No.

Ex-Post Evaluation Report of Japanese Technical Assistance Projects • Grant Aid Projects 2009 (Indonesia, Nepal, Laos)

August 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

OPMAC Corporation

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Preface

Ex-post evaluation of ODA projects has been in place since 1975 and since then the coverage of evaluation has expanded. Japan's ODA charter revised in 2003 shows Japan's commitment to ODA evaluation, clearly stating under the section "Enhancement of Evaluation" that in order to measure, analyze and objectively evaluate the outcome of ODA, third-party evaluations conducted by experts will be enhanced.

This volume shows the results of the ex-post evaluation of Grant Aid projects that were mainly completed in fiscal year 2006. The ex-post evaluation was entrusted to external evaluators to ensure objective analysis of the projects' effects and to draw lessons and recommendations to be utilized in similar projects.

The lessons and recommendations drawn from these evaluations will be shared with JICA's stakeholders in order to improve the quality of ODA projects.

Lastly, deep appreciation is given to those who have cooperated and supported the creation of this volume of evaluations.

August 2010

Atsuro KURODA
Vice President
Japan International Cooperation Agency (JICA)

Disclaimer

This volume of evaluations, the English translation of the original Japanese version, shows the result of objective ex-post evaluations made by external evaluators. The views and recommendations herein do not necessarily reflect the official views and opinions of JICA. JICA is not responsible for the accuracy of English translation, and the Japanese version shall prevail in the event of any inconsistency with the English version.

Minor amendments may be made when the contents of this volume is posted on JICA's website.

JICA's comments may be added at the end of each report when the views held by the operations departments do not match those of the external evaluator.

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Ex-Post Evaluation of Japanese Grant Aid Project
"Project for Rehabilitation of Gresik Steam Power Plant Units 3 and 4"

External Evaluators: Junko Fujiwara, OPMAC Corporation

1. Project Description

Project Location

Steam Turbine of Units 3 & 4

1.1 Background

Majority of the electricity power demand in Indonesia is concentrated in Java Island where the capital city Jakarta is the center of demand. The demand in the Java-Bali power system stagnated in terms of electricity sale volume in 1998 due to the economic crisis in 1997; however, thereafter, the demand had increased by 9.4% on average per year. On the other hand, the economic crisis had hindered the implementation of action plan for new power plant constructions by the State Electricity Corporation (PT PLN (Persero), hereinafter referred to as "PLN") and Independent Power Producers (IPP). Thus shortage in power supply from 2003 to 2005 was anticipated. In 2003, the maximum power supply capacity was between 12,500 and 14,000MW, whereas the actual peak load in 2002 was 13,830MW. This implied that a shortage in power supply would be predicted even when including the electricity sale by private companies in addition to that of PLN.

The Gresik Thermal Power Plant is located in Gresik City, East Java Province, and is connected to the Java-Bali power system, and has largely contributed to the stable power supply not only in East Java but also to the whole of Java and Bali Islands. The plant consisted of four gas turbine power generation facilities (80.4MW in total), four units of steam turbine power generating facilities (600MW in total), and three blocks of gas turbine combined cycle power generation facilities (1,578.78MW in total).

Japan has provided ODA loans and grant aids to the Gresik Thermal Power Plant since the 1970s. Units 1 and 2 of steam turbine power generation facilities (200MW in total) started its operation in 1980 and 1981, and Units 3 and 4 (400MW in total) in 1988 whose construction cost were mostly covered under ODA loans. With respect to Units 3 and 4, in alignment with the national policy that promoted diversification of energy sources and reduction of dependency on oil, Japan provided another ODA loan to modify the generation facilities from oil-fired to both gas and oil-fired model.

The total output of the facilities constructed through Japanese ODA loan in Gresik Thermal Power Plant is 600MW, which contributed to the establishment of high credibility of the whole power plant by securing stable supply of electricity, and the power plant supported the high economic growth of Indonesia.

Units 1 and 2 were rehabilitated through Japanese Grant Aid in 1999 to overcome its aged deterioration, which remarkably improved its availability factor as a result. 15 years of operation also put Units 3 and 4 under aged deterioration, and a need for recovering the maximum output, improving the thermal efficiency and durability for stable operation was confirmed, leading the two governments to decide the implementation of the targeted project.

1.2 Project Outline

The objective of this project is to recover the maximum output, improving the thermal efficiency and durability of Units 3 and 4 of steam turbine power generation facilities of the Gresik Thermal Power Plant, by rehabilitating their steam turbines, major steam valves, and turbine auxiliary system.

Grant Limit / Actual Grant Amount	1,985 million yen / 1,975 million yen
Exchange of Notes Date	July, 2004
Implementing Agency	PT PLN (Persero)
Project Completion Date	March, 2007
Main Contractor	Sumitomo Corporation
Main Consultant	Tokyo Electric Power Services Co., Ltd.
Basic Design	Basic design study report on the project for rehabilitation of Gresik Steam Power Plant units 3 and 4 in the Republic of Indonesia, Japan International Cooperation Agency and Tokyo Electric Power Services Co., Ltd. Dec 2003
Detailed Design	August 2004
Related Projects	"Engineering Services For Gresik Steam Power Plant Project" (L/A signed 14 Oct 1975): 276 million yen
	"Engineering Services For Gresik Steam Power Plant Project" (L/A signed 28 June 1977), 975 million yen
	"Gresik Steam Power Plant Project" (L/A signed 28 June 1977), 12,559 million yen
	"Engineering Services For Gresik Thermal Power Plant" (L/A signed 31 Mar 1981), 368 million yen
	"Gresik Thermal Power Plant" (Unit III And Engineering Services For Unit IV) (L/A signed 30 Apr 1982), 28,210 million yen
	"Gresik Thermal Power Plant" (Unit IV) Project (8 Mar 1984) 8,815 million yen
	"Gresik Thermal Power Plant" (Unit IV) Project (8 Mar 1984) 11,999 million yen
	"The Gas Firing Modification Works Of Gresik Steam Power Plant Units III And IV Project" (22 Dec 1989) 4,445 million yen
	"The Project for Rehabilitation of Gresik Steam Power Plant Units 1 and 2 (1/2)" (E/N dated 25 Mar 1999), 1,182million yen
	"The Project for Rehabilitation of Gresik Steam Power Plant Units 1 and 2 (2/2) " (E/N dated 29 Jul 1999), 1,134 million yen

2. Outline of the Evaluation Study

2.1 External Evaluator

Junko Fujiwara, OPMAC Corporation

2.2 Duration of Evaluation Study

Duration of the Study: October, 2009 – August, 2010

Duration of the Field Study: March 11, 2010 – March 20, 2010

2.3 Constraints during the Evaluation Study

Not specifically.

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

3.1 Relevance (Rating: a)

3.1.1 Relevance with the Development Plan of Indonesia

(1) Relevance with the National Development Program and Plan

At the time of basic design study implementation, the National Development Program Strategy (PROPENAS) from 2000 to 2004 had been implemented, to which this project was relevant. The PROPENAS placed great importance on the rehabilitation and betterment of existing infrastructure and ensuring all citizens' access to basic services.

The National Medium Term Development Plan (RPJMN) from 2005 to 2009, which was outlaid in January 2005 by the new government led by President S.B.Yudhoyono, had continuous focus on the power and energy sector along with other sectors' infrastructure development. In the same document, they pointed out that an extra 22,261MW power-generating capacity will be needed in the next five years in order to forestall a looming energy crisis.

(2) Relevance with National Power Development Plan

At the time of basic design study implementation, five high-priority issues in the power and energy sector were stated in the Power Sector Master Plan (RUKN) for the year 2003, namely: (a) reorganization of the power and energy sector and establishment of a competitive market; (b) reform of the tariff system; (c) adaptation of a policy for the use of generated electricity; (d) promotion of investment from the private sector, and; (e) reform of legal arrangements. With regard to the policy for the use of generated electricity, it is mentioned that 13,365MW will be needed in the Java-Bali area out of the extra 22,261MW of power-generating capacity needed for the whole of Indonesia. In this respect, the project was in alignment with this target and was relevant to the plan.

The current master plan, RUKN 2008 - 2027 published in November 2008, mentions that, as of 2008, the peak demand of the Java-Bali power system is 19,389MW out of the total national peak demand of 25,407MW. The necessary total installed capacity for power generation mentioned in the RUKN is 33,631MW for the entire country, which of that the Java-Bali power system needs 25,205MW, becoming nearly two times of the capacity that was anticipated at the time of 2003.

3.1.2 Relevance with the Development Needs of Indonesia

The total output of the Gresik Thermal Power Plant (2,259.18MW), which accounted for approximately 12% of the Java-Bali power system in 2003, and the total rated output of Units 3 and 4 (400MW), which are the target facilities of this project, supplied 2.1% to the system at that time.

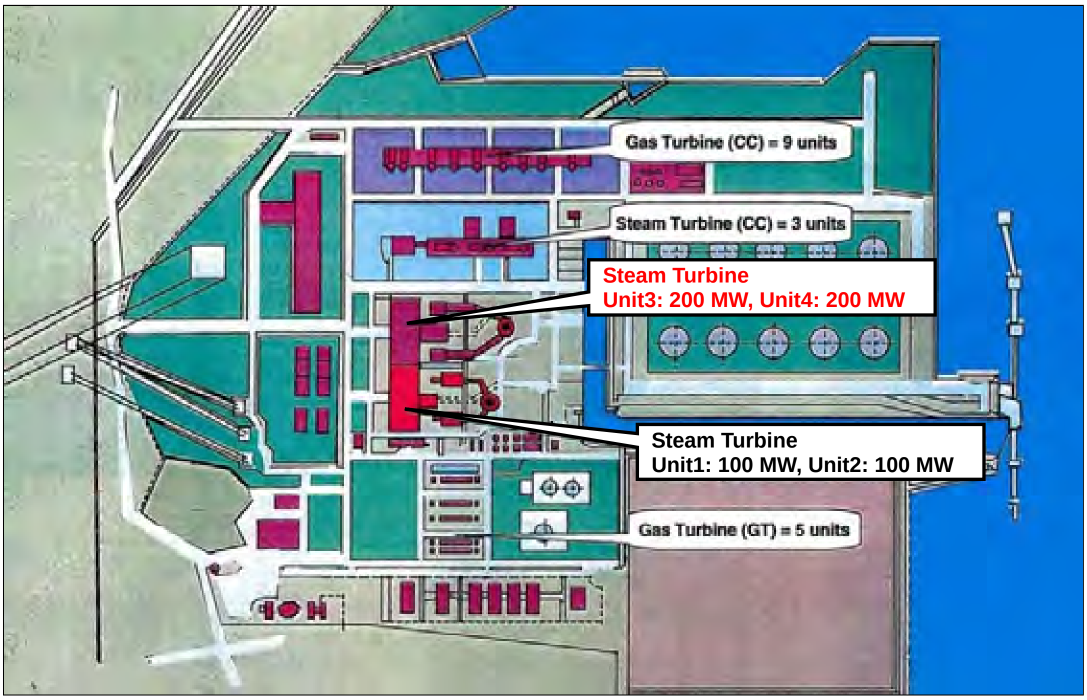

Figure 1: Grand Layout of Gresik Thermal Power Plant

As of 2009, the total installed capacity of the Gresik Thermal Power Plant makes up approximately as much as 10.2% (1.8% for Units 3 and 4) of the total capacity of the Java-Bali power system and still remains an important part of the system (Figure 1).

Photo 1: Gresik Thermal Power Plant
(Note) Taller chimney belongs to Units 3 & 4

The peak load in 2002 for West Java Province, which contains the largest demand area including Jakarta, was 8,251MW, and when considering the reserve margin, a total supply of 10,310MW was needed. This was beyond the total installed capacity at the time of 9,848MW, thus electricity supply from East Java Province where reserve margin for electricity supply exists, was desired. Therefore, the project had the aim of contributing to tackle the problem of this predicted power demand.

At the time of basic design study implementation, a 500kV transmission line connecting Eastern and Western Java on southern-route, in addition to the existing two lines on northern route, was under construction to ensure the stable function of Java-Bali power system. This project was thus planned before the extension of the southern-route transmission line to which the Gresik Thermal Power Plant was to be connected. This southern-route 500kV transmission line was completed in July 2006 and has been operating since August of that same year, meaning the project was completed before the installment of the transmission line.

The power-generating capacity in 2007 improved up to 19,980 MW and the maximum power demand reached 16,896MW, becoming twice of that of the year 2002. Additionally, according to the RUKN 2008 - 2027 (mentioned above), the power demand for Indonesia will grow at a rate of 9.5% per annum (approximately 9.8% for the Java-Bali power system and 8.2% for the outer islands). Easing the pressure of electric power demand and supply is strongly aspired, and there still is a growing need of transmitting electricity from Eastern Java to Western Java where power demand is concentrated.

Reflecting the large increase in crude oil prices in recent years, two crash programs have been underway stipulated by the Presidential Decrees, with which electricity generation using coal and renewable resources such as geothermal and hydro, will be further accelerated (program one: 2006 - 2009 (later amended to - 2013), program two: 2009 - 2014). However, fuel usage shift is largely influenced by the progress of new power plant development in the country. The importance that the Gresik Thermal Power Plant possesses remains high when considering the necessity of ensuring the stable power supply through the existing power plants, applying the optimal power supply configuration using various kinds of fuels, and dealing with emergency.

Considering the above points, while the development of new power plants has been behind the scheduled timing since the initiation of this project until now, a project like this which quickly secured the stable power supply by rehabilitating the existing facilities, is at high priority and urgency.

