Final Evaluation Report
UNDP/GEF Project CPR/97/G31

Capacity Building for the Rapid Commercialization of Renewable Energy in China

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CAPACITY BUILDING FOR THE RAPID COMMERCIALIZATION OF RENEWABLE ENERGY IN CHINA

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China attaches great importance to the utilization and development of renewable energy and considers it as one of the most important instruments to promote socio-economic development. China's Renewable Energy Law will take effect on January 1, 2006. We will continue to pursue economic and social development under the concept of scientific development, accelerate economic restructuring and the transformation of the mode of economic growth, take further steps to enhance innovative ability, develop recycling in the economy, protect the environment, expand renewable energy development, promote the coordinated development of the economy with population, resources and environment, and build a resources-conserving and environment-friendly society.

It is very important to seek international cooperation in order to accelerate the development and use of renewable energy. The international community should enhance cooperation in areas such as research & development (R&D), technology transfer, and financial assistance, etc. that will increase the contribution of renewable energy to the socioeconomic development of man, and benefit people all around the world. I sincerely hope that the conference can play an important role in promoting the development and use of renewable energy worldwide as well as strengthening international cooperation in this field.

HU Jintao
President of the People's Republic of China

On the occasion of the opening of the
Beijing International Renewable Energy Conference (7 November 2005)

Table of Contents

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As the executing agency, UNDESA is being evaluated. In this regard, UNDESA has provided information to facilitate the process, but not direction and leadership. Thanks should go to the Government of China and other partners.

The evaluation was conducted by Mr. Jerome Weingart, a Consultant based in Arlington, Virginia, who participated in the three week in-country evaluation mission in March 2007; Ms. Eugenia Katsigris, a Consultant based in Beijing, China; and Ms. Judy Siegel and Kristin Stroup of the Energy and Security Group based in Reston, Virginia. The Evaluation Team wants to particularly acknowledge the extraordinary hospitality of our Chinese colleagues in both the public and private sectors who gave generously of their time and who provided substantial data, information, and analysis on the Project. For those who provided their time and inputs, acknowledgement is provided under Annex IV of this report. These meetings, together with field tours of facilities in four provinces, provided much of the basis for the evaluation presented in this report.

Acronyms

AG	Project Advisory Group
AQSIQ	General Administration of Quality Supervision, Inspection and Quarantine
BIREC 2005	Beijing International Renewable Energy Conference, 2005
BOD	biological oxygen demand
Bonn 2004	Bonn International Renewable Energies Conference (Bonn 2004)
CABR	China Academy of Building Research
CAE	Chinese Academy of Engineering
CAS	Chinese Academy of Sciences
CCRE	Capacity Building for the Rapid Commercialization of Renewable Energy in China Project
CDM	Clean Development Mechanism of the Kyoto Protocol
CGCC	China General Certification Center
CHP	combined heat and power (e.g., cogeneration)
CIARE	Chinese Industry Association for Rural Energy
CMA	Chinese Academy of Meteorological Sciences
CNAB	China National Accreditation Board for Certifiers
CNAL	China National Laboratory Accreditation Committee
CNCA	Certification and Accreditation Administration of China
CNIS	China National Institute of Standardization
CO_2	Carbon Dioxide
COD	chemical oxygen demand
CRED	Center for Renewable Energy Development
CREIA	China Renewable Energy Industries Association
CSTR	continuous stirred tank reactor (biomass processing)
CTS	National Center for Quality Supervision and Testing of Solar Heating Systems
DESA	Department of Economic and Social Affairs (United Nations)
DFID	UK Department for International Development
EAP	Energy and Atmosphere Program, UNDP
ERI	Energy Research Institute
ESCO	energy service company
ESG	Energy and Security Group
EU	European Union
EUEEP	UNDP-GEF End-Use Energy Efficiency Program
GEC	Global Energy Concepts
GEF	Global Environment Facility
GH	Garrad Hassan and Partners Limited
GHG	greenhouse gas
GIS	Geographical Information Systems
GOC	Government of China
GTZ	Gesselschaft für Technische Zusammenarbeit (German Organization for Technical Cooperation)
GW	gigawatt
GWe	gigawatt-electric
HEEEC	Hangzhou Energy and Environmental Engineering Co.
IMAR	Inner Mongolia Autonomous Region
IOF	Investment Opportunity Facility
IPP	independent power producer
kW	kilowatt
MOA	Ministry of Agriculture

MOC	Ministry of Construction
MOST	Ministry of Science and Technology
Mtce	metric tons carbon equivalent
mu	unit of area equal to 666.7 m^2 or 0.067 hectares
MW	megawatt
NAP	National Action Plan (biogas)
NDRC	China National Development and Reform Commission
NIM	National Institute of Metallurgy
NPD	National Project Director
NPC	National Project Coordinator or National Peoples' Congress (China)
PAO	Poverty Alleviation Office (China)
PMO	UNDP/GEF Project Management Office in Beijing
PPA	power purchase agreement
PRODOC	Project Document
PV	photovoltaic
R&D	research and development
RE	renewable energy
RESCO	rural energy service company
RESO	rural energy service organization
RET	renewable energy technology
SAQSIQ	State Administration of Quality Supervision, Inspection and Quarantine
SBR	sequential batch reactor (biomass processing)
SDDC	Song Dian Dao Cun, Village Electrification Program
SDDX	Song Dian Dao Xiang, Township Electrification Program
SDPC	State Development and Planning Commission (China)
SEPA	State Environment Protection Agency (China)
SETC	State Economic and Trade Commission (China)
SHS	solar home system
SI	system integrator
SPC	State Power Corporation (China)
SQTSB	State Quality Technical Supervision Bureau
STA	Senior Technical Advisor
SWH	solar water heaters
tce	tons of coal equivalent
TPR	Tripartite Review
TWh	terawatt hours
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNF	United Nations Foundation
UNFCCC	United Nations Framework Convention on Climate Change
UNV	United Nations volunteers
WASP	Wind Atlas Analysis and Application Program
WB	World Bank

Executive Summary

Overview

This final evaluation documents the results and impacts of the UNDP/GEF project *Capacity Building for the Rapid Commercialization of Renewable Energy in China*. The Project was executed by UNDESA and implemented in China by the State Economic and Trade Commission (SETC) until government restructuring in 2003, when the Project became the responsibility of the National Development and Reform Commission (NDRC). The Project was co-implemented by the State Environment Protection Agency (SEPA), and was co-financed jointly by the UNDP through the Global Environment Facility (GEF), the Government of the Netherlands, the Government of Australia's AusAID Programme, and the Government of China (GOC).

The principal objective of the Project was to promote the widespread adoption of renewable energy technologies (RETs) in China by diminishing and removing a range of barriers to increased market penetration of the technologies. The Project team approached these objectives through capacity building for key public and private organizations, facilitation of and support for new policy initiatives (notably the China Renewable Energy Law, which went into effect on January 1, 2006), development of new solar water heating standards, and through technical and co-financing support for high-value commercial pilot projects.

China has enormous renewable energy (RE) resources. The potential includes more than an estimated 1000 gigawatt-electric (GWe) of commercial wind electric power capacity (250 GWe on shore and 750 GWe off shore), 76 GWe of small hydro, 300 million mtce per year of biomass, and 6.7 GWe of geothermal energy based power generation. Two thirds of the country's land area receives more than 2,000 hours of sunlight annually, numerically equivalent to the energy equivalent of 1,700 billion tons of coal annually.

China's extraordinary economic growth coupled with the largest national population in the world and its massive dependence on coal for power generation has already led to many adverse environmental impacts on an unprecedented scale, especially air and water pollution. The International Energy Agency (IEA) has predicted that China's increase in greenhouse gas emissions from 2005 to 2030 will be comparable (at 42%) to the increase from the rest of the world (excluding India, at 44%).[1] China was expected to overtake the U.S. in 2007 as the world's largest greenhouse gas emitter. This Project has helped China to expand its commercial and industrial capability and capacity to mobilize clean and sustainable renewable energy resources including biomass waste from agro-industrial facilities, sunlight, and wind.

[1] International Energy Agency. 2007. World Energy Outlook 2007: China and India Insights. Paris, France.

Overall, the Project has helped to create, train, and mobilize a burgeoning industry of renewable energy companies, to directly leverage major government programs and policies, and to demonstrate new market-oriented approaches in project development and implementation of six pilot projects. The Project has strengthened local capacity in the transition from supply-driven to demand-driven technology deployment. In addition, the Project has provided the GOC, project developers, and technology suppliers with first-hand knowledge of market-based approaches through pilot projects in village power hybrid systems, industrial-scale biogas, and bagasse co-generation. For wind electric power and solar water heating (SWH), the Project has established standards for measurement and testing and in SWH has established a certification process. The Project has impacted national policy in the biogas, wind, and village power sectors and made a significant contribution to the development of the Renewable Energy Law.

