People's Republic of China

Yunnan Dachaoshan Power Transmission Project

I. Background of the Project

The PRC is the third largest energy user in the world after the United States and Japan. Coal is the dominant primary source of energy, accounting for 74.1 percent of total commercial energy production in 1997. Although per capita energy consumption in the PRC is low at about 700 kilograms of oil equivalent (about 40 percent of the world average level), energy intensity in 1997 at 1.4 tons of oil equivalent per thousand 1997 dollars of gross domestic product (GDP) was almost double the average for the ADB's developing member countries (DMCs) and for industrialized countries. The main factors causing the PRC's high energy use and intensity are (i) an inappropriate pricing regime with inadequate market-based signals for energy conservation, (ii) energy-intensive industrial output accounting for a high share of GDP, (iii) poor fuel consumption mix, (iv) use of obsolete industrial technologies, and (v) poor energy management.

The PRC is the second largest electricity producer in the world. By 1997, most of the acute shortages in generating capacity had been addressed. However, macroeconomic and sector changes in 1997, coupled with the indirect effects of the Asian currency crisis, resulted in a drop in the growth rate of electricity consumption and generation in 1997. An installed capacity of 290 gigawatt (GW) (220 GW thermal and 70 GW hydro) providing annual electricity generation of about 1,400 terawatt hour (TWh) (1,120 TWh thermal and 280 TWh hydro) is envisaged by the end of the Ninth Five-Year Plan in the year 2000.

The Government's main objective in the power sector during the Ninth Five-Year Plan (1996-2000) is to develop adequate power facilities to support the country's economic growth and to increase people's access to electricity. In March 1998, the Government announced an ambitious plan to invest $1 trillion in infrastructure over the next three years. One of the

Government's priorities is to increase investment in the energy sector. The power sector reform agenda to support this strategy includes (i) rationalization of power tariffs to reflect economic costs; (ii) sector restructuring toward competitive markets and further commercialization and corporatization of power utilities; and (iii) further diversification in financing for power development, including private sector participation through build-own-operate (BOO) and build-own-transfer (BOT), shareholding, and other models. This agenda is being supported by ADB's operations in the PRC power sector.

Because of the energy sector's importance in the national economy, it has been one of the largest recipients of capital and advanced technology financed through multilateral and bilateral sources. As of June 1998, ADB had provided 19 loans totaling almost $2.3 billion to help the PRC implement its energy development and conservation program. In addition, three loans amounting to $535 million have been provided to support energy conservation in the industry sector, and five loans amounting to $668 million to help reduce energy intensity and pollution. ADB has made strategic use of TA to help prepare projects, provide policy support, and build institutional capabilities of power utilities that are the executing agencies of ADB loans. In addition to these policy-support and capacity-building initiatives, future ADB assistance will focus on (i) developing larger power plants with generating units ranging from 350 MW to 600 MW and involving advanced technology and equipment, (ii) rehabilitating existing power plants, (iii) developing clean sources of energy, and (iv) developing and improving power transmission and distribution systems to improve system-wide efficiency and environmental quality.

ADB's operational strategy in the PRC is aimed at helping the country achieve economic growth in an efficient, equitable, and sustainable manner. In the energy sector, ADB's operational strategy supports the Government's two-pronged energy development program aimed at expanding energy supplies and promoting energy conservation and end-use efficiency. ADB is placing priority on the power sector particularly enhancing energy efficiency and reducing adverse environmental impacts. Energy conservation in the industry sector is an integral part of ADB's operational strategy. ADB is also helping the Government to develop more environmentfriendly energy sources, and facilitating the transfer of advanced pollution abatement technologies and development of clean coal power generation technologies. The Project, which focuses on energy efficiency and environmental improvement, fits in with the strategy of ADB.

II. Project Details

Yunnan Province has been selected as one of the two provinces in the PRC in which power sector restructuring reforms will be tested on a pilot basis. ADB involvement will also facilitate the next phase of sector reform that would lead to the introduction of competitive power markets in the province.

