East Asia • China

Self-support development of micro-hydro power for village community

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Sector • Hydropower
Type of lead organization • Cooperative
Executive Summary

Yuli Tun (“the village”) is located in Leye Country, Guangxi Autonomous Region in South Central China, where the residents are mostly from the Zhuang minority. The local economy mainly consists of villagers collecting forest products. The village is located on a mountain, with no common road, nor access to public transportation, nor public utility services. But mountain streams are available.

Electricity service thus remains a key issue for local economy development. But the local electric power company will not extend the power line to the village, since the expected electricity load would be too small. The power consumption by the village would be even less than the losses by the transformer which transfers the high voltage of the transmission line to the local low voltage.

To develop the village’s economy and improve the residents’ living standards, and since the local utility didn’t have any plans for extending the power line to the village in the foreseeable future, the village head organized village households (24 families) in 1992 to construct a 5 kW micro hydro power station, without any outside financial assistance. The village is a low-income community which falls below China’s national poverty line. Since no outside funding or financial assistance was available, each family contributed CNY 230 (US$43), as well as labour. Due to their limited financial means, it took one year for them to collect the money, and one and a half years to construct the power station. The power station is managed by two operators, who are selected from the villagers. These operators receive CNY 10 (US$1.88) per person per month.

The power produced services the entire village’s daily needs. Furthermore, under the leadership of the village head, a tap water supply system and a drain system were constructed. These infrastructure developments have significantly improved the village standard of living. The power system is well kept: periodic routine maintenance is funded by villagers, each family contributing CNY 10 (US$1.88) per maintenance operation. Today, due to the growth of load, the power station has been replaced by an 8KW generator. Because of low efficiency, the power station generated 18-25 kWh/d when the capacity was 5 kW, and now 24-32 kWh/d for the 8KW machine. Annual power produced is about 9,000-11,000 kWh.

The power station provides lighting and powers televisions at night. This does not just improve the living standards, but more importantly, it opens young people’s eyes to the outside world, giving them great impetus to go to surrounding urban areas to look for jobs and earn more money. The money they remit improves the economy in the village.

The power station is tiny, with very small scale capacity. Yet, it demonstrates that a village, especially a remote one, can establish its own power service and improve the life of its inhabitants by relying on its own local resources, without any outside assistance. However, if the government could offer some support, be it technical assistance (such as system design and equipment quality) or financial resources, the
impact could be much greater. Nevertheless, this is a financially sustainable renewable energy project, and a business model that develops the local economy while contributing to poverty alleviation in an environmentally-friendly way.

**Introduction**

Yuli Tun is a tiny village in Guangxi, China. There are many small natural villages, with dozens of farmer or herdsman households, throughout western China. They are almost similar in low economic development and poor living conditions but Yuli Cun’s residents are very proud of their village because of the micro-hydro power system they have developed 17 years ago.

**YULI CUN: ECONOMY AND CULTURAL CONTEXT**

Yuli Tun is one of the natural villages of Yuli Cun, Leye Country, Guangxi Autonomous Region in South Central China. Guangxi is the location with the majority of Zhuang Minority residents. The village is located in the mountains. Even till today, in the 21st century, there is no formal road access to the village, nor public transportation service.

In the map to the left, the yellow doubled line in the upper-left corner is S206, called the provincial road from Guangxi province to Guizhou province. The blue line through the village from left to right is a small river. The photos below show the rural road and trail to the village.

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1 “Cun” is an administration concept. Cun consists of several natural villages.
This is an area with forest type climate, including many mountains with steep slopes and deep valleys. Mountain streams are available in most places. Villages are scattered in the mountains.

Collecting naturally available forest products is the main economic activity. With very little land for cultivation, the main cultivated product is rice. The total available land for planting is only about 500 mu² (4 mu per person on average). The forest products mainly include star anise seeds, chestnuts, Tung oil tree nuts, mushrooms, etc.