The Project accomplished these results through such actions and initiatives as:

- Workshops that trained appropriate technical personnel in the use of international standards for RE resource assessment and advanced technologies for RE implementation;
- Study tours that exposed technical and Government personnel to international technologies, methodologies, approaches, and policies;
- Meetings and workshops that allowed for technical and policy information exchange;
- Pilot projects that provided appropriate equipment, market-based approaches, and international best practices in project development; and
- Extensive dissemination of information about the Project, the technology areas, and the methods employed for key Project activities through presentations at domestic and international conferences and workshops, the media, publication in highly visible magazines and journals, Project documents and guidebooks, and on-the-ground results.

A comprehensive list of documents, publications, and other materials generated by the Project is included in Annex I.

Key Outcomes

Key project outcomes are identified below.

Accelerated Technology Commercialization

Commercial systems approaches in large-scale biogas: The Project's integrated approach of capacity building, pilot projects, and knowledge dissemination has transformed the thinking of experts, industry, and policy-makers. End-users that formerly treated biogas as an environmental cost of doing business now can conceive of biogas production and conversion as a financially attractive option due to its potential for power generation and fertilizer production together with waste water cleanup and minimization. In this way, the Project contributed directly to the growth of the biogas industry and established a new commercial paradigm. Three industrial-scale demonstration projects combined with a series of regional business development workshops led to an expansion in commercial project development and the Project produced several key documents including an International Best Practices Report as well as Project Development Guidebooks. Significantly, the Project also facilitated the development of the National Action Plan for Biogas Development. Finally, the impact the Project had on direct commercialization cannot be overstated. Indeed, more than 50 direct project contracts resulted from the first three workshops with numerous secondary and tertiary development impacts. The Chairman of the Board of the Hangzhou Energy and Environmental Engineering Co. has stated that most of his business development has occurred as a result of contacts from the workshops.

Combined hardware and training support for wind site characterization: The training and equipment installations to characterize wind resources at the 10 wind project sites were well organized. The introduction of advanced technology and management standards led to the establishment of a Chinese wind measurement program, a basic wind profile for China, a national database for wind data, and promotion of commercial wind development. Within the lifetime of the Project, the 10 sites achieved 70% of the development capacity of the estimated 1,000 MWe potential at the sites, and two of the projects were included in the national wind concession program of the GOC. The international standards upheld by the Project have been adopted as the national standards, and capacity building was accomplished within key organizations and with Government partners.

Commercial approaches for village hybrid power systems and rural energy services concepts: The Project played a seminal role in transforming China's village power sector from a traditional supply-oriented approach to a business-oriented energy service approach. The Project supported *Song Dian Dao Xiang* (SDDX), the National Township Electrification Program. The survey conducted by the Project Team led to establishment of a SDDX database that has been very useful for monitoring the performance of all installed systems and for future planning. The Project has also supported the development of the Renewable Energy Law to include a system subsidy fund for rural electrification; development of a pilot project to demonstrate a service-oriented village power approach; emphasis on productive uses; and a comprehensive assessment of training requirements. While the Government is still determining—through the design phase of *Song Dian Dao Cun* (SDDC)—how to achieve sustainability of the rural infrastructure, the Project investigated management models through pilot projects and provided input on effective methods for electrifying the remaining villages. Overall, the Project succeeded in building capacity in issues of system ownership, system management, tariffs, administration, O&M issues, and productive uses of energy, much of which was reflected in an internationally acclaimed guidebook.

Capacity building in testing and certification: In the SWH sector, the Project identified the activity that best addressed the needs of the industry and market—an integrated national program of standards, testing, and certification—and implemented this program, including a multi-stakeholder process for securing Government and industry support. UNDP support of this initiative facilitated international information exchange, accelerated the timeframe for the program by 5 – 7 years, and resulted in seven new standards; protocols for testing, industry consensus, training, and information sharing; the establishment or support of three national solar water heating test centers; the establishment of a certification system; and the launch of the "Golden Sun" product label. The Project also raised awareness of the importance of quality control within the industry and opened the door to successful exports of Chinese solar water heating units and evacuated glass tubes.

Policy and Planning Leadership

RE legislation and policy advice: The UNDP Project has provided crucial input and support for the development of the Renewable Energy Law, including facilitating the initial decision in October 2003 to start the legislative process to develop the law. From that point on the UNDP Project staff was involved at all stages in the preparation of the Renewable Energy Law. At the start of 2004, the National Peoples' Congress (NPC) of the Government of China made the decision to develop legislation leading to the adoption of the renewable energy law for China. In February 2005, the NPC passed the law that for the first time established the national framework for the development of all sectors of the renewable energy industry. The Table on the following page provides the time-bound targets for the evolving shares of the overall electricity market and the primary energy market to be held by a mix of renewable energy options.

The Project's early advocacy of renewable energy, starting in 1999, contributed significantly to a change of attitude of senior policy-makers and planners toward renewable energy. Activities that contributed to the new and more positive perceptions regarding renewable energy included the presentations at the UNDP Project inception meeting, national conferences and workshops, international study tours to Europe, Australia, Japan and the U.S., establishment of showcase demonstration projects, and broad coverage by the mass media. The Project provided both key personnel and Secretariat services to support the formulation of the RE law, which has led to an acceleration of new renewable energy projects, particularly in wind, solar, and biomass, and has important implications for other countries looking to development renewable energy legislation

These combined actions resulted in a dramatic shift in the broad political and social atmosphere about renewable energy. In the initial stages of the Project it was difficult to get attention for the Project and for renewable energy, even at the vice-ministerial level. Today, the President and Premier of China are actively discussing China's renewable energy future, and this discussion extends to provincial leaders and industry.

Biogas National Action Plan (NAP): This Plan, completed in 2007, supports the market-driven approach promoted by the Project, and has contributed to new directions for biomass utilization by the GOC.

Wind concessions program: Along with the wind resource characterization activities of the Project, more commercial approaches were put forth by wind development experts. The approach of providing practical knowledge on wind resource assessment while moving the discussion on commercialization to a higher level in the concessions program continues to be successful. The standards introduced by the Project have been adopted as China's national standards.

China RE Installed Capacity and Targets			
Renewable Energy Option	**2005**	**2010**	**2020**
Hydro power	115 GWe	180 GWe	300 GWe
Wind power	1.3 GWe	5 GWe	30 GWe
Biomass power	2 GWe	5.5 GWe	30 GWe
Solar PV	0.07 GW(peak)	0.3 GW(peak)	1.8 GW(peak)
Solar hot water	80 million m^2	150 million m^2	300 million m^2
Ethanol	0.8 million tons	2 million tons	10 million tons
Biodiesel	0.05 million tons	0.2 million tons	2 million tons
Biomass pellets	~ 0	1 million tons	50 million tons
Biogas and biomass gasification	8 billion m^3/year	19 billion m^3/year	44 billion m^3/year
Share of total primary energy (including large hydropower)	~7.5%	10%	15%
Share of electric power capacity (excluding large hydropower)	~8%	10%	20%
Sources: Preliminary development planning targets provided by China Energy Research Institute, Energy Bureau of NDRC, and conference presentations by others. Current figures: REN21 Renewables 2005 Global Status Report and 2006 Update.			

Village Power: The UNDP village power team, composed of the PMO and a consortium of national and international experts, played a significant role in making the needs of the rural power sector known to top policy-makers through the Baseline Survey of SDDX and high-level discussions. The UNDP Project can be cited as a key contributor to the idea of inclusion in the RE Law of a system subsidy to support rural RE power systems.

Institutional Development

A major success of the Project was the establishment in 2000 of the Chinese Renewable Energy Industries Association (CREIA) and its current level of self-sustainability. CREIA was Government approved in 2001, and currently has over 200 RE industry and 40 expert members. It is now independent, internationally recognized, self-financed, and led by business. The Association has had a direct impact on the commercialization achievements of the Project, and serves as the clearinghouse for information on the RE industry in China including standards, technology development, market information, investment opportunities, policy, and training. CREIA has been responsible for a wide variety of renewable energy publications, workshops and seminars, and technology transfer activities. Its work has helped to broaden the ties of the industry to international partners and customers.

In a broad sense, the Project's coordination, cooperation, and networking within the Chinese Government and among other international organizations represents an important contribution. The Project has been effective in building networks and facilitating cooperation with other donors and projects.

