

**Asian Development Bank**

**ADB TA-3840**

**OPPORTUNITIES FOR THE CDM IN THE ENERGY SECTOR  
THE PEOPLE'S REPUBLIC OF CHINA**

**Appendix C:  
Background Materials for Social Development Analysis**

**March 2004**

*Submitted by:*  
International Resources Group (IRG)

*In collaboration with:*  
Resources for the Future and  
Tsinghua University Global Climate Change Institute

*Prepared for:*  
Beijing, Government of the People's Republic of China

# CONTENTS

---

1	Guangxi Projects.....	1
1.1	Guilin Municipal Waste Power Plant.....	1
1.2	Guangxi Bio-Organic Fertilizer Plant.....	3
1.3	Guitang Bagasse Wastewater Treatment Plant.....	5
1.4	10,000 Biogas Digesters for Poor Households.....	6
2	Gansu Projects.....	9
2.1	Gansu Yumen Wind Power Plant.....	9
2.2	Lintan County Luertai Hydro-power Station.....	11
2.3	Diebu County Niaojiaga Hydro-power Station.....	14
3	References.....	19

# Appendix C: Background materials for social development analysis

A CDM project can affect social development through its impacts on: (i) employment and compensation, (ii) the availability and affordability of goods and services, (iii) resettlement, (iv) the environment, and (v) economically and socially disadvantaged groups. Below, for each project we provide an analysis of each of these five types of impacts. Except where otherwise noted, the information presented below was collected from project developers by International Technical Experts and National Technical Experts during field visits and interviews in 2003.

## 1 GUANGXI PROJECTS

---

### 1.1 Guilin Municipal Waste Power Plant

#### 1.1.1 EMPLOYMENT AND COMPENSATION

*Job creation: direct impacts.* According to the project developers, the municipal solid waste (MSW) plant will create roughly 300 construction jobs that will last approximately 18 months. In addition, the project will create 80 permanent operations and maintenance jobs. Of these 80 permanent jobs, 20 will entail management positions, and the remainder will entail manual labor.

*Job creation: indirect impacts.* The project will create 60 jobs in waste transportation.

*Job losses.* The project may result in job losses in at least two sectors. First, it will result in some job losses among employees of the Guilin Environmental Protection Bureau (EPB). Currently, approximately 1200 EPB employees work in waste collection and transportation (also 40 EPB employees work at the Guilin landfill site). The proposed plant will hire its own workers to transport waste and these workers will displace some, EPB waste haulers. Second, the project may negatively impact informal activities that depend on scavenging in municipal solid waste dumps.

#### 1.1.2 AVAILABILITY AND AFFORDABILITY OF GOODS AND SERVICES

The MSW plant will have not have much impact in the availability or affordability of electricity.

*Availability of electricity.* According to project developers, there is currently an oversupply of electricity on the grid to which this plant will sell its power. Also, rural electrification in the vicinity of the plant is complete. Therefore, this proposed project will not contribute to making electricity more available. Note, however, that the given increasing links between provincial power grids and severe power shortages in other parts of the country, this oversupply may well be temporary.

*Affordability of electricity.* The proposed plant is not likely to affect the affordability of electricity. The electricity grid will pay the plant \$ 0.45 RMB per kWh, a special price for MSW-based electricity. By contrast, the grid pays nearby coal-fired plants \$ 0.35 RMB per kWh. However, the higher price paid to the MSW plant is not likely to push up the prices that end-users pay for electricity because there is an oversupply of power on this grid.

### **1.1.3 RESETTLEMENT**

The project will not involve relocating any households.

### **1.1.4 ENVIRONMENT**

*Benefits from reduced landfilling and dumping of MSW.* The project will avert environmental damages associated with current polluting methods of disposing of MSW in Guilin City—the collection area for the plant. Currently, Guilin City generates approximately 600 tons of MSW per day. Of this waste, approximately 75% is buried in the Guilin Chongkou Waste Landfill and the remaining 25% is composted. According to project developers, certain environmental controls are in place at the Guilin Chongkou Waste Landfill—MSW and soil are layered and water and gas drainage systems have been put in place to draw out leachates and gases. However, these protections are not completely effective. Therefore, both of the current disposal methods—but especially the composting—contribute to environmental degradation including methane emissions, pollution of the Li and Xiang Rivers, contamination of ground waters, and the creation of odors—all important considerations in an area renowned as a tourist attraction.

