Report No. 12479-CHA

The People's Republic of China

Sichuan Gas Transmission and Distribution Rehabilitation

Project Document
February 1994

CURRENCY EQUIVALENTS
(as of January 1994)

Currency Name	=	Renminbi (RMB)
Currency Unit	=	Yuan (Y)
1 Yuan	=	100 fen
Y 1.00	=	$0.11
$1.00	=	Y 8.7

WEIGHTS AND MEASURES

1 meter (m)	=	3.28 feet
1 square meter (m^2)	=	10.76 square feet
1 cubic meter (m^3)	=	35.3 cubic feet
1 kilometer (km)	=	0.62 miles
1 hectare (ha)	=	10,000 square meters

ABBREVIATIONS AND ACRONYMS

bcm	billion cubic meter
CNPC	China National Petroleum Corporation
ESMAP	Energy Sector Management Assistance Program
GEF	Global Environment Facility
GET	Global Environment Trust Fund
GHG	Greenhouse Gas
JGF	Japanese Grant Facility
mcm	thousand cubic meter
MOPI	Ministry of Petroleum Industry
NEPA	National Environmental Protection Agency
NPV	Net present value
PMO	Project Management Office
PRIF	Preinvestment Facility
SCADA	Supervisory Control and Data Acquisition
SEPC	State Environmental Protection Commission
SPA	Sichuan Petroleum Administration
T&D	Transmission and Distribution
UNDP	United Nations Development Programme

FISCAL YEAR

January 1 - December 31

CHINA

SICHUAN GAS DEVELOPMENT AND CONSERVATION PROJECT

GAS TRANSMISSION AND DISTRIBUTION REHABILITATION COMPONENT

Grant and Project Summary

Grantee: People's Republic of China

Beneficiary: Sichuan Petroleum Administration (SPA)

Amount: SDR 7.3 million ($10 million equivalent)

Terms: Grant

Financing Plan:

	Local	Foreign ($ million)	Total
Global Environment Trust Fund	0.0	10.0	10.0
SPA/CNPC	35.9	23.8	59.7
IBRD	0.0	53.0	53.0
Total	35.9	86.8	122.7

Economic Rate of Return: Not applicable

Maps: IBRD Nos. 25137 and 25138

THE PEOPLE'S REPUBLIC OF CHINA
SICHUAN GAS TRANSMISSION AND DISTRIBUTION REHABILITATION PROJECT

1. Background. China has one of the world's fastest growing industrial economies. Over the past decade, its GNP growth has averaged 13 percent per annum and economic growth is expected to remain robust for this decade. Since the growth of energy supply has not kept pace with energy demand fueled by rapid economic growth, energy shortages are acute in the country. With a view to sustaining both economic development and reduction of air pollution and greenhouse gas (GHG) emissions, efforts to enhance both the supply of cleaner energy resources and the efficiency of energy use have been a cornerstone of the country's energy and environmental policy.

2. Coal has been, and will continue to be, the dominant energy source for China while contributing to increasingly serious environmental concerns, both at the local and global levels. Expanded use of natural gas, an alternative cleaner fuel, would significantly reduce the emissions of greenhouse gases. However, despite the high gas potential in the country, gas exploration and development have been inadequate mainly due to past neglect, financing constraints, and limited access to advanced technologies. Consequently, only a small portion of the potential gas resources have been exploited and natural gas accounts for only 2 percent of the commercial energy consumption in the country.

3. With an annual production of about 6.5 billion cubic meters (bcm), Sichuan Province accounts for 90 percent of nonassociated natural gas and 44 percent of all natural gas (associated and nonassociated) produced in China. The Sichuan Petroleum Administration (SPA) is the primary agency responsible for the exploration, development and transmission of natural gas in the Province.

4. SPA's gas transmission and distribution (T&D) system consists of a pipeline grid and a number of spurs (totaling about 2,800 km in length). SPA supplies about 16 thousand cubic meters (mcm) of natural gas per day to about one million households, commercial entities and small industries through 15 city gas companies and directly to about 600 large industries. Most of SPA's T&D system is 12-20 years old. Mainly due to financing constraints and inadequate economic/financial incentives, there is a large backlog of investments required to rehabilitate the T&D system, which is prone to breakdowns, accidents and gas leakages due to corrosion. Based on the results of a recently completed diagnostic study financed under UNDP's Preinvestment Facility (PRIF), the proposed GEF project would help finance priority environmental upgrades of SPA's T&D system.

5. Significant progress has recently been made in rationalizing gas pricing; since May 1, 1992, the average level of well-head prices in Sichuan has been increased by about 50 percent. However, in order to mobilize the necessary resources for sector development and to provide adequate incentives for efficient supply and consumption of gas, further improvements in both the levels and structure of gas pricing are required. In this connection, a UNDP-financed study on Sichuan gas allocation and pricing was recently completed with the assistance of an international consulting firm. Broad agreement has been reached on the study's recommendations for economic principles that the Sichuan authorities would apply in the allocation and pricing of natural gas. Under the proposed Bank-assisted Sichuan Gas Development and Conservation Project (referred to from hereon as the IBRD Project), assurances have been obtained that the Government would implement the agreed reform action plan for gas pricing and allocation criteria.

6. Environmental Policy Framework. China's rapid industrial growth has been accompanied by greater concern for the environment. The Chinese authorities are increasingly aware of the need to address environmental problems and recent official policy calls for economic development to proceed in tandem with environmental protection. In this connection, the Bank has been actively involved in assisting China in developing its overall environmental policies, strategies and action plans. Furthermore, several environmental operations have been developed and are under implementation with the Bank's assistance.

7. During the last 10 years, China has made significant progress in environmental protection policies and programs. It has set up an institutional and policy framework for environmental protection, established comprehensive and strict pollution guidelines (including a system of pollution levies and effluent fees) and, since 1984, required environmental assessments for most public investments. The State Environmental Protection Commission (SEPC), which includes the heads of all relevant ministries and agencies, and ultimately the State Council are at the apex of decisionmaking on environmental policy in China. SEPC relies heavily on its secretariat, the National Environmental Protection Agency (NEPA) to oversee environmental policies and regulations. Implementation and enforcement are mainly the responsibility of the vast network of provincial, municipal and local environmental protection bureaus. Every line ministry also has an environmental department. As a result of these measures, there are indications that China has made progress in addressing its environmental problems and in reducing the rate of environmental degradation in some regions of the country; however, as in most countries, the implementation of environmental policies and standards has not been uniform, and the impacts of economic policies and very rapid growth have not always been conducive to sound environmental management.

8. China recognizes the serious consequences of global warming caused by the excessive human-induced emissions of GHGs. Relevant government departments and the scientific circles in China have already engaged in extensive research in this regard. To date, preliminary analyses and evaluations have been made on the impact of global warming on China's environment. A Climate Change Coordination Group, an interagency committee of five leading governmental departments, was created in February 1990, and charged with overall policy formulation on the GHG issue. NEPA, together with other ministries and agencies, takes a leading role in policy formulation, especially with respect to the impact of global climate change. In this connection, a national strategy of GHG emissions reduction is being developed with GEF grant support. In tandem with the development of a national policy to address global warming concerns, an institutional framework is being further developed. In addition, China has developed a country program, with the assistance of UNDP and the Bank, which aims at the phasing out of ozone-depleting substances (ODS). Separately, environment-related sector work recently completed by the Bank has included (a) a study of the efficiency and environmental impact of coal use in China (Report No. 8915-CHA), March 20, 1991; (b) an environmental strategy paper for China (Report No. 9669-CHA), April 1992; and (c) China Energy Conservation Study (Report No. 10813-CHA), February 4, 1993.

9. IBRD Project Objectives. The IBRD project aims to: (a) support the implementation of the upstream oil and gas sector restructuring; (b) rationalize both the levels and structure of gas pricing; (c) promote rational gas allocation; (d) reduce acute gas shortages and environmental degradation in Sichuan through increased gas production (and avoidance of coal consumption) and energy conservation; (e) improve the efficiency of gas production and optimize ultimate recovery of gas reserves through sound reservoir management and state-of-the-art enhanced gas recovery technology; (f) under the proposed GEF component, enhance the safety, reliability, operational efficiency and environmental management of the gas T&D system, including the reduction of gas leakage which would, in turn, reduce methane emissions and the GHG effect; and

(g) strengthen the institutional capabilities of China National Petroleum Corporation (CNPC) and SPA.

10. The project would comprise three main components: (a) a restructuring component, implementation of the first phase of restructuring the upstream oil and gas sector, including commercialization and corporatization of CNPC/SPA through their transformation into joint-stock companies, introduction of a commercial accounting system and implementation of productivity enhancement and related human resources development programs; (b) an investment component (98 percent of project cost), including gas field development in Eastern Sichuan through the drilling of about 100 wells; seismic survey and interpretation; and construction of related surface facilities (62 percent); gas field stimulation and rehabilitation of about 90 wells in Eastern Sichuan and 100 wells in Central Sichuan (15 percent); and expansion (9 percent) as well as rehabilitation and environmental upgrade (12 percent) of SPA's gas T&D system; and (c) an institution building component (2 percent), technical assistance and training for the implementation of the above two components as well as for national petroleum education to upgrade the teaching and research capabilities of the local petroleum institutes and develop exchange programs between the local and foreign institutes.

