Technical Assistance Consultant’s Report

Project Number: 40635
April 2009

PEOPLE’S REPUBLIC OF CHINA: GANSU RURAL CLEAN ENERGY DEVELOPMENT PROJECT
(Financed by the Government of Denmark)

Prepared by:
Beijing BJT Consulting Ltd. In association with IT Power Ltd. and Tripod Wind Energy ApS
People’s Republic of China

For Gansu Provincial Government
(Executing Agency)

This consultant’s report does not necessarily reflect the views of ADB or the Government concerned, and ADB and the Government cannot be held liable for its contents. (For project preparatory technical assistance: All the views expressed herein may not be incorporated into the proposed project’s design.)

Asian Development Bank
GANSU RURAL CLEAN ENERGY DEVELOPMENT PROJECT

Final Report

April 2009

Beijing BJT Consulting Ltd.

in association with

IT Power Ltd.

and

Tripod Wind Energy ApS
Asian Development Bank (ADB)

Final Report for

GANSU RURAL CLEAN ENERGY DEVELOPMENT PROJECT

Client contract No.: TA 4935 -PRC

Final
April 2009

Contractor:

BEIJING BJT CONSULTING LTD

1-202, Building 3, Baizhifang Dongjie,
Beijing 100054, P.R. China
Tel: +86 10 6355 4694
Fax: +86 10 6357 0904
E-mail: jicai.hu@bjt.com.cn
http://www.bjt.com.cn

Document control

<table>
<thead>
<tr>
<th>File path &amp; name</th>
<th>C:\Documents and Settings\rebeccag\My Documents\1016 Gansu RE project\2 Work\final report\Gansu Final report\1.0.doc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authors</td>
<td>Rebecca Gunning, Hu Jicai, Zhu Chao, Zhou Wei, Soren Gjerding, Gu Shuhua, Min Deqing, Wei Songxian, Zhao Lixin, Li Jingming, Pei Xiaodong</td>
</tr>
<tr>
<td>Project Manager</td>
<td>Rebecca Gunning (Team Leader for TA)</td>
</tr>
<tr>
<td>Approved</td>
<td>RG</td>
</tr>
<tr>
<td>Date</td>
<td>May 2009</td>
</tr>
<tr>
<td>Distribution level</td>
<td>Not for distribution / Public Domain</td>
</tr>
</tbody>
</table>
KNOWLEDGE SUMMARY

This project aimed to increase the use of clean energy in rural areas of Gansu through enhanced capacity in planning and management of clean energy development in the province.

Energy resource maps have been produced for biomass, wind and small hydro power across Gansu province. The results show that there is abundant solar resource in Gansu and a good hydropower resource in selected areas. The wind resource is particularly good and Gansu is rated fifth in terms of potential in China. Large scale biomass combustion plants in Gansu are limited by the resource and competing uses for the resource. However there is sufficient biomass resource for numerous smaller biogas and gasification plants across Gansu.

Wind development in Gansu has a number of strengths in addition to its resource due to easy development conditions, land availability, government support and local equipment manufacturing. However there are still barriers to its development including limits due to the incomplete 750 kV transmission to export the power, high voltage losses, limits in the transport system and in the grid stability.

A Renewable Energy Development Plan (REDP) has been prepared for Gansu covering biomass and wind power. The aim of the REDP is to provide key recommendations to the GPG for the 12th Five Year Plan up to 2015. The REDP includes the resource assessment and a status of rural energy development in Gansu as well as providing an analysis of future rural energy demand. The development, distribution and scale for the biomass and wind power are then set out with an associated investment analysis. A list of priority projects for development is included and socio-economic and environmental assessment is included. Targets for each of the technologies for 2015 are outlined and key measures for implementation are described.

A list of biomass priority projects has been compiled around Gansu. Almost all these projects are medium scale biogas projects with a few stalk gasification projects. Pre-feasibility studies have been completed for the top two projects.

A list of wind projects was identified. Two wind measurement masts were erected to improve the micro-siting (higher AEP) and to decrease the uncertainty of the wind study. A pre-feasibility study for the 49.5 MW Dong Le farm was carried out. The Annual Energy Production (AEP) has been estimated at 78.4 GWh/year which is lower than expected due to uncertainty because of a short wind measuring period and no long term information.

Two pilot biogas projects were implemented. Both projects are small scale biogas projects, one at Huachi Ecological secondary school and the second at Tianshui dairy farm including electricity generation. The projects have been evaluated and shown to have had a beneficial impact on the environment and to result in savings. Both projects have wide-scale replication potential across Gansu.

A publicity campaign and capacity strengthening was undertaken. A website of Gansu Rural Energy Information has been developed (http://wlgc.gsny.gov.cn/gsnyxxw/), as well as the preparation of a policy handbook for renewable energy development, information dissemination books and video CDs and training workshops to improve their understanding of technology.
TABLE OF CONTENTS

1  Introduction ..................................................................................................... 7
2  Summary of Work Undertaken ........................................................................... 7
   2.1  Project tasks and deliverables ................................................................. 7
   2.2  Summary of missions to Gansu by Experts ............................................... 8
3  Resource Assessment ....................................................................................... 10
4  Review of Renewable Energy initiatives and previous studies ......................... 10
5  Renewable Energy Development Plan for Gansu ............................................. 11
6  Pilot Projects .................................................................................................... 13
   6.1  Tian Shui Dairy Farm biogas power generation ........................................ 13
   6.2  Hua Chi No. 2 Middle School biogas ........................................................ 15
7  Wind Component .............................................................................................. 16
   7.1  Supply and Installation of Wind Measuring Masts ..................................... 16
   7.2  Mast Inspection ..................................................................................... 16
   7.3  Pre-feasibility Study of Dong Le .............................................................. 17
   7.4  CDM revenue of wind power priority projects ......................................... 18
8  Biomass Priority Projects ................................................................................... 19
   8.1  Selection Criteria for Priority Project for ADB TA 4935 PRC ...................... 19
   8.2  List of Priority Project for ADB TA PRC 40637 ......................................... 20
   8.3  Feasibility studies for priority projects ................................................... 24
      8.3.1  Stalk Gasification Project at Shexin Village, Yinda Town, Suzhou District, Jiuquan City ......................................................... 24
      8.3.2  Yuanbo Biogas Power Engineering in Ganzhou District, Zhangye City ............................................................................. 25
   8.4  CDM Financing Evaluation for Biomass Priority Projects .......................... 26
9  Dissemination Activities ..................................................................................... 27
   9.1  Publicity Campaign .................................................................................. 27
   9.2  Training ................................................................................................. 27
   9.3  Study Tours ........................................................................................... 28
      9.3.1  Domestic Study Tour .................................................................. 28
      9.3.2  International Study Tour ............................................................. 28
ANNEXES

Annex 1: List of meetings since Interim Report
Annex 2: Gansu Renewable Energy Development Plan (as separate document)
Annex 3: Tianshui AoNiu Dairy Biogas pilot project feasibility and evaluation report (as separate document)
Annex 4: Huachi No. 2 Middle school biogas pilot project feasibility and evaluation report (as separate document)
Annex 5: Shandan Wind Data Analysis and Pre-feasibility study (as separate document)
Annex 6: Biomass priority feasibility reports (as separate document)
Annex 7: CDM potential of priority projects
Annex 8: Dissemination Material (as separate documents)
Annex 9: Study tours: National and International
# ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADB</td>
<td>Asian Development Bank</td>
</tr>
<tr>
<td>BJT</td>
<td>Beijing BJT Consulting Ltd</td>
</tr>
<tr>
<td>CDM</td>
<td>Clean Development Mechanism</td>
</tr>
<tr>
<td>CER</td>
<td>Certified Emission Reductions</td>
</tr>
<tr>
<td>DRC</td>
<td>Development and Reform Commission</td>
</tr>
<tr>
<td>EA</td>
<td>Executing agency</td>
</tr>
<tr>
<td>EE</td>
<td>Energy Efficiency</td>
</tr>
<tr>
<td>EIA</td>
<td>Environment Impact Assessment</td>
</tr>
<tr>
<td>EIRR</td>
<td>Economic Internal Rate of Return</td>
</tr>
<tr>
<td>FIRR</td>
<td>Financial Internal Rate of Return</td>
</tr>
<tr>
<td>FNPV</td>
<td>Financial Net Present Value</td>
</tr>
<tr>
<td>GEF</td>
<td>Global Environment Facility</td>
</tr>
<tr>
<td>GHG</td>
<td>Greenhouse gases</td>
</tr>
<tr>
<td>GPG</td>
<td>Gansu Provincial Government</td>
</tr>
<tr>
<td>GPDAAH</td>
<td>Gansu Province Department of Agriculture and Animal Husbandry</td>
</tr>
<tr>
<td>IA</td>
<td>Implementing agency</td>
</tr>
<tr>
<td>NEHH</td>
<td>Non-electrified households</td>
</tr>
<tr>
<td>PMO</td>
<td>Project Management Office</td>
</tr>
<tr>
<td>PPTA</td>
<td>Project Preparatory Technical Assistance</td>
</tr>
<tr>
<td>PRC</td>
<td>People's Republic of China</td>
</tr>
<tr>
<td>PV</td>
<td>Photo Voltaic</td>
</tr>
<tr>
<td>RE</td>
<td>Renewable energy</td>
</tr>
<tr>
<td>REDP</td>
<td>Renewable Energy Development Plan</td>
</tr>
<tr>
<td>RMB</td>
<td>Chinese Yuan Renminbi. 1 USD = 6.80 RMB</td>
</tr>
<tr>
<td>SWOT</td>
<td>strengths, weaknesses, opportunities, and threats</td>
</tr>
<tr>
<td>TA</td>
<td>Technical Assistance</td>
</tr>
<tr>
<td>TCE</td>
<td>Tons of Coal Equivalent</td>
</tr>
<tr>
<td>TOR</td>
<td>Terms of Reference</td>
</tr>
<tr>
<td>W</td>
<td>watt</td>
</tr>
<tr>
<td>WACC</td>
<td>Weighted Average Cost of Capital</td>
</tr>
<tr>
<td>WTP</td>
<td>Willingness to pay</td>
</tr>
</tbody>
</table>
UNITS, WEIGHTS AND MEASURES

°C – Degree Celsius
kCal – kilo Calorie
kg – Kilogram
km – Kilometer
kV – kilo Volt
kW - kilo Watt
kWh – kilo Watt hour
m- meter
m² – square meter
m³ – 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 m²
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 = RMB 6.80
1 INTRODUCTION

This is the final report for the ADB’s Technical Assistance TA 4935-PRC, Gansu Rural Clean Energy Development Project.

The objectives of the overall project have been to increase the use of clean energy in rural areas of Gansu through enhanced capacity in planning and management of clean energy development in the province. More specifically the project has:

- Mapped renewable energy resources in Gansu;
- Prepared a Renewable Energy Development Plan for Gansu,
- Identified priority biomass projects for development in Gansu,
- Carried out a pre-feasibility study for a wind farm and measured wind data at a two potential sites;
- Carried out two pilot biomass projects which have widespread replicability across Gansu;
- Assessed the applicability of CDM for the priority projects; and
- Carried out training and dissemination in renewable energy in the province.

The report includes a summary of the project. The key outputs of the work are included in the Annexes.

2 SUMMARY OF WORK UNDERTAKEN

2.1 Project tasks and deliverables

The project was broken down into five key tasks. The work undertaken in each task is outlined below.

Mapping of clean energy resources and preparation REDP:

Energy resource maps have been produced for biomass, wind and small hydro power. Updated biomass information has been received on the current use of waste stalks in most counties.

A final REDP has been submitted to GPDAAH and Gansu Finance Department. A draft REDP was submitted and a number of comments were provided and have been incorporated in the new draft.

Identification and pre-feasibility studies for priority clean energy projects:

A list of biomass priority projects has been compiled around Gansu. Almost all these projects are medium scale biogas projects with a few stalk gasification projects. Selection criteria were developed and agreed by all stakeholders and the list was prioritised according to the criteria. Pre-feasibility studies have been completed for the top two projects.

Two wind sites were identified and wind data measurement and analysis has started at these sites. The wind data has been analysed for the Shandan site and a pre-feasibility for a 50 MW wind farm has been carried out.

Identification, preparation and implementation of pilot biomass energy projects:

Two pilot biogas projects have been implemented. The projects have been evaluated and shown to have had a beneficial impact. Both projects are biogas projects, one at Huachi secondary school and the second at Tianshui dairy farm including electricity generation.

Capacity assessment and strengthening
A national study tour was undertaken in March – April 2008. Training workshops have been carried out for Rural Energy officers to improve their understanding of technology and progress outside of Gansu with a view to introducing in Gansu where appropriate. An international study tour took place in March 2009 to the UK and Denmark.

**Publicity campaign to promote awareness of clean energy use:**

The publicity campaign was organised by the provincial project management office (PMO). The campaign included the development of a website of Gansu Rural Energy Information, preparation of a policy handbook for renewable energy development, information dissemination books on rural stalk use, biogas power generation and wind power development, training workshops and the preparation of a brochure and video on the ADB project.

### 2.2 Summary of missions to Gansu by Experts

Six group missions to Gansu have been undertaken by the Experts. The first was a mobilisation exploratory trip to meet the main stakeholders and visit a potential pilot project site. The second mission was the Inception Mission in January 2008. Following this a short mission was carried out in March 2008 including a Tripartite meeting to clarify points within the Terms of Reference and the objectives of GPDAAH.

A longer mission was undertaken in April 2008 which included work to prepare the feasibility studies for the potential pilot projects, to identify sites for wind measurement, to identify priority projects, to assess capacity and to work on parts of the Renewable Energy Development Plan. At that time the experts visited Tianshui to visit the potential Qingzhou pilot biogas site and visited Qingyang to visit the second potential pilot site. The wind experts visited potential sites in Baijin and Zhangye.

In June/July 2008 a further mission was undertaken. The purpose of this mission was to prepare the draft REDP, to assess the progress of the pilot projects and to select the priority projects and commence the pre-feasibility reports. In addition further meetings will be held with the wind developers and training was undertaken.

Further meetings and discussion was held with the GPDAAH regarding biomass in the region with an aim to get more information on the use of the straw and the plans for livestock growth.

A pilot project initial evaluation trip was undertaken in February 2009 to Ao Nui dairy farm to check their performance against the predicted information. Further pilot visits were undertaken in April 2009 to carry out the final evaluation.

A final mission was carried out in March 2009 to hold a final workshop and provide dissemination.

Some other individual missions were also taken by the related experts during the project progress to execute related biomass and wind tasks.

A list of all the meetings held as part of the project is included in Annex 1.

A summary of the missions is included below:
<table>
<thead>
<tr>
<th>Experts</th>
<th>Dates</th>
<th>Main Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rebecca Gunning, Hu Jicai, Soren Gjerding, Zhu Chao, Min Deqin, Li Jingming, Wei Sngxian, Pei</td>
<td>6th – 13th March 2009</td>
<td>Preparation of final report and all associated reports (feasibility studies, evaluation reports etc) Final workshop</td>
</tr>
<tr>
<td>Hu Jicai, Li Jingming</td>
<td>February 2009</td>
<td>Pilot evaluation at Tianshui</td>
</tr>
<tr>
<td>Hu Jicai</td>
<td>October 2008</td>
<td>Discussions with the PMO regarding REDP</td>
</tr>
<tr>
<td>Rebecca Gunning (wind)</td>
<td>June-July 2008</td>
<td>Preparing REDP</td>
</tr>
<tr>
<td>Pei, Hu Jicai, Zhu Chao, Gu Shuhua, Min Deqing, Li Jingming, Zhou Wei, Zhao Lixin, Wei Songxian</td>
<td></td>
<td>Discussions with GPDAAH re. projects Prioritise projects Discussions with wind developers Visit to two priority projects Start of pre-feasibilities Training Collecting financial data on the pilot projects.</td>
</tr>
<tr>
<td>Rebecca Gunning, Hu Jicai, Zhu Chao, Gu Shuhua, Min Deqing, Li Jingming, Zhou Wei</td>
<td>7th April – 22nd April</td>
<td>• Finalising pilot project feasibilities and visits  • Identifying wind measurement sites  • Identifying priority projects  • Compiling resource, policy and practice information  • Meetings with stakeholders  • Interim workshop</td>
</tr>
<tr>
<td>Rebecca Gunning (team leader), Hu Jicai (social development), Zhu Chao (environmental), Songxian Wei (finance), Gu Shuhua (rural energy expert), Min Deqing (wind energy expert), Zhou Wei (Economist)</td>
<td>1st – 7th March 08</td>
<td>• Tripartite meeting  • Meetings with Meteorological office</td>
</tr>
<tr>
<td>Li JingMing (rural energy), Zhu Chao (env)</td>
<td>19th – 21st Jan 08</td>
<td>- Meeting with RFOs regarding potential priority projects in NW Gansu  - Meeting with provincial REO regarding potential priority projects &amp; REDP</td>
</tr>
<tr>
<td>Hu Jincai (social development)</td>
<td>6th – 14th Dec 07</td>
<td>• Meetings with stakeholders  • Field trip to potential biogas</td>
</tr>
</tbody>
</table>
3 RESOURCE ASSESSMENT

A resource assessment was carried out for the solar, wind, hydro and biomass resource across Gansu province. The information is provided in tables for each prefecture as well as in map format. Unfortunately the GIS maps for Gansu were not available so it was not possible to map the information in an interactive format. Analysis was carried out on the data, in particular the biomass data, to properly reflect the actual available resource once its current use has been taken into account.

The results show that there is abundant solar resource in Gansu and a good hydropower resource in selected areas. The wind resource is particularly good and Gansu is rated fifth in terms of potential in China. The biomass resource is less abundant and is dispersed. The analysis shows that in most cities there is insufficient biomass resource to support a biomass combustion 15 MWe power plant. However there is sufficient biomass resource for numerous smaller biogas and gasification plants across Gansu.

The detailed resource assessments are provided in the REDP.

4 REVIEW OF RENEWABLE ENERGY INITIATIVES AND PREVIOUS STUDIES

A thorough review of national and local level renewable energy initiatives and a review of the 11th 5 year plan in Gansu was undertaken. The key pointers and lessons from these have been incorporated into the REDP along with the Strength Weaknesses, Opportunities and Constraints analysis. The key points from the analysis are summarised here:

**SWOC Analysis of Wind power in Gansu**

**Strengths and opportunities:** Good wind resource and easy development conditions; Good operating conditions; Good transport; Nearby demand; Government support; and Local equipment manufacturing.

**Constraints/Barriers to the development of wind power:** High voltage losses; 750 kV transmission line not completed; Limitations to transport system; Grid stability; and Delays in transformer substation.

**Threats/Risks to wind power development in Gansu:** Feed-in tariff/Non-economic wind farms; Grid stability; and turbine supply

**SWOC Analysis of Biomass power generation in Gansu**

The issues relating to biomass technology development in Gansu have been broken down by the following main technologies since some of the issues are technology specific:

- Biomass power generation (combustion, gasification and co-firing)
- Biogas (household and farm biogas)
- Briquetting

**Biomass power generation with direct combustion, co-combustion and gasification technologies**
**Strengths and Opportunities:** Available resource; Power generation technology is mature; and positive policy support.

**Weaknesses and Constraints:** Lack of clear strategic positioning; Limited size of power generation facilities; Competing demands for stalk biomass; Siting is important; Lack of the key technology and market mechanism for stalks collection; Lack of control on stalk price; Domestic technology needs improving; Higher generating cost; Connections to the grid; Monitoring required of co-feedstock; and Improvement required in biomass gasification technology

**Biogas**

**Biogas project for central gas supply and power generation**

**Strengths and Opportunities:** Abundant resources; Advanced biogas power generation project has been introduced and demonstrated in Gansu; National support; Pollution control requirements; and Support from and cooperation with the international organizations.

**Weaknesses and Constraints:** Size and dispersion of animal farms; Connections to the grid; High investment costs; and Technology improvements needed.

**Household biogas digester**

**Strengths and opportunities:** Abundant resources; Mature technology; Great policy support; and Governmental effort for popularization.

**Weaknesses and Constraints:** Poor quality and maintenance; and a Change in rural infrastructure from household to large scale farms.

**Biomass Briquette**

**Opportunities:** Large potential demand.

**Weakness and Constraints:** The compressing technology should be improved further; and High cost.

## 5 RENEWABLE ENERGY DEVELOPMENT PLAN FOR GANSU

The aim of the REDP under this project is to provide key recommendations to the GPG for the 12th Five Year Plan up to 2015. It is the intention that key elements of the REDP will be taken forward by GPG but that GPG will prepare their own plan taking into account the REDP suggestions.

A framework was initially agreed in stakeholder workshops in Lanzhou. A draft REDP was then developed based on the resource assessment, previous plans and analysis and discussions with stakeholders. The Renewable Energy Development Plan was then circulated to the stakeholders and comments have been incorporated. The full final REDP is included in the Annexes.

The REDP covers both biomass and wind power. The targets and policy recommendations for the biomass part for 2015 have been written by the TA Experts whilst much of the wind targets are based on the existing DRC wind plan for Gansu.

The REDP includes the resource assessment and a status of rural energy development in Gansu as well as providing an analysis of future rural energy demand. The development, focus, distribution and scale for the biomass and wind power is then set out with an associated investment analysis. A list of priority projects for development is included for both technologies. A socio-economic and environmental assessment is included and key measures for implementation and helping Gansu to meet its targets.
The targets for each of the technologies for 2015 are outlined below:

<table>
<thead>
<tr>
<th>Technology type</th>
<th>Target for 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capacity (MW&lt;sub&gt;e&lt;/sub&gt;)</td>
</tr>
<tr>
<td>Wind power</td>
<td>12,145</td>
</tr>
<tr>
<td>Household biogas</td>
<td>1,200,000</td>
</tr>
<tr>
<td>Large and medium scale biogas</td>
<td>50</td>
</tr>
<tr>
<td>Stalk gasification stations</td>
<td>20</td>
</tr>
<tr>
<td>Briquetting stations</td>
<td>15</td>
</tr>
<tr>
<td>Direct-fired biomass power generation</td>
<td>3</td>
</tr>
</tbody>
</table>

For wind power there is already a fairly clear DRC plan for wind development in Gansu. The plan includes for the large Gigawatt (GW) development of wind and focuses on a few key areas. Therefore the REDP includes this as well as incorporating more information on additional smaller wind farms (50 MW) which could be included and how these could be developed, as well as small home wind power systems for use for electrification of rural households.

Some of the key comments from the review of the 11<sup>th</sup> Five Year plan have been included in the REDP. Some of these points are given below:

- Providing a basis for the development of the plan and its targets based on a realistic assessment of the actual resource available in Gansu and their geographical distribution.

- Including technologies not currently considered such as briquetting and biomass combustion. When considering a timeframe into the future it is important to allow for the introduction of new technology to Gansu.

- The energy demand data has used typical farmers data and takes into account that demand will increase with living standards. When comparing with the supply it is important to include for the differing costs of the different technologies available.

- The REDP includes a list of priority projects. The work to determine these projects is still on-going as part of this project. Confidence in projects is required – Investors need confidence in any potential renewable energy projects. This means that there needs to be sufficient information on all aspects of the project, in particular the economics, the technology and as important the management and operation of the project. In most cases projects in Gansu do not have enough information at present.

- The overall investment for implementing the REDP will be an important part of the project and it is important that where comparisons are made that they are made for energy generated rather that the investment costs since renewable energy has high investment costs against lower operating costs.

- The economic benefits will take into account the fact that the operation of renewable energy is low cost and has other societal benefits over fossil fuels.

- The options for market mechanisms have been included rather than only a reliance on government and poor farmers.

- The policies of the Renewable Energy Law have been incorporated into the REDP. The full REDP is included as an Annex to this report.
6 PILOT PROJECTS

In early 2008 a number of projects were identified by the GPDAAH as potential pilot projects for funding under this Technical Assistance project. The REO performed a pre-screening based on the pool of projects and worked out an initial shortlist of five candidate projects. Based on the innovation of the technology, widespread replicability, local environment and capacity two pilot projects were identified from this list by GPG:

- Tianshui Biogas
- Huachi Ecological School biogas.

Feasibility reports were prepared for both these projects and on the basis of these ADB approved funding for the two biogas pilot projects in May 2008. These projects were subsequently implemented and the current status of these two pilots is given below. The feasibility reports and evaluation reports for each project are included in the Annexes.

6.1 Tian Shui Dairy Farm biogas power generation

AoNiu farm is a growing dairy farm and the biogas project was implemented with the aims of improving its environment, helping to meet their environmental regulations and to produce renewable energy. Prior to the project the farm left the animal waste on nearby empty spaces and the liquid waste was deposited in the Wei River. The project now uses the manure and liquid waste from the cows to produce biogas which is used in local households for cooking and to generate electricity from a gas engine. Currently there are 300 cows and the number is expected to grow to 1000.

The electricity meets the dairy’s processing electricity demands as well as being sold to other users in the village. The fertilizer is used on the farm’s own mushroom beds and is sold to local farmers for use on their fruit trees and fields.

The key project design parameters were:

- 2 x 80 kW engines
- 2 x 500m3 anaerobic digesters
- 1 x 500m3 gas holder
- Centralised gas supply to 120 households
- Included a heat exchanger, a waste heat tank and anaerobic digestion heating
- Total cost: 2.78 million RMB
- ADB grant: 610,000 RMB

At the feasibility stage the advantages of the project were listed as follows:

- Reduction in pollution caused by the farm, to both the land and the local river.
- Annual net revenues of between 44,000 RMB and 185,000 RMB depending if the electricity can be sold to the grid. Net losses of around 88,000 RMB/year result if electricity generation is not included.
- Use of organic fertilizer will improve the soil quality and reduce the use of chemical fertilizers and pesticides.
- Improvements to the farm’s local environment through the removal of animal waste at the site.
- Some CO2 savings from offsetting some coal consumption in the household cooking.
• Demonstration of a new concept in Gansu province that can be replicated at many farms in the province.

The project was tendered and the Gansu Eighth Construction Engineering Company was selected to carry out the construction. Unfortunately the project was delayed due to the Sichuan Wenchuan Earthquake and the project was only completed in February 2009. Experts visited the project to undertake an initial evaluation of the project at the same time. The key findings of the evaluation are:

• The number of cows has not increased at the farm and is still at 300, rather than the 1000 anticipated. The dairy market was severely affected by the Chinese milk scares in 2008.

• The daily biogas production is 330 m3/d supplying gas to the households.

• Two electricity generators have been installed differing from the design: 1 x 49 kW and 1 x 120 kW engine to better cater for the winter and summer demands and to allow operation with less cows.

• 5 staff have been identified for the operation and management of the biogas system.

• The project has not been operating for long and therefore further evaluation of the project has been difficult and it has not been possible to assess the electricity generation and actual revenues.
• The final cost of the project increased by almost 26% to 3.5 million RMB due to an increase in the construction materials. In addition the company received less from the ADB grant due to foreign exchange losses. The missing balance in the budget was invested by the enterprise.

6.2 Hua Chi No. 2 Middle School biogas

Hua Chi No. 2 Middle School is a junior and senior combined middle school (13 – 18 year olds) with over 1800 students and teachers. Approximately 1100 of the students/teachers board at the school for most of the year. Hua Chi is a ‘national level poverty’ county.

The school had 18 central dry toilets where the waste collects causing difficulties for disposal, polluting the environment, destroying resource efficiency and harming the health of the students and teachers. With increasing student numbers these toilets were not sufficient and the environmental problems were worsening.

The heating, hot water and cooking fuel is supplied by coal. The school owns 45 mu of land where it grows food and provides labour and demonstration for the school students. The land was fertilized with bought chemical fertilizer.

The project at Hua Chi No. 2 Middle School was implemented with the aim to improve its environment through the construction of new sanitary toilets and an associated biogas project which provides energy to the school kitchen and fertilizer for the school's fields.

The key project parameters are:

- 189 m² new toilet block
- 100 m³ biogas unit including pre-treatment, grey water storage
- 2 kitchen stoves and heater
- Total cost: 590,000 RMB
- ADB grant: 217,500 RMB

At the feasibility stage the advantages of the project were listed as follows:

- Improvements to the school’s local environment through the removal of human waste at the site.
- Coal and CO2 savings from offsetting some coal consumption in the school's kitchens.
- Annual net savings of about 35,500 RMB from reduced expenditure for the school for fertilizer and coal.
- Demonstration of a new concept in Gansu province that can be replicated at many schools in the province.
- Government support from the Education and Agriculture departments

The project was completed in November 2008. An evaluation visit was undertaken in March 2009 and the key findings to date are:

- The project design was changed to include digester heating using the boiler heat rather than solar heating.
- The project was within budget.
- The project is supplying gas to the school kitchens and has improved the environmental conditions at the school by treating the toilet waste.
Gas output is currently lower than anticipated but it is expected to increase with more operating months.

7 WIND COMPONENT

The wind component of the project included the following activities:
- Supply and installation of two wind measuring masts
- Inspection of the masts
- Preparation of a pre-feasibility study for one wind power project.

7.1 Supply and Installation of Wind Measuring Masts

Two wind measurement masts were erected as part of this TA in July/August 2008. These were for the following projects:
- China Automation Control System Company for wind measurement mast at Masheng
- Gansu Heihe Hydropower Development Company for wind measurement mast in Dong le, Shandan county, Zhangye.

The objectives of these masts at the sites were to i) improve the micro-siting (higher AEP) and ii) decrease the uncertainty of the wind study.

7.2 Mast Inspection

The masts were inspected by Soren Gjerding of Tripod Wind Energy in November 2008. A copy of the inspection report is included in the Annex.
During the mission it was concluded that the pre-feasibility study should cover the Heihe’s Dong Le site.

### 7.3 Pre-feasibility Study of Dong Le

A pre-feasibility study for the 49.5 MW Dong Le farm was carried out with Tripod Wind Energy carrying out the wind data analysis and the feasibility and financial evaluation being carried out by Mr Min and Mr Wei, the national consultants. The full pre-feasibility report is included in the annex. The key conclusions and recommendations of the report are given below:

- The wind farm has a rated output of 49.5 MW and will be connected to the 330kV substation in Shandan.

- The study has been carried out assuming 33 domestic wind turbines of 1.5MW output with a 70 m hub height.

- The Annual Energy Production (AEP) has been estimated at 78.4 GWh/year.
• The AEP is lower than expected due to uncertainty because of a short wind measuring period and no long term information: The wind data from the 70m mast was checked against the data from the local 10m mast however it was found that there was little correlation between the masts and therefore the wind analysis was carried out using the 5 month data from the 70m mast only leading to higher uncertainty.

• It is recommended to review the figures following measurement data from one continuous full year. The power production and income profit of this project should also be re-assessed.

• According to NDRC’s requirements for wind power project pre-feasibility study, it is necessary to carry out a site survey by a qualified geological survey institute in advance, and work out a geological survey analyzing report and a geological hazard assessment report before the pre-feasibility study. But the project developer has not entrusted any qualified geological institute to do the site survey yet. Therefore the project site discussions in this report need revisiting. It is suggested that a qualified geological survey should be done before the work of feasibility report and initial design report of this project in the next stage. All the discussions in the feasibility report must be based on the actual geological site survey data of the project.

• The financial analysis is imperfect because this is just a preliminary study. Specifically, the further financial analysis should include:
  • carry out in-depth cost estimate, including identifying local and foreign cost.
  • Review the most current audited and/or un-audited financial statements of the implementation agency (IA) to assess (a) historical financial performance, (b) retail tariff levels, (c) capital structure, and (d) sufficient generation of internal funds to ensure sustainability of ongoing operations (i.e., the ability to self-finance a reasonable percentage of capital expenditures and service existing debt). If possible, obtain recent audited project accounts of the IA to determine proper accounting and cost control.
  • Assess the IA’s financial management capabilities, and make recommendations for institutional strengthening of financial management with a recommended time-bound implementation plan.
  • The financial analysis confirms that the Project is financially viable. The analysis reflects the fact that incentives for the Project are sufficient, and funds are adequate for continuing operation. The financial internal rate of return (FIRR) and financial net present value (FNPV) are calculated for the Project to justify financial viability for the investor. The potential carbon revenues are not included in the base case calculation. The FIRR is 4.57%, higher than the weighted average cost of capital (WACC) estimated at 3.45%, and the FNPV is CNY40.18 million at this WACC. Inclusion of carbon revenues up to 2012 at a conservative estimate, results in the slightly improvement in FIRR (4.95%) and FNPV (CNY52.7 million).

• The project is located in a frail environmental area. It is recommended to pay attention to the protection of local vegetation during the engineering process and the rehabilitation after the construction.

7.4 CDM revenue of wind power priority projects

Both the wind and biomass priority projects have the potential to be CDM projects and are included in Chinese priority CDM project fields. CDM revenue is, therefore, one of the potential financing sources for the identified priority projects. Analysis was carried out for all the projects to assess the potential number of CERs (certified emission reductions or
equivalent tonnes of CO2 emission reductions) and the potential associated revenues. The detailed analysis is included in the Annex but the summary of the analysis is included in the following table.

Assuming that the price of CERs is 10Euro/ tCO2e, the CDM venue of the projects will be:

Table 7. 1: CDM venue of the priority wind power projects

<table>
<thead>
<tr>
<th>New capacity installed (MW)</th>
<th>Annual Emission reductions (tCO2e)</th>
<th>Annual CDM venue for the projects (Euro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,357.5</td>
<td>11,207,000</td>
<td>112,070,000</td>
</tr>
<tr>
<td>7,996</td>
<td>16,668,000</td>
<td>166,680,000</td>
</tr>
<tr>
<td>Total: 13,353.5</td>
<td>27,875,000</td>
<td>278,750,000</td>
</tr>
</tbody>
</table>

8 BIOMASS PRIORITY PROJECTS

One of the important outputs of the Technical Assistance is to identify renewable energy projects in Gansu for development in future. As part of this a priority list of biomass projects has been developed as part of the project. The list was compiled using information provided by the Rural Energy Offices in each city. Since there are a growing number of larger livestock farms and there is no significant stalk resource in Gansu province, the focus of the projects is biogas projects at animal farms although five stalk gasification projects were also identified. There are many very small biogas projects on the list. No actual biomass combustion power plants have been identified. However sufficient resource is potentially available in Zhangye, Jiuquan and Qingyang to warrant 10 MWe power plants.

The selection criteria to prioritise the projects was agreed with stakeholders at an interim workshop and is shown below.

8.1 Selection Criteria for Priority Project for ADB TA 4935 PRC

<table>
<thead>
<tr>
<th>Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource Availability</td>
</tr>
<tr>
<td>Project Scale</td>
</tr>
<tr>
<td>Technology maturity</td>
</tr>
<tr>
<td>Economic Indicator</td>
</tr>
<tr>
<td>Environmental Impact</td>
</tr>
<tr>
<td>Social Impact</td>
</tr>
<tr>
<td>Financing Ability</td>
</tr>
<tr>
<td>Project Management Capability</td>
</tr>
<tr>
<td>Demonstration Effect</td>
</tr>
</tbody>
</table>

Note: Based on project information collected, and in considering the current status of industry development and local social-economic development, the marking shall be done by four grades, i.e. Excellent, Good, Fair and Poor, with ratings of 4, 3, 2 and 1 respectively; In principle, those projects with large scale, good economic benefit, strong management capability, large GHG emission reductions and great potential for project popularization will be recommended.
1. Resource availability refers to the quantities of different varieties of livestock in breeding farms and quantities of dung (ton/year) or total quantity of straws that can be used as fuel (ton/year).

2. Project scale refers to the installed capacity of power system (kW), total yield of biogas (m³/year) and fuel production capacity (ton/year).

3. Technology maturity refers to the technical reliability and application.

4. Economic indicator refers to the investment per unit of energy produced (RMB/m³, RMB/ton) or the investment per kW of installed capacity (RMB/kW), and project static investment payback period (year).

5. Environmental impact refers to the possible environmental benefits upon construction completion, mainly including the reduction of SO2, CO2 and COD discharges (t/a) and amount of water saving;

6. Social benefit refers to the possible social benefits during project operation, e.g. energy saving or energy replacement (tce/year), increase of job opportunities and economic output;

7. Financing ability refers to the structure of different financing sources in total investment, in particular the share of self-financing in total investment (%).

8. Project management capability refers to whether the project has assigned dedicated office and management staff, full-time technical staff or trained staff and established necessary rules and regulations or mechanisms.

9. Demonstration effect refers to the total resource availability in same types of regions in Gansu Province, technology applicability, market demand and willingness of pay or use by end users.

A team of the experts attempted to use the criteria to prioritise the projects. Unfortunately in many cases there was not enough information available to be able to use the criteria accurately. Therefore the Experts used their specialist knowledge to judge many of the projects.

8.2 List of Priority Project for ADB TA PRC 4935

The 46 projects were split into four categories: biogas only, biogas with power generation, stalk gasification only and stalk gasification with power generation. The final order of the projects is included in the table below. In general the larger projects are shown greater priority. These lists and orders were then discussed with the PMO and have been included into the REDP as projects to develop first.
## ADB Priority Projects List

<table>
<thead>
<tr>
<th>No</th>
<th>Location</th>
<th>Project Title</th>
<th>Project Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Straw Power</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Jiuquan city</td>
<td>Suzhou Yinda Town Shexin Village Biomass power generation project</td>
<td>stalks 50,000 ton; gas 3 million m³/year; generator 300kW</td>
</tr>
<tr>
<td>45</td>
<td>Zhangye City</td>
<td>Zhangye stalk direct-combustion power generation project</td>
<td>Generator: 2*12MW, Electricity supply 114 million kWh per year</td>
</tr>
<tr>
<td><strong>Straw Gasification</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Jiuquan city</td>
<td>Dunhuang Huangqu Town Stalks Gas Distribution Station</td>
<td>stalks 30,000 ton; gas 1.5 million m³/year</td>
</tr>
<tr>
<td>24</td>
<td>Jiuquan city</td>
<td>Dunhuang Yangguan Town Stalks Gas Distribution Station</td>
<td>stalks 30,000 ton; gas 1 million m³/year</td>
</tr>
<tr>
<td>44</td>
<td>Wuwei</td>
<td>Tianzhu County Haxi Town Gucheng Village Stalks Gasification Project</td>
<td>Stalks production 1869 ton from 5876 mu plant area in this village; 130 ton can be collected for gasification; gas production is 250,000 m³/year</td>
</tr>
<tr>
<td><strong>Biogas Power</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Linxia</td>
<td>Linxia County Beiyuan village Jinniu Company thousands-dairy cow Breeding Farm Biogas Power Generation Project</td>
<td>Planning 8000 cows, 50,000 sheep; Newly built water collection pool 50 m³, digester tank 2000 m³; Generator capacity is 5000 kW</td>
</tr>
<tr>
<td>14</td>
<td>Linxia</td>
<td>Gansu Xingkang Breeding Farm Large-scale Biogas Project</td>
<td>600 cows; newly built digester pool of 250 m³, gasholder of 100 m³, combined heat and power generation system of 85 kW</td>
</tr>
<tr>
<td>15</td>
<td>Linxia</td>
<td>Yongjing County Yanguo Town Xiaochagou Large scale Breeding farm Biogas power generation Project</td>
<td>Cow 200; pig 2000; sheep 800; digester bank 600 m³, installed capacity of power generation set is 50 kW</td>
</tr>
<tr>
<td>16</td>
<td>Linxia</td>
<td>Yongjing County XianYuan Town Caopijawan Large scale Breeding farm Biogas power generation Project</td>
<td>Pig 12000; biogas 520,000 m³ per year; generator 500 kW</td>
</tr>
<tr>
<td></td>
<td>City</td>
<td>Project Description</td>
<td>Details</td>
</tr>
<tr>
<td>---</td>
<td>----------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>17</td>
<td>Linxia</td>
<td>Yongjing County Yufeng Dairy Cow Breeding Co., Ltd, Biogas Project</td>
<td>Pig production 10000; generator is 100kW.</td>
</tr>
<tr>
<td>18</td>
<td>Tianshui City</td>
<td>Tianshui City Agriculture High-Tech Pilot District large-scale biogas station construction</td>
<td>Cow 2000; biogas 120,000m3/year; generator capacity is 2*80kW</td>
</tr>
<tr>
<td>19</td>
<td>Zhangye City</td>
<td>Zhangye City Yuanbo Pasture Industry Development Co., Ltd with ten thousand beef cattle large-scale biogas project</td>
<td>cow 2000; biogas production is 320,000m3/year.</td>
</tr>
<tr>
<td>20</td>
<td>Zhangye City</td>
<td>Zhangye City Ganzhou District Biomass large scale biogas comprehensive utilization project</td>
<td>cow 15000; biogas production 2330,000m3/year.</td>
</tr>
<tr>
<td>31</td>
<td>Baiyin City</td>
<td>Huining Kangzhuiyuan Breeding Co., Ltd Biogas Project</td>
<td>cow 1000, sheep 1000, pig 100, waste water 70 ton/day; biogas 270,000m3/year; power generation</td>
</tr>
<tr>
<td>35</td>
<td>Baiyin City</td>
<td>Jingtaishengda pig-breeding farm biogas power generation project</td>
<td>current pig 4000; biogas 320,000m3/year; generator 100kW</td>
</tr>
<tr>
<td></td>
<td><strong>Biogas Supply</strong></td>
<td><strong>Lanzhou City Xigu District Kaiyue Dairy Farm Large-medium Scale Biogas Project</strong></td>
<td>1000 cows; Digester capacity of 600 m3; biogas 3200,000m3/year.</td>
</tr>
<tr>
<td>4</td>
<td>Dingxi City</td>
<td>Lintao County gas&amp;electricity integration energy ecological pilot project</td>
<td>666 cows currently; daily yield electricity 690kWh</td>
</tr>
<tr>
<td>5</td>
<td>Linxia</td>
<td>Linxia County Xiaxing Modernization Dairy Cow Breeding Co., Ltd Biogas Project</td>
<td>Planning 1000 cows; Digester capacity of 250 m3</td>
</tr>
<tr>
<td>6</td>
<td>Linxia</td>
<td>Gansu Province Linxia County Xianweier Halal Meat Co., Ltd Environment Protection Biogas Project</td>
<td>Planning 800 cows; Digester capacity of 80 m3</td>
</tr>
<tr>
<td></td>
<td>City</td>
<td>Location and Details</td>
<td>Details</td>
</tr>
<tr>
<td>---</td>
<td>--------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>7</td>
<td>Linxia</td>
<td>Gansu Province Linxia County Lvyuan Dairy Cow Fatten Co., Ltd, Environment protection Biogas Project</td>
<td>Planning 1000 cows; Digester capacity of 100 m³</td>
</tr>
<tr>
<td>21</td>
<td>Zhangye City</td>
<td>Shandan County medium-large scale biogas project</td>
<td>Cow 200, pig 500; biogas production 160,000 m³/year</td>
</tr>
<tr>
<td>32</td>
<td>Baiyin City</td>
<td>Huining Nongyuan Breeding Co., Ltd</td>
<td>Cow 850; biogas 160,000 m³/year</td>
</tr>
<tr>
<td>33</td>
<td>Baiyin City</td>
<td>Huining Changning Forage Livestock Co., Ltd Biogas Project</td>
<td>Currently pig 5600, annual pig production 10,000; biogas 320,000 m³/year</td>
</tr>
<tr>
<td>40</td>
<td>Baiyin City</td>
<td>Baiyin Jingyuan County Guoding Milk-cow Farm Biogas Project</td>
<td>Current cow 1000; biogas 320,000 m³/year</td>
</tr>
<tr>
<td>42</td>
<td>Pingliang</td>
<td>Chongxin County Baishu Town Fuminkegongmao Farm Biogas Project</td>
<td>Farmer 300 household; cow 850; pig 960; biogas 208,000 m³/year</td>
</tr>
<tr>
<td>43</td>
<td>Pingliang</td>
<td>Chongxin County Dongxin Pasture Co., Ltd, Biogas Project</td>
<td>Cow 1000; biogas 192,000 m³/year</td>
</tr>
</tbody>
</table>
8.3 Feasibility studies for priority projects

Of the priority projects two were then selected to take further to a project feasibility study to evaluate the reasonability, financial viability and implementation of the projects. Furthermore the feasibility studies aimed to provide a more accurate estimated of the potential for Gansu’s biomass energy development. The projects were selected for further study for the following reasons:

1. Relatively complete information provided by project owner, credible data, available pre-feasibility study report, listed as high priority among the recommended 46 projects.
2. Sufficient resource, relatively large scale.
3. Suitable process technology selection, technical expert participation in the project.
4. Potential for good demonstration effect compared with other projects of the same type.

The two selected projects were:

- Stalk Gasification Project at Shexin Village, Yinda Town, Suzhou District, Jiuquan City
- Yuanbo Biogas Power Engineering in Ganzhou District, Zhangye City

Based on the available data, the ADB project expert team prepared feasibility study reports covering:

- Project background
- Process technology selection and design
- Construction condition
- Project investment, operation and profit
- Socio-economic and environmental impacts
- Diffusion of demonstration

The full feasibility studies are included in the Annexes and a summary of the projects is provided below.

8.3.1 Stalk Gasification Project at Shexin Village, Yinda Town, Suzhou District, Jiuquan City

Shexin Village has 650 households with 2,650 residents. The village is in the food production area of Jiuquan City with 4,820mu farm land with annual food production of 4,450 tonnes mainly corn and wheat, and stalk production of 6,270 tonnes. There is a large quantity of stalks available excluding 22%, which is returned to farmland and for animal feeding. According to the Rural Biomass Industry Development Plan (2007-2015), a stalk gasification station to supply cooking gas to 650 households in the village has been proposed by Shexin Village following investigation on the stalk gasification technology over several years. This plan has been supported by the government of Yinda Town, Development and Reform Commission of Suzhou District and Rural Energy Office of Suzhou District.

This project will not only utilize the waste stalks and improve the appearance of the rural area but also improve the energy consumption structure of residents in the village. At present, fuels for cooking and heating are mainly from coal and LPG in the village. Annual coal consumption at this village is 5000 tonnes which accounts for 70% of the total living energy consumption. Gas from stalk gasification will be used for cooking and is predicted to
reduce 1000 tonnes of coal consumption for cooking and an associated 100 RMB per household.

The project owner is Shexin Village Committee. A specific management group is planned to be organized to be responsible for the operation, maintenance, management and business development. Price mechanisms of purchasing stalk materials from farmers and selling gas to farmers will follow market mechanisms.

The key parameters of the project are:
- 2 gasifiers with capacity of 600 to 700m3/hour each,
- 1 dry gas container with capacity of 800m3
- 650 household stoves and associated pipework and gas cleaning
- Total cost: 2.56 million RMB. 50% of it will be from national government fund and the rest will be financed by town government and the villagers.

The feasibility study showed that there is sufficient resource for the gasification project and if a reliable cleaning system is installed and a good operation and maintenance team is in place the project could be technically successful. However although the financial IRR of the pilot project is positive it is lower than the WACC (weighted average cost of capital). One effective option to improve the finances is that the stalk gasification be combined with power generation, so as to improve the FIRR and make it attractive to a commercial investor. However this relies on receiving a fair price for the electricity. Alternatively the income from the Clean Development Mechanism could improve the finances of the project (see section 8.4 below).

8.3.2 Yuanbo Biogas Power Engineering in Ganzhou District, Zhangye City

The project owners of this proposed project is Zhangye City Yuanbo Agriculture & Animal Husbandry Industry Development CO., Ltd. The key business of this company is cow breeding and slaughtering, and fodder production. They also plant and produce corn, vegetables, flowers and trees. Currently there are 1,800 cows and they aim to hold 3500 cows and breed 12,000 cows annually. The company has the facilities, imported from Spain and Germany, to meet process 100,000 cows annually. The waste from the farm will produce potential environmental concerns and the plan requires significant electricity. Therefore Yuanbo Company wants to construct a large scale biomass power engineering project to avoid the pollution from the cow waste and develop the circular economy.

The key parameters of the proposed project are:
- Cows planned to have 3500 cows, annual breeding 12,000, annual process 100,000
- Daily waste > 500 tonnes/day
- Anaerobic digester 2 x 4000m3
- Biogas holder 1000m3
- Gas production 5000m3 per day
- Power generation 4 x 120 kW engines
- Total cost: 16 million RMB. In line with the support policy from Gansu and state government, the project owner will apply for 8million RMB from central government grant and 2.4million RMB from local government which is 50% and 15% of the total investment respectively. The remaining 5.60million will be from project owner and a loan.

The feasibility study shows that the project is technically feasible as long as the number of animals projected materialises as well as ensuring that there is an effective operation and
maintenance procedure in place. However the financial returns rely on receiving income from the sales of fertilizer as well as the off-setting and sale of electricity. If each of these is attainable then the project is financially viable with a financial IRR of the pilot project (4.9%) higher than the WACC (3.7%). Further income may be possible with revenues from CDM (see below).

8.4 CDM Financing Evaluation for Biomass Priority Projects

As with the wind, biomass priority projects have the potential to be CDM projects and are included in Chinese priority CDM project fields. CDM revenue is, therefore, one of the potential financing sources for the identified priority projects. Analysis was carried out for all the projects to assess the potential number of CERs (certified emission reductions or equivalent tonnes of CO2 emission reductions) and the potential associated revenues. The detailed analysis is included in the Annex but the summary of the analysis is included in the following tables.

Table 8.2 Summary of emission reductions for priority biomass projects

<table>
<thead>
<tr>
<th>NO.</th>
<th>Project</th>
<th>Brief description</th>
<th>Methodology applied</th>
<th>Emission reductions (tCO2e/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Biogas project</td>
<td>It is to collect biogas from the manure management systems in a livestock farm with 43776 cows. There is power capacity of 3.97MW in the project. And the annual biogas supply of the project is 2,350,000m³.</td>
<td>ACM0010 ‘Consolidated baseline methodology for GHG emission reductions from manure management systems’</td>
<td>67,439</td>
</tr>
<tr>
<td>2</td>
<td>straw gasification project</td>
<td>It is to utilize the residual straws for energy use. Annual syngas generation is 3,250,000m³ which comes from the gasification process of 1,530,120tonnes of straws.</td>
<td>AM0025 ‘Avoided emissions from organic waste through alternative waste treatment processes’</td>
<td>1,172,115</td>
</tr>
<tr>
<td>3</td>
<td>straws power project</td>
<td>It is to generate electricity with power capacity of 24.3MW from 250,000 tonnes of straws.</td>
<td>ACM0006 ‘Consolidated baseline methodology for grid-connected electricity generation from biomass residues’</td>
<td>126,868</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total emission reductions</td>
<td></td>
<td></td>
<td><strong>1,366,422</strong></td>
</tr>
</tbody>
</table>
9 DISSEMINATION ACTIVITIES

9.1 Publicity Campaign

The publicity campaign included a number of different activities as well as training and workshops (included in section 9.2). The publicity material is available in the Annexes to the final report and the activities are summarised below:

**Policy handbook for renewable energy use and technical books on renewable energy**

The PMO prepared:

- “Policy and law collection on renewable energy development”,
- “Main technologies for energy use of stalk’,
- “Biogas power generation technology and application”,
- “wind power resource development and utilization”,

These books are targeted at rural energy management and technical personnel, enterprises and farmers. The books have been distributed through the city and county rural energy offices, together with various publicity campaigns, so as to accelerate the popularisation of the project results.

**Development of an information dissemination website**

An information dissemination website has been developed, which covers renewable energy use policy, technology, development status and potential etc, the website is included in the Gansu Agricultural Information Network. The website has been developed, and data uploading is underway: the website went live on 12th March 2009.

**Workshops and rural technology popularisation**

The ADB TA project results have been publicized by means of workshops, rural technology popularization, brochure and book distribution, and playing the video etc, between December 2008 to February 2009. Large scale workshops and rural technology popularization was carried out in every city and county, so that the ADB TA project results were popularized from city, county and township to village and rural household.

9.2 Training

A number of training workshops have been carried out during the project:

<table>
<thead>
<tr>
<th>Date</th>
<th>Target audience</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2008</td>
<td>&gt; 50 leaders and technical personnel from 14 cities</td>
<td>global experience in biomass technology, policies on renewable energy development, new technologies of rural renewable energy and status analysis of Gansu rural energy consumption</td>
</tr>
<tr>
<td>August 2008</td>
<td>&gt; 100 delegates from 14 cities’ agriculture bureaus and rural energy offices, t</td>
<td>development status of China’s energy, rural energy consumption and technology application in Gansu rural area</td>
</tr>
<tr>
<td>November 2008</td>
<td>Every city and county rural energy office</td>
<td>technical training, radiating and popularizing the training results to rural area</td>
</tr>
</tbody>
</table>
9.3 Study Tours

9.3.1 Domestic Study Tour

A domestic study tour was undertaken between March 28th to April 7th 2008 for 10 staff from the Rural Energy Office. The delegates visited large and medium sized biogas projects in Zhejiang, Fujian and Jiangxi. A report on the study tour is included in the Annex.

