



# Performance Evaluation Report

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## People's Republic of China: Shanxi Environment Improvement Project

Independent Evaluation Department

Asian Development Bank

## CURRENCY EQUIVALENTS

Currency Unit – yuan (CNY)

		<b>At Appraisal</b> (November 1999)	<b>At Completion</b> (March 2006)	<b>At Independent Evaluation</b> (July 2009)
CNY1.00	=	\$0.121	\$0.124	\$0.144
\$1.00	=	CNY 8.278	CNY8.039	CNY6.950

### ABBREVIATIONS

ADB	–	Asian Development Bank
ADTA	–	advisory technical assistance
CBM/CMM	–	Coal-bed-methane/coal-mine-methane
CHP	–	combined heat power
CO <sub>2</sub>	–	carbon dioxide
DDHC	–	Datong District Heating Company
DDHP	–	Datong District Heating Project
EA	–	executing agency
EARD	–	East Asia Department
EIRR	–	economic internal rate of return
EPB	–	Environmental Protection Bureau
ET	–	emissions permit trading
FIRR	–	financial internal rate of return
HES	–	Heat exchange station
ICB	–	international competitive bidding
JGC	–	Jiaoqu Gas Company
LPG	–	liquefied petroleum gas
NEMC	–	national environmental monitoring center
NO <sub>2</sub>	–	nitrogen dioxide
NO <sub>x</sub>	–	nitrogen oxide
PCB	–	price control bureau
PCR	–	project completion report
PDP	–	pollution discharge permit
PGC	–	Pingding Gas Company
PCR	–	project completion report
PMO	–	project management office
PPER	–	project performance evaluation report
PPTA	–	project preparatory technical assistance
PRC	–	People's Republic of China
RESC	–	regional environmental supervision center
RRP	–	report and recommendation of the President
SO <sub>2</sub>	–	sulfur dioxide
SPG	–	Shanxi provincial government
SSCCL	–	Shanxi Shenzhou Coking Company Limited
SOE	–	state-owned enterprise
TA	–	technical assistance
TCGC	–	Taiyuan Coal Gasification Company
TCGEP	–	Trans-Century Green Engineering Program
TCGG	–	Taiyuan Coal Gasification Group
TPL	–	total pollution loading
TSP	–	total suspended particulates

WACC	–	weighted average cost of capital
WTP	–	willingness to pay
YCGC	–	Yangquan City Gas Company
YCMG	–	Yangquan Coal Mining Group

### WEIGHTS AND MEASURES

GJ	–	gigajoule
km	–	kilometer
m <sup>2</sup>	–	square meter
m <sup>3</sup>	–	cubic meter
MW	–	megawatt
mcm	–	million cubic meters
PM <sub>10</sub>	–	particulate matter of less than 10 microns diameter
tph	–	ton per hour

### NOTES

In this report, “\$” refers to US dollars.

#### Key Words

adb, asian development bank, china, energy efficiency, coal bed methane, pollution prevention, coal gasification, district heating, prc, emissions, ghg, shanxi, SO<sub>2</sub> emissions trading, technical assistance

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In accordance with the guidelines formally adopted by the Independent Evaluation Department (IED) to avoid conflict of interest in its independent evaluations, the Director General of IED did not review this report and delegated approval of this evaluation to the Director of Independent Evaluation Division 2. Yu Yang Gong, Li Dongming, and Elizabeth Lat were the consultants. To the knowledge of the management of IED, there were no conflicts of interest of the persons preparing, reviewing, or approving this report.

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**BASIC DATA**  
**Loan 1715-PRC: Shanxi Environment Improvement Project**

**Project Preparation/Institution Building**

TA No.	TA Name	Type	Person-months	Amount (\$ million)	Approval Date
2901	Shanxi Environment Improvement (JSF)	PPTA	NA	0.59	21 Oct 1997
3325	Shanxi Air Quality Improvement (JSF)	ADTA	47	0.70	07 Dec 1999

Key Project Data (\$ million)	As Per ADB Loan Documents	Actual
Total Project Cost	183	182.04
Foreign Exchange Cost	102	99.04
ADB Loan Amount/Utilization	102	99.04
ADB Loan Amount/Cancellation		2.96

Key Dates	Expected	Actual
Fact-Finding Mission		15–28 Apr 1999
Appraisal Mission		5–19 Jul 1999
Loan Negotiations		2–4 Nov 1999
Board Approval		7 Dec 1999
Loan Agreement		27 Nov 2000
Loan Effectivity	27 Nov 2000	25 May 2001
First Disbursement		15 Nov 2001
Project Completion	31 Dec 2003	Jan 2006
Loan Closing	30 Jun 2004	2 Dec 2005
Month (effectiveness to completion)	37	56

Internal Rates of Return (%)	Appraisal			PCR			PPER		
	TAI	DAT	YAN	TAI	DAT	YAN	TAI	DAT	YAN
Economic Internal Rates of Return									
- Without local environment benefits	23.9	14.1	26.6	14.5	19.0	16.1	14.6	11.2	7.8
- With local environmental benefits				19.6	28.3	18.8	20.7	18.9	16.2
Financial Internal Rates of Return									
- Before tax				13.8	10.7	9.1	12.8	5.1	4.1
- After tax	9.2	8.7	10.3	10.5	8.1	6.9	9.9	3.5	3.1

**Borrower** People's Republic of China  
**Executing Agency** Shanxi Provincial Government

Mission Data	No. of Missions	No. of Person-Days
Fact-Finding	1	65
Appraisal	1	84
Project Administration	7	78
- Inception	1	8
- Review	6	70
Project Completion	1	29
Independent Evaluation	1	15

ADB = Asian Development Bank, ADTA = advisory technical assistance, DAT = Datong subproject, JSF = Japan Special Fund, NA = not available, PCR = project completion report, PPER = project performance evaluation report, PPTA = project preparatory technical assistance, TA = technical assistance, TAI = Taiyuan subproject, YAN = Yangquan subproject.

## EXECUTIVE SUMMARY

### Background

The Asian Development Bank's (ADB) Shanxi Environment Improvement Project was selected for evaluation by the Independent Evaluation Department 3 years after completion to provide lessons and recommendation to future projects of this nature. It was also expected to provide input to an evaluation knowledge brief on greenhouse gas implications of ADB's energy sector operations. The project has supported three distinctive clean energy subprojects that resulted in coal savings and reduced emissions of pollutants and greenhouse gases in three of the most polluted cities in the People's Republic of China (PRC). The project also supported capacity building in the executing and implementing agencies. An advisory technical assistance (ADTA) was designed to help set up and begin operating a sulfur-dioxide (SO<sub>2</sub>) emissions permit trading system in Taiyuan City.

The subprojects aim to reduce the causes of environmental pollution through fuel-switching and more efficient use of energy. Two subprojects replace coal for residential, commercial, and industrial consumers: a coking facility generates coal gas for sale in Taiyuan; a coal-bed-methane/coal-mine-methane (CBM/CMM) capture, storage, transmission, and distribution system in the city of Yangquan makes CBM/CMM gas available to local buyers. In Datong city, the third subproject is making more efficient use of coal for residential and commercial space heating.

The project cost at appraisal was \$183 million. ADB approved a loan of \$102 million to cover the entire foreign exchange costs. At appraisal, the balance capital requirements of \$81 million were to be funded by \$23 million in commercial bank borrowings and \$58 million in internal resources. Actual commercial bank borrowings were only \$6.7 million because the Taiyuan Coal Gasification Company (TCGC) was able to access funds raised from the capital market. Through this subproject, ADB was thus also able to support the government's policy of encouraging state-owned enterprises to corporatize and become more commercially oriented.

### Performance Assessment

**Relevance.** The project is *highly relevant*. The project design is consistent with the PRC's environmental protection policies and regulations and the socioeconomic development plans in the 10th and 11th Five-Year Plan periods (2001–2005 and 2006–2010). It conforms to ADB's operational strategy in the late 1990s, which sought to expand the energy resource base, diversify from coal use, and reduce environmental damage from the region's rapid economic growth. The project components and the ADTA were designed to meet the environmental improvement objectives of the PRC and ADB. The subprojects were selected from the investment opportunities available at the time and matched the objectives of the Shanxi provincial government's 9th Five-Year Plan and the PRC Government's Trans-Century Green Engineering Program.

The companies involved in the subprojects had championed them for the PRC's energy and environmental investment pipeline and have demonstrated their ownership in several ways. The ADB-supported coking plant in Taiyuan began commercial operations several months ahead of schedule. The implementing agency in the Datong heating subproject continued expanding and improving operational efficiency of the city's heat distribution network after the subproject was completed. In Yangquan, the gas supply companies have been extending their

gas supply networks; and the CBM/CMM capture and storage facilities were designed to support additional gas capture with increasing coal production expected in the coming years.

**Effectiveness.** The project is rated *effective* in achieving the objectives, outputs, and outcomes. The Taiyuan and Yangquan subprojects achieved the overall intended outputs at appraisal. The Datong subproject has exceeded them. Based on the best available estimates, the outcomes in coal savings and emission reductions have been to a large extent achieved. However, the coal reduction level per unit of gas sales achieved is 32% lower than the appraisal targets for the Yangquan subproject. In Datong, the subproject customers occupy 30% more floor space than was estimated at appraisal, made possible by not having to set up two peak-load boilers but off-taking heat from a combined-heat-and-power (CHP) plant set up by a power company. When this additional service area is taken into account, the coal savings and emission reductions are in keeping with appraisal estimates.

The attempt to introduce emissions permit trading in Taiyuan through the ADTA in 2001 was not implemented as envisaged. At best, it was useful in sensitizing stakeholders, including the Taiyuan EPB, other Taiyuan city government bureaus, and large emitters in the area, to the need for completing crucial groundwork before reintroducing SO<sub>2</sub> ET. After the satisfactory completion of the ADTA, and the conduct of pilot trading, the SO<sub>2</sub> emissions permit trading did not take off. Among the many possible reasons, several are considered important and have led to some concerted action towards putting in place the following prerequisites for a successful, sustainable relaunching of SO<sub>2</sub> ET: (i) the reduction of total SO<sub>2</sub> emissions to a level so that year-to-year reduction targets at the enterprise level are gradual, (ii) the creation of a credible SO<sub>2</sub> emission monitoring system, and (iii) an increase in the pollution levy so that it acts as a deterrent to polluters.

**Efficiency.** The project is rated efficient rather than highly efficient. This rating takes into account economic and environmental benefits, capacity utilization, and implementation delays. Including environmental benefits, the reevaluated economic internal rate of return (EIRR) of all three subprojects exceeds 12%. In the case of the Taiyuan subproject, it is higher than 12% even without quantifying the environmental benefits even though coal gas prices have not changed. This is mainly because TCGC, as market leader, can influence the prices of the subproject's main product, coke, and of such chemical by-products as coal tar and benzene. These prices are not controlled by the government.

Without environmental benefits, the EIRRs of the Datong and Yangquan subprojects are below 12%, reflecting the fact that output prices, such as district heating service tariffs and CBM/CMM gas sales prices, have not increased since the subprojects came onstream. Nonetheless, the Datong subproject's reevaluated EIRR (without environmental benefits) is above 11% and it provides significant local environmental benefits. When a value based on available data is put on these environmental benefits, the reevaluated EIRR rises to almost 19%. The EIRR for the Yangquan subproject exceeds 12% if willingness to pay is considered rather than the prevailing CBM/CMM gas prices. The subproject companies report that consumers' willingness to pay for the CBM/CMM gas services is higher than the prevailing price and that customers would accept a proposed tariff increase of 30%.

The project began to deliver its full overall benefits to users later than originally planned. The Taiyuan subproject began commercial operations only 9 months behind the original schedule, whereas the Datong and Yangquan subprojects were delayed by 24 and 27 months respectively. Technical design changes necessitated time-consuming approval processes, including those required from ADB.



**Sustainability.** The project's three subprojects are *likely to be sustainable* from pricing, financial, market, institutional, and natural resource availability perspectives. The financial reevaluation shows that only the Taiyuan subproject has a financial internal rate of return (FIRR) above the weighted average cost of capital (WACC), although the rate did fall marginally after completion. The FIRRs for the Datong and Yangquan subprojects are below the WACC but the companies concerned have continued to be financially viable because of budgetary support from city governments and government "price coordination", whereby city and provincial price control bureaus take the concerns of the stakeholders into account before approving price revisions. Despite the low FIRR, the Datong District Heating Company has continued to close inefficient, mostly old and small coal-fired boilers even beyond the end of ADB subproject support. All three gas supply companies in Yangquan have been expanding their networks and connecting new consumers even after the subproject ended. Nevertheless, the subproject companies in all three cities have made or are now making attempts to win approval for price increases.

The subproject companies have sought to build customer satisfaction and improve service quality so that clean energy products and services are available to customers. This has substantially improved their accounts receivable situation. They have maintained capacity utilization at high levels and improved operational efficiencies. The subproject companies possess strong technical and engineering skills. This made it possible to achieve the project's institutional strengthening objectives at less than 25% of the cost estimated at appraisal. The subproject companies have continued capacity building measures since project completion. They have established well-structured systems to enhance skills in managerial, technical, financial, information technology, and other disciplines.

The unchanged regulated prices of the clean energy products and services provided by the three subproject companies since the subprojects came on stream indicates the opportunity for continued policy dialog at the central and provincial levels. Among others, the objective of such policy dialog is to encourage the use of appropriate pricing signals to consumers for sustenance of environmental improvement subprojects and the need to ensure financial viability of the subproject companies (to attract investment in such subprojects). The sustenance and expansion of the concerned enterprises can also be enhanced through capacity building at the provincial level for pricing of environmentally friendly utilities (such as those offered through the three subprojects).

**ADB, Borrower, and Executing Agency Performance.** The EA successfully coordinated the execution of three distinct types of subprojects in three different cities. However, environmental benefits, including indoor air quality improvement have not been monitored and the prices of outputs and services of the subprojects have not been adjusted when necessary, although covenanted in the project agreement. It is recognized that neither is within the reasonable control of the EA. As such, the overall performance of the Borrower and the executing agency (EA) is rated *partly satisfactory*. ADB's performance is rated *satisfactory*.

## **Other Assessments**

The project's institutional, environmental, and socioeconomic impacts are *significant*. The project management office set up by the Shanxi provincial government to facilitate project implementation has continued since project completion to provide project management services to a large number of other projects, including some supported by ADB. The subproject companies have shown through activities since project completion that the ADB support

strengthened their ability to execute their mandates with improved technologies, systems, skills, and managerial capabilities. The Taiyuan subproject has set the stage for other coking units in Shanxi province to modernize and set up more efficient and environmentally friendly coking facilities. The Datong District Heating Company and the three gas supply companies in Yangquan continue to build on the work and capacity building achieved under the project

**Environmental and Social Impacts.** The project has helped bring about an improvement in ambient air quality in the three cities in recent years. In Yangquan, SO<sub>2</sub> concentration levels met Class II ambient air quality standards for more than 300 days for the first time in 2007. Taiyuan and Datong achieved these levels the next year. To quantify the project's contribution to these improvements precisely is difficult because other measures have also been put into place, including the shutdown of heavy industrial polluters. Nonetheless, the Datong environment protection bureau acknowledges that the ADB-supported subproject is one of the principal reasons for that city's improved ambient air quality. The selection criteria for the subprojects had included the potential to improve indoor air quality. However, no substantive data or information on indoor air improvement is available from either the city environment protection bureaus or the subproject companies. No pending resettlement issues are reported. The Taiyuan and Yangquan subprojects led to increased employment opportunities during construction and operation. In Datong, the implementing agency reported that no jobs were lost.

### **Issues, Lessons, and Follow-Up Actions**

The project has raised three important issues. First, prices of subproject outputs and services need to be adjusted, at least when per-capita incomes are rising rapidly. Second, the environmental benefits expected from the subprojects on an overall basis, per unit of output or service, and the implications for indoor air quality improvements all need to be estimated more closely. Third, project planning must address prerequisite conditions before reintroducing SO<sub>2</sub> emission permit trading on a sustained basis.

The main lessons from the project are (i) that economically attractive ways to increase coal use efficiency and to substitute coal by gases are available from coal operations like mining and coking; (ii) that, while setting prices in a controlled or regulated market is difficult, the long-term viability of the service provider needs to be considered for items that are desirable alternatives; (iii) that environmental benefits from subprojects that are designed to substitute coal use or utilize coal more efficiently are better assessed through monitoring and measurements that cover the entire range of coal quality, stock of coal using equipment and stock of substitute fuel using equipment; and (iv) that the design of market-based instruments is seldom easy and that continued sensitization of the concerned stakeholders is useful.

On the basis of these findings and lessons, the proposed follow-up actions and recommendations are as follows:

S.No.	Follow-Up Actions	Responsibility	Time Frame
1.	<p><b>Sustainability.</b> Continue policy dialogue with responsible authorities in follow-on engagements to revise prices of clean products and services, such as coal gas, CBM/CMM, and centralized district heating, by focusing on:</p> <ul style="list-style-type: none"> <li>• Highlighting the financial and other consequences of a non-remunerative tariff regime to for provincial and city price control bureaus.</li> <li>• Surveys that help assess willingness to pay for various customer categories, with findings provided to the price control bureaus</li> </ul>	EARD	2010
2.	<p><b>Monitoring.</b> Actively facilitate an improved assessment of environmental benefits of investments in clean energy subprojects by the subproject companies and other enterprises.</p>	EARD	2010

CBM/CMM = coal-bed-methane/coal-mine-methane, EA = executing agency, EARD = East Asia Department, ET = emissions permit trading, PRC = People's Republic of China, PSOD = Private Sector Operations Department, SO<sub>2</sub> = sulfur dioxide.

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## I. INTRODUCTION

### A. Project Description and Expected Results

1. The Shanxi Environment Improvement Project, approved in December 1999,<sup>1</sup> included Asian Development Bank (ADB) support for three clean energy subprojects. Subproject 1, a coal gasification plant in Taiyuan city, supplied coal gas to industrial, commercial, and residential consumers and public welfare buildings<sup>2</sup> to replace high-pollution coal use. Subproject 2 involved an energy-efficient centralized district heating system in Datong city that provides heat to residential and commercial users during the 5.5-month local heating season. Subproject 3, a coal-bed-methane/coal-mine-methane (CBM/CMM) capture, storage, transmission, and distribution system in Yangquan city, supplied CBM/CMM gas to industrial, commercial, and residential energy consumers to substitute for coal. The project included a capacity-building component for the project management office (PMO), considered to be the executing agency (EA), as well as the three implementing agencies in the three cities.

2. The project's long-term impact was to enhance the sustainable development of these three major Shanxi cities by improving the quality of their environments (Appendix 1). The immediate intended outcomes were (i) greater use of cleaner forms of energy by industrial, commercial, and residential users; (ii) improved air quality in the cities and reduced atmospheric emissions of sulfur dioxide (SO<sub>2</sub>), nitrogen dioxide (NO<sub>2</sub>), and total suspended particulates (TSP) or particulate matter of less than 10 microns in diameter (PM<sub>10</sub>). This impact and these outcomes were to be achieved by focusing project activities on reversing a trend of declining air quality in the cities that was attributed largely to increasing coal use for power generation and industrial, commercial, and residential applications.

3. The project also included advisory technical assistance (ADTA) for setting up and operating a SO<sub>2</sub> emissions permit trading (ET) system in Taiyuan city.<sup>3</sup> This market-based instrument was meant to encourage pollution reduction at minimal cost.

### B. Evaluation Purpose and Process

4. The three subprojects support clean energy technologies and options. Two were aimed at replacing coal as a fuel and the third was intended to reduce coal use through energy efficiency and conservation. Although the stated project outcomes relate to air pollutant emissions that affect local air quality—SO<sub>2</sub>, NO<sub>2</sub>, and TSP or PM<sub>10</sub>—the report and recommendation of the President (RRP) recognized that the subprojects would also reduce emissions of greenhouse gases. The findings and lessons learned from this evaluation provide useful insights for the design of similar projects in other developing member countries and on the coal use savings that can be achieved through these three types of subprojects. The inputs for this report were also used for an evaluation study that focused on greenhouse gas implications of ADB's operations.<sup>4</sup> The findings from the ADTA to reduce SO<sub>2</sub> emissions in Taiyuan city through the introduction of the SO<sub>2</sub> ET system have also been useful for the design of further interventions to introduce SO<sub>2</sub> ET in the People's Republic of China (PRC).

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<sup>1</sup> ADB. 1999. *Report and Recommendation of the President on a Proposed Loan and Technical Assistance Grant to the People's Republic of China for the Shanxi Environment Improvement Project*. Manila (Loan 1715, for \$102 million, approved on 7 December).

<sup>2</sup> Unless otherwise specified, commercial energy consumers include public welfare building energy users.

<sup>3</sup> ADB. 1999. *Technical Assistance for the People's Republic of China for the Shanxi Air Quality Improvement (financed from the Japan Special Fund)*. Manila (TA 3325, for \$700,000, approved on 7 December).

<sup>4</sup> ADB. 2009. *Evaluation Knowledge Brief: Greenhouse Gas Implications of ADB's Energy Sector Operations*. Manila.

5. A desk review of the RRP, the project completion report (PCR)<sup>5</sup> and other documentation available at ADB headquarters was followed by an evaluation mission to consult with and gain information from the EA, the implementing agencies, and other relevant government ministries, offices, and bureaus in Beijing and Shanxi province. The draft project performance evaluation report was shared with the East Asia Department, the governments of the PRC and Shanxi province, the executing agency, and the implementing agencies for feedback and comment.

### C. Project Completion Report

6. The PCR found that the project was *successful*. The strong commitment of the project proponents was a key factor. Responsiveness to needs and opportunities to make technical design changes to improve the intended project outcomes played a role. So did implementing agencies' ability to properly administer the bidding process and to select and manage international and national consultants. The PCR recommended that ADB keep track of developments related to the implementation of SO<sub>2</sub> ET. Given that the technical assistance on heating tariff reforms<sup>6</sup> contains recommendations relevant to the district heating subproject in Datong, the PCR also recommended that ADB should continue consultations with the PRC government on this matter.

7. The PCR highlighted the fact that the heating and gas tariffs had not been increased to achieve full-cost recovery. It proposed continuous follow-up with the Shanxi Provincial Government (SPG) on needed tariff increases of CBM/CMM gas supplied by the Yangquan subproject but made no similar recommendation regarding coal gas and district heating tariff increases needed in Taiyuan and Datong. The PCR also should have emphasized the fact that no effort were being made to assess the environmental benefits that might be directly attributed to the subprojects or to adequately monitor improvements in indoor air quality.<sup>7</sup>

## II. DESIGN AND IMPLEMENTATION

### A. Formulation

8. In 1997, the government of PRC requested ADB assistance to improve the environment in Taiyuan and other major cities in Shanxi province. In response to this request, ADB provided project preparatory technical assistance (PPTA) to (i) explore the need for policy and institutional reforms required to reduce air pollution, and (ii) examine the feasibility of investment programs as the basis for a project that ADB could support.<sup>8</sup>

9. The PPTA assessed (i) the environmental problems in Shanxi province<sup>9</sup> and province-wide environmental plans; (ii) the existing institutional structure in the governments of the PRC and Shanxi province; and (iii) policies and regulations, including national laws and their application in Shanxi province, and provincial regulations and environmental monitoring in Shanxi. The PPTA

<sup>5</sup> ADB. 2006. *Project Completion Report on the Shanxi Environment Improvement Project in the People's Republic of China*. Manila (Loan 1715, for \$102 million, approved on 7 December 1999).

<sup>6</sup> ADB. 2001. *Technical Assistance to the People's Republic of China for Pro-Poor Urban Heating Tariff Reforms*. Manila (TA 3673 for \$850,000, approved on 19 June).

<sup>7</sup> In spite of the fact that indoor air pollution reduction was a key subproject selection criterion at appraisal (RRP, para. 60).

<sup>8</sup> ADB. 1997. *Technical Assistance to the People's Republic of China for Shanxi Environment Improvement (financed from the Japan Special Fund)*. Manila (TA 2901, for \$590,000, approved on 21 October).

<sup>9</sup> Problems included air quality in Shanxi's major cities was much below national and international ambient air quality standards, water resources were seriously polluted, serious noise and solid waste pollution, uncontrolled soil pollution that lead to serious land deterioration, and land subsidence and water leakage caused by coal mining.

found that to improve environmental conditions the stakeholders must focus on (i) improving the regulatory framework, (ii) enhancing institutional capacity to implement environmental protection measures and manage environmental problems, and (iii) investing in pollution prevention.

10. **Improving Regulatory Framework.** Environmental laws and regulations formulated by the national government are adopted by the provincial governments. ADB's technical assistance support has contributed towards this process.<sup>10</sup> The environmental laws and regulations formulated at the national level and adopted by SPG include (i) specific measures, such as closure of highly polluting enterprises; (ii) environmental standards, on ambient air quality, for example; (iii) environment improvement targets, including those for SO<sub>2</sub> emissions; (iv) specific guidelines on such matters as environment impact assessments; and (v) administrative and institutional arrangements. When formulating a law or regulation, the Government of the PRC could seek ADB's technical assistance on related social, economic, financial, technical, institutional, and/or environmental aspects. In pursuit of this objective, the project included an ADTA to provide guidance and insights for the introduction of a market-based mechanism for SO<sub>2</sub> emission reduction.

