Performance Evaluation Report

PPE: PRC 26198

Hunan Lingjintan Hydropower Project (Loan 1318-PRC) in the People's Republic of China

December 2005

Operations Evaluation Department
Asian Development Bank

CURRENCY EQUIVALENTS

Currency Unit – yuan (CNY)

At Appraisal (September 1994)		At Project Completion (August 2003)		At Operations Evaluation (September 2005)	
CNY1.00	= $0.1149	=	$0.1205	=	$0.1238
$1.00	= CNY8.70	=	CNY8.30	=	CNY8.08

ABBREVIATIONS

ADB	–	Asian Development Bank
ADTA	–	advisory technical assistance
BOO	–	build-operate-own
BOT	–	build-operate-transfer
EA	–	Executing Agency
EIRR	–	economic internal rate of return
FIRR	–	financial internal rate of return
GWh	–	gigawatt-hour
HEPC	–	Hunan Electric Power Company
HPEPB	–	Hunan Province Electric Power Bureau
IA	–	Implementing Agency
MW	–	megawatt
OED	–	Operations Evaluation Department, Asian Development Bank
OEM	–	operations evaluation mission
PCR	–	project completion report
PPA	–	power purchase agreement
PPTA	–	project preparatory technical assistance
PRC	–	People's Republic of China
SES	–	special evaluation study
SSTA	–	small-scale technical assistance
TA	–	technical assistance
WACC	–	weighted and average cost of capital
WPC	–	Wuling Power Corporation

NOTES

(i) The fiscal year (FY) of the Government ends on 31 December. "FY" before a calendar year denotes the year in which the fiscal year ends.

(ii) In this report, "$" refers to US dollars.

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Operations Evaluation Department, PE-677

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In accordance with the guidelines formally adopted by the Operations Evaluation Department (OED) on avoiding conflict of interest in its independent evaluations, the Director General of OED did not review this report and delegated approval of this evaluation to the Director of Operations Evaluation Division 2. The field work was undertaken by Clifford Brown (International Consultant/Hydropower Engineer), and domestic consultants Dongsheng Wang (Ecological Impact Specialist) and Gong Heping (Resettlement Specialist) under the guidance of the Mission Leader. To the knowledge of the management of OED, there were no conflicts of interest of the persons preparing, reviewing, or approving this report.

BASIC DATA
Hunan Lingjintan Hydropower Project (Loan 1318-PRC)

Project Preparation/Institution Building

TA No.	Technical Assistance Name	Type	Person-Months	Amount ($'000)	Approval Date
1734	Hunan Lingjintan Hydropower	PPTA	6	99.8	21 Jul 1992
1950	Hunan Lingjintan Hydropower	PPTA	2	100.0	10 Sep 1993
2169	Institutional Strengthening of the Hunan Electric Power Company	ADTA	13	400.0	27 Sep 1994
2170	Introducing BOO/BOT Concept for Shanghai Waigaoqiao Stage II Project	ADTA	20	600.0	27 Sep 1994

Key Project Data ($ million)

	As per ADB Loan Documents	Actual
Total Project Cost	366.8	363.4
Foreign Exchange Cost	129.5	89.3
ADB Loan Amount/Utilization	116.0	89.3
ADB Loan Amount/Cancellation		26.7

Key Dates	Expected	Actual
Fact-Finding	II Nov 1993	2–17 Nov 1993
Appraisal	IV Mar 1994	21 Apr–21 May 1994
Loan Negotiations	8–12 Aug 1994	22–24 Aug 1994
Board Approval	20 Sep 1994	27 Sep 1994
Loan Agreement		2 Mar 1995
Loan Effectiveness	31 May 1995	30 May 1995
First Disbursement		7 Feb 1996
Project Completion	31 Oct 2000	Dec 2000
Loan Closing	30 Apr 2001	8 Nov 2001
Months (effectiveness to completion)	65	67

Borrower People's Republic of China
Executing Agency Hunan Electric Power Company

Mission Data	No. of Missions	Person-Days
Reconnaissance	1	20
Fact-Finding	1	69
Appraisal	1	189
Project Administration		
Review	7	85
Disbursement	1	12
Project Completion	1	18
Operations Evaluation	1	40

ADTA = advisory technical assistance, PPTA = project preparatory technical assistance; TA = technical assistance.

EXECUTIVE SUMMARY

In September 1994, the Asian Development Bank (ADB) approved a loan for $116 million equivalent to the People's Republic of China (PRC) for the construction of a hydropower plant with eight generating units in Lingjintan, Hunan Province. The total project cost was estimated to be $366.8 million, of which 35% was foreign exchange cost. The Executing Agency (EA) was to be the Hunan Electric Power Company (HEPC).

The Lingjintan Hydropower Project (the Project) is a low-head, run-of-river hydropower station on the Yuanshui River in Hunan Province. It was built to accelerate the development of hydropower resources in Hunan Province by (i) providing 240 megawatts (MW) (eight 30 MW units) of generating capacity, and (ii) acting as a reregulating station for the upstream 1,200 MW Wuqiangxi hydropower station, increasing the peak capability of the Wuqiangxi station. An additional benefit expected from the Project was the improvement in navigational conditions on the Yuanshui River between Wuqiangxi and Lingjintan as a result of the creation of the Lingjintan reservoir and the reregulation of the Wuqiangxi discharges by the Lingjintan station. The expected beneficiaries of the Project were the industrial, commercial, and residential electricity consumers of Hunan Province, and people navigating the Yuanshui River.

A resettlement plan and an environmental protection program were developed during project formulation. The resettlement plan laid out the design for the relocation of persons affected by the Project, and the environmental protection program established a monitoring system to determine the effects of the Project on air and water quality and noise in the Lingjintan area.

Two small-scale technical assistance (SSTA) grants were provided to support the following project activities: (i) review of the project feasibility report; (ii) formulation of contract packages, technical specifications, and tender documents; and (iii) assistance in prequalifying bidders. Two advisory technical assistance (ADTA) grants were associated with the loan. The first was aimed at (i) improving and strengthening HEPC's organization structure and management, accounting, and financial planning systems, and management information and control systems; and (ii) recommending reforms in HEPC's tariff level and structure. The second ADTA was intended to help the Government introduce an appropriate framework and arrangements for a build-operate-own/build-operate-transfer scheme for the Waigaoqiao Stage II Project, with the Shanghai Municipal Electric Power Company (SMEPC) as the EA.

In May 1995, Wuling Power Corporation (WPC) was set up to implement, own, and operate the hydropower projects along the Yuanshui River Basin, including the Wuqiangxi and Lingjintan hydropower stations. HEPC then transferred all assets and substantive obligations under the project agreement to WPC, including responsibility for implementation and loan repayment, such that the Project was completed under the de facto executive management of WPC.

According to audited accounts of WPC, the actual cost of the Project, including contingencies and interest during construction, was $363.4 million equivalent. The bid prices overall were substantially lower than the appraisal estimates. Taking advantage of the surplus funds, the EA, with the approval of ADB, procured additional items for the Project, including another bulb turbine-generator unit and accessories. Actual resettlement costs were 330% higher than estimated.

Physical construction was as planned, with no major problems, and largely on schedule throughout the contract period. All excavation was done, civil works were built, and metal structures and other structural elements in the dam were installed as programmed. The first 30 MW generating unit was commissioned at the end of 1998, followed by four more units in 1999. The last four units were commissioned in 2000. By December 2000, all nine units were operating. The turbine-generator units were modified and repaired after the construction. The implementation of the project on schedule indicates highly successful planning and scheduling.

The additional bulb turbine-generator unit was expected to increase the station's peaking capacity and reliability. At the time of project appraisal, the peak load demand in Hunan Province was around 5,500 MW. The Province was facing severe shortages in electricity and the load demand was projected to grow at around 9% per year. Most of the increased demand would be met by thermal power stations. The Project aimed to fill in part of this demand with clean hydropower resources in the Province. The additional generating capacity of 270 MW from the Project and the regulating function for the 1,200 MW Wuqiangxi hydropower station substantially increased the power supply capability of the HEPC power system. Although the achievement of the Project's full operational capacity has been delayed by repairs in the generating units and by forced spillage, the Project is expected to perform fully as designed. It has achieved its principal objective of accelerating the development of hydropower resources in Hunan Province, despite some delays due to necessary design modifications and repairs in the turbine-generators. Thus, the Project is considered a beneficial component of the HEPC power system in Hunan Province, relevant to its development and to the achievement of ADB's sector strategy and the priority given by the Government to hydropower resources.

Although project formulation and design were successful, there are three concerns: (i) the supply of the ninth unit, (ii) the prequalification of the bulb turbine-generator manufacturer, and (iii) the absence of a review of the hydrology. There are no documents justifying the ninth unit. The unit cost of capacity for the ninth unit of about $225 per kilowatt is reasonable for peaking capacity, so the procurement is not without merit. But, without a system study, it is not known if this peaking capacity can be used economically. From all indications, nine generating units cannot be dispatched at the same time, and therefore one unit is always on standby. This did not seem to be apparent at the time the ninth unit was added.

The reestimated economic internal rate of return of 14.3% indicates positive construction performance and, hence, an efficient Project, in spite of the negative effects of the repairs and lost generation. Given the quality of construction and maintenance, the Project should be physically sustainable throughout its expected life. It was designed for a long life, with robust civil works and equipment. Moreover, WPC has demonstrated its effectiveness in implementing large hydropower projects and its ability to operate and maintain the Lingjintan station with high efficacy.

There are, however, concerns about the financial performance of WPC because the power purchase agreement with HEPC and tariff setting by the province favor higher tariffs for thermal plants, in an apparent downward bias for hydropower. But all three entities being government institutions, the financial sustainability of the Project is considered highly likely.

Overall, the Project is rated *successful*. It is relevant, effective, efficient, and sustainable. Its institutional development and other impact are substantial. No issues that could significantly downgrade the project assessment are foreseen.

The operations evaluation mission (OEM) visited the resettlement area of the Project and found that (i) more than 50% of those who had resettled reported a decline in nominal income and attributed this to the shortage of farmland and ineffective production rehabilitation,

confirming the findings of the special evaluation study done earlier by the Operations Evaluation Department (OED); (ii) only 8% of survey respondents expressed satisfaction with the outcome of the economic rehabilitation; (iii) relocation has not been completed because of financing constraints and cumbersome procedures; and (iv) while the majority of relocatees were happy with their new houses, many were dissatisfied with production recovery and conditions, and with compensation polices.

An important issue that has emerged is the lack of action and seeming apathy with regard to recommendations that would bring a project to a successful completion. The special evaluation study done by OED in 2000 recommended enforcement measures to ensure compliance with mitigation programs related to resettlement. The project completion report (PCR) reiterated these recommendations and also proposed actions that the EA or the local government could take to address outstanding resettlement issues. Both reports were circulated to the Government, the EAs, and ADB's operating departments. Between November 2003, when the PCR was circulated, and September 2005, when the OEM was fielded, none of these recommendations was acted on. ADB needs to be more proactive in pursuing the recommendations even after the Project is completed.

David Edwards
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HUNAN LINGJINTAN HYDROPOWER PROJECT

IN THE
PEOPLE'S REPUBLIC OF CHINA
(as implemented)

I. INTRODUCTION

A. Evaluation Purpose and Process

1. The country strategy and program update of the Asian Development Bank (ADB) for the People's Republic of China[1] (PRC) identifies several challenges that the Government must meet to sustain economic growth. Two of these challenges are enhancing energy conservation and improving environmental protection. ADB's operations in PRC for 2006–2008 therefore involve (i) energy restructuring; (ii) environmental improvements through the increased use of clean fuels, modern production technologies, and market-based instruments; (iii) tariff reform; (iv) more efficient energy production and use; and (v) better access for the poor to reliable supplies of electricity. ADB will continue to support projects for power plants, transmission stations and substations, multipurpose dams, pumped-storage plants, and urban gas development. For 2006–2008, five projects in the energy sector have been proposed. This evaluation of the Hunan Lingjintan Hydropower Project (the Project), 6 years after the first generating unit started operating and 4 years after all nine units were commissioned, was made to identify lessons learned, for use in designing the five projects.

