ASIAN DEVELOPMENT BANK **IES: PRC 21204**

REEVALUATION OF THE

FUEL CONVERSION PROJECT
(Loan 880-PRC)

IN THE

PEOPLE'S REPUBLIC OF CHINA

December 1999

CURRENCY EQUIVALENTS

Currency Unit – Yuan (Y)

	At Appraisal	At Project Completion	At Operations Evaluation	At Reevaluation
Y1.00	$0.2687	$0.1845	$0.1150	$0.1215
$1.00	Y3.77	Y5.68	Y8.69	Y8.23

The exchange rate of the yuan is determined in relation to a weighted basket of currencies of the major trading partners of the People's Republic of China.

ABBREVIATIONS

ADB	–	Asian Development Bank
CIF	–	cost, insurance, and freight
CTPP	–	Changshan Thermal Power Plant
EIA	–	environmental impact assessment
EIRR	–	economic internal rate of return
FIRR	–	financial internal rate of return
FOB	–	free on board
GDP	–	gross domestic product
HNPGC	–	Huaneng Power Generation Corporation
MUV	–	manufacturer's unit value
O&M	–	operation and maintenance
OPEC	–	Organization of Petroleum Exporting Countries
PCR	–	project completion report
PPAR	–	project performance audit report
PRC	–	People's Republic of China
REM	–	Reevaluation Mission
SOE	–	State-owned enterprise
TSP	–	total suspended particulates
WB	–	World Bank

WEIGHTS AND MEASURES

cal (calorie)	–	unit of energy equivalent to 1.163 x 10 Wh (4.1855 Ws)
GWh (gigawatt-hour)	–	1,000,000 kWh
kWh (kilowatt-hour)	–	1,000 Wh
kcal (kilocalorie)	–	1,000 cal
J (joule)	–	unit of energy equivalent to 0.24 cal
MW (megawatt)	–	1,000,000 watts
mt	–	ton (metric)

NOTES

(i) The fiscal year of the Government and the Huaneng Power Generation Corporation coincides with the calendar year.

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

Operations Evaluation Office, IE-62

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BASIC DATA

INSTITUTION BUILDING

TA No.	TA Project Name	Type	Person-Months	Amount	Approval Date
938-PRC	Institutional Development of Huaneng Power Generation Corporation (UNDP-financed)	ADTA[1]	26	$377,000[2]	21 Dec 1987

KEY PROJECT DATA ($ million)	As per ADB Loan Documents	Actual
Total Project Cost	60.60	56.02
Foreign Exchange Cost	33.3	26.17
Local Currency Cost	27.3	29.85
ADB Loan Amount/Utilization	33.30	26.17
ADB Loan Amount/Cancellation	—	7.13

KEY DATES	Expected	Actual
Fact-Finding		5-22 May 1987
Appraisal		5 Sep -1 Oct 1987
Loan Negotiations		18-20 Nov 1987
Board Approval		21 Dec 1987
Loan Signing		5 Feb 1988
Loan Effectiveness	5 May 1988	5 May 1988
Project Completion	19 Apr 92	Apr 1992
Loan Closing	1 Apr 1993	18 Jan 1993
Months (Effectiveness to Completion)	48	48

KEY PERFORMANCE INDICATORS (%)	AR	PCR	PPAR	Reevaluation
Economic Internal Rate of Return	20.8	8.0	8.3	2.5
Financial Internal Rate of Return	12.1	12.6	7.0	4.7

BORROWER People's Republic of China

EXECUTING AGENCY Huaneng Power Generation Corporation

MISSION DATA

Type of Mission	No. of Missions	Person-Days
Fact-Finding	1	97
Appraisal	1	96
Project Administration	6	68
Review	2	28
Disbursement	3	14

[1] advisory technical assistance.
[2] revised TA amount.

EXECUTIVE SUMMARY

The Project's overall objectives were to (i) reduce the consumption of domestic oil and increase the use of domestic coal for the purpose of electric power generation, and (ii) increase foreign exchange earnings through the export of oil saved from the use of domestic coal. The Project was expected to save about three million barrels of oil annually as a result of fuel conversion.

The conversion of two units of 100 megawatts (MW) each at the Changshan Thermal Power Plant from oil to coal-fired units was planned in accordance with the Government's strategies for the energy sector under the Seventh Five-Year Plan (1986-1990). The strategies pursued under this plan included the reduction in the use of the country's domestic oil and the increase in the use of domestic coal for generating electricity. The Project was expected to increase the country's foreign exchange earnings through additional exports of oil to the world market.

The Project involved the conversion from oil- to coal-firing of Units 6 and 7 (100 MW each) at Changshan Thermal Power Plant in Jilin Province. It provided for (i) a major modification to the steam generators of Units 6 and 7, and installation of associated coal pulverizers and auxiliary equipment; (ii) installation of coal- and ash-handling systems for Units 6 and 7, as feeders and extensions to the coal- and ash-handling systems installed for Units 8 and 9; (iii) installation of particulate emission control equipment; (iv) provision of associated instrumentation, control and electrical equipment and materials, piping and valves; (v) civil works; and (vi) engineering consulting services.

The project cost was estimated at $60.6 million equivalent based on January 1987 price levels. The entire foreign cost of $33.3 million, which included $3.3 million for interest and other charges during the construction period, was to be financed by the Asian Development Bank (ADB). Financing would cover about 55 percent of the total project costs. The balance of $27.3 million equivalent, representing the local currency cost of the Project, was to be financed by the Planning and Economic Commission of Jilin Province through loans raised from the People's Construction Bank of China.

