社会開発調査部報告書

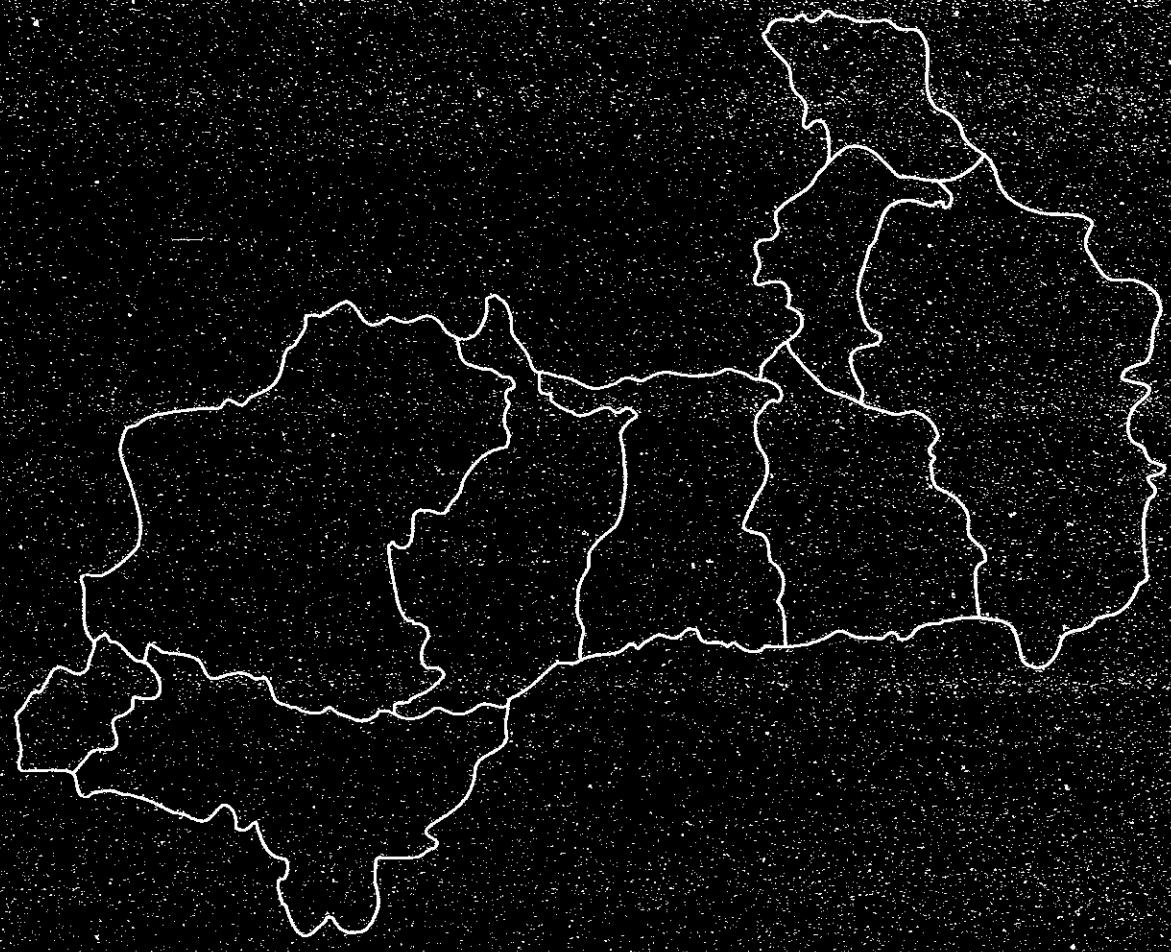
No 202

JAPAN INTERNATIONAL COOPERATION AGENCY

THE GOVERNMENT OF THE KINGDOM OF THAILAND
NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT BOARD

THE STUDY ON THE REGIONAL DEVELOPMENT PLAN FOR THE LOWER NORTHEAST AND THE UPPER EAST REGIONS IN THE KINGDOM OF THAILAND

FINAL REPORT



7. Power and Energy

September, 1993

NIPPON KOEI CO., LTD.

JAPAN INTERNATIONAL COOPERATION AGENCY

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List of Reports

Executive Summary Report
Main Report
Sector Reports

1. Agriculture
2. Industry
3. Tourism
4. Trade and Distribution
5. Land and Environment
6. Water Resources
7. Power and Energy
8. Telecommunications
9. Transportation
10. Urban System
11. Socio-Economy and Social Systems
12. Finance and Institution
13. Preliminary Feasibility Analysis on Selected Priority Projects
    - Regional Artery Establishment
    - Small Pumping Reservoirs Development
    - Integrated Urban Development Program
    - Drip Irrigation Development
    - Dairy Industry
    - Meat Processing Industry
    - Animal Feed Manufacturing
14. Geographic Information System (GIS) and Regional Planning

LEGEND

- International Boundary
- Provincial Boundary
- 202 National Highway (Number)
- Railway
- Airport
- National Park
- Major Tourism Attraction

Major City (Population)

- 100,000~500,000
- 50,000~100,000
- 25,000~ 50,000
- 10,000~ 25,000

N

SCALE

0 6.5 32.5 65.0

km

Laos

Khon Kaen

Bua Yai

Phimai

Satuk

Buri Ram

Nakhon Ratchasima (Khorat)

Sung Noen

Sikhiu

Dan Kwian

Pak Tong Chai

Chok Chai

Nang Rong

Prakhon Chai

Prasat

Surin

Si Sa Ket

Prasart Kamphaeng Yai

Ubon Ratchatani

Warin Chamrap

Phibun Mangsahan

Pha Taem

Kaeng Tana

Chon Mek Border Point

Det Udom

Yasothon

Amnat Charoen

Huai Huat

Mukdahan

Savannakhet

Mukdahan

Bangkok Metropolitan Region

Pak Chong

Khao Yai

Wang Takrai N.P.

Tha Plan

Phanom Rung

Muang Tam

Kantralak

Khao Phra Viharn

Phu Chong Nayoi

Nakhon Nayok

Prachin Buri

Kabin Buri

Sa Kaeo

Aranyaprathet

Eastern Seaboard

Phnom Penh

Cambodia

Note : Basic elements of this map composition were derived from the Geographic Information System (GIS) Database developed in the study.

Location Map of Study Area

The Study on the Regional Development Plan for the Lower Northeast and Upper East Regions in the Kingdom of Thailand

Final Report
Sector Report 7. Power and Energy

Table of Contents

List of Tables

List of Figures

Abbreviations

AAT	Airports Authority of Thailand [MOTC]
ADB	Asian Development Bank
AED	Agricultural Extension Department [MOAC]
BAAC	Bank for Agriculture and Agricultural Cooperatives [MOF]
BMA	Bangkok Metropolitan Area
BMR	Bangkok Metropolitan Region
BOB	Bureau of the Budget [OPM]
BOI	Board of Investment [OPM]
BOT	Bank of Thailand
CAO	Changwat Administration Organization [MOIT]
CAT	Communication Authority of Thailand [MOTC]
CDD	Community Development Department [MOIT]
CPD	Cooperatives Promotion Department [MOAC]
CRDP	Coordinating Committee for the Royal Development Projects
DFPOT	Dairy Farming Promotion Organization of Thailand [MOAC]
DOA	Department of Aviation [MOTC]
DOH	Department of Highways [MOTC]
DOLA	Department of Local Administration [MOIT]
DRDC	District Rural (or Regional) Development Committee
DTEC	Department of Technical and Economic Cooperation [OPM]
EGAT	Electricity Generating Authority of Thailand [OPM]
ESBC	Eastern Seaboard Committee [NESDB]
ERTAT	Expressway and Rapid Transit Authority of Thailand [MOIT]
ETOT	Express Transportation Organization of Thailand [MOTC]
FIO	Forest Industry Organization [MOAC]
GCST	Government Cold Storage Organization [MOAC]
IEAT	Industrial Estate Authority of Thailand [MOID]
IFCT	Industrial Finance Corporation of Thailand
IPD	Industry Promotion Department [MOID]
ITD	Internal Trade Department [MOC]
JICA	Japan International Cooperation Agency
JPPCC	Joint Public / Private Consultative Committee [BOI]
LDD	Livestock Development Department [MOAC]
LNE-UE	Lower Northeast - Upper East
LTD	Land Transport Department [MOTC]
MOAC	Ministry of Agriculture and Cooperatives
MO	Marketing Organization [MOIT]
MOC	Ministry of Commerce
MOD	Ministry of Defence
MOE	Ministry of Education
MOF	Ministry of Finance
MOFF	Marketing Organization for Farmers [MOAC]
MOID	Ministry of Industry
MOIT	Ministry of Interior
MOPH	Ministry of Public Health
MOTC	Ministry of Transport and Communications
MOUA	Ministry of University Affairs
MSTE	Ministry of Science, Technology and Environment
NEB	National Environment Board [MSTE]
NESDB	National Economic and Social Development Board [OPM]

NESDC	National Economic and Social Development Committee
NHA	National Housing Authority [MOIT]
NRDC	National Rural (or Regional) Development Committee
OARD	Office of Accelerated Rural Development [MOIT]
OCSC	Office of the Civil Service Commission [OPM]
OECF	Overseas Economic Cooperation Fund (Japan)
OPM	Office of Prime Minister
OPP	Office of Policy and Planning [MOIT]
PDA	Provincial Development Committee
PEA	Provincial Electricity Authority [MOIT]
PRDC	Provincial Regional Development Committee
PRDCC	Provincial Rural (or Regional) Development Coordination Center
PWA	Provincial Waterworks Authority [MOIT]
PWD	Public Works Department [MOIT]
PWO	Public Warehouse Organization [MOC]
RFD	Royal Forest Department [MOAC]
RID	Royal Irrigation Department [MOAC]
SNRDC	Office of the Secretary to the National Rural (or Regional) Development Committee
SRT	State Railway of Thailand [MOTC]
TAT	Tourism Authority of Thailand [OPM]
TCPD	Town and Country Planning Department [MOIT]
TOT	Telephone Organization of Thailand [MOTC]
TRDC	Tambon Rural Development Committee
UNDP	United Nations Development Program
UNIDO	United Nations Industrial Development Organization
USAID	United State Agency for International Development

Abbreviation of Measures

Length

mm	=	millimeter
m	=	meter
km	=	kilometer

Area

ha	=	hectare
km^2	=	square kilometer

Volume

l	=	lit = litre
m^3	=	cubic meter
MCM	=	million cubic meter

Weight

mg	=	milligram
g	=	gram
kg	=	kilogram
t	=	ton = MT = metric ton

Time

sec	=	second
hr	=	hour
d	=	day
yr	=	year

Money

US$	=	U.S. dollar
B	=	Baht

Energy

kcal	=	kilocalorie
J	=	joule
MJ	=	megajoule
HP	=	horsepower
TOE	=	tons of oil equivalent
kW	=	kilowatt
MW	=	megawatt
kWh	=	kilowatt-hour
GWh	=	gigawatt-hour

Others

%	=	percent
°	=	degree
'	=	minute
°C	=	degree Celsius
cap.	=	capita
md	=	man-day
mil.	=	million
no.	=	number
pers.	=	person
PCU	=	passenger car unit
ppb	=	parts per billion

Unit Conversions

1 rai	=	0.16 hectare

CHAPTER 1

ENERGY POLICIES AND INSTITUTIONS IN THAILAND

1.1 National Energy Policies and Administration

(1) National energy policies

The rapid growth of Thai economy in recent years has been supported by consistent expansion of energy supply capacity. The growth has accelerated since 1987 to attain 13% in 1988, 12% in 1989, and 10% in 1990. During this period, the supply of commercial energy increased from 388,000 barrels of crude oil equivalent per day in 1987 to 605,000 barrels of crude oil equivalent per day in 1990, at 16% per annum. Of this increment, 64% was accounted for by petroleum. With this background, the government has set the following policy framework for future energy supply and use.

1) To continue diversification of supply and utilization of energy by the development and exploration of indigenous energy resources together with further encouragement of efforts to reduce import energy;

2) To readjust price of petroleum products and electricity for more efficient use; the same applies to other forms of commercial energy such as natural gas, lignite, coal and fuel oil;

3) To emphasize energy saving by various conservation activities;

4) To allow the private sector's participation into investments for energy development to reduce financial burden for the government;

5) To promote the development and import of energy in neighboring countries for mutual benefits of Thailand and the neighbor countries; and

6) To develop local indigenous energy for rural areas.

(2) National energy strategy

Within the broad policy framework presented above, the government stipulates in the seventh five year plan the following energy strategy.

1) To emphasize investments into exploration and development of domestic petroleum and lignite;

2) To accelerate the development of hydropower, coal, natural gas and petroleum in neighboring countries by cooperative efforts;

3) To accelerate the construction and expansion of natural gas pipelines by the Petroleum Authority of Thailand (PTT);

4) To improve transmission and distribution system for electricity, particularly for supply to industrial estates and commercial areas;

5) To encourage effective use of renewable energy such as solar, geothermal, and agricultural/industrial wastes;

6) To encourage investments into small scale co-generation system by small enterprises; and

7) To introduce a built-own-sell (BOS) system into the power generation system of the Electricity Generating Authority of Thailand (EGAT).

(3) Energy and environment in Thailand

Environmental awareness has been arisen in all nations of the world. Thailand is no exception and it is found out that various environmental problems occured are cumulative results of the country's economic development deriving from the utilization of natural resources and energy without serious attention being paid to the environmental impact.

Energy-related environmental problem

In Thailand, the major energy related problem is air pollution emitted from the energy production and consumption. Dominant pollutants include lead, sulfurdioxide (SO_2), oxide of nitrogen (NOx), carbonmonooxide (CO) and carbondioxide (CO_2).

Urban air pollution

Especially in case of the Bangkok Metropolitan Area, air pollution arises from lead and CO emitted from vehicles using gasoline. Adding to these, SO_2 and NOx are released from fuel use by vehicles, industrial plants and residential development etc. These pollutants will have significant effect on public health.

Acid deposition and acid precipitation

SO_2 and NOx released from fuel burning can transmit for long distance away from the generated area and cause harmful effects to overall ecosystem such as aquatic life, natural forest, and agriculture products, and also cause deterioration of metal construction.

Global greenhouse effect due to CO_2

Carbondioxide (CO_2) released mainly from energy production and consumption is counted as greenhouse gas and a major contributor to global warming. Longer term effects of increase in the earth's temperature may lead to the rise of the sea water level and lifecycle deterioration of some plant animal species.

Air pollutant emission

- For Carbondioxide (CO_2)

  The 35% CO_2 contribution from electricity generation in 2001 is underlined by the fact that the sector will become the most energy consuming sector and that the sector's coal consumption share will be up by 56% comparing with that of 23% of 1991. By 2001, the sector's emission shared by fuel type will be 66% from coal, 19% from oil and 15% from natural gas. However, CO_2

emission shared by fuel type of all energy system in 2001 will be dominated by oil of 51%, followed by 29% of coal and the rest from renewable energy and natural gas.

CO_2 emission from coal will be higher than that from oil, and oil emission will be higher than that from natural gas.

- For NOx

The most Nox emission in the next decade will be due to the transportation sector which shares up to 57% of total emission resulting from high gasoline and diesel oil consumption, followed by 26% of electricity generation and 13% for industrial sector.

Emission of NOx from diesel engine is higher than gasoline engine.

It is expected that new pollutant absorber techniques may be applied that utilize catalytic reactor for electricity power generation and large scale industries.

- For SO_2

The high SO_2 emission from the electricity generation is due to more consumption of high sulfer fuel such as lignite and fuel oil, containing about 2-3% sulfer by weight, up to 40-50% of sector's total fuel consumptions.

It is expected to apply new pollutant absorber technique for electricity generation. Furthermore, changing to the diesel fuel of low sulfer containing from 1 to 0.5% for the transportation sector is very effective measure.

- For lead

Before 1983, the gasoline lead content was as high as 0.84 gm./liter. The latest decrease in gasoline lead content to low level of 0.15 gm./liter has been enforced since January 1992. At the same time, unleaded premium gasoline (ULG) has also been promoted to the local market by mid-1991. As the result of above, substantial reduction of lead emission will be expected.

- For CO

More than 81% of total CO emission is from the transport sector, especially from gasoline vehicle fleets. To reduce CO emission from vehicles, improvement of fuel combustion technique and adoption of catalytic converter are expected. Pollutant emission by type is shown below and in Figure 1.1.

Pollutants Emission

unit: thousand tons

Year	NO_2	SO_2	CO	CO_2	Lead
1981	184	378	2,424	58,286	1,718
1982	182	325	2,385	59,892	1,649
1983	197	349	2,441	62,130	1,726
1984	225	364	2,494	66,754	1,768
1985	242	428	2,499	70,578	862
1986	252	447	2,606	71,970	935
1987	290	506	2,800	78,519	1,065
1988	327	564	3,002	86,357	1,195
1989	385	682	3,251	98,388	1,359
1990	446	934	3,426	110,269	1,496
1991	519	1,066	3,691	124,819	1,461
1996	761	1,382	4,734	171,379	675
2001	1,162	2,345	5,991	254,060	906

Source: DEA/OIL and Thailand 1991

(4) Energy administration

A number of public entities are involved in energy development in Thailand. They may be classified into policy making administration and development agencies.

Policy making administration

The National Energy Policy Committee (NEPC) chaired by the Prime Minister has the authority to make all the energy policies and to coordinate energy-related activities. NEPC is supported by three subcommittees : the Petroleum Policy Subcommittee for petroleum related matters, the National Energy Policy Formulation Subcommittee for all other energy matters and the Energy Demand and Supply Subcommittee for matters related to energy planning. Under NEPC, the Department of Energy Affairs (DEA) takes charge of specific policy formulation in cooperation with the National Economic and Social Development Board (NESDB) The main emphasis is on the power sector.

Development agencies

The Department of Mining Resources (DMR) has the right of exploration and development of petroleum. It gives permissions for the construction and operation of petroleum refineries. It also controls the activities of the Petroleum Authority of Thailand (PTT). PTT has the responsibility for development and supply of petroleum, petroleum products and natural gas. For electric power generation, transmission and distribution, there are three state-owned utility companies. The Electricity Generating Authority of Thailand (EGAT) is responsible for power generation and transmission to primary substations. The Metropolitan Electricity Authority (MEA) is in charge of power distribution to the Bangkok Metropolitan Area, and the Provincial Electricity Authority (PEA) is in charge of power distribution to the whole kingdom not served by MEA. EGAT is responsible to the Prime Minister's Office and both MEA and PEA are responsible to the Ministry of Interior.

1.2 Electricity Tariff

(1) Electricity sales and prices

EGAT sells its electricity to different customers. The sales prices are as summarized below.

