Thailand

Bhumibol Hydro Power Plant Renovation Project

Project Summary

Borrower:	Electricity Generating Authority of Thailand (Guarantor: Kingdom of Thailand)
Executing Agency:	Electricity Generating Authority of Thailand
Date of Exchange of Notes:	September 1988
Date of Loan Agreement:	September 1989
Final Disbursement Date:	January 1995
Loan Amount:	¥2,425 million
Loan Disbursed Amount:	¥2,324 million
Procurement Conditions:	General Untied (Partial untied for consultant portion)
Loan Conditions:	
Interest Rate:	2.9%
Repayment Period:	30 years (10 years for grace period)

<Reference>

(1) Currency: Baht (B)

(2) Exchange Rate (IFS annual average market rate) / Consumer Price Index (CPI: 1988 = 100)

	1989	1990	1991	1992	1993
JP¥／US$	137.96	144.79	134.71	126.65	111.20
B／US$	25.82	25.11	25.47	25.39	25.35
CPI	105.357	111.607	117.969	122.768	126.897

1994	1995	1996	1997	1998
102.21	94.06	108.78	120.99	130.9
25.00	25.14	25.49	40.66	41.4
133.371	141.071	149.330	157.701	170.414

(3) Fiscal Year: October 1 ~ September 30

【Abbreviations】

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

Figure 1　Project Location

1. Project Summary and Comparison of Original Plan and Actual

1.1 Project Summary and ODA Loan Portion

This project aims to improve the reliability of power generating facilities, increase power generating output and efficiency, and extend the operating life of facilities by renovating part of the equipment at the Bhumibol Hydro Power Plant (generating units 1 and 2) that had deteriorated over time.

The project scope covers the renovation of generating units 1 and 2, as well as the consulting services. The ODA loan covered the entire foreign currency portion for procuring and installing equipment, and the consulting fees.

1.2 Project Location

See Figure 1. This project was conducted at the Bhumibol Hydro Power Plant located in the northern section of Tak Province some 400km northwest of Bangkok.

1.3 Background and Need for the Project

When this project was first planned in the late 1980's. Thailand was experiencing rapid economic growth that produced a sharp increase in the demand for electrical power. Peak demand grew at an annual rate of 13% in 1987, 15% in 1988, and 15% in 1989. Increasing output to meet this rising demand had become an urgent for the country. With this background, the Electricity Generating Authority of Thailand (EGAT) drafted its Power Resources Development Plan (1988~2001) calling for 14,790MW in electrical output by 2001 with annual output capacity expanded to 76,172GWh. EGAT's power generating results are as shown in Table 1.

At the time of planning this project, the Bhumibol Hydro Power Plant[1] had equipment output of 535MW, second to the Srinagarind Power Plant, which had output 540MW. Two of the seven generators at Bhumibol Hydro Plant, generating units 1 and 2, began their operations in 1964 and had become fatigued. Many of the equipment and facilities were out-dated. Efficiency had fallen and maintenance costs had risen in the manner shown below due to deterioration over time. Therefore, prompt renovation had been in need.

(1) Control System:	Control of all operations had been performed manually, which presented more risk of human error. Control of starting, discontinuating and other operations had been inefficient.
(2) Electrical Equipment:	Functions, efficiency and safety had deteriorated.
(3) Hydro Turbine:	Efficiency and the ability to regulate output had fallen.
(4) Other Equipment:	Power generating capacity and reliability of power supply had fallen. Cost of maintaining existing equipment had risen sharply.

[1] The Bhumibol Dam, located in Tak Province in the northern section of Thailand, was the nation's first multipurpose dam with its operation started in 1964. In 1996 the eighth generating unit (175MW) was completed and thus the power plant now has a total capacity of 710MW.

