# X'IAN-XIANYANG-TONGCHUAN ENVIRONMENTAL IMPROVEMENT PROJECT

## I. Background of the Project

Energy production and industry are the two major sources of environmental degradation in the People's Republic of China (PRC). The continued dominance of coal in the energy mix, and the high energy intensity in the PRC's industrial and household sectors, have major environmental repercussions at national and transnational levels. The environmental problems reflect the past practice of locating industrial enterprises within urban centers, the use of inappropriate technology, as well as lack of appropriate regulatory measures and economic incentives to promote sound environmental policies.

The deterioration of the environment is particularly acute in the Shaanxi Province, a poor interior province in the northwest. Widespread environmental damage is occurring in the Province because of rapid industrialization and a growing urban population. Air pollution is a serious problem in the Province and in other industrialized cities, meaning that air quality does not meet PRC standards for Class II and in some instances Class III, particularly during the winter months.[15] The problem is compounded by topography that creates frequent atmospheric inversions that prevent dispersal of air pollutants. Sulfur dioxide emitted from coal burning, along with nitrogen oxide, is causing acid rain.[16] The air pollutants

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*15 PRC environmental standards define three classes for air quality: Class I relates to protection of natural ecology and human health from harmful effects under long-term exposure; Class II relates to protection of human health and animal and vegetation in urban and rural areas against harmful conditions that can arise under long and short-term exposure; and Class III is for the protection of human communities against acute or chronic toxic illnesses, and for normal growth and vegetative life.*

*16 A new law (approved in February 1998) has been passed in PRC defining the control of $SO_2$.*

deposited in the ecosystem are not easily diluted or washed out because rainfall is limited. The serious air pollution in the Province is causing irreversible damage to historical and cultural monuments which abound in Shaanxi. Almost all the rivers and lakes around the major cities are polluted from untreated domestic and industrial wastes.

Approximately 40 million tons (t) of coal is burned each year in Shaanxi Province and this is projected to increase to about 62 million t by the year 2010. In 1996, the waste gas emissions were estimated at 211 billion cubic meters ($m^3$), and are projected to increase by a factor of five to reach 1,100 billion $m^3$ by the year 2010. Industry's current share of 83 percent of the emissions is expected to grow to 94 percent by 2010. Emissions from households will double during the same period, but they will be dwarfed by the increase in industrial emissions. The generation of water pollutants is expected to show a similar pattern, an increase from 700 million $m^3$ in 1993 to 4,400 million $m^3$ in 2010, with the industrial share growing from 53 percent of the total wastewater to 84 percent in 2010. Solid waste generation is forecast to increase from 24 million t in 1993 to 126 million t in 2010. Most of the increase will come from the mining sector where the solid wastes contain a high concentration of toxic heavy metals. Domestic solid wastes of 8 million t in 1993 are forecast to increase by 50 percent by 2010.

The Government's strategy for achieving its environmental objectives include: (i) containing the emissions of airborne pollutants, particularly carbon dioxide and sulfur dioxide; (ii) developing cleaner technologies and energy-efficient devices; and (iii) conducting environmental audits for industrial concerns, with specific reference to pollution control and waste management. From the regulatory perspective, the Government has been using both incentives and punitive control measures to encourage industries to comply with environmental standards and regulations.

ADB has made seven loans to PRC totaling $700 million for urban environmental improvement projects—including the provision of water supply, cleaner forms of energy, wastewater treatment, industrial relocation, and pollution abatement. Under three other loans totaling $535 million, ADB has helped address energy efficiency and environmental improvement in key industrial sectors by introducing advanced process technologies and management practices to reduce inefficiencies and waste.

ADB has provided about $21 million for TA grants that promote improved environmental management.

## II. Project Details

The Project will help to achieve sustainable regional development and encourage the efficient utilization of existing resources by improving environmental quality and energy efficiency. The Project is part of Shaanxi Province's long-term strategy for addressing the serious air pollution in three major cities (Xi'an, Xianyang and Tongchuan).

