India

Ex-Post Evaluation of Japanese ODA Loan

"Ghatghar Pumped Storage Project"

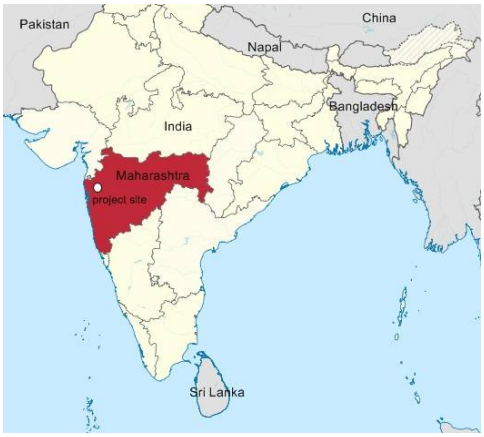
External Evaluator: Misa Oishi, Kaihatsu Management Consulting, Inc.

0. Summary

The project was to construct a pumped storage hydropower station which would pump up water during off-peak hours with lesser demand for electricity and generate electricity by discharging the water during peak-hours with higher demand for electricity, and thereby to contribute to mitigating acute shortages of electricity during peak-hours in Maharashtra, a state located in the Western part of India. The project is in line with the development policy of India, which emphasizes stable power supply as one of the prioritized areas, and with the needs of the country as well as the state, and therefore its relevance is high. According to the indicators which show the quantitative effects of the Ghatghar pumped storage hydropower station, i.e., comprehensive circulating efficiency (CCE)[1], operating hours, operation records during peak-hours, etc., the project largely brought about the planned effects, and also certain positive impacts on the socio-economic development of Maharashtra are perceived; thus the effectiveness of the project is also high.

The significant delay in commencement of the project activities due to prolonged process of obtaining environmental approvals, and consequent cost overruns made the efficiency of the project low. On the other hand, Maharashtra State Power Generation Co. Ltd (MAHAGENCO), who operates the hydropower station, has an appropriate organizational structure, technology and financial sources for operation and maintenance (O&M), and in fact, the actual O&M conditions are observed to be good; thus the sustainability of the project effect is high. In light of the above, this project is evaluated to be satisfactory.

1. Project Description



Project Location

Ghatghar Pumped Storage Hydropower Station

[1] CCE = (Net electric energy production / net energy used for pumping) x 100

1.1 Background

Maharashtra had been faced with severe shortages of electricity during peak-hours since the end of 1980's[2], and the state government had to impose energy restrictions on the industrial sector who was the major consumer (e.g., 10% supply cut to the entire textile industry). The installed generation capacity of Maharashtra as of 1986/87 was 7,021MW[3], and its entire capacity consisted of coal thermal (78%), hydropower (19%) and nuclear power (3%). Since then, the hydro potential has remained unharnessed despite the inherent geographical advantages of the country, and in fact, whereas the growth rate of the entire installed generation capacity was 7% during the three years from 1984/85 to 1986/87, the growth rate of hydropower was only 3.3%, even though hydropower has been well known for its high capacity to meet peak demands[4]. In order to mitigate the severe shortage during peak-hours, in Maharashtra, it was urgently needed to enhance the supply capacity of power generation system by the pumped-storage hydropower station, in other words, through pumping-up water by using surplus

power during off-peak hours and generating electricity by releasing pumped-up water during peak-hours.

1.2 Project Outline

The objective of this project is to generate electricity by utilizing surplus power of off-peak hours; thus to mitigate shortage of power supply at peak hours through construction of the first full-fledged pumped storage hydropower station (250MW) in Maharashtra[5], thereby contributing to enhance socio-economic development of the state.

Loan Approved Amount/ Disbursed Amount	11,414 million yen / 11,393 million yen
Exchange of Notes Date/ Loan Agreement Signing Date	October 1988 / December 1988
Terms and Conditions	Interest Rate: 2.50% Repayment Period: 30 years (Grace Period: 10 years)

[2] According to the JICA's project appraisal document, while demand at peak hours was 4,897 MW as of 1986/87, its supply was 4,399MW, resulting in a shortfall of 498MW.

[3] The installed generation capacity is the sum of the maximum electric outputs per hour that each power plant can produce, while the supply capacity at peak hours is the maximum generation outputs at that time, which can be obtained by deducing generation loss, for example, the capacity of plants offline for maintenance and the decreased capacity caused by decreased flow rate of rivers, from the installed generation capacity.

[4] Unlike the coal thermal and nuclear plants, hydropower plants are highly responsive (easy to start, stop and control outputs) power generating source, and able to function only when the demand situation requires.

