

## Renewable Energy Development Project, China

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### Bringing affordable, high-quality solar lighting to rural China

#### Summary

The nine provinces of the West and North-West of China are among poorest in the country. The rural parts of the region are remote and have a very low population density. Rural people work as herders and have little cash income. They may barter or sell an animal when money is needed. Lighting is provided by kerosene, butter lamps and candles, because few people have access to grid electricity.

The China Renewable Energy Development Project (REDP) was set up in 2001. One of the main aims of REDP was to promote the installation of photovoltaic (PV) solar-home-systems in remote off-grid homes. Solar-home-systems (SHS) are stand-alone electrical systems which use a PV module to provide power. In the REDP programme a typical SHS supplied two lights and was supplied in a metal carry-case so that it was portable. Larger systems could power radio-cassettes, TVs and DVD players.

REDP operated with approved suppliers (about 80) and participating wholesale companies (32), which had to meet increasingly strict standards of product quality, service and management, in order to be approved by the programme. Participating companies were paid a subsidy for each system sold, provided that they passed the regular checks of REDP. As the quality standards were increased, the subsidy was increased from \$1.50/Wp to \$2.00/Wp (about 25% of the final sale price).

402,000 solar home systems were installed through the REDP-subsidised programme between 2003 and 2008, with a total capacity of 11.1 MWp (or an average of 28 Wp per system). Each SHS benefits an estimated four people per household, or a total of 1.61 million people for the programme as a whole. The average sale price was Yuan 1,221 (£88) in 2007, similar to the price of a yak. For users, the main benefit of the REDP programme was brighter, cleaner lighting, for study, work and recreation. Use of radio-cassettes and mobile phones, for entertainment and to keep in touch with the outside world, was also greatly appreciated.

The REDP programme supported the rapid growth of the PV industry in China, and improved the quality of production while keeping costs low. It greatly expanded the market for solar home systems, and supported the development of a network of suppliers, wholesalers and retailers. The model of providing market-driven incentives was a key factor which enabled the programme to work effectively, and this model is now being used by several other donor-funded programmes in China. The REDP programme will close at the end of June 2008 as planned, and the China Photovoltaic Industry Association is being established to continue the work.

## The organisation

The China Renewable Energy Development Project (REDP) was set up in 2001 by the National Development and Reform Commission (NDRC) and the World Bank (WB), with international grant financing provided by the Global Environment Facility (GEF). One of main aims of REDP was to promote the installation of photovoltaic (PV) solar home systems in remote off-grid homes in nine western Chinese provinces; to improve the quality of production of PV modules and other system components in China; to provide free information about PV; and to facilitate cooperation between the PV sector in China and the rest of the world. This programme will close at the end of June 2008 as planned, but the China Photovoltaic Industry Association is being established to continue the work. The scheme funding during the 2007 financial year was over £2.5 million.

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## Context

The nine provinces in the West and North-West of China are among poorest in the country. Qinghai province is typical of the region. Much of the land is very high and cold (around 4,000 metres above sea level). Many people in rural areas live off the land by tending yaks or other animals. They live in the valleys during the winter and move to higher ground with the animals during the summer. Most people live in tents during the summer and houses in the winter, although the poorest may live in tents all year.

The remoteness of the region and the low population density (only 0.2 people per km<sup>2</sup> in some area of Qinghai) mean that there is limited access to the goods and services which are now available in the economically thriving East of China. People have little cash income, and may barter or sell an animal when money is needed. Lighting is provided by kerosene and butter lamps, because few people in rural areas have grid electricity.

One of the main aims of the REDP was to increase the access to electricity and its many benefits for isolated rural populations in China, using PV technologies.

<b>Statistical Information (for China as whole)</b>	
Population (2005)	1313.0 million
Urban population	40.4%
GDP per capita US\$ (2005)	\$1713
- at purchasing power parity	\$6757

Population living on less than \$1 a day (2005)	9.9%
Population living on less than \$2 a day (2005)	34.9%
Population with access to grid electricity (2005)	99%
Annual electricity consumption per person (2004)	1684 kWh
Annual CO <sub>2</sub> emissions per person (2004)	3.8 tonnes
Population undernourished (2002-2004)	12%
Population with access to an improved water supply (2004)	77%
Source: <i>UNDP</i>	

## Technology and use

A solar-home-system (SHS) consists of a PV module, battery, charge controller and sometimes an inverter. The PV module generates direct current (dc) electricity when exposed to sunlight. The module is connected to the rechargeable lead-acid battery, via the charge controller which protects the battery from being over charged or too deeply discharged. The appliances which are powered by the system (the electrical load) are also connected through the charge controller. An inverter is sometimes used to convert dc into alternating current (ac) so that low-powered electrical equipment designed for use with mains electricity can be operated.

