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IMPLEMENTATION COMPLETION AND RESULTS REPORT

IBRD 8348

ON A

LOAN

IN THE AMOUNT OF US\$100 MILLION

TO THE

PEOPLE'S REPUBLIC OF CHINA

FOR A

SHANXI GAS UTILIZATION PROJECT

May 27, 2022

Energy & Extractives Global Practice
East Asia And Pacific Region

CURRENCY EQUIVALENTS

(Exchange Rate Effective March 1, 2022)

Currency Unit = Chinese Yuan (CNY)

CNY 6.3 = US\$ 1.0

FISCAL YEAR

July 1 - June 30

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ABBREVIATIONS AND ACRONYMS

bcma	Billion cubic meters per annum	NDRC	National Development and Reform Commission
CBM	Coal Bed Methane	Nm ³	Normal Cubic Meters
CHP	Combined Heat and Power	NO _x	Nitrogen Oxides
CNG	Compressed Natural Gas	PDO	Project Development Objective
DA	Designated Account	PMO	Project Management Office
EA	Environmental Assessment	QKNGC	Qingxu Kaitong Natural Gas Company
EHS	Environmental, Health and Safety	RAP	Resettlement Action Plan
EIA	Environmental Impact Assessment	RPF	Resettlement Policy Framework
EIRR	Economic Internal Rate of Return	SCADA	Supervisory Control and Data Acquisition
EMP	Environmental Management Plan	SCPTC	Shanxi CBM (Natural Gas) Pipeline and Transportation Company
FIRR	Financial Internal Rate of Return	SNGC	Shanxi Natural Gas Company
FM	Financial Management	SO ₂	Sulfur Dioxide
GJ	Gigajoule		
GWh	Gigawatt Hour	SOE	State Owned Enterprises
GXED	Shanxi Guoxin Energy Development Group	SPAO	Shanxi Provincial Audit Office
IA	Implementing Agency	SPFB	Shanxi Provincial Finance Bureau
ICB	International Competitive Bidding	SSS	Single Source Selection
IPF	Investment Project Financing	TA	Technical Assistance
kWh	Kilowatt Hour	tcm	Trillion cubic meters
LNG	Liquefied Natural Gas	TSP	Total suspended particulate matter
MOF	Ministry of Finance	WA	Withdrawal Applications
MW _e	Megawatt	WTP	Willingness-to-pay
NCB	National Competitive Bidding	CNY	Chinese Renminbi Yuan

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DATA SHEET

BASIC INFORMATION

Product Information

Project ID	Project Name
P133531	Shanxi Gas Utilization
Country	Financing Instrument
China	Investment Project Financing
Original EA Category	Revised EA Category
Full Assessment (A)	Full Assessment (A)

Organizations

Borrower	Implementing Agency
International Economic & Financial Cooperation Department, Ministry of Finance	Huaxin Gas Group

Project Development Objective (PDO)

Original PDO

The proposed Project Development Objective (PDO) is to increase gas utilization to reduce greenhouse gases emission in selected counties in Shanxi province.



FINANCING

	Original Amount (US\$)	Revised Amount (US\$)	Actual Disbursed (US\$)
World Bank Financing			
IBRD-83480	100,000,000	97,950,891	97,950,891
Total	100,000,000	97,950,891	97,950,891
Non-World Bank Financing			
Borrower/Recipient	92,390,000	92,390,000	90,080,000
Local Sources of Borrowing Country	103,000,000	103,000,000	116,580,000
Total	195,390,000	195,390,000	206,660,000
Total Project Cost	295,390,000	293,340,891	304,610,891

KEY DATES

Approval	Effectiveness	MTR Review	Original Closing	Actual Closing
28-Mar-2014	30-Jul-2014	26-May-2017	30-Jun-2020	30-Apr-2021

RESTRUCTURING AND/OR ADDITIONAL FINANCING

Date(s)	Amount Disbursed (US\$M)	Key Revisions
22-Jun-2020	95.40	Change in Results Framework Change in Loan Closing Date(s) Reallocation between Disbursement Categories Change in Implementation Schedule

KEY RATINGS

Outcome	Bank Performance	M&E Quality
Moderately Unsatisfactory	Moderately Satisfactory	Substantial



RATINGS OF PROJECT PERFORMANCE IN ISRs

No.	Date ISR Archived	DO Rating	IP Rating	Actual Disbursements (US\$M)
01	24-Jun-2014	Satisfactory	Satisfactory	0
02	19-Dec-2014	Satisfactory	Satisfactory	0
03	08-Jun-2015	Satisfactory	Satisfactory	.50
04	13-Dec-2015	Satisfactory	Moderately Satisfactory	.50
05	27-Jun-2016	Satisfactory	Satisfactory	12.83
06	21-Dec-2016	Satisfactory	Satisfactory	12.83
07	23-Jun-2017	Satisfactory	Satisfactory	47.85
08	28-Dec-2017	Satisfactory	Satisfactory	57.83
09	27-Jun-2018	Moderately Satisfactory	Satisfactory	69.91
10	12-Feb-2019	Moderately Satisfactory	Satisfactory	80.24
11	23-Sep-2019	Moderately Unsatisfactory	Moderately Satisfactory	90.33
12	16-Apr-2020	Moderately Satisfactory	Moderately Satisfactory	92.71
13	21-Jul-2020	Moderately Satisfactory	Moderately Satisfactory	95.40
14	11-Jan-2021	Moderately Unsatisfactory	Moderately Satisfactory	96.03
15	30-Apr-2021	Moderately Unsatisfactory	Moderately Satisfactory	99.75

SECTORS AND THEMES

Sectors

Major Sector/Sector	(%)
Energy and Extractives	100
Oil and Gas	21
Non-Renewable Energy Generation	79

**Themes**

Major Theme/ Theme (Level 2)/ Theme (Level 3)	(%)
Environment and Natural Resource Management	100
Climate change	100
Mitigation	100

ADM STAFF

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I. PROJECT CONTEXT AND DEVELOPMENT OBJECTIVES

A. CONTEXT AT APPRAISAL

Country Context

1. *Severe pollution facing the country has driven China to speed up clean energy development in its energy and climate change strategy to address the country's environmental challenges.* China's rapid economic development in the past three decades has relied heavily on coal consumption¹ and the country is suffering from serious environmental pollution. China had to accelerate development of clean energy and shift towards a less coal-dominated economy. Gas was one of the important sources to support this clean development in China.
2. *Gas consumption represented a small share in the overall energy mix and the growth of gas consumption was well below its potential, suggesting gas could substantially replace coal consumption.* Despite a rapid increase since the 2000s, gas consumption in 2011 still represented only about 5 percent of total energy consumption, well below the global average share (about 24 percent) and the Asia Pacific region (11 percent).
3. *Dynamic Assessment of Oil and Gas Resources* indicated that the nation had total natural gas reserves of 52 trillion cubic meters (tcm), of which 32 tcm is technically recoverable. Domestic exploration confirmed a total of 3.78 tcm of technically recoverable natural gas by the end of 2010, about 40 times the actual production in 2010.
4. *The Government of China established an ambitious plan to accelerate gas development.* In 2012, the National Development and Reform Commission (NDRC) updated the National Natural Gas Utilization Policy, while the National Energy Administration (NEA) issued the National Natural Gas Development 12th Five-Year Plan (2011-15) and the State Council issued its National Energy Development 12th Five-Year Plan (2011-15), aimed at increasing the share of gas consumption in primary energy to 7.5 percent by 2015. Furthermore, pilot gas pricing reform was initiated by NDRC.

Sectoral and Institutional Context

5. *The Government of Shanxi province launched a provincial gasification program.* Shanxi province is one of the largest coal producing provinces in China² and the provincial government decided to promote the use of gas to transform its economic structure along a green path.

- (a) Targets: The government issued its Gasification Program in late 2010 and planned to increase gas utilization within Shanxi from about 0.7 billion cubic meters per annum (bcma) in 2008 to 9.0 bcma

¹ Coal consumption has been kept at about 70% of the total energy consumption in China since the late 1990s.

² Shanxi used to be the largest coal producer in China. In 2009, coal production in Inner Mongolia exceeded the production in Shanxi province; but Shanxi became the largest coal producer again in about 2020.



in 2015 and 28.0 bcma in 2020. The total gas supply by Shanxi was estimated to be about 12.0 bcma by 2015 and 36.0 bcma by 2020 when gas exports to other provinces are included.³

- (b) Gas Sources: The four main sources of gas in Shanxi province were domestic coal bed methane (CBM), imported natural gas, coke gas, and local coal converted gas (“the four gases”). Both CBM and imported natural gas were the focus of the initiative as Shanxi has abundant CBM resources as well as five main natural gas trunk pipelines passing through the province. Those lines, operated by PetroChina and SinoPec, could provide imported natural gas to the province.⁴
- (c) Targeted Market: The main markets targeted for gas utilization in Shanxi province were city gas, industrial, chemical, power generation, and transportation (both compressed natural gas (CNG) and liquefied natural gas (LNG) fueled vehicles). At appraisal, these consumers relied on coal, coal gas, LPG, or diesel as their main fuels.
- (d) Main Market Players: Both national and provincial state-owned enterprises (SOEs) were engaged in this sector, as well as private local and foreign companies. The upstream gas developers included PetroChina, SinoPec, China CBM (a national SOE), Jincheng Mining Group (a provincial SOE), and several international energy enterprises.
- (e) Infrastructure was led by Shanxi Guoxin Energy Development Group (GXED) in participation with other provincial SOEs. GXED had, by the end of 2011, built about 3,000 kilometers of the main gas transmission network across the province, covering 94 of its 119 counties. Downstream gas utilization was diversified, with GXED’s subsidiaries providing the gas distribution services in most counties.
- (f) Duration. The Provincial Gasification program commenced in late 2010. The annual goals of the program were 0.7 bcma in 2008, increasing to 9.0 bcma in 2015 and 28.0 bcma in 2020. In 2014 the Government of China, at the highest decision-making level, launched an “Energy Revolution” to ensure a transition to a sustainable energy system without disruption. The Energy Revolution superseded the Provincial Gasification program. In September 2017, in response to a proposal by Shanxi province, the State Council endorsed them as a pioneer province to implement the 2016-2030 “Energy Revolution”.

6. *Implementation of the provincial gasification program was not without challenges.* National-level gas regulation was still absent. In addition, distorted gas pricing, a quota system to allocate the use of gas, and government-driven consumption have limited the growth of gas consumption in recent decades. To achieve the targets of the provincial program, the Shanxi provincial government worked closely with the central government to establish enabling gas policies and a regulatory framework to guide the sound development of the sector.

³ Shanxi Provincial Government approved an updated plan to promote the CBM development in August 2013. The aim was to reach a CBM production of 19.5 bcma by 2015 and 40.0 bcma by 2020. Gas penetration by population is targeted at about 20 million in 2015 (more than 50 percent of the total population of 36 million) and expanded to almost the entire population by 2020.

⁴ The gas source for the project was the provincial gas network, which uses both domestic CBM and imported natural gas as the gas sources. Both the coke gas and coal converted gas are not the gas sources of the provincial gas network, so they are not associated with the proposed project.



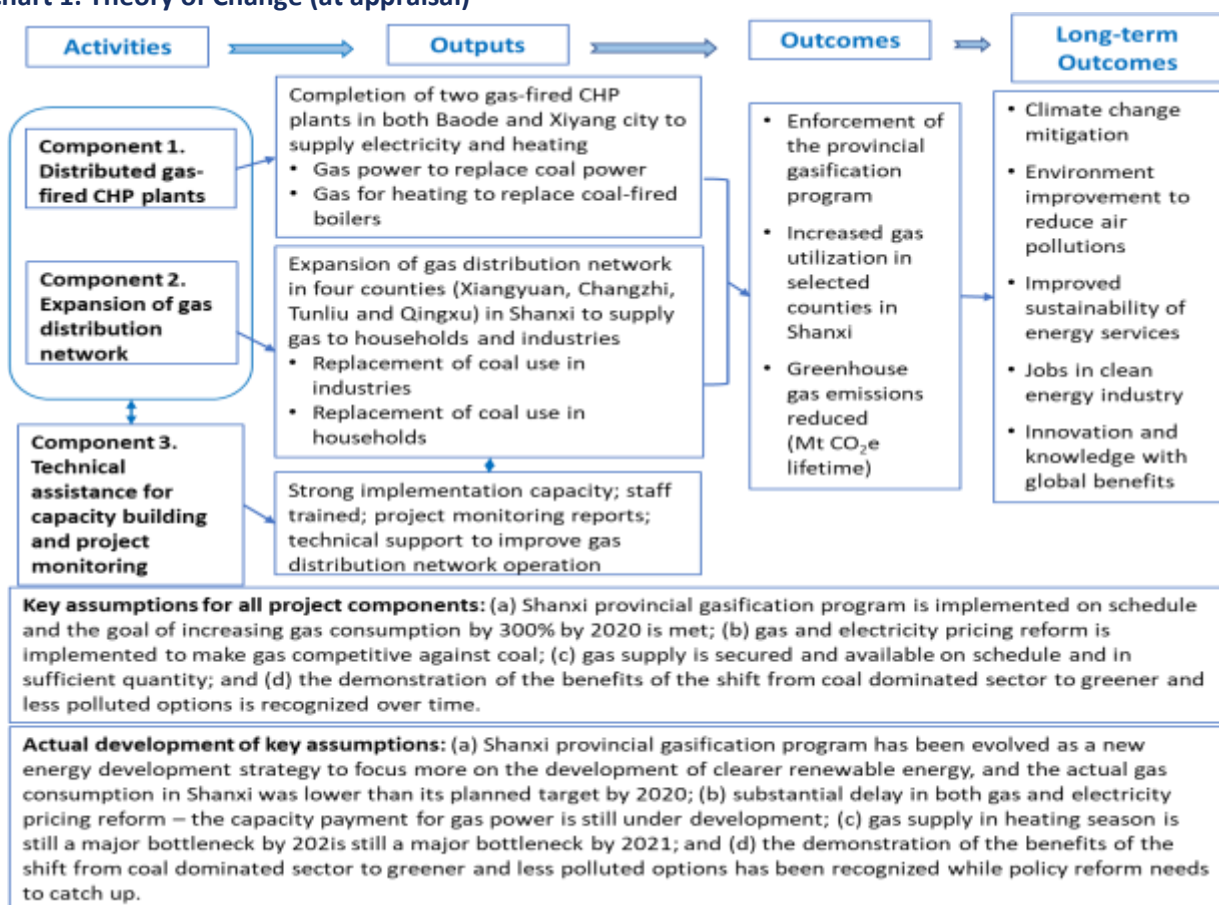
Proper financing mechanisms are also required to fill the gap in infrastructure development, mainly the distribution network in counties and townships. Furthermore, the availability and affordability of gas for consumers needed to be assessed adequately to ensure that the social risk is manageable. By the end of 2011, more than 3,000 kilometers of gas transmission pipeline had been built, covering 94 of Shanxi province's 119 counties. A pricing reform was considered by the central government to link the gas prices to other competitive fuels and is under implementation. This new pricing mechanism was piloted in two provinces (Guangdong and Guangxi) and then applied nationally during the project implementation period.

Theory of Change (Results Chain)

7. The Project Appraisal Document (PAD) did not include a Theory of Change section. Based on the original information in the PAD, the Theory of Change is presented in Chart 1.