3.1.3 Relevance with Japan's ODA Policy

The three focus areas within the Country Assistance Program for the Republic of Indonesia, published by the Ministry of Foreign Affairs in November 2004, are: (a) assistance to realize sustainable growth driven by private sector; (b) assistance to create a democratic and fair society, and; (c) assistance for peace and stability. The above (a) includes the aim of establishing economic infrastructure to improve the investment environment, which refers to the importance of assistance towards upgrading the power-generating capacity in the power and energy sector. Therefore the target project is also relevant to our country's aid policy towards Indonesia.

The Government of Japan has been supporting the Gresik Thermal Power Plant since 1975 through a series of ODA loans and grant aids. Units 3 and 4 were constructed and further modified to adapt plural fuel use (gas and oil) through ODA loans, and the assistance is longstanding. In relation with the Java-Bali power system, to which the Gresik Thermal Power Plant supplies its generated output, the assistance provided by the GOJ plays the core role as seen in the fact that a total of 15 ODA loan projects have been carried out since 1971. At the time of basic design study implementation, erosion and corrosion of the turbines and other facilities of Units 3 and 4 was evident, and a possibility of that resulting in a large-scale hazard, which would also largely influence the Java-Bali power system, was considerable. The necessity and urgency of this project was thus affirmed.

This project has been highly relevant with the country's development plan, development needs, as well as Japan's ODA policy, therefore its relevance is high.

3.2 Efficiency (Rating: a)

3.2.1 Project Outputs

The output of this project was as planned. The details are explained in Table 1. As for the Indonesian side, part of the operation was allocated and carried out.

Table 1: Project Outputs

The Japanese side	
Plan (B/D)	**Actual**
Outputs related to Units 3 and 4 (rated output: 400MW) • Steam turbine facilities Complete replacement of moving blades, repair of high and intermediate pressure turbine rotor and low pressure turbine rotor, replacement and repair of nozzle diaphragm, replacement of all grand / nozzle packing rings • Major steam valves Replacement of internal parts, replacement of parts of hydraulic cylinders and replacement of parts of power cylinder • Boiler feed-water pump Repair and partial replacement of inner parts	As planned
The Indonesia side	
Assigned works • Disassembly, check, and assembly of respective equipment and facilities • Supply of fuel and manpower at trial operation • Inland transportation of procured materials	

(Note) B/D =basic design study

3.2.2 Project Inputs

3.2.2.1. Project Period

In the basic design study report, the project period was envisaged as the following. Total period: 21 months (from conclusion of E/N until trial operation and completion of performance test); detailed design: 3 months (including the preparation of the tender documents); tender: two months (from the tender notice to the tender evaluation); procurement and installation: 16 months (from contract to trial operation and completion of performance test).

The project execution in reality took 20 months (from July 2004 to February 2006) in total, which was shorter than expected (Table 2). It took 5 months (from August to December 2004) for the detailed design and the tender, and 15 months (from December 2004 to February 2006) for the procurement and installation.

Table 2: Project Period

Activities	Plan (B/D)	Actual
Total period (from conclusion of E/N until trial operation and completion of performance test)	21 months	20 months
detailed design including the preparation of the tender documents	3 months	5 months
Tender	2 months	
Procurement and installation	16 months	15 months

3.2.2.2. Project Cost

The actual expense covered by the Japanese government was 1,975 million yen, compared to the E/N limit of 1,985 million yen (99%), and was within the planned amount. Effort to reduce the construction cost was realized by adopting strategies such as contracting three local subcontractors out of the allotted six for procurement and installation.

Table 3: Project Cost

Activities	Plan (B/D)	Actual
Total amount of Grant Aid	**1,985 million (E/N limit) yen**	**1,975 million yen**
Material cost	1,637 million yen	1,911 million yen
Installation cost	286 million yen	
Design and procurement	65 million yen	64 million yen

(Note) Exchange rate: 1 rupiah = 0.0151 yen, 1 US dollar = 119.72 yen (as of August 2003)

Both project period and project cost were within the plan, therefore efficiency of the project is high.

3.3 Effectiveness (Rating: a)

3.3.1 Quantitative Effects

3.3.1.1. Results from Operational Indicators

There is less gas-fired power generation at Units 3 and 4 than described in the B/D study report and the oil-fired generation remains the main power source[1]. However, the operation is going smoothly and stable power generation is secured. The expected residual life of the facilities is 20 years after construction as initially planned.

Along with the maximum output and the gross thermal efficiency that were described as the evaluation indicators to monitor the project achievement in the basic design report, the capacity factor, the planned outage hours and the unplanned outage hours are also confirmed as shown in Table 4. The gross thermal efficiency is above the target figure. The maximum outputs at the time of inspection after the one-year warranty period were confirmed as 197MW for Unit 3 (February 2007) and 195MW for Unit 4 (October 2006) for the oil-fired power generation. However, at the time of this evaluation, both Units 3 and 4 had an output of 195MW (20.4% of recovery) for gas-fired generation, and 187 to 190MW (Unit 3) and 180 to 190MW (Unit 4) for oil-fired generation. The maximum outputs are below the target figures since Units 3 and 4 mainly use oil for power generation. Nevertheless, it still surpasses the maximum output of oil-fired power generation before the implementation of this project (162MW for Unit 3,172MW for Unit 4 as of 2003), and effectiveness of the project therefore is admitted.

Table 4: Operation Performance of Units 3 and 4

Indicators (unit)			Baseline	Target	Actual			
			2003	2006	2006	2007	2008	2009
Maximum output (MW)	Gas-firing (both Units 3 and 4)		-	200	195			
	Oil-firing	Unit 3	162	195	187	187	187	190
		Unit 4	172		185	180	180	190
Gross thermal efficiency (%)		Unit 3	31.55 (35.48)	34.70	38.20	38.00	37.53	38.10
		Unit 4	31.48 (35.23)	34.60	36.70	36.64	36.77	36.97
Planned outage hours (hours)		Unit 3	399.34	-	370.52	720.34	765.10	411.89
		Unit 4	704.03	-	462.47	749.94	412.41	1,041.82
Unplanned outage hours (hours)		Unit 3	187.84	-	273.33	0	0	49.18
		Unit 4	269.382	-	0	154.29	0	0

(Source) Gresik Thermal Power Plant

(Note) Figures with blankets for the baseline of gross thermal efficiency are values from 1994 when the facilities were modified for both gas-firing and oil-firing.

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[1] There is a severe shortage of gas supply throughout Indonesia, and blocks of gas turbine combined cycle power generation facilities are more prioritized to use gas delivered to the Gresik Thermal Power Plant since their thermal efficiency is higher than the rest facilities in the Plant.

As shown in Figure 2, the capacity factor is secured at approximately 70% to 90% for both Units 3 and 4. The net power generation after 2006 for Units 3 and 4 are both above the figures recorded before the project implementation in 2003 and is under smooth operation. The decline in net power generation admitted in some years after 2006 is because the Load Control Center (PT PLN (Persero) P3B) who overlooks the Java-Bali power system is requesting the Gresik Thermal Power Plant to restrict power generation of Units 3 and 4. The reason to this is because of their relatively high generating costs due to the recent rise in crude oil price, which they mainly use for power generation[2], and their aged facilities compared to other power plants after 20 years of its operation. Units 3 and 4 operate at full load during peak load hours and at its minimum output during base load hours.

	2003	2004	2005	2006	2007	2008	2009
Net power generation MWh (Unit 3)	1,058,709	925,389	821,320	1,174,937	1,243,550	1,212,682	1,214,624
Net power generation MWh (Unit 4)	974,878	958,763	848,746	1,188,195	1,183,763	1,255,859	1,087,726
Capacity Factor % (Unit 3)	93.3	56.2	49.9	71.0	75.1	73.0	94.5
Capacity Factor % (Unit 4)	88.8	58.2	51.5	71.7	71.7	75.9	86.6

(Source) Gresik Thermal Power Plant
(Note) Figures 2009 up to the third quarter of the year

Figure 2: Net Power Generation and Capacity Factor of Units 3 and 4

The planned outage hours were spent for periodic inspection. The reason that the planned outage hours rose in 2009 is because the serious inspection of every 4 years was scheduled and implemented (for schedule and records of each periodic inspection, refer to the article *3.5.4 Current Status of Operation and Maintenance*). The main objective of having the unplanned outage hours was to resolve the defects in facilities that are found through the daily inspections. The pressure of the boiler furnace becoming too high, damage to the pipes, and leakage from the boiler tubes are mentioned as the main causes of the unplanned outage, and appropriate repair works have been done against them. Ever since the implementation of this project, a stable capacity factor has been secured, implying that these kinds of unplanned outage hours are relatively suppressed.

3.3.2 Qualitative Effects

Not specifically.

This project has largely achieved its objectives; therefore its effectiveness is high.

[2] Actual fuel cost (oil – gas) in 2009 was 96% - 4% for Unit 3, and 93% - 7% for Unit 4. Gross electric energy production for oil-fired and gas-fired is near 80% and over 20%, respectively, for both Units 3 and 4.

3.4 Impact

3.4.1 Intended Impacts

(1) Benefit to target region and residents

At the time of ex-ante evaluation of this project, the project was regarded to bring benefits to the region covered by the Java-Bali power system and their residents. It was regarded to contribute to the stable supply of electricity to the Java-Bali power system that includes residents in Java, Madura and Bali.

The power generated by Units 3 and 4 accounts up to approximately 20% of the whole power plant. Presently, among the power generation facilities of the Gresik Thermal Power Plant, the gas turbine combined cycle connected to the 500kV transmission line supplies electricity to a wide area including West Java. On the other hand, the generated electricity from Units 3 and 4 is transmitted to the WARU substation using the 150kV transmission line and supplied to Eastern Java.

Since the annual power generation is in general improved, it can be said that the project has considerably contributed to the power supply of the Java-Bali power system.

(2) Reduction on fuel cost

At the time of ex-ante evaluation of this project, through the improvement of the gross thermal efficiency of the target facilities, it was expected that a sum of approximately 700 million yen would be saved when gas-fired as a result of the fuel reduction effect at Units 3 and 4. From the completion of the project up to now, the actual operation using gas was 13% to 25% of the total power generation. KODECO, HESS and MKS are the gas suppliers to the Gresik Thermal Power Plant; however, the supply rate of all three companies was below the contracted amount. This is due to the gas shortage within the country and is inappropriate to assess the impact of fuel usage reduction and reduction of fuel cost realized through the gas usage by comparing the actual and predicted figures of the basic design study report.

(3) Impacts on the natural environment

Likewise the reduction of fuel costs, it is inappropriate to refer to the impact of the project has upon CO_2 reduction mentioned in the basic design study report. This was expected to be realized thought the reduction of fuel usage resulting from the improvement of gross thermal efficiency by gas-firing; however, the operation by gas-firing is limited and it is thus not possible to assess the impact as for now.

As for the enforcement of the environmental monitoring for plant operation, it was confirmed, at the time of basic design study implementation, that concerned environmental management and monitoring reports had been submitted to the institution concerned every three months and they found no need of amendment of the environmental impact assessment, environment management plan and environmental monitoring plan of the target project facilities of Units 3 and 4.

No serious environment impacts caused by the operation of the Gresik Thermal Power Plant have been identified up to the time of this evaluation. First of all, regarding the quality of the oil used at the Gresik Thermal Power Plant, the ratio of C: H: N: S between 2006 to 2009 have been 80.12 - 84.79%: 0.21 - 11.9%: 0.51 - 0.685%: 1.22 - 2.07% and within the given standard by the government. Secondly, results from the two environmental monitoring of the levels of SO_2 from Units 3 and 4 in 2009 recorded by the authorities of the Provincial Government of East Java became far below the national standard although some reports in 2006 and 2008 showed that the level exceeded. The levels of NO_2 and floating particles also have been always below the national standard.

As for now, there are no plans by the PLN of taking countermeasures such as desulfurization / denitrification facilities.

(4) Land acquisition and resettlement

As initially foreseen in respect of land acquisition and resettlement, there was no need of any land acquisition or resettlement since the project aimed at rehabilitating the existing facilities.

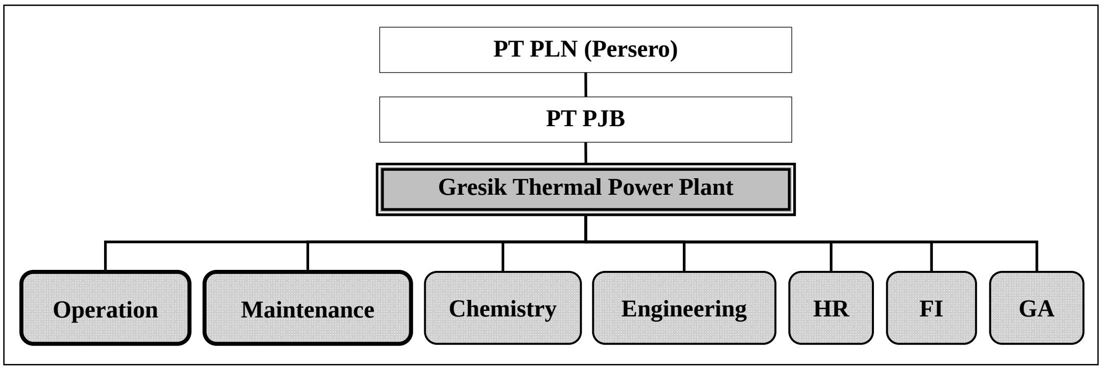
3.4.2 Other Impacts

Not specifically.

