ADB

Technical Assistance Consultant's Report

Project Number: 37300/TA 4309
May 2006

PEOPLE'S REPUBLIC OF CHINA: Renewable Energy for Poverty Reduction
(Financed by the Government of Denmark)

Prepared by:

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New Delhi, India

For: Gansu Provincial Finance Bureau
Executing Agency

Asian Development Bank

FINAL REPORT

Renewable Energy for Poverty Reduction

TA No: 4309 – PRC

Submitted to
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DSCL ENERGY SERVICES

TABLE OF CONTENTS

LIST OF TABLES

ABBREVIATIONS

ADB – Asian Development Bank
CDM- Clean Development Mechanism
CER – Certified Emission Reductions
CNWIDRI – China North-West Investigation & Design Research Institute
DG – Distributed Generation
DHP – Dagushan Hydropower Project
DSCLES – DSCL Energy Services Co. Ltd.
DSCR – Debt Service Coverage Ratio
EA – Executing agency
EDR- Equalizing Discount Rate
EE – Energy Efficiency
EIA – Environment Impact Assessment
EIRR – Economic Internal Rate of Return
FIRR – Financial Internal Rate of Return
FNPV – Financial Net Present Value
LPG – Liquefied Petroleum Gas
MDG – Millennium Development Goals
NDRC - National Development & Reform Commission
GHG- Greenhouse gases
HH Household
HR – Human Resource
IA – Implementing agency - Gansu Heihe Hydropower Stock Company Ltd.
M&E- Monitoring and Evaluation
O_2- Oxygen
O&M Operation and Maintenance
PLF – Plant Load Factor
PMO – Project Management Office
PRC – People's Republic of China
PPTA- Project Preparatory Technical Assistance
PSP – Pumped Storage Power plant
PV – Photo Voltaic
RE – Renewable Energy
ROR – Run Of River
SD – Sustainable Development
SEIA- Summary Environment Impact Assessment
SFERF – Shadow Foreign Exchange Rate Factor
SOCC – Social Opportunity Cost of Capital
SWRF – Shadow Wage Rate Factor
TA – Technical Assistance
TCE – Tons of Coal Equivalent
TOR – Terms of Reference
TVE – Township and Village Enterprise
UNDP – United Nations
WACC – Weighted Average Cost of Capital
WB – World Bank
WHO – World Health Organization

WTP – Willingness to Pay
XHP- Xiagoshuan Hydro Project

UNITS, WEIGHTS AND MEASURES

^{O}C- Degree Celsius
kCal – kilo Calorie
kg – Kilogram
km – Kilometer
kV – kilo Volt
kW - kilo Watt
kWh – kilo Watt hour
m- meter
m^2 – square meter
m^3 – cubic meter
mm – milli meter
mg- milli gram
MJ – Mega Joule
MT – Metric Ton
MW – Mega Watt
MWh- Mega Watt Hour
t/T - Tons

15 Mu = 1 ha = 666.6 m^2
1 MWh = 1,000 kWh
1 GWh = 1, 000, 000 kWh
1 kCal = 4.18 kJ

CURRENCY EQUIVALENTS

Currency Units – China Yuan (CNY)/ Renminbi (RMB)
$1.00 = CNY8.28 (February 2005)
$1.00 = CNY8.00 (February 2006)

EXECUTIVE SUMMARY

INTRODUCTION

1.1 BACKGROUND OF THE TA

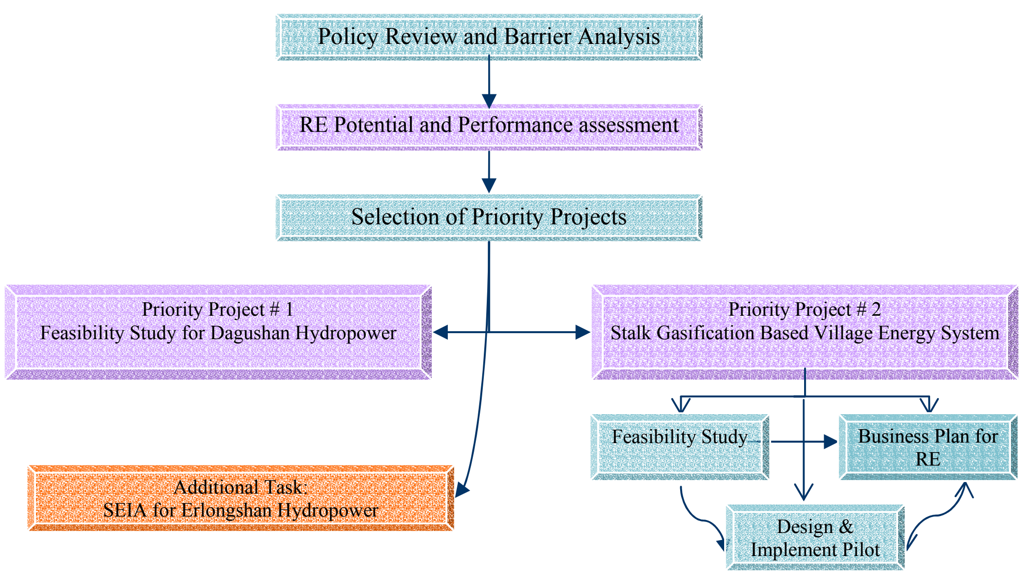
In response to the request made by the Government of People's Republic of China (PRC), Asian Development Bank (ADB) has provided an advisory technical assistance (TA) to promote renewable energy development in poor and rural areas of Zhangye, Gansu Province. ADB and the Government of PRC entered into a technical assistance agreement (TA agreement) on 22nd June 2004 and a consortium led by DSCL Energy Services Company Ltd (DSCLES) was appointed to implement the TA. Work on the TA commenced on February 1, 2005 and concludes with the submission of this final report[1].

1.2 TA OBJECTIVE AND PURPOSE

Consistent with ADB poverty reduction policies, ***the TA's development goal is to improve economic and social development infrastructure in the relatively poor rural areas by improving energy and electric service delivery in a sustainable manner***. The objective of the TA is to examine potential for new energy service initiatives in small towns, villages and rural areas of Zhangye city in Gansu province and develop candidate energy projects suitable for commercial investment in these areas.

2 KEY TASKS PERFORMED

Following key tasks have been performed in line with the TA objectives and TOR and in consultation with the stakeholders:



The detailed methodology adopted by the consultants including interactions with stakeholders for carrying out the tasks is provided at Annex 5.

[1] This report is to be read in conjunction with other interim reports submitted to ADB during the course of the study.

2.1 POLICY REVIEW AND BARRIER ANALYSIS

The bulk of the work was carried out during inception mission and follow-on work during the design of the stalk gasification pilot project in the first interim mission. Reference is made to chapters 3.2, 3.4 and 3.6 of the Inception Report and the PowerPoint presentation made at the inception workshop. Summary findings are presented in section 3.1 of this report.

2.2 RE POTENTIAL & PERFORMANCE ASSESSMENT

This task involved

- Preliminary assessment of the renewable energy (RE) potential;
- Current status on development;
- Performance analysis of the existing initiatives;
- Review of the listed priority projects; and
- Selection of two projects for feasibility analysis

The bulk of the activities under this task was also carried out during Inception Mission and First Interim Mission and details reported. Summary of findings are included in this report at section 3.2 & 3.3.

2.3 FEASIBILITY REPORT OF DAGUSHAN HYDRO PROJECT

The feasibility study of the Dagushan Hydropower Project (DHP) was carried out as one of the priority projects. The summary of the feasibility report has been included as Annex 1 of this report. Based on the presentation and feedback during the final workshop, the final feasibility report has been prepared and submitted in March 2006.

2.4 FEASIBILITY REPORT OF STALK GASIFICATION PROJECT

The feasibility study for a stalk gasification based project was carried out as the second priority project. The feasibility report was prepared and submitted during the first interim mission. Reference is made to the section 3.2 to 3.3 of the first interim report and section 3.4 of the second interim report. The financial and economic, social and poverty and environmental aspects have been further analyzed with more information from the pilot project and have been included in this report at Annex 2, 3 and 4 respectively.

2.5 DESIGN & IMPLEMENTATION OF PILOT PROJECT

The design of the pilot project was based on the stalk gasification feasibility study. The details have been reported in the section 3.2 of the second interim report. The project was formally commissioned on 12th March 2006. The plant was being run for 10 to 12 hours daily since 2nd March and 150 to 160 kW being exported.

2.6 BUSINESS PLAN FOR RENEWABLE ENERGY

The business plan for rural enterprise development was also developed based on the feasibility study and the experience from implementing the pilot project. This was presented during the first interim mission and submitted at section 3.4 of the first interim report.

2.7 ENVIRONMENT ASSESSMENT FOR ERLONGSHAN HYDROPOWER PROJECT

The consultants were assigned an additional task of carrying out an English translation and modification of the Chinese version of the available summary environment impact assessment (SEIA) for Erlongshan hydropower project conforming to ADB requirement. The SEIA

report has been prepared and forwarded to ADB.

3 KEY FINDINGS FROM THE TA PROJECT

3.1 POLICY REVIEW, BARRIER ANALYSIS & RECOMMENDATIONS

> Energy – key element of household expense (nearly 50% of cash expense).
> Zhangye City is well endowed with RE resources viz hydro, biomass, solar and wind.
> Awareness of RE technology benefits is good and some deployment of technology has been achieved through government supported programs.
> However, overall impact on RE technology development is low.
> Building institutional capacity -most important pre-requisite for RE commercialization.
> The example of hydropower development for capacity building and institutional development can be adopted for other RE.

A detailed policy review was carried out during the Inception mission against the backdrop of the new 'Renewable Energy Law' (operational since January 2006), Gansu Provincial Regulation (July 2004) and their impacts in the project area as assessed through field visits and community workshops. Findings were presented in the Inception Report. Subsequently more studies have been carried out during preparation of the feasibility reports and implementation of the pilot projects. Key highlights include:

3.1.1 Rural Energy Access

Practically the entire project area has access to grid electricity supplies. The service reliability has improved from 88.7% in 1998 to 98.9% in 2004. During the same period, system efficiency has been improved by reducing line losses from 21.0% to 14.7%.

However, pockets of dissatisfaction still remain in terms of quality of supply and price particularly for agriculture and township and village enterprises (TVE).

Energy cost represents one of the key elements of household costs; in many villages close to 50% or more of the total household cash expenditure is on energy. Improving the rural energy delivery can therefore, significantly alter the economic and social profile in the rural areas.

3.1.2 RE Development

Summary status on RE development is presented at 3.2. From policy perspective it was observed that program based RE deployment has been achieved as per the laid down targets and awareness levels on RE technologies is good and all the villages visited responded positively to RE programs. However, the impact on technology development is very low despite the achievements and several barriers to RE commercialization needs to be overcome.

3.1.3 Barrier Analysis and Recommendations

Most of the barriers are well known and are being addressed through different initiatives at the State and Provincial levels. In this section of the report, some of the specific barriers experienced during implementation of the pilot project have been highlighted with suggested policy intervention measures.

3.1.3.1 Information Management System

Present information system comprises number of projects and amount of grants. Practically no information could be found on techno-commercial performance of the devices installed under various programs. In the entire project area, no instrumentation exists for measurement

and analytical work.

Even the manufacturers do not have such instruments as has been observed during commissioning of the pilot project.

Some minimum facilities should be created in the Village Energy Office for monitoring the performance of the devices installed under various programs. Similarly, a good monitoring and evaluation (M&E) system should also be developed and operated by the Village Energy Office.

3.1.3.2 Technology Evaluation & Upgradation

In the absence of an M&E system, it is difficult to manage the process of technology development and introduction. For example, the Gaotai stalk gasification project has faced major technical problem causing loss of customers. This problem continues and there is no plan in place for resolving the issues. Similar problems are likely to be encountered whenever a new technology is introduced as in the case of the current stalk gasification pilot project.

Institutional and financial support may also be required for manufacturers as part of technology development, dissemination and wider implementation.

An institutional mechanism should be developed comprising government leaders, universities, technology suppliers and provincial and other concerned village energy offices to periodically review issues and develop improved procedures.

3.1.3.3 Institutional Capacity

Present institutional capacity has been built primarily to manage the subsidy program. Many capacity barriers have been observed during installation of the pilot project. Some of these are:

Project management-Project structuring, documentation, procurement process and contract management had to be entirely managed by the Consultant team. Efforts were made from time to time to let the Pilot project office sort out issues with vendors. (In fact to facilitate the process, the project office was closely involved in the entire procurement process). However almost always intervention of the Consultant team was required for resolution of issues. This is primarily because of non-availability of expertise and experience at the village level for these kinds of projects
.

HR capacity-Setting up the organization for project management and post operation management is still to be done. There has been tremendous sincerity from the stakeholders but adequate human capacity (technical and managerial) is just not available.

Financing-The pilot project is one of the first projects of its kind and it was very courageous on the part of the village community to agree to financially participate in the project. Investigations were made on loan financing for such projects from banks. But difficulty was experienced as the present system does not have provision for lending to such small projects and bank staffs do not have adequate knowledge on how to assess and appraise such projects.

Grid power connectivity-the entire construction of the project was completed in 4.5 months but the trial operation was delayed by 2 months in the absence of clear direction on arrangements to evacuate power. The new RE law provides for grid access for RE but institutional capacity needs to be developed for interpretation and implementation of the law.

Building institutional capacity would be the most important pre-requisite for initiating commercialization of village level RE projects. *Recommendations towards this include:*

- The institutional learning by all the stakeholders involved in the project (in addition to the issues highlighted in this report) should be documented.
- An RE development-training centre should be established at the provincial level with affiliated centers in some of the important RE development project areas. Structured employment oriented training curriculum needs to be developed for project management, operation management, project evaluation system and technology development
- Similar program is also needed for development of financing system and enterprise development.
- Nodal officer should be appointed in the power utilities for one-window clearances for grid connection applications for RE projects.
- Project managers need to be trained on running the pilot project as a commercial enterprise

3.1.3.4 Financial Capacity of the Manufacturers

There are three major manufacturers of gasifiers mostly affiliated to universities. From the experience of the pilot project, it is quite evident that their financial capacity is limited to taking care of the developmental issues. The commissioning of the pilot project was delayed due to time taken for resolving the power connectivity issue. This placed a cost strain on the suppliers and subsequently affected the service quality. These organizations still do not have the wherewithal to withstand unforeseen cost delays and escalation. They would continue to face similar problems while dealing with technology troubleshooting and achieving desired operational performance. Consequently, they would suffer from customer credibility problems.

It is recommended that a technology development fund should be created at all village energy offices and manufacturers supported in accessing this fund during commercialization phase for taking care of unforeseen delays and cost escalation.

3.1.3.5 Commercialization

As per the national policy, the commercialization phase for village-level RE system started from 2001 and will continue till 2010. In addition to some of the specific barriers mentioned above, major barrier will continue to be the higher cost of RE devices because of low market volume. For grid-connected devices, additional problem would be faced in implementation of recently issued tariff guidelines. The stalk gasification pilot project is probably the first such project that is benefiting from these guidelines.

In the section 3.4 of the 1st Interim Report on the business plan, suggestions have been made on commercialization process. It is recommended that stalk gasification pilot project performance is tracked by the Provincial Government and action agenda planned in line with suggestions made for commercialization.

3.2 RE Potential Assessment and Performance Analysis

The project area is richly endowed with RE resources comprising hydro, agricultural waste, potential biogas from animal waste, solar and wind. Broad assessment on availability and status on development was carried out during the various earlier field missions and presented in the workshops and reports. Highlights are as follows:

3.2.1 Hydropower

The Heihe River basin is the major source for hydropower generation in the region. The identified potential and the current status of development for the Heihe basin are given in Table 1.

Table 1 Status of Development of Hydropower in Heihe River

Sl No.	Project	Potential MW	Status
1	Longshuo-1	52	In operation
2	Longshuo-2	157	In operation
3	Xiagoushan	98	Scheduled for commissioning from April 2006
4	Erlongshan	50.5	Under development-2008
5	Sandawan	123.4	Under construction-2008
6	Dagushan	71.2	Feasibility analysis under the present TA project
7	Jiadaogou	124.4	Under investigation by design institute
8	Huangdangsi	71.2	Under investigation by design institute
9	18 nos mini-stations	40.98	In operation
	Total	***788.68***	

Approximately 30% of the potential projects have been completed and are already operating. An additional 35% will be operational in the period from 2006 to 2008. Apart from Dagushan hydropower (DHP), other projects in the basin are also being studied and feasibility analysis is being carried out. Several factors appear to have helped in recent acceleration of hydropower development in the area:

- Government policy for encouraging development of RE and increasing the share of hydropower in the grid system;
- With increase in prices of conventional fossil fuel, the hydropower projects are becoming commercially more attractive. The Xiagoushan hydropower project (XHP) analysis indicated it to be the least cost project against other development option in the project area. Preliminary analysis indicates DHP also offers similar development opportunity;
- Major initiative at the provincial and local government levels for overall economic development in the project area;
- Success in development of institutional capacity for project implementation including support from multi lateral agencies like WB, UNDP and ADB;
- Potential benefit from CDM of Kyoto protocol. XHP will be one of the largest recipients of CERs out of the twenty-eight approved CDM projects in PRC.

In fact, the learning from the institutional capacity building process for hydropower projects can act as model for building similar capacity for development of other RE systems.

3.2.2 Stalk Gasification

It is estimated that 250 stalk gasification stations (similar to the pilot project) can be set up in Zhangye City.

Table 2 Potential for Stalk Gasification in Zhangye City

Particulars	Unit	Shandan	MinLe	Ganzhou	LinZe	Gaotai	Sunan	Total
Stalk production	T/year	153526	237279	481490	210358	103438	12609	1198700
Surplus	30%	46058	71184	144447	63107	31031	3783	359610
Generation potential[1]	MWh	30705	47456	96298	42072	20688	2522	239740
Capacity @ 4500 hrs operation	MW	6.8	10.5	21.4	9.3	4.6	0.6	53

[1]@ 1.5 T/MWh

The surplus availability of stalk after accounting for present usages has been estimated based on the published statistical data and enhanced field survey. The overall energy potential has been estimated as per conversion efficiency data obtained from manufacturers and also experience of the consultants in biomass energy technology development.

The overall power demand in the project area is about 300 MW and household energy consumption is about 173,000 MWh/year. Thus, potential exists for meeting 20% of the power demand of the entire city and entire energy demand of the rural households leaving significant surplus electricity for export.

At the time of the study, one pilot gasification plant was in operation for supplying cooking gas to about 100 households in the Gaotai County. The experience from customer's perspective is mixed. The project is not viable commercially even with capital subsidy. Additionally some serious technological problems (gas quality related) are yet to be solved. (Detailed assessment in Interim Report-3).

3.2.3 Biogas from Animal Waste

The area is rich in availability of manure-the total energy availability has been estimated as shown in the following Table 3:

Table 3 Annual Manure Resources in Zhangye City (in 10000 TCE)

	Shandan	MinLe	Ganzhou	LinZe	Gaotai	Su Nan	Total
Night soil	0.25	0.34	0.53	0.21	0.22	0.04	1.59
Large livestock	1.76	2.69	5.55	2.09	1.56	0.83	14.49
Cattle	0.26	1.14	3.58	1.52	0.51	0.55	7.56
Horse	0.15	0.23	0.10	0.06	0.11	0.14	0.79
Donkey	0.58	0.22	1.36	0.24	0.58	0.07	3.05
Mule	0.76	1.10	0.51	0.25	0.32	0.06	3.00
Camel	0.00	0.00	0.01	0.02	0.04	0.00	0.09
Pig	0.25	1.44	2.89	1.35	0.94	0.04	6.91
Sheep	0.78	0.51	0.98	0.27	0.32	1.07	3.92
Chicken	0.13	0.22	1.18	0.31	0.18	0.01	2.02
Total	**3.17**	**5.21**	**11.14**	**4.22**	**3.21**	**1.99**	**28.93**

(TCE conversion coefficient for night soil & chicken litter- 0.643, cattle –0.471, Camel –0.472, Pig – 0.429, others 0.529)[2]

Aggregate thermal energy need for cooking and heating in the rural population of 250,000 households has been estimated at about 0.6 million TCE. Thus, the entire domestic need can be easily met from this energy source. However, present usage level is very low mainly on account of financial reasons.

- About 4500 biogas plants including 500 '3-in-1' models have been installed under the village energy program
- These biogas plants meet the cooking energy need in the summer months, which is about 10% of the annual thermal energy requirement.
- Mostly coal, surplus stalk or sun dried dung is used for heating. Lean gas from these plants is not suitable for substituting coal used for space heating. The poorer population in the villages therefore, does not see any financial benefits by substituting stalk with biogas.
- Technologically, maturity has been achieved and no further major breakthrough is expected in the near future.
- The cost of a 10-m3 conventional digester integrated with cooking gas system is in the range of 1200-1300 CNY/unit while the 3-in-1 model costs about 5000 CNY/unit.

[2] Assessment of Biomass resource availability in China, China Environmental Science Press

Promotion of this technology is desirable considering the local health and gender benefits and global GHG emission reduction potential but would require continued support under government subsidy program.

3.2.4 Solar Energy

The project area is well endowed with solar energy resources with insolation level of about 148 kCal/m^2. Total exploitable potential has been estimated at over 100,000 TCE per year assuming 10% of the rural households install solar panels of 2 m^2 each. Presently, over 68,000 m^2 panels have been installed mainly in the urban areas. In the rural areas, these devices are yet to make any penetration due to high cost and low returns:

- Typical cost of a standard 1.4-m2 panel is 3100 CNY (Field data)
- Annual savings estimate is about 0.1 to 0.2 TCE or 200 to 250 kWh of electricity representing monetary savings of about 25 to 120 CNY/year depending upon present energy usage for water heating.

890 PV modules of aggregate capacity of 5.3 kW have also been installed.

3.2.5 Wind Energy

Reliable data on wind resources are not available, as wind-mapping exercise has not been carried out. However, some areas have been identified as having good wind resources and preliminary estimate indicates potential of about 200 W/m^2 and overall of about 5000 TCE/year.

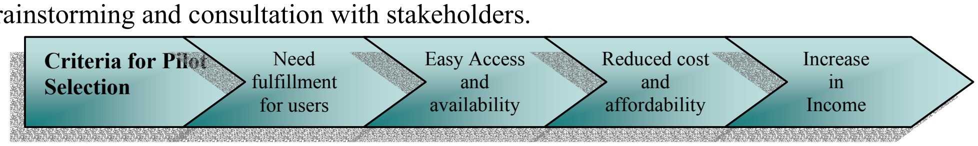
3.2.6 Energy Efficiency

Under the rural energy efficiency initiatives, close to 180,000 high efficiency stoves and 250,000 high efficiency beds have been installed. Propagation of these devices required only information campaign. No subsidy is required as the devices offer attractive financial returns. For example, high efficiency stove (28% against normal of 13%) saves close to 1 T/year coal presently costing about 250 CNY/T. The device costs about 400 CNY yielding a simple payback of less than 2 years. More aggressive campaign needs to be launched to have higher penetration.

Some scope exists for improving efficiency in electricity consumption by encouraging use of high efficiency lighting devices.

3.3 COMMERCIAL DEVELOPMENT POTENTIAL FOR RURAL RE SYSTEMS

One of the important objectives of this TA was to assess the commercial development potential of rural RE projects and the preparation of a business plan for new rural energy service initiative. Underlying criteria for selection of a pilot RE project were determined by brainstorming and consultation with stakeholders.



3.3.1 Need Fulfillment

An enhanced field survey was carried out to assess the energy need fulfillment. The key conclusions from the survey are as follows:

- Availability of electrical energy is the key concern;

- Inadequate availability and poor quality have adverse impact on income, education and health;
- Villagers would like to participate in a community electricity generation plant based on locally available resources so that income generation opportunity can be created.

