People's Republic of Bangladesh

FY2020 Ex-Post Evaluation of Japanese ODA Loan

"New Haripur Power Plant Development Project I, II"

External Evaluator: Hisae Takahashi, Ernst & Young ShinNihon LLC

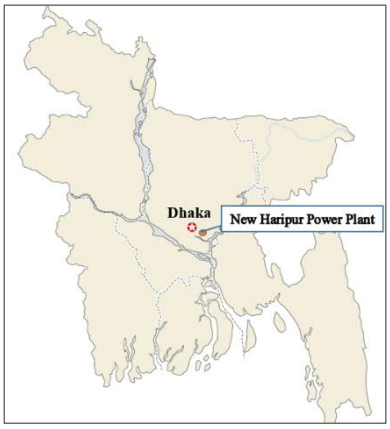
0. Summary

This project was implemented with the aim of meeting the growing demand for electricity by constructing a new thermal power plant (combined cycle) in Haripur of Narayanganj district and supporting the strengthening and streamlining of the operation and maintenance system of power plants, thereby contributing to the enhancement of industrial competitiveness and improvement of people's livelihood.

This project, which aimed to respond to the increasing demand for electricity through the construction of a new power plant, is consistent with Bangladesh's development policy, which has been emphasizing the expansion of power generation and improvement of energy efficiency to meet the ever-increasing demand for electricity, its development needs for the expansion of facilities to ensure the supply of electricity, and Japan's ODA policy, which has positioned power infrastructure as a priority area for support for sustainable growth. Thus, its relevance is high. Although the project cost was within the plan, the project period largely exceeded the plan due to delays in the selection and contracting of consultants, the impact of political instability on the construction work, and the occurrence of a damage at the gas turbine, thus the efficiency of the project is fair. As for the project effects, maximum output, plant load factor, plant availability, auxiliary power rate, gross thermal efficiency, and net generation output all achieved the targets, although power outages were caused by machine failures during a certain period after the start of operation. In addition, the reduction of power outages at factories and markets due to the stable supply of electricity in areas near the power plant contributes to the improvement of the local economy by increasing profits and promoting employment, and also leads to the improvement of the convenience of daily life for households. Impacts such as women's employment and participation in income generation activities have been confirmed, thus, effectiveness and impacts of the project are high. As for the operation and maintenance, no major problems have been observed in the institutional/organizational, technical, financial aspects and current status of the operation and maintenance system. Therefore, sustainability of the project effects is high.

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

1. Project Description



Project Location

New Haripur Power Plant

1.1 Background

In Bangladesh, the demand for electricity was growing in line with the strong economic growth at the time of the project appraisal. However, the power supply generation capacity was about 3,800 MW, which fell far short of the peak-hour demand of around 4,700 MW (2006). Furthermore, the maximum output was far below the rated output due to aging facilities and the other issues, and planned outages were unavoidable at peak hours. At that time, the government of Bangladesh was working on capital investment with the national goal of "providing affordable and stable electricity to all citizens by 2020". However, the gap between supply and demand was expected to widen further as the construction of new power plants had not progressed as planned and power plants in operation were planned to be decommissioned as they aged. Moreover, in order to close the supply and demand gap and achieve a stable supply of electricity, in addition to developing new power sources, a major challenge was to improve the efficiency of the sector as a whole through increasing the utilization rate of power plants and improving system losses.

1.2 Project Outline

The objective of this project is to meet the growing demand for electricity by constructing a new thermal power plant (combined cycle) in Haripur of Narayanganj District and supporting the strengthening and streamlining of the operation and maintenance system of power plants, thereby contributing to the enhancement of industrial competitiveness and improvement of the people's livelihood.

Loan Approved Amount / Disbursed Amount	17,767 million yen / 17,435 million yen (I) 22,210 million yen / 20,641 million yen (II)

Exchange of Notes Date / Loan Agreement Signing Date	December 2007 / December 2007 (I) February 2009 / March 2009 (II)	
Terms and Conditions	Interest Rate	0.01% (I) (II)
	Repayment Period (Grace Period	40 years (I) (II) 10 years) (I) (II)
	Conditions for Procurement	Untied (I) (II)
Borrower / Executing Agency	Government of the People's Republic of Bangladesh / Electricity Generation Company of Bangladesh	
Project Completion	June 2020	
Target Area	Haripur of Narayanganj District (Near Dhaka)	
Main Contractors	Civil Work: Marubeni Corporation (Japan) (I) (II) Procurement of equipment: Marubeni Corporation (Japan) (II), Marubeni Power & Infrastructure Systems Corporation (Japan) (II)	
Main Consultants	・ SMEC International Pvt. Ltd. (Australia)/ ACE Consultants Ltd. (Bangladesh)/ SNC-Lavalin Inc. (Canada)/ AECOM New Zealand Ltd. (New Zealand)/ Sargent & Lundy LLC (United States) (JV) (I) (II) ・ IRG Development Services Ltd (Bangladesh)/ Ernst &Young LLP (India)/ Tractebel Engineering (India) (JV) (I) (II)	
Related Studies (Feasibility Studies, etc.)	・ Feasibility Study (EGCB, 2006) ・ Special Assistance for Project Formation (SAPROF) "Power Generation Capacity Development Project" (2006)	
Related Projects	[ODA Loan Project] ・ Haripur Power Plant Development Project (September 1993) [Another donor's project] ・ Asian Development Bank: Assistance for Power Sector Reforms (2003), Assistance for Power Sector Reforms II (2004) ・ The World Bank: Bakhrabad-Sidhirganj Gas Transmission Pipeline Project (2007 – 2018)	

2. Outline of the Evaluation Study

2.1 External Evaluator

Hisae Takahashi, Ernst & Young ShinNihon LLC

2.2 Duration of Evaluation Study

This ex-post evaluation study was conducted with the following schedule.

Duration of the Study: November 2020 – January 2022

Duration of the Field Study: March, April and August 2021 (The field survey was conducted by the local assistant.)

2.3 Constraints during the Evaluation Study

In this ex-post evaluation, the site survey could not be implemented by the evaluator due to the effect of the spread of COVID-19. For this reason, the site survey was implemented by local assistants under the direction of the evaluator, and the evaluator conducted a desktop evaluation based on the results of the information collected, beneficiary survey, and site inspections carried out by the local assistant. In addition, the planned interviews with end-users were limited due to the prolonged lockdown to prevent COVID-19 infection in Bangladesh. Therefore, the information obtained during the site visit reflects what was confirmed during the limited interviews.