11. GEF Supported Actions. A PRIF-financed study evaluated the gas transmission and distribution system's integrity, efficiency and reliability and determined the most efficient measures for its rehabilitation, including measures to reduce methane emissions. The main findings of the study are summarized as follows: (a) the integrity of the system is threatened; 110 pipe failure accidents were reported during the past two decades. In the absence of adequate remedial measures, further deterioration of the system would result in an increasingly high risk of accidents which would jeopardize the safety of the general public, disrupt gas supply to customers and increase GHG emissions; (b) internal corrosion in the pipelines due to release of sour gas into the transmission system is the most serious problem; (c) in emergencies, the grid control system cannot efficiently respond to rapid changes in the operating conditions; (d) methane losses from the overall SPA natural gas system (from gas production wells to city gate) are estimated to vary between 1.06 and 3.53 percent of throughput, which are close to the original estimate of 1 to 3 percent. However, the relative share of methane losses from gas production and gathering (77 percent) is significantly higher than originally anticipated. Gas distribution (16.7 percent), gas transmission (4.8 percent) and gas purification (1.2 percent) account for the balance of the methane emissions. Almost all of the methane emissions from the SPA gas system are due to fugitive equipment leaks; and (e) until recently, responsibility for the operation of the system was divided between several departments and there was a lack of accountability at the senior management level.

12. To address the above issues, a risk-averse, least-cost rehabilitation program has been formulated based on the above diagnostic study. The remedial measures would include (a) installation of adequate gas treatment facilities, and introduction of practices to allow only dry and sweet gas (in accordance with the specifications) to enter the pipelines; (b) rehabilitation and environmental upgrading of the transmission and distribution (T&D) system to mitigate the risk of accidents and enable optimal upgrading and expansion of the system for safe and efficient operation as well as environmental protection over the next 20 years; (c) enhancement of safety regulation; and (d) institution building through technical assistance and training. Further, all functions relating to gas transmission and distribution have recently been consolidated into a single subunit (SPA T&D Company) which is fully accountable for efficient transportation of gas from the fields to the consumers.

13. Description of GEF Support Actions. The proposed GEF gas transmission/distribution rehabilitation will be a joint effort between SPA, GEF and IBRD to eliminate gas losses and improve the gas pipeline network performance

through two subcomponents to be simultaneously implemented. The first one, to be partly financed by the IBRD loan, would enhance both the safety and operational efficiency of the T&D system through: (a) rehabilitation and upgrading of pipelines, measurement, corrosion control, corrosion inhibition, telecommunication, gas control, gas quality monitoring and emergency response facilities of SPA's entire gas transmission and distribution system; (b) deterioration monitoring and evaluation of the T&D system; (c) provision of a supervisory control and data acquisition system (SCADA) for the whole T&D system; and (d) technical assistance and training.

14. The second subcomponent, to be partly financed by the proposed GET grant, would include cost-effective measures to reduce gas leakages through a program of environmental upgrades, including: (a) installation of additional valves at the vent stacks of both the gas gathering and transmission systems; (b) installation of chained caps or plugs on open-ended pipelines; (c) upgrading or replacement of the seals of control valves; (d) replacement of high performance compressor seals; (e) upgrading of the seals of block valves; and (f) the implementation of comprehensive gas leak detection and repair programs, including repair or replacement of various types of valves (control valves, block valves and pressure relief valves); plugging of open-ended lines; and provision for methane-emission monitoring equipment. The economic values of gas saved as a result of the environmental programs would more than offset the capital and operating costs, thus yielding net economic benefits. Three of these programs (replacement or upgrading of the packing of block valves, replacement of control valves and plugging open-ended lines) would entail net incremental costs which would be partly financed by the proposed GET grant. Further discussions of the proposed GEF component are in Annexes 1 and 2.

15. Cost and Financing. The total component cost (excluding interest during construction) is about $109.5 million, of which foreign exchange expenditures are about $73.6 million (67 percent). The proposed $10 million GET grant would finance an environmental upgrade program representing about 9 percent of the total project cost and 14 percent of the foreign exchange expenditures. The IBRD loan would finance about $53.0 million of the foreign exchange expenditures. SPA and CNPC would provide the remaining funds (including interest during construction of $13.2 million) consisting of $35.9 million in local currency and $23.8 million in foreign currency.

16. Implementation. SPA would be responsible for the implementation of the IBRD project and the proposed GEF component. For this purpose, SPA has established a Project Management Office (PMO) to coordinate the various project activities. Implementation of the GEF component is expected to be completed by June 30, 2000 and the Grant closing by June 30, 2001.

17. Sustainability of the Proposed GEF Actions. The Chinese authorities are fully committed to this component as it offers the opportunity of enhancing the safety, efficiency and environmental protection of the natural gas T&D system in the largest gas-producing province in China. In addition, under the IBRD project, an agreement has been obtained from the government on the implementation of a gas pricing reform action plan which would increase the financial incentives to the gas producer to conserve gas resources, including the reduction of gas leakages. Further, the IBRD project would lend added momentum to enterprise reform and support the implementation of a regular gas leak detection and maintenance program and human resources development to improve the management and operational efficiency of the gas supply system, as well as reducing environmental impacts and improving system safety. All these measures will contribute toward the project's sustainability.

18. Lessons from Previous Bank-Financed Natural Gas Projects. Bank participation in the gas sector in China has thus far included two operations which were completed recently: Weiyuan Gas Field Technical Assistance Project

(Loan 2580-CHA) and Liaodong Bay Petroleum Appraisal and Technical Assistance Project (Loan 2708-CHA). The lessons learned from these projects included (a) fragmentation of responsibilities among various Chinese agencies, coupled with cumbersome internal clearance procedures, contributed to significant delays in initial procurement activities of the Weiyuan Project--in contrast, the streamlined procurement arrangements under the Liaodong Bay Project contributed to the timely implementation of the project; (b) delays in the implementation of institution building components could be mitigated through reaching agreements on the training program and the Terms of Reference for consultant services no later than negotiations; and (c) a strong project management unit with adequate staff to provide requisite coordination among multiple agencies is crucial for efficient project implementation.

19. In addition, the principal lessons indicated in "A Review of World Bank Lending for Natural Gas" (Report No. 10828) include (a) the Bank's assistance has had a significant impact on improving the technical capacity of gas institutions, particularly where there were twinning arrangements with an internationally experienced foreign operating company or gas utility; and (b) a major weakness of the Bank's institutional development approach was its strategy of trying to do everything at once; a more long-term view was needed, given that the goals of institutional development generally will not be achieved within the time span of one project. The design of the proposed project has built on the above lessons learned from earlier Bank operations.

20. Rationale for GET Funding. Based on the recommendations of the PRIF-financed diagnostic study, GET grant funding is proposed to finance the incremental cost of methane reduction measures in order to provide economic incentives for the Chinese authorities to implement a comprehensive program of environmental upgrades. The GEF benefits are clear in that reductions in natural gas leaks (which is mostly methane) will reduce fugitive methane emissions, a powerful greenhouse gas. Global warming concerns are directly addressed since fugitive methane enters the atmosphere where its global warming potential is some 22 times that of CO_2. Successful implementation of the GEF project component would have a significant demonstration effect for other gas T&D systems in China and other developing countries.

21. Agreements Reached. An assurance has been obtained from the grantee that it will make available the proceeds of the GET Grant to SPA under terms and conditions satisfactory to the Trustee. Assurances have also been obtained from SPA that it would: (a) carry out an environmental management program, including the implementation of a regular gas leak detection and maintenance program agreed with the Trustee; (b) carry out training and technical assistance in accordance with the program agreed with the Trustee; and (c) maintain the Project Management Office (PMO) with functions, powers, funds, facilities and staffing satisfactory to the Trustee.

22. Environmental Aspects. The proposed GEF component would reduce emissions of methane, a potent greenhouse gas, by about 77,000 tons per annum. Further, the proposed IBRD project would result in mitigation of environmental degradation and health concerns (notably respiratory diseases) through the substitution of coal (2.9 million tons per annum) by gas, which would, in turn, reduce emissions of SO_2 (171,080 tons per annum), CO_2 (2.3 million tons per annum), nitrogen oxide (6,100 tons per annum), carbon monoxide (64,985 tons per annum) and ash (948,300 tons per annum).

23. No residents will have to be relocated as a result of this project. However, about 700 hectares and 190 hectares of agricultural land would have to be acquired on a temporary and permanent basis, respectively. Public consultation has been built into the process of project preparation and implementation; resettlement site may be changed according to the preferences of the local residents. Procedures for compensation and resettlement have been established in both national and provincial legislation, with the compensation

payment based on the productivity of occupied land in recent years. These procedures are satisfactory.