The objective of the Project is to promote sustainable regional development by supporting Shaanxi Province in implementing its environmental protection plans for improving the ambient air quality in Xi'an, Xianyang and Tongchuan cities (see Map). The Project consists of: (i) strengthening planning and environmental protection agencies to ensure sustainable environmental management and compliance with national environmental standards; (ii) supporting market-oriented energy price reforms; and (iii) financing investments in district heating and natural gas distribution systems to reduce direct coal burning and improve energy efficiency, and in emission control to reduce air pollution.

The scope of the Project includes six investment subprojects in the three cities. The building of co-generation plants that will supply steam (heat) as well as electricity will reduce air pollution in the three cities. Replacing direct coal burning will improve the efficiency with which coal is burned and will generate substantial cost savings. The co-generation plants will have an average efficiency of 80 percent and will replace nearly 400 small and inefficient coal-fired boilers (50 percent efficiency), and a large number of domestic stoves (35 percent efficiency). To further enhance the beneficial environmental effect of the co-generation plants, they will be fitted with modern dust removal equipment and will burn low-sulfur coal. In Xianyang and Tongchuan, natural gas will be distributed to households, commercial enterprises, and industry. Gas will predominantly replace coal as a fuel source, leading to a substantial reduction in air pollution and an increase in energy efficiency. In Tongchuan, the largest source of TSP emissions, the Yaoxian Cement Plant will close down

Map
X'ian-Xianyang-Tongchuan
Environmental Improvement Project

one inefficient and highly polluting production line and will fit modern dust removal equipment to the other production lines. As a result, the plant's particulate emission will be reduced by 98 percent.

The total cost of the Project is estimated at $298 million equivalent with foreign exchange costs estimated at $156 million. ADB will provide a loan to finance the entire foreign exchange cost that constitutes about 52 percent of the total project cost. The repayment period for the loan will be 20 years, including a 4-year grace period.

## III. Analytical Method

The economic analysis consists of: (i) demand analysis, (ii) least-cost analysis, and (iii) cost-benefit analysis. In the cost-benefit analysis, the economic numeraire is border prices expressed in domestic currency. All transfer payments have been excluded from the financial costs and the analysis is based on 1997 constant prices. All tradable costs have been converted using the current exchange rate, while a conversion factor of 0.9 has been used for all non-tradable goods. All tradable energy sources are valued at the appropriate border prices, corrected for local transport costs and quality differences in coal. Natural gas is valued at the economic average incremental cost. Electric power is valued at economic long-run marginal cost of yuan(Y)0.48/kWh.

The economic analysis of environmental impacts compares the Project's viability in the with-Project and without-Project situations. The Project leads to lowering of coal use in the three cities and there are direct environmental improvements in terms of avoided outdoor air pollution. These improvements are valued for their positive impacts on human health and human welfare.

The switch from coal to cleaner fuels for the domestic sector leads to significant improvements in indoor air quality. In fact, the switch in household fuel is found to be the most important way of improving indoor air pollution in a sustainable way. The Project aims to reduce the overall exposure of residents to maximize health-related benefits. This is an important step forward since health-related benefits are substantial; furthermore, there are adverse effects of long-term exposure to coal use, but little quantitative information has been collected.

# IV. Economic Assessment of Environmental Benefits

## A. *Outdoor Air Pollution*

Shaanxi Province has over 2,000 historical relics that face irreversible damage from air pollution—including acid rain. The Project will lead to lowering of coal use and improvements in avoided pollution as shown in Table 1.

