Thailand

Ex-Post Evaluation of Japanese ODA Loan
"Transmission System and Substation Development Project (Seventh Stage Phase II)"

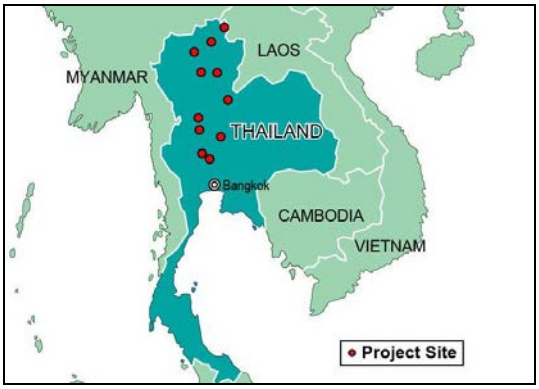
External Evaluator: Toshihisa Iida, Keishi Miyazaki, OPMAC Corporation

0. Summary

The objective of the project is to provide a stable power supply in accordance with increasing power demand and to improve power supply reliability by building distributing substations and constructing transmission lines in nine areas in the north of Thailand, thereby contributing to the promotion of regional industry and the stabilization of livelihoods in the north of Thailand. The project was sufficiently consistent with the development policy of Thailand, its development needs and with Japan's ODA policy, and thus its relevance is high. The stability of the power supply and the reliability of the power system in the north of Thailand have been improved with stable average factors for substations in the project area and with a significant improvement in the voltage drop situation. Also, other project impacts, such as a contribution to the regional economy were seen. Therefore, the effectiveness of the project is high. While the project cost was lower than planned, the project period was significantly longer than planned due to additional time required for coordination between the relevant agencies and for redesign and cost estimation related to changes in the transmission routes because of current power demand states. Thus, the efficiency of the project was fair. Lastly, the operation and maintenance of the project in terms of the structural, technical and financial aspects is good and the project's sustainability is high.

In light of the above, this project is evaluated to be highly satisfactory.

1. Project Description



Project Location

Substation constructed by the project
(Hang Chat substation)

1.1 Background

The power supply system in Thailand consists of 3 major institutions. The Electricity Generation Authority of Thailand (EGAT) is responsible for power generation and transmission. In the power transmission and distribution segment, the Metropolitan Electricity Authority (MEA) distributes electricity to Bangkok and to two adjoining provinces (Samut Prakan Province and Nonthaburi Province) and the Provincial Electricity Authority (PEA) distributes electricity to the other 73 provinces in Thailand. The PEA has continued to invest in the development of its transmission and distribution network aiming at ensuring a stable electricity

supply in the region, reducing electricity system losses and improving the reliability of the electricity supply system. Japan ODA loans have continually supported these kinds of PEA activity since 1970. As a result, the electrification ratio improved from less than 20% in the 1970's to nearly 99% in 1999. Therefore, the focus area of the National Economic and Social Development Plans (NESDP) shifted from quantitative aspects such as expansion of electrification, up to the Seventh Plan (1991 – 1995) to qualitative aspects of the electricity supply in the Eighth Plan (1996-2001).

Peak electricity demand in Thailand increased in line with Thailand's improving economic performance by an average rate of 10.8% per year from 1991 to 1997, marking its highest level in 2000 after a downturn due to the Asian economic crisis of 1998 and 1999. According to the National Energy Policy Office (NEPO[1]), peak electricity demand was forecasted to grow at an average rate of 6% per year from 2001. In the north of Thailand, both general household and industrial demand for electricity was expected to grow at an average of more than 6% per year from 2001. On the other hand, there have been discrepancies between the north and metropolitan areas of Thailand in power outage duration for each customer, an indicator of the reliability of the electricity supply. Therefore, it was necessary to develop efficient power system facilities in line with the increasing power demand in order to ensure a stable electricity supply, to lessen power system losses and to improve the reliability of the power supply system.

1.2 Project Outline

The objective of this project is to provide a stable power supply in accordance with demand in the north[2] and to improve power supply reliability by building substations for distributing power to nine areas in the north of Thailand (Chiang Mai, Chiang Rai, Lampang, Kamphaeng Phet, Phitsanulok, Phrae, Chai Nat, Sing Buri, and Nahkon Sawan) and by constructing transmission lines to supply power from 11 existing substations to the substations for power distribution, thereby contributing to the promotion of regional industry and the stabilization of livelihoods in the north of Thailand.

Loan Approved Amount/ Disbursed Amount	2,326 million yen /1,337 million yen
Exchange of Notes Date/ Loan Agreement Signing Date	March 2002/March 2002
Terms and Conditions	Interest Rate:2.2 % Repayment Period:25years (Grace Period: 7 years) Conditions for Procurement: General untied
Borrower / Executing Agency(ies)	Provincial Electricity Authority/ Same as above Guarantor: The Royal Thai Government
Final Disbursement Date	July, 2009
Main Contractor (Over 1 billion yen)	-
Main Consultant (Over 100 million yen)	-
Feasibility Studies, etc.	None
Related Projects	None

[1] The Ministry of Energy was newly established in October 2002 under an Act for the Administrative Organization of State Affairs (No.5) BE. 2545 (2002) and the Action Organizing Ministries, Sub-ministries and Departments BE. 2545. Supervision of NEPO was transferred from the Secretariat of the Prime Minister to that of the Ministry of Energy and it has been named as the Energy Policy and Planning Office (EPPO).

[2] PEA divides its power supply area into 4 regions, the north, northeastern, central and south. The north region covers 17 administrative provinces in the north of Thailand and 3 provinces, Chai Nat, Lop Buri, and Sing Buri, a total 20 provinces.