8. The project consisted of three components to support both investment in gas-fired combined heat and power (CHP) plants and gas distribution networks, and a technical assistance component. The direct outputs of the project activities include completion of two gas-fired CHP plants and four gas distribution networks. They aimed to provide, once in operation, electricity, heating, and gas supply to the project areas. The project was part of the provincial gasification program, so it contributed to both the improvement of air quality in Shanxi and northern China, as well as improved sustainability of heating/gas supply service.

Chart 1: Theory of Change (at appraisal)





Project Development Objectives (PDOs)

9. The PDO was to increase gas utilization to reduce greenhouse gases emission in selected counties in Shanxi province.

Key Expected Outcomes and Outcome Indicators

10. Description of expected outcome: Significant change in gas utilization, thus leading to a lower share of coal-based generation and utilization and accordingly less carbon emissions in project areas. The achievement of the project outcome objective was to be measured by the following outcome indicators:

- annual gas utilization (cubic meters); and
- avoided carbon emissions (tons of CO₂ equivalent) in the county cities and CHP plants supported by the project.

11. The intermediate result indicators were

- installed capacity (in Megawatt, MW) and annual power supply (in Gigawatt hours, GWh) from the two distributed gas-fired CHP plants;
- annual heating supply (gigajoule, GJ) from the two distributed gas-fired CHP plants; and
- number of households and other gas users supplied by the gas distribution network sub-projects.

Components

12. The project had three components: (1) distributed gas-fired CHP plants; (2) expansion of the gas distribution network; and (3) technical assistance to support project implementation. Components (1) and (2) included a total of six investment sub-projects in six different counties in the province. These were Baode and Xiyang gas-fired CHP sub-projects under Component (1), and Xiangyuan, Changzhi, Tunliu, and Qingxu gas distribution sub-projects under Component (2).

13. **Component 1: Distributed Gas-fired CHP Plants** (Cost estimate at appraisal: US\$260.29 million, with US\$79 million from the IBRD loan. Actual cost was US\$268.59 million). This component included two investment sub-projects with the same capacity: Baode 3x42 MW_e and Xiyang 3x42 MW_e gas-fired CHP plants and affiliated facilities. Both sub-projects were green-field power plants and were to be built for power generation and heating supply to the adjacent county-level cities (Baode and Xiyang County City).

14. The gas source for both sub-projects was the provincial gas network, which had been extended to both cities. The provincial gas network was operated by Shanxi Natural Gas Company (SNGC), which was also the implementing agency of both sub-projects. Annual gas consumption was an estimated 285 million cubic meters for both sub-projects combined. The generated electricity (total installed capacity of 252 MW_e and an estimated generation of 1,160 GWh annually) were to be delivered to the provincial power grid to meet the electricity demand in the province. Heating (total thermal capacity of about 120 MW_t) was to be supplied to the two county cities to meet their expanded heating demand for a total floor area of about 2.37 million square meters. At appraisal, SNGC planned to start the construction of CHPs investment sub-projects in April 2014 and complete



construction in October 2015. The actual construction of both CHP plants started in April 2016 and January 2017 respectively, and construction was completed in December 2019.

15. **Component 2: Expansion of the Gas Distribution Network** (Cost estimate at appraisal: US\$32.35 million, of which US\$18 million was from the IBRD loan. Actual cost was US\$31.67 million). This component included investment in four sub-projects in the four county cities in Xiangyuan, Changzhi, Tunliu, and Qingxu counties. The sub-projects were to install pipelines and pressure regulating stations to expand the gas distribution network to residential, commercial, and industrial consumers. The sub-projects were also to establish Supervisory Control and Data Acquisition (SCADA) systems to monitor the operation of each gas distribution network.

16. The main gas source was the provincial gas network operated by SNGC, with only the gas for the Changzhi sub-project supplied by a local CBM developer who was connected to the provincial gas network. The four sub-projects were expected to meet the increase in gas demand in the four cities by 2020 for an estimated total of 136,700 households and 21 industrial consumers, with an annual gas supply of about 244.15 million cubic meters. At appraisal, the project implementing agencies planned to start the construction of all four sub-projects in October 2014 and complete construction in December 2019. The actual construction of all gas distribution network sub-projects started in November 2015, and construction was completed in December 2019.

17. **Component 3: Technical Assistance** (Cost estimate at appraisal: US\$2.75 million, financed from the IBRD loan. Actual cost was US\$4.35 million). A technical assistance component was included to mitigate the risks related to project design and management, covering activities for capacity building and technical support to the implementing agencies, as well as activities to upgrade the provincial gas network system.

B. SIGNIFICANT CHANGES DURING IMPLEMENTATION

Evolving Government Energy Strategies

18. The overall energy strategy in China (and Shanxi) has evolved towards greener and lower-carbon development since the Shanxi provincial government launched its provincial gasification program in late 2010. This included: (a) the “energy revolution”, launched in China in 2014 to ensure a transition to a sustainable energy system, which encompassed radical changes in energy consumption and supply, institutional reforms, technological innovation, and stressed the need to strengthen international cooperation; Shanxi was selected as the energy pioneer in 2017 and a work plan was approved by the State Council in 2019; and (b) China’s pledge to dual carbon goals (achieving carbon emission peaking by 2030 and carbon neutrality by 2060) in September 2020 to guide the development of all economic sectors (including energy) and which requires further market reforms to establish market prices for energy products. In line with the evolving energy strategy in China, both national government agencies and the Shanxi provincial government issued regulations to guide the utilization of gas. This still encourages the expansion of city gas to replace coal (Component 2), but the role of gas power generation has been repositioned (Component 1):

- Following the 12th national natural gas development Five-Year Plan (2011-2015) and the **Shanxi provincial gasification program**, gas-fired generation was encouraged as one solution to replace coal power nationally and in Shanxi. The provincial gasification program has been integrated into the subsequent energy strategy, in which the role of RE has been emphasized, and gas still plays an important role to replace coal.



- In line with the energy revolution strategy, which was put forward in 2014, a three-year **air pollution control action plan** was issued by the State Council in 2018. Following the plan, renewable energy was considered as one of the major solutions to mitigate air pollution in China, as well as gas for heating and residential use (linked to Component 2). However, gas power generation was not included as a prioritized area for gas use due to the constraint in gas supply (linked to Component 1). This plan is still dominated by the national initiative to guide energy development in the project area.
- A new round of power sector reform resumed after 2015. To address the key challenge of renewable energy (RE) integration in China, the State Council decided to phase down the previous generation quota for coal-fired power plants since 2015 and the remaining generation quota for coal power plants was eliminated in late 2021. A similar arrangement was applied to gas-fired power plants, so the role of gas power is to serve as peaking power plants to improve the RE integration in power systems. The electricity pricing reform was carried out for this purpose – the gas power (and coal power) needs to bid for the electricity generation in the power market. The financial gap is expected to be filled through a planned capacity payment but has not materialized in Shanxi yet.
- Achieving dual carbon goals has become the key driver to guide the new energy development strategy in China since 2020. It builds on the ongoing power sector reform to further promote RE development and requires more coordination and collaboration among different sectors. This is the dominant energy strategy in China and Shanxi.

Revised PDOs and Outcome Targets

19. No changes were made to the PDO throughout the project lifecycle. Changes to the Outcome and Intermediary targets were made in two stages. The project scope of Component 2 was expanded at the Mid-term Review in May 2017 to include a fifth project city, and there was a second revision of the Outcome and Intermediary targets with a formal project restructuring in June 2020. The original and revised PDO and Intermediary indicators targets are shown in Table 1.

20. The project component was revised at the mid-term review in December 2017 to include a new investment sub-project under Component 2. The change was justified because of the slow-down of the Chinese economy since about 2013, which led to a decreased expansion of the gas distribution network in Changzhi, Tunliu and Xiangyuan city. The drop in gas demand and changes in urban zoning required optimization of the planned gas distribution network in all these cities. Some of the sub-projects of urban gas networks in Changzhi, Xiangyuan and Tunliu were modified, while a new gas utilization sub-project in Yangcheng was added under Component 2. No amendment to the legal agreement was required as the flexibility to add or remove investment sub-projects and modification of values of project indicators in the implementation period were taken into consideration when the legal documents were prepared. The related project indicators were revised. Annual CO₂ emission was reduced by 8.9 percent, gas utilization was reduced by 6.8 percent, and the targeted number of connected households and other consumers was reduced marginally by 4.4 percent. The targeted heating supply was also modified, caused mainly by slow urban development in Baode city, so the targeted heating supply was reduced by 34.6%. The other indicators were not modified.

21. In June 2020, the targets of the Outcome and Intermediary indicators were revised with a formal restructuring in order to adapt the project to the evolving provincial energy strategy. Therefore, accelerated energy transition was required in Shanxi, in line with the new national energy strategy of September 2017. Renewable energy (RE) has been planned as the main alternative for coal, and gas power was positioned as one



of the solutions to improve large-scale RE integration. The Shanxi New Energy Strategy placed its focus on cleaner energy, prioritized RE, and targeted a larger proportion of RE in the Shanxi energy mix. Although the project was still aligned with new energy strategies of Shanxi, the operation of the two CHPs was affected, and their generation will be reduced substantially, as they will be run as peaking capacity in non-heating season to improve RE integration in Shanxi province. As a result, two of the PDO level indicators and two Intermediary result targets were modified. The end-of-project target values of the two PDO-level Indicators – Annual Avoided CO₂ Emissions and Annual Gas Utilization – were revised downwards by 28 percent and 25 percent, respectively. Regarding Intermediary indicators, annual power supply was reduced by 36 percent while heat supply was increased by 76 percent. In addition, the project closing date was also extended by 10 months, from June 20, 2020 to April 30, 2021 and savings of US\$2.3 million were reallocated (see para.22-24).

Revised PDO Indicators

Table 1: Revision of Indicators

	Original targets at Appraisal	Revised End-targets	% of change	Explanation
PDO Indicators				
I- Annual CO ₂ emission reduction (ton)	820,290	535,320	-34.7%	Reduced in respond to the reduction of generation and associated gas consumption under Component 1
II- Annual gas utilisation (million m3/year)	365.0	255.0	-30.1%	Reduced due to reduction of generation under Component 1
Intermediate Indicators				
1- Installed Cogeneration Capacity (MW)	252	252	-	
2- Annual Electricity Supply (GWh)	1,100	700	-36.4%	Reduced due to changed role of gas power from base load to peaking power plant, in line with the new energy strategy
3- Annual Heat Supply ('000 GJ)	1,300	150	-88.5%	Expansion in Baode new city was postponed (Component 1)
4- Number of connected households and other consumers	45,000	43,000	-4.4%	Minor revision during the mid-term review – the reduction in four project cities was offset by addition of a new city (Yangcheng)

Revised Components

22. Component 2: the number of counties to benefit from the development of the gas distribution network was increased from four to five with the addition of Yangcheng county. This revision was completed in mid-term review in 2017.



Other Changes

23. **Changes to the main implementing agency of the project.** Shanxi Provincial Government consolidated its gas assets and reorganized its SOEs in late 2020 to manage these gas assets. At appraisal, GXED was the implementing agency of the whole project. After the reorganization and consolidation, the original credits and debts of GXED, on-lending responsibilities and guarantee were shifted to a single entity, Huaxin Gas Group (HXGG), which was established in October 2020. A formal notification was submitted by HXGG to the Bank about the change and confirmed that HXGG is the implementing agency to take all responsibility of GXED. The related subsidiary loan agreements were amended in November 2020. So with this adjustment, the specifics of the projects financed by the World Bank were not affected. This consolidation was a positive development as it integrated all gas transmission pipelines in Shanxi to optimize the dispatch. Additional technical support was provided under Component 3 for the recently organized HXGG to establish a new gas dispatch system.

24. **Changes in loan allocation.** The cost saving of the IBRD loan (US\$2.30 million) from Disbursement Category 1 (goods and civil works under Component 1 of the Project – both CHP plants) was reallocated to Disbursement Category 2 (goods and civil works for US\$0.7 million) under Component 2 of the Project – gas distribution network) and Disbursement Category 3 (Consultant's services, Training and Workshop under Component 3 of the Project – technical assistance for US\$ 1.6 million). The reallocated amounts of the IBRD loan were US\$76.28 million, US\$18.99 million, and US\$2.68 million under Disbursement Categories 1, 2 and 3, respectively. With the reallocation, funds were made available to support the newly-proposed technical assistance (TA) activities, focusing on capacity building of the implementing agency and improvement of the project operation.

Table 2: Changes in Loan Allocation (US\$)

Category			Allocation	Total Loan Disbursed	
Cat. 1	CHP Plants		76,700,000.00	76,298,988.44	
Cat. 2	Gas Distribution Network	Changzhi, Tunliu, Xiangyuan and Yangcheng sub-projects	18,700,000.00	Sub-total	16,452,268.92
		SCADA System			1,152,841.00
		Qingxu Kaitong		18,994,359.30	1,389,249.38
Cat. 3	Technical Assistance		4,350,000.00	2,407,543.46	
	Front-end Fee		250,000.00	250,000.00	
	Total		100,000,000.00	97,950,891.20	

25. **Changes in loan closing date and implementation schedule.** The original loan closing date (June 30, 2020) was extended by 10 months due to the impact of COVID 19 on construction of both CHP plants (mainly testing



and acceptance of the gas turbines) and covering the first full heating season and operation year of the project. The implementation schedule and loan disbursement projections were revised accordingly.

Rationale for Changes and their Implication on the original Theory of Change

26. The major changes to the project scope and indicators are still in line with the original inputs, output, outcomes, and PDO:

- (a) Expansion of the project scope to cover Yangcheng city was a timely solution to maintain the gas consumption under Component 2 in addressing the risk of market development.
- (b) Reduction of the generation of both gas-fired CHP plants (and their gas consumption) resulted in reduction of the direct environmental benefits (and carbon reduction) from the Project. However, the loss can be recovered from the additional renewable generation (zero emission generation) in Shanxi when gas power contributed to the integration of more renewables. The indirect environmental benefit from more renewable energy generation exceeded the reduction of direct environmental benefits from the project.

27. The implication of the alterations to the original Theory of Change is limited. The changes retain the long-term outcomes of the project of carbon emission reduction. However, under the new Province Strategy of 2020, which focuses on expansion of RE, one of the purposes of the project to serve as a model of increasing gas utilization has shifted to CHPs running as a peaking capacity option in non-heating season, while expanding RE power generation and improving RE integration (as noted in para 20). Nonetheless, the overall intention to contribute to a reduction in GHG emissions remained unchanged.

II. OUTCOME

A. RELEVANCE OF PDOs

Rating: Substantial

Assessment of Relevance of PDOs and Rating

28. The relevance of the PDO is rated as **Substantial**, as it was fully aligned at appraisal with the Client and Bank objectives of reducing CO₂ emissions through gas utilization. Changes in the energy strategy and policies in the central and provincial governments affected the gas utilization objective, specifically for Component 1 (CHP plants) while the performance of Component 2 (gas distribution network) is satisfactory. For Component 1, the direct use of gas has been reduced substantially, while its indirect impact to reduce CO₂ emission, contributed by improved RE integration when gas power is operated as peaking units, offset the downsized carbon emission reduction from Component 1. So the key objective of reducing CO₂ emissions is still maintained.