**Table 1: Improvements in Outdoor Environment**

| Pollutant | Decrease in Pollutants (t) | | |
|---|---|---|---|
| | Co-generation Plants | Natural Gas Plants | Particulate Control[1] |
| *TSP* | *13,170* | *17,408* | *84,500* |
| $SO_2$ | *8,552* | *11,304* | |
| $NO_X$ | *13,213* | *16,464* | |
| $CO_2$ | *16,804* | *22,212* | |

*TSP = total suspended particulates;* $SO_2$ *= sulfur dioxide;* $NO_X$ *= nitrogen oxides;* $CO_2$ *= carbon dioxide.*

[1] *via dust removal equipment.*

The reduction in pollutants has a significant impact on human health and welfare. The fine particulate formed by $PM_{10}$, $NO_X$, and $SO_2$ emissions lead to premature mortality and chronic respiratory disease. These impacts are valued using a secondary valuation technique (benefits-transfer method). Specific adjustments are made considering project price levels, appropriate income variations between the US and the PRC, and cost of illness and lost days. The environmental impacts are assessed for the changes in exposure for population depending on the density.

## B. *Indoor Air Pollution*

Indoor air pollution is a serious problem in the PRC. Although there are other sources (such as burning tobacco), most indoor air pollution is due to household use of fuels for cooking and heating. In the three cities under consideration, most households use coal briquettes as their major fuel and thus residents are subjected to extremely high levels of pollutants such as sulfur. Since the 1970s, a number of studies in the PRC have measured various pollutants within both urban and rural households. The World Health Organization and the United Nations Environment Programme have prepared a database summarizing the results of 110 papers published between 1980 and 1994 on the quality of indoor air. This database is used to assess the magnitude of pollutants in households of different sizes using different fuels, types of stoves, and ventilation systems. As much as possible, studies are on the same cities by the same researchers covering similar conditions of ventilation to identify the differences accounted for by the variation in fuels. Table 2 identifies major improvements in indoor air quality as a result of switching from coal to gas. At present, most coal users face serious indoor air pollution, much beyond the norms for indoor air quality in the PRC. Switching to gas will significantly bring indoor air quality to levels within the norms.

**Table 2: Indoor Air Quality with Change in Fuel Use**

| Pollutant | Area μg/m³ | Coal as Fuel μg/m³ | Gas as Fuel μg/m³ | Standard for PRC μg/m³ |
|---|---|---|---|---|
| $PM_{10}$ | *Kitchen* | *1,820* | *510* | *Class I 50-150* |
| | *Bedroom* | *1,750* | *490* | *Class II 150-300* |
| | | | | *Class III 250-1,000* |
| *TSP* | *Kitchen* | *1,560-2,830* | *510* | *Class I 50-150* |
| | *Bedroom* | *390-1,000* | *490* | *Class II 150-300* |
| | | | | *Class III 250-1,000* |
| $SO_2$ | *Kitchen* | *50-2,007* | *10-180* | *Class I 50* |
| | *Bedroom* | *10-1,180* | *10-100* | *Class II 150* |
| | *Apartment (ave.)* | *2,118-4,559* | *48-108* | *Class III 250* |
| $NO_X$ | *Kitchen* | *10-1,950* | *60-310* | *Class I 50* |
| | *Bedroom* | *10-300* | *10-100* | *Class II 100* |
| | *Apt. Kit. (winter)* | *20-202* | *95* | *Class III 150* |
| *CO* | *Kitchen (April)* | *38,000* | *7,900* | *Class I 4,580* |
| | *Bedroom* | *20,000* | *5,300* | *Class II 4,580* |
| | | | | *Class III 6,870* |

*(μg/m³) = microgram per cubic meter; $PM_{10}$ = particulate matter less than 10 microns; TSP = total suspended particulates; $SO_2$ = sulfur dioxide; $NO_X$ = nitrogen oxides; CO = carbon monoxide*

The information was used to value the impact on human health of reduced exposure as a result of moving up the energy ladder. Relevant studies have been used to isolate the effects of the fuel switch. The difference in personal exposure to $PM_{10}$ was derived from K. Smith's (1994) "Indoor Pollution in Developing Countries" study, while the estimates for $SO_2$ came from Gao's (1993) "Relationship Between Air Pollution and Mortality in Dongchen and Xicheng Districts, Beijing." From actual data on fuel usage patterns and cooking time, estimated levels of exposure range from 115 $\mu g/m^3$ to 190 $\mu g/m^3$ for $PM_{10}$ and from 55 $\mu g/m^3$ to 64 $\mu g/m^3$ for $SO_2$.