Electricity Sales Prices by EGAT

(Unit : Stangs/kWh)

Customer	FY 1990	FY 1980	Percent increase (+) decrease (-)
MEA	144.77	144.77	+/- 0
PEA	103.99	103.99	+/- 0
Direct Consumers	137.67	134.90	+ 2.05
Laos	91.03	90.99	+ 0.04
Others	120.21	131.98	- 8.92
Average	125.21	125.30	- 0.07

The bulk transfer price to MEA exceeds that to PEA. As it is more expensive for EGAT to supply PEA's dispersed loads than to supply MEA's concentrated loads, PEA's consumers are cross-subsidized by MEA's consumers. The lower price levied on PEA enables it to maintain reasonable level of financial viability. The marginal cost of supply to remote rural area is estimated to be as high as 8 Baht/kWh, while the revenue is less than 1 Baht/kWh for consumption up to 35kWh/month according to the PEA tariff.

(2) Retail tariff

Recently, the government introduced a new tariff structure in electricity retail. The new tariff reflects supply costs at different voltage levels which will result in a self-financing ratio of at least 25%. For the fiscal year 1990-91, self-financing of 20% is projected. Detailed tariff structure is given in Table 1.1.

CHAPTER 2

ENERGY SUPPLY AND DEMAND IN THAILAND

2.1 Energy Consumption and Supply

(1) Energy consumption

Total energy consumption

The total energy consumption nearly doubled during 1980's from 16.2 million tons of oil equivalent (Mtoe) in 1982 to 30.5 Mtoe in 1991, at the average annual growth of 7.2%. The total energy consumption per capita increased from 332 kg of oil equivalent (koe) in 1982 to 535 koe in 1991. Petroleum products accounted for 57.7% of the total final energy consumption in 1991 (Table 2.1). Consumption of modern energy, including coal and cokes, oil products, natural gas and electricity, corresponds to 76% of the total consumption, and the rest is made up by renewable energy consisting of fuel wood, charcoal, paddy husk and bagasse.

Changes in energy consumption by source

In 1982, the total energy consumption consisted of 48.3% petroleum products, 42.2% renewable energy, 7.9% electricity and the rest by coal, lignite and natural gas. In 1991, petroleum products consumption accounted for 57.7% of the total energy consumption, renewable energy for 24.0%, electricity for 12.1%, and coal, lignite and natural gas for 6.2%. A significant shift from renewable energy to modern energy is apparent. This reflects the high economic growth in the past decade, especially industrialization, farm mechanization, urbanization and expanding transport activities. Increase in lignite consumption is a result of substitution for other energy sources in industries such as tobacco curing and cement manufacturing. Renewable energy is used mainly in residential and industrial sectors. Its use is expected to decline in the residential sector due to substitution by LPG.

Energy consumption by sector

In 1990, the transportation sector was the largest energy consumer, accounting for 11.9 Mtoe or 39.1% of the total consumption (Table 2.2). The residential and commercial sector consumed 7.2 Mtoe or 23.7% of the total. Renewable energy supplied 63.3% of the consumption in this sector. Energy consumption in the industrial sector was 9.5 Mtoe or 31.1% of the total. Of the consumption in this sector, 87.2% is due to modern energy.

(2) Primary energy supply

The total primary energy supply in 1991 amounted to 43.9 Mtoe, 6.35% increase from the previous year (Table 2.3). It consists of 33.0 Mtoe modern energy or 69% of the total supply and 10.8 Mtoe renewable energy or 31.0% of the total.
The energy supply from domestic sources accounts for 58.0% and the supply by import 42.0%. The total import energy is valued at 81,366 million bahts, equivalent to 10.0% of the total import value. Of the total domestic supply, 53% is attributable to modern energy. The modern domestic energy is dominated by natural gas and

lignite. The natural gas from the gas field in the Gulf of Thailand started commercial production in 1981. The production of natural gas and condensate rapidly increased from 1.16 Mtoe and 0.25 Mtoe respectively in 1982 to 7.0 Mtoe and 0.99 Mtoe respectively in 1991. The production of lignite also increased rapidly from 0.61 Mtoe in 1982 to 4.2 Mtoe in 1991. Increase in 1990 was the highest at 38% due mainly to high demand in power generation and cement industry.

2.2 Electricity Consumption and Supply

(1) Electricity consumption

The electricity consumption in Thailand increased from 15,033 GWh in 1982 to 43,398 GWh in 1991 at the average annual rate of 11.0%. The per capita consumption increased from 308 kWh in 1982 to 762 kWh in 1991. Detailed data on electricity consumption, peak generation, per capita consumption and losses are shown in Table 2.4. The industrial sector is the largest consumer accounting for 45.6% of the total consumption, followed by the commercial sector for 32.2% and the residential sector for 21.0%. Growth of electricity consumption from the previous year was 10.5% by the industrial sector, 16.6% by the commercial sector, and 13.2% by the residential sector.

(2) Import and export

Thailand purchases electricity from Laos and Malaysia at respective borders. The total electricity import was 594.8 GWh in 1991, consisting of 563 GWh or 94.6% from Laos and 31.8 GWh from Malaysia. The total value of import electricity was 493.7 million bahts. The total import decreased by 8.8% from previous year. Thailand also sells electricity to these countries. The total export was 39.9 GWh in 1991, and increase of 30.0% from last year. The total value of export accounted for 38.4 million bahts of which 89%were supplied to Laos.

(3) Electricity supply system

Electricity generating capacity

In 1991, the total installed electricity generating capacity of Thailand was 9,707.3 MW, up 11.2% over 1990. The capacity increases came from additional installation of thermal, hydro and gas turbine plants (Table 2.5). The additional installation comprised of two units thermal plant of 600 MW at Mae Moh, Lampang province, two units gas turbine plant of 206 MW in Rayong province and one hydro electric unit of 180 MW at Srinakharin dam in Kanchanaburi province.

EGAT supply system

As of September 1990, EGAT had a total generating capacity of 7,986 MW and generated 43,190 billion kWh. EGAT's transformer capacity, number of substations and transmission line length are summarized in Table 2.6. EGAT power supply net work is shown in Figure 2.1.

MEA system

MEA operates 15 circuit - km of 230 kV transmission lines. As of 1987, its transmission system included also 118 and 519 circuit - km of 115 kV and 69 kV lines,

respectively and its sub-transmission system comprised 6,712 circuit - km of 24 kV and 12 kV lines.

PEA system

As of September 1990, PEA's network comprised 92 circuit -km of 150 kV and 69 kV lines, and over 152,515 circuit - km of 33 kV, 22 kV, 11 kV and 3.5 kV lines. Detailed data are given in Table 2.7 PEA's service areas are shown in Figure 2.2.

(4) Power demand forecast

EGAT's total generation requirement

A load forecast study was made in August 1991, by NEPO, Thailand Load Forecast Working Group. According to the results, average growth was 10.5%, 8.2% and 6.6% over 1992 to 1996, 1997 to 2001 and 2002 to 2006, corresponding to 81,741 GWh, 121,083 GWh and 166,999 GWh in 1996, 2001 and 2006 respectively (Table 2.8).

PEA's power demand forecast

Power demand forecast was made in August 1991, by NEPO, Thailand Load Forecast Working Group. Average growth was 12.0%, 9.1%, and 7.5% over 1992 to 1996, 1997 to 2001 and 2002 to 2006, corresponding to 39,943 GWh, 61,707 GWh, and 88,408 GWh in 1996, 2001 and 2006 respectively (Table 2.9).

CHAPTER 3

ENERGY SUPPLY AND DEMAND IN LNE-UE

3.1 Electricity Consumption and Supply

(1) Electricity consumption

Total consumption

The total power consumption in the Study Area was 22,483.3 GWh in 1991. This consists of 5,736.7 GWh or 25.5% for residential, 4,134.6 GWh or 18.4% for business, 11,008.3 GWh or 49.0% for industry, 1,229.2 GWh or 5.5% for government, and 374.6 GWh or 1.67% for others, each for total consumption respectively. The consumption data by province are given in Table 3.1.

Per capita consumption
The per capita electricity consumption in the Northeast region was 150 kWh in 1991, much smaller than the national average 762 kWh in the same year (Table 3.2).

(2) Electrification

The rate of electrified households is very high at 99.2% on the average, in September 1992. The number of villages and population in non-electrified area are 109 villages and 56,453 population (Table 3.3).

(3) Power supply system

Major power stations serving the Northeast region are the Mae Moh lignite thermal plant with total installed capacity of 1,425 MW, the South Bangkok oil-fired thermal plant with 1,330 MW and the Bang Pakong combined cycle power station with 1,100 MW fueled by fuel oil and natural gas. In the Study Area only two power stations were installed: the Nakhon Ratchasima gas turbine power plant with 14 MW and the Sirindhon hydro-power plant with 40 MW.

(4) Photo-voltaic power generation

In recent year (from 1988), PWD (Public Works Department) strongly promotes to install the photo-voltaic battery charging system and the photo-voltaic water pumping system in areas where PEA cannot supply the electricity because of very long distance from PEA's distribution system and large amount of investment cost.

Photo-voltaic battery charging system

Photo-voltaic battery charging system consists of solar array and battery charger with controller. The villagers have their own battery and they come to the charging station with the battery and then connect the battery to the charging terminal of the station. The villagers carry their charged battery to their house. The villagers can use the electricity for fluorescent lamp, television and radio etc. The outline of the system is shown in Figure 3.1(1).

The outline of the system is as follows:

Solar output	:	800W
Battery	:	DC 12V or 24V 60AH or 100 AH (car use type)
Charging capacity	:	10 batters per day
Operation hour	:	8 hours/day
Charging fee	:	15~20 baht
Nos of households	:	50~100 households
Investment cost	:	250,000 bahts (Including equipment, installation, building and fence etc.)

Photo-voltaic water pumping system

The photo-voltaic water pumping system consists of solar array, DC/AC inverter with controller, pump, piping and water storage tanks. This system is arranged to feed the domestic and drinking water to the villagers. Solar array feeds the DC electricity to DC/AC inverter, and the pump is driven by the AC electricity from DC/AC inverter. Water source is river or pond, the pumped up water is sent and stored into water storage tank, and the villagers can use the water from the storage tank. The system configuration is shown in Figure 3.1(2).

The outline of the system is as follows:

Solar array output	:	500~1,700 W
Pump type	:	Surface water type or submergible type
Pipeline length	:	500~3,500 m.
Pipe size	:	50~100 m/m dia., Vinyle-Chloride
Water demand (Estimated)	:	200 l./day/household
Tank capacity	:	10 m^3
Nos of tanks	:	2~3 tanks
Investment cost	:	600~900 thousand bahts (Including equipment, pipeline pump, tank and installation)

Installation of the systems

The following photo-voltaic battery charging system (PVBCS) and photo-voltaic water pumping system (PVWPS) were installed.

Province	PVBCS	PVWPS
Prachin Buri	1	-
Nakhon Ratchasima	11	51
Surin	9	11
Si Sa Ket	10	11
Ubon Ratchathani	12	-

(5) Distribution system

PEA receives the electricity supplied from EGAT primary sub-stations and distribute to the consumer by 20 kV or 30 kV distribution lines. The primary substations are connected by 69 kV, 110 kV or 220 kV transmission lines to the EGAT's power grid. The distribution network is shown in Figure 3.2.

Within the Study Area, PEA has power transformers of 652 MVA in total capacity and 26 banks of transformers performance of the distribution system is compared by region in Table 3.4.

The number of power interruptions per customer is lower in the PEA service area (NE2 and NE3 corresponding to the Study Area) than in other regions.

(6) Electricity demand forecast

PEA's service area (1990 to 2001)

Demand forecast for PEA's supply area is shown in Table 3.5. Average annual growth rates during 1991 to 1995 and during 1995 to 2000 are 10.0% and 14.0% respectively for Northeast region, and 8.6% and 10.0% respectively in the whole supply area.

PEA's NE 3 Region

Demand for NE 3 Region including Nakhon Ratchasima, Surin and Buri Ram provinces is shown in Table 3.6. Average annual growth rates are as follows.

Year	Growth Rate
1992-1995	11.0%
1995-2000	7.8%
2000-2005	5.8%
2005-2010	4.5%

PEA's NE 2 Region

Demand forecast for NE 2 Region including Mukdahan, Yasothon, Ubon Ratchathani and Si Sa Ket provinces is shown in Table 3.7. Average annual growth rates are as follows.

Year	Growth Rate
1992-1995	8.3%
1995-2000	7.4%
2000-2005	5.5%
2005-2010	5.0%

3.2 Petroleum Product Consumption

The consumption of petroleum product in the Northeast region is compared in Table 3.8 with that in Thailand. The total consumption in the Northeast was 1,798.2 million liters in 1991, corresponding to 7.3% of the national consumption. The consumption in the Northeast increased at the average rate of 8.7% per annum between 1986 and 1991. This is compared with the average increase at 13.3% per annum for the whole Kingdom.

CHAPTER 4

POTENTIAL AND EXISTING PLANS FOR ENERGY DEVELOPMENT

4.1 Potential and Targets

(1) Dependable deposits of primary energy

Thailand

The dependable deposits of coal and lignite are estimated at 1,500 million tons in the whole Kingdom. The dependable deposits of natural gas, petroleum and condensate are summarized below.

Dependable Deposits of Natural Gas, Petroleum and Condensate

Name of Field	Dependable Deposits	
	Petroleum Condensate (MMBBL)	Natural Gas (BCF X 10^3)
Off Shore		
Brawan	55,196	1,884.5
Baanpot	7,520	157.1
Satun	57,673	1,969.0
Platong	12,003	230.4
B	41,110	7,094.0
Nang Muan	22,000	-
L	21,700	-
Others	42,885	2,372.9
Subtotal	260,077	13,708.7
On Shore		
Nam Phong	-	1,500.0
Sirikit	55,400	176.6
Wichian	22,400	-
Others	10,300	170.0
Subtotal	88,100	1,846.6
Total	348,177	15,555.3

Units : MMBBL = Million barrels
BCF = Billion cubit feet
Source: Dept. of Material Resource

Study Area

No fossil fuel deposits exist in the Study Area. Hydro power potential is very small and mostly developed already except mini-hydro power potential.

(2) Development targets

The government has set the following targets in the seventh plan for the energy development.

1) Primary energy production by hydropower, natural gas, coal and imported petroleum will grow at 8% per annum. The total energy production by these sources will increase from 280,000 barrels of crude oil equivalent per day in 1991 to 410,000 barrels of crude oil equivalent per day in 1996.

2) Growth of commercial energy consumption should be suppressed to less than 10% per annum.

3) Activities for petroleum refineries should be upgraded.

4) Electricity generating capacity will be developed by 5,400 MW during the seventh plan period.

5) Reserve capacity of electricity supply system is to be less than 15% of the peak demand for any year.

6) A minimum production of 500 MW for private investment in electricity by the co-generation system should be attained during the seventh plan period.

7) Electricity consumption should be suppressed by 4,500 GWh per year by 1996.

8) Emission of hazardous materials from commercial energy should be reduced.

4.2 Existing Plans

(1) Expansion plans for petroleum, natural gas and lignite production

Existing plans to expand the production of petroleum, natural gas and lignite are summarized. Production of petroleum (crude oil) is planned to expand from 13,000 barrels per day in 1991 to 24,000 barrels per day in 1996. Output from oil refineries will increase from 246,000 barrels per day in 1991 to 740,000 barrels per day in 1996. Natural gas production is planned to increase from 760 million cubic feet per day in 1991 to 1,250 million cubic feet per day in 1996. Condensate production will increase from 22,000 barrels per day in 1991 to 31,000 barrels per in 1996. Production of coal and lignite will increase from 14.6 million tons per day in 1991 to 18.5 million tons per day in 1996. The uses of lignite were 12 million tons per day for electricity generation and 2.6 million tons per day for industries in 1991. These will increase to 14 million tons per day for electricity and 4.5 million tons per day for industries in 1996.

(2) Expansion plan of electricity

EGAT has been planning for the expansion of power supply to meet the rapidly increasing demand and also to respond to the government policy to reduce dependence on imported oil. Targets for fuel use for electricity generation are as follows.

Use of Fuels for Electricity Generation

Fuel	Generation/Consumption	1991	1996
Natural Gas	Generation (GWh)	19,900	31,950
	Consumption (MCF/day)	566	780
Lignite	Generation (GWh)	12,431	14,275
	Consumption (MT/day)	12.1	14.0
Imported Coal	Generation (GWh)	0	766
	Consumption (MT/day)	0	0.20

Source: NESDB

Power development projects under construction or consideration are summarized in Table 4.1. The long term power development plan to the year 2006 will add 19,934 MW to the present generating capacity. Of this, 14,350 MW will come from thermal, 1,752 MW from hydro, 8,032 MW from combined cycle and 800 MW from gas turbine generators.

(3) Improvement and development of electricity supply in PEA's supply area

PEA has proposed four policies towards the electricity supplying development in the seventh year plan.

- To provide an adequate supply of stable power that meets the timely needs of customers at minimum cost.
- To promote the efficient and economical use of electricity.
- To encourage private investment participation in electricity supply management and to improve the national energy management system.
- To conserve natural resources and the environment and prevent adverse generation, transmission and distribution impacts to the communities.

Whole Kingdom

PEA has planned to promote six plans. The total investment cost for these six plans and 19 projects is 48,534 million bahts.

	Plans and Projects	Investment Cost (million baht)	
1.	Power System Expansion Reinforcement Plan (5 projects)	30,803	(63.5%)
2.	Power System Efficiency Improvement Plan (1 project)	3,000	(6.2%)
3.	Rural Electrification Plan (2 projects)	2,875	(5.9%)
4.	Power Supply for New Economic Plan	6,000	(12.3%)
5.	Strengthening Operational and Service (1 project)	5,000	(10.3%)
6.	Research and Development Plan (9 projects)	856	(1.8%)
	Total 6 plans and 19 projects	48,534	(100.0%)

The Study Area

Existing plans for electricity supply expansion in the Study Area are summarized.

- Development of new substation

Substation Name		Province
Sub Chok Chai	1x50 MVA	Nakhon Ratchasima
Sub Hua Thale	2x50 MVA	Nakhon Ratchasima
Sub Huai Thalaeng	1x25 MVA	Nakhon Ratchasima
Sub Tha Tha	1x25 MVA	Surin
Sub Tra Kan Phutphon	1x25 MVA	Ubon Ratchathani
Sub Ongkharak	1x50 MVA	Prachin Buri
Sub Kabin Buri	2x50 MVA	Prachin Buri
Sub Prachantakhon	1x50 MVA	Prachin Buri

Total capacity 425 MVA
Budget 8,000 million bahts

- Development and improvement of distribution lines

  - Length of distribution line for each voltage level
    22 kV distribution line 778 CCT-KM
    230/380 V distribution line 65 CCT-KM
  - No. of transformer and total capacity
    22 kV/230-380 V, 250 kVA 47 sets
    Total capacity 11,750 kVA

(4) Photo-voltaic electricity supply system for village electrification

PWD (Public Works Department) has been planning installation of the photo-voltaic electricity supply system for electrification in non-electrified rural area as reported in Chapter 3, subsection 3.1 (4).

