Country	: Kingdom of Thailand
Project	: (1) Power Distribution Systems Reinforcement Project (IV-2) (2) Power Distribution Systems Reinforcement Project (IV-3) (3) Normal Rural Electrification Project (II) (4) Village Electrification Project (III)
Borrower	: Provincial Electricity Authority (PEA)
Executing Agency	: Provincial Electricity Authority (PEA)
Date of Loan Agreement	: (1) September 1988 (2) February 1990 (3) February 1990 (4) September 1991
Loan Amount	: (1) ¥6,148 million (2) ¥5,488 million (3) ¥7,095 million (4) ¥6,635 million
Local Currency	: Baht
Report Date	: September 1997 (Field Survey: December 1996)

Distribution Line in the Village
Upper level is High - voltage distribution line, lower level is Low - voltage distribution line.
(Sakhon Nakhon, Bannalom

[Reference]

1. Abbreviations

- Organizations and Agencies

  PEA: Provincial Electricity Authority
  MEA: Metropolitan Electricity Authority
  EGAT: The Electricity Generating Authority of Thailand

- Administrative Unit

  Changwat : Province
  Amphoe : District
  Tambon : Sub-district
  Mubau : Village

2. Terminology

Four OECF projects: Four ODA loan projects for electricity distribution equipment under a development plan devised by the Provincial Electricity Authority as part of the Sixth National Economic and Social Development Plan.

Power Distribution Systems Reinforcement Project (IV-2)	→	PSR IV-2
Power Distribution Systems Reinforcement Project (IV-3)	→	PSR IV-3
Normal Rural Electrification Project (II)	→	NREP II
Village Electrification Project (III)	→	VEP III

Transmission lines: Electrical transmission lines and associated facilities between power stations, between substations and from power stations to substations.

Distribution lines: Electrical lines and associated facilities from substations to electricity-using facilities.

cct-km: (Circuit-kilometer) The length of a circuit in kilometers (km)

Power rate: Within an AC circuit, voltage and current both vary in a sine wave form. The peak value on a sine wave divided by $1/\sqrt{2}$ is called effective value. AC electrical power is equal to or less than the product of the effective values of voltage and current. This is because the sine wave for voltage and the sine wave for current are not necessarily in phase. In general there is a phase angle ϕ between them. Letting electrical power be P, voltage (effective voltage) be V and current (effective current) be I, $P=V\times I\times\cos\phi$. The $\cos\phi$ at this time is the power rate (where $0\leqq\cos\phi\leqq 1$).

Electrification rate:

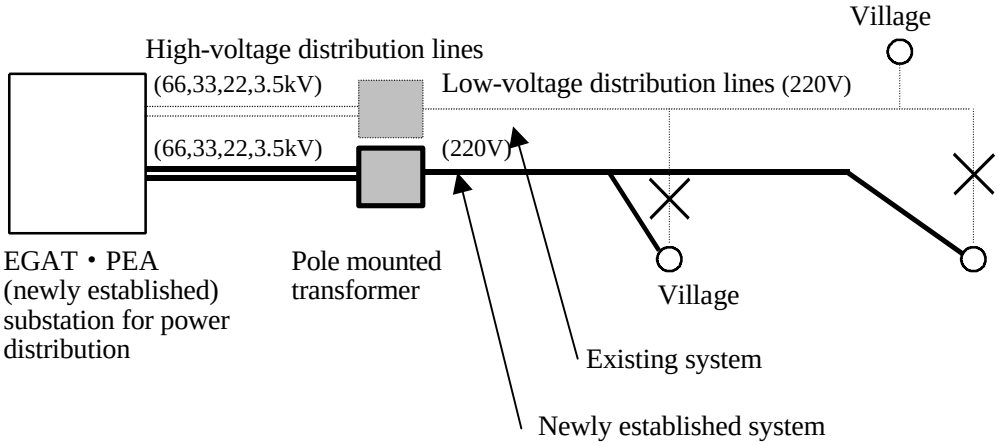
Rural electrification rate (electrification rate in village units)
= number of electrified villages /total number of villages×100 (%).
Household electrification rate (electrification rate in household units)
= number of electrified households /total number of households×100 (%).

3. Type of power distribution systems reinforcement project and electrification project

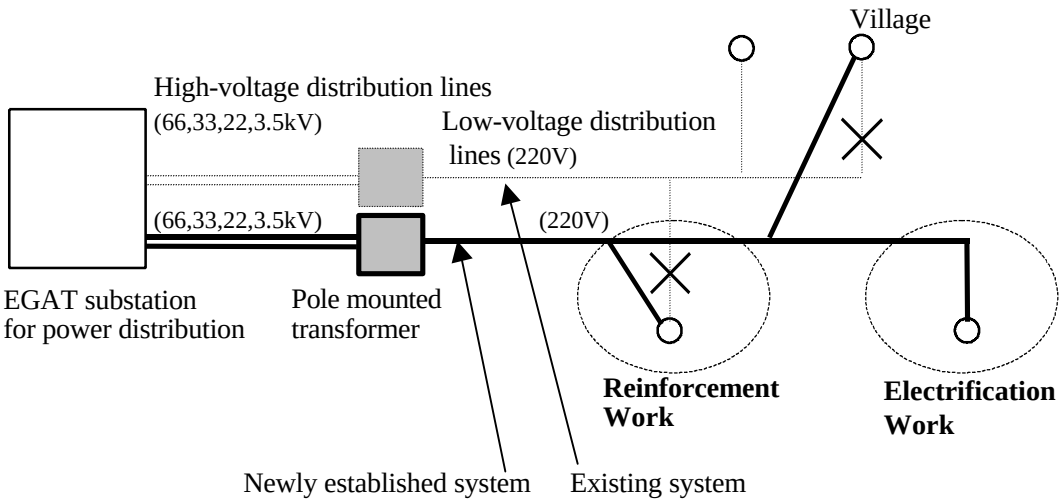
●Legend:

Symbol	Content
	Existing power distribution system
	Existing transformer on the pole for power distribution
	Newly established power distribution system
	Newly established transformer on the pole for power distribution
	Village

●Power distribution systems reinforcement project:



●Electrification project:



Project scale for PEA

Supply area	490,000 km²
No. of offices	4
No. of local offices	73
No. of sales offices	676
No. of customer service centers	526
No. of employees	Approx. 31,000
Circuit length of high-voltage distribution lines	194,711 cct-km
Transformer capacity	30,534 MVA

(as of 1995)

Share of electrical power supply by PEA in Thailand

Electrical volume of demand	57%
Maximum electrical power	38%

(as of 1995)

(OECF from project sites evaluated this time are spread over Thailand, therefore, it is difficult to specify the project site.)

Foreword

The main bilateral donors providing aid to Thailand are Japan, Germany, America and Australia. The main aid agencies are the World Bank and the ADB. ODA loan began in 1969 and 21 loans have been implemented to date. The total of approved ODA loan amount to Thailand is ¥1,377,687 million, spread over 198 projects. In 1996, ODA loans to Thailand represented 37% of all official international loans to Thailand (on a borrowed balance base), far above the World Bank (around 10%) and the ADB (around 7%).

Of the loans made to Thailand so far, approximately 21% have been directed to the electricity and gas sector, making it the second largest recipient after the transport sector, which has received about 40%. Of the loans provided to the electricity and gas sector, approximately 57% has been allocated to electricity transmission and distribution projects. This pattern demonstrates the Thai government's commitment to improving the standard of living for people in rural areas and nurturing regional industries. And for this objective, the Thai government has been consistently expanding its rural electrification projects.

This report aims to review the contribution of ODA loan projects to rural electrification projects through the post-evaluation of four such projects which were implemented by the Provincial Electricity Authority under the Sixth National Economic and Social Development Plan. Chapter 1 is an overview of electrical power projects in Thailand. Chapter 2 examines the position of rural electrification projects within the Sixth National Economic and Social Development Plan and their achievements to date. Chapters 3 and 4 give a post-evaluation of rural electrification projects which used ODA loans and make suggestions for improvements on the operation and maintenance management conducted by the Provincial Electricity Authority. Chapter 5 surveys the development effects generated by rural electrification projects.

1. Overview of Electrical Power in Thailand

Both supply and demand of electrical power have been growing remarkably in Thailand in recent years. In this section we will broadly examine the movements of supply and demand in Thailand, the state of electrical supply equipment and the administration･supply system of electrical power. We will also review the Provincial Electricity Authority (PEA), which is the executing agency for the projects mentioned above.

1.1 Current Status of Electrical Power Supply

1.1.1 Supply and Demand for Electricity

① Movements in Demand

In Thailand during the five years of the Sixth National Economic and Social Development Plan (referred to below as "the Sixth Plan") which was carried out between 1987 and 1991, both maximum power demand and the volume of consumption grew by 70% (maximum demand rose by 3,148MW and consumption rose by 18,504GWh). The elements of this increase include greater industrial demand due to the construction of factories under the Sixth Plan and greater commercial and residential demand due to rural electrification.

【Table 1-1: Current Status of Supply and Demand for Electricity】

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Supply										
Generating power (GWh)	24,717	28,652	32,464	37,406	44,175	50,186	57,098	63,405	71,177	80,060
(Growth rate %)	-	(16%)	(13%)	(15%)	(18%)	(14%)	(14%)	(11%)	(12%)	(12%)
Generating capacity（MW）	6,785	6,985	6,997	7,366	8,725	9,707	11,732	12,734	13,075	14,912
(Growth rate %)	-	(15%)	(12%)	(15%)	(15%)	(11%)	(10%)	(10%)	(12%)	(12%)
Maximum demand（MW）	4,202	4,842	5,414	6,208	7,167	7,990	8,828	9,735	10,911	12,168
(Growth rate %)	-	(15%)	(12%)	(15%)	(15%)	(12%)	(11%)	(10%)	(12%)	(12%)
Demand										
Consumption (GWh)	22,034	24,894	28,253	32,834	38,342	43,398	49,304	56,279	62,510	71,225
(Growth rate %)	-	(13%)	(13%)	(16%)	(17%)	(13%)	(14%)	(14%)	(11%)	(14%)

Source: Electric Power in Thailand 1995, DEDP

Note:1. Maximum demand shows actual volume of generating power.

Note:2. Consumption excludes independent power.

② Composition of Electrical Demand

In the ten years from 1986 to 1995 the breakdown of electrical power demand by application has been changing gradually, although the share taken by industrial demand has been steady at 45% which is the largest component of demand. The other major components, in descending order, are business, residential and agriculture. Over the ten year period there has been a trend towards an increasing share for business demand, with the share for residential demand declining by the same amount. The share for agriculture, which stood at 0.3% in 1986, has been declining continuously, reaching 0.1% by 1995.

【Table 1-2: Movements in Electrical Power Demand by Application】

Year	Consumption volume (GWh) *1	Breakdown				
		Residential (%)	Business (%) *2	Industrial (%)	Agricultural (%)	Others (%) *3
1986	22,034	26.3	27.2	46.1	0.3	0.1
1987	24,894	24.6	29.4	45.5	0.2	0.2
1988	28,253	22.1	31.3	45.8	0.2	0.5
1989	32,834	21.4	30.8	47.0	0.3	0.5
1990	38,342	21.1	31.1	46.8	0.3	0.6
1991	43,398	21.1	32.2	45.7	0.2	0.8
1992	49,304	20.8	36.6	41.4	0.2	1.0
1993	56,279	21.2	38.1	39.8	0.2	0.7
1994	62,510	20.8	32.2	46.3	0.2	0.8
1995	71,225	20.5	32.3	46.2	0.1	0.9
Average		22.0	32.1	45.1	0.2	0.6

Source: Electric Power in Thailand 1995, DEDP

Notes *1 Excluding independent power

*2 Offices, stores etc. including governmental agencies and non-profit organizations

*3 Tentative power supply

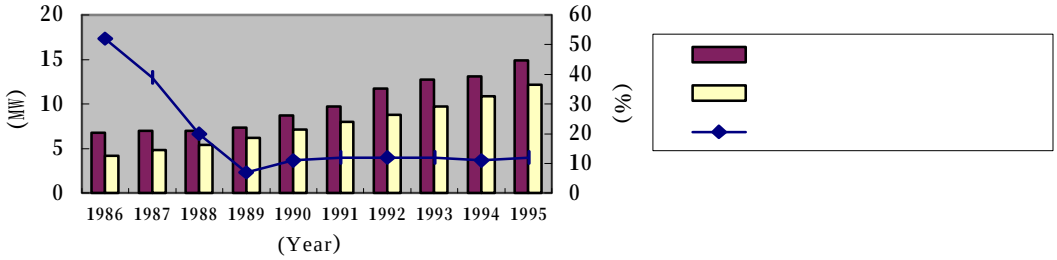
③ Peak Demand Periods

The peak demand period in a day used to occur between 7pm and 8pm until 1993. This is the typical pattern of demand for electric lighting. From 1992 the demand around 3pm started to increase and in 1995 the peak period arose between 2pm and 4pm. The shift of peak demand to the afternoon is apparently the impact of industrial demand and the trend can be expected to continue.

④ Movements in the Supply Margin Rate

In 1987 the supply margin rate[1] was approximately 40%, but thereafter it continued a downward trend every year, reaching approximately 10% in 1989. This trend was due to the Thai government's policy of restricting foreign borrowing, which stalled the construction of new power stations while economic growth brought a steep increase in demand. Now, the Electricity Generating Authority of Thailand (EGAT) aims to improve the margin surplus rate by investing in the construction of 33,676MW of new capacity by 2011. Under this plan, the surplus margin rate should rise to 20% by 1999 and to 25% by 2001.

[1] The ratio of reserve capacity within generation capacity is the supply margin rate. The reserve capacity is the difference between electrical demand and generation capacity, which considers guard against power cuts due to power plant maintenance work or accidents.