Information Dissemination

In the period since the mid-term review, the Project has developed and disseminated information widely, both within China and globally. Mechanisms have included the production of major guidebooks, presentations at domestic and international workshops and conferences, and publication in widely read renewable energy magazines and journals. See Annex I for a comprehensive list.

Physical Hardware and Pilot Projects

Some of the hardware and pilot projects established as a result of the Project include:
1) Hybrid village power:
    a. Rapid installation of five wind-solar hybrid systems in Bulunkou Township, Xinjiang Province;
    b. Installation of a wind-diesel hybrid system on Bei Long Dao island (in progress), a state-of-the-art intermediate-scale village power system;
    c. Linkage to and leverage of NDRC's National Township and Village Electrification programs with the introduction of the Rural Energy Service Company (RESCO) concept as a key input.
2) Wind farm development:
    a. Installation of 40- and 70-meter anemometer towers to characterize wind resources at 10 sites with monitoring program established;
    b. By end-2005, 283 MW developed at four sites;
    c. Key input is that NDRC has built their national wind development program around the expansion of these sites to 20 additional sites for the entire country.
3) Biogas:
    a. Installation of three biogas systems at Dengta and Shunyi Pig Farms and Jiuchang Alcohol Distillery;
    b. Installation of biogas power generation at the Jiuchang Distillery;
    c. Key input is NDRC's use of biogas National Action Plan.
4) Solar water heaters:
    a. Establishment of four National Testing Centers (three supported by the Project) and procurement of equipment to develop test facilities at these centers as well as development of the testing procedures and protocols;
    b. Establishment of a national certification center and program for solar water heating products;
    c. Achieved accreditation as national test centers for Wuhan and Beijing Test Centers.

5) Bagasse:
    a. Installation of Guitang bagasse co-generation plant, resulting in a 28% increase in efficiency.
6) CREIA:
    a. Establishment of China's only renewable energy trade and industries organization.

Greenhouse Gas Reduction Benefits

Because 80% of China's installed power generation capacity is coal-fired, massive carbon dioxide (CO_2) emissions are associated with the power sector. In 2006 about half of all CO_2 emissions for the country were from the power sector. In CO_2-equivalent terms, all sources of methane were about 30% of CO_2 emissions from power generation. Methane and nitrous oxide emissions are primarily from agriculture and land change. A significant source of methane emissions is livestock such as cattle and pigs.

The activities of the UNDP/GEF Project focused on facilitation of commercial application of wind electric power, solar water heating, and use of methane from agro-industrial facilities (e.g. pig farms) for cogeneration of electricity and heat. In terms of GHG reductions, wind-generated electricity directly offsets electricity from coal-fired power plants and other electricity sources. Several of the wind projects developed under this effort have received Clean Development Mechanism (CDM) approval. Solar water heating offsets electricity that would otherwise be used for water heating, with about 60 – 80% of hot water being solar-generated in solar/electric water heating units, depending on the amount of available sunlight. Biogas-based power generation, through combustion of methane that would otherwise be released into the atmosphere from agro-industrial activities, offsets electricity from other sources and also decreases methane emissions.

With a particular emphasis on capacity-building, the Project did **not** have any requirement to address greenhouse gas (GHG) reductions, when it was first conceived in the 1990s. Calculating the impact of the Project on GHG emissions is difficult; however, calculations of the CO_2 emissions avoided through the wind and SWH activities of the Project were made during the last three years of Project operation. For the period of 01-07-2005 to 30-06-2006 it was calculated that wind project installations (200 MW) led to the avoidance of 0.4 million tons of CO_2 emissions per year in 2004 and 2005. Similarly, the Project estimated the CO_2 emissions that are avoided per year due to displacing electric water heaters with SWH. In 2005 if 70% of urban electric water heaters were displaced, the off-set CO_2 was equal to 7.75 million tons. If 35% were displaced, the emissions avoidance was 3.87 million tons. This data is shown in Tables 6 and 7 in the Conclusion section.

It is clear that the Project has led to *accelerated and expanded commercialization* of wind electric power (grid-connected wind farms), solar water heating, and biogas-based cogeneration. The project has also laid the groundwork that will help the industry to achieve larger overall long-term market penetration than might have otherwise occurred. Further, over the longer term (the next three to five decades) the impact of the project, through technical assistance and the provision of a new enlarged vision of possibility for the renewable energy industry, will have facilitated a much larger role for these technologies than might have occurred otherwise. Areas in which the Project is contributing to GHG reductions include the following:

- Directly through demonstration projects that result in the reduction or avoidance of GHG emissions.
- Downstream commercial renewable energy installations that replicate and/or leverage the Project demonstrations.
- Indirectly through policy promotion that is instrumental to the promulgation of policy, incentives, and particularly through the establishment of national targets for renewable energy.

Renewable Energy Links and Leadership in the International Community

One of the key activities of the Project was to expose Chinese decision makers and policy advisors to the latest development trends of the international renewable energy community. This was accomplished through numerous conferences, overseas study tours, and high level dialogues with senior policy makers in Europe, the US, Australia, and others. These activities culminated in China Day at the Bonn International Renewable Energies Conference (Bonn 2004), and hosting of the follow-on Beijing International Renewable Energy Conference (BIREC 2005) in November 2005.

At the Bonn 2004 Conference, the GOC made a landmark commitment to greater support for renewable energy development, including formulation of a renewable energy law for the country and creation of a national renewable energy development strategy and plan. During the Bonn 2004 event, senior Chinese decision makers announced an ambitious target to reach 16% of the country's energy mix from renewables by 2020;[2] this impressive announcement was considered one of the highlights of the meeting.

At BIREC 2005, China reported on its progress since Bonn—particularly the adoption of the Renewable Energy Law— and demonstrated it position as a world leader in renewable energy. At this event, President Hu Jintao stressed the commitment of China to accelerated development and use of renewable energy to address the increasingly serious issues of energy and environment. He also highlighted that China views renewable energy as one of the most important instruments in the promotion of China's economic and social development. Further, President Hu Jintao and several Chinese government leaders called upon the global community to have a shared responsibility in renewable energy development and use. *BIREC 2005 provided a platform for China to showcase its progress, programs, plans, and policies to accelerate adoption of these technologies, and produced the Beijing Declaration which identified areas for joint global collaboration in the areas of renewable energy* research and development (R&D), financing, technology transfer, technical assistance, and international cooperation to enhance poli-

[2] This 16% target was later reduced to 15% in the final development plan set forth in September 2007.

cies, markets, technology development, access to finance, entrepreneurship, and integration of renewables with energy efficiency and other clean fuel options.

This favorable attitude towards renewables, exhibited by the highest levels of the GOC, has had a significant impact on the world community. As noted in a recent report by Worldwatch Institute, China's meteoric rise in one of the most dynamic of today's energy sectors can be traced to a combination of policy leadership and entrepreneurial acumen. The country's new Renewable Energy Law is the product of an extensive process of international research and consultation, as planners within the powerful National Development and Reform Commission sought to learn from the success and failures of other nations.[3]

The UNDP/GEF Project, working in close cooperation with NDRC, played an important role in: exposing Chinese decision makers to international experiences and players in renewable energy; helping to put in place the policies and regulations that are making this one of the most rapidly growing markets worldwide; stimulating a rapidly growing industry base for domestic applications and export; and accelerating the country up the renewable energy learning curve. China's presence in the global marketplace has become a model for other countries worldwide, particularly those in the developing world. These countries are benefiting from the Chinese experience base, and from the South-South support that it offers. It has also contributed to moving clean energy to the forefront in global fora such as the 14th and 15th sessions of the Commission on Sustainable Development (CSD-14, 15) and the UN Framework Convention on Climate Change (UNFCC).

Dynamic Track Record of Growth

Since making its explicit renewable energy commitments in Bonn in 2004, China has realized tremendous growth in renewable energy and emerged as one of the leading countries in the field. Wind energy is the fastest growing technology in China, having doubled installed capacity in 2006 alone. China is now the sixth largest country in terms of wind electric generation capacity. In solar photovoltaics, China is the third largest country in terms of manufacturing; by 2010, solar PV manufacturing capacity is expected to exceed 4,000 MWp annually. For solar water heating, China was both the largest producer and user of these systems in 2006, with over 10% of residential households employing SHW systems. China represents more than 80% of global annual additions of solar hot water. Although the potential for bioenergy for power generation, industrial biogas, and biofuels is significant, these technologies-applications are at earlier stages of development. Overall, in 2007, China is expected to invest more than $10 billion in new renewable energy capacity, second only to Germany[4].