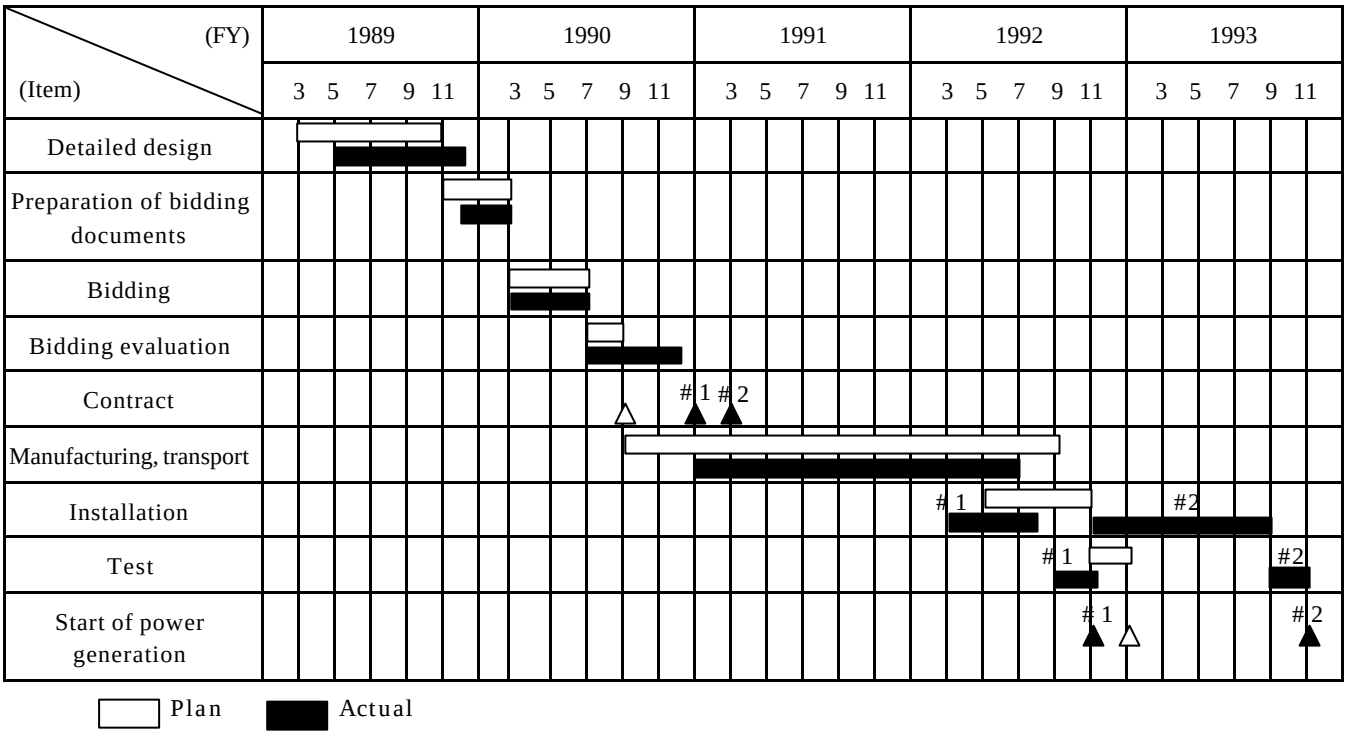
1.4 Comparison of Original Plan and Actual

1.4.1 Project Scope

Evaluation item	Plan (①)	Actual (②)	Difference (②－①)
Project Scope ①Renovation of Units 1 &2 i) Hydro turbine	New runner, adoption of electric governor, replacement of bearing .	Same as left	None
ii) Power generator	Replacement of stator coils and field coils, adoption of static excitation equipment	Same as left	None
iii) Control system etc.	Adoption of automatic control equipment and gas breakers	Same as left	None
②Consulting service	Detailed design, bidding documents preparation assistance, bidding evaluation assistance, construction supervision	Same as left	None

1.4.2 Implementation Schedule

Item	Plan	Actual	Difference
I. Consulting Service			
1. Detailed design	Mar.1989 – Oct.1989	May 1992 – Nov.1989	1-month delay of completion
2. Bidding documents preparation assistance	Nov.1989 – Feb.1990	Dec.1989 – Feb.1990	As planned
3. Bidding	Mar.1990 – Jun.1990	Feb.1990 – Jun. 1990	As planned
4. Bidding evaluation assistance	Jul.1990 – Aug.1990	Jul.1990 – Nov.1990	3-month delay of completion
5. Construction supervision	Sep.1989 – Mar.1992	Dec.1990 – Nov.1993	18-month delay of completion
II. Equipment procurement			
1. Contract conclusion	Sep. 1990	Dec.1990(generator) Feb.1991(Hydro turbine)	3-month delay of completion
2. Procurement (Design, manufacturing, transport)	Sep.1990 – Aug.1992	No.1 Dec.1990-Jun. 1992 No.2 Same as above	2-month advance of completion
3. Installation	May 1992 – Oct.1992	No.1 Mar.1992 – Aug.1992 No.2 Nov.1992 – Sep.1993	No. 1:2-month advance No. 2: 11-month delay
4. Test operation	Nov.1992 – Dec.1992	No.1 Sep.1992 – Oct.1992 No.2 Sep.1993 – Oct.1993	No. 1: 2-month advance No. 2:10-month delay
5. Start of operation	Jan. 1993	No.1 Nov. 1992 No.2 Nov. 1993	No.1: 2-month advance No.2: 10-month delay