[5] In Maharashtra, Paithan pumped storage hydropower station was constructed under the financial support from the government of Japan, but its generation capacity was as small as 12 MW.

	Conditions for Procurement: Partially Untied
Borrower / Executing Agency(ies)	President of India/ Water Resource Department, the State Government of Maharashtra
Final Disbursement Date	January 2003
Main Contractor (Over 1 billion yen)	Nissho Iwai Corporation (Japan)
Main Consultant (Over 100 million yen)	Electric Power Development Co., Ltd. (Japan)
Feasibility Studies, etc.	Detailed Project Report (1982) and Master Plan Study on Pumped Storage Hydroelectric Power Development in Maharashtra (1998) by JICA

2. Outline of the Evaluation Study

2.1 External Evaluator

Misa Oishi, Kaihatsu Management Consulting, Inc.

2.2 Duration of Evaluation Study

Duration of the Study: September 2012 - July 2013

Duration of the Field Study: November 16 - November 30, 2012 / March 5 - March 9, 2013

3. Results of the Evaluation (Overall Rating: B[6])

3.1 Relevance (Rating: ③[7])

3.1.1 Relevance with the Development Plan of India

At the time of project appraisal, in the Seventh Five Year Plan (1985-1990), development of energy sector was prioritized as essential for economic development as well as for improving the quality of life. Also, the Plan stated that the hydro potential still remained unharnessed despite the inherent geographical advantages of the country, and the development of hydropower shall be focused as one of main strategies on along with the development of coal thermal and nuclear power. Thus the project, aiming to mitigate shortage of power supply in Maharashtra and to contribute to socio-economic development of the state, was judged as relevant with the development plan of India.

Also, at the time of ex-post evaluation, the Eleventh Five Year Plan (2007- 2012) which carries "Inclusive Growth" as a main theme places a priority to the development of stable power supply as a preconditions for "Inclusive Growth", and emphasized the importance of an expanding it. Also, in the

[6] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory

[7] ③: High, ② Fair, ① Low

plan, availability and access to energy are considered as catalysts for attaining the envisaged economic growth of 9% per annum as well as for improving the quality of life and empowering individuals through rural electrification. In addition, the Plan states that renewable energy including hydropower should be extensively developed in the medium- to long-term, whereas it is unavoidable to rely increasingly on imported oil, gas, and coal in the short term; thus the project is highly relevant at the time of the ex-post evaluation.

3.1.2 Relevance with the Development Needs of India

The installed generation capacity of Maharashtra as of 1986/87 was 7,021MW, and Maharashtra faced a serious shortage of electricity, showing the demand at peak hours was 4,897 MW, while its supply was 4,399MW at the time of project appraisal.

The entire generation capacity consisted of coal thermal (78%), hydropower (19%) and nuclear power (3%) and in fact, whereas the growth rate of the entire capacity was 7% during the three years from 1984/85 to 1986/87, its rate of hydropower, which is highly peak-responsive, was only 3.3%. In Maharashtra, as seen in Table 1, the rapid growth of supply as well as the similarly rapid growth of demand for electricity were expected at the time of project appraisal, and it was known that although shortages of electricity could not be resolved overnight, enhancing the supply capacity of generation systems especially during peak hours through pumping-up water using surplus power during off-peak hours and generating electricity by releasing pumped-up water during peak-hours were highly needed.

Table1 ：Demand and Supply Forecast during Peak-hours

(Unit: MW)

	Peak-Supply	Peak-Demand	Supply-Demand Balance (Supply – Demand)
1987/88	4,672	5,411	-739
1988/89	4,931	5,905	-974
1989/90	5,311	6,394	-1,083
1990/91	5,792	6,870	-1,078
1991/92	6,422	7,525	-1,103
1992/93	7,266	8,075	-809
1993/94	7,880	8,828	-948
1994/95	8,109	9,335	-1,226

(Source) JICA's Project Appraisal Document

The installed generation capacity of Maharashtra as of November 2011 had increased to 21,379MW, indicating the state government's vigorous power sector development to increase power supply. However, the capacity consists of coal thermal (56%), gas thermal (14%), hydropower (14%), nuclear power (3%) and other renewable energy (13%); it is apparent that the ratio of hydropower still remains low at the time of ex-post evaluation. Also, in Maharashtra, the demand for electricity has been

enormously increased in recent years due to the robust economic growth of the state[8]; thus the shortage of electricity during peak hours is not resolved even at the time of ex-post evaluation as seen in Table 2. Therefore, enhancing the supply capacity of electricity through hydropower stations during peak hours in Maharashtra is still highly needed.