24. Chinese regulation requires the preparation of an environmental assessment (EA) report at the time of project design. The EA report for the project was satisfactory. As part of the EA process, mitigating measures for possible environmental impacts have been developed. In this connection, various preinvestment studies were carried out with the assistance of international consultants, and the project design and implementation will conform with international engineering and safety standards as well as sound environmental management practices.

25. Benefits. The potential global environmental benefits would include the reduction of about 2 million tons of methane (representing 44 million tons of CO_2 equivalent) over the 20-year life of the project. Additional global environmental benefits will accrue from the IBRD project's development component through the increased gas supply which will displace coal. The proposed GEF component would demonstrate the cost-effectiveness of gas loss reduction at the margin of economic viability from a country perspective. It would help indicate the GHG reduction potential of natural gas system rehabilitation and efficient operation to other regions in China and to other countries.

26. The diagnostic study included economic cost and benefit analyses of each of the PRIF environmental programs under the component and, on this basis, a supply curve was derived for the net cost of reducing methane emissions converted to unit cost per ton of CO_2 equivalent reduction (Annex 2). Net costs have been defined as the net present value (NPV, at a 12 percent discount rate) of capital and operating costs net of the economic benefits of the gas saved through leakage reduction. The international price of fuel oil parity (at about $11.8/bbl, FOB Singapore) has been assumed to be the imputed economic value of natural gas (which is equivalent to about $60.34/mcm or $80.47/ton of gas).

27. The results of the above economic analyses indicated that a considerable amount of leakage reduction could be realized at negative cost to be charged to the GHG mitigation account. Specifically, the NPV of the net economic benefits of some of the environmental programs are estimated to be about $20 million. For the other programs, the total incremental cost (the NPV of capital and operating costs net of economic benefits of gas saved) is estimated at $15 million, of which $10 million would be financed by the proposed GEF grant. The incremental unit costs of methane reduction relating to the environmental programs are estimated to range from -$0.9 to $7.9 per ton of CO_2, of which the unit costs of the proposed GEF-financed component are estimated at $0.5-1.5 per ton of CO_2.

28. Risks. No major risks are anticipated for the proposed GEF investment. However, there are risks of delay in project implementation. To reduce these risks, an assurance has been obtained from SPA that it would maintain the PMO with functions, powers, funds, facilities and staffing satisfactory to the Bank.

Attachments

CHINA

SICHUAN GAS DEVELOPMENT AND CONSERVATION PROJECT

GAS TRANSMISSION AND DISTRIBUTION REHABILITATION COMPONENT

Estimated Costs and Financing Plan /a
($ million)

	Local	Foreign	Total
Estimated Costs:			
Rehabilitation			
Upgrade instrumentation & controls	1.5	2.5	4.0
Upgrade gas measurement	2.2	3.5	5.7
Valve replacement	5.6	9.0	14.6
SCADA & telecommunications	5.9	9.3	15.2
Pipeline replacement - river crossings	4.1	6.5	10.6
O&M equipment acquisition	3.1	5.0	8.1
Corrosion control & monitoring	0.5	0.7	1.2
Deterioration evaluation	3.9	6.2	10.1
Subtotal	26.8	42.7	69.5
Environmental upgrade			
Valve replacement	1.9	5.5	7.4
Compressor seals replacement	0.0	0.2	0.2
Cap open ends	0.2	0.9	1.1
Double valve vents	1.3	9.4	10.7
Environmental monitoring equipment	0.0	0.1	0.1
Subtotal	3.4	16.1	19.5
Consultancy and training	0.0	3.3	3.3
Total Base Cost	30.2	62.1	92.3
Physical contingency	3.0	6.2	9.2
Price contingency	2.7	5.3	8.0
Total Project Cost /b	35.9	73.6	109.5
Interest during construction /c	0.0	13.2	13.2
Total Financing Required	35.9	86.8	122.7

	Local	Foreign	Total
Financing Plan:			
GEF	0.0	10.0	10.0
SPA & CNPC	35.9	23.8	59.7
IBRD	0.0	53.0	53.2
Total	35.9	86.8	122.7

/a Figures may not add up due to rounding.
/b Project-financed goods are exempt from import duties and taxes.
/c Interest during construction (IDC) is based on onlending rates for projected disbursement of loan proceeds. Foreign exchange portion of IDC is based on the Bank's standard variable interest rate.

CHINA

SICHUAN GAS DEVELOPMENT AND CONSERVATION PROJECT

GAS TRANSMISSION AND DISTRIBUTION REHABILITATION COMPONENT

Procurement Method and Disbursements
($ million)

Item	Procurement method		
	ICB	NGF /a	Total /b
Civil Works			
Gas transmission & distribution rehabilitation	-	29.5	29.5
Equipment and Materials			
Gas Transmission & Distribution Rehabilitation Equipment	-	53.0	53.0
Gas Transmission Environmental Upgrade	10.0 (10.0)	13.1	23.1 (10.0)
Consultancy and Training	0.0	3.9	3.9
Total	10.0 (10.0)	99.5	109.5 (10.0)

Note: Figures in parentheses are the amounts to be financed by the GEF grant.

/a NGF denotes nongrant financing.
/b Including contingencies.

Category	Disbursement	
	Amount ($ million)	Expenditures to be financed
Goods	10.0	100 percent of foreign expenditures and 100 percent of local expenditures (ex-factory) and 75 percent of local expenditures for other items procured locally
Total	10.0	

Bank FY	Estimated disbursements					
	1995	1996	1997	1998	1999	2000
	($ million)					
Annual	1.5	2.5	2.0	1.5	1.5	1.0
Cumulative	1.5	4.0	6.0	7.5	9.0	10.0

CHINA

SICHUAN GAS DEVELOPMENT AND CONSERVATION PROJECT

GAS TRANSMISSION AND DISTRIBUTION REHABILITATION COMPONENT

Timetable of Key Project Processing Events

Time taken to prepare:	2 years
Prepared by:	Sichuan Petroleum Administration
First Bank mission:	April 1991
Appraisal mission departure:	June 1993
Negotiations:	January 1994
Planned date of effectiveness:	July 1994
List of relevant PCRs and PPARs:	Liaodong Bay Petroleum Appraisal and Technical Assistance Project (dated July 27, 1990, Report No. 8938) and Weiyuan Gas Field Technical Assistance Project (dated October 1993, Report No. 12413)

The project was prepared by the following: S. Shum (Senior Financial Analyst, Task Manager), J. Fritz (Environmental Engineer), S. Khwaja (Senior Gas Specialist), H. Morsli (Senior Petroleum Engineer), C. Amana (Young Professional), D. Caplin (Energy Conservation Consultant) and J. Warren (Geophysical Consultant). The peer reviewers include: Messrs. R. Batstone (Principal Environmental Specialist), N. Berrah (Senior Energy Economist), R. Heath (Principal Chemical Engineer), C. Khelil (Petroleum Group Leader) and B. Svensson (Energy Economist). The Division Chief is R. Newfarmer and the Acting Department Director is Z. Ecevit.

CHINA

SICHUAN GAS DEVELOPMENT AND CONSERVATION PROJECT

GAS TRANSMISSION AND DISTRIBUTION REHABILITATION COMPONENT

Indicative Supervision Plan

Approximative dates	Activity	Anticipated skill requirements	Staff-weeks
Supervision Mission			
6/94	Review overall project implementation progress, including procurement of goods and services, and consultant mobilization; project cost and financing plan.	Engineer Financial Analyst	4
FY1995-96	same as above, two supervisions per year	same as above	8
FY1997-98	same as above, two supervisions per year	same as above	6
FY1998-2000	same as above, two supervisions per year	same as above	5

ANNEX 1

CHINA

SICHUAN GAS DEVELOPMENT AND CONSERVATION PROJECT

GAS TRANSMISSION AND DISTRIBUTION REHABILITATION COMPONENT

GAS TRANSMISSION AND DISTRIBUTION

A. Background

1. The gas transmission and distribution (T&D) system of the Sichuan Petroleum Administration (SPA) comprises a pipeline grid and a number of spurs, totaling about 2,800 km in length. It transports about 16 million cubic meters of natural gas per day from five gas producing regions (Northwest, Southwest, South, Central and East) to about one million, commercial entities and small industries through the city gas companies and directly to about 600 large industries. This system is about 12-20 years old, except for the north loop linking the east and southwest regions, which was built about five years ago. Its maintenance and expansion plans have been underfunded, mainly due to financial constraints. It is prone to breakdowns (110 since 1978), gas leakages and accidents. A preinvestment study (called the Diagnostic Study) of the system was recently completed with the assistance of PRIF-financed international consultants to evaluate the capability, efficiency and reliability of SPA's T&D system and to determine the most efficient measures for its rehabilitation, environmental upgrade and expansion to transport an additional 4 million cubic meters of natural gas per day expected to be produced in the east region.