Whole Kingdom

DEA has been planning installation of the photo-voltaic electricity supply with the total of 2,000 plants and 500 plants per year during 1993-1996. Total budget is 500 million bahts.

The Study Area

In the Study Area, DEA has planned photo-voltaic electricity supply as follows.

(Unit : No. of PV plants)

No.	Provinces	1993	1994	1995	1996
1.	Prachin Buri	10	10	10	10
2.	Nakhon Ratchasima	30	30	30	30
3.	Buri Ram	22	22	22	22
4.	Surin	30	30	30	30
5.	Si Sa Ket	20	20	20	20
6.	Ubon Ratchathani	10	10	10	10
	Six Provinces	122	122	122	122

CHAPTER 5

ENERGY DEVELOPMENT PLAN

5.1 Objectives and strategy

(1) Characteristics of LNE-UE energy situations

Energy consumption

The less developed status of the Study Area (LNE-UE) is reflected in its energy use. The electricity consumption in the Study Area constitutes only less than 7.0% of the total consumption in Thailand. Per capita electricity consumption in the Study Area is only 36.5% of the national average (762 kWh in 1991). Increase in the consumption of petroleum products in the Northeast is much slower (8.7% per annum in 1986-91) than the increase in the whole Kingdom (13.3% per annum during the same period). However the electricity consumption in the Study Area has been growing at high rates in recent years (12.9% per annum in 1987-91).

Energy supply and resources

The Study Area has very limited energy resources. No fossil fuel resources endowment has been reported and hydropower potential is also small within the Study Area. There exist a hydropower plant (40 MW at Sirindhorn) and a gas turbine plant (14 MW at Nakhon Ratchasima). However, there are some bright prospects as well.

Prospect for rural energy seem reasonable. In addition to common agricultural wastes such as rice husk and straw, the Study Area has large amount of bagasse and cassava waste as well as animal wastes. Some other energy crops may also be promising. Another rural energy potentially important in the Study Area is solar energy.

(2) Objectives

Objectives for energy development in the Study Area support the LNE-UE regional development as follows.

1) To increase total energy to support higher industrialization and to diversify sources of rural energy to support income generating activities in rural areas;

2) To make maximum use of locally available energy sources including plant and animal wastes to minimize negative environmental effects of energy development; and

3) To support self-help efforts by rural populace to increase energy supply to minimize social problem associated with large scale energy development for sustainable and socially acceptable development.

(3) Strategy

Rural energy

Use of abundant agricultural and animal wastes should be much expanded. Technology for biogas digester using animal wastes is readily adoptable and used primarily for cooking to reduce the use of fuel wood. Of various agricultural wastes, rice husk alone can generate electricity of some 230 GWh, if half of paddy husk generated is collected and used. Use of biomass should be extended to other energy crops in the future. They may include cassava, sugarcane (by product) and leucaena.

Solar energy has potential for wide application. Use of solar water heaters can be expanded immediately not only for hot water supply to hotels, hospital and other public facilities, but also for industrial process heat and other uses. Photo-voltaic technology can be applied to rural electrification in general, and water pumping and telecommunication purposes among others in particular.

Industrial energy

Probably the only major prospect for power generation within the Study Area is co-generation. Otherwise, extension of power transmission line and distribution system would be the prime option. Improvement of supply stability and reliability by replacement of equipment as well as further network interconnection is as important as the expansion of service area.

5.2 Development Targets

According to socio-economic framework for balanced development of the LNE-UE master plan, the per capita GRDP in the Study Area is expected to increase from about US$ 500 at present to over US$ 2,000 by 2010. This growth would be supported by high industrization, modernization of agriculture and other associated activities. Economic structure will change in the fundamental way.

This will change energy use structure. More commercial energy will be used and per capita energy consumption will increase by several times. While every effort should be made to increase the use of local energy including non-convensional forms of energy, increasing supply will have to be met largely by import from other regions. They are mainly in the forms of import of petroleum products and expansion of power transmission lines. Supply of other sources of energy will also depend much on external supports in the form of provision of technology and use facilities/devices (e.g. solar device). Levels of energy supply expansion are indicated below for commercial energy as a whole and electricity in particular.

Commercial energy

According to the Seventh Five-Year Plan, primary energy production is expected to grow at 5% per annum throughout the Kingdom. The plan states also that the growth of commercial energy consumption should be suppressed to less than 10% per annum. Consumption of petroleum products will become some 60% of the total energy consumption, growth at 15.9% per annum in the Kingdom during 1980-1990, while this rate was lower at 9.8% in the Northeast. The growth of petroleum products consumption in the Study Area will be necessarily at over 10% per annum during the master plan period. Including other forms of energy, the commercial energy consumption in the Study Area will grow at 10% per annum at least. This

exceed growth of primary energy production. Thus increasingly large portion of commercial energy consumption will have to be supplied by import, including necessary electricity import from Laos.

Electricity

The per capita GRDP in the Study Area in 2010 is comparable with that in some of newly industrialized countries (NICs) such Malaysia (US$ 2,213 in 1989), South Africa (US$ 2,446) and Brasil (US$ 2280). The per capita electricity consumption will also increase accordingly. Assuming per capita consumption of 1,000 kWh in 2010, the total electricity consumption will reach 13.360 GWh, representing eight times increase from 1991. Electrification ratio per households in the Study Area is at 99.2% as of September 1992. The government now promotes the electrification to 2000 non-electrified villages in the Kingdom during 1993-1996 where the electricity supply by PEA's distribution system is not expected in the near future.

5.3 Development Projects and Support Measures

To support the LNE-UE regional development, the following measure in the energy sector are particulary important.

- Energy supply expansion to support industrialization, including the Lam Takhong pumped storage power generation plant, Pak Mun hydropower generation plant, and improvement and development of power distribution system, and

- Energy source diversification to enhance living standards of rural people, including new/non-convensional sources of energy such as solar, biomass and biogas.

5.3.1 Projects for industrial energy

(1) Lam Takhong pumped storage power generation plant.

This is an on-going project for which a feasibility study has been completed and detailed design will start soon. A dam will be constructed on the upstreams of Lam Takhong river, a tributary of the Mun river, and pumped storaged hydropower plant will be constructed with 1,000 MW generating capacity by using the existing Lam Takhong reservoir as a lower reservoir for flow regulation. Implementation of the power plant will be in stages.

(2) Pak Mun hydropower plant

Pak Mun hydropower project is located across the Mun River at Ban Hua Heo, Khong Chiam District, Ubon Ratchathani Province. The Pak Mun dam is of run-off river type. The project comprises a concrete roller compacted dam which is 17 meter high and 300 meter long, and four 34 MW units of bulb turbine. This 136 MW power plant will yield an annual energy of 280 million kWh. The project was started in June 1990 and will be completed by December 1994.

(3) Co-generation system

The co-generation system is a modern power generation system with high efficiency to produce both electricity and hot water. The generated electricity will help to upgrade the reliability of power supply system. The hot water exchanged through waste heat exchanger can be supplied to hospitals, hotels and food processing industries. The co-generation comprises gas turbine, gas engine or diesel engine and generator, and heat exchanger. The fuel for these gas turbine, gas engine or diesel engine are mainly city gas, natural gas or high speed diesel fuel oil. The most suitable fuel is the natural gas from the viewpoint of use of domestic energy to reduce import of crude oil.

In the Study Area, only one gas turbine power generation plant exists in Nakhon Ratchasima, it is recommended to improve or replace the existing system to the co-generation system. The improvement of total efficiency of the co-generation system compared with plant for power generation alone are shown below.

- For Diesel engine generator
  Output class : 100-1,000 kW class

  Power generation
  Efficiency : Average 35%

  Co-generation
  Efficiency : Average 75%

- For gas engine generator
  Output class : 100-600 kW

  Power generation
  Efficiency : Average 30%

  Co-generation
  Efficiency : Average 80%

- For gas turbine generator
  Output class : 400-2,000 kW

  Power generation
  Efficiency : 17.5%

  Co-generation
  Efficiency : 60%

(4) Improvement and development of the power distribution system.

Stability and reliability of power supply are essential conditions to allow modern operation of manufacturing lines for high quality products. To reduce power interruption, it is necessary to replace or improve the equipment and devices including transformers, protective relays, circuit breakers, distribution lines and other related devices and equipments.

5.3.2 Projects for rural energy

(1) Solar energy

Background

Thailand is reasonably well endowed with solar radiation, and the situation is more favorable in the Study Area. Solar heaters are presently used at some hospitals, hotels, apartment houses and industrial plants as well as for individual houses mostly in Bangkok and high class resorts. Use of water heaters in the Study Area is still quite limited.

Utilization of solar energy for power generation is done by a TOT radio repeater station. At present some 200 solar power generation plants are planned and some 50 stations are under construction. Their size ranges from 1,000 to 3,600 W. Recently PWA (Public Work Department) strongly promotes the utilization of solar energy for rural electrification and water pumping system. PWD has installed some 30 sites of photo-voltaic battery charging systems and some 73 sites of photo-voltaic water pumping systems in the Study Area. PWD is planning the installation of photo-voltaic system accounted by 488 sites in the Study Area during the 1993-1996 period.

Solar water heater application

Solar water heater supply system is comprised the sunshine (or solar) collectors, heat storage tank, booster tank, collector pump and auxiliary boiler. The system is divided into two systems by heat collecting method. One is direct system, and the other is indirect system. Auxiliary boiler is equipped for additional heat supply of hot water when the heat value becomes insufficient due to increase in heat demand.

The system configuration is shown in Figure 5.1. Solar hot water supply system involves only very simple construction work and very low operation and maintenance cost. With this system, the users can obtain 60°C hot water for several uses. Combination of sunshine collector unit is determined by hot water demand; for example, the application to several sectors such as hospital, hotel and restaurant etc. are shown in Table 5.1. Served energy estimated with kcal/year and baht/year, and also roughly estimated equipment cost are shown.

Solar heat absorption liquid chiller

The solar heat absorption liquid chiller is also a modern technique used to produce chilled water that can be used for room cooler passing through cooling fan units. This system contributes to energy saving and bringing about many benefits to the users. This system consists of solar heat collectors, hot water tank, auxiliary boiler and heat exchanger, absorption liquid chiller, chilled water tank, cooling tower and cooling fan units.

The system arrangement is shown in Figure 5.2. The absorption liquid chiller consists of evaporator, absorber, condenser, regenerator, heat exchanger and cooling medium pump etc. The principle of the absorption liquid chiller can be explained as follows, and as shown in Figure 5.2.

- Cooling medium vapor generated in evaporator is absorbed and diluted by Biomic-Lithium liquid in absorber.

- Temperature of the diluted liquid rises passing through heat exchanger by liquid pump and the liquid becomes heavy by heating in regenerator.

- This heavy liquid returns to absorber transferring heat to heat exchanger.

- Then, the cooling medium vapor generated from the diluted liquid in regenerator returns to evaporator.

An example of the specification and performance of the typical types are shown below. The table shows energy saved annually and benefit of converted electricity: for example for cases of 50 VSRT, 150,000 kWh and 392,000 bahts respectively.

ITEM		Case / Unit	1	2	3
Refrerating Capacity		USRT MW	30 106	50 175	100 350
Chilled water	-Temperature - Flow rate	°c m^3/min	0.30	14/9 0.55	0.96
Cooling water	- Temperature - Flow rate	°c m^3/min.	3.5	31/36 11.0	2.4
Hot water	- Temperature - Flow rate	°c m^3/min.	0.44	85/80 0.8	1.4
Electricity		kW	4.0	4.0	4.0
Solar collector	- Unit size - Nos. of unit - Total area	m x m - m^2	1 x 2 490 980	1 x 2 820 1,640	1 x 2 1,640 3,200
Applied room area		m^2	990	1,650	3,300
Annual energy savings	- Energy - Benefit	kWh Baht	90,000 326,000	150,000 392,000	300,000 557,000
Equipment cost		¥ 10^3	82,000	125,000	240,000

Note : Excluding installation cost

Photo-voltaic electricity supply system for rural electrification system

The system consists of solar array, battery charger, storage battery, DC/AC inverter, transformer and control panels. A study for the system was carried out for three cases, assuming demand of 100 W per household and demand hour of 9 hours per day (6 hours at night and 3 hours in the morning).

- Case 1 output 3 kW 30 households
- Case 2 -do- 5 kW 50 -do-
- Case 3 -do- 10 kW 100 -do-

The specification and equipment cost of the system are shown below.

ITEM			CASE	1	2	3
System Output	- Voltage		(V)	230	230	230
	- Output		(kW)	3	5	10
	- Frequency		(HZ)	50	50	50
Demand Hour			(hr)	9	9	9
Solar Array	- Output		(WP)	18,126	30,528	61,056
	- Arrangement	Serial		18	18	18
		Parallel		19	32	64
	- NOS		(PCS)	342	576	1,152
	- Total area		(m^2)	136	227	455
Inverter Output			(kW)	3	5	10
Battery	- Voltage		(V)	310	310	310
	- Arrangement	Serial		124	124	124
		Parallel		2	2	3
	- Capacity		(AH)	2,200	3,700	7,300
Total Installation Area			(m^2)	800	1,100	2,300
Equipment Cost			(¥ x 10^6)	110	170	300

Photo-voltaic electricity supply system for water supply pump

Photo-voltaic electricity supply system for drinking water by deep well and irrigation or drainage water pumping system is very useful and beneficial for the villagers in rural areas where electricity supply by PEA is not expected.

In the Study Area, shortage of drinking water and irrigation water is a serious problem for public health and agricultural production. The drinking water supply system consists of solar array, DC/AC inverter, deep well, deep well pump, piping and storage tank. Pump capacity was selected assuming water demand per capita of 50 lit/day including drinking and domestic water in household. Irrigation or drainage water pumping system consists of solar array, DC/AC inverter, pump and piping.

The specification and equipment cost excluding installation of well, pond or reservoir, storage tank and piping, and installation of the equipments are shown in Table 5.2. Operation hours and number of population per household are assumed to be 9 hours and 5 persons per household.

(2) Rice husk power generation

Background

Rice husk is already an important component of renewable energy in Thailand. Of the total renewable energy production of 11.0 Mtoe in 1990, rice husk contributed 1.1 Mtoe. The balance was met by fuel wood of 8.1 Mtoe and bagass of 1.7 Mtoe.

These agricultural wastes are used for cooking, steam making and soil enriching ploughed into the land.

In the Study Area, paddy is a dominant crop with production of 6 million tons in 1989 and some 12,000 rice mills are scattered. Rice husk production is about 2 million tons which can be converted to heat value of 4,000 trillion kcal at the average heat content of 3,440 kcal/kg for husk. If half of rice husk, produced in the Study Area is made available for power generation, about 230 GWh electricity can be generated, assuming 10% generating efficiency. This amount corresponds to 13.8% of electricity consumption (1,670 GWh) in the Study Area in 1991.

Case study

To realize the rice husk power generating system, a case study was performed for three cases: 200 kW, 500 kW and 1,000 kW units. Operation hours and months were assumed as below.

- Operation hour (daily)
  100% of rated output for 10 hours
  30% of rated output for 14 hours

- Operating month (per year)
  4 months or 120 days

The study results and system configuration are shown in Table 5.3 and Figure 5.3.

Collection of rice husk is a major problem for successfully establishing the rice husk power generating plant. Initially the plant should be established in an area where existing rice mills are concentrated. Availability of rice husk and existing rice mills are summarized by province is shown below.

Province	Paddy (ton)	Paddy Husk (ton)	Heat Value of Husk (BKCAL)	Nos. of Rice Mill
Nakhon Nayok	396,430	79,286	272,744	97
Prachin Buri	592,269	118,453	467,478	430
Nakhon Ratchasima	1,024,000	204,800	704,512	2,330
Buri Ram	869,229	173,845	507,027	2,302
Surin	87,501	17,500	60,200	37
Si Sa Ket	345,647	69,129	237,804	564
Ubon Ratchathani	905,118	181,023	622,717	2,411
Yasothon	575,107	115,021	395,172	1,651
Mukdahan	1,165,375	233,075	801,778	1,873
Total	5,960,676	1,192,132	4,011,934	11,695

The study results show that electricity generation and benefit from selling electricity to PEA assuming retail price of 1 baht/kWh for Case 1, Case 2 and Case 3 are 348 MWh and 348,000 baht/year, 271,000 MWh and 876,000 baht/year and 1,740 MWh and 1,740,000 baht/kWh respectively. The steam and hot water can be obtained from the process as well as electricity to be used for several purposes. Husk ash can be used as soil conditioning material with the following benefits.

- Good hydro-scopicity can maintain water in soil for long period.
- Bacteridal action to protest bacterial damage.
- Absorption of sunshine due to its black color to help growing of farm crops.

(3) Biogas

Background

The total amount of manure available in Thailand is estimated at 57 million tons. If 50% of cattle manure and 75% of pig manure and fowl droplets are assumed collectable, 30 million tons may be used. The amount corresponds to biogas production of 1,633 million m^3 or 9,758 billion kcal, equivalent to 1,065 million liter of crude oil. There exist some 3,000 units of family size digester each generating 1-2m^3/day, four community size ones, each generating 20-30 m^3/day.

Pilot plant

In the Study Area, the methane gas generating plant is recommended to replace fuel wood for the protection of national forests. The methane gas generating plant using animal residue from 500 heads of swine by digester ferment effect is expected to generate 30 m^3/day of methane gas which can be used for cooking at households. This 30 m^3/day gas can be supplied to 30 households assuming 1.0 m^3/day per household. The plant consists of feces press, pressed waste storage, gas generator, water separator, sulfur separator, gasholder, booster pump and accumulator and pressure reducer. Feces and urine derived from cattle house are separated from waste and pressed by the feces press, and pressed waste is fed to gas generator. In the gas generator, the methane gas is generated derived from the pressed waste by digester ferment effect, and the methane gas is sent into gasholder passing through water and sulfur separator. The piping systems made by vinyl chloride are necessary to dispatch the gas to each households. The system diagram and specification including equipment cost are shown below and in Figure 5.4.