29. At appraisal, the PDO was well aligned with the World Bank Group's Country Partnership Strategy (CPS) in China for the period of FY2013 - FY2016. With the achievement of the PDOs, the project was expected to address the CPS themes of "Supporting Green Growth and More Efficient Use of Natural Resources" (i.e., adjust resource and energy prices to reflect environmental costs by substituting gas for



coal) and “Promoting More Inclusive Development”. The expectation was that the gas consumers served by the project would improve their living standards through use of clean energy and the global community would benefit from avoided greenhouse gas emissions, which contribute to global climate change. At project completion, the project PDO was relevant to the World Bank Group’s China CPF for FY2020 - FY2025, for the pillar of “Promoting Greener Growth” under engagement area # 2.1 Facilitating the Transition to a Lower-Carbon Energy Path⁵ and # 2.2 Reducing air, soil, water, and marine plastic pollution. The PDO remains in line with China’s 13th Five-Year Plan (2016-2020) which refers to in its Tenth Chapter: “Accelerating the Perfection of the Ecological Environment”.

30. The PDO remains relevant to the evolving energy strategy in China and Shanxi. Under the new energy strategy to achieve dual carbon goals, Shanxi continues to promote cleaner energy development in comparison with its previous gasification program, as REs will play a more important role and its share will increase in Shanxi’s overall energy mix. The Shanxi Gas Utilization Project, which was designed to support the provincial gasification program, is still in line with the new energy strategy: (a) all gas distribution network sub-projects under Component 2 are still the main government promoted investment to expand the gas use to replace coal combustion for residential and industrial users, and the achievement of Component 2 is satisfactory as all indicators linked to Component 2 exceeded their end targets; but (b) the operation of both gas-fired CHP plants was affected substantially – the gas power plants have to be operated as peaking units to improve RE integration in Shanxi power grid especially in non-heating season, so the annual operation hours of the gas-fired power plants were reduced substantially – the changed role of gas power plants directly affected the achievement of the Project outcome targets. As a result, the original project indicators targets related to Component 1 – gas-fired CHP plants – could no longer be achieved, while indicators’ targets related to Component 2 – gas distribution network expansion – remained because expansion of gas use for households and industries was still included in the new Energy Strategy. The issue was addressed partially with the project restructuring in June 2020 to ensure that the PDO and outcomes were relevant and consistent with the new Energy Strategy.

Relevance of Design

31. The relevance of design is rated **Substantial**. The preparatory work prior to appraisal was adequate. The project design, including the construction of two power plants and extensions of the gas distribution network, was consistent with the objective of development of gas as a substitute for other fuels to reduce CO₂ emissions. Component 3 of the Project improved the relevance of the design by supporting environmental capacity building, management of gas distribution, and sector planning.

B. ACHIEVEMENT OF PDOs (EFFICACY)

32. The PDO level indicators were highly relevant to the PDO as they capture sufficiently the impacts and contribution of the project to the provincial gasification program in the project areas. As these impacts and contribution were estimated from the direct outputs of the project, the PDO outcomes can all be attributed to the World Bank-financed project.

⁵ Objective 2.1 stipulates “China’s energy transformation requires the reduction of coal consumption and the scale-up of natural gas, renewable energy, and energy efficiency.”



33. The efficacy of the PDOs is rated **Modest**, as the outcome of reduced greenhouse gas emissions was partially met by the project; however, it occurred for reasons outside of the project scope. The second outcome of reduced gas utilization was also significantly less than expected. Target values of both PDO indicators confirm this assessment as they did not meet the revised targets. Three out of four Intermediary Indicators were exceeded. A summary of PDO and Intermediary indicator targets and achievements relating to PDO is provided in Table 3.

Assessment of Achievement of Each Objective/Outcome

34. The actual generation in both gas-fired CHP plants did not achieve the revised targets in its first full operation year, covering the full heating season from November 1, 2021 to March 31, 2022. Although the actual supplied heat exceeded the target by 36 percent, the actual electricity sales were only about 39 percent of the target due to constraints regarding policies on electricity tariff, gas supply, and gas prices. The approved electricity tariff (0.56 Y/kWh), equivalent to a gas price of 2.35 Y/m³, was lower than the required tariff to make profits for both CHP plants at their actual purchased gas prices in 2020 of 2.59 and 2.66 Y/m³, respectively. Accordingly, HXGG had no financial incentive to generate more, and because the shortage of gas supply in winter was a key bottleneck in Shanxi (and in China too), one of the two CHP plants (Baode) was required to stop generation in early December 2020 and the generation of the other plant was reduced. The huge gap of generation and resultant gas consumption in both CHP plants caused both PDO indicators to not meet the planned targets.

35. The electricity pricing reform is the key to enforcing the new Energy Strategy successfully and achieving the project objective. Positive development has been observed since 2021 on the reform: (a) NDRC has initiated a policy on capacity payment for peaking power plants like gas power, so the owners will have financial incentives to run their plants for peaking, with reduced generation hours; (b) increasing electricity price margins for cost pass-through from generators to consumers was announced in late 2021, giving the generators the opportunity to gain their full generation costs in the competitive markets; and (c) both Baode and Xiyang gas-fired power plants were operated in the second half of 2021 to bid their generation and gained profits, in line with their new role of serving peaking load to improve RE integration.

36. The achievement of the objectives of Component 2 to increase the number of connected gas users and direct gas consumption from consumers was **Highly Satisfactory**. By the project closing, the number of connected households and industrial users exceeded the objective by 91 percent. Information provided by HXGG indicated that more households were connected after the project closing, reaching 82,804 by end 2021 or 92 percent higher than the objective, while the gas consumption in 2022 amounted to 116.95 million m³, or 19 percent higher than the target. The objective for Component 2 was fully achieved.

Table 3: Key Results Indicators: Targets and Actual Values

Indicators	Targets at Appraisal	End-targets at Project Closing	Actual at Completion (April 2021)	Achieved %	Explanation
PDO Indicators					
Annual avoided CO ₂ emission (tons)	820,290	535,320	334,000	62.4%	Lower due to less generation and associated gas



					consumption under Component 1
Annual gas utilization (million m3)	365	255	160	62.7%	Lower due to less generation under Component 1
Intermediate Indicators					
Installed Capacity (MWe)	252	252	288	114.3%	Higher capacity due to improved technical design
Electricity Sales (GWh)	1,100	700	250	35.7%	Less generation due to changing role of gas power from base load to peaking power plants
Heating Supply (000 GJ)	1,300	150	204	136.0%	More heating area was supplied in Xiyang City
Connected Households and other users	45,000	43,000	53,639	124.7%	Varied among different cities, overall higher than planned due to market development in Yangcheng city

Note: 2021 data for both CHP plants covers a whole heating supply year (April 2020 – March 2021).

Justification of Overall Efficacy Rating

37. Based on the evidence presented, both key PDOs were not achieved because of a lower-than-expected increase in gas utilization and a corresponding reduction in greenhouse gases emission. This was caused by a lack of tariff incentives to produce electricity for both gas-fired plants, a delay in electricity pricing reform, high gas prices, and a change of policy from accelerated gas utilization to the development of renewable energy. As a result, the efficacy of the project was rated **Modest**.

C. EFFICIENCY

38. The project efficiency was rated **Modest** because the construction of both CHP plants was completed three years behind the original schedule, and the revised estimate of the EIRR and financial justification after tariff reform was lower than anticipated and expected although they are still positive.

Assessment of Efficiency and Rating

Economic Analysis

39. Economic analysis at appraisal. Cost benefit analyses were conducted for all six investment sub-projects at appraisal. The costs include the investment cost and operation cost of each sub-project, while the benefits include both the economic values of the electricity, heating, and gas supply, as well as the global environmental benefits due to the replacement of coal consumption by gas utilization. The cost benefit analysis concluded that the economic internal rates of return (EIRRs) for the two gas-fired CHP plants were 17.5 and 14.0 percent, respectively, and the EIRRs for the four gas distribution network sub-projects ranged from 21.4 to 47.4 percent.



40. Economic analysis at completion. The same methodology is adopted at completion to re-evaluate the economic benefits of each sub-project, but the updated social values for carbon emission (US\$71-143 per ton CO₂e) are used following the latest World Bank guidelines. The EIRRs at the ICR stage in March 2022 for both gas-fired CHP plants were estimated at 12.1 and 12.9 percent, respectively, with low carbon value, and 17.8 and 19.0 percent, respectively, with high carbon value. The EIRRs at the ICR stage for five gas distribution network sub-projects varied from -11.6 to 51.6 percent (weighted 16.5 percent) with low carbon value, and from -9.3 to 66.2 percent (weighted 21.6 percent) with high carbon value. A comparison of the EIRRs at appraisal and completion is provided in Table 4.

Table 4: Summary of Economic Analysis at Appraisal and ICR

Investment Sub-projects	EIRRs at appraisal (\$30/ton CO ₂)	EIRRs at ICR March 2022 (\$71/ton CO ₂)	EIRRs at ICR March 2022 (\$143/ton CO ₂)	Main reasons for differences between ICR and appraisal
Baode CHP Plant	17.5%	12.1%	17.8%	Costs: longer construction period and higher gas price; Benefits: less generation and heating supply areas, lower electricity and heating prices, but much higher carbon values, offsetting the negative impacts of above factors
Xiyang CHP Plant	14.0%	12.9%	19.0%	
Weighted for Component 1	-	12.5%	18.4%	
Qingxu gas distribution	47.4%	13.2%	17.9%	Higher gas purchase price and much lower gas demand
Changzhi gas distribution	28.3%	-11.6%	-9.3%	
Tunliu gas distribution	23.3%	-4.3%	-0.8%	
Xiangyuan gas distribution	21.4%	5.9%	9.8%	
Yangcheng gas distribution	-	51.6%	66.2%	New-added sub-project
Weighted for Component 2	-	16.5%	21.6%	Higher carbon value at ICR

Financial Analysis

41. Financial analysis at appraisal. The financial analyses were carried out at project and corporate levels to assess the financial viability of each investment sub-project and the financial sustainability of the project companies. Financial internal rates of return (FIRRs) were estimated for each of the six investment sub-projects based on cash flow analyses. The income of each sub-project consists of electricity sales, heating supply (for both CHP plants) and gas sales (for gas distribution sub-projects), while the expenditures include investment, gas purchase, other operation expenses, and income tax. The FIRRs for both CHP plants were 6.9 and 3.2 percent, respectively, and the FIRRs for the four gas distribution sub-projects ranged from 9.6 to 11.1 percent.

42. Financial analysis at completion. The same cash flow analyses were carried out to estimate the FIRRs of each of the investment sub-projects, considering the actual operation expenditures and revenues to 2021 and expected expenditures and revenues after 2021. The FIRRs at the ICR stage for both gas-fired CHP plants were



estimated at 2.7 and 3.2 percent, respectively, and the FIRR for five gas distribution network sub-projects varied from -13.8 to 36.2 percent (weighted 11.8 percent). A comparison of the FIRRs at appraisal and completion is provided in Table 5.

Table 5: Summary of Financial Analysis at ICR and Appraisal Stages

Investment Sub-projects	FIRRs at appraisal	FIRRs at ICR	Main reasons for differences between ICR and appraisal
Baode CHP Plant	6.9%	2.7%	Costs: longer construction period and higher gas price; Benefits: less generation and heating supply areas, lower electricity, and heating prices
Xiyang CHP Plant	3.2%	3.2%	
Weighted for Component 1	-	2.9%	
Qingxu gas distribution	11.1%	8.0%	Higher gas purchase price
Changzhi gas distribution	10.0%	-13.8%	Higher gas purchase prices and much lower gas demand
Tunliu gas distribution	10.8%	-8.4%	
Xiangyuan gas distribution	9.6%	3.7%	
Yangcheng gas distribution	-	36.2%	New-added sub-project
Weighted for Component 2	-	11.8%	

43. **Project management.** The overall project administration was effective. The positive aspects include: (a) a streamlined design which resulted in efficient project preparation, implementation, and operation; (b) a stable client team coordinated by a well-established project management office and contracted third-parties for technical support, with effectively monitored safeguards compliance; (c) well-resourced technical and project management supported by the Bank; and (d) effective risk identification, risk mitigation, and technical optimization during implementation, although to a lesser extent at design stage which did not anticipate the evolving energy strategy of Shanxi province and the subsequent need for change and risk mitigation. The Project Management Office (PMO) was efficient in financial management, procurement of the main works contracts, and was professional in construction management. However, the key assumptions as indicated in the Theory of Change did not materialize in a timely manner or were not fulfilled at project closure. This affected substantially the overall performance of the project. Approval delay and subsequent changes to the on-grid electricity tariff for both CHP plants caused serious financial problem for the investors. Key aspects are detailed in Section III on “Key Factors That Affected Implementation and Outcomes”.

44. The project was completed on budget after revisions at the Mid-term Review and Restructuring. The ten-month extension of the loan closing date is considered reasonable to finish the project implementation and provide time for a full year of operation.

Justification of Overall Efficiency Rating

45. The Overall Efficiency rating is **Modest** because the project economic and financial justifications are still positive, although lower than that at appraisal. The utilization of Bank resources by HXGG under the project had



positive benefits; in particular, improving the environmental performance of Shanxi Province. It demonstrated a positive effect for HXGG and a high societal value. However, the project did not deliver all the expected benefits, as demonstrated by the lower than expected (but still significant) achievement of the development objectives. Based on the above assessment of economic and administrative efficiency, the overall efficiency of the project is rated **Modest**.

D. JUSTIFICATION OF OVERALL OUTCOME RATING

46. The Overall Outcome rating is **Moderately Unsatisfactory** because, although the two outcomes of reduction of greenhouse gas and increased gas consumption were the result of the project, their level was significantly less than expected.

47. The PDO was highly relevant at the time of project design and is still relevant to the needs of Shanxi province and China and the World Bank's CPS for China. Nevertheless, the outcome was less positive, as the impact of the project on greenhouse gas emissions and gas substitution was lower than anticipated at appraisal. The efficiency of the project is below initial expectations at appraisal because of the economic and financial impact of the lower-than-expected indicators which affect the economic and financial performance of the project. Although the relevance of the project is still substantial, its efficacy is rated **Modest**, and the efficiency is also rated **Modest**. This leads to the conclusion that the overall outcome is rated **Moderately Unsatisfactory**.

E. OTHER OUTCOMES AND IMPACTS (IF ANY)

Gender

48. Gender aspects were appropriately addressed in project social safeguards instruments, and women's participation and rights were properly considered in resettlement and public consultation processes. The gender impacts attributed to the project include both direct and indirect impacts, and these were analyzed based on the social assessment conducted during the project preparation. The direct impacts include female employment contracted under each of the investment sub-projects, as illustrated in Table 6. Besides the temporary jobs during the project implementation and operation, female permanent employment in the project was 24 percent, which is comparable to the female employment rate in the industry. The indirect impacts include (a) releasing from direct and indirect housework due to coal replacement by gas; and (b) improved health conditions due to improvement in both in-door environment and sanitation conditions.

Table 6: Female Permanent Employment in the Project

	Total	Female	% Female
Component 1: CHP plants	291	66	23%
Component 2: Gas distribution	52	15	29%
Total	343	81	24%

Institutional Strengthening

49. The project had an institutional strengthening dimension in Component 3. It included six sub-components and financed 4.5 percent of the Bank project financing. The key sub-components supported the reinforcement of



social and environmental assessment and monitoring capacity in HXGG, and improvement in occupational safety. As the project proceeded, contractors, regulators, monitoring units and environment units participated in the work, and responsibilities were clarified. In addition, by hiring third-party expertise to implement environmental management plans, the environmental management level of the project was substantially enhanced. The specifics include managers' and implementers' environmental awareness and capacity building at the technical level by training. Beyond supporting the implementation of the project, the capacity building activities contributed to a sustainable enhancement in the competency of staff of HXGG. A SCADA sub-component to the project was added to Component 2 to improve efficiency in the operation of the provincial gas network, including the five counties covered by the gas distribution component of the project.