2. In January 2000, a special evaluation study[2] (SES) prepared by the Operations Evaluation Department (OED) assessed the environmental and social impact of the Project, as a case study. The SES found that, while the Project may have had limited impact on water quality, its biological impact, particularly on fishery species, was uncertain and needed to be better studied. It also concluded that the people who were resettled were generally happy but some reported decreased incomes because of their smaller agricultural plots. This follow-up assessment and its findings will therefore also guide the mitigation of the adverse effects of social relocation in future power projects.

3. The project completion report (PCR), circulated in November 2003, gave the Project a rating of successful. The PCR said that the project objectives had been achieved and found the Project to be highly relevant and efficient, effective, likely to be sustainable, and a substantial contributor to institutional development and other impact.

4. This performance evaluation report (PER) covers Loan 1318-PRC and two attached technical assistance (TA) grants, TA 2169-PRC[3] and TA 2170-PRC.[4] Its primary purpose is to identify the strengths and weaknesses of the Project and its associated TAs, and to extract lessons for future ADB operations in member countries. The assessment is based on (i) the need for the Project (relevance), (ii) the achievement of its purpose and the production of its outputs (effectiveness), (iii) the timeliness and the manner in which it was processed (efficiency), and (iv) the durability of its outcomes (sustainability). This PER was prepared after an operations evaluation mission (OEM) to the PRC was fielded on 14–24 September 2005. Before visiting the PRC, the OEM reviewed the Project's files, examined relevant documents, and met with ADB staff involved with the Project. The OEM comprised a power economist, a hydropower engineer, and two domestic consultants with extensive experience in evaluating resettlement issues and the ecological environment, and the Project's impact on these. A draft of this PER was circulated to the relevant departments in ADB and to the Government and other stakeholders. Their comments were considered before the report was finalized.

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[1] ADB. 2005. *Country Strategy and Program Update (2006–2008) People's Republic of China.* Manila.
[2] ADB. 2000. *Special Evaluation Study on the Social and Environmental Impacts of Selected Hydropower Projects.* Manila.
[3] ADB. 1994. *Technical Assistance to the People's Republic of China for the Institutional Strengthening of Hunan Electric Power Company.* Manila.
[4] ADB. 1994. *Technical Assistance to the People's Republic of China for Introducing BOO/BOT Concept for Shanghai Waigaoqiao Stage II Project.* Manila.

B. Expected Results

5. The principal stated objective of the Project was to accelerate the development of hydropower resources in Hunan Province by (i) implementing 240 megawatts (MW) (eight 30 MW units) of generating capacity, and (ii) providing a reregulating station for the 1,200 MW Wuqiangxi hydropower station upstream, allowing that station to increase its peaking capability. A major benefit of the Project is the improvement in navigational conditions on the Yuanshui River between Wuqiangxi and Lingjintan as a result of the creation of the Lingjintan reservoir and the reregulation of the Wuqiangxi discharges by the Lingjintan station. The energy conservation activities of the Hunan Electric Power Company (HEPC) were also to be strengthened. The expected beneficiaries of the Project were the industrial, commercial, and residential electricity consumers in Hunan Province, and the people navigating the Yuanshui River.

6. Two technical assistance (TA) grants were associated with the loan. TA 2169 (footnote 3) was aimed at (i) recommending improvements in HEPC's organization structure and management, accounting, and financial planning systems, and management information and control systems; (ii) recommending reforms in HEPC's tariff level and structure, considering the economic, financial, and equity implications; and (iii) providing external and internal training for HEPC staff. TA 2170 (footnote 4) was aimed at helping the Government introduce an appropriate framework and arrangements for a build-operate-own (BOO) and/or build-operate-transfer (BOT) scheme for the Waigaoqiao Stage II Project,[5] with the Shanghai Municipal Electric Power Company (SMEPC) as the Executing Agency (EA). TA 2170 would assist in (i) identifying the project scope and developing procedures, guidelines, and documents for bidding; and (ii) providing a field study for key government and EA officials.

II. DESIGN AND IMPLEMENTATION

A. Formulation

7. In 1992, the Government of the PRC, which had a special interest in the hydropower potential of the Yuanshui River basin, engaged the services of local consultants to undertake a feasibility study of the Project. ADB approved a request from HEPC, in July 1992, for a small-scale TA[6] (SSTA) to review and improve the feasibility study in areas where the local consultants had limited experience, such as (i) bulb-type turbines, (ii) foreign exchange requirements for the turbines, (iii) international approach to calculating the economic internal rate of return (EIRR) and the financial rate of return (FIRR) of the Project, and (iv) environmental impact assessment studies. In September 1993, ADB approved another TA[7] grant to review the supplementary feasibility study and assist the Hunan Province Electric Power Bureau[8] (HPEPB) in preparing detailed engineering designs for the Project. The outputs of the two TA grants provided the basis for the fielding of a fact-finding mission in November 1993. The mission noted that the original feasibility study had been satisfactorily updated, supplemented, and

[5] The Waigaoqiao Stage II Project, a proposed 1,800 MW thermal power plant under the Shanghai Municipal Electric Power Company, was identified by the Government as a priority project to be implemented under the build-own-operate/build-operate-transfer scheme.

[6] ADB. 1992. *Technical Assistance to the People's Republic of China for the Hunan Lingjintan Hydropower*. Manila (TA 1734-PRC).

[7] ADB. 1993. *Technical Assistance to the People's Republic of China for the Hunan Lingjintan Hydropower*. Manila (TA 1950-PRC).

[8] Electricity generation, transmission, and distribution in the Hunan Province were the responsibility of the HPEPB until October 1993, when the HEPC was established and took over the utility functions.

improved as recommended by ADB's reconnaissance mission in July 1993. During the appraisal mission in April 1994, HEPC presented a revised cost estimate and requested that a portion of the ADB loan be used to prepare a midterm plan for energy conservation and train HEPC staff in integrated resource planning and demand-side management. The loan was approved by ADB's Board on 27 September 1994 and took effect on 30 May 1995.

8. In formulating the Project,[9] ADB followed standard implementation approaches including those used for consulting services and procurement. Contract packages were procured through international competitive bidding and local competitive bidding. International shopping and local procurement were employed where appropriate, within the guidelines set by ADB.

B. Rationale

9. The Project was, and still is, consistent with the development strategies of the Government and the operational strategies of ADB at the time of project design and at operations evaluation. The central theme of ADB's strategy in the PRC then was to assist the country in achieving economic growth in an efficient, equitable, and sustainable manner. Hence, efficiency improvement, poverty reduction, and environmental protection were the focus for ADB's operations in the country. With the rapid economic expansion of the PRC in the 1990s, the country faced formidable challenges in the power sector. Power shortages were acute. There was also a heavy dependence on coal-based generation, and the accompanying environmental problems prompted the Government to embark on an energy conservation program under which unit coal consumption for thermal power generation was expected to decline as the Government accelerated the development of hydropower resources.

10. In spite of the continued growth in installed capacity and the expansion in power generation, electric supply in the PRC cannot keep pace with the fast-growing demand for power. The power supply in Hunan Province continues to be critical, given the rising price of coal and the recent dry weather in the province. To help sustain the country's rapid economic development, ADB's country strategy continues to support investment in infrastructure, including energy, to ease constraints on economic growth.

C. Cost, Financing, and Executing Arrangements

11. The estimated total project cost at appraisal was $366.8 million, including foreign exchange costs of $129.5 million. The financing plan at appraisal involved an ADB loan of $116 million to finance 90% of the Project's foreign exchange cost (32% of the total cost). The loan would carry a term of 25 years, including a grace period of 6 years, with interest determined in accordance with ADB's variable lending rate system for US dollar loans, and an annual commitment fee. The remaining portion of the foreign exchange cost, as well as the entire local currency requirements, would be covered by loans from the Hunan provincial government and the State Development Bank. The borrower, which was the PRC, was to relend the proceeds of the ADB loan to the HEPC (the EA) on the same terms and conditions as those for ADB's loan to the PRC. HEPC was to bear the foreign exchange and interest variation risks.

12. According to the audited accounts of the Wuling Power Corporation (WPC), a limited-liability company established to implement, own, and operate the hydropower stations covered by the Project, the actual cost of the Project, including contingencies and interest during construction, was $363.4 million equivalent. This is slightly lower than the PCR figure. Engineering estimates of the civil works and equipment were reasonable, with the actual costs

[9] The reconnaissance mission was fielded from 12 to 15 July 1993; the fact-finding mission, from 20 to 29 April 1994; and the appraisal mission, from 21 April to 10 May 1994.

being 10% to 12% lower than estimated. The bid prices overall were substantially lower than the appraisal estimates. Taking advantage of the surplus funds, the EA, with the approval of ADB, procured several additional items for the Project including an additional bulb turbine-generator unit and accessories, a 220 kilovolt (kV) gas insulated switchgear system, four 70 kilovolt-ampere (kVA) transformers, and a number of small sundry items through international shopping. Actual resettlement costs were 330% higher than estimated. A table showing the cost of the major components and a breakdown of foreign and local costs is in Appendix 1. The cost estimate at the time of appraisal and the cost from the PCR are also shown in this appendix.

13. At project completion the actual funding from the ADB loan had been reduced to $89.3 million, but it had covered the entire foreign exchange cost (24% of the total project cost). The loan amount was reduced even with the procurement of the additional items (the ninth turbine-generator unit, etc.).

14. Financing for the two 220 kV transmission lines for evacuating the power from Lingjintan came from HEPC's own resources.

15. As the EA for the Project, HEPC was to be responsible for the overall supervision and coordination of project implementation, including plant operations. The implementation arrangements included the establishment of the Lingjintan project construction unit under a senior staff member of HEPC. The Mid-South Design and Research Institute was to assist HEPC in the engineering design. In May 1995, WPC was established to implement, own, and operate the Wuqiangxi[10] and Lingjintan hydropower stations.[11] HEPC then transferred all assets and substantive obligations under the project agreement to WPC, including responsibility for implementation and loan repayment, making WPC the de facto EA, although not in compliance with the Loan Agreement. When it first became known (in 1995) that HEPC intended to transfer the assets and obligations to WPC,[12] ADB informed HEPC and the Government that the arrangement was not in keeping with the conditions of the Loan Agreement and that, although ADB was not opposed to the transfer in principle, the Loan Agreement would have to be changed and ADB would have to approve the changes. In 1998, before making the required changes in the loan document, ADB engaged the services of a consultant to review the institutional and financial aspects of WPC, the financial position of HEPC before and after the transfer of the Wuqiangxi and Lingjintan projects to WPC, and the power purchase agreement (PPA) between HEPC and WPC for the sale of power from the Project. The consultants' review noted weaknesses that would adversely affect WPC's financial position as owner and operator of the Project, and threaten the Project's financial viability.

16. The PPA between HEPC and WPC put HEPC in a controlling position as the sole purchaser and distributor of electricity for the grid, but it did not guarantee a sufficient revenue stream to keep the Project profitable. The revenue level required to recover fixed and variable costs, and provide for payment of loans, was not assured. The policy dialogue with the Government emphasized the need to address the issues by modifying the PPA to lower the commercial risk. In the end, at the time of the PCR in 2002, the Government had (i) prepaid the

[10] The 1,200 MW Wuqiangxi hydropower plant was under construction at the time of appraisal. It is 47.5 kilometers upstream of the Project.

[11] WPC was jointly established by HEPC (56% of the shares), Hunan Economic Investment Corporation representing the Hunan provincial government (32%), and the Central China Electric Power Group (12%). In addition to the Wuqiangxi and Lingjintan hydropower stations, WPC also owns and operates the 63 MW Jinweizhou hydropower station. Five other hydropower projects, with a total planned installed capacity of 2,260 MW are being developed, and are programmed for completion within 5 years.

[12] Although ADB was aware of the establishment of WPC, it was not until May 1998 that the People's Bank of China formally conveyed to ADB its proposed changes in the implementation arrangements.