3. Results of the Evaluation (Overall Rating: A[1])

3.1 Relevance (Rating: ③[2])

3.1.1 Consistency with the Development Plan of Bangladesh

The national development strategy, the Poverty Reduction Strategy Paper (PRSP), *Unlocking the Potential: National Strategy for Accelerated Poverty Reduction* (2005), and the *PRSP II* (2008), positioned the power sector as a key infrastructure for economic growth which leads the poverty reduction while noting the importance of the power sector reform at the time of the project (I) (II) appraisal. In addition, the sectoral plan for the power and energy sector, the *Policy Statement on Power Sector Reforms* (2000) raised three long-term visions for the power sector: to ensure electricity access for all Bangladeshis by 2020; to provide high quality and reliable electricity; and to provide electricity at reasonable prices[3].

The country's development plan at the time of the ex-post evaluation, the *Eighth Five-Year Plan 2021 – 2025*, followed the policies of the *Sixth and Seventh Five-Year Plan*, and

[1] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory
[2] ③: High, ②: Fair, ①: Low
[3] Source: Document provided by JICA

identified the electricity and energy sectors as playing a central role in the country's economic growth. The plan shows the key issues of increasing the power generation volume to meet the demand and improving the energy efficiency as a strategy of the power sector[4]. In addition, the *Power System Master Plan 2016*, which lays out the power and energy development plan through 2041, set forth a vision for the efficient use of domestic resources, large-scale development of power sources, and the provision of high quality and highly stable power to meet the increasing demand for electricity in line with economic growth, and moreover, in response to the diminishing supply of natural gas in the country. In Bangladesh, as shown in Figure 1, domestic natural gas production has been decreasing, which is a main source of energy, thus the diversification of energy sources as well as improvement of efficiency and enhancement of quality is required.

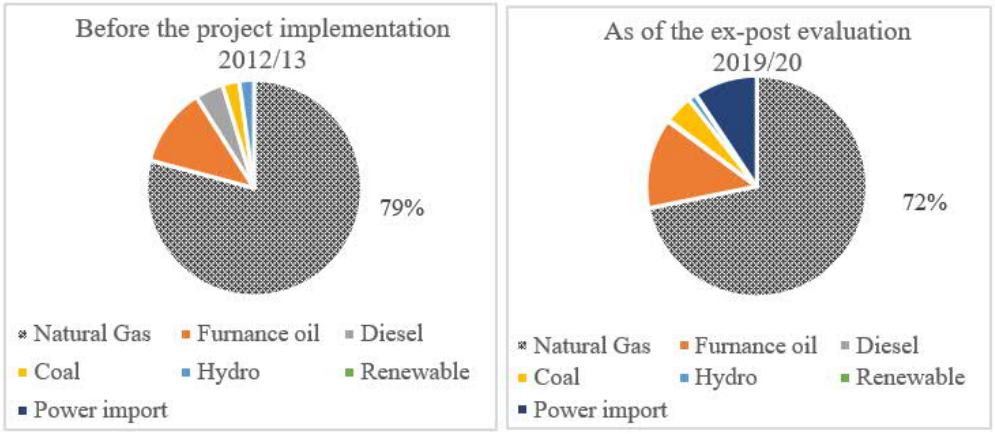


Figure 1 Power Generation Sources in Bangladesh

Source: Bangladesh Power Development Board, *Annual Report* each year edition

As mentioned above, the development document and policy have laid out the power and energy sector as a key sector to boost economic growth of Bangladesh, and prioritized infrastructure development in the sector both at the time of the project appraisal and ex-post evaluation. The project aimed to meet the increase in electric generation capacity by constructing power plants, thus is consistent with the development policy of the country.

3.1.2 Consistency with the Development Needs of Bangladesh

In Bangladesh, the demand for electricity was increasing due to its strong economic growth at the time of the appraisal. However, the gap between supply and demand was widening because power supply capacity did not keep the pace with the growth in demand. As a result, planned outages were forced to be carried out in each area, mainly during peak hours, and 1,400 hours of planned outages were implemented in 2005[5]. Moreover, peak

[4] Source: *8th Five Year Plan FY 2020-FY 2025*
[5] Source: Document provided by JICA

electricity demand was projected to increase at 8 – 10% annually, and it was estimated to increase to 6,608 MW in 2010. Therefore, the construction and renovation of new power supply facilities required 4,355 million USD by 2012, but capital investment was delayed due to a shortage of funds. The national electricity access rate was also only 42% (72% in urban and 23% in rural areas) and electricity consumption by per capita was about 140 kWh/year, one of the lowest in the world[6]. In addition, inefficiencies in the sector as a whole had also been identified, particularly in the power plants maintained by the Bangladesh Power Development Board (BPDB), which were operating at around 60% of their original capacity due to shortages of staff, funds and fuel, inadequate maintenance, and aging equipment.

The country's electricity supply capacity had improved to 96% of its demand (13,300 MW peak-hour electricity demand and 12,738 MW maximum peak-hour generation) (2019/20) by the time of the ex-post evaluation. The electricity access rates also improved to 97.8% in urban and 88.9%[7] in rural areas, and electricity consumption per capita has increased to about 378 kWh/year[8]. Meanwhile, electricity demand continues to increase at an annual rate of 9 – 10% and is expected to continue to increase further. It is estimated that about 21,977 MW of new electricity generation will be required by 2025 to fill the supply-demand gap[9].

As mentioned above, the peak demand for electricity in Bangladesh is increasing with the development of its economy, and there is a need for additional facilities to ensure that the supply which can meet this increase. Therefore, the need for additional power supply facilities was confirmed at the time of the ex-post evaluation.

3.1.3 Consistency with Japan's ODA Policy

The *Country Assistance Policy for Bangladesh* (2006) at the time of the appraisal indicated a lack of capital investment, inefficient management, and inappropriate electricity price setting as challenges in the power sector, and stated that the focus would be on "support for improving sector-wide policies, management, operations, and finance" and "increasing generation capacity". In addition, the *Overseas Economic Cooperation Operations* (2005) also positioned a key economic infrastructure development to promote economic growth to support the power sector. The *Country Assistance Strategy for Bangladesh* (2006) set the power sector as one of the priority areas for support, with a commitment to providing loans to support and promote sector reform, and working to build

[6] Source: Document provided by JICA
[7] Source: World Bank Website https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS (Confirmed on September 3, 2021)
[8] Source: BPDB *Annual Report 2019*
[9] Source: Questionnaire responses, and BPDB *Annual Report 2019*

the capabilities and organizational structures of implementing agencies. Under the project, power plant was constructed near Dhaka, Bangladesh, to increase power supply and support the Electricity Generation Company of Bangladesh Limited (EGCB), which was spun off from the BPDB, to strengthen and improve the efficiency of its power plant operations, and is thus consistent with Japan's ODA policy.

