Far East, Electric Power Bulletin, 1956 (ST/ECAFE/SER.L/4), (Bangkok: 1957), p. 45.

[12] United Nations, Economic Commission for Asia and the Far East, Electric Power Bulletin, 1958 (ST/ECAFE/SER.L/6), (Bangkok: 1959), p. 64.

designed to burn either lignite or fuel oil. It and the Yanhee hydroelectric plant will ultimately be operated on an integrated basis; pending the completion of the Yanhee Project, it has helped greatly to relieve the acute power shortage in Bangkok.

The rapidly growing load in the capital city, due to improvement in facilities and promotion of new industries, together with possible delay in the progress of construction of the hydroelectric dam and the extended fill-up period of the reservoir, necessitated the installation of a second 75,000 kilowatt thermal unit at North Bangkok, adjacent to the first one, early in 1962. It was commissioned in late 1963. The loan for its construction was obtained from the Export-Import Bank. A plan for a third unit of the same capacity is being implemented.

In 1960 the power plants in the Bangkok-Thonburi area produced 365 million out of the national total of some 548.6 million kilowatt-hours.[13] With the present installed capacity of about 243,544 kilowatts they should be able to generate more than 1,000 million kilowatt-hours of electricity (Table 2).[14] The public supply in Bangkok-Thonburi is

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[13] United Nations, Statistical Yearbook, 1962 (New York: 1963), p. 316.

[14] According to one source, in 1960 there were in Bangkok three public utility power stations with generating capacity over 10,000 kilowatts, namely, Lumbini (diesel), 23,000 kilowatts; Samsen (steam and diesel) 27,500; and Wat Lieb (steam), 21,000. They generated 311.3 million kilowatt-hours. (United Nations, Economic Commission for Asia and the Far East, Electric Power in Asia, and the Far East, 1956-1960, op. cit., Table 20, p. 67.

also supplemented by the surplus available from power stations of the State Railways, the Port Authority, and a government-owned cement factory. There are in addition several privately owned generating plants operated by industries and other services. Although they have a sizeable aggregate capacity, precise information concerning this is not available. It is hoped that these agencies and establishments will utilize more public power when it becomes available at reasonably low cost.

Table 2

INSTALLED GENERATING CAPACITY

IN BANGKOK AND THONBURI, 1963

	Steam (kw)	Diesel (kw)
1. North Bangkok	150,000	-
2. Samsen	26,500	5,000
3. Wat Lieb	23,560	-
4. Lumbini	-	22,448
5. Thonburi	-	9,000
6. Klue Nam Thai	-	4,036
7. Bang Kho Laem	-	3,000
Total	200,060	43,484
Grand Total	243,544 kw.	

Source: National Energy Authority (personal communication through the writer's father).

Distribution Facilities

While the increase in generating capacity was taking

place, the shortage of this in relation to rising demand was being gradually overshadowed by the growing inadequacy of the power distribution system in the Bangkok area. In spite of severe restrictions on the off-take of the supply and rotational black-outs in different sections of the city on specified days of the week, and other direct measures, the peak supply that could be delivered was insufficient to meet the demand. Between 1950 and 1956 the peak load, it is estimated, grew by 16 per cent a year on average.[15] By 1961 it was increasing at 1,000 kw. per month. The limited condition of the peak load supplied during the early and middle fifties was primarily due to the inability to satisfactorily deliver the full amount of power that could be generated through the existing distribution facilities. These were not only inadequate, but had to operate as isolated systems because of a lack of switching facilities necessary for interconnection.

The Public Works Department foreseeing the advent of this situation, had introduced a plan for expansion of the Bangkok-Thonburi distribution system in 1953. This included interconnection of existing power stations, increasing the voltage of a portion of the system from 3,500 to 11,000 volts, and expanding feeder and transformer capacity. These additions allowed expansion of the load carried by the existing facilities, but introduction of a large amount of Yanhee

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[15] International Bank of Reconstruction and Development, op. cit., p. 114.

Project power will require further major improvements and additions to the distribution system of the Bangkok-Thonburi area. Consequently, work was begun on a new distribution system with a capacity of 25,000 kilovolts considered enough to meet demands for the next ten years. Started in 1959, it is now being completed.

The system will eventually be connected to that of the Yanhee hydroplant. To finance this improvement in the Bangkok-Thonburi area in anticipation of increased power available from the Yanhee Project, a loan of $20 million was provided by the United States Development Loan Fund. Simultaneously, the Metropolitan Electricity Authority has accomplished the conversion of consumers' voltage from the previously existing 110 volts to the more economical 220 volts, the standard recently adopted in Thailand.

Provincial and Rural Areas

The generation of electricity in Thailand up to now has been almost exclusively for the benefit of consumers in the single large urban center, Bangkok. The electric power supply in provincial areas is in a marked constrast to that in the capital. Out of the total generating capacity of 32,334 kilowatts in 1950, only 7,334 existed in areas outside the city.[16] Although exact information on the pre-war period is not available, very few people indeed outside those in the capital must have enjoyed the ameanity of electricity.

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16 Pendelton, op. cit., p. 261.

The public electricity supply in provinces outside Bangkok was first commenced in 1930. The Public Works Department undertook to provide power in large towns, while municipalities and certain private concerns operated plants under licenses in smaller places. Certain state agencies, such as the railroads, also provided electricity in some towns. Private undertakings, from time to time have been taken over by the municipalities. After World War II the government established the Provincial Electricity Organization, which co-operated with the Department of Public Works in extending service to semi-rural townships previously without electricity.

Although precise information regarding electric power during the pre-war period is not available some idea can be obtained from a survey conducted by the National Economic Council of Thailand in 1952. This reported that the generating capacity in 33 changwads or provinces in the Central Plain was relatively static between 1940 and 1950, at about 5,000 kilowatts.[17]

Early in 1954, the government instituted a provincial electrification scheme with a goal of supplying electricity to every municipality. This scheme envisioned establishment of 217 diesel generating stations with an aggregate

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[17] As quoted in Report on Yanhee Multiple Purpose Project, op. cit., p. 8.

capacity of about 16,000 kilowatts.[18] Of these, eight with a total capacity of 830 kilowatts were put in operation in 1954. Another 36 with a total capacity of 3,840 kilowatts were added in 1955. These plants consisted of either two 55 kilowatt, or two 25 kilowatt diesel units. Twenty-five more stations were installed in 1956, with a total capacity of 5,112 kilowatts. The generating capacity of the provincial electricity undertakings thus rose from 4,670 kilowatts in 1955 to 9,782 in 1956. Moreover, several diesel units were installed by municipalities and by privately owned utilities.

From 1956 to the end of 1958, except the installation of a new 4,000 kilowatt unit in the steam plant at Saraburi which is about 70 miles north of Bangkok, no large facility for the public supply of electricity was added. A number of small units began operation, however, and at the same time some inefficient ones were removed. The result was that generating capacity increased fairly rapidly. As of October 1959, there were 352 power stations, all diesel-engine driven, in provincial towns and villages throughout the country, with a combined installed capacity of 65,600 kilowatts.[19]

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[18] Statistical information presented is from United Nations, Economic Commission for Asia and the Far East, Electric Power in Asia and the Far East, 1951-1955, op. cit., p. 17; and United Nations, Economic Commission for Asia and the Far East, Electric Power Bulletin, 1956, op. cit., p. 45.

[19] United Nations, Economic Commission for Asia and the Far East, Electric Power Bulletin 1959 (ST/ECAFE/SER. L/7), (Bangkok: 1960), p. 79.

A significant development in regard to the energy resources of Thailand has been the opening up of lignite mines in the northwest at Mae Moh. The Lignite Power Organization, established in 1954 and since reconstituted as a statutory authority, has undertaken the mining operations and is also running a lignite-burning power plant, completed in 1960 with a capacity of 12,500 kilowatts. The Australian government provided assistance under the Colombo Plan for the supply and installation of the necessary equip ment for mining and processing the lignite, while the United States International Cooperation Administration (now known as Agency for International Development) financed the cost of the power station. This steam plant, the first to be built in Thailand outside of Bangkok, supplies electricity to the three northern changwads of Lampany, Lampoon and Chiengmai, and is also a source of power for the Yanhee Dam construction.

The supplying of electrical power in the southern provincial and rural areas received impetus in 1961 when the government, authorized the construction of a 40,000 kilowatt steam plant, utilizing the local supply of lignite, at Krabi in the southern peninsula. The first 20,000 kilowatt unit went into commercial operation in August, 1963, while the remaining capacity is expected to be commissioned some time early in 1964.

Installation of electric power in areas outside Bangkok has been very slow in relation to the increase in population

there. In 1961 the population of Thailand was estimated to be 27,181,000 of which some 2,000,000 lived in the Bangkok area.[20] Only about two million inhabitants (238,825 customers) outside of the capital city were being supplied with electricity by the Provincial Electricity Authority and privately owned plants, which together numbered about 384 separate diesel-electric stations (234 operated by the P.E.A. and 150 by private organizations) with installed capacity of 77,000 kilowatts.[21] Addition of 12,500 kilowatts capacity of the lignite plant at Mae Moh to this gave a capacity of 89,500 kilowatts to serve Thailand outside of Bangkok. The same year the total national capacity was 264,470 kilowatts. Today the capacity available in the provincial areas is not less than 109,500 kilowatts, excluding any furnished from Yanhee. This is because of the start of the lignite plant at Krabi.

As far as the electrical load is concerned, the peak demand in provincial areas was reported at 36,000 kilowatts in 1961 and the consumption has been increasing since then about 15 per cent per year.[22] In most of the country outside Bangkok, the use of electric power in industry is presently

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[20] Report of National Energy Authority 1962, op. cit., p. 110.

[21] United Nations, Economic Commission for Asia and the Far East, Proceedings of the Regional Seminar on Energy Resources and Electric Power Development, 1962, op. cit., p. 440.

[22] Ibid., p. 440.

limited to a few major plants which operate their own generating equipment. Thus, the total peak load will increase greatly if industrial establishments, whose power is now non-electrical, shift to electric power if and when it is available at a reasonably low cost.

Summary of Recent Generating Capacity Growth

From the foregoing discussion, the big growth of electric generating capacity in Thailand is very evident. Figure 3 D indicates the increase between the years 1956 and 1962.[23] However, the illustration excludes the Mae Moh lignite and main Bangkok-Thonburi plants. Thus, what is shown includes the electric stations under the Provincial Electricity Authority and the private utilities with franchises of the entire country.

The growth is evident in most of the provinces. Some have shown tremendous increases. In Cholburi in the Central Region, for example, capacity increased over 100 per cent, from 2,196 kilowatts in 1956 to 5,158.9 in 1962. But it is interesting to note that there was little change in a few provinces. In Nonthaburi, the capacity remained practically the same, being 257 kilowatts; in Angthong it declined from 273 to 188 kilowatts; while in Samutsakhon it dropped from 1,120 to 883. One of the main reasons was that more power

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23 The National Energy Authority has figures back to 1956 only, and that for 1962 is the most recent available. This information was obtained from the N.E.A. through the writer's father.

was supplied from the main plants in Bangkok-Thonburi area, as these provinces are located near the capital city (Fig. 1). Local stations were thus closed down or put up on stand-by basis. This situation has also been true of the three northern provinces of Lampang, Lampoon and Chiengmai, where generating capacity declined from 2,310 to 210/200 from to 77, and from 2,967 to 1,688 kilowatts respectively. The most notable decline is seen to be in the province of Lampang. The operation of Mae Moh lignite plant since 1960 is the main factor responsible for the reduction in Lampang and in the other two provinces as well.

The future will probably see the same development throughout the country as several projects, now under implementation, are realized. Local power stations in Northern and Central Regions are already distributing energy generated by the initial stage of the Yanhee hydroplant in Tak; while in the south power from the Krabi lignite plant will supplement and probably eventually replace much of high-cost local power stations.

The total capacity under the jurisdiction of the Provincial Electricity Authority and private utilities with franchises increased from 53,104.4 kilowatts in 1956 to 82,828.5 in 1962. This increment of over 50 per cent must be considered a fairly rapid one. Including the generating capacity of the Mae Moh and main Bangkok-Thonburi plants, the total capacity in 1962 would be 317,098.5 kilowatts. This amount, of course, excludes all industry-

owned capacity, which was fairly sizeable. However, it is possible that the aggregate capacity of these private enterprises might have slightly declined over the years as more power from public utilities became available at lower cost. Since 1962, a second thermal unit of 75,000 kilowatts was added in Bangkok, the 20,000 kilowatt unit of the lignite plant went into commercial operation in 1963, and the initial stage of Yanhee Hydroelectric Project began to generate electricity in May, 1964. These projects alone have raised the total generating capacity to at least 477,098.5 kilowatts. Furthermore, additional capacity installed under the Provincial Electricity Authority and private enterprises with franchises, if any, between 1962 and 1964, would have raised the total generating capacity of the nation over the 477,098.5 kilowatt figure. It is not unlikely that if more Yanhee power is realized and the second unit of Krabi lignite plant is completed by the end of 1964, the aggregate capacity will reach more than 500,000 kilowatts.

Compared to the 1961 capacity, the increase over three years to the end of 1964 would then be nearly 100 per cent. Even if the figure of 477,098.5 for early 1964 is used the growth in capacity was 80.3 per cent. Either gain must be considered a stupendous achievement, All signs indicate even more rapid expansion in the future.

Comparison With Other Countries

Although the electric power supply has considerably improved during the post-war period Thailand is still one

of the lowest power consumers in the world on a per capita basis. It is estimated that total generation in Bangkok, where most of the power is used, amounted to 250 million kilowatt-hours during 1956, as compared to 917 million in Manila, a city of comparable size.[24]

Electric power consumption is one of the indicators of the level of living of a people, as shown by high use in such advanced countries as Norway, the United States, Switzerland, and the United Kingdom. The extent to which electric power use in Thailand is underdeveloped is shown in Table 3, which gives per-capita consumption of electricity in selected countries. Thailand's low standing is very apparent. Consumption per person, nevertheless, increased 100 per cent between 1956 and 1961 (Table 4). This is remarkable except that the amount in 1956 was so small to begin with and the effects of the increase were limited to a relatively small part of the nations people. Even the full development of Yanhee capacity (560,000 kilowatts), which is scheduled in 1975, will not raise the use of electricity per head to the 1960 figure for the Philippine Islands (Table 3).

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[24] International Bank of Reconstruction and Development, op. cit., p. 114.

Table 3

ELECTRIC CONSUMPTION PER CAPITA IN SELECTED COUNTRIES, 1960

Country	Population (thousands)[a]	Consumption (kwh) per capita
Pakistan	88,041	13.1
Thailand	25,520	14.44[b]
India	438,000	31.6
Philippines	27,456	68.7
Japan	93,418	939.2
United Kingdom	52,675	2,470 c
Switzerland	5,429	3,350 c
United States	180,673	4,690 d
Norway	3,586	8,770 c

a Population of the United Kingdom, Switzerland, United States, and Norway is from United Nations, Statistical Yearbook, 1961, Table 1.
b Report of National Energy Authority, 1962, Bangkok, p. 110.
c Represent gross consumption per capita. Figures to the nearest ten kwh.
d Excluding Alaska and Hawaii.

Source: United Nations, Economic Commission for Asia and the Far East, Electric Power in Asia and the Far East, 1956-1960, op. cit., Table 10, pp. 98-100, United Nations, Economic Commission of Europe, The Situation and Prospect of Europe's Electric Power Supply Industry in 1960-61 (ST/ECE/EP.11), (Geneva: 1962), Table 3-4, pp. 9-10.