China is still a developing country. While it is developing quickly in eastern coastal areas, its western area is still behind the national average level, and some places are even further behind. To help the development of these low-income areas, China established national poverty criteria, called the National Poverty Line (NPL), and areas where the average income per capita falls below that line (named as National Poverty County, National Poverty Township, and so on) will receive financial support from the central government.

The NPL is designed at two levels: Absolute Poverty (AP) and Relative Poverty (RP), and are adjusted year to year. The AP and RP for years 1985 to 2008 are shown in Figure 1. These two levels have been combined as one (CNY 1,067³ or ~US$157⁴) by the Chinese central government in 2009. In 1992, the income per capita in Yuli Cun was around CNY 100 (US$18), which is much lower than the national absolute poverty line.

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² Mu is a land unit in China, 1mu = 666.7 square meters.
³ http://www.zsr.cc/zsrAttention/SocialSecurity/200812/269162.html, 2008-12-31
⁴ The exchange rate between US$ and CNY varies over time. In 1985, it was about US$1 = CNY 2.937; the highest was 1994, US$1 = CNY 8.619; currently it is 6.81. source: http://baike.stockcity.cn/Baike_Read_4536.html
Economic development in the area, particularly in Yuli Cun, is very much behind the mainstream in China, and the average income in Yuli Cun was CNY 800 (US$115) per capita in 2008 with a range of CNY 600 (US$86) to CNY 1,000 (US$144) (i.e. less than US$0.40 a day). The few families with the highest income in the village only average an annual income of CNY 1,500 per person (US$0.60 cents a day). It was less than CNY 100 (US$19) in the early 1990s.

ELECTRIFICATION IN WESTERN CHINA

When talking about the rate of electrification, China has a higher rate than most other Asian countries. In 2009, the electrification rate in China was about 99%. But since China has a large population (1.328 billion by the end of 2008)\(^5\), 1% of un-electrified population represents 13 million people who are not able to access electricity. Based upon the statistics, the un-electrified population was 11.47 million by end of 2007\(^6\), and back in the 1980s, the rural electrified rate was only about 60%\(^7\).

“For a community to raise itself out of subsistence and into an upward spiral of increasing prosperity, certain basic services must be available and affordable. These include potable water, health care, education, transportation, and communication. Access to electrical power is both a precondition for the provision of many of these services, and an active agent in

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\(^6\) Xu Honghua, IEE, CAS, China Renewable energy rural electrification, ISES Solar World Congress 2007 (SWC2007), Beijing, China. Sept.2007

catalyzing further advancement.” Further, “Access to electrical power improves living standards, through better health (reduced indoor pollution caused by dependency upon traditional fuels), better health care delivery, improved education (better lighting to facilitate evening study at home), better training facilities, reduced drudgery and less time spent by women in un-productive tasks. Electrical power is also a tool, which can be harnessed for income generation and economic growth. In rural areas in particular, electricity has another important role as a vehicle for the flow of information, enabling a community to take part in affairs beyond its village confines, and promoting national political and social cohesion.” Electricity does not guarantee an increase in income levels, but it does provide greater opportunities for individuals and collectives to pursue income generating activities.

History/Development

Yuli Tun was just one of the villages with no electricity service back in the early 1990s. Since it was too remote and had too little of an electric load, the local government utility had no incentive to extend the grid line to the village due to poor financial viability. Residents were using kerosene, and candles for lighting at night. However, China started its economic reformation in 1976. In 1991 then, more than 15 years of economic reformation had passed. Many young people in the village left home to look for jobs in surrounding regions even in distant metropolises. What they saw brought tremendous change in the village, and gave significant pressure onto the incumbent village head, Mr. Qilin Chen (who passed away a few years ago). The tremendous change resulting from economic reformation from outside drove him to think about what he should do and what he could do. As a village head, he was aware that the living standards and economy in the village was very much behind the outside world, and that the lack of electricity service kept the village far behind modern society due to less information received.

However, the question he faced was how was he going to get the electric service?