2. Outline of the Evaluation Study

2.1 External Evaluator

Toshihisa Iida, Keishi Miyazaki, OPMAC Corporation

2.2 Duration of Evaluation Study

Duration of the Study: August, 2011 – August, 2012
Duration of the Field Study: January 8th -25th, 2012 and April 1st -6th, 2012

2.3 Constraints during the Evaluation Study

None

3. Results of the Evaluation (Overall Rating: A[3])

3.1 Relevance (Rating: ③[4])

3.1.1 Relevance to the Development Plan of Thailand

The major emphasis in the Eighth NESDP (1997-2001) was placed on the "upgrading and expansion of infrastructure provision in the regions and rural areas." The energy development plan formulated by the NEPO at the time of the project appraisal focused on four areas including "the provision of an adequate amount of energy to satisfy demand at reasonable prices while ensuring quality and security of supply" and "the promotion of efficient and economical use of energy.' As parts of the strategies to achieve the focus areas, the enhancement of the reserve capacity for power generation and the improvement of power transmission and distribution system to ensure the reliability of the power system were adopted with the specific target of improvement of power system reliability for the MEA and the PEA[5]. Corresponding to these policies, the PEA prepared its Transmission and Distribution Development Plan (1997-2001), which proposed six system development plans for implementation under the Eighth NESDP. This project was included in the "Transmission Line and Substation Construction Plan", one of the six system development plans.

At the time of the ex-post evaluation, the Tenth NESDP (2007-2011) proposed, as its principal objective, "To ensure fair competition in trade and investment for the national benefit: to create a mechanism for the fair distribution of the benefits of development to all segments of the population." As a strategy to achieve the objective, the Plan adopted "the extension of infrastructure development to the regions in a fair and balanced manner." The energy sector policy[6] under the Tenth NESDP also proposed "the promotion of energy development, production and usage simultaneously with environmental conservation." The objective of the PEA Transmission and Distribution Development Plan (2007-2011) under the Thenth NESDP included (i) provision for a standardized quality, a stable and reliable power supply system, (ii) provision for a quality supply system that is sufficient to meet the demand of customers, and (iii) the extension of electricity services to cover agricultural areas in compliance with Government Policy.

At both the time of the project appraisal and the ex-post evaluation, the Thai government

[3] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory
[4] ③: High, ② Fair, ① Low
[5] In the Eighth Thai Energy Development Plan of NEPO, the target for power outage frequency per customer per year and for power outage duration per customer per year for PEA in 2001 was 17.5 frequency/year and 1,050 min/year respectively.
[6] Energy policy stated in a Policy Statement of the Government of Mr. Samak Sundaravej, Prime Minister, to the National Assembly, 18th-20th February, 2008

development policy of promoting infrastructure development in rural and agricultural area had not changed. This project, aiming at a stable electricity supply, was continuously consistent with the energy sector policy that promotes an efficient use of energy. Furthermore, the project objective is consistent with the current PEA plans as the these continue to prioritize the securement of a stable electricity supply, improvement of the reliability of the power system, and the extension of electricity services to rural area. Thus, it can be said that the project maintained its relevancy to the development policy at the time of the ex-post evaluation.

3.1.2 Relevance to the Development Needs of Thailand

Peak electricity demand in the north of Thailand was 1,457MW in 2000 and both general household and industrial demand for electricity was expected to grow at an average rate of more than 6% per annum from 2001. On the other hand, discrepancies still existed in the power outage duration for each customer between the north and metropolitan areas of Thailand, an indicator of the reliability of the electricity supply. These were 958.5 minutes/year in the north and 63.6 minute/year in the metropolitan area in 2001. Furthermore, there were overloads on the existing distribution substations and the occurrence of voltage drops was beyond the PEA permitted tolerance level, both of which were mainly caused by the increasing electricity demand in the north of Thailand. Thus, to promote the regional economy and to stabilize livelihoods, the country needed continuous reinforcement of facilities to ensure a stable electricity supply, to lessen power system losses and to improve the reliability of the power system in line with increasing power demands.

At the time of the ex-post evaluation, power demand in the north of Thailand had grown at an average rate of 6.6 % per year from 2001 to 2010, almost as forecasted. The general household and industrial demand for electricity in the 9 provinces in which the project was conducted grew at an average rate of 3.5-6.1% and 4.1-11.2% per year respectively during the same period. In particular, industrial power demand in 7 provinces out of the 9 increased by an average rate of more than 7% per year from 2001 to 2010 due to increases in production levels and the entry of new companies. Power demand in the north of Thailand is expected to grow at an average rate of 4.4% per year from 2011 to 2020 according to the PEA. Table 1 below shows the power outage frequency for each customer (time/year) and power outage duration for each customer (minutes/year) in the north and metropolitan areas of Thailand. While both the power outage frequency and duration in the north of Thailand has significantly improved since 2001, discrepancies still exist between the north and metropolitan areas. The country needs continuous reinforcement of facilities to achieve a stable power supply.

Table 1: Power Outage Frequency and Duration for each customer by region

	2001			2010		
	Total (except for metropolitan area)	North	Metropolitan area	Total (except for metropolitan area)	North	Metropolitan area
Power Outage Frequency for each customer (time/year)	16.0	17.2	2.8	8.9	8.76	1.72
Power Outage Duration for each customer (min/year)	921.5	958.5	63.6	350.1	291.7	46.9

Sources: PEA

Note: Metropolitan area includes: Bangkok, Samut Prakan Province and Nonthaburi Province

From above, it can be seen that development needs, including the continuous reinforcement of facilities to improve the stable electricity supply and to diminish regional discrepancies in the reliability of power supply remained intact at the time of the ex-post evaluation.

3.1.3 Relevance to Japan's ODA Policy

Japan's ODA policy for Thailand, established in May 2000, paid special attention to rural and regional development and to the improvement of the economic infrastructure. The Medium-term Strategy for Overseas Economic Cooperation Operations for Thailand (1999-2001) placed priority on the development of the economic infrastructure on which is short due to the rapid economic growth. This project has been consistent with Japanese ODA policy as it assists in the reduction of regional discrepancies in the reliability of the electricity supply by developing the economic infrastructure of Thailand.

From above, it can be seen that this project has been highly relevant to the country's development plan and development needs, as well as to Japan's ODA policy, therefore its relevance is high.