Table 4

RATIO OF ELECTRIC PRODUCTION AND CONSUMPTION

TO THE TOTAL POPULATION OF THAILAND, 1956-61

Year	Population	Generating capacity kw. per 1,000 people	Production per capita (kwh)	Consumption per capita (kwh)
1956	22,812,700	5.95	12.00	8.83
1957	23,348,000	6.07	13.10	10.03
1958	23,908,000	6.29	14.88	11.20
1959	24,481,000	6.29	17.80	12.70
1960	25,520,000	6.96	19.64	14.44
1961	27,181,000	9.73	22.51	17.76

Source: Report of the National Energy Authority, 1962, op. cit., p. 110.

Organization of the Power Industry[25]

National Energy Authority (N.E.A.)

To improve electric power services in Bangkok and in the provinces, the Thai Government created the National Energy Authority (N.E.A.) in 1953. It is a central government organization primarily responsible for the planning and coordination of schemes for development of energy resources, for procuring and establishing energy works, for laying down the policy and devising control in connection with energy production, transmission and distribution, and for establishing standards and prescribing rates for the sale of energy. The N.E.A. is headed by a Board, the chairman of which is the Prime Minister. The actual execution and operation of power projects are in the hands of four other authorities, namely, the Metropolitan Electric Authority (M.E.A.), the Yanhee Electric Authority (Y.E.A.), the Lignite Authority (L.A.), and the Provincial Electric Authority (P.E.A.).

Metropolitan Electricity Authority (M.E.A.)

The M.E.A. is a result of the merging of two old organizations, the "Bangkok Electric Works" and the "Govern-

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[25] Information was obtained from various sources, namely, C. V. Shawler and Athorn Patumasutra, "The Organization and Administration of Power Industry in Thailand," Proceedings of the Regional Seminar on Energy Resources and Electric Power Development, op. cit., pp. 250-252; "Provincial and Rural Electrification in Thailand," ibid., pp. 439-441; Electric Power in Asia and the Far East, 1956-1960, op. cit., pp. 44-47; and Report of the National Energy Authority, 1962, op. cit., pp. 1-12.

ment Power Station". Originally, a special electric energy franchise was first granted to a Danish Company by the Siamese Government in 1884, to provide power for tramway service between Bangkolaem and the Royal Grand Palace. In 1900, the rights were transferred to a Belgian Company, known as the "Siam Electric Co. Ltd." As a result of expansion the power plant was established at Wat Lieb. Still under the same franchise the name of the company was changed later to the "Siam Electric Corporation, Ltd." When the franchise was terminated in 1950, the government took over and carried on the operation under the name of "Bangkok Electric Works." It was a semi-governmental organization and was attached to the Department of Public Works, Ministry of Interior.

In 1904 the "Sam Sen Electric Organization" was established by the government. This agency distributed power to customers in Bangkok and Thonburi outside the service area of the Siam Electric Co. Ltd. In 1934, it was organized as a division, generally known as the "Government Power Station," in the Department of Public Works, Ministry of Interior. Finally, it and the Bangkok Electric Works consolidated into one, called the "Metropolitan Electricity Authority," on August 1, 1958.

The M.E.A. operates some power plants and is responsible for power distribution in Bangkok and Thonburi. It receives wholesale power from the Yanhee Electricity Authority (Y.E.A.), which it serves to the public through its

distribution system. Not only is this power generated locally, some of the major Bangkok-Thonburi plants being operated by the Y.E.A., but starting in 1964 energy began to come from the Yanhee Dam in Northern Thailand. In the future increasing amounts will originate there.

Yanhee Electricity Authority (Y.E.A.)

Y.E.A. was created by the N.E.A. in 1954 to develop and operate the Yanhee Project. Three years later, the Yanhee Electric Authority Act was enacted, thus establishing an autonomous organization. It is largely a generating agency, responsible for generation and high-voltage transmission of power in its grid supply areas of the Central Plain and Northern regions. When its grid system is completed, Y.E.A. will be generating power and carrying it to 35 provinces, including Bangkok and Thonburi. Prior to May, 1964, it concentrated on the primary objective of providing power to Bangkok and Thonburi only. Presently, the initial stage of operation to supply electricity to other provinces is beginning to materialize. It should be noted that the distribution of power within the various provinces covered by the Yanhee grid system will be the responsibility of the Provincial Electric Authority, except for Bangkok and Thonburi where it is the function of M.E.A. Under this arrangement, Y.E.A. is operating other existing power stations in Bangkok-Thonburi area.

Lignite Authority (L.A.)

To render the construction of the Yanhee Project possible, power was needed to start with. Thus, in 1954 the Lignite Thermal Power Organization was established to manage the lignite mine at Mae Moh in the north, and later the one at Krabi in southern peninsula. Besides serving the purpose of making construction power available to the Yanhee Project the organization was to later serve as a standby source of electricity or to produce for industrial purposes. The Lignite Thermal Power Organization became an autonomous body in December, 1960 and was renamed the Lignite Authority.

The Lignite Authority is a generating agency serving the Yanhee Dam site and supplying electric power in bulk to the Provincial Electricity Authority for distribution in three northern provinces of Chiengmai, Lampang and Lampoon; also for distribution by the same authority to areas in southern peninsula from its Krabi lignite thermal plant.

Provincial Electricity Authority (P.E.A.)

Electric service for the rural areas was initiated in 1929 by the government establishing an Electric Section affiliated with the Department of Public Health, Ministry of Interior. This was charged with establishing an electric power station in every sanitary area throughout the country. Later on through reorganization, the Electric Section became

the Electric Division in the Department of Public Works, Ministry of Interior, and still later, in 1953 its name was changed to the Provincial Electricity Division. It should be noted that about 1929 the practice of issuing energy franchises originated and it was this division that had certain jurisdiction over the municipality-owned and privately-owned plants that resulted.

Before the Second World War, the Public Works Department undertook the power supply in large towns, while municipalities and certain private concerns operated under licenses in small towns. State agencies, such as the Railways, also provided electricity in some towns. Certain of the private undertakings were taken over from time to time by the municipalities. After 1945, it was realized that electric service had not been developed extensively enough in most rural areas. Consequently, a new semi-governmental organization called the "Provincial Electricity Organization" was formed. Cooperating with the Department of Public Works it was assigned the primary purpose of providing electrical service for every community. With a view to promoting effectively the development of electric power supply facilities, the Provincial Electricity Organization was reorganized as the Provincial Electricity Authority in September, 1960. The P.E.A. is responsible for the local distribution of power except in Bangkok and Thonburi. It has taken over power stations from municipalities and some government agencies, put up new stations, and augmented existing ones.

The P.E.A., as mentioned above, purchases electricity in bulk from the Mae Moh lignite thermal plant in the north to supply three provinces and also from Krabi plant in southern peninsula for ten provinces. The rest of its system is still supplemented by locally generated electricity from diesel plants. Presently the authority is implementing a plan for tying the distribution systems of 32 provinces to the Yanhee grid system and for the change-over of the supply from the existing diesel stations to that from the Yanhee Authority.

The primary powers and duties of these five authorities are shown in Table 5 below. Referring to these authorities it should be noted that only the N.E.A. was created in the interest of regulation, co-ordination and control of energy entities.

In addition to the power enterprises discussed above, there are a number of privately-owned utilities whose franchises were granted by the government. They operate with either five (PVT-5) or twenty-five (PVT-25) years concession. Most of them are very small in size. They have diesel-alternating sets, associated with local distribution systems. The total number of private utilities in 1961 was 182 (55 PVT-25 and 127 PVT-5).[26] They accounted for only three

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[26] Report of National Energy Authority, 1962, op. cit., p. 104.

Table 5

COMPARATIVE STATEMENT OF PRIMARY POWERS AND DUTIES OF THAILANDS POWER AUTHORITIES

No.	Subject	M.E.A.	P.E.A.	Y.E.A.	L.A.	N.E.A.
1.	Generate, acquire, exchange transmit.....	x[a]	x	x	x	x
2.	Distribute.....	x	x	-	-	x
3.	All related activities.....b	-	-	-	x	x
4.	Determine rates.....	x	x	x	x	x
5.	Free from taxation under revenue code and duties on equipment.....	-	-	x	x	x
6.	Construct.....	x	x	x	x	x
7.	Standard of Construction...	x	-	x	x	x
8.	Investigate, Survey, Plan	x	x	x	x	x
9.	Borrow and Invest Money..	x	x	x	x	x

[a] Until provision of Section 14 of Y.E.A. Act becomes effective
b Indicates use of power in subsidiary industrial operation

Source: C. V. Shawler and Athorn Patumasutra, op. cit., p. 251.

per cent of all electric energy generated that year. In contrast during the same year, as indicated in Figure 4, the M.E.A. and the Y.E.A. together generated 75.1 per cent of the total production, while the P.E.A. was responsible for 12.2 per cent, the L.A. 6.9 per cent and others 2.8 per cent (Fig. 4B).[27]

[27] Ibid., p. 117.

Chapter IV

PROPOSED REGIONAL DEVELOPMENT OF HYDROELECTRIC PROJECTS

Development of Hydroelectricity

The existence of many rivers and waterfalls have long prompted the Thai Government to consider these renewable resources as a means of economical development of electric power. As far back as 1929, general investigation was made of hydroelectric possibilities at sites considered suitable for power supply to a railway line electrification project.[1] But nothing resulted from this. Later, in 1938, a survey of a potential hydroelectric site for producing electricity for Bangkok and other towns in the vicinity was conducted at Kang Rieng on the Kwae Yai tributary in Kanchanburi in 1938[2] (Figure 1 and 3A). Progress on this was interrupted by World War II.

After 1946 the demand for electricity increased so rapidly that it far outstripped the supply. Consequently, the government's attention was again turned to utilization

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[1] United Nations, Economic Commission for Asia and the Far East, Report of the Working Party on Assessment of Hydroelectric Potentials, To the Sub-Committee on Electric Power, (E/CN.11/I & NB/Sub-I/12, 26 August, 1957), (Bangkok: 1957), p. 40.

[2] Report of National Energy Authority, 1962, op. cit., p. 2.

of water resources for electric power generation, supplementing the existing steam and diesel plants. In 1952 the National Power Committee was established, especially to investigate the immediate power shortage in the Bangkok area. The outcome was the Yanhee hydroelectric project for the Northern and Central Plain Regions. The following year the National Energy Authority (N.E.A.) was set up at the recommendation of the World Bank.

The government's realization of the significance of cheap electric power to the nation's economic development is clearly reflected in the words of the Executive Secretary of the Committee on Electric Power, Economic Commission of Asia and the Far East, Mr. C. V. Narasimhan, who stated, "the exploitation of hydroelectric power is important for the economic development of the countries of the region (Asia and the Far East)...Such development of energy is vital for the improvement of ameanities and living conditions of the population of the region."[3] The immediate objective of the government's hydroelectric programs is to increase the supply of electric power to offset the present shortage; in the long run, it is hoped to replace steam and diesel generating plants as the major source of electric supply. The depletion of wood and firewood supplies, the

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3 United Nations, Economic Commission for Asia and the Far East, Report of the Working Party on Assessment of Hydroelectricity Potentials, 1957, op. cit., p. 2.

increasing costs of imported fuel oil and coal, and the limited deposits of lignite which could be better utilized in other ways, have logically supported the government's plan.

From 1954 to 1961 the National Energy Authority conducted preliminary reconnaissance on some twenty-eight hydro-potential sites (Table 6).[4] Some of them are shown in Figure 3 B. Numerous projects are being studied, being surveyed, or are under way. At present (1964) one of the hydroelectric stations is already in service, though its planned capacity will not be reached until much later. It is known as the "Yanhee Hydroelectric Plant."

The future power system of Thailand is taking shape region by region; each region is being independently developed. The interconnection of these regional systems will be made as soon as economically feasible. According to the N.E.A., the country is devided into four zones or regions, as shown in Figure 1. They are: Central (Central Plains), Northern, Northeastern, and Southern (Southern Peninsula). Each of these has a varying number of provinces; the Central--the largest--has 28, the Northern,14; the Northeastern, 15; and the Southern, 14. The three main areas of current development are the Northern and Central regions together,

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[4] Report of National Energy Authority, 1962, op. cit., pp. 60-61.

the Northeastern part of the country, and the Southern Peninsula.

Several of the larger hydroelectric projects are discussed in the following pages. In Northern and Central regions the Yanhee Project (560,000 kw.) is nearly completed, and has partially begun to transmit electricity; the Kang Rieng Project (200,000 kw.) will be developed in the near future (Figure 3 B). In the Northeast, two shcmes, Nam Pong (32,000 kw.) and Nam Pung (10,000 kw.), are currently under construction. In the South two other programs are being developed. One is the Pattani River Project (30,000 kw.) and the other the Nakhonsrithamarat, which is a composite of four small projects (only one will be implemented at first). Other potential sites are being investigated or actively planned.

Northern and Central Plains Region

This area is under the drainage system of two major rivers--the Chaophraya and the Maekong and their tributaries. The Northern area is one of parallel mountain ridges between which the Ping, Wang, Yom and Nan Rivers drain southward into the Chaophraya (Fig. 3 A). These rivers flow in "Entrenched meanders, in elongated level-floored basins"[5] To the extreme north are the wide, level and often swampy basins draining northward to the Maekong. The streams in the north have created conditions which provide good reservoir possibilities and sites for hydroelectric stations.

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[5] Pendleton, op. cit., p. 40.