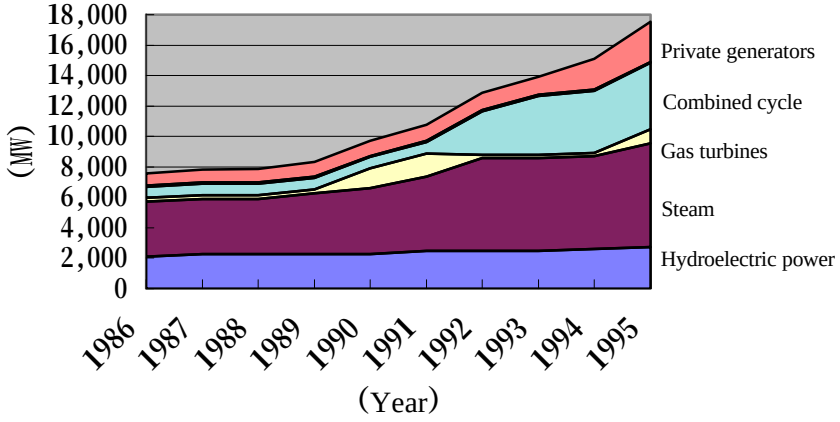
Source: Electric Power in Thailand 1995, DEDP

【Figure 1-1: Movements in the Supply Margin Rate】

1.1.2 Developments in Power Plants

① Composition of Power Plant by Energy Source

Between 1986 and 1995, the breakdown by source was approximately 20% hydroelectric power, and approximately 80% thermal power (steam, gas turbines, combined cycle, diesel). Therefore, thermal power was dominant, with hydroelectric power in a supplementary role. The figure below shows that the rate of increase in hydroelectric generation was low and that for thermal generation was high. This is because, in meeting peaks load, hydroelectric power stations must also consider water for irrigation. On the other hand thermal power generating plant has been constructed over the years to keep pace with rapidly-increasing demand. Characteristic patterns since 1991 shows the increasing share produced by combined cycle generation and private generators.



Source：Electric Power in Thailand 1995, DEDP

【Figure 1-2: Movements in Composition by Energy Source】

The EGAT is dominant in Thai power generation, but the Provincial Electricity Authority (PEA), the Department of Energy Development and Promotion (DEDP), independent power producers (IPPs) and small power producers (SPPs) also generate electricity. Looking at the breakdown of power generation quantity, the EGAT produced over 99% up to 1994. However, figures for 1995 show that the EGAT's share of power production was only 89%, with 11% produced by IPPs. In the future the IPP business is still expected to increase, while the EGAT's share of total generation will gradually diminish.

② Import/ Export of Electricity

Thailand constantly buys surplus electricity from the Nam Ngum hydroelectric power plant in Laos, and also buys electricity from Malaysia. The amount imported in 1995 was 699.1GWh, around 97% of which came from Laos, and the remainder came from Malaysia. In the same year the total amount exported to neighboring countries was 78.9GWh, of which 97.4% went to Laos, 2.1% to Myanmar and 0.5% to Malaysia.

1.1.3 Electricity Transmission and Distribution and Substation Equipment

Electricity from EGAT power stations is transmitted at voltages of 500kV, 230kV, 132kV, 115kV and 69kV. Metropolitan Electricity Authority (MEA) and PEA, as well as large factories, are directly supplied with electricity from EGAT. Trunk transmission lines owned by the EGAT comprise the following:

- The 230kV transmission lines linking thermal power stations and substations around Bangkok.
- The 500/230kV lines linking Mae Moh Thermal Power Plant in northern Thailand with the capital.
- The 230kV lines linking the four major hydroelectric power stations with the capital.
- The 115kV lines linking central and southern Thailand.

MEA receives electricity from the secondary side of primary substations operated by EGAT and transmits it to its own distribution substations at voltages of 230kV, 115kV and 69kV. At the distribution substation, the voltage is stepped down to 24kV and 12kV, and then electrical supply to houses is provided at 220V and for commercial uses at 380V or 220V.

In the case of PEA, PEA also receives electricity from the secondary side of primary substations operated by the EGAT and transmits it on distribution lines of 69kV, 33kV, 22kV and 3.5kV before supplying it to houses at 220V. To meet rapidly-growing demand industrial areas along the eastern seaboard and industrial parks around Bangkok, PEA is constructing and operating its own distribution substations and transmission lines of 115kV and 69kV. Thus their policy is to continue the construction and operation of distribution substations in the future to improve reliability and keep ahead of new demand.

【Table 1-3: Facility Status of Transmission and Distribution Lines in Thailand in 1995】

Transmission and distribution lines	Circuit length (cct-km)		
	Underground buried transmission lines	Overhead transmission lines	Total
Transmission lines			
69 kV	78	912	990
115 kV	5	12,907	12,912
132 kV	-	9	9
230 kV	15	9,061	9,076
500 kV	-	1,201	1,201
Distribution lines			
3.5 kV	-	73	73
12 kV	675	5,299	5,974
22 kV	-	161,975	161,975
24 kV	223	4,608	4,831
33 kV	-	32,191	32,191

Source：Electric Power in Thailand 1995, DEDP

1.2 Electricity Administration and Supply System

1.2.1 Electricity Administration

The three agencies listed below coordinate and determine overall policy on the development of energy sources and the planning of transmission and distribution in the Thai electricity industry.

① National Energy Policy Committee (NEPC)

NEPC is a high-level decision-making body attached to the Prime Minister's Office. As for its executive office, National Energy Policy Office (NEPO) is established. Under the NEPC, the National Economic and Social Development Board (NESDB) and the Department of Energy Development and Promotion (DEDP) hold administrative authority over planning, development, coordination and other aspects of energy as a whole.

② National Economic and Social Development Board (NESDB)

NESDB is an agency attached to the Prime Minister's Office. It holds administrative authority over all aspects of energy planning. It analyses and scrutinizes energy development plans proposed by government ministries, agencies and public corporations from a comprehensive economic and social viewpoint. It is also one of the core agencies involved in drawing up Five-year plans for economic and social development.

③ Department of Energy Development and Promotion (DEDP)

DEDP is attached to the Ministry of Science, Technology and the Environment (MOSTE). It draws up comprehensive development plans for energy supply in Thailand. It also constructs and manages small-scale hydroelectric power plants, develops new energy, and promotes energy conservation. It represents Thailand in joint cross-border river developments with neighboring countries.

1.2.2 Electricity Supply System

The three agencies below, which are all public corporations, are involved in Thailand's electrical power industry. These agencies are divided according to the equipment they hold and the regions they cover. Their roles are as described below.

① Electricity Generating Authority of Thailand (EGAT)

EGAT was established in 1969 under the jurisdiction of the Prime Minister's Office. EGAT supplies electricity through the generation, transmission and transformation stages to MEA and PEA, which are distribution agencies, and directly to major users such as large factories. It also carries out the construction, operation and maintenance of electricity generation, transmission and distribution equipment. Incidentally, most of the distribution substations used in the PEA's distribution network are owned by EGAT.

② Metropolitan Electricity Authority (MEA)

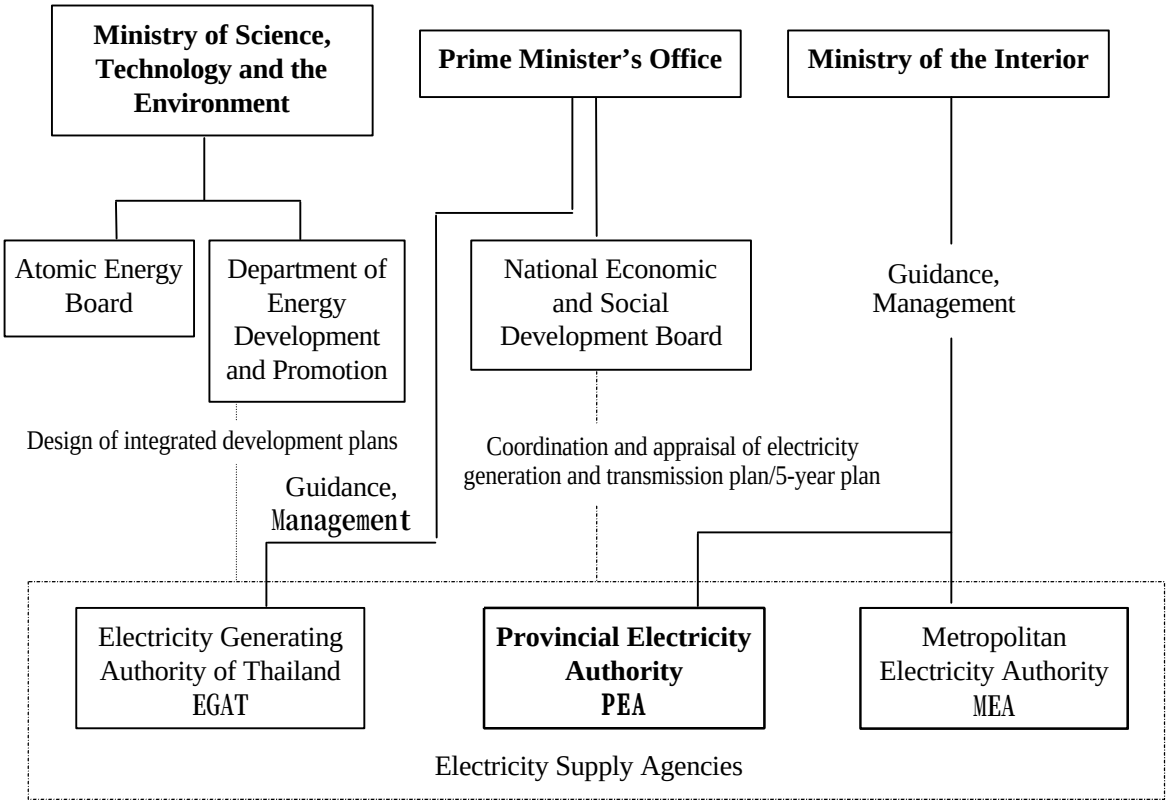
MEA was established in 1958 under the jurisdiction of the Ministry of the Interior. It buys electricity from EGAT which it distributes, through its own transmission and distribution lines, to general users, factories and places of business in Bangkok and around the provinces of Samut Prakan and Nontaburi. It also carries out the construction and the operation and maintenance of distribution substations and distribution lines needed to supply electricity to those areas. They have eight offices in the Bangkok metropolitan region, two in Nontaburi province and one in Samut Prakan, a total of eleven. In 1995 the area supplied with electricity by the MEA was 3,192km^2, while the number of consumers was 1,818,808.

③ Provincial Electricity Authority (PEA)

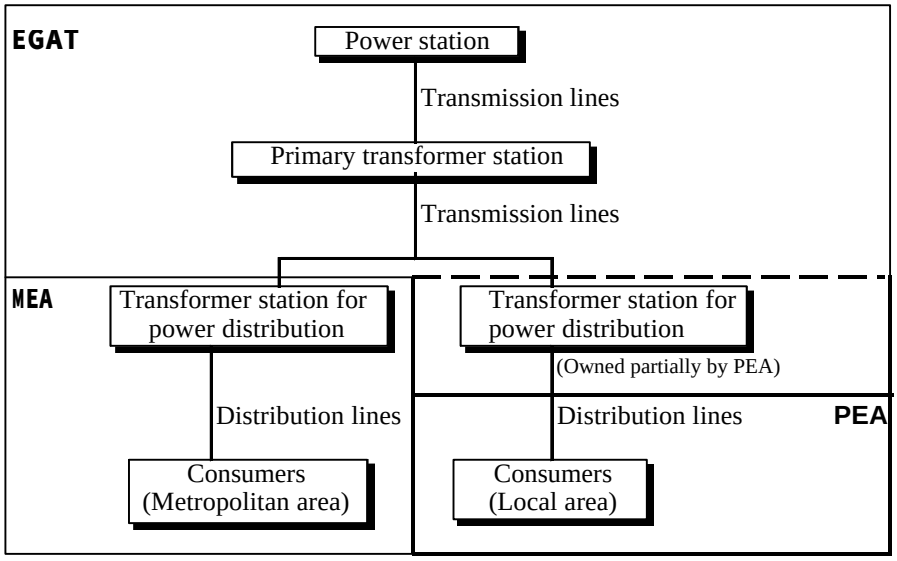
PEA was established in 1960. It is under the jurisdiction of the Ministry of the Interior, as is MEA. PEA buys electricity from the secondary sides of distribution substations under the control of EGAT. It supplies electricity through its own distribution lines, supplying consumers throughout Thailand, except those areas covered by MEA. In some areas it owns and conducts operation and maintenance of its own distribution substations. In some regions beyond the coverage of EGAT’s electrical grid, PEA also generates and supplies its own electricity from diesel or solar generating equipment. In 1995 the area supplied with electricity by PEA was 510,000km^2, while the number of consumers was 9,034,872.

In Thailand, in addition to the above public agencies which generate and supply electricity, there are private companies which own private generating plants. In 1995, their total output was 2.632MW, approximately 15% of Thailand's total generating capacity, which stood at 17.544MW in that year.[2]

[2] Only counting facilities with capacity of 200kVA or more. (Electric Power in Thailand, 1995)



【Figure 1-3: Electricity Administrative Organization in Thailand】



【Figure 1-4: Electricity Supply System in Thailand】

1.3 Overview of the Provincial Electricity Authority (PEA)

1.3.1 Background to the Establishment of the PEA

Until 1953, electrifying provincial cities outside Bangkok was the work of regional public bodies with financial assistance from the central government. The central government also permitted the owners of market and factories in provincial cities to construct private generating equipment. The central government also encouraged the private power plant owners to sell their surplus electricity to nearby consumers.

In 1954, the Provincial Electricity Distribution Union was established. It acquired the power stations and distribution equipment of the regional public bodies and private companies and built new diesel power stations. In doing so it contributed to the expansion and integration of the provincial, non-profit electricity industry.

Later, in September 1960, the Provincial Electricity Authority (PEA) was established on the basis of the Provincial Electricity Authority Act (BE2503) as a supervisory agency under the Ministry of the Interior. The aim was to improve the state of electrification and electricity supply in the provinces. From then until the present, the ongoing development of the PEA and its operations have been directed towards the following three targets.

① To improve the process on provision and distribution services of electric energy for customers; to achieve an acceptable level of sufficiency, efficiency and reliability commensurate with safety practices; to meet the timely need of customers; and to keep pace with changing circumstances.