ADB loan, (ii) implemented a major sector-wide restructuring,[13] and (iii) indicated that it planned to move to market pricing in the power sector. In all of this, the Loan Agreement was not changed and the Project was completed under the de facto executive management of WPC. Although market pricing has not been introduced in Hunan Province, the pricing of WPC's electricity sales to HEPC has at least been taken out of HEPC's control and tariffs are now set by the Government (para. 38).

D. Procurement, Construction, and Scheduling

17. **Procurement.** HEPC engaged an experienced procurement agent[14] to procure imported equipment financed under the loan, including the drafting of the bidding documents, bid evaluation, and subsequent contract management. Goods and services were procured according to ADB's *Guidelines for Procurement*.

18. The ADB loan funded 17 contract packages for equipment supply and consulting services valued at $73.7 million. The bid prices overall were substantially lower than the appraisal estimates, allowing for increases in the scope of work. ADB approved a number of changes requested by the EA requiring the reallocation of proceeds. These included the procurement of (i) a 220 kV gas insulated switchgear system, (ii) four 70 kVA transformers, (iii)an additional bulb turbine-generator set and accessories, and (iv) four additional miscellaneous items through international shopping.

19.. **Construction.** Domestic contractors carried out the civil works and installed most of the equipment. International manufacturers supplied and supervised the installation of the major electromechanical equipment. The Mid-South Design and Research Institute, which prepared the feasibility study, was retained to undertake the Project's engineering design and supervise the foundation and steel works. Other domestic firms were also engaged for site supervision and some aspects of equipment installation. In accordance with the Loan Agreement, HEPC engaged an international consulting firm[15] to assist in the overall supervision of project implementation. An independent international inspection firm[16] was also engaged to certify the origin of supplied items and their conformity with bid requirements. These international consultants were engaged according to ADB's *Guidelines on the Use of Consultants.*

20. The transmission lines were also built by domestic contractors, and were completed in time for the commissioning and start-up of the station. No major problems with the civil works construction or equipment installation have been reported, except for the defects in the bulb turbine-generators. Overall, as indicated by the cost, schedule, and workmanship, the construction was efficient.

21. **Scheduling**. The civil works contractor began mobilizing in October 1994, immediately after the loan approval. Physical construction was carried out as planned, with no major problems, and was largely on schedule throughout the contract period. Actual construction took

[13] The restructuring resulted in the breakup of State Power, HEPC's former holding company, into 11 smaller companies comprising five power generation companies, two grid management companies, and four auxiliary companies, and a planned move to market price restructuring. HEPC's holding company is now the State Power Grid Corporation, one of the two new grid management companies, while ownership of WPC shares was transferred to China Power Investment Corporation, a new power generation company.

[14] The procurement agents were the China National Machinery Import and Export Corporation in association with China Electric Power Technology and Trade Corporation for bulb-turbine generator units and auxiliaries, and China National Instrument Import and Export Corporation in association with China Electric Power Technology and Trade Corporation for other ADB-financed equipment.

[15] Electric Power Development Company, Limited.

[16] SNC-Lavalin International, Inc. Canada.

74 months (compared with the original schedule of 72 months); however, in view of the inclusion of an additional 30 MW unit, project completion is considered by the OEM to be right on schedule. All excavation was done, civil works were built, and metal structures and other structural elements in the dam were installed as programmed. The first generating unit of 30 MW was commissioned at the end of 1998, followed by four more units in 1999. The remaining four units were commissioned in 2000. By December 2000, all nine units were operating. The turbine-generator units were modified and repaired after the construction phase, as discussed in para. 56. The planned and actual project schedules are shown in Appendix 2. The implementation of the project on schedule indicates highly successful planning and scheduling.[17]

E. Design Changes

22. All project components were clearly established at appraisal, and implemented accordingly. In November 1995, HEPC informed ADB of its interest in procuring a ninth generating unit to increase the much-needed installed capacity for peaking to 270 MW and add a further 62 gigawatt-hours (GWh) of secondary energy to the system. The additional costs would be $6.0 million in foreign exchange for electromechanical equipment and instruments, and CNY52.8 million in local currency for the additional civil works. The funding was to come from loan savings resulting mainly from the lower-than-budgeted contract prices for the eight generating units. The request for the ninth unit was approved by ADB in May 1997.

F. Outputs

23. The main component of the Project was the 270 MW (nine 30 MW units) low-head, run-of-river hydropower station on the Yuanshui River in Hunan province. The main structures and equipment of the Project were: (i) civil works, consisting mainly of a concrete dam 1,006 meters (m) long and 53.5 m high across the Yuanshui River, a sluiceway, powerhouse, ship lock, and ancillary structures; (ii) nine 30 MW bulb turbine-generator units; (iii) auxiliary equipment, including transformers, switchgear, communications, and power station control systems; and (iv) metal structures, including sluice gates, gates at the ship lock, cranes, steel trash racks, and rakes.

24. Other components of the Project were: (i) land acquisition and resettlement of affected people, and improvement of adjacent infrastructure and ancillary facilities; (ii) consulting services for project design and implementation; and (iii) consulting services for the development of energy conservation measures for Hunan Province.

25. Two 220 kV transmission lines, not a part of the Project but necessary for its operation, were built to connect the Project to the Hunan provincial power grid; a 20 km line to Taoyuan, which became operational in December 1998 was ready for the commissioning of the first generating unit; and a 50 km line to Taojian became operational in December 1999. These lines were financed from HEPC's own resources.

26. Since the energy conservation program was presented, HEPC has drawn up an enterprise resource plan promoting energy savings, which is still evolving. HEPC initiatives so far include (i) the creation of a department for energy conservation that deals directly with consumers; (ii) a retail tariff structure that recognizes time-of-day and time-of-year usage, resulting in a load shift from peak to off-peak in the grid; and (iii) a program of consultation with major users to promote more use of off-peak energy and energy-efficient equipment (new or upgraded equipment). Energy savings are achieved through such measures as reactive power factor correction, use of higher-

[17] The repair of the turbine-generator units, after the scheduled completion date, is considered a technical/quality issue and not a planning/scheduling issue.

voltage equipment (with lower losses), and promotion of energy-saving air-conditioning (using ice-making or storage air-conditioning).

27. The institutional strengthening TA (TA 2169) provided 6 days of overseas training and follow-up training in financial functions, auditing, tariffs, and energy trading. A 2-day workshop for senior management of HEPC and HPEPB discussed power sector reforms in the PRC, their implications for the organization and its financial and management information systems, privatization trends, and organization options for HEPC. The financial and accounting systems, as well as the organization options, that have resulted from the TA have been extremely useful and have been implemented where appropriate. A financial real-time query system has been established in HEPC, together with other financial management systems. The tariff-setting outputs have strengthened the knowledge base within HEPC and provided the company with a better understanding of the issues related to tariff setting, which HEPC has applied in developing its differential rates (para. 38). While HEPC cannot set provincial tariffs, it can make recommendations to the provincial government and let the government know if it does not agree to the tariffs.

28. As its title indicates, the TA for the BOO/BOT (TA 2170) concept did not pertain to the Lingjintan Hydropower Project but was designed to help SMEPC prepare the Waigaoqiao project for implementation under a BOO/BOT scheme by assisting in the development of procedures, guidelines, and documents for bidding. A significant amount of technical, financial, legal, and environmental expertise went into the preparation of model documents for the restructuring of a BOT power project, according to international standards and practices. The TA produced final versions of the PPA and requests for proposals. The documents were comprehensive and generally of good quality, and can be used in other similar BOO/BOT projects. Two groups were sent for training to power stations where the BOT financing scheme is considered successful. The outputs of the TA were, however, not used for the intended project, since the Government decided not to undertake the Waigaoqiao project under the planned BOO/BOT scheme.[18]

G. Consultants

29. As envisaged at appraisal, HEPC engaged an international consulting firm to supervise overall project implementation. As part of the loan, an independent international inspection firm was also engaged to certify the origin of supplied items and their conformity with bid requirements. Also as part of the loan, an international consultant in energy conservation was recruited to help HEPC strengthen its energy conservation activities by improving planning and exposing HEPC staff to modern concepts and techniques of demand-side management and integrated resource planning. These international consultants were engaged according to ADB's *Guidelines on the Use of Consultants*.

30. The domestic design consultant who prepared the feasibility study was retained by the HEPC to undertake the engineering design for the Project. The same design consultant was also made responsible for supervising the foundation and steel works.

31. HEPC used an experienced domestic procurement agent (footnote 14) to procure imported equipment financed under the loan, including the drafting of the bidding documents, bid evaluation, and subsequent contract management. The equipment was procured without major problems, and the appointment was therefore considered effective. The results of international competitive bidding were favorable.

[18] The Waigaoqiao project was later implemented with World Bank financing.

32. According to the PCR, both international and domestic consultants provided services according to the terms of reference and contributed positively to successful project implementation. The international consultant coordinated activities at the site effectively, and ensured quality control of the work. The performance of these consultants was rated satisfactory in the PCR. On the basis of discussions with the HEPC and WPC and an inspection of the works, the OEM agrees with this assessment.

33. Consulting firms from Hong Kong, China; PRC, and United Kingdom provided consulting services for the institutional strengthening of HEPC. The consultants provided good-quality inputs and their performance was given a good rating in the technical assistance completion report. The OEM confirms this assessment, following discussions with HEPC and improvements in HEPC's financial and accounting systems.

34. The consultants for TA 2170 produced good reports and documents of good quality, and imparted a knowledge of BOO/BOT that was found to be very useful, perhaps not for the Waigaoqiao Stage II Project, but certainly for any BOO/BOT scheme.

H. Loan Covenants

35. As reported in the PCR, loan covenants were generally complied with, except for the following: (i) the provision of adequate tariffs to ensure the Project's viability; (ii) the submission of certain reports, such as the energy conservation plan and action program, the project completion report, and the report on benefit monitoring and evaluation; (iii) the financial covenants for 1999 and 2000; and (iv) the resettlement assurances.

36. From 1996 to 2000, HEPC submitted audited financial statements, with an unqualified auditor's opinion, regularly and on time. But from 2001 onward, no audited financial statements were submitted. The covenants on debt service coverage and self-financing ratios were met, except in 1999 and 2000. The computed ratios for WPC, based on financial statements submitted from 2000 to 2002, were also lower than the prescribed levels because of lower-than-projected revenues resulting from the lower tariff provided in the PPA, and the lower station utilization because of the shutdown of units for repairs. Appendix 3 assesses compliance with the covenants in the Loan Agreement.

I. Policy Setting

37. The Hunan power grid is an important part of the Central grid. By the end of 1995, Hunan was a net power importer from other provinces, as it suffered from acute power shortages and frequent load shedding. Its power grid then had a total installed generating capacity of around 7,750 MW, a peak load of around 5,500 MW, and total electricity supply of 33,934 GWh. HEPC owned and operated almost the whole transmission system for the province, which also included transformer substations. At the end of 2002, the Government implemented a major sector-wide restructuring that resulted in the breakup of the State Power Corporation, HEPC's former holding company, into 11 smaller companies, two grid management companies, and four auxiliary companies. The State Power Grid Corporation, one of the two new grid management companies, became the holding company of HEPC. The ownership of the shares of WPC was transferred to China Power Investment Corporation, a new state-owned group of companies engaged in electric power generation.

38. Although tariff reform was introduced by the Government in 2000, the tariff level for the Project at the time of the PCR, as well as at the time of the PER, was still not in line with economic costs. At the time of the PCR, a shift to market pricing was expected, as part of the

sector restructuring; the shift, as noted in the PCR, would address the issue of tariffs for the Project. There is still no indication that market pricing will be pursued anytime soon. HEPC does not set tariffs, but it makes recommendations to the provincial government and conveys any differences of opinion about tariffs to the government. The tariff structure that is in effect is segmented by type of consumer, by time of day, and by time of year. It has been effective in shifting time of use from peak to nonpeak hours.

