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Renewable energy: China



GENERAL INFORMATION

◆ **Implementing institution**

New Energy Development Division, Department of Electricity Power, State Power Development Corporation of China

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◆ **Implementation period**

Two years (1997-1999).

◆ **Costs**

US\$2.18 million: US\$1,962,000 (90 per cent of total) from the central government and US\$218,000 (10 per cent of total) from the local government (Tibet).

SUMMARY

In China, about 50 million people still do not have access to electricity. Most of the people without power live in remote areas of western China where population density is low and the inhabitants are often nomadic. The climate is dry with intense solar radiation. Solar photovoltaic (PV) energy, therefore, is a good potential source of electricity.

To encourage the development of renewable energy applications, the local government has introduced incentives, including subsidies, tax breaks and access to credit. These policies have promoted the use of PV power and, over the last 10 years, the PV market has increased at an average of 20 per cent per year. From near zero in 1981, more than 3,500 kilowatts of solar power were being generated by nearly 25,000 PV systems throughout China by 2001.

As part of this initiative, between 1993 and 1999, seven PV power stations were constructed in Tibet, the area with the highest incidence of solar radiation in the country. The 100-kilowatt PV power station in Anduo county is the largest of these seven power stations. It offers an excellent example of how PV electricity can help to solve the power problems of China and how such electricity can be generated even in apparently hostile environmental conditions.

BACKGROUND AND JUSTIFICATION

Anduo power station stands at the foot of Tangula Mountain in Naqu district on the plateau of north Tibet at 4,680 metres above sea level. It is located at one of the highest elevations and suffers from one of the harshest climates of any PV power station in the world. Throughout the year, the average temperature is about -3°C ,

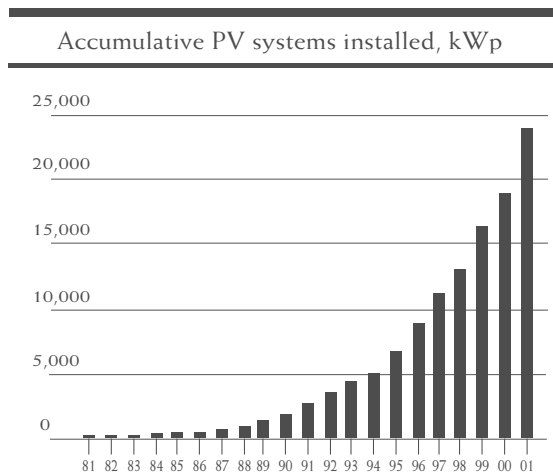


Figure 1 | PV systems installed in China, 1981–2001

ranging from a high of 23.3°C to a low of -36.7°C. The temperature remains below zero for seven months of the year, and only 24 days a year are frost-free. Strong winds are common, average rainfall is 411.6 millimetres and frequent snowfalls have a serious impact on both transportation and peoples' general standards of living.

However, the area is rich in solar energy. It has an average of 2,847.4 hours of sunshine a year, which produce 7,830 megajoules per square metre. As this solar energy is uniform throughout the year, it is an ideal source from which to generate electricity.

When the project began in 1997, the town had a population of about 4,000 people living in about 1,000 households served by a single small diesel-powered generator that was expensive to run and broke down frequently.

In the early 1990s, as part of its efforts to promote local economic development and improve the material and cultural living standards of people in Tibet, the central government decided to build PV power stations in counties without an electricity supply or hydropower resources. Anduo power station was constructed between 1997 and 1999.

The design of the PV station and its plant had to allow a large margin of safety because of the harsh climate, high elevation and thin air. The plateau of north Tibet also suffers from very poor transport infrastructure, including a complete lack of railway lines. Because all the materials for the PV station had to be

purchased elsewhere and transported to Anduo, logistical challenges increased the installation costs. Transport problems also impact maintenance costs. Moreover, specialists and technicians from other areas find it difficult to adapt to the local conditions. Despite these setbacks, PV power stations are still the best and most cost-effective energy option for Tibet.

DESCRIPTION

Standard design criteria for PV power plants had to be modified to suit the special climatic and geographical conditions of Tibet. Reliability and safety were the main concerns in these design adaptations. In addition, extensive efforts were made to improve the efficiency of the systems and reduce their costs. The system at Anduo includes a solar cell array, a bank of batteries, a DC control system, an inverter, a rectifier, a charger, a diesel engine and a distribution system as well as buildings to house the machinery, accommodate workers and support the PV arrays. The thin air means that the design of electrical appliances must allow for an extra large margin of safety, and a deionized water system had to be installed to provide the vast quantities of clean water needed to maintain the batteries for long periods.