In light of the above, this project has been highly relevant to the Bangladesh's development plan and development needs, as well as Japan's ODA policy. Therefore, its relevance is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

The planned major outputs of the project consisted of the construction of the combined cycle thermal power plant and consulting services. The major planned and actual outputs are shown in Table 1.

Table 1 Planned and Actual Output

Plan	Actual
Gas combined power plant development	
1) Installation of 360 MW gas combined power plant and related facilities	1) Installation of 412 MW gas combined power plant and related facilities
2) Long Term Service Agreement (LTSA)	2) As planned
3) Relocation and dismantling of existing substation in the proposed power plant construction site	3) As planned
4) Installation of gas pipeline	4) As planned
Consulting services	
5) Engineering service consultant ・ Detailed design of power plant development and relocation of substations, follow up on procurement, construction supervision (including the measures for HIV / AIDS) ・ Follow up on tendering and contract negotiation for "LTSA".	5) As planned
6) Management service consultant ・ Support for the establishment and revitalization of the operation and maintenance system for new and existing power plant under the project, upon the introduction of the Business Unit (SBU), which is an independent accounting system.	6) Implemented only for the new Haripur power station (Existing power plant are out of scope of this project).

Source: Documents provided by JICA, Project Completion Report (PCR) and questionnaire responses from the executing agency

As shown in Table 1, the major changes of output were an increase in the output of the gas combined cycle power plant, and a change in the support provided under 6) Management service consultant, which were planned for both the new and existing Haripur power plants, wherein support was provided only for the new plant. The details of each change and the reasons for the changes are explained below.

[Change of power output of gas combined cycle]

The power output of installed gas combined cycle under this project was increased from 360 MW to 412 MW. This change was made in response to a recommendation from the contractors, which would allow for an increase in output without changing the price. There is no problem with this change since it contributes to achieving the project's objective of increasing electricity demand.

[Consulting services: Change in the recipient of Management service consultant]

Under this project, support was planned to be provided on the operation and maintenance of the existing power plant in addition to the new Haripur power plant. The EGCB did not have a power plant under its jurisdiction at the time of the appraisal, and the existing Haripur power plant was to be transferred to the EGCB from the BPDB along with the new Haripur power plant after the implementation of the project. This was the reason for the planned assignment of Management service consultant to the existing power plant as well as the new power plant. However, the existing power plant was not transferred to the EGCB at the time of the project's completion, and support for the existing Haripur power plant was not included under the scope of this project. A total of 59 new power plant and EGCB staff have been trained (42 man-months) for the operation and maintenance of the new Haripur power plant.

Photo: Gas Turbine

Photo: Main Transformer

3.2.2 Project Inputs

3.2.2.1 Project Cost

Table 2 shows the planned project cost at the time of the appraisal (I) and the actual project cost. As shown in the table, the project cost was within the plan (80 % of the original plan).

Table 2 Planned and Actual Project Cost

(Unit: million yen)

	Plan [Note 2]	Actual	Actual/planned ratio
Total project cost [Note 1]	54,409	43,690	80 %
Project cost (I)	—	21,748	—
Project cost (II)	—	21,942	—
Loan portion	41,066	38,076	93 %
Project cost (I)	17,767	17,435	98 %
Project cost (II)	23,229	20,641	89 %

Source: Document provided by JICA, PCR

Note 1: Since the documents at the time of the appraisal did not state the breakdown of each cost of (I) and (II) other than the amount covered by the yen loan, the difference for each cost of (I) and (II) was not analyzed.

Note 2: The amount at the time of planning is based on the project cost at the time of appraisal (I).

The main reason why the actual project cost was lower than the planned cost was the fluctuation in exchange rates during the project period. The exchange rate at the time of the appraisal was 1.66 yen per taka, whereas the average exchange rate during the project period was 1.33. It was 1.08 yen when the construction and procurement contract was signed in 2011, and it was less than 1 yen when beginning full-scale work in 2012. Other reasons for the reduction in costs include the cancellation of consultant services assignment for existing power plants planned at the time of the appraisal.

3.2.2.2 Project Period

The project period[10] was planned to be 96 months as opposed to an actual 151 months, from December 2007 to June 2020, which was longer than planned (157% of the plan).

Table 3 Planned and Actual Project Period

	Plan	Actual
L/A	December 2007	
Selection of consultant	September 2007 – April 2009	June 2010
Tender and contract	February 2008 – September 2009	June 2010 – February 2011
Construction and procurement	October 2009 – September 2012	February 2011 – March 2014
Warranty period	No information	March 2014 – January 2018

[10] The project period is defined as the period from the month in which the Loan Agreement (L/A) is signed to the month in which the Long-Term Service Agreement period ends.

Long-term service agreement	October 2012 – September 2015	June 2017 – June 2020
Consulting services	June 2008 – June 2013	December 2008 – December 2017
Project completion	September 2015	June 2020
Project duration	96 months	151 months

Source: Documents provided by JICA, PCR, questionnaire responses from the executing agency

The main reason for this delay was due to delays in procurement and contracting, the impact of hartals[11] and road blocks caused by political unrest, which delayed the movement of equipment, materials, and workers. In addition, the power plant shut down suddenly and damage was found in the gas turbine in May 2015, requiring more time for inspection and replacement of the gas turbine, then the warranty period was extended. The start of a Long-Term Service Agreement (LTSA) was postponed accordingly, which also contributed to the delay in the project period. The impact on construction work due to hartals and other circumstances related to political unrest, and the sudden stop of the power plant due to damage of the gas turbine were unexpected issues, and were events beyond the control of the executing agency and project stakeholders. The selection and contracting of consultants can be deemed as project management issues, however, according to the executing agency, the bidding process consists of two steps, the Expression of Interest (EOI) and Request for Proposal (RFP), which require a lot of time to prepare, revise, and discuss various documents before the contract is signed, often leads to project delays, not only for this project.

3.2.3 Results of Calculations for Internal Rates of Return (Reference only)

The Internal Rates of Return calculated at the time of the appraisal and ex-post evaluation of this project and the conditions are shown in Table 4.