III. PERFORMANCE ASSESSMENT

A. Overall Assessment

39. Overall, the Project is rated successful because of its relevance, effectiveness, efficiency, and sustainability. It has had substantial institutional development and other impact. No issues that could significantly downgrade the project assessment are foreseen.

40. To arrive at the overall assessment, the four criteria were weighted as follows: 20% for relevance, 30% for effectiveness, 30% for efficiency, and 20% for sustainability. The ratings under the four criteria were given in whole numbers, between 0 and 3. The overall assessment is summarized in Table 1.

Table 1: Overall Performance Assessment

Criterion	Assessment	Rating (0–3)	Weight (%)	Weighted Rating
Relevance	relevant	2	20	0.4
Effectiveness	effective	2	30	0.6
Efficiency	efficient	2	30	0.6
Sustainability	sustainable	2	20	0.4
Total Rating[a] (TR)				2.0

[a] Highly successful, TR > 2.7; successful, 1.6 ≤ TR ≤ 2.7; partly successful, 0.8 ≤ TR < 1.6; unsuccessful, TR < 0.8.

Source: Operations Evaluation Mission.

B. Relevance

41. The Project is assessed as relevant. At the time of project appraisal, the peak load demand in Hunan Province was around 5,500 MW. The Province was facing severe shortages in electricity and the load demand was projected to grow at around 9% per year to 12,640 MW in 2003. Most of the increased demand would be met by thermal power stations. The Project aimed to fill in part of this demand with clean hydropower resources in the Province. The 270 MW additional generating capacity and the regulating function for the 1,200 MW Wuqiangxi hydropower station substantially increased the power supply capability of the HEPC power system. Although there have been delays in the Project's full operational capacity, because of repairs in the generating units and forced spillage, the Project is expected to perform fully as designed. Thus, it is considered a beneficial component of the HEPC power system in Hunan Province and relevant to its development, to the achievement of ADB's sector strategy, and to the priority accorded by the Government to the development of hydropower resources.

42. **HEPC System Load Demand**. The severe shortfalls and high incidence of load shedding in the grid at the time of appraisal was expected to worsen as the requirements of the rapidly

growing economy increased. The annual load demand in the grid was expected to grow over the next 10 years (from 1993 to 2003) at around 9%. Over the same period, actual peak demand increased at an average of 11% and energy demand at 10%. Demand is expected to remain strong over the short to medium term, with HEPC forecasting 13% growth in peak capacity demand in 2005 and 12% annual growth in peak capacity demand to 2010, and 10% annual growth in energy demand over the same period.

43. However, the load forecast is no longer significant in the economic performance of Lingjintan because, with the load growth to date, the capacity of Lingjintan has been fully absorbed into the power system and its economic performance should depend only on the hydrology and the reliability of the station operation.

44. Project formulation and design were based on (i) feasibility studies by the domestic design consultants, (ii) review of the feasibility studies and modifications in the project design as proposed by international consultants (footnotes 6 and 7), and (iii) information contributed by ADB's missions, the Government, and HEPC. Given the purpose of the Project, as a run-of-river peaking station and a reregulation station, the layout, structures, and equipment are all appropriate. The dam, sluiceway, and ship lock are all robust concrete structures. The sluice gates, turbine intake gates, trash racks, draft tube gates, and lock gates are heavy steel structures appropriate for their intended use. With the low head, bulb turbine-generator sets are the best type of units. The project formulation was sound, and administratively HEPC and WPC executed the preparatory work and implementation well. The project review and design modifications by the international consultants were appropriate and the initial design was considered optimal for the Project. The appointment of an experienced procurement agent to procure imported equipment financed under the loan, and international consultants for overall implementation supervision, offshore inspection services, institutional strengthening, and energy conservation, was key to the successful implementation of the Project. However, although the formulation and design were successful there are three concerns: (i) the supply of the ninth unit, (ii) prequalification of the bulb turbine-generator manufacturer, and (iii) the absence of a review of the hydrology, as discussed in the following paragraphs. Load growth, which was a significant factor in the formulation of the Project but not a concern at the time of OEM, is also reviewed below. Another problem with structural cracks in the turbine-generator components is a design and construction issue, as discussed further below.

45. To support the Project, a resettlement plan and an environmental protection program were developed in parallel with project formulation. The resettlement plan was aimed at resettling the affected people as close to their original homes as possible and with minimal effect on their sources of livelihood. The environmental monitoring system developed for the Project found no adverse effects on air and water quality and noise levels in the project area. But it did not provide for any possible adverse effects on migratory fish in the river and did not propose any mitigation measures to deal with such effects.

46. **Prequalification of Bulb Turbine-Generator Manufacturer**. At the time of bidding for the bulb turbine-generator units, the prime manufacturer[19] had very limited experience in the design and manufacture of bulb turbine-generator units, having built units for only one other project, in 1989, in its home market. The Project was also its first in the international market.[20] The EA, the domestic and international consultants, and ADB should all have recognized (i) the laxity of the

[19] Major parts of the turbine generator were manufactured in the PRC under a subcontract. To distinguish between the international and local manufacturers, the international manufacturer, with which the contract was placed, is referred to as the prime manufacturer.

[20] Since then, the prime manufacturer has won a bulb turbine contract for another project in the PRC, which was scheduled to be operational in 2003.

prequalification criteria, and (ii) the supplier's lack of experience in evaluating submissions for prequalification for the turbine-generator contract.[21] The Implementing Agency (IA) and the prime manufacturer are to be commended for applying themselves to the problems and resolving these when they appeared.

47. **Supply of Ninth Unit**. During the ADB mission in November 1995, HEPC informed ADB of its interest in procuring a ninth generating unit. It explained that this would increase the much-needed installed capacity for peaking to 270 MW and add a further 62 GWh of secondary energy to the system. The additional costs would be $6.0 million in foreign exchange for electromechanical equipment and instruments, and CNY52.8 million for additional civil works. The bid prices for the original eight generating units had resulted in more than enough savings to cover the cost of the ninth unit. But because a change in scope was involved, the mission at the time advised HEPC to send a formal request to ADB giving detailed technical and economic justification for the proposed changes.

48. The request for the ninth unit was made by HEPC and approved by ADB in May 1997.[22] During the mission, HEPC and WPC staff could not provide documents to justify the ninth unit and were not aware of any such documents. The unit cost of capacity for the ninth unit of about $225/kW is reasonable for peaking capacity, so the procurement is not without merit. But without a system study it is not known if this peaking capacity can be used economically. From all indications, nine generating units cannot be used at the same time; therefore, one unit is always on standby. This did not seem to be apparent at the time the ninth unit was added. Full correspondence relating to the decision was not available to the OEM, and the justification for the position of the EA, the domestic and international consultants, and ADB is unknown.

C. Effectiveness

49. The Project is assessed as effective. The addition of a 270 MW station has met the Project's main objective of accelerating the development of Hunan's hydropower resources, and will help relieve current and future power shortages in the HEPC system. As the system load continues to grow and as the Yuanshui River becomes more fully developed with upstream hydropower projects (and therefore more fully regulated), the Project's operation will be even more effective, particularly for peaking operations.

50. In addition, the Project has also enabled the Wuqiangxi hydropower station to increase its peaking capability. With the Lingjintan station able to reregulate the discharges from the Wuqiangxi station, the latter can provide a total of 1,248 GWh per year of dependable energy for peaking, equivalent to the increased availability of more than 150 MW of peaking capacity.

51. After the Project's completion, river navigation between Wuqiangxi and Lingjintan improved markedly, but no details of river movements have been recorded.

52. The energy conservation consultancy provided tangible results in exposing HEPC and WPC staff to modern concepts and techniques of demand-side management and integrated resource planning. The TA associated with the Project also improved HEPC's institutional

[21] The OEM is of the opinion that, to be qualified, a prime manufacturer should have had more experience in bulb turbine-generators—say, three or at the very least two units of similar or greater capacity, operating successfully for 4 years. In the turbine-generator manufacturing field there are a number of design and manufacturing companies with more than adequate experience in the design and manufacture of bulb turbine units. However, such defects happen to the best manufacturers at times.

[22] The OEM questions the merits of the decision. Studies during the preparation of the Project, by the domestic and international consultants, concluded that the optimum number of units was eight and there are no known studies that go against this conclusion.

capability. Project training programs enhanced the management and institutional perspectives of both the EA and the IA.

53. **Hydrology**. From a review of operational records, the station generation has been much less than expected, having reached only 84% of its rated annual long-term energy production (in 2002 and 2004). The station has been in operation since the start of commissioning in 1998. Between 1998 and 2002, some of the units were not yet commissioned and some had been out of service for repairs; this could account for the lower-than-forecast generation in this period. However, all units have been fully operational since the end of 2003 and generation is still less than the forecast for 2004. It is recognized that this is too short a period to draw firm conclusions, but it does raise a question with regard to the long-term energy production. WPC indicated that energy production was low for two reasons:

(i) The need to spill at Lingjintan station, even in periods without flooding, because the grid demand was being served by coal-fired thermal units that had to be kept online as spinning reserve to meet large load changes (larger load changes than could be handled by Lingjintan). Thus, the thermal units were supplying load that could have been supplied by Lingjintan if it were not for the spinning reserve requirement.
(ii) A dry hydrological period in recent years. WPC was confident that the dry period would end and the station would reach its long-term average potential of 1,215 GWh per year.

54. The operation of the thermal plants and the resulting need to spill at Lingjintan are discussed in para. 57. Regarding item (ii), if a dry hydrological period has occurred in recent years and continues, nothing can be done except to supply the shortfall with thermal power. One other possible reason for the lower generation may be an overestimate of the river flows in the feasibility studies. The OEM noted, from a review of SSTA documents, that no review of the hydrology was made by the international consultants. The OEM also noted that hydrology is the primary and most imprecise input into energy calculations; in its opinion, therefore, the hydrology should have had expert review. The terms of reference for the SSTA did not pointedly specify a review of the hydrology, but it should have. The terms of reference did call for a “review [of] the justification for the choice of bulb turbines,” and that should have prompted a review of the hydrology. The complexity and need for expert analysis of hydrology is a lesson to be learned for all water resource projects.

55. The Project is complete and the hydrology will be fixed by nature, so there is no follow-up action for the Project. The WPC was not knowledgeable about hydrological studies and did not have copies of the studies available. The OEM is of the opinion that, in view of the number of projects still to be built on the Yuanshui River, the WPC should have the hydrology reviewed by an independent expert hydrologist, if such a review has not yet been done.

56. **Station Operation.** On completion of installation, the generating units could not operate at their rated capacity because of cracks in the generator rotor spider arms and breaks in several places in the hydraulic pipe lines for controlling the position of the turbine runner blades. Both the equipment designer and the manufacturer of the bulb units were on site making repairs from 2001 to 2003. At the time of the OEM, the first units repaired had been operating for about three years, and the last one for about one year and nine months, without recurrence of the problems. A review of the station outage records shows a continuing reduction of the forced outages of the station over the years with no forced outage in 2004 indicating a long term reliable operation of the generating units.

57. The station has a peak design capacity of 270 MW, but has reached only 84% of its rated annual long-term energy production (in 2002 and 2004) and has been spilling water in non-flood periods although the occurrence and amount of spill has been declining over the years. The Project has achieved its principal objective of accelerating the development of hydropower resources in Hunan Province, despite some delay due to the necessary design modifications and repairs in the turbine-generators. After the repair of cracks in the generator rotor spider arms and the hydraulic piping, the Lingjintan station has been operating at full capacity. The low energy production is a cause for concern, however. According to WPC, this is a result of an operational constraint (the need to keep thermal units operating on spinning reserve) and a dry hydrological period in recent years (para. 54). Considering the large demand in the national grid and the unserved electricity demand in PRC, spilling in non-flood periods should not occur in a well-planned power system. It is not known if this operating limitation was considered in the system power studies that were part of the feasibility studies. The performance of the thermal units should have been identified in the power system studies since it affects the performance of hydropower projects, particularly run-of-river projects like Lingjintan.[23] Whether or not the operational constraint was recognized in the power system studies appears to be an academic question now because the spill during non-flood periods has been declining over the years and is expected to be eliminated eventually as the load in the power system increases and the operators improve the dispatch operations. Also, as the Yuanshui River becomes more fully developed with upstream hydropower projects (and therefore more fully regulated), the station operation will become more effective, particularly for peak operations.[24]

58. The navigational lock at Lingjintan is working well. The OEM saw a number of cargo-loaded boats entering the lock at Lingjintan and also plying the stretch between Lingjintan and Wuqiangxi. The river was relatively wide and very navigable for the size of the boats using it. Unfortunately, no records on the traffic through the lock were readily available to allow the OEM to determine if the traffic had increased or not as a result of the improvements in the navigation upstream of Lingjintan station. Very large benefits to boaters on this reach of the river are attributable to the Project, but these benefits have not been quantified.