② To develop activities in all areas in order to achieve sufficient revenues to facilitate further development

③ To develop its organizational structure, man power and resources management in order to achieve the highest efficiency and effectiveness.

1.3.2 Organization

The highest decision-making authority in the organizational structure of PEA rests with the Board of Directors. In 1995 the Board had 15 members, all of whom, with the exceptions of the president, were people from other national agencies. Ordinary business is handled by the PEA Governor and six Deputy Governors (with responsibility for planning and system development, engineering, construction and project acceleration, customer service and maintenance, accounting, and administration, procurement and welfare).

The operating area of the PEA is divided into four regions (Northern, North-eastern, Central and Southern) and a regional office is located in each. Until 1994, each regional office was under the authority of the deputy governor for operations. A reorganization in 1995 placed the regional offices under the direct authority of the governor. Each region is further subdivided into three areas, for a total of twelve areas which have branch functions. Below the branch level, each province has provincial offices which have exercise overall control and supervision over district offices (amphoe elec. works)

and customer service units.

The number of offices at the local level has been in decline since 1990, but this is due to an effort to deepen and streamline service through the merging of customer service units and the opening of district offices. Incidentally, of the 30,961 people employed in 1995, approximately 18% were working in the head office and the remaining 82% were working in offices throughout Thailand. The number of customer per employee is 292 customers/ employee, a ratio close to that for Hokuriku Electric Power Co. Ltd. of Japan which has one employee for 320 buildings.

【Table 1-4: Movements in Local Offices and Employees】

	1988	1989	1990	1991	1992	1993	1994	1995
Local offices (nos.)	70	70	70	70	70	70	73	73
District offices (nos.)	602	606	608	630	646	653	660	675
Customer service centers (nos.)	667	664	662	629	586	564	551	526
Total	1,339	1,340	1,340	1,329	1,302	1,287	1,284	1,274
Growth rate (%)	0.3	0.1	0	-0.8	-2.0	-1.2	-0.2	-0.8
No. of employees (prns.)	25,017	26,116	27,380	28,641	29,814	30,884	31,300	30,961

Source：PEA Annual Report（1988～1995）

1.3.3 Equipment

The equipment owned by the PEA was rapidly increased to promote regional electrification under the Sixth National Economic and Social Development Plan (1987~1991). The total circuit length of high-voltage distribution lines rose by 68,492 cct-km over the seven years between 1988 and 1995. This represents an increase of approximately 50% on the scale of the distribution equipment.

【Table 1-5: Movements in Circuit Length of High-voltage Distribution Lines in PEA】

(Unit：cct-km)

Distribution line voltage	1988	1989	1990	1991	1992	1993	1994	1995
3.5kV	58	58	61	61	61	119	119	73
22kV	105,284	115,724	127,946	133,836	144,139	149,249	157,950	161,783
33kV	20,819	22,122	24,508	26,368	27,537	29,412	30,557	32,086
69kV	30	30	31	31	32	32	36	47
115kV	28	37	61	128	304	515	584	722
Total	126,219	137,971	152,607	160,424	172,073	179,327	189,246	194,711

Source：PEA Annual Report（1991～1995）

In recent years the standard voltages of high-voltage distribution lines has been set at 33kV and 22kV. Wherever possible, equipment operating at other voltages is changed to these standard voltages when replaced or upgraded, in order to rationalize the procurement of equipment and materials. There has also been a brisk rise in the total capacity of transformers. In 1995 there were 30,534MVA in operation, up 8.6% on the year before.

【Table 1-6: Movements in Capacity of Transformers】

(Unit：MVA)

Primary voltage	1988	1989	1990	1991	1992	1993	1994	1995
3.5kV	12	11	14	12	12	11	8	7
11kV	145	62	16	7	1	3	3	3
22kV	6,859	7,927	8,897	10,930	12,901	15,139	19,052	20,493
33kV	1,232	1,420	1,685	1,963	2,150	2,733	3,057	3,390
69kV	80	120	480	480	240	80	80	349
115kV	120	133	589	814	1,373	3,830	5,926	6,292
Total	8,448	9,673	11,680	14,205	16,676	21,796	28,126	30,534

Source：PEA Annual Report（1991～1995）

1.3.4 Electric Power Demand

The table below shows movements in the total demand for electricity (the electricity received from EGAT and that generated by PEA), the peak demand and the average consumption. During the five years of the Sixth Plan (1987~1991), the annual average increase in electrical demand was 17% (an increase of 220% on the value at the start of the plan). The figure for peak demand was approximately 15% (203%) and the figure for per-capita consumption of customer was 7.5% (143%). As can be seen, all these figures grew briskly over the period. However, according to the demand forecast prepared by PEA in 1994, the rates of increase in electrical demand and peak demand will slow down in the future, running at around 6% after 2003.

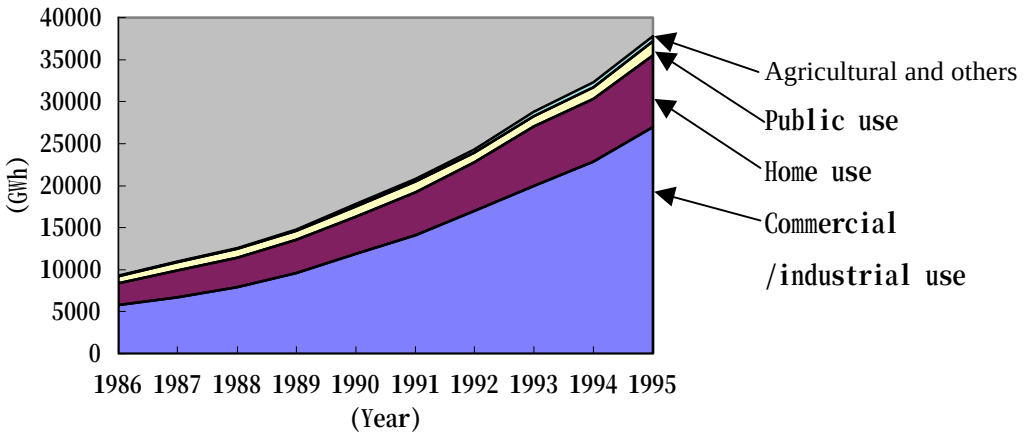
【Table 1-7: PEA Demand】

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Demand volume (GWh)	10,237	11,833	13,781	16,178	19,370	22,551	26,198	29,945	34,380	40,261
Peak demand (MW)	2,111	2,412	2,770	3,266	3,763	4,283	4,983	5,700	6,339	7,304
Average consumption (kWh)	2,049	2,159	2,268	2,442	2,703	2,939	3,230	3,581	3,817	4,191

Source：PEA Statistical Review 1995

The breakdown of electricity sold by PEA is being changed by rapidly rising demand. Comparing the shares in 1986 with those in 1995, "agricultural and others" demand moved from a 1% share to 2%, public use from 9% to 4%, home use from 28% to 23% and commercial/ industrial use from 62% to 71%.

Comparing these shares with the above-mentioned figures for electrical demand in Thailand as a whole, the overwhelming share taken by commercial and industrial demand is a common theme over the ten years. On the other hand, the shares for home and agricultural use in PEA area breakdown reflect the characteristics of the areas covered by PEA, being larger than for Thailand as a whole.



【Figure 1-5: Composition of PEA Demand Volume】

1.3.5 Electrical Demand of PEA and MEA

Now let us examine the share of PEA's electrical power demand to the national electrical power demand. The electrical power demand to PEA (the electricity received from EGAT and that generated by PEA) was a 47% share of the total national power demand (the combined demand of PEA and MEA) in 1986. The share continuously rose and by 1995 it reached 57%. Similarly, PEA's share of peak demand rose steadily from 33% in 1986 to 38% in 1995. PEA must cover the entire provincial land area and, as a result, its operations cannot be as efficient as those of MEA which can concentrate on the capital region. Nevertheless, the fact that its share within Thailand is rising demonstrates that electrical supply to the provinces is expanding. Incidentally, the distribution area covered by PEA is 159 times that of MEA, while the demand supplied is approximately five times larger.

【Table 1-8: PEA's Share in the Total Demand of Thailand】

(Units: GWh, MW, %)

		1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Demand volume	PEA (GWh)	10,237	11,833	13,781	16,178	19,370	22,551	26,198	29,945	34,380	40,261
	Share(%)	*47*	*48*	*49*	*50*	*51*	*52*	*53*	*53*	*55*	*57*
	Others (GWh)	11,751	12,956	14,302	16,472	18,772	20,626	22,860	26,062	27,817	30,609
	Share(%)	*53*	*52*	*51*	*50*	*49*	*48*	*47*	*47*	*45*	*43*
Peak demand	PEA (MW)	2,111	2,412	2,770	3,266	3,763	4,283	4,983	5,700	6,339	7,304
	Share(%)	*33*	*33*	*34*	*34*	*34*	*35*	*36*	*37*	*37*	*38*
	Others (MW)	4,202	4,842	5,414	6,208	7,167	7,990	8,828	9,735	10,911	12,168
	Share(%)	*67*	*67*	*66*	*66*	*66*	*65*	*64*	*63*	*63*	*62*

Source: Electric Power in Thailand 1995, DEDP / PEA Annual Report 1994

2. PEA Development Projects under the Sixth National Economic and Social Development Plan

2.1 Sixth National Economic and Social Development Plan and PEA Development Plan

2.1.1 Summary of the Sixth National Economic and Social Development Plan

The Thai National Economic and Social Development Plan have an implementation period of five years and are mainly drawn up by the National Economic and Social Development Board (NESDB). When these development plans were first created, they took "acceleration of economic growth" as their prime concern. In later plans the emphasis shifted to "correcting disparities between the capital and the local areas" and "social development". Particularly the Fifth and Sixth National Economic and Social Development Plan (referred to below as the Fifth and Sixth Plans), aimed to manage and harmonize both social development and economic stability by adopting the "bottom up" policy planning.

The Sixth Plan, which ran from 1987 to 1991, looked back at the state of progress left by the Fifth Plan and considered the social problems the country could be expected to face in the future. On that basis, the following three points were set as key features of the Sixth Plan. The first is a shift in emphasis from quantitative expansion to qualitative improvement. The second is that the plan was drawn up with a problem-solving approach handling individual problem areas, rather than by taking input from each ministry and agency. The third is a regard for the importance of forming a national consensus behind the implementation of a plan.

The Sixth Plan comprises “Two Major Objectives” as shown in the table below, with “Three Strategies” to achieve them and “Ten Programs” to put the strategies into effect.

【Table 2-1 Summary of the Sixth National Economic and Social Development Plan.】

Objectives and Strategies	Content and Programs
Objectives	
I. Economic targets	Maintain an average rate of growth at a level not below 5 per cent in order to absorb the minimum of 3.9 million persons who will be entering the labour market. Growth should be accomplished in such a way that economic stability is strengthened and the economic problems that arose during the Fifth Plan period are solved.
II. Social targets	Develop the quality of the population so that social development can progress, peace and justice be attained and development of the country as a whole supported. The national identity, culture and system of values will be maintained and the quality of life of the Thai people will be raised in both rural and urban areas.
Strategies	
1. Improving the efficiency of development	Increase the efficiency of national development in regard to human resources, science and technology, natural resources and the formation of integrated systems of administration and management. Especially important is the need to review the state's role to ensure that its duties consist only of those appropriate to the state and its monetary and fiscal capabilities. On the other hand the role of the private sector in national development should be enhanced both in production and in the provision of infrastructure services hitherto provided by the government. ***Programs*** 1 Overall Economic Development 2 Population, Social and Cultural Development 3 Development of Natural Resources and the Environment 4 Development of Science and Technology 5 Improving the Administration and Reviewing the Role of the Government in National Development 6 Development of State Enterprises
2. Restructuring production and marketing performance and improving the quality of the infrastructure services.	Improve the production system and marketing and raise the quality of the basic economic factors to reduce the cost of goods, diversify into more types of goods together with market expansion. This will enable Thai goods to be far more competitive in the world market while simultaneously emphasizing the development of the marketing system within the country. ***Programs*** 1 Development of the Production System, Marketing and Employment 2 Development of Infrastructure Services
3. Distributing prosperity and creating justice fairly to local areas	Increase the distribution of income and prosperity into provincial regions and rural areas by focusing on the low income population in these areas as the main target group for receiving the benefits of national development efforts. ***Programs*** 1 Development of Urban and Specific Areas 2 Rural Development

2.1.2 Summary of PEA Development Program

PEA devised "PEA Development Project Plan Under the Sixth Plan" (referred to below as the PEA Development Plan) in line with the "Development of Infrastructure Services" program of the second strategy (to restructure production and marketing performance and improving the quality of the infrastructure services) and the "Development of Urban and Specific Areas" and the "Rural Development" programs of the third strategy (to distribute prosperity and create justice fairly to local areas). PEA Development Plan set as its final objective "the expansion of an electrical supply of stable quality", in order to contribute to the realization of the higher objectives of the above-mentioned programs of the Sixth Plan.

PEA has been continuously working to build up its electrical supply network. By the end of the Fifth plan (in 1986) the number of electrified villages was 41,374 and the rural village electrification rate had reached 73.1%. With the start of the Sixth Plan, PEA Development Plan mainly called for the improvement and strengthening of 86 transmission circuits, the construction or expansion of 34 substations, the electrification of 10,542 villages, improvement of distribution in 25,818 villages which were already electrified. The completion of this entire range of plans was expected to bring the rural

village electrification rate to 96% (records show that it actually reached 98%). The PEA Development Plan included 18 projects, of which five were completed within the term of the Sixth Plan. The remaining 13 are to be completed within the term of the Seventh Plan. The tables below give summaries of the projects in scope and costs, as originally planned.