3.5 Sustainability (Rating: a)

3.5.1 Structural Aspects of Operation and Maintenance

The Java-Bali Power Corporation (PT PJB, hereinafter "PJB"), which is one of the two companies that have been formed through dividing PLN's power generation department in charge of Java region, is the owner of the Gresik Thermal Power Plant. The Organization Chart of the Gresik Thermal Power Plant is as shown in Figure 3. Under the plant manager, there are deputy managers in charge of operation and maintenance, and working teams assigned for each boiler and turbine facilities work under them with each team appointed with a supervisor. The Environment Unit of the Chemistry Department carries out the environmental monitoring.



(Source) Adapted from Gresik Thermal Power Plant

Figure 3: Organization Chart of Gresik Power Plant

At the time of basic design study implementation, four teams consisting of 36 staff members who belonged to the PJB Generation Unit working in three shifts around the clock conducted the operation of Units 3 and 4 of the Power Plant. The PJB Maintenance Business Unit conducted the maintenance of the Power Plant and the number of members was increased from 15 to 143 by February 2003. Through this increase in working staff, they aimed at, other than to allocate more staff for breakdown maintenances, identifying points for future large-scale rehabilitation of facilities through preventive and monitored maintenance, and conducting repairing work necessary for periodic inspection. This kind of new structure change to the Maintenance Business Unit was adjudged appropriate from the point of view of lengthening of the expected residual life of equipment, prevention of deterioration of the facilities, and replacement of deteriorated facilities of Units 3 and 4.

There are no significant changes in the organizational structure of the Operation Maintenance Unit after the completion of the project. The team that is in charge of Units 3 and 4 is the same one in charge of the Gresik Thermal Power Plant's operation and maintenance indicated in Figure 3. The current number and arrangement of the operation and maintenance staff is as shown in Table 5. Four 10-man teams are assigned for the daily operation and working in three shifts around the clock. There are no problems concerning the organizational structure of operation and maintenance and can be adjudged appropriate.

Table 5: Operation and Maintenance Staff of Gresik Power Plant

Unit	Planned		Actual		
	Number of staff	License level	Number of Staff	License level	Of that Nr. of engineers
Operation	120	3	120	3	12
Maintenance	130	3	130	3	10

(Source) Gresik Steam Power Plant

(Note) Level 3 refers to the national license holders who possess a certain level of knowledge operation and maintenance in Indonesia

3.5.2 Technical Aspects of Operation and Maintenance

Members who are engaged in operation and maintenance are those who hold Level 3 of national license. Level 3 license holders have attained knowledge on such as, thermodynamics, water quality management, combustion theory, boiler operation, steam turbine operation, electrical power system, alternators, control system, various efficiency and steam turbine power plant operation.

Photo 2: Inside of Steam Turbine of Unit 3 (Steam Valve)

Additionally, regular technical trainings are held within PJB. The main courses intended for the training of the workers at the Plant, where experts in boilers and turbines are invited from external training institutions, are shown in Table 6. As for other training courses such as for nondestructive testing (NDT), is done through the dispatching of staff members to external training facilities.

The technical level of staff members in charge of operation and maintenance are considered to be sufficient for routine inspections conducted daily and annually.

Table 6: O&M Trainings for Staff of Gresik Thermal Power Plant

Contents	Objective	Trainee	Instructor	Frequency	Period
Boiler inspection	Improving skills of boiler operation and maintenance	10	1	Every quarter	2 weeks
Turbine inspection	Improving skills of turbine operation and maintenance	10	2	Every quarter	2 weeks
Nondestructive testing (NDT)	Improving engineering skills of condition monitoring	10	3	Every quarter	2 weeks
Pumps/auxiliary engine	Improving skills of pump and auxiliary maintenance	10	1	Every quarter	2 weeks

(Source) Gresik Thermal Power Plant

3.5.3 Financial Aspects of Operation and Maintenance

PLN is mandated to approving the budget plan submitted by the Gresik Thermal Power Plant through PJB. As in Table 7, the actual repairing costs for Units 3 and 4 accounted as much as 14.15% (2007) of that of the whole Power Plant and stable budget is secured for the two Units since 2006.

Table 7: Operation and Maintenance Cost: Gresik Power Plant vs. Units 3 & 4

(Unit: million rupiah)

Item	2006	2007	2008	2009
(1) Plant	200,626	139,241	143,981	201,295
(2) Units 3 and 4	13,097	19,697	18,863	20,443
(2) / (1) (%)	6.53%	14.15%	13.10%	10.16%

(Source) Gresik Thermal Power Plant

The repairing costs of Units 3 and 4 from 2006 to 2010 that PJB presented at the time of basic design study implementation averaged at 21,872 million rupiahs (330 million yen[3]), and when comparing that with the actual costs between 1998 and 2002, which averaged at 7,548 million rupiahs (114 million yen), it has become 2.9 times larger and measures for lengthening the facility life was well underway.

Comparison of the annual planned and actual expenditure of maintenance budget for Units 3 and 4 are shown in Table 8. The actual expenditure has not reached the planned figure apart from the year 2008; however, speedy repair is undertaken when problems with facilities are found through the periodic inspections and even daily inspections. No problems stemming from the lack of budget could be observed and it can be said that necessary coverage of budget has been secured and is spent efficiently.

Table 8: Units 3 & 4 Operation and Maintenance Budget (Plan and Expenditure)

(Unit: million rupia)

	2006	2007	2008	2009
Planned	17,110	23,085	18,764	30,545
Actual	13,097	19,697	18,863	20,443

(Source) Gresik Thermal Power Plant

3.5.4 Current Status of Operation and Maintenance

In the site visit at the time of this evaluation, the operation conditions were inspected and was confirmed that the operation and maintenance was conducted without major problems.

With regards to maintaining the operating condition, PJB has adopted the Maintenance Optimization Program (MOP) since July 2003 and has increased the rate of preventive, corrective and predictive maintenance in order to reduce the accident rate. In the site inspection at Gresik Thermal Power Plant, pervasion of preventive maintenance could be observed and handling of issues was done on demand according to the situation.

In addition to the daily inspections, there are three kinds of periodic inspections carried out: simple inspection (18 days/every two years), mean inspection (30 days/every 4years) and serious inspection (45days/every 4 years). The schedule for periodic inspections for Units 3 and 4 are shown in Table 9. It takes around 432 hours, 720 hours, 1,080 hours for the simple, mean and serious inspections, respectively. When comparing the schedule for periodic inspections on Table 9 with the planned outage hours in Table 4, the initial planned outage hours for 2008 and 2009 becomes close to the actual time for periodic inspections, whereas it was not necessarily reflected in 2006 and 2007 when the units were stopped due to the project implementation and inspection after completion.

[3] 1 rupiah=0.0151 yen (December 2003)

Table 9: Periodic Maintenance Schedule of Units 3 & 4

Unit	2006	2007	2008	2009	2010 (plan)
Unit 3	Serious	Simple	Mean	Simple	Serious
Unit 4	Simple	Mean	Simple	Serious	Simple

(Source) Gresik Thermal Power Plant

No major problems have been observed in the operation and maintenance system, therefore sustainability of the project is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The target project has contributed to the stable power supply in the Java-Bali power system by assisting the large-scale rehabilitation of Units 3 and 4 of the Gresik Thermal Power Plant, caused by aged deterioration. Relevancy of the project has been affirmed in the situation of the power sector in Indonesia. Since the enhanced performance of Units 3 and 4 is realized and maintained, effectiveness and sustainability are high as a result. No problems were observed concerning the efficiency of the execution of the project.

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

4.2 Recommendations

4.2.1 Recommendations to Executing Agency

If oil-fired power generation remains to be the main source of power generation at Units 3 and 4, the effect on facilities and the results of environmental monitoring should be carefully assessed, and when problems such as emission figures continuously exceeding the environmental standards, countermeasures such as the installation of denitrification / desulfurization facilities should be considered as future potential actions.

4.2.2 Recommendation to JICA

Not specifically.

4.3 Lessons Learned

Considering the past ODA loans for construction of Units 3 and 4 and modification works for both gas- and oil-firing use, this Grant Aid project is an example of a well-timed and effective execution of a cross-schematic assistance by the Government of Japan.

A shortage of gas supply still remains in Indonesia, and since Units 3 and 4 can operate at both gas- or oil-fired, it makes it possible to contribute to the stable power supply in Eastern Java by providing a flexible option with its fuel usage. For further assistance towards the power and energy sector, it is recommended to consider points such as, following-up of completed projects, countermeasures against environmental impacts, future repair plans, various rehabilitation programs, lengthening of facility life, and effective project processing.

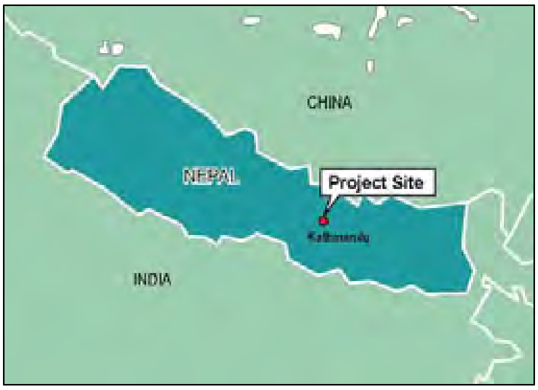
(End)

Nepal

Ex-Post Evaluation of Japanese Grant Aid Project
"Extension and Reinforcement of Power Transmission and Distribution System in Kathmandu Valley (Phase 3)"

External Evaluators: Mitsue Mishima, OPMAC Corporation
: Keiichi Fujitani, Tokyo Electric Power Company

1. Project Description



Project Location

Gas Insulation Switch (GIS) and K3 Substation building

1.1 Background

This project (hereinafter referred to as "the Project") is one of those suggested under the "Master Plan and Feasibility Study on Extension and Reinforcement of Power Transmission and Distribution System in Kathmandu Valley in Nepal" (hereinafter referred to as "MP") implemented by JICA in 1991. Projects developed in accordance with the MP were implemented primarily with the financial cooperation of Japan, prioritizing underdeveloped areas in the Katmandu valley.

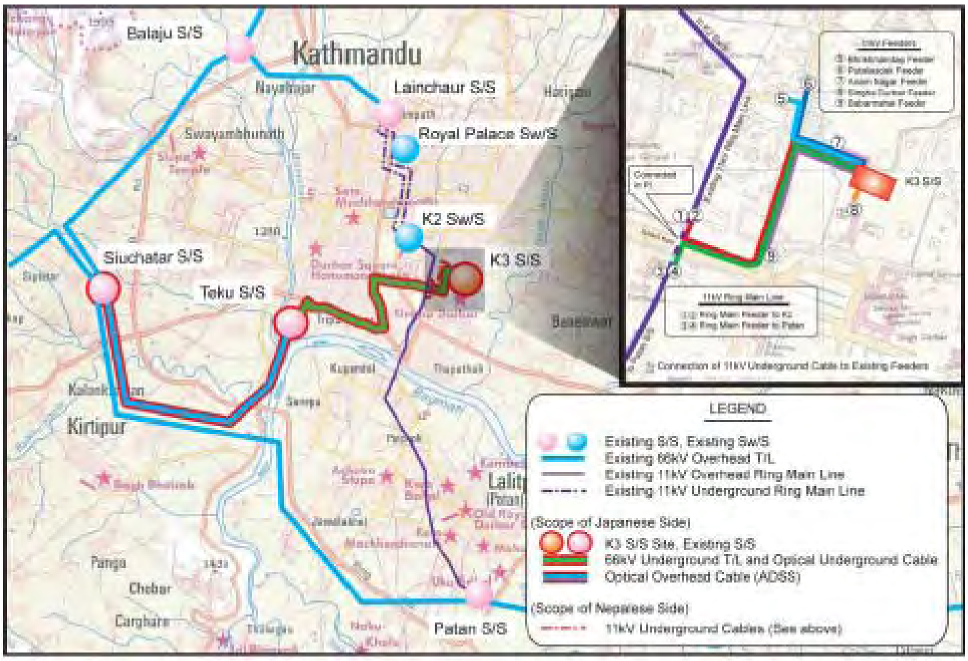
Due to the delay in development of power generation, the power sector in Nepal has suffered from a chronic shortage of power since the first half of 1990. Therefore, as the basic design study for this project (hereinafter referred to as "B/D") stated, the most serious issue was supply shortage in the power sector. With hydropower generation as the source of electricity, scheduled power cuts were conducted in a wide area, particularly during the dry season when power generation capacity declines. In 2002, four new power plants with a total capacity of 254MW (Khimti Khola, Upper Bhote Koshi, Modi Khola, Kali Gandaki A) were completed and commenced operation. In addition, Chilme and Middle Marsyanghi power plants were under construction.

At the time of basic design study (B/D), it was thought that provided this power development plan was implemented smoothly, there would be no problem with power generation shortages until 2013, that is, the shortage of power plants would be mostly solved. Accordingly, at that time, the immediate issues were deemed to be strengthening power transmission capacity and, given the increased use of computer-related equipment, reinforcing the transmission and distribution capacity to obtain a highly stable and reliable power supply.