During the past ten years, the provincial GDP grew at an average of 11.5 percent per year and it is forecast to grow at an average of 8.3 percent per year over the next five years. While this rapid economic growth in Yunnan Province is creating demands for additional infrastructure, including the supply of electricity, the environmental issues in the energy sector need to be addressed in parallel to ensure sustainable growth. Air pollution levels rank Kunming in the middle among major southern PRC cities. It would not be environmentally desirable to meet the growing demand for electricity by constructing additional coal-fired generating capacity in or near Kunming, the provincial capital. The Project will help meet that demand by transmitting hydropower generated at the Dachaoshan Hydropower Plant to Kunming so that no additional stress is placed on air quality. Closing selected old, inefficient and polluting coal-fired power plants as a result of Project-related policy dialogue would also create a significant positive impact on air quality.

Although the PRC is the second largest electricity producer in the world, the expansion and integration of its provincial power grids and regional networks have not kept pace with the growth of installed power-generating capacity. Stronger provincial grids and regional networks will allow bulk power transfers from large coal-fired and hydropower plants to major load centers, and will result in reduced system losses, better use of energy resources, economies of scale, reduced generating reserve margins, and improved power supply reliability. Yunnan Province has a particular potential for realizing such benefits through improved power system integration. The Project, which involves the construction of extra-high-voltage 500 kilovolt (kV) lines and associated substations to connect the Dachaoshan Hydropower Plant with Kunming, provides for such integration with the Dachaoshan plant functioning as an independent power producer (IPP). The Project will also reinforce the high-voltage 110 kV and 220 kV power transmission systems in the province. In addition, the Project will improve power system operational efficiency by strengthening the load dispatch and communications systems (see Map).

The Government's program to reduce poverty depends partly on improving infrastructure in the rural areas, particularly in poverty counties. Yunnan in southwest PRC is a poor interior province with 1997 per capita GDP at two thirds of the national average. In 1997, about 4.7 million people in the province, with a total population of 41.7 million, were living below the national poverty line. The rural electrification component added to the scope of the Project as a result of Project-related policy dialogue will lead to (i) social benefits by expanding rural electrification in poverty areas, and (ii) environmental benefits in these areas by reducing the use of coal for domestic purposes.

The specific project objectives are to support sector and enterprise reforms in the power sector of Yunnan Province and augment power

Map
Yunnan Dachaoshan Power Transmission Project

transmission capacity to support economic development in the province.[18] Other objectives are expansion of electricity supply in rural areas and improvement of the environment through the closure of polluting thermal power. From this section onward, the term Project refers to the specific components identified in the footnote, which in summary comprise of: (i) construction of 500 kV transmission lines, (ii) reinforcement and expansion of the 100 kV and 220 kV transmission networks in Yunnan Province, (iii) closure of old and inefficient coal-fired power plants, (iv) expansion of rural electrification, and (v) assistance for institutional strengthening of the Yunnan Electric Power Group Corporation (YEPG).

The total Project cost is $309.4 million equivalent of which 32 percent is ADB-financed.

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[18] *The Project's specific components are (i) two parallel single-circuit 500 kV transmission lines (Dachaoshan transmission) of about 260 kilometers (km) each from the Dachaoshan Hydropower Plant (Dachaoshan) in western Yunnan to Baofeng substation southwest of Kunming, and one single-circuit, 59 km long 500 kV transmission line from Baofeng substation to Chaopu substation west of Kunming; (ii) one new 500 kV substation at Baofeng and expansion of the existing 500 kV Chaopu substation; (iii) two single-circuit 220 kV transmission lines south of Kunming connecting Jincheng with Baofeng (25 km) and Maan Shan (20 km), and Cheng Xi with Puji (14 km); (iv) two new 220/110 kV substations at Jincheng and Cheng Xi; (v) three twin-circuit 110 kV cables within Kunming connecting Pan Jia Wan with Jindao Ying (8 circuit-km), Xi Ba with Cheng Xi/Haingeng (0.5 circuit-km), and Cha Jie with Nan Yao/Tanhua Si (3 circuit-km); (vi) three new 110/10 kV substations at Pan Jia Wan, Cha Jie, and Xi Ba; (vii) a 65 km long fiber-optic communication system between Baofeng and the Yunnan Power Dispatch Center (YPDC) in Kunming; a microwave communication system linking Dachaoshan and other power plants and substations in southern Yunnan with YPDC in Kunming (covering 600 km via 20 intermediate points); and a power line carrier communication system between Dachaoshan and the Baofeng and Chaopu substations; (viii) new load dispatch and high-voltage metering equipment for YPDC; (ix) closure of three old and inefficient coal-fired power generating plants at Penshuidong (12 MW), Kaiyuan (70 MW), and Xuanwei (200 MW); (x) rural electrification of about 50 administrative villages in the project area that have no electricity supply; (xi) about 40 person-months of training in power sector restructuring, and institutional and technical subjects in the PRC and abroad; (xii) software and hardware to improve YEPG's financial management systems; and (xiii) consulting services.*