Table 2：Supply-Demand Balance during Peak Hours

(Unit: MW)

	Peak-Supply	Peak-Demand	Supply-Demand Balance (Supply – Demand)
2005/06	9,856	14,061	-4,205
2006/07	10,298	14,825	-4,527
2007/08	10,412	15,689	-5,277
2008/09	10,715	15,656	-4,941
2009/10	12,414	16,582	-4,168
2010/11	13,268	17,150	-3,882
2011/12	13,677	18,145	-4,468

(Source) Economic Survey of Maharashtra (2011-2012)

3.1.3 Relevance with Japan's ODA Policy

At the time of project appraisal, neither the Country Assistance Program nor JICA's Overseas Economic Cooperation Policy was formulated, and therefore relevance with Japan's ODA Policy is unverifiable.

In view of the above factors, although relevance with Japan's ODA Policy is unverifiable, the project has been highly relevant with India's development plan and its development needs; therefore the relevance of the project is high.

3.2 Effectiveness[9] (Rating: ③)

3.2.1 Quantitative Effects (Operation and Effect Indicators)

At the time of project appraisal, both operation and effect indicators were not set; thus at the time of ex-post evaluation, typical indicators used for the pumped-storage hydropower station, such as comprehensive circulating efficiency, operating hours, unplanned outage hours, net electric energy production and maximum output, are examined as seen in Table 3.

[8] According to Economic Survey of India (2012-2013), net state domestic product of Maharashtra at current prices for FY2011 was Rs.11,506 billion (approximately 19 trillion yen), which is the largest among all states in India and is an increase of 17.12% from the previous year.

[9] Sub-rating for Effectiveness is to be put with consideration of Impact

Table 3：Operation and Effect Indicators

			FY2008	FY 2009	FY 2010	FY 2011
Comprehensive Circulating Efficiency (CCE) (%)		Unit 1	80.22	75.97	80.11	80.70
		Unit 2	82.33	0.00	72.00	70.01
Operating Hours (hours/year)	Generation	Unit 1	572	1,194	1,543	1,286
		Unit 2	302	0	1,425	1,236
	Pumping	Unit 1	597	1,328	1,591	1,326
		Unit 2	308	0	1,631	1,467
Unplanned Outage Hours (hours/year)		Unit 1	0.0	23.5	116.9	0.0
		Unit 2	0[1)]	—[2)]	143.8	0.0
Net Electric Energy Production (GWh/year)		—	107.82	151.30	372.42	318.29
Maximum Output (MW)		Unit 1	125	125	125	125
		Unit 2	125	125	125	125

(Source) MAHAGENCO's Operation Records of Ghatghar Pumped-Storage Hydropower Station
(Note) Date of commissioning of Unit 1 was April 8, 2008, while that of Unit 2 was June 21, 2008. Date of handing-over from the executing agency, i.e., Water Resource Department, to MAHANGENCO of Unit 1 was August 17, 2009, while that of Unit 2 was January 3, 2011.
1) Unplanned outage hours before the failure of generator stator, which occurred in November 2008.
2) Unit 2 was out of order for the entire FY 2009.

For the pumped-storage hydropower station, usually 70% of CCE is targeted, and that of the Ghatghar station was more than 70% after FY2008, except FY2009, which indicates that it is operating well. The good operational status is substantiated by the fact that operating hours, whose target is usually from 700 to 1,000 hours, of Unit 1 since FY2009 and that of Unit 2 since FY2010 exceed 1,000 hours. On the other hand, as to the unplanned outage hours, Unit 2 was out of order from November 2008 to May 2010 due to the failure of generator stator, whose root cause lay in the fact that Unit 2 was partially submerged at the time of the torrential rain, which caused a landslide in June 2005. However, the unplanned outage hours have been reduced since then, and it indicates that the operation is now going smoothly[10]. Also, the net electric energy production has been increased steadily, and no concerns were identified regarding the maximum outputs, too.

In addition to the above indicators, a role of the Ghatghar pumped storage hydropower station during peak-hours was examined through the operational data for the period of three months, i.e., March, August and October 2012[11], which was submitted by Maharashtra State Electricity Transmission Co. Ltd., (MAHATRANSCO)[12]. As seen in Table 4, the demand for electricity fluctuated

[10] Because of another landslide occurred on December 27, 2012, the unplanned outage hours were increased once again since December 2012. For details, please refer to the section of "Sustainability."
[11] To be precise, the obtained data are demand-supply figures of electricity per hour per day for each March, August and October 2012.
[12] MAHATRANSCO was established in 2005 as a state-owned company in charge of power transmission from the generation end to the receiving in Maharashtra by taking over power transmission lines and

seasonally[13]. For example, the highest average hourly electricity demand, 13,260 was recorded in March. In the same month, the average hourly electricity demand while the Ghatghar station is in generating mode was 13,917 MW, whereas the figure with non- generating mode of the Ghatghar station was just 13,036 MW; thus it is apparent that the Ghatghar hydropower station was indeed in generation mode during hours with higher electricity demand. On the other hand, August is the period with least demand for electricity of the aforementioned three months, and operating hours of the Ghatghar station is lowest of 117 hours. Also, by comparing average hourly electricity demand while the Ghatghar station is in generating mode and average hourly electricity demand while the Ghatghar station is non-generating mode, it became known that the station was not necessarily in generating mode during hours with higher electricity demands. However, once the overall electricity demand had increased again in October, it is apparent through the similar comparison mentioned above that the Ghatghar hydropower station was in generation mode during hours with higher electricity demand.