*Potential environmental damages.* The proposed MSW plant could have at least five adverse environmental impacts. First, it will emit air pollutants, including conventional air pollutants such as sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), total suspended particulates (TSP), and ash. The plant may also emit hazardous air pollutants such as heavy metals. Some of this pollution—for example SO<sub>2</sub>—results from the fact that the plant will burn 20% coal (by weight) in order to increase calorific value and ensure stabilized operation. According to project developers, the plant's boilers will emit 23.5 kg/hr of SO<sub>2</sub> and 7.23 kg/hr of TSP. To control these emissions, the plant will employ flue gas half dry desulphurization technology (a desulphurization system in which calcium or sodium based sorbents, usually hydrated lime, are introduced into the flue gas), and a hop-pocket dust catcher (a type of bag house) which have control efficiencies of 83.0% and 99.7% respectively. Thus, emissions from the plant are expected to be 153 tons of SO<sub>2</sub> per year, and 47 tons of TSP per year. A special concern for power

plants burning MSW is emissions of dioxin and heavy metals due to incomplete combustion of plastics. According to developers, the plant's combustion chamber will be maintained at sufficiently high temperatures (850-920 degrees) to control dioxin. The above-mentioned abatement devices will also contribute to controlling emissions of hazardous air pollutants. Finally, activated carbon will be injected to absorb heavy metals and other hazardous air pollutants.

Second, the plant will emit waste water.

Third, the plant will produce slag and soot. This will be disposed of in the Guilin Chongkou Waste Landfill.

Fourth, the plant will contribute to noise pollution. To mitigate it, the plant will install mufflers and sound insulation devices. The sound levels in the plant are projected to meet relevant standards.

Finally, the plant will exacerbate vehicular air pollution by increasing the distances which solid waste is transported. Currently, MSW is transported in a fleet of 30 sealed trucks, each of which travels an average of 50 km per day. The MSW plant will also employ a fleet of 30 trucks, but each will travel 70 km per day, a 60% increase in vehicle miles traveled, and presumably, a 60% increase in vehicular emissions.

### **1.1.5 DISADVANTAGED GROUPS**

The social benefits (and costs) associated with the proposed project will accrue to a population that is relatively poor. Average annual household income in Xingan County was \$2,400 RMB in 2001. This compared to \$6,982 RMB for all of Guangxi Province, and \$10,182 RMB for China as a whole.

However, Xingan County does not have a particularly high population of minorities. In 2001, 3.4 % of the population of was minority. This compared to 38.3% for the Guangxi and 8.4% for China as a whole. (Statistical Yearbook of Guangxi 200; 2001 15<sup>th</sup> National Census).

## **1.2 Guangxi Bio-Organic Fertilizer Plant**

### **1.2.1 EMPLOYMENT AND COMPENSATION**

*Job creation: direct impacts.* According to the project developer, this project will create 60 temporary construction jobs that will last 3 months. The project will not affect permanent operations and maintenance jobs.

*Job losses.* According to the project developers, the project will not result in any job losses.

### 1.2.2 AVAILABILITY AND AFFORDABILITY OF GOODS AND SERVICES

*Affordability of fertilizer.* According to the project developers, the cost per unit of nutrient for the organic fertilizer produced by the plant—800 RMB per ton—is at the low end of the range of prices for chemical fertilizers—800-1700 RMB per ton. Hence, by effectively increasing the capacity of the plant, this project will place downward pressure on the price of fertilizer in the area served by the plant.

### 1.2.3 RESETTLEMENT

The project will not involve relocating any households.

### 1.2.4 ENVIRONMENT

*Benefits associated with remediation of distillery waste.* This project will end the practice of dumping into a holding pond 20,000 tons per year of excess distillery waste—a highly polluting substance containing 1,905 tons of COD. According to project developers, a number of steps were taken to minimize the adverse environmental impacts from this pond on ground and surface water. It was lined with clay, strategically positioned, and is emptied and cleaned once a year. Also, the pond has no outlets. If these measures were implemented with care, then eliminating the practice dumping distillery waste into the pond may only have minor water pollution benefits. However, the EIA for the project suggests some evidence is beginning to emerge indicating wastes in the pond are seeping through the clay lining and contaminating groundwater. Hence, this project may avert contamination of groundwater.

*Benefits associated with increasing use of organic fertilizer.* By increasing the capacity of the plant, the project may result in the substitution of organic fertilizer for chemical fertilizer. The former has fewer environmental impacts than the latter both during production and application. Specifically, when applied to farmers' fields, chemical fertilizers may contaminate ground and surface water and lead to soil crusting and degradation.

### 1.2.5 DISADVANTAGED GROUPS

The social benefits associated with the proposed project will accrue to a population that is relatively poor and high in minority representation. Average annual household income in Laibin County was \$1120 RMB in 2001. This compared to \$6,982 RMB for all of Guangxi Province, and \$10,182 RMB for China as a whole.

Laibin County is now Xingbin District of Laibin Municipality, which also has a high population of minorities. In the new Laibin Municipality, minorities accounts for 74.6% of the total population, including ten ethnic groups such as Yao and Zhaung. These figures compare to 38.3% for the Guangxi and 8.4% for China as a whole. (Statistical Yearbook of Guangxi 2000; 2001 15<sup>th</sup> National Census).

---

## 1.3 Guitang Bagasse Wastewater Treatment Plant

Note that the baseline for this project, which involves installing an anaerobic digester for wastewater treatment, is not a complete lack of any wastewater treatment facilities. Rather, it is a wastewater treatment facility that uses a conventional aerobic process. As a result, the social development impacts for the project—the difference between the impacts from the conventional aerobic technology and the new anaerobic one—are minimal.