III. Analytical Methods

Environmental impact assessments (EIAs) were carried out for the Dachaoshan hydropower plant and the Project. Both EIAs reflect that measures will be incorporated to reduce adverse environmental impacts to an acceptable level and other environmental impacts are of minor significance. The Dachaoshan hydropower plant is a run-off river station requiring minimal reservoir capacity. The resulting inundation is minimal and other ecological impacts are insignificant. No drastic change in the immediate ecology is expected. Resettlement will take place in 2000 before inundation in 2001. The summary EIA (SEIA) for the Project is found in Appendix 6.

A least-cost analysis shows that commissioning generating units at Dachaoshan and commissioning the proposed 500 kV transmission line are part of the least-cost generation expansion plan for the Yunnan Power System (Table 1). The alternative to the Project is a 4x300 MW coal-fired power plant and a 200 MW gas turbine unit at the load center in Kunming. A comparison of the costs of the two options confirms that the Dachaoshan hydropower plant, with the Project, is the least-cost alternative.

By supporting the development of hydropower resources in the western part of Yunnan Province, the Project will help avoid the construction of coal-fired power plants in more densely populated, urbanized and industrialized areas in the eastern part. Furthermore, the closure of three old and inefficient coal-fired power plants (282 MW) which consume coal at a rate between 141 and 178 percent of the coal consumption of a newer medium-size power plant, will reduce pollution in the Province.

The economic evaluation of environmental impacts has two components. The first component is the estimation of avoided environmental impacts due to the avoidance of the construction of a 1,200 MW coal-fired power plant at the load centers in and around Kunming. The second component involves the estimation of the environmental impacts of reduced emissions from the closure of old and inefficient coal-fired power plants, net of physical dismantling costs. On the quantification of closure impacts, this analysis considers only the closure of a 100 MW coal-fired power plant. This closure can directly be classified as an impact of the Project, and is within the period of analysis. The environmental impacts from the two

Table 1: Least-Cost Analysis

Item	1996	1997	1998	1999	2000	2001
Dachaoshan Hydropower Plant and the Proposed Transmission Project						
Electricity Generation (GWh)						
Electricity Supply to Power System (GWh)						
Capital Cost						
Power Plant	*1,212*	*747*	*606*	*747*	*876*	*1,004*
Transmission			*71*	*348*	*670*	*703*
Operating Cost						
Power Plant						
Transmission						
Total Cost	*1,212*	*747*	*677*	*1,095*	*1,546*	*1,707*
Levelized Cost (Y/kWh)	*0.248*					
The Alternative: 4x300 MW Coal-fired Thermal Power Plant and 200 MW Gas Turbine Units in the Load Center						
Capital Cost						
4x300 MW Coal-fired				*535*	*1,605*	*2,140*
200 MW Gas Turbine						*203*
Operating Cost						
Fixed Cost						
4x300 MW Coal-fired						
200 MW Gas Turbine						
Fuel Cost						
4x300 MW Coal-fired						
200 MW Gas Turbine						
Total Cost				*535*	*1,605*	*2,344*
Levelized Cost (Y/kWh)	*0.275*					
Economic EDR						
Cost Difference between the Project and the Alternative	*1,212*	*747*	*677*	*560*	*(59)*	*(637)*
Equalizing Discount Rate	*14.5%*					
Environmental Cost from the Alternative						
Total Cost (with Environmental Cost)				*535*	*1,605*	*2,344*
Levelized Cost (Y/kWh)	*0.376*					
Economic EDR (with Environmental Cost)						
Cost Difference between the Project and the Alternative	*1,212*	*747*	*677*	*560*	*(59)*	*(637)*
Equalizing Discount Rate	*21.0% (including environmental cost)*					

GWh = gigawatt-hour, kWh = kilowatt-hour, MW = megawatt, NPV = net present value

Notes: (i) Discount Rate = 12%, (ii) Standard Conversion Factor = 0.93, (iii) Conversion Factor for labor = 1.35, and (iv) All costs in Y million.

