Rapid commercialization of renewable energy in China

Introduction

Issues of environment, energy security and least-cost energy access for rural populations have all played a role in making renewable energy an integral component of China's national development strategy. Yet, China's high dependence on fossil fuels, including its extensive coal reserves (63 per cent of primary energy in 2003), petroleum (26 per cent of primary energy in 2003, with imports accounting for 31 per cent of crude oil consumption) and natural gas (3 per cent of primary energy in 2003), has remained firmly in place. Efforts to promote renewable energy in China have intensified in recent years, with several domestically and internationally supported initiatives, but the widespread commercialization and adoption of associated technologies are impeded by many challenges in capacity, financing, policy, technology and information. The project described in this brief is meant to address strategically a number of these challenges.

Project implementation, financing and time line

China's National Development and Reform Commission (NDRC) is the project's lead domestic implementation agency, with implementation support also provided by the State Environmental Protection Agency (SEPA). The United Nations Development Programme (UNDP) is the international implementing agency. The United Nations Department of Economic and Social Affairs (UNDESA) is the executing agency. A project Advisory Group (AG), including all project co-financiers and implementing and executing agencies, meets twice a year to review progress and provide advice and suggestions for future activities.

The project's overall budget is US$ 25.8 million, including funding from UNDP-GEF ($8.8 million), Australia ($3 million), the Netherlands ($2.53 million) and the Government of China ($11.5 million). The Government of China has also made significant in-kind contributions, including setting up the Project Management Office and providing support staff. The project was initiated in April 1999, will have a duration of six years and is projected to close in 2006.

Project objectives and strategy

The overall objective of the project is to support the accelerated commercialization of key renewable energy technologies in promising market sectors. To achieve this objective, the project combines emphasis on two main priorities throughout all components:

- Capacity-building (for the identification, development and implementation of commercial renewable energy projects);
- Commercialization (through lowering of technical, institutional and policy barriers and introduction of international best practice for market-ready renewable energy technologies).

Project strategy is based on a market sector approach, with activities focused on the technology application areas of: (*a*) biogas, (*b*) grid-connected wind, (*c*) solar water heaters, (*d*) hybrid village power and (*e*) bagasse; additional cross-cutting focal areas are (*f*) finance and (*g*) policy. Finally, critical to the project's success has been its close coordination with the central Government in support of the nation's various programmes for renewable energy.

Establishment of the Chinese Renewable Energy Industries Association

The project has supported establishment of the China Renewable Energy Industry Association (CREIA), one of the first completely business-led and self-financed associations in China. CREIA provides its members with the latest information on technology and market developments and acts as an organizer of industry training programmes. From an informal base of 60 members in 2000, CREIA gained official status in 2003 and has grown to 180 members. Now considered the premier channel between China's renewable energy companies and business and organizations in other parts of the world, CREIA will launch its Investment Opportunity Facility (IOF) in 2004 to link project implementers with investors.

Renewable energy market sector work

Demonstration projects, introduction of international best practice, capacity-building (through training, workshops and study tours), standards development, and promotion of business deals have all been important elements of market sector work. Activities are summarized by sector below:

Industrial-scale biogas. The project has supported construction of three modern biogas plants in China, two on pig farms and one at a distillery.[8] Building on these demos, project workshops have been successful in catalysing a substantial number of biogas business deals. The project is now supporting development of the biogas component of the Government's Biomass Strategy to 2020.

Solar water heaters. The project's solar water heater work has provided direct support to the Government in the areas of standards, testing and certification. The project assisted in development of four new standards, which were approved in October 2003, serving to complete China's solar water heater standards framework. The project further supported the selection and equipping of three national solar water heater testing centres, two of which have achieved official laboratory accreditation in China. The project has also supported the establishment of a national solar water heater certification centre in Beijing. These efforts have all received an enthusiastic response from industry.

Wind power. The project has supported wind resource assessment at 10 sites, introducing international best practice and building capacity in local organizations. The sites have been incorporated into the Government's plans for wind power, directly feeding into an ambitious project development pipeline, with a target of 20 MW by 2020. The project's resource assessment methods have also been adopted by the Government, which was planning to conduct 20 more site assessments by 2005.

Hybrid village power. The project has supported two pilot hybrid village power projects, a wind-PV-diesel system serving five remote sites in far western China and a wind diesel system serving an island fishing community off China's eastern seaboard. As the Chinese Government pursues the world's most extensive renewable energy–based rural electrification programme, the project's emphasis on productive applications (e.g., microenterprises) will provide a model for promoting sustainability of village power installations.

Bagasse. The project aims to demonstrate the potential in sugar mills for cogeneration of heat and power (and sale of electricity to the grid) by burning fibrous processing wastes. A pilot project is being constructed at Guitang, Guangxi Province. A study tour to Australia and Hawaii and an upcoming workshop aim to build capacity for bagasse cogeneration in China and promote associated business development.

---

[8] Biogas plants create a substitute for natural gas, through anaerobic fermentation processes, at the same time breaking down polluting organic compounds.