The booming market for renewable energy was catalyzed by the vision and leadership of NDRC, with substantial support by the UNDP/GEF/UNDESA Project Team,

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[3] Eric Martinot and Li Junfeng (November 2007). Powering China's Development: the Role of Renewable Energy. Worldwatch Institute Special Report. Page 5.

[4] Eric Martinot, Renewable 2007 Global Status Report, Report of the REN21 Renewable Energy Policy Network, November 2007.

the AG management structure, and the flexibility in Project design and implementation. The significant advancement of renewable energy in just a few short years was stimulated and made possible by the foundation of activities supported over the Project duration—from legislative training and technical assistance, to policy support, to industrial capacity development and pilot projects, through public awareness and outreach. The Project operated at the right place and at the right time; had a management team that could move from vision to action; worked in close coordination and cooperation with the GOC leadership; helped to strengthen an industrial base and supporting institutions (e.g., CREIA) that today is producing world class products and services; and made critical ties to the global community.

Overall Conclusions and Recommendations

The UNDP/GEF/UNDESA Capacity Building for the Rapid Commercialization of Renewable Energy in China Project has had a significant impact on renewable energy technology commercialization and business development in China. Biogas-based co-generation development was a direct result of the Project, and indirectly both solar water heating and utility-scale grid-connected wind power grew in capacity and commercialization due to the Project. Through its investment in site qualification for wind farms, the Project filled an important gap and helped to make the wind concessions program more commercially attractive. The combination of capacity building, pilots, policy studies, and information exchange in the Project was very effective and created synergies resulting in a whole greater than the sum of its parts.

For village power, the Project promoted a shift in Government thinking from a technology- and supply-driven approach to a holistic and demand-driven approach that includes productive uses and consideration of the operation and management aspects of providing a service. New business approaches were further disseminated with the publication of the China Village Power Project Development Guidebook, which filled the needs of both domestic and international practitioners. Though achieving sustainability is likely to be a long-term process, this shift set the stage for sustainable design of national electrification programs, which should be evident when SDDC is launched.

The Project, representing a true collaboration with GOC/NDRC, played a major role in the development of the Renewable Energy Law as well as the formulation of the implementing regulations. (See Textbox for NDRC Project perspectives.) The establishment of CREIA has been very effective in coordinating national RE development among government, industry, and academia and for promoting international collaboration with the Chinese renewable energy industry. CREIA has also been a major player in identification and facilitation of projects under the Clean Development Mechanism (CDM) in China, with much of the recent CDM initiatives being led by major corporations. CREIA also developed the first CDM project (at the Huitengxile Wind Farm in Inner Mongolia) to be successfully approved in China. Finally, the UNDP/GEF/UNDESA Project has provided valuable information and creative ideas to central and provincial Government agencies, industry, and academia; the multiple stakeholder process was supported through workshops and other forums of information exchange, and the institutionalization of this process within the GOC had a major impact on Project outcomes.

In conclusion, the Project is deemed a considerable success. UNDP/GEF/UNDESA are respected by top levels of national Government and known for delivering results. The redesign of the Project to focus on the four market sectors ensured that business development and commercialization were incorporated in Project outcomes, and resulted in significant development of the renewable energy industry overall.

Project Impacts from the NDRC—Implementing Agency—Perspective

"The Project design was an appropriate fit for the development of renewable energy in China during the period of time in which the Project was implemented. The Project closely complemented the strengths and weaknesses of renewable energy technology development and correctly anticipated the needs and demands for renewable energy development during the past seven years. Examples included: 1) the Wind component has become crucial to the support of industry development and accelerated commercialization of wind in China; 2) the SWH component has been able to serve and strengthen the market during a critical stage of market development; 3) the Industrial Biogas component was able to accelerate and change the market and the nature of technology deployment to move to a true commercial development model, and promote regulations to support commercialization and business development; and 4) the Village Power application component has also had significant and important impacts on the National Song Dian Dao Xiang Program.

All in all, the project was implemented during the right time period for renewable energy development in China and had the right concepts. The Project has provided and continues to provide support for the renewable energy development infrastructure in China. Some significant impacts of the project from the point of view of the NDRC include:

- The Project resulted in the formal initiation of the long term wind resource assessment national project in China, which secured 300 million RMB of financial support from the national budget.
- The Project results prompted the government to establish a national target for building 100 biogas power plants in China, and helped to promote the use of biomass pelletization technologies for practical applications in rural areas to increase the convenience of gathering/utilizing biomass feedstock. The technologies are easy to deal with, and the decentralized characteristics fit well with the realities of rural conditions.
- The Project was directly responsible for mandating SWH installation regulations, which are now in place, and helped to develop regulations that mandate installation of SWH systems in hospitals, department stores, schools, etc. that are across China.
- The Project helped to convince the national government to decide to build solar PV grid-connected demonstrations as concessions, using competitive public bidding to select the project developers and investors; these concessions are expected to help China to achieve its national target for installed solar power.

The project has been implemented in parallel with the development of renewable energy in China, and, with its support, many of the policies that now support renewable energy have been established through the Renewable Energy Law, its implementing regulations, and the national standards and certification system. We are expecting many more such policies to be established even after the project has reached its conclusion. With the foundation that this Project has constructed to assist the government in its support of renewable energy, we foresee a bright future for the continued trend of policy development in the central government and a bright future for renewable energy investment and commercial development. **In conclusion, the Project did what it was designed to do and has even exceeded expectations."**

Comments of Mr. Shi Lishan, Division Director of Energy Bureau, NDRC, at the Final Meeting of the Project Advisory Group and Tripartite Review Team, November 22, 2007.

1. Introduction

Purpose

This document presents the final evaluation report for the UNDP/GEF Capacity Building for the Rapid Commercialization of Renewable Energy in China Project, No. CPR/97/G31. This project was launched in May 1999, and completed in early 2007. Specific objectives of the evaluation report were threefold.

1. Evaluate and assess the *performance* of the UNDP/GEF/UNDESA Project in light of the objectives established in the original Project Document, as well as subsequent modifications in Advisory Group and Tripartite Review (AG/TPR) Meetings and in key project management documents.

2. Assess the overall *impacts* of the Project on capacity building for the commercialization of renewable energy, development of a legislative and policy framework supportive to renewable energy development, and assistance to China's effort in reducing greenhouse gas (GHG) emissions. A series of recommendations stem from the evaluation of the effectiveness of the implementation to increase Project impacts, and for the design of future technical cooperation projects in the field of renewable energy development.

3. Enumeration and summary of *lessons learned* in the project relative to improving the effectiveness of implementation of GEF Projects; experience toward achieving and exceeding GEF and UN energy and climate objectives that can be transferred to GEF project development and implementation activities; and experience relevant to improving project implementation, management, and impacts within the UN system.

Approach

This report builds on the mid-term evaluation report[5] submitted in January 2004. As with the mid-term review, this Project review focused on *four market application areas for renewable energy (RE):*

- Large-scale wind-electric power generation.
- Industrial-scale biogas for power generation and cogeneration at agricultural livestock feedlots and for industrial processes.
- Solar water heating.
- Hybrid village power systems for off-grid communities.

A fifth area—bagasse-based industrial co-generation in the sugar industry—is also addressed, however in much less detail as activities were scaled down during the

[5] Debra Lew and Winfried Rijssenbeek (Jan 2004). *China: Capacity Building for the Rapid Commercialization of Renewable Energy*. Report of the Mid-Term Evaluation Mission. 58 pp. plus annexes. Substantial parts of Sections II and III of the mid-term report have been reproduced herein.

second half of the Project to commit project resources to higher priority areas.

The review also assesses *two cross-cutting areas,* the impacts of which contributed to each of the renewable energy market segments identified above. These are:

- Creation and operation of the Chinese Renewable Energy Industries Association (CREIA).
- Development of the China Renewable Energy Law, in which the Project had a central role.

Methodology

Both primary and secondary data sources were used in the preparation of the final evaluation. Secondary sources included the project documentation base which consisted of project management documents, project semi-annual and annual reports, the mid-term project assessment, project technical reports, and presentations. The Project documentation and other published material used to evaluate the Project are summarized in Annex II.

Primary data was obtained during an in-country assessment which took place during three weeks in March 2007. The in-county mission focused on: (i) a further examination of the Project reports and records; (ii) interviews and meetings with the Project's major stakeholders, including government representatives, industry representatives, experts in the renewable energy community, and beneficiaries of demonstration activities; and (iii) a series of site visits to project pilot demonstration projects and other activities. The schedule of the mission activities and list of key interviews conducted is provided in Annexes III and IV, respectively.