Both the project completion report (PCR) and the project performance audit report (PPAR) rated the Project successful although the economic internal rate of return was lower than initially estimated at appraisal due to the higher unserved energy costs during the turbine conversion process and the resultant lower than expected fuel savings. The Project was efficiently implemented on time and below the cost estimate, and the loan was closed ahead of the original loan closing date. Both the PCR and PPAR also noted that Huaneng Power Generation Corporation generally met the environmental conditions stipulated in the Loan Agreement, environmental mitigation equipment was installed, and initial monitoring of plant emissions indicated the plant was conforming to local environmental standards.

Despite their generally successful implementation and operation, Units 6 and 7 have been much less successful financially. They have been operating at less than 70 percent of their maximum capacity, roughly 912 gigawatt-hours (GWh) electricity generated by these two units last year, compared with the maximum possible of 1,200 GWh which was the target level production projected by both the PCR and the PPAR. Officials at the Changshan power plant

site reported that the two units' direct loss amounted to Y20 million last year and the cumulative losses could be much higher.

During much of the 1980s, in an effort to spare more oil for export to earn hard currency, the People's Republic of China (PRC) embarked on a fuel-substitution policy that encouraged fuel conversions from oil to coal for most of its existing oil-fired power plants. Increased environmental awareness at the policy-making as well as general public levels and the alarming levels of acid rain brought about in large part by the cumulative effects of coal-fired generation throughout the country have since prompted the termination of the fuel conversion policy. The PRC Government has formally expressed its desire to make the country's energy profile less reliant on coal in favor of other cleaner and renewable energies such as hydro, wind, solar, and nuclear power.

Economically, international oil prices have remained significantly lower than projected at appraisal. Although cheaper international oil did not cause much direct threat to domestic oil sales due to the heavily protected market, it did on the other hand make the export of Chinese oil to international markets less feasible. As a result, one of the original economic objectives that underscored ADB's funding of the Project, namely, export of the oil displaced from power generation for hard currency gains, never materialized, contrary to statements expressed in both the PCR and the PPAR. Furthermore, the recent economic slowdown has depressed the demand for electricity serviced by the northeast power grid. The result is a surplus capacity of power generation for this region and few, if any, opportunities for wheeling power to the more dynamic southeast industrial zone. Both elements have strong implications for the economic and financial performance of the Project.

The major cost in the economic reevaluation of the Project consists of unserved energy due to outage of the units during fuel conversion. The recalculated economic internal rate of return at 2.5 percent is lower than that in either the PPAR or the PCR owing to lower border prices for oil as well as lower power production volumes than had been projected in either the PRC or the PPAR. The recalculated financial internal rate of return (FIRR) is also lower (from 7 percent in the PPAR to 4.7 percent) due to uneconomical tariffs charged for power sales, combined with lower-than-expected sales volume. This lower FIRR is also partly attributed to the increase in coal prices over the period from appraisal to project reevaluation.

Three major types of environmental impacts are typically generated by the Project: (i) increased air emissions of total suspended particulates and, to a lesser extent, sulfur dioxide (SO^2) and nitrogen oxide (NOx); (ii) increased wastewater discharge—particularly from the ash-transporting system—and its resultant impacts on ground and surface water quality; and (iii) impacts of ash ponds and coal-handling activities on human and wetland ecosystems. As a result of the findings of the reevaluation, the Mission team concludes that the third category of impacts, namely, those associated with ash ponds and coal-handling activities, are least monitored and perhaps most severe and damaging.

The sustainability of the Project depends primarily on the following three factors: (i) the plant's own cost competitiveness, relative to other power-generating units within the region; (ii) the medium- to long-term economic outlook of Jilin Province in particular, and northeast China in general; and (iii) environmental policies and companion norms being pursued by the PRC regarding coal-fired generation. In the light of the foregoing information, the prospects for the medium- to long-term sustainability of Units 6 and 7 are not very encouraging.

In brief, the Project was efficiently implemented and the plant is running smoothly. However, market realities at the local, national, as well as international levels have all combined to make this Project economically as well as financially unattractive. These market forces are largely exogenous to the Project but nevertheless impact heavily on the outcome. Therefore, the Project has to be considered unsuccessful in financial and economic terms.

An important lesson to draw from this experience is the need to more rigorously screen projects in their initial stages of preparation to assess their consistency with ADB policy objectives within the energy profile of the country. Though some of the main assumptions underlying the initial project appraisal may have been warranted at the time and were indeed plausible in circumstances of yesteryear, it is arguable that the fuel-substitution goals were even at that time out of sync with the emerging ADB policy in the energy sector and are clearly surpassed by today's realities in the recipient country's energy policy matrix. Moreover, since this Project has not met its fundamental economic objectives, it underscores the need to critically assess the main drivers for ADB involvement in a project whose underlying motive was almost exclusively premised on the projected economic gains arising from fuel substitution, a large part of which never fully materialized. The fuel-substitution practice has now been discontinued in the PRC, and ADB may want to reconsider its ongoing involvement in traditional coal-fired generation technologies in light of the new policy initiatives recently announced by the PRC.

I. BACKGROUND

A. Rationale, Objectives, and Scope

1. The conversion of two units of 100 megawatts (MW) each at the Changshan Thermal Power Plant (CTPP) from oil- to coal-fired units was planned in accordance with the Government's strategies for the energy sector under the Seventh Five-Year Plan (1986-1990). The strategies under this plan included reduction in the use of the country's domestic oil and increase in the use of domestic coal for generating electricity. The Project was expected to increase the country's foreign exchange earnings through additional exports of oil to the world market.[1]

2. The Project's overall objectives were to (i) reduce the consumption of domestic oil and increase the use of domestic coal for the purpose of electric power generation, and (ii) increase foreign exchange earnings through the export of oil saved from the use of domestic coal. The Project was expected to save about three million barrels of oil annually as a result of fuel conversion.