Business Development and Financing

The project has held a series of training programmes and workshops on business development and financing for renewable energy. These activities have sought to enhance the business skills of managers and entrepreneurs and to raise awareness and understanding of renewable energy among the financial community.

Policy support. In addition to direct support of government programmes and strategic planning in the market sectors of biogas, solar water heaters, grid-connected wind and village power, the project is also providing cross-sector policy support to the Chinese Government in the formulation of its Renewable Energy Development and Utilization Law.

China Renewable Energy Industries Association (CREIA)

Efforts to increase the use of renewable energy in China have, to date, relied primarily on technology demonstrations. Today, with several renewable energy technologies on the brink of commercialization, the nation's decision makers have recognized the potential of market mechanisms as a more effective means for promoting growth in the sector. Thus, they are exploring avenues for catalysing business deals and ensuring sound market development.

To strengthen the position of the renewable energy industry during this period of critical potential, the National Development and Reform Commission (NDRC)/UNDP-GEF project has supported the establishment of the Chinese Renewable Energy Industries Association (CREIA). As an independent, industry-led association, CREIA aims to provide networking and business development opportunities to its members; act as an industry advocate; raise awareness internationally of renewable energy investment opportunities in China; and provide the Government with policy advice on key issues. A target of financial self-sufficiency has been set for CREIA, so that the association will continue to thrive beyond the project's lifetime.

Within China, CREIA serves as a bridge between regulatory authorities, research institutes and industry professionals. It provides a forum for the discussion of renewable energy development issues at the national level. Based on input gathered, it advises the Government on the formulation of strategic policies.

CREIA is a window through which domestic and international project developers and investors are brought together. It promotes technology transfer and foreign investment in the sector through online approaches, regional meetings and training activities.

The association provides a network for Chinese renewable energy companies, which, in the past, have lacked access to timely information and a medium to communicate across subsectors. CREIA further provides them with a platform to voice their concerns collectively.

CREIA was established in January 2000, temporarily taking on company status. It was formally registered in March 2002 as a non-profit autonomous subsidiary of the China Comprehensive Resource Utilization Association. CREIA's membership consists primarily of domestic renewable energy companies, and its chief objective is to act on their behalf. The association's initial membership strategy has been selective, focusing on the strongest renewable energy companies across all subsectors, so as to build a solid foundation and reputation as a provider of high-value services for its members. CREIA has also invited a number of distinguished domestic experts from government and industry to become individual members, thus enhancing its networking and advisory base. CREIA operates under the guidance of a five-year business plan and an annual operating plan approved by the Board of Directors.

CREIA offers a wide range of services and support, including but not limited to:

- Web-based services, such as the Investment Opportunity Facility (IOF);
- Networking, training events, and study tours for industry;
- Policy and other support for the Government;
- Information and market support for members, provided through various channels, including key media outlets.

CREIA is currently working to upgrade its web-based services, of which the IOF will be a key component. CREIA created the IOF to promote business development and financing for renewable energy companies and projects in China. Databases will be available in both English and Chinese, providing the international audience (developers and investors) with information on domestic companies and government programmes and the domestic audience (Chinese companies) with information on international programmes and financing schemes. The Chinese and English versions of the IOF can be accessed at *www.creia.net*. CREIA's upgraded website will also provide members with training materials, resource assessments and updated information about CREIA activities and events around the world.

Since January 2000, CREIA has offered over 40 workshops and study tours on behalf of the Chinese renewable energy industry. These activities have provided extensive networking opportunities and offered a wide range of training curricula, including advanced business and project development, technology transfer, courses in specific technologies, and marketing. CREIA has been especially active in organizing financing events. Most recently, it has established cooperation with the World Wildlife Fund to provide training for CDM project development.[9]

CREIA has supported Government policy formulation through provision of sector analyses on solar water heaters, photovoltaics, wind and biogas. It is also involved in ongoing work for the development of specific policy recommendations. The association has further supported the Government through standards work in renewable energy subsectors. Finally, CREIA has provided critical assistance in implementation of the Government bond-financed wind programme, which, aiming to stimulate domestic production, resulted in the installation of 80 MW of high-domestic-content wind turbines.

Impacts and successes of CREIA

In its four years of existence, CREIA has developed a strong reputation for providing valued services to its members. It has played an active role in international cooperation and has generally succeeded in stimulating the industry through its multifaceted activities. Evidence of its success is given below:

- From an informal base of about 60 companies in 2000, CREIA has grown to a membership of 120. Companies are attracted by the business development opportunities, information channels and consultation offered. Despite the existence of other associations in some subsectors, CREIA is seen by members as the most effective forum for the industry to exchange information and collectively express its opinion.

---

[9] CDM refers to the Clean Development Mechanism, the mechanism that emerged in 1997 from the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC) to enable developed countries to gain credit for emissions reductions through cooperation in projects implemented in developing countries.