1.4.3 Project Cost

Unit: ¥ million

Item	①Plan		②Actual		Difference (②－①)	
	Foreign currency	Local currency	Foreign currency	Local currency	Foreign currency	Local currency
1. Equipment cost (Including spare parts, installation monitoring)	2,281	30	2,154	151	▲127	＋121
2. Consulting service	73	－	170	50	＋97	＋50
3. Maintenance cost	－	120	－	141	－	＋21
4. Import duties	－	359	－	404	－	＋45
5. Contingency	71	13	－	－	▲71	▲13
6. Interest during construction	－	102	－	44		▲58
Total	2,425	624	2,324	790	▲101	＋166

(Note) 1. Entire foreign currency portion is covered by JBIC loan.
2. Exchange rate: 1 Bhat : ¥5 at the time of plan, Actual: 1 Bhat = ¥3.95

Table 1 EGAT Generation Results
TOTAL EGAT GENERATION REQUIREMENT
(Moderate Economic Recovery Case)

Fiscal Year	Peak Generation			Energy Generation			Load Factor %
	MW	Increase		GWh	Increase		
		MW	%		GWh	%	
				Actual			
1987	4,733.90	553.00	13.23	28,193.16	3,413.63	13.78	67.99
1988	5,444.00	710.10	15.00	31,996.94	3,803.78	13.49	67.09
1989	6,232.70	788.70	14.49	36,457.09	4,460.15	13.94	66.77
1990	7,093.70	861.00	13.81	43,188.79	6,731.70	18.46	69.50
1991	8,045.00	951.30	13.41	49,225.03	6,036.24	13.98	69.85
1992	8,876.90	831.90	10.34	56,006.44	6,781.41	13.78	72.02
1993	9,730.00	853.10	9.61	62,179.73	6,173.29	11.02	72.95
1994	10,708.80	978.80	10.06	69,651.14	7,471.41	12.02	74.25
1995	12,267.90	1,559.10	14.56	78,880.37	9,229.23	13.25	73.40
1996	13,310.90	1,043.00	8.50	85,924.13	7,043.76	8.93	73.69
1997	14,506.30	1,195.40	8.98	92,724.66	6,800.53	7.91	72.97
1998	14,179.90	-326.40	-2.25	92,134.44	-590.22	-0.64	74.17
Average Growth 1988~1998	-	858.73	10.49	-	5,812.84	11.37	-
				Forecast			
1999	14,499.00	319.10	2.25	93,178.00	1,043.56	1.13	73.36
2000	15,254.00	755.00	5.21	97,858.00	4,680.00	5.02	73.23
2001	16,214.00	960.00	6.29	103,685.00	5,827.00	5.95	73.00
2002	17,308.00	1,094.00	6.75	110,436.00	6,751.00	6.51	72.84
2003	18,399.00	1,091.00	6.30	117,341.00	6,905.00	6.25	72.80
2004	19,611.00	1,212.00	6.59	124,532.00	7,191.00	6.13	72.49
2005	20,818.00	1,207.00	6.15	132,228.00	7,696.00	6.18	72.51
2006	22,168.00	1,350.00	6.48	141,300.00	9,072.00	6.86	72.76
2007	23,728.00	1,560.00	7.04	151,322.00	10,022.00	7.09	72.80
2008	25,450.00	1,722.00	7.26	162,438.00	11,116.00	7.35	72.86
2009	27,232.00	1,782.00	7.00	173,532.00	11,094.00	6.83	72.74
2010	28,912.00	1,680.00	6.17	184,213.00	10,681.00	6.16	72.73
2011	30,587.00	1,675.00	5.79	194,930.00	10,717.00	5.82	72.75
Average Growth							
1982~1986	-	318.44	10.06	-	1,763.91	9.20	-
1987~1991	-	772.82	13.99	-	4,889.10	14.71	-
1992~1996	-	1,053.18	10.60	-	7,339.82	11.79	-
1997~2001	-	680.62	4.02	-	3,552.17	3.83	-
2002~2006	-	1,190.80	6.46	-	7,523.00	6.39	-
2007~2011	-	1,683.80	6.65	-	10,726.00	6.65	-

Thailand Load Forecast Subcommittee September 1998

2. Analysis and Evaluation

2.1 Evaluation on Project Implementation

2.1.1 Project Scope

This project is consisted of the renovation of generating units 1 and 2, and consulting services. More details are as outlined below.