3. The Project involved the conversion from oil- to coal-firing of Units 6 and 7 (100 MW each) at CTPP in Jilin Province. It provided for (i) a major modification to the steam generators of Units 6 and 7, and installation of associated coal pulverizers and auxiliary equipment; (ii) installation of coal- and ash-handling systems for Units 6 and 7, as feeders and extensions to the coal- and ash-handling systems installed for Units 8 and 9; (iii) installation of particulate emission control equipment; (iv) provision of associated instrumentation, control, and electrical equipment and materials, piping, and valves; (v) civil works; and (vi) engineering consulting services.

4. The project cost was estimated at $60.6 million equivalent based on January 1987 price levels. The entire foreign cost of $33.3 million, which included $3.3 million for interest and other charges during construction period, was to be financed by the Asian Development Bank (ADB). ADB financing would cover about 55 percent of the total project costs. The balance of $27.3 million equivalent, representing the local currency cost of the Project, was to be financed by the Planning and Economic Commission of Jilin Province through loans raised from the People's Construction Bank of China.

B. Findings at Project Completion

5. The project completion report (PCR) rated the Project as successful although it was noted that the economic internal rate of return (EIRR) was lower than the initial estimate at appraisal due to the higher unserved energy costs and resultant lower-than-expected fuel savings. The Project was efficiently implemented on time and below the cost estimate, and the loan was closed ahead of the original loan closing date. Procurement was managed efficiently, partly as a result of ADB's assistance in procurement matters. The PCR also noted that Huaneng Power Generation Corporation (HNPGC) generally met the environmental conditions stipulated in the Loan Agreement, that environmental mitigation equipment was installed, and that initial monitoring of plant emissions indicated that the plant was conforming to local environmental standards.

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[1] The country has since become a net importer of oil.

C. Major Operations Evaluation Findings

6. The project performance audit report (PPAR) was circulated to the Board in September 1994. The major findings of operations evaluation are highlighted as follows:

1. Institutional Development Aspects

7. Through technical assistance (TA) financed by the United Nations Development Programme (UNDP) and administered by ADB, HNPGC's staff acquired technical capabilities in the areas of project evaluation, fuel conversion, and project and operation management. This improvement in staff capability was demonstrated during project implementation.

2. Environmental Impact

8. Project facilities were being operated and maintained in conformity with the Government's environmental impact standards concerning solid, liquid and gaseous waste disposal, except that the total suspended particulate (TSP) is higher than the standard. The TSP level shows a more than 100 percent increase in 1993 over the level before plant operation in 1989. The Executing Agency (EA) had to install electrostatic precipitators to replace the existing venturi scrubbers, in conformity with current practices in power plants of this type.

3. Cost-Benefit Assessment

9. At time of evaluation for the PPAR, the economic and financial reevaluation of the Project showed an EIRR of 8.3 percent, compared with 20.8 percent during appraisal. The lower recalculated EIRR was due mainly to longer-than-estimated outage of the two units, which resulted in higher unserved energy costs. The recalculated financial internal rate of return (FIRR) of 7 percent was likewise lower than the appraisal estimate primarily because of the higher coal consumption and an increase in coal price from Y120 per metric ton at appraisal to Y246 per metric ton at operations evaluation.

4. Overall Performance and Sustainability

10. According to the PPAR, the Project had achieved its objectives of replacing exportable domestic oil with local coal for electricity generation and increasing foreign exchange earnings through additional export of domestic oil. Although its recalculated EIRR was lower than that at appraisal, the Project remained economically viable. It was thus rated generally successful.

D. Purpose of Reevaluation

11. A reevaluation was required owing to the shorter-than-normal interval between project completion and operations evaluation (approximately eight months), which did not allow for a proper investigation into the impacts and sustainability of the physical outputs generated by the Project.

12. In light of the new macroeconomic and environmental settings, ADB decided to carry out a reevaluation of the *Fuel Conversion Project* to reexamine its economic and financial performance as well as its socio-environmental impacts.

13. In addition to verifying the accuracy of information in the PCR and PPAR regarding the main points of project implementation, the reevaluation exercise explored in depth the main issues that pertain to the economic feasibility of the fuel conversion option itself. This is necessary owing to the changing macroeconomic circumstances that heavily impact on the Project, namely, the long-term decline in world oil market prices (further accentuated in the wake of the recent Asian economic crisis and its ensuing dampening effect on world energy demand). Another key issue is the accounting of the full incremental environmental costs arising from the regression toward the lower end of the fuel chain—from oil to coal—given the adverse environmental impacts associated with coal-fired generation.

II. REEVALUATION FINDINGS

A. Operating Performance

14. After some initial delays, Units 6 and 7 of CTPP were commissioned to feed electricity to the northeastern grid in 1991 and 1992, respectively. Their implementation and operation were smooth and successful. The Reevaluation Mission (REM) site visit reconfirmed that CTPP is well run and maintained on the whole. Environmental health and safety have clearly been integrated as part of the plant's operational guidelines.

15. The plant load factor of the converted units has been consistent through the years of operation following conversion, even though production has failed to keep pace with the appraisal estimates. A recent economic slowdown has resulted in a depressed demand for electricity in areas serviced by the northeast power grid, particularly from the heavy industry sector, which was in a gradual state of decline. The weak demand was validated by expressed statements from officials of the Jilin Provincial Electricity Bureau. The result is excess generation capacity in the power grid with strong implications for the future economic and financial performance of the Project.