B. Diagnostic Study Findings and Recommendations

2. The recently completed Diagnostic Study concluded that:

(a) the integrity of the system is uncertain and the safety of the operating personnel and the general public is being put at risk;

(b) the standards and safety regulations for system operation have been frequently disregarded, and internal corrosion in the pipelines due to release of nonspecification gas (wet and sour gas) into the transmission system is the most serious problem;

(c) in emergencies, the grid control system cannot efficiently respond to rapid changes in the operating conditions;

(d) methane losses from the overall SPA natural gas system (from gas production wells to city gate) are estimated to vary between 1.06 and 3.53 percent of throughput, which are close to the estimate of 1 to 3 percent originally anticipated. However, the relative share of methane losses from gas production and gathering (77 percent) is significantly higher than originally anticipated. Gas distribution (16.7 percent), gas transmission (4.8 percent) and gas purification (1.2 percent) account for the balance of the methane emissions. Almost all of the methane emissions from the SPA gas system are due to fugitive equipment leaks;

(e) the responsibility for the operation of the system is divided between several departments, and there is a lack of accountability at senior management level; and

(f) the expertise of the staff requires upgrading.

Major Issues

3. Major issues in gas transmission and distribution are: (a) damage control and rehabilitation of transmission and distribution system; (b) optimal expansion of the system to meet the enhanced gas supply targets; and (c) efficient and safe operation.

4. To address the above issues, the strategy formulated by SPA, which has taken into account the recommendations of the Diagnostic Study, includes the following:

(a) installation of gas dehydration and purification facilities at identified sour gas locations to ensure that only dry, sweet gas (in accordance with specifications) will enter the transmission and distribution system;

(b) implementation of a rehabilitation and capacity expansion plan, for the transmission and distribution system, as recommended by the Diagnostic Study, that would mitigate the risk and optimize the upgrading and expansion for safe and efficient operations over the next 20 years;

(c) reorganization of gas transmission and distribution operations to clearly focus responsibility for efficient planning and operation of the system;

(d) upgrading of staff expertise; and

(e) enhancement of safety regulation.

Gas Purification

5. To ensure system integrity and to increase the life expectancy of the gas transmission and distribution system, only dry and sweet gas (in accordance with the specifications) would be allowed to enter the pipelines. Gas dehydration and purification facilities will be installed at a central location at each gas field producing nonspecification gas. If this is not feasible, then the facilities will be installed at the receipt stations for gas entering the transmission pipelines. Actual locations will be determined through site feasibility studies.

Rehabilitation and Expansion of Gas Transmission and Distribution

6. The plan, as formulated under the Diagnostic Study, has the dual purpose of (a) upgrading the reliability and capability of the system; and (b) deterioration monitoring and evaluation so that the best rehabilitation and capacity expansion decisions can be made during the next 20 years. In system upgrading, emphasis has been on (a) improvement of control, communication and, maintenance capability and (b) rehabilitation through replacement of parts/components rather than outright substitution of whole plants/sections. Deterioration monitoring and evaluation of the system will be an ongoing process. Once set in motion, this process will provide early warning of any trouble brewing in the system and will enable appropriate and timely remedial measures to be undertaken.

Upgrading Reliability

7. It will take an estimated year and a half under the best possible conditions to set up the gas purification subcomponent under the project. Meanwhile, the mainlines will be pegged clean and dry as required and, where

sour conditions are present or suspected, inhibition by continuous injection and batching will be utilized to mitigate the internal corrosion process. Gas quality monitoring instrumentation will be installed on the system and monitoring will determine the ongoing need for inhibition operations. Once the network has been cleaned and operating according to the newly upgraded standards and procedures, the drying and inhibition operations can be phased out. The exception will be any local short sections which continue to see wet/sour service.

8. External corrosion protection will be upgraded in one section near Well Wei-6, and thermal electric generators will be installed to replace existing rectifiers at nine stations where the power reliability has been identified as being low. However, the most important consideration for the future is to monitor increased current requirements which may be indicative of wide spread coating deterioration in the future.

9. A total of eleven river crossings have been identified, which need to be carefully examined to determine if they can withstand probable flood conditions. SPA has identified these rivers only as high risk and high consequence locations. The plan assumes all eleven will need to be replaced using modern mechanized methods as a cost-effective precaution against flood failure.

10. The plan recommends the implementation of a supervisory control and data acquisition system (SCADA) system tailored to SPA's needs which includes mainline measurement and automation at selected locations and a supporting telecommunications system. These systems will provide SPA with a basic control and data gathering capability which will make their operation more efficient in routing gas to supply customers and in responding to emergency shutdowns and maintenance situations.

11. All meter runs will be inspected and replaced as required. Metering accuracy is a key business consideration for SPA. All mainline valves will be operationally checked and replaced as required with valves which are easy to maintain and fully compatible with the operators required for SCADA. Scrubbers and valves at stations will be upgraded to and over pressurization protection will be provided for the mainlines. Equipment, procedures, and training will be upgraded to provide SPA with enhanced maintenance and construction capability at the district level.

Deterioration Monitoring

12. The plan will also initiate a program designed to determine the extent of deterioration which has already occurred on the pipeline system. This program consists of hydrostatic testing of three to four representative sections of pipeline which have been exposed to a potentially severe corrosive environment inside the pipe. These sections can be removed from service for extended periods of time without a major business disruption to SPA and will provide a good basis for assessing overall system condition. The second important data gathering means put forward in the plan is the in-line inspection (ILI) of the 173 kilometer Lianglu pipeline. This will involve extensive modifications to the existing pipeline but will establish the actual pipeline condition and will provide future ILI capability, as well as increase the efficiency of all pegging operations. The Lianglu pipeline is a major transmission section which moves the gas to the urban centers of Sichuan province from the primary fields in the east region.

Capacity Expansion

13. SPA's plan provides for expansion of SPA's pipeline network in the east region in order to move reserves out of the Wubaiti, Fengjiawan, and

Mingda areas. In order to meet the forecast supply and demand requirements, approximately 211 km of NPS 18 pipeline will be constructed and commissioned by year end 1996. An additional 72 km of NPS 10 and NPS 16 will be installed by year end 1999. In order to handle the maximum supply through Lianglu, facilities expansion is required on the south truckline of the system. The expansion consists of looping the existing Naxi to Fuying pipeline with 35 km of NPS 20 pipe by 1994 and adding a compressor station at Hejiang (West) by 1996. The station will consist of two centrifugal compressor units (5,000 HP each) to begin with, one of which is backup, and a third unit of the same size to be added by the year 2000.

Customer Pipeline

14. It was determined at the outset of this project, during the data gathering and confirmation stage, that detailed consideration of customer pipelines was outside the scope and would therefore not be considered in the rehabilitation planning. These pipelines are not owned by SPA, the majority are not operated by SPA, and no data are available for consideration. Nevertheless, they are the downstream recipient of problems generated by the producers and SPA with respect to gas quality. The Diagnostic Study report has emphasized not merely a cost-effective approach to pipeline rehabilitation but has also put in considerable effort to explain the reasoning for the approach. Volume III, "Assessment of System Integrity," in particular describes the concerns and evaluation process used to formulate a plan. This information should be presented by SPA to its customers in the interest of public safety and avoidance of business disruptions.

15. SPA will be forming a task force to implement the rehabilitation plan. This task force should take the responsibility to inform and educate the customers and, if necessary, work with them to review and upgrade existing construction practices and procedures. If agreement with individual customers can be reached, SPA may extend its cleaning, drying, and inhibition programs to major customer lines. Cleaning and drying runs will give an indication of possible conditions inside the pipeline and gas composition into the customer line should be estimated by SPA prior to recommending any inhibition program.

16. In addition, SPA would advise its customers that no major expenditure such as hydrostatic testing or in-line inspection (if feasible) should be undertaken without the task force first determining the need by evaluating the risks and consequences of failure for the specific pipeline(s). If the decision is made to proceed with such an operation, the standards developed by SPA (with outside consultant assistance) for their rehabilitation program should be adopted for customer use.

Environmental Upgrades

17. In examining control options for reducing methane emissions from fugitive equipment leaks, there are three basic types of leaks: random, chronic and normal operational. Random leaks are those that may be expected to occur due to normal wear and certain irregular effects (improper installation or equipment defects), but that provide little or no trouble once repaired. Chronic leaks are those that require frequent or continuous maintenance due to more persistent and difficult to correct causes such as poor or inadequate designs, demanding process conditions, high usage or abusive environments. Normal operational leaks on the other hand are inherent to the design of some components such as certain pump seals and compressors seals. This type of leak cannot be classed as random or chronic but may become a random leak through wear.

18. Based on observations made by the consultants during the field work, most of the equipment leaks are of the random type. The best, most efficient

method of controlling those types of leaks is to implement regular leak detection and repair (LDAR) programs (inspection and maintenance programs). Based on the experience of industry in the United States, it is reasonable to expect a 70 percent reduction in fugitive emissions if LDAR programs are performed on a regular basis in accordance with U.S. EPA leak performance standards.