Textbox 1. UNDP/GEF Project Activities

Technology and cross-cutting activities addressed a number of areas, including:

- Policy, planning, and strategy;
- Institutional strengthening;
- Development of new standards for the solar water heating industry;

The evaluation consisted of the following:

- Review of the pilot projects supported by the Project with site visits to selected projects.
- Assessment of activities and impacts of the Project's five technology/application sectors that define the scope of the Project's capacity building and commercialization priorities.
- Overview of the policy, business/finance development, and commercialization impacts of the Project.
- Evaluation of the activities and sustainable development of CREIA.
- Evaluation of support for project development and investment.
- Effectiveness and impacts of the Project's information dissemination and promotion campaigns and strategies.

- Critical examination of project management documentation and processes (work plans, reporting documentation/channels, management networks, etc.).

UNDESA provided the general (generic) guidelines for the project evaluation and background information. The Project Management Office (PMO) prepared briefing materials for the evaluator and coordinated the itinerary for site visits and the interview schedule. PMO personnel assisted the evaluator in these tasks. PMO files and documentation were made fully available.

Organization of the Report

The remainder of this report is organized as follows:

- **Chapter 2 Project Concept and Design** provides background information on the rationale for the Project, its consistency with UNDP objectives, funding collaboration, project relevance in China, project objectives and strategy, the role of the project document, and expected project outputs and outcomes.
- **Chapter 3 Project Implementation Assessment** provides an assessment of project management accomplishments and lessons learned.
- **Chapter 4 Wind Assessment** provides an overview of large-scale wind energy development under this project, key objectives, project results, and lessons learned.
- **Chapter 5 Hybrid Village Power Assessment** provides an overview of hybrid village power development under this project, focusing on the Bulunkou pilot project, the Baseline Survey of SDDX systems, and key capacity building activities as well as lessons learned.
- **Chapter 6 Biogas Assessment** provides an overview of industrial bio-gas development under this project, including the results of the three pilot projects; key objectives, project results, and lessons learned.
- **Chapter 7 Solar Water Heating Assessment** provides an overview of solar water heating development under this project, including development of testing and certification centers, and the perspectives of leading SWH industry players; key objectives, project results, and lessons learned.
- **Chapter 8 Bagasse Assessment** provides an overview of the bagasse-based industrial co-generation pilot project, objectives, and results.
- **Chapter 9 CREIA Assessment** provides information on task objectives, impacts, and lessons learned of the establishment and operation of CREIA.
- **Chapter 10 China Renewable Energy Law** provides information on the activities that led to the development of the law, the key components of the law, and the synergy with UNDP Project activities.
- **Chapter 11 Project Management and Cross Cutting Experience** provides an overview of activities, impacts, and lessons learned in the area of project management; and cross-cutting experiences; and project impacts.
- **Chapter 12 Conclusions**, presents concluding remarks and next steps.

2. Project Concept and Design

Background

Overview

China has one of the best renewable energy resource endowments in the world. National wind resource potential exceeds 1,000 gigawatts (GW). Solar insolation is excellent, with 1,700 billion Mtce of solar energy absorbed at the surface annually. Hydro, biomass, and geothermal resources are also abundant in some provinces, with potential annual resources of 300 million Mtce of biomass for energy purposes, 76 GW for mini-hydro (less than 25 MW), and 6.7 GW from geothermal energy.

During the mid-1990s when this Project was being conceived, renewable energy was at the margins of the energy sector and in the eyes of the government, despite this rich potential and its associated environmental and social benefits. Only small hydropower was fully commercial in China, with an installed capacity of 15 GW in 1993, representing 8% of the total national generating capacity. Other renewable energy sources, in contrast, were marginal: 150 MW of wind capacity, 3 MW of photovoltaics (PV), 30 MW of geothermal, and about 800 MW of biomass-fueled power systems.

Additionally, development of renewable energy technologies had focused largely on research and pilot demonstrations in China. For the most part, RE markets were poorly developed, and RETs not yet financially viable. Additionally, RET costs were high due to limited production and lack of economies of scale. Finally, for those RETs such as SWH, which were viable and widely used, hundreds of small companies in this market sector were manufacturing systems of variable quality, and eroding consumer confidence, especially for exports.

A study by the World Bank (WB) and the Government of China on *Renewable Energy for Electric Power* concluded that removal of the economic and institutional barriers could bolster competitiveness of RETs. Furthermore, a UNDP/WB/GOC study on *Issues and Options for Greenhouse Gas Emissions* funded by the GEF demonstrated that minor assistance in helping to level the playing field in the energy sector could release the potential of renewable energy and make a big difference in China's environment and greenhouse gas (GHG) emissions. According to the study, a baseline scenario, in which little or no additional action to promote renewable energy is taken, would lead to RE (excluding large and small hydro power) accounting for less than one percent of electricity used in the year 2020. With moderate action, however, the Chinese economy could draw as much as 6% of its power supplies from RE (excluding large and small hydropower).

With this in mind, the Project was formulated around the removal of the following non-technical barriers to the widespread commercialization of RE:

- **Limited scale of existing investments in RETs:** RE projects had been mostly pilot or demonstration projects, relying on grants, soft loans and support from local authorities. For renewable energy to make an appreciable contribution to sustainable energy development in China and for the industry to generate economies of scale to reduce production costs, a development program of an internationally unprecedented size was required.

- **Lack of familiarity with successful market-oriented efforts to commercialize RETs:** Few policy-makers and professionals were familiar with legislation and regulations which resulted in substantial RE investments in other countries. Other market-oriented approaches such as rural energy service companies had not yet been established in China.

- **Limited awareness of investment opportunities in RETs:** RE investment opportunities were obscure and undifferentiated from other rural and small resource utilization opportunities. In addition, they were perceived as a high-risk and low-return investment by potential investors.

- **High up-front costs and lack of access to credit:** Although RE alternatives can have very low operating costs—and thus lower life-cycle costs than conventional alternatives—the high initial capital cost of the technology was often an insurmountable barrier to its users, particularly for small rural energy users.

- **Incomplete assessment of renewable resources:** Current knowledge of the quantity and distribution of renewable resources and the data collection systems for renewable resources were largely inadequate.

- **High transaction costs:** RETs, particularly off-grid electricity and thermal applications, are often small and decentralized. This leads to proportionally higher transaction costs than for conventional energy sources.

- **Lack of standards and testing facilities for equipment:** The low quality of renewable energy equipment and the resulting lack of consumer confidence have been shown to be an important barrier to the adoption of renewable energy technologies in China. A lack of standards and best practices increased the perceived risks of RETs.

- **Poor linkages from R&D to commercialization:** Many Chinese RET designs had not been widely commercialized in the Chinese market. There was a lack of linkages between research institutes, the business community, and marketing.

Consistency with UNDP Objectives

The Project was a logical effort for the UNDP to initiate since it fits all six areas of policy focus of the UNDP of that time. These areas of policy fit were at that time:

- **Poverty alleviation and grass-roots participation in the Project**. One element of the Project was to develop village power pilot projects and commercial approaches in the management and operation of these systems in the remote areas of China, directly addressing the needs and involvement of the rural poor. The rural poor benefit from access to electricity, commercial approaches that involve local ownership of systems, and jobs created by the installation, operation, and maintenance of the systems.

- **Environmental problems.** The objective of capacity building in RE commercialization is directly linked with the environment. RE is seen as a serious alternative to the use of coal, a highly polluting energy source at a local (smog, particulate emissions), regional (acidification), and global (GHGs) level. It is fully understood that RE markets are at a nascent stage, and that, as such, the contribution to the energy economy is still small (except for hydropower).

- **Management development**. The Project was intended to introduce to Chinese decision-makers not only RETs (e.g. industrial biogas systems) but also the business models that can increase the deployment rate. The aim of the Project was to assist the GOC in developing conditions (legislation, ground data, ownership and operational models, quality control, etc.) so that the businesses (producers, operators, investors, etc.) could play their roles and create viable renewable energy application markets.

- **Technical cooperation**. An important aspect of the Project was the transfer of advanced equipment (e.g. industrial biogas systems, wind measurement systems, GIS systems, solar water heater testing equipment, village power equipment, and co-generation equipment) and know-how through direct collaboration between the UNDP and Chinese and international industries and experts, exchanging expertise and experience in renewable energy.

- **Technology transfer**. Technology transfer was at the heart of the Project. The technology transfer was in both hardware (e.g. biogas and co-generation equipment) and software (e.g. GIS systems operation, business models development, training, etc.).

- **Women in development**. The Project document specifically mentioned benefits to women in development, and this was mostly addressed in the village power sector. For example, the increased convenience brought by modern electric appliances reduces their daily workload and improves their quality of life.