### 1.3.1 EMPLOYMENT AND COMPENSATION

*Job creation/loss: direct impacts.* According to the prefeasibility study report for this project, both the construction and the operation/maintenance of the anaerobic facility will require slightly more labor than the aerobic facility. The aerobic treatment facility will create 20 temporary construction jobs that will last approximately eight months. By contrast, the anaerobic treatment facility will create 27 temporary construction jobs that will last eight months. The aerobic treatment facility will create 10 permanent operations and maintenance jobs. By contrast, the anaerobic treatment facility will create 8 permanent operations and maintenance jobs. Hence, the net impact of the anaerobic treatment facility on employment will be to create seven temporary construction jobs lasting eight months, and to eliminate two permanent operations and maintenance jobs.

### 1.3.2 AVAILABILITY AND AFFORDABILITY OF GOODS AND SERVICES

*Availability and affordability of paper.* According to the project developers, the project will not have a significant effect on the cost of paper produced by Guitang and therefore, will not have a significant impact on the availability and affordability of goods and services.

### 1.3.3 RESETTLEMENT

The project will not involve relocating any households.

### 1.3.4 ENVIRONMENT

*Air pollution benefits.* The project will reduce air pollution in two ways. First, it will eliminate air pollution by substituting clean-burning biogas for the coal used to fire the company's boiler. As detailed in the Project Design Document, the biogas from the proposed project will displace approximately 5,349 tce annually resulting in the elimination of conventional air pollutants such as SO<sub>2</sub>, NO<sub>x</sub>, CO, TSP, and ash.

Second, the proposed project will cut air pollution by reducing consumption of grid electricity generated by highly-polluting coal-burning plants. As detailed in the Project Design Document, grid electricity

consumption associated with the baseline aerobic wastewater treatment process is 4,332,240 kWh per year while grid electricity consumption associated with the anaerobic wastewater treatment process is 3,659,040 kWh per year. Hence, the anaerobic process would cut grid electricity consumption by 673,200 kWh per year.

Emissions factors for electricity produced by the local grid can be used to calculate reductions in conventional pollutants resulting from the reduced consumption of grid electricity. According to 2003 Journal of China's Energy, average emission factors for thermal plants are 8.568 g/kWh of SO<sub>2</sub>, 3.808 g/kWh NO<sub>x</sub>, 0.1224 g/kWh CO, and 0.1904 g/kWh of TSP. These emissions factors imply that adopting the aerobic process will cut annual emissions of these pollutants by the following amounts: 5.77 tons of SO<sub>2</sub>, 2.56 tons of NO<sub>x</sub>, 0.08 tons of CO, 0.128 tons of TSP, and 11.44 tons of ash.

*Water pollution benefits.* Some evidence suggests that the proposed project will reduce water pollution emitted by the plant. According the project prefeasibility study (p. 5), the anaerobic treatment process is more effective at removing COD than the aerobic process. The anaerobic process can treat the COD concentrations as high as 10,000 mg/l while aerobic process can only treat COD concentration below 1,000 mg/l.

### 1.3.5 DISADVANTAGED GROUPS

The social benefits associated with the proposed project will accrue to a population that is relatively poor. Average annual household income in Guigang City, the urban area that contains the project, was \$2,000 RMB in 2001. This compared to \$6,982 RMB for all of Guangxi Province, and \$10,182 RMB for China as a whole.

However, Guigang City does not have a particularly high population of minorities. In 2001, 7% of the population was classified as minority. This compared to 38.3% for the Guangxi and 8.4% for China as a whole. (Statistical Yearbook of Guangxi 2000; 2001 15<sup>th</sup> National Census).

## 1.4 10,000 Biogas Digesters for Poor Households

### 1.4.1 EMPLOYMENT AND COMPENSATION

*Job creation: direct impacts.* The project will create jobs in both building and installing biogas digesters. According to project developers, each unit requires 0.45 person days to build, and 6 person days to install. Thus, if 10,000 units are actually built, sold, and installed, the project will create 4,500 person days of employment in building and 60,000 person days of employment in installing.

*Job losses.* According to project developers and local officials, the project will not result in any significant job losses.

---

### 1.4.2 AVAILABILITY AND AFFORDABILITY OF GOODS AND SERVICES

For households that adopt the digesters, the project will affect the prices of household energy and fertilizer.

*Affordability of household energy.* Biogas digesters significantly reduce the implicit price of household energy. Currently, the targeted households rely on biomass—mainly firewood—for household energy in cooking. Although this biomass is ostensibly “free”, non-electrified households typically spend 20-30 person days per year collecting it and 7.6 person days per year burning it. If we assume the price of unskilled labor is 30 RMB per day, then a rough estimate of the total annual cost of biomass energy for a non-electrified household is 978 RMB.

