India

Western Yamuna Canal Hydroelectric Project (ID-P7)

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Field Survey: October 2006/February 2007

1. Project Profile and Japan's ODA Loan

Map of project area


Control room

1.1 Background

Haryana, a state in northern India, was, until 1966, part of the state of Punjab. It has a population of about 22 million (70% of which is rural), an area of 44,212 km^2 (or 1% of the total area of India), and most of the land is flat. It is bounded by Punjab and Himachal Pradesh in the north, Rajasthan in the southwest, and Uttarakhand and Uttar Pradesh in the east bordering the Yamuna River.

In 1993, when it accounted for 42.5% of Haryana's GDP, agriculture was still the linchpin of the state economy, but in 2004, it dropped to 28.2%. In the meantime, the industry's contribution to the state economy remained at the 26–27% mark in 2004, while the service industry's contribution increased to 140%. This change in the industrial structure of India is manifested in the trend in electricity consumption by sector. The percentage of total electricity consumption that agriculture accounts for peaked in FY2000 and has been on the decline ever since. By contrast, the percentage of total electricity consumption attributed to the industrial sector has been rising at a rate of around 36% from FY2000 to FY2004; therefore, the supply and demand of electric power has remained stringent. In addition, given that the state of Haryana has hammered out a policy of strengthening the manufacturing and service industries, it can be seen that the development of new power sources and enhancement of power generating efficiency will continue to be important issues in the months and years to come.

1.2 Objective

The project objective is to increase the amount of power generated through the construction of a power generating channel in parallel with the existing Western Yamuna Canal as well as through the building of power plants in the Tajewala district of the state of Haryana, thereby contributing to the development of the state economy and improvement of its living conditions.

1.3 Borrower/Executing agency

Borrower: President of India / Haryana State Electricity Board

Executing agency: Haryana State Electricity Board (HSEB); since 1997, changed to Haryana Power Generation Corporation Limited (HPGCL).[1]

1.4 Outline of Loan Agreement

Loan Amount / Loan Disbursed Amount	4,000 million yen / 3,244 million yen
Exchange of Notes / Loan Agreement	March 1981
Terms and Conditions -Interest Rate -Repayment Period (Grace Period) -Procurement	 2.75% 30 years (10 years) Partially untied
Final Disbursement Date	March 1992
Main Contractors	Sumitomo Corporation
Consulting Services	None
Feasibility Study (F/S), etc.	1984 Haryana State Electricity Board[2]

2. Evaluation Result (Rating: D)

2.1 Relevance[3] (Rating: b)

In India, the electric power sector has consistently been a high priority area and given the largest share of the public sector investment plan as stipulated in three of the last five

[1] Under the 1997 Haryana Electricity Reform Act, Haryana State Electricity Board (HSEB) was split into Haryana Power Generation Corporation Limited (HPGCL), which is in charge of power generation, and Haryana Vidyut Prasaran Nigam Ltd. (HVPNL), which, in the beginning, was in charge of the transmission and distribution of power. Additionally, in 1999, while limiting its operations to power transmission, HVPNL established North Haryana Power Distribution Corporation and South Haryana Power Distribution Corporation to handle the distribution of power in their respective regions. Both corporations are wholly owned by HVPNL.

[2] During the 20-year period from the launch of the project and its completion, a detailed project report (dubbed DPR by the government of India) was compiled three times: 1984 DPR (Stage 1, Stage 2), 1994 DPR (the revised version of 1984 DPR, Stage 1 only), and 1998 DPR (Stage 2 only). In addition, although it is recorded in JBIC's internal information that a project report was prepared by the Central Water Commission (CWC) in 1989, it could not be obtained.

[3] In the past, three surveys have been conducted on this project: (1) an interim monitoring and supervision survey (1985); (2) SAPS (1997) targeting the rehabilitation of Stage 1; (3) SAPS (2000) targeting Stage 2.

national five-year plans: the 6th Five-Year Plan (1980–1984), the 8th Five-Year Plan (1992–1997), and the latest, that is, the10th Five-Year Plan (2002–2007).[4]

On the other hand, as part of its electrical power policy, the Central Electricity Authority (CEA) drafted a National Perspective Plan in 2000. The plan aimed to fill the shortage in electricity by renovating and rehabilitating the existing hydro power plants by the 11th Five-Year Plan (2007–2012). The National Electricity Policy 2006, which was based on the Electricity Act 2003 adopted in April 2003, pointed out that hydro power was an important infrastructure for the social economic development of the nation and emphasized as a clean and renewable energy source.

Power supply in the state of Haryana experienced a shortage of 16% in the end of 1979 when the demand for electricity peaked. Power shortage was predicted to continue into the 1980s, and the response to this longstanding shortage in electrical power was included in the Haryana State 6th Five-Year Plan (1982–1987) as one of its top policies. Even in the first half of FY2006, the supply and demand balance experienced a shortage of 11.8%, demonstrating that the power shortage besetting the state continues unabated. Thus meeting the need for power development had become the overriding issue for the state of Haryana.