Table 4 IRR and Conditions

	Financial Internal Rate of Return	Economic Internal Rate of Return
IRR	As of the appraisal: (I) 6.7 %, (II) 8.8 % As of the ex-post evaluation: 4.2%	As of the appraisal: (I) 20.7 %, (II) 20.6 % As of the ex-post evaluation: 13.4 %
Cost	Project cost, operation and maintenance expenses	Project cost (excluding taxes), operation and maintenance expenses
Benefit	Revenue from sale of energy	Revenue from sale of energy based on assumed wholesale electricity prices[12]
Project life	25 years	

Source: Documents provided by JICA

[11] A “general strike” and is part of political campaigns that take place mainly in South Asia.
[12] EIRR was calculated based on the estimated wholesale electricity prices which were estimated based on retail prices from the World Bank’s survey in accordance with conditions at the time of the appraisal.

Financial Internal Rate of Return (FIRR)

The FIRR at the time of the ex-post evaluation was lower than the one at the time of the appraisal. The delay in the start of operation of the facility due to the prolonged project period and maintenance costs exceeding forecast amounts at the time of the appraisal[13] were deemed as the reasons for the lower FIRR, while a decrease in project costs due to fluctuations of exchange rates and an increase in electricity sale revenue[14], etc. were confirmed.

Economic Internal Rate of Return (EIRR)

For calculating EIRR, although taxes are excluded from the project cost, the calculation cost is basically the same as in the case of FIRR. As with the FIRR, the EIRR at the time of the ex-post evaluation also became lower than the one at the time of the appraisal because the project period was extended and maintenance costs were higher than assumed at the time of the appraisal.

In light of the above, although the project cost was within the plan, the project period exceeded the plan. Therefore, efficiency of the project is fair.

3.3 Effectiveness and Impacts[15] (Rating: ③)

3.3.1 Effectiveness

3.3.1.1 Quantitative Effects (Operation and Effect Indicators)

Table 5 summarizes the actual data since the completion year of the facility construction for each of the operation and effect indicators established at the time of the appraisal of the project.

Table 5 Operation and Effect Indicators of the Project

	Target	Actual					
	2017	2014/5	2015/6	2016/7	2017/8	2018/9	2019/20
	3 Years after facility construction Note 1	Construction completion Year	After construction completion				
			1 Year	2 Year	3 Year	4 Year	5 Year
Maximum output (MW) Note 2	**360→412**	474	466	477	483	472	469
Plant load factor (%)	**70**	49	34	85	89	80	81
Plant availability (%)	**86.3**	54	41	89	94	90	93

[13] Although it was confirmed with the accounting team of the executing agency, the reason, why the maintenance cost was higher than the assumption at the time of the appraisal, was unknown. It may be considered as one of the factors that prices, especially the one for fuel, have increased more than expected since the time of the appraisal (2007).

[14] The plant's rate of operation was 10% higher than that of estimated rate (70%) at the time of the appraisal.

[15] Sub-rating for Effectiveness is to be put with consideration of Impacts.

Auxiliary power rate (%)	**5**	3.8	4.1	3.8	3.9	4.1	4.2
Gross thermal efficiency (%)	**50**	47	46	58	58	53	54
Outage hours							
by human errors	**0**	0	0	0	0	0	0
by machine failures	**0**	3,325	5,095	31	14	105	53
by periodical inspections	**1,200**	696	0	0	324	668	0
Outage times							
by human errors	**0**	0	0	0	0	0	0
by machine failures	**0**	15	7	6	4	8	8
by periodical inspections	**1**	1	0	0	1	1	0
Amount of net generation output (GWh/Year)	**2,097**	1,783	1,232	2,855	3,008	2,706	2,783

Source: Documents provided by JICA, questionnaire response from the executing agency
Note 1: Normally, the ex-post evaluation of an ODA loan project is carried out two years after the completion of project, but under this project, a long-term service agreement was provided for three years after construction, so the operation and effect indicator targets were set three years after completion of construction.
Note 2: As the output of the gas combined cycle increased from 360MW at the time of the appraisal to 412 MW, the target has been also revised to 412 MW.

As a long-term service agreement was to be provided for three years after construction under this project, the targets for operation and effect indicators, which were set at the time of the appraisal, were expected to be achieved three years after completion of construction of the gas combined cycle facility. While the construction of the facility was completed in 2014/5, the provision of long-term maintenance services ended in 2020 as already mentioned in "3.2.2.2 Project Period". Therefore, the achievements of the indicators are analyzed based on the data of 2019/20 while also confirming the trends since the completion year of facility construction. All indicators including actual data of maximum output, plant load factor, plant availability, auxiliary power rate, gross thermal efficiency and amount of net generation output in 2019/20 achieved the targets. The reason why the plant's load factor and plant availability in 2015/6 were about 50% of the targets was due to adjustments made to the steam turbine. In addition, a damage occurred in the gas turbine in May 2015, and operations were suspended until January 2016, resulting in the plant's load factor and plant availability for 2015/16 to be less than 50% of targets. Thereafter, both turbines have been operating without problems, and plant's load factor and plant availability have been exceeding targets. Since 2017/18, maximum output and net generation output generation have been decreased in 2018/19 and 2019/20. This was due to the implementation of scheduled inspections of steam and gas turbines in 2018/19, and maintenance of equipment[16] repairs of gas turbines and problems occurred in the gas compressor control systems that needed to be addressed in

[16] Bypass Stack Silencers

2019/20.

The number of stoppage times and hours caused by human error were both zero and in line with targets. However, the actual stoppage hours due to mechanical failure was 53 hours and the actual number of stoppages was eight, exceeding targets (both set at 0). The actual stoppage hours due to mechanical failures exceeded 3,000 hours and 5,000 hours in the year of the completion of the facility construction and one year later, respectively, mainly due to an unexpected turbine accident and the time required to repair it as mentioned above. The problem has since been resolved, and the stoppage times and hours have significantly improved[17]. Stoppage hours were 324 hours in 2017/18, 668 hours in 2018/19 and 0 hour in 2019/20 compared to the planned 1,200 hours, which raises concerns that less planned maintenance was performed than expected[18]. On the other hand, the planned outage times by periodical inspections, which was targeted to be once per year, was as planned in 2017/8 and 2018/19, and the actual number in 2019/20 was 0 time.

3.3.1.2 Qualitative Effects (Other Effects)

At the time of the appraisal, the project was expected to contribute to the "vitalization of local economy and improvement of convenience for residents" as a qualitative effect, however, this is evaluated in the impact section since the content is considered impact.