DEVELOPING A MICRO-HYDRO POWER STATION

Yuli Tun had 24 households in the early 1990s. They were all Chinese minority, Zhuang Zhu, and their ancestry in the village stretches back for more than 300 years. The village is about 57 km away from Leye County town. Of that 57 km, 35 km is through the provincial road S206; the next 22 km consists of a very narrow and rough mountain trail, which does not allow any vehicle, except bicycles or motorcycles. The main utility did not have any plan to

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8 China Village Power Project Development Guide Book: Getting Power to the People Who Need it Most, August 2002
9 Asia-Pacific Environmental Innovation Strategies (APEIS) Research on Innovative and Strategic Policy Options (RISPO) Good Practices Inventory: Promoting household photovoltaic systems in remote areas of China through international funding and establishment of effective mechanisms
extend the grid into that area in the near future. “How can we get electricity? How can I improve the daily life for the villagers?” Mr. Chen was thinking throughout that time. He felt that it was his responsibility to find a solution. He noticed, due to terrains, landforms and climate, that there was no wind in the mountain with fog most of the time. Thus, wind and solar power applications were not viable. But a stream in the valley was just dozens of metres away from the village. Mr. Chen didn’t receive any high education, but he did know that stream may be used for power generation, and China had a long history in hydro-power generation. After consulting with local micro-hydro power generation technicians, an idea of developing a micro-hydro power station came up in his mind. That was in 1992.

Now the first issue was how to implement the idea. Mr. Chen chatted with all the villagers first, then he had several meetings with all households. The idea of developing a micro-hydro power station had been agreed upon unanimously. Considering the potential cost, the capacity agreed upon was 5 kW.

The next issue was that of funding. The 5 kW micro-hydro-power station would cost about CNY 5,000 (US$907), but Yuli Tun is a National Poverty Village. Also, as a natural village, there were no funding sources to develop any infrastructure, such as a power station. This bothered Mr. Chen a lot. He tried his best to get financial support from upper level government (Xiang \(^{10}\) and above) and all possible sources, but without success. “Shall we live as it is?” “Shall we wait until utility extends the power line?” “Shall we wait until the upper government helps us?” Mr. Chen was thinking day by day. An idea came up in his mind: “Let us paddle our own canoe.”

To get the funding and save the costs of any kind of loan, Mr. Chen discussed his idea with the villagers during a meeting. His idea received support from all households, who decided to:

- Raise the money through self-funding of all village households. Each family would contribute CNY 230 (US$43) evenly;
- This money would be used to purchase the hydro generator and necessary materials, and they would use local free materials as much as possible, including using local trees as poles;
- Construct the station by themselves with all families contributing labour.

\(^{10}\) Xiang, is the lowest government administration level in China, which consists of several Cuns. Above Xiang, are county, then province, then central government.
Under the leadership of Mr. Chen, a 5 kW micro-hydro power station was built in 1992 by the villagers. The system is illustrated in Figure 2 above. The power station does not require a dam; neither reservoirs nor pipes for water are needed.

It should be noted that this is a village in which the average income per person falls below the national poverty line (let alone standard global poverty lines). At that time, the average income per person in the village was only about CNY 100 (US$18). For a family with three to four persons (a very typical family size in China, two parents with one to two kids), the total annual income will be about CNY 300 to CNY 400. CNY 230 meant more than half of their entire income. This was an extremely big financial burden to most families. To solve the problem and avoid interest payment if getting a loan from the bank, under the leadership of Mr. Chen, the village committee developed a mechanism for power station development and fundraising:

- The village head, Mr. Chen, was in charge of the project. In China, at the lowest level of administration hierarchy, the village committee consists of 5-7 members. Depending on the village scale, they are: party secretary, village head, security personnel, family planning personnel and so on;
- Each family contributes cash at their availability (CNY 230 per family);
- For those poor families that cannot provide such amount of money in cash, Mr. Chen and other wealthier families in the village would provide extra cash for these poor families to meet the difference on a voluntary basis without any interest;
- Whatever is left remaining as unpaid ensures that the lower-income family has two ways to make the remaining payment: by paying in several instalments, or by paying in-kind.