Despite the fact that most of the state of Haryana is flat, hydro power generation was chosen over thermal power generation because, in the case of Stage 1 of this project, it was decided that it would be possible to use the available drop extending 38.4 m from the existing Tajewala Barrage to downstream Dadupur. And in Stage 2, it was concluded that it would be possible to increase the amount of electricity generated by taking advantage of the available drop extending 48.9 m from the Hathnikund Barrage, which was planned to be built, to Dadupur.[5] This is how the construction of the first hydro power plant in the state of Haryana was attempted in this project.[6]

Figure 1:
Silt that pours into canals from Yamuna River

[4] Stage 1 of this project was included in the electricity development program adopted in the 6th Five-Year Plan of the government of India, which called for the installation of 1,295 MW of hydro power in the northern region of the country. On the other hand, Stage 2 was included among those projects implemented in the 8th Five Year Plan.

[5] In addition, as of 1981,the option of developing a thermal power plant as a way of dealing with the electricity shortage was considered too difficult as there were no nearby coal mines and the transportation cost would be too high. The other alternative was to install a new hydro power plant. While it was not possible to confirm the actual cost of transporting the coal, it is conceivable that, as of 1981, although it was assumed that the "coal linkage" would be realized by 1985, there was a strong likelihood that this date would be postponed to 1990, thus rendering development of thermal power generation as being very difficult. (Coal linkage refers to the rule that ensures steady supply of coal by linking exclusive coal mining to major consumers of coal.)

[6] As of 1981, 109 years had already elapsed since the Tajewala Barrage was completed, so the barrage had become decrepit. Thus, the decision to construct the new barrage at Hathnikund upstream along the Yamuna

Thus was confirmed the policy consistency among this project, the policy of the government of India, the policy of the power sector, and the development plan of the state of Haryana. As described below, however, it cannot be said that the relevance of the planning and the scope of this project were sufficient.

The first difficulty was that, with regard to the prospect of securing the amount of water required in running Power House D in Stage 2, the analysis and verification by those concerned with this project was inadequate.[7] At the time of appraisal, it was assumed that to secure the required amount of water it was absolutely imperative that the dispute with the neighboring states over the water right issue be settled and that the Hathnikund Barrage be constructed. But that issue was not settled until 1994, and it took time to determine a number of important matters, including the location and funding for the Hathnikund Barrage, thus significantly delaying the commencement of work.[8] The water sharing dispute and the delay in the construction of the Hathnikund Barrage were the main reasons why the commencement of this project was delayed.

The second difficulty was that, even after taking into consideration the flat topographical characteristics of Haryana, it was opted to build a hydro power plant in the state.[9] Given the background described above, there was a substantial need for hydro power and several questions remain, including whether the technical specifications of the hydro power plant were properly and adequately examined.[10]

2.2 Efficiency (Rating: c)

River had already been made.

[7] In the water sharing dispute, a memorandum of understanding (MOU) concerning the right to the use of water in the Tajewala Barrage was entered into between the state of Punjab and the state of Uttar Pradesh in 1954, and it was agreed that the MOU would be valid for the next 50 years. However, in 1975, the water sharing dispute surfaced again, prompting the Central Water Commission to intervene four times – in 1981, 1985, 1990 and 1991 – in an effort to settle the dispute. Cognizant of the complexity of the water right issue, since its June 1976 pledge, JBIC had been postponing exchanging notes. However, in the end, thanks to a detailed explanation of the water sharing issue and that of the Hathnikund Barrage offered by the Chairman of the executing agency (HSEB), who arrived in Japan in February 1981, JBIC came around to agreeing to exchange the relevant notes.

[8] As of 1979, the central government of India had not authorized Stage 2 of this project, which was preconditioned on the construction of the new Hathnikund Barrage. Finally, in 1996, construction of the Hathnikund Barrage was implemented with the funding provided by the World Bank as one of the main components of the Haryana Water Resources Consolidation Project.

[9] As of February 1981, total power generation capacity in the state of Haryana was 1,077.5 MW, of which 61.2% and 38.8% were hydro power and thermal power, respectively. It was considered that hydro power was the main source of power and thermal power was an auxiliary source. However, all of the hydro power was purchased from other power plants in the state of Punjab and Himachal Pradesh, and there were no hydro power plants in the state of Haryana.

[10] For example, a horizontal valve turbine was used in this project, but it is debatable whether the use of this technology was appropriate. The use of the horizontal valve turbine is normally considered appropriate for low heads, and on this point, the choice of this type of turbine was appropriate for this project. However, as a precondition for efficient operation of the horizontal valve turbine, it is essential that only clear water be used, and in the Western Yamuna Canal, which is filled with large quantities of gravel and quartz silt, some people are of the opinion that the introduction of a vertical valve turbine, which is relatively easy to operate and maintain, would have been the best choice. (This is based on the analysis of a technical evaluator. See 2.3 "Effectiveness," for a discussion on this problem.)