- In a short time, CREIA has achieved the goal of financial self-sufficiency. In addition to a growing paid membership base, CREIA has been successful in landing contract work with a number of domestic and international organizations.
- CREIA has developed a reputation as the premier channel between China's renewable energy companies and businesses and organizations in other parts of the world. Reflecting growing recognition by the world renewable energy community, the association has recently been chosen as the East Asian Secretariat of the Renewable Energy and Energy Efficiency Partnership (REEEP). Emerging from the World Summit on Sustainable Development in Johannesburg in 2002, REEEP is increasingly seen as an important vehicle for expanding the global market for renewable energy and energy efficiency technologies through international cooperation.
- CREIA is playing an increasingly important role in promoting the latest information and marketing approaches in China. The association secured China's first "Emission Reduction Purchase Agreement" (signed with the Netherlands Government) under the CDM framework for one of its member companies and is well positioned to play a leading role in CDM project development in China.

Wind power programme

Current status

With its vast wind resources, escalating demand for power and growing environmental concerns, China represents a major, untapped opportunity for wind energy development. The nation's wind endowment is estimated to represent a potential of up to 250 GW of power generation, equivalent to 65 per cent of China's current total power generation capacity.[10] Yet, the installed capacity of China's 40 wind farms (containing 1,042 wind turbines) in 2003 was only 567 MW — less than one GW. India, an example of a developing country taking a more aggressive stance on wind power, had 3.7 times this capacity in 2003.

Most of China's existing wind capacity was built using bilateral assistance and soft loans tied to equipment imports, though the industry is now in the midst of a transition to commercial project development. Analysts agree that China's wind sector currently has at most only one successful, fully commercial project. To attract more commercial investment to the sector, the Government of China has recently adopted a concession approach with guaranteed power purchase prices. In 2003, the country's National Development and Reform Commission (NDRC) granted the first two contracts for such wind concession projects to domestic investors.[11]

Indeed, after an extended moratorium on approval of wind projects, recent Government activity presages a potential take-off. NDRC's new and ambitious plans for the sector are outlined in its national wind development programme, which calls for:

- By 2005, 30 potential wind farm sites' wind resources measured and characterized;
- By 2010, 4 GW of installed capacity, through both concessions and other business models;
- By 2020, 20 GW installed (over 30 times 2003 capacity).

---

[10] A gigawatt (GW) is a billion (1,000 million) watts, while a megawatt (MW) is a million watts. Thus, 1,000 MW are equivalent to one GW.

[11] NDRC is a product of government restructuring in 2004. Its predecessor was the State Development and Planning Commission (SDPC).

In addition to this programme, the Government has promulgated a series of incentive policies to promote investment in wind power and is in the midst of formulating the Renewable Energy Promotion Law, which should further enhance the business environment in China's wind sector.

UNDP-GEF project support for wind power in China

All of the UNDP-GEF project's wind power activities are fully integrated into the national wind development programme, and work is carried out in close cooperation with NDRC. The aim of the project's wind power component is to facilitate the Government programme's ambitious pace and ensure that past shortcomings in upstream aspects of wind project development are ameliorated so as to yield bankable projects with high success potential.

In the past, a critical weakness of wind projects in China has been the quality of resource assessment work; projects have, as a result, often not delivered the power expected. To address this issue, the UNDP-GEF project is supporting a series of activities directed at characterizing new wind sites with high potential for commercial development. These activities combine capacity-building with direct support of NDRC's project pipeline, by engaging both domestic and international entities to work together in performing assessment work and by providing training in international best practices.

Working with the Longyuan Power Company (China's top holder of wind farm assets following power sector restructuring), the project supported installation of approximately US$ 1 million of wind resource monitoring equipment in 2002 at 10 sites distributed throughout China. Wind development potential of each site is at least 100 MW and often much larger—up to 1,000 MW or more. A typical site configuration includes one 70-metre tower and three 40-metre towers for data collection. Longyuan coordinates 10 local field organizations responsible for data acquisition and site maintenance; and the project further supports these groups by an extensive training programme.

Data from the 10 field sites will soon be validated and analysed through cooperation with the China Hydropower Engineering Consulting Group. China Hydropower will work with RISO in Denmark to utilize the latter's WASP model in wind flow analysis. The British company Garrad Hassan has been retained to cross-check results and work closely with banks and other investors to ensure that the assessments achieve credibility with the financial sector.

Impacts and successes of the UNDP-GEF project in China's wind sector

The project has been remarkably successful in achieving its goal of supporting the Government of China in the development of wind power, with key indicators as follows:

- Project activities have been fully incorporated into NDRC's strategic planning process for China's national wind development programme. Specifically, NDRC has included all 10 of the project's wind sites under evaluation into its national programme for investigating 30 new, high-potential wind sites by 2005 for near-term development.
- NDRC has directly adopted the project's field installation and data acquisition methods for all of its future wind resource assessments and has already begun to apply these to numerous other sites.
- Chinese organizations (e.g., Longyuan, China Hydropower and local field organizations) have developed increased capacity for wind resource assessment. Policy formulation has also been enhanced through the project's contributions to overall planning and the concession strategy.