In addition, the interview with MAHATRANSCO confirmed the usability of the Ghatghar station, saying that while other conventional hydropower stations would be used also for irrigation, and therefore MAHATRANSCO alone could not decide their operations especially during the dry season, the said corporation could decide when to start and stop generation as to the Ghatghar station, which was specialized for power generation.

Table 4：Performance of the Ghatghar Pumped Storage Hydropower Station during Peak Hours

	Mar. 2012	Aug. 2012	Oct. 2012
Average Hourly Electricity Demand (MW/hour)	13,260	11,296	12,310
Total operating hours of the Ghatghar pumped storage hydropower station			
(hours)	189	117	167
(operating hours/ 24hours x 31days)	25.4%	15.7%	22.4%
Average Hourly Electricity Demand while the Ghatghar station is in generating mode (MW/hour)	13,917	11,289	12,844
Average Hourly Electricity Demand while the Ghatghar station is non-generating mode (MW/hour)	13,036	11,298	12,156

(Source) MAHATRANSCO's Operation Records of Ghatghar Pumped-Storage Hydropower Station
(Note) The above figures are limited to performance which State Load Dispatch Centre (Kalwa) manages.

3.2.2 Qualitative Effects

substations from MSEB. MAHATRANSCO owns and operates 39,871 cct-km of transmission lines, as well as 559 EVH substations (89,178MVA). It also plays a role as Maharashtra State Transmission Utility (MSTU) and State Load Dispatch Centre.

[13] In Maharashtra, three months from March to May are hottest and are considered summer months, resulting in the increased domestic electricity consumption. On the other hand, the average monthly temperature of August is lowest of the year, being in the rainy season, and this moderate climate results in the low level of domestic electricity consumption. In October, the temperature goes up once again and also the agricultural season starts in Maharashtra at this time of the year, and therefore both domestic consumption and agricultural consumption of electricity increase.

At the time of project appraisal, revitalization of local industries was considered as an expected qualitative effect. However, at the time of ex-post evaluation, it became known that 250MW produced by the Ghatghar station is only 1.1% of the current generation capacity of the state, and therefore it is judged that the station's contribution to the revitalization of local industries is unverifiable. Then, through the discussion with the executing agency, the Water Resource Department (WRD) of the State Government of Maharashtra, and the management company of the Ghatghar station, MAHAGENCO, another effect of the project, namely, "grid stabilization", in addition to "meeting demands during peak-hours" was identified; thus the interview with MAHATRANSCO who is responsible for grid stabilization was carried out during the ex-post evaluation.

Prior problem in the Indian power sector was difficulty in performing grid operations without any rules and regulations and in fact the frequency went down during peak hours due to over-drawal without any efforts to generate and it went up during off-peak hours because of not reducing the generation. No economic incentives such as the charges depending on the demand situation existed, and it led to accelerate grid disturbance and finally put the whole grid and many other electrical equipment into danger by dumping large fluctuations in frequencies.

Under such circumstances, Central Electricity Regulatory Commission has introduced Unscheduled Interchange Charges (called UI system)[14], which promote more generation and less drawal at peak hours and less generation and more drawal in off-peak hours, in order to make frequency adjustment through supply and demand control in the short term and maintain frequency efficiency and discipline. The interviews with WRD, MAHAGENCO and MAHATRANSCO confirmed that ensuring grid and frequency stability is indeed a great concern for MAHATRANSCO and one of the important contributions which the Ghatghar station makes is considered as grid and frequency stability itself.

3.3 Impact

3.3.1 Intended Impacts

At the time of project appraisal, the contribution to the socio-economic development of Maharashtra was noted as a positive impact. As previously mentioned, at the time of ex-post evaluation, it became known that 250MW produced by the Ghatghar station is only 1.1% of the current generation capacity of the state, and therefore it is judged as unrealistic to measure quantitatively the station's direct contribution to the socio-economic development of Maharashtra. However, the contribution of the project, i.e., grid and frequency stabilization, is not only appreciated by the power sector in Maharashtra, but it is widely known that reliable electricity supply, the foundation for the envisaged economic growth stated in the Eleventh Five Year Plan (2007-2011) is unattainable without grid and frequency stabilization; thus it is considered that the project indirectly contributes to the socio-economic development of Maharashtra.