3.2 Effectiveness (Rating: ③)

3.2.1 Quantitative Effects (Operation and Effect Indicators)

(1) Average factors of the substations in the project area

The average of the substations' average factors[7] in the area where new substations were constructed by the project ranged from 32% to 73% at the completion of the substations[8]. This met the project target of less than 75% at the completion of each substation, as well as the PEA operational standard[9]. Thus it can be judged that a stable electricity supply was achieved by the project. The average of the substations' average factors in 10 out of 11 project area ranged from 38% to 64% in 2010, and so it can be considered that these substations were stably operated. The average of the substations' average factors in 1 project area was 84% since an existing substation in the project area supplied electricity to broad area, causing more than 100% of average factor for the substation. In order to reduce the average factor, a new substation was constructed in 2010 and another one is planned to be constructed by 2014. Through these measures, the average factor of the area is expected to be reduced to less than 75%.

Table 2: The average of average Factors of the Substations in the project area

	Actual (August 2001)	Target (At completion of each substation)	Actual (at completion of each substation (2005~2007))	Actual (2010)
Average of the substations' average factors in the project area	42~90%	Less than 75%	32~73%	38~84%

Source: PEA data

The average factors of the new substations constructed by this project in 2010, as shown in Table 3, were from 22% to 94%. One substation showed an extremely high factor at 94%, and one showed an extremely low factor at 22%. The other 9 substations maintained average factors ranging from 44% to 73%, which can be considered to reflect stable operation. The extremely high average factor for Rong Kwang substation resulted from the purchase of cheaper electricity from EGAT through the new substation, as much as possible within the bound of maintaining a stable power supply with the consideration of lowering the purchasing price of electricity[10].

[7] The ratio of actual maximum electricity demand to the installed load capacity of substations

[8] The completion dates of the substations of this project were from December 2005 to December 2007.

[9] The PEA standard for the average factor of substations to ensure a stable power supply is less than 75% in a normal situation. There is no minimum standard.

[10] PEA purchases electricity with 115kV and 22kV from EGAT in this area. Since the purchasing price of electricity with 115kV is cheaper than that of 22kV, PEA purchases 115kV from EGAT mainly through Rong Kwang substation which transforms it to 22 kV.

On the other hand, the extremely low average factor for Chiang Dao substation resulted from lower power demands than expected as well as the inadequate improvement of the distribution lines connected with the new substation, which meant that electricity had to be supplied through a different network to the target supply area While this was a factor that potentially limited the emergence of the project impact, the project impact in fact emerged at the time of the ex-post evaluation since the project area receives electricity from other substations. The PEA plans to expand the size of transformers in Rong Kwang substation which has an average factor of 94% and in the other two substations, Chiang Khong and Han Kha substations, through the 11th PEA Transmission and Distribution Development Plan (2012-2016).

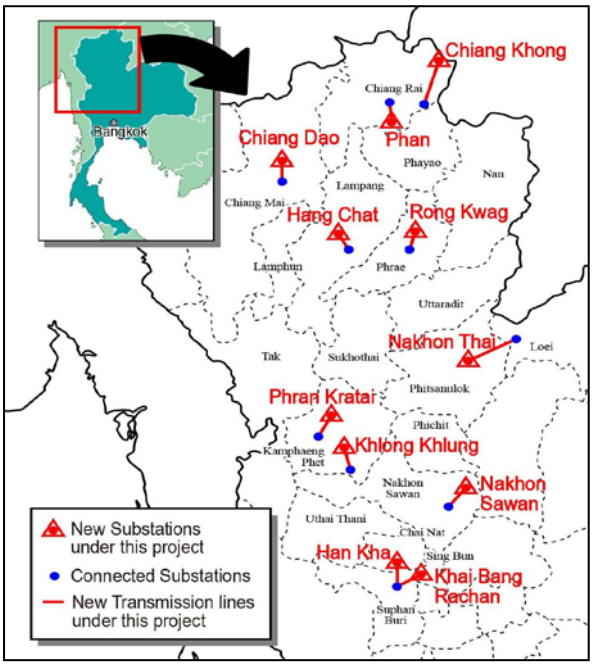


Figure 1: Locations of substations and transmission lines constructed by this project

Table 3: Average factors of substations constructed by this project

Unit: %

	2005	2006	2007	2008	2009	2010
Chiang Dao S/S (Chiang Mai Province)	-	27.96	15.29	14.93	17.11	22.44
Ching Khon S/S (Chiang Rai Province)	-	-	46.47	53.78	64.00	71.11
Phan S/S (Chiang Rai Province)	-	-	39.78	43.56	47.56	49.78
Hang Chat S/S (Lampang Province)	-	-	41.07	54.40	65.24	64.53
Khlong Khlung S/S(Kamphaeng Phet Province)	-	49.33	57.78	57.33	52.22	57.33
Phran Kratai S/S (Kamphaeng Phet Province)	-	39.11	56.89	53.78	70.67	69.33
Nakhon Thai S/S (Phitsanulok Province)	20.44	32.89	37.33	41.33	43.11	44.89
Rong Kwang S/S (Phrae Province)	51.60	78.80	86.40	87.20	83.60	94.40
Han Kha S/S (Chai Nat Province)	-	56.44	66.22	68.89	73.78	73.78
Khai Bang Rachan S/S (Sing Buri Province)	-	-	50.00	53.33	55.83	57.22
Nong Bua S/S (Nakhon Sawan Province)	-	-	29.78	59.38	68.09	69.87

Source: PEA data
Note: S/S stands for substation

(2) Voltage Drop Ratio

The situation of voltage drops in normal conditions in the project area (at end-user level) improved from 7-23% at the time of the project appraisal (August 2001) to 2-9% in February 2012, although evaluation relied only on data available at the ex-post evaluation due limitations in the availability of past data. Thus, it can be judged that the reliability of the power supply significantly improved (Table 4). The current tolerance level of voltage fluctuation in PEA and EPPO[11] in normal conditions is ±5% for 22kV and higher voltage and ±10% for the lower

[11] The current tolerance levels of voltage fluctuation of PEA and EPPO are as follows: (i) 115kv: in normal circumstances (±5%,109.25kV-120.75kV) and in emergencies (±10%, 103.5kV-126.5kV), (ii) 22kV and 33kV: in

voltage level (220V and 380V). While only one substation out of 11 substations met the target for voltage drop (less than 5%) set at the time of the project appraisal[12], the voltage drop level in all substations satisfies the current PEA and EPPO standards. Therefore, together with the distribution lines improved by other projects[13], the construction of new substations by this project has contributed to the improvement of the reliability of the power supply. A further improvement in the voltage drop level will require the improvement of distribution lines such as equipping with Automatic Voltage Regulators.