Indeed, given the substantial lead times necessary for wind resource assessment (generally at least two years), project activities are playing a critical role in supporting the rapid pace targeted by the Government programme and feeding its project pipeline. Wind site characterization conducted through the project is at the level of commercial pre-feasibility studies; NDRC plans to use this work in pursuing commercial development by competitive bidding. Sites characterized by the project potentially represent at least 1,000 MW of the 4,000 MW NDRC has targeted for development by 2010.

Aside from direct catalytic impacts on the wind power project pipeline in China, the UNDP-GEF project can also be seen to have had broader, "multiplier" effects. Now fully convinced of the critical importance of high-quality and extensive resource assessment, NDRC has adopted the project's field installation and data acquisition procedures and protocols for wind resource monitoring to enhance the bankability of projects. While short-term official Government plans call for 20 more site assessments by 2005, recent reports that Longyuan has purchased a total of 200 additional data-collection towers indicate that the advance towards wind power is on an even faster track. This purchase represents a potential for assessment of 50 more sites, an immediate multiplier effect of five times for the project in the short term alone.

Building on these positive impacts, further assistance targeted to stimulate the project pipeline and attract the involvement of a range of industry and financial players is being considered. Potential cooperation would focus on the establishment of innovative financing mechanisms for both wind farms and a national turbine industry.

Industrial-scale biogas programme

Current status

China's extensive biomass resources (estimated at 5 billion tons annually) include substantial animal wastes and organic industrial effluent, appropriate raw materials for the production of biogas. While most biomass resources used as energy in China today are not converted into modern energy carriers, biogas can be used as a substitute natural gas, providing process heat, electricity and/or gas for local distribution. Biogas production, achieved through anaerobic fermentation processes, also serves the important purpose of treating organic pollutants in the waste stream and can yield a quality organic fertilizer.[12]

While China has extensive experience with biogas at the household level (with roughly 2 million rural household digesters in operation), industrial-scale production, appropriate for medium- to large-scale livestock farms and for manufacturing operations in such sectors as liquor, beer, pharmaceuticals and food starch, lags far behind potential. Indeed, as meat consumption continues to rise in China, water pollution from animal manure produced at livestock and poultry farms has emerged as a key environmental problem, creating both a treatment necessity and a sizeable biogas production opportunity. Estimates place manure generated at such farms at over 900 million tons annually, with an electric power potential of over six gigawatts (GW).[13] Industrial organic wastewater effluent, also on the rise as China's economy grows, has reached 2.8 billion m^3. China's industrial sector holds particularly high promise for profitable biogas installations, given its suitability to cogeneration of heat and power and the availability of advanced CHP (combined-heat-power) technologies.

---

[12] In anaerobic fermentation processes, bacteria break down organic compounds in the absence of oxygen, while aerobic processes take place in the presence of oxygen.

[13] A gigawatt (GW) is equivalent to 10^9 watts or 1,000 megawatts (MW). For comparison, a typical scale for a modern coal-fired power plant is 100 MW.

In contrast to the European Union's 1.8 GW (2002) of mainly profit-driven installed capacity, the major driver of China's industrial-scale biogas projects has been compliance with environmental regulations. In 2002, China's State Environmental Protection Agency (SEPA) issued new standards for industrial wastewater discharge and stepped-up enforcement, stimulating greater interest in biogas. The use of anaerobic fermentation technology for wastewater treatment is well developed in China. Aerobic fermentation is often used for second-stage treatment in order to fully meet national discharge standards, as compared to Europe, where first-stage effluent is used in irrigation. China has more than 700 small to mid-size industrial-scale biogas plants, but increased deployment and incorporation of international best practice to promote commercial viability are needed.

UNDP-GEF project support for industrial-scale biogas in China

The project has co-financed three pilot industrial-scale biogas projects, representing advanced international best practice in design and construction of commercial facilities and covering the two key market sectors (industry and livestock). Table 3 provides details on the characteristics of these projects, which include two pig farms (one formerly the largest in the world) and a distillery.

Table 3. Characteristics of pilot biogas facilities

Characteristics	Dengta Pig Farm (Hangzhou, Zhejiang Province)	Shunyi Pig Farm (Shunyi, Beijing Municipality)	Jiuchang Distillery (Qingdao, Shandong Province)
Scale	200,000 pigs	60,000 pigs	10,000 t/year alcohol
Wastewater	3,000 tons/day	600 tons/day	10,000 m^3/day
Biogas produced	8,500 m^3/day	2,200 m^3/day	10,000 m^3/day
Biogas application	Electricity, some heat	Electricity, some heat	Boiler fuel for processing heat
Generating capacity	230 kW	100 kW	N/A
Use of electricity	Sold to grid	Used on site	N/A
Other output	142 tons fertilizer/day	8 tons fertilizer/day	Solids recycling

Business and industry development work aims to catalyse deals among developers, end-users and the financial sector and introduce international best practice. The project has aggressively pursued these goals through a series of four workshops, each held near one of the pilot sites or a similar facility for demonstration of economic and technical performance. Workshops focused on end-users and were held in partnership with SEPA, with input from international and domestic experts. Breakout sessions gave end-users an opportunity to hold discussions with bioengineering companies about potential projects. To further introduce international best practice, the project has financed preparation of a detailed guidebook, *International Biogas Best Practices Report*, which will soon be published in Chinese.