11. **Enhancing Institutional Capacity.** The capacity-building component of the loan supported the SPG's aim to put suitable administrative structures and institutional arrangements in place that would help (i) implement policies and regulations pertaining to economic growth and environmental protection and (ii) achieve national, provincial, and local plans and targets for environmental management.<sup>11</sup> The SPG's project management skills were enhanced through staff for the newly established project management office (PMO). The technical, operational, and managerial skills base of the implementing agencies was also upgraded. Through the ADTA, the Taiyuan Environmental Protection Bureau's (EPB) appreciation and understanding of the issues related to a successful implementation of a SO<sub>2</sub> ET also improved.

12. **Investing in Pollution Prevention.** ADB support for a small number of subprojects required to meet the environmental improvement targets accounted for a major share of the loan. Over 40 candidate subprojects included in SPG's 9th Five-Year Plan (FYP) and the national government's Trans-Century Green Engineering Program (TCGEP)<sup>12</sup> were reviewed. A shortlist was prepared of projects that were (i) based in urban areas to serve as prototypes for the rest of the province; (ii) air pollution reduction projects, rather than water or soil pollution prevention undertakings; (iii) comprehensive projects rather than point source projects; and (iv) projects with implications for indoor air quality improvement. The three subprojects finally selected also met other criteria, which required (i) that the concerned institution have sufficient technical capability to implement the subproject, (ii) that the technical design conform with proven technologies available at the time, and (iii) that the economic evaluation and financial analysis show that the projects were economically efficient and financially viable.

## B. Rationale

13. Several factors contributed to the project's rationale. The PRC was heavily dependent on high-polluting coal, which in the late 1990s met about 80% of its energy demand. Shanxi province,

<sup>10</sup> Two instances: (i) ADB. 1995. *Technical Assistance to the People's Republic of China: Strengthening the Environmental Standards and Enforcement Policies (financed from the Japan Special Fund)*. Manila (TA 2505, for \$600,000, approved on 22 December); and (ii) ADB. 1998. *Technical Assistance to the People's Republic of China for Provincial Legislation on Environmental Protection and Natural Resources Conservation (financed from Norway)*. Manila (TA 3123, for \$300,000, approved on 15 December).

<sup>11</sup> The provincial plans and targets may be same or more aggressive than national plans and targets; likewise, local and city-level plans and targets may be same or more aggressive than national plans and targets.

<sup>12</sup> A comprehensive master plan of environmental projects prepared by the national government.

a major coal producer, was similarly dependent. The strong emphasis on achieving economic growth in the country since the early 1980s had not come with adequate attention to deteriorating environmental conditions. Many state-owned enterprises (SOEs) deployed antiquated, inefficient energy technologies. The PRC suffered from weak environmental management capabilities that were evident in many ways, including inadequate emission and air quality monitoring.

14. In Shanxi province, the problem was compounded by the large number of highly polluting, energy intensive mineral-based and chemical industries as well as several small and large coal-fired power plants. Coal combustion in small boilers for commercial and residential use contributed significantly to air pollution. TSP concentrations exceeded levels permitted under Class II standards in 14 of the 15 cities reviewed by Shanxi provincial EPB in the late 1990s, and exceeded levels permitted under Class III standards in seven cities. SO<sub>2</sub> levels exceeded Class II permitted levels in nine of these cities.<sup>13</sup> Taiyuan, Datong, and Yangquan were among the most seriously polluted cities in the country.

15. Although residential coal use accounted for a small share of overall coal consumption and pollutant emissions in the province, it was the major contributor to indoor air pollution and the associated health problems. The two strategies given priority at the time to reduce indoor air pollution in Shanxi were the development of (i) district heating systems to replace coal combustion for residential heating; and (ii) gas supply networks<sup>14</sup> to replace coal combustion for residential cooking and some of the heating in residential, commercial, and public buildings.

### **C. Cost, Financing, and Executing Arrangements**

16. At appraisal, the project was estimated to cost \$183 million (including contingencies, interest and other loan charges during construction), comprising \$102 million (56%) in foreign exchange costs and \$81 million equivalent (44%) in local currency costs. The actual project cost was \$182 million, which was in line with the appraisal estimates. Foreign exchange costs of \$99 million were about 3% lower than envisaged at appraisal, while local currency costs of \$83 million were 2% higher. Loan savings from some components were reallocated to other components to expand their scope and improve their efficiency.

17. The PMO was responsible for monitoring and guiding the implementing agencies as well as coordinating with ADB, various government agencies, and other entities. It was set up initially under the provincial EPB but was later shifted to the Shanxi Provincial Development Reform Commission to strengthen its outreach. The efficacy of the PMO's role was also high because it reported directly to the deputy governor of Shanxi Province, who also chaired a high-level project steering committee.

18. The Taiyuan Coal Gasification Company (TCGC) was the implementing agency for the subproject in Taiyuan, the second phase of the Taiyuan Coal Gasification Plant (TCGP). The actual foreign currency costs of TCGP, at \$61.51 million, were lower than the \$69.39 million appraisal estimates by more than 11%, largely due to lower than expected prices from international competitive bidding and foreign exchange rate gains. Good contract management

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<sup>13</sup> Class II air quality standards are set for residential, general industrial, and agricultural areas. Class III standards are for specified industrial areas. Permitted annual average TSP levels are 200 and 300 micrograms/cubic meter for Class II and Class III standards, respectively. Permitted annual average SO<sub>2</sub> concentrations are 60 and 100 micrograms/cubic meter for Class II and Class III standards, respectively.

<sup>14</sup> For natural gas, coal gas, and CBM/CMM gas (whichever is available).

and information and data management practices also facilitated timely and coordinated execution of the subproject.<sup>15</sup>

19. Datong District Heating Company (DDHC) was the implementing agency for the Datong District Heating Project (DDHP). The increase in overall costs, including foreign currency costs for DDHP—from the equivalent of \$38.11 million at appraisal to the equivalent of \$40.29 million actually incurred—was due to a change in the technical design of the subproject that connected more customers to the centralized district heating system.

20. The Shanxi Yangquan Gas Company was created to handle implementing agency responsibilities for the Yangquan subproject and it coordinated the implementation of four components.<sup>16</sup> Upon completion, the components were handed over to the respective companies—the Yangquan Coal Mining Group (YCMG), the Yangquan City Gas Company (YCGC), the Pingding Gas Company (PGC), and the Jiaoqu Gas Company (JGC). The total costs increased from \$22.60 million at appraisal to \$25.21 million, with an increase of foreign currency costs of less than \$500,000 and a local cost increase of over \$2 million. Minor changes in scope resulted in higher costs for civil works, which increased local costs for the Yangquan subproject.

21. The financing plan at appraisal comprised an ADB loan for \$102.0 million (56%), equity contributions from the provincial and municipal governments of \$58.0 million (32%), and local borrowings of \$23.0 million (12%). Actual funding came from ADB (\$99.0 million or 54%), equity and customers' deposits (\$76.3 million, or 42%), and domestic loans (\$6.7 million, or 4%). Deposits collected from customers allowed lower local borrowings. A key aspect was the restructuring of TCGC's parent company, the Taiyuan Coal Gasification Group (TCGG), in 1998 to form the Shanxi Shenzhou Coking Company Limited (SSCCL) and the listing of SSCCL on the Shenzhen Stock exchange in 2000. The Shanxi Shenzhou Coking Company Limited raised equity through the public listing of its shares (40%) to address the local funding issue for the subproject. As a result, TCGC, had access to funds raised from the capital markets, which enabled it to avoid high-cost borrowing from a local bank for the subproject. Project costs and financing plans are detailed in Appendix 2.

22. The ADTA was implemented with active participation of the Taiyuan EPB, which provided coordination support for training of personnel from selected power plants and industrial enterprises, and for simulated trading and pilot trading.

#### **D. Design**

23. The overall project design did not change. Nor did the scopes and objectives of the three subprojects. The technical designs for the Datong and Yangquan subprojects were modified from the originally approved feasibility studies. The changes in the Datong subproject enabled DDHP to increase the overall heating service area to 6.59 million square meters (m<sup>2</sup>) from 5.1 million m<sup>2</sup> without installing two high-efficiency peak-load boilers. This was possible because another utility company planned to establish a high-efficiency 400 megawatt (MW) combined heat and power (CHP) facility, from which the DDHC was to source the requisite heat in the form of hot water. In Yangquan, the 20,000 cubic meters (m<sup>3</sup>) CBM/CMM storage tank

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<sup>15</sup> Forty-three bids were managed through 5 rounds. They comprised 25 international competitive bidding (ICB) equipment packages and 18 international shopping materials packages.

<sup>16</sup> The four components comprise (i) the Wukuang gas station, which collects gas from a coalmine belonging to the Yangquan Coal Mining Group; (ii) the Beijiao storage station of the YCMG's Yangquan City Gas Company ; (iii) the Songjiazhuang gas storage station in Pingding county; and (iv) control stations, regulating stations, and gas distribution pipelines of the YCGC, the Jiaoqu Gas Company, and the Pingding Gas Company.



originally planned for Jiaoqu township was replaced by a 50,000 m<sup>3</sup> tank in Pingding county. This changed the gas pipeline configuration. Appendix 3 provides further details on the three subprojects and their respective implementing agencies.

24. Although the design of the SO<sub>2</sub> ET system<sup>17</sup> did not change, the work done to introduce that market-based instrument for environmental improvement brought to the forefront (i) some important changes required in the monitoring of pollutant emissions, and (ii) necessary pre-conditions such as that the pollutant emissions from all sources in a given area should be at or less than the environmental capacity<sup>18</sup> of that area—so that the ET system can be deployed to enable enterprises to reduce their SO<sub>2</sub> emissions gradually.

## **E. Implementation Schedule**

25. The Loan Agreement was signed on 27 November 2000, nearly 1 year after loan approval on 7 December 1999. This was due largely to the delays in obtaining approval of the feasibility reports from the former State Development Planning Commission (now National Development and Reform Commission), which in turn resulted from concerns over local currency financing, especially for the coal gasification subproject in Taiyuan. Another 6 months elapsed before the loan became effective on 25 May 2001, mainly because this was the first ADB financed project in Shanxi province. The SPG and the implementing agencies found it difficult to understand the procedures and requirements for finalizing relending agreements and to compile the required legal documentation.

26. Once implementation began, the TCGP was completed several months ahead of the planned 4-year implementation period. The first coke battery unit was commissioned on 30 April 2004 and reached design capacity in 6 weeks. The second coke battery unit was commissioned on 26 August 2004 and reached design capacity within 2 weeks.

27. The other two subprojects suffered implementation delays, however. The principal reasons were the (i) unwillingness or inability of foreign consultants and foreign equipment suppliers and contractors to visit the PRC during parts of 2003 and 2004, owing to the severe acute respiratory syndrome (SARS) scare; and (ii) time required to obtain approvals from various bodies, including ADB, to implement changes in subproject technical designs. After technical design changes in 2003, the DDHP subproject became fully operational only by the end of 2005. This was 2 years later than envisaged at appraisal, although a major portion was completed by the 2004–05 winter heating season. In Yangquan, the technical design changes delayed the start of commercial operations at the three gas storage stations by more than 2 years, or until May 2006.

## **F. Procurement and Construction**

28. The project awarded 74 contract packages for materials, equipment supply, and installation, with a combined value of \$93.0 million. Procurement followed ADB's *Guidelines for*

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<sup>17</sup> In principle, stabling an SO<sub>2</sub> ET system has a number of basic steps. SO<sub>2</sub> emission permits are allocated to various polluting enterprises. A system is put in place to track SO<sub>2</sub> emissions from each polluting enterprise. A system is also put in place to track the sale and purchase transactions of SO<sub>2</sub> emission permits. For the ET system to function smoothly, SO<sub>2</sub> emission permits must be allocated in a manner that is perceived as fair by all stakeholders. Clear, practical guidelines are also needed to facilitate verification of emissions.

<sup>18</sup> Environmental capacity of a city is defined as the level of SO<sub>2</sub> emissions beyond which the ambient air quality in the city will not meet the stipulated Class II ambient air quality standards. In the PRC, Class II standards are set for residential, general industrial and agricultural areas; and stipulate that the annual average SO<sub>2</sub> concentration should not exceed 60 micrograms per cubic meter.

*Procurement.*<sup>19</sup> ADB's loan also funded international consultants' services as well as training. The three subprojects followed a similar overall approach. They engaged (i) local contractors for civil works and installation; (ii) equipment suppliers to supervise the installation, testing, and commissioning for equipment procured through international competitive bidding route; and (iii) international consultants, largely to work in close coordination with the implementing agency team and to guide, advise, and assist the team in the review of technical designs, preparation of bid documents, bid evaluation, and in supervision of some aspects of construction, equipment installation, testing, and commissioning.

## G. Outputs

29. The project was implemented as envisaged at appraisal. It comprised three subprojects—a coking plant, district heating efficiency improvement and coal mine methane capture and use (Appendix 1).

30. The outputs of these subprojects are summarized in Table 1. The output data shows that (i) the quantity of coal gas available for end-user sale from the TCGP subproject has been close to the design value of 175 million m<sup>3</sup> in each year since 2006, (ii) the DDHP subproject has been operated at 100% capacity and provided heat for 6.59 million m<sup>2</sup> of floor area for three consecutive years; and (iii) the components of the Yangquan subproject combined to reach a 100% capacity factor in terms of increased CBM/CMM gas sales of 49.5 million m<sup>3</sup> for two consecutive years.

**Table 1: Subproject Inputs and Outputs**

Item	2004	2005	2006	2007	2008
Taiyuan subproject					
- Coal feed (million tons)	177	692	743	804	730
- Coal gas production (million m <sup>3</sup> )	44	290	380	398	358
- Coal gas sales (million m <sup>3</sup> )	33	134	176	185	166
- Coke ('000 tons)	232	530	564	599	542
Datong subproject					
- Heat purchase from Datong Pingwang CHP (million GJ)	0.95	2.37	4.73	4.73	4.73
- Heat sales (million GJ)	0.91	2.28	4.55	4.55	4.55
- Heat sales (million m <sup>2</sup> ; useful floor area)	1.32	3.30	6.59	6.59	6.59
Yangquan subproject					
- CBM/CMM capture from Coal Mine No. 5 (million m <sup>3</sup> )		29.6	40.5	52.5	52.5
- CBM/CMM sales (million m <sup>3</sup> )		27.9	38.2	49.5	49.5

CBM/CMM = coal-bed-methane/coal-mine-methane, CHP = combined heat and power, GJ = gigajoule, m<sup>2</sup> = square meter, m<sup>3</sup> = cubic meter.

Sources: TCGC, DDHC, YCGC, PGC, and QGC.

31. The TCGP does maintain data separately for the ADB supported subproject, although only combined data for the ADB supported subproject and the first phase coking plant of TCGP is made available to TCGC for consolidation. In Datong, the data specific to the ADB supported DDHP is also maintained separately, even though the DDHC has continued to expand and improve the efficiency of its heat supply network. In Yangquan, the YCMG maintains data specifically for CBM/CMM gas captured from Coal Mine No. 5, as well as storage and delivery data, and YCGC has separate metering arrangements for gas off-take from YCMG. YCGC,

<sup>19</sup> Equipment with a contract value of \$500,000 or more was procured following ICB procedures, while equipment with a value below \$500,000, but not less than \$50,000, was procured using international shopping procedures. For further details, refer to PCR (pages 8, 9, 40, 41).

however, cannot allocate the actual gas sales volumes through its network back to each of its supply sources.<sup>20</sup>

## H. Loan Covenants

32. Most of the loan covenants have been complied with. The covenants that were not complied with at completion related to tariff adjustments and maintaining accounts receivables within acceptable limits. The status update regarding continued non- or part-compliance is as follows:

- (i) *Tariff adjustment (PA, Schedule, para. 13)*. Tariffs for coal gas supply (Taiyuan), district heating services (Datong) and CBM/CMM gas capture, storage, and supply (Yangquan) have not been raised since the ADB-supported subprojects came onstream. This has adversely impacted the financial viability and economic attractiveness of the subprojects.
- (ii) *Accounts receivables management (Project Agreement [PA], Schedule, para. 17)*. On a month-to-month basis, accounts receivables have not been maintained below the covenanted level of the equivalent of the previous 2 months' sales for any of the subprojects. However, the subproject companies have not allowed accounts receivables to accumulate unchecked either. For instance, the DDHC, which provides district heating services for 5.5 months per year (1 November to 15 April), collects all billed amounts by the start of the next heating season. DDHC also bills the well-off households<sup>21</sup> only once each heating season after considering the cost of billing and collection as well as customers' ability to pay a 5.5 month bill at once.

33. The covenants that had been partly complied with at completion relate to the financial stability of the subproject companies.<sup>22</sup> They involve (i) maintaining the ratio of current assets to current liabilities at 1.1 or more (PA, Section 2.18); and (ii) retaining funds from operations to provide for current operations, as well as maintaining reserves to finance at least 20% of annual capital investment requirements after 31 December 2003 (PA, Schedule, para. 19). The lack of tariff increases since project completion has continued to hamper the subproject companies' ability to meet such covenants. Nonetheless, by December 2008, the TCGC had repaid the entire loan amount and interest to ADB. The DDHC sets aside depreciation reserve and relies on budgetary allocations from the Datong city government to meet its capital investment requirements. YCGC has not been in a position to fully comply with these requirements, even though all three gas supply companies in Yangquan continue to expand their operations.

34. A covenant that is stated to have been complied at completion but is no longer complied with relates to the monitoring of environmental benefits associated with the ADB subprojects (PA, Schedule, para. 24). The SPG was to provide to ADB an annual benefit monitoring and evaluation report for 5 years after the commissioning of project facilities. This report was to have

<sup>20</sup> YCGC has a large gas transmission and distribution pipeline system, which sources gas from a gas storage tank near Coal Mine No. 5, one of the components of the Yangquan subproject, and from four other sources. At each offtake point, YCGC has appropriate metering arrangements. The comingled gas from the five sources is then sold to its customers and supplied to PGC and QGC. It is not possible for YCGC to work out the actual sales—i.e., offtake less pipeline loss—of CBM/CMM coming from Coal Mine No. 5.

<sup>21</sup> High income households comprise over 60% of the DDHC's customer base.

<sup>22</sup> This refers to (i) the two implementing agencies in Taiyuan (TCGC) and Datong (DDHC) that also operate and maintain the respective subproject facilities in the two cities; and (ii) the four facility operators (YCMG, YCGC, PGC and JGC) in Yangquan that were handed the Yangquan subproject upon completion.

been based on individual subproject benefit monitoring and evaluation reports prepared by each implementing agency. No such report has been provided to ADB.<sup>23</sup>

## I. Policy Setting and Framework

35. Since the loan approval in 1999, the basic stated strategy of the Government of the PRC has been to balance economic growth with environmental protection. The government sets environmental protection policies in the country and makes the regulations. It also establishes the standards for pollutant emissions, ambient air quality, and indoor air quality, as well as the monitoring methodologies. All such regulations and measures are implemented across the country through an institutional and administrative structure that relies on a mix of (i) pollution prevention and the remedy of major pollution problems, (ii) the polluter-pays principle; and (iii) enforcement. The details are provided in Appendix 4. The provincial governments can either implement the standards and targets as set by the Government of the PRC or make them more stringent or ambitious.

36. The Government of the PRC's national pilot program on emissions permits in 1991–1997 led the Taiyuan city government to issue Rules on Environmental Offsets for Air Pollutants in 1993. This initiative in turn led to the ADTA grant to introduce SO<sub>2</sub> ET, which provided some learning and insights for policy making.

## III. PERFORMANCE ASSESSMENT

### A. Overall Assessment

37. The overall performance of the project is rated as *successful* on the basis of Independent Evaluation Department's four-category evaluation criteria of relevance, effectiveness, efficiency, and sustainability (Table 2). The project is *highly relevant*. This is evident from the project design, which is consistent with the PRC's environmental protection policies and programs initiated in the 1990s as well as with ADB's objectives of supporting projects that reduce coal consumption and adverse environmental effects of economic growth. The project is *effective* because it meets the targeted outputs in Taiyuan and Yangquan and exceeds the target in Datong; however, the actual coal savings per unit of gas supply or district heating service are significantly lower than initially estimated in Datong and Yangquan. The project is also *efficient*, despite the prevailing tariffs and especially if environmental benefits are considered. The project is *likely to be sustainable* as government price coordination coupled with budgetary support is likely to ensure that (i) capacity utilization levels remain high; and (ii) systematic and well-structured approaches continue to upgrade managerial, technical, financial, information technology, and other skills.

**Table 2: Overall Performance Assessment**

Item	Weightage	Rating	Score
Relevance	20%	Highly relevant	3
Effectiveness	30%	Effective	2
Efficiency	30%	Efficient	2
Sustainability	20%	Likely	2
<b>Overall Rating<sup>a</sup></b>		<b>Successful</b>	<b>2.2</b>

<sup>a</sup> Highly successful  $\geq 2.7$ , Successful  $2.7 > S \geq 1.6$ , Partly Successful  $1.6 > PS \geq 0.8$ , Unsuccessful  $< 0.8$ .  
Source: Independent Evaluation Mission.

<sup>23</sup> The evaluation mission is given to understand that similar covenants in other project loans have not been complied with either.

## B. Relevance

38. The project is *highly relevant* in terms of consistency of project impacts, outcomes, and outputs with the government's development strategy, ADB's strategic objectives, ADB's lending strategy, as well as adequacy of formulation and design.

39. **Consistency with PRC Priorities and Objectives.** The PRC developed several environmental protection programs during the 1990s after emissions of major pollutants peaked in 1995<sup>24</sup> (Appendix 4). At the time, Shanxi province experienced acute environmental degradation—a direct consequence of being a major coal producing and coal consuming province<sup>25</sup>. Its capital, Taiyuan, had the worst air quality in the country in 1999 and ranked among the 10 most polluted cities in the world. Two other cities in Shanxi—Datong and Yangquan—also ranked among the most polluted cities anywhere.<sup>26</sup> In response, the SPG included major investments for pollution prevention and control in its (provincial) 9th FYP. It specifically emphasized air quality improvement goals for Taiyuan, Datong, and Yangquan.

40. With the PRC's growing attention since 2000 to balancing economic growth with environmental protection, the project relevance was enhanced as (i) two subprojects were to substitute use of highly polluting coal in households, commercial and industrial enterprises by less polluting gases and; (ii) one subproject was to improve the efficiency of coal burning, thereby reducing the production of coal emissions.

41. **Consistency with ADB Strategic Objectives and Country Partnership Strategy.** Although the ADB's operational strategy for the PRC at the time of the project's approval incorporated broader objectives of reducing power shortages, it also included environmental protection objectives—in particular, the development of cleaner energy sources such as gas, hydropower, and clean-coal technologies.

42. The project, approved in December 1999, included ADB support for three types of subprojects that have since been pursued and replicated in the PRC. ADB has also approved further loans to support implementation of the these components—a coking plant that generates coal gas for sale,<sup>27</sup> district heating efficiency improvement,<sup>28</sup> and coal mine methane capture and use.<sup>29</sup> The three subprojects met the design requirements and were consistent with the project objectives and goals.

43. **Ownership of Subprojects.** The three subprojects clearly conformed to the objectives of the Shanxi Provincial 9th FYP and the TCGEP. They were selected from the pipeline of investment opportunities available at the time and screened by the project preparatory technical

<sup>24</sup> As quoted in ADB. 2003. *Country Strategy and Program (2004–2006), People's Republic of China*. Manila (October).

<sup>25</sup> Shanxi produces about one-third of the PRC's coal.

<sup>26</sup> The levels of harmful emissions from heavy industries, as well as household stoves, boilers, and commercial furnaces that burn coal were 2 to 3 times the national standards. The release of CBM/CMM into the atmosphere, instead of using it as an energy source, compounded the problem in Yangquan.

<sup>27</sup> ADB. 2009. *Completion Report: Acid Rain Control and Environmental Improvement Project in the People's Republic of China* (draft, September). Manila (Loan 1890, for \$147 million, approved 19 December 2001; coking plant included during project implementation).

<sup>28</sup> Loan 7279/2422-PRC: Dolkia Asia Pte. Ltd. (Dolkia Asia) and local partners, for \$200 million, approved on 2 June 2008.

<sup>29</sup> ADB. 2004. *Report and Recommendation of the President on a Proposed Loan to the People's Republic of China for the Liaoning Environmental Improvement Project*. Manila (Loan 2112, for \$70 million, approved on 25 November); and ADB. 2004. *Report and Recommendation of the President on a Proposed Loan to the People's Republic of China for the Coal Mine Methane Development Project*. Manila (Loan 2146, for \$117.4 million, approved on 20 December).

assistance consultants. There was strong ownership from the SPG and the three city governments. The SPG provided sufficient assurances at approval that consumers would convert to the new energy sources. It proposed a mix of (i) direct compensation to end user to buy gas using stoves and equipment and (ii) setting tariffs that encouraged fuel switch. In all three cities, the SPG also saw that coal-using equipment was discarded and/or dismantled through physical verification. The Taiyuan EPB worked to increase the knowledge base of its personnel and of large emitters in Taiyuan City. It also introduced SO<sub>2</sub> emission permits trading on a pilot basis.