9.3.2 International Study Tour

An international study is planned for March 2009. The tour included a visit to Denmark and the UK to visit both biomass and wind plants. A report on the study tour is included in the Annex.
Annex 1

List of Expert Meetings
List of Expert Meetings Held (December 2007 - March 2009)

Frequent meetings were also held with the Gansu PMO and other stakeholders but these have not been included in the following list.

<table>
<thead>
<tr>
<th>Expert</th>
<th>Dates</th>
<th>Meeting with and Main Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rebecca Gunning</td>
<td>3rd July in Lanzhou</td>
<td>Teng Huayuan &amp; Li Kai (Gansu PMO). TA work taken and work forward and data requirement.</td>
</tr>
<tr>
<td>Hu Jicai</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zhuchao</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gu Shuhua</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min Deqing</td>
<td>5th to 8th July at Shandan County</td>
<td>Mr Zhu (CEO of Heihe Com.), Mr Pan (CATC), Mr Hu (supplier), Mr Pu, Mr Wang, Mr Ding, Mr Zhang, Etc. Wind data measurement and wind mast construction and sites inspection</td>
</tr>
<tr>
<td>Rebecca Gunning</td>
<td>7th July at Jiuquan city</td>
<td>Li Kai (PMO), Yang Guiming (engineer), Mr Liu (town director), Mr Sun (Secretary), Mr Kong, Mr Wang, Mr He, Mr Zhang. Gasification priority project</td>
</tr>
<tr>
<td>Hu Jicai</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zhuchao</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zhou Wei</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rebecca Gunning</td>
<td>7th July at Jiuquan city</td>
<td>Li Kai (PMO), Mr Liu (town director), Mr Sun (Secretary), Mr Huang, Mr Wang, Mr He, Mr Zhang. Rural energy resources and gasification priority project</td>
</tr>
<tr>
<td>Hu Jicai</td>
<td>8th July at Zhangye city</td>
<td>Mr. Niu (CEO), Mr Zhang (Arg Bureau Director), Mr Gu (REO), Mr. Wang, Madam Liu, Li Kai (PMO) Rural energy resources and biogas priority project</td>
</tr>
<tr>
<td>Zhuchao</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zhou Wei</td>
<td>8th July at Zhangye city</td>
<td>Mr. Song (CEO), Mr Zhang (Arg Bureau Director), Mr Qi, Mr. Kou, Mr Han, Mr Wei, Mr Xia, Mr Guan, Li Kai (PMO) Rural energy resources and biogas priority project</td>
</tr>
<tr>
<td>Gu Shuhua</td>
<td>7th to 8th July at Yuanbo Company of Zhangye city</td>
<td>Mr Teng (PMO), GPDAH officers, Priority projects, REDP, rural energy target and resources</td>
</tr>
<tr>
<td>Rebecca Gunning</td>
<td>9th July, in Lanzhou</td>
<td>Mr Pu (Heihe company), Wind data measurement and wind mast construction issues.</td>
</tr>
<tr>
<td>Min Deqing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hu Jicai</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rebecca Gunning</td>
<td>10th July, in Lanzhou</td>
<td>Mr Pan (CATC), Wind data measurement and wind mast construction issues.</td>
</tr>
<tr>
<td>Min Deqing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hu Jicai</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rebecca Gunning</td>
<td>9th July, in Lanzhou</td>
<td>Mr Teng (PMO) REDP and priority projects and resources data issues</td>
</tr>
<tr>
<td>Gu Shuhua</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zhu Chao</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rebecca Gunning</td>
<td>10th July, at Gansu finance bureau</td>
<td>Zhang Xiaoping (GFB), Cheng Mingqing (GFB), Teng Huaiyuan (PMO) TA work taken and work forward including pilot projects, REDP, Priority projects, bidding process and approval, study tours, wind data measurement requirement, etc.</td>
</tr>
<tr>
<td>Name</td>
<td>Date</td>
<td>Location</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Rebecca Gunning, Hu Jicai, Zhuchao, Zhou Wei, Gu Shuhua, Li Jingming, Zhao Lixin, Min Deqing</td>
<td>14th July, In Lanzhou</td>
<td>Mr Luo Jixue (REO director), Mr Teng, Mr Likai, Mr Pan, Mr Lei, Mr Cheng, etc. REDP, training workshop, priority projects, Publicity campaign, work taken and work forward</td>
</tr>
<tr>
<td>Rebecca Gunning, Hu Jicai, Zhuchao, Zhou Wei, Gu Shuhua, Li Jingming, Zhao Lixin, Min Deqing, Wei Songxian</td>
<td>15th July, In Lanzhou</td>
<td>GPDAAH officers, Gansu Finance Bureau, Gansu REO, PMO, city REO officers, etc. Capacity building and information campaign training workshop</td>
</tr>
<tr>
<td>Rebecca Gunning, Hu Jicai, Zhuchao, Li Jingming, Zhao Lixin, Wei Songxian</td>
<td>16th July, in Lanzhou</td>
<td>Mr Teng (PMO), Likai, Methodology and contents and procedure of information campaign.</td>
</tr>
<tr>
<td>Soren Gjerding, Min Deqing</td>
<td>16th July, in Lanzhou</td>
<td>Mr Pu (Heihe) and Mr Pan (CATC), Wind component</td>
</tr>
<tr>
<td>Soren Gjerding, Hu Jicai, Min Deqing</td>
<td>17th to 18th July, in Lanzhou</td>
<td>Mr Ashok (ADB), Mr Zhu (Heihe), Mr Ding, Mr Pu, Mr Pan (CATC), Mr Zhang Wind mast construction, wind data measurement, wind data analysis, and other relevant issues, etc.</td>
</tr>
</tbody>
</table>
CDM Financing Evaluation for Gansu Wind & Biomass Priority Projects

Wind power and biomass project are included in the priority CDM project fields. Therefore, the CDM revenue is one of the potential financing sources for the identified priority projects.

Wind Power Priority projects in Gansu

According to the Gansu Renewable Energy Development Programme Report which refered the documents approved by NDRC “Preparation Works for Jiuquan Wind Power Base and Complementary Power Grid” and the provincial government documents from Gansu, there will be 16 priority wind power projects during 2009 to 2015 in Gansu with total new installation capacity of 13,353.5MW. The plan is as follows:

Table X. 1 Priority Wind Power Projects in Gansu (2009-2015)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Beidaqiao, Guazhou</td>
<td>6000</td>
<td>1600</td>
<td>4400</td>
</tr>
<tr>
<td>2</td>
<td>Ganhekou, Guazhou</td>
<td>1800</td>
<td>1800</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Qiaowan, Guazhou</td>
<td>600</td>
<td>600</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Liuyuan, Guazhou</td>
<td>50</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Changma, Yumen</td>
<td>800</td>
<td>800</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Sanshilijingzi, Yumen</td>
<td>110</td>
<td>110</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Diwpou, Yumen</td>
<td>150</td>
<td>150</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>Mahuangtan, Yumen</td>
<td>800</td>
<td>0</td>
<td>800</td>
</tr>
<tr>
<td>9</td>
<td>Qiduntan, Yumen</td>
<td>400</td>
<td>0</td>
<td>400</td>
</tr>
<tr>
<td>10</td>
<td>Mazongshan, Subei</td>
<td>2000</td>
<td>0</td>
<td>2000</td>
</tr>
<tr>
<td>11</td>
<td>Dongle,</td>
<td>99</td>
<td>49.5</td>
<td>49.5</td>
</tr>
</tbody>
</table>
Assuming that this development plan for 2009 to 2015 will be completed at the end of 2010 and 2015 respectively, the annual net electricity generation by the proposed priority projects is evaluated to be 11,242GWh for new capacity of 5,357.5MW which is to be installed during 2009 to 2010, and 27,962.2GWh annually for the total new capacity of 13,353.5MW after 2015, as show as following table:

Table X. 2: annual net electricity generation of the priority projects

<table>
<thead>
<tr>
<th>Installation Year</th>
<th>New capacity installed (MW)</th>
<th>Annual net electricity generation(GWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009-2010</td>
<td><strong>5,357.5</strong></td>
<td>11,242</td>
</tr>
<tr>
<td>2011-2015</td>
<td><strong>7,996</strong></td>
<td>16,720.2</td>
</tr>
<tr>
<td>Total</td>
<td><strong>13,353.5</strong></td>
<td>27,962.2</td>
</tr>
</tbody>
</table>

Methodology identification for emission reduction calculation

Since each installation capacity of these priority projects is larger than 15MW, and the project activity is to export electricity to North-west Power Grid which consists of Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang Provincial power grids, ACM0002 *Consolidated methodology for grid-connected electricity generation from renewable sources* should be applied for the CDM development of each project above.

According to ACM0002, if the project activity is the installation of a new grid-connected renewable power plant/unit, the baseline scenario is that the electricity delivered to the grid by the project activity would have otherwise been generated by the operation of grid-connected power plants. Prior to the proposed project activity, the electricity would have been generated by North-west Power Grid, which is the same to the baseline scenario.

Calculation of emission reductions

According to ACM0002, emission reductions are calculated as follows:

\[ ER_y = BE_y - PE_y - LE_y \]

Where:
**9.3.3 Project emissions**

According to ACM0002, for most renewable energy project activities, except geothermal power plants and hydro power plants, the project emission, $PE_y$, is taken as zero.

**9.3.4 Leakage**

According to the ACM0002, no leakage is considered for the proposed project.

**9.3.5 Baseline emissions**

For the new project activity, in accordance with ACM 0002, baseline emissions include only CO$_2$ emissions from electricity generation in fossil fuel fired power plants that are displaced due to the project activity, calculated as follows:

$$BE_y = EG_y \times EF_{grid,CM_y}$$

Where:

- $BE_y$ = Baseline emissions in year $y$ (tCO$_2$/yr)
- $EG_y$ = Electricity supplied by the project activity to the grid (MWh)
- $EF_{grid,CM_y}$ = Combined margin CO$_2$ emission factor for grid connected power generation in year $y$

$EF_{grid,CM_y}$ could be calculated using the latest version of the 'Tool to calculate the emission factor for an electricity system'. To simplify the calculation, $EF_{grid,CM_y}$ in this report will adopt the calculation result which officially issued by Chinese DNA. The issued calculation of the CO$_2$ emission factor for grid connected power generation provided by Chinese DNA applies the 'Tool to calculate the emission factor for an electricity system' and can be approved by DOE and EB. Thus we use the latest grid emission factors for North west Power Grid issued by Chinese DNA, as follows:

Table X. 3 OM and BM data issued by Chinese DNA for North West Power Grid(NWPG)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating margin emission factor ($EF_{grid,OM,simple,y}$, in tCO$_2$/MWh)</td>
<td>1.1225</td>
</tr>
<tr>
<td>Build margin emission factor ($EF_{grid,BM,y}$, in tCO$_2$/MWh)</td>
<td>0.6199</td>
</tr>
</tbody>
</table>

The default values used for $w_{OM}$ and $w_{BM}$ for wind power projects are 0.75 and 0.25. Therefore the combined margin emission factor is:

\[
E_{\text{grid,CM,y}} = 0.75 \times 1.1225 + 0.25 \times 0.6199 = 0.9969 \text{ tCO}_2/\text{MWh}
\]

Table X. 4  Summary of OM, BM and CM for North West Power Grid(NWPG)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating margin emission factor ((E_{\text{grid,OM,simple,y}}), in \text{tCO}_2/\text{MWh})</td>
<td>1.1225</td>
</tr>
<tr>
<td>Build margin emission factor ((E_{\text{grid,BM,y}}), in \text{tCO}_2/\text{MWh})</td>
<td>0.6199</td>
</tr>
<tr>
<td>Baseline emission factor ((E_{\text{grid,CM,y}}), in \text{tCO}_2/\text{MWh})</td>
<td>0.9969</td>
</tr>
</tbody>
</table>

9.3.6 Emission reductions

Since both project emissions (\(P_{E,y}\)) and leakage emissions (\(L_{E,y}\)) are zero, the emission reductions (\(E_{R,y}\)) are equal to the baseline emissions (\(B_{E,y}\)), i.e. the product of baseline emission factor (\(E_{\text{grid,CM,y}}\)) and the annual net electricity supplied by the project activity to the NWPG (\(E_{G,y}\)), as follows:

\[
E_{R,y} = B_{E,y} = E_{\text{grid,CM,y}} \times E_{G,y}
\]

Therefore, the emission reductions for the priority wind power projects is as follows:

Table X. 5: Emission reductions for the priority wind power projects

<table>
<thead>
<tr>
<th>Installation Year</th>
<th>New capacity installed (MW)</th>
<th>Annual net electricity generation(GWh)</th>
<th>Annual Emission reductions (tCO\textsubscript{2}e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009-2010</td>
<td>5,357.5</td>
<td>11,242</td>
<td>11,207,000</td>
</tr>
<tr>
<td>2011-2015</td>
<td>7,996</td>
<td>16,720.2</td>
<td>16,668,000</td>
</tr>
<tr>
<td>Total</td>
<td>13,353.5</td>
<td>27,962.2</td>
<td>27,875,000</td>
</tr>
</tbody>
</table>

9.4 CDM revenue of wind power priority projects

Presuming that the price of CERs is 10Euro/ tCO\textsubscript{2}e, the CDM venue of the projects will be:

Table X. 6: CDM venue of the priority wind power projects

<table>
<thead>
<tr>
<th>New capacity installed (MW)</th>
<th>Annual Emission reductions (tCO\textsubscript{2}e)</th>
<th>Annual CDM venue for the projects (Euro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,357.5</td>
<td>11,207,000</td>
<td>112,070,000</td>
</tr>
<tr>
<td>7,996</td>
<td>16,668,000</td>
<td>166,680,000</td>
</tr>
<tr>
<td>Total: 13,353.5</td>
<td>27,875,000</td>
<td>278,750,000</td>
</tr>
</tbody>
</table>
### 9.5 biomass Priority projects in Gansu

According to the Gansu Renewable Energy Development Programme Report (REDP), there will be 27 priority biomass projects during 2009 to 2015 in Gansu which include technologies of straw power, straw gasification, biogas power and biogas gas supply. The brief description of the projects is as follows:

Table X. 7: Priority Biomass Projects in Gansu Province

<table>
<thead>
<tr>
<th>Location</th>
<th>Project Title</th>
<th>Preliminary evaluation result by expert (Project brief description)</th>
<th>Output/capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Straw Power</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Jiuquan City</td>
<td>Suzhou Yinda Town Shexin Village Biomass power generation project</td>
<td>Gas supply with power generation, generator 300kW, gas production: 3 million m³ per year</td>
<td>3,000,000 m³</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>300 kW</td>
</tr>
<tr>
<td>2 Zhangye City</td>
<td>Zhangye stalk direct-combustion power generation project</td>
<td>Generator: 2*12MW, Electricity supply 114 million kWh per year</td>
<td>24 MW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>114,000,000 kWh</td>
</tr>
<tr>
<td><strong>Straw Gasification</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Jiuquan City</td>
<td>Dunhuang Huangqu Town Stalks Gas Distribution Station</td>
<td>Gas supply; Annual gas production: 1.5 million m³</td>
<td>1,500,000 m³</td>
</tr>
<tr>
<td>4 Jiuquan City</td>
<td>Dunhuang Yangguan Town Stalks Gas Distribution Station</td>
<td>Gas supply; Annual gas production: 1.5 million m³</td>
<td>1,500,000 m³</td>
</tr>
<tr>
<td><strong>Biogas Power</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Wuwei</td>
<td>Tianzhu County Haxi Town Gucheng Village Stalks Gasification Project</td>
<td>Gas production: 250 thousand m³ per year</td>
<td>250,000 m³</td>
</tr>
<tr>
<td>6 Linxia City</td>
<td>Linxia County Beiyuan village Jinniu Company thousands-dairy cow Breeding Farm Biogas Power Generation Project</td>
<td>Equivalent to 10,000 cows; Installation capacity: 1200kW</td>
<td>1200 kW</td>
</tr>
<tr>
<td>No.</td>
<td>City</td>
<td>Farm Name</td>
<td>Cows/Pigs</td>
</tr>
<tr>
<td>-----</td>
<td>---------------</td>
<td>---------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>7</td>
<td>Linxia City</td>
<td>Gansu Xingkang Breeding Farm Large-scale Biogas Project</td>
<td>600cows;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Generator Capacity: 80kW</td>
</tr>
<tr>
<td>8</td>
<td>Linxia City</td>
<td>Yongjing County Yanguo Town Xiaochagou Large scale Breeding farm Biogas power generation Project</td>
<td>400cows;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Generator capacity: 60kW</td>
</tr>
<tr>
<td>9</td>
<td>Linxia City</td>
<td>Yongjing County XianYuan Town Caojiawan Large scale Breeding farm Biogas power generation Project</td>
<td>12,000 Pigs, daily biogas yield:1300 m³; generator capacity: 140kW</td>
</tr>
<tr>
<td>10</td>
<td>Linxia City</td>
<td>Yongjing County Yufeng Dairy Cow Breeding Co., Ltd Biogas Project</td>
<td>10,000 Pigs, daily biogas yield:1100 m³; generator capacity: 120kW</td>
</tr>
<tr>
<td>11</td>
<td>Tianshui City</td>
<td>Tianshui City Agriculture High-Tech Pilot District large-scale biogas station construction</td>
<td>2000 cows; generator: 240kW</td>
</tr>
<tr>
<td>12</td>
<td>Zhangye City</td>
<td>Zhangye City Yuanbo Pasture Industry Development Co., Ltd with ten thousand beef cattle large-scale biogas project</td>
<td>2000 cows; daily biogas yield: 2000 m³; annual biogas production: 0.65 million m³; generator: 240kW</td>
</tr>
<tr>
<td>13</td>
<td>Zhangye City</td>
<td>Zhangye City Ganzhou District Biomass large scale biogas comprehensive utilization project</td>
<td>15,000 cows; biogas production: 4.8 million m³/year; generator: 1400kW</td>
</tr>
<tr>
<td>14</td>
<td>Baiyin City</td>
<td>Huining Kangzhiyuan Breeding Co., Ltd Biogas Project</td>
<td>1100 cows; generator: 130kW</td>
</tr>
<tr>
<td>15</td>
<td>Baiyin City</td>
<td>Jingtaishengda pig-breeding farm biogas power generation project</td>
<td>4000 Pigs; annual biogas production: 132,000 m³; generator: 60kW</td>
</tr>
<tr>
<td>16</td>
<td>Lanzhou City</td>
<td>Lanzhou City Xigu District Kaiyue Dairy Farm Large-medium Scale Biogas Project</td>
<td>1000 cows; annual biogas production: 320,000 m³; generator: 120kW</td>
</tr>
<tr>
<td>17</td>
<td>Lanzhou City</td>
<td>Lanzhou City Xigu District Hualong Dairy Farm Large-medium Scale Biogas Project</td>
<td>1000 cows; annual biogas production: 320,000 m³; generator: 120kW</td>
</tr>
</tbody>
</table>

**Biogas Supply**
<table>
<thead>
<tr>
<th>No.</th>
<th>City</th>
<th>County/Company Information</th>
<th>Cows/Pigs/Project Details</th>
<th>Biogas Supply</th>
<th>Power Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Dingxi City</td>
<td>Lintao County gas&amp;electricity integration energy ecological pilot project</td>
<td>666 cows; generator: 60kW</td>
<td>60 kW</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Linxia City</td>
<td>Linxia County Xiaxing Modernization Dairy Cow Breeding Co., Ltd Biogas Project</td>
<td>1000 cows; annual biogas production: 320,000 m³; gas supply: 320,000 m³</td>
<td>320,000 m³</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Linxia City</td>
<td>Gansu Province Linxia County Xianweier Halal Meat Co., Ltd Environment Protection Biogas Project</td>
<td>800 cows; annual biogas production: 260,000 m³; gas supply: 260,000 m³</td>
<td>260,000 m³</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Linxia City</td>
<td>Gansu Province Linxia County Lyuyuan Dairy Cow Fatten Co., Ltd Environment Protection Biogas Project</td>
<td>1000 cows; annual biogas production: 320,000 m³</td>
<td>320,000 m³</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Zhangye City</td>
<td>Shandan County medium-large scale biogas project</td>
<td>Equivalent to 250 cows; annual biogas production: 90,000 m³</td>
<td>90,000 m³</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Baiyin City</td>
<td>Huining Nongyuan Breeding Co., Ltd</td>
<td>850 cows; annual biogas production: 280,000 m³</td>
<td>280,000 m³</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Baiyin City</td>
<td>Huining Changning Forage Livestock Co., Ltd Biogas Project</td>
<td>5600 pigs; annual biogas production: 180,000 m³</td>
<td>180,000 m³</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Baiyin City</td>
<td>Baiyin Jingyuan County Guoding Milk-cow Farm Biogas Project</td>
<td>1000 cows; annual biogas production: 320,000 m³</td>
<td>320,000 m³</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Pingliang City</td>
<td>Chongxin County Baishu Town Fumingkegongmao Farm Biogas Project</td>
<td>Equivalent to 950 cows; annual biogas production: 300,000 m³</td>
<td>300,000 m³</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Pingliang City</td>
<td>Chongxin County Dongxin Pasture Co., Ltd Biogas Project</td>
<td>1000 cattle; annual biogas production: 280,000 m³</td>
<td>280,000 m³</td>
<td></td>
</tr>
</tbody>
</table>

**Total**

<table>
<thead>
<tr>
<th>Biogas Supply</th>
<th>2,350,000 m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Capacity</td>
<td>3.970 MW</td>
</tr>
<tr>
<td>Gasification</td>
<td>3,250,000 m³</td>
</tr>
<tr>
<td>Power Capacity</td>
<td>24.3 MW</td>
</tr>
</tbody>
</table>
It could be seen that most of these projects are in small scale. For convenience of emission reduction estimation, these 27 priority projects can be treated as three bundled projects as per the different methodologies as following:
1) One biogas project with the livestock farm scale of 43,776 cows equivalently, in which the power capacity is 3.97MW and annual biogas supply is 2,350,000m$^3$ at the same time.
2) One straw gasification project with 1,530,120 tonnes of straws which will supply 3,250,000m$^3$ gas annually.
3) One straw power project with 250,000 tonnes of straws which the power capacity is 24.3MW.

9.6 Emission reduction calculation for biogas project

9.6.1 Methodology identification

The proposed biogas project is to recover the methane for electricity generation and biogas supply to users. Therefore ACM0010 Consolidated baseline methodology for GHG emission reductions from manure management systems should be applied.

Prior to the proposed project activity, the methane will be released to atmosphere and the electricity would have been generated by North-west Power Grid, which is the same to the baseline scenario.

9.6.2 Calculation of emission reductions

9.6.3 Baseline emissions

According to the methodology, the baseline emission includes baseline methane emission, baseline N$_2$O emissions for the manure management, and the baseline CO$_2$ emissions from net electricity/heat generation, as following:

\[
BE_y = BE_{CH4,y} + BE_{N2O,y} + BE_{elec/heat,y}
\]

where,

\[BE_y = \text{Baseline emissions in year } y, \text{ in tCO}_2\text{e/year.}\]

\[BE_{CH4,y} = \text{Baseline methane emissions in year } y, \text{ in tCO}_2\text{e/year.}\]

\[BE_{N2O,y} = \text{Baseline N}_2\text{O emissions in year } y, \text{ in tCO}_2\text{e/year.}\]

\[BE_{elec/heat,y} = \text{Baseline CO}_2\text{ emissions from net electricity generation in the baseline in year } y, \text{ in tCO}_2\text{e/year. Assuming that there is no heat generation in the project.}\]

1) Methane emissions:

\[
BE_{CH4,y} = GWP_{CH4} \cdot D_{CH4} \cdot \sum_{j,LT} MCF_j \cdot B_{6,L} \cdot N_{LT} \cdot V_{S,L,y} \cdot MS\%_{BI,j}
\]

Where,

\[BE_{CH4,y} = \text{Annual baseline methane emissions in tCO}_2\text{e/year.}\]

\[GWP_{CH4} = \text{Global Warming Potential (GWP) of CH}_4.\]

\[D_{CH4} = \text{CH}_4\text{density (0.00067 t/m}^3\text{ at room temperature (20 }\degree\text{C) and 1 atm pressure).}\]
$MCF_j$ = Annual methane conversion factor (MCF) for the baseline AWMS$^j$ from IPCC 2006 Guidelines, table 10.17, chapter 10, volume 4.

$B_{0,LT}$ = Maximum methane producing potential of the volatile solid generated, in m$^3$CH$_4$/kg-dm, by animal type LT.

$N_{LT}$ = Number of animals of type LT for the year $y$, expressed in numbers.

$VS_{LT,y}$ = Annual volatile solid for livestock LT entering all AWMS [on a dry matter weight basis](kg-dm/animal/year). Here the average mass of the cow is assumed to be 800kg.

$MS\%_{B_i,j}$ = Fraction of manure handled in system $j$.

According to the information provided in the Gansu Renewable Energy Development Project, estimation of various variables and parameters for above equations as following:

Table X. 8 Annual baseline methane emissions $BE_{CH4,y}$

<table>
<thead>
<tr>
<th>Source</th>
<th>$D_{CH4}$ (t/m$^3$)</th>
<th>$MCF_j$</th>
<th>$B_{0,LT}$ (m$^3$CH$_4$/kg-dm)</th>
<th>$N_{LT}$</th>
<th>$VS_{LT,y}$ (kg-dm/animal/year)</th>
<th>$MS%_{B_i,j}$</th>
<th>$BE_{CH4,y}$ (tCO$_2$e/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPCC</td>
<td>IPCC</td>
<td>IPCC</td>
<td>IPCC</td>
<td>ICC</td>
<td>IPCC,REDP</td>
<td>100%</td>
<td>IPCC</td>
</tr>
<tr>
<td>21</td>
<td>0.00067</td>
<td>80%*0.94</td>
<td>0.13</td>
<td>43,776</td>
<td>800/350<em>2.8</em>365</td>
<td></td>
<td>140,658</td>
</tr>
</tbody>
</table>

2) $N_2O$ emissions

$$BE_{N2O,y} = GWP_{N2O} \cdot CF_{N2O-N,N} \cdot \left( \frac{1}{1000} \cdot (E_{N2O,y} + E_{N2O,ID,y}) \right)$$

$BE_{N2O,y}$ = Annual baseline $N_2O$ emissions in tCO$_2$e/year.

$GWP_{N2O}$ = Global Warming Potential (GWP) for $N_2O$.

$CF_{N2O-N,N}$ = Conversion factor from $N_2O-N$ to $N_2O$ (44/28).

$E_{N2O,y}$ = Direct $N_2O$ emission in kg $N_2O$/year.

$E_{N2O,ID,y}$ = Indirect $N_2O$ emission in kg $N_2O$/year.

The values for variables and parameters in above equation are as following:

Table X. 9: Annual baseline $N_2O$ emissions $BE_{N2O,y}$

<table>
<thead>
<tr>
<th>$GWP_{N2O}$</th>
<th>$CF_{N2O-N,N}$</th>
<th>$E_{N2O,y}$</th>
<th>$E_{N2O,ID,y}$</th>
<th>$BE_{N2O,y}$ (tCO$_2$e/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>310</td>
<td>44/28</td>
<td>0</td>
<td>12,016</td>
<td>5,853</td>
</tr>
</tbody>
</table>

3) CO$_2$ emissions for electricity generation

The baseline emission for the electricity generation of the proposed project is as following:

$$BE_{elec,y} = EG_y \times EF_{grid,CM,y}$$

Where:
Baseline emissions for electricity generation in year $y$ ($tCO_2/yr$)

Net electricity supplied by the project activity to the grid (MWh)

Combined margin CO₂ emission factor for grid connected power generation in year $y$, which is 0.9969 $tCO_2/MWh$ as shown in Table X.4

The result for the baseline emission for electricity generation is as following:

<table>
<thead>
<tr>
<th>Power capacity (MW)</th>
<th>Utilization Hours (h)</th>
<th>$EG_y$ (MWh)</th>
<th>$EF_{grid,CM,y}$ (tCO₂e/MWh)</th>
<th>$BE_{elec,y}$ (tCO₂e/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source: REDP</td>
<td>assumed</td>
<td>13,895</td>
<td>China DNA</td>
<td>13,852</td>
</tr>
</tbody>
</table>

Therefore, the baseline emission is:

$BE_y = BE_{CH4,y} + BE_{N2O,y} + BE_{elec/heat,y}$

The result is as following:

<table>
<thead>
<tr>
<th>$BE_{CH4,y}$ (tCO₂e/year)</th>
<th>$BE_{N2O,y}$ (tCO₂e/year)</th>
<th>$BE_{elec,y}$ (tCO₂e/year)</th>
<th>$BE_y$ (tCO₂e/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>140,658</td>
<td>5,853</td>
<td>13,852</td>
<td>160,363</td>
</tr>
</tbody>
</table>

9.6.4 Project emissions

$PE_y = PE_{AD,y} + PE_{Aer,y} + PE_{N2O,y} + PE_{PL,y} + PE_{flared,y} + PE_{elec/heat,y}$

where:

$PE_y$ = Project emissions in year $y$.

$PE_{AD,y}$ = Leakage from AWMS systems that capture’s methane in tCO₂e/year.

$PE_{Aer,y}$ = Methane emissions from AWMS that aerobically treats the manure in tCO₂e/year.

$PE_{N2O,y}$ = Nitrous oxide emission from project manure waste management system in tCO₂e/year.

$PE_{PL,y}$ = Physical leakage of emissions from biogas network to flare the captured methane or supply to the facility where it is used for heat and/or electricity generation in tCO₂e/year.

$PE_{flared,y}$ = Project emissions from flaring of the residue gas stream in tCO₂e/year.

$PE_{elec/heat,y}$ = Project CO₂ emissions from electricity and/or heat used in the project activity in year $y$, in tCO₂e/year. Because the biogas collected are used for power generation in the project activity, the electricity generated are much more than the electricity consumed by the manure management facilities used by the project activity, these emissions are considered as zero.

The result of the calculation is as following:
### Table X. 12: Project emissions $PE_y$

<table>
<thead>
<tr>
<th>$PE_{AD,y}$</th>
<th>$PE_{Aer,y}$</th>
<th>$PE_{N2O,y}$</th>
<th>$PE_{PL,y}$</th>
<th>$PE_{flared,y}$</th>
<th>$PE_{elec/heat,y}$</th>
<th>$PE_y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>17,676</td>
<td>253,52</td>
<td>43,900</td>
<td>0</td>
<td>5,996</td>
<td>0</td>
<td>92,924</td>
</tr>
</tbody>
</table>

#### 9.6.5 Leakage

Leakage covers the emissions from land application of treated manure, outside the project boundary. These emissions are estimated as net of those released under project activity and those released in the baseline scenario. Net leakage of N2O and CH4 are only considered if they are positive.

\[
LE_y = (LE_{P,N2O} - LE_{B,N2O}) + (LE_{P,CH4} - LE_{B,CH4})
\]

where,

- $LE_{P,N2O}$ = N2O emissions released during project activity from land application of the treated manure, in tCO2e/year.
- $LE_{B,N2O}$ = N2O emissions released during baseline scenario from land application of the treated manure, in tCO2e/year.
- $LE_{P,CH4}$ = CH4 emissions released during project activity from land application of the treated manure, in tCO2e/year.
- $LE_{B,CH4}$ = CH4 emissions released during baseline scenario from land application of the treated manure, in tCO2e/year.

The result of the calculation is as following:

<table>
<thead>
<tr>
<th>$LE_{P,N2O}$ (tCO2e/year)</th>
<th>$LE_{B,N2O}$ (tCO2e/year)</th>
<th>$LE_{P,CH4}$ (tCO2e/year)</th>
<th>$LE_{B,CH4}$ (tCO2e/year)</th>
<th>$LE_y$ (tCO2e/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10536</td>
<td>14048</td>
<td>29927</td>
<td>46761</td>
<td>-20346</td>
</tr>
</tbody>
</table>

According to methodology ACM0010, the leakage covers the emissions from land application of treated manure, outside the project boundary. Net leakage is only considered if they are positive, therefore the leakage is considered as zero for the project activity.

#### 9.6.6 Emission reductions

The emission reduction $ER_y$ by the project activity during a given year $y$ is the difference between the baseline emissions ($BE_y$) and the sum of project emissions ($PE_y$) and leakage, as follows:

\[
ER_y = BE_y - PE_y - LE_y
\]

Therefore, the emission reductions are:
Table X. 14: Emission reductions $ER_y$

<table>
<thead>
<tr>
<th>$BE_y$</th>
<th>$PE_y$</th>
<th>$LE_y$</th>
<th>$ER_y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(tCO$_2$e/year)</td>
<td>(tCO$_2$e/year)</td>
<td>(tCO$_2$e/year)</td>
<td>(tCO$_2$e/year)</td>
</tr>
<tr>
<td>160,363</td>
<td>92,924</td>
<td>0</td>
<td>67,439</td>
</tr>
</tbody>
</table>

**9.6.7 CDM venue of biogas priority projects**

Presuming that the price of CERs is 10Euro/ tCO$_2$e, the CDM venue of the biogas project will be 674,390Euro.

**9.7 Emission reduction calculation for straw gasification project**

**9.7.1 Methodology identification**

The straw gasification project with biomass intake of 1,530,120 tonnes which is to produce syngas and supply it to the end-users. Therefore AM0025 ‘Avoided emissions from organic waste through alternative waste treatment processes’ should be applied. The baseline scenario is that the straws are disposed in a landfill without capture of landfill gas.

**9.7.2 Calculation of emission reductions**

According to ACM0025, emission reductions are calculated as follows:

\[
ER_y = BE_y - PE_y - LE_y
\]

Where:

- $ER_y$ = Emission reductions in year $y$ (tCO$_2$e/yr)
- $BE_y$ = Baseline emissions in year $y$ (tCO$_2$e/yr)
- $PE_y$ = Project emissions in year $y$ (tCO$_2$e/yr)
- $LE_y$ = Leakage emissions in year $y$ (tCO$_2$e/yr)

**9.7.3 Baseline emissions**

\[
BE_y = (MB_y - MD_{reg,y}) + BE_{EN,y}
\]

Where,

- $BE_y$ = the baseline emissions in year $y$ (tCO$_2$e)
- $MB_y$ = the methane produced in the landfill in the absence of the project activity in year $y$ (tCO$_2$e)
- $MD_{reg,y}$ = methane that would be destroyed in the absence of the project activity in year $y$ (tCO$_2$e). The value for this parameter is 0 for the proposed project.
- $BE_{EN,y}$ = Baseline emissions from generation of energy displaced by the project activity in year $y$ (tCO$_2$e). This parameter is not applicable for the proposed project activity.

Therefore,

\[
BE_y = MB_y
\]
$MB_y$ is calculated as:

$$MB_y = BE_{CH4, SWDS, y}$$

$BE_{CH4, SWDS, y}$ is the methane generation from the landfill in the absence of the project activity at year $y$, calculated as per the “Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site”. The calculation result is 1,266,607 tCO$_2$e.

### 9.7.4 Project emissions

$$PE_y = PE_{elec, y} + PE_{fuel, on-site, y} + PE_{g, y}$$

Where:

- $PE_y = $ the project emissions during the year $y$ (tCO$_2$e)
- $PE_{elec, y} = $ the emissions from electricity consumption on-site due to the project activity in year $y$ (tCO$_2$e)
- $PE_{fuel, on-site, y} = $ the emissions on-site due to fuel consumption on-site in year $y$ (tCO$_2$e)
- $PE_{g, y} = $ the emissions from the gasification process in year $y$ (tCO$_2$e)

Estimation for $PE_{elec, y}$ is as following:

<table>
<thead>
<tr>
<th>EG$_y$ (MWh)</th>
<th>EF$_{grid}$ (tCO$_2$e/MWh)</th>
<th>PE$_{elec, y}$ (tCO$_2$e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C=A*B</td>
</tr>
<tr>
<td>Data source: assumed</td>
<td>China DNA</td>
<td></td>
</tr>
</tbody>
</table>

43,800 0.9969 43,664

And according to the methodology,

$$PE_{fuel, on-site, y} = F_{cons, y} \times NCV_{fuel} \times EF_{fuel}$$

Where:

- $PE_{fuel, on-site, y} = $ the CO$_2$ emissions due to on-site fuel combustion in year $y$ (tCO$_2$)
- $F_{cons, y} = $ the fuel consumption on site in year $y$ (l or kg)
- $NCV_{fuel} = $ the net caloric value of the fuel (MJ/l or MJ/kg)
- $EF_{fuel} = $ the CO$_2$ emissions factor of the fuel (tCO$_2$/MJ)

So estimation for $PE_{fuel, on-site, y}$ is as following:

<table>
<thead>
<tr>
<th>F$_{cons, y}$ (tonne)</th>
<th>NCV$_{fuel}$ (MJ/kg)</th>
<th>EF$_{fuel}$ (tCO$_2$/MJ)</th>
<th>PE$_{fuel, on-site, y}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D=A<em>B</em>C</td>
</tr>
<tr>
<td>Data source: assumed</td>
<td>IPCC</td>
<td>IPCC</td>
<td></td>
</tr>
</tbody>
</table>

1000 42.652 20.20*44/12/10^6 3,159

And,

$$PE_{g, y} = PE_{g, f, y} + PE_{g, s, y}$$

Where:
PE_{g,f,y} = \text{Is the fossil-based waste CO}_2\text{ emissions from gasification, waste incineration or RDF/stabilized biomass combustion in year } y \text{ (tCO}_2\text{e)}

PE_{g,s,y} = \text{Is the N}_2\text{O and CH}_4\text{ emissions from the final stacks from gasification, waste incineration or RDF/stabilized biomass combustion in year } y \text{ (tCO}_2\text{e)}

\[ PE_{g,f,y} = A_{MSW,y} \times FCF_{MSW} \times EF \times \frac{44}{12} \]

Where:

PE_{g,f,y} = \text{Is the fossil-based waste CO}_2\text{ emissions from gasification in year } y \text{ (tCO}_2\text{e)}

A_{MSW,y} = \text{Is the amount of MSW fed into the gasifier(t/yr)}

FCF_{MSW} = \text{Is the fraction of fossil carbon in MSW (fraction), the value is zero for the proposed project.}

EF = \text{Is the combustion efficiency for waste (fraction)}

44/12 = \text{Is the conversion factor (tCO}_2\text{/tC)}

\[ PE_{g,s,y} = Q_{\text{biomass,y}} \times (EF_{N2O} \cdot GWP_{N2O} + EF_{CH4} \cdot GWP_{CH4}) \times 10^{-3} \]

Where:

Q_{\text{biomass,y}} = \text{Is the amount of waste gasified, incinerated or RDF/stabilized biomass combusted in year } y \text{ (tonnes/yr)}

EF_{N2O} = \text{Is the aggregate N}_2\text{O emission factor for waste combustion (kgN}_2\text{O/tonne of waste)}

EF_{CH4} = \text{Is the aggregate CH}_4\text{ emission factor for waste combustion (kgCH}_4\text{/tonne of waste)}

The calculation is as following:

Table X. 17: emissions from the gasification process

<table>
<thead>
<tr>
<th>A_{MSW,y}</th>
<th>FCF_{MSW}</th>
<th>EF</th>
<th>PE_{g,f,y}</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>A \times B \times C \times D</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q_{\text{biomass,y}} (Tonne/yr)</th>
<th>EF_{N2O} (kgN2O/tonne MSW)</th>
<th>GWP_{N2O} (kgCH4/tonne MSW)</th>
<th>EF_{CH4} (kgCH4/tonne MSW)</th>
<th>GWP_{CH4}</th>
<th>Conservativeness factor</th>
<th>PE_{g,s,y} (tCO2e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
<td>F</td>
<td>A \times (B \times C + D \times E) \times F/1000</td>
</tr>
</tbody>
</table>

Source: REDP

<table>
<thead>
<tr>
<th>A_{MSW,y}</th>
<th>FCF_{MSW}</th>
<th>EF</th>
<th>PE_{g,f,y}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,530,120</td>
<td>67/1000</td>
<td>310</td>
<td>237/1000</td>
</tr>
</tbody>
</table>

Therefore, \( PE_{y} = PE_{elec,y} + PE_{fuel, on-site,y} + PE_{g,y} = 43,664 + 3,159 + 47,669 = 94,492 \text{ tCO}_2\text{e} \)

### 9.7.5 Leakage

The sources of leakage considered in the methodology are CO2 emissions from off-site transportation of straw in addition to CH4 and N2O emissions from the residual waste from the gasification processed. Leakage emissions should be estimated from the following equation:
\[ L_y = L_{t,y} + L_{r,y} + L_{i,y} + L_{s,y} \]

Where:

- \( L_{t,y} \): the leakage emissions from increased transport in year \( y \) (tCO₂), it is estimated to be zero as the transport distance is assumed unchanged.
- \( L_{r,y} \): the leakage emissions from the residual waste from the gasifier in case it is disposed of in landfills in year \( y \) (tCO₂). Since the replacement of fossil-fuel based fertilizers with organic composts are not accounted for, the value for this parameter can be considered as zero.
- \( L_{i,y} \): the leakage emissions from the residual waste from MSW incinerator in year \( y \) (tCO₂). This parameter is not applicable to the project.
- \( L_{s,y} \): the leakage emissions from end use of stabilized biomass. The value is 0 for the proposed project.

Therefore the leakage of the project is zero.

### 9.7.6 Emission reductions

The emission reductions are calculated with the following equation:

\[ ER_y = BE_y - PE_y - LE_y \]

#### Table X. 18: emission reductions of the project

<table>
<thead>
<tr>
<th>( BE_y ) (tCO₂)</th>
<th>( PE_y ) (tCO₂)</th>
<th>( L_y ) (tCO₂)</th>
<th>( ER_y ) (tCO₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,266,607</td>
<td>94,492</td>
<td>0</td>
<td>1,172,115</td>
</tr>
</tbody>
</table>

Therefore, the annual emission reduction of \( ER_y \) for this project will be 1,172,115 tCO₂.

### 9.7.7 CDM venue of wind power priority projects

Presuming that the price of CERs is 10Euro/ tCO₂, the CDM venue of the projects will be 11,721,150 Euro.

### 9.8 Emission reduction calculation for straw power project

#### 9.8.1 Methodology identification

The straw power project with capacity of 24.3MW which is generate electricity and send it to local grid. Therefore ACM0006 ‘Consolidated baseline methodology for grid-connected electricity generation from biomass residues’ should be applied. The baseline scenario is that the straw is dumped or left to decay or burned in an uncontrolled manner without utilizing it for energy purposes, and the electricity would have been generated by existing and/or new grid-connected power plants.

#### 9.8.2 Calculation of emission reductions

According to ACM0006, emission reductions of this project activity are calculated as follows:

\[ ER_y = ER_{electricity,y} + BE_{biomass,y} - PE_y - L_y \]

Where:

- \( ER_y \): Emissions reductions of the project activity during the year \( y \) (tCO₂/yr)
**Electricity, }y = Emission reductions due to displacement of electricity during the year y (tCO2/yr)

**BE, }y = Baseline emissions due to natural decay or burning of anthropogenic sources of biomass residues during the year y (tCO2e/yr)

**PE, } = Project emissions during the year y (tCO2/yr)

**Ly = Leakage emissions during the year y (tCO2/yr)

### 9.8.3 Baseline emissions

\[
BE, } = ER_{electricity, } + BE_{biomass, }
\]

Where,

\[ ER_{electricity, } = \text{Emission reductions due to displacement of electricity during the year y (tCO2/yr)} \]

\[ BE_{biomass, } = \text{Baseline emissions due to natural decay or burning of anthropogenic sources of biomass residues during the year y (tCO2e/yr)} \]

As stated above, \[ ER_{electricity, } = EG, \times EF_{electricity, } \]

Where,

\[ EG, = \text{the quantity of electricity generation of the project activity during the year y (in MWh)} \]

Given that the value of utilization hour is 4691 (which is deduced from electricity of 114GWh generated by the capacity of 24MW), the value for electricity generation is 113,991MWh

\[ EF_{electricity, } = \text{the CO2 emission factor for the electricity displaced due to the project activity during the year y (in tCO2/MWh)} \]

The value is 0.9969 which is the same as shown in table X.4.

Therefore, \[ ER_{electricity, } = 113,991 \times 0.9969 = 113,638 \text{ tCO2e} \]

\[ BE_{biomass, } = GWP_{CH4} \times \sum BF_{i, } \times NCV_{Biomass, } \times EF_{burning, CH4} \]

Where:

\[ BE_{Biomass, } = \text{emissions from the unused biomass during the year y in tons of CO2,} \]

\[ GWP_{CH4} = \text{the Global Warning Potential for methane valid for the relevant commitment period (21tCO2/tCH4 according to IPCC default value),} \]

\[ NCV_{Biomass, } = \text{the net calorific value of the biomass type i in MWh per mass or volume of biomass (assuming the value is 0.0148TJ/t),} \]

\[ BF_{i, } = \text{the quantity of biomass type i used as fuel in the project plant during the year y, which would in the absence of the project activity not used, i.e. be dumped, left to decay or burned in an uncontrolled manner without utilizing it for energy purpose, in a volume or mass unit. The value is 250,000 tonne as per data from REDP,} \]

\[ EF_{burning, CH4} = \text{CH4 emission factor for uncontrolled burning of the biomass type i in tons CH4 per MWh. (IPCC default value for methane emission factor in agriculture or forestry is 300KgCH4/TJ)} \]

Therefore, \[ BE_{Biomass, } = 250000 \times 0.0148 \times 300 \times 0.73 \times 21 / 1000 = 17016.3 \text{ tCO2e} \]
### 9.8.4 Project emissions

\[
PE_y = PET_y + PEFF_{CO_2,y} + GWP_{CH_4} \cdot PE_{Biomass,CH_4,y}
\]

Where:

- \( PE_y \) = emissions generated by the proposed project during the year \( y \) (tCO2e)
- \( PET_y \) = emissions during the year \( y \) due to transportation of the biomass to the project plant (tCO2e);
- \( PEFF_{CO_2,y} \) = emissions during the year \( y \) due to fossil fuels co-fired by the generation facility (tCO2e);
- \( GWP_{CH_4} \) = the global warming potential for methane valid for the relevant commitment period (IPCC default value is 21);
- \( PE_{Biomass,CH_4,y} \) = the CH4 emissions from the combustion of biomass during the year \( y \).

The estimation of \( PET_y \), \( PEFF_{CO_2,y} \), and \( PE_{Biomass,CH_4,y} \) is as following:

#### Table X. 19: estimation of \( PET_y \)

<table>
<thead>
<tr>
<th>A: Straw demand (t/yr)</th>
<th>B: Average load per trip (t)</th>
<th>C: Average distance from storage site to the power plant (km)</th>
<th>D: Emission factor of the truck transportation (kg/km)</th>
<th>E: ( PET_y ) (GHG emission from the biomass transportation (tCO2e/year))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw demand (t/yr)</td>
<td>Average load per trip (t)</td>
<td>Average distance from storage site to the power plant (km)</td>
<td>Emission factor of the truck transportation (kg/km)</td>
<td>( PET_y ) (GHG emission from the biomass transportation (tCO2e/year))</td>
</tr>
<tr>
<td>Data source: REDP</td>
<td>assumed</td>
<td>assumed</td>
<td>IPPC default value for US Heavy Duty Diesel Vehicle</td>
<td>250,000 15 30 1.011 505.5</td>
</tr>
<tr>
<td>Data source: assumed</td>
<td>assumed</td>
<td>assumed</td>
<td>IPPC default value for US Heavy Duty Diesel Vehicle</td>
<td>250,000 15 30 1.011 505.5</td>
</tr>
</tbody>
</table>

#### Table X. 20: estimation of \( PEFF_{CO_2,y} \)

<table>
<thead>
<tr>
<th>A: Fossil fuel demand (t/yr)</th>
<th>B: Emission factor</th>
<th>C: ( PEFF_{CO_2,y} ) GHG emission from fossil fuel combustion (tCO2e/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil fuel demand (t/yr)</td>
<td>Emission factor</td>
<td>( PEFF_{CO_2,y} ) GHG emission from fossil fuel combustion (tCO2e/year)</td>
</tr>
<tr>
<td>Data source: assumed</td>
<td>IPPC value</td>
<td>( PEFF_{CO_2,y} ) GHG emission from fossil fuel combustion (tCO2e/year)</td>
</tr>
<tr>
<td>28</td>
<td>3.13</td>
<td>87.6</td>
</tr>
</tbody>
</table>

#### Table X. 21: estimation of \( PE_{Biomass,CH_4,y} \)

<table>
<thead>
<tr>
<th>A: Straw burnt Biomass net calorific</th>
<th>B: Methane emission</th>
<th>C: Conservativeness value</th>
<th>D: Global warming</th>
<th>E: ( PE_{Biomass,CH_4,y} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw burnt Biomass net calorific</td>
<td>Methane emission</td>
<td>Conservativeness value</td>
<td>Global warming</td>
<td>( PE_{Biomass,CH_4,y} )</td>
</tr>
</tbody>
</table>
### 9.8.5 Leakage

According to ACM0006, where the most likely baseline scenario is the use of the biomass residues for energy generation (scenarios 1, 4, 6, 8, 9, 11, 12, 13 and 14), the diversion of biomass residues to the project activity is already considered in the calculation of baseline reductions. In this case, leakage effects do not need to be addressed. The scenario 2 is applicable to this proposed project, which is that the project activity involves the installation of a new biomass residue fired power plant at a site where no power was generated prior to the implementation of the project activity, the power generated by the project plant is fed into the grid or would in the absence of the project activity be purchased from the grid, and the biomass residues would in the absence of the project activity be dumped or left to decay or burnt in an uncontrolled manner without utilizing it for energy purposes.

Therefore the leakage $L_y$ is considered as zero.

### 9.8.6 Emission reductions

The emission reductions are calculated with following equation:

$$ER_y = ER_{\text{electricity},y} + BE_{\text{biomass},y} + PE_y - L_y$$

<table>
<thead>
<tr>
<th>$ER_{\text{electricity},y}$ (tCO$_2$e)</th>
<th>$BE_{\text{biomass},y}$ (tCO$_2$e)</th>
<th>$PE_y$ (tCO$_2$e)</th>
<th>$L_y$ (tCO$_2$e)</th>
<th>$ER_y$ (tCO$_2$e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>113,638</td>
<td>17,016.3</td>
<td>3786.6</td>
<td>0</td>
<td>126,868</td>
</tr>
</tbody>
</table>

Therefore, the annual emission reduction of $ER_y$ for this project will be 126,868 tCO$_2$e.

### 9.8.7 CDM revenue of straw power projects

Presuming that the price of CERs is 10Euro/ tCO$_2$e, the CDM venue of the projects will be 1,268,680 Euro.

### 9.9 Summary on emission reductions for priority biomass projects

From analysis above, the summary of emission reductions for the priority biomass projects is as following:
Table X. 23 Summary of emission reductions for priority biomass projects

<table>
<thead>
<tr>
<th>NO.</th>
<th>Project</th>
<th>Brief description</th>
<th>Methodology applied</th>
<th>Emission reductions (tCO₂e/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Biogas project</td>
<td>It is to collect biogas from the manure management systems in a livestock farm with 43776 cows. There is power capacity of 3.97MW in the project. And the annual biogas supply of the project is 2,350,000m³</td>
<td>ACM0010 ‘Consolidated baseline methodology for GHG emission reductions from manure management systems’</td>
<td>67,439</td>
</tr>
<tr>
<td>2</td>
<td>straw gasification project</td>
<td>It is to utilize the residual straws for energy use. Annual syngas generation is 3,250,000m³ which comes from the gasification process of 1,530,120 tonnes of straws.</td>
<td>AM0025 ‘Avoided emissions from organic waste through alternative waste treatment processes’</td>
<td>1,172,115</td>
</tr>
<tr>
<td>3</td>
<td>straws power project</td>
<td>It is to generate electricity with power capacity of 24.3MW from 250,000 tonnes of straws.</td>
<td>ACM0006 ‘Consolidated baseline methodology for grid-connected electricity generation from biomass residues’</td>
<td>126,868</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Total emission reductions</strong> 1,366,422</td>
</tr>
</tbody>
</table>
Annex 8

Dissemination Material
(as separate documents)
Annex 9

Study Tours:
National
International

A delegate of 10 persons, who came from Rural Energy Office of Gansu Province and Asian Development Bank Technical Rural Energy Project Office of Gansu Province joined the study and research in China which supported by Asian Development Bank from March 28th to April 7th, 2008. In this activity, the delegate visited Large and Middle Scale Biogas Projects in Zhejiang, Fujian and Jiangxi Province, and the first biogas of Asian Development Bank Loan Project on Rural Energy which has been implemented in Jiangxi Province. And this delegate had the discussion with experts and leaders from rural energy departments of Zhejiang, Fujian and Jiangxi Province, and also the leaders and persons from the industry who are related to the project. Through this study trip, recognition and understanding on the development of rural clean energy and large and middle scale biogas projects have been strengthened, and initial understanding of the situation of loan of Asian Development Bank used in rural clean energy field has been delivered to the participants.