Table 4: Voltage Drop in the project area

	Actual (August 2001)	Target (at completion of each substation)	Actual (at completion of each substation (2005~2007))	Actual (February 2012)
Voltage Drop in the project area	7~23%	Less than 5%	NA	2~9%

Source: PEA data

Chiang Dao S/S

Khlong Khlung S/S

Phran Kratai S/S

3.2.2 Qualitative Effects

Interviews with 15 bulk electricity users (mainly manufacturing and agro-related businesses) which were beneficiaries of the project were carried out in the ex-post evaluation. Their responses were as follows:

- The number of power outages and short-interruptions[14] significantly declined from 2-3 times per month and 5-10 times per month 5 years ago to 1 time per month and 1-2 times per month respectively, although there are still some short interruptions in the rainy season.
- The voltage has been more stable with a decline in voltage fluctuation from 4~7 times per month 5 years ago to a few times per year at the present time.
- The current electricity supply condition is largely satisfactory.

The perception of the users can be matched to the improvement of the stabilization and the reliability of the energy supply with a more stable average factor of substations and declines in voltage drop.

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normal circumstances (±5%, 20.9kV-23.1kV, 31.35kV-34.65kV) and in emergencies (±10%, 19.8kV-24.2kV, 29.7kV-36.3kV), (iii) 220V and 330V: in normal circumstances and emergencies (±10%, 200V -240V, 342V-418V).

[12] According to the JICA appraisal documents, the permitted tolerance level of voltage fluctuation of PEA was ±5%, which was in line with that by NEPO (currently EPPO).

[13] Distribution improvement projects were implemented by the PEA in distribution networks which are connected with 9 substations out of the 11 substations constructed by this project, under the 9th (2002-2006) and the 10th (2007-2011) PEA Transmission and Distribution Development Plans.

[14] In this interview, short interruptions are defined as blackouts for a few seconds.

3.3 Impact

3.3.1 Intended Impacts

(1) Improvement of the reliability of the power supply in the north of Thailand

The number of power outages and power outage duration for each customer in the north of Thailand significantly improved by 49.0% and 69.9% respectively between 2001 and 2010 (Table 5 and Table 6). These improvement rates in the north of Thailand are higher than those for Thailand as a whole, except for the metropolitan area: 44.3% and 62.0%, while the metropolitan area was 38.8% and 26.3%. Therefore, the discrepancy in the reliability of the power supply among regions has diminished although it still remains. The main factors for the decline in the frequency and duration of power outages include: (i) improvements in the capability of the system to respond to increasing power demands and shorter distribution lines, which makes maintenance activities easier, through the construction of new substations in this project and (ii) SCADA (Supervisory Control Data Acquisition) supported by the World Bank and CSCS (Computerized System Control System) supported by this project which enable PEA to hasten the identification of problems and to dispatch the necessary repair staff. While the impact of this project on reductions in the frequency and duration of power outages in the north of Thailand is limited, as the project covers only a part of the northern area[15], it can be said that the project has contributed to the improvement of power supply reliability and the reduction regional discrepancies to some degree due to the reasons given above.

Table 5: Power Outage Frequency for each customer

Unit: frequency/year

	2001	2006	2007	2008	2009	2010	Improvement ratio (2001-2010)
Thailand (except for the metropolitan area)	16.01	11.82	11.32	10.31	9.57	8.85	44.3%
North area	17.16	11.82	10.90	10.37	9.00	8.76	49.0%
Metropolitan area	2.81	1.67	2.39	2.30	1.87	1.72	38.8%

Source: PEA data

Note: Note: Metropolitan area includes: Bangkok, Samut Prakan Province and Nonthaburi Province

Table 6: Power Outage Duration for each customer

Unit: minutes/year

	2001	2006	2007	2008	2009	2010	Improvement ratio (2001-2010)
Thailand (except for the metropolitan area)	921.51	552.74	508.27	442.64	385.93	350.06	62.0%
North area	958.51	500.16	461.85	382.03	313.99	291.27	69.6%
Metropolitan area	63.65	37.10	59.65	50.65	47.06	46.92	26.3%

Source: PEA data

Note: Note: The metropolitan area includes: Bangkok, Samut Prakan Province and Nonthaburi Province

(2) Contribution to sustainable development of the regional economy

As shown in Table 7, the general household and industrial demands for electricity grew at an average rate of 5.0% and 7.5% per year respectively between 2003 and 2010 in the 9 provinces in which this project was conducted. In particular, the industrial demands for electricity in 7 provinces showed more than 7% of the average annual growth during the same period, reflecting production expansion and the entry of new private companies in the area. The results of interviews with regional chambers of commerce and Provincial Administrative

[15] The volume of the power supply of the 11 substations constructed by this project in 2010 was 918 GWh, which accounted for about 6.4% of the total volume of power supply, 14,436GWh in the north of Thailand.

Offices (PAOs) conducted in this ex-post evaluation revealed that regional economies have become more active in recent years with the entry of new businesses/industries that has created new job opportunities in areas such as textiles, automobile parts, logistics, electronic appliances, hotels, frozen/processed food, shopping centers, restaurants, and gas stations. In addition to this, traditional industries, such as agro-related industries, have also expanded and this has partly contributed the improvements in the stability and reliability of the electricity supply in the region.