The SHS supplied through the REDP programme use between 10 Wp and 500 Wp PV capacity. A typical system consists of a single 20 Wp PV module; a 12 V, 40 Ah battery; a charge controller; one or two 7W to 9W dc lamps; and a dc socket for a radio or for mobile phone charger. This system can be supplied in a metal carry-case, as can a larger version including a radio-cassette player and stereo speakers. Larger systems (75 to 100 Wp) may include inverters for TVs and DVD players. The average system capacity over the whole programme was 28 Wp. Most of the early REDP systems were in the 10 Wp to 20 Wp range, although this gradually increased and 40 Wp systems became common. The small size reflects the low demand for electrical appliances and the need for a portable system compatible with a semi-nomadic lifestyle. The main problems reported by dealers are short-circuits and overloading (by trying to run too many appliances on the SHS), but most systems have proved reliable.

The REDP has also supported some PV village systems (and a few with wind and PV) to provide electricity for public facilities such as, schools, health centres, village satellite telephones, forest protection, road maintaining, climate monitoring and Buddhist temples.

## How users pay

£1 = 13.8 China Yuan or Renminbi (Y) [April 2008]

Purchasers usually paid the full price of a SHS in one payment to the retailer. There was no credit system, except for local arrangements made by retailers. In some areas, local or regional authorities made their own grants which helped finance some systems. The authorities could purchase systems in bulk and distribute them free or at half price, using their Poverty Alleviation Fund. This happened in a small minority of cases.

The REDP operated through 32 participating companies, which acted as wholesalers to supply systems to local retailers. Because of competition between participating companies, sales prices

varied by only about 15% between retailers. A typical 20 Wp system sold for around Y900 to Y1,000 (£65 to £72). (A yak sells for around Y1,000 to Y1,300 so selling one yak is a feasible way of financing a solar home system!) A 75 to 90 Wp system sold for Y4,000 (£290) or more, excluding the accessories of TV, satellite dish and DVD player. The World Bank survey found that the average sale price was Y1,221 (£88) in 2007.

These retail prices are low by international standards. This is partly because of the low cost of the PV module in China, between Y20 and Y35 (£1.40 and £2.50) per Wp. The PV module is the largest single cost in the system, on average just over 50%. Also, the REDP subsidy to participating companies (initially US\$1.50/Wp, latterly US\$2.00/Wp: on average about 25% of the final retail price) also helped to keep prices low. Now that the REDP subsidy to retailers has ended, the retail prices are increasing, probably by about 20%.

### **Training, support and quality control**

Training, support and quality improvement were key aims of the REDP programme. The programme worked directly with suppliers and installation companies, and also provided simple instruction leaflets for users and surveyed their experience of the systems.

Quality improvement in suppliers (both manufacturing and assembling companies) was a very important part of the REDP programme, and accounted for about 40% of the total expenditure. REDP established technical standards for all components, which were revised and updated during the programme. To monitor quality, samples of all equipment were tested to these standards, random tests were made on components, and unannounced factory inspections were made. Technical seminars and training sessions were held to help raise component quality. Any supplier which failed to meet the standards was offered assistance, but was suspended or ultimately expelled from the programme if they continued to produce sub-standard products. Latterly 80 suppliers were meeting REDP requirements, and four had been expelled. REDP reviews suggest that product quality improved considerably since the programme started, in particular for modules. The REDP helped to develop China's first national SHS standard, GBT19064-2003. Latterly production had to meet the more stringent requirements of new REDP technical standards, which require modules to comply with the international module standard.

REDP operated through a number of approved participating wholesale companies (latterly 32), some of whom ran their own retail chains and some sold to independent retailers. A company that wanted to participate in REDP had to buy components from approved suppliers and meet strict technical, financial and management standards, and in addition provide warranties and after-sales service to customers. In return, the participating companies received a subsidy (detailed below) for each system sold, as well as technical, business development, and marketing advice from REDP. Participating companies could also apply for not more than 50% grants for a range of technical and marketing work. To qualify for the REDP sales subsidy, companies had to have samples of their systems checked at regular intervals for overall system quality, and provide the correct reporting data to the REDP audit office. This process was designed so that the subsidies could be used to maintain and improve system quality. By the end of the programme about 73% of claims were allowed.

The participating companies that met the requirements of REDP initially received a subsidy of US\$1.50/Wp on each system sold (so for a 20 Wp system about Y210 or 22% of the retail price). Since June 2005, REDP paid US\$2/Wp (about 29%) for systems in which the module met the higher international standard, IEC61215, and the US\$1.50/Wp subsidy was discontinued in June 2007.

Retailers are able to carry out basic repairs and replacements but send more complex cases to the participating company. Some retailers carry out servicing or additional repairs for free in order to build good relationships with their customers. Informal peer support groups have been established within some communities, whereby those already owning an SHS help their neighbours to use their systems.

REDP produced simple instruction leaflets in Mandarin Chinese and other local languages for retailers to give to users when they explain how the systems work. These include illustrations which are especially relevant to people who cannot read. For instance, one shows a yak head-butting a solar panel with a red cross over the picture, to warn of the fragility of a PV module!

The PV modules are guaranteed for ten years but are expected to last for at least 20. REDP requires retailers to give warranties for other components. These are two years for charge controllers; one year for batteries, inverters and lights; and six months for radio cassette players.