Current project work is focused on (*a*) facilitating a transition from environmental compliance–driven to profit-motivated biogas projects and (*b*) supporting policymakers in promoting biogas. As part of its commercialization strategy, the project is supporting feasibility studies for large-scale centralized biogas digesters, which will each serve several industrial end-users and thus have greater potential for selling electricity to the grid. In the policy arena, the project is assimilating experience and preparing a draft Biogas Action Plan. The plan is to utilize stakeholder input in identifying roles and action items for various groups associated with the technical, business development, financing, environmental and policy aspects of biogas commercialization.

Impacts and successes of UNDP-GEF project in China's industrial-scale biogas sector

The project has already achieved a number of notable successes to date, suggesting a substantial impact on the development of industrial-scale biogas in China:

- The project has achieved concrete results in catalysing the spread of biogas development projects in China. A limited survey of bioengineering companies indicates that 34 new biogas projects at livestock farms have been developed, with deals resulting directly from discussions held at the project's first three workshops. Ongoing multiplier effects are likely much greater. Already, third-party investors have begun to get involved in biogas projects.
- The pilot projects have been shown to provide China with easily replicable designs, as demonstrated when the local government shut down the Dengta Pig Farm, requiring that its biogas plant be reconstructed outside the city limits. The new plant was constructed with great efficiency, in only six months.
- Project outputs are having a direct impact on policymaking. The project's *China Biogas Project Development Guidebook* is already being used by the National Development and Reform Commission (NDRC) in preparation of the biogas component of its Biomass Strategy through 2020. NDRC has also indicated that it will make use of the project's Biogas Action Plan as a key input to the biogas portion of its Biomass Strategy. In addition, the project has had an impact on local governments, such as Hangzhou, which took action to implement new standards once the project demonstrated the potential of biogas solutions.
- The capacity of biogas project developers has clearly been increased by the project. For example, the Hangzhou Bioengineering Company, which developed the Dengta pilot, has reported substantial expansion of its business, including cooperation with multinationals in China and contracts for projects abroad.

Solar water heater programme

Current status

Already the world's largest solar water heater market and manufacturing base, China represents expansive growth potential for the industry. In 2002, sales of solar water heaters in China (by collector area) were 9.6 million m^2 or US$ 1.28 billion, compared to 900,000 m^2 in the European Union, the world's second largest market. China's 2002 production was 10 million m^2; and cumulative installed capacity reached 40 million m^2 (compared to 10.8 million m^2 in the European Union). Recently, sales in China have grown rapidly, more than tripling between 1998 and 2003.

A number of factors suggest the possibility of continued rapid growth of this market, including: the large numbers of Chinese households in small towns and rural areas that do not have bathing facilities at home; the low life-cycle costs of solar water heaters (achieved through fuel savings); the existence of abundant solar resources in many parts of China; and the Government's growing emphasis on energy security and environmental concerns.

Despite recent growth, the sound expansion of China's solar water heater industry has been impeded by the highly variable quality of products on the market. With over 3,000 often small-scale Chinese companies involved in manufacture and distribution in the sector, it is not surprising that quality problems have begun to damage the reputation of the industry among Chinese consumers. While a handful of companies used to dominate sales, the market share of small manufacturers has grown in recent years.

Since the second half of the 1980s, the Chinese Government has been supporting the sector through funding for research and development and technical upgrading loans. In the early 1990s, the Government began establishing standards for the industry and more recently has begun developing its national solar water heater testing and certification programme to ensure that solar water heaters regain and maintain their reputation among households as a reliable alternative to electric and gas water heaters.

UNDP-GEF project support for solar water heaters in China

Working in close partnership with China's National Development and Reform Commission (NDRC) and other relevant agencies, the project has provided critical support to the development of the nation's solar water heater programme in three areas: (*a*) standards, (*b*) testing and (*c*) certification. An aggressive promotion and media campaign has also been undertaken to ensure that industry stakeholders will participate in the programme. In the standards area, the project has addressed the problem of an incomplete and outdated standards system and collaborated with the Chinese National Institute for Standardization (CNIS) to develop a full framework of requirements for component and system performance.

In the area of testing, the project cooperated with CNIS and the State Technical Quality Supervision Board (STQSB) in 2002 to conduct competitive selection of three national test centres. Given China's large and highly dispersed solar water heater production base, an institute in each of north, central and south-west China was selected as follows:

- Institute of Air Conditioning, China Academy of Building Research, Beijing (north China);
- Hubei Product Quality Supervision and Testing Institute (central China);
- Solar Energy Research Institute of Yunnan Normal University (south-west China).