Collaboration in Project Formulation and Funding

Launching this ambitious and path-breaking project took a good deal of effort by the UNDP and UNDESA. They collaborated with other organizations including the Government of Australia, the Government of the Netherlands, GEF, and the World Bank in the formulation and funding of the Project. Furthermore, UNDESA, UNDP, and the GOC cooperated well in integrating their goals for the Project. The result was a GEF contribution of $8.8 million, a contribution from the Australian and Netherlands Government totaling $5.5 million, and a Chinese Government contribution of $11.5 million, plus additional in-kind contributions from the GOC.

Project Relevance

At the time of the Project's conception, renewable energy was mentioned by the GOC in their planning process as important, but there were only limited investments and policy action for these technologies. International partners such as the UNDP and the World Bank were beginning to push for commercialization and widespread dissemination of new renewable energy technologies, a move which in retrospect has helped to leverage quite significant GOC investment and policy action.

The GOC is now looking to widely develop and disseminate the most promising renewable energy technologies. In the past, new technologies had been successfully disseminated using the national budget through centralized programs. However, the present fiscal climate limits this approach and consequently the GOC has been open to complementing government programs with a market-oriented approach to further develop, disseminate, and commercialize renewable energy technologies.

The Project

Project Objective

The development objective of the Capacity Building for the Rapid Commercialization for Renewable Energy in China Project was "the widespread adoption of renewable energy sources in China by removing a range of barriers to increased market penetration of the technology." This objective was supported by two major immediate objectives:

- Development of national capacity for the rapid commercialization of renewable energy in China.

- Removal of barriers to four promising renewable energy technologies.

Project Strategy

The overall strategy of the Project was to strengthen the capacity of China to shift from supply-oriented, state-supported technology deployment to demand-driven, investor- and consumer-friendly approaches to increase investment in renewable energy technologies. The Project complemented the UNDP program for energy and renewable energy in China, which supports the government in developing tools, skills, and capacity to implement RE policy.

The Project aimed to increase the rate of return and reduce the perceived risk of investments in renewable energy technologies for both consumers and producers by developing market-based instruments to increase the financial attractiveness of investments in renewable energy, including: (i) concessionary financing arrangements; (ii) targeted credit lines; (iii) tax relief to investors; and (iv) Power Purchase Agreements (PPAs).

To decrease the risk of investments in RETs, the Project aimed to: (i) carry out a resource base inventory for renewable resources; (ii) identify market potential and investment opportunities; (iii) improve access to information for decision-makers, (iv) develop national capacity for standardization and certification of technology; and (v) demonstrate technologies with near- and mid-term market potential.

To provide hands-on experience with a particular instrument/institution and demonstrate administrative and financial mechanisms, the Project aimed to carry out pilot projects in: (1) rural electrification by solar and wind hybrids; (2) wind farm development; (3) biogas production; (4) bagasse co-generation; and (5) solar water heaters.

Major components of the Project included training of national policy-makers, professionals, and businessmen; data collection and information exchange; and close consultation between regulatory authorities and the business community in the creation of standards and certification for RETs. CREIA was designed to assist in implementing these activities in a cost-effective manner.

It was recognized that the scale of assistance required for full commercialization of renewable energy could not be completed by this Project alone. Some barriers only become apparent as recognized barriers are removed. This Project was viewed as an important first step for the international community to help China with market-based deployment of renewable energy, with an emphasis on catalyzing additional donor support and private resources as well as coordination, information exchange, and RE promotion.

Project Document

The cornerstone of this effort was a Project Document drafted in close collaboration with the UNDESA, UNDP, GEF, the GOC, and domestic and foreign renewable energy experts. The document clearly stated the problem that the Project was intended to solve, the risks of carrying out the Project, the context of the problem, the institutional framework, project justification, the expectations of successfully implementing the project, the identification and interest of the intended recipients of the project outputs, the project strategy, coordination arrangements and detailed sub-objectives, outputs, budgets, training requirements, etc.

The Project Document was comprehensive and set the stage for a complete and integrated approach in terms of the cross-cutting goals of standards, commercialization, and investment. As a result of this cooperative approach, all of the key participants had substantive input to the Project from the beginning. This led to a widely accepted Project Document and broad stakeholder understanding.

As document implementation moved forward however, in the rapidly changing environment of China, it became necessary to update the design of the project. These changes were initiated by the various parties including UNDP, UNDESA, and the

PMO. The Project Advisory Group/Tripartite Review meetings proved an important tool for reviewing and approving the changes, making flexibility possible. Thus, the project staff, with support of other key stakeholders, refocused activities along the lines of the five-sector market focuses (technology/application sectors), including large-scale wind, industrial-scale biogas, solar water heating, hybrid village power, and bagasse-based industrial co-generation. This was necessary as it was determined that commercialization activities had to be tailored differently for each technology area.

Project Outcomes

The Project Document outlined the following outcomes:

1. Development of market-based instruments such as (i) concessionary financing arrangements; (ii) targeted, but market value, credit lines; (iii) tax relief to investors; and (iv) standardized PPAs; establishment of market-based companies such as Independent Power Producers (IPPs) and Energy Service Companies (ESCOs).
2. Establishment of pilot projects to provide national policy-makers and businessmen with first-hand knowledge of market-based instruments and institutions and demonstrate the potential of market-oriented approaches to develop RETs in China; international study tours to visit operating examples and in-country training to enhance exposure to market-based instruments and institutions.
3. Exploration of alternate financing mechanisms to overcome RE high front-end costs for individual households and small rural communities, including ESCOs, and end-user credit.
4. Assessment of the demand and supply for credit for small energy users, particularly for hybrid and biogas systems in the Project areas, and crafting of appropriate recommendations for the GOC to set up funds for renewable energy.
5. Awareness of RE investment opportunities with creation of an industry association and an Investment Opportunity Facility to collect and provide information about RE investment opportunities and returns on existing RE investments.
6. A national renewable resource assessment and a database accessible free of charge to potential Project proponents on the Internet.
7. Lowered transaction costs through "packaging" small investments—pilot projects using ESCOs and IPPs to demonstrate the ability of these mechanisms to increase investment opportunities. Further, lower transaction costs by giving investors easy access to investment information maintained by CREIA and in the database.
8. Development of standards for the manufacture and installation/commissioning of four RETs (SWH, intermediate wind turbines, and industrial-scale biogas and bagasse systems).
9. Improvement of R&D-to-market linkages; generic and appropriate designs developed and/or compiled for hybrid (PV, wind) systems, biogas and bagasse co-generation.

Project Outputs

The Project Document also set forth specific outputs organized according to the two key project objectives.

- Immediate Objective 1: National capacity developed for the rapid commercialization of renewable energy systems in China.
  - 1.1 Output 1: A sound operational basis for the Project established.
  - 1.2 Output 2: Strong institutions to serve as focal points for accelerating market penetration of renewable energy technology.
  - 1.3 Output 3: Capacity developed to implement market-friendly institutional and financial approaches for the commercialization of renewable energy systems.
  - 1.4 Output 4: Capacity developed for increased investment in Renewable Energy systems.
  - 1.5 Output 5: National capacity to assess renewable energy resource potential developed.
  - 1.6 Output 6: Standards and codes of practice established amongst the renewable energy industry.
  - 1.7 Output 7: Certification capacity established for solar water heaters.

- Immediate Objective 2: Barriers specific to four promising renewable energy technologies removed.
  - 2.1 Output 1: Removal of barriers to solar/wind hybrid electricity commercialization.
  - 2.2 Output 2: Barriers to wind farm commercialization removed.
  - 2.3 Output 3: Barriers to large-scale anaerobic biogas commercialization removed.
  - 2.4 Output 4: Barriers to bagasse co-generation removed.
  - 2.5 Output 5: Barriers to local financing of RE projects assessed and proposals for the removal submitted to Government.