(1) Renovation of generating units 1 and 2
   i) Hydro turbine: Adoption of a new-type runner and electrical governor, Replacement of bearings
   ii) Power generators: Replacement of stator coil and field coil, adoption of static excitation equipment
   iii) Control Equipment: Adoption of automatic control system and gas breakers

(2) Consulting Services
   i) Detailed design and bidding documents preparation assistance
   ii) Bidding evaluation assistance
   iii) Construction supervision

The ODA loan covered the entire foreign currency portion for renovating the above equipment and the consultant services. The scope of the project were carried out according to the plan without any major changes.

2.1.2 Implementation Schedule

Even though the consulting services started two months behind schedule, detailed designs and bidding documents were completed within the original implementation schedule. Bidding was conducted as scheduled, however ,it took longer than planned to evaluate the submitted bids and consequently contracts with the equipment manufacturers were completed three months behind schedule. The consultants were employed to provide services up until March 1992, however this period was extended by 18 months due to delays in installing generating unit 2 and the reason mentioned below.

The manufacturing and transport of the equipment was carried out ahead of schedule, thus the installation of generating unit 1 was completed two months ahead of schedule. However, all stator coils in generating unit 2 had to be replaced for the coils were all rusted upon arrival at the site. Some additional parts had to be replaced due to faulty battery fluid in the DC supply system. This all resulted in completion being pushed back by ten months.

2.1.3 Project Cost

Initial costs estimates for the project called for ¥2,425 million for the foreign currency portion and ¥624 million (125 million bahts) for the local currency portion. The actual cost of the project was ¥2,324 million the foreign currency portion, 4.2% less than forecasted, and ¥790

million (200 million bahts) for the local currency portion, 26.6% more than forecasted. The overall project cost came to ¥3,114 million with a slight increase of 2.1% compared to the initial cost estimates.

The foreign currency portion of the equipment costs was within the budget as the amounts quoted by the successful bidder were less than the budgeted amounts. However, local currency costs increased due to inflation. The end result was that expenses were roughly in line with the original plan. Consultant fees increased greatly as the service period had to be extended for 18 months due to the overall implementation schedule delays.

2.1.4 Implementation Scheme

(1) Executing Agency

The Electricity Generating Authority of Thailand (EGAT) was the executing agency for this project. EGAT is a state-owned organization responsible for generating and transmitting electrical power nationwide. The organization was established in 1969 based on the EGAT law through the merger of three existing power authorities. EGAT is Thailand's largest state-owned organization with more than 30,000 employees. The organization chart is as shown in Figure 2.

EGAT had electrical facilities output of 18,176MW as of the end of September 1998, with its possible annual output amount reaching 107,442GWH. In fiscal 1998 (Oct. 1997 to Sept. 1998) peak power generation was 14,180MW and 92,134GWh of electrical power was produced (see Table 1). The generated power was transmitted over 23,000km of cables and through 180 substations. The purchasers of EGAT's electricity are: MEA (Metropolitan Electricity Authority) and PEA (Provincial Electricity Authority). These two authorities purchase 98% of all of the power sold by EGAT.

Even though this project marked the first time that EGAT attempted a major renovation of hydropower equipment, the organization has been credited for its solid performance in executing the project.

The Vice-President at EGAT Headquarters in charge of development of hydropower generation and transmission served as the project manager overseeing the entire project. The actual running of the project was carried out by the Hydropower Engineering Division of EGAT headquarters, the Planning and Bidding Section of this Division, the Hydropower Equipment Section of the Hydropower Construction Division, the Hydropower Equipment Installation Section, the branch office at the Bhumibol Hydro Power Plant, and other related departments. The organization adopted by EGAT for executing this project is as shown in Fig. 3. More than 100 employees were assigned to this project during the mobilization periods.

Equipment design, production and delivery was entrusted to foreign suppliers and carried out in accordance with the specifications made by the consultants. A team directly managed by EGAT handled the installment of equipment in accordance with instructions given by the suppliers. Construction monitoring was performed by the consultants in cooperation with EGAT.

(2) Consultant

This project hired consultants for the following TOR.

(i) Detailed design and bidding preparation assistance
(ii) Bid evaluation assistance
(iii) Construction supervision

Due to the urgency of this project, Japanese consultants with experience in F/S were directly employed. The PCR of EGAT reported that the performance of these consultants was very satisfactory.

(3) Contractor

The contract for equipment was divided into two contract packages, one for the power generating equipment and the other for hydro turbine-related equipment. International bidding was conducted and two European manufacturers submitted the winning bids. These manufacturers were not the original suppliers for generating units 1 and 2.