$PM_{10}$ and $SO_2$ reductions lead to lower mortality rates and respiratory illness among children below 14 years. All major impacts were assessed based on the Ostro (1994) study using central range estimates. The resultant health impacts are summarized in Table 3. These health impacts were valued using data for the US, and corrected for two levels of change in income, nominal income and purchasing price parity values using the World Development Report, 1995. The reduction in exposure leads to annual benefits ranging between Y90 million and Y400 million, comprising essentially prevention of income loss (including losses due to avoidance of premature deaths), and savings in hospital and treatment costs. These benefits have been integrated in the valuation (see Tables 4 and 5).

The aggregate EIRR of the Project improves from 20 percent to 25.7 percent when using the lower limit of outdoor air pollution improvement, and up to 32 percent if the upper limit is considered. On the otherhand if the reduction in indoor pollution exposure is used instead of outdoor air pollution improvement, it improves the integrated EIRR of the Project to 22.9 percent using the lower limit and 23.3 percent considering the upper limit. The overall environmental benefits from the outdoor air pollution improvements range from $127 million to $269 million in net present value (NPV) terms. The reductions in exposure to indoor pollution will result in substantial health benefits for the people in the project area amounting to $11 million-$12 million per year or an additional $65 million-$72 million in NPV terms.

## Table 3: Changes in Indoor Air Quality and Health Effects

| Pollutants | $PM_{10}$ | | | |
|---|---|---|---|---|
| Impacts Item | Change in Mortality (per person) | Respiratory Hospital Admissions (per person) | Emergency Room Visits (annual change) | Restricted Activity Days (per person) |
| *Data used for analysis* | | | | |
| *Dose response coefficient (Ostro)* [a] | *0.00000672* | *0.000012* | *23.54* | *0.0575* |
| *Adjusted population for PRC* | *0.40* | *0.40* | *0.40* | *0.40* |
| *Population affected by Project* | *477.425* | *477.425* | *477.425* | *477.425* |
| *Changes in exposure to pollutants* [b] | *115* | *115* | *9,572.00* | *115* |
| *Physical health effects* | *Premature deaths* | *Number of days* | *Number of visits* | *Number of days* |
| | *148* | *264* | *90,130* | *1,199,650* |
| *Monetary values (US data)* | *3,000,000.0* | *6,306.0* | *178* | *1.93* |
| *PRC PPP GNP (US=100)* [c] | *10.80* | *10.80* | *10.80* | *10.80* |
| *Nominal income parity* | *0.023* | *0.023* | *0.023* | *0.023* |
| *Adjusted to 1995 PPP income* | *277,778.00* | *564.00* | *16.48* | *3.86* |
| *Adjusted to 1995 GNP* | *68,940.00* | *144.91* | *4.09* | *0.04* |
| *Health benefits (in Y million)* | | | | |
| *Assuming PPP adjustments* | *340.00* | *1.28* | *12.33* | *38.43* |
| *Assuming income adjustments* | *84.00* | *0.32* | *3.06* | *0.44* |

*GNP = Gross National Product; $PM_{10}$ = particulate matter less than 10 microns in diameter; PPP = purchasing power parity; $SO_2$ = sulfur dioxide.*

[a] *B. Ostro. The World Bank, 1994. "Estimating the Health Effects of Air Pollutants. A Method with an Application to Jakarta."*

[b] *Change in exposure for $PM_{10}$. (Smith 1994)[d] (1900*4hrs/24 - (1600*3hrs/24)* 116.6.*

[c] *Change in exposure for Sulfur Dioxide (Gao 1994)[e] (464*4hrs/24 - (166*3hrs/24)* 56.6.*