2002	2003	2004	2005	2010	2015	2020	2027	NPV
3,329	*5,415*	*5,673*	*5,635*	*6,827*	*6,827*	*6,839*	*6,839*	
3,276	*5,328*	*5,582*	*5,545*	*6,717*	*6,717*	*6,729*	*6,729*	*22,766*
1,072	*218*							
226								
19	*35*	*45*	*45*	*56*	*56*	*56*	*56*	
18	*18*	*35*	*49*	*60*	*60*	*60*	*60*	
1,335	*271*	*80*	*94*	*116*	*116*	*116*	*116*	*5,644*
1,784	*892*	*178*						
291	*87*							
53	*159*	*212*	*212*	*212*	*212*	*212*	*212*	
12	*23*	*23*	*23*	*23*	*23*	*23*	*23*	
202	*336*	*352*	*350*	*425*	*425*	*426*	*426*	
50	*33*	*33*	*33*	*33*	*33*	*33*	*33*	
2,391	*1,531*	*800*	*619*	*694*	*694*	*695*	*695*	*6,257*
(1,056)	*(1,260)*	*(720)*	*(525)*	*(578)*	*(578)*	*(579)*	*(579)*	
302	*495*	*522*	*523*	*661*	*712*	*757*	*844*	
2,694	*2,026*	*1,322*	*1,142*	*1,355*	*1,406*	*1,452*	*1,538*	*8,567*
(1,358)	*(1,755)*	*(1,242)*	*(1,048)*	*(1,239)*	*(1,290)*	*(1,336)*	*(1,422)*	

components result from the Dachaoshan hydropower plant, with the Project. Hence, the environmental impacts are scaled in proportion to the cost of the project investment.

The analysis is location-specific, and follows the assumptions used in equalizing discount rate[19] (EDR) analysis in project economic analysis. The base case includes the Dachaoshan hydropower plant and a 500 kV transmission line, and the alternative is a 1,200 MW coal-fired power plant and a 200 MW gas turbine unit which generates equivalent electricity in the load center. Note that in this case, the foregone option is hypothetical and based on the least-cost plan. Therefore, it was not possible to use exact site-specific environmental cost/emission information, and a typical 1,200 MW coal-fired power plant with its associated environmental emissions was considered.

IV. Economic Valuation of Environmental Impacts

According to the least cost analysis, the Project will be favored over the alternative if environmental impacts are not taken into consideration. After considering plant maintenance and transmission loss, the electricity generation from the alternative will be 4.84 percent higher than the Dachaoshan hydropower plant. Since the base case does not emit air pollutants, the difference between the two cases will be the emission from the alternative (with a 4.84 percent adjustment).

From a with- and without-project comparison, avoided stressors were identified and screened. The major avoided environmental emissions from the avoided coal-fired power plant are total suspended particulates (TSP), sulfur dioxide (SO_2), nitrogen oxides (NO_x), and carbon dioxide (CO_2). A reduction of these emissions will also result from the closure of an old and inefficient 100 MW coal-fired power plant.

The following are the identified emissions' significant potential impacts on Human Health, Human Welfare, Environmental Resources and Global Systems.

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19 The discount rate at which the present values of two project alternatives are equal. It is the same as the internal rate of return on the incremental effects of undertaking an alternative.

Human health impacts. Health studies currently focus on airborne particles that are small enough to be inhaled deeply into the lungs (called PM_{10}). PM_{10} aerosols resulting from the combustion of fossil fuels include sulfate and nitrate aerosols, acid aerosols, and other chemical constituents. Their impacts include both premature mortality and chronic acute respiratory disease.

Human welfare impacts. Particulate matter (less than 2.5 micrometers in diameter) that is emitted directly from power plants and industries or is formed in the presence of sulfur dioxide and nitrogen oxide gas emissions can reduce visual range. Particulate matter and acid deposition from sulfur dioxide emissions can damage materials. Materials damage can include surface soiling, surface erosion, blistering, paint discoloration, corrosion and tarnishing of metals and electronic components, fading, reduction of fabric tensile strength, and spalling of buildings and monuments.