### C. Effectiveness

44. The project is rated *effective* in achieving the objectives, outputs, and outcomes. The key outputs and outcomes of the three subprojects are summarized in Table 3. The Taiyuan and Yangquan subprojects achieved the overall intended outputs at appraisal (paras. 29–31). The Datong subproject has exceeded the intended output. Based on the best available estimates, the outcomes in coal savings and emission reductions have also been to a large extent achieved. However, the coal reduction level per unit of heat supply service or gas sales achieved is significantly lower than the appraisal targets in two cities (Table 3). In Datong, this is a result of design change. The CHP (from where heat is actually sourced) was set up by another utility company, and the resultant capital cost savings (from not having to install peak load boilers) made it possible to service customers occupying 30% more floor space than was estimated at appraisal under DDHP. When this additional service area is taken into account, the coal savings and emission reductions are in keeping with the absolute value of coal savings as per appraisal estimates. In Yangquan, coal savings are 32% lower than anticipated at appraisal even though the subproject is supplying the envisaged volume of CBM/CMM gas to customers. Given that the CBM/CMM capture, storage, transmission and distribution facilities are performing as per expectations, this discrepancy is most likely a consequence of overestimation at appraisal or underestimation at completion, or a combination of the two. For subprojects in Datong and Yangquan therefore, the appraisal estimates for outcomes and environmental benefits per unit of service or product output appear to have been rather liberal.

**Table 3: Subproject Outputs and Emission Savings related Outcomes at Approval, Completion, and Independent Evaluation**

City	Project Stage	Outputs	Coal Savings (tons per unit output)	Coal Savings ('000 tons)	SO <sub>2</sub> Emission Reductions ('000 tons)	TSP Emission Reductions ('000 tons)	NO <sub>2</sub> Emission Reductions ('000 tons)
TAI	- At approval	175 mcm coal gas	2,133	373.2	9.6	12.1	NA
	- At completion	156 mcm coal gas	2,513	392.0	10.1	12.8	1.6
	- At evaluation <sup>a</sup>	175.7 mcm coal gas	2,163	380.0	9.8	12.4	1.6
DAT	- At approval	Heat for 5.1 million m <sup>2</sup>	63,529	324.0	4.1	8.2	NA
	- At completion	Heat for 6.59 million m <sup>2</sup>	49,317	325.0	5.2	6.5	1.6
	- At evaluation <sup>b</sup>	Heat for 6.59 million m <sup>2</sup>	52,352	345.0	5.3	4.8	2.6
YAN	- At approval	94 mcm CBM/CMM gas	1,483	139.4	2.4	5.6	NA
	- At completion	94 mcm CBM/CMM gas	813	76.4	1.2	1.1	0.6
	- At evaluation <sup>c</sup>	94 mcm CBM/CMM gas	1,005	94.5	1.5	1.9	0.5

CBM/CMM = coal-bed-methane/coal-mine-methane, DAT = Datong, m<sup>2</sup> = square meter, mcm = million cubic meter, NA = not available, NO<sub>2</sub> = nitrogen dioxide, SO<sub>2</sub> = sulfur dioxide, TAI = Taiyuan, TSP = total suspended particulate, YAN = Yangquan.

<sup>a</sup> Average over 3 years (2006–2008).

<sup>b</sup> Average over 3 years (2006–2008) since subproject output stabilized.

<sup>c</sup> Average over 2 years (2007–2008) since subproject output stabilized.

Source: Report and recommendation of the President, project completion report, and Independent Evaluation Mission findings.

45. **Capacity Building.** The training programs supported through the ADB loan enhanced the technical, operational, and managerial capabilities of the subproject companies, as well as their environmental consciousness. PMO staff attended ADB-sponsored training programs on procurement and project management. Personnel from the subproject companies also received training overseas and within PRC on technical and management aspects (see Appendix 5 for details). During project implementation, over 50 personnel from the three implementing agencies were sent abroad for training in (i) environmental management and protection, (ii) pipeline network operation and security, (iii) network planning and strategy, and (iv) other relevant technical and management aspects. In addition, more than 700 of these agencies' personnel received training locally on technical matters, finance and accounting, computers, and personnel administration. The ADTA for Taiyuan EPB improved its institutional capabilities for SO<sub>2</sub> emissions permit trading.

46. **Customer Satisfaction.** Prices of coal gas, district heating services, and CBM/CMM gas have not increased since the subprojects were completed in the three cities. Subproject companies report that this has contributed to high customer satisfaction. While it may be argued that one of the project objectives was to give customers confidence to switch to new fuels in Taiyuan and Yangquan and to a centralized and more distant system of heat supply in Datong, it is also true that the subproject companies and the government bureaus have not sent the right pricing signals to consumers that would encourage efficient and minimally wasteful energy use.

47. **Ambient Air Quality.** At the time of loan approval and loan effectiveness, the air in the cities of Taiyuan, Datong, and Yangquan met national Class II ambient air quality standards for very few days in a year—only 7 during the whole of 2001 in Yangquan City, for example (para. 72). Since then, the air quality has improved consistently with each passing year. Along with the three subprojects, other measures and initiatives (Appendix 4) have contributed to such air quality improvement. In Datong, it is acknowledged that the ADB-supported subproject is one of the principal reasons for improved ambient air quality. In Taiyuan and Yangquan however, the contribution of the ADB-supported subprojects is perceived as being somewhat lower.<sup>30</sup>

#### D. Efficiency

48. Given the high capacity utilization and significant environmental benefits, the project is rated *efficient*. It is not considered highly efficient due to subproject implementation delays. The economic reevaluation that assesses the economic internal rate of return (EIRR) associated with the three ADB-supported subprojects is detailed in Appendix 6. The economic reevaluation results presented in Table 4 show that at prevailing tariffs, the EIRR's are: 14.6% for the Taiyuan subproject, 11.2% for the Datong subproject, and 7.8% for the Yangquan subproject. However, given that the willingness to pay for CBM/CMM gas in Yangquan is assessed to be about 30% more than the prevailing tariff,<sup>31</sup> the EIRR is considered to be 12.6%. With addition of estimated environmental benefits, the EIRRs increase to 20.7%, 18.9% and 16.2% for the Taiyuan, Datong and Yangquan subprojects respectively.

49. A direct comparison with economic analyses conducted at appraisal is possible at best only for the Taiyuan subproject. This is because technical design changes in the Datong subproject resulted in a 30% increase in output, with a 6% increase in capital costs, and the

<sup>30</sup> A plausible explanation is the per-capita coal savings in the urban areas of the three cities; which is about 228 kg of coal savings per capita in Datong compared to 130 and 141 kg/capita in Taiyuan and Yangquan, respectively.

<sup>31</sup> Although the Independent Evaluation Mission is not aware of any formal analysis to assess the level of willingness to pay, the subproject companies in Yangquan are of the opinion that the proposed tariff increase of 30% would be acceptable to consumers, and is therefore a good indicator of the willingness to pay.

technical design changes for the Yangquan subproject, which brought no change in output, contributed to delays and cost increases by about 12%.

50. The total capital costs of the TCGP declined by 3% from appraisal estimates. This reduction came despite delays in beginning construction and high steel prices in the international markets when construction began. The ICB procedures that TCGC followed were in line with established best practices for bid management and produced lower-than-anticipated bids that reduced foreign exchange costs by more than 10%.

51. The economic reevaluation results can be compared with those from economic analyses conducted at completion and provided in the PCR. For the Taiyuan subproject, the reevaluated EIRR is marginally higher than at completion—even though coal gas prices have not changed since the subproject began commercial operations.<sup>32</sup> For Datong and Yangquan subprojects, the reevaluated EIRRs are less than at completion, which reflects the fact that such output prices as district heating service tariffs and CBM/CMM gas sales prices have not increased since the subprojects came onstream.

**Table 4: Economic Internal Rates of Return of Subprojects at Completion and at Independent Evaluation (%)**

Item	At Completion			At Independent Evaluation		
	TAI	DAT	YAN	TAI	DAT	YAN
Without Local Environmental Benefits						
- Direct economic costs and benefits)	14.5	19.0	16.1	14.6	11.2	7.8
- Direct economic costs and proxied benefits						12.6
With Local Environmental Benefits	19.6	28.3	18.8	20.7	18.9	16.2

DAT = Datong, TAI = Taiyuan, YAN = Yangquan.

Sources: Project completion report and Independent Evaluation Mission estimates.

52. **Subproject Implementation.** The three subproject companies adopted similar implementation approaches. They imported equipment selectively. As much as possible, they engaged domestic institutes for engineering design and procured equipment from indigenous sources. They engaged international consultants only for specific, well-defined tasks and had their own personnel work closely with them to enable knowledge transfer. They maximized staff learning opportunities during construction through direct interaction with equipment suppliers, contractors, and consultants. Specific details available for the TCGP are provided in Appendix 3.

53. The project experienced time overruns. The delays were about 9 months for coal gas supply in Taiyuan, 12–24 months in Datong and 9–27 months in Yangquan. In Datong, a part of the centralized district heating system completed 12 months late by end of 2004 could service customers in the 2004–2005 heating season; other customers suffered a 24-month delay. In Yangquan, the various components of the CBM/CMM gas capture and supply subproject were commissioned between late 2004 and March 2006. The effect of these delays have already been taken in to account in the EIRR estimation.

54. **Capacity Utilization and Efficiency of Gas and Heat Supply Operations.** The subproject companies have worked towards maintaining high capacity utilization levels and improving the operational efficiencies of their systems. The ADB- supported second phase of TCGP has averaged a little over 175 million m<sup>3</sup> annually in 2006–2008. As of 2009, the DDHP had continuously off-taken the contracted amount of heat from the CHP to serve its customers

<sup>32</sup> The principle reasons are (i) prices of coke and other by-products are market determined; and (ii) coal (the main feedstock) is internally sourced, and is priced so as to optimize the profitability of the Group (TCGG).



for three consecutive heating seasons and has reduced system heat losses. The three gas supply companies in Yangquan also received and supplied the agreed quantity of CBM/CMM gas in 2007 and 2008. Further details are in Appendix 3.

## E. Sustainability

55. The project is rated *likely to be sustainable*. Sustainability of the various subprojects has been considered from the pricing, financial, market, institutional, and natural resource perspectives. An assessment of various risks associated with continued delivery of the products and services from the three subprojects shows that, other than pricing related aspects, such risks were sufficiently well addressed by the project.

56. **Pricing and Financial Viability.** Table 5 shows the weighted average cost of capital (WACC) for the three subprojects, their financial internal rates of return (FIRR) as estimated at project completion, as well as the reevaluated FIRRs. The basis for the reevaluation is detailed in Appendix 6. The financial reevaluation shows the pre-tax FIRRs are higher than WACC for 2 subprojects, but slightly below WACC for Yangquan. The post-tax FIRRs for the Datong and Yangquan subprojects are below WACC.

**Table 5: Financial Internal Rates of Return of Subprojects at Completion and at Independent Evaluation (%)**

Item	At Completion			At Independent Evaluation		
	Taiyuan	Datong	Yangquan	Taiyuan	Datong	Yangquan
WACC	4.4	4.3	4.3	4.4	4.3	4.3
FIRR before Tax	13.8	10.7	9.1	12.8	5.1	4.1
FIRR after Tax	10.5	8.1	6.9	9.9	3.5	3.1

FIRR = financial internal rate of return, WACC = weighted average cost of capital.

Sources: Project completion report and Independent Evaluation Mission estimates.

57. The prices and tariffs of the coal gas in Taiyuan, the centralized heating services in Datong, and the CBM/CMM gas in Yangquan are not market-driven. Controlled by the government, they have remained unchanged since the subprojects came onstream. The reevaluated FIRR for the Taiyuan subproject remains near that at completion and the implementing agency remains financially viable because it can realize market prices for its primary product, coke, and other by-products. In Datong, the implementing agency had accumulated financial losses of CNY87.5 million by 2008. The Datong city government has extended a financial subsidy of CNY61.3 million thus far and directly services DDHC's debt to ADB. In Yangquan, where the financial viability of the three subproject gas supply companies is also adversely affected by low controlled prices, the city government has routinely budgeted a subsidy payment of CNY4.4 million per year.<sup>33</sup>

58. Yet the subproject companies in Datong and Yangquan have continued to function like financially healthy enterprises. A key is "price coordination"—i.e., the balancing of concerns of the various stakeholders—by the city and the provincial price control bureaus (PCB) before approving any price revisions. The DDHC has continued to close inefficient, mostly old and small coal-fired boilers and setting up more heat exchange stations (HES), as well as adding heat-carrying pipelines upstream of the stations, beyond the completion of the ADB supported subproject. Likewise, all three gas supply companies in Yangquan have been expanding their networks and connecting new consumers even after the Yangquan subproject ended.

<sup>33</sup> The entire city government subsidy goes to YCGC each year. JGC and PGC do not receive subsidies from the Government.

Nevertheless, the subproject companies in all three cities have made or are making attempts to win approval for price increases (Table 6).<sup>34</sup> It is also noteworthy that tariffs of the more widespread and established utility services—water and electricity—have been considered affordable by the respective PCBs during the same period and have increased for certain customer categories. (See Appendix 7 for further details).<sup>35</sup>

**Table 6: Status of Petitions to Raise Subproject Output Tariffs**

Subproject	Existing Tariff	Petition Particulars	Status
Taiyuan	Bulk supply tariff for coal gas sale from TCGP to TCGG's gas supply company: CNY0.26/cubic meter (m <sup>3</sup> )	Submitted to Taiyuan PCB in 2008; proposed tariff increase to CNY0.35/m <sup>3</sup>	Approval expected from provincial PCB in 2009.
Datong	For all customer categories: CNY3.82 per square meters (m <sup>2</sup> ) of useful area	Submitted to Datong PCB in 2007	Clearance obtained to increase tariff for commercial and public welfare customers (to CNY7.00 and 6.30 per m <sup>2</sup> of building area); Not yet implemented. Clearance to increase tariff for households awaited.
Yangquan	Residential: CNY0.55/m <sup>3</sup> Public Welfare: CNY0.70/m <sup>3</sup> Commercial: CNY0.85/m <sup>3</sup> Industrial: CNY0.50/m <sup>3</sup>	Withheld petition to Yangquan PCB in 2008 owing to financial crisis;	Planning to submit petition in 2009 to increase prices by about 30%

CNY = yuan, PCB = price control bureaus, TCGG = Taiyuan Coal Gasification Group, TCGP = Taiyuan Coal Gasification Plant.

Source: Implementation agencies in Taiyuan and Datong; gas supply companies in Yangquan.

59. **Customer Service Orientation and User Perspective.** The subproject companies have sought to build customer satisfaction and improve service quality so that clean energy products and services are continuously available to customers. This has substantially improved their accounts receivable situation. TCGC reports over 99% satisfaction from the end users of coal gas, which in all likelihood also results from the fact that coal gas prices have remained unchanged since 1 April 2003 when only the first phase of the TCGP was in operation. It also reflects the perceived convenience and cleanliness associated with using coal gas rather than coal for cooking and water heating. CBM/CMM gas users in Yangquan are willing to pay the gas supply companies for their services for much the same reasons. In Datong, the customer satisfaction reflects the high quality of service that allows the maintenance of an indoor temperature in the 18–20°C range without hurting the local or indoor air quality.<sup>36</sup>

60. The subproject companies have instituted mechanisms for conducting annual customer satisfaction surveys and obtain feedback on quality and reliability of services as well as safety aspects. They also attend promptly to customer complaints. Further details are provided in Appendix 3.

<sup>34</sup> Among the key factors that the PCBs consider in pricing is the fact that price controlled services/products of all three subprojects are clean and help meet the environmental protection objectives.

<sup>35</sup> Available data shows that annual gross domestic product per capita increased about 17% in Taiyuan and Yangquan from 2004 to 2007 and by 14% in Datong. Sources: China Statistical Press, 2008 and 2006, *Shanxi Statistical Yearbook*, Taiyuan.

<sup>36</sup> The Independent Evaluation Mission understands that prior to the implementation of DDHP, when heat began to be sourced from a distant CHP, some customers were served heat via pipeline from small, inefficient coal-fired boilers in their neighborhoods, while others had their own small indoor heat sources.

61. **Skills.** The subproject companies possess strong technical and engineering skills. This made it possible to achieve the project's institutional strengthening objectives at less than 25% of the cost estimated at appraisal. Formal training programs during project implementation (Appendix 5) were combined with hands-on experience in project management and other construction-related activities. The subproject companies have continued capacity building measures since project completion. They have implemented well structured systems to enhance skills in managerial, technical, financial, information technology, and other disciplines. See Appendix 3 for further details.

62. **Natural Resource Availability.** Even though the subprojects are intended to replace or reduce the use of coal, all three remain dependent on the continued production and supply of coal. The Taiyuan subproject is fed by coking coal; the heat source of the Datong subproject is fed by steam grade coal; and the Yangquan subproject captures gases released during coal-mining operations. Available data shows that coal production levels in Shanxi province since 2005 have remained in the range of 500 to 630 million tons per year and may rise to 650 million tons in 2009. At these rates, the province has enough coal reserves for more than 200 years.<sup>37</sup> It has 56% of PRC's total proven coking coal reserves.<sup>38</sup>

## F. Technical Assistance

63. The attempt to introduce emissions permit trading in Taiyuan through the ADTA nearly a decade back was *partly successful*. It can at best be considered useful in terms of having sensitized stakeholders, including the Taiyuan EPB, other Taiyuan city government bureaus, and large emitters in the area, to the need for making necessary preparations before re-introducing SO<sub>2</sub> ET.

64. After the satisfactory completion of the ADTA and the conduct of pilot trading, SO<sub>2</sub> emissions permit trading did not take off. A number of reasons have been suggested for this. Experience elsewhere, including in the United States, shows that SO<sub>2</sub> ET is useful in reducing pollution levels only gradually. However, since the time the ADTA was approved and implemented in 2001–2003, the Taiyuan EPB has had aggressive plans for reducing SO<sub>2</sub> emissions.<sup>39</sup> Among the other factors important for successful implementation of SO<sub>2</sub> ET is the need to have a credible SO<sub>2</sub> emission monitoring system in place. The prevailing pollution levy must also be increased so that it acts as a deterrent to polluters. Some concerted actions are being taken on these shortcomings. The major achievements of the ADTA are given in Appendix 8.

## IV. OTHER ASSESSMENTS

### A. Impact

65. The project's institutional, environmental, and socioeconomic impacts are *significant* at the local, city, provincial, and national levels.

<sup>37</sup> China Statistical Press, 2006 and 2008, *Shanxi Statistical Yearbook*, Taiyuan.

<sup>38</sup> Source: TCGC.

<sup>39</sup> The Taiyuan EPB set SO<sub>2</sub> emission targets at 185,000 tons/year for 2005 and 100,000 tons/year for 2010 (a 46% reduction in 5 years),

## 1. Impact on Institutions

66. **Executing Agency.** The project management office set up by the Shanxi provincial government to facilitate implementation has continued since project completion to provide management services to a large number of other undertakings, including some supported by ADB and other international development partners. It is now facilitating the implementation of the ADB-supported Coal Mine Methane Development Project.

67. **Subproject Companies.** While the Government of the PRC had initiated a comprehensive series of environmental policies and regulations in the 1990s, and the Ministry of Environmental Protection MEP had also begun setting national level targets for pollution emission and discharge reductions, the implementation challenge had remained. The three ADB supported subprojects provided the opportunity to successfully demonstrate pollution abatement measures by improving the quality of outputs and services that have high replication potential as well as widespread economic and environmental benefits. ADB support has enabled the subproject companies to better execute their mandates even after project completion with improved technologies, systems, skills, and managerial capabilities. The details of institutional impacts of the subproject companies are given in Appendix 3.

68. **Taiyuan EPB.** Recognizing that reduction of SO<sub>2</sub> emissions to about or below the city's environmental capacity—after which SO<sub>2</sub> emissions at the enterprise level need reduce only gradually—as being essential to sustained interest in SO<sub>2</sub> emissions permit trading, the Taiyuan EPB set an aggressive target, to reduce SO<sub>2</sub> emissions to 100,000 tons per year by 2010. This target is much more ambitious than the 155,000 tons per annum target set for 2010 by the SPG's EPB (Appendix 8). Taiyuan is the only city in Shanxi province which has a SO<sub>2</sub> pollution reduction target for 2010 that reflects the city's environmental capacity.

69. The Taiyuan EPB has undergone a massive transformation in its pursuit of this target. It has<sup>40</sup> succeeded in encouraging all 79 key emitting enterprises in Taiyuan<sup>41</sup> to set up continuous and/or on-line pollution emissions and concentration monitoring facilities. It has established a network of eight stations in Taiyuan for monitoring ambient air quality.<sup>42</sup> It has set up the computer and communication facilities and acquired the skills and expertise necessary for a central station to receive data from all monitoring stations and key emitters in real time. It conducts periodic and surprise sample checks on about 200 non-key emitters in Taiyuan City. Taiyuan EPB compiles the relevant information on a daily basis for transmittal to the Shanxi Provincial EPB. From such data compiled on a daily basis and aggregated monthly, quarterly, and yearly, Taiyuan EPB can ascertain whether emissions from enterprises comply with their pollution discharge permits.

70. The prevalent pollution levy regulation stipulates (i) a discharge fee of CNY0.62 (less than \$0.10) per kg of SO<sub>2</sub> equivalent and (ii) a penalty fee that is normally 3-4 times higher. The details for determining the discharge fee and penalty fee payments are in Appendix 4. The regulation caps the total annual payments at about CNY100,000 (less than \$15,000). Given that the SO<sub>2</sub> abatement cost is higher than the penalty rate for many enterprises, they have by and large preferred paying the pollution charges to making emission reduction investments. This may remain the case unless physical targets are set, can be monitored by the concerned EPB, and the threat of closure becomes real. For this reason, discharge fees and penalty rates have been

<sup>40</sup> Facilitated key emitting enterprises to install continuous online monitoring systems, to the extent that Taiyuan EPB verifies/calibrates the system after it is installed, which makes the enterprise eligible to receive a 20% subsidy compensation from the Shanxi Finance Bureau.

<sup>41</sup> Comprising iron and steel, coal mining, chemicals and power generation enterprises.

<sup>42</sup> Air samples are taken every 10 seconds and automatically analyzed.

increased in some parts of the PRC, notably in the vicinity of Beijing. Similar increases in Shanxi province and other parts of the country are anticipated in the next few years.

71. Among several other issues that must be addressed if SO<sub>2</sub> emissions permit trading is re-introduced in the Taiyuan city area is the need for all enterprises to perceive the allocation of permits between various industrial sectors and companies as fair. A system to reallocate permits as enterprises expand, merge, divest, or acquire would also be necessary.

**2. Environmental Impacts**

72. **Ambient Air Quality.** The project has helped bring about a well-documented improvement in ambient air quality in the three cities in recent years (Table 7). In Yangquan, SO<sub>2</sub> concentration levels met Class II ambient air quality standards for more than 300 days for the first time in 2007. Taiyuan and Datong achieved these levels the next year. This was a major improvement from earlier years; in 2001, for instance, Class II standards were met for only 45 days in Datong and 7 days in Yangquan. To quantify the project's contribution to these improvements precisely is difficult because in the same cities other measures have also been put into place since project appraisal, including the shutdown of heavy industrial polluters (Appendix 4). Nonetheless, the Datong environment protection bureau acknowledges that the ADB-supported subproject is one of the principal reasons for that city's improved ambient air quality (para. 46).

**Table 7: Number of Days/Year the Ambient Air Quality Met Class II Standards<sup>a</sup>**

Year	Taiyuan	Datong	Yangquan
2005	245	220	225
2006	261	239	275
2007	269	293	319
2008	302	307	345

<sup>a</sup> Class II Standards are set for residential, general industrial, and agricultural areas; see Appendix 4 for ambient air quality standards.  
Source: Taiyuan Environmental Protection Bureau (EPB), Datong EPB, and Yangquan EPB.

73. **Indoor Air Quality.** The selection criteria for the subprojects included the potential to improve indoor air quality and, given that all three subprojects helped reduce coal use, it may be inferred that indoor air quality for customers serviced in the three cities has also improved with resultant health benefits. However, no substantive data or information on indoor air quality improvement is available from either the city environment protection bureaus or the subproject companies.<sup>43</sup> Nonetheless, an assumption of an improvement in indoor air quality is supported by the findings of studies conducted for households in the Beijing area (Appendix 9).

**3. Socioeconomic Impacts**

74. **Resettlement.** No pending resettlement issues are reported. Resettlement issues associated with the project were addressed in accordance with the PRC laws and regulations. The land acquisition and resettlement process is reported to have been completed by 2005. A consultative and participatory approach was instituted by the PMO and the concerned local

<sup>43</sup> The Independent Evaluation Mission could not confirm that indoor air quality measurements had been carried out to establish a baseline before the subprojects had been tested and/or commissioned or that any measurements had been made after the subprojects had begun commercial operations.

government bureaus, and suitable grievance mechanisms were set up for all subprojects. Further details are in Appendix 10.<sup>44</sup>

75. **Employment.** The Taiyuan and Yangquan subprojects led to increased employment opportunities. As per TCGC, about 1,000 additional jobs can be attributed to the ADB-supported subproject (i) to operate the second phase of the TCGP, whose coking capacity of 930,000 tons per year is higher than the capacity of the first phase (720,000 tons per year); and (ii) to expand and operate the coal gas distribution network to supply additional customers that consume 175 million cubic meters of coal gas annually.