1. Study aim

1) Idea Development: to study the new idea and methods of rural clean energy development in advanced provinces, learn from the successful experience and the new idea to promote the rural clean energy development in Gansu.

2) Management and technology: to study the planning, construction, management operation measurement and technologies of large and middle scale biogas projects to guide the projects of Gansu province.

3) Strengthen cooperation and project preparation: to study how to utilize the grant and loan from international organizations to develop local rural clean energy though the cooperation, and to improve the capability of project planning and preparation.

2. Main content of the study

1) Large and middle scale biogas project. The main arrangement of the study trip were large and middle scale biogas projects in Zhejiang Shaoxing Zhongda Livestock Co., Ltd., Jiaxing Lvjiayuan, Fujian Fuqing City Fengze Agriculture and Livestock Technology Development Co., Ltd., and Wanli Breeding Pig Farm Jiangxi Nanchang Wanli District Luoting Town.

2) ADB projects. Firstly, the delegate visited the village where the first batch of ADB loan project was implemented, the household of biogas project in Zhangjia Group, Jiluo Village, Xiangtian Town, Jing'an County and the comprehensive development pattern of pig-biogas-fruit; Secondly, the delegate leaned the relevant situation on the preparation of the second phase ADB Loan project (large and middle scale biogas project).

3. Main achievements

1) Formalization is the important trend to develop the rural biomass energy (biogas project). Though the study trip in Zhejiang, Fujian and Jiangxi province, the participants can apparently feel that the development speed of the rural biomass energy in these three provinces is fast, the utilization method is more wider, and the development pattern preferred formalization. Taken 2007 as the example, the development situation of biomass energy (biogas project) which was concluded from the visited places is that the household biogas construction scale of Gansu and Jiangxi are larger than those of Fujian and Zhejiang, and at the same time of keeping steady development of the household biogas, the quantity of large and middle scale biogas project of Fujian, Zhejiang and Jiangxi is larger than that of Gansu. This phenomenon fits well with the social and economic development situation in these four provinces. And this fully explained that as the economic development and the
agriculture production, especially the reform of the animal husbandry production method, the utilization of biomass energy (biogas project) will develop from the small scale and the single form to the formalization and multiplication direction.

2) Large and middle biogas project should take the ecology as the premise, and consider the benefit and the sociality comprehensively. The development pattern in Fujian Fuqing, Shaoxing Zhongda and Jiangxi Wanli fully explained this point. Shaoxing Zhongda is one of the pattern breeding pig farm with 33000 live pigs in the livestock, annual supply of 5000 breeding pigs and sale of 60000 commodity pigs. And the initial motive to build the large scale biogas project is to treat the waste water reasonably, to implement the ecological breeding, to generate electricity with biogas, and to breed the fish and fertilize the farmland with digestate. The 1000m³ biogas tank which was built in 2005 with the capacity of 100kW has been in use and it implemented the comprehensive treatment of waste water and utilization of biogas from the pig feces, and it promoted effectively the industrialization process of Zhongda Livestock non-public harm breeding industry and its sustainable development. And currently this breeding farm is planning to build another large biogas project to fully utilize the feces of the farm.

3) Comprehensive development and utilization is the base of sustainable development of large and middle scale biogas project. According to the function requirement of pollution prevention, energy production and ecological agriculture construction, the outstanding characteristics is to make the large and middle scale biogas project construction to be the important public project of new rural area construction, and to realize unification of the economic benefit, social benefit and the ecological benefit. The large and middle scale biogas projects of Fujian Province Fuqing City Fengze Agriculture and Livestock Technology Development Co., Ltd take the guideline of developing the agriculture circulation and carry out the comprehensive utilize of biogas liquid and digestate to develop the ecological agriculture at the same time when it provide the clean fuel to the breeding farm, promote the production of non-public harm fruit (Longan), make the farm meet the emission standard, and realized the dual goals of resource utilization of feces and the environment treatment. And this farm is the production base for non-public harm live pig and Longan in Fujian Province, the research base for China Agriculture University and Fujian Agriculture and Forestry University, and it develops very well.

4) Developing the finance channel continuously, and utilizing international capital actively are also the effectively way to promote the fast development of rural clean energy.

Organized by Foreign Economic Centre of Chinese Ministry of Agriculture, the first batch of rural energy ecological construction project with ADB loan (USD 33.10 Million) has been conducted in June 26th, 2003 undertaken by Shanxi, Henan and Hubei provincial rural energy office and the Utilization Foreign Investment Office of Jiangxi Agriculture Department, and good benefits on economic, sociality and ecology have been achieved. The projects increased the energy supply of the project implemented area, effectively promoted the pollution control from the agro-organic wastes and realized the harmonious development of rural energy, agriculture ecology and agriculture economic society though the demonstration are of ecology pattern with household biogas, formalization of the energy and environment project of the breeding farm, and the project construction of centralized gas supply with straw gasifying technology. Jing'an County of Jiangxi Province, which visited by the delegate during this trip, used 700 thousand USD dollars from ADB totally and installed 430 household biogas projects with loan of 10 thousand per household, the loan term of 3-7 years, and the average investment of 20 thousand RMB per household, and also used the GEF Grant on Poverty Reduction. This county fully considered the harmonious and comprehensive development of breed, biogas and planting during the project implementation, explored and promoted the development pattern of live pig-biogas-fruit (orange) successfully. The pattern of “1 labour force+5 acre orange+6 live pigs + 8m² biogas tank” concluded by this county can realize the net annual income of 18 to 25 thousand RMB. After the conclusion of the
successful experiences in the first batch project, Ministry of Agriculture organized the preparation of second batch of ADB rural energy ecology construction project in Shanxi, Henan, Jiangsu, Jiangxi, Heilongjiang, Shandong and etc provinces. And the preparation is going on, and it proposed to use 0.1 billion USD dollars of Asian Development Bank and certain amount grant to carry out the large and middle scale breeding farm biogas project construction. Preliminary statistics shows that there are more than 330 companies for selection. The responsible person from Utilize Foreign Investment Office of Agriculture Department of Jiangxi Province introduced that it is inevitable to construct and develop the large and middle scale biogas project as the formalization operation of breeding industry and intensification raising area develop fast.

4 the promotion action on current technical aid project

This study will have positive influence on the on-going ADB technical aid project in our province. And it will be presented on renewable energy development planning, construction of demonstration project, selection and development of prior projects and promotion on rural clean energy development using domestic and foreign finance. Though the study, all participants of the delegate thought that as the transformation of production method of livestock in Gansu Province, large and middle scale biogas project construction in raising farm is the inevitable trend of biogas energy development of Gansu Province, the combination of pollution prevention, energy production and ecological agriculture is the development direction, thermal-electricity-and fertilizer cogeneration is the basic mentality. Through the investigation and study on the comprehensive development situation of energy production, breeding and planting in the large and middle scale projects in Zhejiang, Fujian and Jiangxi Province, decision to construct two demonstration projects of Tianshui Aoniu Biogas Power Project and Huashi Ecology School has been consolidated which will act positively on the aspects of expansion the biogas energy utilization method and the innovation of the utilization pattern. At the same time, the pattern of mainly developing large and middle scale biogas project construction in biomass energy prior projects in renewable energy development planning has been clarified. Concerning the actual situation of Gansu, and compared with Zhejiang, Fujian and Jiangxi Province, the delegate feel that as a western province with less-developed economy Gansu should do more in the aspect of rural clean energy, the demand of utilizing the capital from home and abroad to support the development is more urgent, and the main tasks from now on is to widen the finance channel and promote the development of rural clean energy with the capital from home and abroad widely.

5 Main suggestions

1) When the consulting expert group makes the renewable energy development planning, they should consider the actual condition of Gansu, adopt the new pattern of biomass utilization when develop the household biogas steadily and develop the large and middle scale biogas project fast, and apply for the capital support from ADB and other international organizations positively to carry out the trial construction such as straw direct-fired, solidify and local centralized biogas power generation and etc.

2) Asian Development Bank and other international organization should consider the actual condition of economic development in different areas comprehensively, more support and larger preference should be given to the economy less-developed provinces such as Gansu, procedure should be simplified further, and support to the development of Gansu clean energy should be increased and fastened.

April 14th, 2008
### Participants List of ADB TA4935 PRC Domestic Study Tour

<table>
<thead>
<tr>
<th>Name</th>
<th>Unit</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pan Xiaoren</td>
<td>Gansu Rural Energy Office</td>
<td>Senior engineer</td>
</tr>
<tr>
<td>Chen Junqi</td>
<td>Gansu Rural Energy Office</td>
<td>Senior agronomist</td>
</tr>
<tr>
<td>Meng weiguo</td>
<td>Gansu Rural Energy Office</td>
<td>Senior engineer</td>
</tr>
<tr>
<td>Bian Shoue</td>
<td>Gansu Rural Energy Office</td>
<td>Economist</td>
</tr>
<tr>
<td>Hu Chunrong</td>
<td>Gansu Rural Energy Office</td>
<td>Engineer</td>
</tr>
<tr>
<td>Li Mingjun</td>
<td>Gansu Rural Energy Office</td>
<td>Engineer</td>
</tr>
<tr>
<td>Fan Shengrong</td>
<td>Gansu Rural Energy Office</td>
<td>Agronomist</td>
</tr>
<tr>
<td>Teng Huaiyuan</td>
<td>Gansu ADB TA 4935 PMO</td>
<td>Researcher</td>
</tr>
<tr>
<td>Lei Baiyue</td>
<td>Gansu ADB TA 4935 PMO</td>
<td>Engineer</td>
</tr>
<tr>
<td>Li Kai</td>
<td>Gansu ADB TA 4935 PMO</td>
<td>Engineer</td>
</tr>
</tbody>
</table>
Six government officials organized a delegation on behalf of the GPDAAH, GDRC and GFB have conducted an international tour study supported by ADB from February 23rd to March 4th 2009. They have inspected wind power and biomass energy development in Denmark and England, met and had discussions with related directors of energy industry and companies. Through inspection, acknowledgement and understanding for RE development have further strengthened, enhanced the confidence to popularize the rural clean energy development and clear the development target for the way forward.

1. Study purpose

1.1. Development target—to study European clean energy development ideas and ways, to adopt successful experience and promote rural clean energy development for Gansu.

1.2. Management and technology—Study matured management mode and technology of biomass energy and wind power development in Europe, plan and monitor Gansu's project construction.

1.3. Enhance corporation—Through inspection and study, explore the way to strengthen corporation, utilize international resource and market for RE development in Gansu.

2. Study details

The study focuses were RE development, acquired achievement, development strategy, policies and measures for encouragement of RE development in Denmark and England, having a site visit to Danish Wind Energy Middelgrunden Offshore Wind Farm and Wilton International, Sembcorp Utilities (UK) Limited, having a discussion with experts from English IT Power LTD and Danish COWI Energy Company for further corporation feasibility.

3. Main acquisitions

3.1. Fast development of RE development is the tendency, more and more becoming the countries’ energy construction focus.

Via the study in Denmark and England, officials of the delegate have deeply felt that RE development in these two countries has started early with matured management and technology, wide utilization way and fast development tendency. Governments have paid great attention to RE development and it has become the focus for current and future energy construction in both of the countries. Since 1950s, Denmark has started the wind turbine development and the first wind turbine was installed in 1957. With the approach and overspread of petroleum crisis in 1970s, Denmark has fastened wind power utilization development. In 1982,
modern wind turbine has formally produced, from 15kW & 45kW household wind power to installation of national and international wind power plants, 40% of world wind turbines are produced and supplied by Denmark, 20.8% power in Denmark is wind power. RE power in England is 5% and grows annually, it increased 8.4% in 2007 compared with 2006, 82% RE is biomass energy. England has planed that by 2020, RE will reach 20% of the total energy. In addition, the delegate has known that RE development in Europe has developed very quickly, especially in Germany, England and Spain, the wind power has greatly developed in 2002-2006 (See details in table 1), annual growth for England and Spain is above 30%.

Table 1: Wind development in several countries in Europe in 2002-2006

<table>
<thead>
<tr>
<th>Country</th>
<th>Wind power installation (MW)</th>
<th>Accumulative growth (%)</th>
<th>Annual average growth (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2002</td>
<td>2004</td>
<td>2006</td>
</tr>
<tr>
<td>Spain</td>
<td>4830</td>
<td>8263</td>
<td>11615</td>
</tr>
<tr>
<td>Germany</td>
<td>12001</td>
<td>16629</td>
<td>20622</td>
</tr>
<tr>
<td>England</td>
<td>552</td>
<td>888</td>
<td>1963</td>
</tr>
</tbody>
</table>

3.2 Big support from government, right policies and measures and obvious effect

In order to support RE development, the two countries have established a series of policies and measures to encourage RE development. Since 1990, England has carried out NFFO (Non Fule Obligation) to guarantee the RE development and continual policies have been carried out to promote RE development. In 2002, England adopted RE law obligation, which required that the power suppliers should have a certain amount of RE power offered to customers. The proportion of the RE power concides with those regulated by the government. Power suppliers can choose RE project to invest for power generation or purchase needed power from other RE supplies to offer consumers based on fixed price. It has been monitored by special agency and implemented as per RE obligation. It has planned that by 2010, the RE power will reach 10% and 15% in 2015. 2007 Energy White Book of England has reaffirmed that by 2050, CO2 emission will reduce 60%. In 2020, substantial progress and four aims of energy policy to ensure reliable energy supply must be realized. Through restrictions to power supply enterprises, RE power development can be ensured. Though there is no direct preference for RE tariff, practice proves that it's very effective. Since 2002, market tariff has increased from 1.5 pennies/kWh to 4 pennies/kWh. Renewable Obligation Certification (ROC) is 3 pennies/kWh and 1.5 pennies/kWh extra income can be got from revolving fund, meanwhile from 2003-2006, British government offered 0.7 billion pounds every year to support RE enterprise development and the fund continually increased annually. Denmark has focused on promotion energy supply diversities, encouraged the RE development, improved energy utilization efficiency, saved energy, funded by government to support RE research and utilization, upheld power grid connection to wind power close to sea and land, privileged taxes also offered to wind power.
3.3 Social concern and wide public participation, the key factor for success of RE development

Successful operation practice of Danish Wind Energy Middelgruden Offshore Wind Farm has proved that social concern and wide public participation have played an important role for RE development. Installed capacity for Denmark Offshore Wind Farm is 40MW (20×2MW) and annual power generation is 89000MWh and offer 3% power to Copenhagen. The total investment is 48 million Euro. There are 8527 individuals, groups and companies investing in the wind farm, which is a pilot wind farm with wide community participation. This kind of operation has made public more concerned and understood clean energy development, thus laid a good foundation for RE development, currently 81% of Danish wind power projects are based on local and community development. As per investigations from related Danish institutes, 75-80% public have supported more constructions of wind power farm to ensure clean energy supply, including people who see and contact with wind turbine every day, only 2% complain about the wind turbine noise which comes from the old wind turbine that is now banned to use.

3.4 High-quality construction and stable efficient operation, the foundation for sustainable development of RE

From the RE development history of Denmark and England, RE development and utilization has started from the end of 1970s and speedy developed from the end of 1980s to early years of this century. From the beginning, the two countries have paid great attention to project planning demonstration. Take Denmark wind power development as an example, quality has put in the first place since the manufacturing of the wind turbine in 1950s, currently the quality and development of wind turbine in Denmark is in the leading position of the world. In addition, the principal of Danish Wind Energy Middelgruden Offshore Wind Farm introduced that with the promotion of wind power development, Denmark has been concerned more about the wind power construction quality and operation efficiency since 2001. Though the growth rate of wind power installed capacity in Denmark is less than Spain, England and Germany, its operation efficiency is in the leading position of the world, thus attracting wide participation from all sides and ensuring the Danish wind power development level and economic benefit, laying a solid foundation for sustainable development.

3.5 Integrated utilization and scaled development, the key factor for RE development

Either in Denmark or in England, RE is in integrated utilization and scaled development. Take biomass energy development as an example, the installation capacity of which is MW. In Sembcorp Biomass Power Station of England, annual consumption is 300,000 ton firewood (including renewable old furniture, wood chips of timber mill, energy core wood) with 30 MW annual power generation supplying power to 30,000 households. Besides, biogas project and biomass energy combustion have adopted combined heat and power generation and integrated utilization, which has greatly improved energy efficiency, promoted resource saving, high efficient utilization and economic benefit.

3.6 Strengthening international corporation, positively using international capital-an effective way to promote speedy RE development

RE utilization of Denmark and England is in the leading role all over the world and the two countries have still paid much attention to cooperate with other countries. They not only have focused on technology cooperation, equipment & technology export, but actively encouraged and supported RE development of
other countries and multinational companies, using international capital to promote RE development. Sembcorp biomass energy power plant is a multinational company that has been invested by Singapore and built in England. Denmark has concentrated on international, multilateral and bilateral energy cooperation to upgrade international position of Denmark in energy field. Denmark, along with bordering countries of Northern Europe, as Norway and Sweden, has set up North Europe Power Grid, which can regulate supply and demand as per power import and export at any time, also conduct cross-border energy trade with the whole European Union.

4. Promotor action to the current TA project

The study have had a great significance to current implementing TA projects in Gansu. First, it has widen the view and is in favour of the improvement of REDP. Second, it has cleared the train of thought and promoted REDP’s application in the next phrase RE development practice and better guided the RE development in Gansu. Third, it can speedily utilize the foreign capital to fasten the RE development and strengthen the corporation with ADB. Fourth, the delegate is organized by several government departments, which will be of great benefit for the next stage project preparation.

Gansu is an underdeveloped province in west China, rural clean energy development is far behind, urgently needs national and international fund to support development. Actively widening the fund-raising way and widely making use of the national and international fund will be the major task for promoting rural clean energy development in future.

Annexes:

1. Name List of International Tour Study
2. Travel Route of International Tour Study

March, 19th, 2009
Figure A9-1 Director Steve and the delegates in Sembcorp Biomass Plant of UK

Figure A9-2 Director Neils Lund and the delegates in Middelgrunden Offshore Wind Farm of Denmark

Figure A9-3 Discussion with Director Neils Lund
## Annex 1:

Name List of International Tour Study

<table>
<thead>
<tr>
<th>Name</th>
<th>Sex</th>
<th>Nationality</th>
<th>Working department</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wu Wenbin</td>
<td>male</td>
<td>China</td>
<td>Gansu Province Department of Agricultural and Animal Husbandry</td>
<td>Director</td>
</tr>
<tr>
<td>Sun Xiaowen</td>
<td>male</td>
<td>China</td>
<td>Gansu Development and Reform Committee</td>
<td>Vice director</td>
</tr>
<tr>
<td>Luo Jixue</td>
<td>male</td>
<td>China</td>
<td>Gansu Rural Energy Office</td>
<td>Director</td>
</tr>
<tr>
<td>Teng Huaiyuan</td>
<td>male</td>
<td>China</td>
<td>Gansu Rural Energy Office</td>
<td>Researcher</td>
</tr>
<tr>
<td>Chen Mingqing</td>
<td>female</td>
<td>China</td>
<td>Gansu Financial Bureau</td>
<td>Project officer</td>
</tr>
<tr>
<td>He Qikong</td>
<td>male</td>
<td>China</td>
<td>Qingyang Financial Bureau</td>
<td>Vice director</td>
</tr>
</tbody>
</table>

## Annex 2:

Travel Route of International Tour Study

<table>
<thead>
<tr>
<th>Date</th>
<th>Travel Route</th>
<th>Transportation Tool</th>
<th>Details</th>
<th>Person connected and met</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb, 23rd, Monday</td>
<td>Beijing—Paris—Copenhagen</td>
<td>CA933 1330/1745 and SK568 2045/2240</td>
<td>Visit MIDDELGRUNDEN WIND FARM</td>
<td>Inger Blomstrand Sorensen COWI (energy company) Mr. Niels Lund Director of Danish Wind Energy Middelgrunden Offshore Wind Farm</td>
</tr>
<tr>
<td>Feb, 24th, Tuesday</td>
<td>Copenhagen</td>
<td></td>
<td>Visit MIDDELGRUNDEN WIND FARM and other related places</td>
<td>Mr. Niels Lund Director of Danish Wind Energy Middelgrunden Offshore Wind Farm</td>
</tr>
<tr>
<td>Feb, 25th, Wednesday</td>
<td>Copenhagen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Location</td>
<td>Flight Code</td>
<td>Activity/Contact Information</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>---------------------------</td>
<td>-------------</td>
<td>-------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Feb, 26th</td>
<td>Copenhagen ★</td>
<td>SK503</td>
<td>26FEB CPHLHR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>London ★</td>
<td></td>
<td>Hilary Branfield IT Power LTD</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mr. Terry Waldron</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Semcorp Public relation manager</td>
<td></td>
</tr>
<tr>
<td>Feb, 27th</td>
<td>London ★</td>
<td></td>
<td>Visit related clean energy projects besides London</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mr. Steve Semcorp Biomass power plant technology manager</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb, 28th</td>
<td>London ★</td>
<td></td>
<td>Discussion with Ms. Hilary Branfield from IT Power LTD and group discussion</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March, 1st</td>
<td>London ★</td>
<td></td>
<td>Travel to Middlesborough</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Middlesbrough ★</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March 2nd</td>
<td>Middlesbrough ★</td>
<td></td>
<td>Visit Wilton International, Semcorp Utilities(UK) Limited</td>
<td></td>
</tr>
<tr>
<td></td>
<td>London ★</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March 3rd</td>
<td>London ★</td>
<td>CA938</td>
<td>03MAR travel to Beijing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Beijing ★</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March 4th</td>
<td>Beijing ★</td>
<td></td>
<td>Arrive in Beijing</td>
<td></td>
</tr>
</tbody>
</table>
GANSU RURAL CLEAN ENERGY DEVELOPMENT PROJECT

Gansu Renewable Energy Development Plan

May 2009

Beijing BJT Consulting Ltd.

in association with

IT Power Ltd.

and

Tripod Wind Energy ApS
Gansu Renewable Energy Development Plan

Annex 2 for the final report of GANSU RURAL CLEAN ENERGY DEVELOPMENT PROJECT

Client contract No.: TA4935PRC

FINAL
June 09

Contractor:

BEIJING BJT CONSULTING LTD

1-202, Building 3, Baizhifang Dongjie,
Beijing 100054, P.R. China
Tel: +86 10 6355 4694
Fax: +86 10 6357 0904
E-mail: jicai.hu@bjt.com.cn
http://www.bjt.com.cn

Document control

<table>
<thead>
<tr>
<th>File path &amp; name</th>
<th>N:\Drive1\DATA\0Work\ITP\0Projects\1016 Gansu RE project\2Work\REDP\Gansu REDP v2.5.doc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author</td>
<td>Rebecca Gunning, Hu Jicai, Gu Shuhua, Min Deqing, Zhu Zhao, Zhao Lixin, Wei Songxian, Zhou Wei, Li Jingming, Soren Gjerding, Pei Xiaodong</td>
</tr>
<tr>
<td>Project Manager</td>
<td>Rebecca Gunning</td>
</tr>
<tr>
<td>Approved</td>
<td>RG</td>
</tr>
<tr>
<td>Date</td>
<td>April 2009</td>
</tr>
<tr>
<td>Distribution level</td>
<td>not for distribution</td>
</tr>
</tbody>
</table>
TABLE OF CONTENTS

1 Background ......................................................................................................................... 4
  1.1 Rural natural conditions ............................................................................................... 4
  1.2 Rural socio-economic situation .................................................................................. 5
  1.3 Rural energy consumption .......................................................................................... 8
    1.3.1 Low consumption level ....................................................................................... 8
2 Potential resources ............................................................................................................. 10
  2.1 Biomass Energy .......................................................................................................... 10
  2.2 Wind energy ................................................................................................................. 18
  2.3 Solar energy ................................................................................................................ 20
  2.4 Mini or small hydro ..................................................................................................... 21
3 Rural Energy Development Status ..................................................................................... 27
  3.1 Current Status of rural energy ..................................................................................... 27
    3.1.1 Main technologies used ....................................................................................... 29
  3.2 Rural Energy Case Studies ......................................................................................... 29
    3.2.1 Lanzhou Huazhuang Biogas Power Project ......................................................... 29
    3.2.2 Stalk Gasification Power Plant in Shandan County .............................................. 32
  3.3 Current status of wind development ............................................................................ 35
  3.4 Major issues in renewable energy development ........................................................ 37
    3.4.1 SWOC Analysis of Wind power in Gansu ............................................................. 37
    3.4.2 SWOC Analysis of Biomass power generation in Gansu .................................... 39
4 Rural living energy analysis to 2015 ................................................................................. 47
  4.1 Targets for rural Socio-economic development plan .................................................... 47
    4.1.1 Targets to 2010 ................................................................................................. 47
    4.1.2 Major social economic indicators of 2010 .......................................................... 48
    4.1.3 Targets to 2015 ................................................................................................. 49
  4.2 Rural Energy demand forecast ..................................................................................... 49
5 Master Idea and Development Targets ............................................................................. 51
  5.1 Direction ...................................................................................................................... 51
  5.2 Basic Principles .......................................................................................................... 51
  5.3 Targets for development and use ............................................................................... 52
    5.3.1 Biomass development targets to 2010 ................................................................. 52
    5.3.2 Biomass development targets to 2015 ................................................................. 53
    5.3.3 Wind Development Target .................................................................................. 53
6 Development Focus, Distribution and Scale ..................................................................... 57
  6.1 Development focus ...................................................................................................... 57
10.2.1 Clear Responsible Organisation for Gansu REDP ......................... 101
10.2.2 Perfect the policy and increase the investment ............................ 101
10.2.3 Increase manufacturing .............................................................. 101
10.2.4 Increase private sector participation ........................................... 102
10.2.5 Improve project management ..................................................... 102
10.2.6 Improve technology efficiency and further technology introduction and increase the number of demonstration projects. .............. 102
10.2.7 Capacity Building - Training and Dissemination ........................ 102
10.2.8 Clarify pricing policy for developing rural clean and renewable energy ......................................................................................... 102

10.3 Measures for implementation and safeguarding ............................ 103
10.4 Monitoring .................................................................................. 108
  10.4.1 Indicators ............................................................................... 108
  10.4.2 Data Availability and Responsibility for Monitoring .................. 109
  10.4.3 Review of the REDP ............................................................... 109

Annex 1 - New Rural Renewable Energy Technologies Introduction .......... 110
Annex 2 Overview of Biomass Power Generation in China Rural Areas .......... 121
Annex 3 – Wind Turbine Supplies in Gansu .......................................... 146
1 BACKGROUND

1.1 Rural natural conditions

Gansu province is located at China’s geographic centre on the upper reaches of the Yellow River. The geography in Gansu is complex and varied, including mountains, plateaus, plains, valleys and desert. The topography in Gansu can be divided into six regions, including South Longnan mountains, Longzhong Gansu loess plateau, Gannan plateau, Hexi Corridor and Qilian mountains and the Hexi Corridor in the North. Gansu is dominated by mountains and plateaus with the majority of land greater than 1000m above sea level. The main mountains include the Qilianshan, Wuqiaolin and Liupanshan. The forests are mainly distributed in the mountainous area and most rivers originate from these mountains.1

The climate in Gansu is “continental temperate zone monsoon climate”, with a long and cold winter, little separation between spring and summer, short summers with high temperatures; then the temperature in autumn falls rapidly. The average temperature in Gansu is between 0-16°C, depending on altitude and the daily temperature range is large. The rainfall in Gansu is between 36.6-734.9mm, reducing from southeast to northwest, the rainfall is concentrated during the summer months, June to August, accounting for 50-70% of annual total. The non-frost period is between 140-280 days.

Gansu province has a total area of 454,000km², including 48,800 km² farmland, 48,000km² forestland, 141,800 km² grassland and 190,900km² undeveloped land.

In 2006, of the 15 rivers in Gansu, 7 rivers had good water quality, 2 rivers were slightly polluted and 6 rivers were seriously polluted. The main pollutants are COD, BOD and NH3-N. The drinkable water sources had good water quality, most cities water supplies met water quality standards except Baiyin city. In 2006, urban air quality in most cities dropped; the main factor being the increase of TSP pollution. The 4 cities including Lanzhou, Baiyin, Jinchang and Zhangye, listed in the national SO2 control zone effectively controlled the SO2 pollution and their annual SO2 concentration is decreasing. In 2006 there were 16 sandstorms, and the frequency of sandstorms increased.

Gansu is a region with a relatively weak ecological environment. Across Gansu the geographic and natural conditions are quite different. The Loess hilly regions in Gansu are one of the areas with most serious soil loss. In the Longnan region on the upper reaches of Yangtze River, soil loss is caused by over cutting of forest, steep slope development and mining, meanwhile slope sliding, mudslide and desertification of land surface also takes place. In the Hexi region, due to existence of large amount of gravel, Gobi and sand dunes, sandstorms and dry hot wind becomes main natural disasters in the region. In the grassland region, due to over-grazing and erosion, the grassland suffers serious degradation, and the desertification is exacerbated.

Currently the ecological environment has the following key issues:

1. The soil loss is being exacerbated. In Gansu soil erosion affects 389,000 km² of land, accounting for 85.6% of the provincial total area. The serious soil loss has

1 Because of the data availability, the majority of data in this report is from 2006 statistics for Gansu.
not only hindered the economic development and social progress in the river basins, but also deteriorated the ecological environment. Natural disasters such as drought, frost, hail and rainstorm take place frequently.

2. The water storage capacity of forest is decreasing. It is estimated that the annual reduction of water storage capacity could be more than 5.597 billion tones due to the deterioration in forest quality, compared with storage water source and optimum forest status.

3. Desertification continues to spread, the land desertification area in Gansu has reached 82,800km², accounting for 18% of the provincial total area.

4. The drought disaster is exacerbated. According to the historical data, droughts occurred 1-2 times per 100 years in the 13th century and 12-15 times per 100 years after the 14th century. During the 100 years before 1950, there were 71 droughts in Gansu. Over the recent 50 years after 1950, droughts occurred more than 30 times. The non-rain days have increased from 55 days to more than 190 days. During the crop growth period of May to September, the non-rain days amount to 46-136 days, which brings serious threat to agricultural production.

5. The bio-diversity has suffered serious destruction. The destruction of natural vegetation greatly reduces the vegetation’s ecological function such as wind prevention and sand fixing, water storage and soil loss prevention, water source conservation and air quality improvement. On the other hand, a large amount of animal and plant species have suffered serious threat and destruction, meanwhile destroying forest for land development and step slope crop planting has exacerbated the loss caused by natural disasters.

The main reasons for this deterioration in the ecological environment in Gansu include:

1. Expanded human activity, resettlement, land development and over extraction of ground water

2. The short supply of rural energy has led to over-cutting, illegal mining and grass vegetation destruction, causing the destruction of the ecology and vegetation. The Gansu Forest Industry Survey and Planning Institute survey found that the total firewood consumption in Gansu reached 3.52Mt in 2006, while the environmentally acceptable firewood production is 1.76Mt, over cutting of firewood has resulted in the destruction of the ecological environment.

3. The growth in population has increased the resource demand; the rural population in Gansu has increased from 20.31 million in 2000 to 20.79 million in 2006;

4. Over-grazing has resulted in the desertification of grassland;

5. There is low input and investment in restoring the ecological environment.

1.2 Rural socio-economic situation

There are 14 cities/states or 87 counties/districts under the administration of Gansu province. There are 21 minority concentrative inhabit counties in Gansu. The minority population is about 9% of the total population. There are 16 major minorities in
Gansu including Hui, Zang, Dongxiang, Tu and Yugu etc. There are 5 religious faiths in Gansu including Islam and Buddhism\(^2\).

Since China’s reform and opening-up, Gansu has undergone rapid social and economic development and increasing integrated productivity, the living standard of rural residents has been improved dramatically. But Gansu is still one of the poorest provinces in China in because of the limitations of its geological and environmental conditions. In Gansu there are still a number of counties/districts with national levels of poverty. In 2005, there were 43 national level poverty counties with a population of 11.02 million, which represents 42.79% of Gansu’s total population or 56.69% of Gansu’s rural population. Among them, in terms of rural residents’ annual net income, 1.96 million were under RMB625, 5.6 million were between RMB625—RMB865 and 3.46 million were between RMB865—RMB1000, which represents 7.61%, 21.75% and 13.44% of Gansu’s total population respectively or, 10.08%, 28.81% and 17.80% of Gansu’s total rural population respectively\(^3\). Tables 1.1 and 1.2 below show the major social and economical conditions of Gansu and its relative conditions in China in 2005 and 2006.

Table 1.1 Gansu’s social and economical conditions\(^1\)

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gansu’s total population</td>
<td>2594.36</td>
<td>2606.25</td>
</tr>
<tr>
<td>(10,000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total rural population</td>
<td>2074.76</td>
<td>2079.37</td>
</tr>
<tr>
<td>(10,000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total rural households</td>
<td>463.69</td>
<td>464.50</td>
</tr>
<tr>
<td>(10,000HH)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural population percentage</td>
<td>80%</td>
<td>79.78%</td>
</tr>
<tr>
<td>(% )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Province GDP per capita</td>
<td>7477</td>
<td>8757</td>
</tr>
<tr>
<td>(RMB)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural resident GDP per capita</td>
<td>2514</td>
<td>2700</td>
</tr>
<tr>
<td>(RMB)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cultivated land per capita</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>(hectare)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per capita annual disposable income of urban residents (RMB) A</td>
<td>8087</td>
<td>8921</td>
</tr>
<tr>
<td>Per capita annual expenditure of urban residents (RMB) B</td>
<td>6592</td>
<td>6974</td>
</tr>
<tr>
<td>% of expenditure to income of urban residents (％ ) B/A</td>
<td>81.5%</td>
<td>78.2%</td>
</tr>
<tr>
<td>Per capita annual net income of rural residents (RMB) C</td>
<td>1980</td>
<td>2134</td>
</tr>
<tr>
<td>Per capita annual living expenditure of rural residents (RMB) D</td>
<td>1820</td>
<td>1856</td>
</tr>
<tr>
<td>% of rural living expenditure to the net income (％ ) D/C</td>
<td>92%</td>
<td>87%</td>
</tr>
<tr>
<td>Gansu total energy production (10,000)</td>
<td>3605.12</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) Gansu Year Book, 2006; Gansu Rural Year Book, 2007.


\(^3\) Gansu Year Book, 2006; Gansu Rural Year Book, 2007.
tons of standard coal

Gansu total energy consumption (10,000 tons of standard coal) 4367.67

Annual rate of energy production during the 10th “five-year-plan” (%) 17.30

Annual rate of energy consumption during the 10th “five-year-plan” (%) 7.72

Per capita rural annual production electricity consumption (kwh) 113

Per capita rural annual living electricity consumption (kwh) 50

Table 1.2 Percentage of Gansu’s major national economical indicators to the whole nation in 2005

<table>
<thead>
<tr>
<th></th>
<th>China A</th>
<th>Gansu B</th>
<th>B/A %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (10,000)</td>
<td>130756</td>
<td>2594.36</td>
<td>1.98</td>
</tr>
<tr>
<td>GDP (100 million RMB)</td>
<td>182320</td>
<td>1934</td>
<td>1.06</td>
</tr>
<tr>
<td>Government revenue (100 million RMB)</td>
<td>31649</td>
<td>255</td>
<td>0.8</td>
</tr>
<tr>
<td>Average wage (RMB)</td>
<td>18364</td>
<td>14172</td>
<td>77</td>
</tr>
<tr>
<td>Per capita disposable income of urban residents (RMB)</td>
<td>10493</td>
<td>8087</td>
<td>77</td>
</tr>
<tr>
<td>Per capita net income of rural residents (RMB)</td>
<td>3255</td>
<td>1980</td>
<td>61</td>
</tr>
<tr>
<td>Per capita foodstuff holds (kg)</td>
<td>379.46</td>
<td>310.79</td>
<td>82</td>
</tr>
<tr>
<td>Per capita agricultural gross output value (RMB)</td>
<td>5030</td>
<td>2514</td>
<td>50</td>
</tr>
</tbody>
</table>

The following are characteristics of Gansu’s rural social economics:

- A rapid and stable development in rural social economics, an increasing integrated productivity strength, the living standard of rural residents has markedly improved;
- Compared to the whole nation, rural residents’ net income is low and unevenness is also appeared among different geological areas;
- Poor natural conditions, agricultural production is limited by many natural factors, which results in poor agricultural economical return;

---

• Mountainous and large area, poor information communication in rural areas and poor infrastructure construction conditions to both rural production and household living.

1.3 Rural energy consumption

Table1.3 shows the rural energy consumption in Gansu. From the table, we can clearly see the characteristics and the main problems.

<table>
<thead>
<tr>
<th></th>
<th>Production energy /million tce</th>
<th>Household energy /million tce</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Physical quantity</td>
<td>Standard coal /million tce</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Physical quantity</td>
<td>Standard coal /million tce</td>
</tr>
<tr>
<td>Commercial energy</td>
<td>3.03</td>
<td>42.1</td>
<td>9.29</td>
</tr>
<tr>
<td>In which: coal (Including coke)</td>
<td>1841.1kt</td>
<td>1.34</td>
<td>18.7</td>
</tr>
<tr>
<td>Product oil</td>
<td>940.9kt</td>
<td>1.34</td>
<td>18.7</td>
</tr>
<tr>
<td>Power</td>
<td>2786GWh</td>
<td>0.34</td>
<td>4.7</td>
</tr>
<tr>
<td>Fuel gas</td>
<td>8111.8km³</td>
<td>0.01</td>
<td>0.1</td>
</tr>
<tr>
<td>LPG</td>
<td>25.7kt</td>
<td>0.04</td>
<td>0.3</td>
</tr>
<tr>
<td>Traditional power</td>
<td>4.16</td>
<td>57.9</td>
<td>4.84</td>
</tr>
<tr>
<td>In which: Fuel wood</td>
<td>8.16million ton</td>
<td>4.16</td>
<td>57.9</td>
</tr>
<tr>
<td>Stalk</td>
<td>64769kt</td>
<td>3.04</td>
<td>21.3</td>
</tr>
<tr>
<td>Local new energy utilization</td>
<td></td>
<td>0.14</td>
<td>1.0</td>
</tr>
<tr>
<td>In which: biogas</td>
<td>62.57Mm³</td>
<td>0.04</td>
<td>0.3</td>
</tr>
<tr>
<td>Solar energy</td>
<td>2.25Mm³</td>
<td>0.1</td>
<td>0.7</td>
</tr>
<tr>
<td>Total</td>
<td>7.19</td>
<td>100</td>
<td>14.27</td>
</tr>
</tbody>
</table>

Source: Nation’s Rural RE Statistics Table (2006), Scientific and Educational Department of Agricultural Ministry, June, 2007

1.3.1 Low consumption level

A. The rural energy consumption in Gansu in 2006 was 2.15Mtce, which is 2.34% of the nation's 91.7 million nation's rural energy consumption.

B. From Table 1.3, per capita energy consumption of rural area in Gansu is 1.03tce, 55.7% of 1.85tce per capita of the nation, 83.1% of 1.24tce per capita of rural area in the nation.
Table 1.4 Energy consumption of rural area in Gansu and the Nation

<table>
<thead>
<tr>
<th>Population</th>
<th>Energy consumption</th>
<th>Per capita</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>/million</td>
<td>/million tce</td>
<td>/ tce</td>
<td>/%</td>
</tr>
<tr>
<td>The whole nation</td>
<td>1314</td>
<td>2423</td>
<td>1.85</td>
</tr>
<tr>
<td>Rural area in the nation</td>
<td>737</td>
<td>917</td>
<td>1.24</td>
</tr>
<tr>
<td>Rural area in Gansu</td>
<td>20.79</td>
<td>21.46</td>
<td>1.03</td>
</tr>
</tbody>
</table>

Statement: Data from Table 1.3, Yearbook of China’s Statistic in 2007 and Yearbook of Rural Statistic in Gansu in 2007

C. From Table 1.4, it can be calculated that annual per capita power consumption in rural area of Gansu is 38.8kWh, which is 61% of the nation's 63.8kWh, lower than 35%.

1.3.2 Unreasonable energy consumption structure

A. The total rural energy consumption in Gansu is 21.46 million tce, however production energy only accounts for 7.19 million tce (33.5%) of this. This shows that rural economy development in Gansu is relatively lagged and small scale peasant economy is still the main function of Gansu province.

B. Of the household energy 65.1% comes from commercial energy sources, which shows that the increase in rural production energy and household energy mainly depends on the commercial energy supplied by the nation, it is likely that the commercial energy supply of the nation will increase. In the table, we can see that rural stalk and fuel wood use is still in high proportion, which explains the changes to farmer’s living style and quality are still small.

1.3.3 Low utilization of new energy

In the last line of Table 1.3, we can see that the development and utilization of new energy such as biogas and solar energy only reaches 143.1 thousand tce, only 1% of household energy consumption in rural area. At present, there are many advanced and suitable technologies for renewable energy development in rural areas in the country; we should commit more labour, physical resource and financial power to strengthen this development

1.3.4 Environmental pollution caused by commercial energy consumption

In Table 1.3, rural household energy consumption is 1.8 million tce firewood, which is equivalent to 3.52 million ton fuel wood. An expert from Gansu Forestry Investigation Planning Institute offered fuel forest data of Gansu, which suggested that the annual reasonable development of fuel wood is only 1.76 million ton. Over-cutting fuel wood as rural cooking and heating energy has had a negative impact on forestry ecological environmental protection in Gansu.

In addition, 61% of household energy comes from coal. The environment pollution from city’s coal burning expands to the countryside, causing negative effect on rural kitchen’s sanitation and air quality
2 POTENTIAL RESOURCES

2.1 Biomass Energy

There are many kinds of biomass energy which include agricultural crop wastes, forest waste, oil plants, energy crops, household garbage and animal dung, etc. This report will mainly focus on analysis of the key resources in Gansu of agricultural stalks and animal dung, although forestry is included for completeness.

Crop Stalks

Gansu produces a large variety of crops. While the main produce from these crops are shipped and eaten, the stalks which are a waste product can be used as a main source of biomass energy.

Wheat, corn, potato, cotton and oil plants are the main crops in Gansu, occupying 33.38%, 37.76%, 8.52%, 4.55% and 8.23% of the total crop land area respectively. Stalk gross in the whole province is 8.92 million tonnes, equivalent to 342 kg per capita. This is lower then the national figure of 560 kg/capita, largely because Gansu is a dry and cold inland province, and the soil is very poor.

Stalk distribution varies across the region according to the data provided by local Rural Energy Offices, as seen in Figures 2.1 to 2.3. Quingyan, Wuwei, Pingliang, Zhangye and Jiuquan are richer in stalk volume and per capita. The source data for the maps is included in Tables 1.1-1.3 in Annex 2. It is calculated using the proportion of grain to stalk using agricultural output figures per administrative region for Gansu in 2006.

Stalks are used in a number of different ways, especially as fertilizer. However, in China, especially west China, stalks are mainly used for living fuels, more than 60% compared to the national average of 50%. Based on the data supplied by the Rural Renewable Resource Energy Statistics of the Country in 2006, stalks used for rural living fuels in Gansu totals 6.47 million tonnes, 72.6% of the province’s total production. Considering the stalk resource’s non-energy use and Gansu's actual condition, 60% of stalks used for living fuel is reasonable. In other words, stalks produced in Gansu would provide 5.35 million tons, equivalent to 2.60 million tce.

According to the data for 2006 provided by Rural Energy Office in the prefectures, the regional distribution of the quantity of stalks for cooking and remained or burnt is also very varied, as seen in Table 2.1 and Figure 2.2. Qingyang and Zhangye are richer in stalk gross for energy use and remained/burned, with 1.16million and 0.61 million tonnes respectively. As for the quantity that remains or is burnt which will be the resource with the most potential biomass projects, Qingyang and Zhangye also rank higher than other prefectures, with the amount of 0.65 million and 0.42 million respectively, as seen in Table 2.2 and Figure 2.3.

Table 2.1 Statistics on stalks for cooking and remained/burned in Gansu

<table>
<thead>
<tr>
<th>Prefecture</th>
<th>stalks for cooking and remained/burned (unit:10,000ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qingyang</td>
<td>116.65</td>
</tr>
<tr>
<td>Wuwei</td>
<td>7.317</td>
</tr>
<tr>
<td>Jiuquan</td>
<td>25.62</td>
</tr>
<tr>
<td>Prefecture</td>
<td>Stalks remaining/burnt (unit: 10,000 ton)</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Qingyang</td>
<td>65.19</td>
</tr>
<tr>
<td>Wuwei</td>
<td>1.70</td>
</tr>
<tr>
<td>Jiuquan</td>
<td>11.55</td>
</tr>
<tr>
<td>Tianshui</td>
<td>0</td>
</tr>
<tr>
<td>Zhangye</td>
<td>42.41</td>
</tr>
<tr>
<td>Pingliang</td>
<td>0.16</td>
</tr>
<tr>
<td>Linxia</td>
<td>8.50</td>
</tr>
<tr>
<td>Lanzhou</td>
<td>0.21</td>
</tr>
<tr>
<td>Dingxi</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2.2 Statistics on stalks remaining/burnt in Gansu
Figure 2.1 Regional distribution of total crop stalks in Gansu

Graphic illustration:
- ≥1 million ton: Qingyang, Wuwei
- 0.5-0.99 million ton: Jiuquan, Zhangye, Tianshui, Longnan
- 0.2-0.5 million ton: Jiuquan, Zhangye, Tianshui, Longnan
- 0.01-0.2 million ton: Wuwei, Lanzhou
- ≤0.01 million ton: Lanzhou, Jiayugan, Jinchang, Gannan, Agricultural reclamation

Figure 2.2 Regional distribution of stalks for cooking and remaining/burnt in Gansu

Graphic illustration:
- ≥0.5 million ton: Qingyang, Zhangye
- 0.2-0.5 million ton: Jiuquan, Pingliang, Tianshui, Linxia, Dingxi
- 0.01-0.2 million ton: Wuwei, Lanzhou
- No data provided
Resources of animal manure

Livestock is divided into pig, sheep, and big cattle (including horse, cow, donkey, mule, and camel). Based on data from the Yearbook of Gansu 2006, livestock inventories are used to calculate the yearly animal droppings and regional distribution in Gansu. The tables are included in the Annex 2 (Table 1.4).

Gansu Province is a big province in the field of animal husbandry. In 2006, the quantity of large livestock and sheep was 6,230,000 and 15.7 million respectively in Gansu, with its total number ranking at the 8th and 9th respectively among the provinces in China. Pig breeding is also important with a total number of 7,080,000 pigs. In view of the future, as stated in the Eleventh Five-year Agricultural Development Planning in Gansu Province, after five years development (2006-2010), the production value of the stockbreeding should account for more than 33% in 2010 compared to that of 25.5% in 2005. The quantity of beef cattle, dairy cattle, and sheep stock in Gansu will reach up to 6.7 million, 150,000 and 35 million respectively, with an average annual increase rate of 4.6%. With the expansion of the breeding volumes, the animal manure will increase accordingly, which will bring forward additional feedstock for biogas project development.

In the Eleventh Five-year Agricultural Development Planning of Gansu Province, it is stressed that the livestock husbandry industry should follow a new mode of growth from traditional breeding and that the development of the large scale animal keeping farms should be encouraged through expanding the livestock breeding zone and developing the husbandry industry standardization. Statistics from the industry show that the scale-up animal breeding farms increased continuously in recent years, the breeding zones increased by 400 sites every year; there are more than 10 cattle farms with more than 1,000 cattle, which will expand to 15 to 20 sites.
The volume of animal manure in Gansu in 2006 was estimated at 11.487 million tons (dry animal dung). There is a large difference in regional distribution as shown in Figures 1.4 and 1.6. Animal dropping resources are plentiful in pasture areas such as Gannan – most commonly cow droppings –, Zhangye – mainly sheep droppings – and Wuwei – mainly sheep droppings –, with Gannan having the top volume per capita as well as general mass. In rural areas the most common type of animal droppings are from pigs.

Poultry droppings, such as chicken and duck, along with rabbit, are not counted as they are less useful as a biomass resource and there is a lack of data regarding them. Animal manure is traditionally used as energy in Gansu: cooking and heating use animal waste and in rural areas it is also used for ondol, or under-floor heating.

Graphic illustration: total cattle droppings are 11.4867 million ton

- ≥1100 thousand ton: Gannan, Wuwei, Longnan, Dingxi
- 1000-1100 thousand ton: Qingyang, Pingliang, Zhangye
- 600-1000 thousand ton: Baiyin, Linxia, Tianshui
- ≤600 thousand ton: Jiuquan, Lanzhou, Jiayuguan, Jinchang, Agricultural Reclamation Bureau

Figure 2.4 Regional distributions of cattle droppings

To estimate the amount of animal droppings available for biogas, the amount which could be collected per year should be considered. According to the investigations of local experts, the collected coefficient of big cattle in pastures is approximately 20%. The sheep droppings are widely dispersed and difficult to collect. In rural areas the collection coefficient for droppings of pig, big cattle and sheep can reach 70%, 20% and 20% respectively. As the economic development in rural and pasture areas
increases, there is a change in the feeding methods, especially with the development of dairy farming and large-scale pig farms. Animal droppings are then presumed to be developed as clean energy such as biogas with good prospects.

Supposing the average collected coefficient of animal droppings in the whole province is 20%, the raw material available for biogas would be 2.3 million tons, equal to 92 million m$^3$ biogas development. This, converted to a thermal value, gives the equivalent of about 0.723 million tce.
Figure 2.5 Cattle dropping resource and regional distribution in Gansu

Firewood and timber processing residues

Firewood is collected from trees and used as fuel; the majority of firewood in Gansu comes from specialised firewood forest and the pruning, nurturing and cutting residues from other forest categories (for example, high, shelter or production forest and residues from forest timber processing such as tree bark, wood dust and shavings).

Gansu has a lack of forest resources. Due to twenty years of hardship, forested areas in 2006 numbered 9.8 million hectares, 21.82% of the total area in Gansu, and 3.44% of the national 285 million hectares. Gansu also has less undeveloped forest, instead having more secondary forest as consumption is larger than growth. The largest areas of
forest are mainly in the south and south-east in Gannan, Longnan and Tianshui – these three places constitute 70% of Gansu’s total forested area.

The sixth forest resource inventory of Gansu was conducted in 2006, and the main results are included in Table 2.3.

Table 2.3 Data information of forest resource in Gansu in 2006

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>proportion %</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest area/10 thousand hm²</td>
<td>981.21</td>
<td>100</td>
<td>21.82% of the whole land in Gansu</td>
</tr>
<tr>
<td>Including Forest land</td>
<td>232.5</td>
<td>23.69</td>
<td>2.32 million highwood hm², 2.32 million bamboo grove 900hm²</td>
</tr>
<tr>
<td>Open forest land</td>
<td>17.16</td>
<td>1.75</td>
<td></td>
</tr>
<tr>
<td>Shrub land</td>
<td>351.85</td>
<td>35.86</td>
<td>Shrub land 2.38 million hm², especially fixed by the country</td>
</tr>
<tr>
<td>Non-forest land</td>
<td>67.74</td>
<td>6.89</td>
<td></td>
</tr>
<tr>
<td>Nursery lands</td>
<td>0.86</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Other forest land</td>
<td>311.2</td>
<td>31.72</td>
<td></td>
</tr>
<tr>
<td>Total amassment of living tree/10 thousand m³</td>
<td>21708.26</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Including Forest (high-wood)</td>
<td>19363.83</td>
<td>89.2</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>2344.43</td>
<td>10.8</td>
<td></td>
</tr>
<tr>
<td>Forest coverage rate/10 thousand m³</td>
<td>13.42</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data source: Press conference of the sixth forest resource investigation result in Gansu

Based on the firewood area and the proportion of different wood species, along with a firewood production table, the amount of available firewood in Gansu can be estimated, and is shown in Table 2.4.