16. Despite their generally successful implementation and operation, Units 6 and 7 are much less successful financially. They have been operating at less than 70 percent of their maximum capacity, roughly 912 gigawatt-hours (GWh) electricity generated by the two units last year, compared with the maximum possible of 1,200 GWh. According to one of the accompanying officials, the two units' direct loss amounted to Y20 million last year and the cumulative losses could be much higher.

17. CTPP is currently under pressure from the Huaneng Group to cut costs down.[1] For this year, Huaneng's stated goal is to achieve break even with Units 6 and 7. But due to a number of inherent factors such as high coal price and transportation cost, it might prove difficult to achieve this objective. Presently, the cost of producing electricity using Units 6 and 7 is 20 fen[2] per kilowatt-hour (kWh) (equivalent to $0.024 per kWh—including fuel, labor, depreciation, etc.), compared with the regulated tariff of 30.8 fen per kWh ($0.037 per kWh) kWh sold to the grid.[3] Alternatively, HNPGC may also consider closing down the two units should they sustain losses without any further significant reduction in sight.

18. Another important factor for the relatively high cost of electricity production for CTPP as a whole is its overstaffing, a practice common to most—if not all—of PRC's state-owned enterprises (SOEs). CTPP currently employs 2,800 people, of whom about 1,000 jobs are tied directly and indirectly to Units 6 and 7. In comparison, a plant of a similar size but with more efficient technology and better management would need only 980 people. Like most other SOEs, CTPP does not have the liberty to lay off workers.

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[1] CTPP refers to a stand-alone power plant with multiple owners. Units 6 and 7 are owned and operated by Huaneng Power Generation Corporation/Huaneng Power Group.

[2] 1 yuan = 100 fen.

[3] Unaccounted for social costs associated with the surplus workforce eliminate any nominal cash surplus inferred by official figures (with reference to the positive gap observed between unit production costs and corresponding tariffs).

B. Financial Performance

1. Huaneng Power Generation Corporation

19. The Huaneng Power Group is a major SOE operating in the electricity sector in the PRC, with generating plants located in several areas of the country apart from CTPP. The consolidated financial statements—using accounting standards prevalent in the PRC—are provided in Appendix 1. They indicate overall a marginally positive financial situation, with a net profit in the order of Y1.4 billion registered over the past three years (1996-1998), although at modest levels relative to total asset size. Though financial losses could be sustained at CTPP, given the overall financial position of HNPGC management is nevertheless concerned about the long-term financial viability of providing support to CTPP as well as similar power plant facilities.

2. Project

20. Despite the relatively successful implementation and operation of CTPP's Units 6 and 7, plant operations are less than financially successful. With current production nearly 30 percent below plant capacity, CTPP officials estimate the two units' direct loss amounted to Y20 million in 1998 and the cumulative losses could be much higher.

21. The average cost of producing electricity for Units 6 and 7 was about 17.2 fen per kWh (fuel, labor, materials, repair and maintenance, depreciation, etc.) between 1992 and 1996 (Appendix 2). Fuel costs accounted for about 55 percent of production costs during 1994-1996. CTPP noted that the current production cost of about 20 fen per kWh was within industry standard, being at midpoint compared with other power plants in Jilin Province. Likewise, CTPP data indicate a nominal cash surplus of about 10 fen per kWh, based on the current unit production cost, and the regulated tariff of 30.8 fen per kWh for electricity sold to the grid. However, unaccounted-for social costs, over and above CTPP's wage and welfare costs, which are associated with CTPP's excessive workforce, are apparently offsetting any nominal cash surplus between the reported production costs and revenues.

22. CTPP is currently under pressure from the HNPGC to cut down its costs. The goal set by HNPGC for 1999 is to break even with Units 6 and 7. However, due to a number of internal factors such as the high coal costs (due to long-distance hauling of coal from more than 500 kilometers [km] away), it might prove difficult to achieve this target.

C. Organization and Institutional Capacity

23. CTPP, in particular Units 6 and 7, is being operated efficiently in physical terms, even though it is hampered by the reality of an excess labor force over which it has little control (para. 18).

24. In regard to environmental management, the institutional capacity of CTPP for environmental monitoring and mitigation appears to be adequate and has been sustained since project completion. CTPP's environmental management team is staffed and equipped to design and implement mitigating measures during operations.

D. Environmental Impacts

25. All the recommended environmental remedial measures have been implemented and operated as specified in the project appraisal report. In particular, its particulate emission control equipment (Venturi scrubbers) is claimed to have achieved its designed efficiency of 95 percent; however, monitoring data on particulate emission were not available. The residential wastewater treatment facility and two other wastewater treatment facilities (for industrial and ash-transporting wastewater) are also fully operational. As a further validation, CTPP's environmental monitoring unit received an award the from the PRC's State Environmental Protection Administration (SEPA) as a model unit for its environmental monitoring and management efforts.

1. Atmospheric Emissions

26. The atmospheric emissions of CTPP are regulated mainly by a very high stack of 180 meters (m) (240 m is generally considered maximum) with Venturi scrubber, a particulate-removal device using water precipitated from the top to filter the particulate in the flue gas that goes in the opposite direction. Presently, the facility has no sulfur-removal device, nor was it expected to have one according to the initial project design.