19. An LDAR program consists of using a portable organic vapor analyzer to check (screen) potential fugitive emission sources for leaks. Those sources that give a maximum screening value above some specified limit (for example, 10,000 ppm) are considered to be in need of repair or replacement and are said to be leaking. Those components that screen below this value are considered to be in an acceptable state of repair and are said to be not leaking. Leaking equipment components are to be tagged and scheduled for repair.

20. If less than two percent of all potential sources are leaking then fugitive equipment leaks are considered to be well controlled. Otherwise, more frequent LDAR programs are required. To apply an ongoing LDAR program for all potential leak points at all facilities on the SPA system could be a onerous task. However, a more selective approach which targets sources with the highest leak frequency may provide a much greater return on control efforts would be much more cost effective. Specifically, efforts should be focused on leakage past valve seats into the vent systems, and on leakage from valve packing systems since these sources account for 85.2 percent of total fugitive methane emissions. Secondary efforts should focus on compressor seals and packing, open-ended lines and pressure relief devices as these source are relatively few in number and are prone to leaking; they account for an additional 7.0 percent of fugitive methane emissions.

21. Recommendations. Initial efforts to control methane emissions from the SPA natural gas system should be focused on the problem of fugitive equipment leaks. Comprehensive ongoing leak detection and repair programs should be implemented, and that they be conducted at a frequency of at least once annually. If more than two percent of the components are determined to be leaking (that is have a screening value of 10,000 ppm or more) during these programs, then the frequency of the programs should be increased as required. Specific recommendations for the scope of the LDAR program and for some additional control measures are itemized below by type of source. The incremental reductions in methane losses that may result from each option are summarized in the table at the end of this section.

(a) Valves. Considerable effort may be required to bring all components into a state of good maintenance. A certain portion of the components will likely be beyond reasonable repair and need to be replaced. Based on discussions with several commercial valve repair and remanufacturing companies and on results of the field inspections, it is estimated that probably 30 percent of leaking valves in use on the SPA system will need to be replaced. With the ban on asbestos packing materials in North America, a variety of options have emerged including die formed graphite, and various types of polymeric materials. Some of these new materials have broader ranges of application and can provide superior leak control. These better packing materials should be installed in all valves that can accommodate them. Maintenance teams may require special training to install these packing. These better packing materials should be installed in all valves that can accommodate them.

(b) Compressor Seals. Compressor seals are prone to leaking and can be significant sources of emissions. To repair compressor seals it is usually necessary to have a complete system shutdown unless backup compression facilities are available. Two reasonable solutions to this problem are to either install high performance packing systems

which will last the full period between regular shutdowns, or install a small incinerator to dispose of seal gases when they occur until a convenient shutdown can be arranged. It is recommended that better seals be installed to the extent possible. However, this must be coupled with improved alignment and increased maintenance of the packing case to be effective. Where major modifications or repairs are required, it is recommended that small incinerators be installed to dispose of any seal gases.

(c) Open-Ended Lines. Where a block valve is connected to a vent system, a second valve should be installed immediately downstream to control leakage past the valve seat. Where a block valve opens directly to the atmosphere, it should be equipped with a chained cap or plug. In both cases, the existing valve should be repaired or replaced so that it is in good working condition.

(d) Pressure Relief Valves. When pressure relief valves reseat after having been activated, they often leak because the original tight seal is not regained due to damage of the seating surface or a build-up of foreign material on the seat plug. An effective method of controlling this source of emissions is to install a rupture disk immediately upstream of the pressure relief valve. It is recommended that this be done at all SPA facilities. The rupture disk will shield the valve from corrosive process fluids during normal operation. Moreover, if an overpressure condition occurs, replacement of the disk may be delayed until the next scheduled shutdown period. In the interim, protection against overpressuring is provided by the relief valve. A pressure indicator should be installed between the valve and the rupture disk to show when the rupture disk has failed. If frequent replacement of rupture disks is required, it may be appropriate to install a block valve upstream of the rupture disk to facilitate early replacement or repair of the components.

22. For the LDAR program to be effective there needs to be a strong commitment by both site personnel and by administration. Moreover, some central monitoring and enforcement of the program by SPA is required. It is recommended that a dedicated microcomputer, maintenance software package and data management system purchased to help organize maintenance and inspection activities and track improvements in environmental performance.

23. Methane emissions reductions that are achievable through implementation of the above options are tabulated below.

Emissions reduction option	Methane reductions (tons/year)
Installation of double valves on vent stacks	53,282
Installation of plugs on open-ended lines	1,194
Rupture disk installation and replacement of leaking PSVs	6,736
Upgrade compressor seals	528
Upgrade control valve packing	77
Upgrade block valve packing	15,257
Total	77,074

24. A total methane emissions reduction of 77,074 tons per year can be achieved through implementation of all of the above options. An additional 6,377 tons per year reduction on methane can also be realized through the replacement of 832 defective block valves and 34 defective control valves as part of LDAR programs on block valves, and control valves.

Upgrading of Staff Expertise

25. SPA's transmission and distribution system is quite extensive and requires a broad base of skills to adequately manage, operate and maintain it. In comparing the analysis of skills required to operate and maintain this system to a high level of reliability and accuracy with the skills currently available in SPA, the Diagnostic Study has identified skill deficiencies in key areas which has resulted in severe degradation of the system operations and integrity over the years. SPA would have to place high priority on correcting the skill deficiencies particularly in the management of transmission and distribution operations, project management, long-term planning, demand management, system integrity assessment, pipeline failure investigation, preventive maintenance, measurement engineering, geotechnical engineering, gas control and dispatch, and environmental protection. The program of skill upgrading would include the following:

(a) On-the-job training in parallel with system rehabilitation, deterioration monitoring and capacity expansion with assistance of consultants to be engaged to provide the necessary expertise; and

(b) Courses on specialized topics to be held in Chengdu; these courses would be designed and conducted by experts from an experienced gas utility and/or gas technology institute in North America and Western Europe.

Safety Regulation

26. The standards for design and operation of natural gas transportation systems were compiled by Sichuan Petroleum Administration's Design Institute and were promulgated in 1980, under a decree of the former Ministry of Petroleum Industry (MOPI). The oil and gas safety regulations were prepared by China National Petroleum Corporation (CNPC) and were approved and promulgated in 1989 by the State Council. SPA, in its capacity as an administrative bureau, is responsible for the enforcement of these standards and safety regulations. However, as an operating agency, SPA is not best suited to enforce these standards, also with the forthcoming enterprise reforms, there will several independent agencies and companies operating in the gas sector and it will be necessary to establish an office the Regulator (or a Regulatory Commission). The Regulator's office should be established in the central government with a branch office in Chengdu, to oversee the enforcement of standards and safety regulations in Sichuan Province. This would be addressed under the ongoing oil/gas sector restructuring study.

C. Gas Transmission/Distribution Rehabilitation Component

27. Based on the recommendations of the diagnostic study, the proposed transmission and distribution component of the IBRD project would cover rehabilitation, environmental upgrade and capacity expansion of the system and the necessary technical assistance for project implementation and staff skills upgrading. Specifically it would include:

(a) Rehabilitation and upgrading of pipelines, measurement, corrosion control, corrosion inhibition, telecommunication, gas control, gas quality monitoring and emergency response facilities of SPA's entire gas transmission and distribution system;

(b) Deterioration monitoring and evaluation of the transmission and distribution system;

(c) Cost-effective measures to reduce methane emissions, including:

(i) installation of second valves at vent stacks;
(ii) installation of chained caps or plugs at the open ended lines;
(iii) upgrading of packing for control valves;
(iv) replacement of high performance packing of compressor seals;
(v) upgrading of packing for block valves;
(vi) replacement of block valves;
(vii) plugging of open-ended lines; and
(viii) replacement of pressure relief valves and control valves;
(ix) replacement of control valves which cannot accommodate packing.

(d) System capacity expansion through the construction of:

(i) 20-inch diameter x 35-km long loop line from Fuying to Naxi;
(ii) 18-inch diameter x 16-km long loop line from Wubaiti to Jiangzhi;
(iii) 18-inch diameter x 71-km long loop line from Wulonghe to Daosuiqiao;
(iv) 18-inch diameter x 124-km long pipeline from Jiangzhi to Wulonghe; and,
(v) 10-inch diameter x 40-km long pipeline from Fengjiawan to Wanxian, along with the related corrosion control, measurement and gas control facilities;

(e) Provision of a supervisory control and data acquisition system (SCADA) for the whole transmission and distribution system; and

(f) Technical assistance covering,

(i) consultant services for,
- system deterioration monitoring and evaluation,
- training of SPA staff in Chengdu,
- upgrading the operation and construction manuals, and

(ii) Overseas training of SPA staff.

28. Measures for environmental upgrade (i) through (iv) above are expected to result in net economic benefits; while measures (v) through (ix) would result in net economic costs. The proposed GEF funding would finance most of the incremental costs of measures (v) through (vii).