Table 2.4 Firewood product table in North China

<table>
<thead>
<tr>
<th>Firewood forest</th>
<th>High forest</th>
<th>Shelter forest</th>
<th>Shrub forest</th>
<th>Open forest</th>
<th>Production forest</th>
<th>Four-side forest</th>
</tr>
</thead>
</table>
While the amount of firewood appears to be reasonable, varied distribution of forest resources in Gansu means that there can be a vast difference in availability between different areas.

### 2.2 Wind energy

Gansu Province is one of the most abundant provinces in China in respect of wind power, with a theoretical wind power reserve of 237 GW. Gansu is the fifth-best province in China for wind power with an available resource of 26,670 MW which could be developed. The north-west of the province has the highest wind resource, decreasing as one moves south-east.

The areas rich in wind power are the waste deserts in Beidaqiao of Guazhou County, Ganhekou, Xiaowan, Qiaowan, Changma in Yumen City, Diwopu, Qiduntang and Mazongshan county of Subei, and south area of Dangjin Mountain in Akesai. All are in the north of the Hexi corridor, accounting for approximately 23% of the total area of Gansu.

The reserve of annual effective wind energy is above 800kWh/m², the energy density of the annual average effective energy density is above 150 W/m², and the wind effectively blows for 6000 hours⁵.

Other available areas of wind power resource include Gobi Desert areas of Heishankou in Guazhou, Huangmatan, Kuantanshan, Qingshiliang and Heiyazi in Yumen, Songshan in Tianshu, Xingquan in Jingtai, and mountain area in Huajialing in Tongwei County, Jiancaitan in Baijin City which account for 24% of the total area.

While some areas do not have high and low wind seasons, there are other areas which are seasonal. The latter lie in the middle of Gansu and include areas such as Pinchuan in Baijin; Jingtai and the local area of Jingyuan. This covers about 25% of the whole province area. At these locations the annual effective wind energy reserves is

---

⁵ “Effective hours” is a Chinese standard presenting how many hours per year the wind at 10 m height is between 3.5 m/s and 25 m/s. All numbers presented refer to 10 m height.
approximately 280 kWh/m², the annual average effective energy density is about 60 W/m² and the wind effectively blows for more than 3000 hours per annum.

According to thirty-five years’ records from eighty-nine meteorological stations, the wind velocity changes little during the whole year - the difference between the highest and lowest average wind speed at the meteorological stations at 10.5 m is only 1.0 to 1.5 m/s and the coefficient of variation of annual average wind speed is between 0.02 and 0.025.

The 89 meteorological stations are situated in varied locations measuring the wind at 10.5 m. Many of these meteorological stations are situated in cities and are surrounded by high buildings, thus the data from the meteorological stations is not representative for the “free” wind speed outside the cities, where the wind farms are planned. It shall furthermore be noted, that the negative influence from the surroundings on the wind speed has increased over the years, from the installation of the meteorological station until present.

The maximum wind speed at the meteorological stations has not exceeded 39 m/s and no destructive effect on wind power equipment and blades has been recorded. From the same reports, Gansu Province’s lowest temperature was not lower than -30 degrees Celsius, which is within the working temperature range allowing most wind turbines to operate all year round.

The distribution of the annual average wind speed and power density in recent years is as follows:

![Figure 2.6: The distribution of yearly average wind speeds in recent years](image-url)
2.3 Solar energy

Most of the northern provinces in China are rich in solar energy. Gansu belongs to the first class area that has rich solar energy. Most of Gansu has strong solar irradiation and large temperature differences. The total annual solar irradiation in Gansu varies between about 4800-6400 MJ/m² with annual sunshine hours of 1700-3300h.

The Hexi Corridor has annual average sunshine hours greater than 2500h and the annual average solar irradiation is 6000-6400 MJ/m². The grassland areas have annual average sunshine hour greater than 2800h. In the south forest areas annual average sunshine hours are between 2200-2700h except for the area of Wenxian, Kangxian and Huixian (where it is less than 1700h). The annual average solar irradiation is 4800-5200MJ/m². Finally the middle loess plateau has annual average sunshine hours of about 2100-2700h, with annual average solar irradiation of 5400-6200MJ/m².

Figure 2.8 below shows the variation in solar irradiation around the province.
2.4 Mini or small hydro

Rivers in Gansu belong to three river basins: Longnan and Tianshui in the south of Qinlong and part of Gannan is in the Changjiang river basin which has a drainage area of 38.4 thousand km² with complete run-off. Pingliang, Qingyang in east Gansu, Lanzhou, Baijin, Linxia, Dingxi, the middle of Gannan and most of Tianshiu belongs to the Yellow river basin with 0.1445 million km² with a run-off area of 0.1335 million m². The Hexi corridor in west Wushaoling, which includes three counties and two cities, is an inland river basin with 0.2711 million m² with a run-off area of 0.1081 million km².

The theoretical hydropower potential in Gansu is 17.24 GW, the tenth highest in the country. The actual development capacity is 10.21 GW, with annual power generation of 47.446 GWh. Within that, the small hydropower resources, where installed capacity is less than 25 MW is 2.20 GW, 21.57% of the total development capacity, with an annual energy generation of 5.506 billion kWh. See Table 2.5 for details.
Table 2.5 Statistic table of water resource of three river basin in Gansu

<table>
<thead>
<tr>
<th>Projects</th>
<th>unit</th>
<th>Inland river</th>
<th>Yellow river</th>
<th>Changjiang</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yearly runoff</td>
<td>0.1billion cubic meter</td>
<td>53 (69.9)</td>
<td>143 (387.7)</td>
<td>114 (146.2)</td>
<td>310 (603.8)</td>
</tr>
<tr>
<td>Total area</td>
<td>10thousand sq.km.</td>
<td>27.11</td>
<td>14.45</td>
<td>3.84</td>
<td>45.40</td>
</tr>
<tr>
<td>Runoff area</td>
<td>10thousand sq.km.</td>
<td>10.81</td>
<td>13.35</td>
<td>3.84</td>
<td>28.00</td>
</tr>
<tr>
<td>Noncontributing area</td>
<td>10thousand sq.km.</td>
<td>16.30</td>
<td>1.10</td>
<td>0</td>
<td>17.40</td>
</tr>
<tr>
<td>Theoretical deposit of water resource</td>
<td>10 thousand kW</td>
<td>327.35</td>
<td>959.05</td>
<td>437.75</td>
<td>1724.15</td>
</tr>
<tr>
<td>Possible development capacity</td>
<td>10 thousand kW</td>
<td>135.24</td>
<td>554.94</td>
<td>330.87</td>
<td>1021.05</td>
</tr>
<tr>
<td>Annual power capacity</td>
<td>0.1billion kWh</td>
<td>52.16</td>
<td>249.53</td>
<td>122.75</td>
<td>474.46</td>
</tr>
<tr>
<td>Possible development capacity of small hydropower</td>
<td>10 thousand kW</td>
<td>83.07</td>
<td>72.54</td>
<td>64.63</td>
<td>220.24</td>
</tr>
<tr>
<td>Annual power capacity of small hydropower</td>
<td>0.1billion kWh</td>
<td>20.77</td>
<td>18.14</td>
<td>16.16</td>
<td>55.06</td>
</tr>
</tbody>
</table>

Remarks: Annual runoff capacity; numbers in brackets include water flow entering a country.

Data source: Rural energy resource and regional report in Gansu Table 11 p80.
Though Gansu is relatively rich in small hydropower resources, the distribution is uneven – the south part is richer than the north, and Table 2.2 shows distribution conditions in fourteen regions.

As Gannan Prefecture contains the upper reaches of Bailongjiang, the Yellow River, Xia River and Tao River thus Gannan owns the largest water resources in the province. The total area of Gannan is 38 thousand km² and its population amount is 1.6779 million. The potential installed capacity is 529 MW, which is 24% of that of Gansu.

<table>
<thead>
<tr>
<th>Location</th>
<th>Possible development installed capacity/ 10 thousand kW</th>
<th>share/ %</th>
<th>Per capita consumption/W/person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole province</td>
<td>220.24</td>
<td>100</td>
<td>85</td>
</tr>
<tr>
<td>Lanzhou</td>
<td>3.67</td>
<td>1.67</td>
<td>11</td>
</tr>
<tr>
<td>Jiayuguan</td>
<td>1.58</td>
<td>0.72</td>
<td>77.8</td>
</tr>
<tr>
<td>Jinchang</td>
<td>3.63</td>
<td>1.65</td>
<td>78</td>
</tr>
<tr>
<td>Baiyin</td>
<td>0.11</td>
<td>0.05</td>
<td>0.6</td>
</tr>
<tr>
<td>Tianshui</td>
<td>14.60</td>
<td>6.63</td>
<td>42.8</td>
</tr>
<tr>
<td>Wuwei</td>
<td>18.93</td>
<td>8.60</td>
<td>99.9</td>
</tr>
<tr>
<td>Jiuquan</td>
<td>28.84</td>
<td>13.09</td>
<td>293.4</td>
</tr>
<tr>
<td>Zhangye</td>
<td>33.59</td>
<td>15.25</td>
<td>264.2</td>
</tr>
<tr>
<td>Dingxi</td>
<td>6.94</td>
<td>3.15</td>
<td>23.7</td>
</tr>
<tr>
<td>Longnan</td>
<td>42.15</td>
<td>19.14</td>
<td>161.5</td>
</tr>
<tr>
<td>Pingliang</td>
<td>3.65</td>
<td>1.66</td>
<td>16.7</td>
</tr>
<tr>
<td>Qingyang</td>
<td>2.01</td>
<td>0.91</td>
<td>8.0</td>
</tr>
<tr>
<td>Linxia</td>
<td>7.65</td>
<td>3.47</td>
<td>39.7</td>
</tr>
<tr>
<td>Gannan</td>
<td>52.90</td>
<td>24.02</td>
<td>780.4</td>
</tr>
</tbody>
</table>


There is also a rich resource area in Hexi. It belongs to an inland water system and consists of Shulehe, Helhe and Shiyanghe and includes:
- Jiuquan in Zhangye (except Gaotai),
- Wuwei in Jiayuguan (except Minqin, Gulang),
- Yongchang County in Jinchang City
- Yongdeng in Lanzhou.

Thus Hexi totals 17 counties and cities with 249 thousand km² and the installed capacity of developable small hydropower is 889.7 MW, 40.4% of the whole province. Sunan County in
Zhangye City has the highest installed capacity of Sunan County and Gansu Province, having a capacity of 252.5 MW.

Longnan is another resource-rich area, belonging to Jialingjiang, Hanjiang of the Changjiang river basin and part of Weihe, Tahoe of the Yellow river and includes nine counties in Longnan and Qinzhou, Maji District and Min County in Tianshui, totalling twelve counties and prefectures with an area of 37.7 thousand km² and a population of four million. The installed capacity in developable small hydropower is 562.9 MW, 25.6% of the whole province, among which developable installed capacity in Wen County is 103.6 MW.

The middle of Longnan has a reasonable resource area in terms of hydropower. Located in the north of west Qinlong, the middle and upper reaches of Weihe, Tahoe and Daxiahe, it also includes five counties in Tianshui City, Zhang Country, Weiyuan County and Lintao County in Dingxi, and the Linxia sub-prefecture (except Yongjing, Dongxiang). This totals fourteen counties/cities with an area of 20.3 thousand km² and an installed capacity for developable small hydropower being 0.1488 GW, 6.8% of the whole province.

Resource capacity of developable small hydropower, regional distribution and per capita resource distribution can be seen in Figures 2.9-2.10, and will be discussed later.
Graphic illustration: resource capacity of developable small hydropower is 2.2024 million kW

- much richer area ≥ 40 kW: Gannan, Longnan
- rich area 0.10 million kW-0.40 million kW: Zhangye, Jiuquan, Wuwei, Tianshui

Figure 2.9 Regional distribution of developable small hydropower resource capacity
Figure 2.10 Developable small hydropower resource and per capita capacity
3 RURAL ENERGY DEVELOPMENT STATUS

3.1 Current Status of rural energy

The shortage of rural energy has been a constraint to local development for a long time. Therefore rural energy policy has focussed on complementary applications of energy; comprehensive utilisation of resources and energy efficiency. Gansu Provincial Government has developed renewable energy sources such as biogas, solar, wind, pico-hydro and geothermal energy. This effort has played an important role in improving the ecological environment, relieving rural energy shortages, increasing farmer’s incomes, improving the living quality and accelerating rural socio-economic development. The rural energy consumption in Gansu totalled 21.46 Mtce in 2006 including 66.5% (i.e 14.27 Mtce) for living energy consumption and 33.5% (i.e 7.19Mtce) for productive consumption, equal to a per capita average energy consumption of 0.69 tce. Table 3.1 shows Gansu’s current energy consumption structure.

<table>
<thead>
<tr>
<th>Rural energy consumption</th>
<th>percentage</th>
<th>consumption (10,000tce)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. productive consumption</td>
<td>33.5%</td>
<td>718.96</td>
</tr>
<tr>
<td>2. living consumption</td>
<td>66.5%</td>
<td>1427.26</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakdown of living consumption</td>
<td>percentage</td>
<td>consumption</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(10,000tce)</td>
</tr>
<tr>
<td>2.1 stalks</td>
<td>21.3%</td>
<td>304.41</td>
</tr>
<tr>
<td>2.2 firewood</td>
<td>12.6%</td>
<td>179.56</td>
</tr>
<tr>
<td>2.3 Coal</td>
<td>61.0%</td>
<td>870.43</td>
</tr>
<tr>
<td>2.4 electricity</td>
<td>0.7%</td>
<td>9.9175</td>
</tr>
<tr>
<td>2.5 Oil</td>
<td>3.0%</td>
<td>43.24</td>
</tr>
<tr>
<td>2.6 natural gas</td>
<td>0.1%</td>
<td>0.99</td>
</tr>
<tr>
<td>2.7 LPG</td>
<td>0.3%</td>
<td>4.4</td>
</tr>
<tr>
<td>2.7 biogas</td>
<td>0.3%</td>
<td>3.79</td>
</tr>
<tr>
<td>2.8 solar energy</td>
<td>0.7%</td>
<td>10.52</td>
</tr>
<tr>
<td>2.9 Wind home system</td>
<td>0.02%</td>
<td>0.2</td>
</tr>
</tbody>
</table>

It can be seen that conventional energy consumption (coal, oil, gas and electricity) accounted for 65.1% of the total living energy, or 9.29 Mtce. Coal is the largest energy resource with coal consumption at about 8.70 Mtce, accounting for 61% of the total. The remaining energy use is of stalks/straw and firewood, totalling 4.84Mtce, accounting for 33.9%. The use of stalks and firewood is dominated by direct combustion, mainly meeting the requirement for cooking and heating. Newer technologies, such as biogas and solar energy, only accounted for 1%.

In order to increase the combustion efficiency of conventional stoves and firewood cookers and to improve the rural environment and sanitation, 3.79 million high-efficient firewood cookers, 1.945 million energy saving kangs and 1.46 million energy conservation stoves have been installed, with an annual energy saving of 2Mtce from coal and firewood.
With the development of renewable energy technology in China’s rural area, as in other provinces in China, Gansu actively employs renewable energy technologies including biogas, solar energy use, micro and small hydropower generation and small wind power generation. Although their development currently makes a small contribution (1%) to rural energy consumption, about 150,000tce, they represent the development direction of rural renewable energy. Table 3-2 below shows the status of the rural renewable energy technologies. Gansu has developed 2 middle and large scale biogas projects with digesters of 1300 m$^3$ in total and an annual gas production of 453,000 m$^3$. There are 6 stalk gasification projects in Gansu.

Table 3.2 presents the status of Gansu rural renewable energy in 2006 and the application of technology.

<table>
<thead>
<tr>
<th>No</th>
<th>technology</th>
<th>Newly installed in 2006</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>firewood-saving cooker</td>
<td>111,622</td>
<td>3,790,578</td>
</tr>
<tr>
<td>2</td>
<td>energy conservation kang</td>
<td>50,486</td>
<td>1,944,690</td>
</tr>
<tr>
<td>3</td>
<td>energy conservation stove</td>
<td>30,610</td>
<td>1,463,480</td>
</tr>
<tr>
<td>4</td>
<td>solar heater(m2)</td>
<td>62,000</td>
<td>418,100</td>
</tr>
<tr>
<td>5</td>
<td>solar energy heated house(m2)</td>
<td>34,500</td>
<td>1,807,200</td>
</tr>
<tr>
<td>6</td>
<td>solar heated school(m2)</td>
<td>6,500</td>
<td>27,200</td>
</tr>
<tr>
<td>7</td>
<td>solar stove</td>
<td>103,928</td>
<td>578,023</td>
</tr>
<tr>
<td>8</td>
<td>PV power (Wp)</td>
<td>100,196</td>
<td>240,922</td>
</tr>
<tr>
<td>9</td>
<td>stalk gasification</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>Household stalk biogas</td>
<td>97</td>
<td>156</td>
</tr>
<tr>
<td>11</td>
<td>small wind power(kW)</td>
<td>75</td>
<td>4,425</td>
</tr>
<tr>
<td>12</td>
<td>mini-hydro(kW)</td>
<td>492</td>
<td>15560</td>
</tr>
<tr>
<td>13</td>
<td>household biogas</td>
<td>47,260</td>
<td>181,452</td>
</tr>
<tr>
<td>14</td>
<td>Breeding farm biogas project</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Although development of rural energy in Gansu has been improved in recent years and played a significant role in improving the quality of life and the ecological environment, there is still a gap between living energy demand and energy supply. The main problems associated with rural energy development are:

- Although there are rich resources in rural areas, they are unevenly distributed. The energy supply cannot meet the demand and development is at a low level.
- Rural energy construction is lagging. The method of energy utilization is old and traditional with associated low efficiency.
- The consumption structure of households is not well developed, with very low electricity consumption and high coal and straw use.
- New energy technologies are not popular.
3.1.1 Main technologies used

As described in the previous section the main technologies currently used in Gansu are firewood saving cookers, energy saving kangs, energy saving stoves, solar thermal heaters, passive solar homes, solar cookers, PV, wind power, mini-hydro, stalk gasification, household biogas and breeding farm biogas project.

The following figure shows the potential biomass conversion technologies available. The future development of rural energy in Gansu should take into account all the technologies included here:
1) biogas power generation;
2) stalk gasification power generation;
3) stalk direct-fired thermal generation;
4) biomass cogeneration;
5) stalks briquetting;
6) biological fuel with fuel crops cultivated in wasteland.

![Figure 3.1 Flow chart of the rural biomass energy exploration](image)

3.2 Rural Energy Case Studies

3.2.1 Lanzhou Huazhuang Biogas Power Project

This project was a subproject of the Sino-Dutch cooperative project “Promotion of Rural Renewable Energy in Western China”, and the implementation unit is Gansu Holstein Cow Breeding Center, located at Huazhuang Town, Honggu District, Lanzhou City, Gansu province. With a land area of 300 Mu (20 hectares), the breeding center has a design capacity to raise 3,000 dairy cows. At present there are 2,300 dairy cows of which 1,100 heads are the mature dairy cows.

Through pre-feasibility study and the field investigation, the project experts from the Sino-Dutch co-operative project had the view that Gansu Holstein Cow Breeding Centre possessed good conditions and strong economic strength for future development, and can meet the requirements of the selection criteria from the pilot and demonstrative project. Selection criteria included: availability of substantial amounts of cow manure for biogas fermentation, sufficient land available for project construction, large electricity demand at the farm, sufficient and convenient arable land for the consumption of the effluents from the anaerobic digestion tanks, good transport links and good dissemination effects.
According to the whole project design, the project objective at the first stage is to deal with the manure and sewage from 1,100 dairy cattle. The fermentation adopted a mesophilic digestion process, the volumes of the fermentation tanks and the biogas storage tanks are 1,200 m³ and 200 m³ respectively with a capacity of the feedstock volume of 80 tons per day, 15 days of hydraulic retention time, and daily biogas yield of 1,200 m³.

The total biogas yield is designed for electricity power production, and the generation sets can run in parallel operation with the public grid. By means of public bidding, the power generation equipment was procured by importation from the Czech Republic. The generator sets were made by the TEDOM Co. and had the property of co-generation of heat and power (CHP). The model of the generator is Cento T88 SPE BIO, with a maximum electric output of 76 kW, electric efficiency and heat efficiency of 31.5% and 50.2% respectively. One cubic meter of biogas can yield two kilowatt hours of electricity, the electrical efficiency of the imported equipment is 20% higher than that of similar domestic products.

After the engineering construction and equipment test running, the Huazhuang biogas power generation project started its trial operation in August 2006. To date the system runs steadily and smoothly, with biogas production maintained at the designed level with an average daily output of 1,200 m³ and methane content exceeding 55%. The daily electrical output is on average 1,500 kWh, with a maximum daily-output value of 1,900 kWh.

**Advanced technology and performance**

The operation, superior technology and advanced performance of the project are summarized below:

- Advanced biogas CHP generator sets. Under normal conditions, when the methane content exceeds 62%, 1 m³ of the biogas can generate 2 kWh of electric power. Through multiple thermal energy recovery system, the heat efficiency reaches 50%. In other words, 1 m³ of biogas can produce 3 kWh of heat along with the electricity production, and the total energy efficiency is over 80%.

- Advanced fermentation setting and heat-up system. The project adopted advanced USR biogas fermentation process that required less land and less investment. Through cogeneration of heat and power from the biogas power generation unit, the biogas fermentation tanks realized its normal operation in the cold winter and the fermentation temperature reached 28-35°C.

- Advanced monitoring instruments. With various testing sensors at each step of process and the data collection system, all the monitoring indicators can be automatically stored, processed and displayed with the central monitoring computer. These monitoring parameters include: the temperature, solid concentration and pH value of raw material fluid to be feed into the biogas fermentation tanks; the biogas output quantity and its contents’ proportion; the quantities of the biogas feeding into the generator sets and the output of the electricity generation. In addition the monitoring system can also detect methane leakage and noise of the generator set at the power station, exhaust gas emissions of the generator set. The live video vision monitoring system includes the power station and part of the cow keeping field of the farm.
Benefits

The project is an international cooperation project and also a key demonstration project funded by the Ministry of Agriculture. Since the generators and other equipment are imported from Europe, the initial investment is quite high with a total cost of 6.8 million Yuan. The contribution of the Netherlands government is 330,000 Euro for biogas power generator, equipments for biogas purification and heat utilization, and high pressure pump for the sludge effluent transportation. The contribution of the Chinese government and investment of the enterprise is equal to 3.5 million Yuan which are used for the engineering construction of the biogas fermentation and other components as well as for the power generation and transportation engineering.

At present, the project has shown its multiple benefits:

- Daily biogas production is 1200m³ and the annual biogas production is 488,000 m³, and the annual power production is 657,000 kWh. This ensures the electricity supply to the breeding center, avoiding annual losses of 200,000 Yuan which result from black outs of the power grid every year. If the electricity is sold to the grid with the price subsidy of 0.25 Yuan/kWh, the annual revenue from the electricity sale can be doubled.
- The sludge effluent produced by the digestion process is 70 tons per day, and the filtered digested fluid is 40 tons per day with an annual production of 14,600 tons. The annual production of the separated solid residues is 1,350 tons, which can be sold as flower fertilizer at the market with sales value of 135,000 Yuan.
- The breeding centre can save the environmental fine for pollutant discharge in value of 193,200 Yuan each year.

The total annual benefit is summed up to 674,000 Yuan, with reduction of the operation and maintenance cost in value of 250,000 Yuan, the net annual benefit is about 400,000 Yuan, which shows a favourable economic benefit. If the power can be sold to the grid and management of the power plant is improved, this kind of project can completely realize its commercial development with the preference support from the government.

Issues

At present the following issues exist with the project:

- At present the electric power produced is only used by the breeding centre therefore the load is smaller than the potential power generation from the project. In most cases the generator sets have not reached its full load operation.
- The favourable price subsidy for renewable energy power is not yet realised as
an agreement has not been made between the breeding centre and the power grid operation company in Lanzhou for the surplus power feeding into the grid.

- At present, the utilization of the heat energy reclaimed from the generator sets could be improved, and the de-sulfur process needs to be improved to reduce the Hydrogen Sulphide (H₂S) concentration of the biogas.

---

3.2.2 Stalk Gasification Power Plant in Shandan County

The Stalks Gasification Power Plant at Shandan County was one of the Technical Assistance Projects (TA 4309-PRC) funded by the Asian Development Bank (ADB) and implemented at Zhangye Prefecture, Gansu Province. The objectives were to realise social and economic sustainable development by infrastructure construction and exploitation of renewable energy in poor rural areas. Technical Assistance project experts began their investigation and feasibility work in February 2005 on the renewable energy resources and technical service potentials at the countryside of Zhangye. The biomass gasification power generation project was chosen as the poverty reduction activity to be undertaken at Shandan County.

In Gansu province, the poor population accounts for 8.6% of the total which is higher than the country average of 4.6%. The proportion of the poverty population at Shandan County is more than 50% of the total population in this county. The energy expenditure of the farmer households at Shandan accounts for 55% of the total expenditure and 48% of the households' total net income. With utilization of manmade gas from stalk gasification, the expenditure on fuel for cooking can be decreased by 60%. If the added value of the electric power, the stalks as the feedstock, and additional employment opportunities created are taken into account the gasification power plant can play an active role in poverty alleviation of poor local farmers.

Another important factor influencing the decision to set up the pilot project at Shandan County is the abundant biomass resources available in the area. The main crops of the county are wheat, maize, barley and oil plants. The annual production of the stalks is 153,000 tons in Shandan Country. Some of the stalks are used as animal fodder and returns back to the field, however the surplus stalks amount to 46,000 ton a every year that can be used as the raw material for gasification process. This provides cooking gas for the farmer households and can also be used for electric power generation in order to improve the local electric supply and the living conditions of the farmers. According to the surplus amount of the stalks, the total capacity of the gasification power plants can reach 60 MW, and 30 stalk gasification power plants could be built if the capacity of each plant is 200 kW. Therefore, the demonstrative function of the pilot gasification power plant can be realised effectively.
The main parameter and characteristics of the gasification power plant

After discussion and verification by the ADB and national experts, it was ascertained that there is sufficient biomass resource; the gas generated from gasification can supply farmer households with cooking gas to substitute coal and reduce energy expenditure. Also some of the gas generated can be converted into electricity to meet electricity which improves the financial viability if the project. Therefore, the technology mode of the gasification plant is the combination of central gas supply and the electric power generation, which is showed in Figure 3.6 below.

Figure 3.6 Flow chart of the project

According to the end-user requirements and the resources conditions, the power plant was built at Qidian Village of Qingquan Township, Shandan County, Zhangye Prefecture.

The gasification power plant is designed to supply fuel gas to 320 households and to generate electricity in capacity of 200kW of the generator, and the equivalent capacity for feed-in power to the grid is 175kW. The anticipated gas production is 4,320,000 m³ per year, and the real demand will be 3,110,000 m³ with the production of electricity in quantity of 768,000 kWh. Therefore, the selected gasifier has a capacity for gas production of 900 m³/hr and the gas holder volume is 200 m³, as shown in Figure 3.7.
As the project is small scale, there was no interest from international manufacturers and only the domestic tenderers submitted their proposals. The parameters of the gasifier selected are listed here: 1 m³ of gas is produced with stalk consumption of 0.5 kilogram; one kilowatt of electricity is produced from gas consumption of 3.3 m³; the average thermal value of the gas is 5 MJ/m³; the concentrations of CO and H₂ of the gas are 18.5% and 14.1% respectively, and only small amounts of methane and oxygen are also produced; the tar content of the gas is lower than 20 mg/m³.

The total investment of the project was $230,000 (US), which is in equivalent to 1,840,000 CN Yuan. The operation and maintenance cost (excluding raw materials) is 152,000 Yuan. If the stalks are valued at 50 Yuan/ton, the costs of the gas and electricity are 0.14 Yuan/m³ and 0.60 Yuan/kWh respectively. However, the experience of project operation says that the actual cost of the raw materials will be higher than expected.

The actual total investment was 1,620,000 Yuan, financed by the ADB (46.8%), a native loan (9.3%) and the plant owner (43.9%).

**Problem and prospect**

The main problem for the gasification power generation is the treatment of the tar content of the gas. The system was designed to have a tar content of less than 20 mg/m³ however in practical operation the tar content is higher. As a result, the existing tar will lead to
secondary pollution, and most importantly it will result in the choking up of the gas pipes and the equipment which deals with the gas, and thus it may result in system stopping. In the last two years, this problem has been tackled within the new built-up gasification plants with manifest improvement on the treatment of tar, and the tar concentration of the gas can now be controlled under 10 mg/m³.

The operation of the gasification plant at Shandan County indicated that the technology has not reached its commercial stage although it has the function to promote the local social and economic development. Besides the undeveloped economic conditions and the limited financing channel for poverty reduction from the farmers, the deficiency of commercial operation idea and mechanism is also an important reason. Therefore, in the movement for dissemination of this kind of technology at the similar regions like Shandan County, the first-line is the support policy from the government, and secondly the technology should be improved further with the investment to be lowered together, and the system operation performance should be reliable. More over and the indispensable, the mechanism for commercial popularization of the biomass gasification power plant should be exploited, so as the project can survive for long time and realize its sustainable development.

3.3 Current status of wind development

Early in the 1990s some households without electricity installed simple small-sized wind turbines for lighting. In the project of “Song Dian Dao Xiang” in 2002, which was funded by the Government, 21 stand alone wind turbines were installed in off-grid areas of Gansu taking the total installed capacity of small wind power to 35kW.

In 1996 4 sets of 300 kW wind power generators, imported from Denmark, were grid connected in Sanshilijingzi, Yumen. By the end of October 2008, 8 wind power plants were built in Gansu, total installed capacity for power generation reached 410 MW.

In October 2007, the Government approved Gansu to construct a 10GW wind power base in Jiuquan with total installed capacity of 12 710 MW by 2015. Of this: the first stage (before 2010), total installed capacity of wind power in Gansu will reach 5160 MW. The first 20 projects approved by NDRC are 3800 MW, self-directed projects is 300MW, 500MW has been approved by Gansu Province, the total is 4600MW. At present, the total installed capacity of being built and to be built projects has reach 950 MW, 3800MW is still in the first-phase preparations. The second stage (before 2015), the total installed capacity in Gansu will reach 12,710MW, of which, 7550MW is the new capacity. Currently, NDRC and GPG have started the first-phase work, the newly added installed capacity planned by NDRC is 5 GW and GDRC has planned 8.6 GW, the final aim is 7.6 GW.

By the end of 2007, constructed wind power plants in Gansu were divided into three categories:

(1) Household wind plants seperated from network

This kind of wind power plants is scattered in the village, which is small-sized self-installed wind power plants. Based on incomplete statistics, there are about 150-200 sets in the whole province, the output power is 100-200 W and the total installed capacity is about 30 kW.

(2) Centralized off-grid

This kind of wind power plants is small-sized off-grid wind power plants in the villages, which is part of the nation’s Brightness Projects which transmit power to NEHH. Each wind power plant can offer power for lighting, household appliances and small-sized paddy pounders of 10-30 households. The output of single unit is 200-300W, with incomplete statistics, the
number of this kind of power plants in Gansu is 15, each station has installed 3-4 sets wind power units, the total installed capacity of these power plants is about 35kW.

(3) Large and middle-sized grid-connected wind power plants

The first 300kW grid connection wind power generator group was installed in Sanshilijingzi, Yumen. By the end of 31st December, 2007, 8 large and middle-sized grid connection wind plants have been constructed in Gansu. Among which, the minimum power output is 300kW, the maximum is 1500kW and the total capacity of these eight plants is 410MW. By the end of 31st December, 2007, constructed wind power plants in Gansu see in the following table:

Table 3.3: Completed and under-construction wind farms in Gansu

<table>
<thead>
<tr>
<th>Project name</th>
<th>Project location</th>
<th>Project owner</th>
<th>Area</th>
<th>Installed Capacity</th>
<th>Wind turbine type</th>
</tr>
</thead>
<tbody>
<tr>
<td>100MW Beidaqiao, Guazhou Wind Farm (stage III of tender for wind power privilege in China)</td>
<td>The Gobi desert of Jiuquan, Guazhou</td>
<td>China Power International Ltd.</td>
<td>40km²</td>
<td>198.5MW</td>
<td>Goldwind S50/750</td>
</tr>
<tr>
<td>Daliang Guazhou Wind Farm (wind power tender for privilege in Gansu)</td>
<td>The Gobi desert of Ganhekou, Guazhou, Jiuquan</td>
<td>Guangdong Nuclear Power Co., Ltd. in Gansu</td>
<td>20km²</td>
<td>99MW</td>
<td>DFSTW FD77B/1500</td>
</tr>
<tr>
<td>Xiangyang Wind Farm in Guazhou (wind power tender for privilege in Gansu)</td>
<td>The Gobi desert of Ganhekou, Guazhou, Jiuquan</td>
<td>Gansu Xinan Wind Power Co.</td>
<td>20km²</td>
<td>97MW</td>
<td>Spanish Gamesa58/850</td>
</tr>
<tr>
<td>Stage I, II, III of in Sanshilijingzi, Yumen Wind Farm</td>
<td>The Gobi desert of Sanshilijingzi, Yumen, Jiuquan</td>
<td>Gansu Jeyuan Wind Power Co.</td>
<td>25km²</td>
<td>114MW</td>
<td>Spanish Gamesa58/850, Goldwind S50/600</td>
</tr>
<tr>
<td>Jeyuan wind power site in Diwopu , Yumen (the tender for Gansu wind power privilege)</td>
<td>The Gobi desert of Diwopu, Yumen, Jiuquan</td>
<td>Gansu Jeyuan Wind Power Co.</td>
<td>10km²</td>
<td>49.5MW</td>
<td>Spanish Gamesa58/850</td>
</tr>
<tr>
<td>Datang wind power site in Diwopu, Yumen</td>
<td>The Gobi desert of Diwopu, Yumen, Jiuquan</td>
<td>Datang 803 Wind Power Co.</td>
<td>10km²</td>
<td>49.5MW</td>
<td>Vestas V52-850</td>
</tr>
<tr>
<td>Jiancaitang, Pinchuan wind power site</td>
<td>Jiancaitang, Pinchuan, Baiyin</td>
<td>SDIC Huajing Power CO., LTD</td>
<td>9km²</td>
<td>49.5MW</td>
<td>DFSTW FD77B/1500</td>
</tr>
<tr>
<td>The first stage of Xingquan, Jingtai Wind Farm (the tender for Gansu wind power privilege)</td>
<td>Xingquan, Jingtai, Baiyin city</td>
<td>Gansu Datang Wind Power Co.</td>
<td>9km²</td>
<td>49.5MW</td>
<td>JinFeng S50/750</td>
</tr>
<tr>
<td>Dongfeng Wind Farm in Beidaqiao, Guazhou</td>
<td>The Gobi desert of the North of Jiuquan Guazhou</td>
<td>Gansu Huineng New Energy Co. and SDIC Huajing Power CO., LTD</td>
<td>10km²</td>
<td>49MW</td>
<td>Undetermined</td>
</tr>
</tbody>
</table>
3.4 Major issues in renewable energy development

3.4.1 SWOC Analysis of Wind power in Gansu

A Strength, Weakness, Opportunities and Constraints analysis has been carried out for future wind power development in Gansu.

- Strengths and opportunities

**Good wind resource** - Gansu has a very good wind resource, although Gansu is only the fifth-best area for wind power in China. However it has some of the easiest development conditions which make Gansu sites some of the top recommended sites for wind farms. Many areas in Gansu are suitable for large-scale development of wind power projects. The vast majority of the regions rich in wind power are distributed to the west of the Hexi corridor in Jiuquan - these regions are deserts and wastelands which are wide and flat. Judging from the sites under current investigation, the Jiuquan areas of Gansu has the potential for GW size wind farms with the scale as following:

- Guazhou area: Beidaqiao 6GW, Ganhekou 1.8GW, Qiaowan 600MW, Liuyuan 50MW;
- Yumen area: Changma 800MW, Qiduntan 400MW, Mahuangtan 800MW, Sanshili Jinzi 110MW, Diwopu 150MW;
- Subei Mazongshan area: 3GW;

**Good operating conditions** - Having a good climate is beneficial to the wind turbines’ stable and safe operation. The climate is dry with temperatures ranging from 41 to -29 degrees Celsius, which are within the working range generally stated for wind turbines. Judging from thirty years’ worth of meteorological records, the highest wind speed was recorded at 39 m/s. Gansu does not have typhoons, which allows for the installation of wind turbines with longer blades which cannot be installed in areas with extreme wind conditions. These conditions make it even more economically advantageous.

**Land availability** - The planned wind sites have a huge available area, most are located in the Gobi desert where land is not occupied for farming as cultivation is not possible, therefore there are no resettlement issues. Along with the fact that the region is large, flat and largely water-free, the investment of development and construction is relatively low, increasing the economic benefit.

**Good transport links** - The proposed wind farm areas have good transport links: the Lan-Xin railway runs through the east and west counties of Gansu; the 312 national and provincial highways extend in all directions; country roads connect the entire province, villages and towns. All completed, under-construction and planned wind farms are close to some form of road, whether it be national or provincial highways or country roads – for example, all the planned sites in Qiaoma are distributed on both sides of the 216 provincial highway. There are existing railways and roads which could be used to ensures easy transfer of the wind turbines and other facilities to the wind farms, and it’s not necessary to construct additional special roads or enlargement of already-existing roads and bridges

The size of the turbine is constrained by train tunnels, bridges, road bending, etc. It is assessed that most sites are not constrained to less than 1.5 – 2.0 MW wind turbines, which is most common size for on-shore wind turbines.

**Nearby demand** - As rapid development covers the Gansu Province, the power industry also faces the same rapid development. At the end of December 2007, the installed power
generation capacity was 13.6 GW whilst the electrical load was more than 10 GW. Especially in areas such as Jiuquan and Jiayuguan, which are rich in wind power resources, the installed capacity of thermal and hydropower increased dramatically; during the same time, electricity consumption rose by 15% to 20%.

**Government support** At present, the Chinese government and leaders are promoting the development of wind power and it appears to be in the peak development period; the projects in Gansu are now obtaining the effort and support of the State and National Development and Reform Commission (NDRC). The construction of 10 GW of wind in Jiuquan has been approved, and 120 billion Yuan has been spent erecting power lines.

**Local equipment manufacturing** - Gansu has strong foundations in equipment manufacturing. Currently, megawatt-level, constant frequency, dual-feed and the asynchronous speed wind power generators are being constructed due to the cooperation of Lanzhou Electrical Machinery Plant and Qinhua University. These generators are selling well both in China and abroad.

Gansu Electrical Installing Company and other enterprises are able to manufacture the blades, towers, gear boxes and other large-scale parts of the turbines. The quality of the transformers produced by the Gansu Yuhong Transformer Company Ltd is better than those manufactured on the East Coast, and the price is lower. Many local companies are able to produce parts to meet the province’s demands in terms of quantity and quality. This equipment foundation is in favour of introducing overseas advanced equipment and modern manufacturing technologies, and also promoting the development of the equipment manufacturing industry in Gansu.

- **Constraints/ Barriers to the development of wind power**

  **High voltage losses** - The areas rich in wind energy have increased their power consumption load over the past two years, yet it is not enough to meet the local production. The wind power delivered by the newly-built, large-scale wind farms is mostly transported through the 750 kV transmission lines to Lanzhou or exported to other provinces - the transportation distance is often more than 1000 km. The electrical line loss over such distances is very high, and will, from a national point of view, make the wind energy more costly.

  **750 kV transmission line not completed** - The 750 kV transmission line from Jinchang to Guazhou has not been completed yet but is expected to be completed by the end of 2010. Before installation of the transmission line, the newly-installed capacity in Hexi will have many difficulties, and the construction of wind farms in Jiuquan will be greatly restricted.

  **Limitations to transport system** - The size of the turbine is constrained by train tunnels, bridges, road bends, etc. It is assessed that most sites are not constrained to less than 1.5 – 2.0 MW wind turbines, which is the most common size for on-shore wind turbines. Larger wind turbines made in other provinces and overseas cannot presently be installed without development of the transport network. As the transport constraint is a global problem, manufacturers are investigating how to reduce the length and weight on transport units for larger wind turbines.

  **Grid stability** - 10 GW of wind power is planned to be constructed in Gansu. Due to the speed and irregularity of the wind energy production, the changes caused by the concentrated load will have a severe impact on the Gansu network and may threaten the electrical network’s stability.

The wind farms which are being built are concentrated in Jiajiu; the wind turbines installed in the farms have asynchronous motors with a power factor of 0.9 to 0.95 and will absorb a large quantity of reactive power from the electrical network. Thus, if the wind farm’s power
factor is not improved significantly, the power companies in Gansu will have to put large amount of funds into the Jiajiu network to build large-capacity power factor compensators. The installed capacity of electricity generation is currently only 13.6 GW within the existing network, and the fact that the proportion of the total installed wind capacity shouldn't be too high should be considered. Thus, adding the same level capacity of hydro and thermal power generation is necessary. 10 GW of conventional hydropower and thermal power is also needed, making the construction investment large.

Delays in transformer substation - When the development of 10 GW of wind power in Jiuquan was reported to Gansu, the NDRC approved and agreed to set up two new 750 kV transmission lines from Jiuquan, Jinchang to Guazhou. This will solve the electricity load output of 10 GW in Jiuquan area, but because there is no transformer substation in Yumen and the 15 GW electricity dispatching has yet to be developed, after 2015 the electricity dispatching for Mazongshan, Qiaowan, Qiduntan and Sandaqou – must be reprogrammed and submitted, then taken into effect. Before these programs are approved and implemented by the NDRC, these planned wind farms cannot be developed.

- Threats/Risks to wind power development in Gansu

Feed-in tariff/ Non-economic wind farms - In accordance with the regulations and detailed rules approved by NDRC, the feed-in tariff for wind power projects is controlled by the SCPD in accordance with public bidding. At present, the completed and under-construction wind power project’s electricity prices are relatively low in Gansu and the standard price would not give a reasonable profit.

Grid stability - According to the wind power development plan in Gansu, the total installed wind power capacity will surpass 10 GW by 2015. At that time, the Gansu electrical grid and the installation of conventional and/or hydro power must match this aggregate wind power capacity. Otherwise safe and stable operation of the electricity network will be threatened. This poses a difficult problem for the provincial electricity grid and high quality system impact studies must be carried out, in order to secure the grid stability.

Turbine supply - Although the development of domestic wind manufacture has increased there is a shortage of domestic turbines. Installation of 10 GW of wind power by 2015 may be limited by the supply of turbines.

3.4.2 SWOC Analysis of Biomass power generation in Gansu

The issues relating to biomass technology development in Gansu have been broken down by the following main technologies since some of the issues are technology specific:

- Biomass power generation (combustion, gasification and co-firing)
- Biogas (household and farm biogas)
- Briquetting

3.4.2.1 Biomass power generation with direct combustion, co-combustion and gasification technologies

- Strengths and Opportunities

Abundant resources. The total volume of crop stalks production in Gansu is not the highest in comparison with other provinces in China, but comparatively there are rich stalk resources in the area of the Hexi Corridor and the Loess Plateau, concentrated in the prefectures of Wuwei, Zhangye, Jiuquan, Qingyang and Pingliang. Therefore, in some
counties of these prefectures where the stalks are abundant, the biomass electric power generation has good resource conditions for gasification or direct combustion technology application.

**Power generation technology is mature.** From 2005, the biomass power generation in direct combustion and co-combustion grew quickly in China. Up to 2007, there were 80 sites approved for biomass power plant construction with a total electric power capacity of 1.5 GW and 19 plant stations with a total capacity of 400 MW had been put into operation. In these power plant stations, some of the technology and equipment was imported from abroad (Denmark) and some of them used native technology and equipment, and all of them can operate well. In Gansu there are no biomass power plants installed to date and it can be developed very fast by way of technology introduction and learning. There are 6 biomass gasification stations in Gansu and the technology is well developed. With support from the Asian Development Bank a 200 kW power generation plant with biomass gasification was established at Shandang County of Qingyang Prefecture. Although some improvements should be made on the technology, the biomass gasification has laid a solid base for central gas supply and power generation in Gansu.

**Positive policy support** The implementation of the Renewable Energy Law and the detailed rule for its implementation should promote the development of biomass power generation with direct combustion, co-combustion and gasification technologies:

- The biomass power generation with direct combustion, co-combustion and gasification technologies has been listed in the national *Directive Category for Development of Renewable Energy Industry*
- In the *Regulations of Management for Renewable Energy Electric Power Generation*, it is prescribed manifestly that the power grid company should accept all the feed-in electricity generated from renewable energy resources and stipulated that the point of divergence is the first pole exit to the booster transformer station of the power plant.
- In the *Trial Measures for Apportion Management of the Price and Cost of the Electric Power Generated from Renewable Energy Resources*, it is prescribed that renewable energy power can acquire a price subsidy of 0.25 Yuan per kWh for 15 years from the power plant put into operation. For Co-combustion power plants subsidies are only available when the proportion of the biomass feedstock exceeds 80%.
- In the *Management Method of the Special National Fund for Renewable Energy Development*, one of the main emphases is to promote the development of renewable energy power generation.

- **Weaknesses and Constraints**

  **Lack of clear strategic positioning** - and prominent status in the overall energy development in Gansu Province. Although there is an 11th Five Year plan for biomass development in Gansu it focuses primarily on the use of gas, rather than power generation. To date there are no targets for power generation, no actual implementation plan and the 5 year plan for biomass development in Gansu is not publicly available.

  **Limited size of power generation facilities** - The feedstock supply for a 25MW biomass power plant operating 6,000 hours per year is approximately 200,000 tons, which is equal to all the crop stalks within the total cropland area of 400.000 Mu (26,000 acres). In Gansu province, only Qingyang, Wuwei, Pingliang, Zhangye and Jiuquan prefectures are able to meet the requirement volume of crop stalks. If the capacity of the electric power plant is
set lower at a level of 12MW, then the Tianshui, Baiyin, Linxia and Dingxi prefectures can also be taken into consideration.

**Competing demands for stalk biomass** - Although some rural areas are rich in biomass, such as Zhangye and Qingyang, there are competing demands for the stalks for their use as a household fuel for cooking and heating, for use as fertilizer and as an input into paper manufacturing. This latter demand seriously affects the ability to design economically viable power generation projects since the price of the fuel is prohibitively expensive.

**Siting is important** - At present there are about a dozen biomass power plants in China, and nearly all of them have encountered the problem of feedstock supply shortage. This demonstrates that the placement of a power station is an essential issue for biomass power generation that should be paid given due consideration.

**Lack of the key technology and market mechanism for stalks collection** - Like in the whole country, the agricultural production in Gansu is still at the stage of small farm holdings. Each farmer household only possesses cropland of less than 10 Mu (0.5 acre) and the total feedstock provision for the biomass power plant can only reach 1.5 to 2 tons. So, a 25MW biomass power plant should collect the raw materials from 100,000 farmer households and then transport them to the storage yard with labour work and traditional vehicle and equipments, without particular tying machine, special lorry and special depository.

**Lack of control on stalk price** - Since there is no effective contract for collection of the stalks, some farmers would raise the stalk price when the feedstock supply is in limited supply. In some places, the price of the corn stalk has reached up to 300 Yuan/ton from the general price of 200 Yuan/ton and the feedstock collection radius expand from 30 kilometres to 100 kilometres. Based on this experience consideration should be given to establishing contracts with farmers supply stalks which specify volumes and prices, providing guarantees for the farmer and power plant.

**Domestic technology needs improving** - The domestic boiler should be improved for better performance with the stalk feedstock. Some problems and disadvantages were shown in the feeding process including air distribution, sufficient combustion and slag bonding. The cost of importing boilers is higher and will require more investment for example a 130t/h boiler costs 60 million Yuan.

**Higher generating cost** - The initial investment for the biomass power plant exceeds 10,000 Yuan per kW, which is almost double the cost of a traditional coal power plant. And the generator capacity of the biomass power plant is much lower than the coal plant. So, with the fluctuation of the stalk price and low energy conversion efficiency, the cost of the biomass electric power generation will be twice that of the coal plant power generation.

**Connections to the grid** - Despite the Renewable Energy Law enforcing local grid companies to connect all renewable power projects to the grid there are still problems receiving payment for any power exported for small-scale power projects. The feed-in tariff for biomass based projects should be 0.25 RMB/kWh above the local coal generated electricity. However the power companies are not paying anything for the power, let alone the higher feed-in tariff. Since this income cannot be relied upon potential small projects are not financially viable.

**Monitoring required of co-feedstock** - The monitoring of the co-feedstock quantity is the key issue for the co-combustion biomass power plant operation. The co-firing power plant can elevate the combustion efficiency and reduce the air pollution, and can reduce the risk of feedstock shortage with concern of the stalk supply. But there is no reliable monitoring and evaluation mechanism at present to show effectively the proportion of the co-feedstock, so the co-firing power plant can only be regarded as the traditional coal power.
plant and therefore not receive price subsidies for electricity generation.

**Improvement required in biomass gasification technology** - Gasification can be put into practice for power generation when the tar of the gas is reduced and the secondary pollution can be avoided. Compared with the direct combustion power plant, the biomass gasification power plant has a lower generation capacity, which ranges from several hundred kilowatts to several megawatts. Therefore there is sufficient feedstock supply. However the initial investment and operating cost is quite high for the biomass gasification power generation, and removing of the tar in the gas and re-treatment of crashing water will easily result in secondary pollution, therefore some improvements are required for the biomass gasification technology.

### 3.4.2.2 Biogas

Biogas units are split into household biogas digesters and small to large biogas projects. Household systems have a volume of 6-20 m³ and are designed for the scattered households to use the manure of the livestock and poultry, like pig, cattle, sheep and chicken. The larger systems are for farms and are classified as shown in Table 3.4 below.

<table>
<thead>
<tr>
<th>Cattle keeping number</th>
<th>Large</th>
<th>Medium</th>
<th>Small</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt;400</td>
<td>100-400</td>
<td>≤100</td>
</tr>
<tr>
<td>Pig keeping number</td>
<td>&gt;5000</td>
<td>1000-5000</td>
<td>500-1000</td>
</tr>
<tr>
<td>Meat chicken keeping number</td>
<td>≥1.5million</td>
<td>0.30-1.00million</td>
<td>0.10-0.30million</td>
</tr>
</tbody>
</table>

Biogas has received much attention from the central and local governments in China for its rapid development and widespread extension. By the end of 2006, there were 21,740,000 household biogas digesters in the whole country, accounting for 9% of the total number of rural households with an annual biogas production of 8.187 billion m³. On average each household biogas digester yields 396 m³ of biogas per year, which possesses an energy value of 436 kg coal for its thermal equivalent. By the end of 2006, there were 17,475 biogas project plants in China with a total anaerobic fermentor volume of 1,889,000 m³ and annual biogas yield of 218 million m³ that is equivalent to 2,080,000 tons of coal. Of these 1,228 project plants are the large-scale biogas projects and the total fermenter volume is 800,000 m³ and the annual biogas yield is 111 million m³.

In the view of future development, central government has put forward strategic targets in the building of new villages and development of West China, and development and use of rural renewable energy has been included as one of the important targets for the strategy. Especially since the global financial crisis starting at the end of 2008, in order to increase domestic demand and promote economic development, central government has formulated a series of incentives, it is planned to increase 4 trillion RMB yuan on ecological environment building, improving people's lives and enhancing infrastructure construction during 2008-2010. Among 230 billion yuan governmental budget from end of 2008 to the beginning of 2009, 8 billion yuan is used for the construction and development of rural biogas projects, including household biogas projects, large and middle biogas projects and biogas service system building. Therefore, in the near future, rural biogas will have a great development potential.
A. Biogas project for central gas supply and power generation

- **Strengths and Opportunities**

**Abundant resources.** Gansu province is a large province in the field of animal husbandry and the number of medium and large scale farms is increasing significantly in line with demand. The potential for biogas projects is therefore immense.