3.3.2 Easy Access and Increased Availability

The development status of various RE technologies was reviewed. It was clear that hydropower offers the best option as the technology has matured; major potential for development and adequate institutional capacity has been built to manage projects and its O&M. The impact of the recently developed projects has been very good, manifested by increased availability of electricity at the village level. However, this falls short of 'need fulfillment' aspirations on two counts. Distributed system cannot be built and direct income generation opportunity is low.

All the other RE technologies were reviewed briefly as under:

- Stalk gasification technology for gas supply is reasonably mature and a large number of systems (thermal) are operating in the PRC. Power generation technologies are under development all over the world including PRC. Optimally sized power and gas distributed generation (DG) module can be built to meet part of the thermal and entire electricity need at village level. However, technology has to be established and institutional capacity built before commercialization. As already stated earlier, enough potential exists for meeting the total electricity need of the rural areas with easy access.
- Animal waste based biogas technology is well developed and easily accessible, but is only able to meet partial requirements. Power generation technology based on animal waste biogas has not yet been developed.
- Solar and wind systems do have potential, but at current level of technology development and cost levels it was not possible to configure a potential commercial DG model.

3.3.3 Reduced Cost and Affordability

Preliminary economic analysis was carried out for the different technologies and the attractiveness of various systems was rank ordered as follows:

- Hydropower both in terms of potential and economic attractiveness
- Stalk gasification (Power generation model only gives the best financial return but falls short in meeting other development needs like gender empowerment, health etc. the integrated gas and power model serves both the purposes better).
- Other systems-Commercialization does not appear feasible in the immediate future.

Detailed techno-commercial feasibility analysis has been carried out for the DHP and a 200 kW integrated gas and power supply stalk gasification project. The results are shown in the following Table 4.

Table 4 Results of Financial & Economic Analysis of Priority Projects

DAGUSHAN HYDROPOWER PROJECT	
Investment	Financial & Economic Analysis
(i) Base Costs – 400 Million CNY (ii) Contingencies and Financing Costs – 100 Million CNY Total Project Cost – 500 Million CNY Unit cost of investment is 6270 CNY/kW (based on base costs of investment excluding cost of grid interconnection) Where all contingencies and financing charges are included then cost per kW is 8416 CNY/kW. This is within the acceptable range of 7000-10000 CNY/kW applicable for such projects	Assumed that the tariff of 0.227 CNY/kWh as applicable to XHP will also be applicable to DHP Least cost compared with coal thermal power station with an EDR of 20.2% FIRR is 5.9 % (compared with a WACC of 3.1%) EIRR is 22.3% against the hurdle rate of ADB at 12% The project is both financially and economically viable.
STALK GASIFICATION PILOT PROJECT	
Investment	Financial & Economic Analysis
Total investment of 1.7 Million CNY The pilot project has been financed through grant from ADB and equity contribution from other stakeholders.	Power priced at 0.49 CNY/kWh and gas at 0.12 CNY/m^3. FIRR is 3.3% against a WACC of 2.15% EIRR is 23.5% well above the hurdle rate of 12%

3.3.4 Income Generation

The DHP offers large direct employment at the construction stage. During the construction of XHP, at peak level over 3000 persons were directly employed. Further during operational stage, it is estimated that about 35-50 persons would be employed. These estimates would be applicable for Dagushan hydro with a few thousand people involved in construction phase and 45 persons in the implementation phase.

Stalk gasification projects have higher employment potential during operation. Each 200 kW project offers opportunity for direct employment to 8 persons. For 250 such projects, 2000 persons can benefit from direct employment. Additional jobs will be created in the fuel logistics operation and to individual households from sale of surplus stalk.

Increased power availability from both the systems would create secondary TVE related income generation opportunities.

Summarizing…

Hydropower development offers the most attractive commercial investment option considering overall development objectives and the absolute level of financial and economic benefits.

Stalk gasification and power model on the other hand can have more direct impact on poverty reduction. However, the investment cost is still high and technology has to be commercially established. Therefore, development support would be required until sufficient number of such plants has been set up.

COMMERCIAL DEVELOPMENT OF RE

THE NEED: Even though Zhangye City is fully electrified many areas are faced with inadequate availability and poor quality of electricity. The area is well endowed with renewable energy resources.
TECHNOLOGY AVAILABILITY: Stalk gasification technology offered best opportunity for utilizing local resources in a distributed generation model.
AFFORDABILITY: Stalk gasification has a lower scale of investment as compared to the most attractive alternative viz hydro.
INCOME GENERATION: Returns from stalk gasification project are attractive and immediate.

Integrated stalk gasification and power generation model provides best option for development of commercial RE based rural energy service initiative in the project area in terms of income generation and poverty reduction.

3.4 SOCIAL DEVELOPMENT & POVERTY ANALYSIS OF PRIORITY PROJECTS

The social and poverty impact of the identified two priority projects is presented at Annex-3. Salient observations are summarized below.

Zhangye city has over 70% rural population with a significant number under the poverty line. Gansu province itself has a relatively large proportion of population under the national poverty line- estimated at 8.6% against a national average of 4.6%. Recently there has been some improvement, but still below the national average.

Development of hydropower has brought large economic benefit at the macro level. Economic benefits from DHP would comprise estimated contribution of CNY 25 Million/year to the local economy from project profit and Government revenue, permanent direct employment to 45 persons, large temporary employment during construction, creation of social infrastructure and catalytic macro development inherent from such projects.

Stalk gasification project has potential for sizeable impact on poverty reduction and social development. Shandan County, one of the priority project areas has 50% of the population under the poverty line due to prevailing poor development conditions. Energy cost for the household represents 48% of the net income and 55% of the total expenditure. It has been estimated that the energy cost for cooking can be reduced by over 60% by using the stalk gas. The other economic benefits include direct income generation from electricity sale, stalk sale, direct employment in the plant and indirect employment in fuel delivery logistics. There would be significant positive social impact on gender from improved household conditions, reduced cooking time and increase in time available for education/ productive activities.

The combined impact of both the projects would make major contribution towards the millennium development goal (MDG) particularly in the following areas.

- Eradication of poverty
- Primary education
- Gender equality & women empowerment
- Improved maternal health
- Environmental sustainability &
- Global partnership to reduce poverty

The overall poverty reduction impact has also been determined using ADB guidelines and presented in the Table 40 of the report at Annex 3. ***The PIR was calculated for the stalk gasification project.*** The PIR of ***0.67*** indicates that the stalk project should have a positive poverty reducing impact as it is greater than the number (%) of poor in the project area of 50.3% and greater than the poor's share of GDP estimated at 6.6%.

3.5 ENVIRONMENTAL IMPACT OF PRIORITY PROJECTS

3.5.1 Dagushan Hydropower Project

The environment assessment (EA) study has been carried out and the findings included in the summary feasibility report at Annex 1. The project location is in the hilly area with very limited vegetation and animal habitats. There is no human habitat in the project area.

Both the water and air quality in the project area are rated at grade-1. During the construction period, there would be increased pollution load due to the following reasons:

- Solid pollution as a result of excavated rock and earth
- Water pollution due human activities at the construction sites and residential camps and also oil leakages from heavy machinery deployed for construction.
- Dust pollution due to heavy construction activities
- Noise pollution from machinery operations.

Appropriate management control for dealing with each of these issues has been recommended. Another area of concern is water and soil loss that can happen due to construction activities. Appropriate measures for improved soil conservation than those prevailing before the project have been recommended.

Practically no pollution results from the operational phase except for sewage generation from human habitats. Appropriate control measures and treatment have been recommended.

Total investment for environment control and up gradation has been estimated at CNY 4.5 Million. ***There would be significant beneficial environmental impact on GHG emission reduction***. Close to ***200,000 T***, ***carbon-di-oxide would be offset*** considering the present carbon emission factor of 0.86 from the thermal power plants in the area.

3.5.2 Stalk Gasification Project

The environment assessment report is attached at Annex 4 of this report. The project has been located in a wasteland, which is unfit for agriculture. There would be some minor pollution like tar generation estimated at about 69 kg/year, which can be used as waterproofing material. Ash generated from the gasifier is good soil nutrient and can be used as such. Noise pollution from the engine can be minimized by keeping the generator room closed.

Certain safety measures are required at the plant and households. Recommendations have been made on these issues and their mitigation.

The project will have major beneficial impact on women by providing smoke free kitchen and improved kitchen productivity as a result of time savings. While the pilot project is small it would nevertheless make a positive contribution of reducing GHG emission by close to 1000 T carbon dioxide per year.

4 WORK PROGRESS

The methodology adopted for carrying out the TOR tasks, the work progress statement is provided at Annex 5. The minutes of the final workshop is enclosed as Annex 6. The following observations made at the workshop required post workshop action by consultants:

- As per the present guidelines tariff for the hydro project can be around 0.227 CNY/kWh.

Financial analysis for the DHP has been revised as per the above guidelines and results have been incorporated in Annex- 1, Section 6.1.20.

5 CONCLUSION

It has been established that Zhangye city is very rich in renewable resources. Exploitation of these resources would have major impact on development of the City and reduction of poverty.

Considerable impact has already been made by existing hydropower development projects. Excellent institutional capacity has been built for development of hydropower. Similar efforts in developing non-conventional energy resources can make big impact on the employment and income generation at the village level. Additionally, such development would also have major impact in achieving many of the important millennium development goals (MDG). To make these happen, the village energy set up has to be significantly upgraded and institutionalized as has been done for the hydropower development.

The final mission of this TA has deliberated on these issues extensively in addition to commissioning of the pilot project and completing preparation of the feasibility report. The Consulting team does believe that some of the important recommendations made would be followed up for the development of renewable energy in the Zhangye city.

6 LIST OF ANNEXES

6.1 ANNEX 1 - SUMMARY OF DAGUSHAN FEASIBILITY REPORT

6.1.1 General Description

Dagushan Hydropower Project (DHP), the fifth hydropower station planned in "Optimized Report on the Cascade Development Scenario of Heihe River", is situated in the Yugu county of Gansu Province, the middle section of Heihe River Gorge, 70 km distance from Zhangye. It is situated between Erlongshan Hydropower station upstream and Xiaogushan Hydropower station downstream. The main features of the proposed project are:

- Its development river length is 11.12km with 84.5m natural water drop
- The project adopts ROR development plan, with 2143m normal storage level in its reservoir, and 2062.5m tail-water level.
- The design discharge is 99.4m^3/s
- 59.5MW installed capacity
- The annual output is 211.8 million kWh considering 3560 hours annual operation time.

The project consists of head works, power diversion systems and powerhouse etc. The head works include dam, 4 opening flushing sluice gates and intake. Its normal water level follows the tailrace water level of Erlongshan Hydropower station. The total length of the power diversion tunnel system including diversion tunnel and penstock tunnel is 7.908km; of this, 7.542km tunnel of 6m diameter (after lined) is power diversion tunnel. The powerhouse is at river floor level with 3 generating units, 2 of 24MW each and one of 11.5MW capacity. The construction period required is about 3 years. The total static investment of the project is estimated at CNY 388 Million, which includes 15 million CNY for the transmission line. Its unit kW cost is 6270 CNY/kW, and unit kWh cost is 1.76 CNY/kWh respectively.

6.1.2 Brief Summary-Hei He River Basin

Heihe River, originating between Qilian Mountain and Datong Mountain, is the second largest inland river in China and also the largest in Hexi Corridor of Gansu Province. This extends through Qinghai Province, Gansu Province and Inner Mongolia Autonomous Region with a length of over 800km and a catchment area of over 69,000km^2. At its upstream, there are 2 tributaries separated in east and west meeting together to be the main stream of Heihe River at Huangzhang Temple, northwest of Qilian County, Qinghai Province. Heihe basin is rich in hydropower resources. The mean annual runoff amounts to 3.629 billion m^3, including tributary contribution. The main river has annual yearly runoff of up to 1.58 billion m^3. The river is providing important resources for the development of national economy in Hexi region. The section from Huangzhang Temple to Yingluo Gorge is having the highest hydro-energy exploitation potential since in this region are located steep cliffs at both banks, with torrential currents. There the average gradient in the riverbed is 9.8‰ and the fall in the whole length of 95km reaches almost 1000m, which is called the Great Heihe Gorge, a bonanza for hydro-energy.

6.1.3 Hydro-Energy Development Of Heihe River & Dagushan Project

Since the 1950s, this river section has ever been technically evaluated by China Northwest Investigation & Design Research Institute (Design Institute) and Gansu Hydropower Investigation & Design Institute for several times. A *"Research Report on the Cascade Development of Heihe River Basin"* was prepared and submitted. In early 2004, Gansu Hydropower Investigation & Design Institute carried out further study again on the hydro-energy exploitation potential in the river section from Huangzhang Temple to Dagushan on the basis of latest data, and formulated an *"Optimized Report on the Cascade Development Scenario of Heihe river"* for this section. In this report, the original cascade development option was amended and adjusted and 5 cascade developments viz. Huangzhang Temple, Jiadaogou, Sandaowan, Erlongshan and Dagushan were finalized. DHP was conceptualized to have a normal storage level of 2140m in its reservoir, tail-water level of 2060m, 105m^3/s diverted design flow, 79.37m design head and 71.2 MW installed capacity. This report was approved by Zhangye City government, Gansu Province. In the recent past Longshou and Xiliu hydropower stations at the downstream of

DHP have already been put into operation and Xiaogushan Hydropower (XHP) station is to be started in 2006. Erlongshan and Sandaowan hydropower stations at the upstream of DHP are under construction.

During the course of finalization of the TOR of this TA, discussions were held between ADB and Government. Based on the topographical & geological conditions near Dagushan and the future peak & off-peak demand in Zhangye power grid, Zhangye government advised that this TA should examine the feasibility of DHP considering pumped storage option as an additional option.

During the inception mission of the TA (Feb/Mar'05), the Consultants undertook a preliminary study of all the project options for renewable energy (RE) development and short listed DHP and stalk gasification for feasibility analysis. Based on the available reports with the Design Institute and site visits, experts group put forward three development options:

- Option 1-A mixed development plus a pumped storage power plant (PSP)
- Option 2-A long tunnel diversion development mode plus a PSP
- Option 3-A short-tunnel diversion development mode plus a PSP

Based on the pre-feasibility analysis, Option 3 was been considered as the most feasible and economical development choice. Further analysis also revealed that in the foreseeable future, the region is unlikely to be benefited from a PSP. On the other hand, increased capital cost for of such a unit would make the project commercially less attractive.

The city government appreciated the findings of the consultant team particularly in the scientific and technical areas. However, the recommendations made by the consultants necessitated changing the already approved river basin cascade development plan. This required wider consultation amongst all stakeholders including Government leaders at the City and Provincial levels. Considerable efforts were made by the TA Project Management Office (PMO) and City Government leaders in driving the decision process, which was finally communicated to the Consultants team on 27th December 2005.

During the course of the TA, the Consultants team with assistance from Heihe Hydropower Company (IA) carried out more detailed site investigations. In addition to the original dam site location proposed in the initial stages of the study for Option-3 (hereinafter referred to as the middle dam site option), two more locations were selected. One site was located 2.5km upstream of the middle dam site (hereinafter referred to as upstream dam site option) and the second 2.3km downstream of the middle dam site (hereinafter referred to as downstream dam site option). The site investigation revealed that the middle dam site had complex geological issues and was therefore discarded. It was also decided that more geological and topographical data should be gathered for making a proper feasibility assessment. Accordingly, IA entrusted the job of further geological and topographical investigation to the Design Institute. This report, "The Dagushan Hydropower Feasibility Report of Heihe River" is based on the inputs provided by the Design Institute.

While recommending DHP for investment, the Consulting team would like to recommend more intensive geological and topographical work before finally freezing the construction and investment option, as geologically the site is quite complex.

The main technical and economical indices of DHP are shown in the following Table 5.

Table 5 Optimized Index on Cascade Development Scenario of Heihe River (Section from Huangzhang Temple to Dagushan)

Item		Unit	Cascade Index					Notes
			Huangzhang Temple	Jiadaogou	Sandaowan	Erlongshan	Dagushan	
Objective			Multi-purpose	Power generation	Power generation	Power generation	Multi purpose	1 Inside ().of Huangzhang Temple is "02 site selection index." 2. Jiadaogou hydro station has combined original Sandaoheigaou and Quoniugou
Development style			Behind the dam	Behind the dam	Mixed type	Diversion	Behind the dam	
Damsite/powerhouse site			Flow station/ Flow station	Jiadaogou/ Jiadaogou	Hongshibangou/ liushuyuan	Liushuyuan/ Erzilongguo	Changganguo/ Changganguo	
Reservoir Characteristics	Normal water level	m	2630.3	2530	2365	2210	2142	
	Water surface area at normal level	km^2	11.31	4.21	0.354		3.19	
	Total reservoir volume	10^8m^3	4.44	2.15	0.07		1.4	
	Usable reservoir volume	10^8m^3	3.51	0.02	0.02		0.7	
	Regulation ability		yearly	Daily	Daily		Uncompleted yearly	
Hydro-Energy Characteristics	Design discharge	m^3/s	(55) 88	95	100	100	105	
	Average water head	m	(86) 94.86	153.64	144.56	59.8	79.37	
	Installed capacity	MW	(33) 71.2	124.4	123.4	50	71.2	
	Guarantee output	MW	8.79	14.8	14.0	5.85	8.79	
	Annual operation time	Hours	3637	3427	3410	3494	3661	
	Annual output	10^8kwh	2.59	4.27	4.2	1.74	2.6	
Project Characteristics	Dam type		Rockfill with concrete surface	Rockfill with concrete surface	Gravity Dam	Connecting Sandaowan tailrace water flow	Rockfill with concrete surface	
	Max. dam height	m	120.5	170	62.5		105	
	Power conduit system length	km	0.43	1.0	9.8	5.0	0.6	
	Tunnel type/ Diameter	/m	Round/5.0	Round/6.0	Round/6.0	Round/6.0	Round/6.0	
	Powerhouse type		Right bank ground	left bank ground	Right bank ground	Right bank ground	Right bank ground	
	No. of units		(2) 3	4	4	4	4	
	Normal tailrace water level	M	2535	2375	2212	2145	2060	
	Diversion type		Tunnel Diversion	Tunnel Diversion	Tunnel Diversion	Tunnel Diversion	Tunnel Diversion	
	Construction term	year	4	4	3.5	3	3.5	

6.1.4 Hydrology

6.1.4.1 Climate & Precipitation

According to the Yinlouxia Hydrological station, in the Heihe river basin area, the annual rainfall is 175.4mm, annual average water surface water evaporation is 1378.7mm and annual average temperature is 8.5°C. The maximum recorded temperature has been 37.2°C and the minimum -33 °C. The maximum recorded ice earth depth has been 1.5m.

The rainfall distribution in the basin gradually reduces from south to north and from east to west. The rainfall figures from the different monitoring stations are as follows: Qieliang 390.8mm, Zamashike 435.3mm, Yinlouxiao 175.4mm, Zhangye 124.9mm, Gaotai 98.6mm, Zhenyixia 65.6mm. It is obvious that the Qieliang district is the water resources foundation of Heihe river.

6.1.4.2 Annual runoff

The runoff of Heihe river comes from rainfall, snow & ice melt. The distribution around the year is not even. Corresponding to the yearly rainfall, the runoff is highest in the period from June to September (about 68.2% of annual runoff). From April to May, the runoff is about 11.69%, the corresponding figures from October to November and December to March are 10.48% and 9.63% respectively.

The annual mean flow at the design frequency for DHP is given below:

Table 6 Annual Mean Flow at Different Frequency

Location	Average volume (m^3/s)	Cv	Cs/Cv	Annual Average Discharge at Different Design Frequency				
				15%	25%	50%	75%	85%
Damsite	43.9	0.16	2.0	50.6	47.9	43.1	38.5	36.3

6.1.4.3 Flood

The flooding season in the Heihe River basin is from Jun to Sept. generally peaking during July to Aug. The peak flood is caused by heavy rain, which usually continues for 3~6 days at a stretch. The results of flood flow at different frequency for DHP are as shown below.

Table 7 Flood Flow at Different Frequency

Cross-section position	Item	P(%)				
		0.1	0.2	0.5	1	2
Damsite	$Q_m(m^3/s)$	3160	2800	2350	2010	1660
	$W_{One\ day}$ (10^8m^3)	1.708	1.534	1.296	1.122	0.949
	$W_{Three\ day}$ (10^8m^3)	3.769	3.395	2.892	2.524	2.156
Powerhouse	$Q_m(m^3/s)$	3170	2810	2360	2010	1670

6.1.5 Silt & Ice Condition

According to statistics from the regional hydrological stations, the annual average suspended silt passing through the damsite is about 204×10^4t. The annual average cubic meter water flow contains silt at about 1.47kg. The sand flow occurs mainly during the rainy period from June to September (more than 95% of the annual amount). July itself accounts for 41% of the annual load. The bed loads is about 15% of the suspension sand. Accordingly, annual bed loads passing through the damsite has been estimated at 31×10^4 t. According to statistics at Inlouxiao hydrological Station, the sand particle sizes are d50%=0.041m, d=0.101mm.

According to the same station, the water flow starts freezing from November and by January to February it gets fully frozen. By the end of March, ice begins to melt. The maximum ice thickness on the riverbank is 1.1m and in the river, o.8m.

6.1.6 Engineering Geology

6.1.6.1 Regional Geology

The topography in the Heihe river basin is high in the south and low in the north. The elevation difference in the upstream of Qilianshan mountainous area is greater than 1500m, belonging to high mountain canyon area. The river valley mostly has "V" shape. The mountains extend along the WNNW-ESSE direction, and are consistent with the direction of regional tectonic line. The south corridor of the mountain has a maximum elevation of 4701m rising gradually and reducing east north-eastward to 4571m (Jixing mountain), and 3819.6m (Dagushan mountain). The mountains with elevation greater than 4,000m are mostly covered by snow throughout the year with well developed modern glaciers. The glaciers are the main sources for the surface water and underground water in the river basin.

Riverbanks in the project area enjoy large gullies, including Changgangou creek, Sidalong gully, Sanzilong gully, Jibeigangou gully, Ezilong gully, Duantou gully, Dagushan gully, Xiliushui creak and Changshiti creek etc. These gullies are nearly vertical to the Heihe river, with steep slope. There is thick flood induced deposit and slope deposit in the gullies. Changgan creek, Xiliushui creek and Changshiti creek systems developed along faults have perennial running river flow with high vegetation coverage.

The project area is located in the Sunan sub-area of Qilianshan mountainous area, the outcropped formations mainly include Hanwu system, Ordovician system, Silurian system, carboniferous system, Permian system, Tertiary system and large amount of intruded magma stone from Jialidong period.

The project area is located on the Jialidong fold zone of the north Qilianshan at the front arc west wing of the Qilianshan-Luliangshan-Helanshan tectonic system. It consists of a series of NWW, NNW and NE combined drapes and associated broken structure as well as Mesozoic collapsed basins.

According to the Zoning Map of China Earthquake Parameters and the Zoning Map of China Earthquake Response Spectrum Characteristics Circle, the dynamic peak acceleration in the project area is 0.20g, corresponding to earthquake intensity. The earthquake response spectrum characteristics circle is 0.40s. The project area belongs to relatively stable part of tectonically unstable region.

6.1.6.2 Geological Conditions in the Reservoir

For the presently recommended "upstream damsite option", the proposed normal storage level is 2143m, the backwater of the reservoir is about 1.48km long river trough non-regulating reservoir, the water level of the reservoir is limited under the Grade II terrace. Therefore the reservoir will have no submersion, leakage and riverbank collapsing. Only at some area on the left riverbank, the road along the river will be affected.

6.1.6.3 Engineering Geology – Project Structural Areas

The gate site of the upstream damsite is a deeply cut "U" shaped canyon. The river route runs in a snaking pattern. The river bank width is 50-120m and at water level it is 30-40m wide. The river water level is 2134-2135m in the winter. The riverbanks have steep topography with bare base rock. The grade of left riverbank is 50～65°and right riverbank 40～70°. The cover thickness in the river bed is 30.6-33.0 m thick, the riverbed base rock surface seems having 55-75 m wide "U" shaped deep trough. The outcropped formation at the gate site is dominated by Slurian sandstone, gravel and Quaternary loose sediments.