“This mechanism worked well,” the current village head Mr. Ban said, “but you know, to most families, it was a large amount of money. I was told that it took more than one year to finally get the money ready.” The project got enough cash to purchase the generator and materials. They then purchased the power generator, carried the generator and other materials from the county town into the mountain by man power and animals, using tree trunks as poles,
and spent one and a half years to successfully construct the power station. The construction labour was organized by the village head and contributed by village families voluntarily.

To manage the electric load, the village committee meeting decided that each family was allowed to equip four lamp holders with a socket for other electric appliances, such as radio and TV. Households received the electric service for free. The operation of such kind of micro-hydro power station is simple and does not need extensive skills. The village committee also decided to invite two knowledgeable people who are residents in the village to manage and operate the power station. These two people also later received some basic training from the local agricultural power corporation in the county for free. Each one would receive compensation (not salary) of CNY 120 per year for their contribution. The expense would be shared by all households. CNY 10 per month means nothing for most urban people, but such amount of compensation is fair to both villagers and operators. The hydro-power generator needs two services every year. Each service costs CNY 200. The service expenses are shared by all families and each family contributes CNY 10 for every single service. The operators are responsible for the equipment maintenance, mostly to be sent to a near-by service station in county town, which is more than 100 km away from the village. Again, “they have to carry the equipment by animals to the town,” Mr. Ban said. After seven years of operation, the electric load was increased as the power station couldn’t match the power demand. The village committee decided to expand the capacity of the power station from 5 kW to 8 kW. They sold the old power station and bought a new one with 8 kW capacity. The funding difference was about CNY 2,000 and each family contributed CNY 100 for the replacement. Today, the power station has been in operation for 17 years, and the village head has been replaced twice. The current village head is Mr. Rongdu Ban.

WATER SERVICE

After the successful construction of the micro-hydro power station, Mr. Chen and the villagers were excited about their solidarity and cooperation. They were thinking how to continue improving their living standards. Mr. Chen realized that getting drinking water was another issue bothering villagers’ lives. Villagers had to go down to the valley and then carry the water up the hill.

Mr. Chen convened the village committee meeting once again with all village households. They decided to develop a water service system, again by themselves. A water tank was built at the highest point above the village to collect the mountain mere trickles and rain, without using electricity. Then a pipeline system was developed leading the water into each household. They also developed a simple waste water drain system. Water service greatly improved their lives.

VALUE PROPOSITION
The micro-hydro power station developed by the villagers is significantly changing the village households’ life. The electricity service allows households to use electric appliances, especially, from the very beginning, lighting and TV, even electric fans, radios and telephones. (mobile phone service is not available in these mountains).

Most of the villagers were very excited when the electric lights were lit that first night. They killed pigs and slew sheep, and got together to celebrate the milestone of the new life. Some villagers said: “This is our second liberation (getting electricity service).” Some young people said, “Without electricity, I even couldn’t find a girl who is willing to marry me. Now our village is much better than others, I can marry now.” Since it is an isolated village in the mountains, TV and telephone are the only ways for villagers to reach the outside world and the importance of electricity can never be underestimated. This bonds the villagers together and has kept the power station running over years. When people are used to electricity, they cannot live without it. The villagers are aware that electricity not only enables to light the household, watch TV, listen to the radio, study at night, thus improving their living standards, but also provides the power for productive use for adding value onto local agricultural and forestry products to alleviate poverty. A villager said: “we know electricity can be used to power electric tools, such as grain blower and crop cutter, but unfortunately the capacity of the power station is too small and we were not able to afford a large power station although we DO need a larger one.”

At the time of writing this case, the station has been operating for more than 17 years. The village head and villagers are very proud of what they have achieved. “We invested in the power station by ourselves, managing by ourselves, and servicing the entire village community,” said Mr. Ban, “the village had 24 families at that time, now we have 35 families.”
We were using kerosene for lighting before. The electric lamp greatly improves illumination, allowing housewives and children to do what they want to do in the evening. Since then, we have had seven students who graduated from technical school and above. Electric lighting is also improving the indoor air quality; before, kerosene burning was used at night. Each family usually used 1.5~2.5kg kerosene every month, it cost us about CNY 10-12 (US$2). Since we are using electricity free of charge, it is worth – financially speaking – to develop such a micro-hydro station!”