27. Flue gas was monitored once a year for sulfur dioxide (SO^2) and nitrogen oxide (NOx). TSP was said to have been monitored, but the data were considered too unreliable to use. Without such data, it is impossible to ascertain whether the TSP concentrations have violated the Period I TSP emission standards (standards for those projects completed prior to August 1 of 1992). However, judging by the relatively light color of the smoke (Photo 1) which varies considerably during different periods of operation within a day, even if such standards were violated, the margin of violation may be relatively small.

28. There were no standards for the pollutants SO^2 and NOx for projects completed during Period I. However, the snapshot monitoring data for 1997 in Appendix 3 indicate that both SO^2 and NOx emissions are far below the Period III concentration standards for those power projects completed after 1 January 1997 (2,100 micrograms per cubic meter [Mg/m^3] for SO^2 and 1,000 Mg/m^3 for NOx). No emission standards for SO^2 and NOx were in existence for power projects completed prior to 1997.

29. Apart from emission concentrations, the PRC emission standards also dictate the total mass loading of SO^2 and NOx for a given region within a year. Each region is assigned a maximum limit of total emissions of SO^2 and NOx according to the region's soil characteristics and other physical environmental variables that affect the formation of acid rain and its damages. Jilin Province, for example, has 10 subregions labeled as "dual control" (sulfur and acid rain) areas. The Changshan area is not included within the "dual control" areas, which means the total allowable SO^2 and NOx emissions are considerably more relaxed than those for the 10 subregions. Nonetheless, the increased emissions of SO^2 and NOx at CTPP (after the *Fuel Conversion Project*) inevitably add to the formation of acid rain and may therefore contribute to the cumulative impacts regionally and even globally. By the same token, its emission of carbon dioxide (CO^2) as a greenhouse gas will also affect global climate in an incremental manner, although empirical data cannot substantiate whether the Project increased the CO^2 emissions by Units 6 and 7 following conversion to coal. Generally, subject to variations due to specific technologies employed and their different combustion efficiencies, the CO^2 emission factors for coal-fired power plants are measurably higher—though variable depending

on the technology used—than that coming from oil-fired power plants. Although no specific data are available for this particular site, available data indicate that, for the United States, on average combustion of coal generates approximately 16 percent more CO^2 than combustion of oil to generate the same amount of electricity.

30. The site visit indicated that the plant area's ambient air quality remains relatively good, compared with that in most Chinese urban centers and towns, despite the stack emissions. This was confirmed by the ambient air quality monitoring data obtained later from Jilin Provincial Electric Power Administrative Bureau.[4]

31. The above ambient air quality monitoring data were then compared with the monitoring data collected in 1989, prior to the Project, using similar sampling and measuring techniques. The comparison indicates that, for SO^2 and NOx, the observed maximum concentrations for both before and after the Project were far lower than the State's Class II standards. Nevertheless, the maximum observed SO^2 concentration slightly increased after completion of the Project, while that for NOx remained steady. In contrast, the observed maximum TSP concentration exceeded the standards for both before and after project conditions. The maximum concentration level exceeded the standard was an average 0.22 to 1.24 times before-project testing levels, and 1.20 to 3.41 times after project testing, signaling a significant increase in ambient TSP concentrations after Units 6 and 7 became operational.

2. Wastewater Discharge and Treatment

32. Three types of wastewater are generated by a coal-fired power plant: industrial (generated by plant activities), ash-transporting (water used to pump coal ashes through a piping system from the plant to ash ponds), and residential (generated by households in the plant area). CTPP presently treats all three types of wastewater. The site visit included two of the three wastewater treatment facilities (residential and ash-transporting) and confirmed their full operation. The industrial wastewater treatment facility adopts a process similar to that for the ash water treatment facility. The residential wastewater treatment facility is said to be the only one of its kind in the entire electric power industry in the PRC, which was cofinanced by the Huaneng Group and JEPAB.

33. There are currently no specific industry standards for wastewater discharge. The water quality monitoring data provided by CTPP's environmental monitoring unit (Appendix 3, Table A3.2) indicate that the wastewater discharge meets State Class I (most stringent) standards. However, some plant officials expressed concerns that heavy metals in the ash-transporting wastewater may potentially contaminate groundwater; however, no specific data are currently available.

[4] The monitoring, which was carried out by Jilin Provincial Electric Industry Environmental Monitoring Station, collected and analyzed air samples from ten sampling locations in and around the plant area during May and June of 1993 after Units 6 and 7 were in full operation. Three air parameters were monitored: SO^2, NOx, and TSP.

3. Environmental and Health Impacts of Ash Ponds and Coal-Handling Activities

34. Ash ponds are unique to coal-fired power plants. Prior to the Project for Units 6 and 7, CTPP had an existing ash pond system, which was completed together with the two 200-MW coal-fired units (Units 8 and 9) in 1987. There are three ash ponds, each with a diameter of roughly 3 km. Several hundred kilometers to the west of these ponds exists a national bird sanctuary. During the site visit, many birds of different species were observed to rest in the wetland areas near the ash ponds.

35. The fact that there was an existing pond system before the *Fuel Conversion Project* allows for a relatively thorough assessment of the impacts of the ash ponds on local air quality, wetland ecology and ground water contamination as part of the environmental impact assessment (EIA) conducted for the Project in 1989. The EIA Implementing Agency, Northeastern Electric Power Design Bureau, affiliated to the then Ministry of Energy, designed and conducted an elaborate scheme aimed at testing the impacts of ashes on local ecology and groundwater contamination. The results are summarized as follows.