There were some minor problems, however, with the performance of contractors. There were faults with the stator coils for the generating unit 1 and the battery fluid used in the power supply system. Some of the delivered products did not meet certain specifications. This resulted in the executing agency having to place re-orders, which delayed the project schedule. However, even though the project as delayed some 10 months, a maximum power output greater than that of original plan was achieved. The generating equipment and turbines have been performing smoothly since the completion of the project. Overall, it can be said no major problems were seen with the performance of the contractors.

Figure 2 Organization Chart of EGAT

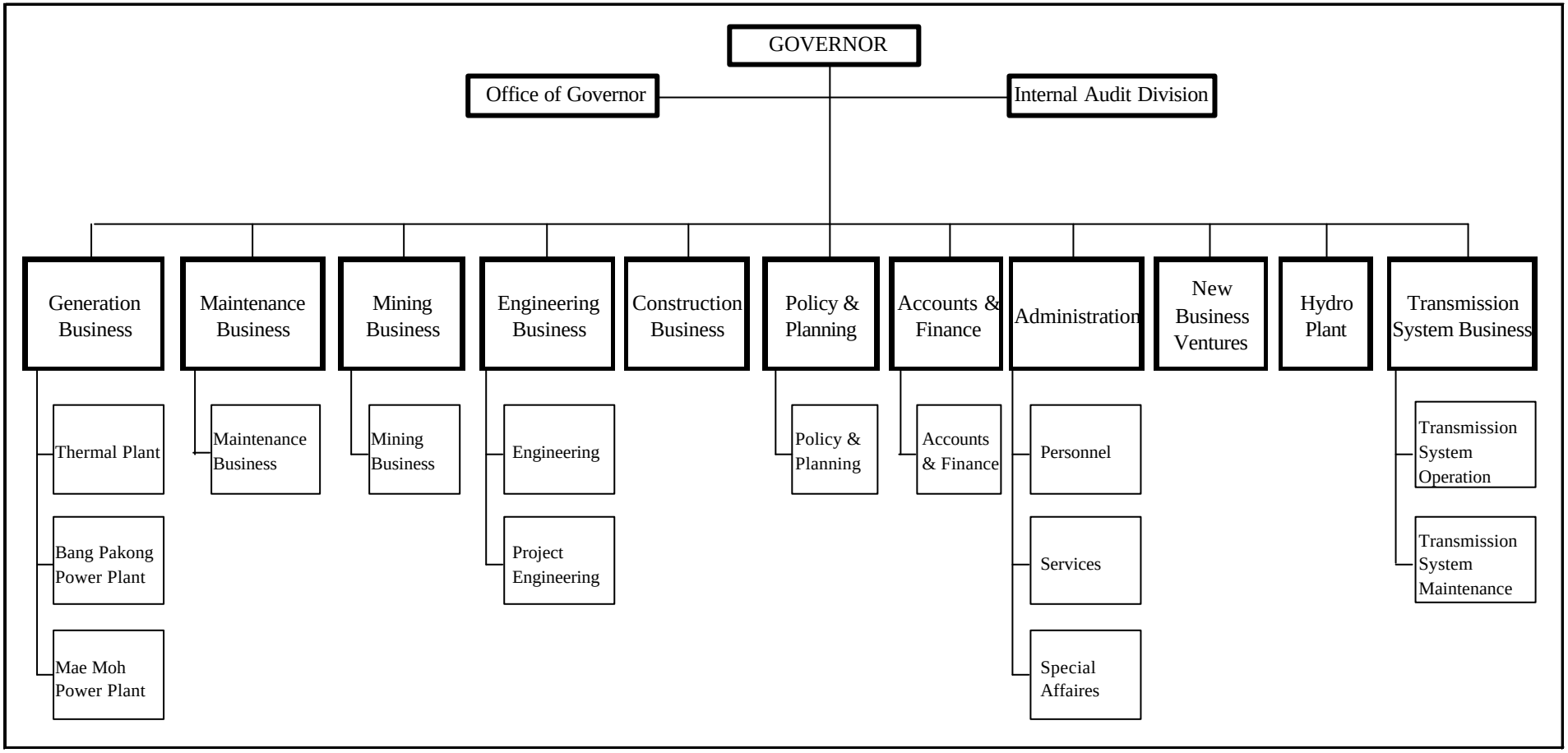
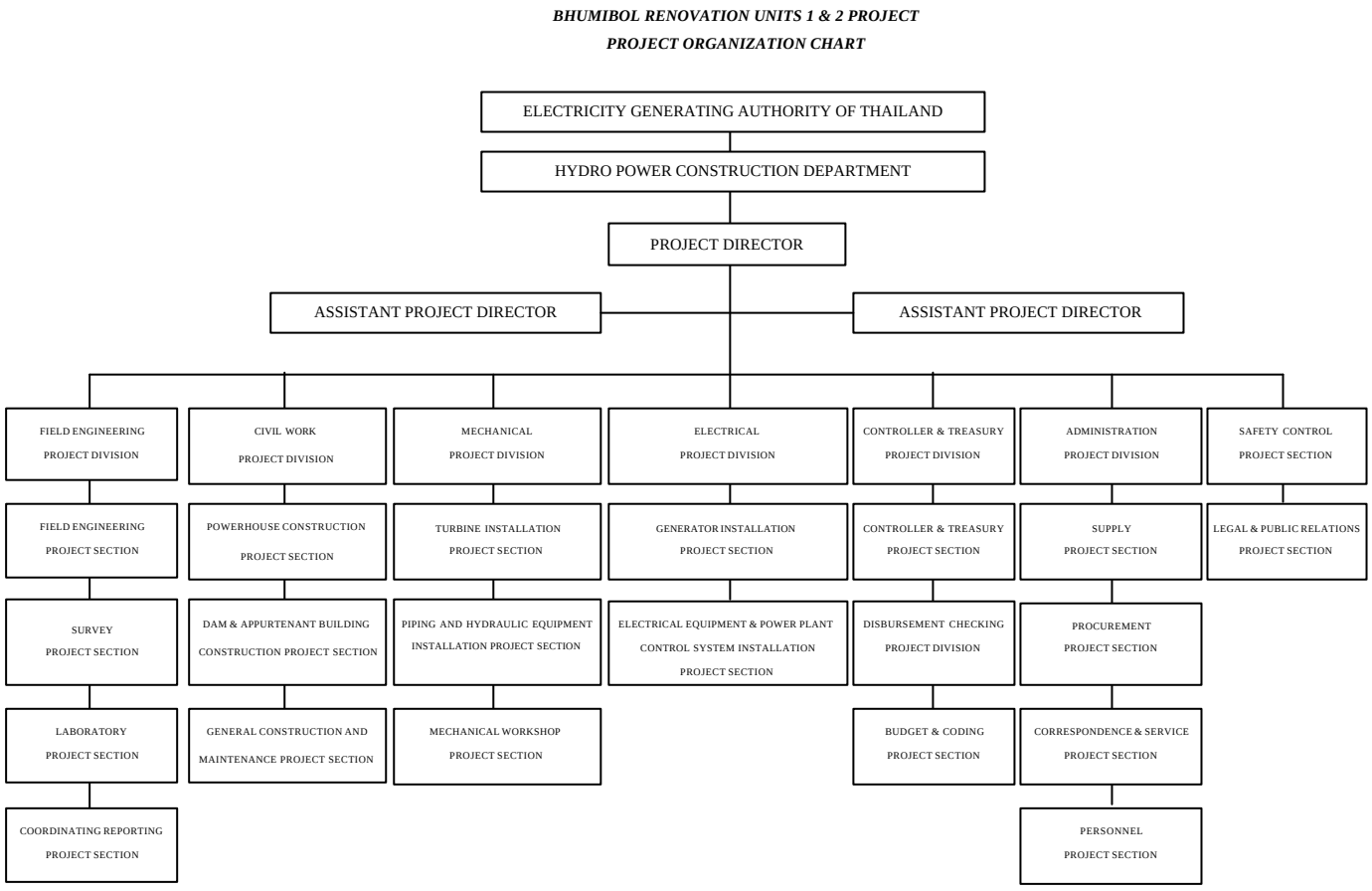