Since the solidarity that emerged during the power station project development and construction, the atmosphere in the village has become more harmonious. People help each other without charge. For example, if one household needs labour to build an extra room, his neighbour will help voluntarily. Later, the family that received assistance from its neighbour may let the neighbour use its bicycle to deliver goods to another neighbour.

Villagers are also highly appreciative of the water supply system: “We had to carry the water daily for drinking and washing. It was a heavy burden since we had to carry the water then climb up the hill for hundreds of metres. You know, it is not a road; it is just a steep hill with free rocks. Since we have had the tap water, we are free from carrying water and can enjoy our life by doing other things, including entertainment. Furthermore, since we have had the water supplying system, we shall not worry about how the kids get the water if we are busy for work away from the home. Also, the drain system improves the surrounding environment in our village. It becomes much cleaner than it was and we feel healthy.” People investments and people management means that benefits are distributed to everyone involved (see Figure 3).

**Figure 3: Proposition Chart**

This is a unique model that is fully conceptualized by the people, developed for the people, and enjoyed by the people.
Actors

The actors involved in this project are the following:

- Village head
- Villagers
- Two villagers taking responsibility for technical operation and maintenance
- The agency that provided training to the two operators, and also advised on the design and building of the mini-hydro power plant

The village head has the responsibility to lead the village to change its socio-economic situation. He is aware that the lack of electricity service is a major barrier for local economic development and that it keeps the village far behind the outside modern society due to little information received. He is an initiator of the entire project.

A lot of factors influence a person doing or not doing something: responsibility, personality, self-motivation, and pressure from residents in the village, especially younger people working outside and who are back during holidays or vacation time.

In this venture, the villagers are serving many roles. They are supporters, investors, workers, final users, and beneficiaries. It is obvious that involvement in this activity will improve their own life situation, and may directly or indirectly change financial situations by using electricity in receiving information and increasing productivity.

In this socio-economic activity, no outside partners or upper level government were involved, and no government subsidy was provided, except for the design advice and training to operators provided by one agency.

The village head and villagers work together well not just in the power station, but also in other affairs, such as the development of the water supply system. Also, the villagers help each other in their daily life.

Constraints and solutions

To provide electric power service by itself, the village encountered many constraints. The main barriers were coming from three aspects:

- Lack of funding, especially cash, to develop the power station;
- Lack of professionals in power station construction;
- Lack of knowledge in operation and maintenance.

To remove the constraints and overcome the barriers to get electric service, Mr. Chen organized villagers to work together. Without any outside financial support, all families
shared the costs and developed a payment mechanism for lower income families. The local county utility company provided the training of operations and maintenance (see Figure 4). These measures were so effective that the power station has been operating successfully for 17 years.

![Figure 4: Constraints and Solutions Matrix](image)

Surveys of this area indicate that the system design, power station and power line configuration, equipment selection and overall power station efficiency of many such micro-hydro power stations are poor. A little upgrading would result in significant improvements and outside technical assistance would be welcome. Assistance may be provided by some government sponsored projects or NGOs and could provide a policy direction for promoting such a model at a larger scale.

This is a great example of community-based economic development. Yuli Tun is a very small village. However, there are so many small but poor villages around the world. Most of these villages are not able to access electricity, have low incomes, and lack outside financial support (neither from the government nor other donors). These factors hinder socio-economic development. These villages should not just have to wait for outside assistance, if they desire to change their situation. This case tells people how important self-motivation is, and how it can make a significant contribution to local economic development. It is a business, entirely owned by villagers, which is increasing the value of local products for retail and would increase incomes directly if the capacity of the micro-hydro power station was larger.
Results

The micro-hydro power station was developed by the village itself. It covered 24 families at the beginning, and later, the number of families increased to 35, including up to 160 people. Because of low efficiency (about 30%), the power station generated 18-25 kWh/d when the capacity was 5 kW, and then 24-32 kWh for the 8 kW machine. Annual power produced (or more accurately one can say power consumed, since even if the stream is available but there is no load, the power is just wasted) is about 9,000-11,000 kWh. The contribution and impacts of the power station includes three aspects: social, economic and environmental.