【Table 2-2: Power Transmission and Distribution Systems Reinforcement Project in the Course of PEA Development Plan】

	Project Name	Unit	Project Profile	Project Cost (million Baht)	
				Foreign Currency	Local Currency
	Power Distribution Systems Reinforcement Project IV				
①	PSR.Ⅳ-1	No. of circuits	12	350	270
②	◎PSR.Ⅳ-2	No. of circuits	44	1,160	1,026
③	◎PSR.Ⅳ-3	No. of circuits	30	980	555
④	Accelerated Power Systems Expansion and Reinforcement Project	No. of substations	8	1,250	2,750
⑤	Transmission System and Substations Development Project I	No. of substations	26	2,295	2,663
	Total	No. of circuits No. of substations	86 34	6,035	7,264

Note.◎ : Projects taken up by this survey report

【Table 2-3: Electrification Projects in the Course of Development Plan】

	Project Name	Unit	Project Profile	Project Cost (million Baht)	
				Foreign Currency	Local Currency
⑥	Distribution System Expansion for Laem Chabang New Town Project	District	1	0	44
⑦	Distribution System Expansion for Map Taphut New Town Project	District	1	0	23
⑧	• Normal Rural Electrification Project Phase II	No. of electrified villages No. of reinforced villages	2,000 8,000	1,267	858
⑨	◎Village Electrification Project Phase III	No. of electrified villages No. of reinforced villages	2,000 17,735	1,249	2,343
⑩	Normal Rural Electrification Project (Additional I)	No. of electrified villages	2,000	0	1,000
⑪	Normal Rural Electrification Project (Additional II)	No. of electrified villages	2,000	0	1.360
⑫	Normal Rural Electrification Project (Additional III)	No. of electrified villages	2,000	0	1,600
⑬	Village Electrification in Thung Kula Rong Hai Project	No. of electrified villages	300	0	182
⑭	Doi Tung Electrification Project	No. of electrified villages	34	0	55
⑮	Remote Village Electrification Project (1)	No. of electrified villages	100	0	243
⑯	Remote Village Electrification Project (2)	No. of electrified villages	100	0	300
⑰	Prathiu – Tha Sae Project	No. of reinforced villages	83	0	55
⑱	The Submarine Cable to Ko Change Project	No. of electrified villages	8	0	162
	Total	No. of electrified villages No. of reinforced villages No. of electrified districts	10,542 25,818 2	2,516	8,225

Note.◎：Projects taken up by this survey

2.2 Project Plans

The plans included in PEA Development Plan are listed below, subdivided between the following three classes:

① Power Transmission Systems Reinforcement Projects
② Power Distribution Systems Reinforcement Projects
③ Electrification Projects

A fourth area, also mentioned below, has been carried out to study projects for implementation during the Seventh Plan.

④ Feasibility Study of New Projects.

2.2.1 Power Transmission Systems Reinforcement Project

Accelerated Power Systems Expansion and Reinforcement Project, Transmission System and Substations Development Project (I)

These projects aim to improve the volume and the reliability of the electrical supply through the construction and improvement of substations and transmission lines, and also to meet rapidly-rising demand from the fringes of Bangkok and from industrial areas on the Eastern Seaboard. In some areas the capacity of the existing high-voltage distribution lines was not expected to keep up with the rising demand. Therefore, the construction of high-voltage (115kV) transmission lines is also included in the plan.

【Table 2-4: Outline of Power Transmission Project Plan】

National development plan	Project	New substations	Reinforced substations	Foreign currency fund source
Sixth	Power Transmission Circuits Reinforcement Promotion Project	7	1	KfW
Sixth	Power Transmission Systems Expansion Project I	26	0	OECF/IBRD
	Total	33	1	-

Source: PEA material

2.2.2 Power Distribution Systems Reinforcement Project

(1) Power Distribution Systems Reinforcement Project (I)~ (IV)

Even before the Sixth Plan, continuous efforts to promote electrification had succeeded in steadily raising the electrification rate. However, in regions which had been electrified early, rising demand for electricity made the capacity of the existing equipment inadequate. This equipment undercapacity, which risked excessive voltage drop and power losses, prompted PEA to implement Power Distribution Systems Reinforcement Projects (I)~(III). These projects constructed and expanded the main electrical grid which is at the heart of the rural electrification plan. Continuing this work, the Power Distribution Systems Reinforcement Project (IV), part of the Sixth Plan, planned work on 86 circuits of the power distribution network nationwide.

【Table 2-5: Outline of Power Distribution Systems Reinforcement Project】

National development plan	Project	No. of circuits	Foreign currency fund source
Third	Power Distribution Systems Reinforcement Project (I)	29	OECF
Fourth	Power Distribution Systems Reinforcement Project (II)	45	OECF
Fifth	Power Distribution Systems Reinforcement Project (III)	56	OECF
Sixth	**Power Distribution Systems Reinforcement Project (IV)**	**86**	**OECF, KfW**
	Total	216	-

Source: OECF appraisal material / PEA material

The Power Distribution Systems Reinforcement Project (IV) was divided into three phases, for reasons of finance. Phase IV-1 was funded by KfW and phases IV-2 and IV-3 received loans from the OECF. Considering the urgency of improvements in the distribution networks concerned, each phase was further divided into part A and part B.

【Table 2-6 Subdivision of the Power Distribution Systems Reinforcement Project (IV) into Phases and Parts】

Part	Number of circuits in each phase			Total	Circuits included
	IV-1	**IV-2**	**IV-3**		
Part A	12	28	20	60	● Distribution circuits which are already suffering excessive voltage drop and power losses and are deemed to need urgent improvement. ● Major distribution grid lines which support other electrification projects. (The predicted rate of increase in electrical power demand over the period 1986~1996 was 7.7%).
Part B*	-	16	10	26	● Distribution circuits which are not experiencing problems yet, but have reached the limit of their distribution capacity and require expansion to meet the increasing demand. (The predicted rate of increase in electrical demand over the period 1986~1996 was 6.8%).
Total	12	44	30	86	

Note) *： Power Distribution Systems Reinforcement Projects (I)~(III) did not include the sort of work included in part B here. Whenever improvements and reinforcements became necessary, they were handled under separate projects (the PEA-financed Distribution System Improvement Program). However, the sharp rise in the number of circuits requiring such improvements and the PEA's financial limitations led to these category being included in distribution network expansion projects under part B.

(2) Distribution System Expansion in Newly-industrialized Regions

Distribution System Expansion for Laem Chabang New Town Project and Distribution System Expansion for Map Taphut New Town Project aimed to expand distribution line coverage in order to supply electricity to the industrial areas developed along the Easter seaboard under the National Development Plans of the time. Project costs were covered by grants from the Thai government.

2.2.3 Electrification Projects

(1) Village Electrification Projects (I)~(III)

The Village Electrification Projects constructed electrical distribution equipment as an element in the development of rural areas. The Project scopes are to construct new distribution equipment to link the electrical grid constructed under the Power Distribution Systems Reinforcement Projects and to upgrade the distribution equipment in villages which already have electricity. The projects are divided according to their source of funding. Village Electrification Project (I) was financed by the Kreditanstalt für Wiederaufbau (KfW), while Village Electrification Projects (II) and (III) were

financed by the OECF. Village Electrification Project (I) targeted the Northern and Northeastern regions, project regions where the KfW had provided financial assistance in the past. Village Electrification Project (II), which received a loan from the OECF, targeted villages in the Northern, North-eastern and Central regions, which had not previously been covered by the KfW. Following on from these electrification projects, the Village Electrification Project (III) was implemented under the Sixth Plan. Its scope reached electrification of 2,000 villages which had not previously been electrified and improvement of distribution to 17,735 electrified villages.

【Table 2-7: Outline of Village Electrification Project】

National development plan	Project	No. of electrified villages	No. of reinforced villages	No. of provinces	Foreign currency fund source
Fifth	Village Electrification Project (I)	480	0	7	KfW
	Village Electrification Project (II-1)	2,700	0	35	OECF
	Village Electrification Project (II-2)	820	0	35	OECF
Sixth	**Village Electrification Project (III)**	**2,000**	**17,735**	**70**	**OECF**
	Total	6,000	17,735	-	-

Source: OECF appraisal material / PEA material

The villages targeted by the Village Electrification Projects were studied with regard to the aspects listed below, in order to achieve the most effective allocation of investment costs. A further condition of selection for electrification was the existence, or at least the potential for, plans for development in other sectors.

① Scale of the village.
② Distance from existing transmission lines.
③ Amount and cost of construction work.
④ Number of existing facilities, such as temples, schools, rice mills, shops, clinics, water pumping stations, repair shops, water and sewerage, irrigation, and industrial facilities.
⑤ Villages with high development potential, villages of defensive importance located along national borders, villages which are making spontaneous efforts for their own development, villages which are already subject to other development projects, etc.

The electrical distribution equipment installed under the Village Electrification Projects was constructed along the main roads of each village, starting from substations or existing distribution lines. Therefore, PEA bore the cost of lines constructed along public roads while the end users bore the costs of low-voltage lines from the nearest distribution lines to their houses or business premises. These low voltage hook up works were contracted to PEA or private electrical contractors. Where the work is done by private contractors, PEA has a system for inspecting the facilities before starting to supply power. The maximum distance approved for the low voltage lines is 20m according to PEA standard. The PEA installs service meters on the utility poles to meter each user's electricity usage.

(2) Normal Rural Electrification Projects (I) and (II), (Additionals (I)~(III))

The Normal Rural Electrification Projects worked alongside the Village Electrification Projects as elements of rural development. PEA has been making great efforts in its electrification projects, but its limited budget made it practically impossible to achieve the goal of electrifying all villages in the short term. To cope with this situation, PEA established the Normal Rural Electrification Projects in which a portion of the project cost is borne by its beneficiaries. This approach promoted electrification while reducing the burden on PEA.

The greatest characteristic of Normal Rural Electrification Projects, which make the beneficiaries bear a portion of the project cost, was that even villages which receive relatively low priority under Village Electrification Projects, but strongly desire electrification or improved service, could have it done with priority if they paid around 30% of the project cost. According to the rules of implementation laid down by PEA, villages involved in these projects pay for [1] a portion of the cost of materials for electricity poles and cross arms and [2] half of the labor cost. PEA experience shows that in that case, the village pays approximately 30% of the total cost of construction. The use of this system has enabled efficient electrification, but there were problems for the villages in procuring finance. For example, there were cases where it is impossible to reach a consensus within the village on how much each person should pay. This made it impossible as a village to pay the cost and electrification did not take place. In other cases the wealthiest villagers pay all or part of the cost or members of parliament elected in a region have given public funds (the regional development budget allocated to the member) to subsidize the construction. Such cases led to the breakdown of the system's concept and in January 1990 the parliament abolished the Normal Rural Electrification Projects system. From 1991 onwards the costs of projects has been borne by PEA (70%) and the Thai government (30%).

Normal Rural Electrification Project (I) was divided according to source of funding between the OECF and the IBRD portions. The OECF targeted villages in the Northern and North-eastern regions while the IBRD targeted villages in the Central and Southern regions. Normal Rural Electrification Project (II) used OECF finance and targeted villages nationwide. Normal Rural Electrification Project Additional (I)~(III) were projects funded by PEA and the Thai Government.

【Table 2-8: Outline of Normal Rural Electrification Projects】

National development plan	Project	No. of electrified villages	No. of reinforced villages	No. of provinces	Foreign currency fund source
Fifth	Normal Rural Electrification Project (I)	2,000	1,000	37	OECF
		1,500	**1,500**	**33**	**IBRD**
Sixth	**Normal Rural Electrification Project (II)**	**2,000**	**8,000**	**70**	**OECF**
	Normal Rural Electrification Project (Additional I)	2,000	0	64	(Local currency fund*)
	Normal Rural Electrification Project (Additional II)	2,000	0	64	(Local currency fund*)
	Normal Rural Electrification Project (Additional III)	2,000	0	64	(Local currency fund*)
Total		11,500	10,500	Thailand	-

Source: OECF appraisal material / PEA material
Note. * ：Local currency fund by Thai Government and PEA

The method of selection for villages to be the subjects of Normal Rural Electrification Projects differed from that employed in the Village Electrification Projects. The villages had to request the construction and had to be able to pay as mentioned above. The order of priority for the commencement of construction was determined as follows, according to the state of payment of the costs borne by the village.

[First priority]	Villages which have already paid their portion of the project cost in full.
[Second priority]	Villages which have paid at least 50% of their portion of the project cost and can pay the remainder before construction starts.
[Third priority]	Villages which have paid at least 50% of their portion of the project cost and have the provincial governor acting as their guarantor for payment of the remainder, and will be able to pay the entire amount within one year.

(3) Doi Tung Electrification Project

The Doi Tung region, which lies along the border with Burma, is important for Thailand's national defenses. Thai government drew up the Doitoon Development Plan to stabilize the region through development. To support this development project, PEA planned the Doi Tung Electrification Project to electrify 34 villages in the region. This plan was also intended to be a model for the electrification of other regions in similar situations.

2.3 PEA's Accomplishment in Development Projects

In the course of its development plans PEA has reinforced 86 circuits of the transmission system (100% of those planned), reinforced 34 substations (100% of those planned), electrified 10,272 villages (97% of those planned) and expanded electricity distribution in 49,987 villages (194% of those planned). The times of completion of projects have been between one year early and four years late, compared to original plans, with the exception of one project which is now (1997) one year overdue. The total cost of all projects has been 24.061 billion Baht, which is largely as planned[3].

[3] See attached documents

3. Accomplishment of Rural Power Distribution Projects Funded by ODA Loans under PEA Development Plans

3.1 Rural Power Distribution Projects Funded by ODA Loans

The following four rural power distribution projects have been implemented using ODA loans (referred to below as "the four OECF projects"):

①Power Distribution Systems Reinforcement Project (IV-2) ②Power Distribution Systems Reinforcement Project (IV-3) ③Normal Rural Electrification Project (II) ④Village Electrification Project (III). The loans for the four OECF projects have covered the entire foreign-currency cost of procuring materials and equipment for these projects. PEA was responsible for the design, tendering and construction management of the four OECF projects and also directly implemented the construction works.