Institutional Plan

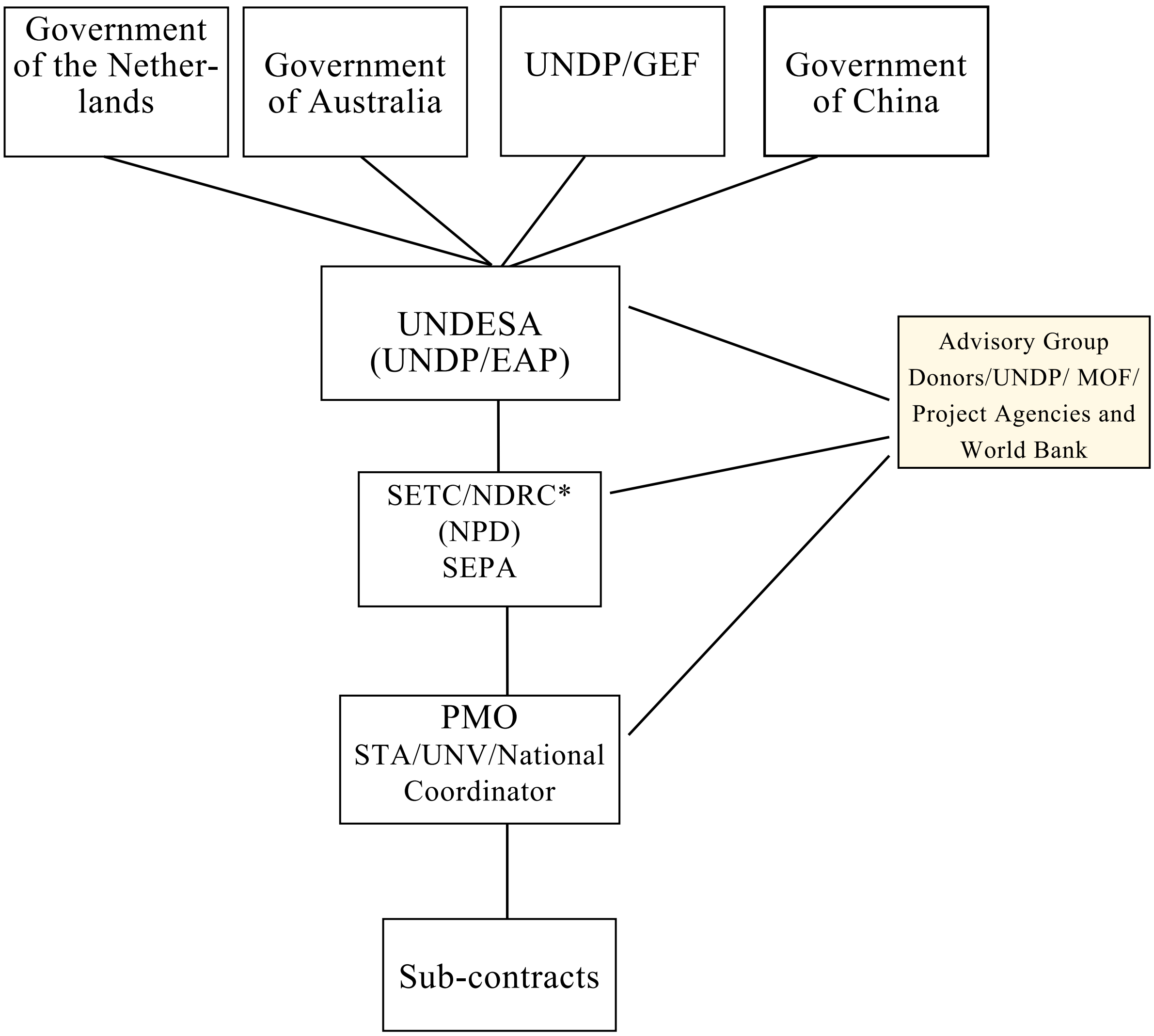
The Project Document presented a well thought out institutional plan for implementing and monitoring the Project (depicted in Exhibit 1, next page). Specifically, it called for:

- Execution by UNDESA with responsibility for procurement and payment of all services, subcontracts, and equipment in accordance with UN rules and procedures. UNDESA has been responsible for technical and financial reporting to GEF through the UNDP China office.
- Support on technical issues by the *Energy and Atmosphere Program* (EAP) of UNDP for selecting international experts and sub-contractors.
- A project *Advisory Group* consisting of: all project donors, Ministry of Finance, and the executing and implementing agencies. The Advisory Group has met twice per year to (1) review six-monthly progress reports (2) review brief documents outlining project strategy and targets for the following six months; and (3) provide general advice to the Project.
- Implementation by SETC with assistance from SEPA. The National Project Di-

rector (NPD) was originally Zhai Qing, who was replaced by Liu Xianfa, and then Shi Lishan when the Project moved from SETC to NDRC. The Director of the PMO was originally Liu Hongpeng, who was later replaced by Liu Wenqiang. This position moved to NDRC in 2003.

- A PMO to handle day-to-day implementation of the Project including preparation of work plans and reports, preparation of TOR and monitoring of subcontracts, and preparation of biannual and annual AG meetings. The PMO was staffed by four full-time professionals: one National Project Coordinator (NPC), one international Senior Technical Advisor (STA) and two UN volunteers (UNV). Wang Zhongying of ERI/CRED was the NPC; William Wallace was the STA; Fred Asseline and James Graham, the original UNVs, were later replaced by Jorge Ayarza. Wu Haiou served the PMO as the most recent Project Assistant. For the first three-quarters of its existence, the PMO operated with an average staff of six personnel. During the final two years of the Project, the PMO operated with an average full time equivalent staff of 3–4 personnel.
- The Deputy Directors of the PMO were Li Shaoyi of UNDESA and Luo Gaolai of SEPA.

Exhibit 1. Project Implementation Arrangements
(*National Project Director SETC replaced by Energy Bureau of NDRC in mid 2003)



3. Project Implementation

Introduction

Overall, the implementation of the Project followed the plan of the original Project Document. Many activities and outputs were completed within budget and on schedule. Some activities and outputs were delayed by specific issues with local cost-sharing or by changing situations and local conditions. Government restructuring and other national events led to unavoidable delays. Some adjustments were made to the original scope of the Project Document as market conditions in China changed and also through the normal learning process of the government and PMO in the Project.

The original document was prepared in the mid-1990s, but the Project did not begin practical operation until 1999. In some cases, changes in the local situation, especially the 2003 transfer of project leadership to NDRC, led to the original Project Document having even greater relevance. Examples include:

- Wind measurement program becoming a model for an additional 20 sites and being used as NDRC competitive bidding sites;
- The biogas National Action Plan feeding into the national energy strategy and the Renewable Energy Law;
- The village power program feeding into lessons learned for the National Township Electrification Program and the impending National Village Electrification Program.

The Project overcame many obstacles to implementation of the twin (and sometimes conflicting) goals of capacity building and commercialization. Considering the scope of the Project Document, the five market sectors, the limited staffing at the PMO, and the large number of workshops and pilot projects, the Project results are a tremendous achievement. The Project was designed over 10 years ago, and China, including its renewable energy situation, has changed considerably during that time. The pilot projects were particularly difficult due to top-down political pressures and need for local government support. In some cases, local governments were not willing to accept new approaches, which they viewed as risky. Transitions of staff at key organizations and donor partners, and government restructuring made it challenging to keep all stakeholders informed and integrated. Project management communication through annual and semi-annual reports and Advisory Group meetings allowed for opportunities to revise the scope of the Project Document.

Project Management

The effective and efficient Project Management team, consisting of the Beijing-based Project Management Office and the New York-based UNDESA Project Manager, was crucial to the implementation of this project. The number of components of this project and the tremendous number of activities planned, including 88 workshops over five years, were incredibly ambitious for a PMO staff of six and UNDESA staff of one. The dedication and long hours can be attributed to the following personnel:

- William Wallace, the STA, performed a yeoman's effort in managing activities in China, preparing TORs, directing subcontractors, liaising with UNDESA and the donors.
- Li Shaoyi, the UNDESA Project Manager and Deputy Director of the PMO, directed the Project activities, kept the Project on schedule, dealt with administrative issues, and facilitated the UN procurements, which were identified early on as a difficulty.
- Wang Zhongying, the National Project Coordinator, provided overall coordination between project components and with other Chinese programs, and Wu Haiou, Project Assistant, provided invaluable assistance in implementation of activities and monitoring of subcontractors.
- Professional Chinese staff, UNVs and administrative Chinese staff in the PMO were essential to carrying out many of the activities, including a tremendous number of workshops in the first 2.5 years. However, the initial two UNVs (Fred Asseline and James Graham) left after two years and after some time were replaced with only one UNV (Jorge Ayarza). The turnover of the domestic staff positions in the PMO, except for the NPC, was 50 to 100% per year.
- While CREIA is nominally a separate organization, the overlap of staff, office space, and information led to CREIA providing significant support to the PMO in executing the Project.

Lessons learned in project management will be discussed in later sections of this document.