No.	Item	Application	Numerical Value
1.	Head of swine	15 kg/day/head	500
2.	Processed manure	1 x 3%	750 kg
3.	Necessary urine water	1 + 2	225 l
4.	Total feces an urine water	3 x 30%	975 kg
5.	Quantity of separated water	(3 - 4)	292 kg
6.	Pressed liquid	For one day	683 kg
7.	Dressed liquid storage capacity		700 l
8.	Gas generator capacity		About 16 m^3
9.	Storage of raw material in generator		23 days
10.	Gas generation		30m^3/day
11.	Water separator capacity		100 l
12.	Sulfur eliminator capacity		100 l
13.	Gasholder capacity		14 m^2
14.	Quantity of digestered water		670 l
15.	Equipment cost excluding installation of the equipments and piping system million Japanese yen		35.0

(4) Mini-hydro development

The development of 10 hydropower plants are expected in the Study Area which are planned by the Water Resource Sector in the Study Team and named the multipurpose weir irrigation water supply system. The system is planned so that the water is stored in storage reservoir from the river, and surplus water can be used for power generation utilizing the head between weir water level elevation and down-stream water level elevation. In the dry season, water released into intake canal will be stopped due to decreasing river water level; accordingly the irrigation water is supplied from the storage reservoir and water discharge in the intake canal for power generation will be stopped. Thus the mini-hydro power can be operated for only about six (6) months per year in the wet season.

The type of the water turbine will be selected by flow rate. For the flow rate below 10 m^3/s vertical axis fixed blade Kaplan type is selected, and for the flow rate over 10 m^3/s horizontal axis fixed or semi-fixed blade tublar tublar turbine type is used. An outline of the mini-hydro scheme are shown in Table 5.4.

5.3.3 Development of energy resource in the neighboring countries

Background

Energy consumption in Thailand rapidly grew in recent years following the high economic growth. Accordingly, imported energies have also increased. The Thai government emphasizes diversification of energy utilization, especially domestic energy use such as natural gas and lignite in place of imported fossil oil in industries and electricity generation. On the other hand, air pollution has been increasing caused by emission of pollutants such as CO, CO_2, SO_2 and NOx from vehicles and energy production and consumption plants. Air pollution gives strong impact on public health, global warming phenomenon and acid precipitation. The hydropower electricity is the best clean energy, but development of the water resource in Thailand is limited. There exist many undeveloped water resources in the neighboring countries of Laos, Cambodia, Viet Nam and Myanmer. At present, Thailand imports electricity from the Nam Ngum hydropower plant in Laos. Major water resources exist in the Mekong River basins in the neighboring countries. The Mekon River runs along the eastern part of the Study Area and electricity supply from Laos is highly expected.

Water resource development of the Mekong River Basin

The Mekong River is an international river running through China, Viet Nam, Laos, Cambodia and Thailand. There are a number of constraints to develop the Mekong River, the major constraint being political one.

From early time, the Mekong Committee under by ESCAP (Economic Commission for Asia and Pacific) and the concerned countries have been studying several development plans. Nowadays, development studies of Mekong river basin have been conducted with focus on the lower Mekong River basin. The basin's technical hydropower potential is estimated at 37GW, equivalent to 150-180 TWh/year, of which 33 percent is in Cambodia and 51 percent in Laos. Currently, less than 1 percent of this potential is being exploited and there is thus ample scope either for more intensive electrification of the basins or exporting surplus power to earn foreign exchange. The major development plans under study are as follows:

On the main steam basins
- High Luang Prabang, 14-16 TWh/year
- Upper Chiang Khan, 8-13 TWh/year
- Low Pa Mong
- Namdong

On the tributary basins
- Nam Theum 1, 7-9 TWh/year
- Nam Song
- Nam Leurk
- Nam Mang 3
- Nam Ngiap 1
- Nam Theum 2

A location map of the existing and planned hydro plants are shown in Figure 5.5.

Tables

Table 1.1 Electricity Tariff Structure (1/3)

1. RESIDENTIAL

1.1 CONSUMPTION NOT EXCEEDING 150 MWH. PER MONTH

ENERGY CHARGE	:	FIRST	5 KWH.	OR LESS	5.00 BAHT
		NEXT	10 KWH.		0.70 BAHT/KWH.
		NEXT	10 KWH.		0.90 BAHT/KWH.
		NEXT	10 KWH.		1.17 BAHT/KWH.
		NEXT	65 KWH.		1.58 BAHT/KWH.
		NEXT	50 KWH.		1.68 BAHT/KWH.
		NEXT	250 KWH.		2.22 BAHT/KWH.
		OVER	400 KWH.		2.53 BAHT/KWH.
		MINIMUM CHARGE 5.00 BAHT/MONTH			

1.2 CONSUMPTION EXCEEDING 150 KWH. PER MONTH

ENERGY CHARGE	:	FIRST	35 KWH.	OR LESS	89.00 BAHT
		NEXT	115 KWH.		1.14 BAHT/KWH.
		NEXT	250 KWH.		2.22 BAHT/KWH.
		OVER	400 KWH.		2.53 BAHT/KWH.
		MINIMUM CHARGE 89.00 BAHT/MONTH			

2. SMALL GENERAL SERVICE

(MAX. DEMAND LESS THA 30 KW.)

ENERGY CHARGE	:	FIRST	35 KWH.	OR LESS	94.00 BAHT
		NEXT	115 KWH.		1.14 BAHT/KWH.
		NEXT	250 KWH.		2.22 BAHT/KWH.
		OVER	400 KWH.		2.53 BAHT/KWH.
		MINIMUM CHARGE 94.00 BAHT/MONTH			

3. MEDIUM GENERAL SERVICE

(MAX DEMAND 30 KW. AND NOT MORE THAN 2,000 KW.)

3.1 AVERAGE CONSUMPTION OF THE LAST 3 CONSECUTIVELY MONTHS DOES NOT EXCEED 355,000 KWH. PER MONTH

3.1.1 AT VOLTAGE OF 69 KV. AND OVER

DEMAND CHARGE	:	188.00	BAHT/KW.
ENERGY CHARGE	:	1.03	BAHT/KWH.

3.1.2 AT VOLTAGE OF 11-33 KV.

DEMAND CHARGE	:	210.00	BAHT/KW.
ENERGY CHARGE	:	1.07	BAHT/KWH.

3.1.3 AT VOLTAGE OF LESS THAN 11 KV.

DEMAND CHARGE	:	237.00	BAHT/KW.
ENERGY CHARGE	:	1.10	BAHT/KWH.

Table 1.1 Electricity Tariff Structure (2/3)

3.2 AVERAGE CONSUMPTION OF THE LAST 3 CONSECUTIVELY MONTHS EXCEEDS 355,000 KHW. PER MONTH.

3.2.1	AT VOLTAGE OF 69 KV. AND OVER			
	DEMAND CHARGE: ON PEAK	(18.30-21.30)	240.00	BAHT/KW.
	PARTIAL PEAK	(08.00-18.30)		
	(CHARGE ONLY EXCESS ON PEAK)		32.00	BAHT/KW.
	OFF PEAK	(21.30-08.00)	NO DEMAND CHARGE	
	ENERGY CHARGE:		1.03	BAHT/KWH.
3.2.2	AT VOLTAGE OF 11-33 KV.			
	DEMAND CHARGE: ON PEAK	(18.30-21.30)	305.00	BAHT/KW.
	PARTIAL PEAK	(08.00-18.30)		
	(CHARGE ONLY EXCESS ON PEAK)		63.00	BAHT/KW.
	OFF PEAK	(21.30-08.00)	NO DEMAND CHARGE	
	ENERGY CHARGE:		1.07	BAHT/KWH.
3.2.3	AT VOLTAGE OF LESS THAN 11 KV.			
	DEMAND CHARGE: ON PEAK	(18.30-21.30)	356.00	BAHT/KW.
	PARTIAL PEAK	(08.00-18.30)		
	(CHARGE ONLY EXCESS ON PEAK)		73.00	BAHT/KW.
	OFF PEAK	(21.30-08.00)	NO DEMAND CHARGE	
	ENERGY CHARGE:		1.10	BAHT/KWH.

4. LARGE GENERAL SERVICE (TOO RATE)

(MAX. DEMAND OF 2,000 KW. AND OVER)

4.1	AT VOLTAGE OF 69 KV. AND OVER			
	DEMAND CHARGE: ON PEAK	(18.30-21.30)	240.00	BAHT/KW.
	PARTIAL PEAK	(08.00-18.30)		
	(CHARGE ONLY EXCESS ON PEAK)		32.00	BAHT/KW.
	OFF PEAK	(21.30-08.00)	NO DEMAND CHARGE	
	ENERGY CHARGE:		1.03	BAHT/KWH.
4.2	AT VOLTAGE OF 11-33 KV.			
	DEMAND CHARGE: ON PEAK	(18.30-21.30)	305.00	BAHT/KW.
	PARTIAL PEAK	(08.00-18.30)		
	(CHARGE ONLY EXCESS ON PEAK)		63.00	BAHT/KW.
	OFF PEAK	(21.30-08.00)	NO DEMAND CHARGE	
	ENERGY CHARGE:		1.07	BAHT/KWH.

5. SPECIFIC BUSINESS

(HOTEL OR GUEST HOUSE OR OTHER LODGING)

5.1	NORMAL RATE			
5.1.1	AT VOLTAGE OF 69 KV. AND OVER			
	DEMAND CHARGE	:	236.00	BAHT/KW.
	ENERGY CHARGE	:	1.03	BAHT/KWH.
5.1.2	AT VOLTAGE OF 11-33 KV.			
	DEMAND CHARGE	:	274.00	BAHT/KW.
	ENERGY CHARGE	:	1.07	BAHT/KWH.
5.1.3	AT VOLTAGE OF LESS THAN 11 KV.			
	DEMAND CHARGE	:	296.00	BAHT/KW.
	ENERGY CHARGE	:	1.10	BAHT/KWH.

Table 1.1 Electricity Tariff Structure (3/3)

5.2 (OPTIONAL RATE) FOR CUSTOMER'S AVERAGE CONSUMPTION OF THE LAST 3 CONSECUTIVELY MONTHS EXCEEDS 355,000 KWH. PER MONTH.

5.2.1	AT VOLTAGE OF 69 KV. AND OVER				
	DEMAND CHARGE:	ON PEAK	(18.30-21.30)	240.00	BAHT/KW.
		PARTIAL PEAK	(08.00-18.30)		
		(CHARGE ONLY EXCESS ON PEAK)		32.00	BAHT/KW.
		OFF PEAK	(21.30-08.00)	NO DEMAND CHARGE	
	ENERGY CHARGE:			1.03	BAHT/KWH.
5.2.2	AT VOLTAGE OF 11-33 KV.				
	DEMAND CHARGE:	ON PEAK	(18.30-21.30)	305.00	BAHT/KW.
		PARTIAL PEAK	(08.00-18.30)		
		(CHARGE ONLY EXCESS ON PEAK)		63.00	BAHT/KW.
		OFF PEAK	(21.30-08.00)	NO DEMAND CHARGE	
	ENERGY CHARGE:			1.07	BAHT/KWH.
5.2..3	AT VOLTAGE OF LESS THAN 11 KV.				
	DEMAND CHARGE:	ON PEAK	(18.30-21.30)	356.00	BAHT/KW.
		PARTIAL PEAK	(08.00-18.30)		
		(CHARGE ONLY EXCESS ON PEAK)		73.00	BAHT/KW.
		OFF PEAK	(21.30-08.00)	NO DEMAND CHARGE	
	ENERGY CHARGE:			1.10	BAHT/KWH.

6. GOVERNMENT AND NON-PROFIT ORGANIZATION

6.1 AT VOLTAGE OF 69 KV. AND OVER

ENERGY CHARGE :	FIRST	10,000 KWH. OR LESS	14,800.00	BAHT
	OVER	10,000 KWH.	1.48	BAHT/KWH.
	MINIMUM CHARGE 14,800 BAHT/MONTH			

6.2 AT VOLTAGE OF 11-33 KV.

ENERGY CHARGE :	FIRST	300 KWH. OR LESS	495.00	BAHT
	OVER	300 KWH.	1.65	BAHT/KWH.
	MINIMUM CHARGE 495.00 BAHT/MONTH			

6.3 AT VOLTAGE OF LESS THAN 11 KV.

ENERGY CHARGE :	FIRST	10 KWH. OR LESS	18.70	BAHT
	OVER	10 KWH.	1.87	BAHT/KWH.
	MINIMUM CHARGE 18.70 BAHT/MONTH			

7. AGRICULTURE PUMPING

ENERGY CHARGE :	FIRST	100 KWH. OR LESS	117.00	BAHT
	OVER	100 KWH.	1.17	BAHT/MWH.
	MINIMUM CHARGE 117.00 BAHT/MONTH			

Source : PEA

Table 2.1 Final Energy Consumption by Sources

unit : ktoe

SOURCES	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Modern Energy	9,371	10,371	11,420	11,794	12,500	14,098	16,023	18,995	21,684	23,198
Coal & Coke	256	259	301	446	464	674	808	1,082	1,344	1,559
Steam Coal	58	59	88	151	112	156	185	237	120	192
Antheracite	3	3	3	6	3	2	5	5	10	14
Coke	40	46	53	56	26	38	50	55	60	56
Other Coal	-	-	-	-	-	-	-	3	28	69
Lignite	155	151	157	233	323	478	568	782	1,126	1,228
Oil Product	7,834	8,639	9,342	9,463	10,071	11,263	12,747	15,001	16,809	17,581
LPG	379	523	606	718	757	807	899	1,009	1,098	1,184
Pre-Gasoline	515	551	626	632	695	829	968	1,142	1,304	1,409
Reg-Gasoline	986	989	952	924	995	1,106	1,209	1,337	1,442	1,495
Jet Fuel	884	934	985	1,012	1,120	1,218	1,500	1,774	1,931	2,083
Kerosene	317	440	237	126	117	105	103	98	101	92
HSD	3,322	3,688	4,423	4,675	4,874	5,451	6,130	7,219	8,213	8,413
LSD	44	72	88	69	60	80	84	111	101	121
Fuel Oil	1,387	1,442	1,425	1,307	1,453	1,667	1,854	2,311	2,619	2,784
Natural Gas	-	32	194	178	87	40	60	114	264	360
Electricity	1,281	1,441	1,583	1,707	1,878	2,121	2,408	2,798	3,267	3,698
Renewable Energy	6,850	6,651	6,852	7,062	7,056	6,950	6,904	7,579	7,220	7,281
Fuel Wood	2,676	2,740	2,837	2,875	2,885	2,835	2,825	2,798	2,745	2,793
Charcoal	2,227	2,183	2,161	2,138	2,103	2,103	2,066	2,008	1,946	1,857
Paddy Husk	560	564	742	830	838	788	729	884	814	663
Bagasse	1,387	1,164	1,112	1,219	1,230	1,224	1,284	1,889	1,715	1,968
Total	16,221	17,022	18,272	18,856	19,556	21,048	22,927	26,574	28,904	30,479

Note : 1_/ Including ULG
Source : DEA, MOS, TAE, Thailand Energy Situation 1991

Table 2.2 Final Energy Consumption by Economic Sectors

unit : ktoe
%

SECTORS	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Agriculture	1,128	1,243	1,292	1,355	1,405	1,441	1,523	1,639	1,803	1,827
	7.0	7.3	7.1	7.2	7.2	6.8	6.6	6.2	6.2	6.0
Mining	74	102	86	74	53	49	49	56	58	53
	0.5	0.6	0.5	0.4	0.3	0.2	0.2	0.2	0.2	0.2
Manufacturing	4,728	4,547	4,930	5,219	5,250	5,598	6,062	7,712	8,539	9,286
	29.1	26.7	27.0	27.6	26.8	26.6	26.4	29.0	29.6	30.4
Construction	111	78	100	125	123	111	99	109	147	194
	0.7	0.5	0.5	0.7	0.6	0.5	0.4	0.4	0.5	0.6
Res. and Com.	5,669	5,977	5,948	6,058	6,233	6,421	6,674	6,889	6,989	7,209
	34.9	35.1	32.6	32.1	31.9	30.6	29.2	25.9	24.2	23.7
Transportation	4,511	5,075	5,916	6,025	6,492	7,428	8,520	10,169	11,368	11,910
	27.8	29.8	32.3	32.0	33.2	35.5	37.2	38.3	39.3	39.1
Total	16,221	17,022	18,272	18,856	19,556	21,048	22,927	26,574	28,904	30,479
	100	100	100	100	100	100	100	100	100	100

Source : DEA, MOS, TAE, Thailand Energy Situtation 1991

Table 2.3 Total Primary Supply by Sources

unit : Ktoe
%

Sources	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Modern Energy	12,647	14,001	15,298	16,173	16,862	19,505	21,816	25,726	30,340	33,075
	53.2	56.3	58.1	59.0	60.2	63.9	66.7	69.1	73.4	75.3
Steam Coal	58	59	88	151	112	156	185	237	120	192
	0.2	0.2	0.3	0.5	0.4	0.5	0.6	0.6	0.3	0.4
Antheracite	3	3	3	6	3	2	5	5	10	14
	-	-	-	-	-	-	-	-	-	-
Coke	40	46	53	56	26	38	50	55	60	56
	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.1	0.1
Other Coal	-	-	-	-	-	-	-	3	28	69
	-	-	-	-	-	-	-	-	0.1	0.2
Lignite	577	544	642	1,376	1,486	1,898	2,031	2,463	3,575	4,135
	2.4	2.2	2.4	5.0	5.3	6.2	6.2	6.6	8.6	9.4
Petroleum	7,929	8,251	7,988	8,134	8,502	8,949	9,085	11,249	12,104	12,425
	33.4	33.2	30.4	29.7	30.4	29.3	27.8	30.2	29.3	28.3
Oil Product	1,949	2,835	3,460	2,322	2,301	3,135	4,388	5,233	7,630	8,110
	8.2	11.4	13.1	8.5	8.2	10.3	13.4	14.1	18.5	18.5
Natural Gas	1,178	1,394	2,101	3,250	3,139	4,390	5,200	5,194	5,657	7,011
	5.0	5.6	8.0	11.9	11.2	14.4	15.9	13.9	13.7	16.0
Electricity	913	869	963	878	1,293	937	872	1,287	1,156	1,063
	3.8	3.5	3.7	3.2	4.6	3.1	2.7	3.5	2.8	2.4
Renewable Energy	11,117	10,869	11,032	11,222	11,132	11,031	10,886	11,529	10,969	10,858
	46.8	43.7	41.9	41.0	39.8	36.1	33.3	30.9	26.6	24.7
Fuel Wood	8,912	8,859	8,870	8,837	8,736	8,690	8,551	8,446	8,137	7,933
	37.5	35.6	33.7	32.3	31.2	28.5	26.2	22.7	19.7	18.0
Paddy Husk	818	846	1,050	1,166	1,166	1,117	1,051	1,194	1,117	957
	3.5	3.4	4.0	4.3	4.2	3.6	3.2	3.2	2.7	2.2
Bagasse	1,387	1,164	1,112	1,219	1,230	1,224	1,284	1,889	1,715	1,968
	5.8	4.7	4.2	4.4	4.4	4.0	3.9	5.0	4.2	4.5
Total	23,764	24,870	26,330	27,395	27,994	30,536	32,702	37,255	41,309	43,933
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source : DEA, MOS, TAE, Thailand Energy Situation 1991

Table 2.4 Consumption/Installation/Generation and Losses

Items	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1. Electricity Consumption (Gwh) 1/	15,033	16,906	18,572	20,032	22,034	24,894	28,253	32,834	38,342	43,398
2. Installed Capacity (MW) 1/	4,403	5,032	6,128	6,705	6,785	6,985	6,997	7,366	8,725	9,707
3. Installed Capacity (MW) (Privat self-Generation)	474	516	614	690	765	816	875	948	1,002	1,064
4. Peak Generation (MW) 1/	2,823	3,200	3,545	3,826	4,202	4,842	5,414	6,208	7,167	7,990
5. EGATS Peak Generation (MW) 1/	2,783	3,170	3,511	3,795	4,146	4,795	5,373	4,822	7,123	7,941
6. Generation (Gwh) 1/	16,620	18,857	21,025	23,074	24,717	28,652	32,464	37,406	44,175	50,186
7. Population (thousand)	48,847	49,433	50,853	51,796	52,969	53,873	54,961	55,888	56,303	56,961
8. Consumption Per Capita (kWh/capita)	308	342	365	387	416	462	514	587	681	762
9. Average Thermal Efficiency at Sending End (%)	35.99	37.31	37.52	37.65	38.31	38.25	37.95	37.95	36.50	34.44
10. T&D Losses (5)	9.90	10.71	10.07	11.53	9.75	10.35	10.21	9.97	10.56	10.77

Sources : DEA, EGAT, PEA and POF

Note : 1-/ excluding private self-generation.