3.1.1 Project Scope

【Table 3-1:Comparison of Original Plan and Actual, Scope 】

Item	Plan		Actual		Difference	
Power Distribution Systems Reinforcement Project (Ⅳ-2)						
Circuits	47	circuits	Same as left		-	
Transmission lines	18	cct-km	Same as left		-	
Substation transformer	3 x 40	MVA	Same as left		-	
High-voltage distribution lines	2,743	cct-km	3,370	cct-km	+627	cct-km
Low-voltage distribution lines	553	cct-km	1,642	cct-km	+1,089	cct-km
Power distribution transformer	273,400	kVA	173,933	kVA	-99,467	kVA
Capacitor	42,430	kVAR	69,980	kVAR	+27,550	kVAR
Service meter	250,118	nos.	307,290	nos.	+57,172	nos.
Power Distribution Systems Reinforcement Project (Ⅳ-3)						
Circuits	30	circuits	Same as left		-	
High-voltage distribution lines	1,673	cct-km	2,601	cct-km	+928	cct-km
Low-voltage distribution lines	400	cct-km	1,303	cct-km	+903	cct-km
Power distribution transformer	205,100	kVA	116,907	kVA	-88,193	kVA
Capacitor	31,070	kVAR	39,459	kVAR	+8,389	kVAR
Service meter	192,731	nos.	237,170	nos.	+44,439	nos.
Normal Rural Electrification Project (Ⅱ)						
High-voltage distribution lines	3,157	cct-km	3,184	cct-km	+27	cct-km
Low-voltage distribution lines	8,421	cct-km	8,494	cct-km	+73	cct-km
Power distribution transformer	101,320	kVA	101,170	kVA	-150	kVA
Service meter	190,000	nos.	190,247	nos.	+247	nos.
No. of electrified villages	2,000	villages	1,645	villages	-355	villages
No. of circuits reinforced villages	8,000	villages	31,465	villages	+23,465	villages
Village Electrification Project (Ⅲ)						
High-voltage distribution lines	10,000	cct-km	9,564	cct-km	-436	cct-km
Low-voltage distribution lines	14,300	cct-km	16,035	cct-km	+1,735	cct-km
Power distribution transformer	160,200	kVA	156,290	kVA	-3,190	kVA
Service meter	250,000	nos.	329,905	nos.	+79,905	nos.
No. of electrified villages	2,000	villages	2,032	villages	+32	villages
No. of circuits reinforced villages	17,735	villages	18,439	villages	+704	villages

Comparing the results of the four OECF projects as a whole against the plans, there is some discrepancy. These mainly arose when changes in demand for electricity in the regions where the projects were implemented led to revisions to the original plans. This degree of discrepancy seems to be unavoidable in the implementation of electricity distribution projects in general.

(1) Numbers of Villages Electrified and Numbers of Circuits Reinforced

In the plan, number of villages to be electrified was 4,000, but the actual number electrified was 3,677 (92% of the plan), largely fulfilling the plan. The number of villages planned to have their circuits reinfroced was 25,735, but the actual number was 49,904 (194% of the plan), an enormous increase. The reasons for this increase were the dilapidation of existing lines and changes in demand for electricity. The scope of the construction was expanded to meet these needs. Another reason was utilization of the remaining funds.

(2) Distribution Lines

In the plan, the length of high-voltage distribution lines was 17,573cct-km, but the actual length was 18,719cct-km (107% of the planned length). Length of low-voltage distribution lines planned was 23,674cct-km, but the actual length was 27,474cct-km. (116% of the planned length). Thus the construction of distribution lines went largely according to plan.

However, comparison of plan and results for each project shows major increases in the Normal Rural Electrification Projects (IV-2 and IV-3), in the region of 268~440% of the plan. One reason for this increase in the number of distribution lines was the difference of the planned route, which was made on the desk and the detail design which was carried out referring the site. Another reason was the changing demand for electricity in the subject regions which required constant alterations to the plan, leading to increased construction. The reason the plans required constant revision is that on the end-user side there were small-scale development projects (both public and private) under way at the same time and it was necessary to meet these demands by the project. However, as these projects aimed to distribute electricity to end users throughout Thailand, the above actions on the part of the PEA can be seen as appropriate.

(3) Transformers

The total capacity of substation transformers installed was 120MVA, which was as planned. On the other hand, the total capacity of distribution transformers installed was 548,300kVA, well down at 74% of the planned 740,020kVA. This is because some users obtained their own private distribution transformers, and also because PEA was able to use some of the transformers removed from existing distribution circuits in other regions / projects.

(4) Capacitors

The total capacity of capacitors installed was 109,439kVAR, 149% of the planned 73,500kVAR. This is because, at the planning stage, it was only possible to predict the capacity, and the final decision was based on the results of supplying electricity to completed lines. Therefore, the increase on the planned capacity seems to have been, to some extent, unavoidable.

(5) Service Meters

The total number of installed service meters was 1,064,612, which is 121% of the planned 882,849. The increase was due to the same factors of reviewing the plan as in the case of distribution lines, and this also seems to have been unavoidable.

3.1.2 Implementation Schedule

【Table 3-2: Comparison of Original Plan and Actual, Implementation Schedule】

Item	Plan (Commencement) – (Completion)	Actual (Commencement) – (Completion)	Completion period (No. of months)	Period required (No. of months)
Power Distribution Systems Reinforcement Project (IV-2)				
Tendering process	1989.01 - 1990.03	1989.01 - 1993.08	+29	+29
Procurement of equipment and materials	1989.11 - 1991.10	1989.08 - 1993.12	+26	+29
Construction	1989.01 - 1991.12	1989.01 - 1994.03	+27	+27
Power Distribution Systems Reinforcement Project (IV-3)				
Tendering process	1990.01 - 1991.04	1990.04 - 1995.03	+47	+44
Procurement of equipment and materials	1990.11 - 1992.12	1991.07 - 1996.03	+44	+41
Construction	1990.01 - 1992.12	1990.01 - 1995.03	+27	+27
Normal Rural Electrification Project (II)				
Tendering process	1989.11 - 1991.07	1990.08 - 1994.09	+38	+29
Procurement of equipment and materials	1990.06 - 1992.07	1991.05 - 1994.09	+26	+15
Construction	1990.01 - 1992.12	1990.01 - 1992.09	-3	-3
Village Electrification Project (III)				
Tendering process	1991.10 - 1995.03	1991.11 - 1995.10	+6	+4
Procurement of equipment and materials	1992.04 - 1995.12	1992.06 - 1996.06	+6	+4
Construction	1991.10 - 1996.02	1991.10 - 1996.06	+4	+4

One factor which was common to Power Distribution Systems Reinforcement Projects IV-2 and IV-3 and Normal Rural Electrification Project (II) is that the tendering process and the procurement of equipment and materials required more time than planned.

Looking at the projects individually, there were construction delays of 27 month in both, Power Distribution Systems Reinforcement Project (IV-2) and (IV-3). One cause of delay was the power shutdown for construction. As each project involved reinforcement of the existing distribution network, there was no alternative to imposing power shutdowns for safety during construction. The power shutdowns had a great impact on the lives (and incomes) of the electricity users who already relied on that supply, and demands from these users made it difficult to move ahead with the construction schedule as planned. Another was the increased number of low-voltage distribution lines to be constructed.

The Normal Rural Electrification Project (II) and the Village Electrification Project (III) were largely completed in the planned construction period. However, there was a delay of nine months in the start of tendering for the construction of Normal Rural Electrification Project (II). This delay was due to the executing agency's administrative procedures and revisions to the procurement list for equipment and materials which needed approval of the OECF. The alterations to the list were:

(1) Deletion of equipment / material which the PEA had in stock in adequate quantity.

(2) Deletion of some types of materials due to consolidation and standardization of the specification.

(3) Revision of the actual quantities of equipment and materials.

It is considered that these alterations would have been avoided if there had been adequate stock control of equipment and materials and if the design standards etc. had been well defined.

3.1.3 Project Cost

【Table 3-3: Comparison of Original Plan and Actual , Project Cost 】

(Units: Foreign currency = 1 million yen, Local currency = 1 million baht)

Project	At the time of appraisal		Actual		Difference	
	Foreign currency	Local currency	Foreign currency	Local currency	Foreign currency	Local currency
Power Distribution Systems Reinforcement Project (IV-2)						
Transmission /transformer equipment	281.00	13.90	405.25	10.86	124.25	-3.04
Distribution equipment	5,460.00	313.70	5,619.05	223.74	159.05	-89.96
Construction machines etc.	114.00	28.60	117.27	28.60	3.27	0.00
Design, construction management	0.00	49.60	0.00	31.20	0.00	-18.40
Tax, maintenance fee	0.00	402.30	0.00	212.90	0.00	-189.40
Others	293.00	217.90	0.00	152.20	-293.00	-65.70
Subtotal	6,148.00	1,026.00	6,141.57	659.50	-6.43	-366.50
Power Distribution Systems Reinforcement Project (IV-3)						
Substation	680.90	0.00	804.27	0.00	123.37	0.00
Distribution equipment	4,083.10	178.65	4,289.60	192.05	206.50	13.40
Construction machines etc.	226.00	0.00	156.44	0.00	-69.56	0.00
Design, construction management	0.00	13.39	0.00	11.51	0.00	-1.88
Tax, maintenance fee	0.00	196.46	0.00	199.16	0.00	2.70
Others	498.00	166.50	0.00	88.12	-498.00	-78.38
Subtotal	5,488.00	555.00	5,250.31	490.84	-237.69	-64.16
Normal Rural Electrification Project (II)						
Distribution equipment	6,451.00	354.87	6,819.85	446.30	368.85	91.43
Design, construction management	0.00	36.66	0.00	27.40	0.00	-9.26
Tax, maintenance fee	0.00	91.15	0.00	52.20	0.00	-38.95
Others	644.00	375.32	0.00	154.30	-644.00	-221.02
Subtotal	7,095.00	858.00	6,819.85	680.20	-275.15	-177.80
Village Electrification Project (III)						
Distribution equipment	5,980.00	1,637.00	6,628.24	1,361.00	648.24	-276.00
Design, construction management	0.00	72.00	0.00	128.10	0.00	56.10
Tax, maintenance fee	0.00	176.00	0.00	83.40	0.00	-92.60
Others	655.00	458.00	0.00	617.70	-655.00	159.70
Subtotal	6,635.00	2,343.00	6,628.24	2,190.20	-6.76	-152.80
Total	25,366.00	4,782.00	24,839.97	4,020.74	-526.03	-761.26
			Plan / Actual		97.93	84.08

The actual foreign currency cost of the four OECF projects amounted to ¥24,840 million, while the actual cost in local currency amounted to 4,021 million Baht (98% and 84% of the estimation, respectively). The foreign currency cost covered by the ODA loan went largely according to the estimate because even after the initial procurement of equipment and materials was complete, the additional requirements of work was covered by utilizing the remaining fund.

Comparing the plans and results for each project individually, the actual foreign currency cost was between approximately 96% and 100% of the planned amount in each case. The actual local currency

costs were between approximately 64% and 94% of the planned amounts. This was due to reduction of management costs in some projects and reduced procurement costs for local Thai equipment and materials.

The actual unit costs for major classes of items procured for the four OECF projects are compared against their actual costs below. The classes are:

① Substation Transformers (transmission / transformer equipment).

② Distribution Lines (distribution equipment).

③ Auxiliary Equipment and Materials (distribution equipment).

Firstly, the actual cost of ①, the substation transformers, was 334% of the estimated cost. This occurred because the estimate was made for only one transformer of 40MVA capacity (estimation ¥49.5 million), even though the plan called for three transformers of 40MVA capacity (actual cost ¥165.45 million)[4]. The total cost of ② high-voltage and low-voltage distribution lines was largely as estimated. However, the average unit cost per cct-km for the length of cable laid was ¥299,000, which is 64% of the estimated ¥468,000/cct-km. One reason for the decrease of actual cost was that in the course of construction work to reinforce the existing distribution lines, some of the cable removed from the existing lines was utilized again for the newly construction portion. The total cost of ③ auxiliary materials, such as insulators, cable-supporting materials and iron wires was largely as estimated. The average unit price of these materials per cct-km was also close to the estimated value, costing ¥95,200/cct-km against the estimation of ¥98,500/cct-km (97%).

3.1.4 Project Implementation Scheme

① Design and Construction Scheme

PEA, which was the executing agency for the four OECF projects, handled the design and construction management without employing consultants. PEA was also in direct control of the execution of construction works. PEA head office and regional offices each formed project teams, but the implementation scheme differed between Power Distribution Systems Reinforcement Projects and Electrification Projects as described below.