Implementation

29. Implementation of the GEF component will be organized through SPA's subsidiary, the Gas Transmission and Distribution Company, with the manager of the company as the Project Manager. Services of international consultants, in accordance with procedures acceptable to the Bank, will be retained to advise and assist in system rehabilitation. The Terms of Reference for the consultancy services are attached.

30. Procurement. GEF financed goods would be procured through International Competitive Bidding (ICB) by an agent specialized in international procurement authorized by the government. A model bidding document, recently prepared by the Ministry of Finance in accordance with the Bank's Standard

Bidding Documents, would be used. To avoid procurement delays, SPA has recently established a Procurement Unit to coordinate between the procurement agent and SPA's regional company in charge of the rehabilitation of the gas transmission and distribution system. Local bidders participating in ICB would receive a preference in bid evaluation of 15 percent of the CIF price or the prevailing customs duty applicable to nonexempt importers, whichever is less, provided the local value added to the product is not less than 20 percent of the ex-factory bid price. Contracts expected to cost the equivalent of $250,000 or more would be subject to Bank prior review in accordance with the Bank's Procurement Guidelines. Contracts expected to cost below the equivalent of $250,000 would be subject to Bank post review.

31. Disbursement. The GET Grant would be disbursed against 100 percent of foreign expenditures, 100 percent of local expenditures ex-factory cost and 75 percent of local expenditures for other items procured locally. Funds will be disbursed to finance eligible expenditures through a Special Account to be opened by SPA at a commercial bank on terms and conditions acceptable to the Bank. The Bank will make an initial deposit of $0.6 million in the Special Account, which will be subject to standard Bank procedures and audits. The initial deposit would represent 4 months of disbursement activities. Disbursement for contracts costing the equivalent of $250,000 or more will be subject to full documentation. Contracts costing below the equivalent of $250,000 will require only statements of expenditures (SOEs). Supporting documents for SOE claims will not be submitted to the Bank but will be retained by SPA and made available for review by Bank supervision missions and project auditors.

ANNEX 1

CHINA

SICHUAN GAS DEVELOPMENT AND CONSERVATION PROJECT

GAS TRANSMISSION AND DISTRIBUTION REHABILITATION COMPONENT

REHABILITATION AND CAPACITY EXPANSION OF GAS TRANSMISSION AND DISTRIBUTION SYSTEM

IMPLEMENTATION AND TECHNICAL MANAGEMENT ASSISTANCE

TERMS OF REFERENCE

Introduction

1. The gas transmission and distribution (T&D) system of Sichuan Petroleum Administration (SPA) comprises a pipeline grid and a number of spurs, totaling about 2,800 km in length. It transports about 16 million cubic meters of natural gas per day from five gas producing regions (Northwest, Southwest, South, Central and East) to about one million, commercial entities and small industries through the city gas companies and directly to about 600 large industries. This system is about 12-20 years old, except for the north loop linking East and Southwest regions, which was built about five years ago. Its maintenance and expansion plans have been underfunded, mainly due to financial constraints. It is prone to breakdowns (110 since 1978), gas leakages and accidents. A preinvestment study (called the Diagnostic Study) of the system was recently completed with the assistance of international consultants to evaluate SPA's T&D system's capability, efficiency and reliability and to determine the most efficient measures for its rehabilitation and for its expansion, if required, to transport an additional 4 million cubic meters of natural gas per day expected to be produced in the East region.

2. The plan, as formulated under the Diagnostic Study, has the dual purpose of (a) upgrading the reliability and capability of the system and (b) its deterioration monitoring and evaluation so that the best rehabilitation and capacity expansion decisions can be made during the next 20 years. In system upgrading, emphasis has been on (a) improvement of control, communication and, maintenance capability and (b) rehabilitation through replacement of parts/components rather than outright substitution of the whole plants/sections. Deterioration monitoring and evaluation of the system will be an ongoing process. Once set in motion, this process will provide early warning of any trouble brewing in the system and will enable appropriate and timely remedial measures to be undertaken.

3. SPA will be the agency responsible for the implementation of the plan which will be organized through its subsidiary, The Gas Transmission and Distribution Company, with the manager of the company as the Project Manager. SPA would like to engage the services of a qualified consultant, hereinafter called "The Consultant" to assist the Gas Transmission and Distribution Company in the implementation of the rehabilitation plan.

Scope

(a) Review of the rehabilitation plan and detailed planning of its implementation.

(b) Review of detailed specifications for the materials and equipment required, procurement documents and bid evaluation.

(c) Organization and planning of system deterioration monitoring and evaluation which, inter alia, include;

(i) Hydrostatic testing of the pipelines; establishing appropriate procedures including test pressures and environmental protection measures; determi... ...lity of

hydrostatic testing approach on the basis of test failures; and analysis of failures and correlation of data.

(ii) Inline inspection of pipelines, including development of detailed inspection plans; preliminary cleaning/gauging, drying, caliper runs, profile tool and ILI; tracking and handling; and evaluation of results.

(iii) Drying/caliper pegging; identifying sections which should have priority; and sizing/gauging and judging the need for further caliper pig runs.

(iv) Evaluation of data, assessment of integrity and recommendations for repair, and preventive maintenance or replacement of the pipelines and related equipment.

(d) Assistance in the planning of internal and external corrosion mitigation.

(e) Assistance in rehabilitation management, formation of task force and teams, integrity data gathering, deterioration and mitigation effectiveness assessment, data management and trend analysis, failure analysis and root cause assessment, and relevant counterpart training.

(f) Upgrading of operational and construction manuals.

4. The consultant will closely coordinate his work with the system expansion activities and will advise on the specifications of the materials required for system expansion.

5. On assignment, the consultant will promptly plan and render all necessary advice/assistance to the Gas Transmission and Distribution Company of SPA towards successful completion of the rehabilitation plan. He will be responsible to the manager of the company and will closely liaise with the vice managers. Except for certain backup services from the consultant's headquarters organization to be specified in the contract, the consultant will carry out the assignment in the field, associating the company's staff to the fullest possible extent in order to provide on the job training using modern up-to-date techniques of the industry.

ANNEX 2

CHINA

SICHUAN GAS DEVELOPMENT AND CONSERVATION PROJECT

GAS TRANSMISSION AND DISTRIBUTION REHABILITATION COMPONENT

COST-EFFECTIVENESS OF GREENHOUSE GAS REDUCTION

1. The proposed project will demonstrate the cost-effectiveness of, and define the technical approaches to, gas loss reduction at the margin of economic viability from a country perspective. It will help indicate the GHG reduction potential of natural gas system rehabilitation and efficient operation in other countries, and other provinces of China. It will provide an action framework and indications of the cost-effectiveness of reducing gas losses from natural gas transmission and distribution (T&D) systems.

2. The diagnostic study included economic cost and benefit analyses of each of the eleven environmental subcomponents under the project and, on this basis, a supply curve was derived for the net cost of reducing methane emissions converted to unit cost per ton of CO_2 equivalent reduction. Net costs have been defined as the net present value (NPV, at a 12 percent discount rate) of capital and operating costs net of the economic benefits of the gas saved through leakage reduction, over a 20-year life of the project. The international price of fuel oil parity (at about $11.8/bbl, FOB Singapore) has been assumed to be the imputed economic value of natural gas (which is equivalent to about $60.34/mcm or $80.47/ton of gas). For purposes of converting methane to CO_2 equivalent, the Intergovernmental Panel on Climate Change (IPCC) 100-year-time horizon equivalent factors would be used.