**Advanced biogas power generation project** has been introduced and demonstrated in Gansu. Prior to 2006, there were no large biogas projects in Gansu. In 2007, 2 large-scale biogas projects have been set up and put into operation. These projects can have a successful demonstrative role and wide influence and will effectively promote the development of biogas power generation project in Gansu.

**National support.** Besides the national support policy described in section 2.(2) for the biomass energy development, the Ministry of Agriculture has a policy to provide special subsidy for the development of the large biogas project. In 2007, 1.5 million Yuan was assigned to Gansu province for the support of new biogas power generation plant construction on animal farms with more than 10,000 pigs or 1,000 milk cows in stock. This subsidy is intended to be used to support the biogas power plant construction of Aoniu Milk Industry Company Limited at Tianshui, which is one of the two projects that the Asian Development Bank is supporting. In 2008, there are 3 projects in Gansu that will receive the national subsidy from the Ministry of Agriculture for the biogas power generation project construction that have been approved. Up to 2010, there will be a quite lot of financial subsidy from the central government to support the development of the biogas power generation project in Gansu.

**Pollution control requirements.** With the development of the animal husbandry industry, the pollution control work would be simultaneously carried out, which will be supported financially by the government. Therefore there is opportunity for biogas projects. The Ministry of Agriculture has issued a regulative document for the pollution control at the larger livestock farms, and will deliver a subsidy of 80,000 Yuan to each animal farm for environmental condition improvement. In 2007, an animal farm of Gansu will get the subsidy for pollution control in quantity of 800,000 Yuan, and it will be increased in the future years.

**Support from and cooperation with the international organizations.** At the present time, many international organizations show their enthusiastic attention to the development of renewable energy development in Gansu, which should became a positive drive to attract more capital and technology to Gansu for the accelerated promotion of the biogas power generation.

- **Weaknesses and Constraints**

**Size and dispersion of animal farms.** Throughout Gansu there are dairy, pig and sheep farms. However none of them are very large and they are quite dispersed. In most cases where biogas is considered the projects are too small to make power generation worthwhile.

**Connections to the grid** – Despite the Renewable Energy Law enforcing local grid companies to connect all renewable power projects to the grid there are still problems receiving payment for any power exported for small-scale power projects. The feed-in tariff for biomass based projects should be 0.25 RMB/kWh above the local coal generated electricity. The power companies are not paying anything for the power, let alone the higher feed-in tariff. Since this income cannot be relied upon potential small projects are not financially viable. If the electricity is only used for on-site consumption, there will be problems matching the output with the electric load therefore resulting in sub-optimum operation of the generator sets. Therefore, the biogas projects are mostly designed to
supply biogas as cooking fuel to the farmer households nearby and many of them has the welfare characteristic.

**High investment costs.** The initial investment of the biogas project is high and therefore so is the biogas electricity cost. The cost of biogas is higher than that of natural gas and double the cost of coal power generation.

**Technology improvements needed.** At present the special designed biogas power generator set can be made in China from several tens to 600 kW capacity. But there some disadvantages in comparison to the advanced international biogas power generation system, such as lower efficiencies (20% lower), high exhaust temperature from 650 to 700 °C, and the low dependable durability. Furthermore, the automatic control, monitoring and self-protection systems all have room for performance improvement. The use of the waste heat is also not as good as foreign manufactured engines.

## B. Household biogas digester

- **Strengths and opportunities**

  **Abundant resources.** Gansu province has plenty of animal manure. At present, the main type of livestock breeding is still based upon traditional household-size husbandry. A farmer household usually possesses 1 beef cattle or milk cow, or 2 to 3 pigs, which is sufficient to set up a household digester. So, a great number of the scattered livestock keeping households have a sufficient resource base for the potential development of household biogas digesters.

  **Mature technology.** The technology of the household biogas digester in China is very mature, with the standardized digester designs, construction blueprints and operation stipulation. The biogas yield and by-product fertilizer production are in steady performance, and the lifetime of the digester is more than 15 years. Therefore, the application of the household digester can be seen all over the country, and is widely accepted by farmers in Gansu with different types of fermenter design and operation modes. In many cases, the household biogas digester is maintained in coherence with the agricultural production by way of fertilizer utilization. A new trend prevailed for the household digester construction is combined with the reconstructions of the pig pen, human toilet and the household kitchen, the “3-in1”, and even further it may be integrated with the reconstruction of the courtyard and freshwater supply of the households, that is called “5-in1”.

  **Great policy support.** Since 2004, the central government has a subsidy program with a national-debt fund for supporting household biogas digester construction in rural areas. Until 2008, the total amount of subsidy equals 2 billion Yuan.

  **Governmental effort for popularization.** For the present time, one of the main routine efforts of the related governmental sectors is to promote the popularization of the household biogas digester in rural areas. The agricultural department of the government at different levels is in charge of organising and implementing the extension campaign. The detailed management and operation of the program are realized by the rural energy offices established under the agricultural bureaus at each county.

  With such an atmosphere and support policy, the household biogas digester was popularized very quickly in Gansu. In 2006, the total number of the new household digester reached up to 453,000, with an increase rate of 33.2% in comparison to 2005, and the accumulated number of the household biogas digester in Gansu has reached to 181,500. Each household can obtain biogas as the cooking fuel in volume of 300 to 5000 m³ every year, which can substitute the coal consumption of 400 kilogram or so, and the each household can also obtain the fermented organic fertilizers in liquid and solid type for about 20 tons each year,
which can substitute the chemical fertilizer in quantity of several hundred kilogrammes. Furthermore, the sanitation conditions of the household have been improved a lot, especially for cooking in the kitchen. All the benefits and effective improvements from the practical application became a driving force to promote the extension of the household biogas digester continuously.

- **Weaknesses and Constraints**

**Poor quality and maintenance.** Although the number of the household biogas digester has increased rapidly in recent years, there are some problems in household digester popularization.

- The governmental extension plan for the household biogas digester only focuses on the quantity of digesters and lacks attention on the quality.
- During the process of the digester construction, the supervisor is usually the farmer technician. Although they have been trained in some professional courses, their limited skill and knowledge may result in some quality problems in the construction.
- Little attention is paid to the technical service. For routine operation and management of the biogas digester, the service system is weak, such as lack of spare parts supply or in-time professional maintenance, and no real market oriented service mechanism is set up in practice. This hinders the long-time effective application of the digester.

Based on some incomplete investigation results, the proportion of the household digester in normal operation accounts for 70%, i.e. 30% of the household digester are not working.

**Change in rural infrastructure from household to large scale farms.** With the development of the rural economy, the animal breeding mode will transfer from the traditional household keeping mode to scale-up animal keeping farms. The decentralization of the livestock husbandry will decrease gradually, which has been shown in the eastern area in China where the rural economy is developed. For example in Jiangsu and Zhejiang provinces, most of the household biogas digester are not in use. This trend may appear in Gansu in ten years time.

### 3.4.2.3 Biomass Briquette

- **Status quo**

Biomass material can be compressed to form biomass briquettes, small regularly shaped blocks which can act as a kind of solid fuel. The briquettes reduce the difficulties of transportation as they have a smaller volume and higher density than the unprocessed biomass material. Also the briquettes can be used conveniently as boiler fuel or as household cooking and heating fuels to substitute coal consumption. In recent years, the biomass briquette technology has developed very quickly in China.

From the 1980s in China the main type of the biomass briquette processing technology is the thermal compression technology. It requires that the raw biomass materials should be first heated up and the humidity ratio of the feedstock should be controlled properly. After the compression process, the shaped briquette has to be cooled down, so the energy consumption of the whole process is very large while the processing equipments are complex and high cost. Therefore, it is hard to realize commercial development. In recent years, some institutes and enterprises have worked out a new type of biomass compressing technology, which don’t require pre-heating and the compressing process can be realized at normal temperature. Compared with the old thermal compressing technology, the new one does not need the accurate control of the raw material humidity and there is no requirement...
for cooling after the compressing stage. Therefore it is easy for the new machine to deal with the feedstock and the shaped biomass products. In addition, the energy consumption is much lower and the equipment maintenance is easier. Therefore there are lower processing costs, and the new processing technology is developing very quickly.

At the present time, the new processing technology is still in the stage of the pilot demonstration for its commercial development. Although some products have begun to sell at the market, this is minimal. It will need about one year for the production line to be built up for batch production. According to the investigation, there is no biomass briquette processing machine in Gansu, nor any end-use facility. Figure 2 to Figure 5 show some of the biomass compressing machines and the biomass briquette products and as well as some of the end-use facilities.

- **Opportunities**

  **Large potential demand.** As a kind of solid and clean fuel, the biomass briquette can substitute the coal, stalk and firewood, the traditional rural household fuels. Of the rural energy consumption in Gansu province, in total 14.27 million tons of standard coal equivalent, coal consumption accounts for 61%, and firewood and stalks take for 33.9%, therefore the potential market of the biomass briquette in Gansu is very large.

- **Weakness and Constraints**

  **The compressing technology should be improved further.** It is not yet commercial and the lifetime of the parts is short.

  **High cost.** At present time, the current price of the biomass briquette in China is more than 500 Yuan per ton, which is 20% higher than the coal price of same class with similar thermal value.
4 RURAL LIVING ENERGY ANALYSIS TO 2015

4.1 Targets for rural Socio-economic development plan

The general targets of Gansu rural social economics to 2015 are to: gradually increase the per capita agricultural gross output value and the net income of rural residents; adjust the agricultural industrial structure and upgrade the agricultural industrialization and marketing level; enhance the construction of rural infrastructures, upgrade rural education, medical service, sanitation and social security level; improve environmental condition and family planning, speed up the development of rural abstemious society; expedite the steps of opening and reform, encourage rural technical innovation and international cooperation; continuously implementing rural renewable energy development strategy; strengthening the unity of nationalities and improve the development of a harmonious society.

4.1.1 Targets to 2010

1. Annual agricultural output rate to increase by 5%, agricultural gross output value to 66.6 billion RMB, per capita agricultural gross output value above 3200 RMB.

2. Annual average increasing rate of per capita disposable income of urban residents 8%, Annual average increasing rate of the net income of rural residents about 6%, the living quality of urban and rural residents commonly and notably improved.

3. Adjust agricultural industrial structure and upgrade the agricultural industrialization and marketing level. The three industry structure be adjusted to 12.5: 46: 41.5 in 2010, the added value of industries reaches to 40% of the gross output value, urbanization rate reaches about 35%.

4. Enhance the construction of rural infrastructures, upgrade rural education, medical service, sanitation and social security level. Thoroughly achieve the aim of Nine-year Compulsory Education, senior middle school and higher education gross enrolment reaches above 50% and 20% respectively, speed up the vocational education and narrow the gap of per capita education years between Gansu and national average. Continuously improve the medical service and infrastructure in both urban and rural areas, and all the rural residents be basically covered by the New Type Rural Cooperative Medical Service. Continuously boost up public commodity and service supply capacity, continuously improve social security system and reduce the number of poverty population.

5. Improve rural environmental condition and family planning, speed up the development of rural abstemious society. Keep the ecologic environment deprivation within limits, forest cover rate reaches to about 16%; Improve urban environmental quality and key area’s ecological environment, major contaminants discharge be controlled within the national standard targets; The energy consumption of 10,000RMB production be reduced 20% comparing to that of 2005, and the comprehensive utilization ratio of industry solid waste be increased to above 50%; the rate of population natural increase be controlled at about 7‰.

6. The utilization ratio of rural animal waste and crop stalk and the treatment ratio of residential rubbish and wastewater should increase by more than 10%; rural water supply improvement and toilet upgrading will be pushed forward smoothly, the spreading ratio of rural sanitation will reach 65% and serious rural environmental health risk will be effectively controlled; industrial and residential pollution control in rural areas will achieve initial success, ecological
demonstration activity will be widely carried out and farmers’ living and production environment will be improved.

7. Continuously adopt the strategy of rural renewable energy development, speed up the integrated utilization of rural renewable energy, and strive to implement 5 to 8 large scale rural integrated utilization agricultural projects.

8. Further expedite the steps of opening and reform, encourage agricultural scientific innovation and international cooperation, upgrade the rural opening economics to a higher lever.

9. Further strengthen the national unity, improve the construction of democracy and legal system, and promote the development of harmonious society.

### 4.1.2 Major social economic indicators of 2010

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Unit</th>
<th>2010</th>
<th>Annual average increasing rate (%)</th>
<th>Property of the indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional gross production (price of 2005)</td>
<td>100 million RMB</td>
<td>&gt;3000</td>
<td>10</td>
<td>anticipation</td>
</tr>
<tr>
<td>Per capita GDP (price of 2005)</td>
<td>RMB</td>
<td>&gt;10000</td>
<td>9</td>
<td>anticipation</td>
</tr>
<tr>
<td>Resident consumption price index</td>
<td>%</td>
<td>103</td>
<td>3</td>
<td>anticipation</td>
</tr>
<tr>
<td>Gansu total population</td>
<td>10,000</td>
<td>&lt;2730</td>
<td></td>
<td>obligatory</td>
</tr>
<tr>
<td>Rate of population natural increase</td>
<td>%</td>
<td>About 7</td>
<td></td>
<td>obligatory</td>
</tr>
<tr>
<td>Urbanization rate</td>
<td>%</td>
<td>&gt;35</td>
<td></td>
<td>instructional</td>
</tr>
<tr>
<td>Per capita disposable income of urban residents</td>
<td>RMB</td>
<td>11900</td>
<td>8</td>
<td>instructional</td>
</tr>
<tr>
<td>Per capita net income of rural residents</td>
<td>RMB</td>
<td>2630</td>
<td>6</td>
<td>instructional</td>
</tr>
<tr>
<td>Population covered by New Rural Cooperative Medical Service</td>
<td>10,000</td>
<td>About whole province</td>
<td>obligatory</td>
<td></td>
</tr>
<tr>
<td>Per capita education years</td>
<td>years</td>
<td>8</td>
<td></td>
<td>anticipation</td>
</tr>
<tr>
<td>Higher education gross enrolment rate</td>
<td>%</td>
<td>&gt;20</td>
<td></td>
<td>instructional</td>
</tr>
<tr>
<td>Senior middle school gross enrolment rate</td>
<td>%</td>
<td>&gt;50</td>
<td></td>
<td>instructional</td>
</tr>
<tr>
<td>Cultivated land holding</td>
<td>10,000m</td>
<td>&gt;5040</td>
<td></td>
<td>obligatory</td>
</tr>
</tbody>
</table>
### 4.1.3 Targets to 2015

1. Per capita agricultural gross output value, per capita disposable income of urban residents and per capita net income of rural residents arrive at the national average level on the whole.

2. Optimize and upgrade the industrial structure, agricultural industrial structure becomes rational by and large, the agricultural industrialization and marketing reaches to the national average level on the whole.

3. Enhance the construction of rural infrastructures, upgrade rural education, medical service, sanitation and social security level. Thoroughly achieve the aim of Nine-year Compulsory Education, senior middle school and higher education gross enrolment reaches above 70% and 30% respectively, per capita education years arrive at the same level of national average. All rural residents are covered by the New Type Rural Cooperative Medical Service. Basically eliminate absolute poverty population.

4. Rural ecological environmental conditions are fundamentally improved; major contaminants discharge be controlled within the national standard targets; energy consumption of 10,000RMB gross production and comprehensive utilization ratio of industry solid waste come to same level of national average. By 2015, rural residential and ecological environment will be improved markedly, the exacerbation of rural plane source pollution will be reversed, rural environment supervision and monitoring capability and public environmental awareness will be improved, coordinated development among rural environment, economy and society will form.

5. Basically popularize the integrated utilization of renewable energy in rural areas, notably improve resource utilization rate; foster a group of large scale international competitive rural integrated utilization agricultural projects.

6. Further strengthen the national unity, improve the construction of democracy and legal system, and gain a marked achievement in the construction of a new countryside.

### 4.2 Rural Energy demand forecast

The total rural energy consumption in Gansu in 2006 was 21.46 Mtce, the per capita rural energy consumption was 1.03tce, about 55.7% of national per capita average (1.85tce), or 83.1% of national per capita rural energy consumption (1.24tce). Considering annual growth rate of 7.72% in energy consumption in Gansu during 2001-2005, as well as the impact of investment, price, technology on rural energy development, especially large amount of investment and preferential policies by central government for Great West Development, returning farmland to forest land and rural biogas development, it will result in adjustment in rural energy supply and consumption structure in Gansu.
It can be predicted that in the next few years, on the one hand, with the social and economic development and the improvement of living standard, rural residents will have higher requirement of energy amount and quality, more rural residents will use clean and convenient renewable energy as residential energy; on the other hand, with wide implementation of national policy for energy conservation and emission reduction, large amount of high efficient and low emission energy facilities will be applied, the energy efficiency will be improved notably, therefore the growth of energy demand will be offset by increased energy efficiency to certain degree.

Based on the above analysis, it can be predicted that the annual growth rate of rural energy consumption in Gansu will be high, about 8%; during the 12th five year period, due to the implementation of energy conservation and emission reduction measures, the annual growth rate will decrease to about 7.5%. That is to say, by 2010, the total rural energy consumption is predicted at 29.20Mtce; by 2015, the total rural energy consumption is 41.90Mtce. If the accrual rate of rural population in Gansu is 7‰, the rural per capita energy consumption is 1.37tce in 2010 and 1.89tce in 2015, reaching the national rural per capita energy consumption and national per capita energy consumption respectively.
5 MASTER IDEA AND DEVELOPMENT TARGETS

5.1 Direction

The REDP should take the Scientific Outlook on Development as the guidance, constructing resource economization and environmental friendly society. In accordance with the rural energy building policy of “standing on the actual situation, multiple energies complete supplement to each other, comprehensive utilization and attaching importance to benefit”, sticking to the sustainable development strategy, pursuing the target of increasing farmers’ income, improving ecological environment, increasing living standard and optimizing energy mix. Paying attention to the rationale of technology and economy. Greatly developing rural renewable energy with focus on rural biogas, energy use of stalk and wind power, gradually changing the conventional energy consumption structure dominated by coal, stalk and firewood. It is required to speed up the commercial development of rural renewable energy and the structure adjustment, speeding up the demonstration and popularization of rural renewable energy technology in rural area. It is required to promote the application of new technology, new process, new materials and new products etc advanced technology in rural renewable energy development, so as to increase the competitive ability of rural renewable energy. It is planned that the provincial rural average per capita energy consumption and renewable energy consumption proportion reaches national level by 2015, and building Gansu province into clean and beautiful rural renewable energy strong province.

5.2 Basic Principles

5.2.1 Insist on the principle of “emphasizing the key point and making overall plans and taking all factors into consideration”. Attach most importance on regulating the structure of energy in rural region, combining the characteristics of Gansu province, distinguish the degree and emergency, and try to solve the problem of farmer’s utilization of energy for living as a priority. In the purpose of trying to cement the achievement of the construction of environment, combine the development of rural renewable energy with the important project such as grain for woods, pasturage for grass and so on. Band together with the plan of rural social-economic development, and realize the comprehensive development of a socialist new countryside.

5.2.2 Insist on the principle of “adjusting measures to local conditions and arranging reasonably”. According to the condition of resource and climate in Gansu province and the different styles among different rural renewable technologies and meanwhile taking the development of agriculture and rural economics and society into account, plan jointly and try to construct with concentration, promote entirely and guide in sort in the unit of farmer or village. In some conditional areas, encourage and guide the provision of multiple forms of energy to complement each other in the construction of rural renewable energy system.

5.2.3 Insist on the principle of “policy guiding and masses willing”. Make sure that all the farmers recognize that rural renewable energy is a social project through the direction of government typical demo project, and try to make the construction of rural renewable energy system turn out to be a self-conscious and willing action. Meanwhile, the government should support and attract the relative enterprises, individuals and organizations with policy, funds and service, and encourage them to throw themselves into the construction of rural renewable energy system.

5.2.4 Insist on the principle of “depending on science and technology and promoting industry”. Adopt every kind of technology and production of rural renewable energy, which is considered to be technique-developed and quality-reliable, and make sure that farmers can benefit from its extension and application. Taking the scientific research and enterprise as
the principle part, boost the innovation speed of renewable energy, promote its market competitive capacity and make the industry develop fast and healthily

5.3 Targets for development and use

The overall development targets of this plan are to: speed up the exploitation and utilization of rural renewable energy and increase its proportion in the energy structure of rural regions. The problem of shortage of domestic fuel in rural areas should be solved and the number of people without access to electricity should be gradually reduced. Promote the development of rural renewable technology and industry and enhance the level of its research capacity and industrialization.

The provincial targets for rural energy in wind and biomass are set out in Table 5.1 below. Further details are provided in Section 6.

Table 5.1: Rural energy provincial targets for Gansu for 2015

<table>
<thead>
<tr>
<th>Technology type</th>
<th>Target for 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capacity (MW)</td>
</tr>
<tr>
<td>Wind power</td>
<td>12,145</td>
</tr>
<tr>
<td>Household biogas</td>
<td>2,100,000</td>
</tr>
<tr>
<td>Large and medium scale biogas</td>
<td>50</td>
</tr>
<tr>
<td>Stalk gasification stations</td>
<td>20</td>
</tr>
<tr>
<td>Briquetting stations</td>
<td>15</td>
</tr>
<tr>
<td>Direct-fired biomass power generation</td>
<td>3</td>
</tr>
</tbody>
</table>

5.3.1 Biomass development targets to 2010

(1) In Gansu, there will be 1.05 million household biogas systems, 20 middle or large scale biogas projects, 5 biomass gasification gas supply projects, 5 briquetting demonstrations, 1 stalks direct combustion power station and 1 stalks gasification power station with 300kW generator.

(2) Based on the average energy-consumption level at the moment, the rural regional residents’ energy consumption should be increased by 10% and reach 435kg standard coal. Under these circumstances, the supply and demand will be balanced. The target average energy consumption levels for farmers living in moderately well-off conditions is 500kg standard coal per year, while for those who are just above the poverty line it is 400 kg standard coal.

(3) The total efficiency of domestic energy consumption in rural region across the whole province should reach 20% at least, and the proportion of households using biomass energy should be reduced from 70% to 45%. The utilization of renewable energy should be increased by 10%, reaching about 13%, with the objective of saving 1.5 million tons standard coal per year for domestic energy.

(4) Due to the implementation of policies of grain for woods and pasturage for grass, the problem of farmers’ energy utilization for living should be solved in the whole province and the phenomenon of destroying vegetation due to the lack of living fuels should be stopped.

(5) For farmers who live in some conditional remote countryside and pasturing areas, the problem of electrification for living should be solved.
(6) Build a perfect renewable energy management, technical services and quality inspecting system, which is in accordance with the market economy, across the rural regions in the whole province.

5.3.2 Biomass development targets to 2015

(1) There will be 2.1 million household biogas systems, 50 middle or large scale biogas projects, 20 biomass gasification gas supply projects, 15 briquetting demonstrations, 2 stalks gasification power stations including a new one built during 2010 to 2015, and another 12MW generator will be added to the existing stalk direct combustion power station. For farmers across the whole province, their average energy utilization level for living is close to or equal to the level of the whole country.

(2) The total efficiency of domestic energy consumption in rural region across the whole province should reach 30% at least, and the proportion of renewable energy in the energy consumption structure in rural region should be increased by about 30%. The structure of energy for living will get more reasonable.

(3) The phenomenon of destroying vegetation due to the lack of domestic fuels will have been stopped across the whole province.

(4) Realize a good circle in the farmer's fundamental living condition and the inside of the production unit. The farmer's living quality and environment will both be improved.

(5) A perfect renewable energy management, technical-service and quality inspecting system, which is in accordance with the market economy, across the rural regions in the whole province, will have been built.

5.3.3 Wind Development Target

The targets for installation of wind power in Gansu falls into three groups. The targets for the 10 GW wind power base in Jiuquan, targets for smaller (multiple of 49.5 MW) wind farms, primarily outside Jiuquan, and off-grid small wind power home systems.

Development targets for 10 GW wind power base construction in Jiuquan

The plan for development of large scale wind power in GW size in Jiuquan and the plan for the necessary expansion of the power grid in Gansu are as follows:

(1) By the end of 2010, new wind power installed capacity in Gansu will reach 5,000MW. Construct two-loops 750KV transmission line from east Lanzhou to Jinchang and one loop 750KV transmission line from Jinchang through Jiuquan to Guazhou.

(2) By the end of 2015, 10 GW wind power base will be built in Jiuquan, the newly installed capacity will reach 7,600MW, total installed capacity of Gansu will reach 12,710MW. To finish 750KV four loop transmission line from East Lanzhou to Jinchang, 750KV second loop from Jinchang through Jiuquan to Guazhou and 750KV one loop transmission line from Jiuquan to Mazongshan and 750KV transmission line in Jiuquan.

(3) After 2020, the long term development of the wind power installed capacity in Gansu is to reach 40 GW. The main wind power projects are in table 5.2.
Table 5.2 Installed capacity plan of 10GW wind farms in Jiuquan, Gansu province

<table>
<thead>
<tr>
<th>No.</th>
<th>Wind power plant name</th>
<th>Planned area(km²)</th>
<th>Planned installed capacity (MW)</th>
<th>New capacity installed to 2010 (MW)</th>
<th>New capacity installed to 2015 (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Beidaqiao, Guazhou</td>
<td>1200</td>
<td>6000</td>
<td>1600</td>
<td>4400</td>
</tr>
<tr>
<td>2</td>
<td>Ganhekou, Guazhou</td>
<td>400</td>
<td>1800</td>
<td>1800</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Qiaowan, Guazhou</td>
<td>150</td>
<td>600</td>
<td>600</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Liuyuan, Guazhou</td>
<td>20</td>
<td>50</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Changma, Yumen</td>
<td>200</td>
<td>800</td>
<td>800</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Sanshilijinzi, Yumen</td>
<td>25</td>
<td>110</td>
<td>110</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Diwopo, Yumen</td>
<td>50</td>
<td>150</td>
<td>150</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>Mahuangtan, Yumen</td>
<td>200</td>
<td>800</td>
<td>0</td>
<td>800</td>
</tr>
<tr>
<td>9</td>
<td>Qiduntan, Yumen</td>
<td>100</td>
<td>400</td>
<td>0</td>
<td>400</td>
</tr>
<tr>
<td>10</td>
<td>Mazongshan, Subei</td>
<td>700</td>
<td>2000</td>
<td>0</td>
<td>2000</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td><strong>Accumulative installed</strong></td>
<td><strong>5,110</strong></td>
<td><strong>7,600</strong></td>
</tr>
</tbody>
</table>

Development targets for grid-connected small and mid-size wind power projects

Beyond the rich wind resources in Jiuquan, there are also other relatively rich wind resources regions in Gansu which have the potential of developing wind power projects. The main areas lie in Shatangzi Township in Jingta County, Dongle Township and Mayintan Township in Shandan County, south of Dangjin mountain in Akesai, and Huajialing Laozhan in Tongwei etc. These regions correspond to approximately 12 % of the total area of Gansu. The efficient wind capacity is 600kWh/m² per year, the average efficient power density is about 150-200w/m² per year and the efficient wind speed capacity is about 5500h per year.

There are no overall plans for smaller (< 50 MW) wind power projects. The consultant's findings in regard to development of smaller wind power projects beyond the 10 GW wind power base construction in Jiuquan are as follows.
<table>
<thead>
<tr>
<th>No.</th>
<th>Wind farm name</th>
<th>Planning area (km²)</th>
<th>Planning installed capacity (MW)</th>
<th>Development construction period</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dongle, Shandan</td>
<td>20</td>
<td>99</td>
<td>2009—2012</td>
<td>Two 49.5MW wind power projects, wind mast has been started to build since 2008 with good grid connection and transmission condition</td>
</tr>
<tr>
<td>2</td>
<td>Mayingtan, Shandan</td>
<td>20</td>
<td>99</td>
<td>2009—2015</td>
<td>Two 49.5MW wind power projects, wind mast has been started to build since 2008 with good grid connection and transmission condition</td>
</tr>
<tr>
<td>3</td>
<td>Shatangzi site in Jingtai, Baiyin</td>
<td>20</td>
<td>99</td>
<td>2009—2012</td>
<td>Two 49.5MW wind power projects, pre-feasibility report has been finished, with good grid connection and transmission condition</td>
</tr>
<tr>
<td>4</td>
<td>Huajialing, Tongwei</td>
<td>10</td>
<td>49.5</td>
<td>2009—2011</td>
<td>Wind measurement is being conducted, with good grid connection and transmission condition</td>
</tr>
<tr>
<td>5</td>
<td>South Jin mountains, Akese</td>
<td>30</td>
<td>148.5</td>
<td>2009—2012</td>
<td>Three 49.5MW wind power projects, wind measurement is being conducted, 330KV transmission line will be built</td>
</tr>
<tr>
<td>6</td>
<td>Fengshigou, Akese</td>
<td>30</td>
<td>148.5</td>
<td>2012—2015</td>
<td>Three 49.5MW wind power projects, wind measurement is being conducted, 330KV transmission line will be built</td>
</tr>
</tbody>
</table>
### Development targets for off grid small-sized wind power home system

In addition to the 10 GW wind power base in Jiuquan and smaller (multiple of 49.5 MW) wind farms, off-grid wind power home system should be built in local townships, household, distributed small-size factories and border posts, which are rich in wind resource. Measurements should be taken such as to update and extend wind-light complementary wind power group installed in “Power Transmission to Village Sunshine Project”, popularize and utilize low wind speed, high efficiency small wind turbines, and to make full use of household small-size off-grid wind power plant. According to the meeting “Strategy Workshop for Common Development of Off-grid Small-sized Wind Power System in Gansu and Jiangsu” held in Lanzhou, the strategic position of off-grid wind power system should be improved in Gansu wind power development.

**Table 5.4 Planned Development targets for household off-grid small-sized wind power plant of Gansu in 2009-2015**

<table>
<thead>
<tr>
<th>Construction and development year</th>
<th>Total of Gansu</th>
<th>Five cities in Hexi</th>
<th>East and middle area</th>
<th>Longnan, Gannan and Linxia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household built in 2007</td>
<td>2,000</td>
<td>1,260</td>
<td>420</td>
<td>320</td>
</tr>
<tr>
<td>Household to be built in 2010</td>
<td>3,000</td>
<td>1,890</td>
<td>630</td>
<td>480</td>
</tr>
<tr>
<td>Household to be built in 2015</td>
<td>12,800</td>
<td>2,835</td>
<td>945</td>
<td>720</td>
</tr>
</tbody>
</table>
6 DEVELOPMENT FOCUS, DISTRIBUTION AND SCALE

6.1 Development focus

Gansu Province has abundant biomass and wind resources and therefore the focus for development for 2008-2015 should be on the following areas:

- Wind power
- Relying on farms and schools, developing large and medium-sized biogas projects, and further promoting the household biogas system;
- Straw gasification and power generation projects should be developed in straw-rich areas.
- Biomass power generation projects.
- With agricultural and forestry waste as raw material, developing biological briquette projects.
- Bio-fuel projects can be developed, through using rich land resources in Gansu.
- Popularization of wood-saving stoves and kangs and solar homes and solar cookers.

6.2 Biomass energy

6.2.1 Development focus

6.2.1.1 Rural biogas

— Scale the animal husbandry. Biogas project should be developed into cycling agriculture, plan and unify the animal husbandry, biogas project, around farms and grass. Synthetically utilize the bio-liquid and bio-sludge, develop ecological agriculture, spur harmless farm product, to realize the resource utilization and environmental management. Produced biogas can offer clean energy for animal field and nearby household. Where possible develop biogas power generation.

— Basic construction unit for rural household biogas is “3-in-1” including household biogas, animal pen, toilet and kitchen. 3-in-1 will be planned and constructed together. The capacity of the biogas pool is 6-10m³. Based on the local conditions, development focus of the national standard pool model is “normal water pressure”. Each pool is planned to realize the automatic feeding, automatic and half-automatic discharging system should be installed. Reconstructed toilet should be incorporated with animal pen with hardened floor and connected to the biogas pool. Install the biogas stove, regulated and controlled purifier and transmission pipeline, harden the hearth and floor. According to the different natural, economic and agricultural industry structure, popularize the energy ecological mode of “four in one” and “five matches”. The subsequent service system will be constructed together and professional service team will be set up to offer construction, maintenance and utilization of bio-liquid to ensure the normal operation and efficiency of the biogas pool.

6.2.1.2 Energy utilization of crop stalks

A Centralized stalk gasification

Stalk gasification station is the village unit, including gasification station, pipeline, biomass fuel energy will be transmitted to the households. The focus in the near future: expand stalk gasification demonstration scope, improve stalk production biogas technology, strengthen and regulate the operation of stalk gasification station, solve the problem of high
tar content in the gasification fuel and improve the stability of system operation. Power generation from stalk gasification should be considered at all sites.

**B  Stalk power generation**

Stalk power generation can not only effectively reduce environmental pollution, but also increase farmer’s income and boost the new socialism rural construction. It should be sited in areas with rich stalk resource.

With reference to the resource conditions and the technological development level, there is some potential to adopt the biomass power generation technology in Gansu, especially with the support policy for carrying out the strategy of western development in China. So, a proper development planning and overall arrangement should be made with consideration of the local resources conditions. Further attention should be paid to the following:

- Select proper sites, and begin with pilot demonstration project before wide extension in successive steps
- The generating capacity for the direct combustion biomass power plant should be controlled within the range of 12 MW maximum
- More attention should be paid on the technology selection process
- Select a place where the stalk resources are abundant and a small coal power plant has been set up there, and take it into priority consideration for establishing a biomass power plant there when the price subsidy privilege for the co-combustion biomass power generation is put into effective practice.
- Special attention should be paid on the stalk collection issue and some corresponding market mechanism should be first set up
- Try to get more international cooperation

Further analysis should be conducted to confirm the possibility of stalk direct-fired power generation.

**C  Briquetting**

A pilot project should be developed in the major grain producing areas in the near future. Briquetting, extend accessory stoves, offer cooking and heating energy to rural household. Progressively solve basic energy demand, change the way of energy utilization and improve the resource transition efficiency. Based on the local conditions, confirm the reasonable production scale, explore stalk collection, storage and pre-treatment mode. Expert to solve the contradiction of stalk dispensability, periodic supply and centralized supply. The experience will be popularized throughout the whole province.

**6.2.2 Geographical distribution**

Gansu can be divided into four major rural energy districts according to the natural conditions and rural energy resource distribution\(^6\), including Hexi desertification area, grassland area, south forest area and middle loess plateau which classification is as following:

<table>
<thead>
<tr>
<th>Table 6.1 Distribution of the districts in Gansu</th>
</tr>
</thead>
<tbody>
<tr>
<td>6Source: page 8-10 of Gansu Rural Energy 11th Five Year Plan; <a href="http://www.gansu.gov.cn/GsgIItemQw.asp?id=130">http://www.gansu.gov.cn/GsgIItemQw.asp?id=130</a></td>
</tr>
<tr>
<td>Prefectures</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Zhangye City</td>
</tr>
<tr>
<td>Wuwei City</td>
</tr>
<tr>
<td>Jiuquan City</td>
</tr>
<tr>
<td>Jinchang City</td>
</tr>
<tr>
<td>Jiayuguan City</td>
</tr>
<tr>
<td>Lanzhou City</td>
</tr>
<tr>
<td>Baiyin City</td>
</tr>
<tr>
<td>Tianshui City</td>
</tr>
<tr>
<td>Qingyang City</td>
</tr>
<tr>
<td>Pingliang City</td>
</tr>
</tbody>
</table>
Hexi desert area: Hexi is the production base for marketable grain, which is the nation’s planting base for “west vegetable to east”. The rural economy develops relatively fast and natural resource is rich. In which, per capita stalk resource in Jiuquan, Zhangye, Wuwei is more than 500kg/person/year; per capita for animal waste is more than 400kg/person/year. In connection with the current ecological environment status, focus should be as follows:

Backland oasis: animal-raising household should construct “quaternity” household biogas pool to offer high-quality clean cooking energy for household. In the centralized animal-raising area, large and medium-sized animal raising field, construct large or middle scaled biogas project, to offer concentrate gas for household or realize biogas power generation. Based on large area orchard, sunlight greenhouse and vegetable production, by sufficient utilization of bio-liquid and bio-sludge, build harmless rural production base. In the rich resource area, build stalk gasification gas supply station to offer cooking energy for household. Make full use of light and heat resource, expand solar stove, solar heating house to improve the living standard of household in the area.

The focus for crossover area of oasis and desert is to popularize the solar stove. In the area with good economy and rich stalk resource, set up solidifying molding fuel demonstration project, develop lump solid molding fuel with accessory stove, offer cooking and heating energy for household, improve energy efficiency to prevent local desert vegetation from being damaged.

Conservation forest in Qilian Mountain mainly popularize solar stove and coal-saving stove, refuse the forest damage behaviour for lack of the fuel.

Grassland area. With rich solar energy and advanced raising industry in this area, the focus is to expand solar house, stove and household opto-electronic system, develop heating
pen to raise animals, construct “quaternity” household biogas pool, to fundamentally solve the rural energy shortage problem.

**Southern forest area.** Households in this area currently use wood as their energy, thus it’s necessary to popularize highly-efficient wood-saving stove to increase the energy utilization efficiency. Animal waste in this area is rich, waste resource in Ganan, Longnan and Dingxi is more than 1.1 million tonnes. Construction of rural household biogas pool, large and medium sized biogas project is the focus. Offer centralized gas to households or conduct biogas power generation. By all these measures, prevent farmers from deforestation, to stop the damage to the forestry resource.

**Drought and half-drought loess plateau in the middle east area.** With poor natural conditions and weak ecological environment, it is the key area for returning land to farming. The focus for this area is household rural energy accessory construction, generally form the positive cycle of ecology.

A. Suburbs and river valley are the main vegetable production area for the city. Through biogas construction and animal raising development, promote economic crop plant to reduce the production cost and produce harmless vegetable to increase farmer’s income, form the new growth for local rural economy.

B. In the mountains, it’s often shortage of water, fertilizer and fuel. “Five accessory facilities” (mainly household biogas and solar stove) should be promoted. Every household should have two cisterns, one biogas pool, one solar stove. Combined with returning land for forestry, build up an orchard (vegetables or medicines), one household is one unit to reach the positive ecology cycle for the region. Fundamentally solve the problem of eating, income, fuel, fertilizer and drinking problem, finally protect and improve the ecological environment.

### 6.2.3 Contents and scale

#### 6.2.3.1 Rural biogas

**A. Household biogas**

By the end of 2007, quantity of household biogas projects in Gansu had reached 0.31 million, which is 8.6% of the rural households which are appropriate for biogas application. As per natural conditions and resource availability in different areas, it is planned in 2010, that rural household biogas can reach 1.05 million households, or 25% of rural households. In 2015, it will reach 2.1 million, 50% rural households.

——Hexi desert region. By the end of 2010, rural household biogas in this area will reach to 0.21 million, 20% of the total rural households. By the end of 2015, the number will reach 0.42 million, which is 20% of the total household biogas projects in the whole province.

——Grassland region. By the end of 2010, rural household biogas will reach 31.5 thousand households, 3% of the provincial total. By the end of 2015, the number will reach 63 thousand, 3% of the provincial total.

——Southern forest and forest edge region. By the end of 2010, rural household biogas will reach 0.42 million households, 40% of the total rural households. By the end of 2015, the number will reach 0.84 million, 40% of the total.

——Loess plateau in middle east part. By the end of 2010, rural household biogas will reach 0.3885 million, 37% of the total. By the end of 2015, the number will reach 0.777 million, 37% of the total.

**B.Scaled animal raising plant, biogas project in animal raising subdistrict**

By the end of 2007, there were 2 livestock farm biogas plants in Gansu, distributed in grassland region (Jiuquan) and loess plateau region (Lanzhou). By 2010 it is predicted there
will be 20 large and middle livestock farm biogas projects, rising to 50 by 2015.—Hexi dessert region. The number of biogas projects in the area will reach 10, which is 50% of the total amount of large biogas projects for Gansu Province. In 2015, the number will be 23, 46% of the total.

—Hexi dessert region. The number in the area will reach 10, 50% of the total. In 2015, the number will be 23, 46% of the total.

—Southern forest and forest edge region. The newly built biogas plant in the region will reach 6, 30% of the total in Gansu; In 2015, it will reach 17, 34% of the total.

—Loess plateau in middle east part. The number in this region will reach 4 by the end of 2010, 20% of the total. In 2015, it will be 10, 20% of the total.

6.2.3.2 Energy utilization of stalks
A. Centralized stalk gasification station and briquetting demonstration
By 2015, it is planned to build 20 centralized stalk gasification stations in Gansu, it is planned that 5 of these will be built by 2010. By 2015 it is planned that there will be 15 briquetting fuel demonstration projects. In Hexi desert region and drought and half-drought area of loess plateau in middle east, stalk resource is rich, which is suitable for centralized use.

—Hexi dessert region. By 2010, it is planned there will be 2 stalk gasification stations and 2 biomass briquetting fuel demonstration plants. By 2015, these numbers are planned to rise to 8 and 6 respectively.

—Drought and half-drought area in east loess plateau. By 2010, there will be 3 stalk gasification stations and 3 briquetting fuel demonstration plants. By 2015, the number will be 12 and 9 respectively.

B. Biomass combustion power generation and gasification power generation
Considering the rich stalk resource in Hexi desert region and loess plateau in middle east area, to 2010, one 12MW stalk direct-firing or stalk-coal co-firing power generation station will be built in Zhangye City. One stalk gasification power station with capacity of 3million gas and 300kW generator will be built in Jiuquan. And another stalk gasification power station will be built before 2015 somewhere in loess plateau in middle east part of Gansu.

C. Utilization of solar energy and small-sized renewable power
By 2010, 1 million new solar stoves and 100 solar heating houses should be developed, popularise 23.5 thousand household solar power (100W) system, build 7500 household micro hydropower systems (300W), and popularize 10000 wind power generation (200W).
### Table 6.2 Rural Energy Targets in Gansu until 2015

<table>
<thead>
<tr>
<th>Project name (Unit)</th>
<th>Total</th>
<th>Hexi dessert area</th>
<th>Grassland area</th>
<th>Forest edge in south forest edge</th>
<th>Loess plateau in middle east</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biogas utilization project</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Having built by the end of 2007</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household biogas (10 thousand)</td>
<td>31</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large and middle sized biogas project</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>To be built by the end of 2010</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household biogas pool (10 thousand)</td>
<td>105</td>
<td>21</td>
<td>3. 15</td>
<td>42</td>
<td>38.85</td>
</tr>
<tr>
<td>Large and middle sized biogas project</td>
<td>20</td>
<td>10</td>
<td>0</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td><strong>To be built by the end of 2015</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household biogas (10 thousand)</td>
<td>210</td>
<td>42</td>
<td>6. 3</td>
<td>84</td>
<td>77.7</td>
</tr>
<tr>
<td>Large and middle sized biogas project</td>
<td>50</td>
<td>23</td>
<td>0</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td><strong>Energy utilization of stalks</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Having built in 2007</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centralized gasification station</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Stalk solidifying modeling</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To be built by the end of 2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centralized stalk gasification station</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Stalk solidifying modeling demonstration spot</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Stalk direct-fired power generation station</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Stalk gasification power generation station</strong></td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Centralized stalk gasification station</strong></td>
<td>20</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td><strong>Stalk solidifying modeling demonstration spot</strong></td>
<td>15</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td><strong>Stalk direct-fired power generation station</strong></td>
<td>1(one generator added)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Stalk gasification &amp; power generation station</strong></td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

| **Solar stove(10thousand)** | 100 | 12.6 | 4.4 | 40.2 | 42.8 |
| **Solar energy heating house** | 100 | 22 | 9 | 30 | 39 |

| **Solar stove(10thousand)** | 210 | 25 | 10 | 85 | 90 |
| **Solar energy heating house** | 215 | 45 | 20 | 65 | 85 |

| **Household solar PV power system** | 4700 | 600 | 2400 | 1000 | 700 |
| **Household wind power generation system** | 2000 | 420 | 1260 | 100 | 220 |

| **Household solar PV power system** | 7050 | 900 | 3600 | 1500 | 1050 |
| **Household wind power generation system** | 3000 | 630 | 1890 | 150 | 330 |

| **Household solar PV power system** | 10570 | 1350 | 5400 | 2250 | 1575 |
| **Household wind power generation system** | 4500 | 945 | 2835 | 225 | 495 |
6.2.4 **New Rural Renewable Energy Technology Introduction**

A number of different new rural renewable energy technologies are currently under development in China and overseas, and in the future may be able to contribute to Gansu’s rural energy requirements. In particular the technologies that are relevant to Gansu are:

- Dry anaerobic biogas
- Briquetting
- Biomass liquid fuel technology
- Fuel ethanol
- Biodiesel
- Biogas engineering technology
- Straw gasification technology
- Biomass power generation technology

Further details of these technologies and their current status of development and role they could play in Gansu is given in Annex 2.

6.2.5 **Priority projects**

A number of projects have been identified which should be prioritised as part of the REDP. In total there are 46 priority projects covering biogas only, biogas with power generation, stalk gasification only and stalk gasification with power generation. No biomass combustion power projects have been identified but there is sufficient resource in Zhangye and Qingyang to develop projects in these prefectures. Similarly no briquetting projects have been identified yet.

These projects meet the development targets for 2010 and work towards the targets for 2015. Further projects will need to be identified to meet the overall target of 2015.

The projects have been prioritised in the order that they should be developed. The selection criteria to prioritise the projects in the REDP is shown in the box below. The same criteria should be used in the analysis of future project proposals to be included within the REDP.

The final projects is shown in Table 6.3. In general the larger projects are given greater priority.
Selection Criteria for Priority Project for REDP

Factors

- Resource Availability - refers to the quantities of different varieties of livestock in breeding farms and quantities of dung (ton/year) or total quantity of straws that can be used as fuel (ton/year).
- Project Scale - refers to the installed capacity of power system (kW), total yield of biogas (m³/year) and fuel production capacity (ton/year).
- Technology maturity - refers to the technical reliability and application.
- Economic Indicator - refers to the investment per unit of energy produced (RMB/m³, RMB/ton) or the investment per kW of installed capacity (RMB/kW), and project static investment payback period (year).
- Environmental Impact - refers to the possible environmental benefits upon construction completion, mainly including the reduction of SO2, CO2 and COD discharges (t/a) and amount of water saving;
- Social Impact - refers to the possible social benefits during project operation, e.g. energy saving or energy replacement (tce/year), increase of job opportunities and economic output;
- Financing Ability - refers to the structure of different financing sources in total investment, in particular the share of self-financing in total investment (%).
- Project Management Capability - refers to whether the project has assigned dedicated office and management staff, full-time technical staff or trained staff and established necessary rules and regulations or mechanisms.
- Demonstration Effect - refers to the total resource availability in same types of regions in Gansu Province, technology applicability, market demand and willingness of pay or use by end users.