In terms of qualitative effects, the executing agency explained that the construction of the new Haripur power plant has increased the reliability of the power supply system by reducing load shedding[19]. In addition, the new Haripur power plant has higher thermal efficiency[20] than other power plants in Dhaka Division (see Table 6), which contributes to the reduction of fuel consumption and improvement of power generation efficiency. In fact, a comparison with the other two power plants owned by EGCB confirms that the new Haripur power plant has the lowest fuel cost per unit of electricity generated (see Table 7).

[17] With regard to the stoppage hours and number of times due to mechanical failure, documents at the time of the appraisal stated that target goals should be set, although mechanical failure may occur suddenly. Therefore, while the target was set as zero, a certain degree of mechanical failure was also expected.

[18] In this project, the planned outage hours by periodical inspections was planned to be 1,200 hours per year. On the other hand, with regard to the gas combined-cycle thermal power plants constructed with the support of Japanese ODA loans, the target values for the same indicators were set at 775 hours per year for the Simar Power Plant Unit 2 (400 MW) (Azerbaijan) and 192 hours for the Bheramara Power Plant (360 MW) (Bangladesh), indicating that the target values for this project may be higher than for similar projects.

[19] A system that temporary shutdowns the power supply to a specified location or device to prevent an overload that could result in a total blackout caused by demand exceeding supply when power use increases.

[20] Thermal efficiency is the rate at which the thermal energy (calorific value) of fuel can be converted into electrical energy (power generation). The higher the thermal efficiency, the more electricity can be produced with less fuel.

Table 6 Thermal Efficiency of Each Power Plant

Power plant	Haripur (New)	Haripur (Existing)	Sidhirganj 2 x 120MW PPP Note1	Ghorasal Unit 1&2	Ghorasal Unit 7	Sidhirganj 335 MW CCPP
Thermal efficiency	55.2%	18.5%	24.6%	25.0%	47.2%	36.6%

Source: BPDB *Annual Report* 2019-20
Note 1: Peaking Power Plant.
Note 2: Combined Cycle Power Plant

Table 7 Cost of Fuel per Unit Generation at the Power Plant Managed by EGCB

(Unit: taka/kWh)

	Sidhirganj 2 x 120MW PPP Note 1	Haripur (New)	Sidhirganj 335 MW CCPP Note 2
2018/19	1.20	0.58	0.88
2019/20	1.72	0.82	1.05

Source: EGCB *Annual Report*, each year edition
Note 1: Power generation capacity was 210 MW.
Note 2: Power generation capacity was 335 MW.

3.3.2 Impacts

3.3.2.1 Intended Impacts

(1) Contribution to the vitalization of the local economy

In this ex-post evaluation, it was examined for obtaining information and analyzing the impact generated by the project implementation, after confirming areas where the effects of power generation have been spread to the power distribution companies. However, since the power generated in Bangladesh is integrated into the national grid from each power plant, it has been difficult to determine the exact impact on the economy in a particular area. Therefore, although exact areas cannot be identified, the power generation capacity of the new Haripur power plant accounted for about 4.2% of the total power generation capacity in Bangladesh at the time of completion of facility construction, and about 2%[21] at the time of ex-post evaluation, which means that the project has made a certain level of contribution to the country's power system.

Furthermore, interviews with the executing agency and beneficiaries[22] indicate that the project has reduced the frequency and number of power outages, and that the stable supply

[21] In contrast to the 420 MW capacity of the new Haripur power plant, the total capacity of the country's power generation facilities at the completion of facility's construction was 9,821 MW, and the same capacity at the time of the ex-post evaluation was 18,961 MW. (Source: Questionnaire responses from the executing agency)

[22] As mentioned above, it is not possible to specify the exact areas where the power generated from the new Haripur power plant is distributed, but according to the executing agency, the contribution by the project would be significantly high in the area near Dhaka because of its location near the Load Center, which is located near Dhaka. Therefore, interviews were conducted by the local staff in the suburbs of Dhaka and near the city of Narayanganj, where the power plant is located. Interviews were conducted on April 1 and 2 at four locations: a chemical factory, a food plant, a steel factory, and a cotton mill.

of electricity has positively affected the operational status of factories. Specifically, the following impacts were reported.

- Increased factories operating hours, increased work efficiency by reducing the time and frequency of work interruptions, resulting in increased production and improved product quality
- Reduction of food loss due to interruption of work (especially in factories that handle food), and increase in profits through the reduction of the food loss
- Increased employment due to longer operating hours and increased production

According to the executing agency, 130 staff members were employed at the new Haripur power plant after its construction and continue to work at the time of the ex-post evaluation. In terms of boosting employment, in addition to the staff, the services of many suppliers and contractors involved in the operation of the power plant have been expanded, contributing to the economic vitality of the neighboring areas.

(2) Improving convenience for residents and contributing to their daily lives[23]

Through interviews with residents, all respondents answered that both the duration and frequency of power outages have improved as a change after the implementation of this project. As a result, the following lifestyle and economic changes were mainly reported.

- Increased study time of students and increased study through the use of PCs and the Internet
- Use of electrical appliances (such as fans, ovens, refrigerators, battery chargers, mixers, electric heaters) reduced housework and improved convenience in daily life.
- Improved security in the areas at night
- Reduced expenses on lamp fuel, and reduced fire risks associated with lamp use.
- Improved convenience by extending market operation hours
- Boosted employment (in factories for beverages, sewing, flour milling, hospitals, etc.) and generated/increased income

Through these effects, the stabilization of electricity supply by this project is believed to have contributed to the improvement of convenience in daily life and also the reduction of poverty in the region.

3.3.2.2 Other Positive and Negative Impacts

(1) Impacts on the natural environment

In accordance with the *JBIC Guidelines for Confirmation of Environmental and Social*

[23] Interviews with end-users were conducted by the local assistant in the neighboring area of Narayanganj city. The interviews were conducted on March 23 and 24. Six people (two in their 20s, three in their 30s, and one in his 40s) were interviewed.

Considerations (April 2002), the project falls into Environmental Category A, as this project is categorized as a thermal power generation sector. An Environmental Impact Assessment (EIA) report of this project was approved in September 2006 by the Department of Environment (DOE). During the implementation of the project, a required wastewater treatment facility was constructed, and measures were taken to discharge the exhaust emissions through a 65-meter high exhaust duct, as well as to construct a cooling tower for recycling and to install a sound-absorption system. In addition to the above items specified in the EIA, monitoring of other components (dust and noise during construction, noise, air quality, and wastewater after construction) has been conducted, and they meet standards set by the DOE and World Bank[24]. The monitoring logs have been confirmed at the site through the site visits of this ex-post evaluation, and it has been confirmed by the executing agency that there have been no negative impacts due to the implementation of this project during and after the completion of construction.