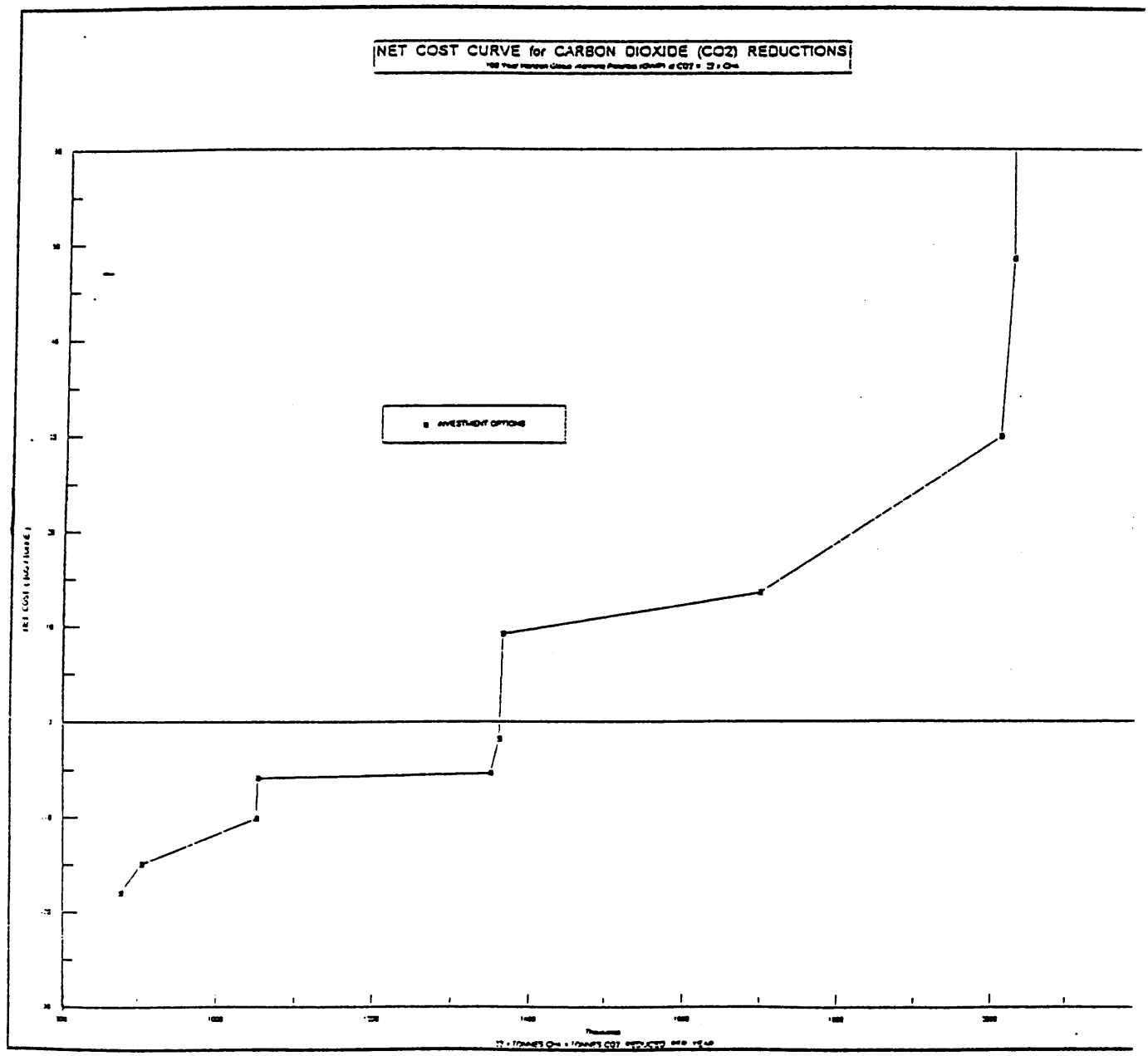
3. The results of the above economic analyses indicated that a considerable amount of leakage reduction could be realized at negative cost to be charged to the greenhouse gas (GHG) mitigation account. Specifically, the NPV of the net economic benefits of six environmental subcomponents are estimated to be about $20 million. For the balance of the five subcomponents, the total incremental cost (the NPV of capital and operating costs net of economic benefits of gas saved) is estimated at $15 million, of which $10 million would be financed by the proposed GEF grant. The incremental unit costs of methane reduction relating to the eleven environmental subcomponents are estimated to range from -$0.9 to $7.9 per ton of CO_2, of which the unit costs of the proposed GEF-financed subcomponents are estimated at $0.5-1.5 per ton of CO_2.

ENVIRONMENTAL INVESTMENT OPTION

Investment Option	Capital Cost of Investment Option $US,000	* CO_2 Reduced per Option thousand tonnes CO_2/year	Net Cost per Tonne CO_2 Reduced per Year $/tonne CO^2	Net Cost Per Tonne CO_2 Reduced Over 20 Years
Vent Stack (Gas Gathering only) install 2nd valve	6,832	877	-17.48	-0.90
Open Ended Lines-install chained caps or plugs	188	26	-14.93	-0.75
Pressure Relief Valves-LDAR	1,769	148	-10.15	-0.51
Control Valves-upgrade packing	9	2	-5.92	-0.30
Vent Stacks (other)-install 2nd valve	6,016	295	-5.40	-0.27
Compressor Seals-High Performance Packing	175	12	-1.81	-0.09
Control Valves-LDAR	75	4	9.22	0.46
Block Valves-upgrade packing	3,070	336	13.51	0.68
Block Valves-LDAR	7,990	313	29.86	1.49
Open-Ended Lines-LDAR	1,152	16	48.42	2.42
Control Valves-cannot accommodate packing	141	1	158.96	7.95

* Global Warming Potential (GWP includes direct and indirect effects, therefore tonnes CO_2 reduced = 22 times tonnes CH_4 reduced).

NET COST CURVE FOR CARBON DIOXIDE (CO_2) REDUCTIONS




RUSSIAN FEDERATION
KAZAKHSTAN
MONGOLIA
KYRGYZ REPUBLIC
UZBEKISTAN
TAJIKISTAN
AFGHANISTAN
XINJIANG
NEI MONGOL
HEILONGJIANG
JILIN
LIAONING
D.P.R. OF KOREA
REP. OF KOREA
JAPAN
Sea of Japan
Yellow Sea
East China Sea
PACIFIC OCEAN
TAIWAN
QINGHAI
XIZANG
GANSU
NINGXIA
SHAANXI
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HEBEI
BEIJING
TIANJIN
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JIANGXI
HUNAN
GUIZHOU
FUJIAN
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GUANGXI
GUANGDONG
HONG KONG, U.K.
Macao, Port.
HAINAN
South China Sea
VIET NAM
LAO PEOPLE'S DEM. REP.
MYANMAR
THAILAND
NEPAL
PHILIPPINES
Urumqi
Harbin
Changchun
Shenyang
Hohhot
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Xining
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Taiyuan
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Hefei
Wuhan
Hangzhou
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Lhasa
Changsha
Nanchang
Fuzhou
Guiyang
Kunming
Nanning
Guangzhou
Haikou
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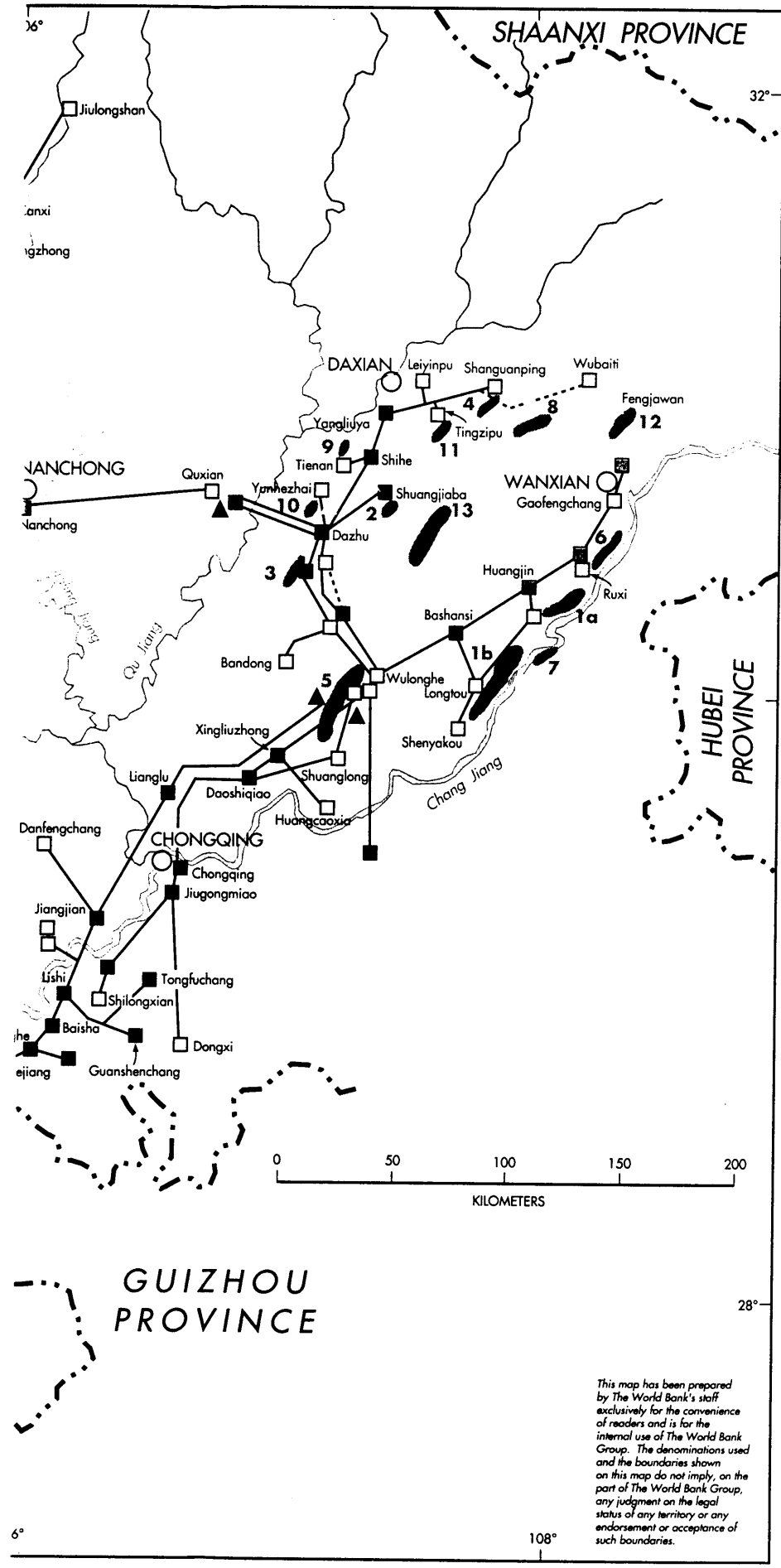
CHINA
OIL AND GAS RESOURCES
ON SHORE CONCESSION AREAS OPEN TO BIDDING IN 1993
SEDIMENTARY BASIN BOUNDARIES
PROVINCE CAPITALS
NATIONAL CAPITAL
PROVINCE BOUNDARIES
INTERNATIONAL BOUNDARIES
KILOMETERS 0 200 400 600 800
MILES 0 100 200 300 400 500
FEBRUARY 1994
IBRD 25137