The Slurian formation mainly consists of sandstone and agglomerate, the petrology is simple, the strata occurrence appears N60～80°W、SW□50～60°, inclining towards upstream. The single strata thickness is about 20-30m, with the minimum of 0.3-0.5cm.

The fresh rock is tight and hard being able to bear weathering but its surface is broken due to weathering and load releasing. The strongly weathered depth is usually 3.0-5.0m, and weakly weathered thickness is about 10-15m.

The Quaternary formation mainly consists of riverbed gravel layer and sediments at foot of riverbank slope. The gravel layer is about 30-40m thick, and 45m at the middle line of the river. There is some fine sandstone in it. The collapsed sediments mainly distributed at the foot of riverbanks, are about 5-10m thick with the maximum thickness of 20-25m. The structure is loose.

6.1.6.4 Engineering Geology – Power Diversion System

The power diversion system consists of water intake, power diversion tunnel, surge shaft and high pressured tunnel (penstock). The power diversion tunnel is 7.45km long.

6.1.6.4.1 Engineering Geology – Power Diversion Tunnel

The power diversion tunnel is arranged between Erzilong gully and Sidalong gully on the right riverbank. It is proposed that the axial line direction of the tunnel is NE45º—NE8º, the buried depth of the tunnel is 00—350m with the maximum of 800m and the minimum of 50m. The middle section of the tunnel will pass through Sanzilong gully. The cutting depth of the Sanzilong gully is 100m. Thus it may pose some engineering geological challenges.

The structure area of the power diversion tunnel has the outcropped formation featuring Silurian metamorphosed sandstone, agglomerates and sandy slate. The formation through which the tunnel passes consists of two large anticline and syncline, the strata occurrence varies a lot, but the overall occurrence appears with NW320～350°，, SW(NE) 50～70°.

Controlled by regional tectonic structure, the geology structure of the tunnel passed section is complex, the fractures and fissures are well developed. The surrounding rock of the tunnel is dominated by Grade III (slightly weathered) rock and partly Grade II rock. The outlet section of the tunnel and section of Sanzilong gully belongs to Grade IV (slightly weathered) surrounding rock. The fault broken zone and partial fissure zone belong to Grade V rock(strongly weathered).

Based on the initial investigation by the Design Institute, Grade III (partial Grade II) surrounding rock accounts for 70-80% of the total tunnel length; Grade IV (partial Grade V) surrounding rock accounts for 30-20%. According to the geology data, it can be inferred that tunnel will pass through 8 faults, most of them running west-north with large angle to tunnel axial line. It can facilitate the chamber stability. There will be no major engineering problems. This will not pose a risk if proper engineering measures are adopted. The tunnel inlet and outlet as well as partial rock body at surge shaft is strongly released and weathered. The horizontal distance of the released zone is about 10-15m. It is estimated that the weakly weathered depth is usually 20-40m.

In addition to fault broken zones and partial fissure dense zones, the tunnel and chamber rock body is of tight structure overall and is complete and hard. The strata strike has a 60～80° angle with tunnel axial line, the angle is large, and tunneling conditions are good. The problems with the water intake system include: high wall instability at surrounding rock of tunnel inlet and outlet as well as tunnel face; water inrush at fault broken zone; instability of tunnel wall rock; possible water inrush from thick overburden at Sanzilong gully; and rock outburst.

The underground water of the intake tunnel is mainly base rock fissure water. Rainfall and snow melt water would not cause erosion related problem.

6.1.6.4.2 Engineering Geology – Surge Shaft and Penstock

The ground elevation at the surge shaft is 2196m with base rock high wall inside. The

gradient is 40～60°. At the downstream, of the surge shaft, there is gully, with gully bed width of 9-12m, cutting depth 20-50m; the gradient of the gully bed is 36%. The overburden on the base rock high wall is collapsed broken rock and soil, 5-10 m thick. On the upper part is bare rock, the lithologic character is sandy slate with metamorphosed sandstone, the strata occurrence is NW340°SW48°

The strata inclines towards the riverbank. The release and weathering of the rock body is strong, with releasing depth of 10-12m. There is collapsing on the surface. It is estimated that the weakly weathered depth is greater than 30m. The rock body appears lamella structure, belonging to Grade IV surrounding rock; the lower slightly weathered rock body appears lamella with middle thick layer structure, with good integrity , belong to Grade III surrounding rock.

According to the spatial layout of the surge shaft, it can initially be judged that the upper chamber rock belongs to Grade IV surrounding rock; its top part wall rock has bad stability. Slicing and zoning excavation should be performed and grouting supporting should be given in time and advance bolting measures can be taken if necessary.

The outcropped rock at pressured tunnel is mainly sandy slate with metamorphosed sandstone. The strata occurrence is NW300°NE63° and inclines toward riverbank. The dip angle is gentle in the upper part and steep in the lower part, the released rock body is 6-8m thick, the horizontal depth is 15m, the slightly weathered rock body is 30-35m thick, the released zone and slightly weathered rock body belongs to Grade IV. The rock body at partial tunnel section is not stable. Especially the upper arc section and outlet section should be enhanced by strong grouting and bolting support. The slightly weathered rock body belongs to Grade III with good stability.

6.1.6.4.3 Engineering Geology – Powerhouse Site

The powerhouse site comprise of Silurian sandy slate with metamorphosed sandstone and Quaternary loose sediments. The base rock occurrence is NE30～40°NW□40～50°. The faults in the powerhouse site are less developed but the fissures are well developed. The Quaternary loose sediments are mainly distributed over riverbed, floodplain, terrace and gentle slope area at the foot of the slopes. The lump stone and gravel are the main construction foundation of powerhouse.

The sand and gravel layer at the powerhouse site is about 40m thick. The elevation of base rock roof under the gravel layer is bout 2120m. The base bearing capacity and its deformation module can meet the design requirement.

The main engineering geology issue is the instability of powerhouse high slope and non-uniform settlement of powerhouse foundation and possible sand liquefaction.

6.1.7 Natural Construction Material

The survey team performed investigation over gully valley terrace within 10-20km around the project area. It is initially determined that the natural cement aggregates required by DHP can be from Xiliushui creek, Changgan creek and right riverbank terrace of Heihe river. Their reserves can meet the design material requirement.

Based on geological conditions and material available, it is proposed that left riverbank rock body at former Shiyanglin damsite can be selected as the gravel material site for the project, where the mountain body is grand, the lithology is silicon slate and hard and would be able to bear weathering. The reserves are rich and transport is convenient and can meet the entire design material requirement.

6.1.8 Hydro Energy

6.1.8.1 Power supply arrangement & engineering task

After DHP is put into operation, the electricity generated will enter Hexi power grid through Zhangye power grid. Hexi power grid has high proportion of thermal power. Consequently, the peak shaving capacity is limited. DHP is middle sized project, its main task is power generation. It can undertake partial peak shaving in tandem with Erlongshan and Sandaowan hydropower stations.

6.1.8.2 Load prediction of HEXI power grid

In August 1995, the 656km Haishiwan-Jinchang-Jiayuguan single loop 330kV transmission line was put into operation, which marked the forming of integrated Hexi power grid and became a branch of Gansu power grid. Because the peak load of Hexi power grid is mainly transmitted by Gansu power grid, the transmission distance reaches 600km. The transmission loss is high and power supply quality is poor. In accordance with the 10th five year Plan and 2020 outlook for Power industry Development in Gansu prepared by Gansu Power Corp. in December 2002, and the 2015 Gansu Power Grid Plan prepared by Northwest Electric Power Design Institute, the maximum load of Hexi power grid was 996MW in 2000 with the maximum peak-valley difference of 242MW. Annual electricity consumption was 5759GWh. It is predicted that the maximum load will reach 2460MW and 3380MW in 2010 and 2015 respectively, and the maximum peak-valley difference would be 689MW and 1048MW. Correspondingly, the annual electricity demand will reach 14006GWh and 19051GWh respectively.

6.1.8.3 Electricity Balance

2015 has been considered for as the reference year for determination of power balance and system planning. Status and planning of hydropower and thermal power sources is briefly summarized as under:

6.1.8.3.1 Hydropower

Currently Hexi power grid has 35 middle and small hydropower stations in operation, with a total installed capacity of 160.8MW, and guaranteed output of 17MW. The annual electricity generated is 522.8GWh. In addition to Longshou No.1 and Longshou No.2 which are daily adjustment hydropower stations, other hydropower stations are water intake ones without water adjustment. The guaranteed output is the operation output, and without peak shaving capacity. By 2015, the operated, constructed and planned hydropower stations will have a total capacity of 1014.85MW; the working capacity would be 534MW and the annual electricity.

6.1.8.3.2 Thermal Power

Hexi power grid has 9 thermal power stations with a total installed capacity of 679.3MW and annual electricity output of 3057GWh. According the provincial plan, the total installed capacity of thermal power plants will reach 2800MW by 2015, the working capacity is 2240MW and annual electricity output 16800GWh.

6.1.8.3.3 Electricity Balance

Although the total installed capacity of thermal power and hydropower will exceed the load demand, both the thermal and hydropower stations have smaller working capacity in winter. Shortfall during such period would be met by supply from Gansu main power grid. When balancing the power in the Hexi region, first of all local power sources should be fully utilized and the balance made up from the main power grid. During wet months, the flow of Heihe river usually exceeds the designed flow of hydropower stations. At this time, hydropower stations can provide the base load.

In winter, DHP can operate in tandem with Erlongshan and Sandaowan hydropower stations for daily adjustment. Being close to load center, it can undertake 10MW spare load if necessary for local peak shaving task.

6.1.8.3.4 Working and Surplus Capacity

The maximum working capacity of 11 hydropower stations with daily adjustment function in Hexi power grid is 455MW of which, the maximum working capacity of DHP is 12MW.

By electricity balancing, DHP can have 10MW spare load capacity

Emergency spare capacity – Because Dagushan hydropower station is in joint operation with Erlongshan and Sandaowan hydropower stations, it does not have daily regulating reservoir capacity. Therefore no emergency spare capacity will be set.

6.1.8.3.5 Conclusions

- Hexi power grid will lack 330MW peak shaving capacity in 2015. It would be necessary for Gansu power grid to address to this issue including exploration of feasibility of constructing a daily adjustment hydropower stations along the Heihe river.
- For the electricity balance, the surplus electricity of Hexi power grid is 1633GWh in 2015. It can be transmitted to Gansu power grid for coal saving. Balance seasonal electricity can be consumed locally. Hexi region lacks coal supply. It is therefore, necessary to develop medium and small hydropower stations to the maximum extent possible.
- The shortage of peak shaving electricity in 2015 will reach 401GWh. This shortfall has to be met by Gansu power grid. Presently, every year, Gansu power grid supplies 401GWh (330MW) peak shaving electricity to Hexi power grid and hexi power grid supplies 1633 GWh seasonal electricity to Gansu power grid.

6.1.9 Hydro Energy Indices

6.1.9.1 Normal Water Storage Level

According to the report of Heihe (Huangzangsi to Dagushan river section) Hydropower Cascade Development Option Optimization, the head works of the project will connect upstream tail water of Erlongshan hydropower station. The powerhouse site will be located at the mouth of Sidalong gully and connect to downstream reservoir of XHP. The normal storage water level is initially determined as 2143.0m. The tailrace water level at powerhouse site is 2062.50m.

6.1.9.2 Installed Capacity and Kinetic Energy Index

Based on the calculation of runoff of five typical years, the maximum water head of the hydropower station is 81.20m, with minimum net water head of 67.70m, average being at 73.87m. The rated water head is 70m. The designed intake water flow is 99.4m3/s, equal to that of Erlongshan hydropower station. The installed capacity is 59.5MW (2x24MW + 1x11.5MW), and guaranteed output is 8.44MW (P=85%). Annual electricity output is 211.8GWh and annual working hours are 3560h.

The hydropower station will operate in tandem with upstream Erlongshan and Sandaowan hydropower stations. The reservoir of Sandaowan hydropower station has daily regulation function. Therefore, this hydropower station would also have daily regulation function. The operation water level at head pivot will be kept at 2142-2143m throughout the year. It can undertake partial peak shaving task in the Hexi power grid during dry months, so as to increase the working capacity of the hydropower station during dry months. During wet months, the river flow is usually greater than rated flow of the hydropower station. At this

time, the hydropower station runs in full operation and work as base load station.

6.1.10 Civil Works

6.1.10.1 Project Grade and Standard

According to the stipulations in the" Flood Control Standard (GB50201-94)" and the "Grade Classification and Flood Control Standards of Water Control and Hydropower Projects (mountainous and hilly area section, SL252-2000)", the project belongs to middle grade III category. The main buildings would be designed with Grade III standards, secondary buildings with Grade IV standards and Grade V for temporary buildings. The flood control standards of buildings: dam site, designed flooding frequency is P= 2%, (one flood every 50 years in the long term), verified against a flooding frequency of P=0.2% (one flood every 500 years in the long term); powerhouse designed flooding frequency is P=2% (one flood every 50 years), verified against a flooding frequency of P = 0.2% (one flood every 200 years); The energy dissipation and scour prevention standard at the downstream of headworks is P = 3.3% (one flood every 30 years in the long term).

The designed earthquake intensity in the project area: 8 degree.

6.1.10.2 Site Selection and Options

DHP is connected with Erlongshan hydropower station to the upstream and with XHP to the downstream at the levels of 2143.0m and 2062.5m respectively. Two potential sites have been proposed: upstream dam site and downstream dam site. In both cases, the power generating plant will be in the same place. The dam site and the power plant will be connected through a water diversion system.

The proposed upstream dam will be sluiceway with 4 opening gates. The concrete dam will be 17.3m high and the normal water level at the headworks will be 2143m. The power diversion tunnel will be 7.542km in long.

The proposed downstream dam will be a rockfill dam with reinforced concrete surface at 69m height. The normal water level at the head-works will be 2142.０m and the power diversion tunnel will be 3km long.

The problems with the upstream dam site would be the long tunnel and loss of water head. But it is more economical and has less settlement and technical difficulties. The downstream dam site has larger reservoir volume. There are issues related to geology and consequently anticipated higher capital costs and low economy. But this issue needs to be further examined by more intensive geological survey before final investment decision is made. Considering the present findings under this TA project, the upstream dam site is recommended as it has been found technically easier to construct and financially viable.

6.1.10.3 Main Engineering Structures

<u>1. The upstream dam</u>

The dam is located at the site 0.2km downstream away from Er Zi Gou. The river there is 18～55m wide and the water level is around 2133.6～2136.00m. At both sides of the river bank the upper slope is 40～50°and the lower slope is 80～85°. The covering layer above the rock is around 25m. The reservoir is 1.48km long. The dam is 17.3m high. The soil is close-grained and the dam can be directly built on soft foundation without further treatment to the earth. The sluiceway has 4 gates and gravity concrete dam at the left bank. The invert elevation of sluice is at 2132.2m high with 59.0m width. Four gates are 10m×8m in each. The concrete dam is 6m long and 5m wide at the top. It is straight to upstream and sloping at 1：0.75 to downstream.

2. Power diversion system

The Power diversion system comprises intake, tunnel, surge shaft, penstock etc. The tunnel will be set at the right bank. The level of intake is at 2133.70m and 50m far away from the center of the dam. The intake is connected with a tunnel, 7542m in long and 6m wide. The water flow is 99.4m3／s.4m^3/s. The penstock is 350m long. (Four adits will be provided). The surge shaft will be at the end of the tunnel and its diameter is 15m.

3. Powerhouse area

The power plant will be located at the river bank 200m upstream from Si Da Long Gou. The river there is 200～220m wide and 1.5～3m deep. The land level is 2080.0～2085.0 m. The place is ideal for a hydropower plant. The structures include the plant, tailrace tunnel, switch yard, flood-proof buildings, etc. The main plant will have two big generators at 24MW each and one small generator at 11.5MW.

6.1.11 Mechanical and Electrical Works

6.1.11.1 Hydro Equipments

The types of the turbine are HL220are HL220/A153-LJ-215 and HL220/A153-LJ-149 supplemented with generators of SF-J24000-22/4600 and SF-J11500-14/4250 respectively for the larger and smaller sets. There are sewage system with two pumps and fire-fighting water system. The hoist is of 125/35t capacity.

6.1.11.2 Electrical Equipment

The electrical equipment will comprise the following method of electricity connection.
A new substation with 330kV will be built

- Three transformers at 380/220V to be used in the plant.
- Control system and protection.
- Computerized monitoring system will be installed in both the plant and headworks.

6.1.11.3 Metallic Structures

There will be totally 9 metal gates for various usages, 3 sets of sewage materials, 14 packages of buried components and 9 hoists. The total weight of metal has been estimated at 875t.

6.1.12 Project Management & Organization

DHP will belong to the IA viz. Gansu Heihe Hydropower Joint Stock Co. Ltd. The IA will operate and manage the facilities after construction. The number of staff operating the plant will be about 45.

6.1.13 Permanent Buildings

Permanent buildings include those at the plant site and an office building. The total area will be 4000m^2 including 1600m^2 for the plant and 2400m^2 for the office building.

6.1.14 Permanent Access Road

The distance between XHP powerhouse and downtown area of Zhangye City is 86 km comprising a 50 km stretch of Grade IV road between Zhangye City and Dayekou and the remaining stretch of simple gravel road. There is a simple road from the XHP to the powerhouse and weir location of DHP. This is sufficient to meet the construction requirement with a little development. Thus, the transportation link is more or less already available for this project. The distance from the dam site of this project to Zhangye city is about 112km and the distance from the weir of XHP to the weir and power house of this

project are 12km and 3km respectively.

6.1.15 Construction Power

During the construction period, power for weir site and powerhouse site can be directly connected in T type to the 35kV line which is connected to Sandaowan hydropower station and passes through this project site. During the construction period, power would be transmitted by 10kV lines via a 35/10kV substation and to the end user by a 10/0.4kV transformer. This transmission line would also serve as the permanent power supply and emergency standby line for the weir and powerhouse. 2 sets of 200kw each diesel engine would also be kept for emergency.

6.1.16 Permanent Land Acquisition

This project is located in the gorge of Heihe river. There are no residents and other important establishments. There is also no farmland, no relics, no mineral resources etc. Therefore no problem would be faced relating to resettlement, submergence and immergence. The entire portion of the permanently acquired land comprises of Barren Mountain and river bottomland.

The permanent land acquisition includes the weir land and powerhouse land. The total area requirement has been estimated at 125 mu including 50 mu for the weir and 75 mu for powerhouse.

6.1.17 Construction Planning

6.1.17.1 Construction of Diversion Structure

The water retaining structure is a gate type dam, the flood frequency of diversion structure is P= 20% in dry season (one flood every 5 years in the long term in dry season), corresponding flood discharge is 318 m^3/s and the flood frequency of water retaining structure after coffer dam collapse during construction period is 10% (corresponding flood discharge is 930m^3/s. The diversion way is cofferdam with single time cut-off river flow and tunnel divert river flow. The total length of the diversion tunnel is 480.0m located on the right bank of the river. The cross section of the tunnel is round with a diameter of 7.5m.

The upstream cofferdam would be constructed with soil and rock at an altitude of 2142.00m and height of 10m. The downstream cofferdam is also of soil and rock construction at an altitude of 2135.5m and height of 5.5m.

6.1.17.2 Construction of major civil works

2 m^3 grabs and 15~20t automatic unload vehicles would be deployed for grit excavation and transportation for the construction of the water retaining weir. Wind driller and dynamiting would be used for rock excavation. Concrete from the concrete-mix station would be transported by 20t vehicles.

Rock chisel vehicle would be used for the excavation and 5～8T vehicles for transportation for construction of the diversion system. The tunnel lining would be done by deploying 6m^3 mix-and transport vehicles, concrete pumps, steel model moldings, mechanical distributing and manual maintenance.

The excavation of the pressure well would adopt guiding-well adverse-excavation-enlarge technique from top to bottom. Wind driller and dynamiting would be deployed rock excavation.

Similar methods would be used for the grit and gravel excavation and filling for the construction of powerhouse.

6.1.17.3 General Construction Layout

A temporary construction road of 3.4km and 4 construction adits totaling 1360m have to be constructed according to the general engineering layout and characteristics, construction material exploitation and sediment dispose plan etc.

Construction power supply: connected in T type to the 35kv transmission line which passes through the site to Sandaowan station. 2 other 200kw diesel engine sets would also be installed.

The construction site would be divided into two zones- weir district and powerhouse district.

According to the engineering layout, following space requirement has been estimated: an area of 12050m^2 for the supporting infrastructure including 1700m^2 for simple houses and 10350m^2 for engineering sheds, an area of 5500m^2 for warehouses including 1800m^2 for simple houses and 3700m^2 for engineering sheds, an area of 15630m^2 for office and other living facilities.

6.1.17.4 Quantity for Major Civil Works

Work Estimate - Soil and rock excavation 731.3 thousand m3 (including 328.9 thousand m3 tunnel rock excavation), soil and rock filling 117.3 thousand m3, concreting and steel concreting 139.1 thousand m3, concrete grouting 43.75 thousand m3, fill back grouting 61.5 thousand m2, seep preventing concrete wall 1.182 thousand m2
Major construction materials: Major construction material estimates are as under:
Cement 49000t, reinforcing steel bar 8402t, armor plate 875t, timber 2300m3

6.1.17.5 Construction period

The construction is expected to be completed over a period is 3 years.

6.1.18 Environmental Protection & Soil Conservation

6.1.18.1 Current Status of Environment

Dagushan hydropower project DHP, is located in Xishui, Sunan, Zhangye , Gansu , Sunan County, Zhangye City, Gansu Province and , belongs to Qilianshan-Qinghai Lake Sub climate zone of the Qingzang Plateau, and has extreme cold and featuring high coldness and semi-dry climate.

The multiple year average flow of Heihe river in the project area is 43.9m^3/s, the mineral content in the water ranges from 0.1-0.3g/l, comprising mainly calcium carbonate. The soil around the project area includes consists of Hanzhan and Ligai materials.

The proposed project will be located in the experimental zone of the Qilianshan National Nature Reserves. In the project area, there are few very few vegetations, and animal habitat conditions are poor. There is no State protected animal and plant in the project area, but some birds, amphibian and reptile do inhabit the area. In addition, there is no human settlement in the project area.

6.1.18.2 Environmental Function Planning

- Surface water environment - In accordance with the "Stipulations governing surface water environment function division in Gansu", the river section affected by the project belongs to Grade I water environment function zone.
- Air environment - In accordance with the Ambient Air Quality Standards (GB3095-1996), the project area belongs to Grade I air quality function zone.

6.1.18.3 Pollution Emission and Impact Assessment

- Ecological environment-Project construction requires excavation of rock and earth, it will result in the damage of land in the project area, the vegetation coverage will be reduced, and soil loss will be increased, and silt content of Heihe river water will be increased. In addition, gravel washing induced wastewater and waste oil from machinery operation may enter water body causing pollution of the surface water.
- Waste gas sources and emissions -During project construction, dust and flying dust may pollute local environment, it will cause certain impact on air quality in the project area.
- Wastewater pollution source and discharge -Due to activities by construction workers, production wastewater and residential wastewater will be generated, which could have certain impact on Heihe water quality in affected river section.
- Noise pollution sources and its intensity -During project construction, a number of large and medium construction machinery will be used. Their noise level usually ranges around 65～114dB（A）. This will have impact on the sound environment in sensitive sites nearby.
- Solid Waste - Solid waste mainly includes waste rock and residential rubbish. In general, the above impacts are temporary; they can be eliminated after the end of project construction.
- Pollution emission and environmental impact of project operation -There is no generation of waste gas, wastewater and solid waste from hydropower station operation. The main pollutants are sewage, rubbish and mechanical noise from hydropower machinery operation.