76. In Yangquan, the additional gas sales that result from capture of CBM/CMM gas from Coal Mine No. 5 are estimated at about 49 million m<sup>3</sup>.<sup>45</sup> YCGC, PGC, and JGC employed more than 1,300 people, including about 130 women, during the subproject implementation phase. The same gas supply companies have employed more than 1,000 people, among them 400 women, since commercial operations began. With continued increases in gas supplies since 2005, the construction and expansion of gas sales service continues in all three gas companies. As a result, YCGC has been able to redeploy personnel from its liquefied petroleum gas sales division to CBM/CMM gas sales after requisite training.

77. In Datong, the implementing agency assured that no jobs were lost. Personnel working in boiler rooms of the small, inefficient boilers were retrained to be deployed in HES or pipeline operations. The DDHC has continued with this approach over the past few years as it continues to dismantle the remaining 280 inefficient boilers in the network and lay pipelines upstream to connect them to large, efficient boilers and CHPs.

78. **Other Socioeconomic Impacts.** All households that<sup>46</sup> have been connected to the gas or heat supply services from the three subprojects have benefited from the absence of tariff hikes. They would have likely continued to use coal for cooking and heating in the absence of the subprojects and been subject to swings in domestic coal prices.<sup>47</sup> In Taiyuan, the urban poor were exempted when coal gas prices were raised in April 2003; they continue to pay CNY0.50/ m<sup>3</sup>; effectively receiving a 33% subsidy from the TCGG's gas supply company.

79. The city governments of Datong and Yangquan have provided budgetary support to the heat and gas supply companies, respectively. This has to a certain extent alleviated the need to raise tariffs. Unchanging gas and heat supply tariffs in times when water and electricity tariffs have risen has contributed to the high level of customer satisfaction reported in the cities. On the other hand, customers have not been getting appropriate price signals to use gas and heat supplies efficiently and avoiding waste.

## B. ADB Performance

80. ADB's overall performance is rated *satisfactory*. The policy dialog under the project focused on supporting the Government of PRC and SPG in the implementation of environmental

<sup>44</sup> All information pertaining to acquisition of land for permanent use or temporarily for subproject implementation is based on information provided by the respective subproject companies. To the knowledge of the independent evaluation mission, no external agency monitored the land acquisition and resettlement process.

<sup>45</sup> This includes: (i) 33.8 million m<sup>3</sup> of additional YCGC sales; (ii) 14.3 million m<sup>3</sup> of PGC sales; and (iii) 1.7 million m<sup>3</sup> of JGC sales.

<sup>46</sup> Defined by the Government of the PRC as households with income levels less than \$30/person/month.

<sup>47</sup> Coal prices in Shanxi province have varied widely each year. Following the closure of several small coal mines after a series of mining accidents in 2007, the prices rose to about CNY800/ton (\$115/ton) in 2008 from CNY560/ton (\$68/ton) in 2005.

protection measures and the strengthening of regulatory enforcement. It included the introduction of market-based instruments for improving environmental management, including the SO<sub>2</sub> ET. Prior to loan effectiveness, ADB provided guidance and advice to SPG<sup>48</sup> and the implementing agencies necessary to prepare the relending documents, consistent with ADB guidelines and procedures. During the implementation phase, ADB monitored the progress through frequent consultations and briefings with the Ministry of Finance, fielded six review missions, spent adequate time reviewing physical progress and resolving issues with implementing agencies staff. ADB also promptly approved changes in the technical designs of subprojects, the reallocation of loan proceeds, and the contracts it financed as well as the necessary loan disbursements. The performance of the ADTA consultant was also rated "excellent" by the Taiyuan EPB. However, available data shows that the ADB overestimated the environmental benefits in two of the three cities, and gave insufficient attention to the monitoring of indoor air quality aspects in all three cities. As a result, suitable empirical data on the indoor air quality improvements from the three subprojects and the associated health benefits is not available today.

### C. Borrower and Executing Agency Performance

81. The overall performance of the Borrower and the executing agency (the PMO) is rated *partly satisfactory*. Support from the governments of PRC and Shanxi province was strong—perhaps because the three subprojects were on the national government's list of approved projects under the TCGEP and also in the SPG's pipeline. The selected subprojects met the agreed criteria.<sup>49</sup> The SPG facilitated their implementation by moving the PMO from the Shanxi provincial EPB to the Shanxi Provincial Development and Reform Commission—the most influential of SPG's bureaus and commissions. Although some of the delay for loan effectiveness is ultimately attributed to the availability of counterpart local funding, the SPG and the city governments ascertained that financial closure could be reached by making commitments of up to \$58 million equivalent, or 32% of the estimated cost.

82. Subproject output and service prices have not been adjusted when necessary, as agreed to by the SPG during loan processing (as per PA, Schedule, para. 13), even though the respective subproject companies made the necessary attempts to do so. As a result, the gas and heat supply enterprises are not able to recover full costs<sup>50</sup> or to increase consumer awareness about the true economic costs of the products and services they now receive to substitute or reduce the use of coal. Nonetheless, the city governments of Datong and Yangquan have extended budgetary support to help the enterprises continue with their plans to expand the gas and heat supply networks. Although the environmental benefits associated with the subprojects are not being monitored by the respective city EPBs (as per PA, Schedule para. 24), the processes to implement environmental protection measures—closures of high polluting enterprises, for example, and the regular monitoring of key emitters—have been steadily streamlined. It is recognized however, that the implementation of the covenants related to price adjustments and post-completion environmental benefits monitoring were and remain beyond the reasonable control of the PMO, the executing agency.

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<sup>48</sup> In particular, the SPG's Finance Bureau and Legal Bureau.

<sup>49</sup> Subproject selection criteria related to location (in urban areas), environmental improvement (ambient and indoor air quality improvement focus), potential for replication (in several cities), potential for demonstration (of best available technology at the time), and confidence in the concerned implementing agency having technical and managerial strength.

<sup>50</sup> To cover operation and maintenance costs, debt service, depreciation, and to provide an adequate return on investment, this required at least 12% in nominal terms.

## V. ISSUES, LESSONS, AND FOLLOW-UP ACTIONS

### A. Issues

83. **Pricing of Outputs and Services.** Prices of coal gas, CBM/CMM gas, and district heating services have remained unchanged for several years—while the per-capita incomes were rapidly rising. Unchanging end-user prices meant that the output and service providers in Datong and Yangquan had to rely on budgetary support from the respective city government. It is imperative that gas and heat prices be increased for long-term sustainability of the subprojects.

84. **Estimation of Environmental Benefits.** The overall environmental benefits of the Taiyuan and Datong subprojects are more-or-less in line with appraisal estimates. In Datong, due to lower than expected environmental benefits per unit area, the projected environmental benefits are met only by taking into account the additional 30% floor area serviced. The estimated environmental benefits in Yangquan since subproject completion fall significantly short of appraisal estimates. While potential benefits appear to have been overestimated at appraisal, such overestimation may also reflect the quality of the underlying data. The benefits are estimated on the basis of simple coefficients for emissions savings per ton of coal use reduction owing to the three subprojects, as provided by the respective EPBs at project completion. The Independent Evaluation Mission was not informed of any benefits monitoring work since project completion that could have served as a basis for gradually refining the estimated environmental benefits.<sup>51</sup>

85. **Prerequisites for SO<sub>2</sub> ET.** The attempt to introduce SO<sub>2</sub> ET in Taiyuan City has shown that several prerequisites need to be in place before an emissions permit trading system can be sustained. Actual emissions should be at or below the environmental capacity. Mechanisms to reliably monitor SO<sub>2</sub> emissions must be created. Stakeholders must perceive emissions permits allocated to industrial sectors and individual enterprises as fair.

### B. Lessons

86. **Integrated and Holistic View of Coal Industry.** Coal is considered a highly polluting fossil fuel. Where the coking industry produces significantly more coal gas than needed for processing, the coal gas can be distributed to households, commercial and industrial consumers to replace coal—which will reduce emissions of SO<sub>2</sub> and other local pollutants. Where coal mining provides an opportunity to capture and use CBM/CMM gas global environment benefits can be derived from preventing its atmospheric release, and local environmental benefits can be achieved by using CBM/CMM gas as a fuel instead of coal.

87. **Setting Prices of Outputs and Services.** While price setting in a regulated or controlled market is often a balancing act involving multi-faceted concerns, it is important to make the long-term sustainability of the service provider, including investment in its modernization and expansion, one of the prime considerations.

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<sup>51</sup> The coal use savings and emission reductions per ton of coal saved will depend on the quality of coal, the efficiency profile of the stock of coal consuming equipment in use by households/commercial/industrial users before the subprojects came on stream, the efficiency profile of the stock of coal gas using stoves/boilers in Taiyuan after TCGP began commercial operations, the efficiency profile of the stock of CBM/CMM gas using stoves/boilers etc. in Yangquan after the subproject came on stream, and heat plus electrical efficiency of the CHP in Datong. The Independent Evaluation Mission was not informed of a systematic attempt at environmental benefits monitoring that spanned the entire range of energy using equipment and fuel quality.



88. **Successful Implementation of Market-Based Instruments for Pollution Control.** The PRC experience shows that it is difficult to design a market-based instrument and make it work, be widely accepted, and achieve the intended results. The existing pollution levy system in Shanxi was not punitive enough to encourage enterprises to invest in pollution abatement. Experience now makes clear the need for higher discharge fee rates and steps are being taken in that direction. The attempts to introduce the more complex SO<sub>2</sub> emissions permit trading system also highlighted issues that need to be addressed before the SO<sub>2</sub> ET can be successfully implemented. Against this background, enhancing the awareness and sensitization of the stakeholders, including the enterprises and government bureaus at all levels, is very important.

89. **Estimation of Environmental Benefits.** Towards making reasonable estimates of environmental benefits, it is important to give specific attention to emissions estimated before and after the three subprojects began commercial operations in the respective cities. A statistically significant sample of measurements should cover the entire range of fuel quality, type and quality of fuel using equipment, and equipment utilization levels. If necessary, measurements should be taken year-round for certain customer categories, to adequately capture the effects of seasonal variations.

### C. Follow-Up Actions

90. Based on the issues and lessons from the study, the project performance evaluation report makes recommendations and proposes follow-up actions below:

(i) **Sustainability.** Continue policy dialogue with responsible authorities in follow-on engagements to revise prices of clean products and services, such as coal gas, CBM/CMM, and centralized district heating, by focusing on:

- Highlighting the financial and other consequences of a non-remunerative tariff regime to for provincial and city price control bureaus.
- Surveys that help assess willingness to pay for various customer categories, with findings provided to the price control bureaus

(ii) **Monitoring.** Actively facilitate an improved assessment of environmental benefits of investments in clean energy subprojects by the subproject companies and other enterprises. A possible approach would be to institute systems whereby:

- A good baseline for before-project case can be established by conducting appropriate measurements to ascertain (i) quality and quantity of fuel use (e.g., coal), (ii) equipment performance (e.g., stove, boiler), (iii) fuel emission factors (e.g., SO<sub>2</sub> emission per ton of coal), and (iv) indoor air quality measurements.
- At completion of the project, this before-project data could be used along with indicative data for after the follow-on project to arrive at up-front estimates of environmental benefits.
- Post completion, measurements similar to that for establishing the baseline are made. With the before-project and after-project measurement data thus available, estimates for environmental benefits and indoor air quality can be refined.

## PROJECT FRAMEWORK

Design Summary	Appraisal Performance Target/Indicators	Project Achievement
<p><b>Impact</b> Sustainable development of 3 major cities of Shanxi province (Taiyuan, Datong, and Yangquan) by enhancing environmental quality</p>	<ul style="list-style-type: none"> <li>• Number of days that meet Class II standards of ambient air quality</li> <li>• Better institutional framework and other measures for efficient environmental management</li> <li>• More industrial and commercial enterprises meet national emissions standards</li> <li>• Further projects along the lines of the various subprojects in the three cities</li> <li>• Better market based incentives for energy conservation by industrial, commercial and residential energy consumers</li> </ul>	<ul style="list-style-type: none"> <li>• The ambient air quality met Class II standards for more than 300 days per year for the first time (i) in 2008 in Taiyuan and Datong and (ii) in 2007 in Yangquan.</li> <li>• The EPBs of the three cities have made a beginning towards acquiring requisite expertise as well as facilities and equipment to position themselves to better monitor environment, as well as implement targets and measures that are set by the national, provincial, and city governments.</li> <li>• Plans to establish a more sophisticated and efficient coking plant by the Taiyuan IA; continued investment by the Datong IA to expand the centralized district heating system; continued expansion by the Yangquan SFOs to source and supply more CBM/CMM gas.</li> <li>• Increasing commercial orientation of all IA-SFOs, as evident from petitions made to respective government bodies for increases in controlled prices of coal gas (Taiyuan), district heating (Datong) and CBM/CMM gas supply (Yangquan)</li> </ul>
<p><b>Outcome</b> Improved air quality in three cities and reduced indoor air pollution</p>	<ul style="list-style-type: none"> <li>• Coal use reduction targets in the three cities through (i) replacement of coal by coal gas for households, commercial and industrial applications in Taiyuan; (ii) increasing energy efficiency of district heating services in residential and commercial establishments in Datong urban areas; and (iii) replacement of coal by CBM/CMM gas for households, commercial and industrial applications in urban and suburban areas of Yangquan</li> <li>• Targets for SO<sub>2</sub>, TSP and NO<sub>2</sub> reduction as set in the RRP, for each of the cities</li> <li>• Improved institutional</li> </ul>	<ul style="list-style-type: none"> <li>• Average annual coal savings from the three subprojects, of about: (i) 360,000 tons in Taiyuan from 2005 to 2008; (ii) 345,000 tons in Datong from 2006 to 2008; (iii) 94,500 tons in Yangquan from 2007 to 2008. For Taiyuan and Datong, these are essentially in line with estimates made at appraisal—but have been achieved because of 20% higher than anticipated volume of coal gas sales in Taiyuan, and 30% more floor area serviced by centralized heat supplies in Datong. For Yangquan, the actual outcome is 32% less than the appraisal estimate.</li> <li>• Average annual reductions of SO<sub>2</sub>, TSP and NO<sub>2</sub> from the three subprojects, of about (i) 7,700 tons, 9,800 tons and 1,200 tons respectively in Taiyuan; (ii) 5,300 tons, 4,800 tons and 2,600 tons respectively in Datong; and (iii) 1,500</li> </ul>

Design Summary	Appraisal Performance Target/Indicators	Project Achievement
	<p>capacity for sustainable environmental management</p> <ul style="list-style-type: none"> <li>• Policy reform that provides for market based incentives for SO<sub>2</sub> ET</li> </ul>	<p>tons, 1,900 tons and 500 tons in Yangquan. Although substantial reductions in local pollutant emissions have been achieved through the three subprojects, on a per unit of gas sales or district heating service basis, the emissions reductions fall significantly short of appraisal estimates in all three cities.</p> <ul style="list-style-type: none"> <li>• Automated air quality management systems have been installed in EPBs in all three cities. Continuous pollution monitoring facilities have also been installed in all key emitters in Taiyuan, Datong and Yangquan; and a system for regular monitoring of emissions from other emitters has been instituted in all three cities. In addition, the various IA-SFOs have also instituted well-structured capacity building programs on various managerial, technical, financial, and other relevant aspects.</li> <li>• Specifically pertaining to SO<sub>2</sub> ET, (i) the Taiyuan city government passed the SO<sub>2</sub> Emission Trading Management Regulation in 1993, and approved operational guidelines for the setting up of a SO<sub>2</sub> emissions trading enterprise; and (ii) through a comprehensive training program, personnel from 26 large enterprises as well as the Taiyuan EPB gained an understanding of the issues related to SO<sub>2</sub> ET. The reasons behind the little interest in SO<sub>2</sub> ET thus far are also increasingly understood by Taiyuan EPB.</li> </ul>
<p><b>Outputs</b> Taiyuan Coal Gasification</p>	<p>To set up the second unit of a coking plant by December 2003, from which 175 million cubic meters of coal gas is available for sale each year.</p>	<ul style="list-style-type: none"> <li>• Coking unit began commercial operation in August 2004</li> <li>• Has generated a saleable volume of coal gas of about 210 million cubic meter per annum per year (from 2005 to 2008)</li> </ul>
<p>Datong District Heating</p>	<p>To have an improved and efficient centralized heating system in parts of urban Datong by December 2003 that services residential and commercial customers with a combined floor area of 5.1 million square meters</p>	<ul style="list-style-type: none"> <li>• Centralized heating subproject began operating partially in the 2004–2005 heating season, and began full commercial operations by the 2005–2006 heating season.</li> <li>• Following design changes (to source heat from a CHP, and to not set up two large coal-fired boilers), serves residential and commercial customers with a combined floor area of 6.59</li> </ul>

Design Summary	Appraisal Performance Target/Indicators	Project Achievement
		million square meters. Has sustained full capacity utilization for three consecutive heating seasons.
Yangquan Coalbed Methane	From December 2003, to supply CBM/CMM gas captured from Coal Mine No. 5 to residential, commercial, and industrial customers in urban and suburban Yangquan.	<ul style="list-style-type: none"> <li>• Various components of this subproject (including three CBM/CMM storage tanks, control stations, monitoring stations, pipelines) were commissioned between late 2004 to mid-2006, and began full commercial operation in the second half of 2006.</li> <li>• Design changes affected the capacity of CBM/CMM storage tanks but not the volume of CBM/CMM capture from Coal Mine No. 5.</li> <li>• Since beginning commercial operations, the capture of CBM/CMM gas is as per appraisal estimates, as are sales volumes.</li> </ul>
Institutional Strengthening	Training in project management to PMO and training in various aspects of managerial, technical, and other matters to IAs	<ul style="list-style-type: none"> <li>• Given the resident technical skills available within the IAs, the institutional strengthening budget was not fully utilized.</li> <li>• PMO staff attended ADB-sponsored training programs on project management and procurement.</li> <li>• 51 personnel from the IAs received 745 person-days of training overseas on environmental management and protection, pipeline network operation, network planning and strategy, and other relevant technical and managerial aspects.</li> <li>• 716 personnel from the IAs received nearly 37,000 person-days of training within the country on technical, finance and accounting, information technology, and other relevant aspects.</li> </ul>
SO <sub>2</sub> Emissions Trading System in Taiyuan	Assist the SPG to develop an emissions trading system for SO <sub>2</sub> , and modify the existing pollution levy system to ensure the sustainability of environmental improvement measures.	<ul style="list-style-type: none"> <li>• Through consulting services provided by overseas and domestic consultants, assisted in sensitization of the stakeholders on the requisite preconditions before SO<sub>2</sub> emissions trading can be implemented successfully and sustained</li> <li>• Also provided a rationale for increasing pollution levies to encourage enterprises to invest in pollution abatement measures.</li> </ul>

ADB = Asian Development Bank, EPB = Environmental Protection Bureau, CBM/CMM = coal-bed-methane/coal-mine-methane, CHP = combined heat and power, ET = emissions permit trading, IA = implementing agency, NO<sub>2</sub> = nitrogen dioxide, PMO = project management office, RRP = report and recommendation of the President, SFO = subproject facility operators, SO<sub>2</sub> = sulfur dioxide, SPG = Shanxi Provincial Government, TSP = total suspended particulate.

## PROJECT COST AND FINANCING SOURCES

**Table A2.1: Project Cost**

Project Component	Appraisal (\$ million)			Actual (\$ million)			Actual/Appraisal (%)		
	FC	LC	Total	FC	LC	Total	FC	LC	Total
Part A Subproject 1: Taiyuan Coal Gasification Plant	69.39	50.90	120.29	61.51	54.57	116.08	89	107	97
Part B Subproject 2: Datong District Heating System	17.81	20.30	38.11	23.33	16.96	40.29	131	84	106
Part C Subproject 3: Yangquan CBM/CMM Capture, Storage and Distribution System	13.50	9.10	22.60	13.99	11.22	25.21	104	123	112
Part D Institutional Strengthening	1.30	0.70	2.00	0.21	0.25	0.46	16	36	23
<b>Total</b>	<b>102.00</b>	<b>81.00</b>	<b>183.00</b>	<b>99.04</b>	<b>83.00</b>	<b>182.04</b>	<b>97</b>	<b>102</b>	<b>99</b>

CBM/CMM = coal-bed-methane/coal-mine-methane, FC = foreign currency component, LC = local currency component.

Source: Implementing Agencies, PCR.

**Table A2.2: Financing Sources**

Project Component	Appraisal (\$ million)				Actual (\$ million)				Actual/Appraisal (%)			
	ADB Loan	Commercial Bank Loan	Own Resources	Total	ADB Loan	Commercial Bank Loan	Own Resources	Total	ADB Loan	Commercial Bank Loan	Own Resources	Total
Part A Subproject 1: Taiyuan Coal Gasification Plant	69.39	21.08	29.82	120.29	61.51	0.00	54.57	116.08	89	0	183	97
Part B Subproject 2: Datong District Heating System	17.81	0.00	20.30	38.11	23.33	3.60	13.36	40.29	131	NA	66	106
Part C Subproject 3: Yangquan CBM/CMM Capture, Storage and Distribution System	13.50	1.96	7.14	22.60	13.99	3.11	8.11	25.21	104	159	114	112
Part D Institutional Strengthening	1.30	0.00	0.70	2.00	0.21	0.00	0.25	0.46	16	NA	36	23
<b>Total</b>	<b>102.00</b>	<b>23.04</b>	<b>57.96</b>	<b>183.00</b>	<b>99.04</b>	<b>6.71</b>	<b>76.29</b>	<b>182.04</b>	<b>97</b>	<b>29</b>	<b>132</b>	<b>99</b>

CBM/CMM = coal-bed-methane/coal-mine-methane, FC = foreign currency component, LC = local currency component.

Source: Implementing Agencies, PCR.

## IMPLEMENTATION AGENCIES AND SUBPROJECT DETAILS

### A. The Taiyuan Subproject

#### 1. Taiyuan Coal Gasification Group/Company

1. The Taiyuan Coal Gasification Company (TCGC), which implemented the subproject, has a coking plant that was built in two phases. The first phase coke production facility has a capacity of 720,000 tons of coke. The capacity of the second phase is about 930,000 tons. The second phase was built with ADB support and also produces 504,000 cubic meters (m<sup>3</sup>) of coal gas per day, or 175 million cubic meters (mcm) per year.

2. The TCGC is part of the Taiyuan Coal Gasification Group (TCGG), which was formed in 1981 as a limited liability state-owned enterprise (SOE). TCGG is now a large, well-diversified multi-business entity engaged comprehensively in the coal chain—including coal mining, washing, coking, coal gas, coal chemical products, coal gangue power generation, heating, pipelines, and city gas distribution. All TCGG activities are in Shanxi province and are concentrated largely in the Taiyuan city area. A group restructuring exercise that began in 1998 carved out some group companies to create the Shanxi Shenzhou Coking Company Limited (SSCCL). The SSCCL was listed on the Shenzhen stock exchange by the year 2000. The SSCCL raised equity through the public listing of its shares (40%) to address the local funding issue for the subproject. As a result, TCGC, the implementing agency (IA) for the TCGP, had access to funds raised from the capital markets, which enabled it to avoid incurring high-cost debt from a local bank to execute the subproject.

3. At the time, TCGC included the Taiyuan Coal Gasification Plant (TCGP), which then comprised the first phase of the coking plant. TCGP later implemented the second phase with ADB support. For the construction of TCGP's second plant, TCGC raised more than \$21.08 million equivalent of local currency through the stock exchange, which enabled TCGC to reach financial closure<sup>1</sup>. These funds, along with the equivalent of \$29.82 million from internal resources and equity contributions from SPG and Taiyuan city government and consumer contributions, plus the \$61.51 million from the ADB loan, met the entire capital cost requirements of the ADB-supported subproject.