By contrast, the total annualized costs of biogas units—including capital costs and operations and maintenance costs—are minimal. According to the project developer, households spend roughly 20 minutes per day—or 4.95 person days per year—to empty animal and human wastes into the digester. Assuming the price of unskilled labor is 30 RMB per day, then the total annual operations and maintenance cost of biogas energy is 149 RMB. The annual capital cost of a biogas digester—assuming the household’s out-of-pocket expense is 500 RMB—is 86 RMB per year (including a biogas stove and lighting devices), the useful lifetime of the digester is 15 years, and the interest rate is 15%). Thus, over a 15 year lifetime, the total annualized cost of a digester is 234 RMB, just 24% of the costs of biomass energy. (Note that this ratio would be even lower if we made the reasonable but less conservative assumption that the time spent emptying animal and human wastes into the digester would otherwise be spent emptying such waste into cesspools.)

*Affordability of fertilizer.* Households can use wastes that collect in the digester as fertilizer. According to project developers, each biogas digester typically produces 10 tons of fertilizer per year which can be used to improve crop and vegetable garden yields, and may also substitute for chemical fertilizers costing roughly 550 RMB per ton.

### 1.4.3 RESETTLEMENT

The project will not involve relocating any households.

### 1.4.4 ENVIRONMENT

*Benefits associated with displacing biomass fuels.* The extent to which biogas from the digesters replaces biomass as a household fuel is not clear. Project developers are hopeful that biogas will completely replace biomass for cooking and for lighting in non-electrified households. Heating is generally not needed in this part of the country. China currently has implemented pilot programs aimed at disseminating biogas digesters in 100 counties that are deemed ecologically fragile (Gu 2003). (The

county in which this project is located is not one of them.) Efforts to disseminate biogas digesters in China have generally had considerable success (Barnes 2003).

Experience with biogas digesters worldwide suggests that households generally do substitute out of biomass for both lighting and cooking when biogas becomes available. Experience in other areas of China, suggests that the typical 8 m<sup>3</sup> digester fed with the manure of at least three pigs can provide enough gas for the entire cooking demand of the household. However, biogas is generally not used for heating (Barnes 2003).

In any case, to the extent that biogas does supplant biomass as a source of household energy it will have a number of significant environmental benefits. First, it could slow deforestation in Guangxi Zhuang Autonomous Region. Evidently, deforestation in Guangxi Zhuang Autonomous Region mainly stems from the harvesting of trees for use as household fuel for cooking. Project developers estimate that households dependent on biomass collect 1-3 tons each year.

Second, to the extent biogas replaces biomass as a household fuel, it will cut indoor air pollution, a significant health hazard for rural households, especially for women who are responsible for cooking and for children who are especially vulnerable to respiratory disease.

Finally, biogas digesters can improve sanitary conditions on rural farms. In the absence of biogas digesters, households generally deposit manure in open top cesspools which become breeding grounds for flies and mosquitoes. Digesters eliminate this hazard.

#### **1.4.5 DISADVANTAGED GROUPS**

The social benefits associated with the proposed project will accrue to a population that is relatively poor and high in minority representation. Average annual household income in Wuming and Pingguo Counties was 900 RMB in 2001. This compared to 6,982 RMB for all of Guangxi Province, and \$10,182 RMB for China as a whole.

The project area also has a high population of minorities. Two of the counties in this area—Wuming and Pingguo—had minority populations (primarily Zhuang and Yao) of 86 and 95% respectively. These figures compared to 38.3% for the Guangxi and 8.4% for China as a whole. (Statistical Yearbook of Guangxi 2000; 2001 15<sup>th</sup> National Census).

# 2 GANSU PROJECTS

---

## 2.1 Gansu Yumen Wind Power Plant

### 2.1.1 EMPLOYMENT AND COMPENSATION

*Job creation: direct impacts.* According to the EIA for the project (p. 22-27), the wind farm will create 60 temporary construction jobs that will last 6 months, and 40 temporary installation jobs that will last 18 months. In addition, the project will create 13 permanent operations and maintenance jobs. Of these 13 permanent jobs, 5 will entail management and the remainder will entail manual labor.

*Job losses.* According to project developers and local officials, the project will not result in any job losses.

### 2.1.2 AVAILABILITY AND AFFORDABILITY OF GOODS AND SERVICES

*Availability of electricity.* The project's stated goal does not include enhancing the availability of electricity. According to project developers, the Yumen wind farm will sell 100% of its output to the provincial power grid. The project will contribute indirectly to enhancing the availability of electricity. According to a Chinese expert on the power sector in Northwest China, the grid to which the plant will sell its power experiences frequent shortages. In part, these shortages arise because 43% of the grid's installed capacity is hydropower. Output from such plants generally falls during the dry season when river flows diminish. Also, fully 70% of the households in county served by the grid are not yet electrified (Gu 2003). Hence, by boosting the supply of electric power, the plant will contribute to both reducing shortages and furthering electrification.