2.2.1 Outputs

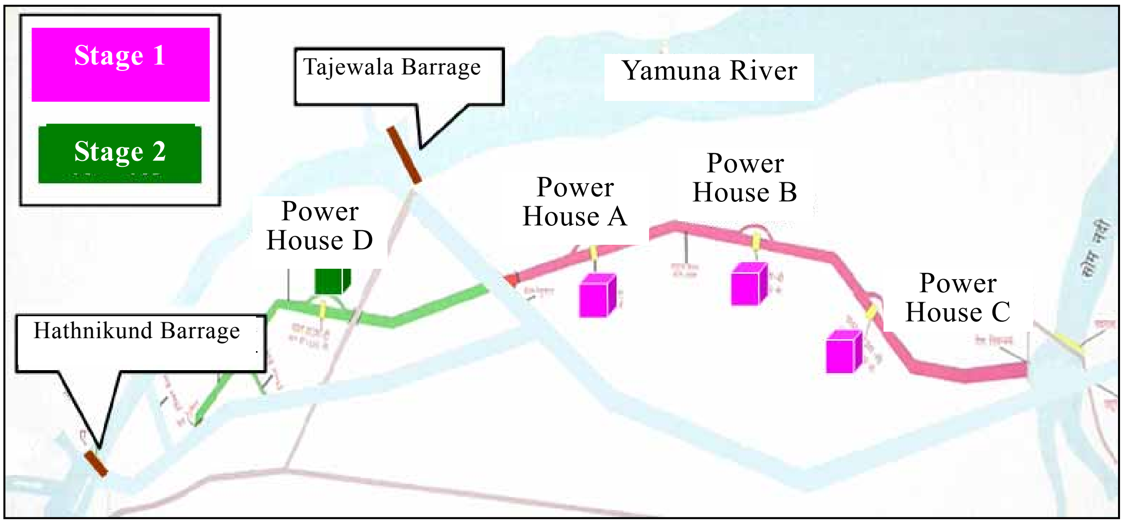
The output that was expected under this project comprised of following items: a hydraulic turbine (valve turbine), a synchronous generator, a process inspection in Japan, a water level measuring gauge, and funds to purchase a 100-ton trailer. With regard to the hydraulic turbine and the generator actually procured, while changes were made in specifications (due to reduction of a head drop and a change made by the supplier), the overall output was according to plan. However, detailed information on the process inspection in Japan, water level measuring gauge, and the 100-ton trailer was unavailable.

Additionally, all of the aforementioned equipment and materials, including the ones ordered for use in Stage 2, were delivered at the time construction work in Stage 1 started. However, because of the long delay in Stage 2, some of these equipment, materials and parts were used as spare parts for Stage 1. The equipment, materials and parts (mainly AVR, governor, and lubricating device) were procured with the funding provided by India's Power Finance Corporation (PFC). According to a hearing held by the executing agency, the cost of these equipment and materials were equivalent to about 20% of the construction cost of Stage 2 of this project.

Table 1: Composition of the Western Yamuna Canal Hydroelectric Project

Stage 1	Stage 2
A channel for generating electricity was constructed from the existing Tajewala Barrage to Dadupur (18 km downstream), and three power houses (A, B and C) were built. Each power house was equipped with two electric generators.	A channel for generating electricity was constructed from Hathnikund (4 km upstream of the Tajewala Barrage) to the Tajewala intake. Power House D was built on the channel, and equipped with two electric generators.

Figure 2: Western Yamuna Canal Hydroelectric Project: Location of Each Power House



Source: HPGCL

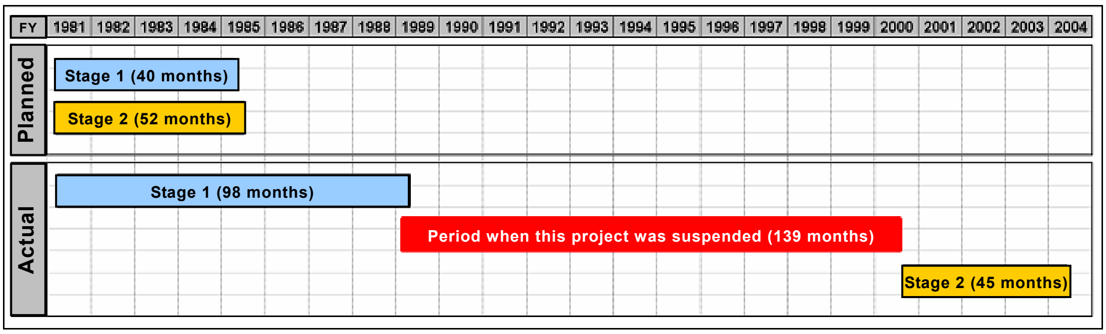
Table 2: Details of Changes in the Outputs of this Project

	Stage 1		Stage 2	
	Planned	Actual	Planned	Actual
Hydraulic turbine	Rated head: 13.59 m Speed: 166.7 min-1 Diameter of the runner: 3.30 m	Rated head: 12.80 m Speed: 187.5 min-1 Diameter of the runner: 3.15 m	Rated head: 10 m Speed: 166.7 min-1 Diameter of the runner: 3.30 m	Rated head: 12.80 m Speed: 187.5 min-1 Diameter of the runner: 3.15 m
Electric generator	Max. output: 8.0 MW Voltage: 6.6 kV Speed: 166.7 min-1 Bulb diameter: 3.5 m Power Houses (A-C) × 2 (each 8 MW) = Total max. output: 48 MW Annual energy production: 275 GWh	Speed: change to 187.5 min-1 Annual energy production: change to 225−284 GWh	Max. output: 8.0 MW Voltage: 6.6 kV Speed: 166.7 min-1 Bulb diameter: 3.5 m Power Houses (A-C) × 2 (each 6 MW) = Total max. output: 12 MW Annual energy production: 64 GWh	Speed: change to 187.5 min-1 Power House (D): Total max. output: increased to 14.4 MW (7.2 MW ×2)

2.2.2 Project period

In the original plan, the implementation period of this project was 52 months, from March 1981 to June 1985, and Stage 1 and Stage 2 were to be implemented simultaneously. However, in actuality, the implementation period was 282 months, from March 1981 to May 2004. In short, the actual period of implementation was 540% of the original plan. The biggest reason for the delay was the delay in the commencement of work of Stage 2.