[14] UI system was introduced in 2001.

3.3.2 Other Impacts

1) Impacts on the natural environment

At the time of project appraisal, types of clearances necessary for the project were not identified, but during the course of activities, the necessary clearances were identified and indeed obtained by the executing agency, as seen below.

- Environmental clearance: June 1985
- Forest clearance: May 1992
- Wildlife protection clearance: April 1997

Construction work of the project started only after obtaining the above mentioned clearances from the central government. Also, the Ghatghar station is a pure pumped storage hydropower station, neither inflow nor outflow of natural streams; thus negative impacts on the natural environment were minimized[15]. The field observation and the interview with the executing agency during the ex-post evaluation confirmed that no land erosion occurred in the basin and also neither complaints nor grievances were expressed by residents, environmental NGOs, etc[16].

2) Land Acquisition and Resettlement

Under the project, 189.95ha for the upper dam and 130.146ha for the lower dam, in total 320.096ha of the lands were acquired.

Table 5: Land Acquired by the Project

(Unit: ha)

	Private land	Forest land [1)]	Total
Upper dam	177.86	12.09	189.95
Lower dam	80.146	50.00	130.146
Total	258.006	62.09	320.096

(Source) Water Resource Department, the State Government of Maharashtra
(Note) 1) The land owned and managed by Forest Department, the State Government of Maharashtra.

The total forest land, 62.09ha, was acquired from the Forest Department, the State Government of Maharashtra, based on the Forest Conservation Act of 1980, and in return the same size of land was transferred from the Revenue Department to the Forest Department for afforestation. During the ex-post evaluation, the Forest Department confirmed that the afforestation in the transferred land has

[15] A bigger dam for another hydropower station had been constructed in the upstream of the Ghatghar's upper dam, and therefore the construction of the upper dam did not impose any direct impacts to the natural stream flows. As to the Ghatghar's lower dam, it was constructed in a tributary of the small river, and therefore the catchment area which the lower dam may impose impacts itself is substantially small.

[16] During the ex-post evaluation, a focus group discussion targeting approximately 20 households, which included both resettled households due the land acquisition for the upper dam construction and affected households due the land acquisition for the lower dam construction, was conducted. Residents' opinions towards the natural environment were collected during this focus group discussion. Moreover, it was confirmed during the interviews with the executing agency that neither complaints nor grievances were filed by environmental NGOs.

been completed.

In terms of the affected households, 176 households were resettled due to construction of the upper dam and 96 households' lands were acquired for construction of the lower dam. These affected households have received compensation based on The Maharashtra Project Affected Persons Rehabilitation Act. 1986 and the Rehabilitation Act vide Government Resolution Dated. 5-12-1994.

3) Unintended Positive/Negative Impact

The project adopted Roller Compacted Concrete (RCC) method for construction of dams. Dams were constructed by the said method for the first time in Maharashtra, and many visitors within the state as well as from other states, e.g., students of technical colleges, engineers of National Water Academy (Pune), engineers of National Thermal Power Cooperation, senior officers and engineers of the State Government of Uttarakhand, etc., visited the Ghatghar station.

In view of the above factors, this project has largely achieved its objectives, therefore its effectiveness is high.

3.4 Efficiency (Rating:①)

3.4.1 Project Outputs

According to the project appraisal document, major outputs of the project consist of three components, namely, (i) construction of dams and tunnels, (ii) construction of power house and electromechanical plants and (iii) consulting services. As seen in Table 6, the type of dams was altered from masonry to RCC, and accordingly consultation services employed were increased. The rational behind this alteration was to curtail its construction period and cost by employing RCC method known as a rapid construction technique. Curtailing its construction period was a major concern for the project after experiencing significant delays, and thus this alternation is considered justifiable. Besides this point, no other substantial changes were made, and major outputs were produced mostly as planned as seen in Table 6.