Power supply in the center of Katmandu came from a rim of suburban substations which transformed the 66kv and 132kV from external lines to 11kV, with onward transmission from the substations through 11kV lines. Power supply to the center of Katmandu heavily depended on the K2 switchyard, which is located on the site of a Nepal Electricity Authority (NEA) building; however, there was a shortage of power supply line capacity from the Patan substation to the K2 switchyard. Moreover, Patan substation was short of transformer capacity, so there was a constraint to the load or load shedding to other substations during the dry (winter) season when the load peak occurs. If one transformer in the Patan substation failed, or an 11kV transmission line from the Patan substation to the K2 switchyard had a problem, a power failure in a wide area for a long time could be triggered. Consequently, new substation construction was indispensable to reinforce the power supply line to the K2 switchyard and to reduce the burden at the Patan substation.

1.2 Project Outline

The objective of this project is to supply highly reliable electric power in the center of Katmandu city, by constructing a new substation for distribution lines (K3 substation) and by extending high voltage underground transmission lines from existing substations (Teku and Siuchatar substations) to a new substation (for locations, refer to Figure 1 "Project Area and Related Facilities").



(Source) "The Kingdom of Nepal: Basic Design Study on the Project for Extension and Reinforcement of Power Transmission and Distribution System in Kathmandu Valley (Phase 3)" November, 2002

Figure 1: Project Area and Related Facilities

Grant Limit / Actual Grant Amount	16 million yen / 16 million yen (Detailed Design) 138 million yen / 113.6 million yen (Main construction)
Exchange of Notes Date	February, 2003 (Detailed Design) July, 2003(Main construction)
Implementing Agency	Nepal Electricity Authority: NEA
Project Completion Date	February, 2005

Main Contractors	Joint Venture of Sumitomo Corporation and Kinden Corporation
Main Consultants	Nippon Koei Co., Ltd.
Basic Design	November, 2002
Detailed Design	February, 2004
Related Projects	[Development Study] "Master Plan (MP) and Feasibility Study on Extension and Reinforcement of Power Transmission and Distribution System in Kathmandu Valley in Nepal" (1991) [Grant Aid] "Extension and Reinforcement of Power Transmission and Distribution System in Kathmandu Valley" (FY 1992-1993) "Extension and Reinforcement of Power Transmission and Distribution System in Kathmandu Valley, Phase 2" (FY 1994-1995)

2. Outline of the Evaluation Study

2.1 External Evaluators

Mitsue Mishima, OPMAC Corporation
Keiichi Fujitani, Tokyo Electric Power Corporation

2.2 Duration of Evaluation Study

For the post evaluation on the Project, evaluators conducted the survey according to this schedule:

Duration of the Study: October, 2009 – August, 2010
Duration of the Field Study: March 12, 2010 – March 21, 2010

2.3 Constraints during the Evaluation Study

With respect to information during the project construction, evaluators checked documents such as project reports and interviewed the Japanese consultant in charge at the time of the project implementation. All personnel in charge on the NEA side at the time of project implementation had already retired and therefore could not be interviewed. In addition, evaluators could not obtain some of the documents (the IEA, or Initial Environmental Assessment) regarding the project implementation from the NEA side. However, through verifying the project site facilities from a technical point of view, interviewing current staff of NEA's Construction Department, and examining the existing documents from the Japanese side, enough evidence for a proper evaluation was obtained.

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

3.1 Relevance (Rating: a)

3.1.1 Relevance with Development Plan of Nepal

At the time of the Project implementation, the Ninth Five-year Plan (1997/98 – 2001/02) aimed at poverty reduction and listed 20 priority issues including electric power development. Within electric power development, increase in power supply was prioritized, coupled with institutional reform in the power sector, rural electrification, and so on. In particular, transmission and distribution reinforcement were discussed in response to the demand for electricity in urban areas. Later, the Tenth Five-year plan (2002 - 2007) was integrated with the Poverty Reduction Strategy Paper (PRSP) and indicated the objectives of each sector, pursuing poverty reduction. It emphasized the importance of accelerating economic growth and infrastructure development in order to achieve poverty reduction. In this context, expansion of the power supply, centered on the main issues of rural electrification and export of electricity through hydro power development, was listed as an aim. This project aimed at increasing and stabilizing power supply in Katmandu, and was therefore consistent with power sector goals in the national development plan of the time.

After 2008, no new five-year plans have been forthcoming. The most recent national development plan is the "Three Years Interim Plan" (2008 - 2010). One of the four priority areas is to increase investment in infrastructure such as hydropower, roads, irrigation, and telecommunications to support agriculture, tourism and industry. In the field of electric power and energy, the objectives were discussed as promoting development of hydro power generation and improving access to electricity for people in rural areas. The plan states that reinforcement of transmission capacity (construction of new transmission lines and substations) and expansion of the distribution system will be implemented in both rural and urban areas.

3.1.2 Relevance with the Development Needs of Nepal

The Project was originally planned to be implemented under part of the Japan's general grant scheme, nemely, Extension and Reinforcement of Power Transmission and Distribution System in Katmandu Valley (Phase-2) (FY 1994-1995); however, in the end this was not undertaken due to the shortage of power generation sources in Nepal side. While the shortage of power was being alleviated by the completion of new power plants and projected output capacity of those under the construction, the lack of capacity of power supply lines and substation transformers was becoming an obstacle in realizing stable power supply to the center of Kathmandu. Given this situation as a background, it appears there was a need for the construction of a new substation in the center of Kathmandu. Necessity for construction of power supply lines and improvement of substation transformer capacity shortage is affirmed as it was examined at the time of planning.

Even after the implementation of this project, however, serious power shortages have continued, due to delays in the development of power plants, lack of power generation caused by shortage of water, and trouble with the transmission line from India. As of March 2009, while peak load was 790MW, actual supply capacity was 420MW, far below the peak load. During 2009, scheduled power cuts were conducted for up to 16 hours per day in the Kathmandu area; in 2010, cuts continue at up to 12 hours per day.

On the other hand, the most recent system plan by NEA, "System Planning Report" (2008)[1], discusses reinforcing transmission and distribution lines, together with basic principles such as a power development plan focusing primarily on hydropower and power transmission with India and so on. This report also indicates that the reliability and quality of the power supply in the power system network plan is secured under any circumstances. Planning the system in line with the "N-1" standard[2] were described in the system plan in 1998, and this planning policy

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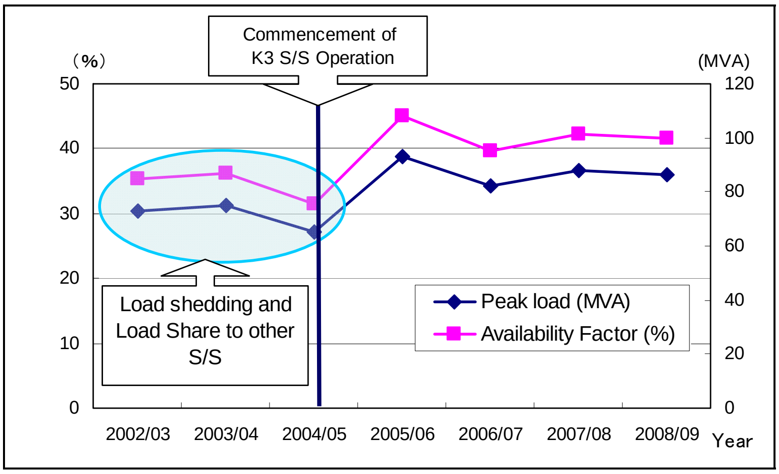
1 This report is basically a version of "Power system Master Plan for Nepal: Transmission System Master Plan" (drafted with ADB support in 1998) updated with new data. .

2 System planning which avoids forced outage in electricity supply upon having trouble in one unit of the facilities – such as power generators, transformers, transmission and distribution lines – comprising the power system.

continues.

This project is consistent with the N-1 standard system plan. At present, the K3 substation and K2 switchyard are each supplying 50% of the load in almost the same area. Without the K3 substation, load shedding due to overload would presumably have continued in power source substations for the K2 switchyard such as the Patan substation. As shown in Figure 2, examining the trends in availability factor and peak load at the Patan substation, stable power supply (without load shedding or replacing the load to other substations) has been realized since the K3 substation commenced operation. If there were no K3 substation, the power supply may have deteriorated further as additional load shedding would have been necessary to meet the increasing demand.



(Source) NEA Document

Figure 2: Availability and Peak Load at Patan Substation

To summarize, the power shortage has not been alleviated as predicted at the time of pre-evaluation; however, the Project is consistent with development needs in terms of avoiding power failures in a wide area in line with the Project objective.

3.1.3 Relevance with Japan's ODA Policy

At the time of the B/D, ODA policy for Nepal had "Economic growth to contribute to poverty reduction" as a basic principle and stated that Japanese assistance would be implemented to meet the Tenth Five-year Plan (PRSP). It recognized the necessity of accelerating further infrastructure development, the basis of economic development, since for poverty reduction it was indispensable to have the Nepalese economy grow even while the peace is more firmly established. Priority areas were stated as (a) improvement of the social sector, (b) agricultural development, (c) economic infrastructure development, (d) human resource development, and (e) environmental conservation. It indicated specifically that continuing grant aid and technical cooperation from Japanese ODA would primarily support basic infrastructure development in areas such as electric power, road, water supply and sanitation, information and communication and so on. The Project is in line with support for basic infrastructure development and thus consistent with Japan's ODA policy.

The Project is one of the projects stemming from "the Master Plan (MP) and Feasibility Study on Extension and Reinforcement of Power Transmission and Distribution System in Kathmandu Valley in Nepal", which was implemented with Japanese assistance. Some higher priority projects suggested by the MP were conducted as phase 1 and 2, and then the Project was conducted as phase 3. The target area of this project is the center of the Kathmandu city, where electricity demand is high and reinforcing transmission and substation systems was considered to be urgent.

This project has been highly relevant with the country's development plan, development needs, as well as Japan's ODA policy, therefore its relevance is high.

3.2 Efficiency (Rating: a)

3.2.1 Project Outputs

Outputs on the Japanese side are shown in Table 1. Comparing the plan and actual implementation, the scope of outputs was as planned.

Photo 1: Overview of Equipment in Siuchatar Substation

Regarding outputs on the Nepalese side, the plan indicated land acquisition and reclamation by soil filling for the area for the K3 substation building, wall construction, 11kV distribution line connection (procurement of materials and construction), telephone and water connection, and furniture procurement. Other than cancellation of wall construction, all works were undertaken as planned. The reason why the wall construction was not necessary was, according to NEA, "the indoor substation is within the premises of Singha-Durbar which already has a safe and secure wall". After examining the Project site, this reason was considered to be appropriate.

Table 1: Project Output

The Japanese side	
Plan (B/D)	**Actual**
• K3 Substation Building, Installation of Remote Terminal Unit (RTU) • Modification of Teku substation • 66kV underground transmission line construction (K3 − Teku) • Extension of 66kV switchgear at Siuchatar substation • Installation of Remote Terminal Unit (RTU) and optical fiber cable to protect transmission line (K3-Siuchatar)	As Planned
The Nepalese side	
Plan (B/D)	**Actual**
• Land acquisition and reclamation by soil filling for K3 substation building • Wall construction for K3 substation • Construction of 11kV distribution line and connection to existing lines (procurement of materials and construction) • Connection of telephone line and water supply, and procurement of furniture	Cancellation of substation wall construction. Other than the above, as planned

3.2.2 Project Input

3.2.2.1. Project Period

As agreements for Exchange of Notes (E/N) for this project were made separately for the detailed design and the main construction work, the planned and actual period for each is compared in Table 2. Detailed design required about twice the planned period: according to the Japanese consultant, this was because the detailed design had to be reviewed after reclamation work was completed by the Nepalese side, and approval for the detailed design took time. The bidding phase also required more time than planned, with two months passing between public announcement of the bidding to disclosure of its result and again because of the lengthy approval process required by the Nepalese government side before the contract was signed.

The period from commencement to completion of main construction work was shorter than planned. It took 14 months compared to 15 months in the plan for total main construction work, which is 93% of the planned period. Main construction work was finished within the due date set by E/N. Examining the total project period, except for the delay caused by the Nepalese government side, the Project was completed within the planned period.

Table 2: Project Period

Items	Plan (B/D)	Actual
Detailed Design	4.5month	10 Months
Main work (construction, procurement, installation)	**15 Months**	**14 Months**
Bidding	2.7 Months	5 Months
Commencement and completion of work	12.7 Months	9 Months

3.2.2.2. Project Cost

The total project cost for detailed design was the same as planned, and the cost for main construction work was less than planned: actual cost was 1.154 billion yen, compared to 1.417 billion yen in the plan. The Japanese grant aid amount was 1.136 billion yen, about 81% of the 1.38 billion yen limit given in the E/N. The main reason why the project cost was less than planned was primarily a decrease in equipment procurement cost as a result of competitive bidding.

Table 3: Project Cost

Items	Plan	Actual
Detailed Design	**16 million yen**	**16 million yen**
Main construction work	**1,417 million yen**	**1,154 million yen**
Japanese side (Grant Aid)	1,380 million yen (E/N due amount)	1,136 million yen
Construction cost	50 million yen	100 million yen
Procurement of equipment and materials cost	1,257 billion yen	965 million yen
Equipment design supervision cost	90 million yen	71 million yen
Nepalese side	20 million yen	17.7 million yen

(Note) exchange rate as of 2002 for the Nepalese side cost: 1 rupee = 1.58 yen、1 US dollar = 121.92 yen

Both project period and project cost were mostly as planned, therefore efficiency of the project is high.