Note: Based on project information collected, and in considering the current status of industry development and local social-economic development, the marking shall be done by four grades, i.e. Excellent, Good, Fair and Poor, with ratings of 4,3,2 and 1 respectively; In principle, those projects with large scale, good economic benefit, strong management capability, large GHG emission reductions and great potential for project popularization will be recommended.
Table 6.3 Evaluation of initial investment of 27 priority projects

<table>
<thead>
<tr>
<th>Location</th>
<th>Project Title</th>
<th>Project Description provided by local stakeholders</th>
<th>Financing expected (^7) ADB/ fund/ self (Unit: 10000RMB)</th>
<th>Total funding (^8) (Unit: 10000 RMB)</th>
<th>Preliminary evaluation result by expert brief description</th>
<th>Initial investment (10000RMB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw Power</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Jiuquan City</td>
<td>Suzhou Yinda Town Shexin Village Biomass power generation project</td>
<td>stalks 50,000 ton; gas 3 million m³/year; generator 300kW</td>
<td>450/0/400</td>
<td>850</td>
<td>Gas supply with power generation, gas production: 3 million m³ per year</td>
<td>480</td>
</tr>
<tr>
<td>2 Zhangye City</td>
<td>Zhangye stalk direct-combustion power generation project</td>
<td>Stalk 200 thousand ton/year, capacity 2X12MW, 2X48t/h boiler</td>
<td>30,000</td>
<td>30,000</td>
<td>Electricity supply 114 million kWh per year</td>
<td>30,000</td>
</tr>
<tr>
<td>Straw Gasification</td>
<td>Dunhuang Huangqu Town Stalks Gas Distribution Station</td>
<td>stalks 30,000 ton; gas 1.5 million m³/year</td>
<td>160/40</td>
<td>200</td>
<td>Gas supply; Annual gas production: 1.5 million m³</td>
<td>300</td>
</tr>
</tbody>
</table>

\(^7\) The data is provided by local stakeholders.
\(^8\) The data is provided by local stakeholders.
<table>
<thead>
<tr>
<th></th>
<th>Jiuquan City</th>
<th>Dunhuang Yangguan Town Stalks Gas Distribution Station</th>
<th>stalks 30,000ton; gas 1million m³/year</th>
<th>160/40</th>
<th>200</th>
<th>Gas supply; Annual gas production: 1.5 million m³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wuwei</td>
<td>Tianzhu County Haixi Town Gucheng Village Stalks Gasification Project</td>
<td>Stalks production 1869ton from 5876 mu plant area in this village; 130ton can be collected for gasification; gas production is 250,000m³/year</td>
<td></td>
<td>55</td>
<td>Gas production: 250 thousand m³ per year</td>
</tr>
<tr>
<td></td>
<td>Biogas Power</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Linxia City</td>
<td>Linxia County Beiyuan village Jinniu Company thousands-dairy cow Breeding Farm Biogas Power Generation Project</td>
<td>Planning 8000 cows, 50,000 sheep; Newly built water collection pool 50m³, digester tank 2000m³; Generator capacity is 5000kW.</td>
<td>400/80/93.5</td>
<td>573.5</td>
<td>Equivalent to 10,000 cows; Installation capacity: 1200kW</td>
</tr>
<tr>
<td></td>
<td>Linxia City</td>
<td>Gansu Xingkang Breeding Farm Large-scale Biogas Project</td>
<td>600 cows; newly built digester pool of 250m³, gas holder of 100m³, combined heat and power generation system of 85kW</td>
<td>130/20/33</td>
<td>183</td>
<td>600 cows; Generator Capacity: 80kW</td>
</tr>
<tr>
<td></td>
<td>Linxia City</td>
<td>Yongjing County Yanguo Town Xiaochagou Large scale Breeding farm Biogas power generation Project</td>
<td>Cow 200; pig 2000; sheep 800; digester bank 600m³, installed capacity of power generation set is 50kW.</td>
<td>70</td>
<td>300</td>
<td>400 cows; Generator capacity: 60kW</td>
</tr>
<tr>
<td>No.</td>
<td>City</td>
<td>District Name</td>
<td>Project Details</td>
<td>Pig / Biogas / Generator</td>
<td>Efficiency</td>
<td>Capacity</td>
</tr>
<tr>
<td>-----</td>
<td>--------------</td>
<td>----------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>--------------------------</td>
<td>------------</td>
<td>----------</td>
</tr>
<tr>
<td>9</td>
<td>Linxia City</td>
<td>Yongjing County XianYuan Town</td>
<td>Caojiawan Large scale Breeding farm Biogas power generation Project</td>
<td>Pig 12000; biogas 520,000m³ per year; generator 500kW.</td>
<td>320/160/150</td>
<td>630</td>
</tr>
<tr>
<td>10</td>
<td>Linxia City</td>
<td>Yongjing County Yufeng Dairy Cow</td>
<td>Breeding Co., Ltd Biogas Project</td>
<td>Pig production 10000; generator is 100kW.</td>
<td>580</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Tianshui City</td>
<td>Tianshui City Agriculture High-Tech</td>
<td>Pilot District large-scale biogas station construction</td>
<td>Cow 2000; biogas 120,000m³/year; generator capacity is 2*80kW</td>
<td>500/355</td>
<td>855</td>
</tr>
<tr>
<td>12</td>
<td>Zhangye City</td>
<td>Zhangye City Yuanbo Pasture Industry</td>
<td>Development Co., Ltd with ten thousand beef cattle large-scale biogas project</td>
<td>Cow 2000; biogas production is 320,000m³/year.</td>
<td>250/120/130</td>
<td>500</td>
</tr>
<tr>
<td>13</td>
<td>Zhangye City</td>
<td>Zhangye City Ganzhou District Biomass</td>
<td>large scale biogas comprehensive utilization project</td>
<td>Cow 15000; biogas production 2330,000m³/year.</td>
<td>250/400/353.5</td>
<td>1553</td>
</tr>
<tr>
<td>No.</td>
<td>City</td>
<td>Project Name</td>
<td>Details</td>
<td>Capacity</td>
<td>Generator</td>
<td>Notes</td>
</tr>
<tr>
<td>-----</td>
<td>---------------</td>
<td>---------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>----------</td>
<td>-----------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>14</td>
<td>Baiyin City</td>
<td>Huining Kangzhiyuan Breeding Co., Ltd Biogas Project</td>
<td>Cow 1000, Sheep 1000, Pig 100, Waste water 70 ton/day; Biogas 270,000m³/year; Power generation</td>
<td>160/30/70</td>
<td>260</td>
<td>1100 cows; generator: 130kW</td>
</tr>
<tr>
<td>15</td>
<td>Baiyin City</td>
<td>Jingtaishengda pig-breeding farm biogas power generation project</td>
<td>Current pig 4000; Biogas 320,000m³/year; Generator 100kW</td>
<td>250/120/130</td>
<td>500</td>
<td>4000 pigs; annual biogas production 132,000m³; Generator: 60kW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Biogas Supply</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Lanzhou City</td>
<td>Lanzhou City Xigu District Kaiyue Dairy Farm Large-medium Scale Biogas Project</td>
<td>1000 cows; Digester capacity of 600 m³; Biogas 320,000m³/year.</td>
<td>250/120/130</td>
<td>500</td>
<td>1000 cows; annual biogas production 320,000m³; Generator: 120kW</td>
</tr>
<tr>
<td>17</td>
<td>Lanzhou City</td>
<td>Lanzhou City Xigu District Hualong Dairy Farm Large-medium Scale Biogas Project</td>
<td>1000 cows; Biogas 320,000m³/year</td>
<td>250/120/130</td>
<td>500</td>
<td>1000 cows; annual biogas production 320,000m³; Generator: 120kW</td>
</tr>
<tr>
<td>18</td>
<td>Dingxi City</td>
<td>Lintao County gas&amp;electricity integration energy ecological pilot project</td>
<td>666 cows currently; Daily yield electricity 690kWh</td>
<td>500/0/329</td>
<td>829</td>
<td>666 cows; Generator: 60kW</td>
</tr>
<tr>
<td>19</td>
<td>Linxia City</td>
<td>Linxia County Xiaxing Modernization Dairy Cow Breeding Co., Ltd Biogas Project</td>
<td>Planning 1000 cows; Digester capacity of 250 m³</td>
<td>33</td>
<td>188.5</td>
<td>1000 cows; Annual biogas production: 320,000m³; Gas supply? Are there so many gas users?</td>
</tr>
</tbody>
</table>

*ITP/1016*
<table>
<thead>
<tr>
<th>No.</th>
<th>City</th>
<th>County</th>
<th>Company Name</th>
<th>Project Details</th>
<th>Planning Cows</th>
<th>Annual Biogas Production (m³/year)</th>
<th>Digester Capacity (m³)</th>
<th>Gas Supply</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Linxia City</td>
<td>Linxia County</td>
<td>Xianweier Halal Meat Co., Ltd Environment Protection Biogas Project</td>
<td>Planning 800 cows; Digester capacity of 80 m³</td>
<td>35</td>
<td>125</td>
<td>800 cows; annual biogas production 260,000 m³; gas supply; Are there so many gas users?</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Linxia City</td>
<td>Linxia County</td>
<td>Lyuwan Dairy Cow Fatten Co., Ltd Environment Protection Biogas Project</td>
<td>Planning 1000 cows; Digester capacity of 100 m³</td>
<td>20</td>
<td>135.5</td>
<td>1000 cows; annual biogas production 320,000 m³</td>
<td>270</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Zhangye City</td>
<td>Shandan County</td>
<td>medium-large scale biogas project</td>
<td></td>
<td>130</td>
<td>500</td>
<td>Equivalent to 250 cows; annual biogas production: 90,000 m³</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Baiyin City</td>
<td>Huining Nongyuan</td>
<td>Cow Breeding Co., Ltd</td>
<td>Cow 850; biogas production 160,000 m³/year</td>
<td>100/20/35</td>
<td>155</td>
<td>850 cows; annual biogas production: 280,000 m³</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Baiyin City</td>
<td>Huining Changning</td>
<td>Forage Livestock Co., Ltd Biogas Project</td>
<td>Currently pig 5600, annual pig production 10000; biogas 320,000 m³/year</td>
<td>77.5/52.5/25</td>
<td>155</td>
<td>5600 pigs; annual biogas production: 180,000 m³</td>
<td>220</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Baiyin City</td>
<td>Baiyin Jingyuan County</td>
<td>Guoding Milk-cow Farm Biogas Project</td>
<td>Current cow 1000; biogas 320,000 m³/year</td>
<td>250/120/130</td>
<td>500</td>
<td>1000 cows; annual biogas production: 320,000 m³; Are there so many gas users?</td>
<td>270</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Pingliang City</td>
<td>Chongxin County</td>
<td>Baishu Town Fuminkegongmao Farm Biogas Project</td>
<td>Farmer 300 household; cow 850; pig 960; biogas 208,000 m³/year</td>
<td>245/30/50</td>
<td>325</td>
<td>Equivalent to 950 cows; annual biogas production: 300,000 m³</td>
<td>260</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pingliang City</td>
<td>Chongxin County Dongxin Pasture Co., Ltd Biogas Project</td>
<td>Cattle 1000; Biogas 192,000m³/year</td>
<td>300/40/60</td>
<td>400</td>
<td>1000 Cattles; Annual Biogas Production: 280,000 m³</td>
<td>240</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>----------------</td>
<td>--------------------------------------------------------</td>
<td>-----------------------------------</td>
<td>----------</td>
<td>-----</td>
<td>------------------------------------------------</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>41,552.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40,990</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6.3 Wind power

6.3.1 Development focus

10 GW wind power base construction in Jiuquan

Based on the spirit of the documents about the developments of the Jiuquan wind power base and the supporting power net’s early work, which is authorized by national development and reform committee (NDRC) on June 20th, 2008, the development focus of 10 GW wind power base construction in Jiuquan are as follows.

(1) Stepping up the wind resource’s measure and evaluation work, according to the principles that i) good wind resource, ii) adequate transport facilities, iii) safe and economic access network, and iv) attention to the protection of the eco-environment. Choose the right wind power project locations of the 10 GW wind power base in Jiuquan, developing the most viable sites initially further follow present, so to arrange the location of wind power base in north large bridge in Guazhou, Ganhekou, Liuyuan, Qiaowan and Mazongshan respectively in the north of Gansu and to arrange the wind power construction plan during “the 11th and 12th five year plan” in Changma Yumen, Jingzi thirty miles, Diwopu, Kuangtanshan, Qingshiliang, Qiguocai, Mapoutan.

(2) Accomplish the planning and construction of the power net which supports the wind power base well, in accordance with the request that integration into the northwest power net, and on the basis of the apprehensive consideration of the near and long term need, the economic and social efficiency, technical and safety, and finally to come up with the overall planning programming of the 10 GW wind power base construction in Jiuquan and the power net construction programming during “the 11th and 12th five year plan”.

(3) Coming up with the specific wind power projects for the 10 GW base, and on the principle of attracting the multiple investments, mobilizing the positive facts of all sides, and finally to come up with a specific programme, which are to be developed and constructed by various investors and equipment suppliers, selected through tender procedures.

The development and construction of the 10 GW wind power base in Jiuquan of 2008-2015 is as shown in Table 5.2

2 Other potential wind power projects

To promote wind power industrialization development in Gansu, “Gansu Wind Power Plant Engineering Plan” was worked out in 2005 and selected 15 grid connection wind power plant locations. The work focuses on potential small wind power projects (< 50 MW) beyond the 10 GW wind power base construction in Jiuquan:

(1) Develop the wind resource’s measuring and evaluation work in other regions with good conditions besides the 10GW wind power base in Jiuquan. Following the principles of making sure that the resource is good, the transport facilities are adequate, the grid connection is safe and economic, and pay attention to the protection of the eco-environment, select the right wind power project locations with big development potential in Dongle, Mayingtan, Xingquan, Huajialing, and Fengshigou which are respectively in Shandan, Shandan, Baijin, Tongwei and Akesel. Follow the principle of developing the most viable project first to prepare a plan for developing smaller wind power projects and include the plan in “the 11th and 12th five year plan”.

(2) Being authorized and commissioned by DRC of Gansu incorporate the reports of pre-
study, grid connection and environment assessment, in order to build a data base for wind power projects with high development potential.

(3) Do well in the planning and construction work of the relative matching grid for other wind power projects with high development potential besides the 10GW wind power base in Jiuquan. Authorize the relevant electrical design departments to design the programming of the grid for small scale wind power plants and grid construction during the “the 11th and 12th five years plan”.

(4) On the principle of attracting multiple investments, mobilizing the positive factors for all parties. Finally to come up with the specific programme which is developed by various investors and equipment suppliers, who shall be selected to take part in the construction of small scale wind power projects through tender procedures.

Developing plan and status for small scale wind power projects with high potential during 2008-2015 see in Table 5.3.

3. Development targets for off-grid small wind power home system

To speed up the scaled industrialized development of wind power and seek multi-utilization fields of wind power, in addition to the 10 GW wind power base in Jiuquan and smaller (multiple of 49.5 MW) wind farms, off-grid small wind power home system should be built in local townships, households, small factories and border posts, which are rich in wind resource. Update and extend wind-light complementary wind power group installed in “Power Transmission to Village Sunshine Project”, popularize and utilize low wind speed, high efficiency “magnetic suspension wind power generator”, make full use of off-grid small wind power home system. According to the meeting “Strategy Workshop for Common Development of Off-grid Small-size Wind Power Home System in Gansu and Jiangsu” held in Lanzhou, largely develop off-grid wind power industry, to improve its position in wind power generation in Gansu.

6.3.2 Geographical distribution

1 General situation for 10GW wind power base in Jiuquan, Gansu province

This base including three regions in Jiuquan, which is Guazhou, Yumen and Subei. The planned wind power plants during “the 11th and 12th 5 years plan” is respectively called Guazhou Beidaqiao, Ganhekou, liuyuan, Qiaowan, Yumen Changma, Diwopo, Sanshilijinzi, Qiduntan, Kuantanshan, Mahuangtan, Qingshiliang and Mazongshan. The total installed capacity in these regions is 10650MW.

Jiuquan City is located among the mountains of Aerjin, Qilian and Mazong and borders on Zhanye in the east, Xinjiang in the west, Qinghai in the south and Mongolia in the north. The distance between its east and west border is 680km, while south and north is 550km. The total area of Jiuquan is 191,200 km², which accounts for 42% of the whole province.

The topography of Jiuquan City is high in the south and low in the north with an incline from southwest to northeast. To its south is the Qilian Mountain which is a series of high mountains with their altitudes from 3000m to 5000m. From the east to west, there’s also a series of mountains called Qilian, Taolai, Daxue, Yema, Aerjin and Seshiteng. In the south, at altitudes above 4000m, it gradually gets into the frozen earth area and also has current glacier which is the headstream of some local rivers. Among the mountains, there are big basins existing which are called Suganhu, Shibaocheng, Changmabao and some other small basins. The middle area of this region is a part of Hexi Corridor.

In the north of this region, the land is covered with gravel and soil, namely Gobi and borders on Bei Mountain, which is part of Alashan altiplano. This area is huge and its altitude is about 1500-2000m. For the dry weather and being eroded all the time, the mountains here
are gravel. For the impacts of strong wind and flood, part of the mountain is already to be peneplain.

The wind resource in Jiuquan, Gansu province is very high, the land for wind power plant sites is flat and the landform is simple, so it is very suitable for the development of huge wind power projects. As the improvement of national production ability for national wind power generation, with the policy of “energy-saving and pollute emissions reduction” and the encouragement of developing clean energy, conditions are ideal for wind power development in Gansu. According to the analysis on wind resource, geology, transport and grid capacity planning in Jiuquan District, the number of wind farms in Jiuquan is adjusted to 10, with total installation capacity of 12,710MW, including Jiuquan 10GW wind power base in Jiuquan to be built by 2020.

2 General situation of the areas with developing potentials besides the 10GW wind power base in Jiuquan

In addition to the Jiuquan region which is rich in wind resource, there are also some other areas which has enough wind resource and potential to develop wind farms. They are mainly located in Shatangzi of Xingquan, Dongle, Mayingtang, South of Dangjin Mountain, and Laozhan of Huajialing which respectively belong to the county of jingtai, Shandan, Akese and Tongwei in Baiyin City.

(1) General situation of Dongle, Shandan County.

Dongle Town is located in the northwest of Shandan, Zhangye City and is close to the 312 National Highway and Lanxin Railway in the north. The distance between the east boundary of Dongle and Shandan is about 30km. In this area, the landform is flat and wide Gobi, the average altitude is about 1580m, and available area is 24km². There are no constraints preventing the development of wind turbines in the area as there as no buildings, tall trees, archeological remains and it is not an environmental protection zone. The distance between the center of the area and Shandan substation is about 35km. The substation’s has sufficient capacity for the connection of new turbines to the grid and the conditions for wind power grid connection are good. A weather inspecting station and a 10.5m wind measurement mast were built in November 2007 by Shandan Weather Bureau. According to wind measurement analysis over four months wind measurement analyses, we conclude there is abundant wind resource here. For a further complete analysis of the wind resource, a professional wind measurement mast is required and measurements would need to be taken for at least a year to ensure a wind farm would be appropriate.

(2) The general situation of Mayingtang, Shandan County

Mayingtang is located in Shandan horse farm in Zhangye City and approximately 55km from the south of Shandan. In this area, the topography is flat and wide, the altitude is 3000m-3060m, and it belongs to the continental and plateau climate. As Mayingtang is located in the valley between the mountains of Longshou in the north and Qilian in the south, the main wind orientation is parallel with them and it will amplify the wind in this direction. The climate is damp and changes frequently. A weather inspecting station and a 10.5m wind measurement mast were built in November 2007 by Shandan Weather Bureau. According to four months of wind measurement analyses, we conclude there is abundant wind resource at this location. For a further complete analysis of the wind resource, a professional wind measurement mast is required and measurements must be taken over at least a year. The distance between the center of the area and Shandan 330KV substation is about 60km. The substation’s has sufficient capacity for the connection of new turbines to the grid and the conditions for wind power grid connection are good.
(3) General situation of Shatangzi of Xingquang Township, Jingtai County in Baiyin.

This area is located at E103°04′~104°00′, N37°04′~37°10′ and there is one kilometre distance to the northwest of the Xingquan Town. The distance between the factory site and the center of Jingtai County is 11km and 201 Provincial Highway and the Xijishui railway station are next to the southern part of the factory site So the transport network is well developed. Most of the land in Xingquan town is Gobi, the topography is flat and wide, and the available area here is 50 km². According to the topography tendency and plantation distribution, this area will be divided into three areas for the development of wind power and can arrange four wind farm sites for 50MW wind power generators, which is called Xingquan wind farm (Stage I, II, III and IV)

All the land at these four wind farm sites is flat due to flooding and the altitude is 1713m-1883m. The level of site ground and groundsill is middling complex. This is an earthquake prone area so the geological configuration is not stable in this area. There are no important resources under the ground of the factory sites and it is in accord with the relative rules on environment protection.

The wind main direction is in accord with the direction of maximum density of wind energy. The maximum wind speed, wind energy and frequency are in the north-westerly and southerly directions. According to the continuous wind measurement by the 40m mast constructed in May 2006 during September 2006 – December 2007, we conclude that at a height of 65m, the average wind speed is 6.70m/s and the average power density is 354W/m². In this area, the wind speed doesn't change significantly and it's available for power generation during the whole year. The distance from the proposed area to the 0110KV Huadong and 330kv Shicheng substations in Baiyin are respectively 12km and 25km. The capacity of them is respectively 150MVA and 350MVA. In addition, other relative conditions are also good and there is a large development potential to construct wind farms smaller than 100MW in this area.

(4) General situation of south of Dangjin Mountain in Akese region

Akese which is a Kazakhstan autonomy county is located in the boundary of Gansu, Qinghai and Xinjiang. The average altitude of this area is about 3700m. Fengshigou is located in the foothills of the Arjin and Jin mountains. The landform here is Gobi, topography is high in the north and low in the south and the gradient is about 0.8%. It's very flat and there are no mountains, trees or other obstacles in this area and the area available is big enough for a wind farm. The distance between the initial project site and the foot of Arjin and Jin mountains is about 10km. At this site the average altitude is 2800m. The distance between the bearing stratum and the earth’s surface is 2m, so the bearing strength is high enough. It's very dry here and the average temperature is about 8°C. According to the continuous wind measurement during September 2006 – October 2007, we conclude that at a height of 10m, the average wind speed is 6.2m/s, the annual average effective energy density is about 280 W/m², and the wind effectively blows for about 6000 hours a year. So it meets the standard of Stage III for wind farm and of course has good economic impact. However, the area is at the end of the Gansu grid, and there's only one route existing from Guazhou to the 110kv substation in Akese by way of Dunhuang with a length of 230km, so only 40-50MW wind power generators can be installed here.

(5) General situation of Laozhan in Huajialing region
Wind in this area is formulated by the special mountainous terrain. The initial wind farm is located in the village of Huomatan in Hualing town, Tongwei County. Taking the mountaintop of Huajialing Mountain as the centre, the site is in the circle of an 8km radius and its altitude is about 2300m. At this site, the landform is upland and around it is barren hills of different heights. In the centre of the site is basin, and villagers of Matan village live here. Besides the barren hills, most of the land is plantation. According to the continuous wind measurement during October 2005 – June 2008, we conclude that at the height of 10m, the average wind speed is 5.55m/s, the energy density of the annual average effective energy density is about 160W/m², so it meets the standard of Stage III for wind farm. The distance between the site and 330kv substation in Tongwei County is 35km. The substation’s capacity for the voltage change is enough and the condition for wind power grid connection is good. The site is close to the old 312 National Highway and the gradient is low, so huge mobile machinery shop can arrive here. This site meets all the relative demands of wind power plant development and can be developed.

6.3.3 Contents and Scale

1 Wind Power Base of 10 GW or Above

According to the document approved by NDRC “Preparation Works for Jiuquan Wind Power Base and Complementary Power Grid”, the master plan for wind power bases at 10 GW or above is shown in Table 5.2 with the totals shown below:

<table>
<thead>
<tr>
<th>No.</th>
<th>Wind power plant name</th>
<th>Planed wind power area km²</th>
<th>Planed installed capacity MW</th>
<th>Installative capacity 2008--2010 MW</th>
<th>Installative capacity 2011--2015 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>12,710</td>
<td>5,110</td>
<td>7,600</td>
<td></td>
</tr>
</tbody>
</table>

2 Master Plan for Small Wind Power bases in 2008—2015

The overall plan for development of small wind power projects (< 50 MW) is shown in Table 5.3. The totals are shown below:

<table>
<thead>
<tr>
<th>No.</th>
<th>Wind power plant name</th>
<th>Planed wind power area km²</th>
<th>Planed installed capacity MW</th>
<th>Development and construction period</th>
<th>Details for each power plant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>130km²</td>
<td>643.5MW</td>
<td>2009—2015</td>
<td>13 plants</td>
</tr>
</tbody>
</table>
6.3.4 New Rural Renewable Energy Technology Introduction

6.3.4.1 Main Wind Generator Suppliers in China

According to China’s “Renewable Energy Law”, for approved wind power projects the proportion of equipment made nationally should not be lower than 70%. Therefore the majority of equipment in the current wind power projects is produced by Chinese manufacturers or Chinese-foreign joint ventures. Due to the low quality of technology in Chinese manufacturers, most suppliers have imported technology from abroad.

In China there are at least 40 wind generator manufacturers. Only a few of these manufacturers have obtained core technology that has been developed by foreign companies and established production capacity with guaranteed quality. A number of those manufacturers are: Jinfeng Science and Technology Company in Xinjiang, Dongqi Wind Generator Company in Sichuan, Huarui Wind Power Science & Technology Co. in Tianjin, Dalian Heavy Industry Co., Jiangsu Yunda Co., Mingyang Wind Power Technology Co. and Shanghai Electrical Co. A brief summary of these companies is given in the Annex 3.

6.3.4.2 Brands and Technical Specifications of the Main Suppliers

Table 6.9 Key suppliers in China with the specifications of the products

<table>
<thead>
<tr>
<th>Brand Specification</th>
<th>Jinfeng S70/1500</th>
<th>Gamesa G58-2.0MW</th>
<th>Dongqi FD77B</th>
<th>Suzlon S82-1.5MW</th>
<th>Vestas V80-2.0MW</th>
<th>Mingyang MY1.5s</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Roller</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diameter (m)</td>
<td>70</td>
<td>80</td>
<td>77</td>
<td>82</td>
<td>80</td>
<td>77.36</td>
</tr>
<tr>
<td>Wind area (m2)</td>
<td>1963.5</td>
<td>5027</td>
<td>4656</td>
<td>5281</td>
<td>5027</td>
<td>4638</td>
</tr>
<tr>
<td>Speed (rpm)</td>
<td>9-19</td>
<td>9.0-19.0</td>
<td>9.6-17.3</td>
<td>15.6~18.8</td>
<td>16.7</td>
<td>17.4</td>
</tr>
<tr>
<td>Direction</td>
<td>Up wind</td>
<td>Up wind</td>
<td>Upwind</td>
<td>Up wind</td>
<td>Up wind</td>
<td>Up wind</td>
</tr>
<tr>
<td>No. of lamina</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Power adjustment</td>
<td>Varying oar</td>
<td>Varying oar</td>
<td>Varying</td>
<td>Varying oar</td>
<td>Varying oar</td>
<td>Varying oar</td>
</tr>
<tr>
<td>Wind in (m/s)</td>
<td>3</td>
<td>3.0</td>
<td>3.0</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Wind out (m/s)</td>
<td>25.0</td>
<td>21.0</td>
<td>20</td>
<td>20</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Standard (m/s)</td>
<td>11.8</td>
<td>12.0</td>
<td>12.5</td>
<td>14</td>
<td>15</td>
<td>11</td>
</tr>
<tr>
<td>Limit (m/s)</td>
<td>70</td>
<td>52.5</td>
<td>56.3</td>
<td>67</td>
<td>56.3</td>
<td>70</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>-30~40°C</td>
<td>-20~40°C</td>
<td>-20~40°C</td>
<td>-20~40°C</td>
<td>-20~40°C</td>
<td>-10~40°C</td>
</tr>
<tr>
<td>Weight (t)</td>
<td>15.6</td>
<td>11.5</td>
<td>34.9</td>
<td>17.64</td>
<td>11.5</td>
<td>33</td>
</tr>
<tr>
<td>2. Generator</td>
<td>asynchronous</td>
<td>frequency conversion</td>
<td>Double</td>
<td>Change pole</td>
<td>optispeed</td>
<td>Double</td>
</tr>
<tr>
<td>Rated Power (kW)</td>
<td>1880</td>
<td>2000</td>
<td>1500</td>
<td>1500</td>
<td>2000</td>
<td>1500</td>
</tr>
<tr>
<td>Rated Voltage (V)</td>
<td>690</td>
<td>690</td>
<td>690</td>
<td>690</td>
<td>690</td>
<td>690</td>
</tr>
<tr>
<td>Frequency (Hz)</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50/60</td>
<td>50</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Speed (rpm)</th>
<th>1900</th>
<th>1680</th>
<th>1800</th>
<th>800 – 1200</th>
<th>1620</th>
<th>1800</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current (A)</td>
<td>660</td>
<td>1500</td>
<td>1200</td>
<td>670/72</td>
<td>670/720</td>
<td>1200</td>
</tr>
<tr>
<td>Factor</td>
<td>0.98</td>
<td>0.98</td>
<td>-0.95 ~ 0.98</td>
<td>-0.95 ~ + 0.98</td>
<td>0.98</td>
<td>-0.95 ~ + 0.98</td>
</tr>
<tr>
<td>Protection</td>
<td>IP23</td>
<td>IP54</td>
<td>IP54</td>
<td>IP54</td>
<td>IP54</td>
<td>IP54</td>
</tr>
</tbody>
</table>

3. Tower

<table>
<thead>
<tr>
<th>Weight (t)</th>
<th>11, excluding</th>
<th>67</th>
<th>56</th>
<th>50</th>
<th>67</th>
<th>56</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Steel cone</td>
<td>Steel cone</td>
<td>Steel cone</td>
<td>Steel cone</td>
<td>Steel cone</td>
<td>Steel cone</td>
</tr>
<tr>
<td>Highness (m)</td>
<td>65</td>
<td>67</td>
<td>61.5</td>
<td>65</td>
<td>67</td>
<td>75/60</td>
</tr>
<tr>
<td>Weight of tower (t)</td>
<td>130</td>
<td>145</td>
<td>100</td>
<td>130</td>
<td>158</td>
<td>120/100</td>
</tr>
<tr>
<td>Total weight (t)</td>
<td>79</td>
<td>108</td>
<td>189</td>
<td>165</td>
<td>104</td>
<td>185</td>
</tr>
</tbody>
</table>

**Development of unit wind turbine size in China**

As seen above the market leader measured in single unit capacity is the 1.5 MW wind turbine.

The main suppliers of wind turbines in the world are producing wind turbines in the range of 1.0 MW to 3.6 MW. Prototype wind turbines up to 5.0 MW have been installed in Europe, but serial production of wind turbines in the 4.0 to 5.0 MW range have not yet been developed in the wind energy market.

Transport limitations due to the length of the blades and a lack of sufficient crane capacity onshore result in the 2.5MW and greater capacity turbines primarily being used for off-shore applications.

Many inland wind sites in China are restricted by transport limitation and in Gansu an overall assessment finds that the 2.0 MW wind turbine size (approximately) is the upper single unit limit.

It should be noted that the numbers shown above are generalisations. Individual differences between the products and special circumstances at a specific site, may mean that a larger wind turbine could be installed. Furthermore one of the research focuses is the development of components and transport applications, which overcome some of the transport barriers in order to increase the unit size capacity which can be installed at inland sites.

**6.3.5 Priority projects**

According to the document approved by NDRC “Preparation Works for Jiuquan Wind Power Base and Complementary Power Grid” and the research outcome on wind resource in Gansu
Province, the planned wind power projects have been prioritized as follows and as set out in Table 5.2.

Table 6.10 Prioritized Planned Wind Power Projects in Gansu

<table>
<thead>
<tr>
<th>No.</th>
<th>Wind power plant name</th>
<th>Planned wind power plant area km²</th>
<th>Planed installed capacity MW</th>
<th>2008—2010 Installed capacity MW</th>
<th>2011—2015 Installed capacity MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Beidaqiao, Guazhou</td>
<td>1200</td>
<td>6000</td>
<td>1600</td>
<td>4400</td>
</tr>
<tr>
<td>2</td>
<td>Ganhekou, Guazhou</td>
<td>400</td>
<td>1800</td>
<td>1800</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Qiaowan, Guazhou</td>
<td>150</td>
<td>600</td>
<td>600</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Liuyuan, Guazhou</td>
<td>20</td>
<td>50</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Changma, Yumen</td>
<td>200</td>
<td>800</td>
<td>800</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Sanshilijingzi, Yumen</td>
<td>25</td>
<td>110</td>
<td>110</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Diwopu, Yumen</td>
<td>50</td>
<td>150</td>
<td>150</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>Mahuangtan, Yumen</td>
<td>200</td>
<td>800</td>
<td>0</td>
<td>800</td>
</tr>
<tr>
<td>9</td>
<td>Qiduntan, Yumen</td>
<td>100</td>
<td>400</td>
<td>0</td>
<td>400</td>
</tr>
<tr>
<td>10</td>
<td>Mazongshan, Subei</td>
<td>700</td>
<td>2000</td>
<td>0</td>
<td>2000</td>
</tr>
<tr>
<td>11</td>
<td>Dongle, Shandan</td>
<td>25</td>
<td>99</td>
<td>49.5</td>
<td>49.5</td>
</tr>
<tr>
<td>12</td>
<td>Mayingtan, Shandan</td>
<td>25</td>
<td>99</td>
<td>49.5</td>
<td>49.5</td>
</tr>
<tr>
<td>13</td>
<td>Shatangzi, Jingtai</td>
<td>20</td>
<td>99</td>
<td>49.5</td>
<td>49.5</td>
</tr>
<tr>
<td>14</td>
<td>South Jin Mountains, Akesai</td>
<td>30</td>
<td>148.5</td>
<td>49.5</td>
<td>99</td>
</tr>
<tr>
<td>15</td>
<td>Fengshigou, Akesai</td>
<td>30</td>
<td>148.5</td>
<td>49.5</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td>Huajialing Old Station, Tongwei</td>
<td>10</td>
<td>49.5</td>
<td>0</td>
<td>49.5</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------</td>
<td>-----</td>
<td>------</td>
<td>-----</td>
<td>------</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>3,185</td>
<td><strong>13,353.5</strong></td>
<td><strong>5,357.5</strong></td>
<td><strong>7,996</strong></td>
</tr>
</tbody>
</table>
7 INVESTMENT ANALYSIS

7.1 Investment estimation

7.1.1 Capital Cost Estimates for Rural Renewable Energy Projects

The total capital cost for renewable energy projects in Gansu Province (not including wind power bases) during 2009-2010, and from 2009 to 2015, and assuming no fluctuation in currency value, is estimated to be RMB3660.64 million, and RMB 8651.27 million respectively. Detailed cost estimates are shown in Table 8-9 for the capital costs and Table 8-1 to Table 8-8 for capital cost estimation for each type of project).

1. Rural Biomass Projects

Total capital costs for biomass utilization projects will be RMB3100.07 million from 2009 to 2010, and the accumulated costs are RMB7510.18 million from 2009 to 2015.

(1) RMB4, 000 would be needed for a household biogas project (with digestion capacity of 10 m³). 1050 thousand households in the whole province would be required by the end of 2010, costing approximately RMB2960 million. 2100 thousand households would be required by the end of 2015, costing approximately RMB7160 million.

(2) RMB7 million would be needed for a biogas project for an animal breeding farm, totalling RMB140.07 million for 20 such projects in the province by the end of 2010, and RMB 350.17 million for 50 such projects from 2009 to 2015.

2. Rural Straw Utilization Projects

The total capital costs for rural straw utilization projects are estimated at RMB146.32 million for the period of 2009 to 2010, and approximately RMB326.66 million for the period of 2009 to 2015.

(1) RMB3.0 million would be needed for a stalk gasification - gas project, and RMB15 million in total are for 5 such projects in the province by the end of 2010. RMB60.06 million are for 20 such projects by the end of 2015.

(2) RMB800,000 would be needed for a stalk briquetting project with an annual output of 5000 tons, and RMB4 million in total are for 5 such projects in the province by the end of 2010, and RMB 12 million are needed for 15 such projects by the end of 2015.

(3) RMB125 million would be needed for a stalk combustion power project at capacity of 12MW in Zhangye City by the end of 2010. And another RMB125 million would be required for added capacity of 12MW to this power project by the end of 2015. RMB2.3 million is required for the stalk gasification power station with capacity of 300kW generator by 2010. RMB 4.6 million is required for another new gasification power station in Gansu.


Total capital costs for solar energy projects would be RMB300.25 million during 2009 to 2010, and it will be about RMB630.5375 million during 2009 to 2015.

(1) RMB300 would be estimated for a single solar cooker, and so RMB300 million in total for one million such projects in the province by the end of 2010, and RMB 630 million are for 2.1 million such projects by the end of 2015.
(2) RMB2500 would be estimated for a single solar energy heating room, and so RMB250 thousand for 100 such projects in the province by the end of 2010, and RMB 537.5 thousand are for 215 such projects by the end of 2015.

4. Small Power Supply Projects

Total capital costs for small power supply projects are estimated at RMB114 million during 2009 to 2010, and it will be about RMB179.6 million.

(1) RMB4000 is the calculation for a household solar PV lighting system at capacity of 100 W, and so RMB94 million in total for 23.5 thousand such projects in the province by the end of 2010, and RMB 154 million are for 38.5 thousand households such projects by the end of 2015.

(3) RMB2,000 is the calculation for a household wind power project at capacity of 200 W, therefore RMB20 million in total for 10,000 such projects in the province by the end of 2010, and RMB 25.6 million are for 12,800 such wind home systems by the end of 2015.

5. Institutional Capacity Building

Total capital costs for institutional capacity building would be in the region of RMB4.3 billion.

(1) RMB1.88 million is the calculation of funds that would be required for establishment of rural energy service institutions at the village level.

(2) RMB2.41 million is the calculation of funds that would be required for training of rural energy technicians at the village level.

Table 7-1 Summary of Capital Costs for Rural Renewable Energy Projects in Gansu Province

<table>
<thead>
<tr>
<th>Year</th>
<th>Total in Gansu</th>
<th>Hexi desert region</th>
<th>Grassland</th>
<th>Forestry region</th>
<th>Loess region</th>
</tr>
</thead>
<tbody>
<tr>
<td>total</td>
<td>184663</td>
<td>503726</td>
<td>49188</td>
<td>115200</td>
<td>9180</td>
</tr>
<tr>
<td>Rural biogas project</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household biogas system</td>
<td>116000</td>
<td>356000</td>
<td>23988.8</td>
<td>74154.8</td>
<td>1798</td>
</tr>
<tr>
<td>Biogas project in animal breeding farm</td>
<td>12606.3</td>
<td>33616.8</td>
<td>6303.15</td>
<td>15464</td>
<td>3782</td>
</tr>
<tr>
<td>Rural straw utilization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stalk gasification with gas supply</td>
<td>1501.5</td>
<td>6006</td>
<td>600.6</td>
<td>2402</td>
<td></td>
</tr>
<tr>
<td>Stalk briquetting</td>
<td>400</td>
<td>1200</td>
<td>160</td>
<td>480</td>
<td></td>
</tr>
<tr>
<td>Stalk gasification power</td>
<td>230</td>
<td>460</td>
<td>230</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stalk combustion power</td>
<td>12500</td>
<td>2500</td>
<td>12500</td>
<td>12500</td>
<td></td>
</tr>
</tbody>
</table>

Although this plan does not include the institutional capacity building, the investment estimation is listed in the whole cost estimation on the basis of the actual need for the rural energy development.
7.1.2 Capital Cost Estimates for Wind Power Projects

1. Wind Power Stations at 100 MW or Above

It is estimated that the capital cost for wind power generation is RMB 8900/kW at 2008 prices. Therefore the total capital costs for wind power bases at 100 MW or above are calculated at RMB45,479 million from 2009 to 2010, and the accumulated capital costs are RMB113,119 million from 2009 to 2015 (see the following table for capital cost estimation for each of project).

<table>
<thead>
<tr>
<th>Wind power plant name</th>
<th>Investment Cost from 2009 to 2015</th>
<th>Investment cost from 2009 to 2010</th>
<th>Investment cost from 2011 to 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 North bridge of Guazhou</td>
<td>5,340,000</td>
<td>1,424,000</td>
<td>3,916,000</td>
</tr>
<tr>
<td>2 Guazhou Ganhekou</td>
<td>1,602,000</td>
<td>1,602,000</td>
<td>0</td>
</tr>
<tr>
<td>3 Guazhou Qiaowan</td>
<td>534,000</td>
<td>534,000</td>
<td>0</td>
</tr>
<tr>
<td>4 Guazhou Liuyuan</td>
<td>44,500</td>
<td>44,500</td>
<td>0</td>
</tr>
<tr>
<td>5 Yumen Changma</td>
<td>712,000</td>
<td>712,000</td>
<td>0</td>
</tr>
<tr>
<td>6 Yumen Sanshilijingzi</td>
<td>97,900</td>
<td>97,900</td>
<td>0</td>
</tr>
<tr>
<td>7 Yumen Diwopu</td>
<td>133,500</td>
<td>133,500</td>
<td>0</td>
</tr>
</tbody>
</table>
2. Small Wind Power bases

The total capital cost for small wind power bases in the province is calculated at RMB5727.15 million from 2009 to 2015. The capital cost for each project is shown in Table 7-3 below.

<table>
<thead>
<tr>
<th>Wind power plant name</th>
<th>Planned investment cost</th>
<th>Period for investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dongyue Village, Shandan County</td>
<td>88110</td>
<td>2009—2012</td>
</tr>
<tr>
<td>2. Mayingtan, Shandan County</td>
<td>88110</td>
<td>2009—2012</td>
</tr>
<tr>
<td>5. Dangjinshan power plant in Akesai</td>
<td>132165</td>
<td>2011-2015</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>572,715</strong></td>
<td><strong>2009—2015</strong></td>
</tr>
</tbody>
</table>

7.2 Financing

7.2.1 Currently investment projects in China use a variety of financing sources as follows:

- Self-raised equity capital: For any commercial project, there must be a portion of self-raised capital as the equity investment. This type of capital generally comes from private investors, privately-owned enterprises, state-owned enterprises or from individual households.

- Long-term bank loan: This kind of commercial banks' loan could be provided to investment projects in various industries including infrastructure. For a large-scale project this loan may require financial guarantee based on the project’s asset itself. For medium and small projects it will require guarantee based on the equity investors’ other assets.

- Equipment leasing: In China the equipment leasing business is done not by equipment suppliers but by specialized leasing companies, which are defined as non-
bank financial institutions. The nature of this business is just like the bank's long-term loan. Small-scale businesses and rural industries have difficulties to get access to the leasing business.

- Special foundations: To encourage development of special products or new technologies in an industry, the government often establishes foundations at the national level. The foundations provide grant, low-interest loan or equity capital to those commercial firms or non-profit organizations that have huge potential market.
- Government investment or grant: In some cases the governments at different levels may directly invest in certain selected projects that would be particularly beneficial to the publics. Small amount of grant would also be available in this regard.
- Funds from international development institutions: From the middle of 1980s China started to use funds offered by the World Bank, Asian Development Bank, UNDP, UNIDO and the like. The fund users can take advantages of the relatively lower interest expenses and longer repayment period, but have to satisfy strict conditions imposed by those institutions in correspondence with the fund utilizations.

7.2.2 Potential Financing Mechanisms for Rural Renewable Energy Projects in Gansu Province

The specific financing terms and conditions that future rural renewable energy projects could be suitable for will be highly dependent on the financial position of the project owner, the nature of ownership (government-owned versus privately owned), the type of energy (wind power, solar energy, biomass, etc.), project type (e.g., power generation, gas generation or building materials), scale of capital cost (large, medium or small), capital structure (the ratio between owner's equity and debt), and project cash flow (stability in the long-run versus periodic fluctuation). Due to lack of sustainable and applicable financing mechanism, the development of rural clean energy industry is greatly restricted. However, one or more of the following financing sources represent possible candidates for future rural clean energy projects:

- **Government investment of grant and cross-subsidy.** The rural clean energy industry is still at the initial stage. The projects are small, and locations are spread around broad areas so that it is rather difficult to manage these decentralized projects. The customers are singular and the pricing mechanism has been established. More importantly the return on investment is uneasy to predict. Under these conditions the government must be the main player in the field for quite a long time. The market itself without government commitment will definitely not be able to gear up the development of the industry. It is obvious that along with China's rapid economic development and increase in the government annual finance income, with more and more people understanding the importance of rural renewable energy, the total amount of finance resources given by the government to development of rural renewable energy industry will increase year on year. However, a focus of the government spending would be on the demonstration or pilot projects, which represent different sources of renewable energy, different types of technology, different scales of production and different areas with various people's income layers. These demonstration projects may be able to get full financial support from the government. Another focus of government spending would be on those areas where the natural resources are really affluent, external conditions are optimal and there is an obvious potential to build up a renewable energy industry in a large scale. In this circumstance, the first round of projects, whether invested by individuals/households or by communities/enterprises, would benefit from government subsidies along with preferential policies.

In accordance with the national “11th Master Plan for Renewable Energy Development”, the government will promulgate guidelines and manual on renewable
energy development funds based on the actual demand. A proper scale of fiscal spending will be arranged during the 5-year period to support renewable energy technology innovation, project construction, rural renewable energy development and utilization, etc. Preferential tax treatment will be implemented to renewable energy projects, technology research and development and equipment manufacture.

In particular, the Chinese central government is stimulating domestic demand in the near future which will promote the domestic economy continuously as the development strategy. Enforcement in agriculture infrastructures and increasing investment in improvement of living environment has been put forwarded explicitly. In addition to the 1,000 billion RMB at the end of 2008, 3.0 billion is to support rural biogas project. In addition, the Ministry of Agriculture is working on the “Construction Plan of National Rural Clean Project” in order to implement the rural clean energy project sponsored by central government. It is foreseeable that in the next few years continuous capital cross-subsidy will be input into the large scale demonstration projects of the rural clean energy and their promotion.

- **Private or enterprises’ commercial investment.** Fully commercialized enterprises would require rather high return on investment. The internal rate of return shall be above 10%. Due to the current unhealthy status of rural clean energy industry, to expect large amount of investment from those big companies is unrealistic. A possible option is that a joint fund contributed by local small enterprises and rich rural households be established to invest in a predetermined clean energy project. The investors can manage and run the project nearby.

- **Loan from commercial banks.** The commercial banks, whether fully state-owned or joint-stock registered, would mainly target urban customers and large or medium-sized projects. The rural collective credit community, which is now the dominant financial vehicle in the countryside, is basically providing short-term loan to rural households who are engaged in seasonal agriculture production. Consequently, among the rural renewable energy projects only wind power projects with a certain amount of capacity would probably be able to get access to bank long-term loan.

- **Investment from the special foundations.** Some energy development investment funds have been set up under several ministries in the central government, such as the Ministry of Science and Technology and Ministry of Environment Protection. For example, Ministry of Finance set up the Specific Fund of Renewable Energy Development in 2007 which is to support the development of renewable energy. Rural clean energy projects are generally eligible to those types of fund. However, due to its limited funding amount, it would be impossible for them to distribute the money solely to one region. Even so, those preliminary experimental projects or pilot projects are easily qualified for the funds. And if new technology is applied or imported from abroad, the projects are much more likely to be financed in this regard.

- **Funds from international development institutions.** The institutions such as the World Bank, ADB and some foreign government agencies are willing to finance energy infrastructure. Particularly, they are enthusiastic in development of renewable energy. An optimal option might be to combine diversified clean energy projects from different regions into one packaged project and then apply for funding from the international development institutions. The approach would require very high quality project management expertise, so it may be suitable only for the agencies at the provincial level to undertake such initiative.

A real example (November 2008) is taken hereby to compare the lending terms and conditions between international development institutions and Chinese commercial
banks. This is an energy project that ADB is appraising for sovereignty loan financing. The Table below shows that the ADB lending rates are obviously lower than those of Chinese domestic banks during both the construction period and the operation period. Furthermore, the lending periods of ADB loan are longer as well for both the grace period and repayment period. Even though ADB charges a commitment fee, it normally should not happen if a project is planned and implemented as usual. Additionally, the international development agencies will bring in not only fund but also, more importantly, fresh ideas, management approaches and advanced technologies. Particularly for the China’s renewable energy sector, which lags behind the developed countries, valuable technical assistances from abroad can let China avoid many troubles on the way. That may be the most critical point that many borrowers of international loads would hold. In general, the benefits from financing from international multi-lateral financial institutions are considerable.

<table>
<thead>
<tr>
<th>Loan</th>
<th>ADB</th>
<th>Chinese Banks</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIBOR 5-year fixed rate</td>
<td>3.46%</td>
<td></td>
</tr>
<tr>
<td>LIBOR 10-year fixed rate</td>
<td>4.15%</td>
<td></td>
</tr>
<tr>
<td>ADB spread</td>
<td>0.20%</td>
<td></td>
</tr>
<tr>
<td>LIBOR discount</td>
<td>0.33%</td>
<td></td>
</tr>
<tr>
<td>Lending rate for construction</td>
<td>3.33%</td>
<td>7.20%</td>
</tr>
<tr>
<td>Lending rate for operation</td>
<td>4.02%</td>
<td>7.20%</td>
</tr>
<tr>
<td>Commitment charge</td>
<td>0.15%</td>
<td></td>
</tr>
<tr>
<td>Grace period</td>
<td>5 years</td>
<td>4 years</td>
</tr>
<tr>
<td>Repayment period</td>
<td>20 years</td>
<td>15 years</td>
</tr>
<tr>
<td>Short-term lending rate</td>
<td>6.66%</td>
<td></td>
</tr>
</tbody>
</table>

- **Capital from users.** Part of the investment should be funded by users themselves since most of the investment from the government or other channels is used for the promotion of rural clean energy technology and the demonstration of the product, and generally it will be spent in the form of cross-subsidy to support producing activity and the utilization of clean energy. For example, the proportion of the investment for rural clean energy demonstration project which is carried out by Ministry of Agriculture is 1:1:2 which represents investment inputs from central government, local government and farmers respectively. Although the requirement for investment input from local government became less, the demand of capital inputs from users will not be cancelled to ensure the effect of demonstration of project promotion and encourage conscious participation of users.

- **Mini-credit.** According to the International Finance Company, China is the largest potential mini-credit market in the world and the mini-credit system is being introduced gradually into China, even though the mini-credit practice targeting to small private business, individual households and small farmers, is at the very early stage. Since October 2007 the China Banking Regulatory Committee started to promote mini-credit concepts throughout the country. So far 25 rural commercial banks and 7 specialized mini-credit companies have been built up. In the principle of serving rural people, rural industries and agricultural economy, the mini-credit companies can independently select their customers. With the policy of “mini amount, decentralization”, the mini-credit is to be provided to farmers and mini-business entities in a big number and huge coverage. The mini-credit line has been increased from RMB3,000-5,000 to 10,000 – RMB300,000. For instance, the mini-credit line in
compared to other regions. In comparatively developed regions, the credit line is up to RMB100,000 - 300,000. In under-developed regions, the figure is around RMB10,000-30,000. While in other regions, the credit line is increased to RMB50,000-100,000.
8 ENVIRONMENTAL IMPACT ASSESSMENT

8.1 Environmental impact of rural energy development

Rural energy production includes biomass, wind power, solar energy and micro-hydropower, with this list being non-exhaustive. The highlights of these being small scale and decentralization. Currently in Gansu rural area, local energy production is dominated by domestic energy systems.

With the centralized development of agriculture and stock breeding, more and more large and middle scale biogas, stalk gasification and biomass based power generation projects will be developed. The REDP focuses on the development of biomass and wind power, the biomass development focuses on the development of human and animal waste and crop stalk. The development of biomass can not only replace partial stalk and coal widely used as residential fuel in rural area, but also notably improve indoor air quality in farmers’ houses, and make rural human and animal waste harmless and becoming a new resource. In addition, the implementation of the REDP can reduce a large amount of greenhouse gas emission, which will be favourable for global environmental protection.

In general, rural energy development will facilitate environmental protection, however, if treated improperly, rural energy development could have certain negative impact to water and air environment. Here, attention is mainly paid to the environmental impact with regard to the development of biomass and wind power projects.

1) Biogas projects

Biogas projects mainly include household biogas projects, large and middle stock breeding farm biogas projects and biogas power generation projects. The main environmental impact of biogas projects include; the occupation of land, soil loss, destruction of vegetation, unpleasant odours, noise and solid waste.

During project construction, the main environmental pollution is from foundation excavation, earthwork refilling and materials transport etc. the main environmental impact includes land occupation, soil loss, vegetation destruction, dust discharge and noise pollution. The construction activities will result in short-term impact on air quality in areas surrounding construction sites. The construction activities also have certain noise impact.

During project construction, the main environmental pollution is caused by foundation excavation, soil loss, vegetation destruction, dust and noise emission. The construction activities only impact local air quality for a short time. Construction activities also generate noise pollution.

During project operation, the environmental impact is mainly from waste gas, wastewater, solid waste and noise. Waste gas is the source unpleasant odours emitted from human and animal manure and urine. The wastewater of large and medium-sized biogas projects is mainly residential wastewater, with main pollutants being COD, BOD, SS and NH3-N. In the case of the bio-liquid storage being insufficient, the bio-liquid could flow out, and pollute the environment. Noise commonly emanates from the gas engine, mixing device and pump.

2) Stalk gasification projects

There are two kinds of stalk gasification projects, namely;

- Stalk gasification only
- Integrated stalk gasification and power generation
During project construction, the main environmental impact includes soil loss, dust emission and noise. The project construction permanently and temporarily occupies land, which will have certain impact on the vegetation. The project construction would also discharge some construction wastewater.

During project construction, the main environmental issues are wastewater treatment and tar recovery. The production wastewater is from gas purification system, with main pollutants of SS and tar, especially tar, which is a carcinogenic chemical. Generally, 1m$^3$ of gas would generate 10-16mg tar. The temperature around the gasifier is high, and smoke given off may have an impact on operator's health if safety measures are not implemented properly. The air blower, water pump and gas fired power generation system generate noise. The solid waste is mainly stalk ash, although the amount of ash is small, and it can be used as fertilizer. The CO concentration in stalk gas is high, about 21.4%, certain safety risk exist during the use of stalk gas.

3) Wind power projects

Wind power projects mainly include grid connection wind power and domestic wind power generation system. The domestic wind power generation system occupies small amounts of land, and are easy to install, it has less environmental impact than larger scale grid connected projects.

The environmental impact of grid connection wind power projects are discussed below.

Construction activities could bring about environmental issues such as dust emission, noise and vegetation destruction. The excavation operation will generate solid waste. The construction site will generate certain amount of production and residential wastewater. Wind power projects require the construction of wind generator tower, electricity connection system and substation, which all occupy land.

During project operation, the main environmental impact includes noise, change of landscape and shrinking birds' activity space. The noise level from wind generation is in the region of 40-50dB(A), the noise impact on people 500m away from the wind generator is minimal, but it may still have an affect on bird population in the area. Wind power projects changes local landscape to certain degree, and commonly have effects on rural beauty. Wind farms commonly have an impact on bird life. For example, when a generator is installed in the birds’ flying route, some birds may be killed if they happen to hit the rotating blade of the wind generator, especially where bird activity is frequent. The operation of wind power farm could reduce the active flying space of the birds. In addition, the construction process of a wind power farm needs to occupy land, in order to construct the wind generator foundations, road and transmission lines.

8.2 Mitigation measures

1) Biogas projects

During project construction, the main mitigation measures include: (1) rationally arranging working time to reduce the noise impact on local residents, and low noise construction machinery should be used as far as possible; (2) adopting sealed transportation and water spray to control dust emission; (3) waste earth and waste should be cleared as soon as possible; (4) during pipeline placement, excavation and filling by layer should be conducted, and top soil should be returned to the surface, re-vegetation should be carried out immediately after the construction is ended.

During project operation, sealed anaerobic biological treatment processes should be adopted, and the submerged water entering and outgoing should be used so as to reduce the emissions of unpleasant odours to the atmosphere. The residential wastewater from biogas
projects should be discharged into a central water pool for treatment and reuse. The solid waste is mainly waste and bio-waste. The waste is usually collected and disposed by type; the useless waste should be transported to the designated landfill for treatment in a timely manner. The bio-liquid and bio-waste is commonly stored and then used as organic fertilizer for farmland, orchards and on vegetable crops.

Low noise equipment should be selected to control noise level; providing sealing measures within the generator room, blending and mixing room and pump room, installing noise adsorption material in the above rooms. With these noise control measures, the noise level is likely to be reduced to acceptable levels for the residents 50m away from the noise source.

2) Stalk gasification

During project construction, the above mitigation measures for biogas projects can be taken for stalk gasification projects, so as to reduce soil loss, dust emission and noise impact.

During project operation, production wastewater can be treated in a settling pool, the treated wastewater is recycled by inclusion into a gas purification system and a cooling system. The tar can be recovered from the settling pool, it can be used as a waterproofing material, such as a house roof coating. The stalk gas contains high CO concentration, and so attention must be paid to the safe use of stalk gas by residents. A daily check system should be established, to ascertain any gas leakage as soon as possible. Stalk and stalk gas are combustible elements, fire-proofing should be undertaken, for example, smoking should be prohibited in the project area, and adequate fire-proof facilities should be prepared. The noise produced would be mainly from power generation system, an isolation method could be used to control noise level. At the operation platform of stalk gasifier, the operator should wear mask to reduce the inhalation of smoke. The solid waste is mainly stalk ash, which can be used as fertilizer.

3) Wind power projects

During project construction, residential and works wastewater must be treated before discharge, the residential wastewater can be reused for watering trees and grass after treatment. The disposal site and method of construction and residential waste should get approval from local environmental protection bureau. The construction site and road should be rationally arranged, so as to minimize the land occupation for project construction. Water spray should be conducted on a regular base at construction site, the material and waste piles should be covered, and construct activity is restricted during windy days. The on-site access road and permanent road should use waste earth from the foundation excavation. The construction waste and residential waste should be centralized at a designated site and transported in a timely manner.