Table 6: Performance of Major Activities

Item	Planned		Actual	
1. Construction of dams and tunnels				
	Upper dam	Lower dam	Upper dam	Lower dam
Reservoir				
Catchment area	18.43 m^2	1.97 m^2	18.43 m^2	2.5 m^2
Level (full)	756.0 m	387.0 m	756.0 m	346.0 m
Level (low)	749.80 m	331.00 m	750.25 m	310.00 m
Gross storage	6.71 Mm^3	3.65 Mm^3	5.82 Mm^3	3.21 Mm^3
Live storage	6.05 Mm^3	3.57 Mm^3	5.14 Mm^3	2.73 Mm^3

Dam Type	Masonry	Masonry	RCC	RCC
Tail race tunnel Length Diameter	450m 5.8m		590m 6.0m	
2. Construction of power house and electromechanical plants				
Power house Type Installation capacity Transformer capacity Machine hall Transformer hall Pump-turbine Type Capacity	 Underground, Ferroconcrete 250MW (125MW x 2) 138.880MVA 75.0m x 15.0m x 30.0m 60.0m x 17.0m x 40.0m Vertical shaft, Francis type 130.200KW		 Underground, Ferroconcrete 250MW (125MW x 2) 138.880MVA 123.0m x 23.4m x 46.8m 81.35m x 20.0m x 26.0m Vertical shaft, Francis type 130.200KW	
3. Consulting service				
Service	Foreign consultant 20.0MM		Foreign consultant 17.0MM Local consultant 103.5MM	

Inside of the power house

Pump-turbine of Unit 1

3.4.2 Project Inputs

3.4.2.1 Project Cost

While the planned project cost was 28,305 million yen (of which 11,414 million yen was ODA Loan), the actual cost amounted to 41,452 million yen (of which 11,393 million yen was ODA Loan), which was higher than planned (146% of the planned). A breakdown of the actual project cost is as seen in Table 7. Even after the final disbursement date of January 20, 2003, the Ghatghar station had not been completed, but the executing agency continued its construction by obtaining an additional loan worth Rs. 3,775 million from the Power Finance Corporation Ltd. in March 2004.

Table 7: Project Costs

Item	Planned			Actual		
	Foreign Currency	Local Currency	Total	Foreign Currency	Local Currency	Total
	million yen	million yen	million yen	million yen	million rupee	million yen
1. Dams and tunnels	0	7,840	7,840	0	5,063	13,670
2. Power house	0	723	723	0	872	2,354
3. Electromechanical equipment and civil engineering machinery	7,532	3,789	11,321	11,068	2,027	16,541
4. Consulting service	81	41	122	174	10	201
5. Administration cost, land, etc.	0	6,956	6,956	0	2,743	7,406
6. Physical contingency	377	966	1,343	0	474	1,280
Total	7,990	20,315	28,305	11,242	11,189	41,452

(Source) JICA's Project Appraisal Document, Project Completion Report
(Note) The exchange rate at the time of project planning (April 1988) was 1Rs. = 9.8Y, however, the planned local portion is indicated in yen term as so did in the appraisal document. As to the actual figures, 1Rs. = 2.7Y, the average of 14 years between 1995, the year loan disbursement actually started, and 2008, the year the project completed, was used to calculate its local portion.

The sharp fluctuation of exchange rates from 1Rs. = 9.8Y at the time of project appraisal to 1Rs. = 2.7Y used at the time of ex-post evaluation led to the high cost of imported equipment. As to the foreign portion, despite the benefits of rupee's depreciation, the actual cost overran the planned one due to the substantially prolonged project period, which resulted in increased material costs, labour costs, insurance, etc.

3.4.2.2 Project Period

The actual project period was significantly longer than planned. At the time of project appraisal, the planned period of 85 months from December 1988 to December 1995 was expected, however the commencement of construction itself was delayed as later as November 2003 for the upper dam and December 2004 for the lower dam. Consequently, the date of commissioning for Unit 1 was April 2008, while that for Unit 2 was June 2008. The actual project period, which is from December 1988 to June 2008 (235 months), ran (276%) longer than planned.

Taking time to obtain forest clearance as well as wildlife protection clearance was raised as the major reasons for such a significant delay. Regarding these governmental clearances on natural environments, while current practices allow the executing agency to hire external consultant specialized in these fields, officers of the executing agency themselves prepared all the necessary documents at that time; according to the executing agency, thus it took a tremendous amount of time. In addition, as stated earlier, the torrential rain and the subsequent landslide that occurred in June 2005 was another reason for delay, which required a few years before re-starting construction works.

In accordance with the delay of the project, the period of disbursement was extended six years,

originally from January 20, 1997 to January 20, 2003.

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

At the time of project appraisal, financial internal rate of return (FIRR) was calculated as 8.0% based on the following conditions.

(Cost) Total project cost, operation and maintenance cost
(Benefit) Sales profit of electricity
(Period) Construction period plus 20 years of operation

At the time of ex-post evaluation, FIRR was recalculated as 3.9% using the actual project cost, the lease rent[17] for the Ghatghar station approved by Maharashtra Electricity Regulatory Commission (MERC) in December 2012, etc., in addition to the following conditions.