D. Efficiency

59. The Project is considered efficient, considering the positive construction performance and the positive indication of the EIRR (reestimated at 14.3%) in spite of the negative effects of the repairs and lost generation. The Project was completed on schedule and within budget (even considering that additional equipment was procured with surplus funds), with no major construction problems or contract disputes. However, energy generation has been less than expected because of the turbine repairs and less-than-average rainfall, and this has affected the financial and economic performance. Significant cost overruns on the resettlement were considered necessary (these overruns being offset by lower costs for other project components).

60. The reestimated EIRR of 14.3% (Appendix 4), while slightly below the appraisal estimate of 16.6%, exceeds the assumed economic opportunity cost of capital of 12% and the PCR estimate of 12.4%. The economic evaluation of the Project followed the methodology used for the PCR except for the assumed life of the Project, which is assumed to be 50 years in the

[23] When asked about the power system studies, HEPC and WPC informed the OEM that they no longer carry out power system studies (the Government now does these) and did not know the system that was simulated in the feasibility studies.

[24] Although the OEM believes that the hydrology should have been reviewed, the dry period could be the major reason for the low energy production to date, as indicated by WPC. In the long term, the hydrology should improve and the Project will achieve its predicted long-term energy production. System studies and the hydrology for the Project were not readily available for review by the OEM.

PER, compared with 25 years in the PCR. The EIRR at appraisal assumed transmission and distribution losses of 20%. The OEM believes that this proportion is too high and instead used the 10% figure assumed in the PCR. The recomputed willingness-to-pay is marginally higher, at CNY0.68 per kwh, than the calculated CNY0.62 per kwh in the PCR.

61. Sensitivity tests were used to separately consider the effects of a decline in generation output and an increase in operating costs. A decline in generation by 10% would bring EIRR to 13.6%, while an increase in operating costs by 10% would hardly affect EIRR. A combination of a decline in generation by 10% and an increase in operating costs by 10% would give an EIRR of 13.5%. Generation would have to decrease by more than 32% to push EIRR down to 12%.

62. The turbine-generator manufacturer paid liquidated damages for the loss of generation due to the major repairs in the units. However, the information about how much was paid is deemed confidential and was not made available to the OEM. The liquidated damages are unwanted, but recovery of lost benefits to the Project should nevertheless be included in the economic and financial analysis. Because the value of the liquidated damages could not be determined precisely, it was not taken into account in the basic economic and financial evaluation but was noted in the overall evaluation.

E. Sustainability

63. The Project is rated sustainable. The basic need for clean energy is foreseen to outlast the Project. Given the quality of construction and maintenance, the Project should be physically sustainable throughout its expected life. WPC has demonstrated that it can maintain and operate the Lingjintan station with high efficacy. Although the Project has reached only 84% of its rated annual long-term energy production to date, there are positive indications that the Project will reach its rated capacity and be sustainable over its lifetime.

64. The OEM reviewed operation and maintenance practices at the site and inspected all major structures and operating plant, except submerged components. On the basis of the organization and staffing provided for operation and maintenance and discussions with station personnel on maintenance practices, the OEM concluded that maintenance arrangements were effective. It was noted that safety helmets were mandatory for all personnel, including visitors, and that the equipment, buildings, and surrounding property were kept meticulously clean.

65. The Project was designed for a long life, with robust civil works and equipment. WPC, in its short existence, has demonstrated its effectiveness in implementing large hydropower projects and maintaining a high standard of operation and maintenance of the stations. Problems and the solutions to these problems have been identified, and it is fully expected that WPC staff can effectively deal with similar problems. Also, with nine units in the station, any repairs can be dealt with one unit at a time, keeping eight units operational, and the impact on generation should therefore be minimal.

66. There are concerns about the financial performance of WPC because the power purchase agreement with HEPC and tariff setting by the province favor higher tariffs on thermal plants, in an apparent downward bias for hydropower. But all three entities being government institutions, the financial sustainability of the Project is considered highly likely.

67. The FIRR was reestimated at 6.1%, higher than the PCR estimate of 5.6% but lower than the appraisal estimate of 9.3% (Appendix 4). The difference between the current FIRR estimate and the estimate at appraisal can be attributed mostly to the difference in tariff assumptions. The reestimated FIRR is higher than the 4.4% estimate for the weighted average

cost of capital (WACC). Sensitivity tests undertaken indicate that a decrease in generation by 10% and an increase in operating costs by 10% would pull down FIRR to 5.4%. Any decrease in generation by more than 30% would drive the FIRR below the WACC.

IV. OTHER ASSESSMENTS

A. Impact

1. Assessment of Impact

a. Impact on Institutions

68. The Project provided wide-ranging support for institutional development, generally through domestic staff working with the international consultants on the design, preparation, and supervision of the Project. Directly, the Project provided capacity-building programs in energy conservation for modern demand-side management and integrated resource planning concepts and techniques, as well as institutional management assistance with (i) improvements in HEPC's organizational structure and management, accounting, and financial planning systems, and management information and control systems; and (ii) reforms in HEPC's tariff level and structure, considering the economic, financial, and equity implications.

69. The positive impact of these programs was noted during the PCR mission and recognized by the OEM from the enthusiasm and positive response shown by HEPC and WPC staff in discussions on energy conservation and financial management during the training. The institutional development and other impact is substantial.

b. Socioeconomic Impact

70. The Hunan Lingjintan Hydropower Project was one of four cases in the SES (footnote 2) prepared by the OED in January 2000. The OED study found that while people who resettled to give way to the Project were generally happy with their new houses, some reported decreased incomes because of their agricultural plots had become smaller. The OED study concluded that "The current trend, which appears to be gradual impoverishment of some affected persons, is not satisfactory."

71. The operations evaluation mission conducted a survey of 110 respondents to determine the social, economic, and environmental impact of the Project. Public facilities in the resettlement area, the construction site, and other related structures were inspected (Appendix 5). The OEM survey indicated that (i) nominal income had declined for more than 50% of those who had resettled, and they attributed this to the shortage of farmland and ineffective production rehabilitation, confirming the findings of the SES (footnote 2); (ii) only 8% of survey respondents said they were satisfied with the outcome of the economic rehabilitation; (iii) relocation has not been completed because of financing constraints and cumbersome procedures; and (iv) while the majority of relocatees were happy with their new houses, many were dissatisfied with production recovery and conditions, and with compensation policies. A common complaint of persons affected by the Project was the lack of consultation. Consultations involved mostly the village leaders, and those directly affected seemed to be hardly involved.

72. The PCR recommended several follow-up actions related to outstanding resettlement issues. Between November 2003, when the PCR was circulated, and September 2005, when the OEM was fielded, these recommendations had not been acted on. But the recent field

survey by the OEM seems to have prompted the provincial government to be more resolute in addressing the remaining issues, as it has met to discuss the needed actions.

c. Environmental Impact

73. With the assistance of Mid-South Design and Research Institute, HEPC prepared an environmental impact assessment, which was later approved by the National Environment Protection Agency. At the request of ADB, an environment monitoring system was set up by WPC through county environment protection agencies, and an environmental monitoring station was set up at the Wuqiangxi and Lingjintan reservoirs to monitor environmental impact during operation. Air and water quality and noise levels were periodically monitored from 1997 to 2000, and the results of this exercise gave reason to conclude that air and water quality and noise levels in Lingjintan were not significantly different after the Project and all indicators monitored were stable. The SES (footnote 2) prepared by OED reported that aquatic organisms or other biological indicators were not monitored. The same study found the design lacking in procedures to sample for accidental spills or toxic substances or conduct point-source sampling at the Project's effluent locations. The SES also reported that the Lingjintan Project, together with Wuqiangxi and 15 other proposed projects along the Yuanshui River, may adversely affect migratory fish in the river and possibly Lake Dong Ting. The SES therefore recommended that fish yield be monitored and that a fish biologist or aquatic ecologist be added to the district environmental staff.

74. At the time of the OEM, the issue of flooding in the reservoir area remained unresolved. In the last 10 years flooding has been increasingly frequent and severe. After the construction of the Wuqiangxi dam, flood waters peaked after 6 hours, much faster than the 24 hours it used to take before the construction. This has adversely affected the livelihood of local communities and individuals. It is not clear if the increased flooding is caused by the dam or changes in hydrology conditions (paras. 86 and 94).

75. Interviews conducted and records obtained by the OEM confirm that, except for total phosphorous content, water quality has mostly been within the standards set by the PRC's Ministry of Water Resources. Although Lingjintan hydropower is a run-of-river facility and the potential for eutrophication is relatively low, algae bloom could occur in the river mouth of the tributary. Therefore, the monitoring site should be extended to include the confluence of the main stream and the tributary, and the monitoring index should now include chlorophyll as an indicator.

76. There has been no monitoring and evaluation for biological impact. Information gathered mostly from interviews suggests that the dams have potentially adverse impact on migratory fish, as they may block the spawning migrations of a number of species. The four main migrating fish species in the area—grass carp, black carp, silver carp, and big head—all spawn in rapid flowing water. Local fisherfolk have also noted a decline in the population of static water fish and attribute this to other factors (heavy fishing, inappropriate electronic cage, habitat change) not related to the construction of the dam.

77. One concern noted by the OEM is that the concrete batching plant that was used for the construction of the Project has been left on-site after construction. It is dilapidated, has loose cladding and appears dangerous for entry, especially by local children, and is an eyesore. Station personnel said that the concrete batching plant belonged to the contractor and was his responsibility. It is recommended that, particularly for safety reasons, WPC should take steps to have the structure dismantled and the area rendered safe.

B. ADB Performance

78. Overall, ADB performed satisfactorily. It did well in project preparation, providing timely and effective SSTAs for the feasibility study review, arranging the project loan, and arranging for the international consulting services. The OEM is of the opinion that the terms of reference in the SSTAs for project preparation should have been broader and should have included an expert review of the hydrology. Also, ADB should perhaps have given more critical scrutiny to the prequalification procedures and HEPC's request for an additional turbine-generator unit. However, these are two issues against all the right things that were done. When there were problems with the Government and the EA with respect to the ownership of assets and obligations under the Loan Agreement, ADB was quite amenable to considering the changes. Unfortunately, the Government and the EA preempted any real dialogue on the subject by unilateral actions. ADB showed great restraint and remained positive in its support of the Project, the Government, and the EA.

79. ADB fielded nine missions during implementation, including the PCR mission. The composition of the missions varied according to need. Most missions included liaison with the Government, as well as the EA and IA. Through the missions, ADB provided very good and timely support for the Project.

C. Borrower Performance

80. The Government, as the Borrower through the Ministry of Finance, also performed satisfactorily. Requirements for loan effectiveness were completed within a reasonable time. The Loan Agreement and the subsidiary loan agreement for the relending of loan proceeds to HEPC were signed and took effect within 8 months of loan approval. Government supervision and monitoring of the Project was minimal because HEPC and, subsequently, WPC were technically qualified and experienced in project implementation.

81. The performance of HEPC, as the EA, mainly through WPC, was likewise satisfactory. The Project was implemented systematically and on time, and well within the overall budget. These are the most important performance indicators for an EA in project development. Quarterly progress reports were submitted on time. However, the Government and HEPC, without consulting or notifying ADB and in violation of the Loan Agreement, transferred the assets and obligations for the Project to WPC during implementation. ADB requested HEPC to clarify the arrangements for the transfer, and the Government and HEPC to cooperate in modifying the Loan Agreement, yet the clarification and cooperation were slow in coming. The Government and HEPC believed that the transfer of assets and obligations did not affect the Loan Agreement. In the end the loan was prepaid and the Loan Agreement was never modified.