During and after the project construction is completed, measures should be taken to restore the vegetation and landscape, in order to mitigate any risk of harm the wind generators may pose to the birds. At wind power farms where bird activity is frequent, it is advisable to install an alarming light system at the wind generator and adopt different colour matching at wind farm.
9 BENEFIT ANALYSIS

9.1 Social impact

1. The exploitation and utilization of renewable energy is a primary requirement of scientific development, which forms part of constructing a resource-conserving society and achieving sustainable development. A sufficient, safe and clean renewable energy supply is the fundamental guarantee to Gansu’s future economic growth, social progression and sustainable development.

2. The exploitation and utilization of renewable energy is an important way to build a socialist new countryside. Rural areas are currently still weak in terms of economic development of and society in Gansu. Energy infrastructures in many rural areas in Gansu are still very poor. The living energy of rural residents is mainly supplied by the traditional way of direct combustion of agricultural stalks, firewood and biomass, which are considered now as a lower efficiency resource utilization. Gansu rural areas are rich in renewable energy resources. To speed up the exploitation and utilization of renewable energy can not only solve the living energy consumption problems of rural residents by making full use of local resources, but also can convert the rural biomass resources into commercial energy, which will make the renewable energy become a special rural industry, extend the agricultural industry chain, increase the agricultural return and the net income of rural residents, improve rural environmental condition and expedite the sustainable development of rural economics and social progress.

3. The exploitation and utilization of renewable energy is the scientific choice of Gansu province to exploit new domains of economic growth, expedite economic re-construction and increase employment opportunities. Gansu is quite rich in renewable energy including wind energy, hydropower, solar energy and biomass. There are considerable available renewable energy resources in every region of Gansu. The exploitation and utilization of rural renewable energy will bring up a batch of high technology industries that will become the bright spots of social and economic development in Gansu.

4. The exploitation and utilization of renewable energy can also bring up some disadvantages to local economics and society. The exploitation and utilization of any kind of renewable energy will inevitably result in some kinds of land occupation. Many kinds of rural renewable energy have relationship with large amount of common rural households, which may bring up some safety and legal problems. In order to make use of rural renewable energy and avoid its disadvantages, it is necessary to strictly implement relative technical safety standards and national regulations and laws in the planning and construction process, to ensure safety throughout.

As a whole, the social and economic benefits of the exploitation and utilization of renewable energy are far beyond its disadvantages. Based on the outlines laid out in this report, the exploitation and utilization of renewable energy favourable for the sustainable development of socio-economics and in complying with the requirements of the construction for a harmonious, resource-conserving and environment-friendly society.

9.2 Environmental benefits

1) Biogas projects

The implementation of biogas projects has multiple environmental benefits, mainly including:
Biogas project belongs to environmental protection project, which can provide biogas and electricity to local households and enterprises, and provide bio-fertilizer to local orchard and farmland.

The biogas project uses human and animal manure and urine to produce biogas, the bacteria in the manure and urine can be killed during digesting process, it can thoroughly eliminate the second environmental pollution by human and animal manure and urine, so as to improve local health environment. The implementation of biogas project can reduce the COD emission to local water environment remarkably, so as to improve local water environment.

The central and sealed treatment of manure and urine by biogas projects can avoid the impact of bad smell on the surrounding environment;

The biogas projects can provide clean fuel to local residents and power plant. The residential use of biogas can reduce the labor burden of cooking, and improve indoor air quality. The biogas power plant can avoid the emissions of TSP, SO₂, NOₓ, CO₂ and other pollutants otherwise by conventional coal fired power plants.

Biogas use as residential fuel and power generation fuel can replace partial conventional fossil fuel, so as to reduce greenhouse gas emission and air pollutants emissions. Considering combustion efficiency and heating value of different energy, 1m³ biogas can replace 1.6kg raw coal or 2.48kg stalk. When 1t raw coal is replaced by biogas for cooking fuel, it can reduce emissions of 1.98tCO₂, 13.4kg SO₂ and 0.7kg smoke; when 1 t stalk is replaced by biogas for cooking fuel, it can reduce emissions of 0.964t CO₂ and 2.1kg smoke. When biogas is used for power generation, 1m³ biogas can produce 1.8kWh electricity (CO₂ emission factor of Northwest Power Grid is 0.841g/kWh), equal to reduce 0.34kgCO₂.

2) Stalk gasification projects

The stalk gasification projects have notable environmental benefits, including replacing coal as cooking fuel, increasing clean energy supply and reducing greenhouse gas emission etc.

The stalk gasification project provides solution to the remaining stalk treatment. Such project can improve rural visage, reduce the air pollution by stalk combustion, reduce the fire risk caused by randomly piled stalk, and improve rural health conditions.

The stalk gasification projects can improve rural energy structure. With the development of rural economy, cooking fuel develops from low grade energy to high grade. The consumption of coal, oil and LPG is increasing in Gansu rural area. The development of stalk gasification projects can replace partial conventional fossil energy, so as to reduce the environmental pollution by use of fossil energy, especially coal combustion.

The integrated stalk gasification and power generation can produce clean energy, 1kg stalk can produce 2m³ stalk gas, and 2.8m³ stalk gas can produce 1kWh electricity. Assuming the CO₂ emission factor of local power grid is 0.841kg/kWh, Use of 1kg stalk for power generation can reduce 0.60 kg CO₂.

3) Wind power projects

The environmental benefits of wind power projects can be realized by replacing conventional fossil energy power generation, especially it will have notable environmental benefits when coal fired power generation is replaced, the environmental benefits mainly include:

(1) Improving local, regional and global air environment by reducing emissions of TSP, SO₂, NOₓ and CO₂ etc. Compared with conventional coal fired power plants, producing every 10,000kWh electricity by wind power can reduce 8.4tCO₂, 8.40kg smoke, 8.40kg SO₂ and 20kg NOₓ: By 2010, the electricity from wind farms would reach 11.352 billion kWh, it can reduce CO₂ emission by 0.9534 Mt, smoke emission
by 953t and SO2 emission by 953t; by 2015, the electricity from wind farms would reach 12.768 billion kWh, it can reduce CO2 emission by 1.0723 Mt, smoke emission by 1072t and SO2 emission by 1072t.

(2) Wind power projects can avoid solid waste and wastewater discharge that conventional coal fired power plants have, wind power projects do not need to consume fresh water, so as to save land resources and protect ecological environment, especially in dry region.

(3) Reducing the environmental problems caused by developing fossil energy. The development of fossil energy usually destroys forest, farmland and vegetation. The off-shore oil development could destroy ocean ecological environment.

9.3 Rural economic development impact

9.3.1 Economic Benefits for Rural Renewable Energy Projects

If the target in this rural renewable energy master plan (not including wind power bases) is achieved after 2010, the value of energy saving each year will be equivalent to 19.77 million tce and the actual economic benefit could be as much as RMB474.638 million. The value of energy saving each year will be equivalent to 21.43 million tce and the actual economic benefit would be as much as RMB1247.238 million after 2015.

- A household biogas project is projected to generate 540 m³/year from the gas saving energy of 1.2tce. Therefore 600 thousand households would save energy of 120 thousand tce and create economic benefit of RMB362.5 million by saving energy, fertilizer and pollution discharge fees at RMB1,250 for each project. The 1200 thousand households will save energy of 380,000 tce and create economic benefit of RMB1112.5 million after 2015.

- A biogas project for animal breeding farm could produce 550,000m³ of biogas or 430 tce. The total projects would save energy of 7746 tce after 2010, and would save approximately 21,517 tce after 2015. Each project will save energy, fertilizer and pollution discharge fee at RMB300,000, and RMB4.8 million in total are for 20 such projects in the province after 2010, and RMB14.4 million in total are for 25 such projects after 2015.

- A stalk briquetting project with an annual output of 5000 tons can save energy of approximately 2145 tce and realize economic benefit of RMB560,000. The total 5 projects will save energy of 10725 tce and create economic benefit of RMB8.4 million after 2015.

- A stalk gasification project can generate approximately 360,000m³ of gas or 283 tce. The total 5 projects will produce 1.8 million m³ or 1415 tce after 2010, and the total 15 projects will produce 5.4 million m³ or 4244 tce after 2015. The total projects will create economic benefit of RMB 750,000 at unit benefit of RMB150,000 each after 2010, and will create economic benefit of RMB 2250,000 after 2015.

- After 2010, the stalk combustion power project with capacity of 12MW will generate electricity of 86.4 million kWh annually or save energy of approximately 28,512 tce so as to create economic benefit of RMB43.2 million. After 2015, the stalk combustion power project with capacity of 24 MW will save energy of approximately 57,024 tce and create economic benefit of RMB86.4 million annually. The stalk gasification power station with capacity of 300kW will generate electricity of 2.16million kWh per year with the energy saving of 7.128 million tce
and create economic benefit of RMB1.08 million. After 2015, the two stalk gasification power projects will save energy of 1425.6 tce and create economic benefit of RMB21.6 million.

- A solar heating room annually can generate energy of approximately 3.2 tce. The total 100 projects will generate 320 tce, and create RMB 680 thousand at RMB 680 thousand for each.
- A household PV lighting system annually can generate electricity of approximately 250kwh or save energy of 0.0825 tce. Therefore 23500 households would save energy of 19.38 million tce, and create economic benefit of RMB2.82 million at RMB120 for each.
- A household micro-hydropower system can annually generate electricity of 600kwh or save energy of 0.198 tce. The total 7500 households will save energy of 1485 tce, and create economic benefit of RMB2250 thousand at RMB300 each.
- A household wind power project annually can generate electricity of 600kw/h or otherwise save energy of 0.198 tce. The total 10,000 households will save energy of 1980 tce, and create economic benefit of RMB3 million at RMB300 for each.

9.3.2 Economic Benefits for Wind Power Bases

Jiuquan wind power bases greater than 100MW could annually generate electricity of 11,242GWh and save energy of 3.71 million tce, and create economic benefit of RMB 5621 million after 2010. After 2015, all wind power projects greater than 100MW will generate electricity of 279,622 GWh and save energy of 9.22 million tce, and create a revenue of RMB13,981 million. Small Wind Power bases have the potential to generate electricity of 1415.7 GWh and save 0.47 million tce, and create economic benefit of RMB707.85 million.
10 IMPLEMENTATION AND GUARANTEE

10.1 Main Barriers

The main barriers to the implementation of the REDP and to meeting the targets set out here are outlined below. They fall into four broad categories:

- Financial barriers
- Institutional barriers
- Technical and information barriers
- Regulatory barriers

10.1.1 Financial barriers

Gansu provincial government lacks the financial resources to rapidly expand their clean renewable energy programmes and most rural households have no means to finance the investment. With the availability of relatively cheap supplies of coal (which causes serious environmental degradation and health problems), the use of firewood (which causes destruction of forested areas), and no alternate means to utilize crop residues and animal wastes, farm households would continue to heat and cook as they presently do and continue to burn crop residues in open fields. Consequently, greenhouse gas (GHG) emissions from coal, firewood, animal wastes, and crop residue burning would continue. It is therefore important that the barriers to the promotion and rapid adoption of clean energy systems be identified and removed.

The key financial barriers that restrict the promotion and expansion of rural clean renewable energy are as follows:

a) **Lack of a replicable financing model and shortage of available capital and credit in rural areas.** The expansion of clean renewable energy is restricted because there is no sustainable and replicable financing model. For example, if there is no stable financing source and preferential policies which support the operating costs to be dropped, it is very difficult to build a stalk gasification or breeding farm biogas project in scale. It is only possible if the project developer has its own means. Moreover, it is difficult for this type of projects to operate sustainably.

b) **Shortage of investment from governments.** The social benefit from a clean energy project is high, but often the financial benefit is small. Therefore, financial organisations are not willing to invest in rural clean energy projects. Gansu adopted policies including subsidies for R&D and projects, and discounted government loans to promote the clean energy development from 1980s. However, compared with the other nations and even with the other provinces in China, the investment from the governments has been too little. The rural clean energy projects have not been included in the financial budgets of the government at all levels, and this has been an important factor that has restricted rural clean energy development.

c) **Expensive imported equipment.** Much of the key equipment had to be imported due to a lower localization rate of equipment for clean energy generation in Gansu, which resulted from the shortage of sufficient R&D. At present, there are over 500 plants producing solar energy water heaters, but there are only 31 plants with sales of more than five million yuan, and the number of enterprises reaching economies of scale is too small. The plan of localization for large and middle scale wind-driven generating sets are just commencing and the economies of scale to be formed need to be supported.
d) **Limited financial capacity of local manufacturers.** Some of the equipment for the clean energy generation can not be provided by the domestic market. The demand for the equipment to generate clean energy is small, resulting in manufacturing enterprises operating at a loss. Therefore, enterprises also do not have the enthusiasm to invest in manufacturing the equipment. There are three major manufacturers of gasifiers, mostly affiliated to universities. Their financial capacity is limited to taking care of the development needs. These organizations cannot withstand unforeseen cost escalation. They face problems while dealing with technology troubleshooting and achieving good operational performance.

e) **Shortage of available capital and credit in rural areas.** Longer term credit facilities are not available to rural households for the adoption of clean energy systems. The rural commercial banks such as the Agricultural Bank of China, rural credit cooperatives, and other financial institutions are uncertain about the viability of clean energy technology and do not provide longer term financing to small farmers. In addition, the relatively low incomes of small farmers make it impossible for them to obtain credit from commercial sources. Medium-scale clean systems, such as gasifiers, have low operating and maintenance costs compared with conventional alternatives, but these systems have high front-end costs. This poses a barrier to prospective investors such as village organizations, township and village enterprises, or entrepreneurs, who do not have either collateral or access to long-term financing. The overall weak financial situation of the communities makes it difficult for them to obtain commercial loans offered by rural financial institutions.

f) **Lack of reasonable Pricing Mechanism for clean energy.** One of the key obstacles restricting the promotion and expansion of clean renewable energy is the generation cost since it is higher than conventional power. For example, the cost for hydropower, wind-driven, biomass and solar energy power generations is about 1.2, 1.5, 1.7 and 1.8 times of coal fired power generation, respectively. In addition the current small market for clean rural energy restricts the clean energy cost reducing. The price for farm products is low, and the raw material for energy production is also inexpensive, but the technology and equipment needed during the power generation are expensive. The environmental and social benefits cannot be present under the actual pricing mechanism. Accordingly, it is difficulty to expand the rural clean energy project under the current pricing mechanism.

g) **Lack of fiscal support.** Fiscal and taxation policy involved in supporting rural clean and renewable energy development includes: budget policy, treasury bonds investment policy, financial subsidies, preferential tax policies, government procurement policies, financial policies, the security of the fund, etc. The specific fiscal and tax policy recommendations are presented as follows:

- **Terms of income tax.** At present, high-tech enterprises and enterprises with comprehensive utilization of resources are given greater encouragement concerning on income tax through direct ways as reduce productivity or regular relief. Most enterprises in field of rural clean and renewable energy resources also use more advanced technology, so they should be referred to the high-tech enterprises and enterprises with comprehensive utilization of resources on tax policies, which enjoy certain income tax concessions. Specific measures may include: investment compensation, a case in point is that 30 percent of business investment in purchasing key equipment should be compensated from enterprises value added tax credits; direct concessions, a case in point is that the corporate income tax should be halved; accelerated depreciation concessions, a case in point is that the depreciation period of the key equipment is appropriately shorten, with minimum...
three years yet; plus deduction privileges, a case in point is that related research and development costs are exerted pre-tax deductions or amortization separately, according to whether they had been transformed to intangible assets; factually related costs deduction, a case in point is that the related promotional expenses can be factually deduced pre-tax.

- **Terms of Value Added Tax (VAT)**. VAT is currently the largest type of tax, and the transformation of VAT from production-based to consumption-based is the trend of the times. At that time, problem of double taxation will be completely solved, which embodies its neutral characteristics. Clean renewable energy resources in rural areas has not yet enjoyed unified VAT concessions, but only VAT concessions in some rural clean and renewable energy products, such as VAT rate of 13 percent for artificial biogas, VAT rate of 6 percent for small hydropower and VAT rate of 8.15 percent for wind generating. However, the overall policies lack systemic integrity, which need adjustments to meet the demands for the development of clean renewable energy in rural areas.

- **Terms of tariff**. According to the existing policy, relevant foreign advanced rural clean renewable energy equipment could not enjoy preferential tariff policy, if domestic funds owned are used to import those equipments. Meanwhile, preferential policies enjoyed by foreign-invested enterprises are much larger, which makes an unequal status between domestic-funded and foreign-funded enterprise in sector of rural clean renewable energy. As a result, it will affect the healthy development of the industry.

### 10.1.2 Institutional barriers

Weak institutional capacities, inadequate technical expertise, and a lack of viable service infrastructure constitute a barrier to the implementation of the REDP.

The current institutional capacity in Gansu, outside of Lanzhou, has been built primarily to manage the rural energy subsidy programmes. Therefore there are a number of institutional barriers in particular to do with the availability of suitably trained staff with the required technical and management skills. Building institutional capacity would be the most important pre-requisite for initiating commercialization of rural RE projects.

- **a) Qualified technical staffs needed to promote and support clean energy expansion are in short supply.** There are inadequate numbers of clean energy system designers, contractors, maintenance technicians, and extension staff to rapidly promote and expand the use of clean technologies. This inhibits the expansion of clean systems.

- **b) Weak implementation and management capacity.** Implementation agencies at local municipal and county's levels are weak, and lack experience in implementing large-scale clean energy technology projects. They require technical support to further strengthen their institutional capability and coordination functions.

- **c) Inadequate and poor rural infrastructure for effective clean technology.** Poor access to remote villages in rural areas hampers the efficient extension of technical services and the availability of spare parts and accessories for effective operation and management of biogas digesters.

- **d) Little private sector involvement.** Technical support is required to help potential investors to prepare feasibility studies, designs, and cost estimates, and to develop business plans in order to secure financing. To ensure sustainable operation of individual biogas units, biogas plants, and clean gasification plants, a viable and
effective private service sector must be developed to provide spare parts, operation and maintenance (O&M) services and to help improve technology as new techniques become available. Incentives such as concentration of a minimum number of biogas units in one location to support a service agency unit must be ensured, along with government policy to provide incentives for service personnel to earn an adequate income for the provision of such services.

e) **Lack of confidence** for local county Government to provide adequate assistance to the poor, resulting in the inability of a large number of disadvantaged and poor households to participate in clean energy projects. Disadvantaged and poor households have been unable to participate in renewable energy program, even though they are important partners to meet the Government’s overall environmental objectives, as well as to improve the quality of their lives. Millions of poor farmers are in need of assistance. Poorer households have very special and extraordinary problems that inhibit them from participating in income-generating projects. Major constraints include lack of capital, weak technical capability, and lack of education and training. Special assistance is needed to help this group of disadvantaged and poor farmers to adopt clean technology. The Government’s efforts to help the poor are constrained by lack of an appropriate approach to enable a large number of the poor to participate in clean technology development. Without an appropriate clean technology development approach or model, the Government lacks the confidence to commit itself for larger scale assistance to enable the disadvantaged and poor rural households to participate in clean technology development.

10.1.3 **Technical/Information awareness**

a) **Limited access to the modern technologies.** Modern technologies and technical links are not readily available, inhibiting the ability to incorporate advanced technologies such as more efficient gas engines, efficient gasification plants, biomass combustion and briquetting. Institutional and financial support may also be required to be extended to manufacturers for technology upgradation.

b) **Lack of monitoring system.** The current information systems comprise numbers of systems and grants. There seems to be almost no information on the technical and commercial performance of the rural energy projects. There is no instrument available for measurement and analytical work.

c) **Lack of public awareness and information.** There is a general lack of knowledge of the different clean energy technologies available and their applicability. In addition there is little knowledge of the overall environmental and human health concerns and possible benefits that are directly related to clean energy systems.

d) **Lack for feedback from environmental reporting.** At the provincial level, there is a need for assistance to develop environmental programs and to assist in their implementation. Environmental monitoring at the county level is poor due to inadequate equipment and personnel. The generation of quality environmental data and information could provide a good demonstration effect to convince local governments to develop appropriate environmental policies and protection measures. Local county government officials, in particular the decision makers from the planning commissions, finance and agricultural bureaus, as well as farmers and potential investors, lack information about the implications and use of clean energy systems. Consequently, they are unable to make practical decisions on an investment.
10.1.4 Regulatory
The Renewable Energy Law has clear provision for the purchase of electricity from renewable energy power projects that are connected to the grid. However, the grid companies are not honoring the Law for small scale projects meaning that small projects are financially unfeasible unless they can use all their electricity on-site. Further clarification on the implementation of the Law for small projects is needed.

10.2 Policy guarantee

The following guarantee measures and policies should be taken in order to make sure that the targets of the “Gansu REDP (2008-2015)” will be realized and support the development of renewable energy in rural regions.

10.2.1 Clear Responsible Organisation for Gansu REDP
The organization and application of the plan will be charged with the leading superintendent of the province and implemented by the Leading Group of Gansu Rural Renewable Energy (LGGRRE), which includes Provincial West Development Office and some other member agencies in respect of planning, funding, agriculture and stockbreeding, water conservation and forestry. All the members will assign special organizations and people to take charge of the project in the range of their own responsibility. There is an office subjecting LGGRRE and managed by GPDAAH and it is responsible for the daily management and corresponding work. Every city, county and town should enhance the construction of the system, comprehend their own responsibility, establish the measures of assessing, checking and accepting and make sure that the project construction quality is good and the schedule goes well.

10.2.2 Perfect the policy and increase the investment.

The construction of rural renewable energy system should follow the principle of “who constructs, who invests and then who benefits from it” and activate the positivity in all aspects of the society. The “Law of renewable energy” should be fully implemented and applied and the relative departments of the government at all levels should establish and perfect the relative codes and policies as soon as possible. As an important province of grain for woods in the west area of China, the government should also establish some allowance policies that is in favour of cementing the achievement of grain for woods and can promote the construction of rural renewable energy in depressed areas. They should try their best to strive for the nation’s special funds and support, in addition, they should also arrange some necessary funds to support the research of rural renewable energy, the construction of a demonstration project, the assessment of resources, the establishment and emendation of the standard, the development of industrialization and so on. According to the nation’s relative policy, do well in the perfection and application of relative regulation such as the renewable energy power generation and grid connection, grid electricity price, the charge apportionment and so on and the relative policies such as finance allowance and preferential tax.

10.2.3 Increase manufacturing
Select some technologies and products of rural renewable energy which have high development potential and comprehensive benefits, try to establish an accumulative business development system through the approach of production in factory, management in market and supervised by the logistic department, and gradually build and perfect a multiple levels, orientations, channels and factors invested system.
10.2.4 Increase private sector participation

Meanwhile, in the implementation process of the plan, we should carry out the system being charged with the corporation, build some systems for the project bidding and inviting public bidding, supervision, and operators working by right of license, and make the management of project construction be standard and regulated.

10.2.5 Improve project management

Enhance the management of project archives and perfect the system of information accounting and issuing. Enhance the supervision and checking of each project, carry out special capital management system and invite the audit, discipline inspecting, and supervising agencies to supervise, audit and check the project.

10.2.6 Improve technology efficiency and further technology introduction and increase the number of demonstration projects.

On one hand, attract every scientific research organization and college in Gansu province participating in the project and create some technologies about rural renewable energy that can be applied extensively in the province. On the other hand, collect the new achievements fulfilled by the experts and enterprises out of Gansu, create a good environment for the demonstration and extension of the project, and provide necessary fund allowance and preferential tax policy. Develop various types of technique exchange and cooperation, encourage the enterprise to adopt new technology, process, production and material, and attract the talents, advanced technique and production in accordance with the situation of rural renewable energy. Try to enhance the ability of innovation and marketing competition and promote the progress of the science and technology on rural renewable energy across Gansu province.

10.2.7 Capacity Building - Training and Dissemination

Building institutional capacity would be the most important pre-requisite implementing the REDP. Training is needed by the Rural Energy officers, by farmers and by potential commercial enterprises.

Organize the farmer technicians attending the professional technique training and authentication, and gradually realize the system of working by right of license. Enhance the science training, direct and educate farmers using the technologies and productions of rural renewable energy properly and safely, and make sure that the construction of rural renewable energy is sustainable.

Government at all levels and the relative departments should take advantage of the media such as broadcast, TV, newspaper and magazine, and try to propagate the significances, policies and achievements of the construction of rural renewable energy system. Provide and donate scientific books, hanging pictures and brochures in the way of going to the countryside with science and going to the house of farmers directly and introduce the knowledge of useful technique on rural renewable energy and its comprehensive and safety utilization.

10.2.8 Clarify pricing policy for developing rural clean and renewable energy

The relative government sectors should stipulate the detailed rules according to the central governmental policy to ensure the biogas/biomass electric power can be feed into the grid in different capacities and subsidy price should follow the regulation of 0.25 Yuan/kWh surplus to the electricity feed-in price of the local coal power plant.
10.3 Measures for implementation and safeguarding

The specific measures to implement the policy and to achieve the aims of the REDP are set out in the following sections.

1 Responsibility for the REDP and inter-departmental planning

GPDAAH to take a unified lead for the REDP. This should include comprehensive coordination and to practice the system of departments assuming responsibility for different kinds of work. All departments should insist on co-ordinated planning and enforcing sustainable energy, economy society and environment development. Specifically this includes:

1.1 Cross sector planning.

Establish a provincial rural clean energy working group with members from each department involved (DRC, state electricity, GPDAAH, poverty alleviation, building, industry and energy) to ensure co-ordination in strategies concerning energy.

1.2 Each prefecture should make a plan for the development of rural renewable clean energy.

Rural Energy offices in each prefecture must prepare a detailed plan for their area and also provide support to any project in their area.

1.3 Ensure energy objectives are integrated into economic development policy

The economic benefits of renewable energy should be recognized in economic development policy. The potential of the provinces universities and institutes should be exploited and linked to development of renewable energy, helping to develop enterprises and innovation in the sector.

1.4 Ensure energy objectives are included in rural development and poverty alleviation policy

Rural development and poverty alleviation policy should recognize the role and benefits of sustainable energy. Representatives responsible for rural development policy should discuss energy issues with GPDAAH to ensure sustainable energy is included and report on progress to provincial working group.

1.5 Ensure linking with other government legislation such as closing other demand points for stalks

Ensure linked up policy, for example where paper-mills must close due to environmental considerations explore the opportunities of stalk for energy uses in that area.

1.6 Integrate traditional energy policy and sustainable energy plan

Ensure that the main energy policy for Gansu is integrated with the sustainable energy plan, for example the use of biomass in coal fired power stations.

2 Improving technology efficiency and introduction

Ensure links between research and development, technology introduction, demonstration, pilots and dissemination. More specifically:

2.1 Increase research and development

Increase R&D for new technology and new products through technology investment and improved research conditions. Efforts should be focused on application research with potential commercial value such as:

- advanced conversion technologies of biomass gasification, liquefaction, and
• electric power generation so that the condition of high energy consumption at a low efficiency in rural area can be improved.

2.2 Ensure Intellectual Property Rights for R&D

Ensure IPR protection for those involved in sustainable energy to encourage greater investment in R&D.

2.3 Improve technology transfer

Introduce and promote all kinds of mature advanced technology adapted to local conditions, optimize and assemble them, improve the conversion and utilization efficiency of sustainable energy.

2.4 Introduction of biomass power combustion technology

Invite the biomass power combustion companies to Gansu to evaluate the possibilities of developing a couple of plants in Gansu.

2.5 Guidelines for rural sustainable energy

Prepare guidelines on the use of renewable energy in the rural context providing guidance on where sustainable technologies can be used based on local resources, needs and conditions.

2.6 Support establishment of pilot demonstration sites

Support pilot demonstration sites of: wind farm construction, demonstration programmes of biomass gasification and biomass electric power generation. Support to be both financial and regulatory.

3 Increase manufacturing in sustainable energy

3.1 Establish and support exemplar sustainable energy enterprises

Help to establish a group of backbone enterprises with good appropriate technology and relative large scale, strengthen the management of present enterprises, help to reduce the costs and improve the quality, boost the competitiveness, and so speed the sustainable energy products’ commercialization so as to enter into the market as early as possible and meet the needs of the users. This can be done through training sessions as well as information dissemination.

4 Ensuring that fair prices are paid for renewable energy

4.1 Enforcement of the “Gansu circular July 2008” needs to be carried out to ensure that renewable energy projects receive an income for the electricity they sell to the grid

Responsible persons should be appointed in the Grid company, DRC and GPDAAH to facilitate the implementation of the Law.

5 Encourage new sustainable energy market entrants and create new national cooperation methods

5.1 Introduce market mechanisms into sustainable energy construction

Introduce capital market into sustainable energy construction by making best use of market mechanism to gain more support from financial organisations. For example the introduction of competitive bidding for construction projects to ensure best value for money.

5.2 Encourage national and international co-operation

There is potential for Gansu to gain economic, societal and environmental benefit from developing wind power and biomass power and gas by means of introducing foreign capital
and technology. Gansu should actively create conditions to introduce and absorb more international advanced renewable energy technology.

Good experiences in Gansu can be can widely communicated in cooperation with other provinces and developing countries, in particular in the use and exploitation of biogas for middle and large sized livestock farms.

6  Capacity Building
Improving training, awareness and strengthening leadership and project management

6.1  Skills assessment
Carry out an assessment of the local skills in rural clean energy to identify what may be needed to meet the targets and plans.

6.2  Improve skills and training in sustainable energy
A Rural Energy development training centre should be established at the provincial level with satellite centres 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

Work with the existing training providers to ensure that the energy industry is kept fully up to date and is providing appropriate training.

Establish partnerships with centers of excellence to develop training courses.

6.3  Improving team quality
Establish a system to ensure the quality of teams and trained personnel in renewable energy. This will initially include additional work in regular checking and supervision and may expand or retract based on the training needs.

6.4  Strengthening project management
Establish a systematic and highly efficient management mechanism. This would have to include adequate checks at each level to ensure that projects proceed optimally and as intended, as well as keeping information updated and verifiable. All the cities, counties and districts should apply the mechanism to ensure the best use of resources.

6.5  Strengthening the finance sector
Development of financing system and enterprise development requires dedicated training to be provided to finance institutions and potential enterprises on the running of rural energy businesses.

6.6  Promotion
Design and implement a dissemination programme to increase awareness of the opportunities in sustainable energy

7  Introduce and maintain high quality in sustainable energy

7.1  Strengthen renewable energy guidelines for procurement
Develop guidelines for procurement of renewable energy to help expand the market for good quality technology and products.

7.2  Ensure quality standards for sustainable energy
Establish quality standards for products, construction and training in sustainable energy. National and/or international standards can be adopted where appropriate.

8  Encourage finance into sustainable energy sector
8.1 Include sustainable energy in annual capital budget

The government yearly budget should include capital for sustainable energy construction as well as for conventional energy sources, with the capital increasing in line with overall spending. Budget input to develop rural clean and renewable energy from the Government should be increased. First, it should be clear that development of clean and renewable energy in rural areas is within one important field of the government's public budget support. Government budget should cover the research and development, technology demonstration promotion, education and training for rural clean and renewable energy development.

8.2 Establish technology development fund at each energy office.

Provides support during commercialization phase of technologies and would take care of unforeseen circumstances such as cost escalation.

8.3 Financial policies to support rural clean energy should be constructed.

Support projects with market profitability, stability and predictability

8.4 Incentives and support policies

Relevant incentives and support policies should be designed and implemented to encourage farmers and enterprises into sustainable energy - as manufacturers, processors, buyers and sellers. Support policy should be established for preferential taxes, credits, prices and subsidies.

For example the government takes the investment as public one, and allows relevant enterprises tax preferential policies.

8.5 Specific incentives and support for small and medium size companies to enter market

State policy banks should refer the international micro-loans to improve related system and business process within field of environmental protection, including: loans management of small businesses, the accounting systems, separate assessment, risk management. In this view, it is to improve loans mechanism of small businesses and small projects, which makes it stable and fast- developing. Aim to encourage development of the regional small and medium enterprises (SME) guarantee institutions, the amount of new loan guarantees and risk loss of the security institutions are needed to enjoy certain incentives and subsidies. Activities, in the relevant department and agencies, such as credit registration for SME and operators, credit collection, credit assessment and credit issue should enjoys certain financing, and the reserves of credibility security agencies for SMEs’ financing can be extracted pretax.

8.6 Supportive fiscal and taxation policy

Tariffs and import VAT should be exempted for advanced rural clean renewable energy equipment imported by own domestic funds from overseas, which can promote rural clean renewable energy development.

Investment of national bonds should also strengthen in field of rural clean and renewable energy resources, and to improve their investment effectiveness. In the meanwhile, it should be combined with the current budget input and decentralized management of the national bond investments to perform reasonable reforms, which makes the financial resources to be well concentrated. As a result, it is to play an effective role to concentrate financial resources and to focus on investment. Initial investment for the biomass technology is much more, so it needs the state to support its technology research and development, including scientific research institutions and enterprises which have strong R&D capabilities, which helps the new technologies to be mature and available as soon as possible.
Infrastructure investment for rural energy should be integrated into the development and construction of rural modernization in the overall considerations, such as engineering to help the poor and needy in rural areas, watershed management project, returning farmland to forest and grassland, lakes project, greening and environmental sanitation in rural transformation projects, in order to promote integrated green energy efficiency, and to solve some of the problem of inadequate funding of for energy construction.

Government can take concrete guidance with market operation through various ways to invest energy infrastructure projects, such as application of national bonds, establishment of special construction credit fund for energy development by the Agricultural Development Bank, introducing International Monetary Fund, raise private funds, work for dole, etc.

Implementation of carbon tax cycle policy, and to support rural renewable energy industries. The CDM Fund collects funds from the generation of CERs from Chinese projects and provides subsidy the rural areas in the renewable energy industry.

Adjust and improve the relevant taxation policy.

8.7 Encourage investment (domestic and international)

Establish clear incentive mechanisms and transparent regulations for investment in renewable energy

8.8 Encourage the use of CDM for renewable projects

Establish an awareness and information programme for CDM in Gansu so that all sustainable energy projects have the opportunity to receive additional income from Carbon Emission Reductions (CERs).

8.9 Establish subsidy policy

Subsidy policies should be established according to different development stages, for example, provision of subsidy on investments directly for new technologies/demonstrations, lending money at reduced interest rates to the enterprises with more accepted technology etc.

8.10 Financial policies for developing rural clean and renewable energy should be constructed.

In addition, it is also important to enhance investor’s confidence. Consequently, it often requires the introduction of appropriate support mechanisms for financing, including project early investment, subsidies, loan discount, depreciation concessions, emissions trading, the market quota mechanism and voluntary agreements, etc, in order to help investors reduce investment costs and control market risks.

What's more, on different basis, different risk-sharing mechanisms, such as different PPP means of financing, should be used, and the role of insurance companies should be fully played. Bonds, shares and other direct financing investment occupy an important position in the demand of long-term funding for general business investment, in companies or corporate in Europe, the United States and other developed countries. It is commonly accounted for more than 30% of proportion in those developed countries, and in contrast, status of Chinese direct financing has long been low. Comparatively speaking to bank loans, equity financing will improve corporate capital structure and enhance the role of business credit, while the corporate bond have the advantages of lower cost, both of which are suitable for projects investment needs of rural clean and renewable energy. Therefore, we should vigorously develop direct financing, such as corporate debt, and expand the size and proportion of direct financing, issuance of the stock or corporate bonds by which should have the priority to be approved. As for monetary policy, a greater investment risk exists in rural clean and renewable energy resources, but it has greater social benefits and external positive
effect, which is well in line with objectives of government financial loans. Policy-oriented financial institutions, such as National Development Bank, Agricultural Development Bank need to expand efforts of loans support and preferential support to renewable energy, such as clean and renewable energy in rural areas.

10.4 Monitoring

Monitoring will be required to assess progress against the targets for deploying and procuring rural energy and wind power. Monitoring to date has been of number of systems installed and does not take into account energy generated or if the systems continue to work. This is of equal importance.

10.4.1 Indicators

The following provides a context for monitoring. The key indicators are outlined below.

- **Installed Capacity for Energy Production from Renewable Sources**
  Monitoring of the installed capacity (in terms of megawatts of electricity generation capacity, kWe, number of units and in terms of m$^3$ of gas) of renewable energy will be essential to track delivery against the REDP targets.

- **Energy savings**
  Annual monitoring of output (electricity, and electricity/gas displaced by heat – kWh and m$^3$) will also be required to complement the installed capacity and enable estimation of CO$_2$ savings.

- **Impact on poverty alleviation**
  Measured change in socio-economic situation of the farmers involved in the rural energy projects from changes in fuel consumption, sales of stalks etc.

- **Impact on environmental improvement**
  The implementation of the REDP will dispose of large amount of human and animal waste, remaining stalk resources, so as to notably improve rural water environment and air environment, the use of clean energy can also improve indoor air quality of farmers’ houses.

- **Raising the Profile of Sustainable Energy**
  Number of village notice boards with information rural renewable energy.

- **Involvement of private sector**
  Number of schemes initiated by the private sector.

- **Ensuring Policy Integration**
  Coverage of rural energy issues in associated policies and plans, for example in Agricultural and Animal Husbandry plans and Electricity plans.

- **Employment opportunities**
  Employment in rural energy industries (projects, fuel supply, manufacturing and R&D)
10.4.2 Data Availability and Responsibility for Monitoring

The monitoring of installed capacity and output of rural energy projects will be possible by the Rural Energy Offices. Some minimum facilities should be created in the Township Energy Offices for monitoring and evaluating the performance of the devices.

Reporting should be at county, city and provincial levels which would be very helpful for monitoring.

Poverty Reduction Bureau may be best placed to monitor employment in renewable energy including research and development, manufacture of components, construction, operation and fuel supply (biomass) and on impact on poverty alleviation.

Gansu DRC will take responsibility for the wind data (installed capacity, generation figures).

Gansu Environment Bureau will be responsible for the monitoring of environment quality in the rural area.

10.4.3 Review of the REDP

The REDP will need to be reviewed periodically to reflect progress against the provincial and sub-regional targets, to respond to technological developments and enhanced funding regimes. Reviews should also address the social, economic and environmental benefits and dis-benefits associated with implementation.

Establish an institutional mechanism comprising government leaders, universities, technology suppliers and provincial and other energy offices to periodically review the issues and solve the same.
ANNEX 1 - NEW RURAL RENEWABLE ENERGY TECHNOLOGIES
INTRODUCTION

Dry anaerobic biogas
Dry process anaerobic fermentation refers to anaerobic fermentation without or almost without free flowing water. In recent years, with high energy demand and strengthened environmental protection, dry process anaerobic fermentation has developed fast in China, as it can produce biogas without polluting the environment.

Dry process anaerobic fermentation is different from that of wet process: the material of the dry process is solid state, content of dry material is commonly 20%~50% with the solid biomass treatment. While wet process is liquid state, dry material is about 5% with the organism waste treatment.

The advantages of dry process anaerobic fermentation are:

1. When solid organism waste produces biogas through dry process, the residues are solid organism fertilizer, there is no water pollution in the treatment process and no secondary pollution.

2. In the operation, the energy consumption of dry process anaerobic fermentation system is low, only using 10%-15% of the energy produced in the winter.

Technical difficulties for dry process anaerobic fermentation are:

1. The crucial factors of pH and reaction temperature for anaerobic fermentation are hard to control, therefore dry process anaerobic fermentation is less stable then wet process.

2. The main obstacle for dry process industrialization production is difficulty in feeding and out-feeding.

3. Dry process anaerobic fermentation reactor is batch-type, in the out-feeding process, biogas residues in the reactor touches the air, forming explosive mixed gas, which can be dangerous.

4. Batch-type dry process system requires adequate anaerobic bacteria in the reactor in the first batch, it is different from wet process, which can gradually cultivate anaerobic bacteria in the reactor.

5. Selection, collection and mixture of highly-efficient anaerobic bacteria of different material is difficult.

Technological development of overseas dry process anaerobic fermentation:
The Batch processing dry fermentation system was first developed in the 1940s. From 1970s to 1980s, America, France, Holland and Denmark have set up experimental factories for garbage disposal adopting dry process anaerobic fermentation. In the 1990s, Germany has conducted research into biogas batch-type dry process technology and technical grade equipment. Currently, there are four types of dry process in Europe: garbage-type, air bag type, exudation storage barrel type and dry-wet joint-type.

Domestic technological development:
From the 1980s, national study institutes and universities have conducted many studies of dry process anaerobic fermentation, but currently there are few technologies which can be used practically. The technology scale is very small, capacity gas production rate is about
0.3m³/m³·d. In 2002, Chemical Engineering University of Beijing and Planning & Designing Institute of Agricultural Ministry carried out a study of stalk medium-temperature fermentation gas-supply experiment, using horizontal tank equipment, bio-liquid recycled as culture and obtained a capacity gas production rate above 0.5m³/m³·d.

Study and design for a new type of anaerobic organism reactor- tectorial membrane dry process anaerobic fermentation dip tank reactor:

In 2005, Planning & Designing Institute of Agricultural Ministry adopted advanced national and international technologies, putting forward a new mode of anaerobic organism reactor, which is tectorial membrane dry process anaerobic fermentation dip tank. By lab experiment and industrialization equipment modelling study, a preliminary outcome was reached. The best result of the lab experiment is the third group, average daily gas production in 31 days is 1.09L/L·d, the highest is 2.09L/L·d. At present, the construction of biogas project with a 180m³ digest tank in Beijing Daxing Pangge Village Zhenxueying Group has already been completed. Average capacity gas production is over 1L/L·d and the methane density is 60.7%.

Process flow: as per scheduled C/N proportion and water content, using mechanical loader to put various materials into fermentation dip tank in proportion, using stirring engine on the fermentation dip tank to mix the material, conducting aerobic fermentation. After materials reached about 70°C, putting in prepared anaerobic germ, stirring and removing from stirring engine. Cover flexible membrane on fermentation dip tank to seal it, inserting soft tube into slot wall groove and pumping to muffle the flexible membrane. Under sealed condition, anaerobic ferments and produces biogas. Spray pump sprawls anaerobic mild water to hasten fermentation. Leachate enters water collection tank for reuse, biogas produced from fermentation tank and collection tank transmits to gas storage tank by gas pump. Anaerobic gas production period is over, pumping the biogas from groove, collecting sealed membrane, stirring materials to produce fertilizer.

Briquetting

Biomass solid molding technology: various scattered stalks are dried, smashed and pressed under pressure into compressed fuel. The process flow generally includes drying, crashing, conditioning treatment, molding (pelletisation, briquetting), cooling and packaging.

From 2000, biomass solid molding technology has developed fast and is commercially viable. Current technologies include pendular press roller, horizontal press roller, double roll squeezing, mechanical valve, hydraulic pressure, screw heat pressing, screw normal temperature, screw wet press molding. Biomass molding fuel equipment in China has entered batch production and marketisation, with good research, production and development prospects.

1. **Pendular press molding technology**

This technology is mature and has entered commercialisation. An issue with the technology is the high requirement of the material characteristics, if the material has a high or low water content it is not easy to mold. The ideal water content for the technology is about 15%-20%. To meet this demand, many materials must be dried before pelletisation. Pressed hot kernels (95～110 °C) must be cooled before packing. The energy consumption cost for these two processes is high, approximately 35～55% of the total energy produced. The cast of the core parts of the molding equipment is complicated therefore the application cost is very high.

2. **Horizontal press roller molding technology**
This technology is mature, commercially viable and has been used in some applications. The cost is low and can press fibrous materials. With low production ability, it is suitable for small-scale production and national equipment is mainly small-sized horizontal press roller. But serious problems such as high requirements on material characteristics and wearing-out of mould still exist.

3. **Double roll squeezing molding technology**

Dry materials are not required for this technology as the adaptability for humidity level is high; materials can be pelletised with 10%~35% humidity level. Most materials can be used directly without drying. The temperature will rise 10~15°C after granulation. The pressed kernels are only 55~60°C, which can be packed without cooling. Compared with traditional technology, energy consumption is reduced 60%~70%, machine deterioration has improved a lot. Due to the low production abilities of this technology the large scale production applications of this type of technology are limited.

4. **Mechanical valve molding technology**

The advantages of this technology are that the briquettes produced are easy to store with high density and are of good quality. Existing problems are that the vibration load in the production process is high which puts a strain on operatives, the operation is not very stable, and oiling pollution is very severe.

5. **Hydraulic pressure molding technology**

The technology has entered commercialised stage. Hydraulic pressure molding is used, which greatly improves the life span of the molding parts, as well as reducing energy consumption. The hydraulic drive has both “oil pressure” and “hydraulic pressure”. The design of oil pressure is more mature, the operation is stable and the oil temperature is easy to control. With the small volume and large driving force, when the outside diameter of the product is 8~10cm, the productivity can reach 1t/h. While hydraulic pressure, with big volume, high investment, small driving force, the production capacity is very low, which is 0.25t/h, sometimes it can reach 0.35t/h. Because the valve running speed is much lower than mechanical drive, the production will be affected in some degree. The water content of the material must be controlled within 12%. If the water content is too high the water can be converted to gas in the moulding process causing molding fuel splitting and ‘shot firing’.

6. **Screw heat pressing molding technology**

With this technology materials can be made into square, hexagon and octagon molded fuel. Molding equipment mould adopted outside electric heating way. The molding pressure changes according to different materials and molding fuel density, generally it is between 49~127 MPa, the product is a fuel rod with a centre hole with a diameter of 50~60mm, the density is between 1200~1400kg/ m³. The water content for this technology must be controlled between 8%~12%, if the water content of the material is high, it can cause molding fuel splitting and shot firing. In addition the compressed screw and molding sleeve is in a dry friction state, so attrition of the compressed screw and molding is very severe.

7. **Crew normal temperature molding technology**

The technology is at the demonstration stage. During operation the pressure range is 60~100MPa, molding fuel density is 1200~1400kg/m³, production capacity is 600~1000kg/h and the energy consumption is 0.15kW•h /kg. But the screw head and mould can easily be deteriorated therefore, maintenance costs are high.

8. **Screw wet press molding technology**
The technology is at the demonstration stage. In the compression process, fraction heating dries the stalks and materials in the machine, producing steam. The characteristics of the material are not critical, material granularity changes between 30~80mm, water content can reach 30%, and dry equipment is not necessary. Wet basis compression molding fuel density is relatively low. Wet basis molding equipment is very simple and easy to operate, but molding parts can easily be deteriorated and the drying cost is high. The fuel capability of most products is very bad, and to date the technology hasn’t been widely applied.

**Biomass solid molding fuel production pilot project of Agricultural Ministry**

By the end of 2007, the biomass solid molding fuel production pilot project of Agricultural Ministry had finished in Beijing Daxing. Through scientific matching and priority design for various processes, adopting reasonable blended process, the result was a stable biomass solid molding fuel production in China with an annual production capability of 10000 ton. This offers crucial technology and popularization base for industrialized development of biomass solid molding fuel.

**Biomass liquid fuel technology**

Biomass liquid fuel refers to using biomass resource to produce liquid fuel, such as methanol, ethanol and biodiesel.

Since 2002, due to the high rise in the petroleum price, ethanol fuel has become more popular and the production and sales have risen quickly. To further expand the application of biomass fuel, the Energy Law passed by American Congress put forward a standard for renewable energy fuel. In 2007 the total production of ethanol globally was 39.17 million tonnes, about 19.45 million tonnes of which came from the USA (using corn as material) and 15 million tonnes came from Brazil (sugar cane as material). Meanwhile the USA has actively developed the technology that extracts ethanol from fibrin, to further enlarge the utilization of biomass resource to replace petroleum in the larger scale.

Biomass liquid fuel development in China has also made great progress. By the end of the last century, under the condition of over-production of grain for consumption, China started to develop biomass energy ethanol. In the “Tenth five year plan”, Henan, Anhui, Jilin and Heilongjiang constructed ethanol production factory using aging grain as material, the annual production is 1.3 million ton. At present, car fuel ethanol gasoline sale has reached about 10 million ton, 20% of the total gasoline sales in China. Guangxi Zhongliang Biomass Energy Ltd., Co. has finished ethanol project, the annual production is 0.20 million ton using cassava as the biofuel material. Currently, it has realized to use car ethanol gasoline in the whole Guangxi.

Biomass diesel is applied mainly in Europe, using rapeseed oil as its material. The quota for biomass diesel in Europe is 5% of the product oil. In 2007, biomass diesel production in EU is about 5.71 million tonnes. Of this Germany accounts for approximately 2.89 million tonnes.

The scientific research institute has conducted in depth study into energy plants such as smooth bark tree, mastic tree and rape seed. The study aim is to establish material planting, breed cultivating, oil producing, biomass diesel transfer and comprehensive utilization technology popularization system. Cultivated Gaoyou No.1, No.2, rape seed production is over 200kg/Mu, oil content is more than 50%. Oil seed cultivation and biomass diesel technology for mastic tree is at a mature stage preliminarily bearing the popularization technology base. Sichuan University has finished study for using gene technology to control oil-content and carbon chain length for oil plant as Jatropha Curcas tree, establishing gene pool, planting standard and seed-raising base. Oil plant office of China Agricultural Scientific Institute and Huazhong University of Agriculture has established biomass diesel semi-workshop. National standard for GB/T20828-2007 diesel fuel compound biomass fuel BD—
100 was published and implemented at the beginning of the year. Recently, a biomass diesel car performance experiment study undertaken by Tianjin Car Technology Study Center has passed expert demonstration, obtaining ideal experimental result.

China has a lack of fossil fuel energy resource; explored petroleum and natural gas reserves are only 2.4% and 1.2% of the world reserves. In 2006, imported petroleum in China reached 145 million tonnes, imported product oil was 36 million tonnes. Petroleum imports accounted for 47% of total petroleum used in China and this is expected to rise to 70% by 2020. Therefore developing multiple energy resource, in particular producing biomass liquid fuel from non fuel crops will be important for the nation’s energy security.

**Fuel ethanol:**

From the materials, fuel ethanol can be divided into three types: starch, sugar and wood.

**Technical principle:**

**a. starch**

Starch ethanol aims to use starchy biomass materials, mainly tuber crops, corn and wheat, through pre-treatment, saccharification, fermentation, distillation process, using maltogenic amylase to hydrolyze starch into glucose, produce fuel ethanol without oxygen, by distillation and fractionation, biomass fuel ethanol can be produced.

**b. sugar**

Sugar biomass ethanol uses sugar biomass as its materials, such as sugar cane, beet and sweet sorghum. Use microzyme or hydrolyze to make sugar into glucose or fructose, produce fuel ethanol without oxygen, by distillation and fractionation, biomass fuel ethanol can be produced.

**c. wood**

Wood fuel ethanol uses woody fiber biomass as its material, such as wood and rural wastes, to produce fuel ethanol. Use cellulose and half-cellulose from glucosyl group and xylose of woodiness fiber biomass, use acid and cellulose as catalyst, hydrolyze to get glucose and wood sugar. By microorganism fermentation, fuel ethanol can be made. In recent years, using stalks to make fuel ethanol has drawn much attention, and is considered to have good development prospects. There are two steps to produce ethanol from cellulose materials: First, hydrolyze cellulose into fermentation sugar, viz. saccharification. Second, use zymotic fluid to ferment into ethanol.

**Current development**

At present, Henan, Anhui, Jilin and Heilongjiang have already set up ethanol factories using corn and aging wheat as material with total annual production of 1.02 million tonnes. As per national standard 8%-12% addition proportion, 9 provinces (the whole cities in five provinces, 27 cities in 4 provinces) have started to sell car ethanol gasoline. As China has restricted grain production capacity grain will not be used as a material in the expansion of fuel ethanol production. In order to get more sources of biomass fuel, China has developed the technology using sweet sorghum to produce fuel ethanol (called sweet sorghum ethanol). Heilongjiang, Neimenggu, Shandong, Xinjiang and Tianjin have planted sweet sorghum and developed a fuel ethanol experimental unit. The experimental project in Heilongjiang can produce 5000 tonnes of ethanol annually. Recently, cassava and sweet potato ethanol factories have been built in major cassava and sweet potato producing areas. The cost for starch ethanol has strated to decrease. Using Jerusalem artichoke as a material to produce fuel ethanol is still in the development stage. Using cellulose to produce ethanol, no matter acid hydrolysis or enzymatic hydrolysis technology, hasn’t reached a commercial level. The key technology problem is: concentrated acid hydrolysis needs highly concentrated acid, the
reaction time is long, acid needs to recycle and the cost is very high. Diluted acid hydrolysis needs high-quality equipment, there are many reaction side products, and there is restriction to fermentation. Enzymatic hydrolysis lacks a highly efficient pre treatment technology and suitable cellulose. In addition, main product of half-cellulose hydrolysis-high efficient zymogen of pentose has been in the study stage. Currently, cellulose ethanol technology study has become a major focus globally, part of the technology has entered the industry demonstration stage, but economically, it still cannot compete with fossil fuels. Considering the wide application prospects for fuel ethanol, developing an economically feasible technology for making cellulose ethanol is of extreme importance.