Improvement in Air Pollution and Social Service

50. The project contributed to an improvement in air quality in the project cities, as part of the overall air pollution control strategy in Shanxi and northern China. A third-party review of the project environmental impacts concluded that all major air pollutants (PM_{2.5}, SO₂ and NO₂) were reduced substantially after the project commissioning, based on the local environmental monitoring data. For example, the annual average SO₂ and PM_{2.5} concentration in Qingxu County reduced by 37.2 and 20.3 percent, respectively; in Xiangyuan County SO₂ and PM_{2.5} concentration reduced by 12.9 and 1.8 percent, respectively; and in Yangcheng County SO₂ and PM_{2.5} concentration reduced by 13.3 and 18.4 percent, respectively.

51. A household-based third-party investigation of the social services in the 2020 heating season was also conducted to examine the quality of these services, mainly heating supply under Component 1 and gas supply under Component 2 in the project cities. The heating supply in Xiyang City showed the following: (a) all the connected households that relied previously on coal for space heating switched to centralized heating from the project (with clean gas heating); (b) the connected households heating supply service was improved – the indoor temperature of all surveyed ranged from 18 to 27 degrees centigrade (an average of 23.7 degrees) meeting the government requirement; and (c) the households heating bills varied – 50 percent were unchanged, 32 percent paid higher and 18 percent paid less. The survey on gas supply service under Component 2 concluded that: (a) expansion of gas service for cooking is the most advantageous as it significantly reduces the workload for housewives and elders and improves people's lives in the project cities; and (b) cooking expenses were reduced by 22 to 48 percent in different cities (an average of 33 percent).

Mobilizing Private Sector Financing

52. Out of all seven investment sub-projects, private investors had a small share in the Yangcheng gas distribution sub-project. All other sub-projects are invested by the state-owned enterprises. Mobilizing private sector financing is not an intended impact of the project.

Poverty Reduction and Shared Prosperity

53. The project improved the efficiency and enhanced the reliability of heat and gas supply services in peri-urban districts that were undergoing fast population, commercial and industrial growth and enhanced the prosperity of commercial and industrial enterprises. Coal replacement by gas will contribute to local shared prosperity and, indirectly, to poverty reduction. By avoiding substantial local pollutants that would have resulted



from coal, the gas distribution component will contribute to an improved quality of life among the population through the improvement of air quality in households, particularly for women and elders.

54. The project was aligned with the WBG's 2013 Energy Sector Directions Paper, which pledged to support clients in delivering affordable, reliable, and sustainable energy needed to help achieve the Bank Group's twin goals of eliminating extreme poverty and promoting shared prosperity. This was achieved through the project's cleaner and more efficient supply of gas network development and in the sustainable environmental gains from the CHP plants.

55. Direct impacts on poverty reduction and shared prosperity: The total number of permanent employees in Xiyang and Baode cogeneration companies reached 291. After the completion of the five urban gas pipeline network sub-projects, four of them have recruited 52 people (37 men and 15 women) in the gas-supplied villages to be responsible for line patrols, household safety inspections and maintenance, and to solve various difficulties encountered in the process of using gas for the elderly, low-income households, and disabled people. The project also contributed to poverty alleviation. Baode company set up a poverty alleviation task force comprising 13 people. Poverty alleviation work was done by helping poor households to buy fertilizer, seeds, and helping them sell vegetables and other crops; organizing vocational skills training for villagers; and providing relief to the poor. In 2019, Gucheng Village was successfully lifted out of poverty. The achievements of the poverty alleviation task force have been unanimously affirmed by the Baode County Government and the Gucheng Village Committee.

Other Unintended Outcomes and Impacts

56. No other unintended outcomes and impacts are reported in the ICR.

III. KEY FACTORS THAT AFFECTED IMPLEMENTATION AND OUTCOME

A. KEY FACTORS DURING PREPARATION

57. **Project Design.** The project design was sound as the preparatory work prior to appraisal was adequate. The selection of both Component 1 and 2 (and investment sub-projects) was consistent with the objective of development of gas as a substitute to other fuels for reducing CO₂ emissions, and Component 3 of the project improved the relevance of the design by supporting environmental capacity building, management of gas distribution and sector planning. The key determining factor of the electricity tariff was handled at appraisal to secure a commitment letter from Shanxi Provincial Government to approve the tariff prior to the completion of both CHP plants, and this is included as a legal covenant.

58. **Environmental and Social Safeguards:** Environmental and Social Assessment (EA and SA) reports were prepared by the EA and SA consultant, respectively (Coal Chemistry Institute of China Academy of Sciences, Shanxi Economic Association), hired by GXED in accordance with relevant national laws, regulations, and technical guidelines and standards applicable to the project, as well as the Bank Safeguards Policies. The Bank team supervised the preparation of the Environmental Management Plan and Resettlement Action Plan (RAP) for the project and ensured compliance with Bank safeguards policies.



59. **Project Risk Assessment.** The overall risk of the project was initially rated as Substantial. Key risks identified included: (a) financial losses because of low tariffs or if the approved tariff could not be adjusted by the government in a timely manner to cover the potential increase in electricity and gas prices; (b) insufficient gas availability, if the production of coal for gasification was not sufficient to meet the demand; and (c) below targets performance concerning electricity production, gas consumption and reduced GHG emissions.

60. **Risk mitigation.** Mitigation measures were included in the project design and project preparation as follows: (a) the provincial government issued a note to guarantee the financial viability of the project and committed to approve the on-grid tariff for distributed gas-fired CHP plants after the project was put into operation. A dated covenant was included in the Project Agreement to request the government's approval of the on-grid tariff for both CHP plants; (b) GXED and its subsidiaries signed gas supply agreements with PetroChina, Sinopec, and other local gas suppliers, and negotiated the gas supply contracts with each supplier before the commissioning of each investment sub-project; and (c) the provincial grid company was consulted and had committed to support clean energy and accelerate the review of the grid connection schemes. Capacity building was included in the TA component to ensure the companies would have adequate capacity to operate and manage the project.

61. **Readiness for Implementation.** When the project was prepared, the PMO and the Implementing Agencies (IAs) were new to Bank-financed projects. A PMO, established at project identification, was led by GXED with the participation of its three subsidiaries. The PMO remained active throughout the implementation period and was responsible for coordinating project implementation. It supervised the preparatory studies for the project, including the two CHPs which were prepared with the support of international consultants. The preparatory work for the socio-environmental studies and Action Program was found to be Satisfactory.

B. KEY FACTORS DURING IMPLEMENTATION

62. Project implementation started in 2014 when Shanxi province was preparing its 13th Five-Year Plan (FYP, 2016-2020), and the provincial gasification program was considered as a major action to promote energy transition in Shanxi, to shift from a coal-dominated economy and revise the energy mix to a greener economy and cleaner energy. As of 2013-14 during project preparation, the large involvement of renewable energy (solar, wind) was not considered a high priority until the approval of Shanxi as the Energy Revolution Pioneer in 2017 and China repositioned the role of gas utilization in its energy mix.

63. **Changes in the context during implementation.** The main changes which affected the project were (i) the slow-down in economic growth; (ii) the adoption of the Energy Revolution strategy to accelerate RE development; (iii) delay in the implementation of the gas and electricity tariff reform; and (iv) the institutional restructuring of the gas sector.

- Lower economic growth: The Chinese economic growth in Shanxi province dropped to 1.9 percent in 2015. The economic depression affected the [existing](#) urban areas in the other project cities, causing the gas demand in the local market to be lower than expected. This led another county (Yangcheng) being added to the project. The slow urbanization in Baode city also reduced the numbers of new buildings in the city and as a result the planned heating demand was reduced.



- **Energy Revolution:** In 2014 the Government of China launched an “Energy Revolution” to ensure a transition to a sustainable energy system without disruption. The “Energy Revolution” encompassed radical changes in energy supply and technological innovation. In September 2017, in response to a proposal by Shanxi province, the State Council endorsed them as a pioneer province to implement the “energy revolution”. Shanxi was empowered with special authority to enforce its new energy strategy. The impact on the project was that with the development of interruptible renewable energy, gas fired plants were expected to increase their role to stabilize the system rather than generating for a base load. Moreover, with the decrease in the cost of supply of energy for renewable energy, the gas fired plants priority order decreased, putting additional pressure on gas-fired generation. Consequently, the number of hours of operation of gas turbines was reduced.
- **Delay in gas and electricity tariff reforms:** The agreement was that the increase in the local electricity tariff (10 percent) would be implemented by December 31, 2016, in a manner which would support the development of CHPs. The electricity tariff was approved in 2020, but later lowered to boost the post Covid-19 economic recovery. On the other hand, the actual tariff for heating was also much lower than was required. These factors created huge pressure on the financial viability of both CHP plants.
- **Sector restructuring:** The previous Guoxin Energy Development Group was restructured as Huaxin Gas Group, and the CBM assets have been transferred or merged into the new HXGG. As a result, HXGG is the only provincial SOE to invest and operate a full chain of CBM business in Shanxi and is also responsible for achieving the provincial targets of gasification as part of its overall energy revolution program. This institutional restructuring had a positive impact on the performance of the project.
- **The impact of the changes during implementation was:** (a) a decrease in power demand from the CHPs leading to a lower than anticipated avoided CO₂ emissions and gas consumption; (b) a reduction in the load factor of the CHPs as renewable energy substituted to gas; (c) a difficult financial situation for the CHPs; and (d) a downsizing of the gas system.

64. **Sound Construction Management.** The construction of the CHPs was scheduled to be completed in October 2015. The construction of both gas-fired CHP plants was started in March 2017 and completed in April 2019 and the trial operation test was completed in December 2019. Accordingly, both plants were ready for commercial operation in 2020 when the final acceptance was approved by local authorities in October 2020 and started to supply heat and electricity for the 2020/21 heating season. On-site completion occurred satisfactorily, but three years behind schedule due to longstanding government approval process before the construction, delayed electricity approval during the construction and impact of Covid pandemic to the acceptance test of gas turbines. The construction of gas distribution networks in all five counties has been completed in stages and started to supply gas to customers after 2017, while the remaining project activities (installation of gas meters in Yangcheng county) were completed in mid-2020. Several important activities were delayed due to Covid-19, including the final acceptance test of gas turbines in both CHP plants, completion of some gas distribution network, and procurement of additional proposed TA activities.

65. **Unforeseen Disruptions.** The shift in government policy to prioritize RE and the slow-down in demand for electricity and heat as well as a gas shortage were the main unforeseen disruptions to the implementation of the project.



66. **Design and Implementation of TA Activities.** Design: GXED and the other three project implementing agencies were new in the gas business. Under the TA component, training programs, study tours, and workshops were executed to improve the capacity of the project implementing agencies and operating entities in both project management and operation. The second sub-component of Component 3 was providing technical support to the project implementation agencies. HXGG completed the TA activities, including a series of trainings, environmental and social monitoring, technical support to improve the operation of city gas network, and the establishment of an online operation simulation system for gas-fired CHP plants in Xiyang. The last TA activities included monitoring of the compliance of both environmental and social safeguards requirements, contracted to two third-party institutes, and installation of the SCADA systems under Component 2 that was agreed in December 2020.

IV. BANK PERFORMANCE, COMPLIANCE ISSUES, AND RISK TO DEVELOPMENT OUTCOME

A. QUALITY OF MONITORING AND EVALUATION (M&E)

67. The quality of M&E is rated **Substantial**. The monitoring indicators were consistent with the PDOs; they were readily available to the stakeholders. These indicators were still highly relevance as they provided relevant indications concerning the implementation of the project and progress with the PDO. The measurement of the indicators linked closely to the actual operation of each investment sub-project. They provided highly relevant indications to allow the Bank and the borrower to take corrective measures when relevant.

M&E Design

68. The project M&E was designed to measure the achievement of the PDO, as well as project output indicators. The PDO-level indicators measured the achievement of PDO in two ways. These were: (a) tons of avoided CO₂ emissions in Shanxi province; and (b) cubic meters of gas consumption through the two project components. The original end-of-project targets for these two indicators, which were determined based on estimates of hours of operation of the CHPs and number of connections for the gas network, accurately reflected and measured the achievement of the PDOs and were easy to evaluate on a real-time basis; hence they were available very shortly before annual or ISR monitoring. The targets were revised due to circumstances which could not be anticipated (new Energy Revolution and economic slow-down). The definition of the target was not revised, only the values at the mid-term review in May 2017 and through a project restructuring in June 2020.

69. Intermediary Results included (a) installed capacity (in Megawatt, MW) and annual power supply (in Gigawatt hours, GWh) from the two distributed gas-fired CHP plants; (b) annual heating supply (gigajoule, GJ) from the two distributed gas-fired CHP plants; and (c) number of households and other gas users supplied by the gas distribution network sub-projects. The selected indicators were suitable for the purpose of the project and correctly represented the project outputs. The Intermediary Indicators were consistent with the PDO Indicators. The Intermediary Indicator for Component 2 of the project (number of gas consumers) was nevertheless less directly linked to the PDO Indicators, which focused on gas substitution and did not include a social objective. The number of consumers measured only indirectly the contribution of Component 2 of the project, as several parameters can de-link the number of consumers from gas consumption. The direct measure of the gas



consumption through the gas distribution systems of the selected counties may have been a simpler and more direct indicator.

70. An additional observation is that the M&E system did not include indicators concerning the sustainability of the project.

M&E Implementation

71. The M&E methodology and indicators remained unchanged during implementation. The PMO provided clear reports of excellent quality to the Bank on a regular basis as per the agreed schedule. The data for M&E were reliable and produced on time. Supplementary data for 2021 for this ICR were collected by year-end to integrate the entire heating season based on the operational records of HXGG. In addition, the project team maintained constant and close dialogue with the provincial government authorities and local county governments, and the state-owned companies involved in the project. The utilization of the M&E system was particularly efficient in monitoring the safeguard aspects of the project through permanent contact and exchanges with the client.

72. Reporting arrangements dealt with routine project implementation progress reports, including both environmental and social monitoring reports. They covered all key aspects of project management, reporting on fiduciary aspects and safeguards. M&E design included appropriate arrangements for data collection, compilation, analysis, and reporting, and was fully satisfactory. In addition, survey reports were required and completed at both project appraisal and completion regarding the quality of social services (gas supply and heating supply) in the project cities to provide firsthand information on the project impacts.

M&E Utilization

73. The efficient implementation of the M&E system provided both HXGG and the Bank with a firm basis to assess progress and make appropriate adjustments, including restructuring of the project. The M&E system was utilized very effectively for monitoring progress and identifying emerging issues in project implementation. It was a determining factor in the identification of the emerging issues which led to the mid-term adjustment of the project in May 2017 and its 2020 restructuring as well as for discussing revised objectives. The M&E system was used extensively during the preparation of the ISRs. The results of M&E were also shared with the provincial government authorities to improve their policy making, especially regarding electricity and gas pricing policies, and sustainability of gas for heating in county-level cities.

B. ENVIRONMENTAL, SOCIAL, AND FIDUCIARY COMPLIANCE

Environmental and Social Compliance

74. The environmental, social, and financial safeguard compliance was rated **Satisfactory**. A sound and comprehensive environmental assessment documentation including EA Summary, Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) was prepared by the borrower. During the project implementation, the borrower maintained a strong commitment to implementing the EMP. All pending social issues were openly identified and addressed. The procurement and financial management of the project were also handled satisfactorily.