Photo 2: Transformer in K3 Substation

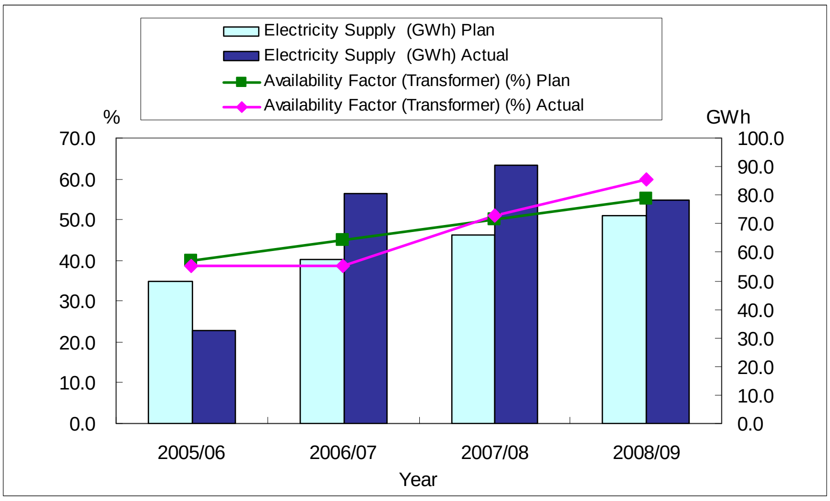
3.3 Effectiveness (Rating: a)

3.3.1 Quantitative Effects

3.3.1.1. Results from Operation Indicators

In view of the function and outputs of the Project in the power system, at first examining availability factors and electricity supply from the transformer, it is judged that facility operation is satisfactory as shown in the Figure 3.

The availability factor (total of two transformers) is nearly the same as planned for each year after the third year of operation commencement. The target operation indicator is approximately 50%, so that one transformer can cover the total electricity supply in case of a problem with the other transformer. Actual availability factors have been slightly above or below 50%. The volume of electricity supply has been nearly as per the yearly plan.



(Source) NEA Documents

Figure 3: Availability factor and electricity supply of K3 Substation

In Kathmandu city, scheduled power cuts have continued. Some further indicators were also examined as potentially relevant to the operation of the Project. Table 4 shows such main indicators.

Peak load in the Project area was increased by more than indicated in the plan in years 2007/08 and 2008/09. Unplanned outage time increased in 2008/09; however, the reason was identified as proper functioning of the relay in response to overload or over current. Transmission loss also increased in year 2008/09. According to NEA, this was due to electricity volumes being too high to be measured; therefore this was not attributed to the Project equipment operation. As a result, no problems related to the Project facilities have been identified.

Table 4: Relevant indicators in Project Area

Indicators		**2005/06**	**2006/07**	**2007/08**	**2008/09**
Peak load in Project Area (kW)	Plan	20.00	22	24.2	26.62
	Actual	**19.3**	**19.3**	**25.58**	**29.98**
Planned Outage Hours (hr/year)	**Actual**	**0:00**	**0:00**	**0:24**	**0:00**
Unplanned Outage Hours (hr/year)	**Actual**	**0:00**	**8:55**	**1:25**	**3:14**
Transmission loss (%)	Plan	0.25	0.25	0.25	0.25
	Actual	**0.23**	**0.17**	**0.18**	**0.49**

(Source) NEA Document

(Note) Planned outage is for equipment maintenance. Unplanned outage included those in areas outside of the Project area.

3.3.2 Qualitative Effects

None in particular.

This project has largely achieved its objectives; therefore its effectiveness is high.

3.4 Impact

3.4.1 Intended Impacts

(1) Positive impact on the Project area and beneficiaries (Socio-economic impact)

According to NEA at the time of the ex-post evaluation, there was no change in the scope of the Project area and beneficiaries, that is, approximately 260 thousand people, the same number as at the time of planning. In the target area, there were almost no new electricity consumers after the Project implementation. The impact of the Project was primarily in meeting an increase in electricity demand from existing electricity consumers.

Reliability of power supply was enhanced by the Project; however, scheduled power cuts continue to be conducted. Thus, impact of the Project on the socio-economic activities of residents in the target area cannot be identified.

(2) Technical Impact

A staff member in charge of maintenance and inspection at the time of the Project implementation still works in the same section and trains other staff in related departments and sections within NEA as an instructor (refer to Photo 3). This instructor explained in interview that NEA has applied what they learned about the maintenance and inspection of gas insulated switchgear (GIS; refer to the photo in section *1. Project Description*) to other GIS in other substations. The Project therefore had some technical impact on GIS maintenance and inspection.

Photo 3: Class room of a training instructor who is in charge of the Project facility maintenance and inspection

3.4.2 Other Impacts

(1) Impacts on natural environment

At present, no unintended impact on the natural environment has been reported. The B/D noted that since the new substation site was inside the joint government building area, there would be no environmental impact on residents in surrounding areas and no negative impact on the environment in that area. Transmission lines are underground cables; therefore no visual or electromagnetic radiation problems were predicted.

An examination of the Project site, revealed only a very minor length of underground cable above ground level where crossing a river (Photo 4); no problems were identified with the current situation. Consequently, the chance that serious environmental impact occurred is considered to be almost nil.

Photo 4: Underground Transmission Line Cable (at river-crossing point)

(2) Impacts on social environment

No resettlement of residents or land acquisition was planned. Ex-post evaluation confirms that no new resettlement and land acquisition was required during the Project implementation.

3.5 Sustainability (Rating: b)

3.5.1 Structural Aspects of Operation and Maintenance

The department and section in charge of operation and maintenance (hereinafter referred to as “O & M”) for the Project facilities are the Grid Operation Department under the Directorate of Transmission & System Operation, as shown Figure 4. Under the Grid Operation Department, there are several divisions in charge of particular areas. The Katmandu Valley Transmission Division, Bagmati Transmission Branch is in charge of operation and maintenance of the 66kv transmission line and substations related to the Project, and the Distribution & Consumer Services Department is in charge of the 11kv distribution lines. There has been no major change to the units in charge at the time of B/D, however, there was some organizational reform whereby the section in charge of the Katmandu valley became one division and then two branches were established within it.

The total number of staff at the Bagmati Transmission Branch is 160. Of this number, 11 staff are in the Transmission Section for transmission line maintenance, and 10 staff are in the Substation Maintenance Section. They are in charge of operation, preventative maintenance, and dealing with accidents. One engineer is assigned to each of these groups. Eight staff were assigned to K3 substation, including one assistant engineer, three supervisors, and four electricians.

NEA has established 12 technical levels related to job position, running from level 1 (Junior helper) to level 12 (Director). Those with bachelor degrees or higher are at least Level 7 (Engineer). Assistant engineer is level 6, supervisor is level 5, and electrician is equivalent to level 3. Each substation has an assistant engineer who is relatively experienced and supervises both operation and maintenance.

This arrangement of personnel is clearly defined is deemed to be appropriate, since no problems with assignments or shortage in personnel numbers were identified after hearing from stakeholders and verifying the site during the field survey.

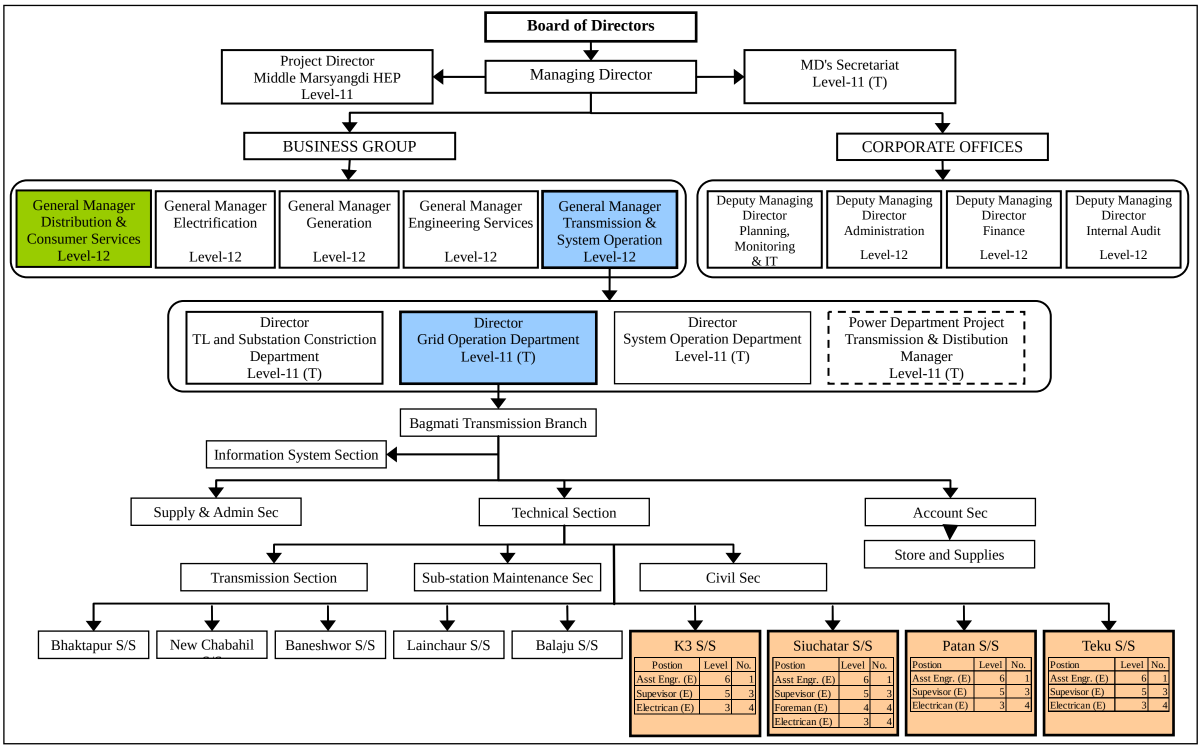


Figure 4: NEA’s Organization Chart related to O & M Sections of the Project Facilities

3.5.2 Technical Aspects of Operation and Maintenance

At the time of the B/D, no problems were expected with technical standards or operation and maintenance in particular for the Grid Operation Department under the Transmission and System Operation Directorate, since this department had experience in operating and maintaining facilities similar to the K3 substation. At the time of ex-post evaluation, no particular technical problems were observed.

As for training, targeting level 6 technical staff, a one week training course is conducted every year to enhance their technical capacity with respect to equipment such as high voltage switchgear and O & M of the facility.

Equipment operation manuals which were distributed by the Project for were confirmed to be at necessary locations and, according to NEA, no problems were reported in referring to them. During the site survey, this was verified through checking the content of manuals and interviewing relevant staff.

In addition to the above, a comprehensive assessment including interviews of O&M staff and verification of the equipment status at the Project site indicated their technical level was sufficient for identifying problems and managing basic problems with the equipment.

3.5.3 Financial Aspects of Operation and Maintenance

At the time of the B/D, the yearly operation and maintenance cost for the facilities was predicted to be 2.6 million rupees per year after the third year of operation. The actual cost for the most recent year, 2009, was approximately as predicted. Examining the details by cost item, personnel costs exceeded the predicted amount by 1.2 million rupees, and the spare parts purchase cost was lower than the 1.4 million rupees which was predicted as a necessary cost from three years after the facility commenced operation. In interviews with NEA, however, it was revealed that equipment maintenance funds are allocated as necessary when an emergency arises. In addition, since discussion with relevant personnel and inspection of the Project site during the field survey did not indicate any financial problems affecting the management of maintenance, it is considered that O &M cost has been allocated at the necessary and sufficient level.

Table 5: Operation and Maintenance Cost for the Project facilities

(Unit: Million rupees)

Items	2005 (year of completion)	2006	2007	2008	2009
Operation and Maintenance Cost	**1.73**	**1.74**	**2.32**	**2.23**	**2.55**
Personnel cost	1. 68	1.68	1.92	2.16	2.4
Equipment maintenance (purchase of spare parts)	0.05	0.06	0.4	0.065	0.15

(Source) NEA Documents

3.5.4 Current Status of Operation and Maintenance

Necessary maintenance and inspection for the facilities established by the Project involve a patrol inspection which is conducted every day and periodic inspection conducted once every three to six months.

At the time of inspection at the end of the warranty period after the Project completion, it was judged that no new recommendations were necessary since K3 substation was operated, maintained, and inspected along in accordance with the initial purposes. At the time of visiting the Project site, daily and periodic maintenance and inspection were implemented as recommended at the time of B/D.

Recently in the Grid Operation Department, "Enhanced Performance Reward (EPR)" was introduced. This system sets target indicators for (for example) O&M of the equipment each operation and maintenance group is responsible for, and reflects the degree of target achievement in staff remuneration. According to the most recent annual NEA transmission & system report (August 2009), introduction of the EPR system contributed to the stability and enhancement of system operation.

According to a NEA report on the Project facility operation status, there were accidents involving a short circuit and an earth fault[3] in year 2006 and 2009, however, the problem is reported to be solved at present. Short circuit between cables was caused by a malfunction in a relay (2006) and the earth fault was caused by trouble with a cable (2009). The settings of the relay[4] were checked with its manufacturer and have been modified, and the cable was changed for another one.

Regarding the current status of the equipment, the GIS is currently operated with the DS/ES interlock system is locked, since the GIS's interlock system could not be properly set because of a malfunction in a rotary switch. This requires inspection and repair by a technical expert from the manufacturer. NEA has no plan to solve this problem until the next periodic inspection of the GIS by the manufacturer once every ten years.