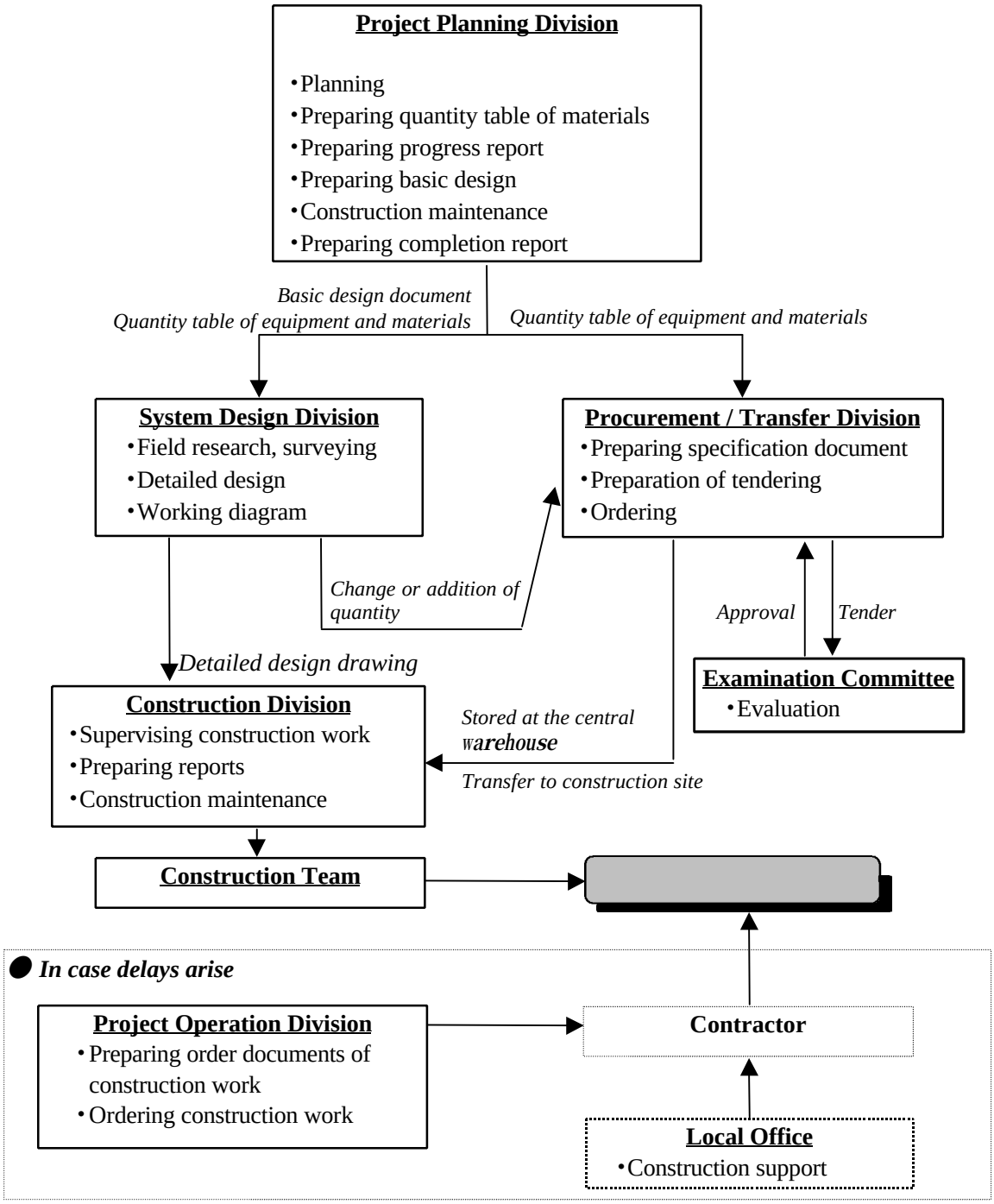
In the Power Distribution Systems Reinforcement Projects, the project teams formed in PEA head office conducted planning, design, procurement, and the execution and supervision of the project. In the event of delays in the construction works, there was a system for ordering portions of the work to the regional offices or outside construction contractors, however in actual it was not used in these projects.

In the Electrification Projects, the project teams formed in the PEA head office conducted planning and procurement and the design and supervision of line construction longer than 10km. The project teams formed in regional offices were responsible for design and construction execution of distribution lines shorter than 10km. In the event of delays in the construction works, the head office were authorized to order a portion of the construction work to outside contractors, but, as for the Power Distribution Systems Reinforcement Projects, no external orders were made.

The total number of staff involved in on-site supervision of the four OECF projects was 1,310

[4] The cost of a similar 40MVA transformer in Japan would be around ¥50 million, so the actual cost for three units, ¥165 million, seems reasonable.

supervisors. The construction team on each site comprised 1 site foreman, 2~3 cable layers and 10 construction laborers. No major problems arose in the PEA's design and execution of the projects and furthermore as mentioned above, in case delays arose they had prepared suitable countermeasures. Therefore in overall, the implementation scheme seems to have performed well.



【Figure 3-1: Implementation Scheme of Power Distribution Systems Reinforcement Project】

② Quality Management of Equipment and Materials Procurement

PEA procured equipment and materials through international competitive bidding to obtain many

types of materials from a large number of suppliers. Regardless of the source of funding for a project, all general materials procured by PEA are defined by common, standard specification documents. Therefore, all materials procured can be expected to have satisfied these standard criteria.

However, between 1991 and 1995 the most common cause of accidental power outages was always "due to defective equipment" (between 35% and 42% of all cases). "Defective equipment" includes defects of the equipment itself and defects due to incorrect construction/installation. Therefore, it is very important to improve the supervision of construction and to eliminate defective equipment through improved quality control of procurement. Especially in the case of insulators, the differences in quality between different suppliers and different times of production are marked, so improved inspection on delivery is very important to guarantee the quality of equipment and materials.

3.2 Support Through Technical Cooperation

One of the most important elements of the Japanese government's technical cooperation with PEA is the dispatching of JICA technical experts[5]. JICA has been dispatching experts to PEA providing technical cooperation continuously since 1968. The content of their guidance is set by the Japanese government, following consideration of requests from the PEA. Specifically, the content to date has been the planning of electricity distribution systems between 1968 and 1979, the modernization of electricity distribution between 1980 and 1981, the reinforcement of electricity distribution systems from 1982 to 1985, the automation of electricity distribution systems from 1986 to 1992 and improvement of the reliability of supply from 1993 to 1996. JICA experts have thus been able to deliver the new technical information that PEA needed, as it needed it, in the gradual process of improving the distribution system in Thailand. In addition to guidance in the fields mentioned above, the JICA experts were able to give overall guidance on the operational maintenance and management of distribution equipment, introduce new technologies, give advice on the reduction of power black outs, supervise the OECF projects and coordinate with the Japanese side.

The JICA experts act as technical advisors attached directly to the president of the PEA. Their advice on business direction and policy is submitted in writing to the president and their technical guidance is given directly to their counterpart section head. These counterparts and their staff are largely university graduate in technical posts, so there was never a need to teach the basics of electrical engineering, therefore technical cooperation made efficient progress.

[5] PEA was receiving technical assistance from other countries besides Japan. In 1996 the long-term stationed technicians were two from Germany, one from England and one from America. There were also technicians from Germany and America on short-term postings.

The content of the work of the JICA technical experts between 1986 and 1992, the time period of the four OECF projects, is listed below.

The work of JICA technical experts during the implementation period of the four OECF projects

① Advice on the operation and maintenance of electricity transmission equipment.
② Advice on systems for the electrical distribution command center plan.
③ Advice on the pilot electrical distribution system dispatching center plan.
④ Advice to assist the progress of OECF projects.
⑤ Follow up on solar power generation plant projects.
⑥ Helping to supply electricity to industrial estates for Japanese enterprises.

The work of JICA experts in connection with OECF projects includes the following:

- Advice within PEA on how to promote the progress of OECF projects.
- Guidance in the preparation of specification documents.
- Advice on approval for the results of tendering for the procurement of equipment and materials.
- Guidance and advice for the solution of technical problems.
- Advice on the operation and maintenance.

In this way, the JICA experts have been able to support PEA, helping it to reach appropriate solutions to any problems which arise in the implementation of OECF projects. Electricity distribution projects are implemented over wide areas and can easily become complex and difficult, but the assistance of JICA experts has helped do bring these projects efficiently to completion. Also, apt technical guidance strengthens both the success of the projects and their sustainability.

3.3 Position of the Projects within PEA's Overall Plans

PEA Development Plan, which comprises a total of 18 projects, began and was overall completed largely as originally planned. One project was completed one year early and six within the planned year. Completion of the remaining 11 projects was delayed by between one and four years. The combined total cost for each project was approximately 100% of the planned amount.[6]

The proportion of the recorded results of the PEA Development Plan represented by the four OECF projects is examined below.

The PEA Development Plan electrified 10,272 villages, of which 3,677 (36%) were electrified by the four OECF projects. Similarly, The PEA Development Plan reinforced electrical distribution systems to 49,987 villages, of which 49,904 (approximately 100%) were reinforced by the four OECF projects. In fact, the Power Distribution Systems Reinforcement Projects supplied electricity to households which were without electrical supply despite being located in electrified villages. In this way, the project complemented the electrification projects in raising the household electrification rate. Furthermore, existing users were able to receive a more stable supply of electricity than they did before the project.

The Power Distribution Systems Reinforcement Projects made an extraordinary contribution to the

[6] See the attached document.

expansion of electrical distribution in Thailand. The 3,677 villages electrified in Thailand under the four OECF projects were 6% of the existing 63,227 electrified villages in the country in 1995.

【Table 3-4: PEA Development Plan under the Sixth Plan and Actual Results of Four OECF Projects】

	Unit	Actual results of OECF Loan Projects (A)	Actual results of PEA Development Plan (B)	(%) A/B
Transmission System				
Circuits	Circuits	75	132	**57**
115kV transmission lines	cct-km	18	1,173	**2**
Transformer of transformer station	MVA	120	3,361	**4**
Distribution System				
High-voltage distribution lines	cct-km	18,719	21,918	**85**
Low-voltage distribution lines	cct-km	27,474	28,564	**96**
Transformer for distribution	kVA	548,300	557,410	**98**
Service meters	Pieces	1,064,612	1,233,735	**86**
Villages				
Electrified	Villages	3,677	10,272	**36**
Reinforced	Villages	49,904	49,987	**100**

Source: Replies from questionnaire by PEA

Looking at the share of total expenditure for PEA Development Plan taken by the four OECF projects, their cost in foreign currency was approximately 5,764 million Baht (The weighted average rate from the records of funding for the four OECF projects was 1 Baht = ¥4.310). The local currency cost was approximately 4,021 million Baht. This converts to a total cost in Baht terms of approximately 9,785 million Baht. The total cost of the entire PEA Development Plan was 24,061 million Baht, so the four OECF projects represent 41% of the entire cost. For this share of expenditure, the four OECF projects achieved 36% of village electrification and around 100% of distribution system amplification.

When comparing the share of accomplishment among the funds, between 1989, during the Sixth Plan, and 1995 in the Seventh plan, the number of villages electrified under each source of project funding were as follows: 3,677 villages under the four OECF projects, 807 villages financed by the IBRD & the Saudi Fund in cooperation, 301 villages by the IBRD acting alone, and 8,902 villages using other sources of finance or financed by the PEA itself (through its own funds and borrowing). In total, the number of villages electrified was 13,687 villages.

4. Operations and Maintenance of Rural Power Distribution

4.1 Operations and Maintenance Scheme

In PEA head office there is an operation department and a maintenance department under the authority of the deputy governor for operation and maintenance. These departments handle all aspects of plans and policy direction in their fields. The electrical technicians of the technical sections of offices are mainly responsible for transformers and other major equipment, carrying out operations and maintenance according to the instruction manuals prepared by the equipment manufacturers. The operations and maintenance of electricity distribution lines is conducted by the electrical engineers of branches and provincial offices, using manuals prepared by PEA.

In the event of a power failure, which is the most serious problem for the customers, the repair and recovery process follows the procedure described below. First, the affected residents telephone PEA customer service unit to report the black out. In rural communities where there is not a telephone in every house, the villagers report the black out to the head of the village, who will use his telephone or wireless set to relay the report to the customer service unit. Therefore, the unit is ready to receive calls 24 hours a day. The staff member who takes the call will investigate the condition of the circuit breakers in the substation which serves the affected area. He will then go to the area affected by the power failure and examine the distribution transformers, fuses and low-voltage distribution lines, working through the distribution system from upstream to downstream, to find the cause. He then eliminates the cause and restores power. This process is inefficient and time-consuming, so PEA has asked the Japanese government for assistance and is now receiving technical cooperation from JICA to improve the matter. The cooperation provided includes, JICA experts dispatched to "Improvement of Distribution System Reliability Project" and "Training in Distribution Automation System" by project type technical cooperation.

4.2 Status of Training

PEA provides the staff responsible for electricity distribution works and maintenance management with two years of occupational training at the head office. During the field survey we were able to observe workers being trained at the head office to work with live high-voltage distribution lines. The progress of this training was quite satisfactory. Staff who have completed two years of occupational training are posted to branches all over the country, where they work as electrical construction engineers. Other than occupational training, an annual average of 1,080 staff receive training in the operation of individual pieces of equipment. Besides training its staff within Thailand, PEA sends staff to England, America, Germany and elsewhere every year to acquire new technical skills. Considering the above and the enhancement of the training system, for example, the progressing construction of the PEA Technical Training Center which is located on the grounds of the head office, the training of the staff is clearly quite adequate.

4.3 Status of Operations and Maintenance

Within electrical power systems, the load imposed by the customers' consumption is varying constantly. Late at night and early in the morning, when consumption is low, voltage may build up. Conversely, it tends to fall in daytime when load is high. This kind of variation of voltage in a circuit reduces both the efficiency and the longevity of electrical equipment used by electricity consumers. As has already been mentioned, on the field survey we observed cases of voltage drop during heavy load, and rising during low load.

4.3.1 Voltage Rise

On the field survey, we examined the logs of the Udon Thani No. 1 substation, which showed a lead phase[7] in three of nine feeders during the night when the demand is low. The voltage in these circuits rose above the rated value at the receiving end. This excess voltage can be expected to put a strain on electrical equipment. In short, while the public are asleep the consumption of electricity drops and the load on distribution lines lightens. When this happens, the voltage supplied to the receiving end of the circuit rises, placing a strain on automatic pumps, light fittings etc. For the future, it is very important to study and implement measures that will solve this kind of problem described above.

In this survey, we were unable to inspect other substations, so we cannot say whether this is a common phenomenon nationwide, but we were able to confirm the existence of this problem through interviews in other areas. Therefore, PEA must conduct a nationwide study of the quality of the electric power it provides and study whatever corrective measures may be necessary.

4.3.2 Voltage Drop

After the electrification of villages under these projects, pumps for raising water from wells and for supplying water to the houses were installed in the villages. However, in the field survey we found that both pumps had broken down and were inoperative. These pumps had already broken down and been repaired before. The apparent cause of the breakdowns in each case was motor burnout due to reduced voltage.

The electricity supply situation there was that the water raising and supply pumps were situated 400m away from the distribution transformer, and most of the villagers' houses were connected to the low-voltage distribution line in that interval. In the records of the Udon Thani substation referred to earlier, the demand peak occurs at dinner time, between 6pm and 8pm. In this period, when demand is concentrated, the decline in voltage is greatest at the ends of distribution feeders. The motors also run automatically at such times, and this leads to the pump motors burning out, due to the principle explained below. Incidentally, there is a law prohibiting the use of agricultural pumps at night, so they are not used in the same peak period.