75. **Safeguards Policies Triggered.** This project was classified as Category A as per OP 4.01 at the project appraisal stage, due to the risk of fire and explosion in the operation phase. Three World Bank safeguard policies were triggered by the project: Environmental Assessment OP/BP 4.01; Physical Cultural Resources OP/BP 4.11; and Involuntary Resettlement (OP/BP 4.12).

76. **Environmental Safeguards:** The environmental impacts of primary concern are operation-related, such as flue gas and the associated risk of fire and explosion, as well as other issues including noise and dust. OP/BP 4.01 was triggered from the start because the project directly supported construction of two distributed gas-fired CHP plants for power generation and heating supply to the adjacent county cities, and expansion of the gas distribution network. In addition, OP/BP 4.11 Physical Cultural Resources was triggered because the whole territory of Baode County—project site of one gas-fired CHP sub-project—has been classified as a Vertebrate Fossil Area and is protected at provincial level, and Baode CHP plant will be located within the protection area of Diaoyutai Rock Cave which is protected at municipal level. At the restructuring stage, Yangcheng County was added to the project, but without triggering new safeguard policies. The environmental safeguards performance rating has been **Satisfactory** consistently throughout all the Implementation Status Reports (ISRs).

77. Environmental Assessment (OP/BP 4.01). A sound and comprehensive environmental assessment documentation, including Environmental Assessment (EA) summary, Environmental Impact Assessment (EIA) and EMP was prepared by the borrower per the OP 4.01 during project preparation to ensure that potential impacts of the project on environmental and human safety/health issues were fully understood and appropriate mitigation measures developed and agreed on. Mitigation measures to be adopted by the client were detailed in an EMP. During restructuring, an EIA report, an updated EMP and an EA summary report were prepared by the PMO for the component to be carried out in Yangcheng County.

78. A Risk Assessment Report was prepared by a certified institute and incorporated into the EIA. Methodology in line with good international industrial practice was adopted. The critical risk sources and probability of risk were identified, and mitigation measures and a monitoring plan were developed. The aftermath of the risks was also estimated.

79. During the project implementation, the borrower maintained a strong commitment to implement the EMP and provided the monitoring results reports in timely manner, which showed satisfactory environmental performance of the project. The Bank conducted project implementation support and field visits to both CHP plants and discussed with the PMO and their environmental consultant the development of the gas networks and preparation of the post evaluation of the environmental issues. A project implementation completion report was prepared by HXGG after the project closure, including an extensive review of the environmental and social performance during implementation and operation; it also reviewed the EMP implementation report. The EMP implementation, the E&S management and environmental performance in the CHP plants and gas networks were satisfactory.

80. Physical Cultural Resources OP/BP 4.11. A Physical Cultural Resources Management Plan was prepared as part of the EIA/EMP, which includes the mitigation measures, institutional strengthening, monitoring plan and the Chance Find procedures to be applied throughout the construction stage of the project. The monitoring reports were provided by the PMO on time which showed that the mitigation



measures were satisfactorily implemented and that the impacts on the physical cultural resources were negligible.

81. There are no outstanding environmental safeguard issues after the project closing. The PMO has directed adequate resources in environmental management, particularly the design and construction of noise control within the CHP plants and their sensitive receptors, and nitrogen oxides (NOx) control in flue gas as well. The grievance redress mechanism was established and operated/maintained at site by the PMO.

82. **Social Safeguards:** The Involuntary Resettlement safeguards (OP/BP 4.12) was triggered due to the land acquisition and associated affected households. RAP and Resettlement Policy Framework (RPF) were prepared and disclosed during the project preparation, and were implemented. A social consultant was recruited to monitor the compliance of social safeguards throughout the overall project implementation period, and prepared monitoring report on semi-annual basis. The social consultant also prepared a social survey report regarding the heating and gas supply service covered by the project in 2020. The report was completed and submitted to the Bank in late April 2021 prior to the project closing and did not identify any pending issues. HXGG acknowledged the positive impact and capacity building of the project concerning social and environmental aspects. The Bank was satisfied with the social dimensions of the project implementation, as all pending issues were openly identified and addressed.

83. The conclusion is that all required environmental and social safeguards issues have been addressed, and the monitoring of the E&S implementation is satisfactory over the implementation period. The achievements were recorded in the project post-evaluation report by HXGG. The evaluation of the project performance regarding the environmental and social dimensions was **satisfactory**.

Procurement

84. Contracts financed by the loan were procured in accordance with the rules and procedures articulated in the Loan Agreement and the Project Agreement. All contracts were procured in a timely manner and below cost estimates. Work variations and extension of contract durations for unexpected obstructions during contract implementation were professionally examined, and changes were processed in compliance with the terms and conditions of the contracts. Procurement performance of the project is rated **Satisfactory**.

Financial Management (FM)

85. Financial management arrangements in place during the project cycle provided assurance that the Bank loan was being used for the intended purposes. All audit reports were issued on time with unqualified (clean) opinions and did not disclose significant FM-related control weaknesses. The FM-related issues identified by auditors in audit reports were addressed by the project agencies in a timely manner. Delays in project interim financial reports (IFRs) were flagged by the Bank team and quickly resolved by the project agencies. The IFRs were of acceptable quality. FM performance of the project is assessed to be satisfactory.



C. BANK PERFORMANCE

Justification of Overall Rating of Bank Performance

Quality at Entry

86. The project design included limited flexibility and was unable to adapt to changes in the policies of the central and provincial governments. However, it was aligned with the policies of the central and provincial governments as stated at appraisal time. The project design had a limited forward-looking vision, although it was aligned with the National Natural Gas Development 12th Five-Year Plan (2011-15) and the State Council issued National Energy Development 12th Five-Year Plan (2011-15), aimed at increasing the share of gas consumption in primary energy. It was also aligned with the goals of the Country Partnership Strategy (CPS) for 2013-2016 (Report No. 67566-CN, dated October 11, 2012), and is in line with the Strategic Theme One of the CPS, "Supporting Greener Growth." and the WBG CPF for FY13-FY16.

87. Project preparation was sound and paved the way for efficient implementation. The mostly field-based Bank team worked closely with counterpart agencies to ensure high quality and full compliance with both domestic and Bank requirements on feasibility, design, economic and financial aspects, as well as fiduciary and safeguard considerations. Key operational risks such as safety and environmental sustainability were identified and carefully assessed, and optimal mitigation measures were adopted. The M&E design had some weaknesses in terms of the lack of an outcome-level results indicator for the institutional strengthening element of the project under Component 3 and for monitoring project sustainability. An important element was that a key condition for sustainability of the project was the reform of the gas and electricity tariff, which was covenanted in the project, but was a high-risk assumption. This risk materialized, and the tariffs were not adjusted as expected, but minimal risk mitigation measures were imbedded in the project, except the assurance that the Shanxi provincial government would accelerate its gas and power pricing reforms to ensure the financial sustainability of Component 1 of the project.

Quality of Supervision

88. The Bank maintained constant dialogue with the provincial and national authorities and all beneficiaries. The Bank provided proactive and effective implementation support to the project through routine missions and visits to the field as needed. As part of project supervision, the Supervision team offered guidance to the PMO on Bank policies and standards, reviews, and comments to key documents, and expeditious clearance of bidding documents. Issues were identified in a timely manner and addressed properly, except for the tariff issue which had been raised in each mission by the Bank team to the line government agencies. Each Bank supervision mission, comprising technical, fiduciary and safeguard specialists, conducted a comprehensive review of implementation to ensure quality of supervision and compliance, and to provide necessary guidance. A two-year delay in construction and testing of the CHPs slowed implementation but was closely monitored during construction.

89. There was no change in the TTL after loan approval. The TTL was field-based and maintained a strong relationship with counterparts and effectively coordinated day-to-day Bank task management and liaison with the client. An external Social Safeguard expert and two technical experts were hired to assist the task team



throughout implementation. Bank fiduciary and safeguards specialists remained stable for most of project implementation.

90. The Bank team provided strong oversight and guidance and coordinated systematic environmental risk mitigation for the construction of the CHPs, the extension of the gas network, and the land resettlement aspects throughout project implementation. The Bank closely monitored the satisfactory implementation of the EMP.

91. Given the nature of the project, the comprehensive appraisal envisaged that a mid-term review would be conducted. Accordingly, through regular and careful monitoring, the Bank ensured that appropriate changes were made to the project as necessary at the mid-term review in May 2017 as well as for restructuring as approved in June 2020. The Bank discussed and confirmed the operation and management of project-financed infrastructure and the sustainability of project outcomes with the project agencies prior to project completion.

92. However, the project could be benefited from a deeper restructuring when the Bank team realized the substantial delay of the original policies and impacts of changing energy strategy to the operation of both CHP plants. The restructuring could consider adjusting the project design, even with changes to the PDOs and expected outcomes and key project indicators, to ensure the successful implementation of the project and achieve the expected outcomes, thereby avoiding a rating of MU of the PDO.

93. Bank performance is rated **Moderately Satisfactory**, based on the discussion above on quality at entry and project implementation support. Project design was sound and mitigation measures had been taken into consideration at appraisal, especially the government's commitment to approve electricity tariff. During the implementation period, the Bank team acted quickly on depressed market development for Component 2 and added a new investment sub-project, so the outcome of Component 2 was fully achieved. The Bank team also worked closely with the implementing agencies and the concerned government departments to restructure the project to adapt to the changing energy strategy. However, the project could have taken advantage of deeper restructuring once it became evident that the original policy expectations will not materialize, and thus original project targets will not be achieved. Other factors like impacts of Covid-19 and surging fuel prices globally are out of the control of the project, while the Bank team also made efforts to communicate with the concerned government departments in moving ahead with electricity pricing reform in Shanxi.

D. RISK TO DEVELOPMENT OUTCOME

94. **Operational Risk.** HXGG is a new institution, but as it is the merger of four existing entities with operational experience, the operational risk is limited. The technical performance risk concerning the CHPs is limited, as the operation and efficiency of the plant have been thoroughly tested. There are no significant risks concerning the operation of the gas networks. The main risk is that the load factor of the CHPs is not known with certainty, as it depends on the priority and dispatch given to RE plants and unpredictable gas prices. The events of 2017 when the dispatch of the CHPs was substantially reduced by the provincial government may repeat in the future as further adjustments cannot be ruled out. Another risk relates to the CHP nature of the plant. The CHPs produce heat and power, and the production of heat is a "must run" for local industries and households. There is a risk that if the electricity demand for the CHP moves to a peaking pattern as it is presently, it may result in a non-optimal combination of heat and power during certain periods, with a loss of efficiency. The overall operation risk is rated as **High**.



95. **Competition Risk.** Both main components of the project faced, and continue to face, a significant competitiveness risk because the cost of electricity produced by the project CHPs may not be competitive under the new price and dispatch situation compared to other electricity sources. Similarly, considering recent steep international gas price increases, gas may become non-competitive for households and industries compared to other fuels. The price risk is discussed above; however, the technological risk remains regarding the possible entry in the medium-term of new low-cost RE technologies which may make the project non-competitive. The implementation of the gas and electricity price reforms would mitigate the competitiveness risk. Overall, the competition risk of the project is rated **High**.

96. **Financial Risk.** The reduction in the energy production of the plant may affect the financial sustainability of the project component and will require special arrangement in the tariff structure to ensure it fully covers the fixed costs of the units. Moreover, the delay in the gas and electricity price adjustments threatens the competitiveness of the gas-fired CHPs and the attractiveness of gas for households and industries. In consideration of the delay in adjusting the prices and the uncertain future in this respect, this price risk and associated financial risk is rated as **High**. The envisaged shift to a capacity payment for the CHPs will mitigate this risk. As an additional mitigation factor, the Bank team is actively engaged in discussions with the local authorities concerning this issue, with a possibility that it may be addressed satisfactorily soon.

97. **Institutional Risk.** The restructuring of the sector with the establishment of HXGG reduced the institutional risk related to the multiplicity of entities involved in the project. As a result, the institutional risk is rated as **Moderate**.

98. **Environmental and Social Risks.** There is limited environmental risk for the future, as all social and environmental issues have been managed during project implementation. The operation of the CHPs and gas networks has positive environmental impacts, while the safety risk is manageable if the well-prepared safety procedures are followed. Pending social risk is limited as all pending social issues (mainly compensation for land acquisition) were addressed. The environmental and social risks are rated as **Moderate**.

V. LESSONS AND RECOMMENDATIONS

99. The key lessons learnt include the following:

- Drafting the PDOs in terms of project-related outcomes preferably to outputs. In the case of the Shanxi Gas Utilization Project, the PDOs implicitly supported a restrictive scope of outcome by setting not only the reduction of emissions of greenhouse gases through the project but also the fuel choice and implicitly, the technology. The PDOs could have focused on a broader outcome such as the reduction of greenhouse gas emissions, without seeking to specify the details concerning how the broad outcome would be implemented. The broadening of the terms of the PDO would have avoided the project being impacted by a policy change, while remaining in line with the overall outcomes.
- Covenants are advisable if the commitment of the client to comply is confirmed and the Bank has the capacity to act in the event of non-compliance. In the case of the Shanxi Gas Utilization



Project, electricity and gas pricing reform was critical for the success of the project. Electricity tariff adjustments were needed, (although the covenant does not specify the principles to be applied for the revisions), but the upfront commitment of the client was less definitive as the Bank may not have adequate influence in the decisions by the Central Government and the Shanxi province. The result was that the tariff covenant was breached; however, the Bank could not impose penalties and had to accept the non-compliance, despite the negative impact on the credibility of the Bank. The Bank should include covenants only if it has the capacity to enforce them, which was not the case in the Shanxi project.

- When a project is contingent on Government policies, reforms, and regulations that are expected to happen to enable the project implementation, the lessons learnt show the need to manage the risk that these policies or reforms may not materialize in time.
- Given the complexity of energy transition, the lesson to be learnt from this operation is that when expected country and sector contexts do not occur or are changed, how can a Mid-term Review or project restructuring better adjust the project design, even with changes to the PDOs and expected outcomes and key project indicators, to ensure the successful implementation of the project and achieve the expected outcomes, thereby avoiding a rating of MU of the PDO, as is the case with this project.

100. Following recommendations can be considered on Bank's future engagement in gas sector in developing countries under current context:

- Usage of gas in the power sector in countries where dependency has been predominantly on coal has seen challenges with increases in the gas price, while the reduced cost of renewable energy and battery storage has made gas power less viable as base load for power plants, thereby resulting in gas power only acting as peaking units to stabilize the grid; and
- Ensure that forward looking design be considered for any gas facilities supported by the Bank, e.g. the gas facilities can be paired with a CCS operation to reduce its carbon emission as this could be required in the medium term, or can be converted to fuel hydrogen or blended gas and hydrogen in the short and medium term.



ANNEX 1. RESULTS FRAMEWORK AND KEY OUTPUTS

A. RESULTS INDICATORS

A.1 PDO Indicators

Objective/Outcome: Annual Avoided CO2 Emission

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Annual avoided CO2 emission	Metric ton	0.00	820,290.00	535,320.00	288,647.00
		31-Dec-2013	01-Jul-2014	15-Jun-2020	30-Apr-2021

Comments (achievements against targets):

The avoided carbon emission target was not achieved by the project closing, as the actual gas consumption in both CHP plants was much lower than planned though the gas consumption under Component 2 exceeded the planned target.