(2) Resettlement and land acquisition

As the new Haripur power plant was constructed on the existing power plant premises, it was planned that neither land acquisition nor resettlement would be necessary. It was confirmed with the executing agency that neither resettlement nor land acquisition had occurred as planned at the time of the appraisal.

(3) Unintended positive/negative impacts

Impact from a gender perspective[25]

With the stable supply of electricity procured through the implementation of this project, the operations of markets and factories are accelerating in the neighboring areas of Narayanganj city. At the same time, the use of electrical appliances has reduced the burden of housework on women, which is thought to have contributed to the expansion of employment opportunities for women by allowing them to use their time to engage in income generating activities or to obtain jobs.

For example, 17 women were employed during the construction of the new Haripur power plant, and they have been working in the operation and cleaning of the plant after the start of operations[26]. According to a woman who got a job at the power plant, getting a job has enabled her to become financially independent and support her family

[24] Source: Documents provided by JICA and the executing agency, and questionnaire response from the executing agency

[25] Interviews were conducted in August 2021 with 10 women (four in their 20s, three in their 30s, and three in their 40s) who obtained jobs or started income generating activities after the completion of the project at the new Haripur power plant and near Narayanganj city. The breakdown of occupations was: five power plant employees, two tailors, one milk plant worker, and one hospital worker.

[26] Source: Interviews with local residents of the new Haripur power plant

financially. In addition, she explained that her family and relatives began to respect her opinions and ideas in the decision-making process by becoming financially independent. In addition, the extended hours of operation of markets and factories have increased the opportunities for women to obtain jobs in various factories, hospitals, and other workplaces. Cases were also reported that women earn income from tailoring clothes and making and selling handicrafts, which enables them to pay for their children's education and house rent[27].

As mentioned above, at the new Haripur power plant has mostly achieved targets for plant load factor, plant availability, auxiliary power rate, gross thermal efficiency, outage hours and times by human error and periodical inspections, and net generation output. In addition, after the turbine was repaired, the hours and number of times of outages due to machine failures significantly decreased. Accordingly, a continuous and stable electricity supply was made possible, and factories and markets were able to conduct their operations stably without being affected by power outages in neighborhoods near the power plant, contributing to the improvement of the local economy by increasing profits and boosting employment. In addition, it has been confirmed that the convenience of daily life has been improved in households, etc. In light of the above, this project has mostly achieved its objectives. Therefore, effectiveness and impacts of the project are high.

3.4 Sustainability (Rating: ③)

3.4.1 Institutional/Organizational Aspects of Operation and Maintenance

The EGCB, the executing agency of the project, is a power generation company spun off from BPDB in 2004, and the new Haripur power plant is under the jurisdiction of the EGCB. The number of staff of the EGCB increased from 71 at the time of the appraisal shortly after the spin-off to 553 at the time of the ex-post evaluation (including the number of staff at each power plant). Currently, the EGCB has jurisdiction over the new Haripur power plant as well as two other power plants.

[27] Source: Questionnaire responses from the executing agency

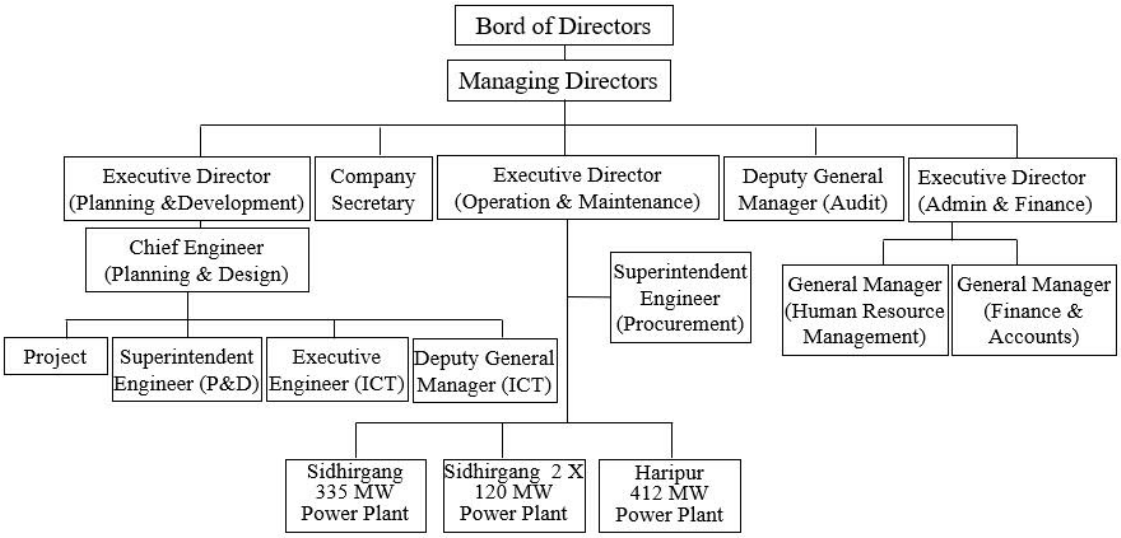


Figure 2 Organization Chart of EGCB

Source: EGCB Website http://www.egcb.gov.bd/site/page/bb844d1c-13ad-4689-9bc9-7c3028c56c48/- Accessed on September 3, 2021)

At the time of ex-post evaluation, 143 staff members were assigned to the new Haripur power plant, with engineers from the plant's operations and maintenance departments in charge of maintenance, and 107 staff members, including drivers and other workers, engaged in operation and maintenance. A part of the regular maintenance is carried out with the support of manufacturers, but no problems such as personnel shortages have arisen.