*Affordability of electricity.* The wind power plant is *not* likely to put downward pressure on the price of electricity supplied by the provincial power grid. According to the prefeasibility study, the provincial grid is expected to pay the plant a price of \$0.65 RMB per kWh. The average price paid to plants on the grid is roughly \$0.36 RMB per kWh (Gu 2003).

*Benefits from electrification.* A recent rigorous multi-year study sponsored by the World Bank and the United Nations Development Programme (UNDP) found that the total benefit of electrification for a typical Philippine household is US \$81-150 per month (World Bank 2002). The principal benefits of electrification were:

- ◆ expanded use of lighting;

- ◆ expanded use of radio and television;
- ◆ improved returns on education and wage income;
- ◆ time savings for household chores; and
- ◆ improved productivity of home business.

The Philippine report emphasized that one of the key benefits of electric lighting is educational—electric lighting facilitates improved reading and longer homework hours.

A related World Bank study of the potential benefits of electrification in poor rural areas in four northwestern Chinese provinces (including Gansu) found that household perceived the first three benefits listed above as most important (Voravate et al 2000).

### 2.1.3 RESETTLEMENT

The project will not involve relocating any households.

### 2.1.4 ENVIRONMENT

*Adverse impacts.* According to the project EIA (p. 13), the wind farm is not expected to have any significant adverse impacts on the environment. The farm will cover approximately 1.5 square kilometers of a desert area, a site that is uninhabited and that is not used for any productive purposes. In fact, the entire area within 10 kilometers of the wind farm is uninhabited. Noise pollution is expected to be minimal. Noise generation will not exceed 100 decibels, and relevant standards will be met at distances exceeding 200-500 meters. Finally, the wind farm is not expected to have a significant impact on bird life. There are no water bodies in the area, and no local migrations of birds.

*Benefits associated with displacing coal-fired electricity.* Wind power from the proposed plant will displace coal-fired power on the provincial power grid which is mainly supplied by coal-fired plants. Therefore, the proposed plant will effectively reduce emissions from these coal fired power plants of conventional pollutants—sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), total suspended particulates (TSP), and ash. Back-of-the-envelope estimates of the amounts of these reductions were calculated as follows. According to 2003 Journal of China's Energy, emission factors for thermal plants are 8.568 g/kWh of SO<sub>2</sub>, 3.080 g/kWh NO<sub>x</sub>, 0.1224 g/kWh CO, and 0.1904 g/kWh of TSP. Assuming that the wind power plant sells 100% of its annual generation to the grid (43.654 GWh), then the plant will cut emissions of these pollutants by the following amounts: 372 tons of SO<sub>2</sub>, 134 tons of NO<sub>x</sub>, 5.3 tons of CO, 8.3 tons of TSP, and 2,272 tons of ash.

### 2.1.5 DISADVANTAGED GROUPS

The social benefits (and costs) associated with the proposed project will accrue to a population that is relatively poor. The project is located in Yumen Township, which is under the jurisdiction of Yumen City 69 kilometers away. Average annual household income in Yumen City was \$1,900 RMB in 2001. This compared to \$7,206 RMB for all of Gansu Province, and \$10,181 RMB for China as a whole. However, Yumen City does not have a particularly high population of minorities. In 2001, 4% of the population of the city was minority. This compared to 9% for the Gansu and 8% for China as a whole. (Statistical Yearbook of Gansu 2001; 5<sup>th</sup> National Census 2001)

## 2.2 Lintan County Luertai Hydro-power Station

### 2.2.1 EMPLOYMENT AND COMPENSATION

The hydropower dam could have direct and indirect impacts on employment.

*Job creation: direct impacts.* According to interviews with the project developers, the project will create 582 part time construction jobs lasting for approximately six months, 230 full time construction jobs lasting for approximately one year, and 58 permanent operations and maintenance jobs. Of these 58 permanent jobs, six to eight will entail management, and the remainder will entail manual labor.

*Job creation: indirect impacts.* The project developers have not made a point of claiming that the proposed plant will have indirect impacts on employment by stimulating new business investments.

*Job losses.* According to project developers and local officials, the project will not result in any significant job losses.

### 2.2.2 AVAILABILITY AND AFFORDABILITY OF GOODS AND SERVICES

*Availability of electricity.* The proposed project will significantly boost the availability of electricity in an area that is isolated from the existing provincial power grid. (Please see Project Design Document for exact location.) According to project developers, currently, the only available electricity in the rural parts of the project area is provided by a mini-hydro plant connected to a mini-grid that supplies the town government and approximately 1,500 households. The country-town, however, has access to grid electricity.

Eighty % of the electricity generated by the proposed plant will be used by the residential sector and the remaining 20% will be used to replace grid power. The Luertai hydropower project aims to electrify approximately 2500 households.