Ash water after treatment to remove most suspended solids is channelled through the Venturi scrubber to filter the particulate matter in the flue gas. Besides removing TSP in the flue gas, the process would lower the ash water's pH value through reaction with CO^2 in the flue gas. The water would then be recycled to the ash-transporting pipe system to minimize water use and environmental impacts.

Experimental simulations using the particular type of coal to be used by Units 6 and 7 indicated that, except for pH and chromium, all other pollutant concentrations would meet at least Class III standards for surface water discharge.

The soil in the area has very poor permeability; thus, a relatively small portion of the ash water will be lost. This would minimize the chances for groundwater contamination.

It was anticipated that in the case of inadequate management, windy weather, and accidents, flying ash and accidental spills of ash water may cause significant damage to the surrounding air quality and wetland ecosystem.

36. It is difficult to verify the above assertions on the minimal impacts of ash water on groundwater contamination due to lack of monitoring data following completion of the Project. Results from groundwater samples collected and analyzed in the ash pond area indicated that the groundwater was contaminated during the testing period in 1989, two years after the ash ponds went into operation. The main pollutants are chloride and manganese.

37. On the other hand, problems associated with flying ash are abundantly clear. Pond 1 has reached its designed life of 10 years. Since 1998, and with increasing frequency, the water level is kept below the ash level because of the concern that the injected water may accidentally exceed the dike. This results in "dust storms" during the windy season and has significant environmental and health implications for the surrounding three villages and several thousand villagers. In addition, the surrounding ecologically fragile wetlands with abundant fish and bird species may also have been negatively affected during the dust storms. Recently, an instruction

was issued to raise the dike by 2 m to prolong the life of Pond 1. This would cost approximately Y30 million.

38. No specific health data are available indicating the damage from flying ash on human health. A general health survey, conducted in 1989 for the EIA with surrounding villages and town residents, showed that their health status was good two years after the two 200-MW units and the ash ponds were put into operation. However, it has been almost 10 years since then and the cumulative impacts on human health are uncertain. Interviews with three people attending the ash ponds revealed that during windy times, people some meters apart cannot see each other. Interviews with locals from Xi Miao, a village 2.5 km east of the pond, confirmed the impacts of flying ashes reaching the village. However, all the people interviewed were convinced that the cartridge-like fine particles generated by the neighboring fertilizer plant in Changshan caused far more damage on people's health, and on birds and fish species than the coal ashes since the former consist of much finer and darker particles.

39. Although coal ashes are a nuisance from the environmental and health point of view, they are on the other hand a valuable economic commodity for road construction. An enormous demand (more than the existing supply) is anticipated next year due to the recently commenced road upgrading project.

40. Besides ash ponds, another unique feature of a coal-fired power plant is its coal-handling system, which has significant environmental and health implications. Coal handling involves transporting coal using a semi-automated belt system from incoming trains to either a coal deposit area or directly to the boiling system. Presently 450 workers in five shifts are employed to attend the system. These 450 people are at special risks of exposure to an extremely dusty working environment even though the plant's environmental health and safety rules mandate wearing of a mask filter.

41. Since 1993, CTPP has been conducting annual physical checkups for the workers. Appendix 4 provides an indication of the health risks for coal-handling workers. The table indicates that since 1995 there have consistently been four or more cases of "particle lung," a very early indication of tuberculosis. This is likely to be caused by the workers' cumulative exposure to an extremely dusty working environment. A drop in cases has been observed since 1998, possibly due to the reduced number of workers working in the areas, shorter shifts, and stricter implementation of mask-wearing rules.

42. To summarize, three major types of environmental impacts were likely to have been introduced by the Project: (i) increased air emissions of TSP, and to a lesser extent, SO^2 and NOx; (ii) increased wastewater discharge—particularly from the ash-transporting system—and its impacts on groundwater and surface water quality; and (iii) impacts of ash ponds and coal-handling activities on human and wetland ecosystems. The reevaluation team considers that the third category of impacts, namely, those associated with ash ponds and coal-handling activities, is least monitored and is perhaps severe and the most damaging.

E. Policy Issues

43. During much of the 1980s, in an effort to spare more oil for export to earn hard currency, the PRC had in effect an energy policy that encouraged fuel conversions from oil to coal for most of its existing oil-fired power plants. Increased environmental awareness at the policy-making and general public levels in the wake of the severe acid raid problem caused in large part by coal-fired emissions has since prompted the termination of the fuel conversion policy. In

a 1995 program statement entitled New and Renewable Energy Development Program 1996-2000, jointly prepared by State Development and Planning Commission (SDPC), State Economic and Trade Commission (SETC), and State Science and Technology Commission (SSTC), the Government explicitly expressed its desire to make the country's energy profile less reliant on coal in favor of other cleaner and renewable energies, such as hydro, wind, solar, and nuclear power.[5]

44. Economically, international oil prices have remained low at approximately $10-15 per barrel, compared with the Chinese regulated price of Y1,100 per ton in 1998 or $18 per barrel of crude. Although cheaper international oil did not cause much direct threat to domestic oil due to the heavily protected market, it does on the other hand make the export of Chinese oil to international markets economically nonviable, coupled with the fact that the country has since become a net importer of oil. Therefore, one of the primary economic rationales that underscored the ADB's funding of the Project, namely, export earnings associated with the volume of displaced oil, has not materialized, contrary to statements expressed in both the PCR and the PPAR. Furthermore, the recent economic slowdown and depressed demand for electricity serviced by the northeast power grid (according to statements expressed by the JEPAB have resulted in excess capacity of power generation for this region. Both have strong implications for the economic and financial performance of the Project.