Objective/Outcome: Annual Gas Utilization

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Annual Gas Utilization	Cubic Meter(m3)	0.00	365,000,000.00	255,000,000.00	160,800,000.00
		31-Dec-2013	01-Jul-2014	15-Jun-2020	30-Apr-2021

**Comments (achievements against targets):**

The actual gas consumption under Component 1 (gas-fired CHP plants) did not meet the planned target due to their actual generation hours were reduced. Delayed electricity tariff and gas pricing reform put pressure on the financial sustainability on the two gas-fired CHP plants so the owners had no incentive for generation.

A.2 Intermediate Results Indicators**Component: Expansion of Gas Distribution Network Component**

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Number of household and other gas users	Number	0.00	45,000.00	43,000.00	53,673.00
		31-Dec-2013	01-Jul-2014		30-Apr-2021

Comments (achievements against targets):

The actual connected number of households exceeded the planned target.

Component: Distributed Gas-fired CHP Component

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Annual electricity supply	Gigawatt-hour	0.00	1,100.00	700.00	250.06



	(GWh)	31-Dec-2013	01-Jul-2014	15-Jun-2020	30-Apr-2021
Comments (achievements against targets): Due to high gas price and low electricity tariff, the owners of both CHP plants had no financial incentive to generate. So the actual generation in the first operation year did not meet the planned target.					
Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Installed capacity of the CHPs	Megawatt	0.00	252.00	252.00	288.00
		31-Dec-2013	01-Jul-2014		30-Apr-2021
Comments (achievements against targets): Improvement in the design during construction led to an installed capacity above target, without impact on the cost.					
Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Annual heating supply	Mega Joules (MJ)	0.00	130,000,000.00	150,000,000.00	204,400,000.00
		31-Dec-2013	01-Jul-2014	15-Jun-2020	30-Apr-2021



Comments (achievements against targets):

Both CHP plants supplied heat as planned in 2020/21 heating season.

**ANNEX 2. BANK LENDING AND IMPLEMENTATION SUPPORT/SUPERVISION****A. TASK TEAM MEMBERS**

Name	Role
Preparation	
Ximing Peng	Task Team Leader(s)
Yunlong Liu	Procurement Specialist(s)
Haixia Li	Financial Management Specialist
Youxuan Zhu	Social Specialist
Yiren Feng	Social Specialist
Dan Xie	Team Member
Supervision/ICR	
Ximing Peng	Task Team Leader(s)
Jianjun Guo	Procurement Specialist(s)
Haixia Li	Financial Management Specialist
Youxuan Zhu	Social Specialist
Yan Zhang	Procurement Team
Yongli Wang	Environmental Specialist
Shanshan Ye	Team Member
Na Han	Team Member

**B. STAFF TIME AND COST**

Stage of Project Cycle	Staff Time and Cost	
	No. of staff weeks	US\$ (including travel and consultant costs)
Preparation		
FY13	5.150	64,914.87
FY14	10.950	120,468.59
FY15	0	0.00
Total	16.10	185,383.46
Supervision/ICR		
FY14	0	31,231.31
FY15	6.350	53,182.74
FY16	7.767	61,654.95
FY17	11.492	73,279.93
FY18	10.594	84,000.63
FY19	10.800	102,574.49
FY20	12.300	92,222.60
Total	59.30	498,146.65

ANNEX 3. PROJECT COST BY COMPONENT

Components	Amount at Approval (US\$M)	Actual at Project Closing (US\$M)	Percentage of Approval (US\$M)
Distributed Gas-fired CHP Component	260.29	268.59	103.2%
Expansion of Gas Distribution Network Component	32.35	31.67	97.9%
Technical Assistance Component	2.75	4.35	158.2%
Total	295.39	304.61	103.1%



ANNEX 4. EFFICIENCY ANALYSIS

1. The project level economic and financial analyses for the ICR were carried out following the same methodology as adopted in the PAD, while actual operation data was used in the ICR stage to re-evaluate the Economic Internal Rate of Return (EIRR) and Financial Internal Rate of Return (FIRR) for each investment sub-project. Cost benefit analysis was used to calculate the EIRRs, and carbon emission reduction was quantified following the latest Bank guideline. Cash flow analysis was used to calculate the FIRRs, and actual production data by the project closing was used.

Economic Analysis

2. Key parameters considered in the cost benefit analysis at the appraisal and ICR stages are detailed in Table A4.1.

Table A4.1: Summary of Key Parameters for Economic Analysis at Appraisal and ICR stages

Key Parameters	At Appraisal	At ICR stage	Note
Electricity Tariff (CNY/kWh)	0.65	0.5605 in heating season Spot market price in other seasons	Shanxi provincial government reduced the approved electricity tariff
Gas Prices (CNY/Nm ³) – purchase	1.73-1.8 in CHP plants 1.67-1.99 in city gas	1.91-2.21 in CHP plants 1.87-2.96 in city gas (1.20-1.42 in Yangcheng)	2 is assumed for future years in CHP plants Same as 2021 in city gas for future years
Gas Prices (CNY/Nm ³) – sales	2.19-2.36 in city gas	2.4-3.29 in city gas (1.61-1.85 in Yangcheng)	Same as 2021 in city gas for future years
Heating tariff (CNY/GJ) - sales	40	Less than 30	Same as 2021 for future years
Carbon Value (US\$/Ton CO ₂ e)	30	Low 71; high 143	Following the Bank's guideline
Avoided Carbon Emission Factors (kgCO ₂ /Nm ³ gas consumption)	2.49 for CHP plants 1.383 for city gas	2.49 for CHP plants 1.383 for city gas	No change

Economic Analysis at Appraisal

3. At appraisal, cost benefit analyses were carried out to estimate the EIRRs of each investment sub-projects, based on the feasibility studies undertaken by the consultants hired by the project implementing agencies. The economic costs include investment cost and operation cost of each sub-project, while the benefits include both the economic values of electricity, heating, and gas supply, and the global environmental benefits due to replacement of coal consumption by gas utilization.

4. Based on the key assumptions, as indicated in Table A4.1, the EIRRs for both Baode and Xiyang CHP plants were 17.5 and 14.0 percent respectively, and the EIRRs for the other four gas distribution network sub-projects ranged from 21.4 to 47.4 percent. All EIRRs were higher than the social discount rate of 10 percent as required by the Government of China. Sensitivity analyses on uncertainties related to investment cost, gas purchase price, carbon value, and project commission schedule were conducted



to test the robustness of the economic justification. It indicated that EIRRs of both CHP plants varied from a low-end (4.6 and 8.5 percent, when environmental benefit was excluded) to 10.8-15.9 percent. However, uncertainty on the electricity tariff was not included in the sensitivity analysis when the Bank team was provided with a government paper to guarantee the approval of electricity tariff for both CHP plants.

Economic Analysis at Project Completion

5. At project completion, the EIRRs of all investment sub-projects were calculated based on the same methodology, while the actual investment costs and operation costs until the project closing were adopted. The key changes in calculating the EIRRs at ICR stage were:

- Electricity tariff: the actual approved electricity tariff is much lower than the level the government committed at appraisal (0.56 vs. 0.65 Y/kWh), and the approved tariff is applied in heating season only.
- Annual generation hours of both CHP plants: the plants were assumed to be operated at 5,000 hours annually as base load plants to maximize its replacement of coal power generation at project appraisal. Due to the evolvement of the energy strategy, both CHP plants are operated as peaking plants to improve the integration of variable REs, so their actual annual generation hours have been reduced substantially, from the original planned 5,000 to about 1,000 actual hours in the 2020/21 heating season.
- Gas prices: a substantial increase of gas prices was observed, and this increased the operation costs of all investment sub-projects substantially.
- Commission schedule: the construction period of both CHP plants was much longer than expected (5 years vs. 2 years) and although this did not result in significant change to the total investment costs, the long construction period increased the discounted investment cost.
- Carbon values: the Bank's 2017 guideline has been followed to use much higher carbon values in comparison with the figure used at appraisal.

Table A4.2: Summary of Economic Analysis at Appraisal and ICR Stages

Component/Sub-project	EIRR at appraisal	EIRR at ICR stage	Main reasons for differences between Appraisal and ICR stages
Baode CHP	17.5%	12.1%	Much less generation, lower electricity tariff and longer construction period, but higher carbon values
Xiyang CHP	14.0%	12.9%	Same as Baode
Component 1 (aggregated)	-	12.5%	
Qingxu Gas Distribution	47.4%	13.9%	Much higher gas price to reduce the profit margin substantially
Changzhi Gas Distribution	28.3%	-11.6%	Substantial reduction of gas sales, and longer construction period
Tunliu Gas Distribution	23.3%	-4.3%	Substantial reduction of gas sales, much higher gas price to reduce the profit margin, and longer construction period
Xiangyuan Gas Distribution	21.4%	5.4%	Less gas sales than planned
Yangcheng Gas Distribution	-	51.6%	New added sub-project during mid-term review, high gas sales volume
Component 2 (aggregated)	-	16.2%	



6. The economic analyses at the ICR stage concluded that the EIRRs of different investment sub-projects varied widely from -11.6 to 51.6 percent. In summary, the EIRRs for both CHP plants decreased modestly due to reduced electricity generation and tariff and although the higher carbon values offset part of the impacts the EIRRs for all gas distribution network sub-projects decreased substantially, mainly caused by lower than planned gas sales, higher gas prices which reduced their profit margin, and a longer construction period. The inclusion of Yangcheng gas distribution network sub-project during the mid-term review was an appropriate change to the project, as its EIRR is relatively high (51.6%) due to high gas sales volume and associated benefit from carbon emission reduction.

Financial Analysis

7. The financial analyses at appraisal were carried out at both project level and corporate level to assess the financial viability of the project and financial sustainability of the project companies. Due to restructuring of the gas industry in Shanxi, quite complicated institutional reorganization was completed in 2020 and 2021, so only the project level financial analyses were carried out at the ICR stage to compare the financial performance of each investment sub-project. The same cash flow analysis was used to calculate the FIRR of each sub-project, taking into account the main assumptions as indicated in Table A4.3.

Table A4.3: Summary of Financial Analysis at Appraisal and ICR Stages

Component/Sub-project	FIRR at appraisal	FIRR at ICR stage	Main reasons for differences between appraisal and ICR stages
Baode CHP	6.9%	2.7%	Much less generation and lower electricity tariff, and the delayed pricing reform to put in place capacity payment
Xiyang CHP	3.2%	3.2%	Same as Baode
Component 1 (aggregated)	-	2.9%	
Qingxu Gas Distribution	11.1%	8.0%	Much higher gas price to reduce the profit margin substantially
Changzhi Gas Distribution	10.0%	-13.8%	Substantial reduction of gas sales
Tunliu Gas Distribution	10.8%	-8.4%	Substantial reduction of gas sales, much higher gas price to reduce the profit margin
Xiangyuan Gas Distribution	9.6%	3.7%	Less gas sales than planned
Yangcheng Gas Distribution	-	36.2%	New added sub-project during mid-term review, high gas sales volume
Component 2 (aggregated)	-	11.8%	

8. The financial analyses at the ICR stage concluded that: (a) the financial viability of both gas-fired CHP plants has been affected seriously by the delayed pricing reform, as the current electricity tariff does not provide adequate incentive for the operators to generate, while higher gas prices have also increased the operation costs of both CHP plants; and (b) the FIRRs of the gas distribution network sub-projects varied widely, similar to the EIRRs. The newly added Yangcheng gas distribution network sub-project has a sound financial performance, contributed by their market development and profitable gas prices. Qingxu sub-project also has sound financial performance, although its FIRR is moderately lower than at appraisal. Xiangyuan sub-project is marginally profitable as its gas sales have been less than planned, but



the other two sub-projects (Changzhi and Tunliu) are suffering from serious financial losses, caused by much lower gas sales, and regulated low gas sales prices (in some years the gas sales price was lower than its purchase price). Gas pricing reform is also key to improving the financial sustainability of the investment sub-projects.

ANNEX 5. BORROWER, CO-FINANCIER AND OTHER PARTNER/STAKEHOLDER COMMENTS

A virtual meeting was held with HXGG on May 25, 2022 to hear from them on their comments to the ICR. HXGG appreciated the Bank's consultation, and provided the following comments:

1. HXGG agrees with the rating of the overall project, and considered the justification was objective, especially the two CHP plants, as their achievement was lower than planned target, and the two CHP plants were suffering from major financial loss. However, HXGG also confirmed that success has been made for Component 2 (gas distribution network) though the performance of each sub-projects varied a lot.
2. HXGG considered that unclear role of gas power in the energy strategy, changing government policies, and inappropriate pricing mechanism are the major factors of not meeting the targets. The provincial government approved the electricity tariff in early 2020, more than three years later than they committed at project appraisal, then reduced the tariff level in 2021, so the generation costs of both CHP plants are higher than their sales price so HXGG has no incentive to generate. HXGG welcome the capacity payment, which has been discussed by both central and Shanxi provincial government for years, but is not confident when the policy will be issued.
3. HXGG explained the reasons of long construction period: (a) long approval process prior to starting construction; (b) long delayed electricity tariff approval held both CHP plants from connected to Shanxi power grid; and (c) Covid pandemic had delayed the acceptable test of gas turbines for more than six months. The actual on-site construction period was about 2 years, comparable with other similar gas power plants in China.
4. HXGG considered the role of gas in the overall energy strategy is still not clear, so they expected clear guidance can be provided by both the central and provincial governments. This will facilitate the gas sector in their decisions in future investment.
5. HXGG appreciated the Bank team's dedicated work and professional support in the past years, and they considered the team's work could be highly satisfactory.



ANNEX 6. Summary of Borrower's Project Completion Report

6. The implementing agency – Huaxin Gas Group – prepared a project completion report (PCR) and submitted it to the Bank prior to the project closing. The PCR includes total six chapters: (1) introduction of the project, (2) adjustments to the project, (3) overall implementation, (4) environmental, resettlement and safety management, (5) environmental, economic, and social benefits of the project, and (6) evaluation of Bank team's performance. This annex provides a summary of the PCR but any duplicated contents that are described in the main text of the ICR have been omitted.

I. Introduction of the Project

Context and project components

7. To fully utilize local coal bed methane, reduce air pollution and greenhouse gas emissions, Guoxin Energy Development Group (GXED), according to the provincial coalbed gas utilization plan of the 12th FYP and the provincial gasification program, planned to implement the Shanxi Gas Utilization Project with the World Bank loan.

8. Guoxin's Shanxi Gas Utilization Project is aimed at increasing the proportion of gas in energy consumption in some counties and reducing greenhouse gas emissions in Shanxi province. The project is of great significance to guarantee power supply in the whole province, especially where the project is located, replacing coal consumption, improving the ecological environment, and enhancing the lives of urban and rural residents.

9. The project includes the following components:

(1) Cogeneration Plants

10. Xiyang County is administrated under Jinzhong City. It met its power demands by receiving external power transmission during the 12th FYP period. In 2013 and 2015, the external power received by Jinzhong City was 233 MW and 1,064 MW, respectively showing an expanding gap in power supply of Jinzhong. Therefore, commissioning the Xiyang Cogeneration Plant will generate power to meet local demand in Xiyang city, and the Baode Cogeneration Plant will generate power to meet local demand in Baode city.

11. For heating supply, an existing coal-fired CHP plant – Anping Thermal Power Plant – supplies heat to the old downtown in Xiyang city. The heat supply in suburban areas and the newly expanded city zone is provided by outdated coal stoves and has resulted in serious air pollution during the heat supply period in winter, caused by waste from coal burning. A similar situation existed in Baode city, where scattered coal-fired boilers were the main heating sources. Both Xiyang and Baode Cogeneration Plants will not only benefit energy conservation and emission reduction, but also improve the power grid in stability, reliability, emergency response, and peak load regulation capacity.