In order for the electricity generated by the plant to reach the targeted consumers, a new expanded distribution grid will need to be built, a significant complementary investment that is planned by the State Power Corporation as part of 10<sup>th</sup> Five-year plan. This requirement casts some doubt upon the social benefits from this project claimed by the project developers. However, a number of factors suggest that the necessary grid expansion will, in fact, take place. First, over the past 40 years China has demonstrated a steadfast commitment to rural electrification. Today, fully 96% of the country's villages are electrified (Voravate et al 2000). Second, grid expansion in this region is a mandate of the 10<sup>th</sup> Five-Year Plan.

*Affordability of electricity.* As noted above, the proposed project will replace power supplied by a mini-hydro project connected to a mini-grid. This grid charges households 0.35 RMB per kWh. The proposed plant will charge 0.45 RMB per kWh for households using less than 100 kWh per month and 0.36 RMB per kWh for households using more than 100 kWh per month. (This split rate is designed to encourage the use of electricity for cooking as well as lighting). Therefore, for those few households in the project area that already have access to electricity, the proposed plant will have a negative impact on the affordability of electricity. That said, according to a Lintan county official, the prices that the Luertai hydro plant charges households will be lower than average prices in the county. In Lintan county, rural households currently pay an average of 0.90 RMB per kWh, while households in the county-town pay roughly 0.47 RMB per kWh.

According to a Lintan county official, the dam is likely to put downward pressure on the price of electricity supplied by the provincial power grid. The grid will pay the proposed plant a price of 0.16 RMB per kWh. The average price paid to power plants on the grid is 0.21 RMB per kWh.

*Benefits from electrification.* As noted above, World Bank (2002) and Voravate et al. (2000) suggest that the benefits of rural electrification are typically substantial (on the order of US \$100 per month in the Philippines) and stem mainly from expanded use of lighting, radio, and television, and the educational benefits these appliances generate.

Finally, in addition to the benefits measured by these World Bank studies, the proposed hydroelectric power plant may contribute to the growth of new industrial enterprises that will enhance the local supply of consumer items.

### **2.2.3 RESETTLEMENT**

Some hydroelectric dams have a negative impact on the availability of land, a critical good in a rural economy. According to the Preliminary Design Report for this project (p. 177), the Luertai dam reservoir will flood 23 hectares. As a result, twenty-five families comprising of 150 people will have to be relocated. However, according to local officials, each family will be offered a resettlement compensation subsidy of approximately \$4,000 RMB.

## 2.2.4 ENVIRONMENT

*Benefits associated with displacing biomass fuels.* The extent to which electricity from the plant will replace biomass as a household fuel is not at all clear. The project developers are hopeful that electricity will replace a high percentage of the biomass households currently use for lighting, cooking and heating. However, worldwide experience with rural electrification suggests that in poor households, electricity generally only replaces fuels used for lighting. Typically, electricity does not substitute for biomass used for cooking or heating. Moreover, fuels rural households use for lighting are often petroleum-based (e.g., kerosene), not biomass. Hence, rural electrification often has minimal impacts on biomass use.

There are no obvious features of the proposed Lintan County plant—or the policy environment for this plant—that suggest the impact of electrification on household energy use will run counter to worldwide experience. In fact there are at least two reasons to suspect that it will conform to this experience. First, proposed electricity prices are not likely to create incentives for extensive fuel switching. According to a leading World Bank expert on rural electrification (with extensive experience in Gansu province) rural households in northwest China will only switch from using biomass for cooking and heating, to using electricity when the electricity is priced below 0.08 RMB per kWh (Barnes 2003). Given that electricity from the proposed plant will be sold at a significantly higher price (see above), substantial cuts in biomass use appears unlikely. Second, even if households in Lintan County do use newly-supplied electricity for lighting, this switch is not likely to have much impact on biomass use. In Gansu, 99% rural households use kerosene—not biomass—for lighting (Voravate et al 2000).

In any case, some substitution of electricity for biomass may result from the proposed project. If it were significant, such substitution could have a number of environmental benefits. First, it could slow deforestation in Lintan County. Currently 54.1% of Gansu is forested. Evidently, deforestation in Gansu mainly stems from the harvesting of trees for use as household fuel for cooking and heating. Second, to the extent electricity replaces biomass as a household fuel, it will cut indoor air pollution, a significant health hazard for rural households, especially women who are responsible for cooking and children who are especially vulnerable to respiratory disease.

*Benefits associated with displacing coal-fired electricity.* Hydropower from the proposed plant will displace coal-fired power on the provincial power grid which is mainly supplied by coal-fired plants. Therefore, the proposed plant will effectively reduce emissions from these coal fired power plants of conventional pollutants—sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), total suspended particulates (TSP), and ash. Back-of-the-envelope estimates of the amounts of these reductions were calculated as follows. According to 2003 Journal of China's Energy, the average emission factors for plants are 8.568 g/kWh of SO<sub>2</sub>, 3.808 g/kWh NO<sub>x</sub>, 0.1224 g/kWh CO, and 0.1904 g/kWh of TSP. Assuming that the hydropower plant sells 20% of its annual generation to the grid (9.91 GWh), then the plant will cut emissions of these pollutants by the following amounts: 85 tons of SO<sub>2</sub>, 38 tons of NO<sub>x</sub>, 1 tons of CO, and 2 tons of TSP.