Table 7: Power Demand Growth in the 9 provinces in which this project was conducted

	Annual average growth of power demand (2003-10)			Annual average growth of power demand (2003-10)	
	Household	Industrial		Household	Industrial
Chiang Mai Province	6.1%	5.8%	Phrae Province	4.2%	7.5%
Chiang Rai Province	4.9%	10.1%	Chai Nat Province	4.2%	10.3%
Lampang Province	3.5%	4.1%	Sing Buri Province	3.9%	11.2%
Kamphaeng Phet Province	4.9%	8.2%	Nakhon Sawan Province	4.9%	8.0%
Phitsanulok Province	5.1%	7.9%	9 Provinces	5.0%	7.5%

Source: PEA data

Table 8 shows the growth rates of the real Gross Provincial Product (GPP) of the 9 provinces in which the project was conducted between 2003 and 2010. It is difficult to estimate the impact of this project on regional economic growth as growth is influenced by a number of different factors and also because this project was carried out only in a part of each province. However, as mentioned previously, staff in PAOs and regional chambers of commerce mentioned that regional economies have been quite active with the entry of new businesses, thanks to the stability of the power supply. Also, the production level in Chiang Mai, Chai Nat, and Sin Buri Provinces grew significantly in line with the significant increase in the industrial power demands in these provinces. Thus it can be said that the improvement of the stability and reliability of the power supply brought about by this project has partly supported economic growth in these provinces.

Table 8: Economic growth in the 9 provinces in which this project was conducted

	Average annual GPP growth (real) (2003-10)			Average annual GPP growth (nominal) (2003-10)
	Real GPP Growth	Manufacturing Production	Agriculture Production	
Chiang Mai Province	2.36%	3.33%	-0.14%	6.43%
Chiang Rai Province	4.08%	21.49%	0.81%	11.42%
Lampang Province	1.08%	2.36%	0.49%	7.13%
Kamphaeng Phet Province	0.17%	-2.42%	0.88%	8.12%
Phitsanulok Province	2.00%	6.29%	0.16%	8.59%
Phrae Province	1.59%	3.28%	1.92%	7.09%
Chai Nat Province	0.21%	2.40%	-2.59%	8.25%
Sing Buri Province	2.75%	5.96%	-3.14%	7.96%
Nakhon Sawan Province	1.48%	2.05%	-0.04%	8.59%
9 Provinces	1.72%	1.37%	-0.15%	
Thailand	4.15%	5.30%	0.75%	

Source: National Economic and Social Development Board

(3) Improvement of livelihoods

According to the interviews with PAOs and regional chambers of commerce conducted in the ex-post evaluation, the stable electricity supply and the improvement of power supply reliability brought about by this project have had a positive effect on the livelihoods of residents. People have started to purchase expensive electric devices such as TVs, computers, washing machines and refrigerators with less concern about damage caused by voltage fluctuation, and with income that has increased through the activation of the regional economies.

(4) Impacts on CO_2 reduction through a reduction of transmission losses

According to the PEA estimation[16], this project has reduced CO_2 emissions by 5,944 tons per year. This estimation can be utilized for reference since it uses multiple simulations due to the lack of available data such as for transmission loss of each transmission line. However, it is considered that the shortening of transmission and distribution lines by this project resulting from the construction of new substations has resulted in the reduction of transmission loss and thus, in turn, a reduction of CO_2 emission to some degree.

[Column] Interview with bulk electricity users

In this evaluation, interviews with 15 bulk electricity users (mainly manufacturing companies and agro-related businesses) were conducted in order to identify the project impact on business activities in the project area. While changes in the power supply situation in the project area are mentioned in 3.2.2, Qualitative Effects, some positive impacts of the project on business activities were identified, such as improvement in productivity, less damage of machines and improvements in product quality. Specific impacts identified in the interviews are as follows:

1. Improvement of productivity by reductions in idling and restarting time of production lines caused by power outages and short-interruptions
2. Improvement of the quality of services and products including on-time delivery and the homogenization of products by the reduction in the incidence of defective products caused by power outages, short-interruptions and voltage changes during the manufacturing process.
3. Reduction of damage of machines caused by voltage changes
4. Reduction of fuel costs by less frequent use of generators
5. Increase in production levels and expansion of sales channels through the improvement of productivity and product quality

From above, it can be seen that the project, aiming at ensuring a stable electricity supply and the improvement of the reliability of the power supply, has contributed to the development of business activities in the project area, although other factors have also contributed to that development.

3.3.2 Other Impacts

(1) Impacts on the natural environment

According to the PEA, there were no negative impacts on the natural environment. There were no complaints about noise from the substations, which are required to keep their noise level below 77 db, and there were no oil leakages from the transmission lines or the substations.

(2) Land Acquisition and Resettlement

In the project, 198,400m^2 of new land for 9 substations was acquired with a total cost of THB 43.9 million. A total of 15,200m^2 out of the whole acquisition of land was obtained from private owners while the rest was acquired from the Thai Government. The land from private

[16] Office for Climate Change, JICA Global Environment Department, "JICA Climate-FIT (Mitigation): Draft Ver1.0," June, 2011, a reference document to facilitate the consideration of policies and the formulation of projects for assisting climate change related measures in developing countries (JICA website).

owners was acquired through a bidding process where the PEA advertised for land owners who would sell land in the planned substation construction area. Thus, all land was acquired with the agreement of landowners and there were no resettlement cases The PEA did not acquire new land for the transmission lines as it has the rights to roadside lands for the construction of transmission lines on a preferential basis.

From above, it can be seen that the project has largely achieved its objectives, and therefore its effectiveness is high.

3.4 Efficiency (Rating: ②)

3.4.1 Project Outputs

The planned project outputs included, in 9 provinces of the north of Thailand (Chiang Mai, Chiang Rai, Lampang, Kamphaeng Phet, Phitsanulok, Phrae, Chai Nat, Suing Buri, and Nahkon Sawan): (i) the construction of 115kV transmission lines (11 routes, total length of 455km) and (ii) the building of 115/22 kV distribution substations (11 substations (11 transformers), total transformer capacity of 375MVA). As for the final project outputs, while (ii) was completed as planned, the total length of the transmission lines was shortened to 362km. The main reasons for the shortening were: (a) A route change due to the construction of a new substation by EGAT close to the substation construction site for the project during the project implementation. This caused a change in the connected substation to the new substation after consideration of lower transmission losses and construction costs caused by the shorter distance of the transmission line; (b) A change of construction site for a substation and a route change due to the difficulty in laying down new transmission lines; (c) Route changes due to emergence of new electricity bulk users in the project area during project implementation; (d) Difference in distances between the estimation from maps and the actual survey.