[d] *K.S. Smith, et al. 1994. "Indoor Air Pollution in Developing Countries."*

[e] *Gao, et al., 1993. "Relationship Between Air Pollution and Mortality in Dongchen and Xicheng Districts, Beijing."*

| | | | | SO2 | | |
|---|---|---|---|---|---|---|
| **Bronchitis in Children** (per person) | **Asthma Attacks** (per person) | **Respiratory Symptoms** (annual change) | **Chronic Bronchitis** (per person) | **Respiratory Change in Mortality** (per person) | **Symptoms in Children** (per person) | **Chest Discomfort** (per person) |
| *0.00169* | *0.0326* | *0.183* | *0.0000612* | *0.048* | *0.0181* | *0.01* |
| *0.40* | *0.40* | *0.40* | *0.40* | *0.40* | *0.40* | *0.40* |
| *477.425* | *477.425* | *477.425* | *477.425* | *477.425* | *477.425* | *477.425* |
| *115* | *115* | *115* | *115* | *115* | *115* | *115* |
| *Number of incidence* | *Number of incidence* | *Number of days* | *Number of incidence* | *Number of deaths* | *Number of incidence* | *Number of incidence* |
| *37.115* | *125.291* | *34.948* | *111.871* | *1.0* | *190.111* | *105.034* |
| *6.0* | *30.0* | *5.0* | *6.0* | *3,000,000.0* | *5.0* | *6.0* |
| *10.80* | *10.80* | *10.80* | *10.80* | *10.80* | *10.80* | *10.80* |
| *0.023* | *0.023* | *0.023* | *0.023* | *0.023* | *0.023* | *0.023* |
| *0.49* | *2.76* | *0.50* | *0.55* | *277,778.0* | *0.49* | *0.55* |
| *0.12* | *0.69* | *0.12* | *0.14* | *68,940.0* | *0.12* | *0.14* |
| *0.15* | *2.87* | *14.00* | *0.51* | *2.43* | *0.78* | *0.48* |
| *0.04* | *0.71* | *0.04* | *0.13* | *0.60* | *0.19* | *0.12* |

### Table 4: Summary of Economic and Environmental Analysis *(Y million)*

| **Item** | **Without Environmental Impact** | **With Outdoor Environmental Impact** | | **With Reduction in Indoor Impact** | |
|---|---|---|---|---|---|
| | | **Low** | **High** | **Low** | **High** |
| *Net present value @12%* | *1,238.6* | *2,290.4* | *3,469.0* | *1,777.6* | *1,837.4* |
| *Net present value @10%* | *1,803.3* | *3,079.1* | *4,490.7* | *2,455.6* | *2,528.0* |
| *EIRR (%)* | *20.0* | *25.7* | *32.0* | *22.9* | *23.3* |

*EIRR decreases by less than one percent if the computed global benefits from carbon sequestration are removed.*