The project was implemented by the State Power Development Corporation of China which, in 1992, identified PV energy as the best choice for supplying electricity to Tibet. Construction was implemented in a step-by-step process

with the approval of and funding from the government. In early 1993, the Power Development Department of Tibet invited bids for the construction of PV power stations in seven counties across Tibet.

The Institute of Electrical Engineering of the Chinese Academy of Science won the contract and began work on the initial designs for Anduo in 1997. Construction took place between May and September 1998, and the station started to operate in October. During construction, five technicians from Anduo were sent for training to learn how to operate the PV power station. The completed project was checked and approved by the government in August 2000. Most devices were found to be working correctly, and the station had also operated safely for more than 21 months, which proved that its design, installation and construction met the requirements of the initial plan.

During the assessment by the government, it was demonstrated that the Anduo power station generated an average of 240 kilowatts a day, supplying electricity for seven hours a day. The diesel engine generated 1,600 kilowatts of electricity. The charge and discharge function of the PV system was also found to meet with design requirements. The cost of the oil saved as a result of having the PV station was US\$180,000, and supplying electricity to the service industry had generated \$12,000 of revenue. Therefore, there were good social and economic results from the installation and use of the PV power station.

PATENTING AND COMMERCIALIZATION

The successful design, installation and implementation of the seven initial PV power stations, including Anduo, are being used as a model for similar projects across western China. PV technology is becoming one of the most important commercialized technologies for providing electricity to communities that currently lack access to power across the region.

PARTNERSHIPS

The Institute of Electrical Engineering, the project contractor, was responsible for the overall design and construction of the PV systems as well as the development or purchase of other required machinery and equipment. It subcontracted the Hydropower Company of the Electricity Division in Naqu District to construct some of the necessary technical equipment, including the invert/transform devices, and the building to house the generating equipment. The Anduo County government was subcontracted to construct the supports for the PV array, the workers' accommodation and the enclosing wall around the whole plant.

REPLICABILITY

PV technology can easily be extended to other countries. It is relatively straightforward to install and use, so most countries will have the necessary technical expertise to do so. PV power is unlikely to encounter

barriers from national or international policy because it is a clean, renewable source of electricity whose development is encouraged all over the world. The work done by this project to adapt standard PV power-station designs to local climatic and geographical conditions, and the strict quality controls to which all the components of the PV systems were subjected resulted in a PV system that could be replicated in western China and other regions with similar conditions throughout the developing world. High costs are the main obstacle to the spread of PV technology in developing countries.

LESSONS LEARNED

Despite the high annual growth rate in PV energy production, the Chinese PV industry still lags far behind those of developed countries and regions such as Japan, the United States and Europe. The output of PV production and the number of PV systems installed in China account for only about 1 to 1.5 percent of world totals. One of the main reasons for this is that the central government has not yet introduced systematic incentive policies such as the Renewable Portfolio Standard (RPS) of Europe and the United States. This lack of a supportive government policy is one of the main obstacles facing the Chinese PV market and industry today. However, the central government is working on new policies and regulations that will encourage the development of renewable energy technology.

The economy of China is rapidly

changing and expanding, but the PV market has not yet been standardized. For example, there are no product standards, product quality is not uniform and the maintenance service system is inefficient and unreliable. In some areas, the PV market is in disorder, owing to a lack of regulations and systems for examining and checking product quality and the fact that a few traders have been overcharging for products, equipment and services. All of these factors have an adverse effect on consumer confidence in and acceptance of PV power systems. At present, the PV market is being reorganized through such measures as the setting up of standards for marketed PV products, the introduction of a bidding system and the establishment of a supervisory system for training in PV engineering and technology. A national standard — Technology Standards of Home Solar PV Systems — has been drafted and several institutions for quality control and certification have been created.

PV-generated electricity is still expensive to produce and supply. In terms of price, therefore, it can compete with conventional electricity only in special situations where there is no access to regular electricity supplies. If PV technology is to replace fossil fuels, the technology it uses must be improved and made far more cost-effective. In addition, developed countries dominate PV technology and the PV industry and they prefer to export their high-priced products to developing countries rather than making them more readily available through the production of lower-priced versions. This contributes to the high prices of PV power and affects

developing countries more than developed ones. Governments of developing countries could work towards reducing the technology gap between developed and developing countries by dedicating research and development (R&D) funds to improving the cell efficiency and the manufacturing technology of PV systems.