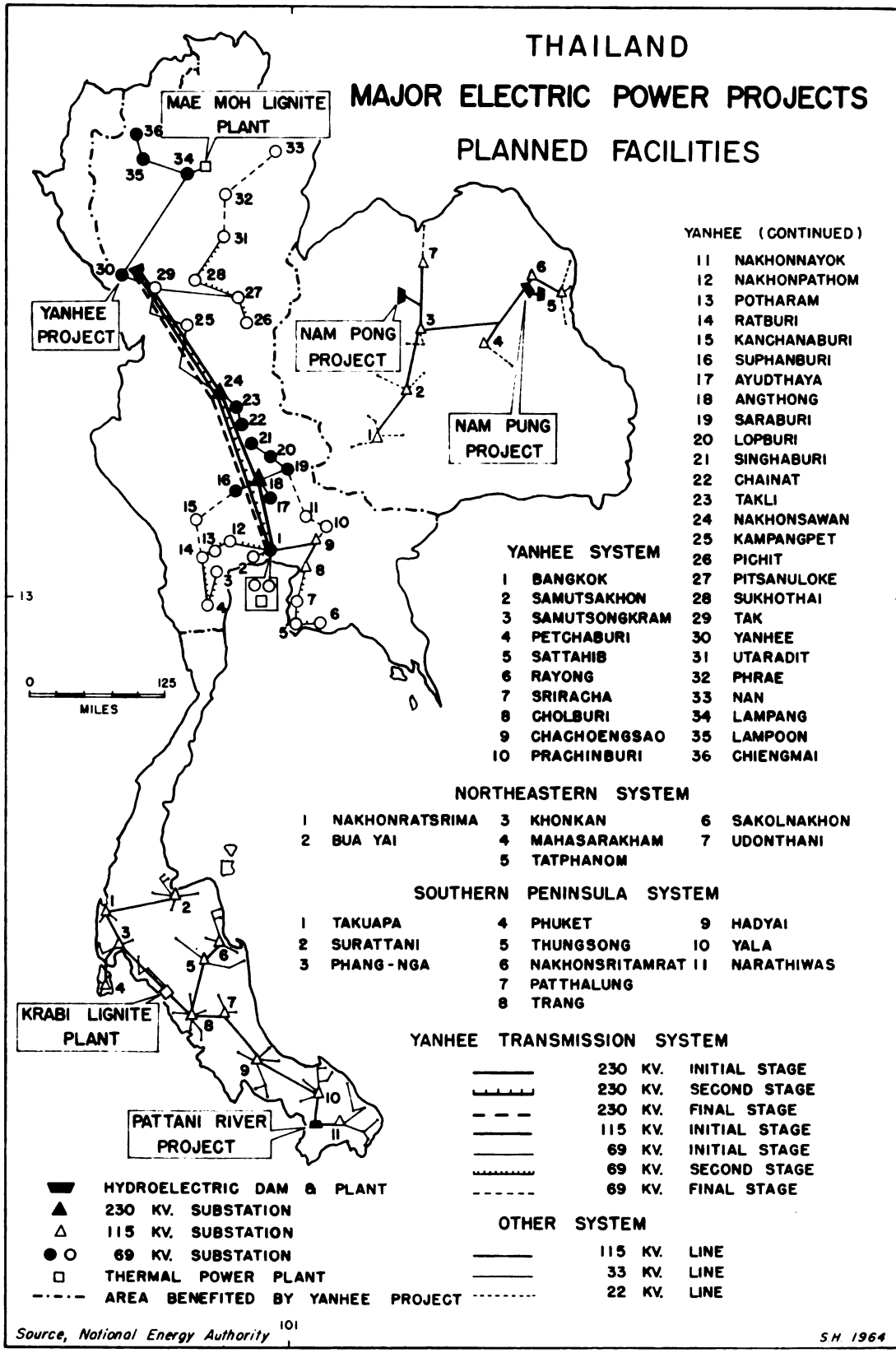
THAILAND
MAJOR ELECTRIC POWER PROJECTS
PLANNED FACILITIES
MAE MOH LIGNITE PLANT
YANHEE PROJECT
NAM PONG PROJECT
NAM PUNG PROJECT
KRABI LIGNITE PLANT
PATTANI RIVER PROJECT
0 125
MILES
YANHEE SYSTEM
1 BANGKOK
2 SAMUTSAKHON
3 SAMUTSONGKRAM
4 PETCHABURI
5 SATTAHIB
6 RAYONG
7 SRIRACHA
8 CHOLBURI
9 CHACHOENGSAO
10 PRACHINBURI
YANHEE (CONTINUED)
11 NAKHONNAYOK
12 NAKHONPATHOM
13 POTHARAM
14 RATBURI
15 KANCHANABURI
16 SUPHANBURI
17 AYUDTHAYA
18 ANGTHONG
19 SARABURI
20 LOPBURI
21 SINGHABURI
22 CHAINAT
23 TAKLI
24 NAKHONSAWAN
25 KAMPANGPET
26 PICHIT
27 PITSANULOKE
28 SUKHOTHAI
29 TAK
30 YANHEE
31 UTARADIT
32 PHRAE
33 NAN
34 LAMPANG
35 LAMPOON
36 CHIENGMAI
NORTHEASTERN SYSTEM
1 NAKHONRATSRIMA
2 BUA YAI
3 KHONKAN
4 MAHASARAKHAM
5 TATPHANOM
6 SAKOLNAKHON
7 UDONTHANI
SOUTHERN PENINSULA SYSTEM
1 TAKUAPA
2 SURATTANI
3 PHANG-NGA
4 PHUKET
5 THUNGSONG
6 NAKHONSRITAMRAT
7 PATTHALUNG
8 TRANG
9 HADYAI
10 YALA
11 NARATHIWAS
YANHEE TRANSMISSION SYSTEM
230 KV. INITIAL STAGE
230 KV. SECOND STAGE
230 KV. FINAL STAGE
115 KV. INITIAL STAGE
69 KV. INITIAL STAGE
69 KV. SECOND STAGE
69 KV. FINAL STAGE
OTHER SYSTEM
115 KV. LINE
33 KV. LINE
22 KV. LINE
HYDROELECTRIC DAM & PLANT
230 KV. SUBSTATION
115 KV. SUBSTATION
69 KV. SUBSTATION
THERMAL POWER PLANT
AREA BENEFITED BY YANHEE PROJECT
Source, National Energy Authority
101
SH 1964

Figure 5

Table 6

HYDROPOTENTIAL LOCATIONS IN THAILAND

Surveyed 1954-1961

Rivers and Waterfalls	Provinces	Estimated Generating Capacity (kw.)
Northern		
Mae Khan	Chiengmai	2,500
Mae Cham	"	20,000
Kok River	Chiengrai	40,000
Central		
Kwae Yai River[1]	Kanchanaburi	200,000
Huey Klong-ngu	"	4,000
Utaradit[2]	Utaradit	500,000
Kang Krachan[2]	Phetburi	n.a.
Southeastern		
Tung Pane Waterfall	Chantaburi	12,000
Soi Down Neear Waterfall	"	1,000
Troug Nong Waterfall	"	500
Krating Waterfall	"	1,000
Southern Peninsula		
Koa Samui Waterfall	Surattani	300
Klai Kao River[3]	Nakhonsrithamarat	15,000
Krarome Waterfall[3]	"	4,000
Phrom Loak Waterfall[3]	"	500
Yoang Waterfall[3]	"	500
Pattani River[4]	Yala	30,000
Tone Nga Chang Waterfall	Songkla	4,000

Hydropotential Sites in Thailand (continued)

Rivers and Waterfalls	Provinces	Estimated Generating Capacity (kw)
Lung Saun River	Chumporn	10,000
Tha Sae River	"	4,000
Rub Roe River	"	12,000
Chumporn River[2]	"	n.a.
Northeastern		
Huey Bang Sai[5]	Nakhonphanom	5,000
Lam Dome Noi[5]	Ubol	5,000
Lam Dome Yai	Ubol	5,000
Mune River (at the mouth)	"	35,000
Nam Lai	Luey	3,000
Nam Pong[4]	Khonkan	32,000
Nam Pung[4]	Sakyonakhon	10,000
Nam Chern	Khonkan	2,500
Lamplaimet	Burirum	2,500
Pasak River[2]	Petchaboon	-

Note: [1] Known as Kang Rieng Project. It is a first-priority scheme under National Eonomic Development Plan and is currently being surveyed for a comprehensive feasibility report for further development.

[2] Not included in the Report

[3] Known as Nakhonsrithamarat Project, which is a first-priority scheme under the National Economic Development Plan. Only the Klai Kao River Scheme is being developed.

[4] Currently under construction or implementation

[5] First-priority projects under National Economic Development Plan, and presently being investigated for preparation of comprehensive feasibility reports.

Source: Report of National Energy Authority, 1962, op. cit., pp. 60-61; and other sources.

The government has long considered that this area would be developed to supply electricity to the populous concentrations in the Central Plains, especially Bangkok, as well as to the Northern provinces. After years of investigation, a site on the Ping River was selected as the most suitable spot for hydroelectric generation. This is where the Yanhee Hydroelectric Project is being constructed.

Yanhee Project[6]

This project is by far the most important component of the present expansion plan. It is now nearing completion 260 miles north-northwest of Bangkok on the Ping River, the largest of the four main tributaries of the Chaopraya. The dam site is on massive outcrops of bedrock, about 32 miles upstream from Tak, where the river flows out of the northern mountains into the Upper Plain of the Central Valley. Here the land on both sides of the river rises over 600 feet from the level-floored gorge. No peaks reach above 5,000 in the immediate vicinity. Long under consideration, this project will eventually provide enormous quantities of electricity, as well as aid in irrigation, flood control and navigation.

When completed the Bhumiphol Dam, named after His

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[6] Statistical information taken from Chatikavanij, Kasame and Vanapruk, Prachuab, "Yanhee Project, 1962" in United Nations, Economic Commission for Asia and the Far East, Proceedings of the Regional Seminar on Energy Resources and Electric Power Development, op. cit., pp. 71-73; also Electric Power in Asia and the Far East, 1956-1960. op. cit., pp. 46-47.

Majesty the King, will be the largest and highest dam in Southeast Asia. Measuring 505 feet high and 1,510 feet long, with a reservoir area of about 116 square miles, it will have maximum water-storage capacity of about 10 million acre-feet, of which 8.6 million will be active storage available for power release. This latter amount is 41 per cent greater than the active storage of the Grand Coulee Dam on the Columbia River.

The hydroelectric capacity of Yanhee will eventually reach 560,000 kilowatts of installed capacity, equivalent to 2,230 million kilowatt-hours of firm energy per year. During the initial stage two of the eight projected 70,000 kilowatt generators will be installed. These units and a main high voltage transmission line to Bangkok and other towns in the Central provinces were expected to be placed in service in February or March, 1964. The generators actually began operating in May, 1964. The other six 70,000 kilowatt units will be added as needed, with final completion scheduled in 1975.

As previously indicated, there are now no inter-connections among small diesel power stations existing in towns and villages within the area. This lack will be remedied in the future, as the plan calls for construction of 230 kilovolt transmission lines to Bangkok with convenient tappings on route to supply power to 32 other provinces (Figure 5). Two intermediate 230 kv. sub-stations will be erected at Nakhonsawan and Angthong, and three terminal sub-stations at Bangkok.

A part of the 69 kilovolt sub-transmission network to link the Mae Moh steam plant and existing stations in the three Northern Provinces of Lampang, Lampoon and Chiengmai has been built. The 69 kilovolt line between Mae Moh and the Yanhee construction switchyard will be used as a tie line between the two sources after the Yanhee station is in service. Under the proposed transmission system cities and towns in the Northern and Central provinces will be supplied through 69 kilovolt substations which will be added during the second and final stages of construction (Fig. 5). The estimated cost of the first stage of the Yanhee project, including the dam, the power plant, transmission lines and substations, is $107 million. Of this, $66 million has been provided by a loan from the International Bank of Reconstruction and Development to cover foreign exchange costs. The rest of the funds are coming from the Thai government.

Power Market

The government established the Yanhee Electric Authority which became an autonomous organization in 1957, to undertake the construction and operation of power supply in the Yanhee-grid area. It is the exclusive agency for generation, transmission, and wholesale delivery of power in this area, which includes the Northern and Central provinces having a population of more than 14 million. Since this is over 55 per cent of the total population of Thailand, and the power used in the area constitutes over 80 per cent of the total national

consumption, the Yanhee Electric Authority covers most of Thailand's present and potential market for power. Bangkok-Thonburi is naturally the chief load center.

The estimated present peak demand for the Yanhee area was approximately 120,000 kilowatts with about 100,000 kilowatts of this concentrated in Bangkok area. The latest information reveals that the peak load for Bangkok-Thonburi in 1963 was 133,500 kilowatts.[7] The load growth rate experienced during the past decade has been about 20 per cent annually for Bangkok and close to 10 per cent for other provinces. In the future, however, the growth rate for Bangkok is expected to decline to between 10-15 per cent, as experienced elsewhere in the world. The estimated peak demand for the Bangkok area in 1970 is 275,000 kilowatts. This represents an average of 14 per cent annual growth for the decade. The combined system load is expected to reach 310,000 kilowatts in the same period.

Power Development

After the completion of the dam, it will take about three years to fill up the reservoir. During this period, water will be released for the minimum requirement of irrigation downstream, with power production as a subsidiary goal. To meet the interim demand for electricity, the Yanhee Electric

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[7] The total peak load for the whole country in 1963 was 203,800 kilowatts. This information was obtained from personal communication with the National Energy Authority through the writer's father.

Authority has erected two 75,000 kilowatt thermal stations in North Bangkok, as already mentioned. A third 75,000 kilowatt unit is to be installed later. These steam plants are designed to eventually form a part of the Yanhee system, operating in coordination with the hydro station.

It should be noted that the responsibilities of the Yanhee Electric Authority are confined to generation and high voltage transmission. Distribution of power in the various provinces covered by the Yanhee-grid system will be the responsibility of the Metropolitan Electric Authority (for Bangkok-Thonburi) and of the Provincial Electric Authority. Under this arrangement the Yanhee Electric Authority is operating the existing power stations in Bangkok and Thonburi.

Benefits

The primary objective of the Yanhee Project is to generate large quantities of cheap electric power. During the initial period of operation, it is estimated that the wholesale rate of electricity will be 0.375 Baht (about US 1.8¢) per kilowatt-hour. After 1965 when the major portion of the load can be supplied by hydro power, the wholesale rate is expected to be revised downward. Although there will be a substantial drop in the cost of generation, the Mission from the International Bank of Reconstruction and Development pointed out that it would not be desirable for this to be fully reflected in a reduction in price to the consumers. The reason is that present prices are probably not adequate even to cover depreciation on existing plants, whereas it

is considered important that the price of Yanhee power be sufficient to provide not only for depreciation, but also for the accumulation of resources to help finance future electric power development.[8] Even with such a policy, however, it is expected that the price of electric power in Bangkok can be reduced somewhat below existing rates after Yanhee power is on the line. Outside the city, in the eleven provinces that will be served by Yanhee in the initial stage, the price reduction will be much larger, since present charges for electricity in the provincial areas are a great deal higher than they are in Bangkok.

From the viewpoint of power, Yanhee has two great virtues. One is that it not only assures electricity for Bangkok, the commercial and industrial center of Thailand, but also for the first time links a broad cross-section of the country into one power system. The other is its size, which means that from 1964 onward it should, by adding other generating units, be able to meet Thailand's power needs at least until 1975.

Another great contribution of Yanhee will be to agriculture, the basis of the Thai economy. About 600,000 acres of potentially arable land nearby, down-stream from the dam site, could be opened up for farming. In the past this area

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8 International Bank of Reconstruction and Development, op. cit., p. 117.

has been subjected to severe floods in the wet season and to drought in the dry season. The 10 million acre-feet storage capacity of the dam will permit flood control and, for the first time, year-around irrigation of some 2.2 million acres of land by means of a barrage and canal system, through diversion of Chainat on the Chaophraya, installed some years ago. This is the major rice-growing area of the country.

In addition to power, irrigation and flood-control benefits, navigation in the lower reach of the Ping River will be made possible all year around due to the regulated flow now possible. The reservoir formed behind the dam will provide a reliable waterway extending 125 miles further upstream.

Other Planned Projects

Besides Yanhee there is at present no other hydro-electric scheme under implementation in the Northern and Central Plain Region. Included in the national economic-development plan, however, there is a first priority project called Kang Rieng. The National Energy Authority has already completed the survey and is now preparing a comprehensive feasibility report for future construction. The site of this development is on the Khwae Yai River, a tributary of the Maeklong, about 100 miles north-northwest of Bangkok (Figs. 3A and 3B). The Royal Irrigation Department proposed this scheme originally and conducted a preliminary survey as early as 1938. The main purpose

was to develop electric power for the Bangkok area and other towns in the western-central provinces. However, the program was interrupted by the war.

The Kang Rieng project is planned to produce about 200,000 kilowatts of electricity, while the reservoir behind the dam will store water for agricultural use in the province of Kanchanaburi and the surrounding area. No other detailed information concerning the features of this scheme is available at present. Although the project is part of the National Economic Development Plan, perhaps it will take several more years before construction can begin. Loan negotiation has yet to be completed.

Undoubtedly, the Kang Rieng project will greatly supplement the supply of electric power in the western-central provinces and in Bangkok as well. It could also relieve many downstream areas of seasonal floods, making them more suitable for agricultural purposes, and supply water for their irrigation during drought periods. It could be said that if future demands increase to such an extent that more generating capacity is needed than can be provided by projects now under way, implementation of this project will be the most logical step for Thailand to take to increase its power supply capability.