(Cost) Total project cost incurred till the date of leasing-out
(Benefit) Lease rent approved by MERC[18]
(Period) Construction period plus 20 years of operation (The first year which lease rent was paid is considered as the first year of operation.)

According to the order issued by MERC, the period of lease as well as the amounts of lease rent are decided till 2043 (for 32 years of operation). Just for reference, FIRR is recalculated as 5.0% for a case which a condition regarding the project period is changed to "construction period plus 32 years of operation".

As the reasons for such a low FIRR, three factors, i.e. the project period was significantly longer than planned; lease rent not sales profits of electricity was used as a benefit; and lease rent was politically decided by MERC and considered less than sales profits, were suggested.

The project cost exceeded the plan, while the project period significantly exceeded the plan, therefore efficiency of the project is low.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

O&M of the project was carried out by MAHAGENCO, to whom WRD leased out the Ghatghar station. At the time of project appraisal, the station was supposed to be leased out to Maharashtra State Electricity Board (MSEB). The very MSEB was unbundled to three companies in charge of generation, transmission and distribution in June 2005[19], headed by MSEB Holding Company Limited under the

[17] The executing agency of the project, i.e. WRD, constructed the Ghatghar station. Once its operation was confirmed, WRD leased out the station to MAHAGENCO for operation and maintenance, and in return, WRD receives lease rent.
[18] WRD leased out the station to MAHAGENCO for operation and maintenance, and WRD receives lease rent as earnings; thus lease rent is considered as a benefit for FIRR calculation.
[19] They are Maharashtra State Power Generation Co. Ltd. (MAHAGENCO), Maharashtra State Electricity Transmission Co. Ltd. (MAHATRANSCO) and Maharashtra State Electricity Distribution Co. Ltd. (MAHADISCOM).

Electricity Act of 2003, aiming at restructuring the electric power sector. Among the three, MAHAGENCO is in charge of generation.

The Ghatghar station has been operated and maintained by Electrical and Mechanical Team of Hydro Power Circle (Nashik) of MAHAGENCO. Currently 66 personnel are working in the team whereas the number of sanctioned posts is 92; its fulfilment rate remains approximately 70%. However, the said rate for senior engineers is more than 93% and several minimum-required measures, i.e., four more senior engineers are seconded to the team from other hydropower stations and temporary staff are employed as drivers and typists, have been already taken, and therefore no acute problems in O&M are observed. Also, the necessity of personnel recruitment as a long term measure is understood well and the Hydro Power Circle (Nashik) has presented a petition on this matter to the Headquarters of MAHAGENCO. According to the team, process of the personnel recruitment has been started at the headquarters level.

3.5.2 Technical Aspects of Operation and Maintenance

MAHAGENCO manages, as of March 2011, seven coal thermal plants (7,980MW), two gas thermal plants (672MW) and 12 hydropower stations (2,885MW). The Electrical and Mechanical Team of Hydro Power Circle (Nashik) of MAHAGENCO, who is actually responsible for O&M of the Ghatghar station has been technically supported by and learned from a team of engineers in Hydro Power Circle (Nashik) called as a testing team as well as by another team of engineers in the headquarters called as a monitoring team and also provided with opportunities of on-the-job training; indeed there is no fundamental problems in terms of technical aspects of O&M.

Management of the Ghatghar station has been consigned to MAHAGENCO since August 17, 2009 for Unit 1 and since January 3, 2011 for Unit 2, and thus the actual O&M period by MAHAGENCO is rather short. Although in 2009 and 2010, right after handing-over of the station to MAHAGENCO, unplanned outage occurred for 24 hours and 117 hours respectively, since then till December 2012 no unplanned outage occurred both in Unit 1 and Unit 2. In this way, O&M activities had been carried out smoothly. Once again, unfortunately 253 hours of unplanned outage for Unit 1 and 278 hours for Unit 2 were recorded from December 27, 2012 to March 2013 due to rock slides that occurred on December 27, 2012. However, the recovery work was done by the engineers of MAHAGENCO themselves. Also, annual maintenance plans and maintenance manuals have been formulated and the routine maintenance based on the plans and manuals has been conducted regularly by the team. In addition, overhauls[20] of generation machineries have been carried out by themselves, too; thus, in view of the above factors, technical capacity for O&M has been developed sufficiently.

3.5.3 Financial Aspects of Operation and Maintenance

As seen in Table 8, the net income of MAHAGENCO remains reasonably stable. Also, the overall

[20] Overhaul is a thorough process of restoring and maintaining an equipment, machine, or system, which can not be done by routine maintenance works, through partial or complete disassembly of the item, inspection to detect damaged, defective, or worn parts, and repair or replacement of such parts.

profitability is maintained steadily in surplus; thus it is concluded that financial stability of MAHAGENCO is substantial.