Wherever PV systems are demonstrated, more and more people come to accept and welcome their use. Awareness-raising activities, such as Renewable Energy Day and Environment Protecting Day, have been launched as a way of increasing public awareness and acceptance of PV technology and products.

IMPACT

Since the PV station was installed in Anduo, local people have had reliable access to lighting, television, radio and electrical appliances in their homes. As a result, their standard of living has improved. Moreover, freed from the drudgery associated with securing other, more traditional sources of energy, people have been able to assume additional positions outside the home or to participate more readily in cultural events. Economic development has progressed owing to the new industries and restaurants that have opened up, and the revenue of the Anduo municipal government has increased greatly over the first two years of the operation of the power station. The situation is similar in the areas of Tibet and other parts of the country

where PV power stations have been built to provide a local electricity supply.

Beijing Solar Energy Research Institute (BSERI) is making efforts to reduce the cost of PV electricity. BSERI was set up in 1979 to carry out R&D in solar energy technology (both PV and thermal) and to transform its R&D achievements into commercial production technology. Its PV laboratory is one of its main departments and also one of the main centres for solar PV R&D and application in China. In 1991, the State Science and Technology Ministry (SSTM) established the National Engineering Research Centre for Renewable Energy (NERCRE) to provide backup to BSERI. The PV R&D efforts of BSERI and NERCRE focus mainly on crystalline silicon high-efficiency cells, polycrystalline silicon film cells and PV application technology.

There have been many successes. The conversion efficiency of monocrystalline silicon solar cells has reached 19.8 per cent, while that of buried-contact solar cells is now 18.6 per cent. The PV application technologies that BSERI is developing include system design, controllers and inverters. These activities have already reduced the North-South technology gap, and the Chinese PV industry is expected to make great advances over the next 10 years.

PV technology has now been in use in China for more than 20 years, but the already fast-growing PV industry is set to expand even more quickly in the near future. A large-scale PV project to provide electrical engineering for towns

without electricity in seven provinces of western China was launched in 2002 with the objective of generating up to 15 megawatts of PV power. Provincial governments will be responsible for half the budget of this project, with the central government providing the other half.

The construction of the seven PV power stations in remote areas of Tibet has induced local governments in Tibet, Inner Mongolia, Qinghai Province and elsewhere to introduce regulations to promote PV systems. In 1998, the central government, the State Development Planning Commission, the Ministry of Technology and Science and the State Economic and Trade Commission sent out a joint circular instructing all Chinese electricity companies to allow electricity from renewable energy sources to be attached to the grid. These measures are designed to promote the development of renewable energy technologies.

As a renewable source of energy, PV technology contributes to sustainable development because it protects the ecology and the environment. In addition, the application of PV technology can promote and encourage the development of other renewable energy technologies. The inspiring example of the use of PV technology in western China is a source of satisfaction for people involved in sustainable development strategies.

FUTURE PLANS

Rapid local and national economic development is leading to increased

demand for electric power both in areas without electricity and in those where the existing supply is insufficient. In addition to the building of new PV power stations in western China, future plans include enlarging the seven existing stations to meet the increased demand.

The State Development Planning Commission has drawn up a blueprint, known as Bright Engineering, for the development and commercialization of PV technology. Under this plan, PV systems supplying a total of 105 megawatts will be installed by 2005 and will expand to supply 300 megawatts by 2010.

PUBLICATIONS

Anding Li. (2001). *Solar Energy Photovoltaic System Engineering*. Publishing House of Beijing Industry University. (In Chinese).

Ying Xu, Yuan Yu and Xudong Li. (2002). Poly-Si thin film solar cell with 10% on modeling ceramic substrate. *Acta Energiae Solaris Sinica*, 23(1): 108-110.

Yuwen Zhao, Zhongming Li, Shaoqi He et al. (1998). Solar cell R&D activities in the National Engineering Research Centre for Renewable Energy. *Second World Conference and Exhibition on Photovoltaic Solar Energy Conversion*, pp. 1452-1455. 6-10 July 1998. Vienna, Austria.

Zhao Yuwen, Li Zhongming, Mo Chundong et al. (1997). All-aluminium BSF high-efficiency silicon solar cells. *World Solar Conference*, pp. 137-140. 24-29 August 1997. Taejon, Republic of Korea.