**Table 5: Integrated Economic and Environmental Analysis (Y million)**

| | Economic Cost | | Economic Benefit | | Environmental Benefit | |
|---|---|---|---|---|---|---|
| Year | Capital Cost | Operating Cost | Benefits | Net Benefits | Low | High |
| *1998* | *1,079.8* | – | – | *(1,079.8)* | – | – |
| *1999* | *897.4* | – | – | *(897.4)* | – | – |
| *2000* | *205.8* | *114.0* | *396.5* | *76.7* | *134.6* | *292.2* |
| *2001* | *114.8* | *205.2* | *633.0* | *313.0* | *161.8* | *349.9* |
| *2002* | *14.5* | *219.6* | *754.1* | *520.0* | *167.7* | *361.9* |
| *2003* | *28.5* | *236.2* | *824.8* | *560.1* | *170.0* | *366.6* |
| *2004* | | *241.7* | *824.8* | *583.1* | *170.0* | *366.6* |
| *2005* | | *241.7* | *824.8* | *583.1* | *170.0* | *366.6* |
| *2006* | | *241.7* | *824.8* | *583.1* | *170.0* | *366.6* |
| *2007* | | *241.7* | *824.8* | *583.1* | *170.0* | *366.6* |
| *2008* | | *241.7* | *824.8* | *583.1* | *170.0* | *366.6* |
| *2009* | | *241.7* | *824.8* | *583.1* | *170.0* | *366.6* |
| *2010* | | *241.7* | *824.8* | *583.1* | *170.0* | *366.6* |
| *2011* | | *241.7* | *824.8* | *583.1* | *170.1* | *366.8* |
| *2012* | | *241.7* | *824.8* | *583.1* | *170.1* | *366.8* |
| *2013* | | *241.7* | *824.8* | *583.1* | *170.1* | *366.8* |
| *2014* | | *236.2* | *824.8* | *588.6* | *170.1* | *366.8* |
| *2015* | *(0.7)* | *236.2* | *824.8* | *589.3* | *170.1* | *366.8* |
| *2016* | | *203.9* | *757.2* | *553.3* | *170.1* | *366.8* |
| *2017* | | *203.9* | *757.2* | *553.3* | *170.1* | *366.8* |
| *2018* | | *203.9* | *757.2* | *553.3* | *170.1* | *366.8* |
| *2019* | | *203.9* | *757.2* | *553.3* | *170.1* | *366.8* |
| *2020* | *(0.3)* | *185.6* | *328.8* | *143.5* | *170.1* | *366.8* |
| *2021* | | *152.5* | *254.8* | *102.3* | *170.1* | *366.8* |
| *2022* | | *152.5* | *254.8* | *102.3* | *170.1* | *366.8* |
| *2023* | | *152.5* | *254.8* | *102.3* | *170.1* | *366.8* |
| *2024* | | *152.5* | *254.8* | *102.3* | *170.1* | *366.8* |
| *2025* | *(0.9)* | *77.2* | *127.8* | *51.5* | *488.8* | *101.4* |
| *EIRR* | | | | *19.95* | | |
| *NPV @12%* | | | | | | |
| *Y million* | | | | *1,238.60* | *1,051.90* | *2,230.50* |
| *$ million* | | | | *149.20* | *126.70* | *268.70* |
| *NPV @10%* | | | | | | |
| *Y million* | | | | *1,803.60* | *1,275.80* | *2,687.40* |
| *$ million* | | | | *217.30* | *153.70* | *323.80* |

*Exchange rate: $1 = Y8.3*
*NPV = net present value.*

| Total Benefit | | Indoor Improvement | | Total Net Benefit | |
|---|---|---|---|---|---|
| Low | High | Low | High | Low | High |
| *(1,079.8)* | *(1,079.8)* | – | – | *(1,079.8)* | *(1,079.8)* |
| *(897.4)* | *(897.4)* | – | – | *(897.4)* | *(897.4)* |
| *211.3* | *368.9* | *62.1* | *68.9* | *138.8* | *145.6* |
| *474.8* | *662.9* | *78.0* | *86.7* | *391.0* | *399.7* |
| *687.7* | *881.9* | *90.0* | *100.0* | *610.0* | *620.0* |
| *730.1* | *926.7* | *90.0* | *100.0* | *650.1* | *660.1* |
| *753.1* | *949.7* | *90.0* | *100.0* | *673.1* | *683.1* |
| *753.1* | *949.7* | *90.0* | *100.0* | *673.1* | *683.1* |
| *753.1* | *949.7* | *90.0* | *100.0* | *673.1* | *683.1* |
| *753.1* | *949.7* | *90.0* | *100.0* | *673.1* | *683.1* |
| *753.1* | *949.7* | *90.0* | *100.0* | *673.1* | *683.1* |
| *753.1* | *949.7* | *90.0* | *100.0* | *673.1* | *683.1* |
| *753.1* | *949.7* | *90.0* | *100.0* | *673.1* | *683.1* |
| *753.2* | *949.9* | *90.0* | *100.0* | *673.1* | *683.1* |
| *753.2* | *949.9* | *90.0* | *100.0* | *673.1* | *683.1* |
| *753.2* | *949.9* | *90.0* | *100.0* | *673.1* | *683.1* |
| *758.7* | *955.4* | *90.0* | *100.0* | *678.6* | *688.6* |
| *759.4* | *956.1* | *90.0* | *100.0* | *679.3* | *689.3* |
| *723.4* | *920.1* | *90.0* | *100.0* | *643.3* | *653.3* |
| *723.4* | *920.1* | *90.0* | *100.0* | *643.3* | *653.3* |
| *723.4* | *920.1* | *90.0* | *100.0* | *643.3* | *653.3* |
| *723.4* | *920.1* | *90.0* | *100.0* | *643.3* | *653.3* |
| *313.6* | *510.3* | *90.0* | *100.0* | *233.5* | *243.5* |
| *272.4* | *469.1* | *90.0* | *100.0* | *192.3* | *202.3* |
| *272.4* | *469.1* | *90.0* | *100.0* | *192.3* | *202.3* |
| *272.4* | *469.1* | *90.0* | *100.0* | *192.3* | *202.3* |
| *272.4* | *469.1* | *90.0* | *100.0* | *192.3* | *202.3* |
| *540.3* | *152.9* | *90.0* | *100.0* | *141.5* | *151.5* |
| *25.71* | *31.95* | | | *22.98* | *23.30* |
| *2,290.40* | *3,469.00* | *539.00* | *598.90* | *1,777.58* | *1,837.42* |
| *276.00* | *418.00* | *64.90* | *72.20* | *214.17* | *221.38* |
| *3,079.10* | *4,490.70* | *652.20* | *724.70* | *2,455.55* | *2,527.97* |
| *371.00* | *541.00* | *78.60* | *87.30* | *295.85* | *304.57* |