*Damages due to flooding.* The principal environmental hazard from hydropower plants results from flooding. According to the local officials, the project will flood an area estimated at 23 hectares. In addition, the dam may contribute to water pollution and may adversely impact river ecology.

## 2.2.5 DISADVANTAGED GROUPS

The social benefits (and costs) associated with the proposed project will accrue to a population that is relatively poor and includes a relatively high percentage of minorities. Average annual household income in Lintan County was \$1,900 RMB in 2001. This compared to \$7,206 RMB for all of Gansu Province, and \$10,181 RMB for China as a whole. In 2001, 67% of the population of Lintan County was minority. This compared to 9% for the Gansu and 8% for China as a whole. (Statistical Yearbook of Gansu 2001; 5<sup>th</sup> National Census 2001)

## 2.3 Diebu County Niaojiaga Hydro-power Station

### 2.3.1 EMPLOYMENT AND COMPENSATION

The hydropower dam may have significant direct and indirect impacts on employment.

*Job creation: direct impacts.* According to the environmental impact assessment (EIA), the project will create 200 temporary construction jobs that will last 24 months as well as 50 permanent operations and maintenance jobs.

*Job creation: indirect impacts.* In addition, according to the draft prefeasibility study, the hydropower dam will create roughly 250 jobs indirectly by facilitating the creation and expansion of small-scale semi-private manufacturing plants known as township and village enterprises (TVEs), a development which until now has been precluded by an inadequate supply of electric power. Sectors expected to flourish include: mushroom cultivation, herbal medicine, and mining, especially magnesium mining. It is important to note that these indirect impacts on employment are far more uncertain than those associated with building and operating the plant, and that the prefeasibility study may well have been overly optimistic in this regard. That said, these indirect effects on employment are unlikely to be completely negligible.

*Job losses.* According to project developers and local officials, the project will not result in any significant job losses.

### 2.3.2 AVAILABILITY AND AFFORDABILITY OF GOODS AND SERVICES

*Availability of electricity.* The proposed project will significantly boost the availability of electricity in an area within Diebu County that is isolated from the existing provincial power grid due to its remote mountain location. (Please see Project Design Document for exact location.) Currently, the only available electricity in this area is provided by a 400 kWh mini-hydro plant connected to a mini-grid. The commercial sector consumes 60% of the electricity generated by this system, and households consume the remaining 40%. The latter—approximately 900 households—represent just 30% of all the households in the area. Thus, approximately 70% of households in the area currently have no access to grid electricity.

According to project developers, the Niaojiaga hydropower project aims to electrify approximately 5000 households and to provide power for new and expanded TVEs. 49% of the power generated by the plant will be supplied to these local sources, and only 61% will be sold to the provincial grid.

In order for the electricity generated by the plant to reach the targeted consumers, a new expanded distribution grid will need to be built, a significant complementary investment that is not guaranteed by the project developers. This requirement casts some doubt upon the social benefits from this project claimed by the project developers. However, a number of factors suggest that the necessary grid expansion will, in fact, take place. First, over the past 40 years China has demonstrated a steadfast commitment to rural electrification. Today, fully 96% of the country's villages are electrified (Voravate et al 2000). Second, grid expansion in this region is a mandate of the 10<sup>th</sup> Five-Year Plan (Journal of China's Energy 2002).

*Affordability of electricity.* The project will reduce the price of electricity for consumers in the project area. Electricity prices are differentiated by the type of end user—households, industries, and the provincial electricity grid all pay different prices. Households currently pay \$0.43 RMB per kWh for electricity supplied by the mini-hydro power plant. The new plant will charge households \$0.36 RMB per kWh. Thus, the new plant will reduce the price of electricity supplied to households by 16%. Industries pay 0.65 RMB per kWh for electricity supplied by the mini-hydro power plant. The new plant will charge industries 0.60 RMB per kWh. Thus, the new plant will reduce the price of electricity supplied to industry by 8%.

The dam's likely impact on the price of electricity supplied by the provincial power grid is unclear. According to the feasibility study, the grid will pay the proposed plant a price of \$0.192 RMB per kWh. Data on the average price paid to power plants on the grid is not available.

*Benefits from electrification.* As noted above, World Bank (2002) and Voravate et al. (2000) suggest that the benefits of rural electrification are typically substantial (on the order of US \$100 per month in the Philippines) and stem mainly from expanded use of lighting, radio, and television, and the educational benefits these appliances generate.

Finally, in addition to the benefits measured by these World Bank studies, the proposed hydroelectric power plant may contribute to the growth of new industrial enterprises that will enhance the local supply of consumer items.

### 2.3.3 RESETTLEMENT

Some hydroelectric dams have a negative impact on the availability of land, a critical good in a rural economy. However, according to the EIA (p. 42), the Niaojiaga dam reservoir will occupy a relatively small area—31 hectare, of which just under half will be water. No families will have to be resettled.