This type of project, which involves the construction of multiple substations and transmission lines, is likely to cover the development of a power supply network system rather than the construction of a single transmission line. It is preferable that substations and transmission lines be constructed in the most efficient locations bearing in mind the whole power supply network system, and with consideration made of construction costs and transmission/distribution losses as well as the actual situation of power demands such as for new bulk electricity users. With these factors in mind, the routes and distance of transmission lines are likely changed from plan. Therefore, it is appropriate for PEA to change the total length of transmission lines in this project since the changes were caused by the reasons above.

115kV Transmission Line

50MVA Transformer

Capacitor

3.4.2 Project Inputs

3.4.2.1 Project Cost

The actual project cost amounted to 6,742 million yen, including the 1,337 million yen of the Japanese ODA loan, which was lower than the planned cost of 9,048 million yen including the 2,326 million yen of the Japanese ODA loan (75% of the planned cost) (Table 9). According to the PEA, the main reasons for this were the reduction in the material costs of transmission lines due to the shorter length and the lower contract prices with contractors due to a high level of competition.

Table 9: Planned and actual costs of the project

Unit: million JPY

	Planned						Actual					
	Foreign Currency		Local Currency		Total		Foreign Currency		Local Currency		Total	
	Sub-Total	Yen-Loan	Sub-Total	Yen-Loan	Total	Yen-Loan	Sub-Total	Yen-Loan	Sub-Total	Yen-Loan	Sub-Total	Yen-Loan
Construction Work	2,124	2,124	4,529	-	5,653	2,124	1,337	1,337	5,380	--	6,717	1,337
Price Escalation	72	72	438	-	510	72	-		-	-	-	-
Physical Contingency	130	130	611	-	741	130	-		-	-	-	-
Taxes and Duties	-	-	295	-	295	-	-		25	-	25	-
Total	2,326	2,326	6,722	-	9,048	2,326	1,337	1,337	5,405	-	6,742	1,337

Source: JICA appraisal documents and PEA data

Note: Exchange rate THB 1=2.87 (as of August 2001) (Planned), THB1=2.98 (average between March, 2002 and July, 2009) (Actual)

3.4.2.2 Project Period

The planned project period was a total of 43 months from March 2002 (the signing of the loan agreement) to September 2005 (completion of construction work). However, the actual project period was significantly longer than planned, from March 2002 to December 2007, a total of 70 months and 163% longer (a delay of 27 months) (Table 10)[17]. The main reasons for the delay were: (i) a longer time required to coordinate with and obtain the necessary approvals from the relevant agencies such as Department of Highways in the Ministry of Transport, the State Railway of Thailand and EGAT, (ii) a longer time required to obtain cabinet approval for those public entities which were required for the procurements of foreign goods due to the lack of foreign currency reserve caused by the Asian Crisis[18], (iii) a longer time required for the redesign of routes and re-cost estimations caused by route changes for transmission lines according to the current of power demands, and (iv) a delay in the bidding procedures for substation contractors.

[17] One contractor for substation construction faced a liquidity problem and could not provide the maintenance guarantee for the constructed substations after the completion of substation construction and the substation AC high voltage test. While the PEA could not make a final payment to the contractor, the contractor went into a rehabilitation process in court in December 2009. The repair costs incurred during the maintenance guarantee period (2 years from the date of AC high voltage test) were paid from the final payment to the contractor. Thus, it is judged that the completion date was the completion date of the substations (operation start date of the substation).

[18] This special measure continued until May 2007

Table 10: Planned and actual project period

	Planned	Actual
Signing of Loan Agreement	March 2002	March 2002
Procurement	March 2002 – July 2003 (17 months)	January 2002 – December 2003 (24 months)
Construction of Transmission Lines	July 2002 – March 2004 (21 months)	March 2001 – April 2006(note) (55 months)
Construction of substations	February 2003 – September 2005 (32 months)	July 2003 – December 2003 (54 months)
Project completion	September 2005	December 2007

Source: PEA data

Note: The construction of transmission lines financed by the PEA's own source prior to the signing of loan agreement was included in this project scope and the necessary costs for the construction were excluded from Yen-Loan portion.

3.4.3 Results of Calculations of Internal Rates of Return (IRR)

On both the Financial Internal Rate of Return and the Economic Internal Rate of Return, a quantitative analysis of the internal rate of return was not conducted at the time of the project appraisal due to the nature of the project where it is not feasible to estimate the benefits attributable to it. A recalculation of IRR was thus not conducted at the time of the ex-post evaluation.

From the above, although the project cost was within the plan, the project period exceeded it and therefore the efficiency of the project is fair.

3.5 Sustainability (Rating: ③)

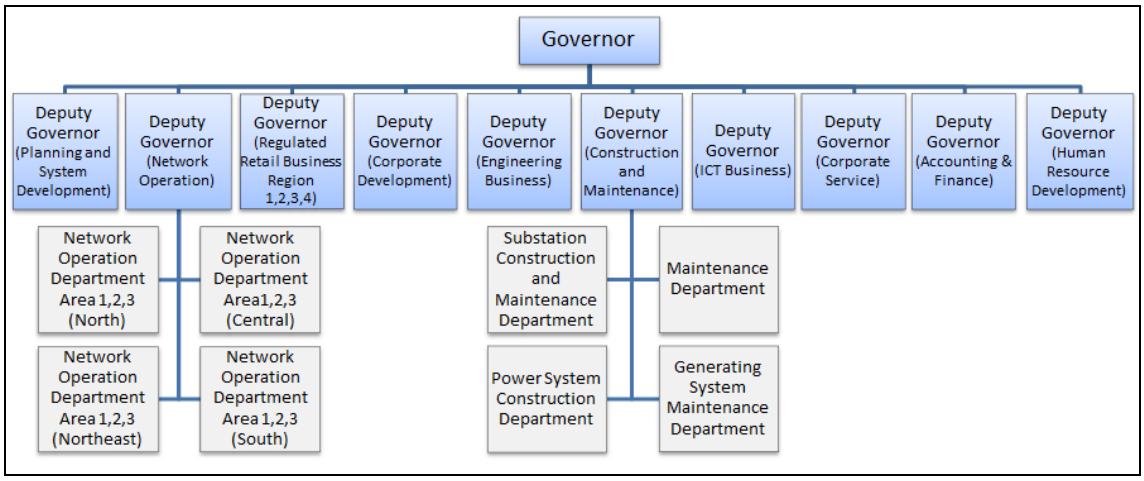
3.5.1 Structural Aspects of Operation and Maintenance