The project has emphasized the introduction of international best practice in building up collector and full system test capabilities and has arranged for the Netherlands' Ecofys and Australia's University of New South Wales to work with the test centres. In addition, as preparation for finalizing the design and construction of testing equipment and facilities supported by project cost-sharing, the project sponsored visits by test centre staff to test centres in Greece, Portugal, Switzerland and the Netherlands.

Finally, in the area of certification, the project has worked with the Certification and Accreditation Administration of China (CNCA) in setting the stage for a solar water heater certification system. In October 2003, CNCA established the national solar water heater certification centre at Beijing Jianheng, an organization under the China National Institute of Measures. With support from the project and input gained through exchange with Europe's Solar Keymark programme, the centre is now working to develop a certification and labelling programme for solar water heater products in China, which it will eventually oversee. It will also be responsible for coordination and final approval of procedures and protocols used at the three national test centres. Once certification and labelling are officially launched, the project will support Jianheng in managing an extensive publicity campaign to promote, in cooperation with industry, awareness of solar water heating labelling and quality issues.

Impacts and successes of UNDP-GEF project in China's solar water heater sector:

From the start, the project's solar water heater component has been highly integrated with the Government's work, so that project activities in essence have been equivalent to the Government programme for completing its standards framework and establishing testing and certification. Highlights of specific project successes include the following:

- Four new standards were developed with CNIS and approved, accomplishing (as of October 2003) the updating and completion of China's standards framework for solar water heaters and their components. The new standards form the basis for a national testing system and are consistent with the ISO and European EN systems.
- Two of the three test centres (Beijing and Wuhan) established by the project received laboratory accreditation from the STQSB and were formally designated national solar water heater testing centres by the Chinese Government in March 2004.
- Promotion work and efforts to involve industry have met with considerable success: industry has expressed strong enthusiasm for the new standards and plans for testing. These have also gained substantial coverage in the media.

Beyond accomplishments to date, the national solar water heater testing and certification programme facilitated by the project has enormous potential impacts. In short, it is poised to play a critical role in promoting the strong and continued growth of the world's largest solar water heater market by increasing the confidence of Chinese consumers in the sector's products.

UNDP-GEF support for China's national rural electrification programmes

From 2002 to 2004, the Chinese Government supported the installation of ~15 MW of PV in hybrid village power systems in rural areas in a major programme designed to electrify the remaining 1,065 unelectrified townships in 10 provinces in western China. Known as the Song Dian Dao Xiang or the National Township Electrification Programme, by the end of 2004 approximately 660 townships were electrified with PV/battery hybrid storage systems (~15 MW) and by the end of 2005 an additional 300 townships will be electrified with small hydropower stations (~275 MW). At present, planning for a follow-on programme, known as Song Dian Dao Cun, is directed at the 20,000 remaining smaller unelectrified natural villages, located mainly in the remote western regions of China. The UNDP-GEF has been providing support to the National Development and Reform Commission to address some of the key issues affecting sustainability of the township programme, including performing surveys and assessments, providing training support, exploring business models for managing township systems, and developing recommendations for national policies. With the passage of the Renewable Energy Law in China in February 2005, national policies are now being developed to provide a sustainable support basis for China's national rural energy development programmes.

Background

China has extensive historical experience with the development of renewable energy systems for rural electrification. From the late 1970s through the 1980s, system integrators and equipment manufacturers underwent a period of capacity-building, developing experience with Government-supported demonstration programmes and a commercial market for remote telecommunications systems and other industrial applications. Starting in 1996, the Chinese Government initiated the "Brightness Program", representing a domestic programme for pilot village power projects using small wind systems, solar home systems and hybrid village power systems, with a particular focus on Tibet, Inner Mongolia and Gansu. Examples of projects include: 5,500 hybrid PV/wind/battery hybrid household systems

installed in Inner Mongolia in 2003; 10,000 solar home systems installed in Gansu in 2002; and 30 PV/battery village power systems and 11,000 solar home systems installed in Ali in Tibet in 2001.

International bilateral and multilateral programmes have also provided access to international experience and best practices for rural electrification using renewable energy technologies. Examples include: a 21 million euro Shell Solar and Sun Oasis solar home system project in Xinjiang targeting the installation of 78,000 household systems in 2000-2006; a 20 million euro GTZ/KFW project in four provinces to install and monitor village power systems; and capacity-building programmes supported by the World Bank, UNDP, the United States Department of Energy etc. in general having a significant business and commercialization focus.

China's national programme

With the extensive foundation laid during the more than 15 years of experience with rural energy systems, in 2001 China began preparation of a major national rural electrification programme authorized by the State Council. The National Township Electrification Programme (Song Dian Dao Xiang) was initiated in 2002 with the goal of electrifying the remaining 1,065 administrative townships in rural western China. The programme was funded with 2 billion RMB (US$ 240 million) from the central Government and 2.7 billion RMB (US$ 330 million) from local provincial and township governments. The programme was executed with competitive bidding at the provincial level, and most systems were installed during the mid-2002 to 2004 time frame.