**Biodiesel**

**Technology principle**

Biodiesel uses animal & plant oil (rapeseed, sunflower, soybean bean and palm oil) as material, by ester exchange reaction with low carbon pure (methanol and ethanol) to get a biomass fuel, viz. ester fatty acid low carbon phosphate. It can replace diesel to be used alone, or can be mixed with diesel in certain proportion (2%~30%). Commonly biodiesel is mixed with diesel with 20% proportion and is called B20 diesel. Materials for biodiesel are numerous and include: waste animal & plant oil (as trench oil and industrial waste oil) and oil plants (as cole, soybean, sunflower, mastic and oil palm).

The ester exchange process is the technology adopted by the biodiesel industry. Various natural plant oils (Consisting of various triglyceride, a small amount of free fatty acid and non-oil substances), animal fat and waste oil from food industry, proceed ester exchange reaction with methanol or ethanol under certain temperatures, producing fatty acid methyl ester or ethyl ester, viz. biodiesel and its by-product, viz. glycerin. Currently, most factories use a traditional two step-process to use ester exchange process;reaction and purification. The following figure shows the process flow for producing biodiesel. The pure for ester exchange including methanol and ethanol, among which, most commonly used is methanol.

![Figure A1-1 Biodiesel process](image)

**Current development status**

The national standard for biodiesel “GB/T20828-2007 diesel engine fuel concoctive biodiesel (BD—100)” has been issued and implemented in 2007. Recently a biomass diesel car performance experiment study undertaken by Tianjin Car Technology Study Centre has
passed expert demonstration, obtaining ideal experimental result. But compared with overseas products considerable improvements are required. Biodiesel development in China is still in the preliminary stage, the main players are mainly private-owned enterprise, with small scale, low technology level, different quality standard, non-standard market circulation. Comprehensive utilization and processing levels need to be improved.

**Biogas engineering technology**

Biogas project is an eco-environmental protecting project which finally realizes the comprehensive utilization of biogas, waste water, and sediment by the means of anaerobic digestion and goal of energy production. The technology type, which can be classified into eco-energy and environment-friendly energy type, is chosen according to the goal of project and surrounding environmental conditions, for we must meet environmental requirements and can not cause secondary pollution during the process of producing biogas.

**Process of eco-energy technology**

Eco-energy technology is utilizing the sufficient area of farms, fish ponds, plants tong etc. around work site of the project to absorb/dissolve waste water and sediment after biogas fermentation so that the gas project become bonds of eco-agriculture park. Through this project, we can realize a reasonable allocation of aquaculture and farming industry, not only costing less on the post-processing of waste water but also promoting the development of ecological agriculture.

**Process of environment-friendly energy technology**

Environment-friendly energy technology is used when surrounding environment cannot be satisfied to eliminate waste water and sediment after biogas fermentation, so solid waste must be made into fertilizer products and sediment must reach the national emission standard after a series of aerobic fermentation post-processing. After fermentation, most organic matter in waste water is eliminated. Comparing with simple use of aeration aerobic approach to dispose sewage, it can both produce and save energy, but the quantity of biogas output can be reduced accordingly.

Biogas project generally consists of pre-treatment system, anaerobic digestive system, biogas utilization system, biogas post-processing devices, sediment processing system, etc., as seen in the following chart.
(1) Pre-treatment system

The main purpose of the pre-treatment is to carry out solid-liquid separation to reduce the content of BOD, COD and SS in the liquid and the load of follow-up dung processing. After solid-liquid separation, solid-waste is used to make fertilizer and liquid goes into the processing unit.

(2) Anaerobic digestive system

At present, anaerobic reactors, which are widely used in China’s building of large and medium-size biogas projects, are continually stirred tank reactor (CSTR), up-flow anaerobic solid reactor (USR), combined anaerobic reactor of high concentration, plug flow and stirring (HCPF). CSTR and HCPF is preferred at a lower level of management and simple and convenient operation; USR and CSTR is preferred for chicken manure with a higher level of sand, HCPF and CSTR is preferred for the coarse and dry cow dung.

(3) Biogas utilization system

This system includes water-gas separation, purification desulphurization, gas storage and distribution, and biogas user system. First of all, biogas is collected and desulphurization purified, then is carried to the gas storage tank by the gas transmission system and delivered to the user by the gas distribution system. Gas storage tank is generally sized for 25% to 40% of average daily gas production. Water-based sealing in the appropriate place of gas pipeline is to adjust and stabilize pressure to form isolation among digestion tank, gas storage cabinets, compressor, and boiler room and so on. Besides, water-based sealing can also be used to rule out water condensate. The volume of hydrogen sulfide in the biogas is generally 0.005 percent to 0.01 percent. Biogas user system includes gas combustion devices, gas torch, gas cooker etc.

When there are a large number of residents in the vicinity of farms, it is more appropriate to use biogas as a domestic fuel. When the farm is far away from the residential area, biogas can be used to generate electricity or as boiler fuel.

(4) Discharge post-processing devices

In the absence of a corresponding land satisfactory to eliminate anaerobic digestive liquor, aerobic biological treatment process must be adopted so that the water can be discharged up to environmental standards. Anaerobic technology which has been used in sewage treatment of the livestock and poultry manure includes completely mixed aerobic activated sludge process, sequencing batch reactor (SBR), oxidation ditch technology, biological aerated filter, contact oxidation process, and so on.

(5) Sediment processing system.

With a more comprehensive nutrient and rich organic matter, sediment is a good organic fertilizer which can be used as basic fertilizer and additional fertilizer. This system contains equipment for processing dry solid residue after fermentation, solid-liquid separation and production of fertilizers and feed particles, etc. which improves economic efficiency of the entire project and comprehensive utilization of resources.

**Application of technology**

In China, rapid development of livestock and poultry industry brings about lots of faecal contamination emissions, so large and medium-size biogas projects becomes an effective measure of pollution management. If the farm is near the village, large and medium-size biogas projects can be used by farmers for cooking; if the farm is far away from the village, the biogas project can generate electricity for farmers to use.

**Current development status**
According to the statistics from China Agricultural Department, by the end of 2007, there are 26586 biogas projects which use agricultural waste as raw materials with annual output of 0.35 billion cubic meters of biogas. Among them, there are 1646 large projects with annual output of about 0.17 billion cubic meters, 6930 medium-sized projects with annual output of about 0.12 billion cubic meters, and 18010 small projects with annual output of about 600 million cubic meters.

**Trends of development**

Although China's biogas engineering has developed a variety of technology with independent intellectual property rights, compared with advanced technologies of foreign countries, particularly that of European countries, there are still many shortcomings. They are mainly in the following aspects: a single raw material of fermentation, low rate of gas conversion and production; a wide range of technology but lack of standardized design; lack of automatic monitoring system and control equipment, poor control; small-scale and scattered projects, poor utilization of thermal, mostly fermentation at room temperature, low rate of gas production, ineffective solution of temperature insulation, non-functioning of biogas system built in the northern region in winter; Inadequate utilization of biogas technology, poor practical utility, low level of specialization in gas engineering equipment (power equipment, transmission equipment, mechanical mixing devices, bio-desulphurization unit, and so on); the biogas intensive engineering system did not go far enough, anaerobic fermentation gas separates with storage gas, and occupying a larger area; poor portability system and, if necessary, can not be relocated as a whole.

**Straw Gasification Technology**

**Technical Description**

The straw biological gasification technology is a new technology. It uses straw as raw material for fermentation. First of all, it joins the straw-stack steep to deal with for bio-bacteria, and then puts together into the digester with the inoculating material to produce biogas. The technology makes full use of raw materials such as straw and effectively solves the “bottleneck” problem about raw materials in the process of promoting biogas, so farmers who not raise pigs can also use clean energy. Moreover, after producing the biogas, the straw in the digester is a very good fertilizer, thus improving the use efficiency of straw resources. The process of straw bio-gasification technology is showed as the chart below.

![Straw Biological Gasification Process](image)

*Figure A1-3 Straw Biological Gasification Process*
Current development status

At present, straw biotechnology gasification technology has been used in pilot demonstrations in more than 100 counties across the country, and has achieved good results. According to the survey results and investigations of the users, farmers put into 400 kg rice husk or rice straw in an 8 cubic meters of methane-generating tank at one-time, and add 1 kg agents and 15 kg ammonium bicarbonate in it, then normally, the biogas produced can be used by a 5-members family for more than 6 months. If the waste of the 5-members family can usually put into the methane-generating pits automatically, then the gas production normally will last more than 12 months. The farmers just need to increase 10 Yuan in the average monthly expenditure. However, the technology still faces many problems: relatively high price of bacteria, the feeding material of the methane-generating tank, day-to-day management and the collection of biogas production to make organic fertilizer, such management services are relatively cumbersome.

Development Trend

With the development of agriculture, scattered farming has been decreasing and large scale farming is increasing. So the rural households, who rely on livestock and poultry manure as the main raw material to ferment, are restrained in using and producing biogas in everyday life. Some farmers stopping raising pigs so lacked fermentation raw materials, and the built methane-generating tanks are faced with the problem of no raw materials and are out of use. Therefore, some farmers lose enthusiasm to build methane-generating tanks. On the other hand, a large amount of straw is burned in the fields of rural areas; it is both environmental pollution and waste of organic fertilizer. The straw biological gasification technology effectively solves the "bottleneck" problem about raw materials in the process of promoting biogas, so farmers who raise pigs can also use clean energy.

Biomass Power Generation Technology

The Principle of Biomass Power Generation Technology

Biomass power generation refers to the use of biomass straw as a raw material, burning in the steam boiler of dedicated biomass to produce steam then driving the steam turbine to operate the power generators. The main differences between biomass power generation and fossil fuels power generation lie in the straw pre-treatment and the straw boiler. The pre-treatment equipment of raw materials, which specialize in straw, together with the boiler, are the key technology to guarantee the heat exchange efficiency, the operational life, and the stability of the direct combustion power generation.

![Figure A1-4  Biomass power generation](image-url)

The main varieties of crops used in China's biomass power generation including corn stalks, wheat straw, rice straw and cotton stalks. Compared with coal, the crops straws usually have a high water content, high volatility, low-ash, low heat value, and different burning characteristics. Particularly, the content of alkali metal in crops straw is higher than in the coal, and the straw ash has low melting point, it is easier to foul and slag in the burning process. The alkali metal in the ash and the chlorine in the gas can also erode the heating surface. There are relatively high content of alkali metal in such rice husks and yellow straw: rice straw, wheat straw, corn stalk etc. so it is involved with greater risk of combustion slag.
and corrosion. The content of alkali metal is much smaller in cotton stalk, branches such kind of grey straw than in the yellow straw, and the risk of slag and corrosion is relatively small.

The pre-treatment equipment, boiler, and other devices used in China's biomass power generation are lacking experience in design, manufacture and operation aspects. The foreign technology about straw boiler and related equipment which was introduced into our country has been used for demonstration projects of power generation. The domestic straw boilers which have completely independent intellectual rights have begun to be installed and put into use in the biomass power plant.

**Current status biomass power generation technology**

Biomass power generation technology, whether introduced from other country or produced in domestic routes, it is relatively mature. The biomass power generation technology has such advantages: it is a relatively large scale of construction, the efficiency of energy conversion is relatively high, and there is no secondary pollution. At the same time, it can consume a large volume of straw, thus effectively solving the problem of remaining large number of crop stalks in China. It is one of the technical routes to develop the economy in China's rural areas, increase farmers’ income and improve the structure of rural energy. At present, the 6 or 7 biomass power generation projects are put into use and basically meet the designed target.

Biomass power generation is still facing many technical problems, such as fouling, slag and corrosion, the technology of domestic boiler and the pre-treatment of raw materials, further improvement of equipment and localization of the foreign technology. With the continuous operation of the straw direct-fired demonstration power plant, the foreign technology and boiler equipment began to withstand a variety of biology materials tests in China, and the pre-treatment equipment, with independent intellectual property rights, and the straw boiler also work in project practice. It is evident that, in the process of actual operation, straw direct-fired technical and its equipment will have all kinds of problems. However, it is only through a series of demonstration projects, including the actual installation, debugging, long-time operation practice, that we may find the problems, amend them and resolve all the problems.
ANNEX 2 OVERVIEW OF BIOMASS POWER GENERATION IN CHINA RURAL AREAS

1. The biomass power generation in China presents the situation of full and accelerated development

The biomass in China has a variety sorts and the quantity is large, which could be transformed into terminal fuel (gas, liquid and solid) through many technologies. At present, the technology on utilization of biomass power generation includes: power generation through directly biomass oxidation burning; through mixing burning with fossil fuel (such as coal); biomass gasified to inflammable gas and used as fuel for power generation in internal combustion engines and gas turbines; transform biomass to biogas for power generation through microorganism fermentation and other technologies.

The research and application on biomass power generation started late in China, and the scale was not big. However, from January 2006, the date that “The Renewable Energy Law” implemented, and with the support and encourage of some preferential economic policy, all sorts of biomass power generation technologies developed very fast.

1.1) Total installed capacity of biomass power generation is 2million KW (2.0GW) before 2005

The south part of China planted sugarcane, and many sugar factories make use of sugar residua for power generation, generally not on-gird, the installed capacity is about 1.7GW. In addition, south parts of China mainly produces rice, many rice processing factories buy paddy from framers, and then centralized grind the paddy, at last they make use of rice husk gasification to generate electricity, which could meet the their demand on power. Some large-scale rice processing factories will generate electricity through rice husk direct fired technology; the installed capacity is about hundreds of thousand kilowatts.

1.2) There are over 80 new biomass (various kinds of biomass) power generation factories after 2005, the total installed capacity is over 1.5GW.

The Renewable Energy Law regulates that the factories will get subsidy as 0.25Yuan/kwh of benchmark on-grid price if they use biomass for power generation, which greatly promotes the development of biomass (various kinds) power generation. At the end of 2007, there are over 80 biomass power generation programs ratified to set up, with the total installed capacity over 1.5GW.
1.3) Biomass direct fired for power generation

Biomass direct fired power generation means that all the fuels are biomass materials, and burned in steam boiler exclusively for biomass, and then the produced steam will drive the steam turbine to generate electricity. Except the pretreatment for biomass materials and the different capability & structure of boilers, the biomass power generation system is same to coal-fired power generation system. Refer to chart Figure A2-1.

To the end of 2007, there are over 12 constructed projects in whole country, with the capacity of 400,000KW. The representative projects are:

- The first national demonstration project in Dan county, Shandong province (chart 1-2). The installed capacity is 25MW. The boiler is a high temperature & high pressure water cooled vibrating stoker boiler, the technology of the boiler is from Denmark, and it is processed by JiNan Boiler Factory, with the treatment capacity of 130ton/hour, and it is also equipped with an extraction condensing steam turbine (25MW). Because it is the first direct-fired power generation factory in China, so the initial investment is high (337 million Yuan). The materials include local cotton stalk, wheat stalk and some residua of forest.

After the National Bio Energy Dan County biomass power generation project putted into production, the biomass power generation projects constructed by National Bio Energy Company in Wei County, GaoTang and KenLi successively put into production. To the end of 2007, the number of projects predicted put into production is 8, with the installed capacity of 200,000KW.
Figure A2-2 National Bio Energy Power Generation factory

- **HeBei JinZhou national demonstration project.** The installed capacity is 25MW. They use 2 boilers that produced by WuXi Boiler Factory with the capacity of 75ton/hour (it is a middle temperature & middle pressure water cooled vibrating stoker boiler and equipped with 2*12MW extraction condensing steam turbine). It will be put into production in 2007, the main materials are stalk of corn and wheat and some fruit trees branches.

- **The Jiangsu Suqian biomass power generation project constructed by CECIC.** All the equipments are domestic, and the total investment is 0.28billion Yuan. They adopted the 2*75ton/hour middle temperature & middle pressure circulating fluidized bed boilers, equipped with 2*12MW power generation set. They put it into production at the end of 2006. The main materials are stalk of rice and wheat.

- **Hebei Jinzhou biomass direct-fired power generation factory.** It is constructed by Hebei Construction Investment Co. and Shijiazhuang Energy Investment Development Center. The project equipped 2*75ton/hour middle temperature & middle pressure water cooled vibrating stoker boiler which is produced by Wuxi Huaguang Boiler Factory. The steam turbine is extraction condensing. The designed capacity is 24MW, and the total investment is 0.25billion Yuan. Except power generation, it could provide 0.53million GJ thermal energy and supplied to residents of 1million square meters.

- **Henan Changge Electricity Factory Reconstruction Project.** It was constructed in 1976. At present, after they demolished the previous coal-fired boilers, they constructed a 75ton/hour chain grate stoker biomass power generation boiler, and equipped with 12MW power generation assembly, the total investment is 30million Yuan. The boiler is produced by Shanghai Sifang Boiler Factory affiliated to Shanghai Electric Power Generation Group. The
1.4) Mixing-fired biomass power generation

Crush the biomass material, transported it in front of the boiler, and then the crushed biomass fuel would be put into the coal-fired boiler by exclusive burner, and mixing burned with coal. The power station featured mixing burned with coal is widespread abroad. In domestic, there are some research institutions conducted the research and trial demonstration, proved that if the weight percentage of biomass fuel not exceed 20%, the coal-fired boiler will operate normally without changing it, and the boiler would not be corrupted by chlorine and alkali contained in biomass material, and would not be affected by the fouling and slagging. The capability of burning and gas discharge also improved. The best solution of biomass mixing burned in the coal-fired boiler is to choose fluidized bed boilers, because it could use the noninflammable fuel such as coal-peat and low grade coal.

Figure A2-3 Exterior appearance of coal-straw mixing burning boiler.

In China, presently, there isn’t any effective measurement on biomass fuel in the mixing burning biomass power generation, so there doesn’t have any clear preferential policies on it, and the mixing burning power generation technology has been conducted only as...
demonstration trial in several power stations. The ShiLiQuan power station in Shandong Zaozhuang has conducted the trial on mixing burning on the No.5 boiler. The capacity of the boiler is 400ton steam, equipped with 140MW power generation assembly, and the percentage of biomass mixing burning is 20%, the yearly mixing burning amount is 250,000 ton. The actual quantity of mixing burning in 2006 is 55,000ton. Chart A2-3 is the exterior appearance of coal-straw mixing burning boiler.

In addition, HongKong Xiexin Group (joint venture) has 7 small-scale thermal power generation stations respectively located in Shandong, Jiangsu and Anhui, which used the biomass mixing burning including straw, rice husk, tree bark and reed.

1.5) Biomass gasification power generation

The main material of biomass gasification is biomass. Under the condition of oxygen deficiency, inputting air, vapor or oxygen to conduct pyrolysis, and then produced CO, H2 and other inflammable gas; through purification and then the burned gas will drive the internal combustion engine and gas turbine to generate electricity.

The technology of Biomass Gasification in Circulating Fluidized Bed for power generation was developed by Guangzhou Energy Institute. This technology has been demonstrated and applied. It adopts multi-level sprinkler to purify the inflammable gas; adopts bacteria on the spray water which contains tar and conducts tar cracking then transforms it to sludge, at last recycling the spray water. This technology has been practically applied, but still under development, at the same time, the relevant institutes have been studying on high-temperature cracking detar technology.

In 2000, the first biomass rice husk gasification power generation station (1MW) was constructed in Putian, Fujian Province. Afterwards, several demonstration gasification power generation stations were built in Sanya, Handan and other places. Then 20 sets of gasification power generation systems (rice husk and straw) were built in Heilongjiang. On the basis of these projects, some middle-scale (install capacity below 10MW) gasification power generation stations were respectively built in Zhejiang, Henan, Hebei and Jiangsu provinces, the total installed capacity is over 40MW. Among them, the biggest one is in Xinghua County, Jiangsu province, with the installed capacity 4 MW. The biggest gasification power generation station was approved to build in Shiyang, Hubei province, with the installed capacity 12MW.

Chart A2-4 and A2-5 are the 4MW gasification power generation station and the first phase of its technological process which equipped with a circulating fluidized bed gasification boiler, 1×400KW and1×600KW internal combustion engine, and waste-heat boiler as well as the gas turbine. The main fuels are rice husk and cotton stalk. The content of silicon in rice husk is high, so the residua also have good utilization value. The tar in inflammable gas was removed by water, and the waste water could be recycling used after purification. This project has been put into production in October 2005, with the cumulative operational hours over 2000.
Figure A2-4  Jiangsu Xinghua biomass gasification power generation station

Figure A2-5 biomass circulating fluidized bed gasification power generation

1.6) Biogas power generation

Biogas is inflammable, the main element is CH4. It is produced under anaerobic condition, and agricultural & industrial waste (such as straw, human and livestock feces, industrial organic waste and living waste) are treated by Biological treatment (namely microorganism’s
fermentation) to generate biogas. The biogas remainder is called as biogas leachate and residua; it is the good organic fertilizer and feedstuff. So the biogas project is to realize the full procedure of anaerobic digestion of organic waste, producing biogas and disposing pollution. It accords with the sustainable development concept, and is the indispensable environment protection project, and also the energy project that could provide effective clean gas.

The biogas projects in the last 20 years, whatever the small-scale or the industrial-scale, both got fast development. To 2006, there are household biogas digesters 21.74million, with the production capacity of 8.2billion cubic meters biogas and calculate in terms of caloric value, equal to 9 million ton coal, and could provide fuel to 2million rural households. There are 17,475 different scaled biogas projects in breeding farms with the total digester content of 189,000 cubic meters; the yearly production capacity is 0.218billion cubic meters.

Most of the biogas projects are used for producing and used as living fuel within the breeding farms. Only a small amount of biogas used for power generation. In 2006, the installed capacity of biogas power generation in breeding farms is 6.7MW, and the yearly power generation capacity is 8.73million kwh. Because most of the breeding farms are small-scaled, so the size of the biogas power generation projects is between hundreds watts to thousands watts, and the electricity only used for their own. But when the “Renewable Energy Law” implemented in January 2006, the factories will get 0.25Yuan/kwh subsidy on biomass power generation, so there are many large-scale breeding farms started to build on-grid biogas power generation projects.

The typical projects are:

a. Excretion disposal biogas power generation project in Hangzhou Dengta breeding farm (chart A2-6, A2-7, A2-8 are the demonstration projects that co-conducted by UNDP/GEF). There are 0.2million pigs, with 8,000 cubic meters anaerobic fermentation tank and a full set waste disposal system. The waste water would be treated by aerobic and emitted if achieve the emission standard. The daily biogas production is 10,000cubic meters, which has multiple usages --- part of the biogas used as the 2-ton boiler fuel (the boiler produces steam); part of the gas used in factory eatery. There also has the biogas power generation system (installed capacity is 500KW) used for their own. The biogas residua will be used to produce compound organic fertilizer.
b. The Taihu Basin biogas power generation projects: Taihu Basin crosses the provinces of Jiangsu, Zhejiang and Anhui and city of Shanghai, chart A2-9. It is a densely populated area, and one of the developed rural areas. The Taihu water quality evaluation in 2004 showed that the water on I-III level only accounted for 9.4% (I level is the highest quality water),
the area of eutrophication water accounted for 77% (developed livestock husbandry is the main pollution source). So from 2000, over 10 large & middle scale biogas projects were built in the area surrounding Taihu Lake, among them, ten projects had the biogas power generation system, such as the Yixing Xingwang Biogas Power Generation project in 2006, chart A2-10 and A2-11; Yixing Changxing biogas power generation project built in 2004, chart A2-12, A2-13 and A2-14.

![Figure A2-9 location of Taihu Basin](image1)

![Figure A2-10 Yixing Xingwang Biogas project](image2)
Figure A2-11 Yixing Xingwang biogas power generation equipment

Figure A2-12 Yixing Changxing biogas project

Figure A2-13 Yixing Changxing biogas power generation equipment and its utilization
c. Inner Mongolia Mengzhong Aoya Pasture Biogas Power Generation Project, chart A2-15. Mengniu dairy product is one of the most famous dairy brands in China. In Aoya pasture, there are dairy cattle over ten thousand and the daily waste disposal capacity is 500ton. In 2007, a 4MW cogenerated heat-power fertilizer large-scale biogas power generation project was built. It is grid-connected power. The thermal energy is used themselves; the biogas residua and leachate used only for themselves but also supplied to surrounding area.

2. Case Study

2.1 NBE Shan County Biomass Direct Combustion Generation Project

This project is a demonstration project validated by NDRC and its operation was the first in China for bio-mass direct combustion generation project. It was invested and developed
by National Bio Energy Co., Ltd (BNE), a subsidiary of State Grid Corporation. The plant is equipped with a 130t/h biomass combustion boiler with high temperature high pressure water cooled vibration grate. The total installed capacity is 25 MW and the total investment is 337 million RMB. The boiler was manufactured in China (by Jinan Boiler Plant) with technology from BWE, a Denmark company and some key-equipment was imported from foreign countries.

The bio-mass fuels were grey straws like cotton stalk and forestry waste. There were 8 straw collection centers, each with capacity ranging from 5000tons to 20,000 tons. Their total capacity is 40,000-50,000 tons which can meet the demand of the plant for 100 days. The fuels are collected mainly from areas located around the plant within 30-50kms in diameter while a few fuel supply sources are 100kms away. There are about 1000 local farmers involved in fuel collection. The average daily straw collection exceeds 600 tons with a loss of 25%. The price at the collection center is about 240 Yuan/ton and the price for milled straw at plant is about 280 Yuan/ton.

The plant which was equipped with a 25 MW steam extraction condensing steam turbine generator was put into operation on December 1st 2006. The system ran over 6000 hours in 2007, which is the best record among all the bio-mass direct combustion power plants in China. The plant consumes about 200,000 tons of straws per year.

As the price of power generated from this project was validated before January 1st 2006, the additional 0.25 Yuan policy for Shandong province was not adopted and the price was fixed at 0.796 Yuan/Kwh by the provincial price bureau.

The flowing table shows the financial statement, production statistics and unit cost of the plant during January – February 2007. According to the table, the power generation cost/KWh is 0.812 Yuan (including tax and AV) while the sales price is 0.796 Yuan, leading to a negative profit of -0.087 Yuan before tax.

<table>
<thead>
<tr>
<th>Indexes</th>
<th>Value</th>
<th>Yuan/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales income</td>
<td>11940</td>
<td>0.796</td>
</tr>
<tr>
<td>Substituted money on VAT</td>
<td>2029.8</td>
<td>0.135</td>
</tr>
<tr>
<td>Changeover withholdings on VAT</td>
<td>1055.7</td>
<td>0.070</td>
</tr>
<tr>
<td>Tax and AV</td>
<td>1071.5</td>
<td>0.071</td>
</tr>
<tr>
<td>Material cost</td>
<td>6210</td>
<td>0.414</td>
</tr>
</tbody>
</table>
2.2 Case 2 Lanzhou Huazhuang Biogas Generation Pilot Project

This project is a technology transfer project under the program of “Promotion of Rural Renewable Energy in Western China” of Sino-Dutch Cooperation Project. Huazhuang DairyCattle Breeding Center locates at Huazhuang Town of Honggu District of Lanzhou City. The breeding center possesses 20 hectare of herbage land and 2300 dairycows (the designed capacity is 3000 cows) of which 1100 are lactating.

The first stage of the project mainly aims at treating the waste of the 1100 lactating dairycows for biogas power generation. The volume of the anaerobic fermentation tank is 12000 m³ and that of the gas storage tank is 300 m³. Its daily treatment capacity is 80 tons of black water and gas productivity is 1200m³/day.

The bio-gas output is all used for power generation and the power can be connected to grid. Two Cento T88 5PE BIO co-firing CHP generators manufactured by TEDOM, a Czech company were selected after public tendering and price inquiry. The maximum power output is 76 KW and heat output is 121 KW. Power generation efficiency and heat efficiency are respectively 31.5% and 50.2%. This generation system with advanced technology produces 2KWh from per cubic meter biogas, 20% higher than the existing systems in China whose figure is 1.6KWh/m³.

The test-run of the plant started from August 2008 and it has so far been proved to be under stable operation with a daily output of 1200m³ bio-gas which meets the designing index. Methane concentration of the biogas exceeds 55%. An average daily power generation of 1500 KWh has been witnessed with a peak of 1900 KWh. The waste heat utilization rate exceeds 50%. While generating power, every m³ of biogas produces 3kwh of heat with heat efficiency over 80%.

The introduced bio-gas generation system is of advanced technology, good performance, high automation, low noise and little emission.
As an international cooperation project and a key demonstration project of the Ministry of Agriculture this project imports generator from abroad, which leads to a large amount of initial investment of RMB 6.8 million including EUR 330,000 donated by the Dutch Government. The operation of the project secures the power supply for Huazhuang DairyCow Breeding Center and avoids loss from off of power which happens in the case of grid-connected power. In addition, it saves RMB 300,000 from power consumption. Moreover, the utilization of treated effluent and sludge forms a resource using cycle for agro-livestock feeding industry and presents a benign circular economy model.

The existing problem is that the expected grid connection has not yet been realized and the output of the generator is limited and affected by the power consumption load of the dairy cow breeding center and long-term full load operation can not be secured. There has been no contract with the local grid corporation and thus favorable policy for renewable energy price can not perform. In addition, the H2S concentration in the bio-gas is too high, which requires further improvement of the desulphurization system.

3. Problems facing Chinese biomass energy sector

3.1 Biomass direct combustion generation

(1) biomass fuel supply

Biomass direct combustion generation is a large-scale process for use of biomass resource and thus requires sufficient fuel supply. According to the present biomass generation efficiency in China, 1 KWh power requires 1.2 Kg of biomass resource. Taking into consideration of losses in collection and treatment, the actual efficiency is about 1.4Kg/KWh power, which doubles that of coal. For a 2 MW biomass power plant running 6000 hours per year, 200,000 tons of biomass fuels are required. The average land productivity for either crop straws or forestry waste is 7.5ton/ha. In this case, it requires 26,000 ha farming land or forestry land to meet the demand.

As a matter of fact, almost all the biomass direct combustion power plants and co-firing biomass plants in China have met the problem of fuel supply shortage. The fuel collection diameter for Shan County has been expanded from the designed 30-50 km to 100 km. In case of Suqian Biomass Power Plant in Jiangsu Province, the most far away fuel supply source has reached 150km. Fuel supply is also impacted by the distribution of the power plants. In the north part of Jiangsu Province, 10 25MW biomass power plants were put into operation in 2007 and another one is under construction. Although North Jiangsu has abundant of straw resources from large amount of rice, cotton and wheat production, fuel
supply for biomass power plants is still a big trouble due to dense distribution of these power plants. The 9 operating plants of NBE which possess over 50% of Chinese biomass generation capacity have faced the problem of fuel supply. As a result, NBE re-assessed its planned projects, cancelled 5 of them and adjusted the capacity of the rest from 25MW to 12MW.

The shortage in fuel supply guides us to see the issue more objectively. The annual straw production from agriculture in China is 730 million tons. Deducting those fed back to the cropping land and used for livestock feeding, 380-400 Million tons are left for fuel supply. A reasonable use of forestry waste should be 250 million tons per year. These big figures are actually small when averaged into the rural area and by 800 million peasants. Except in some more developed areas in East China, most peasants in central and western China are using straws and fire wood for cooking and heating. Respectively 360 million and 190 million tons of straws and fire wood were consumed as energy in China in 2006. When large amount of biomass resource is used for power generation, the government should provide alternative commodities to the peasants for the resources consumed by biomass power plants which otherwise should be used by the peasants themselves. In conclusion, power generation as an option for biomass utilization shall be scientifically arranged after comparison in a whole picture for biomass utilization options and effective application.

(2) Shortage of key technology for fuel collection, transportation and storage and lack of market running mechanism

Although there has been a rapid development of Chinese agricultural industry and rural areas, the self-sufficient peasant economy has not been abandoned. Most cropping lands are scattered under management of 200-300 million peasants, about 5-6 Mu per household. There are only about 1.5 tons of residue straws available except those demanded by feeding into cropping land and for livestock. Therefore a 2.5 MW biomass power plant needs the residue straws from hundred thousands of households. On the other hand, Chinese biomass power plants have been developed just in the past few years and collection of fuels, from transportation and storage, still depends on manual operation and traditional facilities, lacking special-purpose crop harvest packing machine, transportation truck and storehouse dedicated to bio-energy industry. (See picture A2-16)
Discharging of cotton stalks  Packing of wheat straws

Transportation after milling

Transportation of cotton stalks

Figure A2-16  Packing, transportation and discharging of fuels
Cost for fuel collection climes up due to tight supply and backward facilities. More over, in the absence of functional marketing mechanism, peasants may deliberately increase the price of straws when supply is tight. The average price of straws has increased from 200 Yuan/ton to 320 Yuan/ton in the recent 2 years. Taking north Jiangsu Province for example, price of bio-mass fuels has reached 340Yuan/ton, closing to the 469Yuan/ton price of coal with equivalent heat value purchased from Shanxi Province. This has not only deviated the original concept of making use of biomass materials which otherwise would be considered as waste, but also played negative effect on the stable development of Chinese biomass energy generation industry.

(3) Direct combustion boiler technology needs to be improved

Boiler is the key equipment for biomass power plant. There are two types of boilers under operation in China: (1) Direct combustion boiler with water cooled vibration grate imported from BWE, a Denmark company. This technology is matured and the 8 boilers and auxiliary equipment using this technology are under stable operation. However, this technology requires higher investment. The price for a 130ton/h boiler is over 60 million Yuan. From the perspective of development, only technology import and localization can help to reduce investment and cost. (2) Boilers with water cooled vibration grate, endless grate and circulating fluidized bed. Although these boilers can operate normally, boiler efficiency and block risk may exist to be problems caused by uneven fuel feeding, uneven air distribution and ash output.

(4) Continuous monitoring of biomass fuel consumption is the key for co-firing policy decision

Similar problems, such as fuel supply and collection, also exist for co-firing plants. However, as biomass accounts for less than 20% of the total fuel for co-firing plant, the risk in biomass fuel supply and fluctuation of its price can be mitigated. However, there is no functional monitoring facility and method to monitor the quantity of biomass fuel combusted in the co-firing plant and therefore policy maker has not issued any favorable policy for the power price of co-firing plants.

3.2 Biomass gasification power plant

Compared with direct combustion plant, the capacity of biomass gasification power plant is smaller, ranging from xKW to 3 MW. Thus, pressure on fuel supply is less. Due to less capacity and adoption of dead bed thermal gasification, the system efficiency (including power generation) is only 11-14%. The initial investment requirement is relatively high and cost-efficiency is low. This constrains the possibility to put large investment in treatment and control of tar content, which impacts the stable operation of the plant as well as control of secondary pollution by tar.
The biomass gasification power plant under construction in China is developing towards middle and large scale, ranging between xMW to 10 MW. Such technologies as ambient pressure and high pressure fluid bed as well as integrated gasification combined cycle are adopted. Efficiency of the generation system can reach 40%.

3.3 Biogas power generation

(1) The capacities of bio-gas generation projects are too small to industrialize

The fuel for bio-gas generation is bio-gas from livestock waste. Wherever there is livestock raise, there will be bio-gas production from collection of animal waste. However, it takes certain amount of bio-gas for power generation. Although there have been 17,800 biogas projects of different scales in China in 2006 with annual output of 210 million m³, only 5.5 million m³ bio-gas was used for power generation, accounting for 2.6% of the total amount collected from livestock farm. In china, a large-scale pig farm with 10,000 pigs can only produce 160 Mwh power per year and only suites a generator of 70-100 KW. In a world, biogas generation is featured in small scale.

The capacity of biogas generation projects is constrained by the scale of the livestock farm. A 1MW biogas power plant with daily output of 12000 KWh needs 7000 m³ biogas everyday, equal to output of a pig farm with at least 70,000 pigs. And this kind of super-scale livestock farm will be developed with the progress of Chinese agricultural modernization. The biogas generation projects developed in 2007 of Beijing Deqingyuan Chicken Farm and Inner Mongolia Dairy Cow Farm have respectively reached installed capacity of 2MW and 3MW.

Another way to increase the capacity of biogas power plants is to establish central biogas power plant in areas where livestock breeding is well developed so as to gather the animal waste in the livestock farms around the plant for integrated treatment. A large scale biogas power plant for treatment of waste from 300,000 pigs is under planning in Nanhu District Jiaxing City Zhejiang Province.

(2) High initial investment and cost for biogas generation project

Biogas project is also a waste treatment project which is necessary for livestock farms. However, biogas project (excluding power generation) for a pig farm with 10,000 pigs takes an investment of 1.7 million Yuan while the initial investment for the pig farm itself is only 2 million Yuan. For the livestock farms, it is unacceptable to add 85% of its investment for waste treatment.

Based on the existing technologies of waste treatment, biogas production and power generation, backwater treatment cost averages at 3.0Yuan/m³ and biogas production and
power generation cost will respectively reach 1Yuan/m³ and 0.62Yuan/KWh. Compared with natural gas, the cost of biogas is higher. And the cost of biogas generation doubles that of coal generation. On the hand, high cost of biogas generation also results from its limited scale.

(3) Chinese biogas generation technology needs to be improved

China has developed special-purpose equipment for biogas generation with capacity from tens of KW to 600 KW. However, compared with foreign countries, there are still disadvantages of Chinese technologies, like accidental engine combustion delay, low gas discharging temperature at 650℃-700℃ and low reliability. Due to weak organization of the combustion process, energy convert efficiency is as low as 1.6KWh/m³, 20% less than the 2.0 KWh/m³ of foreign countries. Automation system, inspection system and protection system also need improvement. Moreover, the waste heat utilization technology for the biogas generation system in China has not reached the qualified level.

4. Policies and their enforcement

4.1 Development and enforcement of “the renewable energy law of the People’s Republic of China”

The first article of the renewable energy law has clearly stated the purpose for developing this law — “to promote the development and utilization of renewable energy resource, increase energy supply, improve energy structure, ensure energy security and realize sustainable economy and social development”. This reflects the challenges faced by China for realizing both economic growth and environmental protection in the 21 century. Development and application of renewable energy can increase energy supply, save common energy and protect atmosphere environment and reduce local pollution.

There are 8 chapters and 33 articles in the renewable energy law regarding various aspects. Main contents regarding biomass generation include: (1) an overall development goal for biomass energy shall be defined in the “mid/long-term development plan of renewable energy” to be developed by relevant government sector and specify the key development domain and specific objectives. This is a clear message telling the energy market that the government is promoting and guiding the development of renewable energy. (2) The grids shall purchase all the power produced by renewable energy power plant, which provides good market environment for renewable energy industry. (3) A classified price and cost sharing mechanism has been established. (4) Fiscal incentive policies are in place, including special fund, concessional loan, tax exemption and inclusion in the Catalogue of Renewable Energy Development, etc., which reflect the government’s determination provide financial support to accelerate the technology development and market establishment for renewable energy industry.

4.2 Policies correspondent to the renewable energy law
Based on the renewable energy law, the state council has developed a series relevant of regulations and policies. The issued ones include:

(1) **Catalogue of Renewable Energy Development Industries**

It describes the sectors, technologies and equipment for the renewable energy development encouraged by the government. The items listed in the Catalogue regarding agricultural waste power generation are as follows:

**Catalogue of Renewable Energy Development Industries & power generation from agricultural and forestry waste**

<table>
<thead>
<tr>
<th>No.</th>
<th>Projects</th>
<th>Description and indicators</th>
<th>Development status</th>
</tr>
</thead>
<tbody>
<tr>
<td>59</td>
<td>Gas and power supply from mid/large-scale biogas projects</td>
<td>Large scale livestock farm, small-scale breeding center, organic industrial waste and municipal sewage treatment</td>
<td>Commercialized, wide application</td>
</tr>
<tr>
<td>60</td>
<td>Biomass direct combustion generation</td>
<td>Direct combustion of straw and forestry waste for power generation</td>
<td>Piloting projects in place, technical improvement needed</td>
</tr>
<tr>
<td>61</td>
<td>Biomass gasification for gas supply and power generation</td>
<td>Using straws and forestry waste for gas supply and power generation</td>
<td>Under technology development and for wide application</td>
</tr>
<tr>
<td>62</td>
<td>Solid city waste generation</td>
<td>Treat solid city waste for power generation, including waste combustion generation and land fill gas generation</td>
<td>Basically commercialized</td>
</tr>
</tbody>
</table>

**Equipment/parts and material production**

<table>
<thead>
<tr>
<th>No.</th>
<th>Projects</th>
<th>Description and indicators</th>
<th>Development status</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>Biomass direct combustion boiler</td>
<td>Used for biomass direct combustion generation system with suitable specification and performance</td>
<td>Under technological improvement</td>
</tr>
<tr>
<td>66</td>
<td>Internal combustion engine for biomass gasification</td>
<td>Used for biomass gasification generation with suitable specification and performance</td>
<td>Under technology development</td>
</tr>
<tr>
<td>67</td>
<td>Device for tar cracking in biomass gasification</td>
<td>Used for cracking the tar from biomass gasification</td>
<td>Under technology development</td>
</tr>
</tbody>
</table>

(2) “Regulations on renewable energy generation”
It clearly stipulates that the provincial government shall be responsible for the renewable energy generation management in its jurisdiction. It emphasizes that renewable energy planning shall be included in the overall energy plan of the local government at the same level. It is clear that the renewable energy generation project including biomass generation shall strictly abide by relevant articles in national infrastructure construction regulation. It is regulated that the grid corporation shall be responsible for the construction and management of grid connection of renewable energy power and they shall be responsible for the investment of grid connection for mid/large-scale renewable energy projects. The ownership boundary for these projects is the first pole out of the power plant.

(3) “Tentative management measures for price and sharing of expenses for electricity generation from renewable energy”

The document regulated that the grid-connected renewable energy price shall be decided based on the provincial coal power price plus a favorable compensation of 0.25Yuan/KWh. The renewable energy power plants can enjoy this compensation for 15 years upon its operation. From 2010, the compensation for newly approved power plants shall decrease 2% year by year. For the co-firing power plants, if its fossil fuel consumption proportion exceeds 20%, it should be deemed as fossil fuel generation project and can not enjoy the compensation.

The compensation source is defined as “renewable energy added value” to be paid by all the power consumers. Regulations on exemption of “renewable energy added value” charge are also specified in the document.

(4) “Management measures on renewable energy special fund”

Article Five of this document priorities three areas of this special fund: (1) oil substitutes that have great potential and prospect, (2) heating and air conditioning of buildings, and (3) development and application of renewable energy in such area as power generation.

(5) “Supervision measures on Electric Grid Enterprises’ Acquisition of the Whole Power Produced by Renewable Energy” by National Power Supervision Commission

This document re-stated that a power supply enterprise shall, according to the provisions of laws and state policies, give priority to an enterprise of power generation from renewable energies that has obtained an Electric Power Business License according to law and purchase the power volume fed into the grids thereof in full amount.
June 09

Temporary measures on additional income regulation of renewable energy power” by the Price Department of NDRC and “Circular of price compensation and quota trading Scheme for renewable energy in the year 2006” by NDRC and National Power Supervision Commission

These documents put the compensation policy for renewable energy enterprise enforceable.

4.3 Improvements needed for policy making

1. Calling for favorable VAT policy

“Contents on resource comprehensive utilization (Version 2003)” clearly defines biomass generation as a way for comprehensive utilization of resource. Biomass generation is included in catalogue of national prioritized industries. However, favorable tax polices are not in place and biomass generation can not enjoy the same favorable policy as city waste treatment. The actual VAT for biomass energy enterprises is above 10% which is even higher than traditional fuel generation. This policy which deviates from national industry policy constrained the development of biomass industry.

2. Collection, storage and transportation equipment have not been listed in the compensation catalogue for agricultural equipment

The agricultural equipment related to collection and transportation of biomass fuel has not yet been listed in compensation catalog of any province. As a result, traders dealing in collection, process and transportation of biomass fuel can not enjoy compensation. This additional cost leads to price increase of biomass fuel.

3. Not available of Special Fund

It is stipulated in the “tentative management measures on renewable energy special fund” that this fund is to support “the technological development, standard development and piloting projects for development and utilization of renewable energy”. However, as there is no implementation regulation and operating manual, no biomass generation piloting project has got support from this special fund.

4. Lack of Relevant Standards

There have been no standards on resource investigation, feasibility study, equipment manufacturing, project construction and project operating of biomass power plants, which constrains the standardized healthy development of the industry.

5. Prospects and Suggestions
5.1 Till the year 2000, the potential biomass resources in Chinese rural area reached 366 million tons of coal-equivalent. Biomass resource is renewable and can be increased through plantation (it may also decrease due to destroying). It is expected that the total amount of biomass resource which can be utilized will reach 540 million tons of coal-equivalent, of which 366 tons of coal-equivalent are those from the rural area and can be utilized, including 400 tons of agricultural waste, 260 tons of fire wood and forestry waste and 37 billion m³ of biogas from human/animal waste. The full utilization of these resources will increase clean energy supply to the rural area, optimize energy structure, improve the peasants' living conditions, reduce greenhouse emission for about 1 billion tons, reduce SO2, dust and NOx emission for about 10 million tons. The utilization of 300 million tons of biomass resource will help to develop renewable energy industry, promote rural development and increase the peasants' income. Development and utilization of biomass energy will be a fundamental industry of China and should obtain support from the government while operating under market mechanism.

5.2 Installed capacity of Chinese biomass power plants will reach 30,000 MW in 2020

Power generation is one of the options for utilization of biomass energy. According to the national “mid/long-term development plan for renewable energy”, installed capacity of Chinese biomass power plants will reach 30,000 MW in 2020, including 2000 MW from biogas from organic industry sewage, 3000 MW from city waste and sewage treatment biogas, 2000 MW from bagasse residue of sugar industry and 23,000 from agricultural and forestry waste and human/animal waste biogas generation.

Till 2010, 4700 livestock farm biogas projects will be constructed and this number will reach 10000 in 2020. Most of the biogas to be produced will be used for power generation and accumulated installed capacity will reach 2000 MW in 2020, annual consumption of 4 billion m³ biogas.

Based on these figures, the installed capacity for biomass direct combustion, co-firing and gasification generation will reach 21,000 MW in 2020. If running 5000 hours per year, annual power generation will reach 105 billion KWh. Annual straw consumption will reach 140 million tons, 21.2% of the total 660 million tons of useful biomass resource in the rural areas.

5.3 A few comments on biomass direct combustion generation

1. Good planning and reasonable distribution
   - Construction of power plants combusting straws around grain and cotton
production centers

♦ Construction of power plants combusting bagasse and forestry waste around sugar production center and forestry areas
♦ Development of biomass power plants in barren areas where large scale of plantation is possible. For example use the forestry waste from the sand break forest in North China

(2) Scale of the power plant shall depend on sustainable fuel availability

(3) improve equipment for fuel collection and transportation, including packing machine, special transportation truck and suitable storehouse

(4) Well-planned distribution of fuel collection centers and establishment of fuel collection market mechanism

(5) Choose suitable technology based on fuel availability, market demand and grid connection condition. Priority shall be given to co-firing generation.

5.4 Comments on bio-gas power generation

Biogas generation project as a pollution treatment and clean energy production project shall also be developed in an industrialized way and gradually form a fundamental industry of biogas generation.

The government shall develop objectives and plans to guide the market and pull the development of biogas generation projects by providing favorable polices regarding price, compensation and tax to attract more enterprises to participate in.

Enterprises dealing in biogas generation shall improve efficiency, enlarge scales, productivity and prioritizing co-firing projects to improve the enterprises sustainability and profitability.

(1) Choose suitable anaerobic digestion process to improve fermentation efficiency and productivity. Priority shall be given to integrated biogas project so as to increase productivity, reduce cost and make full use of effluent and sludge.
(2) The capacity and scale of single biogas project shall be increased to improve efficiency and reduce cost. Centralized biogas power plant shall be developed to integrate waste treatment and build large scale power plant.

(3) Heat power cogeneration project produces various products like heat, power and fertilizer. The plant can be connected to grid and enjoy favorable power price with additional benefit.

Biogas generation equipment shall be upgraded to improve generation efficiency and comprehensive energy efficiency.

(5) Specialized biogas generation enterprises separate from livestock farms shall be developed to realize independent management and running so as to reduce risk and be dedicated in the development of biogas project itself.

Note:
Most data in this article is from site investigation and some is provided by my friends to whom I would like to extend my thanks: Prof. Qin Shiping, NDRC; Cai Changda, GM, Hangzhou Energy and Environment Co., Ltd; Mr. Lv Zengan, China-Dutch Cooperation Project; Li Jingming, Division Chief, Scientific Development Center, Ministry of Agriculture.
ANNEX 3 – WIND TURBINE SUPPLIES IN GANSU

(1) Jinfeng Science and Technology Company
Set up in 1998 and with registered capital of RMB100 million, this company is a high-tech entity well known within Xinjiang Autonomous Region. It is the largest wind power generator manufacturer and research center in China. The company is able to make wind power equipment at 600kW, 750kW, 800kW and 1500kW capacities and has DC drive technology which is suitable for different wind types.

Currently research and development in being undertaken for 2000kW and 2500kW capacities as well as preparation for offshore wind power production. 90% of the wind power generator equipment produced by Jinfeng is produced nationally through collaboration with other suppliers.

(2) Dongqi Wind Power Equipment Co.
Dongqi is one of the leading wind power equipment manufacturers. Through technological innovation the company has the highest power voltage capability and largest nationalization rate of parts. In November 2004 it successfully introduced the MD70/77 wind generator at 1500kW from Germany and now the company can produce it at 70% of nationalization rate.

(3) Huarui Wind Power Science & Technology Co.
Huarui is a high-tech company engaged in the development, design, manufacture and sale of wind power equipment. The company was the first in China to import wind power technology with a capacity of 1.5 MW and is able to produce it to suit various wind zones and different temperature scales. The nationalization rate has reached 89.7%. Its annual production capacity is 1000 sets of 1.5 MW wind generators.

(4) Mingyang Wind Power Technology Co.
Established in June 2006 and owned by Mingyang Electrical Co., the company deals with technical consultancy and wind power technology trade. The large scale wind power generator at MW or above is the main product, complemented by wind power control systems, frequency conversion systems, generation systems and experiment facilities. In cooperation with a world famous design company it has developed MY1.5 series wind power generators. The output of 1.5MW wind power equipment represents an advanced level of technology innovation in China. The company expects to develop 3 MW generators within 2 years and 5 MW offshore wind generator within 5 years. The company aims to become one of the top three wind power generator producers in China.

(5) German Repower company and Chinese Ruineng North Wind Power Equipment Co.
Repower Co. is the largest wind power equipment manufacturer in the world with the most advanced technology. The company can produce up to 6MW wind power generators. In September 2006 a joint venture was built up with registered capital of RMB100 million contributed by REpower Systems from Germany, North Heavy Industry Group from China Inner-Mongolia and Honiton Energy company from England. Targeting the wind power market of Inner-Mongolia the company aims to secure 30% of the local market and become a globally known manufacturer.

(6) Indian Suzlon Energy Company
Indian Suzlon is a fast-growing transnational corporation engaged in wind power technology development, design, manufacture and consultancy. The company entered China in 2002. As the largest wind power equipment manufacture in India, the company is now the 5th largest
in the world, and takes 5% of the world market share and 30% of the Asian market share. The company will invest further in its R & D center in Tianjin.

(7) Spanish Gamesa Wind Power Co. in Tianjin

The company is a leading wind power equipment supplier in the world. In 2005 it ranked 3rd in the world in terms of cumulative installed capacity, which is greater than 7500 MW. Headquartered in Spain, the company has 28 factories worldwide. Its factory in Tianjin can produce 600 sets yearly.

(8) Danish Vestas Wind Power System Co. in Xuzhou

This global company is one of the biggest manufacturers in the area. It has installed 35,000 sets of equipment in 63 countries which generate 60 million MW. The new factory in Xuzhou will be built in August 2009.