The O&M agency for the project facilities is the Provincial Electricity Authority (PEA). The PEA is a 100% state-owned enterprise. In electricity distribution in Thailand, while the MEA supplies electricity to Bangkok and two adjoining provinces (Samut Prakan Province and Nonthanburi Province), the PEA distributes electricity to the rest of the country. The Network Operation Department is responsible for the operation, preventive and corrective maintenance of the transmission lines constructed by this project. The Substation Construction and Maintenance Department is responsible for the operation, preventive and corrective maintenance of substations. These departments have 100 staff including 40 engineers, and 40 staff including 15 engineers respectively in their northern regional offices[19].

The O&M activities for the transmission lines are carried out by staff of the Network Operation Department allocated to the regional offices and the O&M activities for the substations are conducted by staff of the Substation Construction and Maintenance Department allocated to the regional offices and operators in the substations. In the case of severe damage to transmission and substation equipment, staff from the relevant department in the headquarters conduct repair works in collaboration with staff in regional offices. The PEA has undergone the testing of a un-manned substation plan by making use of SCADA system. While in normal operation, 4 operators are always in each substation, the number of operators in the 11 substations constructed by this project is 0~3 (0 operators: 1 substation, 1 operator: 1

[19] PEA has 12 regional offices in total (three each for the North, the Northeast, the Central and the South). The regional offices in the North are located in Chiang Mai, Phitsanulok and Lop Buri.

substation, 3 operators: 9 substations)[20]. No issues affecting O&M activities have been found from the institutional aspects. At the time of the ex-post evaluation, the Thai government had no policy to privatize the PEA.



Source: PEA data

Figure 1: PEA Organization Chart

3.5.2 Technical Aspects of Operation and Maintenance

Training activities for the substation operators engaged in the O&M of the substations include annual desk training conducted by the staff who are in charge of the O&M of substations in regional offices and OJT in substations, also under the instruction of such staff. Exams are conducted after desk training to identify how much technical knowledge has been acquired. The following shows the desk training courses relevant to this project:

- O&M of transmission lines: once a year, 40 staff
- Power system protection: once a year, 30 staff
- Hotlines maintenance improvement: once a year, 60 staff

Some operators in the substations constructed by this project commented that while the desk training was quite useful with a high quality of context and technical knowledge on the part of lecturers, they felt that they needed more training in order to efficiently handle newly introduced sophisticated systems such as SCADA. The O&M staff in the regional offices and in headquarters were satisfied with the technical skills of the substation operators engaged in O&M activities and had strong confidence in them.

3.5.3 Financial Aspects of Operation and Maintenance

As shown in Table 11, the PEA maintains a stable liquidity position and its debt service capacity has been improved with a decreasing debt/equity ratio in the last 5 years. With the steady increase in sales revenue, net income has also increased, except for 2008. There is thus no serious problem in its financial performance. Although the net income declined in 2007 and 2008, this was mainly the result of foreign exchange losses related to foreign currency borrowings[21].

[20] At the time of the ex-post evaluation, out of a total of 490 PEA substations, the number of substations with less than two resident operators was 117. In the case of substations at which no one resides, staff in charge of O&M can be found in the PEA provincial offices.

[21] While gains on foreign exchange in 2006 and 2007 were 1,984 THB million and 8 THB million, the PEA suffered a 1,498 THB million loss on foreign exchange in 2008. This gain (loss) on foreign exchanges mainly comes from unrealized gain (loss) of foreign currency borrowing at the end of the accounting period.

Table 11: PEA Financial Indicators

Unit: billion THB

	2006	2007	2008	2009	2010
Current ratio(time)	1.22	1.21	1.18	1.19	1.23
Quick ratio (time)	1.00	1.01	0.95	1.00	1.07
Debt/Equity ratio(time)	1.75	1.76	1.64	1.59	1.50
Return on assets (%)	5.93	4.84	4.15	5.50	5.57
Sales revenue	245.6	253.0	257.2	280.9	313.6
Net income	12.9	11.3	10.2	14.0	14.8

Source: PEA annual reports (2006-2010)

As shown in Table 12, the actual expenses for O&M exceeded the budget allocation except for 2008. This is due to the fact that the O&M budget was estimated based on preventive maintenance and corrective maintenance activities were not included in the O&M budget due to difficulties in estimation. The O&M cost accounts for 0.3-0.4% of sales revenue and 3-6% of the net income, which implies that the cost is not a significant burden. The ratio has declined since 2007. Thus, it can be concluded that there is no serious problems in the project sustainability from the aspect of O&M expenses.

Table 12: O&M expense budget and actual for PEA

Unit: million THB

	O&M expenses		(A)/ Sales Revenue	(A)/Net Income
	Budget	Actual（A）		
2006	516.8	774.2	0.3%	6.0%
2007	540.9	1,131.4	0.4%	10.0%
2008	937.1	701.7	0.3%	6.9%
2009	581.0	597.0	0.2%	4.3%
2010	587.9	596.9	0.2%	4.0%

Source: PEA data, PEA annual reports

3.5.4 Current Status of Operation and Maintenance

The facilities constructed by this project are in a good condition. Although a new transformer installed in new substation under the project broke down due to an internal defect, the PEA immediately re-operated the substation by installing a back-up transformer from another substation. After repair work, the broken transformer could be properly operated in a different substation[22].

Substation operators conduct daily visual inspections of the substation facilities according to the O&M manual. Staff stationed in PEA provincial offices conducts visual inspection of the substation facilities weekly in a case of substation where no-one is resident. Staff from the Network Operation Department in the regional offices conduct visual inspections of transmission lines monthly. The frequency and the context of the maintenance activities for the facilities installed by this project are as follows.