Figure 3: Implementation Period of this Project: Planned and Actual



If the Stage 1 and Stage 2 were treated separately, it can be seen that the implementation period of Stage 1 was 204% of the original plan. Although the commencement of work was delayed in Stage 2, its implementation period was 87% of the original plan. The period when this project was actually suspended was 139 months.

The following reasons may be cited for the delay in Stage 1: (1) drawing of the construction diagram for Power House A was delayed 20 months due to lack of experience of the designer from CEW; and (2) the water level in the pond was changed at the request of the State Irrigation Department, and as a result, the depth and width of the channel had to be changed, resulting in additional civil works. In addition, (3) due to an overflow of ground water, construction of Power Houses B and C had to be interrupted and 24 additional months (from February 1981 to February 1983) were required to review the draining and drilling plans.[11]

Meanwhile, commencement of work was delayed in Stage 2 due to a dispute that broke over the rights to use the water in the Yamuna River. In the implementation plan, work in Stage 2 was scheduled to commence at the same time as the work on the Hathnikund Barrage. This was because unless the construction of the said barrage was assured and the link channel completed, it would be meaningless to commence work in Stage 2. As noted above, the water sharing dispute in the Yamuna River basin was settled in 1994, and the construction of the new barrage commenced in 1996. The new barrage went into operation in December 2000.

2.2.3 Project cost

The planned cost of this project was 17,280 million yen (5.819 billion rupee), but the actual cost was increased by 36%, to 23,531 million yen, due to the long delay of the actual construction work and the resultant additional civil works.

[11] According to the Mid Term Monitoring Report, the work of drilling the gravel bed containing ground-water is the most difficult and uncertain. So the method of construction adopted at the time of planning is regarded as relevant.

2.3 Effectiveness (Rating: a)

2.3.1 Operation and effect indicators

(1) Maximum output

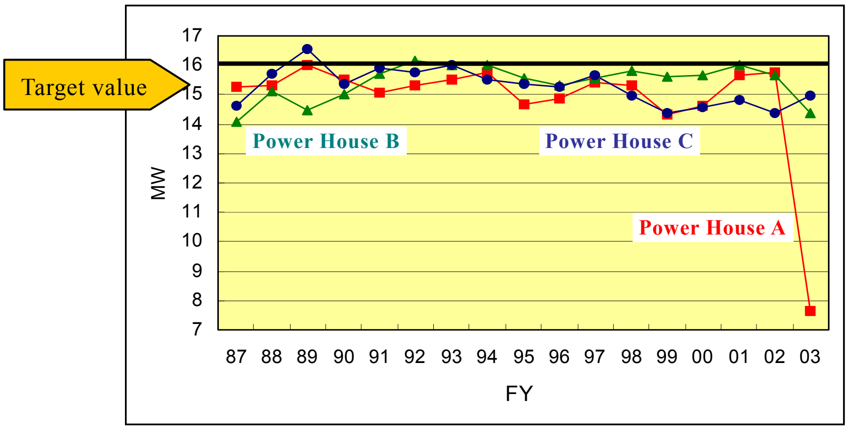
The maximum output was, in the case of Stage 1, 16 MW × 3 (Power Houses A, B and C) = 48 MW; in the case of Stage 2, 7.2 MW × 2 = 14.4 MW. For the 16 years for which data on Stage 1 (Power Houses A, B and C) was available, the target value was achieved only in a very small number of years. In Stage 2 (Power House D), the target value was never once reached. However, except for Power House A in FY2005, all power houses achieved more than 80% of their target.

Table 3: Date of Completion / Start of Operation of the Western Yamuna Power Plant

	Power House		Completion/ start of operation
Stage 1	A	Unit 1	May 30, 1986
		Unit 2	June 23, 1986
	B	Unit 1	May 15, 1987
		Unit 2	June 20, 1987
	C	Unit 1	March 27, 1989
		Unit 2	April 18, 1989
Stage 2	D	Unit 1	April 20, 2004
		Unit 2	May 16, 2004

In addition, the main reason why the power houses cannot achieve 100% of their target value is the recent reduction in the discharge of the Yamuna Canal.[12] On the other hand, the main reason why the maximum output was so low in FY2003 is that the silt ejector at Power House A Unit 1 broke down, and a month and a half later, the front gate could not be opened due to silt, ultimately causing a shutdown of the channel. The operation of Unit 1 was stopped for a period of one year. A new silt ejector has been procured from a local manufacturer, so the problem has already been solved.

Figure 4: Stage 1 Maximum Output



Source: Based on data obtained from the executing agency (HPGCL)

[12] The maximum usable amount of water (5,400 cusecs) agreed upon between the state of Haryana and the state of Uttar Pradesh can be obtained only during the rainy season, from July to September.