The reason voltage drop causes motor burnout is that, due to the properties of motors, a 10%

[7] When the load on an AC electrical supply is capacitative, the current phase advances ahead of the voltage phase. This makes the voltage at the receiving end higher than the distribution voltage.

reduction in the supplied voltage brings a current of 113% of the normal. When current increases, the heat generated in the coil also increases. The motor burns out when the temperature exceeds the allowable heat resistance of the insulation material around the coil. The electrical power of the electricity which powers the motor is the product of the current and the voltage, so if the voltage drops when the motor is working under a given load, the current in the coil increases in order to drive the load. If this makes the current exceed the rated value, the coil itself heats up, causing the insulation to deteriorate, leading eventually to the motor burning out.

This kind of failure can be avoided by improved design standards for distribution lines and the application of certain standardized features. One specific on-site countermeasure would be the addition of a further transformer to reduce the length of line extending from each distribution transformer. In this field survey we were able to check the PEA's distribution network design and their basic approach and guidelines. However, when we asked to see their design standards, including standard design values and calculation methods, we were told that individual engineers use their own methods and the PEA does not have any unified design standards.

4.3.3 Power Failure

One of the major challenges the PEA faces is to reduce the frequency of power failure. The total numbers of power failure in Thailand nationwide in 1994 and 1995 were 4,960 times and 6,147 times, respectively. The breakdown of power failure by cause in 1995 was ①defective equipment 35%, ② people or animals 21%, ③contact with trees 10%, ④disasters and unknown causes 4%, ⑤other causes 30%. [8]

Looking at the impact of power failure on each customer, the average number of power cuts per user in 1995 (System Average interruption Frequency Index, SAIFI) ranged from 5.03 (in the Northeast) to 7.45 (in the South), the national average being 6.08. The average continuous duration of power failure for each user (System Average Interruption Duration Index, SAIDI) ranged from 196 minutes (Central region) to 480 minutes (Southern region)[9]. These figures, reported by the PEA, do not agree with the figures in the table below, which are the results of a survey conducted by Chulalongkorn University, but either set of figures demonstrate that, when compared with other countries, the impact of power cuts on consumers is remarkably large.

【Table 4-1: Current Status of Power Failure in Each Country】

Item	Thailand (PEA)	Korea	France	Japan
SAIFI	9.72	2.29	N/A	0.11
SAIDI	607	268	121	5

Source: Study documents for the Project to Improve the Reliability of Electricity Distribution Systems
Note 1 SAIFI: Average number of power failure experienced by each consumer (times/consumer).
Note 2 SAIDI: Average power failure duration per customer (minutes/customer).
Note 3 Values for Thailand are the results of a survey by Chulalongkorn University.

[8] Source: PEA documents, January 1996
[9] For the Tokyo Electric Power Co., Ltd. (TEPCO), the SAIFI is 0.22 and SAIDI is 5 minutes (in 1994).

In 1988 the Deputy Minister of the Ministry of the Interior directed PEA to reduce the annual number of power failure to 1,000 or less, in an effort to improve the serious power failure problem in industrial parks. (In 1987, there were 24,550 recorded power cuts)[10]. To deal with this situation, PEA has been improving its equipment maintenance and inspection system, raising the level of education of its employees, thoroughly cutting back interfering trees, and replacing bare lines with insulated lines. However, to date, their highest priority has always been electrification and it seems that it will take time for these measures to bear fruit.

4.3.4 Inventory Control of Materials for Equipment

PEA holds stocks of electricity distribution equipment and materials which are enormous in their size and variety. It is therefore very important to promote the efficient inventory control of these stocks. Realizing this, PEA obtained funding from the IBRD and the ADAB (Australian Development Agency Bureau) in 1984 to introduce modern methods of inventory control. At the time of this survey, it was seen some branch had a computer for aggregation which was not linked to the head office. PEA reports that it is to network these computers on line in the near future. The current inventory control method is to use the computer to total the quantities of all types of inventory every month and send an order to the head office for any items which are in short supply. The head office aggregates the data from the branch offices and either forwards equipment and materials from central inventory or orders its transfer between branches. A certain level of inventory of all items is held in central inventory to guard against shortages.

In this survey, we investigated the state of inventory at the head office and at the Udon Thani branch and both were satisfactory. However, we would like the cause of the major delays in the on-line linkage of aggregation computers to be identified and rapid action taken to improve the situation, so that equipment and materials can be put to more effective use.

4.3.5 Suggestions for Operations and Maintenance

Immediately after an area is first electrified, its electrical demand is primarily for lighting. At this stage the impact on the public of breakdowns due to voltage drop etc. is likely to be relatively slight. However, before long, motorized electrical goods start to appear in the lives of consumers as economic development advances. With the arrival of these refrigerators, air conditioners, washing machines and other devices, the electricity consumer is sure to demand much greater stability of supply. An electrical supply of well-maintained quality is then a necessity. The task then is to make the kind of nationwide survey that was mentioned earlier, to ascertain the current quality of electrical power. The findings must be analyzed and studied and measures to improve the situation, including the stipulation of design standards for electrical distribution lines, must be devised and implemented.

[10] Source: The Nation, January 15, 1988.

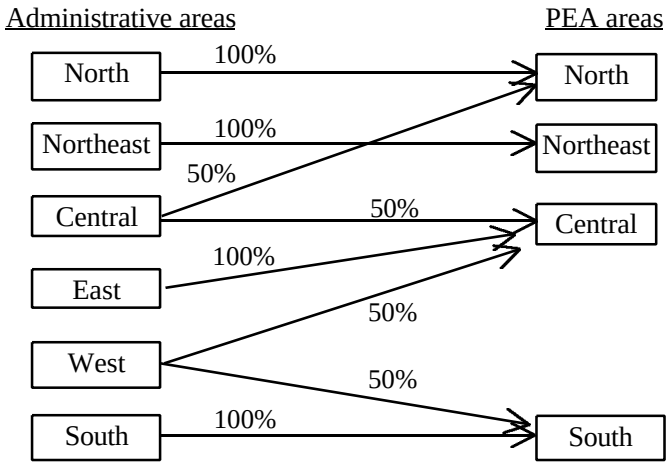
5. Development Effects of Rural Power Distribution Projects

Since PEA was established, it has made increasing the electrification rate in its areas of operation its most important task. To promote efficient electrification, it has used its own funds and taken loans from many international aid agencies for projects throughout the country. As a result, in one region there were multiple electrification projects proceeding in parallel. This makes it difficult to quantitatively assess the impact of the four OECF projects studied in this report. Therefore, in this section we will examine the all electrification projects which were implemented during the implementation period of the four OECF projects in order to gauge the impact of electrification. We will particularly study the following points:

① Movements in per-capita power consumption and Gross Regional Product (GRP).
② Improvement in the rural and household electrification rates.
③ Movements in domestic sales of home electrical appliances.

5.1 Movements in Per-capita Power Consumption and Gross Regional Product (GRP)

As Figure 5-1 shows, PEA's operations are divided between four regions. On the other hand, in statistical documents, the country is divided into seven areas for administrative reasons. For the purposes of examining movements in GDP, the GDP is conveniently divided in proportion to land area between the six regions (excluding Bangkok and the surrounding area, which is supplied with electricity by MEA), and divided between the four PEA regions as shown below.



【Figure 5-1: GDP Portion by Region】

【Table 5-1: Movements in Per-capita Power Consumption】

(Units: kWh/capita, %)

	1989	1990	Growth rate	1991	Growth rate	1992	Growth rate	1993	Growth rate	1994	Growth rate
North	219	246	12.61	278	12.90	302	8.53	351	16.24	374	6.72
Northeast	122	135	10.71	150	11.15	172	14.59	205	19.21	215	5.07
Central	902	1,071	18.73	1,230	14.77	1,437	16.82	1,678	16.80	1,887	12.49
South	311	361	16.09	413	14.51	470	13.88	525	11.60	569	8.38

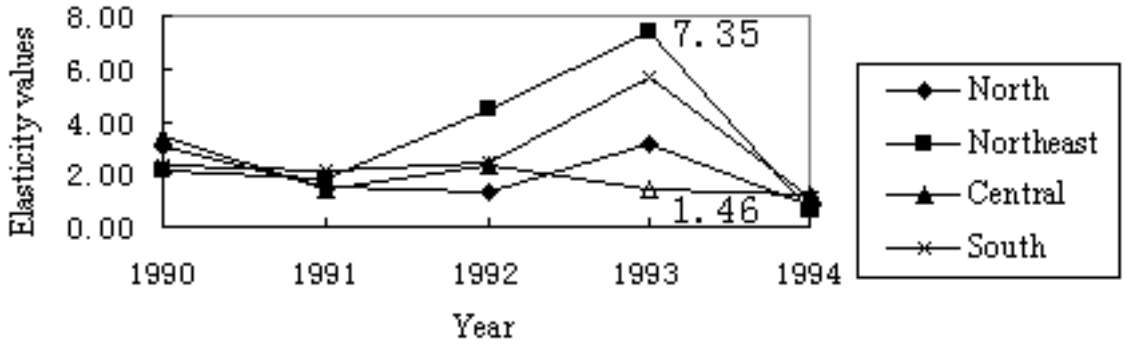
Source: Electric Power in Thailand 1995,DEDP

【Table 5-2: Movements in Per-capita Gross Regional Product (GDP)】

(Units: Baht/capita, %)

	1989	1990	Growth rate	1991	Growth rate	1992	Growth rate	1993	Growth rate	1994	Growth rate
North	18,366	19,129	4.15	20,724	8.34	22,065	6.47	23,210	5.19	25,208	8.61
Northeast	11,337	11,921	5.15	12,655	6.16	13,074	3.31	13,415	2.61	14,632	9.07
Central	37,934	39,995	5.43	44,192	10.49	47,318	7.08	52,755	11.49	58,023	9.99
South	22,857	24,410	6.80	26,113	6.98	27,617	5.76	28,181	2.04	30,309	7.55

Srouce: National Statistical Office



【Figure 5-2: Movements in Elasticity Values】

Considering the elasticity value[11] between the rate of increase in per-capita GRP and per-capita electricity consumption in each region over the five years from 1990, the peak values in the Northeast, the North, and the South occurred in 1993. Of these, the highest elasticity value was 7.35 in the Northeast. This is because per-capita electricity consumption was rising rapidly, reaching a maximum of 19% over the preceding five years, while the minimum GRP growth rate over the same period was approximately 3%. In the North and the South the elasticity value is also increasing, albeit slowly, for similar reasons. The elasticity value in the Central region, on the other hand, has been declining as the two factors converge, reaching 1.46 in 1993.

The reason for the increase in per-capita electricity consumption in each region in 1993 was the success in spreading electrification and reinforcing existing distribution circuits, which led to greater electricity consumption by customers. The decline in per-capita GRP at the same time was due to poor performance in the agricultural, forestry and fisheries sectors. According to the statistics, the real economic growth rate in these sectors, outside the Bangkok region, was approximately 5.31%, followed by -2.06% in 1993 and 4.97% in 1994. Growth in 1993 was actually negative (the real economic growth rate for Thailand as a whole in 1993 was approximately 8.3%). The growth rates in each region in these sectors were -2.83% in the North, -5.36% in the Northeast, -3.74% in the Center, and 1.74% in the South (approximate figures). In the North, Northeast and South, the agricultural, forestry and fisheries sectors represent over 20% of the overall GRPs (the national average is 11%), so the overall

[11] (Electrical consumption against GRP) Elasticity value = Rate of increase in the consumption of electricity/ rate of increase in GRP

GRP in these regions was dragged down, resulting in an increased elasticity value. However, in these three regions, the consumption of electricity rose by approximately 1.9 fold over the five years between 1989 and 1994. This, combined with the increased electrification and the greater domestic sales of home electrical appliances, indicates that the consumption of electricity is deeply linked to the way people live in these regions.

In the central region, the completion of many new factories in the Eastern Seaboard industrial zone and elsewhere under the Sixth Plan, and the resulting increase in production, has had a great impact and the share of GRP produced by the agricultural, forestry and fisheries sectors has dropped (the real value being 12% in 1993). As a result, the Central region achieved a higher growth rate than other regions, even in 1993, and its elasticity value was close to one.

From the above, it can be seen that in regions which are primarily agricultural there are few major industrial users of electricity. This means that the linkage between the rate of increase in the consumption of electricity and the rate of increase in GRP is tenuous, but nevertheless, the consumption of electricity is deeply linked to the way of life. In regions which are primarily industrial, the presence of factories, which increase production and are major consumers of electricity, means that the linkage between the rate of increase in the consumption of electricity and the rate of increase in GRP is very close.

【Table 5-3: Percentage of Electricity Consumption Between Home and Business】

Percentage (%) of electricity consumption quantity

	1989		1990		1991		1992		1993		1994	
	Home	***Business***	Home	***Business***	Home	***Business***	Home	***Business***	Home	***Business***	Home	***Business***
North	56	***44***	55	***45***	54	***46***	51	***49***	51	***49***	49	***51***
Northeast	47	***53***	46	***54***	47	***53***	45	***55***	48	***52***	47	***53***
Central	15	***85***	14	***86***	14	***86***	13	***87***	13	***87***	12	***88***
Sourth	35	***65***	34	***66***	33	***67***	33	***67***	34	***66***	32	***68***

Source: PEA Statistics Report

5.2 Improvements in the Rural and Household Electrification Rates

The four OECF projects are recognized to have achieved the electrification of 3,677 villages and made a great contribution to improving the rural electrification rate nationwide. The number of villages electrified under these projects is a 27% share of the 13,687 villages electrified in Thailand nationwide between 1989 and 1995 in which the projects were implemented. It is also 6% of the total number of electrified villages in the country in 1995, which was 63,227 villages.

During the implementation period of the four OECF projects, the total number of villages in Thailand, which is the denominator of the rural electrification rate, rose by approximately 5,000 villages, but despite this change, the rate rose by eight points, from 90.1% to 98.1% (Table 5-4). The 1.9% of villages which remained without electricity at the end of 1995 were all in isolated areas such as mountains and islands. Therefore, excluding regions which PEA cannot easily connect to the national distribution grid, nationwide electrification of rural villages is practically complete.