The interlock system is intended to prevent accidents caused by mistaken operation through human error. There is no problem if NEA staff remain conscious that they are operating the equipment with the interlock locked. Incorrect operation would cause a risk of harm to personnel or power failure. Consequently, constant attention is required for this equipment malfunction.

As a result of the above-mentioned analysis, O&M of the Project has no major problems with organizational, technical or financial aspects, and sustainability of the effects of the Project is verified; however, since malfunction of a part of the equipment requires ongoing operational attention, sustainability of the project is judged to be fair.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

Since the shortage in power generation was not resolved as predicted at the time of pre-evaluation, the expected impact of the Project is not observed. However, the Project was relevant, because it was necessary and urgent to stabilize the power supply and enhance its reliability in order to avoid power failures in wide areas for a long time. The Project facility operation is smooth, achieving the project purpose, and thus effectiveness is high. Verifying current equipment status, malfunction of a part of equipment was identified, however, with careful attention to that, it does not affect the facility operation. The Project is sustainable in organizational structure, and in its technical and financial aspects.

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[3] A short-circuit occurs when a current flows as a result of losing insulation between conducting parts which have different phases to each other in an electric power system, facilities, and so on. An earth fault occurs when a current flows by losing insulation between conducting part and the earth. Accidents in 2006 and 2009 involved a short circuit and an earth fault respectively.

[4] A relay is a device used in a control or signal circuit that is set in advance to open or close depending on the value of physical parameters. Relay setting involves selecting the standard at which to respond to the certain level of the working indicators, time, and so on.

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

4.2 Recommendations

4.2.1 Recommendations to Executing Agency

While the inter-lock system of the GIS in K3 substation is locked, it is necessary to prevent operation errors by instructing operators to pay close attention to it.

4.2.2 Recommendations to JICA

None.

4.3 Lessons Learned

None.

(End)

Laos

Ex-Post Evaluation of Japanese Grant Aid Project
"The Project for Nam Ngum I Hydropower Station Rehabilitation in the Lao People's Democratic Republic"

External Evaluators: Hisami Nakamura, OPMAC Corporation

1. Project Description

Project Location


Water Turbine Generator (Unit No. 1)

1.1 Background

The Nam Ngum I Hydropower Station (hereinafter refereed to as "Nam Ngum I HPP") is located approximately 90km north of Vientiane, the capital of Laos, and 140km upstream from the watershed of the Nam Ngum River and the Mekong. Its construction was undertaken in three stages, beginning with the first stage in 1966 supported by financial assistance from various donors, including Japan. It was formerly the largest hydropower station operated by Electricite du Laos (EDL) and has a total installed capacity of 150MW. The Nam Nguam I HPP supplies electricity to the Central-1 Region, including Vientiane Municipality. In addition, it plays an important role in the national economy of Laos through the export of surplus electricity to Thailand which generated foreign earnings.

The facilities of Units No.1 and 2 including power generators, major transformers, switchgear and control boards, were built in 1971. However, since its start of operation, the facilities and equipment have exceeded their normal service life and no major rehabilitation work has been carried out on them. The potential for serious accidents or stoppages has been a continuous cause of concern for the operator. In December 1999, a 115kV circuit breaker experienced problems due to aging, leading to a complete shutdown of the power station.

Under the Nam Ngum I Hydropower Station Rehabilitation financed by Japanese grant aid (654 million JPY) in 1980, Units No. 1 and 2 were rehabilitated, involving the dismantling and re-assembling of the turbines. Eighteen years have passed since then, and it was recognized that there was an urgent need for further rehabilitation.

Furthermore, the construction of spillway gates for the Nam Ngum Hydropower Project (II), which involved the installation of two additional generators (Units No.3 and No.4), raised the water level of the reservoir. As a result, the turbine discharge and turbine output of Units No.1 and 2 decreased. It was therefore necessary to recover the turbine discharge to the original design level.

Finally, at the time that this project (hereinafter referred to as "the Project") was being planned, it was projected that domestic demand for electricity would continue to steadily increase, while there were no clear plans for alternative energy generation in the region. It was therefore deemed necessary to rehabilitate the Nam Ngum I HPP in order to ensure a stable supply of electricity.

1.2 Project Outline

The objective of the Project is to restore performance and reliability of electricity supply as well as to improve skills of technicians in charge, by rehabilitating the significantly deteriorating Unit No. 1 and Unit No. 2 of the Nam Ngum I Hydropower Station and their associated common equipment which were essential to their operation.

Grant Limit / Actual Grant Amount	1,204 million yen / 1,124 million yen
Exchange of Notes Date	May 2002
Implementing Agency	Electricite du Laos (EDL)
Project Completion Date	June, 2004
Main Contractor(s)	Hitachim Ltd (Lot1), Tsukuba Denki Co., Lod (Lot2)
Main Consultant(s)	Nippon Koei Co., Ltd
Basic Design	Basic Design Study on the Project for Nam Ngum I Hydropower Station Rehabilitation
Detailed Design	December, 2002
Related Projects (if any)	[ODA Loan Projects] "The Nam Ngum Hydropower Project" (1974) "The Nam Ngum Hydropower Project II" (1976) [Grant Aid Projects] "The Project for Repair of Nam Ngum Dam Power Station" (1980) "The Project for Repair of Nam Ngum Dam Power Station Unit No.3 and No.4" (FY 1989/90) [Cooperation after the implementation of the project] "Preparatory Survey on Nam Ngum I Hydropower Station Expansion" (FY 2009) "Assistance to Reservoir Operation for the Nam Ngum 1 Hydro Power Station" (FY 2010)

2. Outline of the Evaluation Study

2.1 External Evaluator

Hisami Nakamura, OPMAC Corporation

2.2 Duration of Evaluation Study

The study was carried out over the following periods:

Duration of Study: October, 2009 – August, 2010
Duration of Field Study: March 14– 20, 2010

2.3 Constraints during the Evaluation Study

None

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

3.1 Relevance (Rating: a)

3.1.1 Relevance with the Development Plan of Laos

(1) Consistency with National Development Plan

The 6th Congress of the Lao People's Revolutionary Party in 1996 set as its national goal that the country should graduate from Least Developed Country (LDC) status by 2020. The *Socio-Economic Development Strategy for 2020* was formulated to achieve this goal. The *Ten Year Socio-Economic Development Strategy 2001-2010* and the five-year *National Socioeconomic Development Plan (NSEDP)* were also formulated as milestones within the overall strategy.

At the time that the Basic Design Study for the Project was being conducted in 2001, one of the six key strategies in the medium term strategy was the expansion of infrastructure including hydropower stations. In the 5^{th} NSEDP (2001-2005), a 3.7 percent annual growth rate of total installed capacity and energy production was proposed as a sectoral goal. For the 6^{th} NSEDP (2006-2010), it was expected that 2,000MW would be added to the existing total installed capacity, resulting in a capacity of 2,700MW with energy production at 14-15 billion kWh by 2010.

In the National Growth and Poverty Eradication Strategy (NGPES), it is stated that the national electrification rate should increase to 70% by 2010 though the development of hydropower.

Given this context, the Project was highly relevant for the country's development plans and was consistent with the country's goals related to hydropower generation, as set out in the medium and long-term development strategies.

(2) Consistency with Hydropower Development Plan

In August 2004 (after the completion of the Project), the Power System Development Plan (PSDP) was formulated which indicated pipeline hydropower projects to develop new energy sources for both export and domestic consumption. The implementation of the PSDP was underway at the time of this ex-post evaluation and the potential expansion of the Nam Ngum I HPP through the construction of Unit No. 6 was also mentioned. The Nam Ngum I HPP continues to be vital for electricity development in Laos.

[Priority given to the Project]

For domestic electricity supply in Laos, service areas are divided into four regions: Northern Region, Central-1 Region, Contral-2 Region and Southern Region. There has been no change in the classification of these service areas since the Basic Design Study was conducted. The Nam Ngum I HPP provides service to Central-1 Region and Northern Region.

Central-1 Region includes the capital city and five municipalities which account for 70 percent of domestic electricity consumption. It is the area with the highest demand in the country (at the time of this ex-post evaluation). At the time when the Project was planned, the energy production level of the Nam Ngum I Power Station was 1,117GWh. This figure exceeded the electricity consumption in the area (456.61GWh) and the surplus was exported to the Electricity Generating Authority of Thailand (EGAT), contributing to foreign exchange earnings. As of 2009, the Nam Ngum I HPP supplied 70% of the total electricity production in this area, confirming its status as one of the most important power stations[1] in Laos.

As the Basic Design Study highlighted, the shutdown of power supply in 1999 was induced by the deteriorating performance of Units No. 1 and 2. Since mitigation of such an unstable and vulnerable situation was critical, the implementation of the Project was highly prioritized

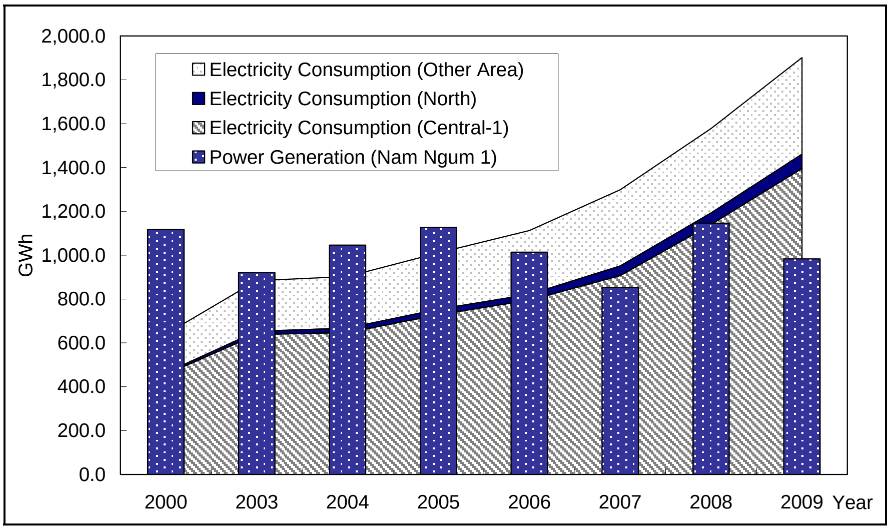
In addition, the Project was expected to increase the capacity of Units No.1 and 2 by an additional 5,000kWh (5MW) in total. Based on a cost-benefit analysis, it was found that the Project would be financially advantageous compared to the construction of an alternative power plant to generate 5,000kWh.

3.1.2 Relevance with the Development Needs of Laos

It was found that the Project is highly relevant to the development needs of Laos, as suggested in the Basic Design Study.

Electricity consumption of Central-1 Region (GWh) increased by 1.6 times from 456.61GWh in 2000 (when the Project was planned) to 729.01GWh in 2005 (when the Project was completed). Consumption in 2009 reached 1,396.05GWh, three times the level in 2000 and 1.9 times the level in 2005. Meanwhile, EDL made efforts to expand electricity networks to achieve rural electrification. As a result, electricity demand grew further, particularly in the Northern Region. It increased ninefold from 7.04GWh in 2000 to 64.67GWh in 2009 (Figure 1).

Maximum electricity demand during the peak hour (MW) reached 217.01MW in the Central-1 Region in 2006. In parallel, total installed capacity in the region expanded from 216MW in 2003 to 256MW in 2006. Of this 256MW, the Nam Ngum I HPP covered 155MW, accounting for 60% of the total installed capacity in the region. Therefore, it can be concluded that the expansion achieved by the Project met the increasing electricity demand in the region, as determined by peak load and electricity consumption.



(Source) A document provided by EDL Department of Planning (2010)

Figure 1: Electricity consumption and Amount of Power Production of the Nam Ngum I

[1] Currently, primary power stations in Laos are Nam Theun 2 Hydropower Station and the Nam Ngum I Hydropower Station.

Table 1: Electricity Demand and the total installed capacity in Central-1 and Northern Region

	2000 (Plan)	2003	2004	2005 (Completion)	2006	2007	2008	2009
Electricity Demand (Peak Time) (MW)								
Central-1	116.4	164.49	175.66	213	217.01	140.90*	155.30*	117.80*
North	-	7.01	7.06	8.27	12.78	6.7**	6.7**	6.32**
Laos	159.74	208.82	238.75	313.09	364.54	374.69	344.84	405.35
Total Installed Capacity (MW)								
Central-1	211	216	216	216	256	256	256	256
North	0	1.5	1.5	1.5	2.7	2.7	2.7	2.7
Nam Ngum 1	150	150	150	155	155	155	155	155
Laos	270.12	271.62	271.62	307.54	307.54	308.74	308.74	384.74
Maximum Output (MW)								
Nam Ngum 1	150	175.7	190.5	182.9	170.0	169.2	191.5	172.5

(Source) Documents provided by EDL Department of Planning (2010)
(Note) The data on electricity demand (peak load) in 2007-2009 is available only at province level. For the Central-1 Region, the maximum value of Vientiane Municipality (the area with the highest demand) is indicated. For the Northern Region, the value at municipality level is used.

Electricity exports (GWh) from Central-1 and Northern Regions fell from 744.51GWh in 2000 to 363.78GWh in 2008 because of the continuous rise in electricity consumption in these regions. The sales price for electricity exports has also been decreasing which has resulted in a reduction of income for the Nam Ngum I HPP. The income which had been 205.6 billion kip (approximately 1.3 billion JPY) in 2005 fell to 113.6 billion kip (approximately 2.1 billion JPY)[2] in 2008. Nevertheless, electricity is still one of the most important exports and accounts for 7% of total exports from Laos. The Nam Ngum I HPP produced electricity equivalent to 11% of the total export income in 2008, which contributed to the economy of Laos.