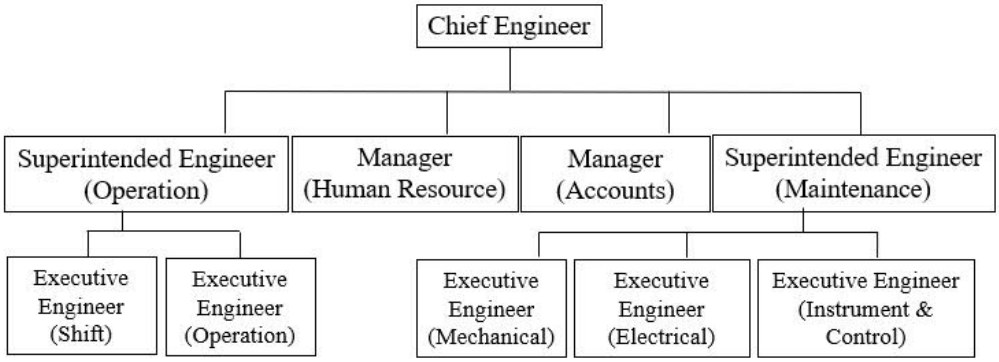


Figure 3 Organization Chart of New Haripur Power Plant

Source: EGCB Website http://www.egcb.gov.bd/site/page/bb844d1c-13ad-4689-9bc9-7c3028c56c48/- (Accessed on September 3, 2021)

As indicated in the organizational chart of the EGCB (see Figure 3), the new Haripur power plant is under the jurisdiction of the EGCB, and adequate communication is in place. In addition, the number of staff at the EGCB has increased since the time of the appraisal in line with the increase in the number of power plants under its jurisdiction,

and the number of staff at the new Haripur power plant has been also appropriately assigned, indicating that there are no problems from an institutional/organizational aspects.

3.4.2 Technical Aspects of Operation and Maintenance

The core members of the EGCB have been assigned by BPDB personnel with experience in the construction and operation of thermal power plants. The new Haripur power plant is a gas combined cycle power plant, which requires more advanced operation and maintenance capabilities than the simple gas-fired power plants prevailing in Bangladesh at the time of the appraisal. Thus, EGCB engineers, including those of the new Haripur power plant, had the opportunity to improve their technical expertise through consulting services. Through the consulting services, EGCB's engineers were able to be on site during the construction of the power plant to learn and understand in detail the functioning of the new power plant facilities and equipment. Through hands-on experience, such as collaborating with engineers from Japanese manufacturers on overhaul work at the site, it became possible to perform operation and maintenance of equipment using the latest technology as routine tasks. In addition, more than 30 staff members participated in overseas training in South Korea for four weeks on operation and maintenance. According to EGCB staff, compared to the simple gas-fired power plant equipment they had handled in the past, the latest gas turbines, heat recovery steam generators[28], turbine bypasses[29], and other equipment installed in gas combined cycle plants were facilities and equipment they had less experiences before. Thanks to the adequate training opportunities provided by the project, the staff engaged in operation and maintenance are performing the necessary operational and maintenance tasks leveraging these experiences after the new Haripur power plant went into operation. The EGCB has also arranged capacity building and performance improvement training for their staff. The EGCB has set a goal and worked to ensure 70 hours of training per person per year, and, it achieved 83 hours of training in 2018/19 to improve staff capacity.

As planned at the time of the appraisal, LTSA was signed for the gas turbine and maintenance support has been received. At the time of the ex-post evaluation, the initial contract for three years had already been completed and the contract was renewed. Based on the LTSA, about 90% of the services mainly relate to the procurement of spare parts required for gas turbines. The remaining 10% of the services are provided by specialists, who provide remote monitoring of the gas turbines and a certain level of support during

[28] A heat recovery steam generator is one of the main components of a gas turbine combined cycle power plant with high thermal efficiency and low CO_2 emissions. This is a heat exchanger that uses the heat of exhaust gas to generate steam.
[29] A device installed mainly to reduce time to start up boilers and improve start-up performance.

maintenance when spare parts need to be replaced.

Although some support is provided as mentioned above, the EGCB staff, including those at the new Haripur power plant, have the technical expertise required to carry out the necessary operations and maintenance. Moreover, although it has been pointed out that consumables and spare parts are time-consuming and costly to obtain, they have been properly managed through the LTSA and there are no concerns that could seriously affect the operation of the power plant.

3.4.3 Financial Aspects of Operation and Maintenance

As shown in the Table 8, the EGCB's profits over the past three years have been increasing. The sales of energy have also been increasing year by year, therefore, it can be considered that the EGCB has been receiving stable energy revenue. In terms of key financial indicators (see Table 9), the debt-servicing capability, financial sustainability and profitability are all stable, thus its financial condition is generally sound.

Table 8 Profits and Losses of EGCB

(Unit: million taka)

	2017/18	2018/19	2019/20
Revenue			
Sales of energy	8,340	9,353	11,786
Non operating income	689	590	727
Total revenue	9,029	9,943	12,513
Expenditure			
Cost of revenue	5,954	6,982	8,854
Administrative expenses	279	226	232
Financial expenses	793	740	782
Foreign exchange gain/loss	103	21	(2)
Other	95	99	132
Total expenditure	7,224	8,068	10,000
Profit before tax	1,805	1,875	2,513
Net profit after tax	1,751	1,816	2,439

Source: EGCB *Annual Report* each year edition

Table 9 Major Financial Information of EGCB

		2017/18	2018/19	2019/20
Debt-servicing capability	1. Current ratio (%)	1.30	1.38	1.43
	2. Debt equity ratio (%)	4.12	3.74	3.47
	3. Debt service coverage ratio (%)	1.50	1.22	1.24
Financial sustainability	4. Equity ratio (%)	0.17	0.18	0.19

Profitability	5. Operating profit ratio (%)	29.00	5.99	4.75
	6. Return on asset (ROA) (%)	2.13	2.15	2.69
	7. Return of equity (ROE) (%)	12.90	12.12	14.01

Source: EGCB *Annual Report* each year edition

The operation and maintenance costs for the new Haripur power plant also have been increasing based on the data for the past five years. The costs for the LTSA have been paid from the operation and maintenance budget, and expenditures can be recognized without any problem if the contract is re-signed in the future[30]. In interviews with the new Haripur power plant, it was reported that the necessary budget for operations and maintenance has been allocated, thus there is no concern about operations and maintenance from a financial perspective.

Table 10 Operation and Maintenance Cost of New Haripur Power Plant

(Unit: million taka)

	2015/16	2016/17	2017/18	2018/19	2019/20
Operation and maintenance cost	2,184	3,554	3,689	3,522	4,488

Source: EGCB *Annual Report* each year edition

3.4.4 Status of Operation and Maintenance

It was confirmed through the questionnaire responses from the executing agency and the site visit that there were no problems in the operation and maintenance of the gas combined cycle and auxiliary facilities developed in this project, and the status at the time of the ex-post evaluation was generally good.