6.1.18.4 Environmental Protection Targets

The environmental protection measures are designed to meet the environmental protection requirement of the project and achieve following targets:

- During project construction, wastewater, waste gas and noise emissions should comply with the standards accepted by local environmental management department, and mitigate the impact on downstream water, air and sound environment.
- For people's health, the infection incidence should be controlled below original level.
- Ensuring the water supply and life and property safety of people living along the water reduced river section;
- Taking advantage of effective engineering and biological measures to control the soil loss, the water and soil conservation level should be better than that before project construction and meeting the requirement of landscape restoration. The waste rock protection ratio should reach 98% within responsible area and the vegetation coverage in greening area should be greater than 90%.

The environmental protection measures of the project include water environment protection, air and sound environment protection, ecological environment protection, and water and soil conservation.

6.1.18.5 Water & Soil Conservation

In accordance with the Gansu water and Soil Conservation Zoning, the erosion type in the project area includes hydraulic erosion and freezing-melting erosion and dominated by hydraulic erosion. The wind erosion is weak in Heihe canyon area. The soil water erosion module is 100～300t·km2·a-1 rated as slight erosion. The potential risk of the soil erosion is classified as risky type. The allowed soil loss in the project area is 200 t·km2·a-1.

The project is located at Heihe canyon area, belonging to the experimental zone of the Qilianshan natural forest protection area. It is predicted that a great amount of waste rock will be piled at canyon riverbanks and gully and partial riverbed terrace will be occupied. Therefore, effective measures should be taken to control soil loss.

During project construction, soil loss is mainly caused by material mining and solid waste disposal. It can generate water and soil loss risk and reduce the comprehensive protection

function of water and soil conservation measures.

In the water and soil conservation option, the water and soil loss control scope is divided into project construction area and directly affected area. Evaluation of water and soil conservation measures has been carried out for waste rock sites, borrow pits, construction area and production management area, greening engineering not proposed in main engineering; and water and soil conservation measure designed for directly affected area. In accordance with the characteristics, the water and soil loss control can be divided into: production management control area, waste rock site control area, borrow pit control area, temporary engineering control area. Control measures:

- High wall and land treatment should be carried out at borrow pits based on the topography;
- Waste rock blocking dam should be constructed at waste rock site and the waste rock should be leveled and compacted;
- Land treatment engineering: temporarily occupied land should be treated after project construction. It can be restored or used as greening land.

6.1.18.6 Investment Estimate for Environmental Protection

The total investment of the environmental protection and water and soil conservation is estimated at CNY 4.50 million.

6.1.19 Project Cost Estimate

The total investment calculated according to the relevant PRC standards as per Table 8.

Table 8 Project Cost Estimates in Million CNY

		Foreign	Local	Total
A	**Project Costs**			
1.	Land Acquisition	0.0	0.0	0.0
2.	Main Civil Works	100.4	100.4	200.8
3.	Temporary Civil Works	25.2	25.2	50.4
4.	Equipment Procurement	80.8	0.0	80.8
5.	Equipment Installation	0.0	15.2	15.2
6.	Commissioning and Start Up	0.0	0.8	0.8
7.	Survey $ Designing	0.0	17.6	17.6
8.	Project Management	0.0	5.6	5.6
9.	Others	0.0	2.4	2.4
10.	Transmission Line	0.0	15.2	15.2
	Total Project Costs	206.4	182.4	388.8
11	Taxes and Duties	0.0	12.0	12.0
	Total Base Cost	**206**	**194**	**400**
B	**Contingencies**			
	Physical Contingency	10.4	9.6	20.0
	Price Contingency	9.6	8.8	18.4
	Total Contingencies	**20**	**18**	**38**
C	**Financing Charges**			
	Interest During Construction	24.8	8.8	33.6
	Commitment Charges	26.4	0.0	26.4
	Front End Fee	3.2	0.0	3.2
	Total Financing Charges	**53**	**9**	**62**
D	**Total Costs**	**280**	**220**	**500**
	% of total costs	56%	44%	100%

[a] In current 2006 prices.

[b] Physical contingency is provided at 5% of base cost estimate for all expenditure categories

[c] Price contingency is based on 1.9% on foreign exchange costs. Price contingency on local currency costs is assumed at 3.0%.

[d] IDC has been estimated at ADB's LIBOR-based interest rate at 5.84%.

[e] Commitment charge is based on 0.75% of the undisbursed funds (less assumed expenditure profile).

[f] Front-end fee is estimated at 1% of the loan amount.

[g] Includes taxes and duties of $1.5 million.

Inflation and exchange rate assumptions for calculating price contingencies and Project costs with the official exchange rate assumed is 8.0 CNY to the US dollar. Domestic inflation rate is assumed to be 3% annually and international inflation 1.9% per annum.

6.1.20 Financial & Economic Analysis

6.1.20.1 General Methodology

The economic analysis is undertaken in accordance with ADB Guidelines, including *Guidelines for the Economic Analysis of Projects, Handbook for Integrating Poverty Impact Assessment in the Economic Analysis of Projects*, and *Guidelines for Integrating Risk Analysis in the Economic Analysis of Projects*. The financial analysis of the Project is undertaken in accordance with *The Guidelines for the Financial Governance and Management of Investment Project Financed by the Asian Development Bank (2001*).

The following sections presents project economic and financial analysis, in support of detailed feasibility study. In addition the analysis relies heavily on work undertaken by SMEC in 2002[3] and the ADB RRP for the XHP, 2003[4].

The analysis of DHP includes the following:

- Examination of least cost generation plan for Gansu Province and Zhangye City;
- Analysis of alternative generation development options to DHP and calculation of Equalizing Discount Rate, EDR;
- Calculation of the EIRR and FIRR of DHP and sensitivity analyses;

This study does not include preparation of financial projections of the IA - HeiHe Hydropower Development Company, incorporating the DHP.

6.1.20.2 General Assumptions

Economic analysis is carried out using economic prices, with financial prices adjusted to allow for transfer payments including taxes, duties or subsidies, and to correct for any other market distortions. For the present study, the following general assumptions are adopted:

- All costs are expressed in current 2006 prices
- The real opportunity cost of capital employed in the economic analysis is assumed to be 12% per annum, and represents the social opportunity cost of capital (SOCC) for China.

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[3] ADB. 2001. *Technical Assistance to People's Republic of China for Gansu Hydropower Development*. Manila.

[4] Report and Recommendation of the President on a proposed loan to the People's Republic of China for the Gansu Clean Energy Development Project, November 2003

- Capital costs include physical contingencies, but exclude price contingencies and interest during construction and other financing charges. The physical contingency is assumed at 5.0%.
- The hydro project is assumed to have a useful economic life of 25 years after construction with a residual value averaging 50% of project costs in year 25. After 10 years it is assumed rehabilitation/replacement expenditure equivalent to 20% of electromechanical costs.
- In least cost analysis of thermal plants assume economic life of 25 years with no residual value. In addition to annual overhauls it is assumed rehabilitation/replacement expenditure equivalent to 10% of capital costs are incurred every ten years.
- The official exchange rate assumed is 8.0 CNY to the US dollar
- Domestic inflation rate is assumed to be 3% annually, and international inflation 1.9% per annum
- Annual capital expenditure is assumed at 5%, 35%, 35% and 25% over the construction period.
- Based on Chinese terms of trade and import and export duties a Shadow Foreign Exchange Rate of 1.00, is adopted and applied to tradeable inputs to convert to border price equivalents (- the UNIDO approach).
- It is assumed that there are no significant distortions in the wage rates for skilled labour. In the case of unskilled labour, underemployment exists in the economy, resulting in the opportunity cost of unskilled labour being less than the promulgated minimum wage rates. A Shadow Wage Rate (SWR) of 0.67 is used to place an economic value on unskilled labour costs during implementation. The unskilled labour component is estimated at 20% of the labour operating costs.
- Project financing is expected to come from three sources with ADB meeting the foreign exchange costs, with the balance met by equity contribution from Heihe Hydropower Development Company (60%), and domestic loan (40%). The cost of equity is assumed to be 10% after tax.
- It is assumed that the potential ADB loan will have a term of 24 years including a grace period of 4 years. The ADB loan is based on the 6 month LIBOR-based floating interest rate. For calculating WACC over the construction period the LIBOR-based 5-year fixed swap rate (5.24% as of 10 March 2006) is adopted, plus ADB fixed spread of 0.6%.
- For the long-term domestic loan, the basic assumption is for a 15-year repayment term commencing immediately after construction completion at a fixed annual interest rate of 6.12%. Over the construction phase interest only is paid at 6.12% per annum.
- Any working capital required for the operation is assumed to be financed with short-term domestic loan at an annual interest rate of 5.58%, which will be renewed each year. In practice this requirement will be met by the Heihe Company.
- The projected tariff is RMB 0.227/kWh. This tariff assumption is the rate advised by the Gansu Power Bureau at the Final Workshop on the 14 March, 2006.
- Available capacity is 59.5 MW with 3560 hours operation, or a 41% load factor resulting in average annual generation of electricity of 213.7 GWH. The effective generation will be 211.5 GWH assuming self-consumption of 1%. 90% of the capacity is assumed to be realized for the first operating year and full capacity would be reached from the second operating year.
- The operating expense assumptions applied in the calculation of the FIRR and EIRR and least cost analysis are as follows:
    - Average number of employees of 40 with an annual average salary of RMB20,000 per employee, with 10% of total relating to unskilled labour;
    - Salary-based costs to be incurred are assumed as:
    - Annual welfare expense at 14% of the total salary;
    - Labor protection expense at 17% of the total salary;
    - Housing fund at 8% of the total salary;
    - Education fund at 1.5% of the total salary; and
    - Labour union expense at 2% of the total salary.
- Materials expense estimated at a rate of RMB6 / kW.
- Administration expense estimated at a rate of RMB12 / kW.
- Reservoir maintenance expense assumed to be RMB0.001 / kWh.
- Insurance fee assumed to be 0.25% of the original fixed asset value.

- The above equate to approximately 0.7% of capital costs from second year in operation. In the first year while labour costs are assumed at 100%, other operating costs range from 20% to 70% of full values.
- Hydro assets will be depreciated using a straight-line depreciation method over 25 years for tax calculation purposes. However, the economic life of the assets is assumed to average 50 years
- VAT is assumed at 17% and city construction tax and education tax are 5% and 3% respectively.
- The company tax rate is assumed at 33%.

6.1.20.3 Indicative Financing Plan

The proposed financing plan for the Project is set out in Table 9. The Government has requested ADB to provide financing for the entire foreign exchange cost of the Project of $35.0 million. The Project costs assume that ADB will provide a loan from its ordinary capital resources (OCR loan) to finance the foreign exchange costs of the project. The loan will have a 24-year term, including a grace period of 4 years, an interest rate determined in accordance with ADB's London interbank offered rate (LIBOR)-based lending facility, a commitment charge of 0.75% per annum, and a front end fee of 1% of the loan amount. For the purposes of calculation interest during construction (IDC) the fixed five year US Dollar LIBOR rate has been adopted, which is equivalent to 5.84% per annum (inclusive of ADB's margin of 0.6%). Relending terms to Heihe Company are assumed to be on the same terms, with the Company taking the foreign exchange risk.

Heihe will finance 60% of the balance by way of equity, with the remaining 40% financed through a local loan at 6.12% for 15 years. IDC has been calculated at 6.12% on funds drawn down. There are no commitment or front end fees.

Table 9 DHP: Indicative Financing Plan

	Per cent			Million CNY		
	FX	LC	Total	FX	LC	Total
ADB Loan	100%	0%	56%	280.0	0.0	280.0
Heihe-Equity	0%	60%	26%		132	132.0
Domestic Loan	0%	40%	18%		88	88.0
Total	**100%**	**100%**	**100%**	**280.0**	**220**	**500**
% of total costs				56%	44%	100%

6.1.20.4 Calculation WACC

Based on the above financing plan the WACC is calculated at 3.12%

Table 10 DHP Calculation of WACC

A. Financial component	ADB	Domestic Loan	Equity	Total
B. Amount (CNY million)	35.0	88.0	132	220
C. Weighting	56%	18%	26%	100%
D. Nominal cost	5.89%	6.12%	15.00%	
E. Income tax rate	33%	33%	33%	
F. Tax-adjusted nominal cost [D x (1 - E)]	3.95%	4.10%	10.05%	
G. Inflation rate	2%	3%	3%	
H. Real cost [(1+F) / (1+G) - 1]	2.01%	1.07%	6.84%	
I. Weighted component of WACC	1.12%	0.19%	1.81%	
Weighted average cost of capital	**3.12%**			

6.1.20.5 Detailed Least-cost Generation Planning and Analysis

Introduction

Supplementary Appendix J of the RRP November 2003 set out in detail generation planning and least cost analysis of the 95 MW XHP run of river project financed by the Bank. The current study draws on that analysis. The Supplementary Appendix J analysis used the power balance in Gansu province. It assumed that XHP although located in Zhangye City, could supply electricity to the provincial network and compete against other generators in the whole province. The key steps in the analysis were (i) load forecast and analysis of power balance in the local, and provincial or regional grid, (ii) identification of technology options, (iii) evaluation of potentially viable project alternatives, and (iv) detailed analysis using the Generator of Electric System Planning (GESP II) model[5].

The least-cost analysis for electric power generation planning ensures overall production efficiency, and involves the forecast of future energy demand and the evaluation of viable technological alternatives to select optimum plant design. It involves comparing investment alternatives based on capital costs, operating and maintenance (O&M) costs, and a fixed time period for which discounted cash flows are calculated. For the Dagushan project least cost analysis compared the run of river project against a 300 MW Coal Fired Power Station alternative.

Gansu Network Electricity Demand

Electricity demand in the North-West network was expected to grow at 7% and 6.4% in the Tenth and Eleventh Five-Year planning periods (2001-2005 and 2006-2010), respectively. Similarly, energy demand growth in Gansu province was expected to be 6.0% and 5.7 % for the same period (Table 11). These projections are consistent with the historical growth and overall national electricity demand forecast as endorsed by State Power Corporation. Considering the current emphasis of the Government on economic development in the Western region, the above forecast is considered valid.

Table 11 Electricity Demand Forecast - NW PRC & Gansu Network (TWh)

Electricity Demand Network : (TWH)	10th Five-Year Plan						11th Five Year Plan		
	2001	2002	2003	2004	2005	Ave.% p.a. Increase	2006	2010	Ave. % p.a. Increase
North-West Power	85.40	91.8	98.2	105.1	112.6	7.0 %	119.8	153.5	6.4%
Gansu Network	30.61	33.2	35.2	37.3	39.5	6.0%	41.7	52.0	5.7%
Gansu Year Book 2/		34.2	39.8						
% Increase forecasts		+3.0%	+13.1%						

Source : 1. Supplementary Appendix J, RRP, November 2003, and 2. Gansu Year Book 2005

Data from the Gansu Year Book, 2004, suggests that electricity consumption has exceeded 10th Five Year Plan Forecasts, so that the assumptions made with regard to overall provincial electricity demand and shortfalls in generating capacity are still valid. These assumptions and forecasts would be reviewed as part of the detailed feasibility studies, when the Generator of Electric System Planning (GESP II) model[6].

Zhangye City Network

The peak load for the Zhangye City network was 167 MW in 2001 and reached about 200 MW in the summer of 2002. This demand is significantly higher than the installed capacity in the City of 94.5 MW: Longshou (52 MW); Longqiu Stations 1–4 hydropower (34 MW); and a small thermal power plant of 8.5 MW. These generating stations are together capable of producing about 163 GWh per year. Electricity demand reached 900 GWh in 2001; a deficit of 737 GWh was met through imports from outside the City. The energy demand and peak load are shown in Table 12. The load factor is the ratio of the average load to the peak load during a period of time. In other words, if for a year the average load

5 Developed by the Power Research Institute, Beijing, People's Republic of China (PRC).
6 Developed by the Power Research Institute, Beijing, People's Republic of China (PRC).

is 55MW, but at least in one specific period the load jumped to 100MW, then the load factor would be 55%. A lower load factor means that the peak load is relatively higher than the average load. In the case of Zhangye City, it may be concluded, that a declining load factor indicates an increasing trend in peak demand.

Table 12 Power Balance Zhangye Grid

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Demand (GWH)	900	1,000	1,110	1,230	1,400	1,510	1,630	1,760	1,910	2,057
Peak Load (MW)	167	182	206	227	281	306	334	364	396	432
Load Factor (%)	62	63	62	62	57	56	56	55	55	54

Source : Supplementary Appendix J, RRP, November 2003

The Xiliushi and Xiaogushan hydropower stations are the two proposed hydropower plants on Heihe River expected to start producing power around 2005 to 2007 onwards. The energy balance in Zhangye, including the generation from Xillushui and XHP is expected to be as follows.

Table 13 Energy Balance - Zhangye GWh

	2005	2006	2010
1. Power Consumption	1,400	1,510	2,057
2. Power Generation	756	1,163	1,163
Xiliushui Station	120	527	527
Longshuo Station	180	180	180
Other Small Stations	85	85	85
Xiaogushan Station	371	371	371
3. Energy Balance	(-644)	(-347)	(-894)

Source : Supplementary Appendix J, RRP, November 2003

The Zhangye City network has two comparable but distinct peak demand scenarios, winter and summer (Table 14 and Table 15). The summer peak imposes maximum demand on the existing network as shown in Table 15. The summer demand is made up of a larger peak mainly due to agricultural (pumped irrigation) load. XHP will provide maximum generation during summer months and is particularly suited to alleviate the peak electricity demand gaps in summer months for the Zhangye City network.

Table 14 Power Balance, Winter Maximum Demand MW

	2005	2006	2010
1. Peak Load	280.0	301.0	426.0
2. Available Capacity	35.6	49.6	49.6
a. Xiliushui Hydropower Station	17.6	17.6	17.6
b. Longshuo Hydropower Station	8.0	8.0	8.0
c. Other Small Stations	10.0	10.0	10.0
d. Xiaogushan Hydropower Station	-	14.0	14.0
3. Power Balance	**-244.4**	**-251.4**	**-376.4**

Source : Supplementary Appendix J, RRP, November 2003

Table 15 Power Balance, Summer Maximum Demand MW

	2005	2006	2010
1. Peak Load	295.0	310.0	453.0
2. Available Capacity	138.0	348.0	348.0
a. Xiliushui Hydropower Station	45.0	157.0	157.0
b. Longshuo Hydropower Station	59.0	59.0	59.0
c. Other Small Stations	34.0	34.0	34.0
d. Xiaogushan Hydropower Station	-	98.0	98.0
3. Power Balance	**-157.0**	**47.0**	**-105**

Source : Supplementary Appendix J, RRP, November 2003

Assuming the above analysis is still valid, with the Gansu actual demand in 2002 and 2003, indicating that the gap between supply and demand would have widened, there is justification for including DHP in the least cost generation expansion plan, as it will be able

to provide overall energy (kWh) as well as assist in meeting both the summer and winter peak capacity (kW) shortfalls in Zhangye City and Gansu Province.

Least-cost Analysis
After finalizing demand forecast, the option or alternative that is least-cost to meet the electricity demand has to be identified. Because of the large gap between demand (1,400 to 2,000 GWh) and supply (750 to 1,200 GWh) in Zhangye City, demand side responses were not considered as full alternatives in the analysis. Only supply side options—new generation plants—were used as viable options.

Project Alternatives
Gansu province has its own primary energy sources for power generation for example, sufficient coal reserves to meet local demand. Hydropower resources are mainly located in the Yellow River and its tributaries.

The RRP of November 2003 Supplementary Appendix J Compared XHP with two alternative coal fired thermal plants - small 300 MW and large 600 MW. For the analysis of Dagushan the 300 MW coal fired plant was chosen. Capital and annual O&M costs for each technology alternative were discounted over a 25 year period at a 12.0% discount rate.

For direct comparability the output of each alternative was normalized. Adjustment were also made for load factor differences, for example, a run off river hydropower like DHP will generate limited energy (about 213.7 GWh with a load factor of around 41%) whereas its immediate alternative, from fossil fuel generation, would generate much more. For direct comparability of costs, it was assumed that aside from the benefit for capacity substitution for DHP, the alternatives would generate more energy (load factor of 68%) to substitute generation from small size coal fired plants. Adjustment was also made to compensate for the 48 days annually out of service of the Thermal option.

Table 16 Assumptions for Technical Options for Least Cost Analysis

Options	Hydropower	Coal Fired
	DHP	300MW
Capacity (MW)	59.5	67.3 1/
Annual Generation (MWH) Production	213700	224257
Annual Generation (MWH) Sent Out	211563	211563
Plant Consumption Rate (%)	1.0%	6.0%
General Coal Consumption (gce/kWh)	-	320
Fuel Price (CNY/tce)	-	322 2/
Maintenance Period (Days/year)	-	48
Capital Cost (CNY/kW)	6848	5190 3/
Total capital costs (CNY million)	400	349
Fixed O&M Cost (%)	0.7%	3.0%
Variable Cost (CNY/kWh)	-	0.005
Load Factor (%)	41%	68%

Source: SMEC 2002 Report and updated Consultants estimates
Notes 1. Adjusted by load factor, plant consumption and days available to provide annual generation (sent out) to match hydro sent out.
2. RRP price of CNY 222/tonne 2003 adjusted by WB Commodity Prices - Australian Coal FOB Calendar year 2003 to February 2006 and/or as set out in Table 10 below.
3. RRP estimate adjusted for movement in WB Commodity Prices - Steel Products Index Calendar year 2003 to February 2006 of 1.758 times for 25% of capital costs and International Inflation of 1.06 times for the balance (75%).

Table 17 Least Cost Analysis: DHP Vs Thermal (Amounts in Million CNY)

	Hydro			Coal Fired "300 MW"					
Year	Capital	O&M Fixed	Total	Capital	O&M Fixed	Variable	Coal	Total	EDR
2007	20.37		20.37	0.00				0.00	-20.37
2008	142.60		142.6	98.97				98.97	-43.63
2009	142.60		142.6	113.11				113.1	-29.50
2010	101.86		101.9	70.69				70.69	-31.17
2011		2.03	2.03		8.48	1.06	23.11	32.65	30.62
2012		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2013		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2014		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2015		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2016		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2017		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2018		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2019		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2020	16.21	2.93	19.14	28.28	8.48	1.06	23.11	60.92	41.78
2021		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2022		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2023		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2024		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2025		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2026		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2027		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2028		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2029		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2030	16.21	2.93	19.14	28.28	8.48	1.06	23.11	60.92	41.78
2031		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2032		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2033		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2034		2.93	2.93		8.48	1.06	23.11	32.65	29.72
2035	-203.72	2.93	-200.79		8.48	1.06	23.11	32.65	233.44
	NPV	12%	308.9	NPV	12%			374.7	18.8%

Table 18 Least Cost Analysis - Summary of Results

	Dagushan Hydro	300 MW Thermal
Capacity assumptions	59.5	67.3
NPV (CNY million) (@12% discount rate)	309	375
EDR (Base Case)	18.8%	
EDR (with Hydro capital costs plus, +10%)	14.2%	

EDR (with - 10% reduction in coal prices)	17.6%	
EDR (with coal prices at 2003 levels, ie CNY 222/tonne)	15.2%	

The equalizing discount rate—the discount at which the present value of two life-cycle cost streams are equal, thus indicating a discount rate at which preference changes—shows that hydropower remains a better alternative up to the discount rate of 18.8% after which smaller thermal power will be preferable. Hydropower, with its high capital costs and very low operational cost is the preferred option when lower discount rates are used. Where Hydro capital costs increase by 10% then EDR falls to 14.2%. Where coal cost were 10% lower the EDR falls to 17.6%, and if the coal price is at 2003 levels of CNY 222 per ton then the EDR would be 15.2%.

6.1.20.6 Economic Analysis (EIRR) for Dagushan Hydropower Project

General

On the basis of the assumptions set out above, the economic analysis is carried out in economic prices, with financial prices adjusted to allow for transfer payments including taxes, duties or subsidies, and to correct for any other market distortions. The analysis does not quantify environmental impacts of the project.