(2) Net electric energy production

The planned value of net electric energy production was 275 GWh for Stage 1 and 64 GWh for Stage 2. However, the only time 100% of the target value was actually reached was in FY1990 for Stage 1. As for Stage 2, this happened only in FY2004, the first in which it started operations. The main reason, in addition to the reduction in the aforementioned reduction in the discharge of the Western Yamuna Canal, is the increase in the number of forced outages.

In respect of Stage 1, since its completion in FY1989, more than 80% of the target was achieved, except for FY2005. With respect to Stage 2, more than 80% of the target was achieved in FY2005. After taking into consideration the hours when the power houses are shut down every fiscal year for planned inspections and maintenance and repair, the executing agency (HPGCL) establishes a separate set of planned values. If these targets were used as benchmarks, it would mean that more than 80% of the target was achieved every fiscal year. Thus it can be concluded that an acceptable level has been achieved.

(3) Plant load factor[13]

For Stage 1, when based on the average discharge year, the plant load factor (PLF) was 67.54%. When based on the draught discharge year, the PLF was 53.51%. In regard to Stage 2, the PLF was 51.37% for both cases.[14]

When the average discharge level is used as the standard, Stage 1 has never accomplished 100% of the target with the exception of Power House A in FY1990. However, all power houses have achieved anywhere from more than 80% to less than 100% of the target. In addition, Stage 2 has also achieved more than 80% of the target with the exception of FY1988. From these data, it can be concluded that although the operation of the power houses is not prefect, an acceptable level has been achieved.

(4) Hydro utilization factor[15]

Since there are no comparable standard target values based on the values planned at the time of appraisal or those based on periodical reviews, in this evaluation, target values of approximately 90% were used based on the “operation indicators for hydro power” set by

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13 $\mathrm{PLF} = \dfrac{\text{Net electric energy production}}{\text{Maximum output} \times 8{,}760\ \text{Hrs}} \times 100$

14 The PLF value for Stage 1 planned at the time of appraisal was 79.9% when it was based on the average discharge year, and 65.3% when based on the draught discharge year. In regard to Stage 2, the figures were 55.9% and 45.8%, respectively. However, by taking into consideration the reduction in the amount of water available for use in the Yamuna Canal, in this evaluation, the net electric energy production and the planned value were recalculated.

15 $\text{Hydro utilization factor} = \dfrac{\text{Net electric energy production}}{\text{Possible annual electric energy production in the reference year}} \times 100$

JBIC.[16]

Over the past 19 years, for both Stage 1 and Stage 2, the number of years in which the power houses achieved 100% of the target values is, as shown below, extremely low. However, more than 80% of the target value was achieved in most of the years.

Table 4: Hydro Utilization Factor

(A) Number of years when 100% of the target value was achieved

Stage 1	PHA: 0 years out of 19
	PHB: 4 years out of 19
	PHC: 1 year out of 17
Stage 2	PHD: 0 years out of 2

(B) Number of years when more than 80% and less than 100% of the target value was achieved

Stage 1	PHA: 17 years out of 19
	PHB: 18 years out of 19
	PHC: 17 years out of 17
Stage 2	PHD: 1 year out of 2

(5) Planned and forced outages

The number of forced outage hours has never been zero, thus casting doubt over any claim that the power houses are being properly operated. On the other hand, the executing agency sets 20 days (480 hrs) as its target for the planned outage hours per annum. However, for all power houses and for nearly all fiscal years, the target values were exceeded by a large margin. In FY2004, the actual number of planned outage hours was 138 days. Even in Stage 2, which was completed only recently, the actual planned outage hours exceeded the target value. This suggests that either there is a need to revise the target to a more realistic one, or the power house is not being operated and maintained properly. This also suggests that problems that are not easily solved, like the failure of the silt ejector and the front gate in Power House A Unit 1, are also occurring frequently in Power House D.

Table 5: Number of years when actual planned outage hours exceeded the target value

Stage 1	PHA: 13 years out of 18	72%
	PHB: 15 years out of 18	83%
	PHC: 13 years out of 16	81%
Stage 2	PHD: 2 years out of 2	100%

2.3.2 Economic analysis

As shown in Table 6, at the ex-post evaluation the EIRR value was in the negative, which indicates that the earnings generated by this project are not enough to recover the initial investment. The negative IRR means that the profit or loss generated by the project swings to the negative side compared to a project that brings about an equivalent positive

[16] This method was taken based on discussion with a technical evaluator.

IRR value.

Table 6: Economic Analysis

	At time of appraisal		At time of ex-post evaluation	
IRR	FIRR: 11.14%	EIRR: 14.63%	FIRR: -9.74%	EIRR: -3.56%
Cost	Project cost, operation and maintenance expenses			
Benefit	Net profit from sale of electricity (Unit price 4.4 yen/kWh)	Construction and operation cost of thermal power plant	Earnings from sale of electricity (for the years after FY2006 calculated based on the average electricity sale fares of FY2001 to FY2005)	Construction and operation cost of thermal power plant
Project life	35 years			

Note: In calculating EIRR, custom duties and VAT were excluded, while an exchange conversion coefficient (SPF) was used.