Table 2.5 Installed Capacity by Types of Power Plants

unit : MW

Year	Installed Capacity 1/						Private Self-Generation				Grand Total
	Hydro	Steam	Gas Tubine	Diesel	Combined Cycle	Total 2-/	Steam	Diesel	Gas Engine	Total 3/	
1982	1,519	1,928	490	106	360	4,403	266	208	-	474	4,877
1983	1,501	2,477	250	84	720	5,032	290	226	-	516	5,548
1984	1,714	3,327	265	102	720	6,128	377	237	-	614	6,742
1985	2,004	3,628	265	88	720	6,705	411	279	-	690	7,395
1986	2,096	3,608	265	96	720	6,785	488	274	3	765	7,550
1987	2,256	3,608	267	82	772	6,985	528	284	4	816	7,801
1988	2,268	3,608	267	82	772	6,997	562	311	2	875	7,872
1989	2,271	3,982	267	74	772	7,366	590	355	3	948	8,314
1990	2,274	4,307	1,308	75	761	8,725	603	396	3	1,002	9,727
1991	2,455	4,906	1,514	71	761	9,707	625	436	3	1,064	10,771

Sources : DEA, EGAT, PEA and POF

Note : 1/ excluding private self-generation.
2/ excluding installed capacity of geothermal 0.3 MW since 1990.
3/ excluding installed capacity of private-owned hydro gnerator 0.43 MW since 1978.

Table 2.6 Substations, Transmission Line Length and Transformer Capacity of EGAT System

(1) Substations

Voltage Level (kV)	Fiscal Year 1990		Fiscal Year 1989	
	Number of Substations	Percent	Number of Substations	Percent
500	2	1.41	2	1.41
230	28	19.72	28	19.72
132	1	0.71	1	0.71
115	102	71.83	101	71.12
69	9	6.33	10	7.04
TOTAL	142	100.00	142	100.00

(2) Transmission Line Length

Voltage Level (kV)	Fiscal Year 1990		Fiscal Year 1989		Percent Increase
	Circuit-kilometres	Percent	Circuit-kilometres	Percent	
500	325.635	1.83	325,635	1.97	-
230	7,023.368	39.40	6,122,278	36.99	14.72
132	8.705	0.05	8,705	0.05	-
115	9,817.968	55.07	9,488,280	57.32	3.47
69	651.386	3.65	608,066	3.67	7.12
TOTAL	17,827.062	100.00	16,552,964	100.00	7.70

(3) Transformer Capacity

Voltage Level (kV)	Fiscal Year 1990		Fiscal Year 1989		Percent +Increase -Decrease
	kVA	Percent	kVA	Percent	
500	1,800,000	10.64	1,800,000	11.43	-
230	9,310,070	55.04	8,410,070	53.40	+10.7
132	133,340	0.79	133,340	0.85	-
115	5,481,410	32.40	5,195,910	32.99	+5.50
69	182,430	1.08	202,670	1.29	+9.99
22	8,000	0.05	8,000	0.04	-
TOTAL	16,915,310	100.00	15,749,990	100.00	+7.4

Table 2.7 (1) PEA's Activities

Number of Customers	6,586,412
Total Sales of Electricity (Million kWh)	17,804.6
Average Customer Consumption (kWh)	2,703.2
Average Price of Electricity (Baht/kWh)	1.63
Total Maximum Demand (MW)	3763.2
Total Electric Energy (Million kWh)	19,369.5
Purchased Power (Million kWh)	19,351.7
PEA Generation (Million kWh)	17.8
H.V. Distribution Lines (Circuit-km)	152,607
Installed Transformers (MVA)	11,680.0
Total Villages	60,222
Number of Electrified Villages	55,851
% of Electrified Villages	93

Table 2.7 (2) Transmission Line (Km)

VOLTAGE (V)	1990
3,500	61
11,000	-
22,000	127,946
33,000	24,508
69,000	31
115,000	61
Total	152,607

Table 2.8 EGAT's Total Generation Requirement (Including Station Service)

Fiscal Year	Peak Demand (MW)	Peak Demand % Increase	Energy Load (Average MW)	Energy Load (Gwh)	Energy Load % Increase	Annual Load Factor (%)
Historic						
1987	4,734	13.2	3,218	28,193	13.8	68.0
1988	5,444	15.0	3,653	31,997	13.5	67.1
1989	6,233	14.5	4,162	36,457	13.9	66.8
1990	7,094	13.8	4,930	43,189	18.5	69.5
Forecast						
1991	8,072	13.8	5,662	49,600	14.8	70.1
1992	9,000	11.5	6,333	55,475	11.8	70.4
1993	9,924	10.3	7,002	61,339	10.6	70.6
1994	10,892	9.8	7,712	67,561	10.1	70.8
1995	11,946	9.7	8,507	74,522	10.3	71.2
1996	13,075	9.5	9,331	81,741	9.7	71.4
1997	14,205	8.6	10,195	89,307	9.3	71.8
1998	15,354	8.1	11,026	96,591	8.2	71.8
1999	16,531	7.7	11,921	104,431	8.1	72.1
2000	17,765	7.5	12,860	112,653	7.9	72.4
2001	19,000	7.0	13,822	121,083	7.5	72.7
2002	20,219	6.4	14,778	129,455	6.9	73.1
2003	21,482	6.2	15,790	138,322	6.8	73.5
2004	22,795	6.1	16,839	147,509	6.6	73.9
2005	24,150	5.9	17,938	157,137	6.5	74.3
2006	25,515	5.7	19,064	166,999	6.3	74.7
Average % Growth						
1987-1991		14.06			14.89	
1992-1996		10.13			10.51	
1997-2001		7.76			8.18	
2002-2006		6.07			6.64	

Source : NEPO 1991 Load Forecast

Table 2.9 PEA Power Demand Forecast

Fiscal Year	Peak Demand (MW)	Peak Demand % Increase	Energy Load (Average MW)	Energy Load (Gwh)	Energy Load % Increase	Annual Load Factor (%)
Historic						
1987	2,376	14.1	1,346	11,792	15.7	56.6
1988	2,745	15.5	1,568	13,737	16.5	57.1
1989	3,239	18.0	1,841	16,130	17.4	56.9
1990	3,737	15.4	2,205	19,318	19.8	59.0
Forecast						
1991	4,291	14.8	2,584	22,633	17.2	60.2
1992	4,852	13.1	2,951	25,847	14.2	60.8
1993	5,415	11.6	3,323	29,110	12.6	61.4
1994	6,011	11.0	3,720	32,583	11.9	61.9
1995	6,626	10.2	4,133	36,207	11.1	62.4
1996	7,258	9.5	4,560	39,943	10.3	62.8
1997	7,913	9.0	5,005	43,844	9.8	63.3
1998	8,605	8.7	5,478	47,989	9.5	63.7
1999	9,340	8.5	5,983	52,413	9.2	64.1
2000	10,099	8.1	6,510	57,028	8.8	64.5
2001	10,858	7.5	7,044	61,707	8.2	64.9
2002	11,639	7.2	7,600	66,575	7.9	65.3
2003	12,458	7.0	8,187	71,714	7.7	65.7
2004	13,311	6.8	8,801	77,095	7.5	66.1
2005	14,193	6.6	9,443	82,719	7.3	66.5
2006	15,078	6.2	10,092	88,408	6.9	66.9
Average % Growth						
1987-1991		15.57			17.30	
1992-1996		11.08			12.03	
1997-2001		8.39			9.09	
2002-2006		6.79			7.46	

Source : NEPO 1991 Load Forecast

Table 3.1 Power Consumption in Study Area (1/2)

Ptovince	Description	1987	1988	1989	1990	1991
Whole PEA's	Energy Sales (GWh)					
Supply Area	- Residential	3,197.9	3,455.2	3,905.0	4,477.0	5,082.2
	- Business	1,832.6	2,194.8	2,492.9	3,078.3	3,816.6
	- Industrial	5,012.8	5,940.1	7,317.4	9,006.5	10,521.3
	- Government	801.4	878.0	914.2	982.0	1,039.6
	- Others	99.3	122.4	187.2	260.8	352.7
	TOTAL SALES	10,944.0	12,590.5	14,816.7	17,804.6	20,812.4
Nakhon Nayok	Energy Sales (GWh)					
	- Residential	16.1	17.2	19.9	22.8	25.9
	- Business	6.2	7.8	7.7	10.3	11.7
	- Industrial	3.2	4.3	4.0	5.7	6.5
	- Government	11.0	10.8	13.6	14.3	16.2
	- Others	0.9	0.5	1.1	0.7	0.8
	TOTAL SALES	37.4	40.7	46.3	53.8	61.1
Prachin Buri	Energy Sales (GWh)					
	- Residential	51.1	58.8	60.7	73.1	84.4
	- Business	19.0	21.7	23.6	27.0	31.2
	- Industrial	17.8	18.4	21.2	22.8	26.3
	- Government	19.3	18.9	22.9	23.5	27.1
	- Others	1.3	1.8	1.5	2.2	2.5
	TOTAL SALES	109.3	119.6	129.9	148.6	171.5
Nakhon Ratchasima	Energy Sales (GWh)					
	- Residential	127.3	147.7	164.1	186.0	207.4
	- Business	71.7	84.9	92.4	106.9	119.2
	- Industrial	239.3	268.9	308.5	338.7	377.7
	- Government	47.9	52.3	61.8	65.9	73.5
	- Others	3.4	5.6	4.4	7.1	7.9
	TOTAL SALES	489.7	559.4	631.2	704.6	785.8
Buri Ram	Energy Sales (GWh)					
	- Residential	40.4	45.3	51.4	60.8	71.6
	- Business	15.0	17.3	19.1	23.2	27.3
	- Industrial	10.2	10.6	13.0	14.2	16.7
	- Government	6.5	6.9	8.3	9.3	10.9
	- Others	0.6	0.7	0.8	1.0	1.2
	TOTAL SALES	72.8	80.9	92.6	108.5	127.7

Table 3.1 Power Consumption in Study Area (2/2)

Province	Description	1987	1988	1989	1990	1991
Surin	Energy Sales (GWh)					
	- Residential	36.1	38.8	43.5	52.6	68.6
	- Business	16.5	20.5	19.9	27.8	36.2
	- Industrial	10.6	10.2	12.8	13.8	18.0
	- Government	8.5	8.3	10.2	11.2	14.6
	- Others	0.3	0.3	0.4	0.4	0.5
	TOTAL SALES	72.1	78.0	86.8	105.8	137.9
Si Sa Ket	Energy Sales (GWh)					
	- Residential	36.0	39.4	44.2	48.7	56.4
	- Business	12.3	15.2	15.1	18.8	21.8
	- Industrial	7.0	7.3	8.6	9.0	10.4
	- Government	5.5	5.9	6.7	7.3	8.5
	- Others	0.4	0.7	0.5	0.9	1.0
	TOTAL SALES	61.1	68.5	75.1	84.7	98.1
Ubon Ratchathani	Energy Sales (GWh)					
	- Residential	71.9	71.6	85.1	85.3	99.2
	- Business	26.1	39.3	30.9	46.8	54.4
	- Industrial	12.3	14.1	14.5	16.8	19.5
	- Government	21.0	22.0	24.9	26.2	30.5
	- Others	4.4	3.7	5.2	4.4	5.1
	TOTAL SALES	135.7	150.6	160.6	179.5	208.7
Yasothon	Energy Sales (GWh)					
	- Residential	18.0	18.5	21.8	22.9	26.7
	- Business	5.0	7.1	6.1	8.8	10.3
	- Industrial	3.6	3.2	4.3	4.0	4.7
	- Government	3.6	3.8	4.3	4.7	5.5
	- Others	0.8	1.2	1.0	1.5	1.8
	TOTAL SALES	31.0	33.8	37.5	41.9	48.9
Mukdahan	Energy Sales (GWh)					
	- Residential	9.9	10.5	13.3	13.4	14.3
	- Business	2.3	4.3	3.1	5.5	5.9
	- Industrial	4.2	5.3	5.6	6.8	7.2
	- Government	1.8	2.0	2.4	2.6	2.8
	- Others	0.7	0.8	0.9	1.0	1.1
	TOTAL SALES	18.8	22.9	25.3	29.3	31.2

Source : PEA

Table 3.2 Index of Electric Consumption Per Capita

AREA	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
WHOLE KINGDOM										
1. Electric Consumption (GWh) 1/	15,033.0	16,906.3	18,572.2	20,031.9	22,034.4	24,894.2	28,252.7	32,833.8	38,342.2	43,397.6
2. Population (thousand)	48,847	49,433	50,583	51,769	52,969	53,873	54,961	55,888	56,303	56,961
3. kWh Per Capita	307.76	342.00	367.16	386.95	415.99	462.09	514.05	587.49	681.00	761.88
4. Index (kWh per capita) 2/	221	246	264	278	299	332	370	423	490	548
NORTHEASTERN AREA										
1. Electric Consumption (Gwh) 1/	1,095.1	1,240.0	1,430.6	1,544.8	1,712.5	1,889.7	21,009.2	2,388.5	2,678.5	3,009.5
2. Population (thousand)	16,720	17,147	17,638	18,061	18,552	18,884	19,254	19,576	19,829	20,044
3. kWh Per Capita	65.50	72.32	81.11	85.53	92.31	100.07	109.55	122.01	135.08	150.14
4. Index (kWh per capita) 2/	327	362	406	428	462	500	548	610	675	751

Source: DEA, DOLA, EGAT, MEA, PEA and POF
Note: 1/ excluding private self-generation
2/ base on 1972=100

Table 3.3 Summary of Village Electricification for Study Area (As September 1992)

Province	Overall		Electrified		Non-Electrified	
	No. of Village	No. of Household	No. of Village	No. of Household	No. of Village	No. of Household
Nakhon Nayok	391	33,965	391 (100%)	33,965	-	-
Prachin Buri	1,148	131,336	1,114 (97%)	127,505	34	20,661
Nakhon Ratchasima	2,976	320,537	2,928 (98.4%)	315,367	48	29,055
Buri Ram	2,173	201,514	2,173 (100%)	201,514	-	-
Surin	1,864	175,812	1,863 (99.9%)	175,718	1	540
Si Sa Ket	1,997	196,576	1,991 (=99.7%)	195,985	6	3,622
Ubon Ratchathani	2,680	269,923	2,666 (=99.5%)	268,513	14	9,165
Yasothon	754	87,486	752 (=99.7%)	87,254	2	1,346
Mukdahan	459	38,253	455 (99.1%)	37,920	4	2,064
TOTAL	14,442	1,455,462	14,333 (99.3%)	1,443,741	109	66,453

Source : PEA

Table 3.4 Power Interruption of Distribution System By Fault on HT Line

Region	Sub-Region	Nos. of Feeder		Nos of Customers		Circuit Length (CCT-KM)		Nos of Interruption		Duration of Inerruption (HR. min)	
		1990	1991	1989	1990	1989	1990	1990	1991	1990	1991
North	N1	78	82	707,552	763,706	10,557	11,381	312	380	210.09	253.27
	N2	51	53	548,903	589,530	11,978	12,628	203	183	194.37	183.16
	N3	53	-58	440,091	474,141	10,723	11,552	262	272	232.29	211.21
	TOTAL	182	193	1,696,546	1,827,377	33,258	35,561	777	835	637.15	648.04
Northeast	NE1	73	79	759,415	820,156	15,644	17,823	318	270	334.33	213.12
	NE2	43	48	827,700	887,889	18,274	20,496	166	193	213.57	206.05
	NE3	52	52	639,568	711,871	14,290	18,196	215	210	152.40	160.50
	TOTAL	168	179	2,226,683	2,419,916	48,208	56,515	699	673	701.10	580.07
Central	C1	105	128	393,234	425,059	10,674	11,289	572	641	458.44	454.09
	C2	81	88	336,196	376,505	10,266	10,509	315	405	224.48	266.21
	C3	77	94	378,121	406,943	10,545	10,932	386	527	437.06	579.39
	TOTAL	263	310	1,107,551	1,208,507	31,485	32,730	1,273	1,573	1,120.38	1,300.09
South	S1	39	43	281,824	302,144	6,849	7,359	279	289	243.58	184.09
	S2	40	40	340,019	384,560	9,600	11,399	420	347	384.49	293.14
	S3	44	44	419,739	444,838	8,476	8,887	317	354	154.44	213.01
	TOTAL	123	127	1,041,582	1,131,542	24,925	27,645	1,016	990	783.31	690.24
	GRAND TOTAL	736	809	6,072,362	6,587,342	137,876	152,451	3,765	4,071	3,242.34	3,218.44