Figure 3 Project Organization Chart of EGAT



2.2 Evaluation on Operations and Maintenance

2.2.1 Operations and Maintenance Scheme

The Bhumibol Hydro Power Plant had 641 employees as of the end of November 1998. Of these employees, 108 were working in the department for operations, 102 were assigned to the equipment maintenance department, 181 were in charge of civil works maintenance, and 132 were assigned to general affairs (see Figure 4).

The power plant has 44 electrical engineers working to provide basic day-to-day operations. These engineers work in three alternating shifts in order to keep the plant running for 24 hours a day. Experienced technicians have been placed in charge of operations and maintenance and therefore it can be said there are no problems with the plant's operations and maintenance scheme.

2.2.2 Operations and Maintenance

(1) Operating Conditions

After completing this renovation project, operations for generating unit 1 resumed in November 1992 and operations for generating unit 2 in November 1993. A maximum output of 76.3MW was achieved, surpassing the original expectations of 75.4MW. The power generation results after operations were restarted are as shown in Table 2 below. The output amount from fiscal 1996 was pretty much in line with the original plan. Power output for fiscal 1998 was lower due to a drought that would not occur during an average year.

Table 2 Power Generating Results of Units 1 & 2 After Rehabilitation

FY (Note 1)	Plan (Note 2)	Power generating results				
		Total	Unit 1		Unit 2	
	Power generating volume (GWh)	Power generating volume (GWh)	Power generating volume (GWh)	Power generating time (hr)	Power generating volume (GWh)	Power generating time (hr)
FY1994	378.0	46.7	46.7	830.2	—	—
FY 1995	377.2	313.9	149.6	2,489.8	164.3	2,540.3
FY 1996	376.4	368.5	185.5	3,005.8	183.0	2,862.9
FY 199	375.6	364.2	182.0	2,972.8	182.3	2,961.4
FY 1998	374.8	225.3	111.0	1,895,5	114.3	2,061.4

Note 1: The fiscal accounting period is from October to September of the following year.
Note 2: Assumed output level based on economic analysis at the time of the appraisal.

(2) Maintenance

The Equipment Maintenance Section (102 employees) is responsible for performing daily inspections, and the Storage Section (20 employees) is in charge of storing the necessary spare parts. Maintenance conditions of the spare parts are favorable. The following system has been put in place for the supply of spare parts. The inventory of fuses, lamps and other such expendable parts are replaced when 20%~40% have been used in accordance with the inventory

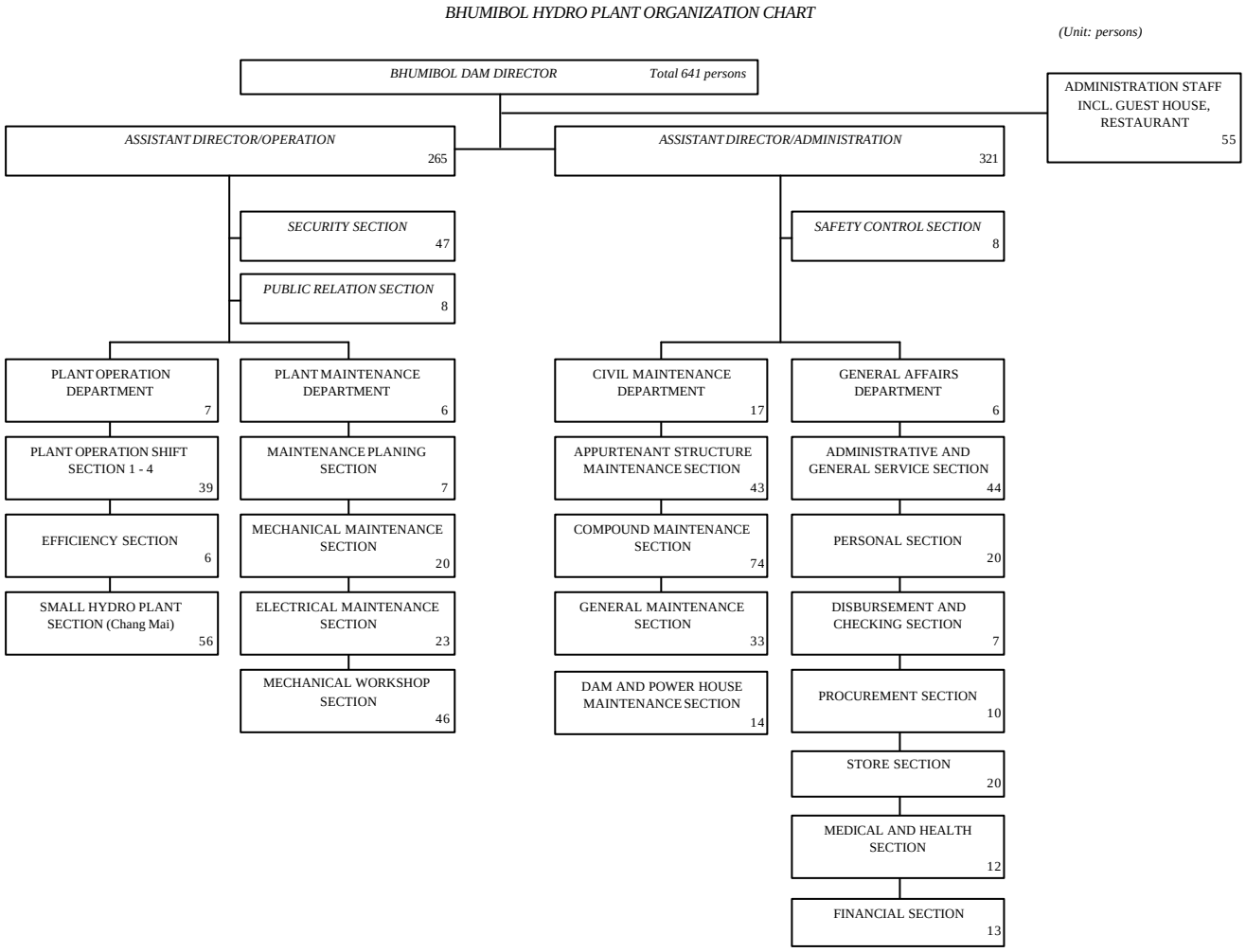
sheet. Main parts are replaced when necessary and maintained on a regular basis.