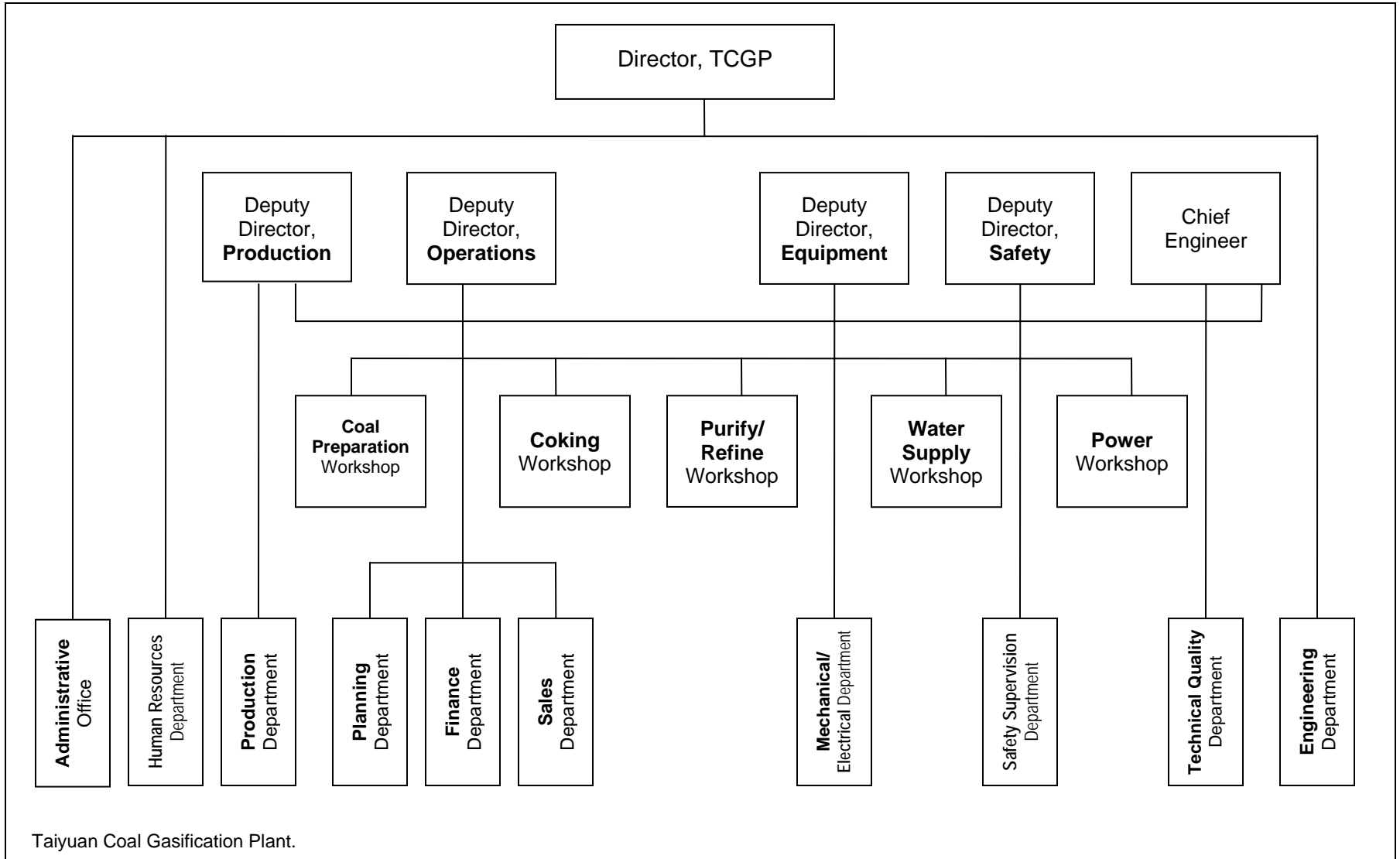
4. The TCGP, which now comprises two coal gasification units, is structured as an independent profit center of the TCGC. Figure A3.1 shows the broad organizational structure of TCGP. The Director of TCGP is supported by deputy directors in charge for production, operations, equipment/technology, and safety, and a chief engineer. The administrative office as well as human resources and engineering departments report directly to the Director. The TCGP management is responsible for the day-to-day operations of the two coal gasification plants and for implementing strategic decisions, including business plans, taken by the TCGG management or/and endorsed by TCGG's Board of Directors.

5. Having gained significant experience in operating this facility over the past five years, TCGC is planning to set up a more advanced, sophisticated 5 million tons per annum coking facility, which will have 7.63 meter high coke oven batteries. In line with its mandate of being an integrated coal-chain enterprise and also assuring fuel and coking coal supplies for its coking plants, the TCGC has ambitious expansion plans to set up of five industrial zones to have integrated production chains comprising coal mining, coking, gasification, coal chemicals, power generation, and gas supply.

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<sup>1</sup> The commercial bank with which financing arrangements had been previously agreed withdrew support after changes in its senior management in January 2000.

Figure A3.1: Organizational Structure of the Taiyuan Coal Gasification Plant



## 2. Capacity Building

6. In addition to the Board of Directors, the Supervisory Committee, and company management, the TCGC's governance system also includes annual shareholders' meetings.

7. TCGC established its integrated management system and internal company policies for capacity building and skills upgradation programs on the basis of the code of corporate governance for listed companies in the PRC. Some of the aspects that provide a backdrop against which TCGC approaches capacity building are elaborated in Box A3.1. In addition, TCGC is engaged in activities that need to be managed according to commercial principles and has established internal company policies and systems for capacity building and skills upgrading. Personnel recruitment, training, and incentive systems are devised on the principles of providing equal opportunity to all and encouraging the best. Training programs are organized for all relevant disciplines (management, strategy/planning, production and operations technology, administration, sales and marketing, customer service, accounting, and financial management etc.) and several hundred person-months of training is provided to TCGP personnel each year. All personnel engaged in production are required to pass through training courses at regular intervals.

### Box A3.1: Background Information for TCGC's Capacity-Building Initiatives

**Operations.** The functions that the TCGP manages in conjunction with TCGC management are: procurement of feedstock/raw materials, product marketing and sales, contracting arrangements with entities outside the TCGG for procurement and sales, and arrangement of finances to meet working capital and other requirements.

**Accounting.** TCGC has established an independent accounting unit (outside the TCGP), which compiles relevant accounting/financial data from all TCGC entities, as per consistent and established accepted accounting principles.

**Marketing and Sales Management.** This enables the tracking of international and domestic market information through sales activities and market research and formulates price adjustment plans as per the prevailing and likely market conditions in the short term. The recommended price adjustment plans are also part of production planning.

TCGC = Taiyuan Coal Gasification Company, TCGP = Taiyuan Coal Gasification Plant.  
Source: TCGC.

## 3. Customer Orientation and User Perspective

8. The TCGP sells coal gas to the TCGG's gas supply company. The latter on-sells gas to the ultimate users. About 550,000 households are supplied coal gas from the two TCGP coking plants. This includes a small number of poor and low-income households, with income levels of less than \$1/person/day. The tariff for poor and low-income households is CNY0.50/ m<sup>3</sup> of coal gas. Other households (more than 95% of the total) pay the normal tariff of CNY0.75/ m<sup>3</sup> of coal gas.

9. The gas supply company conducts a sample survey of its consumers every year to ascertain the level of satisfaction with quality of service. The results for surveys conducted in 2008 and 2009 are presented in Table A3.1. The very high (over 99%) satisfaction regarding the operation and maintenance and billing and collection system likely also reflects: (i) the fact that



coal gas prices have remained unchanged since 1 April 2003 (when only the first phase of the TCGP was in operation); (ii) the convenience of using coal gas rather than coal for cooking and water-heating; (iii) the cleanliness associated with not using coal; and (iv) the freeing of space used previously to store coal.

**Table A3.1: Coal Gas User Survey Findings** (% of satisfied customers)

	<b>Survey in 2008</b> (% of satisfied customers)	<b>Survey in 2009</b> (% of satisfied customers)
Maintenance of Gas Supply System	99.02	99.06
Turnaround time for Pipeline Repair	98.00	98.08
Safety Check	98.63	98.63
Billing/Collection as per Metered Amounts	99.08	99.12
Mode of Bill Payment	98.03	97.95

Note: (i) In 2008, questionnaire sheets were distributed to 1200 customers, of which 1,162 responded; and (ii) in 2009, questionnaire sheets were distributed to 1000 customers, of which 966 responded.

Source: Taiyuan Coal Gasification Company.

#### 4. Taiyuan Coal Gasification Project

10. On 23 December 2001, the construction of the second phase of TCGP was started. On 30 April 2004, the first coke oven batteries were put into operation; on 28 August 2004, the second coke oven battery came onstream. TCGG and TCGC officials report that the TCGP began normal production operations on 1 October 2004. By June 2005, following all necessary certifications<sup>1</sup>, the TCGP subproject went in to full commercial operations. Since then, the plant's technical performance and product quality have consistently met design requirements.

11. Although hundreds of coal gasification and coking plants have been in operation in Shanxi province since the 1980s, the ADB supported subproject (see subproject schematic in Figure A3.2) has unique environmental protection features:

- (i) A special high fence wall was developed, tested, and placed around the coal storage area. This fence wall stops most of the dust that is generated in the coal-storage area from crossing the fence wall<sup>2</sup>. Special light and low-cost materials have been used to develop the fence wall.
- (ii) This the first plant to have 6-meter-high coke oven batteries. It has 100 coke oven batteries. The coke furnace is designed to be suitable for Shanxi coal, the best available equipment at the time the subproject was implemented has been deployed, and the high capacity reduces energy loss and dust emission. The quenching system also collects most gas and dust generated during the quenching process and thus greatly reduces pollutant emissions.
- (iii) The production line is equipped with a full range of coke oven gas treatment processes. The key equipment for the production line is the compressor. Two compressors by KKK of Germany are the only equipment that is imported. The compressors transfer all raw coke oven gas passing through different separators and reactors, and send the purified gas to storage tanks. The compressors also provide gas to the furnace and control the operating pressure of the coke oven, making quality very important. TCGP officials say the two KKK compressors

<sup>1</sup> As per the PRC project completion and acceptance procedures, the subprojects need to be certified by the city fire brigade, the city health services bureau, the provincial production security supervision and management bureau and the provincial environmental protection bureau.

<sup>2</sup> At the same time, the fence does not prevent air flow from outside to inside the fence wall.

have worked very well since the subproject was commissioned, are maintained in good condition, and therefore produce good quality with improved efficiency and reduced pollutant emission. The treatment process can reclaim coal tar, ammonia, sulfur, thiamine, and benzene. The quality of the gas is also improved by removing all the chemicals that are not good for transportation and combustion. The effluent of the treated wastewater can be fully reused for the quenching system.

12. **Implementation.** The international competitive bidding procedures produced lower-than-expected bids, which allowed TCGC to lower its foreign exchange costs. The TCGC consistently followed established practices for bid management, contract management, project supervision, data and information management, construction security, and standardization. It engaged an international consulting firm only to assist with the review of technical design, preparing bid documents, evaluating bids, and supervising some aspects of construction and equipment installation. The main compressors for the coking unit were imported essentially to gain an understanding of the latest technology and to demonstrate its use under local conditions.

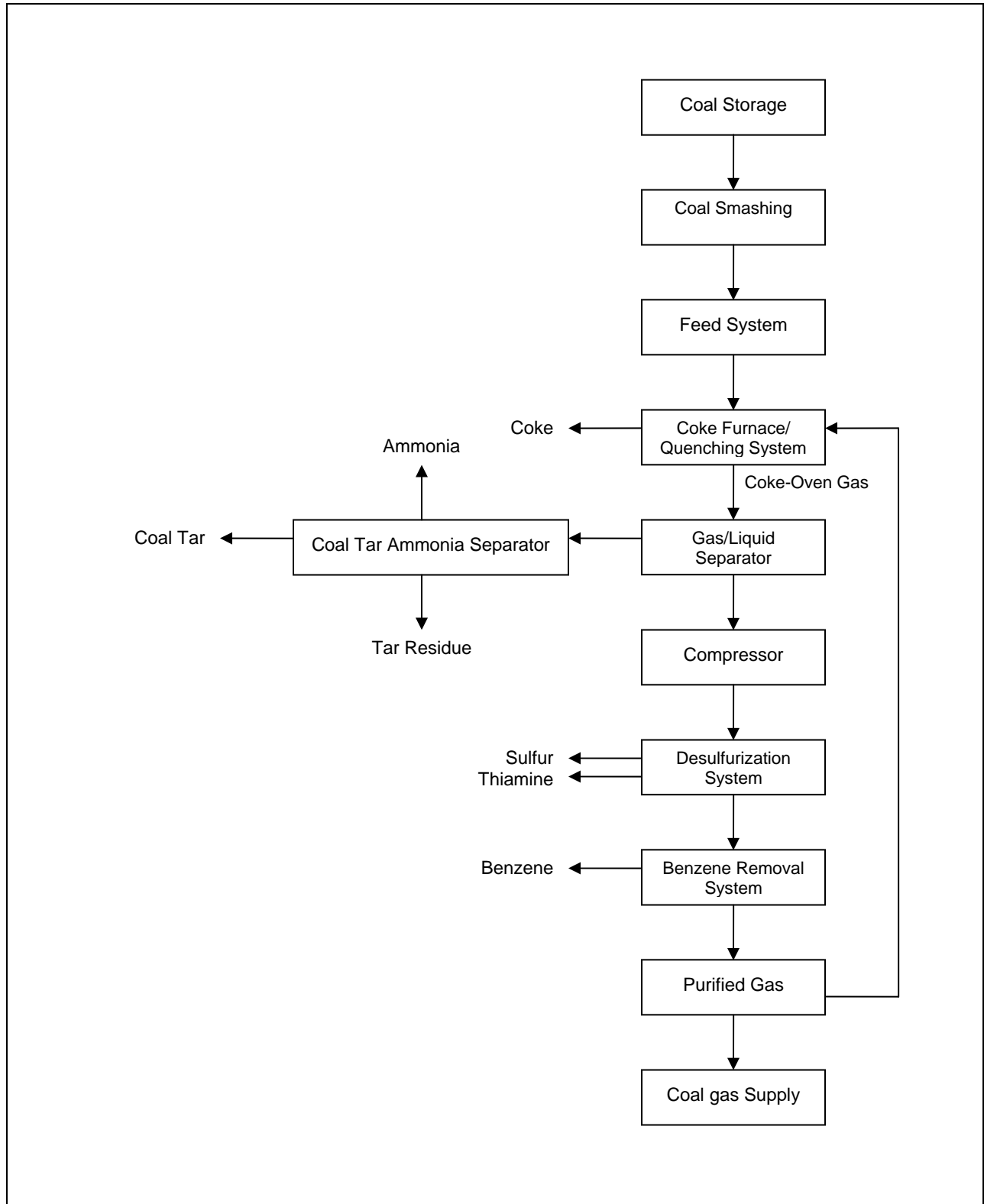
13. **Performance.** Since it went in to full commercial operation, the subproject's technical performance and product quality have consistently met design requirements. In particular, (i) the capacity factor has consistently exceeded 100%; (ii) the subproject has been operated with due consideration to safety of personnel and property; (iii) the subproject has been awarded the blue mark of environmental performance<sup>3</sup>; (iv) production of coke has consistently conformed to required standards<sup>4</sup>; and (v) coal gas production has been maximized to help realize greater environmental benefits from coal gas sale to end users. This possibly sets the stage for other coking units in Shanxi province to modernize and set up more efficient, environmentally friendly coking facilities.

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<sup>3</sup> The highest certification for environmental management, awarded by the Taiyuan EPB.

<sup>4</sup> These require ash content of 12.3% at most, sulfur content of up to 0.7%, and other thermal strength properties to meet production process requirements of large steel-making furnaces.

Figure A3.2: Schematic of Taiyuan Coal Gasification Plant



## **B. The Datong Subproject**

### **1. Datong District Heating Company**

14. The Datong District Heating Company (DDHC) became an independent state-owned enterprise (SOE) with limited liability in 1999, with the mandate to provide district heating services in urban areas of Datong city. Since then, the DDHC has focused on becoming a commercially viable and sustainable organization by (i) seeking to rationalize and increase heat prices, and obtaining the necessary approvals from the Datong Price Bureau and Shanxi Price Bureau for doing so; (ii) strengthening the management function to improve operational efficiency and reduce the cost of heat supply; (iii) reducing or slowing increases in labor costs; and (iv) improving service quality and collection efficiency.

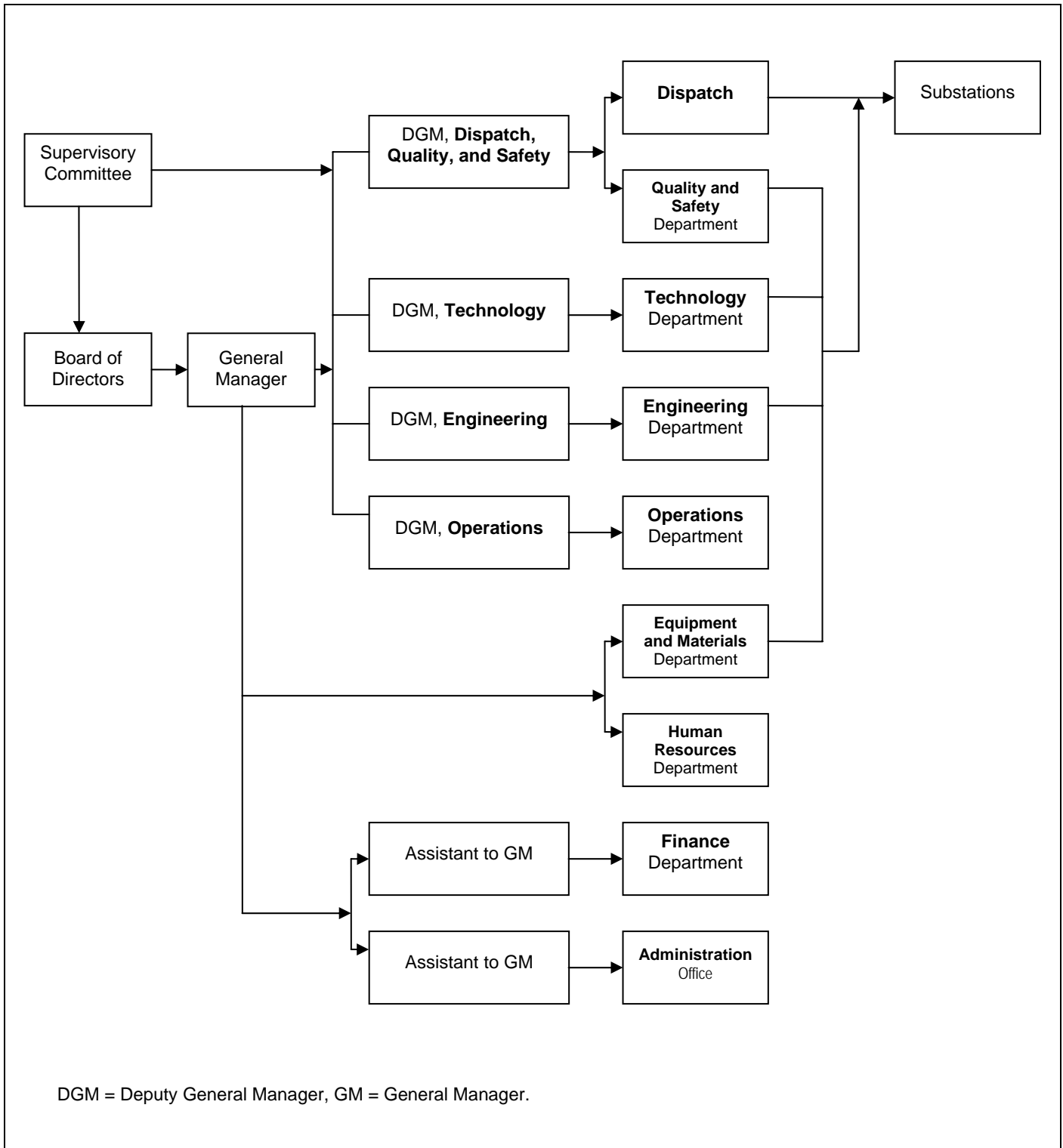
15. DDHC has set up high-accuracy metering systems (ultrasonic flow meters with flow computers) at points along the network to monitor heat losses in the entire system and thus establish priorities for investing in measures to reduce losses. DDHC has also become a forward-looking organization and has plans to make necessary investments to take advantage of the anticipated changes in the regulatory framework for district heating<sup>5</sup>.

16. The DDHC's organizational structure is shown in Figure A3.3. DDHC's Board of Directors firms up investment and financing plans, while the Board of Supervisors oversees the implementation of operational and investment plans. The general manager is responsible for day-to-day operations and reports to the Board of Directors. A deputy general manager reports to the Board of Supervisors.

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<sup>5</sup> These may enable district heating service providers to charge customers on the basis of actual heat use rather than charging a fixed amount per month (or per heating season) on the basis of floor area.

**Figure A3.3: Organizational Structure of the Datong District Heating Company**



17. DDHC now serves about 75,000 households and about 500 public buildings and commercial consumers in the urban areas of Datong. It has no industrial customers, as industry is located in suburban and rural parts of the city. DDHC has no other business interests. With a heating season of only 165 days per year (1 November through 15 April), DDHC's main activities during the other months are construction and expansion of the district heating network, equipment maintenance, and ensuring full payment from all customers before the start of the next heating season.

## **2. Training**

18. DDHC's capacity-building efforts aim (i) to improve the overall operational efficiency of its heat supply network and improve the quality and reliability of heat supply services; (ii) to manage the necessarily simultaneous construction activities at multiple locations; (iii) to enhance customer service standards and improve customer satisfaction; (iv) to successfully introduce customer metering and other necessary technical systems as policy evolves; and (v) to evolve in to a commercially oriented organization.

19. DDHC's capacity-building programs include (i) advanced enterprise management courses (including courses for CEOs) at Tsinghua University for top and senior management; (ii) suitable technical training at Tangfang Corporation for operations and dispatch personnel; (iii) on-the-job training for other personnel through secondments to other district heating supply companies both in and outside Shanxi province; and (iv) inviting technical experts for classroom type training and teaching on selected technical matters. DDHC has also encouraged its talented and experienced personnel to provide training to personnel from other district heating enterprises.

## **3. Customer Orientation and User Perspective**

20. The DDHC also conducts a survey of its residential and commercial customers each year. This survey is conducted during the heating season (1 November to 15 April). DDHC officials report that the surveys have consistently shown that all customer categories, including poor, low-income, and high-income residential customers, as well as public welfare and commercial organizations of various types, are generally satisfied. The underlying reason may be the fact that user tariffs have not increased since even before the Datong District Heating Project (DDHP) came onstream.

21. DDHC has a Consumer Reception Division, which includes a customer complaint center at its headquarters. Upon receiving a complaint, the division responsible for servicing customers in the concerned part of the Datong urban area is alerted. After attending to and addressing the complaint, the concerned division reports back to the customer complaint center at headquarters, which then checks with the customer on whether the complaint has been adequately addressed.

22. To help balance the heat supply system and maintain indoor temperature within  $18\pm 2^{\circ}\text{C}$ , and preferably in the  $18\text{-}20^{\circ}\text{C}$  range—and thus reduce customer complaints— DDHC's standard operating procedures now require at least 30 temperature measurement points for every 10,000 square meter ( $\text{m}^2$ ) of floor area serviced.

23. DDHC's billing and collection system is as follows: (i) poor residential customers are billed and are required to pay on a monthly basis; (ii) the more well-off residential customers are billed and are required to make payment just once in the heating season; and (iii) the

commercial and public welfare customers are billed and required to pay each month. DDHC has established five offices where customers can pay their bills across the urban area; however, DDHC may also go to the customer premises for collection. On a month-to-month basis during the heating season, the collection efficiency is 93–95%. However, DDHC has been successful thus far in ensuring that by the start of the next heating season, all bills have been paid.

#### 4. Datong District Heating Project

24. The ADB supported subproject (DDHP) is part of the district heating service area now managed by the DDHC. The DDHP was in keeping with DDHC's mandate, as it sought in its original design to (i) replace old and/or small and inefficient coal-fired boilers by new, larger, and more efficient boilers of 80 tons per hour (tph) and 120 tph capacities; (ii) construct the associated 60 kilometers (km) transmission network and 37 heat exchange stations (HES) to connect the new boilers to existing sub-transmission and distribution lines; and (iii) to thus serve customers with a total useful floor area of 5.1 million m<sup>2</sup>.

25. As another utility company conceived the idea in 2003 to set up a 400 megawatt (MW) Datong Pingwang combined heat and power (CHP) plant, the DDHP design was modified. In particular: (i) with heat to be supplied from the 400 MW CHP, there was no need to set up two large peak-load boilers; (ii) the capital investment resources so freed enabled the expansion of the DDHP service area to about 6.59 million m<sup>2</sup> of useful floor space, by constructing 75 HES (i.e., 38 additional HESs) and 104 km of transmission pipeline (i.e., 44 km additional pipeline). A total of 273 small/inefficient coal-fired boilers were shut down with the implementation of the DDHP. Following the completion of 81.4 km of pipeline and 55 HES, the DDHP began supplying heat in the 2004–2005 heating season. The DDHP went in to full commercial operation by start of the 2005–2006 heating season.

26. **Performance.** Since the 2005–2006 heating season, DDHP has achieved 100% capacity utilization each year. The heat losses upstream of HES (from CHP to HES) are about 1%, and downstream (from HES to customers) are a further 4%. Through loss reduction measures and proper metering, heat losses in the system have therefore reduced from about 6% to about 5%.