Northeastern Region

The Northeastern Region, generally known as the Khorat Plateau region, is a saucer-shaped, low platform drained to

the southeast. Bordered on the north and east by the Maekong River, the interior is undulating and dotted by low hills and shallow lakes. The altitude varies from less than 200 feet in the southeast to a group of hills which rise over several hundred feet in the north and east. A few isolated peaks near the Maekong exceed 1,600 feet.

Almost the entire region is drained by the Mune River which is a tributary of the Maekong (Fig. 3A). A few small rivers on the north and eastern edges flow directly into the Maekong. Annual flooding occurs especially on the lower course of rivers. The Maekong itself floods the lowlands along the lower parts of its tributary streams. Although large areas are flooded during the wet season, the region suffers in the dry season from lack of water. A large area of the western part of the region receives 40 to 50 inches of rainfall annually. Precipitation increases toward the Maekong River, where in some provinces it reaches 85 to 100 inches (Fig. 2B).

The Maekong Basin International Development Plan

The Northeast is generally regarded as the poorest region in the kingdom. The soils for the most part are thin and sterile. Lack of water during the dry season and severe flooding during the wet one have impeded agricultural development. The government therefore attaches maximum importance to plans for economic development of the area. Power and irrigation programs are receiving first priority. Development of hydroelectric power in this region is overall a part of the

more comprehensive international program being implemented on the lower Maekong.

The lower part of this great river flows from Burma into Laos, then along the border of Laos and Thailand, through Cambodia, and empties into the sea from South Vietnam. The river is completely unharnessed. Some twenty million people of four nations--Cambodia, Laos, Thailand and Vietnam--live with this watershed. Their number is expected to double in the next twenty-five years.[9] The dominant rythm of their economic life is the annual cycle of summer monsoon rains and the winter dry season. To advance the welfare of these peoples, a scheme to develop the river was conceived by the four riparian countries in 1957, through an invitation to the United Nation Economic Commission for Asia and the Far East to form a committee for coordination of the investigation of the potentials of the Lower Maekong Basin.[10] The investigation has been underway since 1959 and

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[9] White, Gilbert F., "The Mekong River Plan," Scientific American, Vol. 208, Number 4, (April 1963), p. 49.

[10] The broad plan--the Grand Design--of the Maekong Scheme is set forth in the UmN., ECAFE study, "Development of Water Resources on the Lower Mekong Basin," (Bangkok: October, 1957) endorsed, as indicated, by Cambodia, Laos, Thailand, and Republic of Vietnam in their joint declaration at the Thirteenth Session of ECAFE, 1957. Progress of work is reported in many subsequent U.N. publications, such as "Putting the Mighty Mekong to Work: A Progress Report on a Great International Venture," U.N. Review, Vol. 6, No. 9, March 1960, pp. 6-11. Many articles and papers have been written on this subject. The most recent ones include, Schaaf C. Hart and Russell H. Fifield, The Lower Mekong: Challenge to Cooperation in Southeast Asia, D. Van Nostrand Co., Inc., (Princeton, N. J: 1963) and White, Gilbert H., "The Mekong River Plan," op. cit. pp. 49-59.

the scheme has received financial and technical assistance from fourteen countries, including the United States, the United Kingdom, Canada, Australia, France and Japan.

Several projects in the lower Maekong River Basin under planning have direct bearing upon energy development in Thailand. The most interesting one is the Pa Mong on the main stream of the Maekong. This is one of the first-priority main-stream projects of the Maekong Scheme. In addition, development of projects on several tributaries in the riparian countries are to parallel the ones on the main stream. There has been close cooperation from the ECAFE Secretariat and assistance from the United Nation Special Fund for the surveying and investigation of the tributaries projects since 1959. Nam Pong Project in Thailand, currently under implementation, is one of these.

Nam Pong Hydroelectric Project[11]

This undertaking is located on the Nam Pong (or Pong River) about 225 miles northeast of Bangkok (Figs. 3B and 5). The Nam Pong, a tributary of the Chee River, originates in the highlands of the Khorat Plateau. It flows southeastward and meets the Chee east of the town of Khonkan (Fig. 3A). The dam-site is about 36 miles north of this town. The dam will be known as the Pong Neeb Dam. A smaller diversion dam; called the Nong Wai Dam, also to generate electricity, but

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11 Statistical information was obtained from Report of the National Energy Authority, 1962, op. cit., pp. 81-87.

mainly for distribution of irrigation water, will be erected in the future at Ban Wangchai about 18 miles north of Khonkan.

This is one of the poorest parts of the country and the government attaches highest priority to planning its improvement. The Japanese expert-group which undertook preliminary reconnaissance of the Maekong tributaries in 1959, supported the development of the Nam Pong. Two years later, with financial assistance from the United Nation Special Fund, a comprehensive feasibility report was completed by an American firm. Main dam, power plant, high voltage transmission lines, substations and diversion dam are expected to be completed by the end of 1965 or in 1966. The total cost of it is estimated at $17 million. The government of the West German Republic has agreed to loan $11 million of this construction cost.

Benefits

The completed project is designed to produce some 95 million kilowatt-hours of firm energy annually from an installed capacity of about 32,500 kilowatts. Of this total, 25,000 kilowatts will come from two 12,500 kilowatt units at the main dam, and the remaining 7,500 kilowatt from five turbine generators at Ban Wangchai. The sub-transmission system is being built to cover most of the major load centers of the region with 115 kilovolt lines reaching Udon, Khonkan, Chaiyaphum and Nakhonratsima and smaller ones with 22 kilowatt lines joining smaller urban centers with major substations. (Fig. 5). Future interconnection with the Nam Pung Project,

which is being constructed in the province of Sakolnakhon will be made as soon as the two schemes are completed.

The benefit of electric power from Nam Pung will cover the provinces of Khonkan, Udonthani, Nongkhai, Chaiyaphum, Mahasarakham, Roy-et, and Nakhonratsima (Fig. 1). The population in these provinces in 1960 totaled over 4,5 million people. Like other parts of the country, cost of electricity in this region is high due to the as yet small local power demand. Only residential customers are served, there being practically no high load factor industrial users. Fuel is predominently diesel oil. It is hoped that availability of cheap hydroelectricity will stimulate industrial development and the market for power generally.

As in the case of the Yanhee project, another benefit to be derived from this one is in agriculture. It is to afford gravity and pumping irrigation to some 95,000 acres from the two reservoirs, thereby enabling year around growing of crops on this land. The control of water by the dam and lock will also eliminate floods which have in the past inflicted damage to thousands of acres of agricultural land down stream on both banks of the Chee River. A fishing industry in the reservoir area will be developed, which it is estimated will bring in some $2 million a year. The government believes that the Nam Pong Project, together with the one at Nam Pung, will contribute largely to raising the standard of living and well being of the people in the Korat area.

Nam Pung Hydroelectric Project[12]

This is another of the Maekong tributary programs. The National Energy Authority, with cooperation from the Japanese government, began surveying this river in 1959. It was concluded that this project should be included among those receiving first priority in development. The Japanese prepared a comprehensive project-feasibility report in 1962 which could be used for loan negotiations. The government has designated 1964-1966 as the period for constructing the dam, power plant, and other pertaining features.

Physical Background

Nam Pung is a small river about 75 miles in length, which originates in the hills to the southwest of the town of Sakolnakhon (Figs. 3A and 5). It flows through the plain into the Ghum River, a tributary of the Maekong, south of Laharn Lake. It has a total rain catchment basin of about 1,328 square miles.

Rainfall records of the past 50 years reveal that this river basin receives one of the largest amounts in the Northeastern region--an average annual precipitation of about 70-85 inches (Fig. 2B). The heaviest rain which occurs during the months of May to October drains into Lake Laharn from the southwestern hills. To prevent flood damage around the lake and along the flood plain of the Ghum River, the National Energy Authority has proposed the construction of a dam which

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[12] Statistical information was obtained from the Report of National Energy Authority, 1962, ibid., pp. 92-96.

will also be used to generate electricity.

Features and Benefits

Actually, the project calls for the eventual erection of two dams. The first, now being built, is located on the Upper Pung about 18 miles southeast of Sakolnakhon (Fig. 5). The 90-foot high structure will create a reservoir holding about 162,140 acre-feet of water, and will have an installed electrical generating capacity of 6,000 kilowatts. The dam, power plant and transmission system are expected to be completed by the end of 1965, at a total cost of about $5 million to be financed by the government of Thailand.

The second dam will be constructed about 13 miles downstream from the first. Approximately 80,000 acre-feet of water will be retained by the 126 foot high dam, which will have an generating capacity of about 3,000 kilowatts. The total firm energy production which will be possible from both dams is estimated to be 45 million kilowatt-hours. Electricity will be made available to the provinces of Sakolnakhon and Nakhonphanom through 69 kilovolt lines supplemented by 22 kilovolt sub-transmission lines. These lines will reach Sakolnakhon in the province of Sakolnakhon, and Thalphanom and Mukdoham in the province of Nakhonphanom. Interconnection with the Nam Pong system, as indicated before, will be made as soon as both projects are completed.

Some 56,000 acres west of Sakolnakhon will be irrigated when the projected irrigation canals, gathering waters from the two reservoirs and other streams, are built. In addition,

a companion scheme calls for the development of Laharn Lake for irrigation through locks and irrigation ditches. A pumping station utilizing the hydropower, will be erected to pump lake water to irrigate about 64,000 acres.

Besides the plans to provide electric power and irrigation water, there is one to control flooding around Laharn Lake and long the banks of the Ghum River which is being investigated. To facilitate the flow of the water into the Maekong, the National Energy Authority intends to dredge the river channel. This will help to prevent the occurrence of annual flooding.

Pamong Hydroelectric Project[13]

This multipurpose scheme is located at Ban Pamong in the province of Nongkhai (Figs,1 and 3B). It is some 15 miles upstream from Vientiene (Laos), where the Maekong is the boundary between Laos and Thailand. Thus, the dam is to abut in each country. This first priority mainstream project has been under comprehensive survey since 1963, a phase expected to terminate in 1971. Australia has undertaken the dam-site geologic investigation, while the United States has agreed to plan the project, including preparation of a comprehensive feasibility report containing both technical and economic assessments.

Benefits

The large reservoir to be created by the dam having a

13 Statistical information was obtained from the Report of National Energy Authority, 1962, ibid., pp. 99-100; also from Schaff and Fifield, op. cit., pp. 103-107.

height of 240 feet, will provide storage area for all downstream projects and thus advantageously affect them all. The scheme's multiple benefits will contribute a great deal to northeastern Thailand. Severe floods which in the past have inflicted unaccountable damage to property, killed livestock and also claimed many human lives, will be brought under control. Irrigation will be extended through the whole year and seasonal shortage of water supply will be solved. The reservoir of about 78 million acre-feet, will irrigate approximately 2 million acres in Thailand, not to mention additional area in Laos. Power from the project, however, will be the most important benefit to the future of the region. An estimated 10 billion kilowatt-hours of firm energy from some 1.6 million kilowatt installed capacity will become available. Upstream navigation for a distance of 210 miles will be improved. Other benefits promised by the project include increased production of a fishing industry from the reservoir and use of the dam as a bridge between Thailand and Laos.

It should be noted that the progress of this grand scheme will depend a great deal upon the political situation prevailing in these countries, and this applies also to other projects in the Lower Maekong Basin. If political conditions are favorable and if reason and vision can continue to find their way into the construction and administration of not only Pa Mong, but the entire Lower Maekong program, to the same degree that they have in the study stage, this vast

scheme may become the first genuinely international and peaceful venture in river-basin development.

Other Planned Projects in the Northeast

Other high-priority schemes in the northeastern region, that are part of the National Economic Development Plan, and which have been under comprehensive survey, include the Huey Bang Sai and Lam Dome Noi Projects. Both are in the province of Nakhonphanom (Fig. 1). The Huey Bang Sai Project is on a tributary of the Maekong near the town of Mukdaharn. The reconnaissance survey conducted by the National Energy Authority in 1960 reveals several favorable dam sites for the generation of power and the development of irrigation. The N.E.A. has assigned high priority to the development of this project, likely to involve an installed capacity of about 5,000 kilowatts from a dam to be located in the vicinity of Ban Nakham, Amphur Mukdaharn.[14] This scheme will also help to irrigate some 60,000 acres for agricultural purposes. It is anticipated that a feasibility study may commence sometime during 1964.

The Lam Dome Noi hydroelectric project is located on a tributary--Lam Dome Noi--flowing into the Mune River (Fig. 3A) east of Phibul Mansahan. The reconnaissance survey completed by the Japanese team for the Maekong Committee shows several

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[14] The term "Amphur" denotes further sub-political division from Changwad.

suitable sites for the development of power and irrigation. The dam may be erected in the vicinity of Saei Noi Waterfall. The feasibility study will be undertaken in 1964. It is expected to have a capacity of about 5,000 kilowatts of power and provide water for irrigation some 60,000 acres of land on the left side of the tributary, i.e. in the vicinity of Huey Kwang.

Southern Peninsula

Krabi Thermal Project

In order to reduce power cost, improve quality of service, and gain benefit of integration, a 40,000 kilowatt steam power plant utilizing local lignite was built near Krabi in 1961 (Fig. 2A). The first unit of 20,000 kilowatts capacity went into operation in August 1963, and the other one is expected to be completed very soon. A 115 kilovolt transmission system is being implemented to join and supply all existing systems independently operated at present (Fig. 5). The diesel-alternating sets now in use will be kept for standby service for sometime, however, until more lines can be economically built. The Krabi plant has made electricity available to the provinces of Krabi, Trang, Phangnga and Phuket on the Peninsula West Coast (Fig. 1), through the 115 kilovolt transmission lines, connecting major substations, and the 22 kilovolt systems. Tin mining in Phangnga, where the main deposits are found, and in adjacent provinces should receive impetus in development and thus increase production. As soon as the projected hydro-

electric programs in Nakhonsrithamarat and Pattani Provinces are implemented, interconnection of Transmission lines will be carried out with the Krabi thermal plant.

Hydroelectric Development

Hydroelectric potentials in Southern Thailand are scattered all over the region. Physically speaking, plains fringe the coastal areas and the highlands, with isolated peaks reaching over 5,000 feet elevation, which form the backbone of the peninsula. Small streams or rivers dissect the mountains which extend from north to south as short ridges or ranges. These either flow into the Gulf of Thailand along the Peninsula East Coast, or the Adaman Sea along the Peninsula West Coast. Although there are no large rivers or drainage basins, the steep gradient of the small streams and the numerous waterfalls along with more than average precipitation, does provide considerable potential for power development. Several of these sites have been surveyed by the National Energy Authority, the more significant ones being the Pattani River near the south border with Malaysia, the Klai Kao River near the town of Nakhonsrithamarat, and the rivers in the province of Chumporn. Two waterfalls whose hydroelectric potentials are particularly promising are Krarome near Nakhonsrithamarat, and Tone Nga Chang near Songkla (Fig. 2A). A project harnessing the Pattani River is currently being implemented. Another near Nakhonsrithamarat is also being

developed. Both are first-priority programs under the National Economic Development Plan.

Pattani River Hydroelectric Project[15]

The Pattani is the second largest river in the Southern Peninsula. Originating in the mountain ranges which form the boundary between Thailand and Malaysia, it flows through north of Yala and empties into the sea at the town of Pattani (Figs. 3A and 3B). With a length of about 94 miles, the river has a catchment basin of about 1,168 square mile area. The Upper Pattani flows through forested, mountainous land, having sections devoted to rubber plantations. The lower Pattani, on the other hand, from the town of Yala to the mouth, crosses river plains and basins which are suitable for agriculture and cultivation of rubber trees.