Maintenance inspections are divided into three categories: minor inspections (MI), overhauls (MO), and preventative maintenance (PM). These inspections are carried out on a regular basis. One of the main reasons for renovating the Bhumibol Hydro Power Plant was a sharp rise in the cost of maintaining the equipment. After completion of the renovations, the intervals for performing periodic maintenance inspections were extended as shown in the table below. In this manner the project made a considerable contribution in helping to reduce maintenance costs.

	Before renovations	After renovations
Minor inspections （MI）	Every year	Every 2 years
Overhauls （MO）	Every 5 years	Every 8 years

Preventative maintenance is performed on a daily basis and a log of corrective maintenance is kept. According to this log, trouble was reported with generating unit 1 on 16 occasions and with generating unit 2 on 18 occasions from the completion of the project up until December 18, 1998. Most of these problems were minor and proper countermeasures were taken based on the cause of the problem investigated.

Figure 4 Organization Chart of Bhumibol Hydro Power Plant



2.3 Project Effects and Impacts

2.3.1 Economic Impact

FIRR was calculated at the time of the appraisal to serve as a quantitative measure of economic results.

FIRR calculated at the time of the appraisal was 14.4%.

(Premise) (1) Benefit: Increased revenue through improved productivity and higher output.

(2) Expense: Investment in rehabilitation and additional expense associated with increased power output.

(3) Project life: 15 years

Plans were to increase output for each generating unit by 5.4MW, from 70.0MW to 75.4MW, through this renovation project. However, output was actually increased to 76.3MW, a full 17% over the original projections. The fact that the results were better than had been originally planned is very noteworthy. However, the fact that the project was delayed by almost a year is a minus. With this all taken into account, the actual FIRR came to around 14%, roughly in line with the original projection from outside.

2.3.2 Technical Impact

This projected helped to greatly elevate the level of technology held by EGAT in the area of hydropower renovation. This was reflected in the fact that following this renovation project, EGAT was able to directly supervise the renovations of generating units 3 through 6 without having to hire consultants.

2.3.3 Environmental Impact

This project was basically centered on the renovation of existing facilities and thus there were no particular burdens placed on social and natural environments.

Comparison of Original Plan and Actual

1. Comparison of Original Plan and Actual

Evaluation item	Plan (①)	Actual (②)	Difference (②－①)
Project scope			
①Renovation of Units 1 &2			
i) Hydro turbine	New runner, adoption of electric governor, replacement of bearing etc.	Same as left	None
ii) Power generator	Replacement of stator coils and field coils, adoption of static excitation equipment	Same as left	None
iii) Control system etc.	Adoption of automatic control equipment and gas breakers	Same as left	None
②Consulting service	Detailed design/bidding, preparation assistance, bidding evaluation assistance, construction supervision	Same as left	None
Implementation Schedule			
Start of construction	March 1989	May 1989	2-month delay
Completion of construction	December 1992	October 1993	10-month delay
Start of operation	January 1993	November 1992 (Unit 1)	2-month advance
		November 1993 (Unit 2)	10-month delay
Project Cost (Note)			
Total project cost	¥3,049 million	¥3,114 million	¥＋65 million
Foreign currency	¥2,425 million	¥2,324 million	▲¥101 million
(JBIC portion)	(¥2,425 million)	(¥2,324 million)	(▲¥101million)
Local currency	¥624 million	¥790 million	¥＋166 million
Local currency	(125 million Baht)	(200 million Baht)	(＋75 million Baht)

(Note) Exchange rate
At the time of plan: ¥5/Baht, Actual: ¥3.95/Baht