### 2.3.4 ENVIRONMENT

*Benefits associated with displacing biomass fuels.* The extent to which electricity from the plant will replace biomass as a household fuel is not at all clear. The project developers are hopeful that electricity will replace 100% of the biomass households currently used for lighting, cooking and heating. However, worldwide experience with rural electrification suggests that in poor households, electricity generally only replaces fuels used for lighting. Typically, electricity does not substitute for biomass used for cooking or heating. Moreover, fuels rural households use for lighting are often petroleum-based (e.g., kerosene), not biomass. Hence, rural electrification often has minimal impacts on biomass use.

There are no obvious features of the proposed Diebu County plant—or the policy environment for this plant—that suggest the impact of electrification on household energy use will run counter to worldwide experience. In fact there are at least three reasons to suspect that it will conform to this experience. First, proposed electricity prices are not likely to create incentives for extensive fuel switching. According to a leading World Bank expert on rural electrification (with extensive experience in Gansu province) rural households in northwest China will only switch from using biomass for cooking and heating, to using electricity when the electricity is priced below 0.08 RMB per kWh (Barnes 2003). Given that electricity from the proposed plant will be sold at a significantly higher price (see above), significant cuts in biomass use appears unlikely. Second, households in Diebu County rely on specialized traditional devices called *kangs*—essentially masonry beds with air ducts—for household heating. Local households are not likely to replace these devices with conventional electric heaters. Finally, even if households in Diebu County do use newly-supplied electricity for lighting, this switch is not likely to have much impact on biomass use. In Gansu, 99% rural households use kerosene—not biomass—for lighting (Voravate et al 2000).

In any case, there may be *some* substitution of electricity for biomass that results from the proposed project. If it were significant, such substitution could have a number of environmental benefits. First, it could slow deforestation in Diebu county, which is now quite severe. Currently 54.1% of Gansu is forested. Evidently, deforestation in Gansu mainly stems from the harvesting of trees for use as household fuel for cooking and heating. Second, to the extent electricity replaces biomass as a household fuel, it will cut indoor air pollution, a significant health hazard for rural households, especially

---

women who are responsible for cooking and children who are especially vulnerable to respiratory disease.

*Benefits associated with displacing coal-fired electricity.* Hydropower from the proposed plant will displace coal-fired power on the provincial power grid which is mainly supplied by coal-fired plants. Therefore, the proposed plant will effectively reduce emissions from these coal-fired power plants of conventional pollutants—sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), total suspended particulates (TSP), and ash. Back-of-the-envelope estimates of the amounts of these reductions were calculated as follows. According to 2003 Journal of China's Energy, average emission factors for thermal plants are 8.568 g/kWh of SO<sub>2</sub>, 3.808 g/kWh NO<sub>x</sub>, 0.1224 g/kWh CO, and 0.1904 g/kWh of TSP. Assuming that the hydropower plant sells 61% of its annual generation to the grid (49.70 GWh), then the plant will cut emissions of these pollutants by the following amounts: 426 tons of SO<sub>2</sub>, 153 tons of NO<sub>x</sub>, 6 tons of CO, 9 tons of TSP, and 2,602 tons of ash.

*Damages due to flooding.* The principal environmental hazard from hydropower plants results from flooding. However, according to the EIA for this project (p. 42), the Niaojiaga dam reservoir will occupy a relatively small area—31 hectare, of which just under half will be water. In addition, the dam may contribute to water pollution and may adversely impact river ecology.

### **2.3.5 DISADVANTAGED GROUPS**

The social benefits (and costs) associated with the proposed project will accrue to a population that is relatively poor and includes a relatively high percentage of minorities. Average annual household income in Diebu County was \$2,400 RMB in 2001. This compared to \$7,206 RMB for all of Gansu Province, and \$10,181 RMB for China as a whole. In 2001, 40% of the population of Diebu Country was minority (primarily Tibetan). This compared to 9% for the Gansu and 8% for China as a whole. (Statistical Yearbook of Gansu 2001; 5<sup>th</sup> National Census 2001.)



# 3 REFERENCES

---

World Bank. 2002. Rural Electrification and Development in the Philippines: Measuring the Social and Economic Benefits. Energy Sector Management Assistance Programme (ESMAP): Washington, D.C.

Voravate, T., D. Barnes, and V.S. Bogach. 2000. *Assessing Markets for Energy in Rural Areas of Northwestern China*. Energy Sector Management Assistance Programme (ESMAP): Washington, D.C.

Barnes, D. 2003. Personal Communication with Allen Blackman. April 22.

Statistical Yearbook of Gansu. 2001. Available at [www.tpt.tj.cn](http://www.tpt.tj.cn) and <http://www.cyol.com>.

Gu Shuhua. 2003. Personal interview with Zhao Xuisheng. November.

<http://www.gog.com.cn/gzrb/g0214/ca314488.htm>

<http://www.gx-info.gov.cn/guanggao/lb/indexa.htm>