The Pattani River Basin is one of the wettest areas in the Southern Peninsula. Rain occurs at all seasons brought by the southwest as well as the northeast monsoon. The annual amount exceeds 85 inches, with the heaviest fall from October to January during the northeast monsoon (Figs. 2B and 2D). During the rainier season floods cause great damage to areas in both Yala and Pattani Provinces. The Pattani River Project is designed to better control the floods, as well as to provide power and aid agriculture.

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15 Statistical information is obtained from the Report of National Energy Authority, 1962, op. cit., pp. 88-91.

Features and Benefits

Reconnaissance of this scheme, which originally was known as the Southern Region Electricity Development, began in 1959. The spot considered most suitable for the dam-site has been chosen at Banrang. The power plant is planned to generate 27,000 kilowatts or 80 million kilowatt-hours of firm energy per year. Electricity will be carried over 115 kilovolt transmission lines through various substations as shown in Figure 5. Eventually interconnection with the Krabi Lignite system will be established to provide integrated power supply to the southern region.

If work continues as scheduled preparation for construction should be completed by the end of 1965 and erection of dam, power plant, transmission lines, and other features should be accomplished by 1969. The cost of the project is estimated at about $16 million, of which $13 will be a loan from a foreign source.

The benefits derived from the completed project will be two fold. First, cheap electric power will become available to inhabitants and industry in the provinces of Yala, Pattani, Nrathiwas and Satul (Fig. 1), costing no more than 0.40 Baht (2 cents US) per unit. Electricity will be transmitted through 115 kilovolt lines, with a 22 kilovolt system branching out to connect various population centers (Fig. 5). It is estimated that about $1.8 million of foreign exchange annually for importing fuel will be saved. Tin mining, a

very important industry in southern Thailand, should greatly benefit from the increased supply of low-cost power. The province of Yala is one of the leading tin producers of the country.

Second, annual flooding during the rainy season of cultivatable area of over 72,000 acres in the Pattani River Basin will be eliminated. The damage sustained from this yearly inundation covers about 60 per cent of agricultural land and amounts to some $3.5 million in terms of cost. Regulation of water will, in addition, aid agricultural production when needs arise.

Nakhonsrithamarat Hydroelectric Project[16]

The main mountain range of the peninsula, beginning with the part forming the offshore islands along the East Coast in the Gulf of Thailand parallels the coast all the way into Malaysian territory. This is generally known as the Nakhonsrithamarat Range. Some isolated peaks reach over the general crest level of 2,000 feet, the highest being Khao Laung which is located some 16 miles north-northwest of Nakhonsrithamarat city and rises to 5,860 feet elevation (Fig. 2A). Many short rivers flow both east and west from this mountain range. On the eastern side they flow through coastal plains and empty into the Gulf of Thailand. These rivers and several waterfalls provide very good sites for hydroelectric power installations.

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16 Statistical information was obtained from the Report of National Energy Authority, 1962, ibid., pp. 66-69.

Features of Project

The Nakhonsrithamarat Project is comprised of four separate programs. These are:

a. Klai Kao Scheme-located about 28 miles north of the city of Nakhonsrithamarat. The dam impounding the water on the Klai Kao River is estimated will produce 15,000 kilowatts of electric power at peak operation.

b. Krarome Scheme-is on a tributary of the Mai River. The site of the dam is on the Krarome Waterfall, situated about 15 miles west of Nakhonsrithamarat. The estimated capacity of the power to be installed here is 4,000 kilowatts,

c. Phromloak Waterfall Scheme-on a tributary of Tha Pah River. The proposed dam site is about 15 miles west of Nakhonsrithamarat. About 700 kilowatt capacity will be generated by this hydro-source.

d. Yoang Waterfall Scheme-situated about 3 miles east of Thung Song; the estimated generating capacity is to be about 700 kilowatts.

Preliminary reconnaissance of these four schemes was completed before 1961. Only Klai Kao, a first-priority program, is now being developed, although no start of construction date has yet been set. Preparation for implementation of the project is expected to continue until 1966.

Purpose of the Project

The primary purpose is to produce cheap electricity for the local inhabitants and to promote industrial development in the province of Nakhonsrithamarat. Utilization of iron ore

deposits found near the city of Nakhonsrithamarat at Rong Lek and Ban Nasarn will be encouraged. Tin mining from a large deposit at Khao Laung and around Ronphibul will also benefit from increased availability of electric power. In addition, flooding of lowlands on both side of the Klai Kao River will be prevented, making year around cropping possible. Finally, navigation and transportation on the Klai Kao River will be facilitated. Tin and wolfram ores and products will be more conveniently transported.

The Future in Southern Thailand

As previously indicated, the hydroelectric potentials in Southern Thailand are scattered over the peninsula. While the Pattani and Nakhonsrithamarat projects are the only ones now being implemented, development of other sources will probably take place in the intermediate future. Several thousand kilowatts, probably about 30,000, could be harnessed from rivers in the province of Chumporn alone. It is reported that at least one scheme in this area is now being prepared for further development. The government envisions future interconnection of the generating facilities of this region with those of the Central Plain. It will be many years, however, perhaps several decades, before this plan will be fully realized. Meanwhile, the northern part of the peninsula will continue to rely mainly upon electric power from diesel generating units.

General Features of the Future Integrated System

There is little doubt that the Bangkok area will be the most important load center of the country for many years to

come. Within the area to be supplied by the Yanhee Project, Bangkok presently takes about 95 per cent of the energy produced and will no doubt continue to use a major part of the new power as it becomes available. The next project, probably the Kang Rieng, for providing additional capacity in the Yanhee service area is also expected to send most of its output to Bangkok.

In the Northeastern region, a transmission network will be laid out tying together most of the existing plants and the new ones constructed on the Maekong tributaries, such as those of the Nam Pong and the Nam Pung Projects. When the main stream schemes, like the Pamong one, are completed, a still higher voltage transmission system will be superimposed on this one. It is also expected to eventually tie in with the Bangkok load center. An exchange of energy between the two regions will be through interconnections located in Bangkok.

The Southern Peninsula on the other hand, will probably be independently developed since its major power sources and consuming centers are separated from those of the other two regions by considerable distance over a long thin isthmus. It is unlikely that integration of the Southern system with the others will be economically justified for many years to come. Eventually, however, there may be a national super-power system joining together all parts of Thailand.

Chapter V

PROBLEMS AND PROSPECTS OF THE FUTURE

Problems

Thailand recognizes the importance of developing her energy resources as a means of economic progress and is therefore anxious to augment the electric power supply facilities, but several handicaps and difficulties have hampered rapid progress. While within the country each region or area of development may encounter its individual problems, as for instance, the more distinct wet and dry season in the Northeast, there are certain basic problems facing the industry in the country as a whole. Briefly, these can be classified under the headings: (1) organization and control; (2) financing, including foreign exchange; (3) technical personnel; (4) long-term planning and co-ordination with industrial development.

Organization and Control

In some of the more highly industrialized countries such as the United States and Japan, the greater emphasis in electricity development and sales seems to be on private ownership, but in others like England and France the opposite appears to be true. In Thailand most of the industry is under public ownership, with several government agencies

assuming the burden of development and the responsibility for generation and distribution of almost all the electric supply. This seems inevitable, because the huge capital requirements and the low uncertain return, as compared to returns available in unregulated enterprises, have inhabited private investment except in the case of large industrial plants generating for their own use. Electric power supply is an exceptionally capital-intensive industry, in proportion to the volume of labor employed. Being a public utility industry, it is subject in any event to overall direction and control by the government--especially regulation of the rates charged to the consumers. Private enterprise, as a result, shows relatively less interest in investing in electricity supply than in other industries, particularly in an underdeveloped country like Thailand where the amounts of capital that must be risked are huge in relation to the market immediately available and the uncertainties of favorable relations with future governments.

The development of the power industry in Thailand is under the direction and control of the N.E.A., M.E.A., Y.E.A., L. A., and P.E.A. It is evident from Table 4 that these five authorities have overlapping powers and duties. This is where a major problem lies. Each authority is supposed to be working toward the same goal, that is, to render the best electric power service to the public at the lowest possible rates. It is obvious that within the scope of their respective operations certain conflicts arise between these energy

authorities. This has had a deterrent effect on electric power development.

In order to prevent the continuance of conflict, a central regulatory authority should therefore be set up so that effective uniformity of control and coordination can be attained. This regulatory body, answering either to the Cabinet or Parliament, should have broad powers of control over the rates, practices and procedures of all Energy Authorities. In some functions this new agency would replace N.E.A. and place responsibility under a different head, but it would not assume all activities of the present authority or mean its complete elimination. The need for a single controlling agency is further emphasized by the divergent lines of jurisdiction over the major nationally owned Energy Authorities. For instance, Y.E.A. and L.A. are answerable to the Prime Minister, the N.E.A. is directly under the Prime Minister's Office, and M.E.A. and P.E.A. come under the administration of the Ministry of Interior.

It is interesting to note that new energy authorities --Northeastern Energy Authority and Southern Energy Authority-- might conceivably be created to run new power projects, such as Nam Pong and Nam Pung in the Northeastern Region and on the Pattani River and others in the south. So far no information regarding this is available.

In the present state of underdeveloped economy of Thailand, it is perhaps inevitable that the state has had to take the initiative and accept the responsibility for all nation-building activities, including electric power

development. The question is not whether public ownership of electric power utilities is preferable to private ownership. It has been, how to get the job done. In the almost total absence of managerial and technical skill, and in view of the shortage of private capital resources, the state necessarily has had to step in and endeavor to find ways and means of overcoming the handicaps and of promoting essential energy development schemes. There is no doubt that even the little progress that has here-to-fore been achieved by Thailand in the field of electricity supply would not have been possible without state participation in the industry.

Finance

The heavy capital outlay involved in electric power development is a common problem not only of Thailand, but of other underdeveloped countries the world over. Private capital, in general, has been reluctant to invest because of low rates of return in a closely regulated industry. Furthermore, the level of domestic private savings which could be tapped is low, and commercial banks prefer not to tie up their available capital in long term loans. Consequently, the government has to accept the responsibility for electricity supply. But even the government has been strained; it is faced with competing demands from various sectors for the allocation of inadequate financial resources. It has resorted to legislative appropriation of funds which come from taxes and this takes away from such normal undertakings as schools, roads, public health facilities, etc.

The problem is compounded by the need for foreign exchange to purchase equipment, and fuel to run thermal plants. The demand for foreign exchange has been mitigated to some degree by generous assistance from the more prosperous countries of the West and from International Agencies. Both the World Bank and the Export-Import Bank of Washington, for example, have extended many loans to Thailand for electric power development. The Yanhee Project is being financed by the World Bank which has lent some $66 million for construction. The Agency for International Development of the United States has also given assistance to Thailand. It has made development loans for construction of the $20 million power distribution system for Bangkok, and has also financed the installation, of 10,000 kilowatts of generating capacity powered by diesel engines in Bangkok and the 12,500 kilowatt steam-power station at the Mae Moh lignite mine in the North. Thailand has also taken advantage of the Colombo Plan and of the assistance offered by such countries as Japan and West Germany.

The search for capital will always be a pressing problem, until and unless government regulatory agencies approve adequate rates for power and energy supplied, so as to permit both a resonable return on investment and the self financing of a significant percentage of future expansion. The government must also allocate annually

from their foreign exchange earnings sufficient amounts to service the foreign loans contracted for construction of the power facilities.

Technical Personnel

Side by side with the problem of finance there exists an equally important one of providing trained managerial and technical personnel. In Thailand there is shortage of persons with such skills which, for as long as it continues, will make progress difficult if not impossible, even if financial resources are made available in an adequate measure. Technical education to provide trained personnel and the acquisition of experience in modern technology, etc., are matters which cannot by any means be hurried forward beyond certain limits; yet, it is imperative that Thailand advance in approximately one decade over ground which it took the industrialized West almost a century to cover. The need for accelerated development is all the more urgent in that the present gap between the developed and underdeveloped nations, already very large, may otherwise become larger still.

If Thailand is to undertake rapid development of her power resources, it is important that she equip herself with "know-how" and accept responsibilities as rapidly as possible for the investigation, planning, design, construction, operation, and maintenance of the projects. The long term solution, of course, lies in expanding the educational system of the country--the establishment of technical schools,

colleges, and universities providing competent instruction and sending abroad of gifted students for specialization. But this takes time and money, both of which are in short supply. In the meanwhile, Thailand may avail herself of the various technical assistance programs organized under the United Nations and the Colombo Plan and by various individual countries.

After trained men are available, the establishment of strong technical organizations to handle the planning, co-ordination and execution of power schemes is essential. The able men of these organizations should be assured a tenure relatively free from politics, adequate salaries and opportunity for advancement. Too often the young man who has acquired expert knowledge through his studies abroad is not able to apply this because of a senority system which places him at the same level or below many with less education.

Long-term Planning

Another significant problem confronting Thailand is the need for long-term planning co-ordinated with industrial development. Electric power development cannot be pursued independently of growth in other sectors of the economy. After all, electricity is only a means to an end and not an end in itself; power supply has to be closely co-ordinated with other economic development schemes.

The technique of development programming consists essentially of making an inventory of the sum total of the resources available and then deciding the order in which

the various development projects should be undertaken within the limit of those resources. The inventory and priorities must also take into consideration the needs and the possibilities of expanding facilities for training and services. In the context of the limited resources of Thailand, a well-formulated overall economic plan is of vital importance.

Power development has necessarily to be related to the agricultural and industrial development programs. An essential test of the economic value of a power project involving large capital outlay is to determine how soon the power generated will be utilized. The provision of power capacity much in advance of launching of industries using the power would result in locking up valuable capital, whereas power shortage arising from delays in the implementation of essential electrical projects would be equally detrimental to the economy. Most of the high-priority hydroelectric projects in Thailand have the advantage of being multiple-purpose in nature, providing flood prevention, irrigation waters, and improvements in navigable waterways, as well as power. Even so careful planning is essential so as to benefit the most from the least investment. Such planning is more complicated in the case of multiple-purpose projects because of the greater number of factors and intangibles involved.

Thailand has experiences acute power shortage conditions since the end of the Second World War. Development programs based on economically sound and rational plans

necessarily involve considerable time; but, in view of the urgency of the power demand, short term measures which are not necessarily most economical in the long run were resorted to in the early stages of development. In this context, it should be remembered that the planning and the execution of large power projects have to be initiated much in advance of the need for power. A big thermal power station may take about three years to complete, while the building of a large hydroelectric facility may require five years or more for construction alone. On the other hand, it may in most cases be possible to establish manufacturing industries within two or three years. The conclusion is inescapable that advance planning of power projects on a long term basis by competent personnel is very important.

Thailand is one of several countries in Asia and the Far East that has accepted the concept of advance planning for coordinated power development. The current Six Year Plan is for the period 1961 to 1966. But planning is a painstaking and lengthy process requiring a considerable amount of basic data. In Thailand the task of planning is still very difficult, not only because of the lack of technical and administrative skill, but because the required basic data is usually not available, or if so, it is often fragmentary and unreliable. Up to about ten or fifteen years ago, there was practically no complete and dependable statistical records concerning the generation, transmission and consumption of electricity. In fact,

such information is very fragmentary and its accuracy is opened to question. However, since the establishment of the National Energy Authority in 1954, the effort to compile and collect such statistical data has improved tremendously. Much work remains to be done, however, particularly in collecting hydrological and geological facts.