Table 2: Electricity Export and Domestic Sales

(Unit: GWh)

	2000	2003	2004	2005	2006	2007	2008
Electricity Consumption							
Central-1	456.61	638.09	646.91	729.01	794.76	907.56	1,140.65
North	7.04	14.91	20.55	24.87	26.01	43.49	52.32
Laos	639.85	883.73	902.76	1,011.06	1,112.40	1,298.41	1,577.86
Electricity generation							
Laos	1,578.54	1,316.84	1,416.45	1,715.05	1,639.29	1,398.37	1,777.57
Nam Ngum HPP1	1,117.00	919.85	1,046.39	1,127.28	1,013.77	852.94	1,145.77
Electricity Export	862.94	434.66	507.05	727.75	547.05	267.97	391.78
Central-1	744.51	348.30	452.79	653.79	455.22	206.75	363.78
Electricity Import	159.92	229.34	277.59	325.63	334.55	475.94	509.95

(Source) Documents provided by EDL the Nam Ngum I Hydropower Station
(Note1) The consumption level includes system losses
(Note 2) Electricity exported from Central-1 Region is a total of the Nam Ghum I, Nam Mang 3, and Nam Luek

[2] The sales price of electricity generated by the Nam Ngum I for export to Thailand is 1.6 baht/kWh at peak hour and 1.2 baht/kWh at off peak hour as of 2008. The cross exchange rate with kip is 96.67 JPY in 2005 and 84.50 JPY in 2008.

3.1.3 Relevance with Japan's ODA Policy

When the Project was being planned in 1998, Japan's ODA policy for Laos stated that careful attention should be given to the development of hydropower within the framework of infrastructure improvement, by considering various factors including potential to acquire foreign currency, increase in electricity demand in neighboring countries and potential environmental impact.

Japan provided continuous assistance to the Nam Ngum I HPP from the outset when Units No. 1 and 2 were constructed, and therefore support for the rehabilitation of obsolete facilities was a means to respond to the rapid increase in electricity demand without causing a negative environmental impact. Thus it can be concluded that the Project was consistent with Japan's ODA policy for Laos at the time of the Basic Design Study.

The Project has been highly relevant to the country's development plan and development needs, and as well as Japan's ODA policy, therefore its relevance is high.

3.2 Efficiency (Rating: a)

3.2.1 Project Outputs

The planned inputs by both the Japanese and Laotian side were completed as scheduled. The major outputs are indicated in Table 3. As a result of the Project, the measured outputs of Units No. 1 and 2 expanded by 5MW in total as planned.

Table 3: Outputs produced by the Project

Japanese Side	
Plan (Basic Design Study)	**Actual**
The Units No.1 and 2 • Turbines, Generators (standard outputs 17.5MW) • Transformers, 115kW Switchyard Equipment and Busbars • Control Boards • DC Power Supply Equipment • Rehabilitation and Renewal of Intake Gate Facilities, etc	As panned * However, according to the Project Completion Report, there were some changes in a pipe arrangement and a configuration between disconnectors and the existing transmission lines.
Lao Side	
Plan (Basic Design Study)	**Actual**
The rehabilitation and update of common equipments for the Unit No. 1 and 2, air compressors of emergency diesel generators, and fuel and labor for test operation	As planned

Photo 1: Motor Control Center

Photo 2: Main Transformers (the Unit No. 1)

3.2.2 Project Inputs

3.2.2.1. Project Period

The Project implementation period between the Exchange of Notes (E/N) through to completion was 26 months (104% of the plan), which was slightly longer than planned. Nevertheless, the period required for equipment procurement and rehabilitation work was 18 months (85% of the plan) which was shorter than planned. It can be concluded that overall, the Project was efficiently implemented.

Table 4: Project Period

Item	Plan (Basic Design Study)	Actual
Exchange of Note (E/N)-Completion of the rehabilitation works	**25 months**	**26 months (Completed in June 2004)**
Exchange of Note (E/N)- Completion of the rehabilitation of the Unit No. 1	20 months	23 months (completed in March 2004)
Procurement of equipments for the Units No. 1 and 2 – Completion of rehabilitation works	21months	18 months

3.2.2.2. Project Cost

As indicated in Table 5, the total Project cost was 1.129 billion JPY which accounts for 93.7% of the planned budged (1.205 billion JPY). While the planned cost financed by Japan was 1.204 billion JPY, which is the limit for E/N, the actual cost was 1.124 billion JPY which was about 7 percent lower than planned. Exchange rate devaluation and increase in labor cost doubled the actual cost financed by Laos. However, the part covered by Laos accounts for only 0.5 percent of the total cost and its overall influence was limited.

Table 5: Project Cost

Item	Plan	Actual
Total Project Cost	**1.205 billion JPY**	**1.129 billion JPY**
Japan Side (Grant Aid)	1.204 billion JPY (E/N/ Limit)	1.124 billion JPY
Procurement of Equipments	1.118 billion JPY	1.044 billion JPY
Equipment Design and Supervision	85 million JPY	80 million JPY
Lao Side	2.02 million JPY	5.45 million JPY

(Note) Exchange Rate for the cost financed by Lao Side 1 USD = 112.4231 JPY 1USD＝10,826 Kip (July 2004)

In light of the above, both the Project period and Project cost were mostly as planned. Therefore efficiency of the Project is high.

3.3 Effectiveness (Rating: a)

3.3.1 Quantitative Effects

3.3.1.1. Results from Operational Indicators

Upon completion of the rehabilitation work in 2005, utilization of Units No.1 and 2 was above the target (82.38%). However, with the exception of 2008, utilization remains below the target. This is due to the low water level in the reservoir. In particular, the amount of rainfall in 2007 was below average which caused drought and a low utilization rate (below 60%).

The duration of unexpected shutdowns due to system failures was only 1-4 hours per year. This indicates that reliable operations were achieved.

Based on observations of the conditions of Units No.1 and 2, the expected service life remains as planned. While the number of accidents per year was initially foreseen to be about 11 for 10 years after the rehabilitation, the number of reported accidents was 0 since rehabilitation (to the date of this ex-post evaluation). Therefore, it is considered that the expected results of improving the electrical and mechanical functions as well as the recovery of the reliability and security of Units No.1 and 2. has been achieved by the Project.

Table 6: Utilization of Units No.1 and 2 (Performance Indicators)

	Target (2005)	**2005**	**2006**	**2007**	**2008**	**2009**
Facility Utilization (%)						
Unit No.1	82.38	84.14	77.84	55.39	84.84	73.98
Unit No.2		84.98	77.33	59.93	84.85	74.04
Hours of Operation (h)						
Unit No.1	-	7,903.17	7,549.01	5,489.26	7,260.57	6,872.40
Unit No.2		8,008.38	7,601.25	5,902.25	7,273.21	6,885.44
Planned outage for Inspections and Rehabilitation (h)						
Unit No.1	-	192	288	522	0	144
Unit No.2	-	144	408	504	0	144
Unplanned outage (h)						
Units No. 1 and 2	-	1:00	2:48	1:56	4:02	4:26

(Source) Developed based on a document provided by the Nam Ngum I Hydropower Station

Table 7: Functions and Conditions of Units No.1 and 2

Performance Indicator	**Baseline(2001)**	**Target (2005)**	**Actual (2005～2010)**
Expected service life*	15～35 (0～3.7) Year	15～35 Year	15～35Year
Number of Accidents **	25	11.6	0

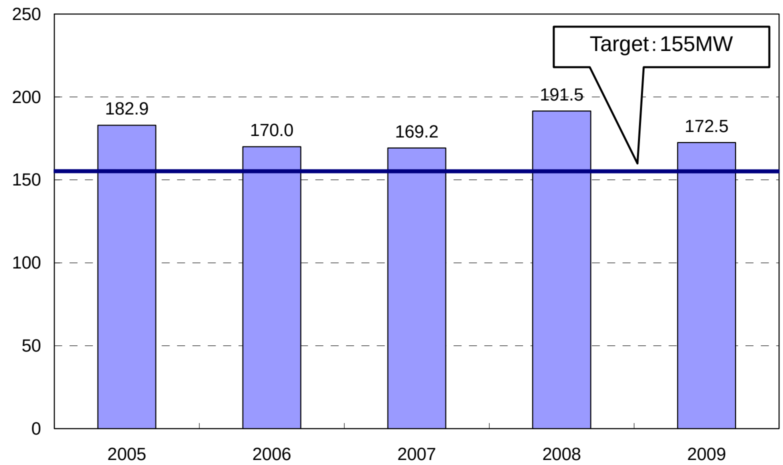
(Source) Developed based on a document provided by the Nam Ngum I Hydropower Station

(Note1) *Standard of expected service life is average years of durability and ( ) indicates the expected residual life at the time of rehabilitation (year 2003)

(Note2) ** The total number of accidents of Unit No.1 and 2 between 1990 and 2000. The target is the number of accidents foreseen in the first 10 years after the rehabilitation.

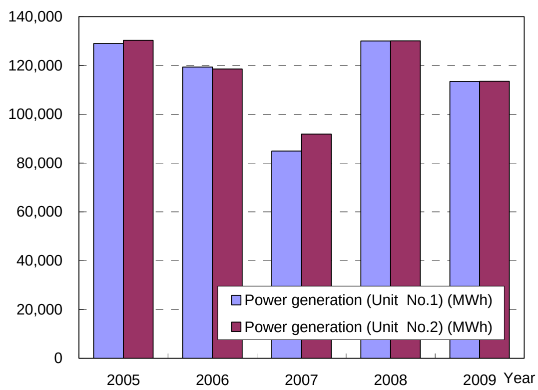
Another expected result of the Project was an increase in maximum output of the Nam Ngum I HPP from 150MW to 155MW. The Project led to the functional recovery of Units No.1 and 2, resulting in a maximum output of 170-190MW (in 2005-2009), which is more than planned.

After 2005, the total maximum output of Units No.1 and 2 constantly covered 21-23% of overall power generated by the Nam Ngum I HPP. Immediately after the completion of the Project in 2005, the total power generated by the two units was 259.3GWh. In the year 2008, which had the highest utilization rate, 260.1GWh were generated.



(Source) Developed based on a document provided by the Nam Ngum I Hydropower Station

Figure 2: Maximum Output of Nam Ngum I Hydropower Station



(Source) A document provided by the Nam Ngum I Hydropower Station

Figure 3: Power Generation (Units No. 1 and 2)

Photo 3: Full View of Nam Ngum I Hydropower Station

3.3.2 Qualitative Effects

In the Project, training was held in Japan to transfer technology for dismantling and reassembling turbines and generators. Trainees from the Nam Ngum I HPP are currently engaged as trainees at the EDL Training Center. This contributed to improving the maintenance skills of engineers of hydropower stations.

The Project has largely achieved its objectives, therefore its effectiveness is high.

3.4 Impact

3.4.1 Intended Impacts

(1) Benefits for the target areas and population

[Beneficiary: EDL]

As of 2009, there were 78 engineers in EDL involved in the maintenance of hydropower stations. Among them, 21 engineers have technical skills to conduct maintenance for generators and other associated equipment.

The training, which aimed to support technology transfer, resulted in the reinforcement of the maintenance system and technical capacity of EDL.

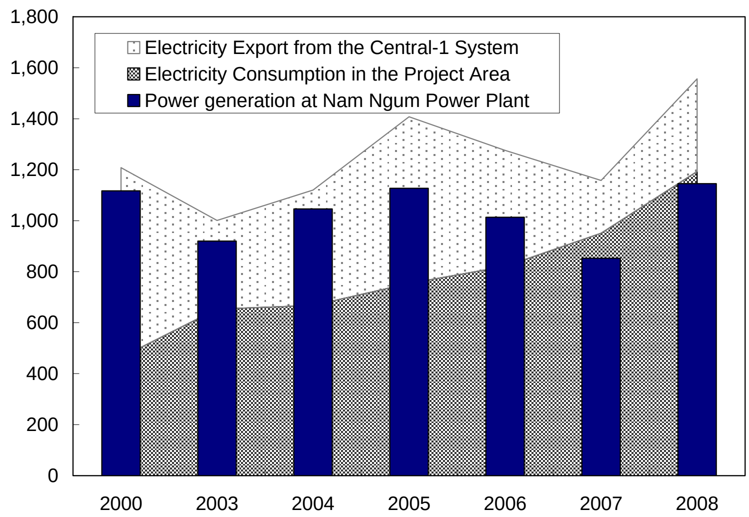
As noted earlier, the engineers who received training in Japan are now engaged in human resource development for hydropower stations. The Nam Ngum I HPP also provides on-the-job training to develop skilled engineers. Therefore, the Project contributed to reinforcement of maintenance system and the capacity development of engineers for hydropower generation in EDL.

Table 8: Training on hydropower technology (2009)

Training Name	Number of Trainees	Number of Days
Maintenance of Hydropower Generation (Group1)	38	27
Maintenance of Hydropower Generation (Grouop2)	34	27
Maintenance of Hydropower Generation (Group3)	39	27

(Source) EDL, "Statistical Year book 2009"

[Beneficiaries: Residents in Central-1 Region and Northern Region]
After the implementation of the Project, the electrification rate improved in Central-1 and Northern Regions (the service areas covered by the Nam Ngum I Hydropower Station) due to newly constructed transmission and distribution networks. In 2009, the electrification rate at the provincial level was 47-98% in Central-1 Region and 12-62% in Northern Region respectively. Accordingly, electricity consumption and electricity sales in these regions have been increasing.