Global impacts. It is well recognized that the Project's environmental impacts are not confined to the immediate location or within country limits but involves impacts on the global level. The economic value of a reduction in CO_2 was assessed using the Intergovernmental Panel on Climate Change values. However, the beneficial impacts of other greenhouse gas reductions were not assessed.

Once the major environmental impacts and their influence on human health, human welfare and environmental resources are properly identified, they can be valued in economic terms. Evaluating the economic impacts of changes in TSP, SO_2, and NO_x emissions was undertaken using the benefits-transfer method (BTM). Specifically, the "emissions-based unit value" approach was used to estimate monetized air pollution impacts. Box 7 gives the procedure for applying BTM. The approach uses dollar values per ton emission per person and captures the variability of the three important factors of location, emissions level and population. The Project's impact on the local, regional and distant environment was also determined. The valuation of the impact of CO_2 assumes that it would contribute to global warming and every unit of CO_2 has similar impacts. The economic evaluation of environmental impacts are based on the following assumptions:

Box 7. Benefits-Transfer Method Steps Used in the Yunnan Dachaoshan Power Transmission Project

FIRST STEP: *Select the literature. In this case we used a study by Rowe, et.al. (1995) which estimated unit damage values by emission and area.*

Dollar per ton per 1,000 person unit damage values for power and energy projects (1992 US$, New York)

	Local (within 30 km)		Regional (30-80 km)		Distant (80-500 km)	
Emission	Low	High	Low	High	Low	High
Particulates (PM_{10})	0.20	0.30	0.10	0.30	0.04	0.08
Sulfur dioxide (SO_2)	0.04	0.08	0.02	0.04	0.01	0.02
Nitrogen oxides (NO_X)	0.06	0.08	0.04	0.06	0.01	0.02

SECOND STEP: *Adjust the literature based on localized information. In this case, the following information was used.*

US per capita 1995 GNP	26,980 ($1995)
Yunnan per capita GNP	1,947 ($1995, purchasing power parity)
US GNP growth	10 percent (1992-1995)
PRC GNP growth	8 percent (1995-1998)

Using this information, the values were first brought to 1995 prices using US GNP growth. Thus with a growth of 10 percent (1992 to 1995), the local low value of PM_{10} becomes 0.22 in 1995. Note that the Yunnan per capita GNP (in PPP) is 7.2 percent of US per capita GNP. Hence the 0.22 local low value of PM_{10} multiplied by 7.2 percent is 0.016 and with a GNP growth rate of 8 percent for PRC (1995 to 1998), the value used for the analysis becomes 0.017. Hence the relevant figures become:

Dollar per ton per 1,000 person unit damage values for power and energy projects (1998 US$, PRC)

	Local (within 30 km)		Regional (30-80 km)		Distant (80-500 km)	
Emissions	Low	High	Low	High	Low	High
Particulates (PM_{10})	0.017	0.025	0.008	0.025	0.0033	0.007
Sulfur dioxide (SO_2)	0.003	0.007	0.002	0.003	0.0008	0.002
Nitrogen oxides (NO_X)	0.005	0.007	0.003	0.005	0.0008	0.002

THIRD STEP: *Another required adjustment is population. The project site population is given in the table below.*

Project site population ('000)

	Local (within 30 km)	Regional (30-80 km)	Distant (80-500 km)
Population	679	3,317	160,537

Thus multiplying the last two tables generates the coefficients to be multiplied to the estimated emissions which is escalated based on population growth. The final yearly estimates of economic values of environmental impacts are shown in Table 2.

(i) Annual coal consumption of the power plant and emissions were based on the following characteristics: carbon content of the coal is 40.4 percent; other components are sulfur (0.6 percent), nitrogen (1.0 percent) and ash (33.9 percent).

(ii) Consistent with the least-cost analysis, the period of environmental impact is assumed to be 25 years (from 2002 to 2026). The period where benefits occur from the closure of a 100 MW old and inefficient coal-fired power plant is assumed to be 10 years (2002 to 2011).

(iii) Local population densities: 240 persons per sq km for the local area (30 km radius); 192 persons per sq km for the regional area (80 km radius); and 209 persons per sq km for the distant area (500 km radius), and estimated population growth rates (1 percent per year) were used.