SOCIAL IMPACTS

Table 1: Social Impacts

<table>
<thead>
<tr>
<th>Service Rendered</th>
<th>Social Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Street Lighting</td>
<td>Improved security</td>
</tr>
<tr>
<td></td>
<td>Stronger sense of community</td>
</tr>
<tr>
<td>House Lighting</td>
<td>General quality of life improvement</td>
</tr>
<tr>
<td></td>
<td>Social evening activities</td>
</tr>
<tr>
<td></td>
<td>Facilitation of evening work/study</td>
</tr>
<tr>
<td>TV &amp; Radio</td>
<td>General quality of life improvement</td>
</tr>
<tr>
<td></td>
<td>Informal education</td>
</tr>
<tr>
<td></td>
<td>Stronger sense of regional and national identities</td>
</tr>
<tr>
<td>Household Appliances</td>
<td>Labor and time saving</td>
</tr>
</tbody>
</table>

The social impacts of the power station in the village are listed in Table 1. These impacts are mostly indirect. For example, due to better lighting in the evening, kids have better study conditions. For these 35 households, there are 30 middle school students and five high-school students. The rate of receiving nine-year compulsory education is above 90%, compared to less than 50% 20 years ago. (It should be pointed out that electrification is not the only factor contributing towards improving the rate of receiving nine-year compulsory education. Other factors include increased government investment in education to improve the school conditions, raising awareness and educating parents to let kids attend school, etc.) TV programs help villagers become aware of the outside world, including new technology and concepts. Also, social activities that had been severely restricted during dark winter nights now became possible. Improving water supply, especially drinking water for residential uses, is another benefit of power availability.

ECONOMIC IMPACTS

Power systems do not only provide the electricity to improve daily living standards, but also stimulate economic development. In this case, since the capacity is limited, the direct economic impact is not too obvious. The most important economic outcome after the
electrification was the fact that more and more young people left the village and found jobs in cities, since TV programs present a colourful and attractive outside world to these young people. They then send money back to their parents to improve their life. This promotes the local economy indirectly.

On the other hand, micro-hydro power generation is the least costly of renewable energy technologies, and the only one that can compete with traditional power generation (utility). Figure 5\(^{11}\) indicates the kWh generation cost for different technologies. The construction cost and kWh generation cost of hydro depends on the civil work (dams) and equipment; grid extension mainly depends on the distance of line extension, wind and solar power generation mainly depends on local renewable energy resources, while diesel power generation depends on diesel price at gas stations and delivery costs. Based upon current advanced technology, pico hydro (<5 kW), micro-hydro (5-100 kW) and micro-hydro (up to 4 mW)\(^{12}\) need the least investment with lowest power generation cost. It can compete with utility power generation.

For this micro-hydro power station, the total cost was only CNY 10,000 (~US$1,300), while it would cost CNY 60,000 (US$8,000) to extend grid line for each km in such area. Based upon the cost in this case, the power production cost per kWh is estimated roughly as follows, about only CNY 0.124/kWh, (~US$0.018), which is much lower than grid power (CNY 0.5-0.6/kWh) in China.

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\(^{11}\) Charlie Dou, Renewable Energy Rural Electrification and Commercialization, South-South-GATE Convention 2009, Shanghai, China, 3-4 Sept, 2009

\(^{12}\) Hydro power of smaller capacity is usually defined as: Pico-hydro (< 5 kW); micro-hydro (< 100 kW); mini hydro (up to 4 mW) and small hydro (about 5-30 mW).
ENVIRONMENTAL IMPACTS
At the time when the villagers developed the micro-hydro power station for their own village, they were not aware of any environmental issues. What they needed was an affordable and locally available energy source. However, when evaluating the impact of the micro-hydro power station, it has not only made the electricity available for 17 years while neither the utility company nor the government could do it, but has also improved the indoor air quality and displaced the fossil fuel consumption, thus contributing to environmental protection.