Table 3.5 Load Forecast in PEA's Service Area

Unit : MW

No.	Description	Actual 1990	FORECAST 1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	North	676.6	764.1	864.6	960.0	1,076.1	1,174.3	1,274.8	1,373.9	1,478.2	1,587.9	1,700.6	1,817.7
2	Northeast	740.4	840.1	939.1	1,060.0	1,148.5	1,234.2	1,327.8	1,421.9	1,518.2	1,617.5	1,719.6	1,825.3
3	Central	1807.5	2,163.8	2,742.2	3,195.3	3,571.5	3,969.1	4,368.8	4,770.6	5,146.1	5,510.0	5,866.0	6,209.5
4	South	656.4	763.7	882.3	1,049.7	1,180.5	1,284.2	1,392.8	1,535.4	1,644.5	1,757.9	1,875.5	1,999.1
	TOTAL	3880.9	4,531.7	5,428.2	6,265.0	6,976.6	7,661.8	8,364.2	9,101.8	9,787.0	10,473.3	11,161.7	11,851.6

Source : PEA

Table 3.6 Load Forecast in PEA's NE3 Region

Substation	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1 Nakhon Ratchasima 1	101.3	117.1	131.6	148.5	166.8	186.0	203.9	221.5	239.4	257.8	276.6	295.3	314.4	324.0	334.1	344.5	355.4	366.6	378.4	390.5
2 Nakhon Ratchasima 2	(include in sub. Nakhon Ratchasima 1)																			
3 Pak Chong	24.6	27.7	30.7	33.6	36.3	39.5	42.6	45.9	49.3	52.9	56.7	60.8	65.1	69.6	74.2	79.0	83.8	88.8	93.8	98.8
4 Si Khiu	27.7	30.3	32.9	35.5	38.1	41.2	44.4	47.9	51.6	55.7	60.0	64.8	69.9	75.2	80.7	86.5	92.4	98.5	104.8	111.3
5 Khong	10.5	16.6	25.4	26.2	26.9	27.7	28.6	29.4	30.2	31.1	32.0	32.9	33.8	34.7	35.6	36.5	37.5	38.6	39.7	40.8
Total load of Nakhon Ratchasima Province	164.1	191.7	220.6	243.8	268.1	294.4	319.5	344.7	370.5	397.5	425.3	453.8	483.2	503.5	524.6	546.5	569.1	592.5	616.7	641.4
6 Surin	39.5	43.6	47.4	50.9	54.1	57.5	61.4	65.2	69.3	73.5	78.1	82.9	88.0	93.2	98.6	104.1	109.8	115.5	121.3	127.2
Total load of Surin Province	39.5	43.6	47.4	50.9	54.1	57.5	61.4	65.2	69.3	73.5	78.1	82.9	88.0	93.2	98.6	104.1	109.8	115.5	121.3	127.2
7 Buri Ram	40.0	44.3	48.3	43.7	46.6	49.9	53.3	56.8	60.5	64.6	68.8	73.4	78.3	83.3	88.5	93.9	99.4	104.9	110.7	116.4
Total load of Buri Ram Province	40.0	44.3	48.3	43.7	46.6	49.9	53.3	56.8	60.5	64.6	68.8	73.4	78.3	83.3	88.5	93.9	99.4	104.9	110.7	116.4
TOTAL LOAD OF NE 3	243.6	279.6	316.3	338.4	368.8	401.8	434.2	466.7	500.3	535.6	572.2	610.1	649.5	680.0	711.7	744.5	778.3	812.9	848.7	885.0

Table 3.7 Load Forecast in PEA's NE2 Region

unit : MW

Substation	FORECAST																		
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1. Amnat Charoen	0.00	0.00	14.82	16.09	17.41	18.75	20.13	21.52	22.94	24.36	25.79	27.20	28.65	30.14	31.66	33.27	34.95	36.71	38.56
2. Phon Thong	0.00	0.00	15.48	16.82	18.20	19.62	21.08	22.56	24.06	25.57	27.09	28.61	30.15	31.73	33.34	35.03	36.81	38.68	40.60
3. Ubon2	0.00	17.81	19.48	21.19	22.94	24.72	26.53	28.35	30.18	32.01	33.81	35.62	37.43	39.28	41.16	43.13	45.19	47.35	49.62
4. Trakan Phutphon	0.00	0.00	0.00	0.00	7.65	8.24	8.84	9.45	10.06	10.67	11.28	11.67	12.48	13.09	13.72	14.38	15.07	15.80	16.56
5. Yasothon	29.41	32.25	24.64	26.77	28.97	31.23	33.54	35.33	38.28	40.65	43.07	45.45	47.90	50.41	52.98	55.68	58.52	61.50	64.64
6. Kalasin	26.45	28.67	24.80	26.76	28.80	30.93	33.14	35.43	39.81	40.26	42.79	45.37	48.06	50.87	53.80	56.92	60.22	63.71	67.40
7. Ubon1	54.01	41.56	42.85	46.62	42.82	46.15	49.52	52.93	56.34	59.96	63.16	66.49	69.87	73.32	76.83	80.51	84.36	88.40	92.63
8. Somdet	19.60	22.04	19.28	21.15	23.85	24.99	28.95	28.91	30.87	32.80	34.70	36.57	38.39	10.19	42.00	43.89	45.87	47.94	50.10
9. Maha Sarakham	27.26	29.49	24.98	26.92	28.90	30.99	33.16	35.41	37.75	40.16	42.61	45.18	47.82	50.58	53.45	56.19	59.69	63.08	66.66
10. Mukdahan	12.79	13.92	13.43	14.51	15.73	16.77	17.94	19.14	20.35	21.59	22.84	24.08	25.36	26.68	28.04	29.47	30.99	32.57	34.32
11. Roi Et	33.04	36.24	35.29	38.44	41.56	44.75	47.98	51.24	54.53	57.82	61.12	61.34	67.63	70.98	74.40	77.98	81.74	85.68	89.81
12. Sirindhorn	5.94	6.51	7.07	7.64	8.21	8.78	9.36	9.92	10.49	11.01	11.58	12.10	12.63	13.15	13.18	14.23	14.80	15.40	16.01
13. Si Sa Ket	38.49	42.47	46.46	50.54	54.70	58.93	63.18	87.45	71.72	75.97	80.18	84.26	88.10	92.60	98.86	101.32	105.98	110.86	116.96
Total	246.99	270.96	288.58	313.45	345.64	364.85	393.35	418.21	447.36	472.66	500.08	527.14	554.77	583.02	611.42	642.30	674.19	707.68	743.79

Table 3.8 Petroleum Product Consumptions

unit : million litres

Region	Year	LPG	Gasoline			Aviation Fuel 1/	Kerosene	HSD	LSD	Fuel Oil	Total
			Premium	ULG	Regular						
BMR 2/	1986	692.2	605.6	-	384.7	1,349.3	52.5	1,925.4	49.9	1,792.4	6,852.0
	1987	713.7	710.1	-	416.1	1,468.0	43.4	2,175.8	75.2	1,668.9	7,271.2
	1988	724.7	821.4	-	476.1	1,811.9	41.8	2,551.2	83.5	2,051.4	8,562.0
	1989	795.2	963.6	-	550.7	2,130.3	46.7	3,095.4	111.7	2,644.8	10,338.4
	1990	873.8	1,084.4	-	607.5	2,285.0	53.9	3,466.8	105.1	3,287.5	11,764.0
	1991	1,011.9	924.3	233.5	614.8	2,481.7	52.3	3,389.7	122.5	3,178.0	12,008.7
Northeastern	1986	71.8	44.0	-	225.3	2.3	18.5	773.3	0.2	47.4	1,182.8
	1987	82.4	50.4	-	250.9	2.2	15.9	798.1	-	49.6	1,249.5
	1988	126.1	55.2	-	257.0	1.4	14.3	834.6	-	48.1	1,336.7
	1989	112.7	64.7	-	279.1	2.9	11.3	942.5	-	50.2	1,463.4
	1990	116.1	75.0	-	307.2	3.7	9.7	1,139.4	-	69.3	1,720.4
	1991	109.7	80.9	5.4	328.7	3.9	6.6	1,198.6	-	64.4	1,798.2
Total	1986	1,201.4	932.8	-	1,336.2	1,369.7	143.1	5,669.0	70.3	2,410.2	13,132.7
	1987	1,282.4	1,112.9	-	1,483.8	1,489.6	129.0	6,335.1	93.0	2,345.9	14,271.7
	1988	1,427.1	1,299.4	-	1,623.1	1,835.0	125.6	7,118.4	96.9	2,800.0	16,325.5
	1989	1,601.1	1,533.1	-	1,794.7	2,170.2	120.2	8,394.6	129.2	3,681.6	19,424.7
	1990	1,743.7	1,749.8	-	1,936.4	2,361.7	123.6	9,693.5	116.7	5,314.4	23,039.8
	1991	1,879.9	1,671.1	273.8	2,006.8	2,549.2	112.3	9,825.4	139.5	6,121.7	24,525.7

Source : Oil companies
Compiled by DEA

Note : 1/ Including the maount consumed at every airportthroughout Thailand
2/ Bangkok, Nonthaburi, Prathum Thani and Samut Prakarn

Table 4.1 Power Development Projects Under Construction or Consideration 1990

Name and Location of the Project	Generation Station			Transmission System				Anticipated Date of Completion
	Number of Generating Unit	Unit Capacity (MW)	Total Plant Capacity (MW)	Transmission and Sub Transmission Line		Main Sub Station		
				Voltage (kV)	Route Length (km)	Number of Station	Aggregate Transformer Capacity (MVA)	
EGAT								
Bang Pakong Combined Cycle#3-4	2	307	614	230	44.5	2	-	May 90 - Sep 91
South Bangkok Combined Cycle#1	1	300	300	230	23.2	3	-	Apr 93 - Apr 94
MEA MOH#10	1	300	300	500	333.0	3	-	Apr-1991
MEA MOH#11	1	300	300	-	-	2	600	Sep-1991
MEA MOH#12	1	300	300	500	215	3	-	Apr-1996
MEA MOH#13	1	300	300	500	120	4	1,800	Oct-1996
Rayong Combine Cycle#1-3	3	308	924	230	54.0	2	-	Oct 90 - Jan 92
Rayong Combine Cycle#4	1	300	300	230/115	5	3	600	Mar 93 - Mar 94
Nam Phong Combine Cycle#1	1	355	355	230/115	135	4	400	Nov 90 - Feb 92
Nam Phong Combine Cycle#2	1	355	355	230/115	116.9	4	-	Jan 93 - Jan 94
Khanom Combine Cycle#1-2	2	300	600	-	-	4	-	Dec 93 - Apr 95
Srinagarind#5	1	180	180	-	-	2	-	Apr-1991
Bang Pakong Thermal#3	1	600	600	230	26.3	4	-	Mar-1991
Bang Pakong Thermal#4	1	600	600	230	45.0	2	-	May-1993
Bhumibol Renovation#1-2	2	(70)	(140)	-	-	-	-	Jan 92 - Jan 93
Sirikit#4	1	125	125	230	-	1	-	Feb-1994
Pak Mun#1-4	4	34	136	115	160	4	50	Jun 94 - Nov 94
Wang Noi Gas Turbine#1-4	4	100	400	230	19	2	-	Nov 94 - Apr 95
Kaeng Krung#1-2	2	40	80	115	42	2	-	Dec-1994
Bhumibok#8	1	175	175	230	-	1	-	Jan-1995
Ao Phai#1	1	700	700	500/230	145	4	600	Aug-1996

Table 5.1 Outline of Solar Water Supply System

Hot Water Supply per Day (ton) (60°c)		2	4	6	8	10	15	20
Nos. of Unit		17	34	51	68	85	127	169
Objectives	Hotel (person)	14	29	43	57	71	107	143
	Public Bath (person)	11	21	32	43	53	80	107
	Hospital (bed)	8	17	25	33	42	63	83
	Sports Center (shower use, person)	87	174	261	348	435	652	870
	Restaurant (Nos. of dishes)	250	500	750	1,000	1,250	1,875	2,500
	Apartment (Household)	9	17	26\	34	43	64	85
Served Energy	10^6 Kcal/year	25	50	80	100	130	190	260
	Thousand Baht/year *1	28.8	57.6	92.0	115.2	150.0	220.0	300.0
Installed Space (m^2)		79.0	137.0	185.0	236.0	285.0	423.0	548.0
*2 System Cost (1,000 Yen)		7,000	11,000	15,500	19,000	23,000	32,000	42,000

Note : *1. Heat value and price (in 1991 Nov.) for Kerosene is assumed as 8,250 Kcal/liter and 9.5 Baht/litre.
*2 Equipment cost including transportation cost, but excinded installation cost.

Table 5.2 Specification of the System

Type	Pumped Volume	Total Head	Solar Output	Array Area	Served		Pump		Cost ¥ 10^6	
									Solar	Pump
	(cu.m./day)	(m)	(kWp)	(sq.m.)	Population	Household	H(m)	Q cu.m./m	Total	
1/8	10	80	1.5	17.5	200	40	88	0.02	10.5	1.4
									11 .9	
1/10	10	100	1.9	22.2	200	40	100	0.02	13.3	1.4
									14 .7	
20/1	200	10	3.8	44.3	N/A	N/A	10	0.42	26.6	0.6
									27 .2	
5/8	50	80	7.5	87.5	1,000	200	80	0.10	52.5	1.8
									54 .3	
5/10	50	100	9.4	109.7	1,000	200	100	0.10	65.8	1.8
									67 .6	
20/8	200	80	30.0	350.0	4,000	800	80	0.42	210	3.8
									213 .8	
20/10	200	100	37.5	437.5	4,000	800	100	0.42	262.5	3
									226 .3	
200/3	2000	30	112.5	1,312.6	N/A	N/A	30	4.2	787.5	5.2
									792 .7	

Table 5.3 Specification of Rice Husk Power Generating System

Description	Case-1	Case-2	Case-3
1. Output (NET)	200 kW	500 kW	1,000 kW
- Self-consumption	60 kW	90 kW	180 kW
- Total output	260 kW	590 kW	1,1800 kW
2. Steam Condition at inlet	30 kg/sq.cm. x 300°c	30 kg/sq.cm. x 300°c	30 kg/sq.cm. x 300°c
3. Steam Consumption by Turbine at max. Load	5,900 kg/hr	8,000 kg/hr	15,000 kg/hr
4. Steam Rating	23 kg steam/kW	13.7 kg steam/ kW	12.5 kg steam/ kW
5. Steam Boiler			
- Boiler type	Superheated water tube boiler	Super heated water tube boiler	Super heated water tube boiler
- Boiler capacity	6,000 kg/hr	8,000 kg/hr	
- Steam condition at outlet	31 kg/sq.cm. x 310°c	31 kg/sq.cm. x 310°c	31 kg/sq.cm. x 310°c
- Fuel consumption of boiler	1,526 kg/hr	2,034 kg/day	3,815 kg/day
- Boiler efficiency	80%	80%	80%
6. Turbine Generator			
- Turbine type	Atomosphere condensing single stage turbine	Atomosphere condensing single stage turbine	Atomosphere condensing single stage turbine
- Generator type	Induction type	Induction type	Induction type
- Output voltage	AC380V 3 ø 50HZ	AC380V 3 ø 50HZ	AC380V 3 ø 50HZ
- Efficiency of turbine-generator	6.2%	10.4%	11.1%
- Total efficiency	5.0%	8.5%	9.0%
7. Fuel Consumption	25.0 tons/day 680 tons/month	30 tons/day 900 tons/month	60 tons/day 1,800 tons/month
8. Generated Energy	2,900 KWh/day 348 MWh/year	7,300 KWh/day 876MWh/year	14,500 KWh/day 1,740 KWh/year
9. Sold Energy	348,000 baht/year	876,000 baht/year	1,740,000 baht/year
10. Equipment Cost (¥ 10^6)	470.0	565.0	803.0

Note : MWh means megawatt hour.

Table 5.4 Mini Hydro Electric Power Development Plant at Multipurpose Weir

Site No.	Province	Name of River	Location		Max. Dicharge (cu.m./s)	Head		Installed Capacity (kW)	Annual Energy Production (kWh)
			Longtitude	Latitude		Maximum	Minimum		
SI-2	Si Sa Ket	Huai Thai	104°29'30"	14°56'00"	8.00	8.00	5.50	550.0	1,600,000
U-1	Ubon Ratchathani	Huai Thap	104°44'	15°08'	9.00	8.00	5.50	270.0	1,000,000
U-3	Ubon Ratchathani	Lam Se Bok	104°48'	15°30'	12.00	10.00	6.50	1,000.0	2,900,000
U-4	Ubon Ratchathani	Lam Se Bok	104°50'	15°35'	20.00	10.00	6.50	1,700.0	5,600,000
M-2	Mukdahan	Hua Bang	104°28'30"	16°27'30"	2.00	6.00	4.00	100.0	300,000
M-3	Mukdahan	Hua Muk	104°43'30"	16°33'30"	11.00	9.00	6.50	840.0	2,600,000
Y-2	Yasothon	Lam Se Bai	104°27'30"	11°50'20"	30.00	10.00	6.50	2,550.0	7,300,000
NN-2	Nakhon Nayok	Nakhon Nayok	14°15'30"	101°17'00"	18.00	8.00	5.50	1,200.0	3,790,000
PB-1	Prachin Buri	Khlong Phra Sathang	13°58'00"	101°44'30"	28.00	9.50	6.50	2,300.0	7,640,000
PB-2	Prachin Buri	Khlong Phra Sathang	13°39'30"	102°04'30"	10.00	10.00	6.50	850.0	2,780,000
								TOTAL	35,510,000