### C. The Yangquan Subproject

#### 1. Shanxi Yangquan Gas Company and Gas Distribution Companies

27. The Shanxi Yangquan Gas Company was created to handle the responsibilities for the IA during the implementation of the various components of this subproject. Upon completion, the assets were handed over to three gas pipeline distribution companies: (i) the Yangquan City Gas Distribution Company (YCGC); (ii) the Pingding Gas Company (PGC); and (iii) the Jiaoqu Gas Company (JGC). The three companies are part of the Yangquan Coal Mining Group (YCMG), which operates several coal mines. The YCMG operates the Coal Mine Number 5—the source of the coal-bed-methane/coal-mine-methane (CBM/CMM) gas, which is captured, stored, and transmitted to three gas distribution companies.

28. YCMG operates 19 coal mines in Yangquan city area, of which only five have CBM/CMM capture facilities thus far. In line with the increasing recognition by the Yangquan city government of the need to prevent atmospheric release of methane during coal mining operations, YCM plans to begin methane capture from more its operating mines. In line with this

objective, YCMG has also formulated a five-year perspective capacity-building plan to increase the number of certified methane capture and storage facility operators.

29. The YCGC is the largest distribution company in Yangquan city, has operated since 1988, and serves customers in urban areas. In 2008, it supplied a little over 165 mcm of gas, to about 80,000 households (30.05 mcm), 354 public buildings (18.75 mcm), 234 commercial consumers (8 mcm) and five industrial consumers (over 108.27 mcm). YCGC also served over 1,000 poor urban households in 2008, which accounted for about 456,000 m<sup>3</sup> of gas. YCGC obtains gas from five gas suppliers, one of them being the Yangquan group's Coal Mine Number 5.

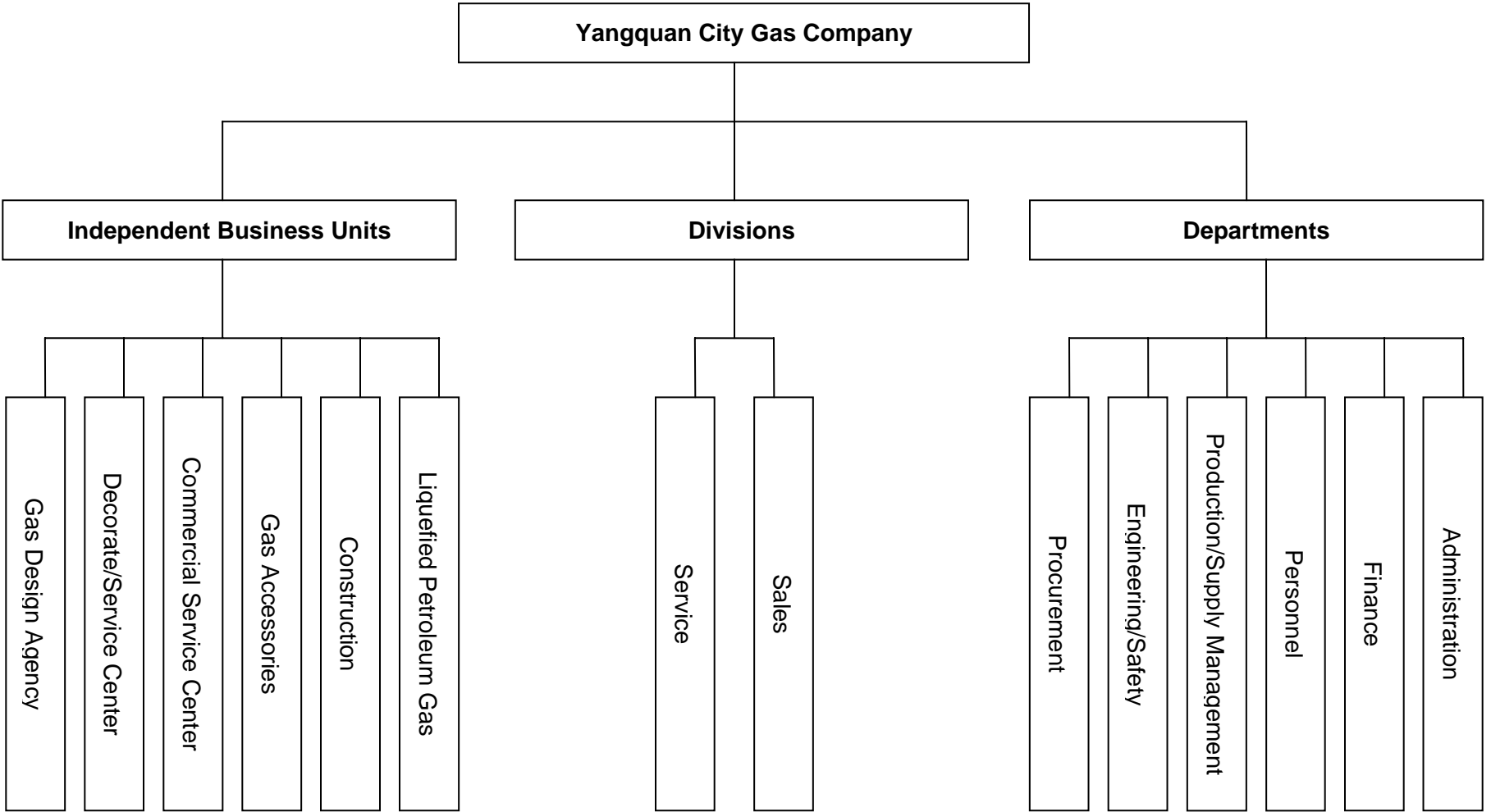
30. The feasibility study for setting up PGC to supply gas in Pingding suburban areas was approved in January 2001 and PGC's first asset is the ADB-supported subproject component (a gas storage tank), along with requisite pipelines to serve its customers. It supplied a total of 27.25 mcm to households (7.75 mcm), public buildings (5 mcm), and industrial customers (14.5 mcm). The JGC was also established in 2001 and in 2008 supplied 3.2 mcm to households (1.05 mcm) and commercial consumers (2.15 mcm). PGC and QGC obtain all gas from the Coal Mine Number 5.

31. The YCGC is structured in three parts: (i) administrative departments; (ii) gas sales and gas service business units; and (iii) other independent units in diversified areas such as engineering design, construction, manufacture and sale of accessories for gas use, and LPG supply. The independent units provide services to the gas sales and gas service business units for a fee. Figure A3.4 shows the YCGC's organization. YCGC provides an example of a state-owned enterprise that is able to respond to changing circumstances. Along with continuing to expand its CBM/CMM gas supply network since the ADB subproject completion, YCGC has tried to overcome some of its financial problems—owing to its inability to raise CBM/CMM gas sales prices—by expanding its profit-making and market-driven gas accessories business. It also has plans to exit the liquefied petroleum gas (LPG) supply business, as its LPG consumers switch to using CBM/CMM gas. With increased CBM/CMM gas sales through the ADB-supported subproject as well as further increases anticipated over the next several years, YCGC has also oriented its capacity-building plans to develop a well-structured system that includes training in various aspects of CBM/CMM business operations, as well as technical training.

32. Both PGC and JGC began operations with the help of financing from the ADB project loan and the Yangquan city government and the respective local governments of Pingding county and Jiaoqu township. The two gas companies started supplying CBM/CMM for the first time to suburban Yangquan consumers with the commissioning of the ADB supported subproject component. They are small companies and depend upon YCGC for technical assistance and guidance on matters from time to time.



Figure A3.4: The Yangquan City Gas Distribution Company Organization



## 2. Training

33. YCGC's training and capacity-building initiatives are influenced by objectives that are similar to DDHC's. Upon completion of the ADB-supported subproject in Yangquan, YCGC reorganized into four divisions to cover its entire CBM/CMM supply business, and established an internal management incentive mechanism to encourage the four divisions to enhance their supply network and improve (i) the operational efficiency of their respective networks, (ii) maintenance practices, (iii) customer service, and (iv) financial management. YCGC also established a comprehensive human resource database, which is used as a basis for planning training activities on a yearly basis.

34. The training program encompasses (i) training in various aspects of company business operations and management, such as finance, accounting, marketing, sales, customer service, and receivables management; (ii) maintenance scheduling and management training; and (iii) training of personnel engaged in work where risks of fire, explosion, or methane leak is high, such as compressor operations, tank maintenance, and pipeline leak repair. All personnel engaged in high-risk positions need to be certified operators.

## 3. Customer Orientation and User Perspective

35. YCGC obtains CBM/CMM gas from five sources, of which one is the ADB-supported storage tank at Wukuang (which collects CBM/CMM gas from Coal Mine Number 5). By the end-2008, YCGC served about 80,000 residential customers, 354 public welfare buildings, 234 commercial customers, and 5 industrial users. Under its tariff collection system, about 30,000 residential customers and about 50% of all other users have pre-paid electronic cards. For the remaining 50,000 residential customers and 50% of non-residential customers, YCGC raises bills each month and collects at individual household and company premises. YCGC reports that all households have been paying regularly. Some non-residential customers could not make full payments in 2008 as their businesses suffered following the financial crisis.

36. YCGC conducts a comprehensive survey each year in September, when it obtains feedback from all customers on quality of service. The company physically inspects gas service connections of all its customers each year to detect supply safety or reliability problems. Maintenance requirements are addressed at the earliest.

37. YCGC has set up a customer complaint center and has service quality standards that require it to address normal complaints within 2 hours. YCGC reports that it has successfully complied with this requirement over the past several years. YCGC also reports that customer complaints are rare, as it routinely conducts physical surveys while transmission and distribution pipelines are under construction, and when service connections are provided.

38. YCGC claims a very high satisfaction level from its customers. The fact that gas prices to customers have not been allowed to rise since 1998 is only one of the reasons; the convenience of using gas instead of coal and high service quality are the other factors. Likewise, PGC and JGC, which service about 10,000 and 2,800 customers respectively<sup>1</sup>, also report a high level of satisfaction from their customers.

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<sup>1</sup> PGC's customers include 130 public welfare customers and one industrial enterprise, in addition to approximately 10,000 households. JGC's customers include 33 commercial users in addition to approximately 2,800 households.

#### 4. Components of the Yangquan Subprojects

39. The ADB subproject comprises several components: (i) a 50,000 m<sup>3</sup> gas storage tank at Wukuang, near Coal Mine Number 5, which serves as a buffer to hold produced CBM/CMM gas before it is sent by pipeline to the three gas distribution companies; (ii) a 50,000 m<sup>3</sup> gas storage tank at Beijiao within the Yangquan urban area; (iii) a 50,000 m<sup>3</sup> gas storage tank at Songjiazhuang in Pingding, which is the gas purchase point for the PGC; and (iv) three control stations, 38 regulating stations, and 131 km of gas distribution pipelines. Two major changes were made from the original project design envisaged at appraisal: (i) the 50,000 m<sup>3</sup> storage tank was constructed at Pingding instead of a 20,000 m<sup>3</sup> gas storage tank in Jiaoqu; and (ii) 38 regulating stations were supported by the ADB fund, compared with the 39 originally planned.

40. The components were constructed, tested for start-up, and commissioned by January 2006. In particular: (i) the final section of the pipelines was completed in September 2004; (ii) the Beijiao storage tank was commissioned in June 2004; (iii) the Wukuang storage tank was commissioned in January 2006; and (iii) the Songjiazhuang storage tank was tested and accepted by January 2006. After certifications for each component, the subproject is stated to have been completed and begun normal operations by December 2006.

41. **Performance.** The Yangquan subproject components have performed well since they began normal operations, as their full capacity utilization levels demonstrate. In fact, the gas storage tank at Wukuang is sized to cater to some further expansion of coal-mining operations of Coal Mine Number 5.

## POLICY FRAMEWORK FOR ENVIRONMENTAL PROTECTION

### A. Overview

1. With an average annual gross domestic product (GDP) growth of over 9% over three decades (1978 to 2008), the People's Republic of China (PRC) has improved living standards of the vast majority of its population and lifted millions out of poverty. An undesirable consequence of PRC's economic growth focus, however, has been pollution and environmental degradation—one of the most important causes being the rapidly rising energy demand coupled to a high dependence on coal. The PRC is now the world's second largest consumer of energy and has the highest dependence on coal among the world's top 10 energy consumers.<sup>1</sup>

2. In the PRC, environmental protection is managed through a four-pronged approach: (i) integration of environmental protection plans with overall socioeconomic development plans; (ii) a combination of pollution prevention and remedy of major pollution sources; (iii) polluters to pay, including fees, fines, and compensation); and (iv) enforcement of laws and regulations.

### B. Balancing Environmental Protection with Economic Development

3. Although the PRC did not formally consider environment improvement as part of its development objectives until the turn of the century, it did introduce projects aimed at improving the local environment, including urban air quality and indoor air quality. Two salient environmental protection-related targets set for the 10-year period 2001–2010 were (i) a 20% reduction of energy consumption per unit of GDP, and (ii) a 10% reduction of total emissions of major pollutants. With the 10th Five-Year Plan (FYP) (2001–2005) for socioeconomic development, there was a change from a singular focus on physical and output targets for economic growth to quality of growth and sustainable development. This was further reinforced in the 11th FYP (2006–2010), which stated that: (i) economic growth is no longer the sole objective but one of several guiding principles for sustained growth; and (ii) other FYP objectives with equal status (priority) include the increased efficiency of resource use and environmental protection.

4. Many aspects of the national environmental protection (NEP) plan for 2001–2005 were incorporated in the socioeconomic development plan for the 10<sup>th</sup> FYP period. Key goals of the NEP, which are still being pursued country-wide, include the following: (i) to phase out/close production lines that consume resources inefficiently and result in substantial environmental pollution; (ii) to enhance development of coal gasification or liquefaction, and to increase coal-bed-methane/coal-mine-methane capture; (iii) to have pollutant emission from industry comply with national standards or local standards<sup>2</sup>; and (iv) to expedite development of district heating and gas supply capacity in urban areas so that no households in high-density city areas directly burn coal. The NEP for 2006–2010, many aspects of which were also incorporated in the socioeconomic development plan for the 11th FYP period, also set target indicators (Table A4.1). It is noteworthy that the targets pertain only to a reduction of SO<sub>2</sub> emissions and keeping SO<sub>2</sub> concentrations within targeted bounds because it is hoped that the measures taken to achieve these targets will also reduce emissions and concentrations of other major air pollutants, such as nitrogen oxides and particulate matter.

<sup>1</sup> Naughton, Barry. 2007. *The Chinese Economy: Transition and Growth*, Cambridge: MIT Press (pp. 334–336). As quoted in ADB. 2008. *Country Partnership Strategy, People's Republic of China, 2008–2010*. Manila.

<sup>2</sup> Environmental standards or pollution reduction targets set by provincial and city governments are more stringent than those of the national Government.

**Table A4.1: Selected Environmental Indicators of the National Environmental Protection (2006–2010)**

NEP Indicators	2005 (Baseline)	2010 (Target)	Targeted Change
Discharged amount of SO <sub>2</sub> ('000 tons)	25,490	22,950	10% reduction
Percentage of key cities where air quality meets Class II standards for at least 292 days annually (i.e., 80% of days per year)	69.4	75	5.6% increase

NEP = National Environmental Protection, SO<sub>2</sub> = sulfur dioxide.

Note: Taiyuan, Datong, and Yangquan are three of the 113 key cities.

5. The target set by the Shanxi Provincial Government (SPG) for SO<sub>2</sub> reduction by 2010 is more stringent than the national target. SPG's targeted reduction is 13% from 2005 levels, i.e., a decline in SO<sub>2</sub> emissions of about 1.3 million tons per year by 2010. The target is to be achieved through various initiatives, such as (i) reducing coal use in households by developing centralized district heating and gas supply systems for including coal gas, CBM/CMM, and natural gas); and (ii) optimizing the industrial mix, keeping in view the natural resource endowments of the province and the need to reduce pollutant emissions while allowing for economic growth. SPG plans to accord environmental protection top priority in highly polluted areas that are also the economic growth centers of Shanxi province. These include Taiyuan, Datong, and Yangquan cities).

### C. Measures to Improve Ambient Air Quality

6. A large number of environmental protection measures have been initiated and implemented all over PRC. Measures designed specifically for checking air pollution and improving air quality are discussed below.

#### 1. Measures Mandated by Government of PRC

7. **Pollution Control in Urban Areas.** In 1996, the Government of the PRC approved the total emission control plan for major pollutants, with the specific objective of improving air and water quality. In line with this objective, the measures that were introduced to reduce urban pollution levels, included (i) closure of industrial plants located within city limits, and relocation to outside cities; (ii) identifying highly polluting enterprises as key polluters<sup>3</sup> for more thorough monitoring; (iii) removing old polluting buses and taxis from service and replacing them with vehicles that met new, more stringent emission standards; and (iv) providing tax incentives to citizens for purchase of cars with small engines.

8. **Pollution Control Zones.** In 1998, the Government of the PRC approved the National Acid Rain and Sulfur-Dioxide Control Zoning Plan, with the objective of focusing environmental protection action on areas that experienced significant acid rain<sup>4</sup> or were otherwise characterized by high sulfur-dioxide pollution. The 10th and 11th FYPs included specific measures to reduce the undesired implications of atmospheric pollutants. These include (i) analyzing the existing conditions and establishing a baseline; (ii) establishing the total mass loading target and concentration target of SO<sub>2</sub>; (iii) controlling SO<sub>2</sub> emissions by, for instance,

<sup>3</sup> Key polluters are subject to continuous monitoring. Where equipment for continuous monitoring in real time is not installed, the enterprise is subject to a regular sampling program and random checks. The pollutants that are monitored include: sulfur-dioxide, nitrogen oxides, suspended particulate matter. For chemical industries, special pollutants such as fluorides and carbon-monoxide may also be monitored.

<sup>4</sup> Acid rain is caused largely by emissions of compounds of sulfur and nitrogen.

pre-treatment of high-sulfur coal prior to use in a boiler or furnace, and closure of small and inefficient power plants; (iv) establishing institutionalized monitoring systems; and (v) setting a budget to realize the SO<sub>2</sub> reduction target.

9. **Total Pollution Loading Control.** Mass loading for air pollutants is one of the key measures being used to control atmospheric pollution. The introduction of SO<sub>2</sub> control zones, pollution discharge permits, and SO<sub>2</sub> discharge fees is part of the overall total pollution loading (TPL) control strategy. Through TPL control, the MEP aims ultimately to ensure that the total amount of pollutants emitted or discharged in a specific area remains within the area's environmental capacity. However, because the amounts now exceed environmental capacity in most areas, this effectively means targets for reducing the total amount of pollutant discharges over a specified period of time (paras. 15 and 16).

## 2. Measures in Shanxi Province

10. **SPG's Supervision Regulation.** In support of the MEP regulations and targets, the SPG accelerated the process of ensuring that all emissions from industrial enterprises comply with MEP standards. SPG's Order No. 189 said that any enterprise that did not comply with standards by December 2008 should be closed. The respective city governments and the city EPBs are held accountable for compliance to standards and for meeting pollution reduction targets.

11. **SPG's Approach to Optimizing the Energy Supply System.** SPG put several measures in place to support environmental regulations and targets from the start of the 10<sup>th</sup> FYP period, such as: (i) relocation or closure of coal-fired power plants, cement factories, and chemical manufacturers that were high polluters, had low operational efficiency, or were located in a relatively more environmentally sensitive area—for example, close to an urban area in a city); (ii) accelerated phasing out of enterprises in sectors approved for closure by the Government of the PRC; and (iii) emphasis on introduction and expansion of centralized heating, gas utilization, clean coal technologies, dust control, and installation of flue gas desulfurizers in coal-fired power plants. SPG also instituted massive rewards for counties and cities that contribute substantively to environmental improvement and improved air quality, in particular.

12. **Shanxi City Governments' Plans for Environmental Protection.** Measures introduced by the governments of the cities of Taiyuan, Datong, and Yangquan reflect the SPG's approach and include the following: (i) comprehensive urban planning, including expansion of centralized district heating and gas supply services; and (ii) equipping all coal-fired power plants with dust removal and desulfurization devices. In addition, specific city governments have instituted other measures, such as: (i) extending subsidies to households for using the relatively less polluting treated clean coal rather than raw coal (Datong); (ii) mandating enterprises that use boilers of above 2 tons per hour (tph) capacity, to have high efficiency desulfurization facilities (Datong); (iii) implementing the coal-to-gas project (Taiyuan); and (iv) ensuring that buses meet new emission standards (Taiyuan).

## D. Implementation of Environment Protection Measures

### Institutional Structure

13. The Ministry of Environmental Protection (MEP) of the Government of the PRC is responsible for policy formulation, making national environmental protection plans, and setting national targets for environmental protection. To ensure that the environmental protection

measures are implemented, the MEP is supported by (i) regional environmental supervision centers (RESC); and (ii) the national environmental monitoring center (NEMC). The six RESCs oversee the enforcement of environmental measures, investigate serious pollution cases, and resolve cross-regional environmental disputes. The RESCs work in conjunction with the city and provincial environmental protection bureaus (EPB). The NEMC is the national focal point for all environmental monitoring data on environmental quality and emissions and discharges and all such data compiled by provincial and city environment monitoring centers flows to the NEMC on a regular basis. The NEMC also provides technical assistance on environmental monitoring to provincial and city EMCs.

14. The provincial EPB is the department of the provincial government responsible for environmental protection. It is supported by the Environmental Supervision and Law Enforcement Team and the provincial environmental monitoring center. The "key emitters" are subject to continuous monitoring, and most "key emitters" by end of 2008 have computerized real-time monitoring equipment. The other smaller emitters are monitored intermittently through regular quarterly, half-yearly, or annual onsite inspections conducted by the supervision and enforcement team and EMCs. In addition, some surprise onsite inspections may also be conducted on all emitting enterprises.

#### E. Environmental Standards/Guidelines

15. The MEP is responsible for formulating national environmental standards and guidelines, especially regarding environmental quality and pollutant discharge limits. The provincial government may also formulate its own environmental standards and guidelines—as long as they are more stringent than those set by the MEP. Industrial pollution control standards fall into three broad categories: (i) ambient environmental quality standards, (ii) pollutant discharge standards, and (iii) monitoring methodology standards. The national ambient air quality standards are shown in Table A4.1.

**Table A4.1: PRC's National Ambient Air Quality Standards GB3095–1996**

Pollutant	Unit	Time for Average	Class I	Class II	Class III
SO <sub>2</sub>	mg/m <sup>3</sup>	Annual average	0.02	0.06	0.10
		Daily average	0.05	0.15	0.25
TSP	mg/m <sup>3</sup>	Annual average	0.08	0.20	0.30
		Daily average	0.12	0.30	0.50
PM <sub>10</sub>	mg/m <sup>3</sup>	Annual average	0.04	0.10	0.15
		Daily average	0.05	0.15	0.25
NO <sub>x</sub>	mg/m <sup>3</sup>	Annual average	0.05	0.05	0.10
		Daily average	0.10	0.10	0.15
NO <sub>2</sub>	mg/m <sup>3</sup>	Annual average	0.04	0.04	0.08
		Daily average	0.08	0.08	0.12
CO	mg/m <sup>3</sup>	Daily average	4.00	4.00	6.00

CO = carbon monoxide, mg/m<sup>3</sup> = milligram per cubic meter, PM<sub>10</sub> = particulate matter of less than 10 microns diameter, NO<sub>2</sub> = nitrogen dioxide, NO<sub>x</sub> = nitrogen oxide, PRC = People's Republic of China, SO<sub>2</sub> = sulfur dioxide, TSP = total suspended particulate.

Note: Class I standards are a statement of long-term objectives of ambient air quality. Class II standards are set for residential, general industrial, and agricultural areas. Class III standards are set for specified industrial zones.

Source: Ministry of Environmental Protection, Government of PRC.

## F. Setting Environmental Protection Targets

16. The MEP is responsible for setting environmental protection targets at the national level. The targets so set are distributed amongst various provinces. The provincial governments may set their own targets, as long as they are more stringent than the environmental quality and pollutant discharge targets it is allocated by the MEP. Ultimately, the targets are achieved through measures implemented by enterprises or through closure of highly polluting enterprises. The distribution of targets follows a complex three-step process that leads to three levels of contracts or agreements. For instance, for SO<sub>2</sub> emission reduction, these contracts and agreements are finalized between (i) MEP and provincial EPB—this specifies SO<sub>2</sub> emission reduction targets to be met by a specific province; (ii) provincial EPB and EPBs of the various cities in the province—this specifies the target to be met by a specific city; and (iii) city EPB and enterprises in the city—this specifies the targets to be met by a specific enterprise. The environment related five-year targets in the national socioeconomic and environmental plans are normally phased in to five successive one-year targets. The contracts and agreements are also normally entered in to on an annual basis.

17. **Pollution Discharge Permit.** The contracts/agreements referred to above are in fact the pollution discharge permits (PDP) that the city EPBs allocate to various enterprises. Without the PDP, the enterprise is not allowed to discharge pollutants. The PDP prescribes the type of pollutants (SO<sub>2</sub> for atmospheric emissions and COD for discharges in water), the permitted amounts of pollutant discharges, and the concentration levels of pollutants. PDP enforcement is being strengthened with each passing year.