82. Further, the PCR reported that the turnaround time was slow—or there was no action at all—on other ADB requests for more information and action on outstanding issues such as the recommendations of OED to ease resettlement difficulties. Also, the EA did not progress substantively in meeting targets in areas that required definitive action as highlighted by ADB missions (e.g., reducing receivables and making necessary changes in the PPA). Energy conservation plans, including the action program, the PCR, and the BME report, were not submitted.[25] Both the EA and IA believed that they were no longer obligated to comply with the loan conditions. Furthermore, no information could be provided on the performance of the EA and the Hunan power system, or on energy conservation. Little additional information on the Project could be obtained during the PCR mission because almost all staff responsible for project

[25] Requests for data on the station's operating parameters and performance indicators were not granted because WPC felt these were no longer relevant to ADB, as the loan had been fully repaid.

implementation had been reassigned. With respect to information collection, both the EA and the IA do not produce an annual report and, as indicated in the PCR, neither HEPC nor WPC has submitted a project completion report.[26]

D. Technical Assistance

83. The technical assistance completion report for TA 2169 rates the TA as successful and states that its objectives were met. HEPC gave the consultants high marks. It was particularly complimentary of the financial training and pleased to have been introduced to, and to have adopted, international accounting and financial management practices. HEPC reported that, as a result of the TA, it has established an integrated financial and power sales income management system (including income, fixed assets, and cash flow management), with a gate and real-time query system that allows people at different levels to access information in the financial management system. The OEM similarly rates the TA as highly successful.

84. The objectives and terms of reference of TA 2170 were met, and the TA produced high-quality outputs. However, the Waigaoqiao Stage II Project was not implemented as a BOT project and therefore the documents delivered under the TA were not used for the intended purpose. For this reason, this TA is rated as only partly successful.

V. ISSUES, LESSONS, AND FOLLOW-UP ACTIONS

A. Issues

85. The SES (footnote 2) circulated by OED in 2000 contained important recommendations related to enforcement measures to ensure compliance with mitigation programs, and to environmental impact monitoring.[27] The PCR reiterated these recommendations and in addition proposed actions that the EA or the local government might take to address outstanding resettlement issues. Both reports were circulated to the Government, the EAs, and the ADB's operating departments. The lack of action and seeming apathy with regard to recommendations that would bring the project to a successful completion is regrettable. ADB needs to be more proactive in pursuing such recommendations even if the Project has been completed.

B. Lessons

86. One feature that the Project apparently lacked is expert review of the hydrology. The OEM considers this of prime importance in water resource projects.

87. Using ADB's international bidding procedures, and an experienced EA and consultants, was important, and deputizing procurement specialists who were familiar with ADB's procurement guidelines was useful in preparing and implementing a successful project in a developing country.

88. More diligence in establishing prequalification criteria and evaluating prequalification submissions (such as the prequalification of the turbine supplier for the Project) should improve the likelihood of success of a project.

[26] During the OEM, the HEPC and the WPC were very cooperative in meetings and provided information that was available, such as tariff schedules, station operation data, and general information. However, in view of the time that had elapsed since the implementation of the Project, and the establishment of WPC and realignment of responsibilities, the OEM found it difficult to get information on such issues as hydrology, the Hunan power system, and even transmission and distribution costs. This was because the information requested was not readily available, and not because HEPC or WPC refused to share it.

[27] Details of the recommendations are in Appendix 6 of the SES.

89. Major changes in contracts, and particularly costly additions (such as the procurement of the Project's ninth bulb unit), should be evaluated in terms of the overall economics of the project, as well as the technical merits.

90. The common practice in the PRC, and at times in other developing countries, of restructuring government and executing agencies during implementation and operation should be anticipated during appraisal so that lengthy deliberations are avoided and separate evaluations of the capabilities of the new entities, and subsequent modifications of loan and project documents, would not be necessary.

91. Certain recommendations for revisions in the PPA to include international commercial practices would have been more appropriate in a more open and mature power market. The realities of PRC's power sector—where both the seller and the purchaser of power are state-owned enterprises, and where contract standards are set by higher authorities instead of being negotiated—have made it difficult for the EA and IA to comply with ADB's recommendations. Certain institutional constraints in implementing desirable contractual provisions should be recognized at the start so that they do not become persistent and contentious issues during implementation.

92. Assumptions for future tariff increases tend to be unrealistic. Greater prudence should be used in developing assumptions that could lead to unrealistic project benefit targets.

93. The ADB project staff should obtain data for the PCR from the EA and IA immediately after the project and before loan closure. This would ensure the availability of accurate and reliable information, and make use of the "institutional memory" of staff who were responsible for project implementation. At appraisal, ADB should emphasize the need for the EA and IA to cooperate with ADB in preparing the PCR and PERs.

C. Follow-Up Actions

94. The OEM is of the opinion that, in view of the number of projects lined up for construction on the Yuanshui River, WPC should have the hydrology reviewed by an independent expert hydrologist, particularly for safety reasons, if it has not already done so. WPC should also have the derelict batching plant near the dam dismantled and rendered safe. These two actions should be done immediately.

95. WPC should include the confluence of the main stream and the tributary as a monitoring site for its environment monitoring system. Monitoring of aquatic organisms or other biological indicators should be in place and the monitoring index should also include chlorophyll as an indicator. This should be done by the end of the second quarter of 2006.

96. The follow-up actions related to resettlement that were recommended in the PCR should be implemented immediately. The EA or local government should (i) determine the number of households whose incomes and livelihoods have not been fully restored, (ii) prepare a mitigation plan to restore incomes; (iii) implement mitigation measures, and (iv) prepare and submit a resettlement completion report.

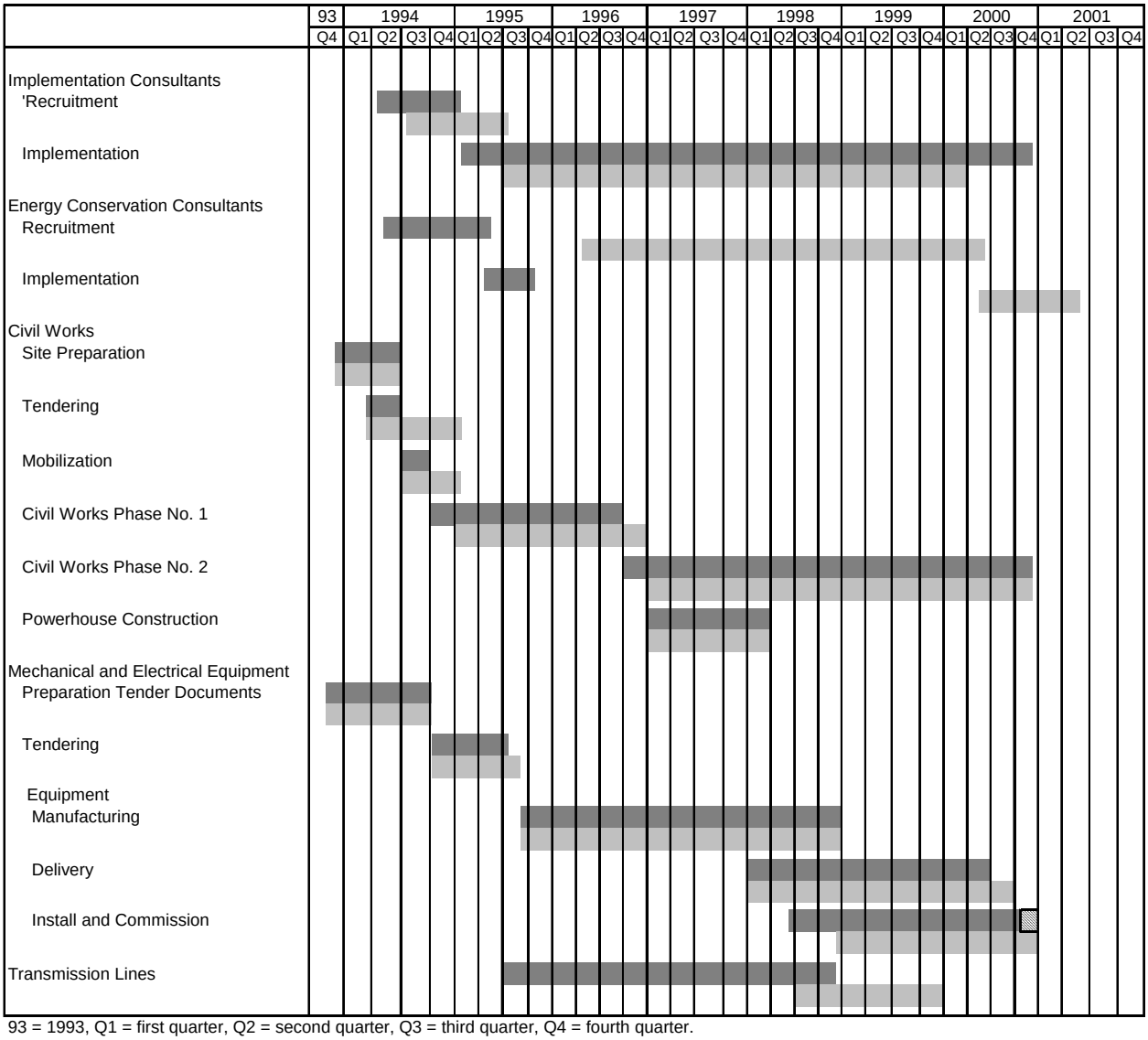
APPRAISAL AND ACTUAL PROJECT COSTS
($ million)

Items	Appraisal			PCR			PER		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
A. Project Cost									
1. Base Costs									
Civil Works	5.9	101.9	107.8	0.0	128.0	128.0	0.0	94.1	94.1
Electromechanical Works	73.4	10.5	83.9	67.4	32.1	99.5	67.4	24.9	92.3
Metal Structures	8.2	9.1	17.3	4.5	18.2	22.7	4.5	21.5	26.0
Resettlement Cost	0.0	7.5	7.5	0.0	24.5	24.5	0.0	32.3	32.3
Consulting Services	2.2	2.0	4.2	1.5	2.0	3.5	1.5	0.3	1.8
Miscellaneous	0.0	18.2	18.2	0.0	45.5	45.5	0.0	63.9	63.9
Subtotal	**89.7**	**149.2**	**238.9**	**73.4**	**250.3**	**323.7**	**73.4**	**237.0**	**310.4**
2. Contingencies	16.4	30.2	46.6	0.0	0.0	0.0	0.0	0.0	0.0
Total Base Costs	**106.1**	**179.4**	**285.5**	**73.4**	**250.3**	**323.7**	**73.4**	**237.0**	**310.4**
3. Interest During Construction	23.4	57.9	81.3	15.9	30.2	46.1	15.9	37.1	53.0
Total Project Cost	**129.5**	**237.3**	**366.8**	**89.3**	**280.5**	**369.8**	**89.3**	**274.1**	**363.4**
B. Financing Plan									
ADB Loan	116.0	0.0	116.0	89.3	0.0	89.3	89.3	0.0	89.3
Domestic Financing	6.8	118.7	125.4	0.0	207.0	207.0	0.0	195.5	195.5
Equity	6.8	118.7	125.4	0.0	73.5	73.5	0.0	78.6	78.6
Total Project Cost	**129.6**	**237.4**	**366.8**	**89.3**	**280.5**	**369.8**	**89.3**	**274.1**	**363.4**

ADB = Asian Development Bank, PCR = project completion report, PER = performance evaluation report.
Source: Wuling Power Corporation.

PROJECT IMPLEMENTATION SCHEDULE
(Planned and Actual)

Project Implementation Schedule
Planned and Actual



93 = 1993, Q1 = first quarter, Q2 = second quarter, Q3 = third quarter, Q4 = fourth quarter.