F. Economic and Financial Reevaluation

45. The economic and financial reevaluation of the Project, in general, followed the same methodology used during appraisal and in the PCR and the PPAR. The analysis was based on actual operational results up to 1997 and projections for future years operations. All costs were converted to constant 1999 prices. The economic life of the Project was taken as 20 years including 5 years life extension due to modifications for fuel conversion. The table shows the recalculated EIRR and FIRR compared with those estimated at appraisal, project completion, and operations evaluation.

Recalculated EIRR and FIRR (%)

Item	Appraisal	Project Completion	Operations Evaluation	Reevaluation
EIRR	20.8	8.0	8.3	2.5
FIRR	12.1	12.6	7.0	4.7

EIRR = economic internal rate of return, FIRR = financial internal rate of return.

46. At project completion, the FIRR and EIRR were about 13 percent and 8 percent, respectively. The FIRR was in line with appraisal expectations since increases in financial coal costs were passed on through adjustments in tariff. On the other hand, the EIRR was lower than the estimated appraisal due to (i) higher unserved energy costs,[6] and (ii) lower expected fuel

[5] Chinese researchers calculate that the costs of pollution can translate in lost output equivalent to a low estimate of 3.5 percent of gross domestic product and possibly as high as 8 percent, according to a recent estimate established by the World Bank. (Source: I.H.T., *Setbacks in Lanzhou, Grittiest Front in China's Clean Air War*, 18 June 1999).

[6] Outage period during construction was more than double the one-year period envisaged at appraisal.

cost savings.[7] During operations evaluation, the recalculated EIRR was computed at 8.3 percent, which was close to project completion estimates, but lower due to the longer outage period of the converted units, which increased unserved energy from 1,200 GWh at appraisal to 2,900 GWh. The recalculated FIRR was still satisfactory at 7 percent although lower than that at appraisal and project completion. The PPAR attributed the deviation to (i) higher capital costs (converted into local currency),[8] and (ii) coal costs.

47. At reevaluation, the recalculated EIRR was 2.5 percent due to the lower-than-expected oil price (Table A5.10) and power production volumes achieved,[9] which resulted in a lower benefits stream after conversion than in the earlier reviews. Financial performance further weakened based on an FIRR of 4.7 percent. The recalculated FIRR is lower than the estimated at appraisal and project completion due to uneconomical tariffs charged for power sales to the grid, combined with lower-than-expected sales volume.

48. The methodology and assumptions in the recalculation of the EIRR and FIRR are detailed in Appendix 5. The base case scenario assumed international oil prices to gradually increase to an annual average of $18 per barrel (2005) based on the World Bank's long-term assessment of oil prices (April 1999). Tables A5.8 and A5.9 show the summary of benefits and costs attributable to the Project. While the project completion and performance audit reports assumed full production capacity in the initial years of project operations, the reevaluation based energy production on actual operational results observed over the period up to the reevaluation. In this evaluation, the REM quantified the equivalent economic value of likely gross domestic product (GDP) losses resulting from the outages during conversion using an energy per GDP ratio obtained from national averages, adjusted on a yearly basis. This has resulted in a higher valuation of unserved energy losses than would have been obtained by estimating the alternate means of power generation. The REM opted for this approach given that northeast China was facing critical energy shortages during the conversion period and that backup self-generation capabilities were being used at full capacity, thereby resulting in real output losses for the region during the conversion of the two thermal units at CTPP.

49. At the same time, the reevaluation also showed that a substantial part of project benefits was established mainly from resource cost savings during construction (i.e., savings in fuel oil created by the phased shutdown of the converted units between 1989 and 1993). A reestimation of project economic feasibility, minus the fuel oil savings and quantified GDP losses, yields an EIRR of a negative 0.8 percent. Indeed, compared with the appraisal estimates, the economics of the Project has adversely changed due to exogenous factors, and the results show a significant reduction in the relative share of benefits generated after the conversion process itself.[10] Based on the quantified benefit and cost streams after conversion, the quality of project performance appears marginal and is considered unsuccessful.

50. Sensitivity analysis was carried out to show the impact on the recalculated EIRR and FIRR of (i) shutting down the plant due to poor cost competitiveness, relative to other power

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[7] While coal price projections remain generally unchanged, weaker oil prices at the time of project completion resulted in less favorable project economics than in the appraisal.

[8] Due to the devaluation of the yuan against the dollar.

[9] Due to a shortfall in demand brought about by the weak economic outlook for Jilin Province in particular, and Northeast China in general.

[10] At project appraisal, the projected benefit and cost stream resulted in an EIRR of 20.8 percent. If fuel savings during conversion in 1990 and 1991 were deducted from the net benefits stream, the recalculated EIRR would still remain convincing at 15.6 percent.

utilities; (ii) sustained operations with reduction in operating cost levels; (iii) increased power tariffs; (iv) price volatility for oil and coal products; and (v) combinations of these conditions.

G. Sustainability

51. Sustainability of the Project depends primarily on the following factors: (i) the plant's own cost competitiveness, relative to other power producer utilities in the region; (ii) the medium- to long-term economic outlook of Jilin Province in particular, and northeast China in general; and (iii) environmental policies, specifically those regarding coal-fired generation, being pursued by the PRC.

52. The long-term economic outlook of the PRC largely determines the demand for electricity. During much of the 1980s, there was euphoria regarding the country's economic prospects and, along with it, a boom of investments in power generation capacity. However, the more recent slowdown in the pace of growth, coupled with the ongoing structural shifts away from the Soviet-styled, energy-intensive heavy industries toward much less energy-intensive high-tech industry and service sectors (electronic industry, automobile industry, hotel and restaurants), has resulted in a significant amount of surplus capacity in the northeast region's overall power balance.