[22] A 50 MVA transformer installed in Khai Bang Rachan by this project broke down due to coil arc failure in 2009. The supplier repaired it free of charge. However, since repair would take 2 years, the PEA brought and installed a transformer from another substation as a back-up in the Khai Bang Rachan substation so that operation could immediately be restarted. After repair work, the broken transformer was installed and is properly operating in another substation.

Table 13: O&M activities

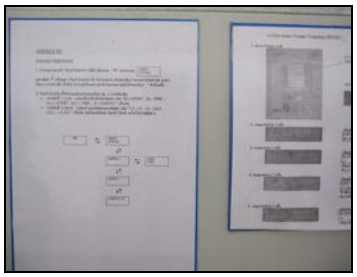
Facilities	Frequency	Activities
Transmission Lines	Monthly	Visual inspection of transmission lines
	Quarterly	Single Circuit Single Conductor, Double Circuit Double Conductor
Substations	Daily	Monitoring through SCADA, visual inspection of the equipment
	Weekly	Visual inspection of the equipment (in case of unmanned substations)
	Quarterly	Maintenance of Relay
	Annually	Maintenance of power transformer, cleaning of switching substation, thermal viewer, checking of contact resistance, maintenance of circuit breaker, relay., CSCS, battery and charger

For the O&M of substation switchgear, the operators in each substation have enhanced O&M activities by establishing the best way to conduct their activities by themselves, such as attaching to O&M manuals, the distribution site and volume for each hour on the switchgear board, in addition to the instructions in the O&M manual.

From the above, it can be seen that no major problems were observed in the operation and maintenance system, therefore sustainability of the project effect is high.

Switchgear in Chiang Dao S/S

Switchgear in Khlong Khlung S/S



Switchgear in Han Kha S/S

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The project was sufficiently consistent to the development policy of Thailand, its development needs and to Japan's ODA policy, and thus its relevance is high. The stability of the power supply and the reliability of the power system in the north of Thailand have been improved with stable average factors for substations in the project area and with a significant improvement in the voltage drop situation. Also, other project impacts such as a contribution to the regional economy have been seen. Therefore, the effectiveness of the project is high. While the project cost was lower than planned, the project period was significantly longer due to additional time required for coordination between the relevant agencies and for redesign and cost estimation related to changes in transmission routes because of current power demand states. Thus, the efficiency of the project was fair. Lastly, the operation and maintenance of the project in terms of the structural, technical and financial aspects is good and the project's sustainability is high.

In light of the above, this project is evaluated to be highly satisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

(1) SCADA/CSCS, which can control the operation of substations and transmission lines through networks from dispatch centers in regional offices, have been introduced to promote more effective and efficient operation of the transmission and distribution system. This, more sophisticated operation, has required the development of more sophisticated skills for staff. Given the ongoing plan for unmanned substations, it is desirable that PEA further develop staff skill in such areas to make effective use of infrastructure developed by this project.

(2) Operators in each substation conduct O&M activities of switchgear in an effective way which has been initiated by each substation operator themselves, although the instructions of O&M manual are also followed. These activities include the attachment of a switchgear operational manual, and a distribution volume of power by hour and distribution area, etc., on the board of switchgear. It is desirable that such O&M initiatives are shared among all substations to further strengthen current O&M activities and develop best practice.

4.2.2 Recommendations to JICA

None

4.3 Lessons Learned

(1) One of the reasons for the project delay was the longer time required for the redesign and re-cost estimation of transmission line routes according to the current state of power demands. For this type of project, it is highly likely that the routes of transmission lines and locations of substations will be changed from plan in order to develop the most efficient and effective power transmission and distribution network possible in line with actual power demands, such as new bulk electricity users and the development of connected distribution networks. Therefore, it is desirable to develop a more practical implementation schedule which considers potential route and location changes for transmission lines and substations, and which relies on the PEA's long experience in implementing such projects at the appraisal stage.

(2) Another reason for project delay was the additional time required to coordinate with and obtain approval from the relevant government agencies such as the Department of Highways in the Ministry of Transport, the State Railway of Thailand and EGAT, due to the broad area of the project site. Thus, when implementing similar projects, it is desirable that the PEA closely coordinate with relevant agencies and other concerned stakeholders from the project concept and design stage by setting up a consultative group or by conducting regular meetings where the PEA and other concerned participants can regularly share information and their concerns for projects. Through these kinds of measures, the PEA can make the project implementation smoother by avoiding useless delays caused by poor coordination.

(3) Some distribution lines connected with new substations constructed by this project and/or neighbor substations were not improved, which has caused lower average factors for the substations. It is desirable that the connected distribution system is developed or improved at the same time as when new substations and transmission lines are constructed in order to maximize the potential impact of the project. Therefore, it is necessary for the PEA to exclude such potential factors that may limit the project effect by reviewing the development plan of the connected distribution network at the appraisal stages.

End

Comparison of the Original and Actual Scope of the Project

Item	Original	Actual
1.Project Outputs	Project area: 9 provinces in the north of Thailand (Chiang Mai Province, Chiang Rai Province, Lampang Province, Kamphaeng Phet Province, Phitsanulok Province, Phrae Province, Chiai Nat Province, Sing Buri Province and Nakhon Sawan Province) (1) 115kV Transmission Lines: 11 routes (single-line transmission), total length of 455km (2) 115/22kV distribution substations: 11 substations (11 transformers), total transformer capacity of 375MVA	As planned (1) 11 routes (single-line transmission), total length of 362km (2)As planned
2.Project Period	March 2002 – September 2005 (43 months)	March 2002 – December 2007 (70 months)
3.Project Cost Amount paid in Foreign currency Amount paid in Local currency Total Japanese ODA loan portion Exchange rate	 2,326 million yen 6,722 million yen (2,342 million THB) 9,048 million yen 2,326 million yen 1 THB = 3.03yen (As of March 2002)	 1,337 million yen 5,405 million yen (1,814 million THB) 6,742 million yen 1,337 million yen 1 THB = 2,98 yen (Average between March, 2002 and July 2009)