To date, approximately 662 community-scale village power systems have been installed in townships (an additional 49 systems have been installed at military posts), consisting primarily of PV/battery systems, with a cumulative installed capacity of about 15.7 MW. These township systems have been installed in Tibet, Qinghai, Xinjiang, Inner Mongolia, Gansu, Sichuan and Shaanxi provinces and autonomous regions in western China. One hybrid system containing 210 kW of wind and 90 kW of PV has been installed at Ma Zhong Shan in Gansu. All systems contain battery storage, but not all systems contain backup diesel generators. Small hydropower systems have been targeted for an additional 302 townships with a cumulative capacity of ~274 MW in 10 provinces/autonomous regions and Chongqing. Approximately 15,000 solar home systems have also been installed in the programme to date.

Institutional development

The execution of the National Township Electrification Programme was extremely rapid, focusing on the bidding, contracting and installation of systems. The National Development and Reform Commission (NDRC), which is responsible for the implementation of the programme, is now in the process of developing an infrastructure to ensure the long-term sustainability of the township systems. The UNDP-GEF project Capacity-building for the Rapid Commercialization of Renewable Energy in China, along with other international organizations, is assisting NDRC to address the following issues:

Ownership. The Chinese Government is accelerating the transfer of ownership of the township systems from the national Government to the local provincial and township authorities.

Tariff regulation. At present, electricity tariffs charged for customers of the township systems vary greatly from province to province and from system to system (a range of 0 to 2.0 RMB based on surveys conducted by the UNDP-GEF project). NDRC is in the process of establishing uniform tariff regulations for the township systems.

Financial support. It is known that the long-term financial requirements of township systems, such as battery replacement etc., will not be covered by electricity tariff revenues alone. The Renewable Energy Law, which was passed in February 2005 by the National People's Congress, will provide a financing mechanism to provide continuing

government cost-sharing for the township systems. The details of the cost-sharing system will be established by the end of 2005. NDRC is currently assessing the detailed cost requirements for maintaining the township systems over a 15-year operating period as input into this process.

Management. Four models are under investigation for management of the township systems (see table 4). To the extent possible, the management of systems will be structured as a small business.

Table 4. Four management models

Utility ownership	Provincial utility companies in Shaanxi and Sichuan will own and operate township systems
Lease contract	Established in Tibet with GTZ assistance for small hydropower systems; village owns system and leases to a professional management company
Community-owned and -operated	Department of township government owns and operates system
System integrator company as RESCO	System integrator establishes a company to manage systems under contract to township

Training. The training requirements for the township programme are substantial and must be addressed on several levels (engineering training for system operators, management training, training for system integrators and equipment manufacturers etc. based on planned future expansion of the national programme). NDRC is in the process of determining the requirements of a continuous training system to be conducted in a network of existing provincial institutions.

UNDP-GEF project assistance

Working in cooperation with the National Development and Reform Commission, the UNDP-GEF project in China has provided support in the following areas:

Capacity-building and information exchange. The project has published the *Village Power Project Development Guidebook* and has executed several workshops emphasizing sustainable development principles for rural energy development, working directly with government decision makers and the system integrator community.

Baseline survey and training. In 2005 the project was conducting a field survey of the installed systems in collaboration with the Energy Research Institute in Beijing to develop a database to provide information for current planning purposes and future evaluation. In collaboration with the Institute of Electrical Engineering in Beijing, the project developed a curriculum and management training programme for future renewable energy service companies complementing an engineering training programme for system operators that was developed with the support of GTZ.

RESCO model. The project established a rural energy service station model for management of village power systems in Bulunkou township in Xinjiang, which was managing 10 hybrid wind/PV/diesel/battery systems during 2002-2005. This project contains characteristics of and is a precursor for RESCO companies operating as a small business to manage large numbers of village power systems. In the near future, NDRC plans to establish RESCO pilot projects in Qinghai, Xinjiang and Tibet with the assistance of the GEF/World Bank renewable energy development programme in China.

China has made a commitment to expand the national rural electrification programme to some 20,000 un-electrified natural villages and a large number of remote rural households in western China, known as the Song Dian Dao Cun programme. Ultimately, this programme could be financed at a level of US$ 5 billion over 10-15 years. A 20 million RMB pilot phase for Song Dian Dao Cun has been approved by NDRC to be conducted in three provinces in 2005.

Bagasse cogeneration programme

Background

The sugar industry is one of the main economic industries in southern China. In 1997/98, total planted area of sugar cane was 1.30 million hectares and produced an output of 79 million tons of sugar cane. The sugar cane, used as raw material for production of sugar, produced 19.75 million tons of bagasse, which is equivalent to 4.95 million tons of coal when used as boiler fuel.

Sugar refining consumes a great amount of steam and electricity. For this reason, sugar refineries generally have their own power station. They use bagasse as fuel for boilers, producing steam to drive turbine generators. The generated power is used by the sugar refinery itself and is usually not provided to external electric networks. The back-pressure steam is used for sugar and alcohol production.