53. The country's recent pledge to search for cleaner and renewable energies casts a shadow on the Project's future. Increased awareness of the adverse environmental impacts of coal combustion not only renders such a fuel conversion project unlikely in the future; indeed many existing small and inefficient power generation units are likely to be systematically decommissioned. Where there is a need, they will be replaced over time with more efficient and environmentally sound clean technologies.

54. The long-term survival of Units 6 and 7, and indeed CTPP, depends critically on how CTPP will meet the challenges of cost cutting and managing its resources, including environmental resources.

III. KEY ISSUES FOR THE FUTURE

A. Dependence on Coal-Sourced Energy

55. The PRC has severe environmental problems, primarily the air and water pollution linked to rapid industrial growth. The policy of fuel conversion has been discontinued following increased environmental awareness, at the policy-making levels as well as through public media, of the adverse impacts of coal-fired emissions in the wake of severe acid rain problems. Nevertheless, coal is foreseen to remain as the primary fuel source for power generation in light of the country's abundant coal reserves and very limited supplies of cleaner fossil fuels (oil and natural gas). With continuing dependence on coal-sourced energy, the Government needs to place strong emphasis on energy efficiency and promotion of the use of clean coal technologies. The Government's strategy under its Ninth Five-Year Plan seeks to improve the overall average efficiency of coal-fired power plants.

1. Environmental Mitigation Measures

56. Mitigation measures related to good housekeeping, waste disposal, and risk minimization need to be fine-tuned to further ensure environmentally clean operations. The REM observed problems with regard to the ash pond handling system. The issue of "dust storms" arising from coal ash dispersion and the occasional spillover from the ash pond due to saturation must be addressed with urgency—given the important health and ecological impacts associated with both factors. The following measures need to be taken to further minimize or remedy its impacts on the environment:

(i) improve ash ponds management by raising the dike to avoid accidental spills of ash water or flying ash (the work has already started);

(ii) increase environmental monitoring from the present once-a-year sampling to a more frequent or continuous monitoring, and including more parameters such as TSP in flue gas and heavy metals in wastewater;

(iii) consider adopting more strengthened pollution control measures such as electrostatic precipitators (electric scrubber) and sulfur-removal devices;

(iv) improve wastewater treatment—particularly ash-water treatment—by increasing the degree of treatment to remove not only suspended solids but also heavy metals to minimize groundwater contamination; and

(v) undertake associated research activities and invest in more efficient and cleaner technologies.

2. Financial Viability

57. The challenges facing CTPP are those faced by most other SOEs: how to survive the tough market competition conditions and still carry many of the planned-economy's burdens such as overstaffing, lack of freedom in electricity pricing, etc. Despite the constraints, there are many areas where CTPP can improve its management of economic and environmental resources. In the economic sphere, the following measures are recommended:

(i) improving staff job training in equipment operation and maintenance but particularly in the area of occupational health and safety;

(ii) gradually dispersing its surplus workforce to other sectors, such as related service sectors;

(iii) privatizing its present housing-provision program by selling off the presently heavily subsidized housing program;

(iv) vastly improving its office work efficiency by reducing the ranks of officials; and

(v) better economic information management and forecasting to be done in association with Huaneng and JEPAB to adapt to the ever-changing electricity market.

IV. CONCLUSIONS

A. Overall Assessment

58. The Project was efficiently implemented and the converted units are adequately maintained and operating at design efficiency. The original project rationale of fuel substitution—going from oil to coal—appeared sound when viewed in the context of the Government's policy framework during project formulation. From an environmental perspective, the adverse impacts brought about by the use of coal in the region, though significant in themselves, do not appear critical for CTPP as the plant emissions lie within the prevailing limits set by the State Price Bureau. Nevertheless, the shift in the country's energy policy in favor of alternative energy sources (clean and renewable energy), combined with its more moderate economic performance than in the past decade, casts doubt on the viability of future project operations at Changshan.

59. The fundamental objective of generating economic advantage from fuel substitution was not fully met. Market realities at the local, national, and international levels have combined to make project results unattractive in financial as well as economic terms compared with what was initially conceived in the late 1980s. These market forces (long-term decline of oil market prices, combined with downward structural shifts in the power demand profile within the service area) will continue to impact heavily on project viability and sustainability. From the foregoing, the Project is considered unsuccessful in economic terms.

B. Lessons Learned

60. The Project was implemented in consideration of expected economic gains from fuel substitution as the indicator of success. An important lesson to draw from this experience is the need to better screen projects in terms of their consistency with ADB policy objectives regarding the promotion of environmentally cleaner fuels for power production. Though some of the main macroeconomic assumptions underpinning project objectives at project appraisal may have been warranted—and were indeed plausible—in the circumstances of yesteryear, clearly the fuel-substitution goals pursued by the Project appear to be out of step with the emerging ADB policy in the energy sector. The goals are downgraded by today's realities in the recipient country's current energy policy stance. Moreover, since this Project has not met its fundamental economic objectives (owing in part to flawed assumptions about international energy prices), it brings to light the need to critically assess the main drivers for ADB involvement in a project whose underlying motive was exclusively premised on the projected economic gains arising from fuel substitution. The Project is in fact a fuel-substitution project—going from oil to coal—with incrementally adverse environmental consequences associated with conventional coal-fired technology (relative to fuel oil technology). This fuel-substitution practice has now been discontinued in the PRC and ADB may want to reassess its current program focus within the energy sector of the country in light of the current Government policy initiatives in effect.

APPENDIXES