*EIRR decreases by less than one percent if the computed global benefits from carbon sequestration are removed.*

## V. Notable Aspects

We see in this project a unique concern for the quality of indoor air. This is a clear example of how "environmental" problems will be misunderstood if they are confined to various aspects of "nature." In the project region, coal briquettes are the major source of energy and the attendant pollution of indoor air is severe. Research on the effects of indoor air pollution was used to estimate the benefits from switching from coal briquettes to gas.

Outdoor air pollution is a serious problem as well and the Project will support market-oriented price reforms for energy, and it will help to improve natural gas distribution systems so that the existing reliance on coal can be reduced. The costs of illness and lost workdays comprise the basis for estimating project benefits.

The Project has been shown to improve environmental quality in Xi'an, Xianyang, and Tongchuan. Economic valuation of environmental impacts shows that the Project leads to substantial direct economic benefits. The health-related externalities are very significant. This has been estimated at $65 million-$72 million per year.

The Project provides special technical assistance on development and implementation of environmental management plans for the Province. This also includes a major training component on environmental management, the provision of pollution monitoring equipment, and institutional strengthening for prudent environmental control. This grant component amounts to $1 million. The motivation for the Government to request ADB's assistance for environmental management was primarily due to the recognition of the large cost associated with air pollution. The economic valuation of environmental impacts was able to show that health costs alone could amount to $60 million-$72 million a year.

This Project also requires the Government to develop and implement a series of environmental policies. Adoption of medium-to long-term environmental management plans, promotion of cleaner production, and the review of various environmental management levies, fees and charge systems in the Province, will help ensure a cleaner environment in the long-run. The economic valuation of air pollution control benefits provided information with which the design of such environmental policies were based.

Another important aspect of this Project is enterprise reforms and restructuring to assure better competition with market-based price determination. Price reforms in natural resource management, especially in the energy sector, will have major impacts on the economy.

Provincial Governments will also establish environmental assessment procedures including strategic environmental assessment for policy, program and economic plan assessment. Air pollution control and wastewater management would be the two main thrusts to be undertaken even after the Project.

The project site is of historical importance, containing valuable ancient artifacts. The Project would provide large benefits in terms of preserving these historically important monuments from damage due to environmental degradation. The economic value of such benefits was not estimated. If more time and resources were available, more information would have been gathered using methods such as willingness-to-pay or travel cost methods to enhance the quality of the economic analysis of the project.