The investigation and evaluation of the country's potential energy resources, especially hydro-power, is a costly time-consuming process. Power market surveys for short and long term objectives have also to be undertaken if an orderly power development program is to be coordinated properly with industrial growth on a country wide basis. But even when all the basic data has been collected, there still remains the task of obtaining optimum benefits from the resources on hand by providing at the right time an adequate supply of power at the lowest possible cost. In a river valley, for instance, there may be several optional power sites from which the best one should be selected; or alternative possibilities of development such as a choice between two successive low dams of lower capacity but correspondingly low cost, and a single, more expensive, high dam, but with a large reservoir and capacity for power development; or a decision as to which of several power sites is to be developed first. Such judgments have to be made because good hydro-sites are not man made; they are where nature placed them.

In the case of thermal stations, similar decisions have to be made. Coal mines are where coal is found and the choice is whether to site a thermal plant at the market,

as local interests dictate, and transport coal over long distances, or to build the plant near the coal deposits and deliver the power by means of high voltage transmission lines. Conflicts of interests, regional or financial in nature, often obstruct the rational solution of such problems. As far as Thailand is concerned, the absence of independent public utility companies has done much to alleviate these problems, but they still exist.

Prospects of the Future

Requirements of Power

Thailand is a tropical country so heat is not required to raise room temperature except during the winter season in the northern extreme of the country. On the contrary, considerable power could be used for cooling, refrigeration and air conditioning. The market for these purposes is very difficult to guess. Needs for household cooking and particular industrial processing, however, can be more accurately estimated in terms of electric energy.

The total consumption of power and heat throughout the country in 1954 was 97,294 kilowatts according to a census made by the National Energy Authority.[1] The figure did not include heat for household cooking. Of the total, 75 per cent was consumed in the Bangkok area, and 25 per cent in the rest of the country.

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1 Binson, Boonrod, "Thailand's Needs and Possibilities for Power and Heat," Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Vol. 1,(United Nations, New York: 1956), p. 236.

Using the 1954 figure as a base, one estimate of the future requirements for power for industrial development in Thailand is shown in Table 7. The projections were made for a period of 40 years, from 1955 to 1995. This appraisal indicates that pending the anticipated completion of the Yanhee Hydroelectric Project in 1960, there would be a yearly increase in demand of 7.5 per cent.[2] The annual demand, it was predicted, would then rise 15 per cent in 1961 and 1962, and 12 per cent in 1963, 1964 and 1965, thus increasing the expected total power and heat demand for industrial development to 278,850 kilowatts in 1965.

A yearly increase of 10 per cent was estimated for the period of 10 years from 1966 to 1975, bringing the total market to 723,367 kilowatts in 1975. From 1976 to 1985 the annual increase was estimated at 8 per cent; and from 1986 to 1995 at 7 per cent, raising the aggregate needed in the latter year to 3,071,667 kilowatts.

The accuracy of this long-term estimate, in view of changes that have happened between 1954 and the present (1964), cannot be effectively discussed because of the lack of certain pertinent information. The data of, for instance, total annual consumption of power from 1954 to the present is not readily available.

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2 It should be noted that the N.E.A. at first expected the Yanhee Project to be completed by 1960 and to harness merely 360,000 kilowatts. The capacity is now revised upward to 560,000 kilowatts. The date when full operation will be attained is set at 1975; two 70,000 kilowatt generators began turning in May 1964.

Table 7

ESTIMATED REQUIREMENTS OF POWER FOR INDUSTRIAL DEVELOPMENT

1955 to 1995

Year	Kilowatts
1955	104,591
1956	112,385
1957	120,814
1958	129,875
1959	139,616
1960	150,087
1961	172,600
1962	198,482
1963	222,300
1964	248,970
1965	278,850
1966	306,735
1967	337,409
1968	371,150
1969	408,265
1970	449,092
1971	494,001
1972	543,401
1973	597,741
1974	657,515
1975	723,267
1976	781,128
1977	843,618
1978	911,107
1979	983,996
1980	1,062,716
1981	1,147,733
1982	1,239,552
1983	1,338,710
1984	1,445,813
1985	1,561,478
1986	1,670,782
1987	1,787,737
1988	1,912,879
1989	2,046,781
1990	2,190,056
1991	2,343,360
1992	2,507,395
1993	2,682,983
1994	2,870,717
1995	3,071,667

Source: Binson, Boonrod, "Thailand's Needs and Possibilities for Power and Heat," Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Vol. 1, (New York: United Nations, 1956), Table 1, p. 236.

As far as electric power is concerned, the demand has been growing steadily since 1956, when the peak demand, that is peak load, of the whole country was 79,966 kilowatts.[3] The use of electric power increased 9 per cent in 1957, 14 per cent in 1958, 16 per cent in 1959, 15 per cent in 1960, and 19 per cent in 1961, bringing the peak load to 154,673 kilowatts in 1961. By 1963 it had reached 203,800 kilowatts, representing an increase of about 31 per cent since 1961. Thus, the average yearly increase in peak electric power use from 1956 to 1963 was approximately 14,8 per cent. To supply the 1956 peak load there was an operating capacity of 135,680 kilowatts, whereas 360,000 kilowatts of capacity was available in 1963. Thus, it would seem that the estimates shown in Table 7 are not far from the actual increase in demand to date and that the present capacity to produce is much closer to the needs than formerly. Assuming that the recent rate of increase in use of electricity continues, as is likely, by 1970 the peak demand will reach more than 415,000 kilowatts.[4]

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[3] Report of National Energy Authority, 1962, op. cit., Table 1, p. 105.

[4] This is a crude estimate based on the recent trend of electricity consumption. The population of Thailand in 1960, according to the census, was about 26 million, with a rate of increase close to 2 per cent. This rate is likely to be maintained and perhaps become higher until 1970 and the years beyond. There is an indication that the population may reach 40 million by 1975 or thereabout. With such a trend of increasing population, it is likely that the number of electricity consumers will also multiply, particularly if the power is made available at reasonable rates.

The Bangkok area will remain the center of greatest electric power consumption for industry, business and home use. Presently, it takes some 70 per cent of the total output of the country. The maximum demand in the city has been growing at the rate of about 20 per cent annually for the past decade. This high rate of growth, partly the result of improvement in electrical facilities and supply, and partly because of establishment here of more commercial and industrial concerns, is expected to decline to 15 per cent or less in the future. In 1963 the peak load in Bangkok area was reported at 133,500 kilowatts; the estimated peak demand in 1970 is 275,000 kilowatts.[5] This represents an average of 14 per cent annual growth for the current decade. Furthermore, the combined system peak load of the Bangkok and Yanhee grid area is expected to reach 310,000 kilowatts in 1970.

Demand and Supply

With the Yanhee hydroplant coming into full operation, Thailand's power needs should be satisfied until at least 1975. After that date more projects of the same kind must be constructed if supply is to keep up with demand.

According to long-term estimates of requirements, it is reported that by 1980 Thailand will again face a shortage of power, unless development of Maekong River is realized.[6]

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5 Chatikavanij and Vanapruk, op. cit., p. 72.
6 Binson, op. cit., p. 237.

With the full utilization of this river, it is predicted, the balance of supply and demand would be maintained only until 1990. After that demand will once again outrun supply. Under the above conditions, it is concluded that because of growing demand,

> "... all Thailand's conventional sources of energy must be fully utilized within 25 years, and including the Maekong source within 35 years. This is most unlikely in a country like Thailand where water records have been taken and aerial mapping of river basins have been made very recently. There is therefore a gap which must be filled by atomic power. It is estimated that 300,000 kilowatts of atomic power will be needed for this purpose from 1971 to 1980, 500,000 kilowatts from 1981 to 1981, and thereafter will multiply."[7]

Although it seems likely that in the long run development of the potentials of conventional sources of energy will not be sufficient to meet growing demand, and Thailand must therefore resort to nuclear energy, it is not possible here to emphatically confirm or deny such a prediction. The study of the power market, its demand and supply, entails considerable field research. Only generalizations can be made otherwise. It seems to the writer, however, expansion of known potentials of conventional sources of power may delay need for nuclear energy later than what has been estimated.

As far as the supply of electric power in the immediate future is concerned, by 1970, possibly the remaining six units at the Yanhee Hydroplant will be installed and in operation, thus bringing the total added generating

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7 Ibid., p. 237.

capacity of this plant to 420,000 kilowatts. Other hydroelectric plants, including Nam Pung (10,000 kw.), Nam Pong (35,000 kw), and Pattani (30,000 kw.), should also be in commission and producing electricity for their designated areas. Regarding thermal plants the second unit of 20,000 kilowatts at Krabi lignite mine will be in operation, and the third unit of 75,000 kilowatts will have been added to the Bangkok plant. Consequently, some 590,000 kilowatts more of generating capacity will become available by 1970, bringing the total capacity of the entire nation to something over one million kilowatts. It is unlikely that projects, other than those mentioned above, will be implemented by 1970. As a rule, it takes at least five years to build a hydroelectric station and about three years for a thermal-power station. Large steam plants of modern design have the advantages of lower initial cost compared with hydro-plants and of a shorter period of construction, but the disadvantage of higher costs of operation and maintenance, and when the fuel has to imported their operation imposes a continuous demand for foreign exchange.

Thermal power plants, however, are deemed necessary for rapid expansion of the electric power program in Thailand. Because of the inherent characteristic of tropical and subtropical rivers of wide variation in flow according to season, hydroelectric projects on them, even when provided with impounding reservoirs, generally have to be operated in conjunction with steam stations.

In the Central Plain, Northern and Northeastern Thailand there are several hydro-resources that will go far towards supplying energy demand for years to come. Many of these resources could be developed as baseload plants. Thermal-power stations would then be needed to supplement the hydro-power ones during periods of peak demand. They would be used most during the dry season.

In the Southern Peninsula the characteristics of hydro-resources are different. Those from the rivers are capable of supplying part of the base-load, since their capacity is not so large in respect to the energy demand of the region. On the other hand, hydroelectric resources from waterfalls which are mostly high-head type seems ideal for peak supply of power. Nevertheless, thermal power plants will play a major role for source of supply of the region.

Use of Atomic Power

As far as the fuel resources are concerned, there are fairly large quantities for supply of thermal power plants in both the Northern and Southern areas. But in the Northeast, no major deposit of fossil fuel has been discovered so far, even though surveys have shown the existence of petroleum in the provinces of Ubol and Nakhonphanom. Neither the quantity nor the quality is known. Due to the high cost in transporting fuel over long distance from other areas, nuclear energy may be the future solution for the Northeast, should there be an need for additional large power plants after the potentials of water power have been exhausted.

Attention will naturally be given first to development of these latter possibilities.

Atomic power has been suggested specifically for the Northeast.[8] In addition to filling the gap between supply and demand, it is argued, nuclear energy will facilitate development of this region. It is envisaged that an atomic pile of a capacity of 100,000 kilowatts should be set up to supply heat for steam engines to drive electric generators on the bank of the Maekong River to pump water for large-scale irrigation as well as to supply cheap electric power. The cost, it is suggested, should be borne partly by the education and research project and partly by irrigation and power project. The feasibility of this kind of program depends to a great extent upon how successful the Government of Thailand is in securing financial and technical assistance either from the leading industrial nations, or from international organizations.

Nuclear energy development was discussed late in 1956, when the Council of Ministers approved in principle an offer made by an United States company to build a pilot atomic plant with an estimated capacity of 12,500 kilowatts; the company was to be granted a fifteen years concession.[9] There has been no further report on this development. Presently,

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8 Binson, ibid., pp. 237-238.

9 Blanchard, Wendell, Thailand, Its People, Its Society, Its Culture, Human Relations Area Files Press, (New Haven: 1957), p. 329.

there is one atomic reactor, established in Bangkok for research purposes, with capacity of 1,000 kilowatts.

A study made by a committee for the Economic Commission for Asia and the Far East, in 1956, noted that:

> "...the application of atomic energy for generation of electric power, though feasible, was not likely to be economical on a commercial basis in the immediate future in the circumstances of most countries of the region (Asia and the Far East), and that in the meantime the development of electric power by conventional means would have to continue. The most immediate practical application of atomic energy in most parts of the region lay in the use of radio-isotope in the fields of medicine, agriculture, and industry, and that training facilities for this purpose were being offered by the advance countries...The committee recommended that the countries of the region should continue to study current developments in the use of nuclear reaction for generation of electric power, determining in each case separately the suitability of its application, and should prepare to take advantage of these developments by prospecting their own resource for radio active minerals and for training technical man-power."10

The application of atomic power for the purpose of generating electricity in underdeveloped countries has, nevertheless, been accepted and encouraged. In a paper presented to the International Conference on the Peaceful Uses of Atomic Energy, in Geneva, August, 1955, by the Department of Economic and Social Affairs, United Nations, several conclusions are reached regarding nuclear power

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10 United Nations, Economic Commission for Asia and the Far East, Observations of the Committee on Industry and Trade and of the Commission on the Report of the Sub-Committee of Electric Power and Activities of the Secretary in the Field of Electric Power during 1956 / 1957, (E/CN.11/I&NR/Sub.1/L1, October, 1957),(Bangkok; 1957), p. 2.

for underdeveloped countries:[11]

> "(a) In the short run the significance of nuclear power for underdeveloped countries will increase with the possibility of developing small rather than large nuclear power stations.
> (b) The possibility of economic utilization of nuclear energy is relatively great in underdeveloped countries where the inadequacy of transportation and certain other facilities has hampered the installation of conventional power systems.
> (c) The savings in annual outlay of foreign exchange that may result from the use of nuclear power will be of importance, in particular to those underdeveloped countries which suffer accute external payment difficulties and where conventional fuel has to be imported."

Other Alternative Sources of Power[12]

In many advanced countries scientist and engineers are pursuing a way to harnessing power economically on commercial scale from such sources as the sea, the wind, chemicals, the interior of the earth, and the sun. Many spectacular developments have been achieved. The harnessing of power from the tides of the Atlantic Ocean, for generation of electricity at St. Malo on the Coast of Brittany in Northeast France, is one of the most recent examples.

One investigation that is worthwhile considering in the

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[11] United Nations Department of Economic and Social Affairs, "Some Economic Implications of Nuclear Power for Underdeveloped Countries," Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Vol. 1, 1956, op. cit., pp. 341-345.

[12] several studies are available: see for example, F. Ba Hli, "Unconventional Sources of Power," Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Vol. 1, op. cit., pp. 71-76; Farrington Daniels, "Alternative Energy Resources" (Unconventional Types), ibid., pp. 77-84.

case of Thailand is the development of power from the wind.[13] As a source of power, the wind appears to be an attractive possibility; it is available everywhere and it does not involve problems of production and transportation of fuel, etc. If the wind could be fully utilized, it could give rather large amounts of energy. For instance, the energy content in the wind passing through a rectangular area 10 miles long, 100 feet wide, at a velocity of 17 miles per hour, is of the order of 2,500 million kilowatt-hours per year.[14] Practical considerations, of course, preclude the possibility of harnessing for useful purposes anything more than a small fraction of this energy.

Despite the enormous power potentialities of the wind, the problem of harnessing this power for useful purposes is beset with major disadvantages and handicaps. There is no means of predicting with certainty how much power will be available at any particular time or period. Thus, the chief drawback of wind-power is its intermittent nature which necessitates expensive storage batteries. The output of power cannot indeed be adjusted to suit the consumer's requirements. This is only one of the very serious handicaps; nevertheless, recent studies have shown that despite all these handicaps, economic development of wind-power appears practicable.

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13 A very good discussion is given in, United Nations, Economic Commission for Asia and the Far East, Electric Power Bulletin, (ST/ECAFE/SER.L/2, August 1954) (Bangkok: 1955), pp. 3-22.

14 ibid., p. 3.