2.4 Impact

(1) Regional economic development

As discussed above, given that the supply capacity of this project accounts for only 4.0% of the supply capacity of the power plants the executing agency currently holds, the project will have only a minimal impact on the regional economic development. Additionally, since the electricity generated is all transmitted to the grid, there is no way to identify and estimate the population that will benefit from this project.

Table 7: Power Plants Owned by the State of Haryana and their Capacity

Name of Plant	Maximum Output	Share
Faridabad Thermal Power Plant	3 × 55 MW = 165 MW	16%
Panipat Thermal Power Plant	4 × 110 MW = 440 MW 2 × 210 MW = 420 MW	80%
Western Yamuna Hydro Power Plant	6 × 8 MW = 48 MW	4%
Total	1,073 MW	100%

(2) Improving the living environment

Being a project for constructing power plants, it is necessary to take into consideration the process through which electricity that has been generated reaches individual consumers (transmission, distribution, etc.). Therefore, it was impossible to determine the direct impact this project has on the living environment of individual consumers.

(3) Environmental aspect

In this project, no impact on the natural environment was observed.

Satisfaction Survey of Large Consumers and Domestic Consumers in the Vicinity of the Western Yamuna Hydro Power Plant

In this ex-post evaluation, a satisfaction survey was conducted on large-scale consumers (industry and agriculture) and domestic consumers in the vicinity of the area where this project was implemented. Although the survey sample was not large enough to make it scientific, nor was it able to clearly specify the degree of direct contribution this project would make, the survey was significant in that it provided a glimpse into the thinking of a limited number of users.

[Objective]

・ Clarify the improvements needed to ensure adequate power supply for areas affected by this project by ascertaining the power condition in those areas.

[Outline of survey method, etc.]

	Large consumers		Domestic consumers
	Industry	Agriculture	
Period of survey	November 15, 2006 – February 10, 2007	November 15, 2006 – November 20 , 2006	November 15, 2006 – November 20, 2006
Place	Yamunanagar	Kalser and Bahadurpur	Yamunanagar and Bhud Kalan
Sample size Sample method	18 companies Randomly selected	20 households Randomly selected	30 households Randomly selected
Valid response rate	56% (10 companies)	100%	100%

[Results]

・ All of the companies and most of the farmers said that they are “not at all satisfied” with the present electricity supply situation (generation, distribution and transmission), while all of the domestic consumers said they are “not satisfied” with the present situation. The reasons given are as follows:

(1) Quality of electricity: Low because of frequent voltage fluctuation which reduces the service life of equipment and materials and damages the irrigation pump.

(2) Frequency of interruption and outages: [Industry] Occurs 3 times a day (with total duration of 1 to 1.5 hours a day,) which forces companies to shut down their production lines. To deal with this problem, all 18 companies surveyed rely on private power generation. [Agriculture] All households experience outages of more than 1 hour a day regardless of the time of year. Especially, those who own more than 10 ha of land have adopted an alternative means of securing electricity, including purchasing diesel pumps. [Domestic consumers] While the household electrification in both villages is 100%, interruption and outages occur as frequently as 2 to 3 times a day, with duration of 2 to 3 hours each.

(3) Costs incurred per year due to outages: [Industry] Most of the companies

shoulder 1 million rupees (about 2.7 million yen), including the cost of raw materials, equipment failure, and contract cancellation. [Domestic consumers] Most households in Yamunanagar have an uninterruptible power supply unit.

(4) Potential areas of improvement: construction of new power plants; renovation of existing power plants; training employees; institutional reform of the power sector; improving customer services; introduction of an efficient billing system.

(4) Land acquisition and resident relocation

At the time of the original plan, 1,837 acres of land was to be acquired in Stage 1 and 50 acres in Stage 2, and no relocation of residents was planned. In actuality, 837 acres of land was acquired in Stage 1 and 120 acres in Stage 2, and, as originally planned, there was no relocation of residents. However, in respect of Stage 2, in 1998, landowners filed a lawsuit demanding an increase in the amount of compensation due. In 2000, the suit was settled when the executing agency paid all of the landowners a total of approximately 8.6 million rupees.

2.5 Sustainability (Rating: b)

2.5.1 Executing agency

2.5.1.1 Technical capacity

This project was the first project handled by the executing agency that dealt with hydro power plants. However, because several of the engineers in charge and other technical personnel had experience at hydro power plants in states other than the state of Haryana, the technical capacity of the agency was sufficient to operate hydro power plants.

At present, the technical level is sustained mainly through on-the-job training (OJT). Since the executing agency does not have its own training institution, training is conducted mainly by external training institutions such as the National Power Training Institute (NPTI). However, these OJT programs are available only to engineers and there are not enough engineers and technicians. As a result, only a limited number of people are able to attend external training courses, for they require participants to be away from their job for a fixed period of time. In addition, in recent years, participation in training related to thermal power generation is given preference over hydro power generation. Given this situation, while sustainability regarding technical capacity is being ensured, there are many areas for improvement.

In reference to overhauling, for small power plants such as this, outsourcing it is the best alternative and it is the norm in India.