(iv) PRC per capita GDP in purchasing power parity is \$2,920[20] and Yunnan Province per capita GDP is two-thirds of the national average (\$1,957).

(v) For the base information, 1998 is the base year; and GDP deflator is estimated at 1.08 per year. Other relevant data include the US per capita GDP of \$26,980 in 1995.

The analysis shows that the Project will have positive environmental impacts. Using a discount rate of 12 percent, and scaling benefits to the project investment level, the net present values of the Project's environmental benefits ranges from \$156 to \$328 million (see Table 2).

There are other beneficial environmental impacts that could not be estimated due to methodological difficulties or lack of data. For instance, implementing the Project will lead to the avoidance of other greenhouse gases (apart from CO_2) that will be emitted by the 1,200 MW

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20 *World Development Report (1997).*

Table 2: Economic Valuation of Environmental Impacts

Emission	NPV[1]	2002	2003	2004	2005	2006
Incremental Quantities ('000 t)						
2x600MW Coal-Fired Power Plant and Turbine						
TSP		3	6	6	5	5
SO_2		21	37	38	36	36
NO_X		13	22	23	22	22
CO_2		3,011	5,241	5,438	5,185	5,104
Closure of 100MW Existing Coal-fired Power Plant[2]						
TSP		5	5	5	5	5
SO_2		2	2	2	2	2
NO_X		4	4	4	4	4
CO_2		850	850	850	850	850
Economic Values[3] *($ million)*						
TSP						
Low Estimate	$48	5.0	6.5	6.7	6.6	6.6
High Estimate	$98	10.1	13.2	13.6	13.4	13.4
SO_2						
Low Estimate	$52	3.5	5.9	6.2	6.0	5.9
High Estimate	$103	7.0	11.8	12.3	11.9	11.9
NO_X						
Low Estimate	$35	2.6	4.1	4.3	4.2	4.2
High Estimate	$68	5.1	8.0	8.4	8.1	8.1
CO_2						
Low Estimate	$485	35.4	56.4	58.8	57.0	56.8
High Estimate	$1,092	79.6	126.9	132.3	128.2	127.8
Total						
Low Estimate	$616	44.2	70.6	76.0	73.7	73.5
High Estimate	$1,296	92.3	150.2	154.5	149.5	148.8
Total (Adjusted to Project Investment)						
Low Estimate	$156	11.2	17.9	19.3	18.7	18.6
High Estimate	$328	23.4	38.1	39.2	37.9	37.7

NPV = net present value; TSP = total suspended particulates; SO_2 = sulfur dioxide; NO_x = nitrogen oxides; CO_2 = carbon dioxide
NPV is calculated at the discount rate of 12 percent.

1 *Economic values for TSP, SO_2, and NO_x are based on benefit transfer method using values adjusted to income and population in the Project area.*

2 *This analysis considers only the closure of a 100 MW coal-fired power plant which can directly be classified as a Project impact.*

3 *Economic values for CO_2 are based on estimates of greenhouse gas emissions by the Intergovernmental Panel on Climate Change (IPCC).*

2007	2008	2009	2010	2015	2020	2025	2026	2027
5	*6*	*6*	*7*	*7*	*7*	*7*	*7*	*7*
35	*38*	*42*	*46*	*46*	*46*	*46*	*46*	*46*
21	*23*	*25*	*28*	*28*	*28*	*28*	*28*	*28*
5,025	*5,502*	*6,023*	*6,594*	*6,594*	*6,605*	*6,605*	*6,605*	*6,605*
5	*5*	*5*	*5*					
2	*2*	*2*	*2*					
4	*4*	*4*	*4*					
850	*850*	*850*	*850*					
6.6	*7.0*	*7.4*	*7.9*	*4.8*	*5.1*	*5.3*	*5.4*	*5.4*
13.4	*14.2*	*15.1*	*16.0*	*9.8*	*10.3*	*10.8*	*11.0*	*11.1*
5.9	*6.5*	*7.1*	*7.8*	*7.8*	*8.2*	*8.7*	*8.8*	*8.8*
11.8	*13.0*	*14.3*	*15.7*	*15.7*	*16.5*	*17.3*	*17.5*	*17.7*
4.2	*4.5*	*4.9*	*5.4*	*5.0*	*5.2*	*5.5*	*5.5*	*5.6*
8.1	*8.8*	*9.6*	*10.5*	*9.7*	*10.2*	*10.7*	*10.8*	*10.9*
56.6	*61.8*	*67.6*	*73.9*	*70.9*	*74.6*	*78.4*	*79.1*	*79.9*
127.4	*139.1*	*152.0*	*166.3*	*159.6*	*168.0*	*176.3*	*178.1*	*179.8*
73.3	*79.8*	*87.1*	*95.0*	*88.5*	*93.2*	*97.8*	*98.8*	*99.8*
148.2	*162.5*	*178.3*	*195.7*	*194.7*	*205.0*	*215.2*	*217.3*	*219.5*
18.6	*20.2*	*22.1*	*24.1*	*22.4*	*23.6*	*24.8*	*25.0*	*25.3*
37.6	*41.2*	*45.2*	*49.6*	*49.3*	*52.0*	*54.5*	*55.1*	*55.6*