Calculation of Economic Benefits

Economic Value of Fuel Prices

Economic prices for the following four main alternatives have been computed as follows:

Table 19 Estimate of Economic Value of Fuel Prices

	Kerosene/ Diesel	LPG	Coal
Price Components	CNY/litre	CNY/kg	CNY/Ton
Landed Price	3.34	4.30	229.17
Duties and Taxes	0.06	0.01	8.41
Transport Cost	0.06	0.06	6.00
Dealers Margin	0.27	0.35	37.42
Total Cost	3.73	4.72	281.00
VAT	0.06	0.12	10.10
Total Cost	3.79	4.84	291.10
Selling Price main centers	3.79	4.84	291.10
Local Retail (Zhangye)	4.04	5.20	330.00
Economic Costs (Excluding Duties + Subsidy)	3.73	4.83	282.69
Distribution Margin	0.25	0.36	38.90
Local Retail	3.98	5.19	321.59
Estimated Economic Costs	3.98	5.19	321.59

Calculation of Consumers WTP

The main benefit of the Project is electricity generation to meet the electricity demand in the power grid. An allowance of 9.5% is provided for transmission and distribution losses from the electricity sent out. The quantification of incremental benefits is based on end-user's willingness to pay (WTP).

For electricity, reliable information on distribution of electricity generation between different consumer classes is available only at Provincial level. Accordingly, for estimating WTP for electricity, the analysis has been performed at the consumer class level and four classes of electricity consumers—agricultural, residential, commercial, and industrial—

based on published information at provincial level[7]. WTP for various customer classes are summarized in table below and described in the following paragraphs.

Table 20 Willingness to Pay for Electricity

Consumer Type		Agriculture	Residential	Commercial	Industrial
Alternative Source of Electricity		Petrol Generator	Kerosene Lamp	Petrol Generator	Small Coal-fired Thermal
Ratings and Usage					
Capacity	kW	5	0.1	5	12,000
Daily Use	hours	10	4	10	12
Daily Energy Output	kWh	50	0.4	50	144000
Annual Use	hours	3,650	1,460	3,650	4,380
Annual Energy Output	kWh/yr	18,250	146	18,250	52,560,000
Design Life	years	5	5	8	25
Design Life	hours	18,250	7,300	29,200	109,500
Annual Load Factor		42%	17%	42%	50%
Investment Cost					
Investment	CNY/kW	5,448	900	5,448	11,000
Total Investment	CNY	27,240	90	27,240	132,000,000
Annual Investment Cost	CNY/yr	3,269	11	3,269	15,840,000
Unit Cost	CNY/kWh	0.18	0.07	0.18	0.30
O&M Costs					
Fixed	CNY/Kw-y	272.4	0	272.4	330
Variable	CNY/kWh	0.1	0.1	0.1	0.1
Total	CNY	3,187	15	3,187	9,216,000
Unit Cost	CNY/kWh	0.17	0.10	0.17	0.18
Fuel Costs					
Efficiency		20%	11%	20%	25%
Fuel Consumption	TCE	11.21	0.16	11.21	25828
Fuel Retail Price 1/	CNY/TCE	2,340	2,340	2,340	321
Annual Cost	CNY/yr	26,232	382	26,232	8,290,783
Unit Cost	CNY/kWh	1.44	2.61	1.44	0.16
T and D Losses		2.0%	0%	2.0%	9.5%
Alternative Energy Cost	CNY/kWh	1.80	2.75	1.80	0.69
WTP Calculation					
Share of Consumer Category	%	14.7%	7.5%	7.8%	70.0%
End-Consumer Tariffs	CNY/kWh	0.344	0.42	0.7	0.45
Consumer Surplus, at 35%	CNY/kWh	0.51	0.81	0.39	0.09
Willingness to Pay	CNY/kWh	0.85	1.23	1.09	0.54
Weighted WTP	CNY/kWh	0.68			

Irrigation is the main use of electricity by agricultural consumers and diesel-fueled engines would be the only viable alternative in the absence of electricity. The cost for diesel generation is about CNY 1.80 per kWh taking the total lifecycle cost of diesel generation.

Residential consumers, in remote rural areas with no access to electricity, mainly use kerosene lamps for lighting. For people in some cities, where power supply is unreliable, kerosene lamps serve as the main source of light or are used as reserve. Kerosene lamps, which are one of the worst choices from an energy efficiency viewpoint, are the next best

[7] The analysis follows the methodology adopted in RRP of November 2003.

viable alternative from the economic point of view. The cost of using kerosene lamps is about CNY 2.75/kWh.

Air-conditioning, heating and lighting are the main uses of electricity for **commercial consumers**. Petrol generators normally serve as reserve sources of energy when electricity supply from the power grid is not satisfactory in term of quality and stability. Thus, petrol generators were selected as the alternative at a cost of CNY 1.80/kWh.

Industrial consumers, with high-energy consumption, are most sensitive to the cost for electricity supply compared with other consumer classes. In remote areas where grid connection is not available, small sized coal fired power plants is a common choice for alternative energy. In this analysis, a coal-fired power plant (12 MW) was used as the alternative energy source for industrial users. The cost of this alternative is calculated at CNY 0.69/kWh.

WTP calculation assumes consumers would be willing to pay more—about 35% of the difference between the current tariff and the cost of alternative—than the current tariff for extra units of reliable electricity. Accordingly, the weighted average WTP is calculated as CNY0.68/kWh, and forms the basis of all economic benefit for sale of power. 0.68 CNY/kWh represents the average WTP for incremental electricity supply.

Calculation Economic Internal Rate of Return (EIRR)

The economic internal rate of return (EIRR) is calculated at 22.3% and exceeds the ADB's 12% hurdle rate for the economic opportunity cost of capital.

Table 21 Calculation of EIRR for DHP - Amounts in Million CNY

Year	Capital	Operating	Benefits	N.C.F.
2007	20	0	0	-20
2008	143	0	0	-143
2009	143	0	0	-143
2010	102	0	0	-102
2011	0	2	111	109
2012	0	3	123	121
2013	0	3	123	121
2014	0	3	123	121
2015	0	3	123	121
2016	0	3	123	121
2017	0	3	123	121
2018	0	3	123	121
2019	0	3	123	121
2020	16	3	123	104
2021	0	3	123	121
2022	0	3	123	121
2023	0	3	123	121
2024	0	3	123	121
2025	0	3	123	121
2026	0	3	123	121
2027	0	3	123	121
2028	0	3	123	121
2029	0	3	123	121

Year	Capital	Operating	Benefits	N.C.F.
2030	16	3	123	104
2031	0	3	123	121
2032	0	3	123	121
2033	0	3	123	121
2034	0	3	123	121
2035	-204	3	123	324
EIRR				**22.3%**

Sensitivity Analyses

Sensitivity analysis has been conducted to measure the effects of changes in key variables on the economic viability of the Project, compared with the base case. Only adverse changes are considered. The Sensitivity Indicator (SI) shows the ratio of percentage change in EIRR to percentage change in a particular variable. The analysis demonstrates that the Project is most sensitive to changes in benefits, but the resulting EIRR is 20.4%. The project is most susceptible to delays with a two year delay resulting in increases in capital costs and delay in benefits, resulting in an EIRR of 17.0%.

Table 22 DHP: Sensitivity Analysis

Sensitivity Analyses			SI
Base Case		**22.3%**	
Capital	+10%	20.6%	7.5%
Operating	+10%	22.2%	0.2%
Benefits	-10%	20.4%	8.5%
All the above		18.8%	
Two year delay		17.0%	
Assuming NO residual value in 2035		22.2%	

6.1.20.7 Project Financial Analysis and Calculation of FIRR

The financial analysis (Table 23), assuming CNY 0.227/kWh revenue to the project after deducting tax (after allowance for depreciation and interest expenses), results in a Base Case FIRR of 5.9% exceeding the WACC of 3.1%. The standard sensitivities in Table 24 show that the project options are most sensitive to reductions in revenues, resulting in an FIRR of 4.9%. Likewise, a delay in the project with an increase in costs would also result in an FIRR of 4.5%.

Table 23 Calculation of FIRR for DHP (Amounts in Million CNY)

Year	Capital	Operating	Benefits	N.C.F.
2007	21			-21
2008	147			-147
2009	147			-147
2010	105			-105
2011	0	2	45	43
2012	0	3	44	41
2013	0	3	43	40
2014	0	3	42	39

Year	Capital	Operating	Benefits	N.C.F.
2015	0	3	41	38
2016	0	3	39	36
2017	0	3	38	35
2018	0	3	37	34
2019	0	3	36	33
2020	16	3	34	15
2021	0	3	33	30
2022	0	3	31	28
2023	0	3	30	27
2024	0	3	28	25
2025	0	3	26	23
2026	0	3	26	23
2027	0	3	26	23
2028	0	3	26	23
2029	0	3	26	23
2030	16	3	26	7
2031	0	3	26	23
2032	0	3	26	23
2033	0	3	26	23
2034	0	3	26	23
2035	-210	3	26	233
FIRR				**5.9%**

Table 24 Sensitivity Analysis

Sensitivity Analyses			SI
WACC		**3.1%**	
Base Case		**5.9%**	
Capital	+10%	5.1%	13.1%
Operating	+10%	5.8%	1.3%
Benefits	-10%	4.9%	15.8%
All the above		4.2%	
Two year delay		4.5%	
Assuming NO residual value in 2035		4.6%	

6.1.21 CONCLUSIONS AND RECOMMENDATIONS

The construction of Dagushan hydropower station is in line with the general plan of Heihe water resources exploitation. The task of the station is power generation.

Detailed practical survey results are available since the establishment of Yinluoxia hydropower station in 1994. The analysis carried out are therefore, based on high quality data. The project is located on a relevant stable area between two distinct faultages. The basic earthquake intensity is grade is VIII and there is no danger of direct damage to the structures of the station.

An annual amount of 211.8 million kwh electricity can be supplied to Hexi district after the completion of the station, which will improve the structure of Hexi grid and power quality. With the completion of the station, 77,000 tons of equivalent standard coal can be saved annually, which will alleviate coal shortage pressure, coal transportation problem and water shortage problem of the local district and would therefore, protect the environment of Hexi district.

This feasibility study has been developed considering low dam and long tunnel diversion option, which based on comparison with other options, offer several advantages like low technological problems, easy construction, little submergence, low engineering cost and simple social problems. It can operate and dispatch together with Erlongshan and Sandaowan power stations.

The project site is conveniently located for transportation, short distance of water and power supply. It would be possible to carry out construction round the year.

The area is also rich in availability of construction materials.

The project offers attractive investment opportunity.

There was a possibility of adopting a short tunnel high dam option. This would have provided increased economic opportunity of day regulation. On the basis of available geology data this option was found risky due to engineering uncertainty. However, it would be desirable to carry out more geological and topographical survey before finally freezing the investment decision.

6.2 ANNEX 2- ECONOMIC & FINANCIAL EVALUATION OF STALK GASIFICATION PROJECT

6.2.1 ECONOMIC EVALUATION OF THE PROJECT

6.2.1.1 Introduction & Conclusion

The economic analysis is undertaken in accordance with ADB Guidelines, including *Guidelines for the Economic Analysis of Projects*, *Handbook for Integrating Poverty Impact Assessment in the Economic Analysis of Projects*, and *Guidelines for Integrating Risk Analysis in the Economic Analysis of Projects*.

The EIRR is calculated in real terms as 23.5% compared to the hurdle rate of 12%.

6.2.1.2 Assumptions for Economic Analysis

Economic analysis is carried out using economic prices, with financial prices adjusted to allow for transfer payments including taxes, duties or subsidies, and to correct for any other market distortions. For the present analysis, the following general assumptions will be adopted:

- All costs are expressed in current 2006 prices based on recent actual costs and estimates/ quotes received for the pilot project.
- The currency used in these analyses is CNY at exchange rate with the U.S. dollar of CNY 8.00 to US$1.
- The project is evaluated over a 15 -year period – the expected life of the project. Therefore no residual value for project assets is applicable.
- The real opportunity cost of capital employed in the economic analysis is assumed to be 12% per annum, and represents the social opportunity cost of capital (SOCC) for PRC.
- All economic costs are net of duties and taxes.
- Based on PRC terms of trade and limited distortions from import and export taxes and duties a Shadow Foreign Exchange Rate Factor (SFERF) of 1.00 has been adopted.
- It is assumed that there are no significant distortions in the wage rates for skilled labour. However in the case of unskilled labour in rural areas there is significant under employment. And therefore a shadow wage rate factor (SWRF) for unskilled labour of 0.67 has been adopted8.

6.2.1.3 Estimation of Costs

The economic costs of the investment components include

(a) Total investment costs of the stalk gasification project and associated power network connection facilities (including physical contingencies, but excluding price contingencies, financing charges and taxes);
(b) O&M costs of the project;
(c) Cost associated with electricity losses incurred during transmission and distribution and station uses.

The capital and operating costs for the stalk gasification project are based on the least cost project that meets design capacity requirements. All the costs exclude taxes and duties and financing costs. Non-tradeable inputs are converted to border price equivalents by the application of a SFERF (of 1.00). Unskilled wages are adjusted for any underemployment in the economy by the application of SWRF (of 0.67).

6.2.1.4 Estimation of Benefits

Three major benefits considered for the analyses are:

(a) Direct benefits from the sales of electricity valued at the cost of alternative generation options, as well as kerosene for lighting in rural households;
(b) Direct benefits from the sales of gas valued at the cost of alternative cooking fuels,

[8] ADB RRP 34476 PRC– Gansu Clean Energy Development Project

especially the costs of collecting, storing and drying stalk for cooking

The direct benefits from the project include electricity generation in rural areas and supply of a clean fuel to meet cooking energy needs. Analysis uses a conservative estimate of actual benefits and has not considered the health and environmental benefits that accrue from the project.

6.2.1.5 Economic Value of Fuel Prices

Economic prices for the following four main alternatives has been computed as follows:

Table 25 Estimate of Economic Value of Fuel Prices

Price Components	Kerosene/ Diesel CNY/litre	LPG CNY/kg	Coal CNY/T
Landed Price	3.34	4.30	229.17
Duties and Taxes	0.06	0.01	8.41
Transport Cost	0.06	0.06	6.00
Dealers Margin	0.27	0.35	37.42
Total Cost	3.73	4.72	281.00
VAT	0.06	0.12	10.10
Total Cost	3.79	4.84	291.10
Selling Price main centers	3.79	4.84	291.10
Local Retail (Zhangye)	4.04	5.20	330.00
Economic Costs (Excluding Duties + Subsidy)	3.73	4.83	282.69
Distribution Margin	0.25	0.36	38.90
Local Retail	3.98	5.19	321.59
Economic Costs	3.98	5.19	321.59

6.2.1.6 Willingness to Pay for Electricity

For electricity, reliable information on distribution of electricity generation between different consumer classes is available only at Provincial level. Accordingly, for estimating WTP for electricity, the analysis has been performed at the consumer class level and four classes of electricity consumers—agricultural, residential, commercial, and industrial—based on published information at provincial level.

Irrigation is the main use of electricity by agricultural consumers and diesel-fueled engines would be the only viable alternative in the absence of electricity. The cost for diesel generation is about CNY 1.80 per kWh taking the total lifecycle cost of diesel generation.

Residential consumers, in remote rural areas with no access to electricity, mainly use kerosene lamps for lighting. For people in some cities, where power supply is unreliable, kerosene lamps serve as the main source of light or are used as reserve. Kerosene lamps, which are one of the worst choices from an energy efficiency viewpoint, are the next best viable alternative from the economic point of view. The cost of using kerosene lamps is about CNY 2.75/kWh.

Air-conditioning, heating and lighting are the main uses of electricity for **commercial consumers**. Petrol generators normally serve as reserve sources of energy when electricity supply from the power grid is not satisfactory in term of quality and stability. Thus, petrol generators were selected as the alternative at a cost of CNY 1.80/kWh.

Industrial consumers, with high-energy consumption, are most sensitive to the cost for electricity supply compared with other consumer classes. In remote areas where grid connection is not available, small sized coal fired power plants is a common choice for

alternative energy. In this analysis, a coal-fired power plant (12 MW) was used as the alternative energy source for industrial users. The cost of this alternative is calculated at CNY 0.69/kWh.

WTP calculation assumes consumers would be willing to pay more—about 35% of the difference between the current tariff and the cost of alternative—than the current tariff for extra units of reliable electricity. Accordingly, the weighted average WTP is calculated as CNY0.68/kWh, and forms the basis of all economic benefit for sale of power. 0.68 CNY/kWh represents the average WTP for incremental electricity supply including allowance for generation and for transmission and distribution losses (9.5%). Therefore, in the case of the economic analysis for electricity sales of the stalk gasification project, the allowance for T&D losses has been netted off.

Table 26 Willingness to Pay for Electricity

Consumer Type		Agriculture	Residential	Commercial	Industrial
Alternative Source of Electricity		Petrol Generator	Kerosene Lamp	Petrol Generator	Small Coal-fired Thermal
Ratings and Usage					
Capacity	kW	5	0.1	5	12,000
Daily Use	hours	10	4	10	12
Daily Energy Output	kWh	50	0.4	50	144000
Annual Use	hours	3,650	1,460	3,650	4,380
Annual Energy Output	kWh/yr	18,250	146	18,250	52,560,000
Design Life	years	5	5	8	25
Design Life	hours	18,250	7,300	29,200	109,500
Annual Load Factor		42%	17%	42%	50%
Investment Cost					
Investment	CNY/kW	5,448	900	5,448	11,000
Total Investment	CNY	27,240	90	27,240	132,000,000
Annual Investment Cost	CNY/yr	3,269	11	3,269	15,840,000
Unit Cost	CNY/kWh	0.18	0.07	0.18	0.30
O&M Costs					
Fixed	CNY/Kw-y	272.4	0	272.4	330
Variable	CNY/kWh	0.1	0.1	0.1	0.1
Total	CNY	3,187	15	3,187	9,216,000
Unit Cost	CNY/kWh	0.17	0.10	0.17	0.18
Fuel Costs					
Efficiency		20%	11%	20%	25%
Fuel Consumption	TCE	11.21	0.16	11.21	25828
Fuel Retail Price	CNY/TCE	2,340	2,340	2,340	321
Annual Cost	CNY/yr	26,232	382	26,232	8,290,783
Unit Cost	CNY/kWh	1.44	2.61	1.44	0.16
Local Losses		2%	0%	2%	10%
Local Costs		100%	100%	100%	100%
Conversion Factor		1	1	1	1
Alternative Energy Cost	CNY/kWh	1.80	2.75	1.80	0.69
WTP Calculation					
Share of Consumer Category	%	14.70%	7.50%	7.80%	70%
End-Consumer Tariffs	CNY/kWh	0.344	0.42	0.7	0.45
Consumer Surplus, at 35%	CNY/kWh	0.51	0.81	0.39	0.09
Willingness to Pay	CNY/kWh	0.85	1.23	1.09	0.54
Weighted WTP	CNY/kWh	0.68			

6.2.1.7 Willingness to Pay for Cooking Energy

The enhanced field survey showed that rural households consumed stalk, coal and LPG for cooking and heating purposes. In the "With project" situation, it is assumed that coal will continue to be used for heating purposes, even with availability of stalk gas, which will be used only for cooking. Therefore, in the "Without project" case the two fuels used for cooking are LPG and stalk in traditional stoves. The survey also showed that 25% of the households used LPG for cooking and 75% used stalk. While the economic (and financial) costs of LPG are based on market prices, it is necessary to calculate the economic cost of using stalk for cooking purposes.

From the survey results, and field observations, it is evident that a considerable amount of time is taken up in the daily collection, storage and drying of stalk for cooking purposes. It is estimated that on an average 2 hours are involved in each day for undertaking the above tasks. In addition, other studies[9] have shown that the use of stalk gas can reduce the time taken in preparing a fire and removing the ash is eliminated, thus saving 2 hour a day for 3 meals. However, we have adopted a conservative assumption of 1 hour saving in total, rather than 3 hours. Considering a 12-hour working day for a woman at an average rate of 15 CNY per day, applying a SWRF of 0.67, results in an economic cost of 0.28 CNY/m^3 of stalk gas equivalent.

WTP for cooking gas has been calculated as described in the previous section as 0.37 CNY/m^3 of stalk gas equivalent as illustrated in Table 27.

Table 27 Willingness to Pay for Cooking Gas

Alternative Source of Energy	Unit	Stalk	LPG
Ratings and Usage			
Annual Fuel Consumption	kg,	4380.00	10.61
Daily Use	Kg	12	0.16
Heating Value	kCal/ kg	3000	11000
Efficiency of Conversion		13%	60%
Daily Energy Output	kCal/day	4680	1085
	kCal/y	1708200	70024.39
Design Life	Years	5	15
Investment Cost			
Total Investment	CNY	260	250
Annual Investment Cost	CNY/year	46.02	36.71
Unit Cost	CNY/kCal	0.000027	0.000524
Operation & Maintenance Cost			
Fixed	CNY	6.5	6.25
Variable	CNY	13	12.5
Total	CNY	19.5	18.8
Unit Cost	CNY/kCal	0.000011	0.000268
Fuel Costs			
Annual Fuel Consumption	kg,	4380.00	10.61
Economic Fuel Price	CNY/kg	0.14	5.19
Annual Cost	CNY	611	55
Unit Cost	CNY/kCal	0.000358	0.000786
Alternative Energy Cost	**CNY/kCal**	**0.000396**	**0.001578**
WTP Calculation			
Share of Consumer category	%	75%	25%

9 World Bank – PRC – Efficient Utilization of Agricultural Wastes Project, 2001

Alternative Source of Energy	Unit	Stalk	LPG
End Consumer Costs for Stalk Gas	CNY/kCal	0.000100	0.000100
Consumer Surplus @ 35%	CNY/kCal	0.000104	0.000517
WTP	CNY/kCal	0.000204	0.000617
WTP – for Equivalent Stalk gas	CNY/m^3	0.24	0.74
Weighted WTP	CNY/m^3	0.37	

This analysis shows that there is no increase in the consumption of stalk for cooking in the with project situation, but reflects the more efficient conversion resulting from the stalk gasification process.

6.2.1.8 Estimation of Economic Internal Rate of Return

The basis for project evaluation is a comparison of benefits and costs between the base case and alternative case. The EIRR has been calculated as 23.5% indicating that the project is economically viable.

Table 28 EIRR of Stalk Gasification Project

Year	Capital Cost	Operating Cost	Total Cost	Benefits	Net Benefit
-	1,618,493	-	1,618,493	-	(1,618,493)
1		197509	197509	594904	397395
2		197509	197509	594904	397395
3		197509	197509	594904	397395
4		197509	197509	594904	397395
5		197509	197509	594904	397395
6		197509	197509	594904	397395
7		197509	197509	594904	397395
8		197509	197509	594904	397395
9		197509	197509	594904	397395
10		197509	197509	594904	397395
11		197509	197509	594904	397395
12		197509	197509	594904	397395
13		197509	197509	594904	397395
14		197509	197509	594904	397395
15		197509	197509	594904	397395
	EIRR		=	23.52%	
	ENPV @	12%	=	971,525	

6.2.1.9 Environmental & Social Benefits

Rural households will also benefit in terms of savings in cooking time for the female household members and better health. While some of these benefits have been quantified (such as the time savings), some such as health benefits have not been quantified.

The heavy reliance on traditional fuels poses serious threats to the health of rural populations, especially women and children who are most exposed to indoor pollution.

Studies on the health effect of smoke from the use of biomass fuels in rural areas have found that indoor levels of particulate matter regularly exceed, by several orders of magnitude, the safe levels cited in World Health Organization (WHO) guidelines. WHO's guidelines recommend that a concentration of 23 micrograms per cubic meter should not be surpassed more than seven days per year. Studies show that during cooking with

biomass fuels, this concentration is actually between 9 and 38 times higher.

Carbon monoxide emissions resulting from indoor burning of biomass fuels may give rise to ambient concentrations that interfere with the body's normal absorption of oxygen. Estimates indicate that smoke contributes to acute respiratory infections that kill some 4 million infants and children per year. Recurrent episodes of such infections show up in adults as chronic bronchitis and emphysema, which can eventually lead to heart failure. Studies in Nepal and India of non smoking women who are exposed to biomass smoke found abnormally high levels of chronic respiratory disease, with mortality from this condition occurring at far earlier ages than in other populations; rates were comparable to those of male heavy smokers.