## G. Special Environmental Regulations

18. **Environmental Impact Assessments.** Three different levels of environmental impact assessments (EIA) are required for projects, according to the potential environmental impact of the project. If the potential environmental impact is considered “significant,” a full EIA report is required. The full EIA report is to be prepared after an all-round appraisal of environmental impacts and includes: (i) an identified set of recommended pollution prevention measures, on the basis of a diligent assessment of integrated and comprehensive approaches to environmental management; and (ii) feasibility analysis and cost implications of the recommended impact abatement measures on impact on air quality, water bodies, and the ecology. If the potential environmental impact is considered “gentle,” the EIA report may only be a tabulated version that spells out the environmental impact and remedial measures. If the potential environmental impacts are considered “negligible,” it is not necessary to appraise environmental impacts.

19. All full and tabulated EIA reports are finalized following feedback from the public and affected parties. For the more sensitive projects, the concerned government department is required to conduct a public hearing that involves all potentially affected parties.

20. **Three Synchronisms.** A three synchronisms regulation declares that (i) design documents for new production facilities (or expansions) can be approved by the concerned EPB only if the design of environmental protection and control facilities is also an integral part of the facilities design; (ii) construction of production facilities can begin only after the implementation plan is approved, and the implementation plan includes the engineering, construction, and/or installation of environmental protection and control facilities; and (iii) production operations can begin only when the concerned EPB has certified the environmental protection control facilities.



21. **Mandatory Pollution Control within a Prescribed Time Period.** An EPB is authorized to enforce pollution control to keep pollution emission and discharge within PDP limits. An EPB can penalize an enterprise or organization that violates environmental PDP limits from CNY10,000 to CNY100,000. The EPB first advises the violator to rectify the situation and regularly inspects the progress. Only if the pollution control activities are not effectively implemented within the prescribed time limit does the EPB order the enterprise to close or suspend production operations pending merger with other organizations or a shift to another less polluting production line.

22. **Pollution Levy.** The pollution levy regulation stipulates a discharge fee and a penalty. The discharge fee is set by (i) computing the equivalent amounts of emissions and discharges of all pollutants from a given polluting source; (ii) ranking the equivalent emissions and discharge amounts in descending order; and (iii) applying the discharge fee rate of CNY0.62 per kg of SO<sub>2</sub> equivalent on the top three pollutants only. To determine the penalty, officials (i) measure pollutant concentrations in the vicinity of the emission and discharge points as per prescribed methodologies and standards; and (ii) apply the penalty charge fee on the entire quantity of the top three pollutants if the measured concentrations exceed the relevant national standards. The penalty fee rate is at least three times higher than the discharge fee rate.

### TRAINING PROVIDED

Participants	Training Venue	No. of Personnel	No. of Person-Days
<b>Overseas Training</b>			
- Taiyuan	Japan	7	105
	USA	8	120
	Germany, USA	7	105
	Australia	3	45
- Datong	Germany, Finland	10	140
	Denmark	10	140
- Yangquan	France, Italy	6	90
<b>Subtotal</b>		<b>51</b>	<b>745</b>
<b>In-Country Training</b>			
-Taiyuan	PRC	300	3,000
- Datong	PRC	190	970
- Yangquan	PRC	226	32,964
<b>Subtotal</b>		<b>716</b>	<b>36,934</b>
<b>Total</b>		<b>767</b>	<b>37,679</b>

PRC = People's Republic of China, No. = Number, USA = United States.

Source: Government of PRC, implementing agencies.

## ECONOMIC AND FINANCIAL REEVALUATION OF SUBPROJECTS

### A. Introduction

1. The objectives of this economic and financial reevaluation are to determine the economic and financial viability of the three subprojects in Taiyuan, Datong, and Yangquan cities on the basis of updated information on subproject operating costs, production of outputs, sales, and prices; and to assess the economic and financial internal rates of returns of the three subprojects. The methodology broadly follows the approach adopted at completion, as given in the project completion report (PCR). The analyses are carried out in accordance with the ADB *Guidelines for the Economic Analysis of Projects* by comparing the with- and without-project scenarios that weigh subproject benefits (i.e., environmental benefits) against the initial investments and periodic and routine maintenance requirements over a 20-year period. All expenditures and revenues are in constant 2008 prices.

### B. Input Data and Assumptions

2. The inputs and assumptions for financial analyses related to the three subprojects are shown in Tables A6.1, A6.2 and A6.3. The approach has essentially been to rely on capital costs data (including interest-during-construction) on the PCR and operating data from commissioning to the end of 2008 provided by the concerned IA.

**Table A6.1: Parameters for Financial Analyses of the Taiyuan Subproject**

Parameter	Financial Model Inputs/Assumptions
Capital Cost	As provided in the PCR
Fixed operating cost	Labor costs, administrative costs and other fixed costs for 2005 to 2008, based on updated data provided by TCGC (the IA).
Variable operating costs	Based on updated data provided by TCGC for 2005 to 2008. Includes financial costs of coal. Coal is procured from the TCGG's coal mining operations. The internal transfer prices of coal are decided by the TCGG Board of Directors. The costs of utilities (electricity, coal gas, etc.) are also provided by TCGC.
Revenues (major products and chemical by-products)	The two major products are coke and coal gas. In addition, the by-product chemicals include coal tar, sulfur ammonia, and benzene. Part of the coal gas is used internally in the coking plants. The remainder is sold to the TCGG's gas pipeline/supply company for sale to ultimate consumers. TCGP's revenue stream comes from sales made to the gas pipeline/supply company. Revenues from sale of all products are also as provided by TCGC.

IA = implementing agency, PCR = project completion report, TCGC = Taiyuan Coal Gasification Company, TCGG = Taiyuan Coal Gasification Group.

Source: Taiyuan Coal Gasification Company.

**Table A6.2: Parameters for Financial Analyses of the Datong Subproject**

Parameter	Financial Model Inputs/Assumptions
Capital Cost	As provided in the PCR
Fixed operating cost	As per data on labor cost, administrative, and marketing expenses, and other fixed costs provided by DDHC for the ADB-supported DDHP for the years 2006 to 2008. Indicative data on a per unit of heat supply basis is also provided for 2002. Data for intervening years is interpolated.
Variable operating costs	As per data for heat purchase (from a 400 MW CHP) provided by DDHC for the years 2004 to 2008. (Note: no steam purchases as DDHC has no industrial customers). As per data on utility and other variable costs provided by DDHC for 2006 to 2008; prorated as per capacity utilization for 2004 and 2005.
Revenues	As per data on heat sales price and square meter of district heating area served; data available for 2004 to 2008.

ADB = Asian Development Bank, CHP = combined heat and power, DDHC = Datong District Heating Company, DDHP = Datong District Heating Project, MW = megawatt, PCR = project completion report.  
Source: DDHC.

**Table A6.3: Parameters for Financial Analyses of the Yangquan Subproject**

Parameter	Financial Model Inputs/Assumptions
Capital Cost	As provided in the PCR
Fixed operating cost	As per data on labor cost, administrative and marketing expenses, and other fixed costs as per PCR
Variable operating costs	As per updates available from YCGC, regarding cost of CBM/CMM off-take price since 2005.
Revenues	As per price data for various customer categories available from YCGC. Volume of CBM/CMM sales per customer category is estimated on the basis of: (i) customer category-wise sales data in 2008 (for YCGC and JGC); and (ii) total volume sales data for 2005 to 2008 for PGC.

PCR = project completion report, CBM/CMM = coal-bed-methane/coal-mine-methane, JGC = Jiaoqu Gas Company, PGC = Pingding Gas Company, YCGC = Yangquan City Gas Company.  
Sources: Yangquan City Gas Company, Pingding Gas Company, and Jiaoqu Gas Company.

3. Further inputs and assumptions necessary for economic analysis of the various subprojects are (i) shadow pricing of capital costs, fixed operating costs, and variable operating costs to reflect economic costs, as per established ADB norms<sup>1</sup>; (ii) using economic price of coal; and (iii) benefits from reduced emissions of local pollutants from reduction in coal use. Economic cost of coal is based on free-on-board price of Shanxi Premium Blend coal at Qinhuangdao port. Given that the coal needs to be transported over 600 km by rail from coal mines in Shanxi province to the Qinhuangdao port, the corresponding economic costs in Shanxi are estimated. Table A6.4 provides the relevant inputs and assumptions to estimate the economic costs of a 5,500 kCal/kg coal.

<sup>1</sup> For capital costs, the conversion factor (i.e., multiplier to convert financial costs to economic costs) for land is 1.0; for civil works is 1.1; for equipment is 1.1; and for other costs is 0.93. For fixed operating costs, the conversion factor for skilled labor costs is 2.0; for unskilled labor costs is 0.7; and for other items is 0.93. For variable operating costs, the conversion factor for coal purchase costs (when based on border prices of coal) is 1.0 and for other items is 0.93.

**Table A6.4: Economic Cost of Coal in Shanxi (2005–2008)**

Item	2005	2006 <sup>a</sup>	2007	2008
Coal price FOB (\$/ton)	47.4	55.6	60.2	106.8
Exchange rate (CNY/\$)	8.19	7.97	7.61	6.95
Coal Price in Qinhuangdao (CNY/ton)	388	438	460	740
Load and unload charges (CNY/ton)	10.00	10.15	10.79	12.16
Railway transportation cost (CNY/ton-km)	0.09	0.10	0.10	0.11
Losses by railway transportation (%)	3	3	3	3
Transport distance (Coal Mine-Qinhuangdao) (km)	638	638	638	638
Coal price in Shanxi (CNY/ton)	306.7	354.1	371.0	633.1
Coal price in Shanxi (\$/ton)	37.4	44.4	48.8	91.1

CNY = yuan.

<sup>a</sup> August–December average.

Sources: (i) China Coal Report (2006 and 2007), Available [www.coalportal.com](http://www.coalportal.com); (ii) China Coal Resource (2006, 2007, 2008). Available [//en.sxcoal.com](http://en.sxcoal.com); (iii) McCloskey's Coal Statistics (2005); and (iv) Platts Insight (December 2006).

4. Benefits from reduced pollutant emissions are based on emissions savings from reduced coal consumption as (i) coal gas replaces coal use in Taiyuan's households, commercial, and industrial consumers; (ii) coal use in Datong for district heating services reduces as old/inefficient boilers are shut down and heat is purchased from a high-efficiency CHP; and (iii) CBM/CMM gas replaces coal use in Yangquan's households and for commercial and industrial consumers. Emissions savings from reduced per ton coal use are as provided by the respective environmental protection bureaus (EPB) of the three cities at the time of project completion (Table A6.5). No reliable updates were available to the Independent Evaluation Mission.

5. Differences in coefficients for reduction of pollutants emissions are to be expected between the three cities, as coal use is reduced for different reasons. Therefore, it is likely that the carbon dioxide (CO<sub>2</sub>) emission reduction coefficient of 44 kg of CO<sub>2</sub> per ton of coal saved provided by the three EPBs is not correct. See Table A6.5.

**Table A6.5: Emission Savings per ton of Coal Use Reduction (kg/ton of coal)**

Emissions	Taiyuan	Datong	Yangquan
PM <sub>10</sub>	32.5	14.0	20.0
SO <sub>2</sub>	25.7	16.0	16.0
NO <sub>x</sub>	4.1	7.6	5.0
CO <sub>2</sub>	44.0	44.0	44.0

CO = carbon dioxide, PM<sub>10</sub> = particulate matter of less than 10 microns diameter, NO<sub>x</sub> = nitrogen oxide, SO<sub>2</sub> = sulfur dioxide.

Source: Taiyuan EPB, Datong EPB, and Yangquan EPB; as provided to ADB at the time of project completion in 2006.

6. A value is ascribed to reduced emissions per person per year on the basis of the findings of an ADB study for which such data is readily available. The study was supported through a PPTA for Loan 2260-PRC<sup>2</sup>. The data from this study is revalued in 2008 prices, and scaled up according to the available population data for Shanxi province and the three cities. The results presented in Table A6.6 are used for further analyses.

<sup>2</sup> ADB. 2006. *Report and Recommendations of the President to the Board of Directors: Proposed Loan to the People's Republic of China: Inner Mongolia Autonomous Region Environment Improvement Project*. Manila (Loan 2260, for \$120 million, approved on 29 September).

**Table A6.6: Benefits from Emission Reductions (CNY/ton of emissions)**

	2004	2005	2006	2007	2008
<b>Taiyuan</b>					
PM <sub>10</sub>	3,441	3,613	3,794	3,984	4,183
SO <sub>2</sub>	832	874	917	963	1,011
NO <sub>x</sub>	916	962	1,010	1,060	1,113
<b>Datong</b>					
PM <sub>10</sub>	3,320	3,486	3,660	3,843	4,035
SO <sub>2</sub>	805	846	888	932	979
NO <sub>x</sub>	883	926	973	1,021	1,072
<b>Yangquan</b>					
PM <sub>10</sub>	2,572	2,701	2,836	2,978	3,127
SO <sub>2</sub>	641	674	707	743	780
NO <sub>x</sub>	673	707	742	779	818

PM<sub>10</sub> = particulate matter of less than 10 microns diameter, NO<sub>x</sub> = nitrogen oxide, SO<sub>2</sub> = sulfur dioxide.

Source: Independent Evaluation Mission findings.

### C. Results of Economic and Financial Reevaluation

**Table A6.7: Financial Internal Rate of Return (Taiyuan Coal Gasification Plant) (RMB million)**

Year	Capital Cost	Fixed Cost	Variable Cost	Total Cost	Revenues Without VAT and Sales Tax	Income Tax	Revenues After Income Tax	Net Benefits
2001	39			39				(39)
2002	134			134				(134)
2003	646			646				(646)
2004	313	91	109	513	262		262	(251)
2005		131	692	823	888		888	65
2006		158	786	944	1,069	22	1,047	103
2007		194	765	959	1,098	27	1,071	112
2008		149	875	1,024	1,250	56	1,194	170
2009		149	925	1,075	1,253	40	1,213	138
2010		149	925	1,075	1,268	45	1,223	148
2011		149	925	1,075	1,268	45	1,223	148
2012		149	925	1,075	1,268	45	1,223	148
2013		149	925	1,075	1,268	45	1,223	148
2014		149	925	1,075	1,268	45	1,223	148
2015		149	925	1,075	1,268	45	1,223	148
2016		149	925	1,075	1,268	45	1,223	148
2017		149	925	1,075	1,268	45	1,223	148
2018		149	925	1,075	1,268	45	1,223	148
2019		149	925	1,075	1,268	45	1,223	148
2020		149	925	1,075	1,268	45	1,223	148
2021		149	925	1,075	1,268	45	1,223	148
2022		149	925	1,075	1,268	45	1,223	148
2023		149	925	1,075	1,268	45	1,223	148
2024		149	925	1,075	1,268	45	1,223	148
2025	(113)	149	925	961	1,268	45	1,223	262
FIRR (After Tax)		=	9.9%					
FIRR (Before Tax)		=	12.8%					

FIRR = financial internal rate of return, VAT = value-added tax.

Source: Independent Evaluation Mission estimates.

**Table A6.8: Financial Internal Rate of Return (Datong District Heating Project)**  
(RMB million)

Year	Capital Cost	Fixed Cost	Variable Cost	Total Cost	Revenues without VAT and Sales Tax	Income Tax	Revenues After Income Tax	Net Benefits
2001	38			38				(38)
2002	58			58				(58)
2003	71			71				(71)
2004	108	38	14	160	28	-	28	(132)
2005	108	43	37	188	69	-	69	(119)
2006		49	88	136	136	-	136	-
2007		46	84	130	130	-	130	-
2008		44	79	123	122	-	122	(1)
2009		44	79	123	140	-	140	17
2010		44	79	123	171	10	161	38
2011		44	79	123	171	10	161	38
2012		44	79	123	171	10	161	38
2013		44	79	123	171	10	161	38
2014		44	79	123	171	10	161	38
2015		44	79	123	171	10	161	38
2016		44	79	123	171	10	161	38
2017		44	79	123	171	10	161	38
2018		44	79	123	171	10	161	38
2019		44	79	123	171	10	161	38
2020		44	79	123	171	10	161	38
2021		44	79	123	171	10	161	38
2022		44	79	123	171	10	161	38
2023		44	79	123	171	10	161	38
2024		44	79	123	171	10	161	38
2025	(38)	44	79	84	171	10	161	77
FIRR (Before Tax)		=	5.1%					
FIRR (After Tax)		=	3.5%					

FIRR = financial internal rate of return, VAT = value-added tax.

Source: Independent Evaluation Mission estimates.

**Table A6.9: Financial Internal Rate of Return (Yangquan Subproject)**  
(RMB million)

Year	Capital Cost	Fixed Cost	Variable Cost	Total Cost	Revenues without VAT and Sales Tax	Income Tax	Revenues After Income Tax	Net Benefits
2001	15			15				(15)
2002	82			82				(82)
2003	101			101				(101)
2004	22			22				(22)
2005	25	4	4	33	18	-	18	(15)
2006	-	4	5	8	23	1	23	14
2007		3	6	8	28	2	25	18
2008		1	5	6	25	2	23	17
2009		1	5	6	25	2	23	17
2010		1	5	6	25	2	23	17
2011		1	5	6	25	2	23	17
2012		1	5	6	25	2	23	17
2013		1	5	6	25	2	23	17
2014		1	5	6	25	2	23	17
2015		1	5	6	25	2	23	17
2016		1	5	6	25	2	23	17
2017		1	5	6	25	2	23	17
2018		1	5	6	25	2	23	17
2019		1	5	6	25	2	23	17
2020		1	5	6	25	2	23	17
2021		1	5	6	25	2	23	17
2022		1	5	6	25	2	23	17
2023		1	5	6	25	2	23	17
2024		1	5	6	25	2	23	17
2025	(25)	1	5	(18)	25	2	23	41
FIRR (Before Tax)		=	4.05%					
FIRR (After Tax)		=	3.12%					

FIRR = financial internal rate of return, VAT = value-added tax.

Source: Independent Evaluation Mission estimates.



**Table A6.10: Economic Internal Rate of Return (Taiyuan Coal Gasification Plant)**  
(RMB million)

Year	Capital Cost	Fixed Cost	Variable Cost	Total Cost	Economic Benefit	Local Environmental Benefit	Net Benefits
2001	41			41			(41)
2002	140			140			(140)
2003	664			664			(664)
2004	320	87	113	521	311	10	(200)
2005		125	97	222	915	43	736
2006		151	908	1,059	1,089	57	87
2007		185	949	1,134	1,119	63	48
2008		143	1,020	1,163	1,268	60	165
2009		143	998	1,141	1,271	66	196
2010		143	998	1,141	1,292	70	221
2011		143	998	1,141	1,292	73	224
2012		143	998	1,141	1,292	77	228
2013		143	998	1,141	1,292	81	232
2014		143	998	1,141	1,292	85	236
2015		143	998	1,141	1,292	89	240
2016		143	998	1,141	1,292	93	244
2017		143	998	1,141	1,292	98	249
2018		143	998	1,141	1,292	103	254
2019		143	998	1,141	1,292	108	259
2020		143	998	1,141	1,292	114	265
2021		143	998	1,141	1,292	119	270
2022		143	998	1,141	1,292	125	276
2023		143	998	1,141	1,292	132	283
2024		143	998	1,141	1,292	138	289
2025	(117)	143	998	1,025	1,292	145	412
EIRR (Without Env. Benefit)				=	14.6%		
EIRR (With Local Env. Benefit)				=	20.7%		

EIRR = economic internal rate of return, Env. = environmental.

Source: Independent Evaluation Mission estimates.

**Table A6.11: Economic Internal Rate of Return (Datong District Heating Project)**  
(RMB million)

Year	Capital Cost	Fixed Cost	Variable Cost	Total Cost	Economic Benefit	Local Environmental Benefit	Net Benefits
2001	41			41			(41)
2002	60			60			(60)
2003	71			71			(71)
2004	110	42	14	166	165	5	4
2005	113	48	36	197	98	12	(87)
2006		54	85	139	140	25	26
2007		52	81	133	139	26	32
2008		49	77	126	215	28	117
2009		49	77	126	173	29	76
2010		49	77	126	173	31	78
2011		49	77	126	173	32	79
2012		49	77	126	173	34	81
2013		49	77	126	173	35	82
2014		49	77	126	173	37	84
2015		49	77	126	173	39	86
2016		49	77	126	173	41	88
2017		49	77	126	173	43	90
2018		49	77	126	173	45	92
2019		49	77	126	173	47	94
2020		49	77	126	173	50	97
2021		49	77	126	173	52	99
2022		49	77	126	173	55	102
2023		49	77	126	173	58	105
2024		49	77	126	173	60	107
2025	(40)	49	77	86	173	64	151
EIRR (Without Env. Benefit)			=	11.2%			
EIRR (With Local Env. Benefit)			=	18.9%			

EIRR = economic internal rate of return, Env. = environmental.

Source: Independent Evaluation Mission estimates.

**Table A6.12: Economic Internal Rate of Return (Yangquan Subproject)**  
(RMB million)

Year	Capital Cost	Fixed Cost	Variable Cost	Total Cost	Economic Benefit	Local Env. Benefit	Net Benefits
2001	17			17			(17)
2002	88			88			(88)
2003	101			101			(101)
2004	23	-	-	23	61	2	40
2005	25	4	7	37	37	4	4
2006		4	9	14	31	5	22
2007		3	11	14	36	7	29
2008		2	10	12	32	7	27
2009		2	10	12	32	8	28
2010		2	10	12	32	8	28
2011		2	10	12	32	9	29
2012		2	10	12	32	9	29
2013		2	10	12	32	10	30
2014		2	10	12	32	10	30
2015		2	10	12	32	11	31
2016		2	10	12	32	11	31
2017		2	10	12	32	12	32
2018		2	10	12	32	12	32
2019		2	10	12	32	13	33
2020		2	10	12	32	13	33
2021		2	10	12	32	14	34
2022		2	10	12	32	15	35
2023		2	10	12	32	16	36
2024		2	10	12	32	16	36
2025	(25)	2	10	(14)	32	17	63
EIRR (revenues as per sales price)					=	7.8%	
EIRR (revenue stream based on proxy WTP)					=	12.6%	
EIRR (revenue stream as per proxy WTP + local environmental benefits)					=	16.2%	

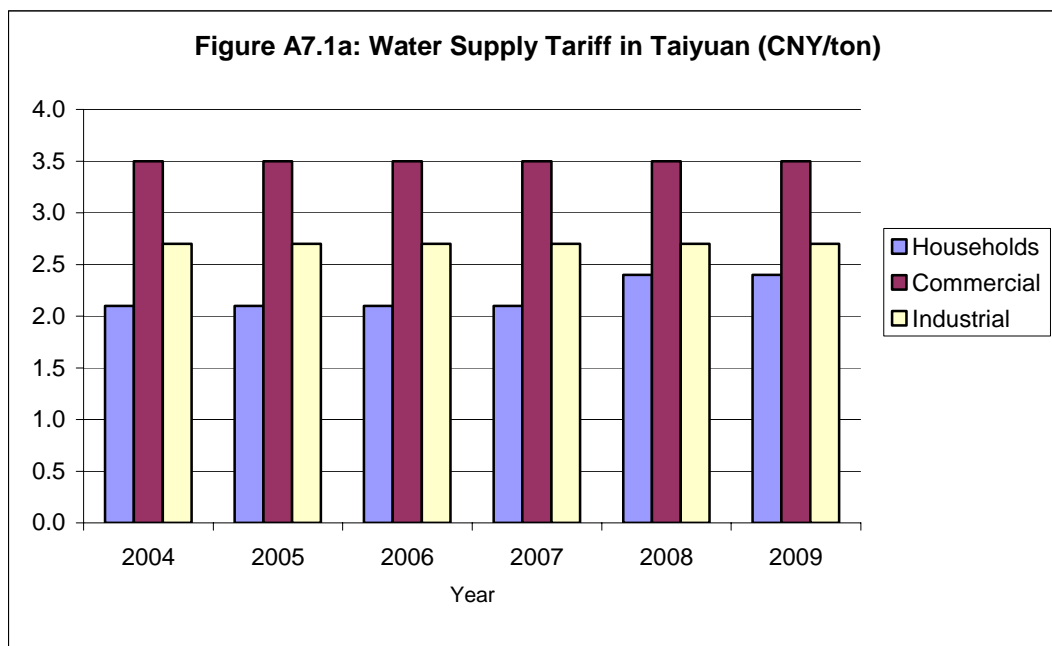
EIRR = economic internal rate of return, Env. = environmental, WTP = willingness to pay.  
Source: Independent Evaluation Mission estimates.