To generate 1 kWh, the following pollution will be emitted:

- CO₂ 0.75 kg
- SO₂ 0.0061 kg
- NO₂ 0.0045 kg
- Dust 0.0052 kg

Based upon the estimation that the micro-hydro power station will generate 10,000 kWh per year, the following pollution will be displaced and the coal consumption will be reduced:

- CO₂ 7,500 kg
- SO₂ 61 kg
- NO₂ 45 kg
- Dust 52 kg

Table 2: Cost for RE technologies

<table>
<thead>
<tr>
<th>Items</th>
<th>Unit</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generator</td>
<td>RMB</td>
<td>5,000</td>
</tr>
<tr>
<td>Other construction</td>
<td>RMB</td>
<td>1,000</td>
</tr>
<tr>
<td>Life time</td>
<td>Years</td>
<td>10</td>
</tr>
<tr>
<td>Service</td>
<td>Time</td>
<td>20 Twice a year</td>
</tr>
<tr>
<td>Expense per service</td>
<td>RMB</td>
<td>200</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>RMB</td>
<td>240 120Yuan/p.y</td>
</tr>
<tr>
<td>Power generated</td>
<td>kWh/y</td>
<td>10,000</td>
</tr>
<tr>
<td>Unit cost</td>
<td>RMB</td>
<td>0.124</td>
</tr>
</tbody>
</table>

To consume Std. coal 0.39 kg or diesel 0.37 kg

Water 3 kg
Based upon the data from China Micro Hydro Equipment Quality Test Center\(^\text{13}\), the number of cumulated installed micro-hydro power stations (capacity of single unit < 10 kW) in China by 2007 was 200,000 units, with installed capacity of 220,000 kW, which equals to a small coal-fired power plant. (In China, there are many small coal-fired power plants, the power generation capacity of a single plant is <300,000 kW. Many of them have been pushed down for energy efficiency and environmental protection). If each kW installed capacity produces 5 kWh on average, then such amount of installed micro-hydro capacity will generate about 400,000,000 kWh a year. The environmental contribution, including greenhouse gas (GHG) emission reduction and resource savings, can be estimated as shown in Table 3.

### Table 3: Environment contribution of micro hydro power station installed in China

<table>
<thead>
<tr>
<th>Items</th>
<th>Unit</th>
<th>Each 10,000 kWh will save</th>
<th>200,000 micro-hydro power stations’ environmental contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce CO(_2) emission</td>
<td>kg</td>
<td>7,500</td>
<td>300,000,000</td>
</tr>
<tr>
<td>Reduce SO(_2) emission</td>
<td>kg</td>
<td>61</td>
<td>2,440,000</td>
</tr>
<tr>
<td>Reduce NO(_2) emission</td>
<td>kg</td>
<td>45</td>
<td>1,800,000</td>
</tr>
<tr>
<td>Reduce dust emission</td>
<td>kg</td>
<td>52</td>
<td>2,080,000</td>
</tr>
<tr>
<td>Save Std. coal</td>
<td>Ton</td>
<td>3,900</td>
<td>156,000,000</td>
</tr>
<tr>
<td>Save Water</td>
<td>Ton</td>
<td>30</td>
<td>1,200,000</td>
</tr>
</tbody>
</table>

### TRADE-OFF

Regarding hydro, people are usually worried about its uncertain negative environmental impacts, such as the Three-Gorges Hydro Power Station on the Yangtze River. But it is not a concern for such a tiny micro-hydro power. It just uses the mountain stream in the valley without any construction of a dam. It has very little negative impact on local biodiversity and balance of the nature.

### Conclusion

### FUTURE OPPORTUNITIES AND CHALLENGES

*Increase system efficiency to improve performance*

Due to limited capital and knowledge by the time the power station was designed and developed, its efficiency was very low. The major reasons are:

- The system configuration is not optimized, the generator efficiency is low;
- The transmission line is not good enough, most wires are just steel wire;

\(^{13}\) Zhong Ting, “The Trend of China Micro Hydro power Generation”, China Micro hydro Equipment Quality Test Center, Beijing, China, May, 2007
• The power regulator is not functioning well;
• There are frequent fails.