12. The Baode Cogeneration Sub-project is in Gucheng Village, Yangjia Bay, Baode County, Xizhou City. The project built three gas-fired units (2*42 MW gas turbine + 42 MW steam turbine). The annual utilization hours were considered as 5,000 hours. The designed heat load is 33.6 MW. The gas source came from the Baode First Gas Station, which is 7 km southeast of the plant site.



13. Xiyang Cogeneration Sub-project is 500 meters north of Houzhuang Village, Dazhai Town, Xiyang County, Jinzhong City, and 2.5 km from Xiyang County seat. The project built three gas-fired units (2*42MW gas turbine + 42MW steam turbine). The annual utilization hours were considered as 5,000 hours. The design heat load was 55.12 MW. The gas source of the project was Yangquan-Pingding-Xiyang natural gas pipeline of the Shanxi Provincial Natural Gas Network.

(2) Urban Gas Pipe Network Projects

14. Urban Gas Pipe Network Projects are of great significance to energy conservation, investment improvement, and raising living standard of residents. Initially, the four sub-projects were in Changzhi County, Xiangyuan County, Tunliu County and Qingxu County. The coal dominated energy mix and outdated coal combustion techniques have caused severe energy waste and air pollution. The gas pipe network project of each county aimed to optimize regional energy mix, promote local economic development, and improve ecological environment. The urban and rural residents can shift from coal gas, liquefied petrol, and coal to natural gas, and gain benefits on savings in energy consumption, strengthening energy safety, improving household health conditions, and alleviating women from house chores.

15. The gas pipe network project of Changzhi County constructed 52.7 km of sub-high-pressure pipes, provided 30,800 households with gas utilization, and realized an annual gas supply of 89.73 million m³. The gas source of the project was Jincheng-Changzhi coalbed gas pipeline

16. The gas pipe network project of Tunliu County constructed 86.4km of sub-high-pressure pipes in 8 towns and villages, providing gas to 12,210 households and using 84.8462 million m³ of gas. The sources of the gas included the Hongdong-Anze-Changzhi pipeline of the Shanxi Natural Gas Group Limited Company and the local Tunliu-Xiangyuan Gas Pipe of Shanxi Coal Bed Methane Co., Ltd.

17. The gas pipe network project of Xiangyuan County constructed 83.2km of sub-high-pressure pipes in 11 towns and villages, providing gas to 88,100 households and using 62.9502 million m³ of gas. The gas sources of the project are the Hongdong-Anze-Changzhi pipeline and the Tunliu-Xiangyuan Gas Pipe.

18. The gas pipe network project of Qingxu County constructed 31.7 km of medium pressure pipes in eight towns and villages, providing gas to 6,500 households and supplying 6.6247 million m³. The gas source of this sub-project was the Taiyuan-Pingyao pipeline and Kongcun-Gujiao pipeline.

19. Total investment of the project amounted to 1,783 million RMB Yuan, which consisted of: Baode CHP 785 million, Xiyang CHP 801 million, Qingxu city gas 15 million, Changzhi city gas 60 million, Tunliu city gas 59 million, Xiangyuan city gas 63 million, and technical assistance 19 million.

20. Major approval process of the overall project included:

- July 25, 2012, Approval by the State Council to include the project in Fiscal Year 2013-15 World Bank Lending Pipeline
- December 2013, approval of feasibility study report by Shanxi Provincial Development and Reform Commission (PDRC)



- May 2014, signing of legal agreements with the World Bank
- March 2015, approval of technical design for city gas sub-projects by Shanxi PDRC
- November 2016, approval of technical design for both CHP plants by Shanxi PDRC

II. Adjustments to the Project

21. The key adjustments to the project include: (a) restructuring of project implementing agencies, (b) project scope and indicators, (c) project closing date, and (d) reallocation of the World Bank loan among sub-projects.

Restructuring of Project Implementing Agency

22. According to the decision and arrangement of Shanxi Provincial Government on optimizing the state-owned capital configuration and promoting upstream and downstream development of the gas industry, a restructuring of the provincial government owned gas operators was conducted in 2020/21 to establish Huaxin Gas Group Co., Ltd as the main enterprise responsible for gas development in Shanxi. It integrated several gas companies in Shanxi, including Guoxin Energy Development Group. As a result, Huaxin Gas Group became the project implementing agency, and assumed the original credits and debts of Guoxin. The project scope of the World Bank financed project was not affected by this restructuring.

Modification of Project Scope

23. During the mid-term review in 2017, Phase II of the projects in Changzhi, Tunliu and Xiangyuan were impacted by the market depression, city planning, and optimization of the urban natural gas pipe network. The four projects of Phase II faced inadequate market demands in gas because of the slow-down in industry in Changzhi, Xiangyuan, and Tunliu as a result of the economic and market environment in Shanxi, accompanied by other factors like villager resettlement. To achieve the project objective, the project scope was modified as follows: Huaxin terminated some planned pipelines in Changzhi, Xiangyuan and Tunliu, and added a sub-project in Yangcheng. After the adjustment, a total of 30.68 km of gas pipelines were constructed in Changzhi, 32.97 km in Tunliu and 35.65 km in Xiangyuan; the new Yangcheng Natural Gas Utilisation sub-project comprised the Anyang-Dongzhi urban gas pipeline, Lanhua 151 # Gas Well-Yanli Town urban gas pipeline and installed 13,400 households with new gas meters, with a total investment of RMB 65.2277 million, of which the World Bank loan consisted of US\$6.45 million.

Modification of Project Indicators

24. The project indicators were modified twice. Once in 2017 to adapt to the change of project scope during the mid-term review (see Table A6.1); the other was in 2020 to adapt to the evolvement of the provincial energy strategy and its impact on the project operation (see Table A6.2).

**Table A6.1: Revised Project Indicators at Mid-term Review**

	Total	Xiyang	Baode	Changzhi	Tunliu	Xiang yuan	Qing Xu	Yang cheng
Annual CO2 emission reduction (unit: ton)	746970							
Annual gas utilisation (unit: 10,000 m3/year)	34000			2130	360	3840	392	3038
Installed Cogeneration Capacity (unit: MW)	252	3x42	3x42					
Annual Power Supply (unit: 1 million GWh)	1100	550	550					
Annual Heat Supply (Unit: 10,000 GJ)	85	45	40					
Households and other Customers using gas	43000			5000	2400	15000	4600	16000

Note 1: These indicators are calculated based on the total gas consumption and emission coefficients of the Project. According to the feasibility study report, the emission coefficient adopts: 2.490 kgCO₂/Nm³ in cogeneration sub-projects and 1.383 kgCO₂/Nm³ in pipeline transmission sub-projects.

25. Evolvement of the provincial energy strategy: the project was a part of the “Shanxi Gasification Program” in 2013. In 2017, when the Central Government approved Shanxi to be the pioneer of the Energy Revolution, Shanxi launched a new energy strategy to boost the development of renewable energy to replace coal and requested the coal industry to reform to demonstrate its ground-breaking achievements in the national Energy Revolution. The Shanxi New Energy Strategy placed its focus on cleaner energy, put higher priority on renewable energy and targeted a larger proportion of new energy in Shanxi energy mix. Although the project was still aligned with the new energy strategies of Shanxi, the operation of these two CHP plants required coordination with new energy application. Hence, Shanxi’s power system adopted an optimized mode of operation for costly gas power generation, and stacked the CHP plants as peak power stations, putting a higher priority on renewable energy without fuel costs. As a result, the gas-fired CHP plants reduced their annual generation hours significantly which had a substantial impact on the project indicators (both generation, gas consumption and avoided carbon emission). Nevertheless, the combined utilization of gas and renewable energy (including storage) was expected to help Shanxi Province to develop renewable energy on a larger scale and reduce the total consumption of fossil fuels and carbon emission.

**Table A6.2: Revised Project Indicators in 2020 to Adapt to the New Energy Strategy**

	2017	2018	2019	2020	2021
CO2 emission reduction (unit: ton)	9,681	48,405	96,810	288,810	535,320
Annual gas consumption (unit: 10,000 m3)	700	3,500	7,000	15,600	25,500
Installed capacity (unit: MW)	-	252	252	252	252
Annual supplied power (unit: million kWh)	-	-	-	280	700
Heat supply (unit: 10,000 GJ)	-	-	-	6	15
Households with gas supply	3,000	14,000	28,000	43,000	43,000

Changes in Project Closing Date

26. The Covid-19 pandemic at the beginning of 2020 disrupted the project implementation. The overall completion of the project was not achieved as originally planned. On March 16, 2020, Huaxin Gas Group applied to the Shanxi Provincial Financial Department for a six-month extension of the project closing date for the Shanxi Gas Utilization Project financed by the World Bank. The World Bank, the Ministry of Finance, and the provincial authorities approved the extension. The World Bank proposed a 10-month extension rather than a six-month extension of the project to April 30, 2021, so one full year operation of the project could be observed and consulted with the Huaxin Gas Group and the Shanxi Provincial Financial Department. This proposal was agreed with by both the Huaxin Gas Group and the Shanxi Authorities.

Reallocation of the World Bank Loans Among Disbursement Categories

27. The original World Bank loan allocated US\$79 million for Category I, US\$18 million for Category II, and US\$ 2.75 million for Category III, and a front-end fee of US\$250,000. Fund reallocation was made in late 2020 to better use the World Bank loan, as indicated in Table A6.3.

**Table A6.3: Reallocation of the World Bank Loan**

Category	Original allocation (US\$)	Revised allocation (US\$)	Paid proportion of loans (%) (tax included)
(1) Goods and projects for Part I of the Project	79,000,000	76,700,000	100%
(2) Goods and projects for Part II of the Project	16,500,000	18,700,000	100%
(3) Consultant service, training and meeting of Part III of the Project	2,750,000	4,350,000	100%
(4) Front-end Fee	250,000	250,000	Payment was exacted according to the Article 2.07(b) of General Provision and Article 2.03 of this Agreement.
(5) Interest rate cap or Interest rate ceiling-floor premium	0		Payment was exacted according to Article 2.07 (c) of this Agreement.
Total Amount	100,000,000	100,000,000	

III. Project Implementation Overview**(1) Baode Heat and Power Co-generation Plant**

This sub-project started construction in January 2017, connected to the power grid in April 2019 and passed the test of operating at rated load for “72+24” hours in December 2019. In May 2020, the sub-project obtained the power generation certificate, completed performance tests in October 2020 and was put into operation.

(2) Xiyang Heat and Power Cogeneration Plant

This sub-project started construction in April 2016, connected to the power grid in April 2019 and passed the test of operating at rated load for “72+24” hours in December 2019. In May 2020, the sub-project obtained the power generation certificate, completed performance tests in October 2020 and was put into operation.

(3) Changzhi Gas Distribution Sub-project

Changzhi sub-project started construction in November 2015, and its branch pipeline commenced in November 2018. A total of 30.684 km (26.18 km of main line and 4.504 km of branch line) of pipeline was constructed and accepted and put in operation in June 2019.

(4) Tunliu Gas Distribution Sub-project

Changzhi sub-project started construction in November 2015, and its branch pipeline commenced in October 2018. A total of 32.97 km (24.4 km of main line and 8.57 km of branch line) of pipeline was constructed and was accepted and put in operation in November 2019.

(5) Xiangyuan Gas Distribution Sub-project

Xiangyuan sub-project started construction in April 2016, and in November 2017 the main line was put in



operation, In August 2019 the gas line was optimized and accepted. A total of 35.164 km of gas pipeline was constructed, accepted, and put into operation.

(6) Yangcheng Gas Distribution Sub-project

Yangcheng sub-project was planned to include Anyang Gas Distribution Station-Dongzhi County pipe line of 20 km and Lanhua 151# Gas Well-Yanli Town gas pipe line of 8 km as well as upgrades to gas meters for 13,000 households in Yangcheng. The Lanhua 151# – Yanli town pipeline was cancelled on November 29, 2018 due to adjustments to the gas sources. The Anyang-Dongzhi pipeline with a length of 21.059 km started construction on March 3, 2018 and completed acceptance on December 20, 2019. The urban gas network upgrade commenced on April 15, 2019 and was accepted on July 25, 2020. 13,411 households were covered in total.

(7) Qingxu Gas Distribution Sub-project

Qingxu sub-project started construction in July 2016 and was completed at the end of December 2017. A total of 28.518 km of pipeline was constructed, completed internal acceptance, and was put into operation thereafter.

Achieved Project Indicators by Sub-project

28. The actual outputs of each sub-projects are provided in Table A6.4 for both CHP plants and Table A6.5 for all gas distribution network sub-projects.

Table A6.4: Actual Operation Performance of Both CHP Plants

		2019	2020	2021
Baode	Electricity Sales (GWh)	5.16	52.92	11.85
	Heating Supply ('000 GJ)	-	9.7	9.7
	Gas Consumption (million m3)	1.29	13.23	3.25
Xiyang	Electricity Sales (GWh)	10.74	197.14	10.47
	Heating Supply ('000 GJ)	-	194.7	-
	Gas Consumption (million m3)	2.54	46.62	2.48

Note: annual data covers the whole heating season, i.e., from Oct. 1 to Mar. 31 of the 2nd year.

Table A6.5: Actual Operation Performance of Gas Distribution Network Sub-projects

		2017	2018	2019	2020	2021
Gas Sales (million m3)	Qingxu	0.05	6.58	4.97	6.5	8.74
	Changzhi	0.30	0.92	1.09	2.33	2.18
	Tunliu			0.58	5.64	6.13
	Xiangyuan	0.60	2.43	5.86	11.26	15.37
	Yangcheng		2.12	30.29	75.23	86.31
	Total	0.95	12.05	42.79	100.97	118.73
Connected HHs (#)	Qingxu	29	1841	6379	8551	10817
	Changzhi	918	918	7854	8702	9044
	Tunliu	-	-	2858	3557	3792
	Xiangyuan	126	1634	9373	16609	18019
	Yangcheng	-	1	4121	16254	18197
	Total	1073	4394	30585	53673	59869

Note: gas sales include both industrial and residential use.



Procurement and Financial Management

Table A6.6: Contracts and Bids with the World Bank Loan (excluding Front-fee)

	Number of Signed Contracts	Total Contract Values (m\$)	Actual Payment (m\$)
Baode, Xiyang CHPs	10	76.88	76.30
Changzhi, Tunliu, Xiangyuan and Yangcheng gas distribution	18	16.49	16.45
Qingxu gas distribution	3	1.39	1.39
Technical Assistance	22	3.80	3.56
Total	53	98.56	97.70

IV. Environmental, Social and Safety Management

Overview of Environmental Management Plan

29. In accordance with the Environmental Management Plan (EMP), internal and external environment management systems were designed and corresponding plans were implemented. Environment management institutions and staff were arranged. As the project proceeded, contractors, regulators, monitoring units and environment units participated in the work, with clear allocation of responsibilities among all participants. In addition, third-party institutions were hired to monitor the implementation of EMPs, which profoundly enhanced the environment management level of project. EMP monitoring reports were submitted to the World Bank and subject to supervision by forming and enforcing an environment report system and public grievance mechanism, so as to resolve issues amid the implementation effectively and in a timely manner and guarantee the effective resolution of the project's impact on residents and successful development of the project.