coal-fired power plant; hence, the global impacts of these gases will also be avoided. Unquantified impacts[21] from the Project need to be taken in proper perspective, because the true environmental benefits from the Project is likely to be larger. Therefore, the estimated economic valuation of environmental impacts should be treated as the lower bound rather than optimistic figures.

In the Project's economic analysis, the period covered was 1998-2020 and used constant 1997 prices and a discount rate of 12 percent. Tradable commodities were valued at border prices with the prevailing exchange rate. Nontradable commodities were valued at shadow price using a mix of standard and specific conversion factors. In the EIRR calculation, the main benefit will be from increased supply of electricity. This was conservatively valued based on consumer's willingness to pay. On this basis, the EIRR is 18.4 percent. A sensitivity analysis shows that even under adverse conditions, the EIRR would exceed 12 percent (Table 3). If the avoided economic cost of the environmental impacts of a comparable coal-fired power plant in the Kunming area, and the reduction in emissions from the closure of old and inefficient coal-fired power plants, were added to the benefits of the proposed Project (with appropriate costs factored in to mitigate environmental impacts of the Dachaoshan Hydropower Plant), the EIRR would improve further.

V. Notable Aspects

The Project will provide significant environmental benefits by eliminating the need to build a large coal-fired power station in the populated and industrialized areas near Kunming that are already experiencing serious levels of air pollution. Additionally, the Project will catalyze the closure of three inefficient coal-fired power plants responsible for significant

21 *These impacts include: human health and environmental resource impacts from the discharge of hazardous chemicals such as inorganic materials and metals; human health and welfare impacts from electro-magnetic radiation; human welfare impacts from noise; human welfare and environmental resource impacts from waste products, acid deposition, water diversion and withdrawal, thermal alteration and land-use changes.*

levels of pollution in the Province, and contribute to a reduction in the use of fuelwood in rural areas of Yunnan.

By foregoing the construction of a 1,200 MW coal-fired power plant and a 200 MW gas turbine (the Project alternative) and by closing three inefficient power plants, the Project will avoid adding approximately 476,000 tons of SO_2 emissions annually to the atmosphere. These emissions would otherwise exacerbate current air quality problems in Yunnan cities and exceed the assimilation capacity of soils and vegetation in the countryside. Combined with the avoidance of other coal-fired power plant emissions in the form of TSP, NO_x, and CO_2, the quantifiable environmental benefits, including avoidance of health hazards, reduction in damage to buildings and materials, improved visibility, and CO_2 reduction are substantial. Unquantifiable benefits, such as: environmental benefits from rural electrification, and global benefits from avoidance of other greenhouse gases, are also significant.

The Project, as defined by ADB financing, does not include the Dachaoshan hydropower plant. However, impacts of the Dachaoshan hydropower was also examined including environmental, social and economic implications. ADB financed a socioeconomic survey of more than 20 percent of the 6,100 people affected by the plant's construction. In addition, ADB required additional consultation and special provisions for vulnerable groups, including minority groups. Social aspects have been carefully examined, and an estimated 15.2 percent of the project's net benefits will accrue to the poor. A resettlement plan has been designed according to ADB's policies and the Government's approval. The inclusion of the Dachaoshan hydropower plant shows the recognition of the complex relationships and possible impacts of a project on other projects and areas beyond the project site.