This means the power system is not cost effective. If the system had been designed by professionals, if the equipment had been selected more carefully through necessary experience and knowledge, the power system would have been more cost effective, and the villagers would have enjoyed more power service and enjoyed more direct and indirect benefits. The capacity of the power generator should be increased to match the increasing load demand, thereby introducing more productive application for value adding.

Also, due to less capital available at that time, the capacity of the generator was too small to service 24 families. Since most of the electricity service is merely for daily life, it is not really used for direct productive and income-generating activities. If the capital came from the households, or was supported from the upper level government, or any other donors, the contributions from the power station would have been more attractive.

**Increased capacity and improved efficiency will impact both society and economy.**

The power station is tiny and very small scale in its capacity (first 5 kW, then 8 kW). Compared with other power stations, including renewable energy power stations, (such as solar, wind and their hybrids), it means very little. However, it demonstrates that such a remote village can generate energy and water services, thus improving the lives of its inhabitants and reducing poverty, by relying on its own local resources, without any outside assistance. Of course, if the government could offer some support, such as technical assistance (system design, equipment quality, etc.) and some financial resources, the result could be much better. A good thing is that the Chinese government is now considering electrification of these very remote areas. After several years of rural electrification practice supported by domestic and international societies, China launched the National Township Electrification Program in 2002 (called “Song Dian Dao Xiang program” in Chinese, SDDX), to electrify about 1,000 villages where local township government is located. As a result, 292 small hydro-power stations and 721 photovoltaic (PV) and PV/wind hybrid village power (VP) systems were developed within two years, providing electricity to 1.3 million people, 300,000 households in seven Western provinces (including 42 villages at Army Farm\(^{14}\) in Xinjiang). The total investment amounts to CNY 4.7 billion (~US$570 million), among which CNY 2.96 billion (~US$358 million) were funded by central state loans and the rest were provided by local governments. It is the largest rural electrification project in the world to utilize renewable energy and also the largest solar PV power project in China. The number of un-electrified

\(^{14}\) Army farm is an economic development system under military management in western China.
population has been reduced to 11.47 million in 2006 from 60-70 million in the beginning of the century.

Furthermore, by the time this case study was prepared, the Guangxi provincial utility had extended the grid line into the mountain areas. The residents who are living in the mountains will be able to enjoy the same full electricity services as urban residents. On the other hand, the grid extension to these areas is worth discussing. The extension cost is very high, the load is too small and without any large agricultural and industrial load in the future, the transmission line would be too long. Therefore, it is not economically viable. The loss caused by the transformer may be more than the real load. A better solution to fully electrify these areas may consist in:

- **Improving the standalone micro-hydro station.** These standalone micro-power stations should be designed technically-sound and constructed and managed (or supervised) by the local utility in order to attain high efficiency and low cost. In the process, residents would enjoy better and sufficient electrical service. This alternative would also have environmental protection benefits.

- **Distributed generation.** Same as above, then connecting it to the extended grid line at user side to form distributed generation. Using this approach, residents would enjoy the true electricity service while also offsetting their bill if the net-metering regulation is established. This alternative would not only have environmental benefits but also reduce the users’ electricity bill.

From the World Bank 2006 statistics, 24.4% of the world population were still not able to access electricity. Most of this population is located in Sub-Saharan Africa and South Asia. In most places of South Asia and some places in Africa, such water streams are available; hence the experience and lessons gained from this case could be applied to other developing countries for rural electrification. For those un-electrified villages with hydro resources and a utility company that does not plan to provide electrical services, the model is definitely ‘bright’.

15 Source: World Energy Outlook 2006
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The case was completed in mid-2010 and released in 2011.

The information presented in this case study has been reviewed by the company to ensure its accuracy. The views expressed in the case study are the ones of the author and do not necessarily reflect those of the UN, UNDP or their Member States.

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