A detailed analysis for this project in included in Annex 3 & Annex 4.

6.2.2 FINANCIAL EVALUATION OF THE PROJECT

6.2.2.1 Introduction & Conclusions

The financial analysis for stalk gasification is based on the pilot project implemented. Zhangye City Government assigned the responsibility of implementing the pilot project to the Shandan County Government and gave the County Village Energy Bureau full responsibility to implement the Project. Financial analysis evaluates the commercial viability of the project and is focused primarily on the pilot project. Analysis presented here excludes details of the commercial model, which is covered in the business plan.

The financial evaluation of the Project has been carried out in accordance with *The Guidelines for the Financial Governance and Management of Investment Project Financed by the Asian Development Bank*. The analysis covers both the cost and revenue side over the entire project life. It makes reasonable assumptions—based on facts and expert opinions/judgments—for project related financials. The financial projections are in current terms, using the following broad assumptions to build the overall financial forecasts for the project.

The FIRR is calculated in real terms as 3 % compared to the Weighted Average Cost of Capital (WACC) of 2.2%. As demonstrated in the business plan, addressing some of the barriers common to all renewable energy technologies can drive volumes and improve the FIRR, so as to make it attractive to a commercial investor.

6.2.2.2 General Assumptions

The Project financial evaluation is carried out in 2006 prices with financial cost flows inclusive of taxes, duties and subsidies. The following general assumptions have been adopted.

- An average exchange rate of CNY 8.00 per $1.00 has been used to convert foreign exchange costs to their local currency equivalent in February 2006.
- Domestic inflation has been assumed as 3%
- The project is evaluated over a 15 -year period – the expected life of the project. Therefore, no residual value for project assets is applicable.
- The stalk gasification plant will be operated for 2 shifts a day (16 hours) for 10 months a year and will supply gas to meet cooking energy needs (6 m^3/day) of 320 households. The plant will also generate electricity (200 kW engine) which will be sold to the Shandan County Power Bureau
- The fuels used include residues of barley and corn crop.
- The auxiliary power consumption is 30 kW.

6.2.2.3 Project Cost and Financing Plan

Project cost estimates for the stalk gasification project are based on estimates/ actual costs incurred for the pilot project. The estimated costs for the stalk gasification project including physical contingencies (but excludes price contingencies and financing charges)

are 1.74 Million CNY. The gestation period for stalk gasification a project is very short (3 – 6 months) and all estimates are in local currency as all procurement is domestic.

The equity contribution for the pilot project included contribution from the villagers (320 households) participating in the project (@1000 CNY/Household); the QingQuan Township Government and the county Government. The remaining portion of the project cost was financed through an ADB grant.

In practice, when considering future projects of this type, it would be reasonable to expect projects to be financed on commercial terms viz. debt of 60% to 70% (6.12% for repayment over 8 years). At present, there is limited opportunity for such projects to utilize loan financing because of the lack of awareness of the potential opportunity and ability of banks to evaluate such projects. The new "Renewable Energy Law" envisages the introduction of an interest subsidy scheme for such projects.

Attracting an equity contribution of 30%-40% would initially be difficult considering the fact that initial projects would have to bear a higher investment cost until full commercialization is reached. Until such a time a phased approach may be more, appropriate for example,

- A part of the equity contribution is supported through provincial government capital contributions which is reduced over time
- Simultaneously, increased availability of debt through commercial banks until a better appreciation of the potential viability of these projects is recognized.

The financing plan is as given in the following Table 29.

Table 29 Financing Plan of Stalk Gasification Project (Unit: CNY)

Source	Foreign Currency	Local Currency	Total	Percent
A. Loans				
1. Asian Development Bank	-		-	0%
2. Domestic Commercial Bank		-	-	0%
Subtotal (1)	-	-	-	0%
B. Equity Capital				0%
1. Villagers		495,827	495,827	28%
2. Township Government		150,000	150,000	9%
3. County Government		100,000	100,000	6%
4. Grant	998,760		998,760	57%
Subtotal (2)	998,760	745,827	1,744,587	100%
Total	998,760	745,827	1,744,587	100%

Analysis is based on the assumption that no new capital expenditure will be required for the life of the project i.e 15 years. Straight-line depreciation of 6.67% has been assumed when calculating after tax revenue streams.

6.2.2.4 Fuel Price

The major element of variable cost in the stalk gasification pilot project is the cost of stalk, which has been assumed as 50 CNY/ MT. Studies have been carried out to validate the availability of adequate quantity of stalk – against the annual stalk requirement of approximately 1600 T, the annual surplus availability in the project area is 2300 T.

6.2.2.5 Operation and Maintenance

Plant operation and maintenance costs are based on estimates provided by the equipment suppliers as follows:

- Gasifier Maintenance– 20000 CNY/year

- Household systems Maintenance – 100 CNY/Year/ Household (In the commercial model, the user would be expected to pay for the maintenance of the household system)
- Generator Maintenance – 5% of capital cost
- Generator consumables - 0.03 CNY/ kWh generated towards consumables

Working capital requirement is assumed to comprise the following

- Accounts Receivable – equivalent to amount receivable on account of sale of power to the grid and gas to the households for a period of one month
- Inventories – Cost of holding fuel stock for one month
- Accounts payable – cost of expenditure to be incurred towards plant operation and maintenance, salaries and wages and consumables for two months.
- Insurance cost of 0.25% of fixed asset value has been used for financial modeling.

6.2.2.6 Wages and Tax Expenses

It is expected that 8 persons will be required to run the stalk gasification pilot project at an average salary of CNY 450 per month (including all applicable benefits).

As per provisions of the recently enacted "Renewable Energy Law of the People's Republic of China" the following benefits will be applicable to the pilot project.

- Income Tax Holiday for the first five years of operation after which the normal tax rate of 33% will be applicable.
- The applicable VAT rate will be 8.5% as against the normal rate of 17%.

Even though the detailed implementation plan is being worked out by the Ministry of Finance and the Administration of Taxation, it has been assumed that the above benefits will be applicable to the pilot project. In addition local taxes @ 8% have been assumed to cover construction and education tax over the project construction period.

6.2.2.7 Tariff

6.2.2.7.1 Electricity

The National Development and Reform Commission (NDRC) have recently (January 2006) issued circulars[10], which includes guidelines for determining tariff for renewable energy based power generation projects. As per these guidelines the government fixed price will be applicable for purchase of power from the stalk gasification pilot project, which will be determined for each region as follows

Yardstick Tariff	=	Yardstick feed-in tariff desulphurized coal based power generation in 2005 in the province	+	Subsidy Price of 0.25 CNY/kWh

The subsidy will be applicable for 15 years from the date of power production.

For Gansu Province the benchmark feed-in tariff for power generation using desulphurized coal is 0.242 CNY/ kWh in 2005[11]. Accordingly revenues for power stream have been calculated assuming a tariff of 0.492 CNY/kWh.

[10] NDRC Document No NDRC Energy (2006) 13 on the Publication of "Relevant regulations on the administration of power generation from renewable energy" and Document No NDRC Energy (2006) 7 on the Publication of "Provisional administrative measures on pricing and cost sharing for Renewable Energy power generation"

[11] Source: ERI, NDRC

6.2.2.7.2 Cooking Gas

In the absence of a wholesale market, from which a yardstick tariff can be determined, a value of 0.12 CNY/m^3 has been adopted, based on the Gaotai project for determining revenues from sale of gas for cooking to 320 households. However, this appears to be a very low price when compared with alternatives such as LPG (WTP = 0.74 CNY/m^3). Therefore, in future, there may be scope to increase the tariff and improve financial viability. This is particularly true where the economic costs of collecting; storing and drying stalk for cooking purposes is also higher (WTP =0.24 CNY/m^3).

6.2.2.8 Weighted Average Cost of Capital

The net cash flows during the lifetime of the project have been discounted at the financial opportunity cost of capital to show the project's worth in financial terms. The calculation of WACC is based on an indicative financing plan set out in Table 30 and it applies only to the project. After adjustment for corporate rate of 33% for tax deductibility of interest payments and for local inflation projection of 3%, the post-tax real WACC is calculated as 1.6%.

Table 30 WACC (Amounts in CNY)

A. Financial component	Domestic Loan	Owners' Equity	Total
B. Amount	998,760	745,827	1,744,587
C. Weighting	57.25%	42.75%	100.00%
D. Nominal cost	6.12%	10.00%	
E. Income tax rate	33%	33%	
F. Tax-adjusted nominal cost [D x (1 - E)]	4.10%	6.70%	
G. Inflation rate	3%	3%	
H. Real cost [(1+F) / (1+G) - 1]	1.07%	3.59%	
I. Weighted component of WACC	0.61%	1.54%	
J. Weighted average cost of capital	**2.15%**		

6.2.2.9 Projected Financial Statements

The Table 31 represents the results of financial evaluation of the stalk gasification pilot project.

Table 31 FIRR for Pilot Project (All amounts in CNY)

Year	Capital Cost	Operating Cost	Net Revenues	Net Cash Flow
-	1,743,921			(1,743,921)
1		219,001	376,128	157,127
2		219,001	376,128	157,127
3		219,001	376,128	157,127
4		219,001	376,128	157,127
5		219,001	376,128	157,127
6		219,001	363,501	144,500
7		219,001	363,501	144,500
8		219,001	363,501	144,500
9		219,001	363,501	144,500
10		219,001	363,501	144,500
11		219,001	363,501	144,500
12		219,001	363,501	144,500
13		219,001	363,501	144,500
14		219,001	363,501	144,500

15		219,001	363,501	144,500
	FIRR			3.3%
	FNPV @	2.2%		148,563

6.2.2.10 Risk Assessment & Sensitivity Analysis

6.2.2.10.1 Sensitivity Analysis

The sensitivity analysis examined increases (+10%) in capital and O&M costs and a reduction in project benefits (-10%). Results are as given in the following Table 32. The analysis indicates that the results are extremely sensitive to underlying paramers. An increase in capital costs of 10% results in 39% reduction in the FIRR, likewise increases in capital csost of 10% which includes cost of stalk input results in the FIRR falling to 1.1% and where revenues decline 10% then the FIRR is negative. Mitigation of these risks are discussed below.

Table 32 Sensitivity Analysis

	Change	EIRR	Sensitivity Indicator	FIRR	Sensitivity Indicator
Base Case		23.5%		3.3%	
Capital Cost	+ 10%	21.1%	10.2%	2.0%	39.0%
O&M Cost	+ 10%	22.2%	5.5%	1.1%	67.0%
Project Benefits	-10%	19.4%	17.4%	-0.6%	97.5%

6.2.2.10.2 Risk Assessment

The risks in the project construction phase have already been discussed in the first interim report. The perceived risks in operation of the pilot are given below in Table 33:

Table 33 Risk Assessments

Risk	Sensitivity	Risk Assessment
Capital Cost Risk	Moderate	It is expected that increased investment in gasification technology will bring down prices further. As per the assessment, a 10% decrease in capital cost can increase the FIRR of the project by over 40%.
Fuel Risk	High	Fuel risks arise based on availability and price, though both are inter-related. During the project concept stage assessment of stalk availability in ShanDan County was done from three sources viz. the Statistical Year Book, the Enhanced Field Survey and assessment by Consultants during the inception mission. Against an estimated annual stalk requirement for 200 kW plant of 1600 – 1800 t/year, the availability is as follows: Though there is abundant availability, artificial shortages can get created due to vulnerability of the project. Further yield variation depending upon the water availability and soil conditions can impact the viability. As per the analysis a 10% increase in fuel cost can impact the FIRR negatively by 67%. Accordingly it is essential that the projects tie contract with local farmers and beneficiaries to provide stalk to the project.
Capacity Utilization risk	High	In view of the unfamiliarity with the technology and long harsh winters in the project region, the financial analysis is based on an assumption that the plant can operate for 2 shifts a day for 10 months a year. Increase in capacity utilization can be achieved through o Increase in number of hours of operation per day (every 1

Risk	Sensitivity	Risk Assessment
		hour increase can increase FIRR by 33%), with no significant change to capital cost o Increasing the surplus capacity available in the gasifier (rated at 1200 m^3/h, but operated at 900 m^3/h) and adding an engine of equal or lower rating. This will involve some capital expenditure, which can be financed either through debt financing or from the project cash flows. This is particularly a feasible option as confidence in the technology increases.
Electricity Interconnection	High	Tariff: During the conceptualization of the project, it was expected that the tariff applicable for the project will be 0.60 CNY/kWh. However the financial analysis has been carried out based on a conservative estimate of 0.492 CNY/kWh, based on the feed- in tariff from desulphurized coal in Gansu Province as per published data being 0.242 CNY/kWh. As per the consulting team's estimate the tariff applicable would be 0.59 CNY/kWh (Considering cost of desulphurized coal as 0.45/kg in Zhangye City and T&D Cost of 0.07 CNY/kWh). As per the financial analysis a 10 % increase in the power purchase price and gas prices can improve the FIRR by 102%. Availability of carbon credits through Carbon trading programs can further improve the viability of the project. A 10% increase in the power price alone would increase the FIRR to 5.6% or a 70% increase. Gas prices are based on those on previous project at Goati and are considerably less than the LPG alternative. A 10% increase would result in an FIRR of 3.8% or a 15% increase. Therefore, while the sensitivity demonstrates high risk, it is more likely that electricity and gas prices will increase in commercial operations so that the above analysis yields conservative results.
	Moderate	Capital Cost: The project cost estimate includes the cost of electrical interconnection with the HT grid (CNY 200000). As per the provisions of the New Renewable Energy Law, this cost has to be borne by the local utility. Eliminating this component from the project cost will improve the FIRR to 5.5% or an increase of 66%.
	Low	Receivables: A negative risk, which has to be managed in the context of this project, is collection of receivables from gas users. This represents the bulk of receivables, with the balance needed to be collected from households utilizing biogas. The expenses provide for the billing and collection of gas bills from households.
Gas interconnection	Low	The risk element is from non-realization of revenues from households. Increasing the gas price by 10 % can increase the IRR by 15%.

6.3 ANNEX 3- SOCIAL DEVELOPMENT & POVERTY ANALYSIS OF PRIORITY PROJECTS

6.3.1 General Introduction

The rapid economic and social development in PRC in the last two decades has resulted in big reductions in poverty in the country in general, but economic development and hence poverty reduction has been unequal across the 31 provinces. Gansu is one of PRC's poorest provinces with per capita gross domestic product (GDP) in purchasing power parity (PPP) less than a third of national average and poverty incidence about double the national average. Some other development indicators such as life expectancy and literary rates also show that Gansu province is significantly less developed compared with national averages as shown below[12] in Table 34

Table 34 Poverty Indicators

<table>
<tr><th colspan="2">Indicators</th><th colspan="2">PRC</th><th colspan="2">Gansu Province</th></tr>
<tr><td colspan="2">Population (million)</td><td colspan="2">1,292.3</td><td colspan="2">26.03</td></tr>
<tr><td colspan="2">GDP per capita (PPP CNY)</td><td colspan="2">6,948</td><td colspan="2">2,171</td></tr>
<tr><td colspan="2">Life Expectancy at Birth (years)</td><td colspan="2">70.1</td><td colspan="2">67.6</td></tr>
<tr><td colspan="2">Adult literacy rate (% age 15 and above)</td><td colspan="2">82.7</td><td colspan="2">74.4</td></tr>
<tr><td colspan="6">Urban Poverty</td></tr>
<tr><td colspan="2">Urban poverty line (CNY)</td><td colspan="2">2,310</td><td colspan="2">1,819</td></tr>
<tr><td colspan="2">Persons below urban poverty line
Expenditure based (million)</td><td colspan="2">37.07</td><td colspan="2">0.792</td></tr>
<tr><td colspan="2">Expenditure based Incidence of urban poverty (%)</td><td colspan="2">11.9</td><td colspan="2">16.8</td></tr>
<tr><td colspan="6">Rural Poverty</td></tr>
<tr><td colspan="2">Rural Poverty Line (CNY, PRC official figure)</td><td colspan="2">635</td><td colspan="2">625</td></tr>
<tr><td colspan="2">Poverty Incidence (%)</td><td colspan="2">4.6</td><td colspan="2">8.64</td></tr>
<tr><td colspan="2">Persons below rural poverty line (million) - $0.67</td><td colspan="2">26.10</td><td colspan="2">1.77</td></tr>
<tr><td colspan="6">Rural Poverty Distribution</td></tr>
<tr><td>Annual net income (CNY)</td><td>0~390</td><td>390~625</td><td>625~865</td><td>865~1000</td><td>1000~2000</td></tr>
<tr><td>Population (million)</td><td>1.14</td><td>0.63</td><td>3.31</td><td>1.5</td><td>2.31</td></tr>
<tr><td>Sub Totals (million)</td><td colspan="3">5.08</td><td colspan="2">3.81</td></tr>
</table>

The measurement of rural poverty in PRC is based on proportion of income for food expenditure to total living expenditure greater than 0.6, and daily calorie intake of less than 2,100 (Feng,1998)[13]. This national official poverty line is only equivalent to $0.67 a day per capita income in constant purchasing power parity (PPP) exchange rate for 1985–reflecting only severe poverty. In Gansu province, 79% of the population is classified as rural and absolute rural poverty incidence is 8.6% [14] compared to the nationwide figure of 4.6%. From 1985 to 1997, the nominal annual average net rural income per capita was lowest in Gansu compared with all of PRC's provinces. The relative ranking has improved recently (China Statistical Yearbook, 2002) but there is still 7.12 million[15] people on the edge of near poverty that are quite likely to fall under the poverty line. The poverty line in Gansu province is lower than the national average. Based on these data, the incidence of urban poverty in Gansu is 16.8% (792,000 persons) on expenditure basis following international standards, and 6.4 percent (304,000 persons) on the income basis, the methodology preferred by the PRC officials. National figures are 11.9% and 4.7 % using expenditures and income respectively.

Summarizing:

Gansu Province has a relatively high poverty incidence in China.

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[12] Source - China Human Development Report. UNDP, 2002; China Statistical Yearbook, 2002; ADB, 2002; State Council Rural Investigation Team, 2000; Gansu Rural Year Book, 2004.

[13] The Engel coefficient is a ratio of food expenditure to total expenditure. For PRC and many other countries, 0.66 is used as typical ratio for those bordering the poor. It was the ratio of rural households in the PRC in 1984.

[14] Gansu province uses CNY625 to determine absolute rural poverty, and CNY865 is used to determine the poverty level. In 2002, 5.08 million had annual rural per capita incomes less than CNY865 putting the poverty incidence at 25%.

[15] Gansu Rural Year Book, 2004, P57.

6.3.2 The TA Project

The TA project has two different components - hydropower and a pilot stalk gasification and power generation.

The hydropower component is located in Qilian Mountains near Gansu's southern border with Qinghai province. The run-of-river diversion scheme will be in Xishui township of Mati district in Sunan county[19], Zhangye city. In Xishui, Bajiaowan village will be the site of the DHP weir.

The stalk gasification and power generation plant has been located at Qidian village, Qingqiang township[20], Shandan county, Zhangye city. An integrated gas and power model stalk gasification pilot project has been established and is operational. The plant can supply stalk gas to 1,245 villagers of the 320 households of Qidian village beneficiaries for their daily cooking use and at the same time sell power for which a 200 kW engine generator has been installed and connected to the grid. The entire project including the gasification plant, gas distribution pipelines and power connection transmission lines are inside the area of Qidian village.

The electricity generated by the two projects is connected to the Zhangye power grid of Hexi Corridor grid. For gas supply, pipeline has been laid and individual households connected.

6.3.3 Poverty Profile of the TA Project Area

Of Zhangye City's 1.268 million populations, more than 76% are classified as rural. Of it's rural population, 293,000 or almost 30% have incomes less than the national rural poverty line of CNY1,100 (Table 35). Though there are no poverty statistics for urban areas in Zhangye city, it can be estimated using the lower range of provincial estimates generated by an ADB study that 17,000 can be classified as poor.

Table 35 Poverty Incidence in Zhangye City[21]

District/ County	Population			Poverty Headcount		
	Rural	Urban	Total	Rural	Urban	Total
Ganzhou	345,649	133,738	479,387	47,531	8,613	56,144
Shandan	146,221	49,111	195,332	74,041	3,163	77,204
Minle	215,839	19,582	235,421	121,609	1,261	122,870
Lingze	121,279	24,908	146,187	21,443	1,604	23,047
Gaotai	130,832	27,074	157,906	22,840	1,744	24,584
Sunan	23,803	12,098	35,901	5,634	779	6,413
Total	983,623	266,511	1,250,134	293,098	17,163	310,261

19 Xishui is located 80 km south of the Zhangye city center. The total population of the township in 2001 was 1,151 people, 98% of whom are of Zang (Tibetan) minority nationality. Xishui township has 5 administrative villages under its jurisdiction: Bajiaowan (population 398), Louzhuangzi (276), Zhengnangou (210), Erjiapi (190) and Bayi (285). The population is sparse due to harsh natural conditions (high mountains, semi-desert temperate climate, sparse arable land and varied grassland).

20 Qidian village (population 1,765, households 425) is one of the 4 villages of Qingquan township (population 28,630, households 7,485) which is about 60 km south of Zhangye city center. Villagers of the township are live on agricultural on the farmland depending totally on pumping underground water.

21 Poverty Reduction Bureau; Zhangye Perfecture Yearbook, 2001

Table 36 Poverty Townships and Villages in Zhangye City[22]

County/Township	Poverty Township	Poverty Village	Poverty HH	Poverty Headcount	Poverty Incidence
Shandan County	3	34	9,180	33,057	50.6%
Chenhu Township		15	5,294	18,342	81%
Laojun Township		10	1,812	6,918	91%
Huazhaizi Township		9	2,074	7,797	82%
Minle County	3	59	12,862	60,983	56.3%
Nanfeng Township		20	4,817	19,627	98%
Fengle Township		13	3,287	20,315	98%
Minlian Township		26	4,758	21,041	97%
Ganzhou District	3	21	5,871	21,575	13.8%
Huazhai Township		7	2,202	7,735	89%
Pingshanhu Township		3	232	561	79%
Anyang Township		11	3,437	13,279	93%
Linze County	1	12	2,397	6,316	17.7%
Nijiaying Township		12	2,397	6,316	68%
Gaotai County	1	16	3,644	9,904	17.5%
Xinba Township		16	3,644	9,904	70%
Sunan County	2	11	1,641	5,643	24%
Mati District		6	1,095	3,766	80%
Minghua District		5	546	1,877	80%
Total	13	153	35,595	137478	

Zhangye until 2002 was designated as a prefecture with five counties and one city. With the change in the status from prefecture to city, the former city area has been redesignated as Ganzhou district. From 1993 to 1997, three of five counties (Sunan, Shandan, and Minle) were classified as provincial poverty counties. Based on the poverty headcounts from Table 36 poverty incidence of these three counties would be the three highest at 24%, 51% and 56%, respectively. In 1997, Sunan was removed from this list but remains classified as a poverty county by Zhangye city.[23] PRC poverty reduction strategy uses units smaller than counties: township, village and household for focused targeting. The administrative areas treated as official poverty units are identified in Table 36. Poverty incidence in villages shows much more divergence than averages at the county level.

For Sunan County, the Poverty Reduction Bureau applies the provincial herder poverty line of CNY 1,650 to determine the level of poverty. Based on this, Mati-the hydropower component location and Minghua, designated as poverty districts, had about 80% of their populations classified as poor. Poverty is concentrated in the remote and sparsely populated herder districts of Sunan county and in farmer townships that have poor irrigation and soils, high altitude with a short growing season, few town and village enterprises (TVE) and that are far from the county town.

Shandan-the pilot stalk gasification location, has the second largest number of poverty by headcounts in Zhangye city with a poverty incidence of 85%. Farmers there mainly live on agriculture on the poor farmland with no gravity irrigation. Only one field crop annually can grow in the 80-170 frost-free days under an average temperature of 5-9°C.