Figures

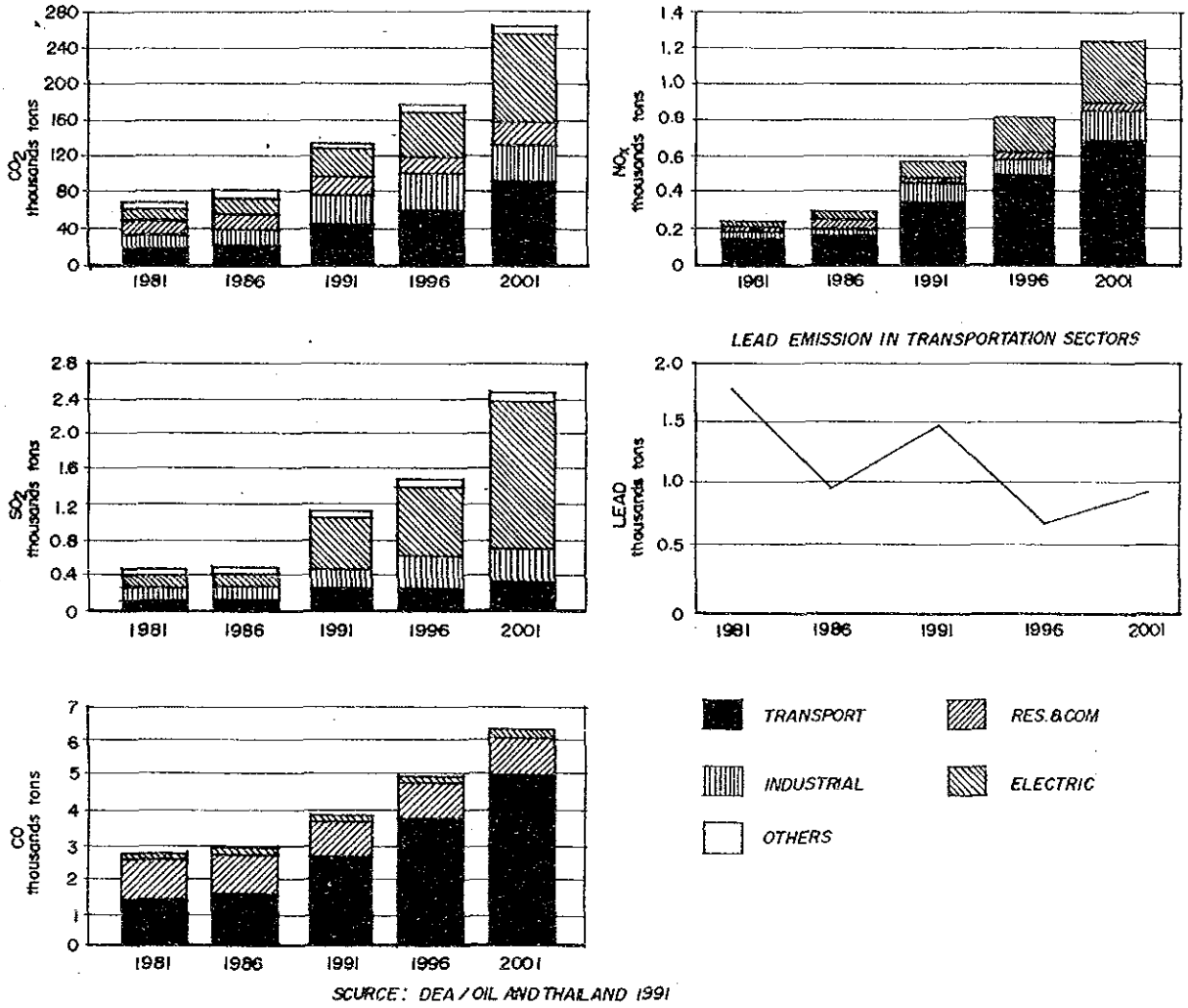

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Figure 1.1

Emission by Types and by Sectors

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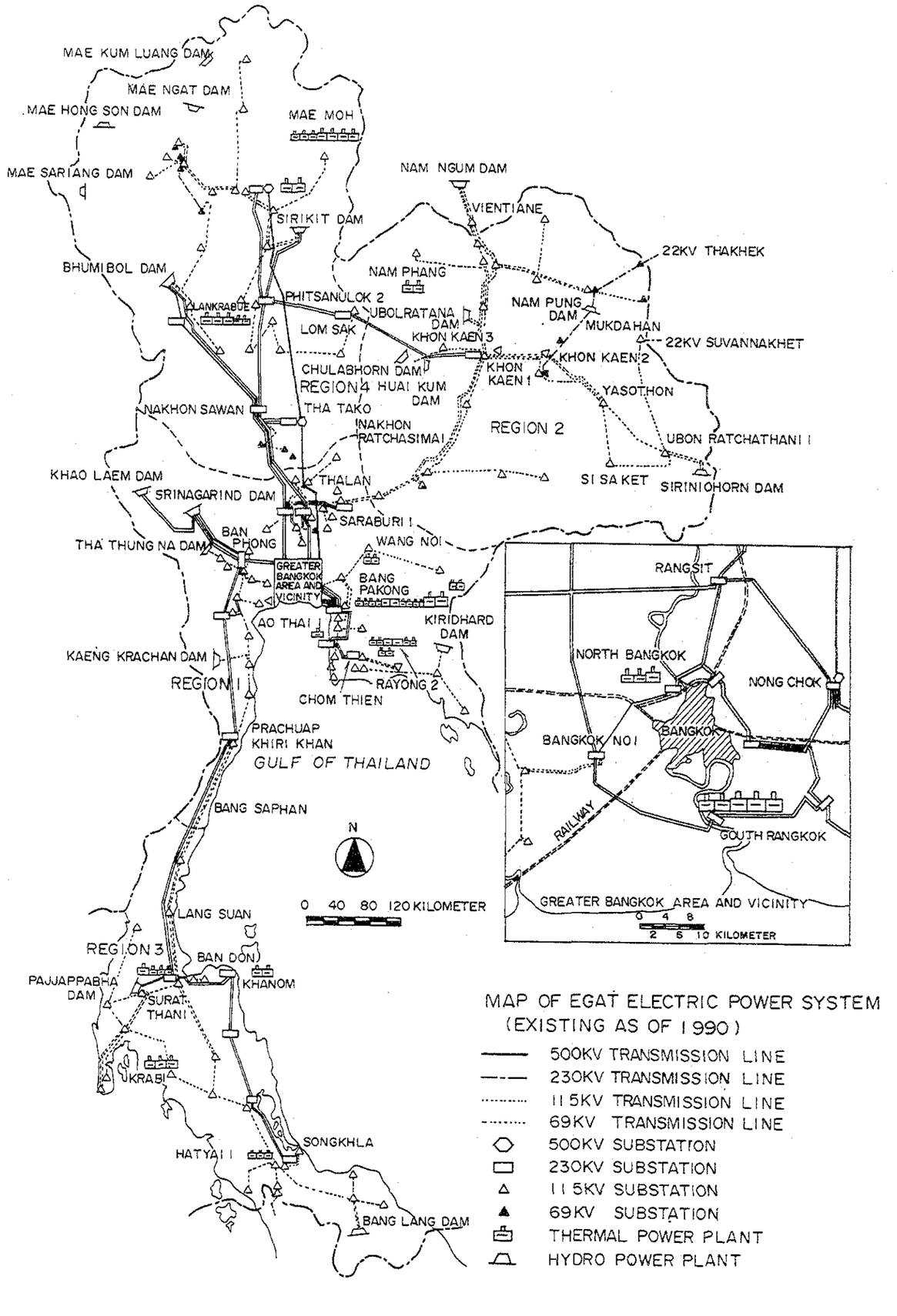

Figure 2.1

Map of EGAT Electric Power System

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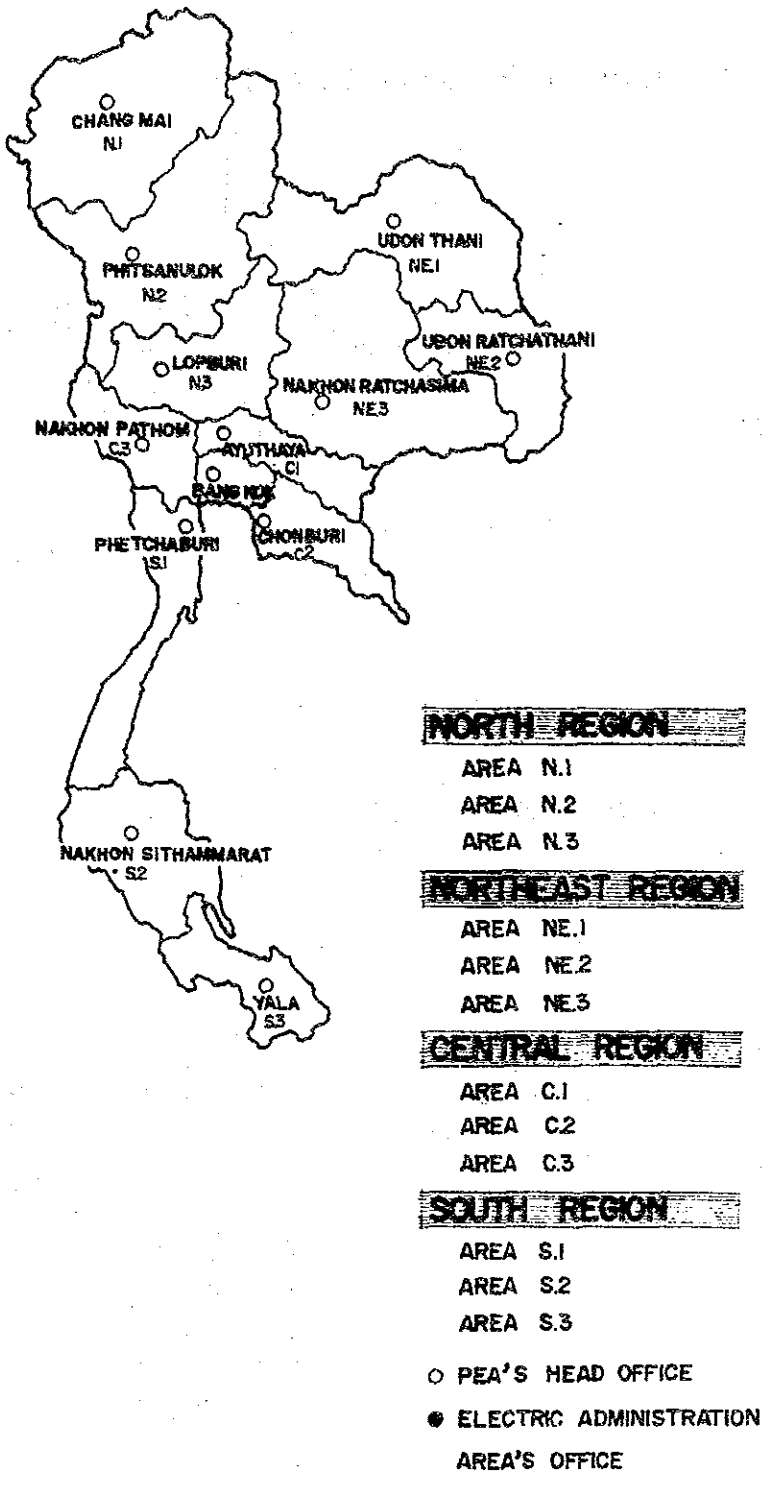

Figure 2.2

PEA's Supply Area

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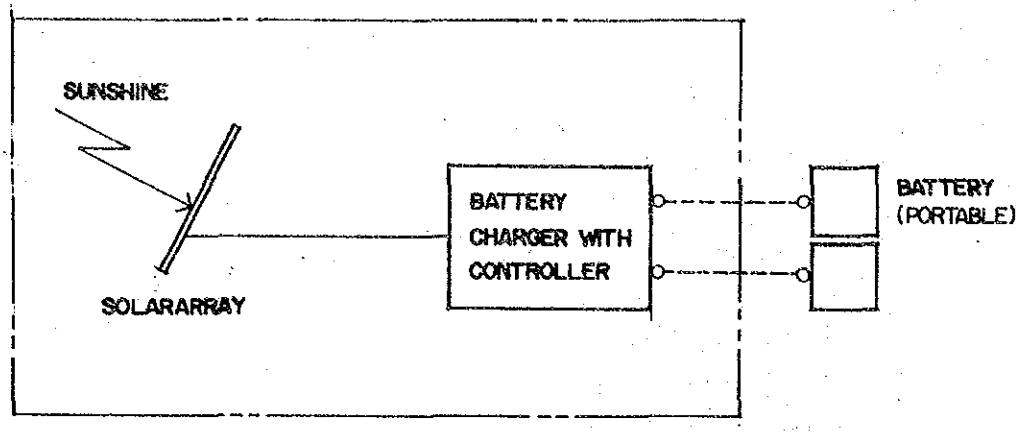
(1) PHOTO-VOLTAIC BATTERY CHARGING SYSTEM



(2) PHOTO-VOLTAIC PUMPING SYSTEM

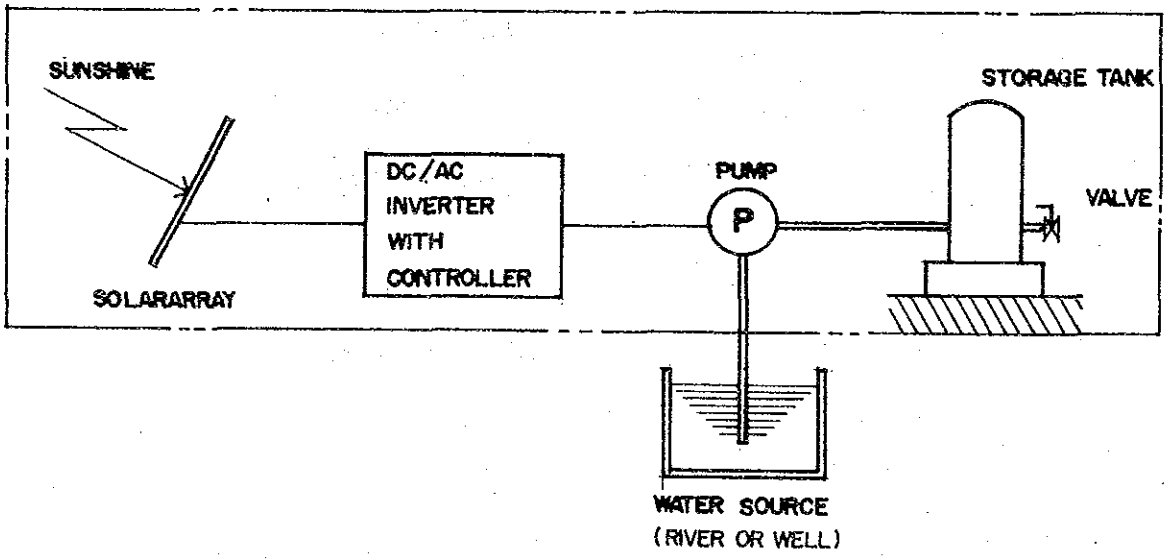


Figure 3.1
(1) Photo-Voltaic Battery Charging System
(2) Photo-Voltaic Pumping System

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LIST OF SUB-STATION

PROVINCE	SUB-STATION		TRANSFORMER	
	MUKDAHAN	SYMBOL	CAPACITY (MVA)	NOS
MUKDAHAN	MUKDAHAN	Mdo	6.5	1
YASOTHON	YASOTHON	Yta	25.0	2
UBON	UBON			
RATCHATHANI	RATCHATHANI	Uoa	50.0	2
	SIRINDHORN	Sia	13.0	1
SISAKET	SISAKET	Sta	25.0	1
			10.0	2
SURIN	SURIN	Sua	25.0	2
BURIRUM	BURIRUM	Boa	12.5	2
NAKHON	NAKHON #1			
RATCHASIMA	RATCHASIMA	Nra	25.0	2
	DO #2	Nrb	50.0	2
	KHONG	Kea	12.5	1
	SI KHIU	Str	25.0	2
	PAKCHONG	Pca	25.0	2
PRACHIN BURI	PRACHIN BURI	Poa	25.0	2
	WATTHANA			
	NAKHON	Wna	25.0	1
NAKHON NAYOK	NAKHON			
	NAYOK	Wna	25.0	1