## PRICING OF ENERGY AND UTILITY SERVICES

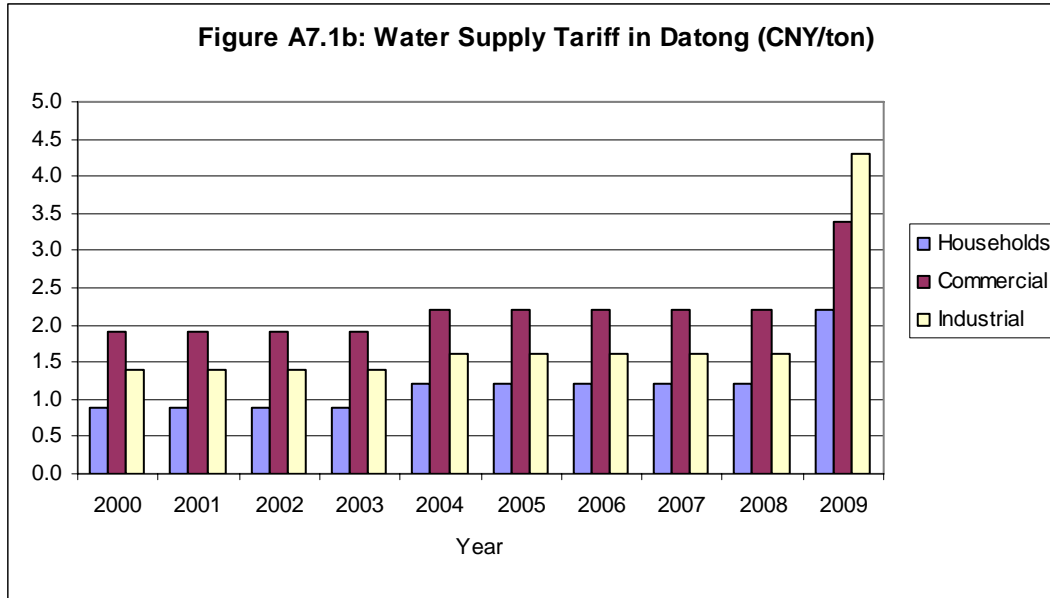
### A. Water Pricing

1. Diminishing government subsidies for water supply began to impair water operations and water infrastructure development by the early 1990s and the Government of the PRC initiated water sector reforms. The National Guidelines on Water Tariffs (NGWT), released by the National Development and Reform Commission (NDRC) in 1998, were an integral part of the reform agenda. The NGWT required the water supply companies to set water tariffs on the principles of (i) full cost recovery, (ii) earning a reasonable profit, (iii) encouraging water conservation, and (iv) social equity. The NGWT also provides for conditions on when to adjust water tariffs, as well as how they should be structured and computed. The provincial, city, and county governments are responsible for setting tariffs. No approval is required from the central government, although it must be kept informed of the tariff regime.

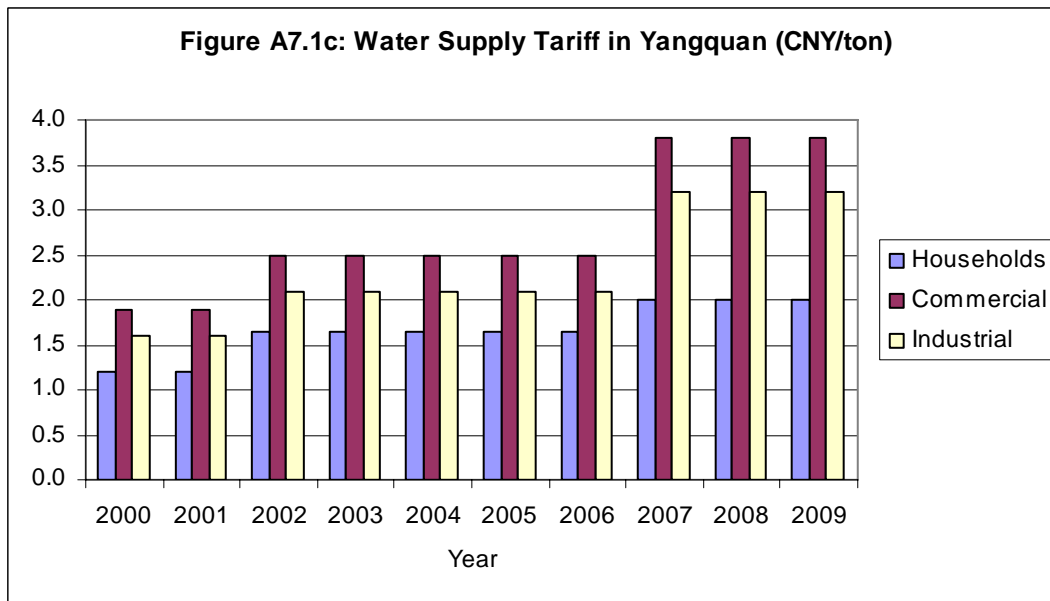
2. The other key elements of the water pricing policy are (i) different water tariffs for the different customer categories, i.e., households and public, commercial, and industrial buildings; (ii) to charge a basic lifeline tariff up to a certain level of monthly water consumption for all customer categories, and a higher tariff rate for incremental amounts of water use per month; and (iii) to install a separate water meter for each household for use in implementation of staged water tariffs. Figures A7.1a–c shows the rise in the average water supply tariffs for various customer categories in the three cities of Shanxi province.



Source: <http://price.h2o-china.com/>



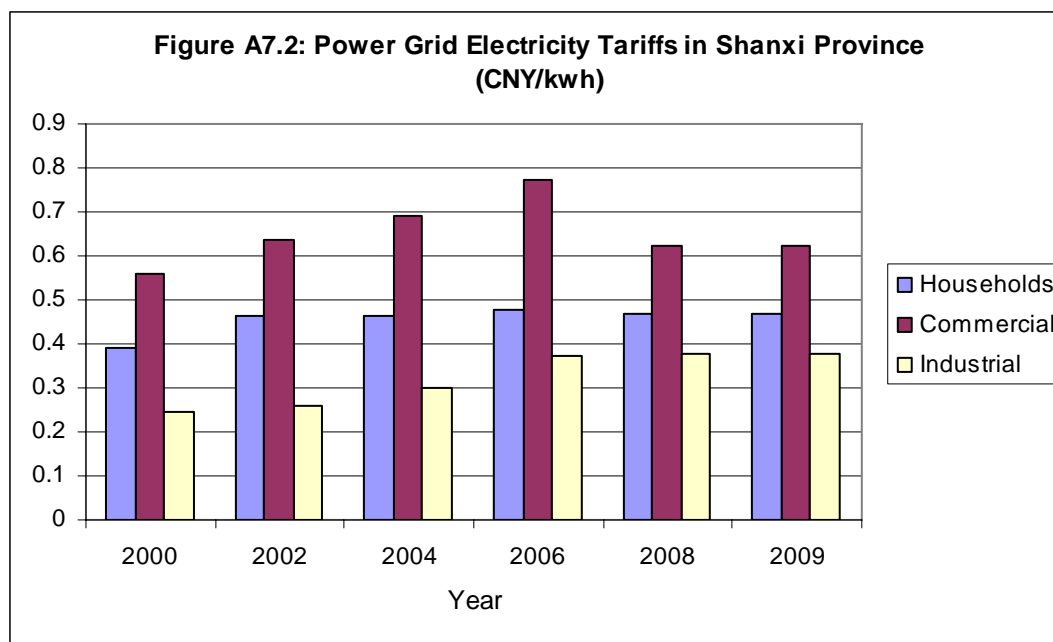
Source: <http://price.h2o-china.com/>



Source: <http://price.h2o-china.com/>

## B. Electricity and Coal Pricing

3. The Government of the PRC issued a plan to reform electricity prices as far back as July 2003. However, progress in revising tariffs has been slow and certain customer categories, including low-income households and other consumers on lifeline rates, are still cross-subsidized. Nonetheless, information suggests that electricity tariffs for various customer categories in Shanxi province have been revised several times since 2000 (Figure A7.2).



Sources: (i) [http://www.sdpc.gov.cn/zcfb/zcfbtz/2008tongzhi/t20080702\\_222220.htm](http://www.sdpc.gov.cn/zcfb/zcfbtz/2008tongzhi/t20080702_222220.htm);  
(ii) <http://www.pd.gov.cn/workonline.asp?id=1>;  
(iii) <http://www.ty12358.sx.cn/wjzc/040706-1a.htm>;  
(iv) <http://wwwold.sdpc.gov.cn/f/f200302121.htm>; and  
(v) [http://www.hebwj.gov.cn/upfiles/xy\\_col28super\\_20050309095211204105.htm](http://www.hebwj.gov.cn/upfiles/xy_col28super_20050309095211204105.htm)

4. Given that 80% of power generation capacity in PRC is coal-based, a link would be normally expected between coal and electricity prices. However, electricity prices remain controlled by the government while steam coal prices have become market-oriented since 2002 and are influenced by coal production levels, stock drawdown and build-ups, available railway capacity, and seasonal factors. The implications for the financial performance of power sector players is the principal reason that the Government of the PRC is seriously considering comprehensive reforms of the electricity pricing system. Coking coal prices are also market-oriented.

### C. Pricing Issues for Taiyuan Subproject

5. For the ADB-supported Taiyuan Coal Gasification Plant (TCGP), the primary input is coking coal. Coking coal is produced by other divisions of the Taiyuan Coal Gasification Company (TCGC), which ensures adequate supplies to the TCGP. Therefore, the coking coal supply to TCGP is in fact an internal transfer within the Group, and the price at which coking coal is supplied to TCGP need not be entirely market-driven. In this particular case, coking coal price is decided by the Taiyuan Coal Gasification Group (TCGG) Board of Directors. The average price at which coking coal has been delivered to TCGP is as shown in Table A7.1.

6. Table A7.1 also shows the prices of various outputs of the TCGP. The prices of coke and chemical by-products (coal tar, sulfur ammonia and benzene) are market-determined and have been rising over the past few years. TCGP makes available coal gas to the Group's city gas distribution company, which in turn sells coal gas to the ultimate consumers. The internal gas sale price from TCGP to the gas distribution company is set by the Shanxi Pricing Bureau (SPB) because coal gas is considered a public good. The internal transfer price of coal gas was CNY0.265/cubic meter ( $m^3$ ) since the subproject went into commercial operation in June 2005 until it was increased to CNY0.350/ $m^3$  in 2009. Although not entirely related to the ADB-supported

subproject, Table A7.1 also shows the average price at which gas is sold to households, public buildings, and commercial and industrial customers.

7. As per TCGG, the SPB normally increases city gas prices both for internal transfer and for retail sale once every five years. The most recent revision was in April 2003, when the tariff was raised from CNY0.50/m<sup>3</sup> to CNY0.75/m<sup>3</sup> for all customer categories except low-income households, which still continue to pay CNY0.50/m<sup>3</sup>. This subsidy to low-income households is not compensated by any government. TCGG submitted another petition to the Taiyuan Price Bureau (TPB) in 2009 for further changes in tariffs of city gas prices. TPB will prepare the justification for the price increase, with inputs from TCGP, and submit the price increase proposals to the SPB for approval.

**Table A7.1: Input and Output Prices of Taiyuan Subproject**

	Units	2005	2006	2007	2008
Input prices					
- Coking Coal	CNY/ton	560	610	620	780
- Electricity	CNY/kWh	0.45	0.45	0.50	0.55
- Water	CNY/ton	2.75	2.75	2.75	3.00
Output prices					
- Coke	CNY/ton	1,000	890	1,150	1,450
- Coal gas	CNY/m <sup>3</sup>	0.265	0.265	0.265	0.265
- Coal-tar	CNY/ton	1,120	2,180	2,200	2,400
- Sulfur ammonia	CNY/ton	630	460	530	520
- Benzene	CNY/ton	4,200	4,400	4,850	5,300
Consumer prices					
- Coal gas	CNY/m <sup>3</sup>	0.60	0.75	0.75	0.75

CNY = yuan, kWh = kilowatt-hour, m<sup>3</sup> = cubic meter.

Source: Taiyuan Coal Gasification Group and Taiyuan Coal Gasification Company.

#### **D. Pricing Issues for Datong Subproject**

8. For the ADB-supported DDHP subproject, the primary input is heat purchased from a CHP run by a power utility company. The utility company relies on steam coal for power and heat generation from the CHP. It increased heat sales price (excluding VAT) to DDHP from CNY7.61/gigajoule (GJ) in 2004 to CNY9.51/GJ in 2006. However, since it began operations in the 2004-05 heating season, DDHP's heat sales price to its customers has remained unchanged at CNY18.58/square meters (m<sup>2</sup>) of useful area. The same heating tariff is applicable to all customer categories. It is noteworthy that heat sales price in Datong city have remained unchanged since 1997.

9. DDHP's financial performance has thus suffered. It has accumulated losses of CNY87.48 million during the 2006–2008 period. With the Datong city government subsidy to DDHP amounting to CNY61.31 million, DDHP's net losses thus come to CNY26.17 million. This is equivalent to nearly CNY4/m<sup>2</sup> of useful area served.

10. DDHC has worked out a proposal for substantial heat sales price increases. It proposes that (i) seasonal household tariffs (excluding VAT) increase from CNY18.58/m<sup>2</sup> of useful area to CNY25.92/m<sup>2</sup> of useful area; and (ii) seasonal public buildings and commercial tariffs (excluding VAT) increase from CNY18.58/m<sup>2</sup> of useful area to about CNY30/m<sup>2</sup> of gross area. With gross area as a basis for computing the monthly bill, the proposed tariff rate increase is much more than 50%. The proposed tariff increase for public buildings and commercial sector customers has been approved by the SPB, while for tariff increase for households is expected to be approved before the start of the 2009–2010 heating season.

11. The Government of PRC's Ministry of Construction heating tariff reform initiatives will require customers to begin being charged according to actual heat use rather than area of floor space. This change would send customers appropriate price signals to reduce wasteful use of heat. However, each customer's premises would need to be fitted with individual heat meters. DDHC plans to introduce a consumption-based tariff system as well as improve its own supply-side efficiency. The measures DDHC contemplates include (i) investing in building retrofits (for heat/thermal energy savings), building heat pipe systems, and metering; (ii) simultaneously investing in supply-side efficiency such as renovation of old pipeline, including insulation, reducing water leakage from the network, reducing hot water discharge from heat exchange stations, and enhancing network heat accounting through appropriate metering; and (iii) claiming compensation from the central government, which is expected to set aside a certain budget to encourage reforms in centralized district heating.

### E. Pricing Issues for Yangquan Subproject

12. The sales price of CBM/CMM gas to YCGC customers (Table A7.2) has remained unchanged from 1998. PGC and JGC also sell gas to their respective customers at the same price. The price at which the CBM/CMM gas is purchased from the coal mining companies has also remained unchanged since 1998 and is usually CNY1.0/m<sup>3</sup> or less. For CBM/CMM gas off-takes from Coal Mine No. 5, the price is fixed at CNY2.0/m<sup>3</sup> and has remained unchanged since the subproject components began commercial operations in 2006. However, the prices of utilities have increased since subproject began commercial operation in 2006. The Yangquan city Government subsidizes YCGC. The subsidy amount was fixed at CNY4.40 million in the late 1990s and has remained unchanged since then, except in 2006, when the subsidy amount paid was marginally higher (CNY5.5 million). PGC and JGC are not offered subsidies.

**Table A7.2: CBM/CMM Gas Sales Price in Yangquan City**

	Sales Price (CNY/m <sup>3</sup> )
Households	0.55
Welfare organization	0.70
Commercial organization	0.85
Industry	0.50
Alumina plant	0.09

CBM/CMM = coal-bed-methane/coal-mine-methane, CNY/m<sup>3</sup> = yuan per cubic meter.

Source: YCGC, PGC, and JGC.

13. In 2008, YCGC forwarded a petition to the Yangquan Price Bureau for an increase of CBM/CMM retail sales prices. With the Yangquan city government preoccupied with fall-out of the global financial crisis, the petition made no progress. The YCGC intends to wait for an opportune time to forward another petition for a price rise of 30% or more.

14. The Yangquan Price Bureau also considers it necessary to revise CBM/CMM off-take prices by gas distribution companies on the basis of costs incurred by coal mining companies on CBM/CMM capture and storage. Given that the Yangquan government now prefers to prevent atmospheric release of methane gas, it is likely that coal mines with inherently relatively less methane accumulations will also be developed for CBM/CMM capture. This is expected to increase the gas supply companies' overall weighted average off-take price of CBM/CMM gas, and provide further rationale for them to pursue their efforts to increase retail prices.



## SULFUR DIOXIDE (SO<sub>2</sub>) EMISSIONS PERMIT TRADING

### A. Taiyuan Experience in SO<sub>2</sub> Emissions Permit Trading

1. The Asian Development Bank's (ADB) advisory technical assistance began in year 2001 and was completed by September 2003.<sup>1</sup> A high-level Steering Committee was set up to guide and provide necessary high-level support during the implementation phase. An office for SO<sub>2</sub> emissions permit trading was also set up. The technical assistance had several key achievements: (i) a comprehensive training program was attended by personnel from 26 large enterprises engaged in coal, power, steel, chemicals and other mining industries<sup>2</sup>; (ii) a broad framework was established for SO<sub>2</sub> emissions trading, with the Taiyuan city government passing the SO<sub>2</sub> Emission Trading Management Regulation in 1993 and approving operational guidelines for the setting up of a SO<sub>2</sub> emissions trading enterprise; (iii) suitable software was procured from the United States to help monitor trades; and (iv) appropriate simulations were carried out. These activities helped stakeholders enhance their environmental management capabilities in general and SO<sub>2</sub> emissions trading in particular.

2. SO<sub>2</sub> emissions trading simulations were conducted during 16–18 December 2002. The participants were (i) Taiyuan No.1 Thermal Power Plant; (ii) Taiyuan No. 2 Thermal Plant; (iii) Taiyuan Heavy Mechanical Corporation; and (iv) Taiyuan Gangyudongshan Thermal Company.

3. Since then, 17 enterprises have engaged in some SO<sub>2</sub> trading. The total SO<sub>2</sub> trades amount to 486 tons of SO<sub>2</sub>, with the commercial transactions valued at CNY744,500. Clearly, the SO<sub>2</sub> trading has not taken off. Two of the specific SO<sub>2</sub> trades are described in Table A8.1.

**Table A8.1: SO<sub>2</sub> Trading Case – Between Enterprises**

TRADE 1	A: Lanxing Chemical Company Limited B: Jinxi Machine Corporation
Trading background	"B" replaced its normal coal-fired boiler by a circulating fluidized-bed boiler and equipped it with high-efficiency desulfurization equipment to reduce SO <sub>2</sub> emission. "A" acquired Taiyuan Chemical Industrial Company for CNY350 million. Taiyuan Chemical Industrial Company produced TDI; the capacity was 20,000 tons per year. "A" planned to upgrade the capacity to 30,000 tons per year and to hire more labor. However, as the Taiyuan Chemical Industrial Company was located in the most polluted area in the city, there was no room for additional SO <sub>2</sub> emission load in this area. "A" was not allowed to apply for additional SO <sub>2</sub> quota.
Trading amount	In 2004, "A" purchased 47 SO <sub>2</sub> quotas at a price of CNY1,500/ton, the total transaction amount was CNY70,500.
Remarks	This was the first SO <sub>2</sub> emissions permit trade in Taiyuan.
TRADE 2	A: Taiyuan Xiaodian District Heating Company B: many newly established companies
Trading background	In Taiyuan Xiaodian District, 54 steam boilers (with combined capacity of 130 tons per hour) were removed and replaced by one 100 tons/hour steam boiler. This resulted in SO <sub>2</sub> emissions reductions by about 572.89 tons.
Trading amount	B purchased 760 tons SO <sub>2</sub> in 18 trades.
Remarks	Most of companies purchased around 10 tons. The largest trade was 256 tons and the smallest 1 ton.

Source: Taiyuan EPB.

<sup>1</sup> ADB. 1999. *Technical Assistance for the People's Republic of China for the Shanxi Air Quality Improvement*. Manila (TA 3325-PRC, for \$700,000, approved on 7 December).

<sup>2</sup> Of these enterprises, some have also carried out specific SO<sub>2</sub> emission permit trades.

## B. SO<sub>2</sub> Emission Targets and Environmental Capacity

4. One outcome of the advisory technical assistance was the recognition by the Taiyuan EPB that the SO<sub>2</sub> emissions permit trading system is unlikely to succeed as long as total SO<sub>2</sub> emission levels remain above the estimated environmental capacity. For Taiyuan city, the environmental capacity is estimated by Taiyuan EPB at 100,000 tons.

5. In its quest to reintroduce permit trading at the earliest, the Taiyuan EPB has set an ambitious target for SO<sub>2</sub> emission reduction by 2010. This target is much more aggressive than the one set by the Shanxi provincial government (Table A8.2). For 2010, Taiyuan is the only city in Shanxi province for which the SO<sub>2</sub> emission target has been set at the environmental capacity level.

**Table A8.2: SO<sub>2</sub> Emission Targets for Major Cities of Shanxi Province**  
(tons/year)

	<b>Taiyuan</b>	<b>Datong</b>	<b>Yangquan</b>
SO <sub>2</sub> emission targets set by Provincial Government			
- for 2005	184,500	164,000	NA
- for 2010	155,500	132,300	NA
SO <sub>2</sub> emission targets set by City Government			
- for 2005	184,500	164,000	NA
- for 2010	100,000	132,300	NA
SO <sub>2</sub> Environmental Capacity	100,000	Below 132,300	NA

NA = not available, SO<sub>2</sub> = sulfur dioxide.

Sources: Taiyuan Environmental Protection Bureau and Datong Environmental Protection Bureau.

## INDOOR AIR QUALITY

### A. Indoor Air Quality Standards

1. The Ministry of Environmental Protection established national indoor air quality standards in 2002, as shown in Table A9. The standards took into account health impacts of continuous exposure to certain types of gases.

**Table A9: National Indoor Air Quality Standard (GB/T18883-2002)**

	Unit	Limit	Remarks
Fresh air flow	m <sup>3</sup> per person	>30	Minimum hourly value
SO <sub>2</sub>	mg/m <sup>3</sup>	0.50	Maximum hourly average
NO <sub>2</sub>	mg/m <sup>3</sup>	0.24	Maximum hourly average
CO	mg/m <sup>3</sup>	10	Maximum hourly average
CO <sub>2</sub>	%	0.1	Maximum daily average
PM <sub>10</sub>	mg/m <sup>3</sup>	0.15	Maximum daily average

CO = carbon monoxide, CO<sub>2</sub> = carbon dioxide, mg/m<sup>3</sup> = milligram per cubic meter, m<sup>3</sup> = cubic meter, PM<sub>10</sub> = particulate matter of less than 10 microns diameter, NO<sub>2</sub> = nitrogen dioxide, SO<sub>2</sub> = sulfur dioxide.

Source: MEP, Government of the People's Republic of China.

### B. Findings on Indoor Air Quality with Coal- and Gas-Fired Cook-Stoves

2. No specific findings from Shanxi province on indoor air quality from use of coal-fired or gas-fired cook-stoves or boilers or other equipment are available. However, a survey of households in and around Beijing city indicates that with coal-fired cook-stoves, indoor concentration of SO<sub>2</sub> is several times the maximum allowable limit and, in some cases, even more than hundred times that when other fuels, such as liquefied petroleum gas or natural gas, are used.<sup>1</sup> When liquefied petroleum gas, coal gas, or natural gas are used, the CO and SO<sub>2</sub> concentrations remain within the stipulated national air quality standards, provided the stove quality is good<sup>2</sup>.

<sup>1</sup> 1996. Pollution Study of the Combustion of Kitchen Stoves in Suburban Areas of Beijing. *Beijing Industry University Transactions*. (22).

<sup>2</sup> Yanghui, et al. 2006. Comprehensive measures to improve household indoor air quality. *Environment Pollution and Prevention*. Beijing.

## SOCIAL IMPACTS

### A. Resettlement Issues

1. Resettlement issues associated with the project were addressed in accordance with the People's Republic of China (PRC) laws and regulations. Land acquisition and resettlement began in 2002 and was completed by the end of 2005. Land acquisition costs totaled \$1.77 million. Compensation was paid before land acquisition and dispossession on assets. The project management office and the concerned local government bureaus adopted a consultative process through which the affected people were kept fully informed about the project, resettlement policies and options, compensation measures, grievance procedures, and legal rights. A grievance redressal mechanism was also established for each subproject.

#### 1. Taiyuan Subproject

2. About 1.4 hectares (ha) of land was acquired, comprising 0.67 ha of waste land from a village, and 0.73 ha of construction land from the Taiyuan Textile Corporation. The total compensation was CNY3 million for the waste land and CNY5.05 million for the construction land.

3. The village invested compensation from sale of waste land in a furniture processing factory to generate employment and income.

4. At the time of acquisition, the construction land only had one warehouse of the Taiyuan Textile Corporation. The main plant had been shut down, according to the government's policies at the time. No jobs were lost due to the acquisition of this land.

#### 2. Datong Subproject

5. Although the subproject budgeted for compensation of CNY8.26 million, actual compensation was CNY4.18 million. The reduction is due to the fact that the cost of acquiring land to locate two peak load boilers that were part of the original technical design but were later removed was not incurred. Approval was obtained instead to purchase heat from a combined heat and power (CHP). Land was acquired for temporary use only for pipeline laying. The affected households and enterprises were compensated as per the PRC's laws and regulations.

#### 3. Yangquan Subproject

6. A total of about 2.8 ha of cultivation land was acquired in Pingding county, for which CNY2.44 million was paid as compensation. The actual land acquisition and compensation paid were much below the estimates made at appraisal (4.57 ha, CNY4.3 million). The land compensation funds were used partly to set up a furniture processing factory and partly to finance new accommodation for senior citizens. A total of 50 persons, including 15 women, were displaced and resettled with a suitable means of livelihood.