The importance of wind-power will depend largely upon the cost of capital equipment to convert it into electricity. The most important cost is that of designing and building a wind-power plant. It is reported that the outlay for such a plant is comparable to that for a steam or diesel plant. Estimates of probable costs in the United Kingdom of wind-power plants of different sizes vary from a cost per kilowatt-hour of $257.6 for a 25 kilowatt set, down to $134.4 for a 6,500 kilowatt set.[15] However, these estimates are merely useful guides upon which to base future undertaking in this field.

The utilization of wind-power should be of special interest to Thailand, where the majority of the population live in rural areas where the provision of power is presently expensive and uneconomic, but the need to make available the minimum of living comforts to the people is paramount. Despite the present program of electric power expansion, it is unlikely that the people in the rural areas will receive significant benefits in relatively short time. Thus, in this context, it is of interest to consider if by utilizing the wind as a source of power, the provision of electricity in the rural area can be accelerated.

It should be noted that power from the wind has been successfully adapted for direct pumping of irrigation water in Thailand. The government should indeed launch a serious study of the possibility of utilizing wind-power for genera-

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15 ibid., p. 15.

tion of electricity. Studies, investigations and experiments conducted by other countries, particularly the United Kingdom, Continental European nations and India, will provide invaluable information and guidance.

Chapter VI

SUMMARY AND CONCLUSION

From the foregoing consideration of energy resources and electric power development in Thailand, several findings emerge.

(1) Realizing that without adequate power industrialization and better living conditions cannot be accomplished, the Thai Government has attached priority to development of energy resources. Large electric power programs occupy a highly important place in public development. This sector of the economy, recognized as being of equal importance to transport, accounted for 20 per cent of proposed capital expenditure during the 1959-1963 period. More money, in view of the urgency and significance to national economic improvement, should be allocated for power development.

(2) Several large hydroelectric projects are either under implementation or are being actively considered and planned to alleviate the shortage of electric power. The Yanhee hydro-plant has begun operation, and when all units of the generators are installed will satisfy power needs until at least 1975 in the major consuming areas. Many areas, however, are in need of large quantities of electri-

city. The Northeast, for instance, has urgent demands for more power. Besides two hydroelectric projects, now under implementation in this otherwise poorly endowed region, other water-power potentials in the area should be exploited as soon as economically feasible. The completion of the Pamong Program (part of the Lower Maekong Basin Development) may not materialize until the end of the 1970's or early 1980's. Elsewhere, especially in the upper part of the Southern Peninsula, water resource should be developed immediately to fill in the gap and to balance the system now being implemented in the lower peninsula.

(3) Electrification in provincial and rural areas is as yet grossly inadequate (Appendix 3). Distribution systems in the whole country should be constructed so that all towns and villages can be interconnected into areas and these into regions that in turn can be linked into a national super-power system, thus joining all generating agencies and the Provincial Electricity Authority's own large plants. The number of consumers in all provincial areas is now equal only to that in the Bangkok area, and each provincial consumer uses only about one-fourth of the amount used by a customer in the Bangkok area. Thus, the major part of Thailand's population is without benefit of electricity. Their purchasing power is such, however, that construction of new, and reconstruction of old, distribution systems must be done as economically as possible, in order to make this large potential market a reality.

(4) The high rate of annual growth of demand which characterized the past ten years is likely to prevail in the present decade. Thereafter, once electricity has been initially supplied most potential customers, it will probably decline to nearer ten per cent, or even less. The undeveloped water-power resources are substantial, but much of these potentials have yet to be surveyed and investigated. This process, which includes the gathering of long-term hydrologic data and making comprehensive topographic surveys, will take time. Consequently, a greater part of the thermal power plants will continue in operation and will provide a desirable technical balance in the system.

In connection with the long-term planning of electric power development, the urgency and importance of systematic surveys of the market for power, as well as of the natural energy resources that are present, cannot be overemphasized. Detailed knowledge of the location and size of the market, the available energy resources, details and costs of the phased programs for harnessing them, and the costs of developing and distributing energy from various types of competitive sources are essential data required for formulating a sound and economic energy development master plan.

(5) Thailand's lack of capital and qualified personnel for establishment of an electrical industry is apparent. Loans in the form of financial and technical assistance have to be secured from many foreign countries and international organizations. Technical training at all levels in the field of electric power must be provided. Sustained progress cannot

be achieved without proper attention to the development of essential human resources. For the short term, technical experts can be loaned from overseas, but a long-term solution appears only in the directions of establishing more technical schools at home and sending as many qualified students for training abroad as is possible.

(6) As far as organization of development and operation of an electrical power system in Thailand is concerned, there is a need for establishing a central regulatory agency or authority, such as the California Public Utility Commission, in order that control, coordination and uniformity at all levels of development of energy resources can be obtained.

(7) Consumption of electric power by industry has been relatively small, as compared to the condition in more developed nations. A substantial portion is consumed by domestic uses. In 1961, 36.7 per cent of total energy sale was to households, and 34.4 per cent to industry. The remainder was used by commercial firms and for other purposes (Appendix 4). Most of the amount consumed by industry was concentrated in the Bangkok area, as were also almost 50 per cent of domestic users. Undoubtedly, consumption by industry will increase as more power becomes available at a cheaper rate, and Bangkok will still take a considerable share of it. Household use will expand most rapidly in the provincial areas, where today there are only a few more consumers than in Bangkok alone.

Availability of cheap electric power should induce capital development at home and an inflow of investment funds

from foreign sources. The Metropolitan Electricity Authority has only recently removed the long-standing anomally and deterrent to investors of charging large users higher rates than ordinary consumers. The new scale of charges offers a special low rate to large industries. Many of these who had established their own generating equipment rather than pay the old penalizing rates, are now turning to the M.E.A. for their supply. The reduced rates offered to households, especially those of low-income group are expected to lose the M.E.A. about U.S. $ ½ million a year, but it is hoped that the increase in industrial consumption will make up for most of this.

(8) Exploitation of conventional sources of energy is likely to continue at a rapid pace. Nevertheless, the idea of utilizing atomic energy is a very attractive one, and it has to be seriously considered in the light of the forecast of shortage of power in a not too distant future. Successful application of nuclear energy depends upon many factors of which economic, financial and technical are the main determinants. Should the government decide to erect an atomic plant for generation of electric power, it will have to rely upon help from leading industrial nations. As yet aid in this area is not necessary or readily forthcoming. It should be borne in mind that it will be hard for nuclear power to compete with diesel power when power requirements are less than 30,000 kw. and load factors are low. Further,

technicians are scarcer and harder to obtain than the few scientists required, and they are essential to this development.

It is extremely unlikely that within the next ten to fifteen years atomic energy will become a significant part of Thailand's power development. Meanwhile, conventional sources of power and energy have to be exploited to their economically optimum limit. Although water power will become the mainstay of energy development, this does not necessarily preclude a search for economical power from other sources. One such possibility is power from the wind.

Some reservations have been raised in regard to prospective benefits to be derived from the expansion of electric power generation because of the fear that the costs of construction and maintenance would not be justified by the meager use. Furthermore, there is the argument that much of the additional capacity would go to private homes and that the incentive it would bring to establishment of new industries would be minimal. Perhaps this may be true. However, the objective of the government is to supply electricity to every province, amphur (Political subdivision), district and village as quickly as possible so that every person can enjoy the benefits of electric lighting and labor-saving devices. This alone will provide a powerful stimulus toward industrialization, not to speak of the direct encouragement provided by availability of cheap power. Then too, there are other benefits to be obtained from the establishment of

multi-purpose hydroelectric dams and rivers development projects.

Without adequate supplies of power, the Thai people cannot hope to raise conditions of living. With rapid increase in population, the predominantly agricultural economy must be diversified if the level of living is to be improved. Industrialization on an extensive scale and expansion of cottage industries are essential. Power is the key to all industrialization, and must be provided if Thailand is to assume a place in the modern world. But sound and economic planning of large electric power schemes requires careful coordination with the program of industrial development so that capital and effort are used most efficiently.

If this thesis, inadequate though it may seem, has only served to focus attention on the nature, magnitude, and some of the problems of electric power development in Thailand, it will have served its purpose.

Appendix 1

GEOGRAPHIC REGIONS OF THAILAND*

(After Thailand Economic Farm Survey, 1953)

North--9 Provinces

1. Chiengrai	2. Chiengmai	3. Nan
4. Prae	5. Mae-Hongsorn	6. Lampang
7. Lampoon	8. Utaradit	9. Tak

Northeast--15 Provinces

1. Kalasin	2. Khonkan	3. Chaiyaphoom
4. Nakhonphanom	5. Nakhonratsima	6. Burirum
7. Mahasarakham	8. Roi-et	9. Loei
10. Sakolnakhon	11. Sisaket	12. Surin
13. Nongkai	14. Udorn	15. Ubol

Central Plain--29 Provinces

1. Bangkok	2. Thonburi	3. Kampaengpet
4. Chachoengsao	5. Chainat	6. Nakhonnayok
7. Nakhonpatom	8. Nakhonsawan	9. Nontburi
10. Patomthani	11. Prachinburi	12. Ayudthaya
13. Pichit	14. Pitsanuloke	13. Petchaburi
16. Petchaboon	17. Ratburi	18. Lopburi
19. Samutprakarn	20. Samutsongkram	21. Samutsakorn
22. Saraburi	23. Singhaburi	24. Sukhothai
25. Supanburi	26. Angthong	27. Uthaithani

Southeast--4 Provinces

1. Cholburi	2. Rayong	3. Chantaburi
4. Trad		

South--7 Provinces

1. Chumporn	2. Surattani	3. Nakhonsritamarat
4. Trang	5. Patthalung	6. Songkla
7. Pattani		

West South-West--8 Provinces

1. Kanchanaburi	2. Prachuabkirikhan	3. Ranong
4. Phangnga	5. Krabi	6. Satool
7. Yala	8. Narathiwas	

* For location of provinces see text Figure 1.

Appendix 2

INSTALLED CAPACITY AND PRODUCTION OF ELECTRIC POWER IN THAILAND, 1930-1961

Year	Installed Capacity (1,000 kw.) T	Installed Capacity (1,000 kw.) P	Production (million kwh.) T	Production (million kwh.) P
1930-[a] 34[a]	28	26		
1935	28	26		10.2[b]
1936	28	26		10.7
1937	29	26		11.6
1938	30	27		12.1
1939	31	27		34.3
1940	32	27		37.1
1941	32	27		31.5
1942	32	27		46.2
1943	32	27		33.4
1944	23	18		20.4
1945	23	18		20.7
1946	23			33.1
1947	23			43.2
1948	28.6	26.7		51.5
1949				60.2
1950	32.3			68.6
1951	42.7	32.7		86.6
1952	48.3	44.8		128.
1953		68.3		158.4
1954		81.5		223.6
1955		107.6		288.5
1956	148.7	135.7	376.8	328.1
1957	162.8	141.7	468.6	373.8
1958	167.1	150.4		408.1
1959		160.3	476.7	420.6 c
1960	191.1	177.6		501.5 d
1961		264.47 e		611.88 e

Note: T= public utilities plus enterprises generating primarily for own use.
P- enterprises generating primarily for public use.
a Between 1930 and 1947 the figures for installed capacity are approximated.
b 1935-38 production for Bangkok and Thonburi only
c 320 million kwh. produced in Bangkok-Thonburi
d 365 million kwh. generated in Bangkok-Thonburi
e Taken from Report of National Energy Authority, 1962, op. cit., p. 105.

Source: United Nations, Statistical Yearbook, (United Nation, New York: 1949-1950), p. 278; (1952), p. 250; (1956), p. 262; (1961), pp. 295, 304; (1962), pp. 306, 316.

Appendix 3

NUMBER OF TOWNS AND VILLAGES WITH ELECTRICITY 1956-1961

Year and Item		Population						
		Over 100,000	50,001-100,000	20,001-50,000	10,001-20,000	5,001-10,000	Below 5,000	Total
1956	Total	37	125	188	38	14	2	404
	Electrified	30	88	110	15	6	-	249
	Percentage	81.2	70.4	58.5	39.5	42.9	-	61.7
1957	Total	36	123	240	65	23	11	498
	Electrified	31	93	139	20	2	-	285
	Percentage	86.1	75.6	58.0	30.8	8.7	-	57.2
1958	Total	36	123	240	65	23	11	498
	Electrified	31	93	139	20	2	-	285
	Percentage	86.1	75.6	58.0	30.8	8.7	-	57.2
1959	Total	49	152	202	57	16	8	484
	Electrified	40	122	113	20	2	1	307
	Percentage	100	80.3	55.9	35.1	12.5	12.5	63.43
1960	Total	49	152	209	60	18	8	492
	Electrified	49	127	130	19	2	1	320
	Percentage	100	83.5	62.2	31.7	11.1	12.5	65.0
1961	Total	49	155	229	52	16	7	508
	Electrified	48	126	145	13	-	1	333
	Percentage	97.95	81.29	63.32	25.0	-	14.28	65.55

Source: Data of 1961 obtained from Report of National Energy Authority, 1962, (Bangkok: 1963), Table 7, p. 111.
United Nations, Economic Commission for Asia and the Far East, Electric Power in Asia and the Far East, 1956-1960, (E/CN.11/597) (New York: 1962), Table 7, p. 83.

Appendix 4

ELECTRICITY CONSUMPTION AND NUMBER OF CONSUMERS BY CATEGORIES OF UTILIZATION, 1961

Categories of Utilization	Bangkok Area			Provincial and Rural Area		
	Unit Consumed (million kwh)	Number of Consumers	Average Consumption per consumer	Unit Consumed (million kwh)	Number of users	Average Consumption per consumer
1. Households	131.40	165,151	796	49.82	222,010	224
2. Commercial & Others	75.22	21,416	3,512	21.56	812,758	1,690
3. Industrial	130.64	20,017	6,526	40.63	3,699	11,074
4. Street Lighting	5.15	1	-	8.79	420	-
5. Miscellaneous	1.43	137	-	1.90	1	-

Categories of Utilization	Country Total		
	Unit consumed (million kwh)	Number of consumers	Average consumption per consumer
1. Households	181.22	387,161	468
2. Commercial & Others	96.78	34,174	2,832
3. Industrial	171.27	23,686	7,231
4. Street Lighting	13.94	421	-
5. Miscellaneous	3.33	138	-

Source: Report of National Energy Authority, 1962, (Bangkok: 1963), Table 3, p. 107.