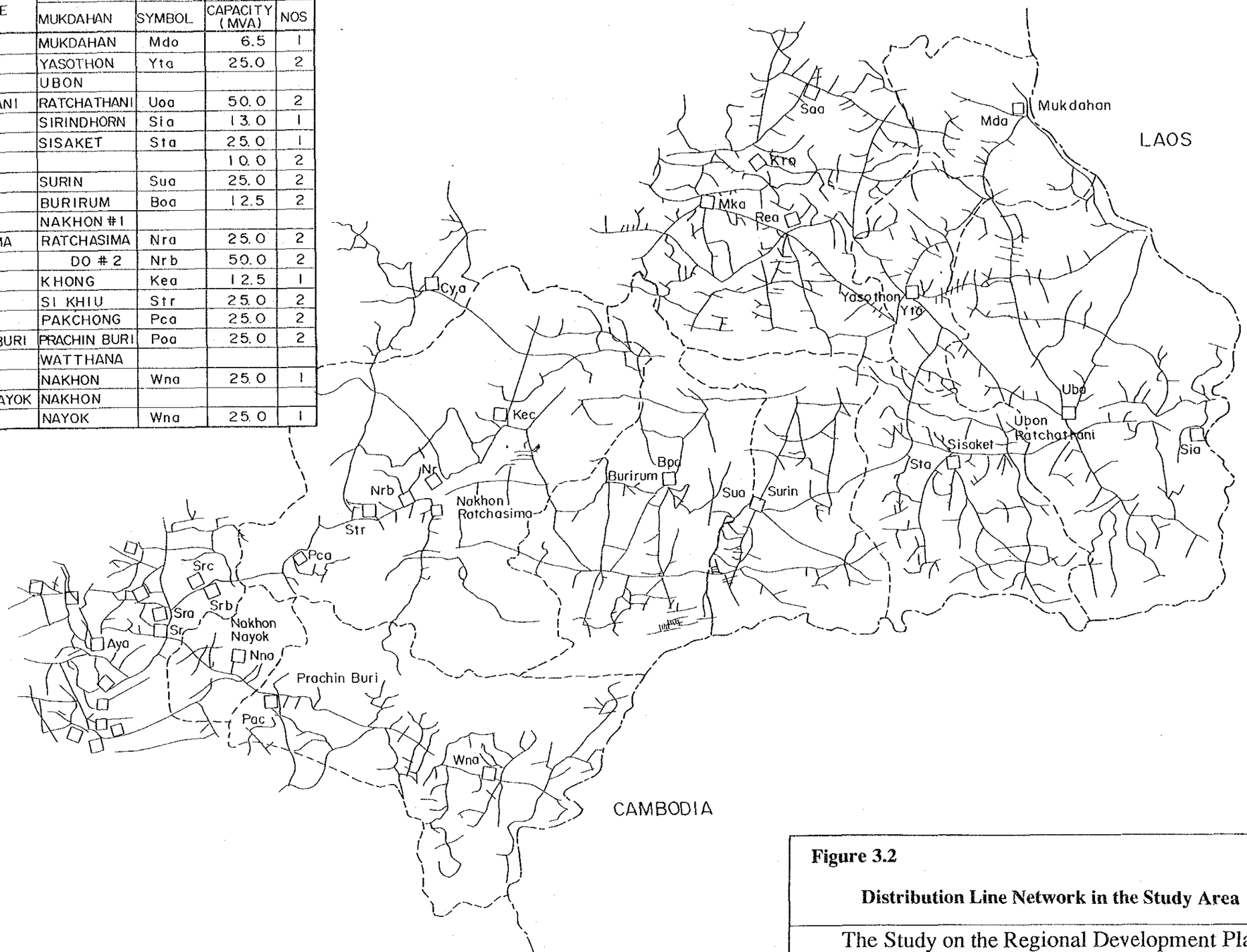

Figure 3.2

Distribution Line Network in the Study Area

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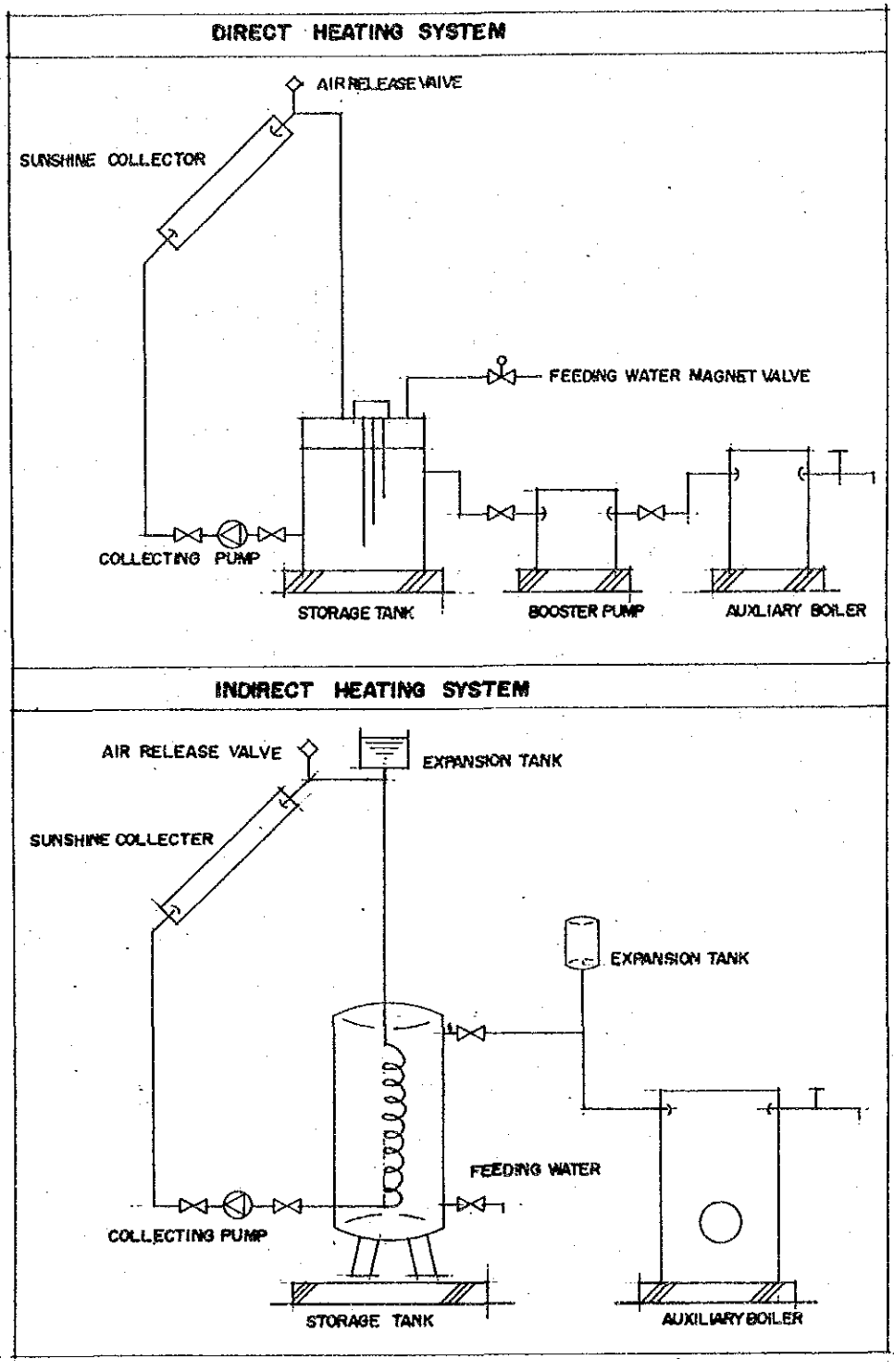

Figure 5.1

System Configulation for Solar Water System

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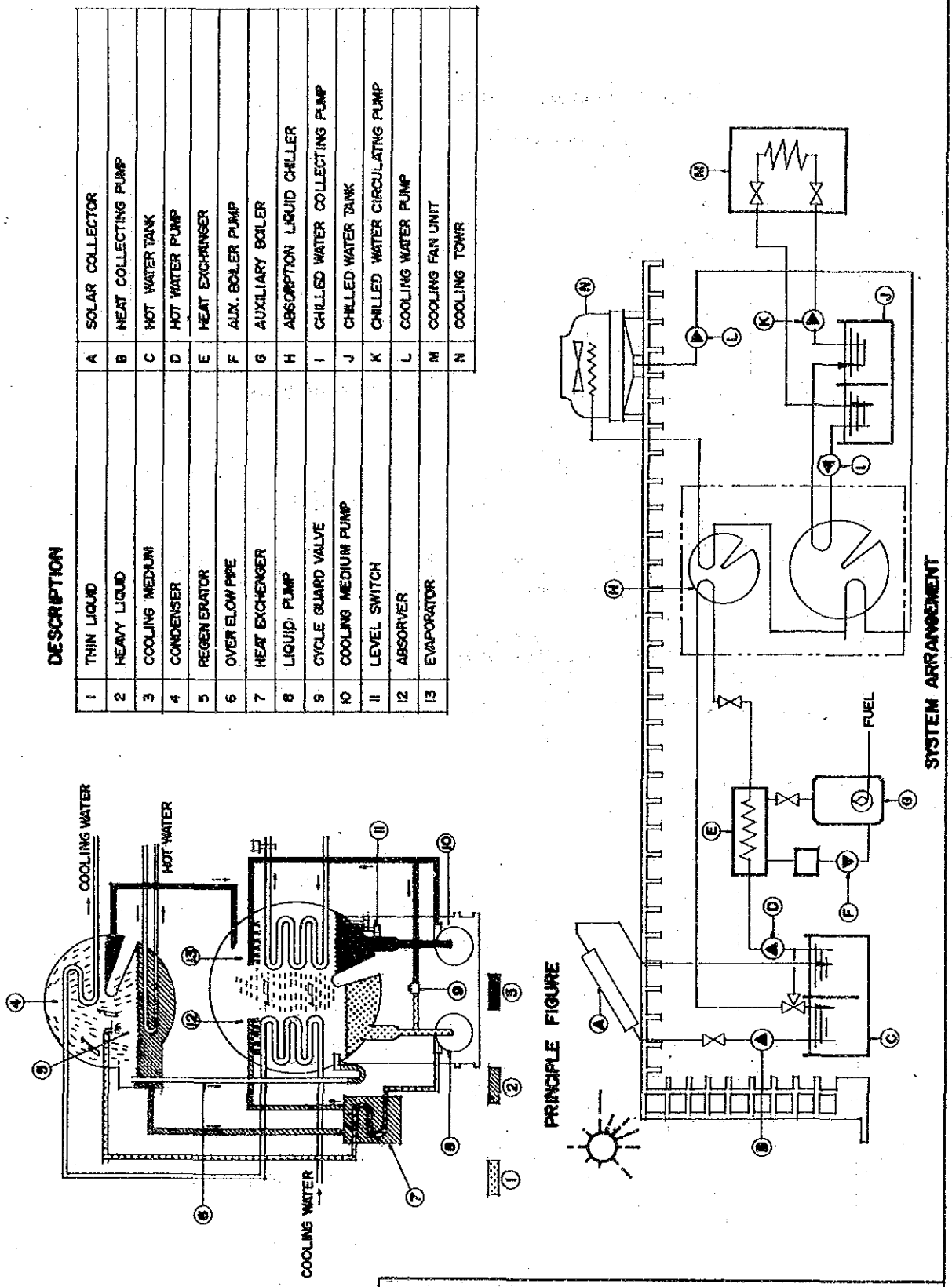

Figure 5.2

Solar Heat Absorption Liquid Chiller System

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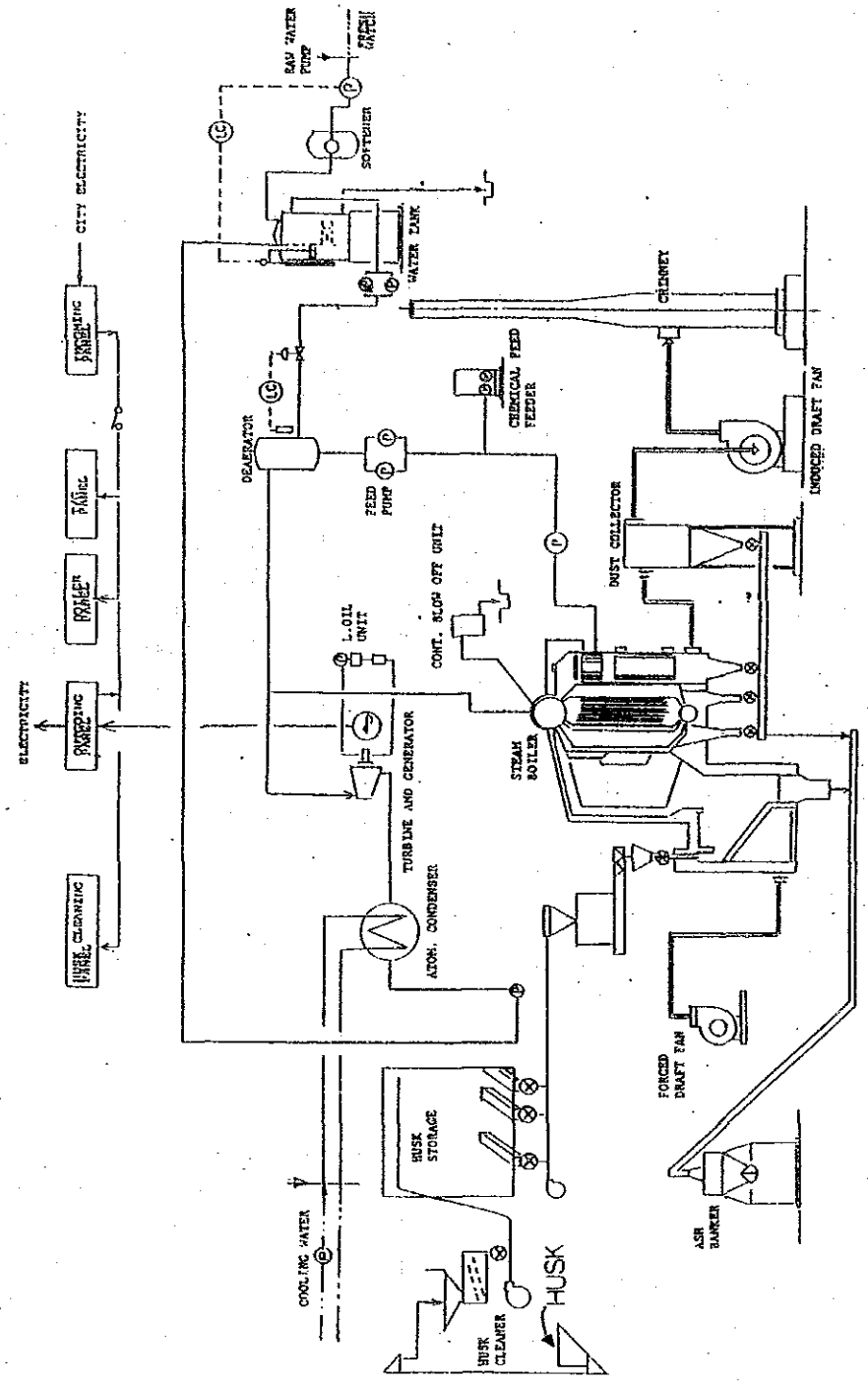

Figure 5.3

Rice Husk Generating System Diagram

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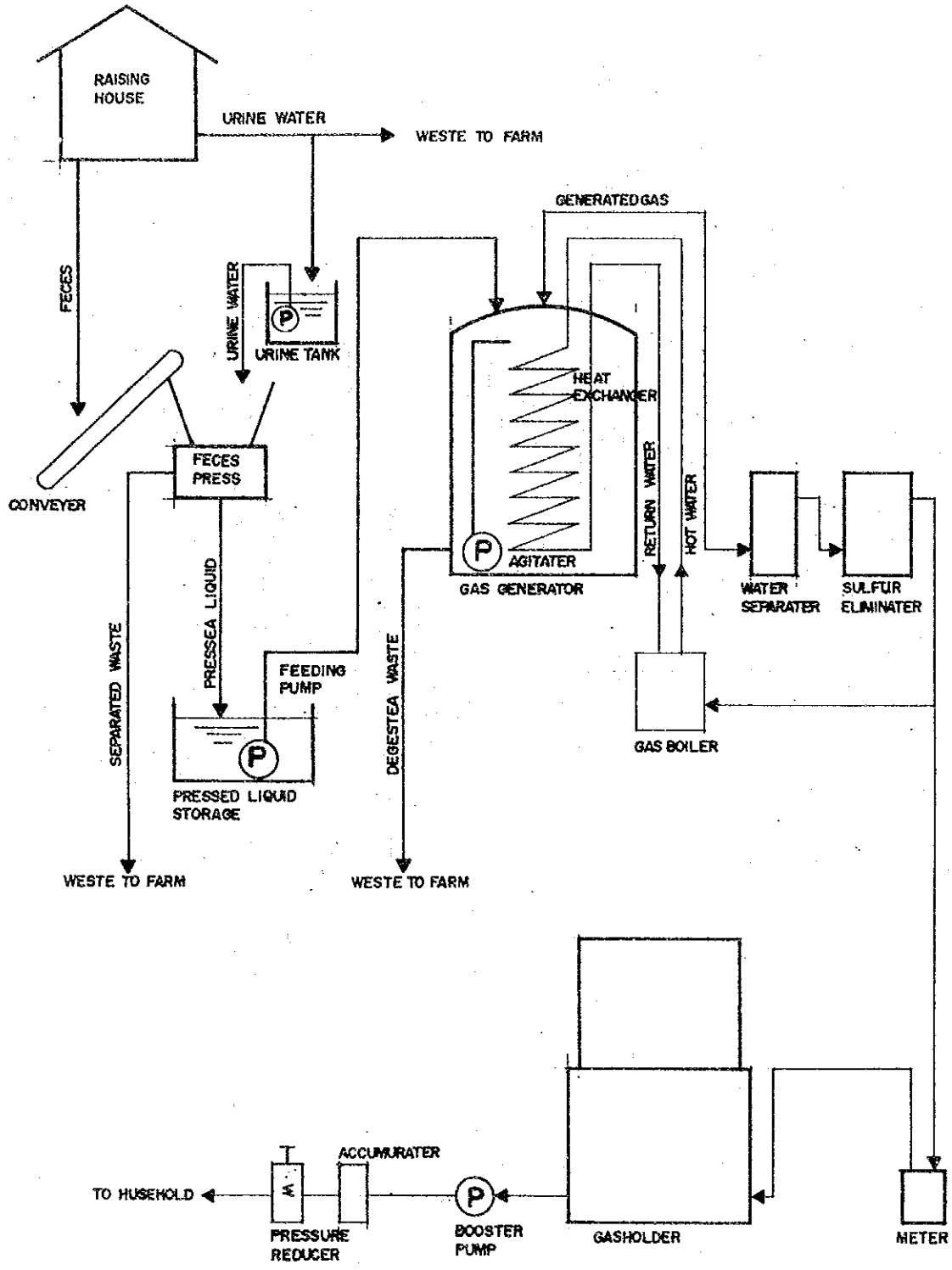

Figure 5.4

Biogas Generating System

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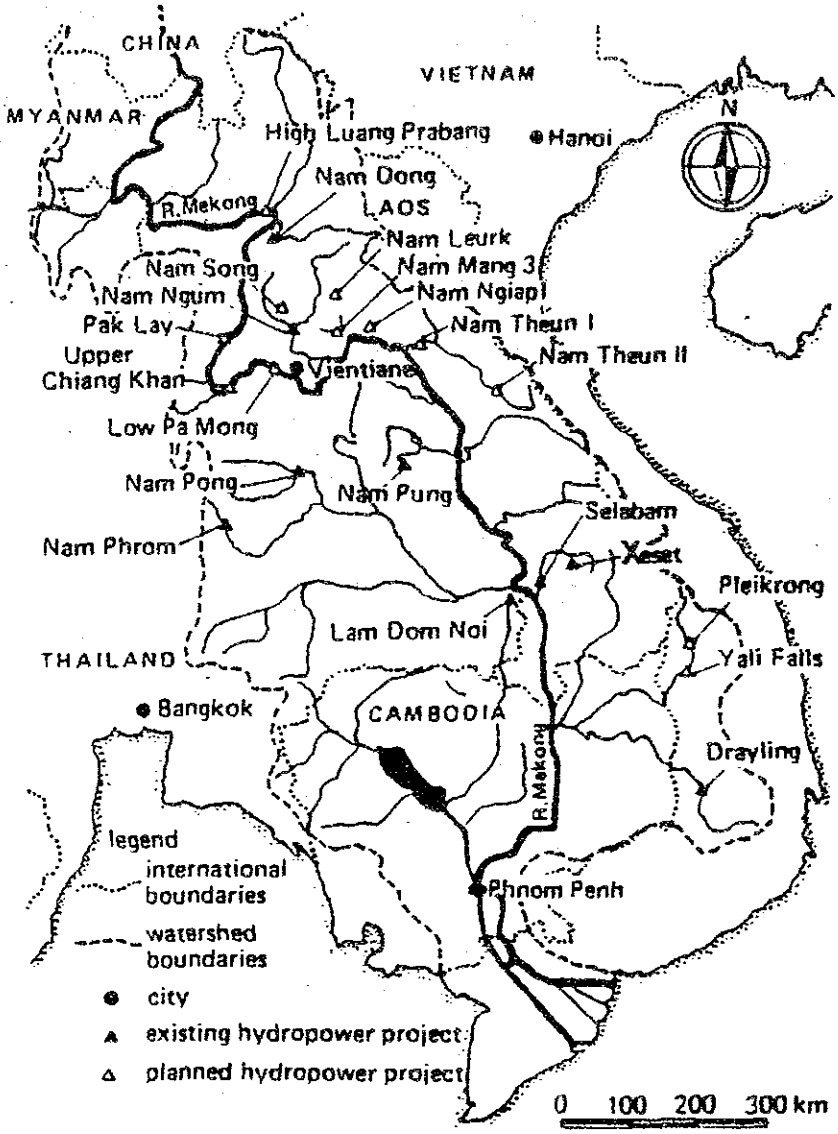

Figure 5.5

Location Map of Existing and Planned Hydro Plants

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