[22] Source: Zhangye City Poverty Reduction Bureau, Nov. 2002. Note: Data are only available for districts in Sunan county.

[23] From 1997 Sunan was dropped as a Gansu province poverty county, largely because on one of 4 criteria -- persons per square kilometer -- it appeared land rich. However Sunan's population is sparse precisely because the quality of most land there is very low. Poverty reduction attention is focussed on the two of its six districts with the highest poverty incidence: Mati and Minghua. The project impact area is in mountainous Mati district. Minghua is a Yugur herder district with some aquifer irrigated areas in a detached segment of Sunan county, on the arid plain toward Inner Mongolia.

Causes of Poverty

In the farming areas of Zhangye city, the main causes of poverty are related to low farm productivity, lack of supplemental income sources, and lack of education. Aside from the harsh natural conditions which includes: high altitude (1,350 to 2,500 m) which limits the growing season to 80 to 170 frost free days, allowing only one field crop per year; poor soils (stony, salt or alkali, or windblown sand); and low rainfall and inadequate irrigation (limits the area that can be planted, crop yields, and the number and productivity of livestock that farmers can feed on crop residues and grass) – farm sizes are small in the limited arable areas. Farmers in Qingquan township have no gravity irrigation but only the unreliable electricity to pump water from either an irrigation canal or from an underground aquifer, hence lower and less stable yields.

In townships where the aquifer is too deep to pump (about 180-200 m), farmers cannot intensively cultivate winter cash crops in plastic greenhouses. Hence farm labor is unproductive during 200 or more days when frosts preclude field crops. In general, there are few TVEs for non-farm employment, and villages in remote townships lack access to non-farm and non-seasonal incomes in secondary and tertiary industries. Low education levels limit human resource capacity, ability to find non-farm jobs, and capacity to adopt new farm technologies.

Herder communities face similar issues of low productivity, lack of supplemental income sources, and lack of education. In Xishui, with a population of 1,151 in 286 households, herding sheep and smaller numbers of other livestock in 894 square kilometers of high altitude (1,500 to 5,000 m) steep dry mountain grasslands is the main source of livelihood. Only 98 persons of a labor force of 526 have non-agricultural livelihoods. About 55% of households depend entirely on livestock and livestock products for direct consumption and sales incomes. The other 45% of households are herders that have some terraced and irrigated cropland in valleys low enough to grow annual crops like grain to supplement their income. The whole of Mati district is a grain deficit area. The average net income for farmers and herders is CNY980, of which 69% of households are below this average.

Education levels in Xishui are low. Of the 1,151 population of all ages, 37 are pre-school; 863 have completed or are in primary school; 204, middle school; 47, high school; and none have completed or begun post-secondary school. The barriers of poverty, wide dispersal of houses among small hamlets and severe winter limit primary school retention. For a child to attend junior middle school, located in the district town of Mati, the family faces the cost of tuition fees, accommodation and food as well as the child's foregone labor. The nearest senior middle school is in downtown Zhangye city (80 km). Similar situation is faced to Qidian villagers.

6.3.4 Household Energy Consumption & Expenditure Profiles

Based on an enhanced field survey carried out across 287 HH in Zhangye City as part of this TA, the HH energy consumption and expenditure profile is given below in

Table 37 Household Energy Use[24]

Parameters		Zhangye City	Qidian village	Shandan county	Sunan county
Household size		4.5	4.5	4.5	4.6
Annual gross income/HH (CNY)		43450	54786	58812	22600
Annual net income/HH (CNY)		15727	16516	16742	6662
Energy Use per year/HH					
Coal	Heating & cooking (ton)	5.05	4.03	4.78	6.17
	Price (CNY/ton)	145~420	220~260	220~280	145~320
Ele ctrici ty	Indoor use (kwh)	537	335	427	440
	Price (CNY/kwh)	0.47~0.95	0.47~0.53	0.47~0.53	0.47~0.95

[24] Sources: enhanced field survey by consultants; Zhangye statistical yearbook 2004; rural energy office of Zhangye city; Gansu rural yearbook 2004; Gansu yearbook 2004 and Gansu yearbook 2002.

Parameters		Zhangye City	Qidian village	Shandan county	Sunan county
	Agricultural use (kwh)	261	561	502	0
	Price (CNY/kwh)	0.31~0.8	0.31	0.31	0.31~0.8
Biomass and others	Crop residue (ton)	1.46	2.16	2.01	0
	Price (CNY/ton)	0.05~0.1	0.05~0.1	0.05~0.1	0.05~0.1
	Raw wood (kg)	346	2	2	1365
	Price (CNY/kg)	1.8	1.8	1.8	0.7~1.8
	Sheep dung (ton)	1.3	0	0	3.4
	Biogas (m^3)	31.7	0	0	0
	Price (CNY/m^3)	0.12	-	-	-
	LPG (kg)	11	8	12	0
	Price (CNY/kg)	4.5~7	5~6	5~6	5~7
Diesel	Household & other use (kg)	220	466	467	-
	Price (CNY/kg)	2.2~5.2	2.9~5	2.9~5	2.9~5.2
Cost of energy use (CNY)		5359	2222	2813	7892
- electricity		534	719	703	283
- coal		1767	1016	1155	1937
- diesel		114	233	234	-
- biomass and others		2944	254	721	5672-
Energy cost as a % of gross income		15.4%	11.6%	18.2%	12%
Energy cost as a % of net income		42.4%	38.3%	48.1%	40.6%
Energy cost as a % of total HH expenditure		40.8%	42.3%	54.4%	17%

Table 37 indicates that poor households face burden of high energy costs, and therefore use local biomass resources as much as possible. Coal generally is the best option for heating. Part of the agro stalks are used for cooking and heating. Electricity is only used for lighting and low wattage appliances (e.g. radios, refrigerators, fans). Farm machinery is operated with diesel or electricity, depending on the local tariff. For irrigation, electricity is preferred to diesel because price is subsidized.

In terms of electricity consumption, rural areas face regular load shedding, Xishui had power outages for 70 days in 2001 due to load shedding. It is common for outages to last one or two days. Outages result in electricity being unavailable during critical periods of the growing season according to farmers. Low voltage prevents the usage of sensitive appliances, motors and equipment (e.g., x-ray machines in clinics) or may damage equipment due to voltage fluctuations. Extra cost is required for voltage stabilizers. Consequently, the average electricity consumption of poor households is very low. Tthis means the poor cannot fully benefit from the advantages of electricity supply, even when they are connected.

Summarizing:
Rural households especially the poor face a heavy burden for energy costs. The energy cost as a percentage of the family net income is 48.1% and 40.6% respectively for Shandan and Sunan county. Poor electricity supply and quality restricts the development of local economy and use of appliances.

6.3.5 Social Issues

Ethnic Minorities
There are 32 ethnic minorities in Zhangye City accounting for 2.1% of Zhangye's total population. The largest groups are Yugur (37.1%), Zang/Tibetan (36.6%), and Hui (15.9%), with the rest of the minorities constituting less than 10% of the total population. Three-fourths of ethnic minorities in Zhangye City are in Sunan, the only Yugur autonomous county in the People's Republic of China.

The nationalities directly affected by the hydro project are the Zang in Mati district and the Yugur in neighboring districts, all located in Sunan county. Despite the large administrative area of 894 km2, the population is only 1,151. Nearly all are of Zang minority nationality. With limited farmland, most herd mountain grasslands between 1,500 and 4,000 m.

The villagers in Qingquan township are all Han.

The Dagushan Hydropower Project will not cause significant adverse impacts on the local people, nor will it alter their pastoral way of life. In fact the local community will benefit economically from its proximity from the construction activities and later powerhouse operation. For example, during construction, it will provide opportunities to earn income from construction labor and the related commercial activities, which will greatly increase the cash income in the communities and help the villagers alleviate poverty. The Xishui township government has formulated a community development strategy and plans to ensure that the economic benefits from the Project can be properly managed in a manner to strengthen the local communities in harmony with traditional values and customs.

Resettlement.
The hydro project is located in the gorge of Heihe river, about 27km and 17km respectively away from Bajiaowan and Luzhuangzi-the nearest villages. There is no resident and other important establishment there. There is also no farmland, no relics, no mineral resources, no animal sheds or trees etc. in the area. Therefore there is no related problems of resettlement. Project permanent land acquisition includes the weir area and powerhouse area, with the total area 125 mu including 50 mu for the weir and 75 mu for powerhouse. Three households (14 persons) from Luzhuangzi village will be affected by the permanent land acquisition. The entire land area marked for the project is barren mountain and river bottomland.

The hydro project will also temporarily occupy about 570 mu of wasteland for the construction camps, borrow areas, spill areas and temporary work areas. No residential structures need to be relocated. The situation will become more clear when the location of the substation and alignment of the 110kv power transmission line are determined later.

Heihe hydropower company has given assurances that it will compensate in accordance with the PRC land law of 1998 any landholders affected by the project works.

The pilot gasification plant is located nearby Qidian village of Qinguan township, Shandan county on the wasteland owned by the village committee. The total area of permanent land acquisition is 0.7 mu using for the plant house, gas tank and fuel stack etc. The land is barren and its use for the plant has not required any resettlement nor cutting of trees or dismantling of existing structures.

Affordability
Electricity is an expensive commodity for the poor in Xishui township. In the project area, the typical consumption of electricity for rural households ranges from 10 kWh to 26 kWh per month, mostly used for lighting. Such consumption rates would cost CNY50–300 per year, which represents 2–10% of the household's net income.

In Zhangye, there is increased use of electricity for groundwater irrigation, especially since the government restricted further development of surface water. However, the groundwater is deep (150 to 400m) and thus expensive to pump, especially with low agricultural prices. Consequently, there has been political pressure to subsidize electricity prices for farmers and irrigation in particular. The official tariffs are CNY 0.27/kWh for irrigation and CNY 0.5/kWh for agricultural processing. Even at these subsidized tariffs, the annual pumping cost of irrigation for crops in Qidian village is about CNY 561 per year, which represents 3.4% of the net income. Electricity for pumping is a significant cost of agro production and affordability is a serious issue for the farmers in general and poor households in particular.

In Qidian village, the present annual cooking fuel expenditure is about CNY554/HH, which represents 3.4% of the net income. With the operation of the pilot gasification plant, the annual gas cost for cooking will be about CNY210/HH at the given price of CNY0.12/m3, which is about 38% of the present cooking cost and which indicates that this project can provide a beneficial impact on the villagers.

Community Enhancement Measures

Heihe Hydro Company is considering implementing additional measures to benefit local communities, including: (i) hiring and training local workers for project construction, (ii) utilizing local work teams for some engineering, for example, the upgrading of the existing road, (iii) allowing access to project facilities (e.g., medical emergency facilities, transportation, electricity supply), (iv) supporting purchases of local supplies and services for the local communities, and (v) provision of more reliable electricity supply to local townships after project completion. These would all result in positive social benefits.

Qinquan township government is considering letting the villagers taking part in the operation and management of the gasification plant to benefit local communities, including: (i) hiring and training local workers for the operation of the plant, (ii)allowing the villagers to share the stock and taking part in the management of the plant to benefit local communities, (iii) collecting the surplus agro residues for the fuel of the plant to increase their income ,(iv) running the plant in a business model by selling power to the grid and gas to the households to increase the income of the communities.

Summarizing:
The consultants' investigation found no "adverse and significant" risks in ADB's terms to minority groups. The lands required for the hydro project siting is all barren mountain and waste land and does not require relocation of residential structures or resettlement.

The Dagushan project would further improve the social development indices particularly for the herder community and ethnic minorities.

The direct project benefits from the pilot gasification project include reduction of the cooking gas expenses by 62% of the present for the Qidain villagers, increased availability of electricity and income generation opportunities.

Both the projects would adopt community enhancement measures, which would have large social transformation impact.

6.3.6 Poverty Reduction

The social development and poverty reduction impact of the RE development in the project area has been examined from both macro and micro perspective considering the followings:

Income would accrue to Heihe power company by development of the Xiagushan, Erlongshan and Dagushan projects, which would have huge economic transformation and social impact for the project area.

Table 38 Annual Contribution to Society By IA (DHP)

	Xioagushan hydro	Dagushan hydro	Erlongshan hydro	Total hydro contribution to society
Installed capacity	98 MW	59.5 MW	50.5 MW	208MW
Estimated company profit	25 million CNY	15 million CNY	13 million CNY	53 million CNY
Estimated contribution to government	15 million CNY	10 million CNY	8 million CNY	33 million CNY
Employed workers	102	45	43	190

It is estimated that Heihe hydropower company will generate 53 million CNY per year with the development of Xiagushan, Erlongshan and Dagushan projects. 33 million CNY per year will accrue to the local government and society through taxes with the development of Xiagushan, Erlongshan and Dagushan projects, which would bring great beneficial economic transformation and social impact to the project area. It is estimated that about

45 permanent workers will be employed by Heihe hydropower company, which will make large social impact for the local project site and the project area.

Good access to the city, better cultural and education condition, better communication and health facility will be also brought to the local people with the development of these projects.

Development of both the hydro component and the integrated stalk gasification and power model would have macro and micro impact on the beneficiaries in line with the important Millennium Development Goals (MDG) and Sustainable Development (SD) as indicated in the following text box.

Illustration 1 Project Impact on MDG

Goal-One-Eradication of extreme poverty & hunger

- Hydro project offers large direct employment at the construction stage. It is estimated that under the construction period, at peak level over 3000 persons will get direct employment. In the operation stage over 45 persons would be employed.
- Hydro project also offers huge opportunities to the local villagers for daily commerce, trading and other businesses to increase their cash income during the construction period and also normal operation time.
- The stalk gasification project can directly increase the income of stakeholders
  - Villagers will increase their income by about CNY300~600/HH per year by selling their surplus stalk to the plant.
  - By replacing the present cooking fuel of coal, LPG and stalk (which can be sold to the gasification plant) with the cheaper and cleaner gas (tariff: CNY0.12/m^3), stakeholders can directly save their expenditure by about CNY323/HH per year (for general HH) ~ CNY1093/HH per year (for LPG user).
  - The village owners would make profit by selling power to the grid.
  - 8 villagers will be employed permanently working in the plant and thus increase their family incomes.
  - With the future potential of 250 such projects, 2000 persons could get direct employment. In Addition jobs would be created in the fuel logistics operation. Additional income would also get generated from sale of surplus stalk. Thus, gasification system is likely to offer big direct income generation benefit.
- The reliability and quality of power produced by the projects will stimulate and promote the villagers to establish more TVEs which can bring both direct and indirect income and job opportunities to the villagers.
- The reliability and quality of power produced by the projects will help the villagers for their agricultural pumping, especially in summer time which is also the highest period of electricity shedding. This may improve agricultural yields and hence harvest.

Goal-Two-Achieve universal primary education

- With the improved income of local government and village families, the present poor conditions of local school can be improved and poor family children-especially the girls would be able to go to school to take their primary education.
- Reliable and quality power supply would ensure better condition of the teaching facilities and classroom lighting.
- Viewing the new and modern technologies brought by the projects, both the villagers and children will be stimulated to realize the importance of technology education and environment.

Goal-Three-Promote gender equality & empower women

- With the high efficiency, clean and sufficient gas and power supply, the daily heavy burden of stalk-burning cooking of women can be largely eliminated.
- With the improved family income and better power supply, villagers can afford electric appliances such as TV, washing machine and refrigerators, etc., which will not only release women's labor but also elevate villagers' social philosophy and promotes gender equality.
- Good education opportunities and better information channels brought by the projects to the women can help empower women and promote gender equality

Goal-Five-Improve maternal health

- Clean energy brings clean conditions to maternal health.
- The releasing of housework of women improves maternal health.
- With better education, modern communication and television brought by the projects, women can learn some basic sanitation knowledge at home.
- With the improved community income and better information channels brought by the

projects, local clinic condition can be improved and pregnant women can give birth of baby in hospital instead of at home to avoid breeding risks.

Goal-Seven-Ensure environmental sustainability

- By using of clean energy, household indoor environment can be greatly improved.
- Making use of surplus and waste agro stalks, the gasification project can improve the outdoor environment and avoid underground water pollution.
- The project directly contributes to reduction of GHG emission from use of coal/liquid fuel for cooking and electricity generation from renewable resources.

Goal-Eight-Develop global partnership to end poverty

- International technology and cooperation are brought into the project area by the projects, which will surely result in future global partnership for poverty reduction in the area.
- With the improvement of education and communication facilities brought by the projects, people can easily get international information and cooperation opportunities from TV and internet etc. to enhance the poverty reduction.
- The straw gasification technology for power generation has wider global relevance. Successful operation of this technology would open the avenues for adaptation of the same in many countries in the South Asian and African regions for development of rural RE system.

6.3.6.1 Project beneficiaries and poverty impact ratio

Project beneficiaries and the proportion of beneficiaries who are poor are identified in Table 39.

Table 39 Distribution of Project Impacts

Impact Category		Impact	Beneficiaries	Poor Beneficiaries
Hydro component	Power generation	Increased power to the grid		
	Rural electrification	Reliable and lower electricity supply for daily, agricultural and TVEs use	24,000	22,200
	Health [1]	Avoid coal-fired power plant pollution related mortality and morbidity	2.3 million	688,000
	Access[2]	Increased access to markets and services	1,151	921
	Direct employment by Heihe company	Income source	45	20
	Indirect employment by Heihe company	Income source	NA[6]	NA
	Indirect employment To the social	Income source	590 person years	470 person years
	Temporary employment	Seasonal income source	5,900	4,200
Stalk gasification and power integrated component	Power generation[3]	Reliable and lower electricity supply for daily, agricultural and TVEs use	1,765	794
	Power selling	Income source by selling power to the grid	1,245	560
	Gas distribution	Replace the coal and stalk burning cooking	1,245	560
	Agro residue selling	Income source by selling agro residue to the station	1,765	794
	Health[4]	Avoid coal-fired power plant pollution, indoor stalk and coal burning pollution and outdoor stalk rotten resulted air and water pollution related mortality and morbidity	28,630	12,883
	Direct employment	Income source	8	6
	Indirect employment[5]	Income source	100	80
	Temporary employment	Income source	500 person month	300 person month

[1]Estimation of health impact assumes 80km regional damages only (i.e. excludes distant damages) for an alternate power plant. Population density used assumed 114 persons/km for Ganzhou district and 30 114 persons/km for rural area.
[2] Benefit to all Xishui township.
[3] Benefit to Qidian village.
[4] Estimation of health impact assumes Qingquan township as the project impact area.
[5] Stalk collection etc.
[6]N.A. – Not available but multiplier would result in greater number of beneficiaries

Analysis of Beneficiaries, Distribution of Benefits and Poverty Impact Analysis for RE Project Component

Project Costs and Benefits in Economic and Financial Prices

The analysis has been carried out for the Stalk gasification pilot project. The economic costs and benefits of the project are set out in the economic spreadsheets. The financial costs (discounted at 12%) are those costs adopted in the economic analysis. The discounted financial benefits or revenue stream results from electricity and gas sales at the tariffs set out in the financial analysis.

Analysis of Beneficiaries, Distribution of Benefits, PIA

The distribution analysis is set out in the table below. The level of poor in the project areas benefiting from the pilot project is 50.3% of the population compared with 16.6% average poor in the Province as a whole. It is assumed that 75% of the unskilled labour on the project, both construction and operations, would be provided by the poor.

The gains and losses to the different participants are determined by the difference between financial and economic benefits and costs. While, the economy gains from the project, the big gainers are consumers while the power bureau as electricity purchaser is the loser. Consumers gain from the large consumer surplus as a result of stalk substitution compared with a very low gas tariff and low electricity tariff compared with the estimated WTP for electricity substitutes. Labor will also benefit where wages of those employed are greater than the opportunity cost of labour in the rural sector. These gains and losses in part compensate for each other with the net gain being positive and equal to the economic net present value (ENPV). The ENPV in this case is CNY 0.97 million.

Calculation of Poverty Impact Ratio

The PIR of 0.67 indicates that the project should have a positive poverty reducing impact as it greater than the number (%) of poor in the project area of 50.3% and greater than the poor's share of GDP estimated at 6.6%.

Table 40 Stalk Gasification - Distribution of Net Economic Benefits & Poverty Impact Analysis

RMB '000	Financial	Economic	Economic	Distribution of Project Benefits				
	Present	Present	less			Present	Present	less
	Values	Values	Financial	Utility		Values	Values	Financial
Total Benefits	2,521.3	3,617.7	1,096.4		Total Benefits	2,521.3	3,617.7	1,096.4
Capital Costs	1,557.1	1,445.1	-112.0		Capital Costs	1,557.1	1,445.1	-112.0
Operating costs	1,491.6	1,201.1	-290.5		Operating costs	1,491.6	1,201.1	-290.5
Total costs	3,048.7	2,646.2	-402.5		Total costs	3,048.7	2,646.2	-402.5
Net Benefits		-527.4	971.5	1,498.9	-527.4	Net Benefits	-527.4	971.5
Gains/Losses				-527.4	Gains/Losses			
Poverty Impact Ratio (PIR).				6.6%	6.6%	75.0%	50.3%	0.67
Benefits accrue to poor			value	16.32	116.30	551.50	649.34	649.34

Note :	1. Proportion of poor/vulnerable in project area is	50.3%
	2. Proportion of poor/vulnerable in country is	16.6%
	3. Proportion of GDP received by the Poor estimated at	6.6%

Summarizing:

Both the Dagushan hydropower development and pilot stalk gasification and power model offer very attractive investment option considering overall development objectives, poverty reduction impact and financial and economic benefits.

Hydro: Through improved electricity supply for the poor, cleaner energy, contribution to the government and employment opportunities during project construction and operation, about 23% of total beneficiaries (1.25 million) are poor persons who will directly benefit from the hydro project. Total additional income for these poor unskilled laborers is estimated around CNY20 million during the 4-year construction phase.

Pilot Stalk Gasification: Through improved electricity and gas supply for the poor, cleaner energy, stalk and power selling, cheaper gas tariff and employment opportunities during project construction and operation, all the beneficiaries (28.63 thousand) including poor persons will directly benefit from the gasification project. Each household of Qidain village (1300 villagers) can have a direct net annual income increase of more than 600 to 1700 CNY.

Through improved cleaner energy supply for the poor and employment opportunities during project construction and after completion due to increased economic development in the project area, about 23% of total beneficiaries (1.25 million) are poor persons who will indirectly benefit from the projects in all aspects such as better TVE and agricultural condition, improved education and gender equality, sustainable environmental and health improvement etc.

6.4 ANNEX 4- ENVIRONMENT ANALYSIS OF PRIORITY PROJECTS

Summary report on the Dagushan project has been included in the summary feasibility report at Annex-1. Environment report for the stalk gasification project is set out below:

6.4.1 Project description

The project is located at Qidian village, Qingquan town, Sandan couty, Zhangye. This project consists of 900m^3 stalk gasification system, 200kW power generation system and gas pipeline. Stalk residues are used for gasification. The Gross calorific value (GCV, 1200kCal/m^3) stalk gas is supplied to 320 households at Qidian village and the electricity is supplied to local power grid. The project can produce gas to meet cooking needs of 320 HH (at 6 m^3/HH) and to generate 768 MWh electricity annually. The annual stalk consumption is 1,555t. The total investment of the project is about CNY 1.7 million.

6.4.2 Description of the Environment

The project is located at Qidian village, Qinquan town, Shandan. South immediately (50m) to the project, Qidian village has 320 households, with average per household annual net income of CNY 16, 516 in 2005. There is rural road passing by the project from west to east. The project area is separated by the road and trees from village and farmland.

In Qidian village, the revenue is mainly from transport services, labor export, farming and livestock feeding. There is no factory nearby, therefore the air and water quality in the project area is sound.

The project permanently occupies 0.7mu wasteland. There is no river in the vicinity of Qidian village and water is supplied from a reservoir via a long distance piping system.

6.4.3 Environmental impact and mitigation measures

The main environmental issues of the project are wastewater treatment and tar recovery. Personal safety should be stressed to stalk gas users and workers.