2.5.1.2 Operation and maintenance system

As is mentioned in the above discussion, although this project was the first project handled by the executing agency that dealt with hydro power plants, the 15 engineers in charge of this project (in administrative positions, including the 2 chief engineers) and 13 technicians all had experience working at hydro power plants in Bhakra (Sutlej River, Punjab), Chukka (Bhutan) and Shanan (Himachal Pradesh), so that the operation and maintenance system and capacity had already been put in place.[17] However, the executing agency is aware of its own lack of administrative ability in regard to the management and monitoring of a number of companies that had been involved in the construction of the Western Yamuna Hydro Power Plant, so it can be concluded that this project was not always executed in an efficient manner.

At present, the executing agency is headed by a Chairman and the total number of personnel is 4,868, of which 124 people work at the headquarters, 415 in hydro-related departments, and 4,329 in thermal-related departments. There were no major organizational changes during the transition from HSEB to HPGCL. Basically, the departments and people that were in charge of power generation at HSEB were transferred to HPGCL without any major changes. The process apparently went without any hitches. With HPGCL, it became possible to specialize in power generation, thus making transfers less frequent. Today, once posted, a person remains at the same post for at least three years.

A total of 312 employees are working at the Western Yamuna Hydro Power Plant, of which 187 are technicians, including engineers, and there are 160 employees who specialize in the operation and maintenance of the power plant. The executing agency is concerned about the lack of human resources, that is, the lack of technicians. Moreover, The Chief Engineer of Western Yamuna Hydro Power Plant is also in charge of the operation and maintenance of Panipat Thermal Power Plant. As already indicated in the SAPS, the excess responsibility and workload on a Chief Engineer still continues even today. These problems are an obstacle for the quick and smooth decision making process required for the operation of the plant. In short, securing the operation and maintenance system of this project still continues to be an important issue.

2.5.1.3 Financial status

Looking at the expenses, these have been increasing in unison with the inflation rate during the past couple of years, and there is no major change in the composition. However,

[17] The Mid Term Monitoring Report mentions that HSEB did lack experience with civil works related to wiring and piping, and HSEB was well aware of this. Thus, in order to avoid any risks, they outsourced such work following the advice of an installation consultant from Fuji Electric.

in keeping with investment in the construction of thermal power plants, loans have also been on the rise, which suggests that the financial burden on interest payments may also grow.

The costs incurred by the executing agency are all supposed to be switched over to the HPVNL. In other words, the before tax profits of the executing agency are basically adjusted so that they become “zero,” and because, at this time, the risk of this adjustment system becoming dysfunctional was not observed, it can be concluded that the executing agency’s financial sustainability was guaranteed.[18]

Table 8: HPGCL’s Financial Status after the Split-up

(unit: million rupees)

FY	Sales	Sales and expense ratio	Cash in-flow	Profit before tax	Outstanding balance of borrowings
98	5,174	91.1%	184.4	0	9,714.6
99	8,078	88.7%	615.3	0	12,492.4
00	8,083	91.8%	505.7	0	14,820.2
01	9,866	88.1%	-194.1	0	14,881.5
02	14,112	88.0%	1,116.4	0	17,804.4
03	15,486	89.3%	1,250.6	0	24,673.6
04	16,470	90.8%	1,257.9	-40.0	32,355.6

Source: HPGCL *Annual Accounts*

The executing agency intends to continue allocating about 4% of the project cost, a valid amount, to its operation and maintenance (allowing for approximately a 5% increase in inflation per annum).

2.5.2 Operation and maintenance status

Although the records of operation and maintenance work are kept at each power house, the manuals are kept only at Power House B, which is considered the central point. When required, photocopies are made and used in the rest of the power houses. Personnel at the executing agency acknowledge that the annual inspection of the power houses, the frequency and contents of the inspections recommended by the manufacturer are not always followed in conducting the annual inspection of the power houses. In addition, the agency acknowledges that significant improvement needs to be made on the frequency and contents of the operation and maintenance work.

Currently the most pressing issue concerning the operation and maintenance of the power houses is their overhaul in Stage 1. Despite the repeated recommendations in the SAPS, the overhaul has not been conducted for over 20 years (generally, it is done once

[18] JBIC’s “Power Sector Study for India” (2005) concludes that, as of FY2004, Haryana is one of the few states in India where the electricity business is turning a profit.

every 5 to 6 years). At the site level, workers understand the necessity of overhauling the power houses and are thus concerned that this is not being done. The reason why an overhaul has not been undertaken is that a complete shut down of the power houses could even trigger political and social problems under the current electricity shortage situation. In addition, the headquarters do not approve an overhaul because the agency cannot devote enough money for "special repair" including an overhaul within a fixed budget. However, in respect of Stage 1, the headquarters have recognized that overhauling is necessary. The executing agency is now requesting the contractors to conduct a technical assessment.

Problems that should be addressed immediately include (1) the damage to the parts of the turbine that are under water caused by the increase in the amount of quartz silt especially during the monsoon season; and (2) the damage to the electronic control panel in the control room in all power houses caused by the air conditioning system's failure to run properly. Most of these problems had to do with the problem of replacements parts (these parts are old designs or their production has been discontinued, there is no technology for the production of spare parts, etc.) and the lack of awareness of the importance of operation and maintenance.