Table 8: Financial Status of MAHAGENCO

	2006	2007	2008	2009	2010
Profit and Loss Account (million Rs.)					
Income	74,406.3	82,487.5	94,806.1	111,865.4	122,201.9
Expenditure	70,547.9	76,494.0	94,186.4	107,729.4	114,312.3
Net Income	3,858.4	5,993.5	619.7	4,136.0	7,889.6
Overall Profitability (%)					
ROE[1)]	8.40	11.08	1.96	5.03	15.06
ROA[2)]	4.71	3.59	2.78	2.82	5.00

(Source) "Data Collection Survey on Pumped Storage Hydropower Development in Maharashtra" (October, 2012) JICA

(Note) 1) ROE = Net Profit / ((Beginning Equity + Closing Equity) / 2) x 100
2) ROA=(Operating Income + Financial Revenue) / ((Beginning Total Assets + Closing Total Assets)/2) * 100

As to the Ghatghar station, Rs. 32.5 million for FY2010, Rs. 58.0 million for FY2011 and Rs. 64.3 million for FY 2012 were spent for its O&M activities, including personnel costs. The station currently secures enough operation hours, and therefore it can be judged that enough budget has been allocated for O&M activities.

3.5.4 Current Status of Operation and Maintenance

The Electrical and Mechanical Team of Hydro Power Circle (Nashik) of MAHAGENCO conducts O&M activities based on the annual maintenance plans and the maintenance manuals, and it was confirmed during the field observation that O&M records were properly filed and also major spare parts were appropriately stored. In addition, the Ghatghar station has been regularly monitored by a testing team in Hydro Power Circle (Nashik) as well as by a monitoring team in the headquarters, and in fact the status of O&M had been good without any unplanned outages since FY2010 to December 2012. As mentioned earlier, unplanned outage hours increased once again due to the rock-slide that occurred on December 2012. However, the recovery work has been completed and the current O&M status is confirmed as good.

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

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The project was to construct a pumped storage hydropower station which would pump up water

during off-peak hours with lesser demand for electricity and generate electricity by discharging the water during peak-hours with higher demand for electricity, and thereby to contribute to mitigating the acute shortage of electricity during peak-hours in Maharashtra, a state located in the Western part of India. The project is in line with the development policy of India, which emphasises stable power supply as one of the prioritized areas, and with the needs of the country as well as the state, and therefore its relevance is high. According to the indicators which show the quantitative effects of the Ghatghar pumped storage hydropower station, i.e., comprehensive circulating efficiency, operating hours, operation records during peak-hours, etc., the project largely brought about the planned effects, and also certain positive impacts on the socio-economic development of Maharashtra are perceived; thus the effectiveness of the project is also high.

The significant delay in commencement of the project activities due to prolonged process of obtaining environmental approvals, and consequent cost overrun made the efficiency of the project low. On the other hand, Maharashtra State Power Generation Co. Ltd (MAHAGENCO), who operates the hydropower station, has the appropriate organizational structure, technology and financial sources for operation and maintenance (O&M), and in fact, the actual O&M conditions are observed as good; thus the sustainability of the project effect is high. In light of the above, this project is evaluated to be satisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

None

4.2.2 Recommendations to JICA

None

4.3 Lessons Learned

None

Comparison of the Original and Actual Scope of the Project

Item	Original	Actual
1.Project Outputs	(1) Dam construction (Upper dam, lower dam and tunnels) Type: Masonry (2) Power house and electromechanical plants Pump-turbine type: Vertical shaft, Francis type Pump-turbine capacity: 130.200 KW Installation capacity: 250MW (125MW x 2) Transformer capacity: 138.880MVA (3) Consulting service Foreign consultant: 20MM	(1) Dam construction (Upper dam, lower dam and tunnels) Type: RCC Method (2) Power house and electromechanical plants Pump-turbine type: Vertical shaft, Francis type Pump-turbine capacity: 130.200 KW Installation capacity: 250MW (125MW x 2) Transformer capacity: 138.880MVA (3) Consulting service Foreign consultant: 17MM Local consultant: 103.5MM
2.Project Period	December 1988 – December 1995 (85 months)	December 1988 – June 2008 (235 months)
3.Project Cost Amount paid in Foreign currency Amount paid in Local currency Total Japanese ODA loan portion Exchange rate	 7,990 million yen 20,315 million yen (2,073 million Rs.) 28,305 million yen 11,414 million yen 1 Rs. = 9.8 yen (As of April, 1988)	 11,242 million yen 30,210 million yen (11,189 million Rs.) 41,452 million yen 11,393 million yen 1 Rs. = 2.7 yen (Average between 1995 and 2008)