The wastewater is mainly from the gas cleaning system with the main pollutants of smoke and tar. Tar, in particular is a harmful and can cause cancer. The wastewater will be treated by two settling ponds and the treated wastewater will be reused for gas cleaning and cooling. Assuming 1m^3 of stalk gas contains 16mg tar, the project would produce 69kg tar annually. Tar will be recovered from the settling pond and used as a water-proofing material.

The stalk gas has a high concentration of CO, averaging 21.4%. Attention should be paid to the safe use of the stalk gas. Regular check should be performed to see if there is any leakage at pipes and gas burner. If allowed, bad smell material can be added to the stalk gas to monitor any leakage during household use.

Both stalk gas and stalk are prone to catch fire easily. Effective fire proof measures should be taken, such as no smoking at project site. Portable fire fighting devices should also be kept in the plant.

Noise is mainly from the power generation system. It can be mitigated by closing the door of the powerhouse.

Air pollutants are minimal, mainly from exhaust of the gas engine. On the operation platform of the gasifier, the smoke could do harm to worker’s health. Workers should wear mask to reduce smoke inhalation.

The solid waste is mainly ash from stalk gasification, the amount of the ash is small, and the ash can be used locally as fertilizer.

6.4.4 Environmental Costs and Benefits

The environmental costs are minimal. The project occupies 0.7 mu wasteland which is owned by the local government. The local government has provided waste land free of charge. The main environmental costs are spent on wastewater treatment and tar recovery. Such costs are limited due to small amount of wastewater and tar.

The environmental benefits of the project are notable, including the replacement coal with stalk gas for cooking, turning waste stalk into energy, increasing the supply of clean energy and reduction of greenhouse gas emission etc.

The project can consume 1,555 t stalk annually, which provides an effective way to solve the rural stalk disposal issue. Such a project can improve rural appearance, reduce air pollution from random stalk combustion, avoid fire which may take place due to random piling of stalk, and improve the hygiene conditions of rural households.

The project can improve the rural energy structure. With the continuous development of rural economy, the energy for cooking is switched from a low grade energy to high grade energy source. Coal, oil and LPG are being increasingly used even in the rural areas. The demonstration and popularization of the stalk gasification project can replace conventional fossil fuels to a certain degree, and reduce the environmental pollution due the excessive use of fossil fuels.

The Shandan project can also produce 768 MWh clean electricity annually, assuming the CO_2 emission factor of local power grid is 0.86 kg/kWh; the project can achieve 660t CO_2 emission reduction.

Replacing stalk with the stalk gas, the collection, storage, drying and cooking time per household can be reduced from an estimated three hours to 1.0 hour per day, and hard physical work handling stalk will be reduced. Household women can enjoy more free time, which means women and girls can be given more opportunities for receiving more education and enjoying life.

The stalk gas can free women from exposure to debilitating fumes from traditional stoves, and can notably improve indoor air quality, which is important to improve the health of family members, especially women.

The main fuel of households in Qidian village is coal and stalk, coal is priced at CNY260/t. By using the stalk gas for cooking, the annual fuel cost per household is about CNY230/year. The fuel costs reduction is notable, while the economic benefits in terms of time savings with reduction in the need to handle stalk on a daily basis is discussed in the economic analysis section.

6.4.5 Conclusions

The environmental issues of Shandan project are mainly wastewater treatment and tar recovery, which can be solved by present technology. The fire and use safety issues of the project can be solved by proper management and safety education.

The Shandan project has multiple environmental benefits , including providing sustainable and clean energy, reducing the air pollution by open combustion of stalk, improving indoor air quality, reducing labor burden for cooking, reducing fuel costs and reducing greenhouse gas emission etc.

The integrated stalk gasification and power generation project is a good option for rural energy development. It is a environmentally friendly energy development model and can be replicated to develop rural energy on a commercial basis.

6.5 Annex 5- Work Methodology & Work Plan

6.5.1.1 General Approach

Pursuant to signing the contract on 24th January 2005 and the notice to proceed from ADB (31st January 2005), the consulting team led by DSCLES carried out several activities through a series of field missions and home office work. Key tasks performed by the various experts are given below in Table 41:

Table 41 Consulting Team Members and Responsibilities

Name	Expert	Key responsibilities
Dr GC Datta Roy	Team leader and international renewable energy and energy efficiency expert	Overall guidance to all team members and coordination Coordination with ADB/EA/IA/PMO and village project office Develop methodology for RE Performance Assessment and selection of projects Project management Preparation of reports
Mr Ian Walker	International Economist	Review of least cost energy studies and economic analysis
Ms Nisha Menon	International Financial Analyst	Financial analysis Configuration and implementation of the pilot project Coordination with pilot project equipment supplier Administrative management & facilitation Report preparation
Dr Amitav Rath	International Social Development Expert	Conceptualizing the framework for social and poverty analysis. Guiding the domestic consultant for social and poverty analysis
Prof Li Junfeng	Domestic Renewable energy and energy efficiency expert	Assessment of RE potential and policy analysis Providing guidance for tariff determination of the pilot project.
Mr Pei Xiaodong	Domestic Financial analyst and economist	Financial performance assessment of RE projects Financing options for RE projects Business models for RE development Financial and economic analysis of investment projects
Prof Hu Jicai	Domestic Social Development Specialist	Detailed social assessment for the identified pilot projects. Undertake beneficiary and stakeholder analysis, considering gender aspects. Conceptualizing and assisting in organizing various workshops and meetings Implementation of the pilot project Assisting the team leader in overall project management.
Mr Cui Cheng	Domestic Environment Specialist	Initial environment assessment during the inception phase. Later replaced
Prof Huang Jianping	Domestic Hydropower expert	Led and directed all activities for the feasibility study for the hydropower project Preparation of the feasibility report for DHP
Prof Hou Ziyuan	Domestic Hydrologist	Hydrology studies for hydropower project
Prof Lv Shengdi	Domestic Geologist	Geological investigations for hydropower project
Mr Meng Jizu	Domestic Renewable Energy Expert – Pilot Project	Site engineer for the pilot project
Nr Zhu Chao	Domestic Environment Specialist	EIA report for the Erlongshan Hydro project & later replacing domestic environment specialist.

In order to coordinate activities at a local level, the city government constituted a project

management office (PMO), comprising representatives from the various stakeholders at the city level. The constitution of the PMO is given in Table 42 and the PMO members were entrusted with responsibility of providing information in a timely manner to the consultants team, enabling timely decisions and providing feedback to the corresponding departments at the provincial level on performance of the TA.

Table 42 Members of the TA Project Management Office

PMO Member	Affiliation
Mr Liao Yonghong, Chairman	Vice Director of Financial Bureau, Zhangye
Mr Zhou Duoshi, Member	Vice Director of Agriculture Bureau, Zhangye
Mr Zhu Xingjie, Member	General Manager, Gansu- Heihe Hydropower
Mr Xu Qingnian, Member	Dy General Manager, Gansu-Heihe Hydropower
Mr Guo Jun, Member	Chief Engineer, Power Bureau, Zhangye
Mr Feng Jianjun, Member	Dy Director, Environment Protection Bureau, Zhangye
Mr Kang Linyun, Member	Water Resource Bureau, Zhangye
Mr Sun Zhidong, Member	Director-Foreign Trade, Finance Bureau, Zhangye
Ms Yin Caifen, Member	Dy. Director -Foreign Trade, Finance Bureau, Zhangye
Mr Wang Bin, Member	Planning Commission, Zhangye
Ms Han Yuying, Member	Section Chief, DRC, Zhangye City
Mr Ding Jianjun	Director of Project Office, Gansu Heihe Co

The implementation of the TA was carried out through a series of field visits supported by home office work as per the following details:

Table 43 Key Activities-Priority projects

From	To	Key Activities
31st Jan 05		Receipt of Notice to Proceed
01 Feb 05	18 Feb 05	Preparatory work for inception mission Including detailed work plan for each team member
19 Feb 05	20 Mar 05	Inception Mission Renewable energy performance and potential assessment Short listed options for priority projects viz- confirmation of Dagushan hydropower project through a pre-feasibility study and stalk gasification as the model for renewable energy based village electrification model Identified barriers for RE development Prepared and presented framework for developing a RE business plan
21 Mar 05	24 May 05	Design of enhanced field survey • To identify underserved energy needs in the project area • To confirm the recommendation of technology choice for the priority projects • To establish baseline social indicators for project area • To provide basic information to support development of business plan Conducting the Survey Data analysis and conclusions
25 May 05	11 Jun 05	First interim Mission • Firm recommendation of development option for the first priority project viz – Dagushan hydropower project (as ROR) • Firm recommendation on the development option for the second priority project viz. stalk gasification for integrated heat and power generation, including the stalk gasification feasibility report for different development options. This also formed the basis for the other recommendations viz. feasibility report, pilot project and business plan • Firm action agenda for implementation of the pilot project including identification of project area. • Developed business plan for RE development
12 Jun 05	07 Aug 05	Dagushan hydro project Information memoranda and communications were exchanged from time to time to get the decision of the Government on the development option. Stalk gasification pilot project • Received and evaluated offers from equipment suppliers for implementing the pilot project

From	To	Key Activities
		• Recommendation to ADB and Provincial Government for implementing the pilot project, including seeking budgetary approval
08 Aug 05	19 Aug 05	3rd field Mission • Dagushan hydro project o Review meetings at different levels for decision on development option for DHP o Plan for feasibility study based on informal clearance received • Stalk gasification pilot project o Finalized contract with equipment suppliers for supply of equipment of pilot project o Identified IA for pilot project and put in place organization structure for civil constructions
20 Aug 05	10 Nov 05	• Dagushan hydro project o Site investigations for 2 options • Second priority project o Civil construction and connection to 120 HH
20 Nov 05	30 Nov 05	4th field Mission • Dagushan hydro project o Enabling coordination for firm decision on development option • Stalk gasification pilot project o Completion of construction of the station and 120 HH gas connection o Finalization of orders for electrical inter-connection o Plan for interconnection with the grid o Plan for connecting 200 HH
01 Dec 05	31 Dec 05	Follow up on decisions of 4th field mission Vendor coordination for installation of the pilot project Project management for the pilot project
01 Jan 06	12 Jan 06	2nd Interim Mission • Dagushan hydro project o Approval obtained for development option and endorsement by the Interim workshop o Plan for completion of feasibility study within the TA Schedule • Stalk gasification pilot project o Completion of electrical connection o Completion of project construction including short duration trial operation • Erlongshan hydro project o Translation of the existing EIA report and presentation in the ADB project format
13 Jan 06	19 Feb 06	Preparation of feasibility report for Dagushan hydro project Preparation of EIA report in the ADB format for the Erlongshan hydro project
20 Feb 06	15 Mar 06	Final Mission • Completion of Dagushan feasibility report • Commissioning of pilot project • Submission of draft final report
16 Mar 06	30 May 06	Submission of final reports

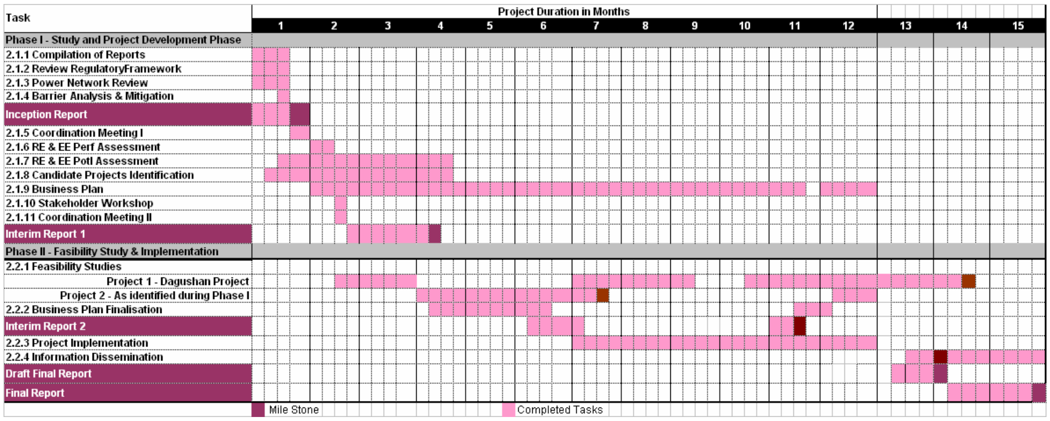
Consultations with stakeholders were carried out through one-on-one interviews, informal consultations and formal consultations – viz – coordination meetings of the PMO, village level community workshops and provisional level consultative workshops.

Table 44 Stakeholder Consultations

Consulting Event	Purpose	Date
INCEPTION MISSION		
Project Preparatory Meeting		20th February 2005
I Coordination Meeting	Mission purpose and stakeholders expectations	23rd February 2005
Project Launch	Inauguration of TA Project	25th February 2005
II Coordination Meeting	Mission de-brief and consultation with	16th March 2005

Consulting Event	Purpose	Date
	PMO	
Inception Workshop	Mission de-brief and consultation involving EA	18th March 2005
Meeting with Hydro Design Institute	Understanding the National procedure for feasibility study for hydropower projects and depth of investigations needed at different stages	19th March 2005
	I INTERIM MISSION	
Meeting with Equipment Suppliers for Pilot Project	Alternative plant configuration for the pilot project and assessment of domestic manufacturing capacity	25th May 2005
III Coordination Meeting	Pre-mission briefing and consultation	27th May 2005
I Community Workshop/	Debriefing on pilot project	30th May 2005
Meeting with IA on DHP	Progress and Way forward	30th May 2005
IV Coordination Meeting/	Post Mission Debriefing and consultation	03rd June 2005
Consultation with City Power Bureau	Pilot project connectivity	30th May 2005, 01 June 2005
Study Tour for Pilot Project	Technology familiarization	04th-07th June 2005
II Community Workshop	Present final design of pilot project and identify approval process for pilot project	08th June 2005
Meeting with City Mayor	TA Progress	09th June 2005
I Interim Workshop	Joint consultation – City and Provincial Government	10th June 2005
Meeting with Equipment Suppliers for Pilot Project	Alternative plant configuration for the pilot project and assessment of domestic manufacturing capacity	11th June 2005
	III MISSION	
V Coordination Meeting	Purpose of Mission and consultation	10th August 2005
Meeting with IA	Progress of DHP Study	12 August 2005
Meeting with City Government and ADB	TA Progress and Decision on DHP	12 August 2005
Pilot Project Construction inauguration ceremony	Construction Inauguration	12 August 2005
3rd Community Workshop		12 August 2005
Negotiation meetings with equipment suppliers	-	10-13 August 2005
Signing of contract for main pilot plant equipment	-	13 August 2005
Meeting with IA	Progress of DHP Study	14th August 2005
Meeting with Hydro Design team and IA	Progress of DHP Study	17th August 2005
Meeting with CREIA	Pilot project power connectivity	18th August 2005
Consultation with IA	DHP progress	24th November 2005
4th Community Workshop	Pre-Commissioning Workshop	25th November 2005
VI Coordination Meeting	Post Mission debriefing and consultation	26th November 2005
Meeting with IA Hydro Institute	DHP progress	28th November 2005
	II INTERIM MISSION	
Meeting with IA	DHP progress	04th January 2006
5th Community Workshop		05th January 2006
VII Coordination Meeting		06th January 2006
Meeting with Design Institute	DHP progress	09th January 2005
II Interim Workshop		10th January 2006
	FINAL MISSION	
Community workshops		3rd March, 7th March and 9th March 2006
Inauguration of Pilot Project		12th March 2006
Final Workshop		14th March 2006

6.5.2 Work Plan



6.6 ANNEX 6- RECORD NOTES OF DISCUSSION OF THE FINAL WORKSHOP

Date: 14th March, 2006
Venue: The Lanzhou Hotel, Lanzhou
Attended By: As per list attached

6.6.1 Introduction and Agenda

Mr. Liao, Yonghong, Vice Director, Financial Bureau, Zhangye City
Inaugurated the workshop and introduced the participants
Applauded the work done by the consultants and their hard working spirit.
Apprised about the progress of the project and the significant milestones.
The process of selection of the two important projects-feasibility report for Dagushan Hydro project and implementation of stalk gasification based pilot project for gas and power supply was explained.
Informed about the satisfactory conclusion of both the projects.
Outlined the agenda for the workshop as follows:

- Presentation by Consultants Team
- Comments from departments and discussions
- Identification of issues for future planning and action

6.6.2 Presentation by Consultants Team

The bi-lingual power point presentation made by the consultant's team was based on the draft version of the final report along with an update on the work carried out since its submission and broadly covered the following areas:
Terms of reference of the TA and design and methodology of work plan in conformity with the same

- Progress of work
- Response to the issues raised in the second interim workshop
- Feasibility report for Dagushan project (Technical, financial and economic analysis, environmental analysis and social development impact analysis)
- Commissioning and operation of the pilot project (technical, financial and economic analysis, social development and poverty impact and environmental analysis)
- Recommended action plan for sustainable commercial operation of the pilot plant and larger scale expansion
- Presentation by Minle Chemical Company on their proposed plan for power generation based on stalk gasification pilot plant experience

6.6.3 Comments from Stakeholders and Discussions: Key Issues

Mr. Pan, Xiaoren, Engineer, Rural Energy Bureau, Gansu Province

- Expressed satisfaction with the way this TA project has been carried out. Wide consultations have been held all through the project culminating in this final workshop. The consultants have made a comprehensive presentation on the project and the results.
- It is a very good pilot project and is the first such project in the northwest China. It would have very positive economic and social impact

Mr. JinTao, Power bureau, Gansu Province

- We are all satisfied with the project progress and the presentations made by the Consultants.
- Data relating to development of power market can be updated after publication of the year book.
- Emergency power arrangement for the pilot project may be looked into.
- New RE law has been passed and guidelines issued for the central sector. Each individual province has to issue the guidelines and as such some time would be required before tariff issues are finalized.

- As per the present guidelines tariff for the hydro project can be around 0.227 RMB/kWh.

Madam Zhang Xiaoping, Deputy Director, Foreign Affairs Office, Financial Department, Gansu Province

- Congratulated consultants for organizing an efficient and fruitful workshop.
- From the presentation made by the Consultants and feedback received, it is clear that the TA project has been concluded successfully
- The Director Finance Bureau has also conveyed his appreciation for the tasks completed in such a short time.
- When the idea of the pilot project was first shared by the Consultants at Manila during negotiation meeting, we did not have idea on the same.
- Now we have seen the plant in actual operation-this is a commendable achievement to install and commission a plant like this in less than a year's time.
- This is the 1st plant of this kind in the entire western China and can be of great benefit for the local people.

Some expectation and suggestions:

- The Consultant team would be leaving today after completion of their work. They have made number of recommendation for sustainable operation. The City Government should remain engaged with the project to implement the recommendations.
- Local Government should compile a comprehensive report on the pilot project and submit to higher authorities.
- All departments of provincial government should continue to extend full cooperation for successful operation and RE development.
- ADB has been very cooperative in development of the Gansu province as evidenced from various TAs and loan support including for the proposed Erlongshan and Dagushan projects. We do hope more resources would be made available for wider replication of the pilot project.
- Would like to thank the ADB, Consultants and leaders from Provincial and City Governments for the extended cooperation which has helped in successful conclusion of the TA project.

Mr. Ashok Bhargava, ADB

- Would like to thank all the participating leaders from the Governments for active participation in the deliberation of the workshop
- The objective of the TA was to assist in development of renewable energy in line with guideline of PRC on 'Socialistic rural development'.
- It is a very happy occasion indeed to see the pilot project in operation-this can make it possible to launch a new rural energy initiative.
- This has been possible due to cooperation from all Government departments and the hard work by the Consultants.
- This project has indicated how through this kind of initiative extra rural income can be generated. This should trigger in rapid development of such projects.
- There is no shortage of funds for such kinds of development projects. What needs to be done is demonstration of sustainable operation of such projects.
- It is in this context that all supports should be provided for smooth operation of the project. Once the cash flow starts, motivation increases.
- Tariff should not be a major issue for this project at least since significant part of the project has been funded by grant.
- This project gives us opportunity to test the efficacy of the new RE law in promoting such projects.
- ADB would be more than willing to cooperate with the Government-Provincial DRC and Finance bureau may consider further action to move this forward.
- ADB is also very happy with the progress of the Dagushan project.
- The TA has fully met the objectives, groundwork has been laid-let us look at the recommendation of the Consultants to move rapidly forward.

Mr. Lin Young, ADB

- Very happy to see the successful conclusion of the ADTA on schedule.

- It is probably the 1st time such a pilot project has been installed as part of an ADTA project. This should be widely publicized. This ADTA is one of the most successful such project and the results may be highlighted at higher forums.
- Consultants have made some good recommendations-these should be looked at seriously for sustainable operation and development of RE projects.

6.6.4 Summary and Conclusions

Mr. Liao, Yonghong, Vice Director, Financial Bureau, Zhangye City

- This TA has achieved its expected goal and all tasks have been successfully completed.
- We are now aware of this new and attractive option for development of RE in the entire Zhangye city.
- The feasibility report for Dagushan project has also been completed
- Both these projects have laid strong foundation for development of the City and its rural areas.
- The pilot project has introduced new technology in the entire province and would provide good learning opportunity for such development in a wider scale.
- On the pending issues and recommendations of the Consultants
    - We would work for early resolution of the tariff issue
    - The organization for operation of the pilot project would be strengthened and the project would be operated commercially.
    - We would request help from ADB, if required since this is a 1st project of this type and therefore, may require some longer-term hand holding.
- Would like to thank the provincial government, the consultant team, the EA and PMO for the excellent cooperation, which have resulted in making good progress despite stated difficulties.
- Would like to conclude by saying the TA project has been successfully concluded.

6.6.5 List of Participants

Provincial Government	PMO Members
Zhang Xiaoping, Department Director, Gansu Financial Bureau Liang Shangjin, Project manager, Gansu Financial Bureau Jing Tao, Department Director, Planning & Development Department, Gansu Power Company Su Tian, Department Director Gansu DRC Qi Jianying, Department Director Gansu Water Resource Bureau Pan Xiaoren, Engineer, Gansu Rural Energy Office	Liao Yonghong Deputy Director Zhangye City Financial Bureau Sun Zhidong Department Director Zhangye City Financial Bureau Ying Caifen Department Director Zhangye City Financial Bureau Zhou Duoshi Deputy Director Zhangye City Rural Office Ding Jianjun Deputy Manager Heihe Hydropower Company Dong Jianqing Deputy Chief Engineer Zhangye City Power Bureau He Gejing Director Zhangye City Rural Office Zhou Jianjun, Department Director, Zhangye City DRC
Special Invitees	**ADB**
Han Denglun, Director, Mingle County Chemical Plant Zhang Yishu, Chief Economist, Mingle County Chemical Plant Nie Bing Deputy Secretary, Mingle County Government	Ashok Bhargava, Project Officer, ADB Lin Young, ADB Resident Mission Anthony Maxwell, Environment expert, ADB
Implementing Agency	**Consultants Team**
Gao Lizhuan Department Director Heihe Hydropower Company	International Experts Mr. G C Datta Roy, Team Leader, DSCL

Wu Xingsheng Department Director Heihe Hydropower Company Liu Mengde Clerk Heihe Hydropower Company Zhou Xuan Clerk Heihe Hydropower Company Ze Jianjun Deputy Director Gansu DRC Ju Qiang Department Director Gansu Financial Bureau Pu Jingcheng Interpreter Heihe Hydropower Company	Ian Walker Economist KCG Consulting Nisha Menon Financial Analyst Domestic Experts Huang Jianping, Hydropower Expert, HRC Lv Shengdi, Geologist, DSCLES Meng Jizu Energy Expert DSCLES Hu Jicai, Social Specialist, Beijing BJT Consulting Company Ltd Pei Xiaodong, Financial & Economic Analyst, Beijing BJT Consulting Company Ltd Zhu Chao, Environment Expert Beijing BJT Consulting Company Ltd

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Backbone projects planning reports for Heihe river.	Mandarin (4)
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Topographical drawings (scale: 1/5000 for all project area, but not including Dagushan project area).	Mandarin (6)
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