CHINA

SICHUAN GAS DEVELOPMENT AND CONSERVATION PROJECT

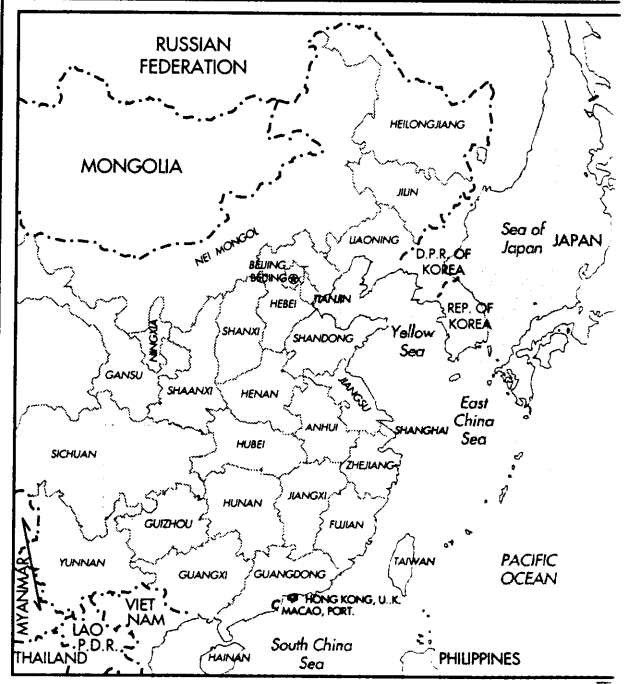
GAS FIELDS AND TRANSMISSION NETWORK



GAS FIELDS
PROPOSED GAS TRANSMISSION LINES
EXISTING GAS TRANSMISSION LINES
PROPOSED GAS PURIFICATION PLANTS
EXISTING GAS PURIFICATION PLANTS
PROPOSED GAS COMPRESSOR STATION
GAS GATHERING STATIONS
GAS DISTRIBUTION STATIONS
CITIES
RIVERS
PROVINCE BOUNDARIES
INTERNATIONAL BOUNDARIES

GAS FIELDS:

1a	Wanshu Chang	8	Wubaiti
1b	Longton-Diaozhongba	9	Tieshan
2	Shuanjiaba	10	Yunhexhai
3	Fuchengzhai	11	Tanmuchang
4	Shaguangping	12	Fengjiawan
5	Waxinshuang	13	Mingda
6	Gaofengchang	14	Moxi
7	Mopanchang	15	Bajiaochang



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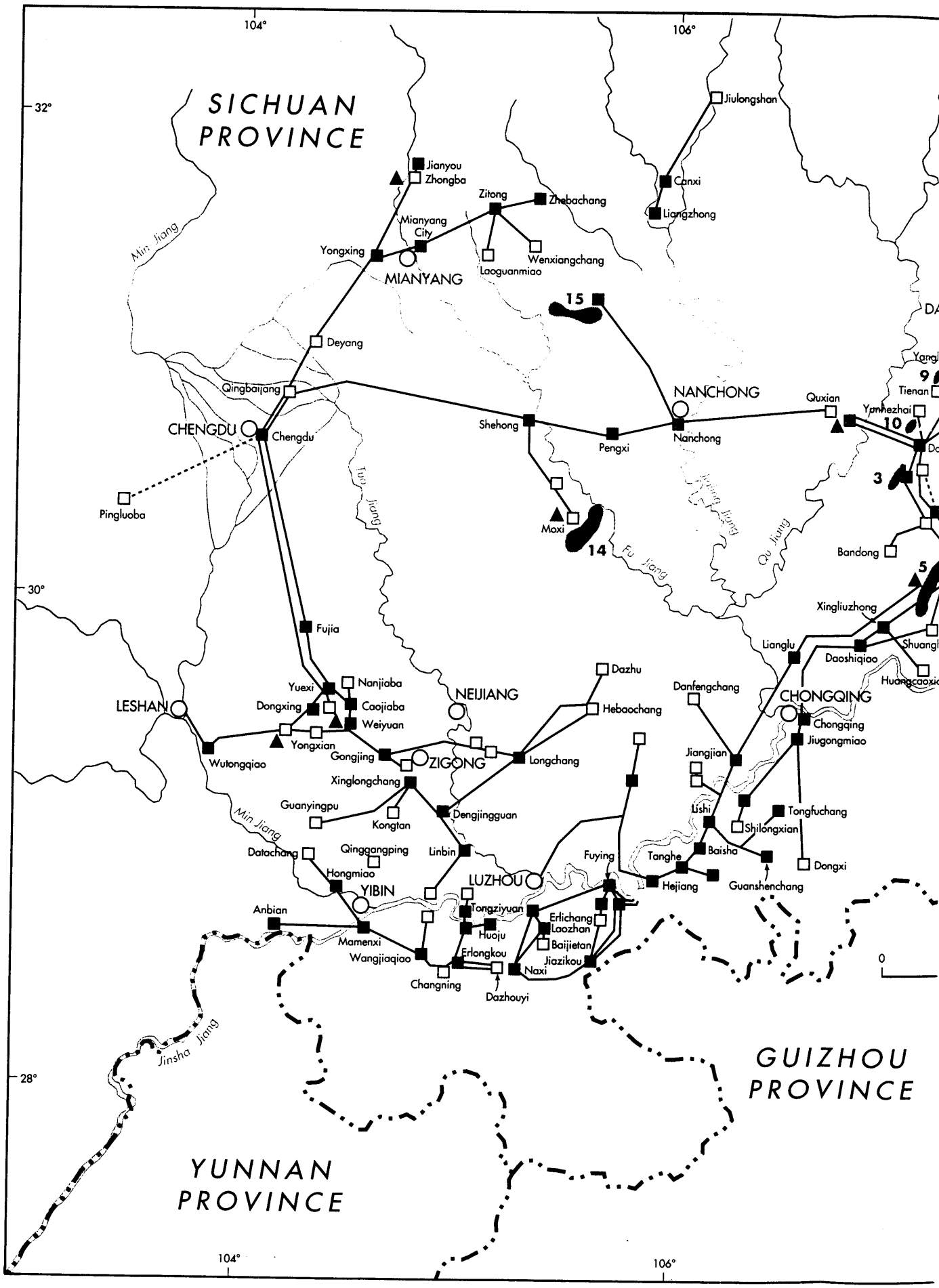
NOVEMBER 1993


SICHUAN PROVINCE
YUNNAN PROVINCE
GUIZHOU PROVINCE
104°
106°
32°
30°
28°
Jiulongshan
Canxi
Liangzhong
Jianyou
Zhongba
Zitong
Zhebachang
Mianyang City
Wenxiangchang
Laoguanmiao
MIANYANG
Yongxing
Min Jiang
15
Deyang
Qingbaijang
NANCHONG
Quxian
Tienan
Yanhezhai
10
CHENGDU
Chengdu
Shehong
Pengxi
Nanchong
Pingluoba
Tuo Jiang
Jialing Jiang
Qu Jiang
3
Moxi
14
Fu Jiang
Bandong
5
Xingliuzhong
Lianglu
Daoshiqiao
Fujia
Dazhu
Yuexi
Nanjiaba
NEIJIANG
Danfengchang
LESHAN
Dongxing
Caojiaba
Hebaochang
CHONGQING
Weiyuan
Chongqing
Yongxian
Jiugongmiao
Wutongqiao
Gongjing
ZIGONG
Longchang
Jiangjian
Xinglongchang
Guanyingpu
Kongtan
Dengjingguan
Lishi
Tongfuchang
Min Jiang
Shilongxian
Datachang
Qinggangping
Linbin
Fuying
Tanghe
Baisha
Dongxi
Hongmiao
YIBIN
LUZHOU
Hejiang
Guanshenchang
Anbian
Tongziyuan
Erlichang
Laozhan
Mamenxi
Huoju
Baijietan
Wangjiaqiao
Erlongkou
Jiazikou
Naxi
Changning
Dazhouyi
Jinsha Jiang
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