After the start of operation, there were some instances where metal particles were mixed in the gas supply through the pipeline, which interfered with the operation of the power plant, and other instances where the power factor of the output was unsatisfactory due to poor current flow in the transformers. However, all of these issues have already been resolved, and the high plant availability at the time of the ex-post evaluation indicates that there has been no impact on the plant's operation. According to the executing agency, maintenance has been carried out in line with the weekly maintenance plan, and manuals have been utilized at the sites as needed. However, as stated in the effectiveness, the actual planned outage hours of facilities have not achieved the target. It is possible that the target of planned outage hours was set too high, but in any case, the fact that there are some years with zero hours is a matter of some concern. At the time of the ex-post evaluation, it was confirmed with the executing agency and the site inspection that no serious problems have

[30] Source: Interview with EGCB

occurred in the facilities, but it is necessary to review the plan for periodic maintenance and to implement maintenance accordingly.

As described in "3.4.2 Technical Aspects of Operation and Maintenance", through the consulting services under this project, the engineers of EGCB and the new Haripur power plant have learned the mechanisms for the newly introduced combined cycle power generation and the operation and maintenance activities through on-the-job training. This know-how has been utilized in the actual operation and maintenance activities after the completion of the project. In addition, the LTSA has been extended the contract after three years of facility construction, and the procurement of necessary spare parts and consumables have been made without any problems while receiving support under the LTSA even at the time of the ex-post evaluation.

In light of the above, no major problems have been observed in the institutional/organizational, technical, financial aspects and current status of the operation and maintenance system. Therefore, sustainability of the project effects is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

This project was implemented with the aim of meeting the growing demand for electricity by constructing a new thermal power plant (combined cycle) in Haripur of Narayanganj district and supporting the strengthening and streamlining of the operation and maintenance system of power plants, thereby contributing to the enhancement of industrial competitiveness and improvement of people's livelihood.

This project, which aimed to respond to the increasing demand for electricity through the construction of a new power plant, is consistent with Bangladesh's development policy, which has been emphasizing the expansion of power generation and improvement of energy efficiency to meet the ever-increasing demand for electricity, its development needs for the expansion of facilities to ensure the supply of electricity, and Japan's ODA policy, which has positioned power infrastructure as a priority area for support for sustainable growth. Thus, its relevance is high. Although the project cost was within the plan, the project period largely exceeded the plan due to delays in the selection and contracting of consultants, the impact of political instability on the construction work, and the occurrence of a damage at the gas turbine, thus the efficiency of the project is fair. As for the project effects, maximum output, plant load factor, plant availability, auxiliary power rate, gross thermal efficiency, and net generation output all achieved the targets, although power outages were caused by machine failures during a certain period after the start of operation. In addition, the reduction of power outages at factories and markets due to the stable supply of electricity in areas near the power

plant contributes to the improvement of the local economy by increasing profits and promoting employment, and also leads to the improvement of the convenience of daily life for households. Impacts such as women's employment and participation in income generation activities have been confirmed, thus, effectiveness and impacts of the project are high. As for the operation and maintenance, no major problems have been observed in the institutional/organizational, technical, financial aspects and current status of the operation and maintenance system. Therefore, sustainability of the project effects is high.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

In this project, the actual number of outage hours by periodical inspections, which was set as an operation and effect indicator, was 324 hours, compared to the planned target of 1,200 hours. The target of this project set at the time of the appraisal might have been higher than that of similar projects, but the fact that there were some years with zero outage hours is a matter of some concern. At the time of the ex-post evaluation, it was confirmed that no serious problems had occurred in the facilities through confirmations with the executing agency and the site visit, however, the EGCB needs to review the plan for regular maintenance and conduct maintenance appropriately according to the plan.

4.2.2 Recommendations to JICA

None

4.3 Lessons Learned

<u>Ensure sustainability through long-term support for operation and maintenance</u>

The power plant constructed in this project is a gas combined cycle power plant, which requires an advanced level of operation and maintenance capability compared to the simple gas-fired power plants that had been prevalent in Bangladesh. In this project, the manufacturers provided guidance on the operation and maintenance activities of the new power plant in the form of on-the-job training during the construction of the power plant, and after the completion of the facility construction, the operations and maintenance staff of the new power plant were able to receive support as needed, such as ensuring the procurement of spare parts through the LTSA. As a result, operation and maintenance have been appropriately conducted through the time of the ex-post evaluation. In cases such as this project, where operation and maintenance require more advanced capabilities and responses than those facilities and equipment that have been widely used in the target country to date, continued support for operation and maintenance for a certain period of time during

and after implementation is effective for continuing appropriate operation and maintenance activities.

Setting of bidding period for selection of consultants

In this project, the project period was 157% of the planned period, which largely exceeded the plan. One of the main reasons was the delay in the bidding and contracting processes for the selection of consultants. Although this delay is a project management issue, according to the executing agency, the bidding process with two processes of EOIs and RFPs takes a lot of time to reach the contract, and there have been many cases in the country, not only for this project, where delays in the bidding period led to delays in the project. Also, in general, there are many instances in the loan projects where delays in bidding were factors in prolonged project periods. In the future, when planning projects in this country, those in charge of project planning in JICA and the executing agency should examine the times required for the bidding processes in past projects and set a realistic time frame for the process, as well as consider ways to reduce project delays related to bidding. In addition, during the project implementation, it is recommended looking into ways to reduce project delays related to bidding, such as by expediting the bidding process.

(end)

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
1. Project Outputs		
Gas combined power plant development	1) Installation of 360 MW gas combined power plant and related facilities 2) Long term service agreement (LTSA) 3) Relocation and dismantling of existing substation in the proposed power plant construction site 4) Installation of gas pipeline	1) Installation of 412 MW gas combined power plant and related facilities 2) As planned 3) As planned 4) As planned
Consulting services	5) Engineering service consultant ・ Detailed design of power plant development and relocation of substations, follow up on procurement, construction supervision (including the measures for HIV/AIDS) ・ Follow up on tendering and contract negotiation for LTSA. 6) Management service consultant ・ Support for the establishment and revitalization of the operation and maintenance system for new and existing power plant under the project, upon the introduction of the Business Unit (SBU), which is an independent accounting system.	5) As planned 6) Implemented only for the new Haripur power station (Existing power plants are out of scope of this project.)
2. Project Period	October 2007 – September 2015 (96 months)	December 2007 – June 2020 (151 months)
3. Project Cost Amount paid in foreign currency Amount paid in local currency Total ODA loan portion Exchange rate	 34,976 million yen 19,433 million yen (11,706 millions taka) 54,409 million yen 34,976 million yen 1 taka = 1.66 yen (As of September 2006)	 37,193 million yen 833 million yen (664 millions taka) 43,690 million yen 38,076 million yen 1 taka = 1.33 yen (Average between December 2007 and June 2020)
4. Final Disbursement	March 2013 (I) June 2018 (II)	

(end)