Planned
Actual
Extension for the ninth unit

Source: Wuling Power Corporation.

COMPLIANCE WITH LOAN COVENANTS

Covenant	Status of Compliance	
	PCR	PER
Environmental		
Ensure that all lands, rights for land and water, and all other rights and privileges required for the Project are acquired or available.	Complied with	Complied with
Ensure that the mitigation and monitoring measures proposed in the environmental impact assessment (EIA) and summary EIA for the Project are properly implemented and reported to the Asian Development Bank (ADB) by 1 April of each year.	Complied with	Complied with
Ensure the transmission line for the Project is constructed in an environmentally sound manner and on time.	Complied with	Complied with
Social		
Implement a comprehensive resettlement program; ensure that the Project displacees do not suffer a material reduction in income, deterioration in living conditions, or unnecessary social and cultural dislocations.	Partly complied with	Partly complied with. Reduction in income has been reported by some people affected by the Project
The Human Resettlement Office shall prepare and furnish Hunan Electric Power Company (HEPC) a progress report concerning the resettlement program at the beginning of each year during the resettlement period; furnish ADB a report on its progress by 1 April of each year; and carry out an independent assessment of the resettlement program within 1 year of its completion.	Partly complied with	Partly complied with
Financial		
Submit audited financial statements no later than 9 months after the close of each fiscal year.	Partly complied with	Partly complied with
Submit by 30 April of each year, a rolling 10-year financial projection, which shall contain projected income statements, statements of sources and uses of funds, and a balance sheet.	Complied with	Complied with
Maintain at least 1.3 times debt service coverage ratio.	Complied with up to 1998	Complied with up to 1998
Maintain self-financing ratios of no less than 25% on a 3-year moving average basis commencing with fiscal years 1995 through 1997. Maintain self-financing ratios of no less than 30% thereafter.	Complied with in 1997 and 1998	Complied with in 1997 and 1998
Ensure that Hunan and HEPC take all necessary measures to ensure that a separate tariff schedule is established for electric power supplied from the Project facilities to HEPC's grid. Ensure that the tariff is adjusted periodically to cover Project investment costs and operating expenses, and to provide a financial rate of return consistent with sound electric power utility practices.	Partly complied with	Partly complied with
Others		
Established, staffed and operating project management unit and project implementation unit.	Complied with	Complied with
Furnish a plan for training HEPC staff to ADB for approval.	Complied with	Complied with

Covenant	Status of Compliance	
	PCR	PER
Retain employees who received training to serve in Project-related positions.	Complied with	Complied with
Furnish ADB a medium-term energy conservation plan, including an action program, within 6 months after receipt of ADB's comments on the final report of the Project energy conservation consultants.	Not complied with	Not complied with
Submit by 1 April of each year, starting with 1995, an annual program for energy conservation and an annual report on past achievements.	Partly complied with	Partly complied with
Furnish an action plan indicating the time frame to implement recommendations in the final report of the Institutional Strengthening Technical Assistance, within 6 months after receipt of ADB's comments.	Complied with	Complied with
Submit quarterly project progress reports.	Complied with	Complied with
Furnish ADB a report on the execution and initial operation of the Project, no later than 3 months after its physical completion.	Not complied with	Not complied with
The Borrower, Hunan, and HEPC shall undertake benefit monitoring and evaluation of the Project, including data provision, using a methodology that is acceptable to ADB. HEPC shall evaluate project benefits after its completion in accordance with a schedule and terms of reference agreed upon with ADB.	Not complied with	Not complied with

PCR = project completion report, PER = performance evaluation report.
Sources: Operations Evaluation Mission and project completion report.

FINANCIAL AND ECONOMIC ANALYSES

A. Background and Basic Assumptions

1. Loan 1318-PRC: Hunan Lingjintan Hydropower Project (the Project) is a 270 megawatt (MW) (nine 30 MW units) low-head, run-of-river hydropower station on the Yuanshi River in Hunan province. In addition to expanding the generating capacity in the province, the Project was also to act as a reregulating station for the upstream 1,200 MW Wuqiangxi hydropower station, allowing it to increase its peak capability. The construction of the plant started in 1995, and the first unit was commissioned in December 1998. By 2001, all the nine generating units had been commissioned.

2. The economic and financial reevaluation of the Project was carried out on an incremental basis. All prices and costs are expressed in first semester 2005 constant values. The prices and costs were adjusted for inflation. The exchange rate for the first semester of 2005 was $1 = CNY8.27.

3. The economic life of the Project is assumed to be 50 years, from 1995 to 2045, as was assumed at appraisal. The project completion report (PCR) assumed a life of 25 years.

B. Financial Performance

4. The financial internal rate of return (FIRR) was evaluated by comparing revenues and costs during the 50-year economic life of the Project. Actual annual generation figures were used until 2004, and 1,215 gigawatts-hours (GWh) per year was used from 2005 onward. The actual tariff rates have been adjusted for inflation, and real tariffs, as of 2005, are expected to remain at the same level for the life of the Project. Given these assumptions, the FIRR is estimated at 6.1%, lower than the appraisal estimate of 9.3% but higher than the 5.6% estimated at PCR and still above the weighted average cost of capital (WACC) estimated at 4.4% (Table A4.1). The difference between the current FIRR estimate and the estimate at appraisal can be attributed mostly to the difference in tariff assumptions and the lower generation in the initial years of operation due to the outages for repair of the turbine generating units.

5. The results of the sensitivity analysis show that it will take a 30% decrease in generation or a 90% increase in operating costs to pull down FIRR to the WACC level. A 10% increase in generation will increase FIRR to 6.5%, while an increase in operating costs will decrease FIRR to 5.9%. The different sensitivity cases and their results are shown in Table A4.2.

Table A4.1: Financial Internal Rate of Return

Year	Capital Costs	Total Revenues	Total Operating Costs	Income Tax	Net Cash Flow After Tax
1995	181.02				(181.02)
1996	220.34				(220.34)
1997	783.63				(783.63)
1998	717.61				(717.61)
1999	364.64	46.83	2.88		(325.68)
2000	289.30	144.14	31.32		(176.49)
2001	138.28	183.75	37.20		8.26
2002		232.52	45.03		187.49
2003		256.49	93.09		163.40
2004		250.14	93.09		157.05
2005		320.96	93.29	5.39	222.29
2006		332.14	93.29	11.18	227.67
2007		332.14	93.29	13.28	225.57
2008		332.14	93.29	15.38	223.47
2009		332.14	93.29	17.48	221.37
2010		332.14	93.29	19.58	219.27
2011		332.14	93.29	21.68	217.16
2012		332.14	93.29	23.78	215.06
2013		332.14	93.29	25.89	212.96
2014		332.14	93.29	27.99	210.86
2015		332.14	93.29	30.09	208.76
2016		332.14	93.29	32.19	206.65
2017		332.14	93.29	33.24	205.60
2018		332.14	93.29	33.24	205.60
2019		332.14	93.29	33.24	205.60
2020		332.14	93.29	40.67	198.18
2021		332.14	93.29	78.82	159.63
↓		↓	↓	↓	↓
2045		332.14	93.29	78.92	159.63
				FIRR	**= 6.1%**
				WACC	**= 4.4%**

FIRR = financial internal rate of return, WACC = weighted average cost of capital.
Source: Operations Evaluation Mission.

Table A4.2: Sensitivity Analysis of FIRR

Item	Changes (%)	FIRR (%)
Base Case		6.1
(i) Increase in generation	10.0	6.5
(ii) Increase in operating costs	10.0	5.9
(iii) Decrease in generation	10.0	5.6
(iv) Combination of (ii) and (iii)		5.4
(v) Increase in operating costs	90.0	4.4
(vi) Decrease in generation	30.0	4.4
WACC		**4.4**

FIRR = financial internal rate of return; WACC = weighted average cost of capital.
Source: Operations Evaluation Mission.

C. Economic Performance

6. The economic project costs were derived from the financial costs and converted to economic cost by applying the conversion factors of 1.10 for civil works and local machinery and 0.93 for other local components. Taxes and duties, and all financial charges, including interest during construction, were not included in the calculation of the economic internal rate of return (EIRR). The economic evaluation of the Project was carried out following the methodology adopted at PCR.

7. The economic benefits from the Project include (i) the net energy sales of from the Lingjintan station; and (ii) the 1,248 GWh per year in firm energy output from the Wuqiangxi station resulting from the operation of the Lingjintan station. The output of the Lingjintan station is valued at willingness-to-pay, estimated at CNY0.683 per kilowatt-hour, which was computed on the basis of the average price of electricity, and a 35% consumer surplus, assumed at appraisal and at PCR. The benefits from the Wuqiangxi plant are valued in terms of cost savings in the fuel cost between a large coal-fired plant and a small coal-fired plant. Transmission and distribution costs were included in the estimation. Appraisal assumed transmission and distribution losses at 20%. The project performance evaluation report follows the PCR's assumption of 10% transmission and distribution losses.

8. The EIRR is computed at 14.3%, lower than the appraisal estimate of 16.6%, but higher than the PCR's 12.4% (Table A4.3). It is still higher than the assumed economic opportunity cost of capital of 12%. The reason for the lower EIRR compared to the appraisal estimate is due to the lower generation in the initial years of operation due to the outages for repair of the turbine generating units.

Table A4.3: Economic Internal Rate of Return
(CNY million)

Year	Capital Costs	Lingjintan	Wuqiangxi	Total Operating Costs	Net Economic Benefits
1995	174.5				(174.5)
1996	215.1				(215.1)
1997	756.6				(756.6)
1998	1,369.0	3.0			(1,365.9)
1999	1,032.5	102.5	62.6	22.5	(889.9)
2000	285.5	356.8	62.6	47.1	86.9
2001	136.1	429.2	62.6	52.3	303.4
2002		573.1	62.6	59.0	576.7
2003		621.1	62.6	58.8	624.9
2004		624.4	62.6	59.4	627.5
2005		742.8	62.6	60.3	745.1
2006		412.8	62.6	60.3	745.1
2007		412.8	62.6	60.3	745.1
2008		412.8	62.6	60.3	745.1
2009		412.8	62.6	60.3	745.1
2010		412.8	62.6	60.3	745.1
2011		412.8	62.6	60.3	745.1
2012		412.8	62.6	60.3	745.1
2013		412.8	62.6	60.3	745.1
2014		412.8	62.6	60.3	745.1
2015		412.8	62.6	60.3	745.1
2016		412.8	62.6	60.3	745.1
2017		412.8	62.6	60.3	745.1
2018		412.8	62.6	60.3	745.1
2019		412.8	62.6	60.3	745.1
2020		412.8	62.6	60.3	745.1
↓		↓	↓	↓	↓
2045		412.8	62.6	60.3	745.1
				EIRR	**= 14.3%**

EIRR = economic internal rate of return.
Source: Operations Evaluation Mission.

Table A4.4: Sensitivity Analysis of EIRR

Item	Changes (%)	EIRR (%)
Base Case		14.3
(i) Increase in generation	10	14.9
(ii) Increase in operating costs	10	14.2
(iii) Decrease in generation	10	13.6
(iv) Combination of (ii) and (iii)		13.5
(v) Increase in operating costs	215	12.0
(vi) Decrease in generation	32	12.0

EIRR = economic internal rate of return.
Source: Operations Evaluation Mission.

RESETTLEMENT AND SOCIAL IMPACT EVALUATION

A. Introduction

1. At appraisal, the Project proposed a reservoir with a surface area of 25.75 square kilometers, and with an inundation length of 47.5 kilometers (km) along the Yuanshui River, inundating 424 hectares (ha) of farmland (362 ha paddy and 62 ha dryland). A resettlement program was prepared in 1993. A comprehensive resettlement program was prepared by the Hunan Electric Power Company (HEPC), with the assistance of Mid-South Design and Research Institute, and approved by the National Environmental Protection Agency. The Hunan provincial government later felt that the socioeconomic conditions had changed so that the demographic survey had to be updated. An updated resettlement plan was prepared in 1996 and approved by the Ministry of Electric Power in March 1998. The report and recommendation of the President indicated that the borrower (the People's Republic of China) and HEPC had given their assurance that "persons displaced by the Project will not face reduction in incomes, deterioration in living conditions, or unnecessary social and cultural dislocations owing to losses of social and cultural ties and difficulties in integration with host communities."