Due to historical reasons, sugar refineries in China are typically small-scale, with daily milling less than 2,500 tons, although some consolidation is under way. These sugar refineries usually have smaller-capacity boilers and turbine generators, which are of lower thermal efficiency. For example, the designed efficiency for boilers with 75 tons/hour is 87 per cent, while that for boilers with 20 tons/hour is 75 per cent. The large difference in their efficiencies leads to a great waste of primary energy.

In order to obtain higher utilization efficiency of primary energy, to control environmental pollution and to reduce emission of greenhouse gases, efforts are needed to replace old boilers and turbine generators having low performance and small capacity with medium-pressure boilers and turbine generators of higher performance and larger capacity. This will improve energy efficiency. Based on this background, the GEF sought to enhance the technical level of energy utilization in sugar refineries and to change their management mode through a demonstration project.

After a study conducted by the Government, it was agreed to take the Guangxi Guitang Group Company as the demonstration refinery because it is the largest sugar refinery of China and leads in comprehensive utilization. In addition, Guitang agreed to fund all technical innovations proposed by the project.

The milling capacity at Guitang is currently 10,000 tons/day, and it can treat more than 1 million tons of sugar cane annually, producing about a quarter million tons of bagasse. The proportion of pith from self-produced bagasse is 40 per cent, which means 100,000 tons of pith from the bagasse can be used as fuel for each year. The remainder is used as input for paper production. The proportion of pith from purchased bagasse is 15 per cent and 30,000 tons of pith can be obtained each year.

In the process of its expansion and technical alteration, most equipment for heat power in Guitang has been updated. Nevertheless, it still cannot satisfy the demand for electricity. A paper production line with output of 40,000 tons per year is in construction and will consume 7,500 kW of electricity and 40 tons/hour of steam. The new paper production line will require more electricity and steam than the old refinery could produce. Therefore,

the demonstration project not only satisfied the demand of expanding production but also enhanced the technical level of power generation and economic efficiency, as well as protecting the environment.

Technical scheme and implementation

The demonstration project installed a 12 MW turbine generator and its auxiliary devices and a new 75 tons/h boiler. In addition to bagasse, the boiler could also burn pulverized coal. Total investment for the project was RMB ¥ 34,936,100.00, excluding interest in construction period and current capital. Project evaluation was performed by the Guangxi Institute of Electricity.

As a result of the completion of the project in December 2004, energy efficiency and environmental conditions improved. The energy savings are shown in table 5.

Table 5

Coal consumption	New 12MW turbine generator	Old 12MW turbine generator
For steam	115.8 kg/t	117 kg/t
For electricity	401 g/kWh	560 g/kWh

The price of electricity if purchased from the grid is RMB 0.50/kWh. The cost of the project was RMB 0.274/kWh. As a result, Guitang will save RMB 18,790,000 a year from the project.

Emerging lessons learned

Industrial-scale biogas investments are feasible by the soundest Chinese firms. The biogas workshop series and the subsequent biogas investments by industry, which were facilitated by the workshops, demonstrated that the top 20 per cent of financially sound firms in the large-scale livestock and industrial sectors are able to finance such investments themselves and see these investments as a necessary and acceptable cost of doing business. At the same time, the project is supporting the development of a national action plan for industrial-scale biogas development, which will offer a blueprint for improving the domestic policy environment for creating favourable investment-grade biogas power projects that will further stimulate the deployment of biogas technologies for industrial applications.

Village-scale power continues to be one of the biggest challenges. Early project experience suggests that village power applications are going to require government assistance for some time, due to economics, the challenges of management arrangements, and the need for local regulatory and tariff frameworks. Most village-scale power systems managed by traditional utilities have not been successful in China. Other operating and management models are needed. Even collecting tariffs high enough to cover operating and maintenance costs can be a challenge; about 1 RMB/kWh (US 15 cents/kWh) seems to be about the maximum that can be collected. Households are willing to pay higher amounts for solar home systems, but as soon as grid extensions arrive, people compare themselves to those paying urban tariffs of 0.5 RMB/kWh or less.

Bottom-up village-scale power development works. Bottom-up development of village power schemes, done by local village organizations and business firms, "seems to invoke a greater chance of success by coordinating mutual interests at the earliest stage of development, generating commitment through face-to-face communications with working-level people, and following a rigorous process for clarifying the interests, roles, and responsibility of all parties".

Greater attention to capacity-building for resource assessment is needed. Resource assessment training activities have shown that potential Chinese capabilities for performing assessments are strong, but that a large training gap exists to bring these capabilities up to international best practices.

New national rural development programmes offer challenges and opportunities. The village-scale power programme was restructured to accommodate the reality of the Chinese Government's National Township Electrification Programme in western China. The project has refocused its efforts in support of this bold Chinese initiative, which represents the most aggressive international programme yet launched for rural electrification using renewable energy–based technologies. In the future, the project will provide training support to SDPC to introduce new ideas for business models for operation and management of village power systems and make linkages between village power systems and income generation, through use of productive applications and support of village enterprise development.

Information sources

General project information is available at the China Renewable Energy Industries Association website *www.creia.net.* Copies of the project proposal, the project document and periodical status reports are available at *www.gefweb.org*.