Price reforms, policy reforms and rural electrification are the Project's other environmentally beneficial components. Among the direct environmental management aspects of the Project are: (i) closure of three old coal-fired power plants with a total capacity of 282 MW by 2002; (ii) implementation of mitigation measures in the EIA and SEIA during construction; and (iii) conservation regulations for the transmission line crossing, including limiting forest loss and compensation planting for felled trees on a 1:1 ratio. These considerations were strengthened by the recognition of the extent of environmental impacts through valuation.

Table 3: Economic Internal Rate of Return

Item	1996	1997	1998	1999	2000	2001
Operating Data						
Generation (GWh)						
Electricity Supply to Power System (GWh)						
Net Electricity Sales (GWh)						
Incremental Electricity Demand						
Incremental Sales						
Replacement Sales						
Benefit (Y million)						
Economic Benefit (Y/kWh)						
Willingness to Pay						
Fuel Cost						
Incremental Demand						
Cost Savings						
Total Benefit						
Cost (Y million)						
Capital Cost						
Dachaoshan Plant	*1,212*	*747*	*606*	*747*	*876*	*1,004*
Dachaoshan Transmission			*71*	*348*	*670*	*703*
Distribution			*57*	*278*	*536*	*562*
Subtotal (Y million)	*1,212*	*747*	*734*	*1,373*	*2,082*	*2,269*
Subtotal ($ million)	*146*	*90*	*88*	*165*	*251*	*273*
Of Which: Labor Cost	*90*	*55*	*54*	*98*	*147*	*161*
Operating Cost						
Variable O&M Cost						
Water Cost						
Subtotal Variable O&M Cost						
Fixed O&M Cost						
Dachaoshan Plant						
Dachaoshan Transmission						
Distribution						
Subtotal Fixed O&M Cost						
Of Which: Labor Cost						
Total O&M Cost						
Total Cost	*1,212*	*747*	*734*	*1,373*	*2,082*	*2,269*
Economic Internal Rate of Return						
Net Benefit (Y million)	*(1,212)*	*(747)*	*(734)*	*(1,373)*	*(2,082)*	*(2,269)*
EIRR (%)	*18.4%*					

GWh = gigawatt-hour, kWh = kilowatt-hour, MW = megawatt, O&M = operation and maintenance, SI = sensitivity index, SV = sensitivity variation

Notes: (i) Discount Rate = 12%, (ii) Standard Conversion Factor = 0.93, (iii) Conversion Factor for labor = 1.35, and (iv) Transmission and distribution loss = 9.5.

2002	2003	2004	2005	2010	2015	2020	2027	NPV
3,329	5,415	5,673	5,635	6,827	6,827	6,839	6,839	
3,276	4,328	5,582	5,545	6,717	6,717	6,729	6,729	
3,079	5,008	5,247	5,212	6,314	6,314	6,325	6,325	
2,204	4,545	7,035	7,035	7,035	7,035	7,035	7,035	
2,204	4,545	5,247	5,212	6,314	6,314	6,325	6,325	
875	464							
0.537	0.537	0.537	0.537	0.537	0.537	0.537	0.537	
0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	
1,183	2,439	2,816	2,797	3,389	3,389	3,395	3,395	
67	36							
1,250	2,475	2,816	2,797	3,389	3,389	3,395	3,395	11,218
1,072	218							
226								
181								
1,479	218							6,161
178	26							
107	16							446
6	9	10	10	12	12	12	12	
6	9	10	10	12	12	12	12	
13	26	35	35	44	44	44	44	
18	35	49	49	60	60	60	60	
14	38	39	39	48	48	48	48	
45	89	123	123	152	152	152	152	514
17	33	46	46	56	56	56	56	190
51	98	133	133	164	164	164	164	557
1,530	316	133	133	164	164	164	164	
(274)	2,168	2,693	2,674	3,237	3,237	3,243	3,243	4,542

Sensitivity Analysis of EIRR	Change in Variable	NPV (Y million)	EIRR (%)	SI	SV
1. Base Case		4542	18.4%		
2. Capital Cost Overrun	10%	4103	17.2%	0.48	206.7
3. Benefit Reduction	-10%	2328	17.1%	2.44	41.0
4. Implementation Delay	1 year	2881	16.9%		
5. Combination of 2,3, and 4		637	14.4%		

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