Figure 5: Turbine damaged by quartz silt

Moreover, the issue of safety and hygiene, which was indicated in the SAPS, has not been thoroughly tackled, and no improvement has been made on this front.[19]

3. Feedback

3.1 Lessons Learned

(1) It is basic knowledge that in India water disputes erupt very often and require a long time to settle. For the future, in implementing hydro power development projects that involve interstate rivers, all stakeholders, including the JBIC and the executing agency, should conduct detailed surveys and analyses of their own, and pay close attention to the impact these water disputes may have on ODA loan projects, and through these activities accurately identify the feasibility of individual projects. In particular, since the construction of the Hathnikund Barrage, which was a precondition for Stage 2 of this project, was a project under the

[19] As of 2007, the problem concerning the under water part of the turbine was in the process of being solved by repairing the runner blade and the discharge ring and by replacing the carbon ring. As for air conditioning, a new system is scheduled to be procured this fiscal year. In respect of safety and hygiene, while it was confirmed that rubber boots and cotton work gloves were provided, helmets continued to be unavailable, and there was no plan to procure them. Outsourcing the cleanup services for the power houses is now being considered.

jurisdiction of India's Irrigation Department and financed by the World Bank, the gathering of information not only from the executing agency of the target project but also from the supporting and executing agencies of other related projects is judged to have also been indispensable for preventing the problem from escalating.

(2) In the development of hydro power plants many factors should be taken into account, such as rainfall, water availability, physiography, topography, underground water, properties of the water, among others, so that the correct type of technology is applied. In this project, because technology that was not appropriate for the characteristics of the Western Yamuna Canal was applied, there was a lot of damage to the equipment even from the very first stages of the operation of the power plants. For future hydro power development projects, the appropriateness of technology should be looked at and judged objectively by conducting thorough research and analysis of the specific factors that surround the project.

(3) The loan disbursement for this project was concluded in 1992. However, since the construction of Power House D had not yet completed, JBIC still regarded the project as an "on-going project." On the other hand, the executing agency did not fully understand that the project was still "unfinished." In the future, when the project has not completed by the loan expiry date, JBIC will be expected to give detailed explanation not only to the borrower but also to the executing agency so that a common understanding is shared among all stakeholders.

3.2 Recommendations

3.2.1 Recommendations to the executing agency

[Close communication with JBIC]

In order to secure the smooth implementation of a project, it is recommended that day-to-day communication with JBIC be maintained. In the case any issues arise, measures should be taken based on discussions with JBIC, so that these issues are solved immediately.

[Thorough operation and maintenance]

(1) Conduct an overhaul for Stage 1 as soon as possible. In addition, personnel of the executing agency's headquarters, being fully aware of the importance of periodic overhauls, should consider including the necessary budget in the regular operation and maintenance budget.

(2) Based on the operation and effect indicators, it is highly likely that, despite the

fact that it has been only two years since it began operating, Power House D is not being operated properly. Especially for FY2005, many of the indicators have not even achieved 80% of the target values. Identify the real cause through discussions with the manufacturer and take appropriate measures to deal with them.

(3) Conduct repair and maintenance procedures (frequency and content) as per recommendations of the manufacturer, so as to strengthen preventive maintenance. Request the manufacturer to provide manuals for each of the four power houses.

(4) Spare no pains to form and enforce safety measures that conform to Indian laws. The staff workers at the power houses should be educated on these laws on a daily basis.

(5) Proceed with the plan of outsourcing cleanup services as soon as possible and spare no pains to operate and maintain the power houses properly.

[Technical capacity]

Based on the amount of water that can be used in the Western Yamuna Canal today, efforts will be made to improve the rate of water utilization by reevaluating the power generation capacity of all four power houses.

3.2.2 Recommendations to the government of India

Problems related to replacement parts are not specific to this project. To solve these problems, it is recommended that the government of India build up its capacity to obtain the required amount of equipment, materials and parts by taking sufficient budgetary steps.

Comparison of Original and Actual Scope

Item	Plan	Actual
(1) Outputs	・ Construction of a power generating channel ・ Hydraulic turbines (valve turbines) ・ Synchronous generator × 8 ・ Process inspection in Japan ・ Water level measuring gauge ・ Funds to purchase a 100-ton trailer	Although there changes regarding, construction of channel, hydraulic turbines and generators (rotation frequency/runner diameter, sum total annual output), nearly all were achieved as planned. Additionally, details information on process inspections, water level measuring gauge, 100-ton trailer was unavailable.
(2) Project Period	[Overall Project] March 1981–June 1985 (52 months) [Stage 1] March 1981–February 1985 (48 months) [Stage 2] March 1981–June 1985 (52 months)	[Overall Project] March 1981–May 2004 (282 months, 542% of original plan) [Stage 1] March 1981–April 1989 (98 months, 204% of original plan) [Period when project was stopped] February 1989–August 2000 (139 months) [Stage 2] September 2000–May 2004 (45 months, 87% of original plan)
(3) Project Cost Foreign currency Local currency Total ODA loan portion Exchange rate	4,000 million yen 13,279 million yen (447 million rupees) 17,280 million yen 4,000 million yen 1 rupee = 29.7 yen (as of March 1981)	3,244 million yen 20,287 million yen (1,568 million rupees) 23,531 million yen 3,244 million yen 1 rupee = 12.94 yen (1980–1998 average)