30. Due to its nature and scale, the project was listed as Category A, triggering OP/BP 4.01 Environment Assessment and OP/BP4.11 Tangible Cultural Resources. The environment assessment, EMP and summary of this project were completed according to the World Bank's environmental policies and China's policies. When environment assessment analysis identified some environmental impacts amid the implementation, proposed measures to avoid or alleviate impact compared various schemes, provided optimization recommendations, verified the environmental feasibility of the project, disclosed information, solicited public comments, and included environmental protection measures in feasibility study, technical design, and EMP.

31. Good environmental mitigation measures have been adopted, especially for air pollution and noise. In both CHP plants, low nitrogen burners were installed to control the NO_x emission lower than 50mg/m³. To alleviate site noise, a noise management EPC was executed. This required professional



acoustic companies to regulate major noise sources on the site by adopting sound absorption walls, acoustic doors and windows, muzzles, and acoustic tiles. The environmental protection related investment amounted to RMB 37.853 million in Baode (4.66 percent of its total investment) and RMB 32.554 million in Xiyang (3.86 percent of its total investment).

32. The negative environmental impact caused by the project was relatively small and acceptable, in line with the requirements in the environmental impact reports, while the project implementation has brought significant positive environmental impacts. During the preparation stage, it was estimated that dust would be reduced by 698.8t/a, SO₂ emission would be reduced by 2,558.5 t/a, NO_x emission by 2,190.3 t/a, and CO₂ emission by 112.80 t/a. After completion, dust was reduced by 204.8t/a, SO₂ emission by 691.2t/a, NO_x emission by 652.0 t/a, and CO₂ emission by 30.3 t/a, accounting for 29.3 percent, 27.0 percent, 29.8 percent, and 26.9 percent, respectively, of the environment assessment prediction. Failure to achieve actual emission reduced as per the prediction level is attributed to the gap in the design and actual generation hours of both CHP plants.

33. According to the monitoring data of the air quality during implementation, locations where the projects were implemented presented a good trend in air quality improvement, which means the project has contributed to local air quality improvement. After the Qingxu sub-project was put into operation, in Qingxu County, the SO₂ and PM_{2.5} were reduced by 37.2 percent and 20.3 percent in annual average, NO₂ increased by 16.7 percent in annual average, and PM₁₀ remained unchanged. After the Changzhi sub-project was put into operation, NO₂, PM₁₀, and PM_{2.5} were reduced by 6.7 percent, 9.9 percent and 4.3 percent, respectively, in annual average, while SO₂ increased by 5.9 percent in annual average. After the Tunliu sub-project was put into operation, NO₂, PM₁₀, and PM_{2.5} were reduced by 23.5 percent, 15.7 percent, and 10.5 percent, respectively, in annual average, while SO₂ increased by 12.5 percent in annual average. After the Xiangyuan sub-project was put into operation, SO₂, NO₂, PM₁₀, and PM_{2.5} were reduced by 12.9 percent, 5.9 percent, 3.9 percent, and 1.8 percent, respectively, in annual average. Lastly, after the Yangcheng sub-project was put into operation, SO₂, NO₂, PM₁₀, and PM_{2.5} were reduced by 13.3 percent, 17.2 percent, 8.6 percent, and 18.4 percent, respectively, in annual average.

34. During the construction, full cycle safety and professional health training was provided, awareness of professional risks, damages, and protections was raised, professional health and preventative safety measures were stringent and there was no health damage or safety issues. During the operation period, safety prevention and emergency measures have been adopted in all gas distribution network sub-projects, such as pipeline patrol, inspection, safety knowledge promotion, safety training in households, setting up warning signs and informative signs, setting up emergency supplies and emergency teams, preparing emergency plans and conducting emergency drills. After the gas distribution network sub-projects were put into operation until the project closure, no safety issues were reported. During the operation period, the project has established occupational health and safety management institutions and systems, clarified the responsibilities of staff at all levels in occupational health and safety, conducted regular occupational health and safety training and publicity, organized regular drills, conducted regular occupational disease medical examinations and regular occupational disease checks and hazard monitoring for employees, and prepared emergency response plans for possible safety accidents, including comprehensive emergency response plans, special emergency plans and on-site disposal plans.



From the time the cogeneration project was put into operation to when the account was closed, there was no occupational damage or safety issue.

Resettlement

35. In accordance with the World Bank's involuntary resettlement and social security guarantee policy, Guoxin Energy submitted a resettlement plan to the World Bank and received the World Bank's approval. To ensure that the plan is implemented and that the social development objectives of the project are achieved, Huaxin Gas has established comprehensive and effective organizational and management institutions to plan, manage, organize, and coordinate and monitor land acquisition compensation and resettlement.

36. An external monitoring and evaluation agency was contracted, independent of the project owner and local implementation agencies, to monitor and evaluate resettlement and social impacts of the project on a regular basis, with a view to ensuring that the agreed resettlement actions would be implemented, and the social development objectives of the project would be achieved. The external monitoring agency collected data and information on resettlement implementation activities and social impacts through on-site surveys and visits. On this basis, the agency conducted objective assessments of project resettlement implementation and social impacts, identified existing or potential problems, made suggestions, recommendations or adjustment plans to solve such problems, and provided feedback to project owners, the World Bank and resettlement implementation agencies. The aim was to promote the project development to meet the needs of target groups and the continuous improvement of resettlement implementation.

Safety Management

37. In the Project Agreement, establishment of an independent safety inspection expert team is required to support the implementing agencies in preparing and monitoring the safety management plan prior to project implementation. Following this requirement, Huaxin Gas Group hired experienced experts to carry out and implement safety inspections during the construction and operation periods. The safety inspection team was independent of the project owner and local implementation agencies. The main tasks of the safety inspection team were to carry out on-site inspection of safety risks and provide suggestions for improvement. The team received guidance from the World Bank on safety-related work; revised the content of safety inspection work in a timely manner according to the World Bank's comments; and guided the owner to make continuous enhancements.

V. Achieved Environmental, Economic and Social Benefits

38. After the project was put into operation, it played an important role in promoting Shanxi's comprehensive high-quality development, implementing the "Shanxi Action" of carbon peaking and carbon neutrality, leading an energy revolution, promoting the structural reform on the supply side, facilitating the transformation and upgrading of industrial structure, supporting the Blue Sky Protection Campaign, promoting people's welfare, and improving life quality.

(1) Strong support to the "Coal to Gas" program and "Blue Sky Protection Campaign"



39. The air pollution prevention and control work in the Beijing-Tianjin-Hebei region and its surrounding areas is a major political task deployed by the Central Government in China. In 2017, the Central Government announced that the 2017 Beijing-Tianjin-Hebei region and surrounding areas were an “Air Pollution Prevention and Control Work Plan”, covering “2+26” cities including most of the project areas. The implementation of the urban gas distribution network project was of great significance to the local community in supporting coal-to-gas conversion, improving air quality, proceeding the Blue Sky Protection Campaign, and achieving synergy between regional economic and social development and ecological environmental protection.

(2) Facilitating energy-saving and emission reduction for affected enterprises, and improving the local investment environment

40. Yangcheng is one of the “2+26” cities covered by the “Blue Sky Protection Campaign”. This means that industrial enterprises such as traditional ceramic manufacturers are banned from coal burning along with other such plants in the area. The Yangcheng project has supplied gas to meet their new energy demand to replace coal and thereby maintained their production. Gas prices in Yangcheng city are lower than other cities, as the local government aims to “attract investment with gas” to promote local economic development.

(3) Optimizing the energy mix and improving power grid security

41. Shanxi is the first pilot province to implement the comprehensive Energy Revolution in China with renewable energy and gas as main alternatives to coal in Shanxi. By the end of 2020, the installed power generation capacity of Shanxi province exceeded 100 GW and the installed capacity of coal-fired power generation accounted for about 70 percent. The cogeneration projects in Baode and Xiyang have been put into operation, and the total annual power generation was estimated at about 760 GWh and annual heat supply about 350,000 GJ for running for 2,700 hours at 75 percent of load, which is conducive to the diversification of power generation. At the same time, the gas power plant generator is characterized by quick start/stop, strong load adaptability, and flexible operation, etc. In terms of safety, the two plants can also run in isolation to allow black starts of the power system to run at full load within 25 minutes. In addition, the plants also play a role in improving power supply reliability and security.

(4) Enhancing the comprehensive competitiveness of Huaxin Gas Group

42. With the technical assistance, a gas-fired cogeneration online simulation training center was established at the Xiyang plant, and it is the first such simulation system for this type of gas turbine in China. It expands the influence and competitiveness of Huaxin Gas in the gas power generation industry.

(5) Improving the Quality of Life of Vulnerable Groups such as Women, Children and the Elderly

43. Most of the residents with access to natural gas in this project are rural and township residents, who used to cook mostly with coal, electricity, liquefied gas, etc. alone or in combination, and supply heat entirely with coal. The living environment was poor, especially in winter. With gas supply under the project, the residents switched to using gas for cooking. When families use natural gas for heating, the home environment becomes clean and hygienic, which is beneficial to the health of family members, and most importantly, greatly reduces the amount of housework for family members, especially women and the elderly, which promotes their physical and mental health. Some elder families with stable income sources rated gas heating particularly highly, as the simplicity and convenience of gas heating made them



no longer worried about the various household chores and smoke pollution brought about by heating with coal in the winter.

(6) Enabling Local Residents to Increase Income during the Project Implementation

44. Both Xiyang and Baode sub-projects are large investments with long construction cycles and a considerable amount of specific work involved in the construction process. This provided opportunities for the local labor force, enabled more economic and social exchanges between the construction units and the local community, and created greater economic and social benefits for the local community. According to incomplete statistics, the direct labor income brought by the two sub-projects for the residents is about RMB 5 million, the rent of various types of construction machinery in the local area is about RMB 7 million, the procurement of materials and supplies in the local area is more than RMB 20 million, and the rate of renting private houses and vacant land to build sheds in the local area amounted to about RMB 600,000. In summary, the project has brought considerable economic benefits to the local people during construction. During the construction of the five urban gas distribution network sub-projects, the firms were either local construction teams or external construction personnel with some temporary workers hired in the local area, which also offered local people some temporary employment chances to increase their income.

(7) Creating many jobs for the society and solving the problem of low income and employment difficulties

45. The total number of employees in Xiyang and Baode cogeneration companies reached 291, including 214 employees and 77 labor dispatchers and labor outsourced workers (mainly engaged in logistics services). Among them, 187 are local people, accounting for 64.26 percent; 66 are female, accounting for 22.68 percent of the total. Among the labor dispatching and outsourcing employees, female employees are mainly engaged in logistic service work such as cafeteria assistant and cleaning. These workers are generally female laborers from the villages where the two cogeneration plants are located or from the surrounding villages, with an average monthly salary of about RMB 2,000. The construction of the cogeneration plants helped them to be employed nearby, earn a fixed salary, and improve their social status. After the completion of the five urban gas distribution network sub-projects, four of them have recruited 52 people (37 men and 15 women) in the gas-supplied villages to be responsible for line patrol, safety inspection and maintenance, and to solve various difficulties encountered in the process of using gas for the elderly, low-income households, and disabled people, with wages generally ranging from RMB 1,800-2,500/month. This employment not only created some stable jobs for the local labor force, but also provided a basic guarantee for the identification and elimination of potential safety risks in the residents' gas consumption.

(8) Actively Undertaking Social Responsibility and Fight Poverty

46. In the first half year of 2020, Xiyang County encountered drought. The rural residents near the power plant suffered water shortages and the Xiyang company actively cooperated with the Xiyang County Drought Emergency Command Center to dig a deep well as the fourth emergency water supply point in Xiyang County to fulfil its social responsibility. More than 3,000 households from more than 10 villages were supplied with more than 8,500 m³ of water. The measures taken by Xiyang company effectively alleviated the impact of the drought on the surrounding communities. To address the difficult problem of travel in the village of Gucheng, the Baode CHP sub-project, provided a total of RMB 4.5 million to the village to build a 1.5-kilometer-long road around the village.



47. The project also contributed to poverty alleviation. Baode company set up a poverty alleviation task force comprising 13 people. The head of Baode company was responsible for poverty alleviation and helping the village of Gucheng. In addition, four members of the poverty alleviation team are stationed in the village. Poverty alleviation work was done by helping poor households to buy fertilizer, seeds, and helping them to sell vegetables and other crops; organizing vocational skills training for villagers; and providing relief to poor households. In 2019, Gucheng Village was successfully lifted out of poverty. The achievements of the poverty alleviation task force have been unanimously recognized by the Baode County Government and the Gucheng Village Committee.

VI. Evaluation of Bank team's performance

48. During the implementation of the project, the World Bank team provided professional and efficient guidance for the project, provided the Group with advanced management concepts, and expanded the Borrower's recognition of business development. The World Bank team arranged many trainings in procurement, finance, information technology, project management, etc., which have enhanced the ability and level of our management staff, expanded their vision, helped them understand international practices and rules, and draw on advanced management experience and lessons learned from other projects, and ensured the smooth implementation of the project and produced tangible social benefits. Meanwhile, to ensure the construction and normal operation of the projects, Huaxin Gas has designated a corresponding management staff for the group companies and each sub-project company and through continuous training has effectively improved the technical level and management capability of the company.

49. The Borrower reported that they were satisfied with the quality of the loan services of the World Bank. During implementation, they noted the following highlights:

- Timely response and disbursements. The World Bank executed each payment within three workdays. Also, World Bank experts responded to questions in a timely and cooperative manner.
- Reasonable settlement of interests. According to the Subsidiary Loan Agreement signed between the Company and the Shanxi Provincial Financial Department on March 28, 2014, the use of World Bank loan had advantages, including a long repayment period, low interest rate and low repayment pressure during the construction period of the project compared with other financial institutions and non-financial institutions. The loan period of the World Bank was up to 20 years and a five-year grace period. The interest rate was about 2.5 percent, which is much lower than the domestic bank loan interest rate of 5 percent, greatly reducing the cost of project financing. At the same time, the reimbursement of principal increased gradually, with no principal repayment during the construction period and increasing repayment when all production capacity was effective, easing the financial pressure on enterprises and being more in line with their actual needs.
- Professional Technical Support. Since the commencement of the project, the Bank team has provided several trainings in procurement, finance, and project management. Through these trainings, the Company's managers have learned about international practices and rules,



advanced management experiences and lessons from other projects, and benefited significantly from them.

- The World Bank's environmental, resettlement and safety experts also provided valuable advice to ensure the successful operation of the project. The Bank's environmental and resettlement requirements are at a higher level than those in China, and under their supervision and guidance, the project was more focused on environmental protection and social benefits than other domestic projects, which is positive for social development and sustainable development.
- Professional and respectable working manner of the World Bank Team. The World Bank project management team has been very patient and careful in every routine supervision and discussed details of project implementation with us. We appreciate the whole Bank team very much, led by Mr. Peng Ximing, task team leader, with participation by Gong Wenqiang (professional gas power engineer), Wang Yongli (environmental specialist), Zhu Youxuan (social expert), Guo Jianjun (procurement specialist), and Ms. Li Haixia (Financial Management specialist).

50. After years of joint efforts, the project construction has made great progress and achieved satisfactory results in terms of construction, progress, quality, and technology in strict accordance with the requirements of the World Bank.



ANNEX 7. SUPPORTING DOCUMENTS

- (1) Project Appraisal Document (PAD)
- (2) Implementation Support Mission Aide Memoires and Implementation Status & Results Reports (ISRs)
- (3) Environmental and Social Management Framework
- (4) Borrower's Implementation Completion Report



ANNEX 8. IMAGES OF THE PROJECT