(Source) Developed based on a document provided by the Nam Ngum I Hydropower Station
(Note) Electricity export is the total exports from three power stations including the Nam Ngum I Hydropower Station in Central-1 Region

Figure 4: Level of electricity consumption in the targeted regions, the amount of electricity export, and amount of power generated by the Nam Ngum I Hydropower Station

As of 2000, the total electricity consumption in Central-1 Region and Northern Region was 463.65GWh which accounts for 40% of the Nam Ngum I HPP's output. The surplus was exported to Thailand. In 2003 during the implementation of the Project, electricity consumption was boosted in the targeted regions while electricity exports decreased to 348GWh. Consequently, 70% of electricity generated by the Nam Ngum I HPP was consumed in those regions. After 2003, electricity consumption in those regions continued to grow and reached 1,192GWh, more than the annual amount of power production by the Nam Ngum I HPP. The Project was a response to this continuous growth of electricity consumption through the rehabilitation of the power generation facilities in the Nam Ngum I HPP, the primary power station in the region. The Project contributed to promoting electrification and expanding power supply in the targeted regions.

3.4.2 Other Impacts

(1) Impacts on the natural environment

The Basic Design Study pointed out that the grease lubricant used for the turbine operating mechanism and out-dated shaft sealing box was causing water pollution. As the rehabilitation transformed the mechanism itself and grease is no longer being used, the water quality has improved. There were no other environmental impacts caused by the Project[3].

(2) Economic Impact

In the Basic Design Study, a positive economic impact was expected through the reduction of maintenance costs after the rehabilitation, as well as an increase in annual income from the increase in power generation.

The actual maintenance cost after the rehabilitation is less than before the Project, as no large-scale maintenance works have been required for Units No. 1 and 2 and their common equipment. Therefore, the Project has contributed to the reduction of the maintenance costs of the entire power station.

The income from power generation has been constantly above that for the base year. However, the actual volume of power generation remains lower than that of the base year (1,138.5GWh) except in the year 2008. The increase in income was a result of the sales price change since the average electricity price rose to 2.25 times as much as the base year. Thus, the increase in the income of the Nam Ngum I HPP was not a result of the Project.

Table 9: Maintenance costs and income from power generation of the Nam Ngum I

	Baseline (2001)	After the Project (2009)
Maintenance Cost	11.30 billion kip	9.68 billion kip
Income from power generation	38.59 billion kip	44.84 billion kip

(Source) A document provided by the Nam Ngum I Hydropower Station

3.5 Sustainability (Rating: a)

3.5.1 Structural Aspects of Operations and Maintenance

The Nam Ngum I Hydropower Station is managed by EDL, a state-owned enterprise which is in charge of power generation, transmission and distribution for domestic and international electricity services. The structure of EDL at the time of the ex-post evaluation is shown in Figure 5. Under the supervision of the Board of Holdings, four Managing Directors are responsible for managing EDL.

[3] Among the items removed by the project, the existing excitation transformers, 11kV voltage transformers and 11kV capacitors used the insulating oils containing toxic chemicals, including Polychlorinated Biphenyl (PCB). It was planned that those toxic wastes should be securely stored under lock and key at a specially designated place in the powerhouse which was protected by an oil fence. At the time of this ex-post evaluation, by reviewing the storage condition, it is found that EDL sold the steel scraps disposed by the Project, including the toxic wastes, to a private steel maker in Vietnam subject to the condition that the steel maker should store the insulating oil with PCB at a proper space with concrete fence for safekeeping.

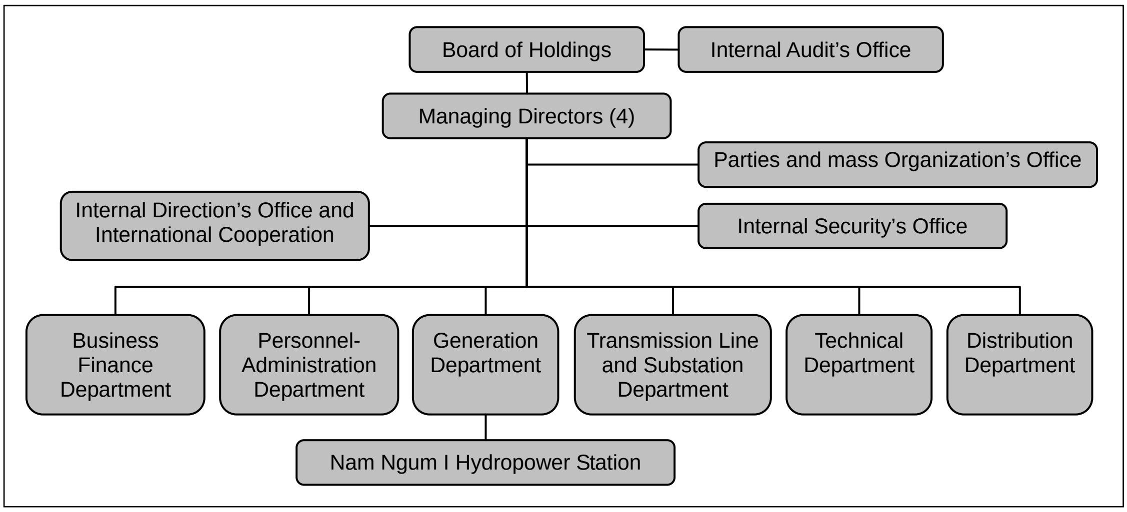


Figure 5: Organizational Structure of EDL

With regard to the maintenance plan for power stations, the EDL Headquarters approves the budget after conducting a technical appraisal of proposals made by each power station.

Maintenance of the Nam Ngum I HPP is conducted by 73 staff including 15 engineers working for four departments: Operations and Control Department, Electrical Department, Mechanical Department and Civil Department (Figure 6).

The Operations and Control Department is in charge of machines and equipment for power generation, as well as for water management. The Electrical Department looks after electrical networks and the Mechanical Department is in charge of all other machines and equipment. The Civil Department conducts inspections, monitoring and maintenance of the dam.

Through the Project, awareness of proper operations and maintenance has been raised and the system and structure for maintenance has been reinforced.

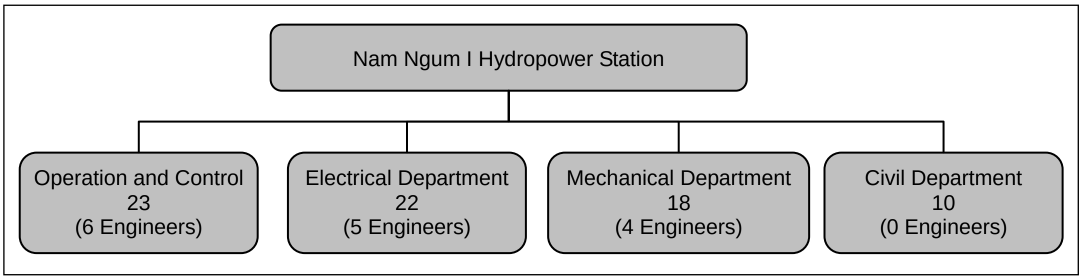


Figure 6: Maintenance Structure of the Nam Ngum I Hydropower Station

3.5.2 Technical Aspects of Operations and Maintenance

Ordinary inspections have been properly undertaken. No detailed inspections including the dismantling and reassembling of turbines or occasional inspections have been undertaken since the completion of the rehabilitation work, as there is usually no need for frequent detailed inspections or special inspections. Currently EDL is in the process of setting up a maintenance structure to conduct detailed inspections, building on the experience gained through this rehabilitation project. Nevertheless, the short term training provided by the Project is not sufficient to build all the capacities required for detailed inspections involving dismantling and reassembling, and make a proper judgment for future maintenance. At this moment, it is still necessary to rely on external support to formulate overhaul plans and commission overhaul work.

Meantime, EDL has made efforts in building internal technical capacity to properly maintain hydropower stations. Engineers working for the Nam Ngum I HPP have also taken technical training at EDL training centers.

Table 10: Training taken by engineers from the Nam Ngum Hydropower Station

Training Course	Number of participants	Frequency	Duration
Hydropower	4	4 times per year	2 weeks each time
Mechanical works	4	4 times per year	2 weeks each time
Electrical works	9	4 times per year	2 weeks each time
Civil works	39	4 times per year	2 weeks each time

(Source) A document provided by the Nam Ngum Hydropower Station

Despite a lack of sufficient skills required for dismantling and reassembling, ordinary inspection has been properly undertaken. As for detailed inspections, EDL is currently formulating a 5 year plan, setting up a team of experts, and commissioning tasks to external consultants when necessary. In light of these activities, no major problem in the maintenance structure is expected.

3.5.3 Financial Aspects of Operations and Maintenance

After the completion of the Project, the operations and maintenance (O&M) cost for the Nam Ngum I HPP in 2006 was 138 billion kip. Although it declined to 10 billion kip in 2008 and 10.3 billion kip in 2009, the budget for O&M again rose in 2010 to over 21 billion kip. Out of the entire O&M cost, maintenance costs take up 94-97% and the remaining 3-6% is used for personnel. Maintenance costs went down by 20% from 134 billion kip in 2006 to 95.6 billion kip in 2008. It then rose to 204.5 billion kip, which is more than double compared to the previous year.

No major repair work has been required for Units No. 1 and 2 since 2005, and there have therefore not been any specific costs for those units.

Table 11: Operations and maintenance cost for the Nam Ngum I Hydropower Station

(Unit: 1 billion kip)

	2005	2006	2007	2008	2009	2010
Operation and maintenance cost	**128.53**	**138.01**	**124.56**	**100.85**	**103.07**	**210.75**
Personnel cost	3.49	3.94	4.29	5.24	6.26	6.19
Equipment Maintenance cost	125.04	134.07	120.27	95.61	96.81	204.55

(Source) Documents provided by EDL and the Nam Ngum Hydropower Station

EDL prepares technical reports analyzing the urgency and necessity of repairs and the need for any significant updating of machines and equipment. Based on these analyses, EDL then gives budgetary approval. In 2008 and 2009, the repair works requested by the office of Nam Ngum I HPP was not approved and was carried over to 2010. This resulted in a significant gap between the planned budget and the actual expenditure in 2008 and 2009.

3.5.4 Current Status of Operations and Maintenance

During this ex-post evaluation, a site visit was undertaken to review the status of the maintenance of machines and equipment installed by the Project. The site visit confirmed that operations and maintenance were being conducted properly, as well as ordinary and periodical inspections.

The spare parts procured by the Project are still in stock and EDL has not yet procured any parts.

Currently, the Nam Ngum I HPP plans and conducts ordinary inspections and maintenance during the dry season to avoid discharges. The Generators are usually stopped for 1 to 3 weeks and necessary repair work such as the removal of mud on the turbine runner are carried out. In 2008, it was not possible to conduct the scheduled maintenance and inspection during the planned period because the rainy season began early that year. The Nam Ngum I HPP was forced to run the generators in order to avoid discharges.

The stabilization of water flow to the reservoir as an effect of commissioning Nam Ngum II Hydropower Station could potentially increase the plant factor of Units No. 1 and No.2, and therefore shorten the period when maintenance can be carried out. However, there is a plan to install another unit, Unit No.6, at the Nam Ngum I HPP. If it is installed, the operational hours of Units No.1 and 2 could be reduced, which would allow the proper maintenance of those units. This would shorten the frequency of the exchange of consumable parts and reduce operation and maintenance costs.

No major problems have been observed in the operation and maintenance system. The sustainability of the Project is therefore deemed to be high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The Project aimed to stabilize the electric supply in the country by rehabilitating equipment and facilitating the functional recovery of the Nam Ngum I Hydropower Station. Since the Station has been one of the primary power stations in the country, the demand for the Project was high. Considering its history, and the continuity of assistance from Japan to this power station, relevance for Japan's aid was high. The expected results of this assistance have been steadily achieved and the Project has had a positive impact, such as capacity building for maintenance skills of hydropower stations in the country. Given that the maintenance structure and system is currently being strengthened, the Project can be considered highly sustainable.

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

4.2 Recommendations

4.2.1 Recommendation to Executing Agency

None

4.2.2 Recommendation to JICA

None

4.3 Lessons Learned

The Nam Ngum I Hydropower Station was constructed and expanded with international assistance from various countries including Japan. It has been one of the primary power stations in the country. Through Japan's continuous assistance and Lao's high reliance on Japanese technology for hydropower generation, the Nam Ngum I HPP has led to the improvement of hydropower generation technologies and capacity development in the country.

In the Project, not only rehabilitation work but also maintenance skills for hydropower generation plants were developed, which led to skill development of engineers of the Nam Ngum Hydropower Station and EDL as a whole. It also promoted the reinforcement of the operations and maintenance system and structure. Such assistance contributing to human resource and skills development has had positive spill-over effects such as development of human resource, technical capacity, and the organizational structure of the overall electricity sector. At the same time, a lack of knowledge and skill required for the overhaul of generators, inspection, and the identification of problems caused by accidents has been recognized as an issue. This was not well integrated as a component of the rehabilitation project. The short-term training by contractors was not sufficient for technology transfer.

It is necessary to give high priority to technology transfer in the above-mentioned areas during future project identification processes, in order to improve operations and maintenance capacity and eventually enhance the sustainability of hydropower generation in Laos. In this regard, it is recommended that the training components of grant aid projects be reinforced or supported through other aid schemes.

(End)