2. The Hunan Lingjintan Hydropower Project was one of four cases in the special evaluation study[1] prepared by the Operations Evaluation Department (OED) in January 2000. The OED study found that, while people who resettled to give way to the Project were generally happy with their new houses, some reported decreased incomes because their agricultural plots had become smaller. The OED study concluded that "The current trend, which appears to be gradual impoverishment of some affected persons, is not satisfactory."

3. The operations evaluation mission (OEM) conducted a survey with 110 respondents to determine the social, economic, and environmental impact of the Project. Physical inspections of public facilities in the resettlement area, the construction site, and other related structures were undertaken.

B. Findings of the Operations Evaluation Mission

1. Resettlement Program

4. A resettlement budget of CNY227.82 million was approved together with the resettlement plan. The resettlement plan identified 7 townships, 36 villages, and 178 village groups in Taoyuan and Yuanling counties that would be affected. It was estimated that a total of 4,753 persons would require economic rehabilitation, and 813 households, with a total of 4,060 persons, were to be relocated (512 households and 2,464 persons in Taoyuan, and 300 households and 1,596 persons in Yuanling). The demolition would cover 150,611 square meters (m^2). To minimize the trauma caused by physical relocation, the relocatees were to be offered alternative dwelling and farm sites close to their original homesteads, and, if possible, within the original village. Alternative occupations were to be

[1] ADB. 2000. *Special Evaluation Study on the Social and Environmental Impacts of Selected Hydropower Projects*. Manila.

offered to those engaged in crop production and training, and extension assistance was to be provided.

5. The resettlement strategy was based on the principle of land-for-land option, with special emphasis on agricultural rehabilitation. The economic rehabilitation program was to provide each rural settler with at least one mu[2] of paddy, 300 kilograms of grain, and CNY1,800 of net income at the completion of the resettlement activities.

6. Wuling Power Corporation was to disburse the resettlement funds to the Hunan resettlement office.

2. Implementation and Assessment of Impact

7. Economic rehabilitation started in 1996 and was to be implemented through farmland readjustment or protection, the planting of fruit or timber or other economic trees, or other nonfarm activities. The Taoyuan county resettlement office has reclaimed farmland for this purpose. At the time of the OEM, a total of 2,110 mu of farmland had been developed. This is 9.3% more than what was originally planned.

3. Assessment of Impact

8. **Income Recovery.** People who were resettled received assistance to restore their incomes through the planting of orange, bamboo, timber, and tea trees. The target number of bamboo, tea and timber trees has been planted, but the trees have not matured to productive stage. It may take another 10 years for them to generate income. A large number of orange trees, on the other hand, have been destroyed by diseases and pests. Because of the long-term nature of these plantations, more than 50% of those who had resettled reported a decline in nominal income and attributed this to the shortage of farmland and ineffective production rehabilitation. Their incomes are reportedly much lower than those of residents of neighboring villages that were not affected by resettlement. Only 8% of survey respondents expressed satisfaction with the outcome of the economic rehabilitation.

9. **Relocation and Compensation.** Resettlement for the reservoir began in 1995 and was implemented and coordinated by the two counties' resettlement offices. When the reservoir began impoundment at the end of 1998, a total of 2,450 persons had been relocated. At the end of 1999, the number reached 3,587 persons, or 88% of the plan (Table A5.1), and a total of 127,684 square meters of houses had been demolished. Dam site resettlement was not included in the resettlement plan for the Project since it started even before the resettlement plan was finalized. It was implemented by the Taoyuan land administration bureau. Table A5.1 summarizes the physical accomplishments of the resettlement program.

[2] 1 mu = 1/15 hectare.

Table A5.1: Scope of Resettlement Impact

Item	Resettlement Plan 1998	Accomplishment 2005
Acquired Farmland (ha)	423.9	423.9
Paddy Riceland	361.6	361.6
Dryland	62.3	62.3
Demolished houses (m^2)	150,611	127,684
Relocated persons	4,060	3,587
Affected by Reservoir Impoundment	1,830	2,317
Affected by Land Loss and Needing to Move	2,230	1,270

ha = hectare, m^2 = square meter.
Sources: 1996 Resettlement Plan and Operations Evaluation Mission.

Table A5.2: Scope of Relocation for Lingjintan Project

Item	Plan	Actual	% of Plan
Relocated within the same village	1,391	2,317	166.57
Relocated to another village	2,669	1,270	47.58
Total	**4,060**	**3,587**	**88.35**

Source: 1996 resettlement plan and operations evaluation mission.

10. Constraints that contributed to the underachievement of the plan targets were (i) lack of funds and delays in disbursements; and (ii) the complicated procedure for identifying and approving the households to be relocated. Relocation will continue as new sources of funds become available, and completion is expected in the next 3 years.

11. Compensation for individual assets that were adversely affected by the Project was implemented fully and on time. Land compensation was only partially implemented. County resettlement officials and village leaders did not have complete and consistent information on the amount available for compensation and the amount disbursed.

4. Resettlers' Satisfaction

12. Most of the relocatees were happy with their new houses, which were mostly brick concrete structures, and many used their own resources to extend the structures. Relocatees were also happy with the transportation and education facilities in their new area of residence. However, there was strong dissatisfaction with production recovery and conditions, and compensation policies. There is a strong sentiment that the persons affected by the Project, and not just the village leaders, should have been consulted. The affected people were aware of the compensation standards for the relocation of houses, and moving and transition allowances, but they were not aware of the standards used for land compensation.

ENVIRONMENTAL IMPACT EVALUATION

A. Introduction

1. With the assistance of Mid-South Design and Research Institute, Hunan Electric Power Company (HEPC) prepared an environmental impact assessment that was later approved by the National Environment Protection Agency. It was established that no precious or rare fish were upstream of the Lingjintan dam. An environmental office was to be set up by HEPC to monitor environmental impact during project implementation, and an environmental monitoring station, at the Wuqiangxi reservoir, was to be set up to monitor the environmental impact of both the Wuqiangxi and Lingjintan reservoirs during operation. Loan covenants likewise included provisions to ensure that (i) mitigation and monitoring measures are properly implemented and reported to the Asian Development Bank (ADB) by 1 April of each year, and (ii) the transmission line for the Hunan Lingjintan Hydropower Project (the Project) was constructed in an environmentally sound manner.

2. Air and water quality and noise levels in certain sections of the reservoir areas were monitored periodically from 1997 to 2000. It was concluded that these had not markedly changed as a result of the Project and all indicators monitored were stable. The special evaluation study[30] (SES) prepared by the Operations Evaluation Department (OED) of ADB in January 2000 reported that aquatic organisms or other biological indicators had not been monitored. The same study found the project design lacking in procedures to sample for accidental spills or toxic substances or to conduct point-source sampling at the Project's effluent locations. It was also reported that the Project, together with Wuqiangxi and 15 other proposed projects along the Yuanshui River, may adversely affect migratory fish in the river and possibly Lake Dong Ting. Since the Project would likely affect biological organisms, the SES recommended that fish yield be monitored and that a fish biologist or an aquatic ecologist be added to the environmental staff.

B. Findings of the Operations Evaluation Mission

1. Hydrology

3. During and after the construction of the Project, there has been increasing anxiety over the inundation line of the reservoir threatening the livelihood of the residents. After the construction of the Wuqiangxi dam, flood waters peaked after 6 hours, much faster than the 24 hours it used to take before the construction. Flood waters also stayed on the ground longer than usual. The flooding can partly be attributed to the discharge from the Wuqiangxi, which usually surpasses the discharge flow of Lingjintan during the flood season. This is not, however, to discount weather as a possible contributory factor. The SES suggested that the topographic and hydrological data be reexamined. This has not been done. The operations evaluation mission reiterates the need to reexamine the data and to implement the flood mitigation plan developed by the Hunan provincial government in 2001.

[30] ADB. 2000. *Special Evaluation Study on the Social and Environmental Impacts of Selected Hydropower Projects*. Manila.

2. Water Quality

4. Interviews conducted and records obtained by the OEM confirm that, except for total phosphorous, the indicators for water quality have mostly been within the standards set by the People's Republic of China's Ministry of Water Resources. Table A6.1 gives the indicators recorded under three different climactic conditions in 2004. The elevated phosphorous levels could have been from a non-point agricultural source, detergent, or other sources. Although Linjingtan hydropower is a run-of-river facility and the potential for eutrophication is relatively low, algae bloom could occur in the river mouth of the tributary. Therefore, the monitoring site should be extended to include the confluence of the main stream and the tributary, and the monitoring index should now include chlorophyll as an indicator.

3. Fish Species

5. Fishes migrate from West Dong Ting to spawning sites along the Yuanshui River from April to July each year. Although Yuanshui River is not a significant spawning ground, the dams have potentially adverse effects on migratory fish, as they may block the spawning migrations of a number of species. There are five spawning sites between Wuqiangxi and Lingjintan dams. These sites may be adversely affected if the dams block fish passage. The four main migrating fish species in the area—grass carp, black carp, silver carp, and big head—all spawn in rapid-flowing water.

6. The LJT dam can potentially alter the flow rates and bring subtle changes in water depth, which may have a positive impact on static-water fish. Local fisherfolk have noted a decline in the population of static-water fish, attributing this to other factors (heavy fishing, inappropriate electronic cage, habitat change) not related to the dam's construction.

7. There has been no monitoring and evaluation for biological impact. Information was gathered mostly from interviews. It is recommended that an assessment of the impact on fish resources in Yuanshui River and West Dongting Lake be undertaken so that, if necessary, mitigation measures could be recommended and implemented.

Table A6:1:
Monitoring Results of Water Quality of Reservoir and Downstream in Different Seasons
(milligrams per liter unless indicated)

Index	**Reservoir**			**Downstream on Right Bank**			**National Standard of Surface Water Quality** (class III)
Monitoring Date	8 Jan	24 May	6 Sept	8 Jan	24 May	6 Sept	
Temperature (ºC)	10	25	25	10	25	25	
Potential hydrogen (pH)	7.16	7.20	7.20	7.15	7.20	7.20	6–9
Dissolved Oxygen	8.60	7.90	8.20	8.60	7.90	8.15	≥5
Chemistry Oxygen Demand	1.98	2.01	2.09	1.98	2.06	2.20	≤6
Chemistry Oxygen Depleted	10.00	8.94	11.40	10.00	9.93	10.80	≤20
Biological Oxygen Demand	2.05	1.80	1.70	2.05	1.80	1.80	≤4
Ammonical Nitrogen	0.04	0.42	0.36	0.06	0.38	0.35	≤1.0
Total Phosphorus	0.13	0.11	0.12	0.10	0.11	0.10	≤0.2(≤0.05)
Nitrate Nitrogen		0.43	0.45		0.39	0.40	≤1.0
Copper	0.03	0.06	0.04	0.02	0.06	0.04	≤1.0
Zinc	0.005	0.004	0.005	0.005	0.004	0.005	≤1
Arsenic	0.007	0.006	0.005	0.007	0.004	0.005	≤0.05
Mercury	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	≤0.0001
Cadmium	0.002	0.005	0.002	0.001	0.002	0.002	≤0.005
Six Valance Chromium	0.005	0.005	0.005	0.005	0.006	0.005	≤0.05
Lead	0.01	0.04	0.01	0.01	0.02	0.01	≤0.05
Cyanide	0.001	0.001	0.001	0.001	0.001	0.001	≤0.2
Volatile Phenol	0.001	0.002	0.001	0.001	0.002	0.001	≤0.005
Sulfate	0.04	0.037	0.047	0.053	0.044	0.045	≤0.1
Colon Bacillus (unit per liter)	3,500	3,800	3,500	3,500	3,800	3,500	≤10,000

ºC = degrees celsius, l = liter.
Source: Lingjingtan hydropower plant environment monitoring station.