【Table 5-4: Movements in No. of Villages Electrified and Electrification Rate】 (Units: No. of villages, %)

	1989	1990	1991	1992	1993	1994	1995	Total
No. of villages electrified	53,265	56,670	59,153	61,537	62,566	62,911	63,227	63,227
(for 4 Projects)	(502)	(990)	(153)	(1,477)	(487)	(68)	(0)	(3,677)
Total No. of villages	59,146	60,222	61,205	62,262	63,256	64,383	64,457	64,457
Electrification rate (%)	90.1	94.1	96.6	98.8	98.9	97.7	98.1	98.1
(for 4 Projects)	(0.8)	(1.6)	(0.2)	(2.4)	(0.8)	(0.1)	(0.0)	(5.7)

Source: Replies from survey questionnaire by PEA

【Table 5-5: Movements in Households Electrified and Electrification Rate】 (Units: No. of households, %)

		1989	1990	1991	1992	1993	1994	1995
Household electrified								
	North	1,696,556	1,827,377	1,964,733	2,084,107	2,216,417	2,313,647	2,454,822
	Northeast	2,221,506	2,419,916	2,598,800	2,768,444	2,942,724	3,086,930	3,276,915
	Central	1,108,923	1,208,507	1,306,144	1,401,130	1,506,476	1,597,089	1,728,940
	South	1,041,575	1,130,612	1,212,751	1,293,181	1,381,848	1,462,556	1,574,195
	Total	6,068,560	6,586,412	7,082,428	7,546,862	8,047,465	8,460,222	9,034,872
Total No. of households		9,415,590	9,738,303	10,091,706	10,893,357	11,370,960	11,890,028	12,443,022
Electrification rate of households		64	68	70	69	71	71	73

Source: Replied from survey questionnaire by PEA

5.3 Movements in Local Sales of Home Electrical Appliances

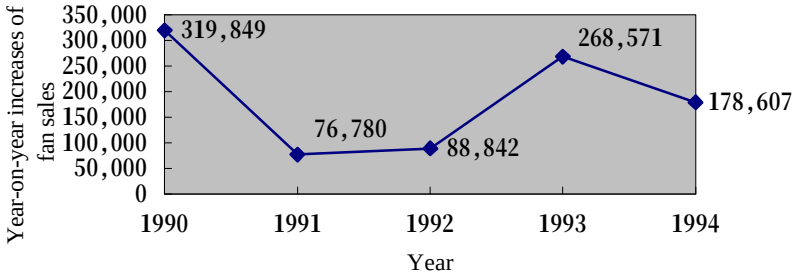
Over the five years between 1989 and 1994 the electrical consumption in the entire area served by the PEA rose approximately 210% and the rural electrification rate exceeded 98% to reach practical completion. The impact of this expansion of electrical supply on Thailand's domestic sales of home electrical appliances is examined below.

Table 5-6 shows that sales of color televisions, fans, refrigerators, air conditioners and microwave ovens rose rapidly until 1990 and, despite the impact of the economic slowdown which began in 1991, sales continued to grow. (Real economic growth rates were 13.3% in 1988, 12.2% in 1989, 11.2% in 1990, 8.5% in 1991, 8.2% in 1992, 8.3% in 1993 and 8.7% in 1994). Of the home electrical appliances sold in Thailand, electric fans are relatively cheap and can be afforded by even those on low incomes, so they are sold in the greatest numbers throughout the country. Therefore, among the movements in sales of electrical appliances, the sale of fans is the indicator most clearly linked to the level of electrification. Between 1990 and 1994, sales of fans rose continuously. Both 1990 and 1993 recorded healthy jumps of 250,000 sales on the preceding years. (See Figure 5-3 "Movements in the Year-on-year Increases of Fan Sales"). The household electrification rate has been in a similarly strong rising trend, with the numbers of newly-electrified households exceeding 500,000 in 1990 and 1993. (See Figure 5-4 "Movements in the Numbers of Newly-electrified Households"). This demonstrates that sales of fans surge forward in periods when large numbers of households are newly electrified. There is a correspondence between the two movements. Color televisions are another widespread product, and they exhibit the same trends, although their high price means that the actual numbers of sales are lower[12].

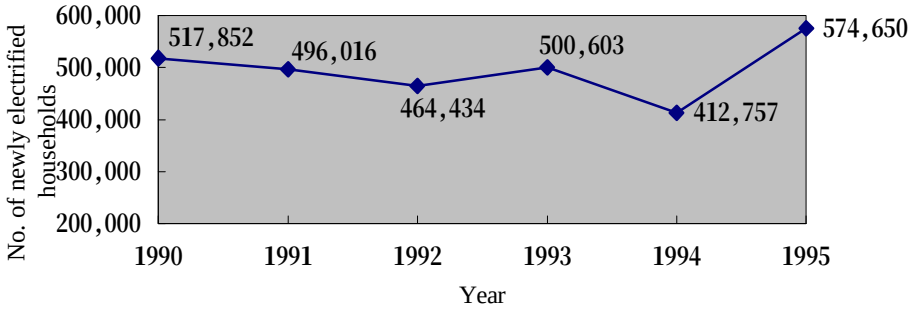
Thus, electrification is spurring sales of home electrical appliances. We have not been able to obtain

[12] According to interviews in the course of the field survey, the first electrical appliance bought by newly-electrified households are fluorescent and other light fittings, fans, color televisions, irons and rice cookers. Radio cassette players are also becoming common, but more expensive items such as refrigerators and washing machines are still rarities.

information on the sales of light fittings, but it is reasonable to assume that the cheaper a product is, the greater the increase in sales that is generated by added electrification. Even though these are only low-cost appliances, they have made the lives of the people more comfortable than they were before they had electricity. This proliferation of low-cost home electrical appliances is a first step towards a more modern standard of living. In future, as the economy moves forward, refrigerators and other expensive appliances will become more common in ordinary homes. In rural areas the installation of drainage pumps can be expected to bring great improvements in sanitation.



【Figure 5-3: Movements in the Year-on-year Increases of Fan Sales】



【Table 5-4: Movements in Newly-Electrified Households】

【Tble 5-6: Movements in Domestic Sales of Home Electrical Appliances in Thailand】

(Unit: Piece)

Year	Color TVs	Fans	Refrigerators	Air conditioners	Microwave ovens
1987	556,378	778,864	370,490	36,697	-
1988	670,100	875,500	491,400	52,500	-
1989	784,020	853,301	549,378	71,698	5,050
1990	990,799	1,173,150	652,548	86,712	11,643
1991	841,449	1,249,930	681,749	81,727	15,500
1992	944,690	1,338,772	845,804	75,898	12,146
1993	927,720	1,607,343	932,767	61,506	14,604
1994	1,078,525	1,785,950	1,090,007	64,939	10,907

Source: Central Bank of Thailand

5.4 Other Qualitative Effects

Other than the quantitative effects which can be expressed numerically, electrification apparently has a great impact (a qualitative effect) on regional society. The following descriptions are based on common factors seen in interviews in the field with the heads and residents of villages.

[Outline of Villages Surveyed]

Name of village	Region	No. of house	Population	Electrification period	Profession
Dong Rai No.9	Udon Tani, Muang	110	700	1989	Agriculture
Passin No.14	Udon Tani, Nong Uaso	127	700	1995	Agriculture
Nerun PanaoNo.4	Nonkai, Muang	275	1,017	1967～1995	Agriculture
Bang Bon No.5	Sakon Nakon, Muani	86	437	1987～1994	Agriculture
Banalom	Sakon Nakon, Melgu	67	400	1997 planned	Agriculture

① Contribution to Regional Society

The way of life of people living in the provinces is that agricultural workers leave home during the day to work in the fields, while others go to work in regional cities. This pattern restricted the times in which they could participate in local activities. However, with the arrival of electricity, electric light has been available in schools, temples and other public buildings in all areas. This has enabled people to take part in local activities after the end of their working day. The view that this has strengthened community ties was expressed in many regions.

② Improving Standard of Living

Electrification has improved the standard of living of the people affected. Their lives are more comfortable and convenient now that they can use lighting, fans, televisions, radios, irons, rice cookers and other appliances. The field survey showed that the first appliances purchased after electrification are light fittings, fans and color televisions. After these, people go on to buy other appliances according to their incomes, but refrigerators and washing machines have yet to appear in many villages.

Electrification has enabled village medical facilities to store drugs, vaccines and other supplies in refrigeration, which improves the public health and sanitation situation.

③ Electrification as a precondition for other infrastructure improvements

Pumps and other electrical equipment must be installed in order to improve water supply and sewerage services. In the short term, the power for pumps can be provided by small diesel generators, but in the long term, connection to electrical supply is a better option in terms of reliability, operation and maintenance management and cost. In other sectors, electronic control of equipment of all kinds becomes a possibility. A stable supply of electricity is a precondition for many kinds of infrastructure improvements. At present, the level of infrastructure is still inadequate in many villages, but electrification of these areas lays the groundwork for infrastructure improvements and promotes their progress.

Reference Material

① Project Plan and Actual under the Sixth National Economic and Social Development Plan by PEA(Outline and fund)

	Project Name	Unit	Outline		Fund (1 million Baht)			
					Plan		Actual	
			Plan	Actual	Foreign Currency	Local Currency	Foreign Currency	Local Currency
	Power Distribution Systems Reinforcement Project IV							
①	PSR.Ⅳ-1	No. of circuits	12	12	350	270	350	270
②	◎PSR.Ⅳ-2	No. of circuits	44	44	1,160	1,026	1,514	660
③	◎PSR.Ⅳ-3	No. of circuits	30	30	980	555	1,295	491
④	Accelerated Power Systems Expansion and Reinforcement Project	___	Thailand	Thailand	1,250	2,750	1,250	2,750
⑤	Transmission System and Substations Development Project Phase 1	Province	18	18	2,295	2,663	2,295	2,663
⑥	Distribution System Expansion for Laem Chabang New Town Project	District	1	1	0	44	0	41
⑦	Distribution System Expansion for Map Taphut New Town Project	District	1	1	0	23	0	23
⑧	• Village Electrification Project (III)	No. of electrified villages No. of reinforced villages	2,000 17,735	2,032 18,439	1,249	2,343	1,458	2,190
⑨	◎Normal Rural Electrification Project (II)	No. of electrified villages No. of reinforced villages	2,000 8,000	1,645 31,465	1,267	858	1,497	680
⑩	Village Electrification in Thung Kula Rong Hai Project	No. of electrified villages	300	300	0	182	0	170
⑪	Normal Rural Electrification Project (Additional I)	No. of electrified villages	2,000	2,014	0	1,000	0	908
⑫	Normal Rural Electrification Project (Additional III)	No. of electrified villages	2,000	2,019	0	1,360	0	1,331
⑬	Normal Rural Electrifucation Project	No. of electrified villages	2,000	2,004	0	1,600	0	1,533
⑭	Doi Tung Electrification Project	No. of electrified villages	34	34	0	55	0	49
⑮	Remote Village Electrification Project (1)	No. of electrified villages	100	102	0	243	0	214
⑯	Remote Village Electrification Project (2)	No. of electrified villages	100	115	0	300	0	231
⑰	Prathiu – Tha Sae Project	No. of reinforced villages	83	83	0	55	0	50
⑱	The Submarine Cable to Ko Change Project	km	6	6	0	162	0	148
	Total				8,551	15,489	9,659	14,402
						24,040		**24,061**

Note.◎ : Projects taken up by the Study Report

② Project Plan and Actual under the Sixth National Economic and Social Development Plan by PEA (Implementation schedule)

	Project Name	Unit	Plan	Actual	Difference (No. of months)	
					Period	Completion
	Power Distribution Systems Reinforcement Project IV				+3	+4
①	PSR.Ⅳ-1	No. of circuits	1988 - 1992	1989 - 1993	±0	+1
②	◎PSR.Ⅳ-2	No. of circuits	1988 - 1993	1989 - 1994	+2	+2
③	◎PSR.Ⅳ-3	No. of circuits	1990 - 1993	1990 - 1995		
④	Accelerated Power Systems Expansion and Reinforcement Project	___	1990 - 1994	1990 - 1995	+1	+4
⑤	Transmission System and Substations Development Project Phase 1	Province	1991 - 1996	1991 - 1997	+1	+1
⑥	Distribution System Expansion for Laem Chabang New Town Project	District	1991 - 1994	1991 - 1995	+1	+1
⑦	Distribution System Expansion for Map Taphut New Town Project	District	1992 - 1994	1992 - 1995	+1	+1
⑧	• Village Electrification Project (III)	No. of electrified villages No. of reinforced villages	1991 - 1993	1991 - 1996	+3	+3
⑨	◎Normal Rural Electrification Project (II)	No. of electrified villages No. of reinforced villages	1990 - 1993	1990 - 1992	-1	-1
⑩	Village Electrification in Thung Kula Rong Hai Project	No. of electrified villages	1987 - 1991	1987 - 1991	±0	±0
⑪	Normal Rural Electrification Project (Additional I)	No. of electrified villages	1988 - 1989	1988 - 1989	±0	±0
⑫	Normal Rural Electrification Project (Additional II)	No. of electrified villages	1989 - 1990	1989 - 1990	±0	±0
⑬	Normal Rural Electrification Project (Additional III)	No. of electrified villages	1990 - 1991	1990 - 1991	±0	±0
⑭	Doi Tung Electrification Project	No. of electrified villages	1989 - 1995	1989 - 1995	±0	±0
⑮	Remote Village Electrification Project (1)	No. of electrified villages	1991 - 1992	1991 - 1993	+1	+1
⑯	Remote Village Electrification Project (2)	No. of electrified villages	1992 - 1993	1992 - 1994	+1	+1
⑰	Prathiu – Tha Sae Project	No. of reinforced villages	1991	1991	±0	±0
⑱	The Submarine Cable to Ko Change Project	km	1992 - 1993	1992 - 1995	+2	+2

Note.◎ : Projects taken up by the Study Report

Freezer at a Local Shop
Electrified village is now using freezer to sell ice cream.
(Nong Khai, Passin No.4)

Pole Mounted Transformer for Distribution
Restricted to the allowable strength of the electric pole, the large size transformer is mounted on a H-shaped structure as show in the picture.
(Sakhon Nakhon, Bang Bon No.5)