## **Benefits**

An impressive 402,000 solar home systems were installed through the REDP-subsidised programme between 2003 and 2008, with a total capacity of 11.1 MWp (or an average of 28 Wp per system). Each SHS benefits an estimated four people per household, or a total of 1.6 million people for the programme as a whole.

The peak year for the REDP programme was 2005, when 100,000 subsidised systems were installed. Numbers decreased to 54,000 by 2007 because the funding for subsidies had been used up. However, by the end of 2006, about 50% of the sales of the participating companies were outside the subsidy programme, suggesting that many will continue to thrive now that subsidies have finished. Research undertaken by REDP suggests that the market for PV SHS will continue to increase by 10 to 20% per year.

### **Direct benefits to users**

According to a World Bank survey, 58% of the SHS energy output is used for lighting. Electric light is a significant benefit. Kerosene lamps, butter lamps and candles are smoky and dim, and carry a significant fire risk since they can be knocked over. It is easier for children to study in the evenings in the brighter and better quality electric light, and adults are able to do more in the home.

About 38% of SHS output powers radios. These bring opportunities for children and adults to learn, as well as providing an important link with the outside world. Other appliances account for about 4% of system use. These include other entertainment systems (cassette tape, DVD and TV) which are much appreciated by SHS users, especially in the remote summer pastures. An SHS also allows users to charge a mobile phone. Many people are taking advantage of this although usage is currently restricted because the networks serve only the villages, not the more remote areas.

Solar home systems make it easier to have evening activities, which strengthen links within communities. Portable systems are ideally suited to the lifestyle of these semi-nomadic users who are able to take them with their tents into the summer pasture in the hills. This also provides a greater sense of safety.

A recent World Bank field survey of households in four counties where REDP operated found that the financial savings from having a SHS were quite low, about Y10 (£0.72) per month per household. However, this is because in the counties surveyed a significant amount of the fuel replaced is home-produced butter for butter-lamps, rather than purchased kerosene or candles. In the survey region, only 19.5% of households used kerosene, whereas pre-REDP studies in other provinces found between 44.0% and 98.5% of households used kerosene.

### **Environmental benefits**

The REDP solar home systems reduce greenhouse gas emissions, through avoiding the use of non-renewable kerosene and candles. The World Bank survey of four counties (above) found that in the 19.5% of households using kerosene, the average decrease in use was 3.2 litres/month. On this basis, the kerosene saving averaged over all households is only 0.62 litres/month, which corresponds to a saving in greenhouse gas emissions of about 19 kg/year CO<sub>2</sub> per household.

These values for kerosene and CO<sub>2</sub> saving are very much lower than found in surveys in other countries (such as Indonesia and Bangladesh). However, they are not representative of the whole of the REDP work, because of the very low use of kerosene in the survey counties.

### **Economic benefits and employment**

About 1,500 permanent jobs and 3,000 temporary ones have been created in the participating companies as a result of this programme. By the end of 2006, 50% of the sales of these companies were outside the REDP, so the support provided by the programme has stimulated a wider market

The programme has had some impact on employment and income in the rural areas. For instance, village stores in the programme areas can generate additional income, because they can stay open later and rent time on mobile phones.

### **Potential for growth and replication**

There are huge opportunities for expanding the use of SHS in China. Over the next decade, China faces a deficit of 10 to 15% between generating capacity (including planned new plant) and electricity demand. The Government has acknowledged the impact of energy use on air pollution and climate change by setting targets for renewable energy. It plans to double renewable energy capacity by 2020. Under China's Renewables Law, 15% of its electricity must come from renewable sources (excluding large hydro) by 2020. Each electricity provider will have to obtain a minimum of 10% of its electricity from renewable sources by 2020.

The total installed capacity of PV in China was 20 MWp in 2007. Initial targets were set to increase total PV capacity to 300 MWp by 2010 and 1.8 GWp by 2020, but the industry is growing so rapidly that intention is now to achieve 10 GWp PV capacity by 2020. The Government rural energy development strategy identifies solar-PV as key to rural electrification, and has a target of 300 MWp of rural PV (including both off-grid home systems and local PV grids) by 2020.

The REDP model of using a market-driven approach to reduce costs, and improve system quality has greatly expanded the market for solar home systems, and also supported the growth of a network of wholesale suppliers and retailers. This model for providing market-driven incentives has now been followed by World Bank projects in some other developing countries.

REDP plans to establish a Photovoltaic Industry Association, which will be part of the Chinese Renewable Energy Industries Association, to act as the expert body on solar PV in China. REDP is also working with the NDRC to develop the National Rural Electrification Programme.

### **Management, finance and partnerships**

REDP was part of the NDRC of the Government of China, one of the key economic development bodies. The World Bank supervision team and the NDRC renewable energy management department monitored the execution of the programme, through regular independent reviews, and also were required to approve all new activities before they commence. About 80 suppliers and 32 participating companies (wholesalers) were directly involved in the REDP programme, and a network of retailers also developed.

REDP was led by Wu Dacheng, Executive Director supported by Wang Wei (PV Manager), Luo Xinlian (Technical and Innovation Manager) and others.

This report is based on information provided to the Ashden Awards judges by the REDP, and findings from a visit by one of the judging team to see its work in China.

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