Appendix 5

THAILAND-AREA AND POPULATION, 1960

(By Changwad)

Changwad	Area Sq. Km.	Population	Population Per Sq. Km.
Central			
Bangkok	1,099	1,577,003	11,435
Thonburi	450	559,532	1,243
Nonthaburi	623	196,196	315
Pathumthani	1,497	189,801	127
Ayudthaya	2,482	478,738	193
Angthong	981	197,865	202
Suphan buri	5,339	491,252	92
Saraburi	2,963	303,505	102
Lopburi	6,588	335,661	51
Singhaburi	842	154,409	183
Chainat	2,636	245,317	93
Uthaithani	6,472	145,504	23
Nakhonsawan	9,677	647,602	67
Samut prakan	934	234,701	251
Samut sakhon	840	165,712	197
Samut songkhram	309	161,899	406
Nakhonpathom	2,178	370,481	170
Kanchanaburi	19,486	233,341	12
Ratburi	5,120	410,573	80
Phetchaburi	6,357	237,853	37
Prachuabkirikhan	6,373	152,456	24
Nakhonayok	2,414	153,683	64
Prachinburi	11,795	334,895	28
Chachoengsao	5,422	322,660	60
Cholburi	4,485	392,025	87
Rayong	3,307	147,713	45
Chanthaburi	6,052	157,803	26
Trad	2,919	66,328	23
Northern			
Phichit	4,530	389,122	86
Pisanuloke	9,659	351,642	36
Phetchaboon	11,166	319,611	29
Sukhothai	6,841	315,948	46
Utaradit	7,614	259,919	34
Phrae	5,847	299,369	51
Nan	11,694	240,471	21
Lampang	12,518	471,699	38
Lampoon	4,407	249,820	57
Chiangmai	22,993	798,483	35
Chiangrai	18,803	811,771	43
Mea Hongson	13,222	80,807	6
Tak	15,609	167,992	11
Kamphaengphet	8,954	173,346	19

Appendix 5 (continued)

Changwad	Area Sq. Km.	Population	Population Per Sq. Km.
Northeastern			
Nakhonratsima	19,590	1,094,774	56
Burirum	10,771	583,585	54
Surin	8,784	581,732	66
Srisaket	8,813	601,356	68
Ubolrajthani	22,758	1,130,712	50
Roi - et	7,856	668,193	85
Mahasarakham	5,780	499,373	87
Kanlasin	7,650	426,795	56
Sakolnakhon	9,539	426,755	45
Nakhonphanom	9,749	436,482	45
Nongkhai	7,223	256,530	36
Udhonthani	16,605	744,174	45
Khonkan	13,404	844,075	63
Chaiyaphum	10,788	486,472	45
Luey	10,936	210,535	19
Southern			
Chumporn	5,746	175,284	31
Suratthani	12,811	324,784	25
Nakhonsrithamrat	10,169	730,402	72
Phatthalung	3,269	233,844	72
Songkhla	6,673	500,285	75
Satul	2,669	69,636	26
Yala	4,716	149,348	32
Narathiwas	4,228	266,038	63
Ranong	3,426	37,628	11
Phangnga	4,100	93,119	23
Krabi	4,624	93,895	20
Phuket	801	75,652	95
Trang	4,944	240,463	49
Pattani	2,013	281,587	140
Thailand Total	514,000	26,257,916	51

Source: Population Census of 1960

Appendix 6[A]

THAILAND

INSTALLED GENERATING CAPACITY, 1956 and 1958

(Kilowatts)

Changwad	1956				1958			
	PEA	PVT-5	PVT-25	TOTAL	PEA	PVT-5	PVT-25	TOTAL
Central								
Bangkok	-	-	187	187	-	-	187	187
Thonburi	-	56	-	56	-	56	-	56
Nonthaburi	257	-	-	257	257	-	-	257
Pathumthani	135	56	-	191	135	56	-	191
Ayudthaya	601	-	110	711	802	-	110	912
Angthong	110	-	273	383	110	-	273	383
Suphan buri	863	12	98	973	863	112	98	1073
Saraburi	72	-	50	122	184	-	50	234
Lopburi	330	-	50	380	330	-	50	380
Singhaburi	303	16	-	319	303	16	-	319
Chainat	330	-	44	374	330	21	44	395
Uthaithani	155	-	50	205	270	-	50	320
Nakhonsawan	396	120	1180	1696	720	203	1180	2103
Samut prakan	110	-	150	260	110	-	150	260
Samut sakhon	1090	30	-	1120	1090	30	-	1120
Samut songkhram	170	56	32	258	170	94	32	296
Nakhonpathom	1740	35	-	1775	1801	44.6	-	1845.6
Kanchanaburi	-	-	137	137	-	-	137	137
Ratburi	2535	65	60	2660	2677	75	124	2876
Phetchaburi	725	-	-	725	780	-	-	780
Prachuabkirikhan	650	-	-	650	650	-	-	650
Nakhonayok	259	-	-	259	584	-	-	584
Prachinburi	864	-	65	929	957	-	65	1022
Chachoengsao	800	17.6	277	1094.6	935	115.6	277	1327
Cholburi	1433	-	767	2196	1433	-	803	2236
Rayong	419	22	55	596	419	22.0	91	532
Chanthaburi	695	-	113	808	695	-	113	808
Trad	168	-	-	168	168	-	-	168

Appendix 6 A (continued)

Changwad	1956				1958			
	PEA	PVT-5	PVT-25	TOTAL	PEA	PVT-5	PVT-25	TOTAL
Northern								
Phichit	344	-	152	496	431	-	328	759
Pisanuloke	1226	44	-	1270	1226	44	-	1270
Phetchaboon	220	-	-	220	220	-	-	220
Sukhothai	120	24.7	128	272.7	180	46.7	152	378.7
Utaradit	778	-	-	778	778	-	-	778
Phrae	775	-	40	815	775	-	40	815
Nan	326	-	-	326	326	-	-	326
Lampang	2310	-	-	2310	2200	-	-	2200
Lampoon	200	-	-	200	200	-	-	200
Chiangmai	2967	-	-	2967	3299	-	-	3299
Chiangrai	866	-	110	970	866	-	110	976
Mea Hongson	270	-	-	270	270	-	-	270
Tak	305	-	-	305	305	-	-	305
Kamphaengphet	110	-	-	110	110	55	-	165
Northeastern								
Nakhonratsima	3822	-	-	3822	3822	-	-	3822
Burirum	368	-	-	368	478	-	-	478
Surin	739	-	-	739	739	-	-	739
Srisaket	435	-	-	435	485	-	-	485
Ubolrajthani	1822	-	-	1822	1937	-	-	1937
Roi- et	357	-	-	357	544	-	-	544
Mahasarakham	220	-	-	220	320	-	-	320
Kanlasin	110	-	-	110	110	-	-	110
Sakolnakhon	334	-	-	334	384	-	-	384
Nakhonphanom	490	-	-	490	490	-	-	490
Nongkhai	766	-	-	766	816	-	-	816
Udhontnani	906	-	-	906	1016	-	-	1016
Khonkan	838	-	-	838	888	-	-	888
Chaiyaphum	160	-	-	160	210	-	-	210
Luey	135	-	-	135	185	-	-	185

Appendix 6 A (continued)

Changwad	1956				1958			
	PEA	PVT-5	PVT-25	TOTAL	PEA	PVT-5	PVT-25	TOTAL
Southern								
Chumporn	538	-	100	638	826	36	100	962
Suratthani	590	-	96	686	880	75	32	987
Nakhonsrithamrat	1352	-	44	1396	1500	95	44	1639
Phatthalung	223	-	-	223	223	223	-	223
Songkhla	1423	-	600	2023	1423	83	1800	3306
Satul	110	-	-	110	110	-	-	110
Yala	922.4	50	166	1138.4	922.4	70	166	1108.4
Narathiwas	1051	82	235	1368	1106	118	235	1459
Ranong	110	-	-	110	110	-	-	110
Phangnga	253.7	-	-	253.7	220	-	-	220
Krabi	56	-	-	56	56	-	-	56
Phuket	1478	-	-	1478	1478	-	-	1478
Trang	932	-	100	1032	932	-	155	1087
Pattani	-	56	235	291	-	84	235	319
Total				53,104.4				58,902.2

PEA = Provincial Electricity Authority
PVT-5 = Privately operated, owned with 5 years concession
PVT- 25 = Privately operated, owned with 25 years concession

Source - National Energy Authority (Personal Communication through writer"s father).

Appendix 6B

THAILAND

INSTALLED GENERATING CAPACITY, 1960 and 1962

(Kilowatts)

Changwad	1960				1962			
	PEA	PVT-5	PVT-25	TOTAL	PEA	PVT-5	PVT-25	TOTAL
Central								
Bangkok	-	24	187	211	-	46	260	306
Thonburi	-	116	-	116	-	48	-	48
Nonthaburi	257	-	-	257	257.3	-	-	257.3
Pathumthani	218	121	55	394	221	82	244	547
Ayudthaya	1860	40	110	2010	1534	128.2	165	1827.2
Angthong	28	-	340	368	-	-	188	188
Suphan buri	923	295	127	1345	1534	245	149	1918
Saraburi	238	24	169	431	28	24	242	294
Lopburi	390	79	50	519	380	103	80	563
Singhaburi	303	16	-	319	375	16	-	391
Chainat	390	21	44	455	489	36	-	525
Uthaithani	325	-	50	375	629	n.a.	50	679
Nakhonsawan	784	282	1620	2686	784	207	1722	2713
Samut prakan	160	-	150	310	247	-	425	672
Samut sakhon	1075	12	-	1087	871	12	-	883
Samut songkhram	1586	118	32	1736	611	76	56	743
Nakhonpathom	2326	44.6	-	2370.6	2631.8	31.6	-	2663.4
Kanchanaburi	-	-	137	137	-	-	137	137
Ratburi	2452	77	164	2693	2254	260	40	3554
Phetchaburi	1248	12	110	1370	1637	12	110	1759
Prachuabkirikhan	790	39	-	829	1232	992.2	-	2224.2
Nakhonayok	562.2	-	-	562.2	541.4	-	-	541.4
Prachinburi	1463.2	-	95	1558.2	1678.5	-	95	1773.5
Chachoengsao	1453	111.8	335	1899.8	1703	97.6	162	1962.6
Cholburi	2174	48	980	3202	4000	118.9	1040	5158.9
Rayong	502	118	170	790	688	189	24	901
Chanthaburi	695	-	301	996	805	-	301	1106
TRad	245	-	-	245	329.5	-	-	329.5

Appendix 6B (continued)

Changwad	1960				1962			
	PEA	PVT-5	PVT-25	TOTAL	PEA	PVT-5	PVT-25	TOTAL
Northern								
Phichit	458	72	328	858	819	138	328	1285
Pisanuloke	1226	44	-	1270	2161	-	-	2161
Phetchaboon	247.2	-	-	247.2	662.8	115	130	907.8
Sukhothai	276	46.7	152	474	336	126.5	-	462.5
Utaradit	910	-	-	910	983	-	-	983
Phrae	755	-	40	795	1103.6	-	50	1150.6
Nan	326	-	-	326	350.4	-	-	350.4
Lampang	1444	-	-	1444	210	-	-	210
Lampoon	331.2	-	-	331.2	77	-	-	77
Chiangmai	3351	-	-	3351	1688	-	-	1688
Chiangrai	921	-	135	1056	1429.1	-	134	1563.1
Mea Hongson	270	-	-	270	243	-	-	243
Tak	519	-	-	519	702.5	-	-	702.5
Kamphaengphet	110	79	-	189	165	-	-	165
Northeastern								
Nakhonratsima	3844	-	-	3844	4213.5	210	-	4423.5
Burirum	545	-	-	545	705	24	80.2	809.2
Surin	671	-	-	671	896	-	-	896
Srisaket	588	-	-	588	713	-	-	713
Ubolrajthani	1560	-	-	1560	2654	-	-	2654
Roe - et	560.2	-	-	560.2	697.4	-	-	697.4
Mahasarakham	425	-	-	425	435.8	-	-	435.8
Kanlasin	182	-	-	182	248	-	-	248
Sakolnakhon	516	-	-	516	585	-	-	585
Nakhonphanom	927	-	-	927	941	-	-	941
Nongkhai	903	-	-	903	1184	-	-	1184
Udhonthani	1816	-	-	1816	1789	-	-	1789
Khonkan	1271.6	-	-	1271.6	1946	14.4	-	1960.4
Chaiyaphum	317	-	-	317	557.3	49	-	606.3
Luey	185	-	-	185	350	-	-	350

APPENDIX 6 B (continued)

Changwad	1960				1962			
	PEA	PVT-5	PVT-25	TOTAL	PEA	PVT-5	PVT-25	TOTAL
Southern								
Chumporn	913	36	100	1049	898	36	100	1034
Suratthani	729	84	32	845	1080	118	75	1273
Nakhonsrithamrat	1618	115	118	1851	1631	81	157.2	1869.2
Phatthalung	452	34.4	-	486.4	494.8	36	-	530.8
Songkhla	1451	179	1800	3430	1476	287	1800	3563
Satul	110	-	-	110	187	-	-	187
Yala	1174	98	220	1492	1142	130	220	1492
Narathiwas	1306	360	521	2187	2332	239	521	3092
Ranong	281	-	-	281	225	-	-	225
Phangnga	335	-	-	335	412	-	-	412
Krabi	111	-	-	111	208	-	-	208
Phuket	1478	-	-	1478	2078	-	-	2078
Trang	1226	-	239	1465	1317	-	112	1429
Pattani	-	-	-	-	106	88	635	829
Total				70,743.4				82,828.5

PEA = Provincial Electricity Authority
PVT-5 = Privately operated, owned with 5 years consession
PVT-25 = Privately operated, owned with 25 years concession

Source - National Energy Authority (Personal Communication through writer's father).

Appendix 7

DEFINITIONS

British Thermal Unit (B.Th.U.). A measure of calorific value representing the quantity of heat that will raise the temperature of 1 lb. of water from 60 F. to 61 F. Calorific value of coal is measured in British Thermal Units per pound.--B.Th.U./lb.

Calorific Value. The amount of heat that may be generated from a given weight of coal; measured in B.Th.U./lb.

Capacity (of generator, etc.). The output in kilowatts under ordinary full load conditions.

Capacity (installed capacity, rated capacity). Applied to power station is the aggregate power of all generators.

Cusec. A measure of river flow- cubic feet per second.

Distribution of electricity. The movement of electricity at relatively low voltage, within a supply authority area, for ultimate use.

Energy. Physical ability to do work, the product of power and time.

Feeder. A cable or other conductor used to supply electrical energy from a station or substation to a point from which it is distributed, i.e. to "feed" the net work at an appropriate point.

Generating Plant. The complete machinery and apparatus required for the production of electrical energy for power or lighting, whether in a large power station or in a private installation.

Generating Station. A works where electrical energy to be distributed for lighting, power or traction purposes, etc. is produced from dynamo-electric machinery driven by water-power, steam engines or turbines, gas or oil engines or otherwise.

Head. The vertical height through which waterfalls between the intake and the turbines at a hydroelectric station.

High Tension. A general expression for high voltage without any definite limits; used particularly where distinction is to be made between systems or circuits of different voltage.

High Voltage. A comparative term employed generally for voltages high enough to require special percautions in dealing with them but without any definite limit.

Horsepower (h.p.). The practical unit of mechanical power. The British horsepower is equal to 33,000 ft. lb. per hour or 746 watts. The metric horsepower is 0.986 of this, being 75 kg. metres per second.

Interconnected system. A transmission network linking several power stations--transmission grid.

Kilovolt (kV). One thousand volts. A unit often used for expressing voltages of high-tension transmission lines, test pressures of insulators, etc.

Kilowatt (kw). The unit of electric power generally used for rating electrical machinery and for practical purposes; equal to k,000 watts. Equivalent to 1.34 h.p.

Kilowatt-Hour (KWh.) The unit of electrical energy usually employed for commercial purposes, being that which has passed in a circuit when an average of one kilowatt has been passing for one hour or its equivalent. (Also called the Board of Trade Unit and the Kelvin.)

Lighting Load. A load on a generating plant or station consisting entirely of lighting and not of electric motors, or that part of the load due to lighting.

Lighting Peak. The peak in the lighting curve, not usually occurring at the same time as the Power Peak.

Load. The output (kilowatts) that a generating plant is being called upon to give at any time, or the horsepower which is being exerted by an electric motor.

Peak. The point where a load curve reaches a maximum.

Peak Load. The magnitude of the load on a generating station or plant at the time of day when there is a maximum, e.g. in a lighting station just after dark.

Power House. Another name for Generating Station, applied more particularly to those supplying large systems.

Power Load. That part of the load on a generating station which supplies electric motors, distinguished from that part supplying lighting. In alternating current systems, the power load has usually a worse (lower) power-factor than the lighting load, unless special precautions are taken.

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