Outcomes

The success of Project implementation can be measured by: (1) timely and high quality performance reports; (2) timely and accurate financial statements in conformance with UNDP financial practices; and (3) smooth and coordinated implementation of different Project activities reflected in a high delivery rate. The UNDP and other donors have been very impressed with the PMO and consider this to be one of the best PMOs they have had. Success is evidenced in the following:

- Reporting was timely and of high quality. The Project's Project Implementation Reports are used as models at UNDP.
- Financial statements were timely and accurate.

- Full compliance with the policy and procedures of UN, UNDP, GEF, and the Government authorities concerning the implementation of the technical cooperation project.
- Implementation of Project activities was coordinated and at a reasonably high delivery rate. Issues that led to less than smooth implementation include difficulties with pilot projects and political selection processes. Issues that slowed the delivery rate of activities include inadequate PMO staffing, lack of contractual timeliness at UN procurement, SARS, and government restructuring.

Some of the issues identified in the mid-term evaluation in project management included: 1) inadequate staffing of the PMO; and 2) slow UN procurement (average of 6 months), which hampered financial and administrative management. There were no clear UN policies or guidelines for how local resources could be used in procurement, so the Project management staff was forced to develop such mechanisms on their own. The PMO was able to utilize a local agent to speed up competitive solicitation processes, China Green Enterprises Ltd., which was approved by the UN.

4. Wind Assessment

Background

China has good wind resources, which to date have been exploited only minimally. Some studies indicate that there are 750 GW of potentially utilizable onshore resources (250 to 300 GW of which is commercially feasible) and over 1,000 GW of offshore resources. The current generally accepted wind power potential in China as announced by the NDRC is approximately 1, 000 GW, of which about 250 GW is on-shore potential and about 750 GW is off-shore potential. By the end of 2006, China had developed a wind capacity of 2,600 MW, with almost 1,400 MW of that installed during 2006. NDRC's wind power target for 2010 is 5 GW, and for 2020 is 30 GW, which would be 3 percent of national capacity. There are many in the field who feel that these targets are too low, and that China could reach 50 or 80 GW by 2020. The highest forecasts are for 100 GW, which would be 10 percent of installed capacity in 2020.

The growth of China's wind sector capacity was sluggish until 2004 or 2005, when it ramped up substantially. There are several reasons for the slow development of wind electric power in China prior to that time. Most of the wind electric power development had been financed or co-financed by bilateral development assistance agencies, based largely on grant assistance or very low interest bilateral loans. This has begun to change. In 2003, the first concession project was bid on and capacity growth began to accelerate the following year. In 2006, capacity doubled to 2.6 GWe. For 2007, the expected wind energy capacity additions are about 2 GWe. The Renewable Energy Law and other promotional policies played a large role in the growth of the wind industry, and this is expected to continue. The future for wind appears bright and there is potential for China to surpass India in installed capacity, even eventually to become the number one wind capacity country globally.

Wind Component Overview

The key focus of the wind Project component was to set the stage for commercial wind farms in China. The wind component grew out of discussions among SETC, SPC, UNDP, and UNDESA, who agreed upon objectives and held an experts meeting with government officials. Later, in order to choose the locations for the wind sites, an experts committee was set up. Ten sites were chosen for development in eight provinces.

The objectives of the Project were to: (1) work with leading organizations to apply international best practices for wind resource measurements and analysis; (2) introduce advanced technology and management for equipment, field installations, data acquisition and quality control, validation, evaluation, and assessment; (3) contribute to the national database with wind measurement and site characterization at 10 sites in China applying principles of international best practices; and (4) encourage commercial wind development at the project sites.

The key activities included:

- Selection of 10 sites with potential for ≥ 100 MW of development at each site;
- Involvement of 13 organizations in capacity building (including training of local institutions for field installation and data acquisition, and in international best practices wind resource measurements);
- Equipment procurement and field installations;
- Wind measurement program (initiated in Dec. 2002);
- Data acquisition and analysis support; and
- Linkages with national and local project development pipelines, including the NDRC national wind concession program.

The Project began in the first half of 2002. The wind resource data measurement and collection work was completed in the second half of 2005. The data collected from the 10 potential wind farm sites covered two complete years, though only one years' worth was validated per the contractual agreement. Under the guidance of the former State Power Corporation, the Long Yuan Electric Power Group (LYEPB) took part in project planning and took responsibility for the wind measurement work. This work included acceptance of wind measurement equipment, micro-siting of the masts (towers), data collection, and backup and transfer of wind data. Long Yuan was also responsible for installation, while the China Water Resources and Hydropower Consulting Corporation (hereinafter referred to as Hydropower), a consulting subsidiary under the Hydropower Research Institute, was responsible for data analysis. UNDP was responsible for contracting equipment purchase.

One of the main activities was to accomplish a wind resource assessment, which included measuring, data collection, and monitoring at the 10 sites based on international standards of data collection and with the intent of using this data in pre-feasibility studies that could be packaged as part of the government's wind concessions program. The 10 wind farm sites are shown in the below Table 1. After they were selected, (1) measurement and data collection was undertaken; (2) Hydropower was supported by the Project to analyze the data; and (3) the world-recognized international consulting organizations, Garrad Hassan of the UK and Risø National Laboratory in Denmark were brought on board to supervise quality control of the work of the involved Chinese organizations. The transfer of the Project to NDRC mid-way through the wind resource assessment program resulted in the monitored sites being used in the second phase of NDRC's Wind Concessions Program. Overall, the Project resulted in establishing the standards for a wind resource assessment and measurement system for China using state-of-the art equipment and analysis techniques.

Table 1. The Project's 10 Field Sites and Corresponding Local Field Organizations

Site	Local Field Organization
1. Datong Wind Farm, Jilin Province	Jilin Wind Power Company
2. Dali Wind Farm, Inner Mongolia	Chifeng Maolin Wind Power Company
3. Huitengxile Wind Farm, Inner Mongolia	Inner Mongolia Wind Power Company
4. Helanshan Wind Farm, Ningxia	Ningxia Power Company
5. Yumen Wind Farm, Gansu Province	Gansu Jieyuan Wind Power Company
6. Lichuan Wind Farm, Hubei Province	Lichuan Power Company
7. Poyanghu Windfarm, Jiangxi Province	Jiangxi Wind Power Company
8. Putian Windfarm, Fujian Province	Fujian Electric Power Survey and Design Institute
9. Gulei Wind Farm, Fujian Province	Fujian Electric Power Survey and Design Institute
10. Xuwen Wind Farm, Guangdong Province	Guangdong Yuedian Group Company

Project Roles and Responsibilities

The Project was structured into three groups of organizations:

- The Steering Committee, including NDRC, provincial DRCs, PMO leadership, and managers from Long Yuan Electric Power Company and Hydropower Consulting Corporation;

- The Advisory Group, including the two international consultants, Risø and Garrad Hassan; and

- The ten local field organizations listed above.

In terms of interactions among these groups, Long Yuan and Hydropower were the two main groups interacting directly with the PMO. Both of these, in turn, interacted directly with the 10 local field organizations and with the second international consultant, Garrad Hassan and Partners Limited in the UK. Hydropower alone interacted with the first international consultant, the Wind Energy Department of Risø National Laboratory in Denmark.

In terms of roles and responsibilities, Long Yuan was the Chinese implementing organization and responsible for coordinating the measurement and data collection activities of the field organizations with Hydropower. Hydropower's responsibilities encompassed implementing field visits and data processing, while staying in touch with the PMO, Long Yuan, the field organizations, and the two international consulting organizations. The 10 field organizations were responsible for completing data acquisition and performing preliminary processing—generally running things at the local level. Risø was responsible for assisting Hydropower to complete data management, site characterization and final data analysis, and field inspection visits.

One main focus was to improve and bring up to international standards the level of experience in wind modeling at the 10 wind sites. Risø was to assist Hydropower in this task, including wind resource assessment and site characterization in complex terrain. Garrad Hassan and Risø were responsible for completing certification of the various reports prepared. In particular, these organizations were to perform a critical assessment of the data acquisition, wind flow modeling and analysis, and site characterization reports to certify that the results met specified levels of accuracy and reliability.

Project Execution

The Project consisted of two phases. The first phase—project preparation—consisted of tower micro-siting, determination of the local implementing agency, execution of two training courses, and customs clearance, transport, and distribution of equipment. The second phase—project implementation—involved guidance on equipment installation, replacement of damaged sensors (anemometers), organization of inspection tours, a third training session, and the movement of two towers due to problems.

Textbox 2. The Concession Concept

A company is given the right to develop a wind farm in the designated concession area, as though the government owns the wind in that area. The company comes up with the investment, builds the wind farm, and builds the transformer station at the site. The connection to the grid may involve some cost sharing or may be fully invested by the utility. The government is responsible for building road access to the site. In return for its investment, the company

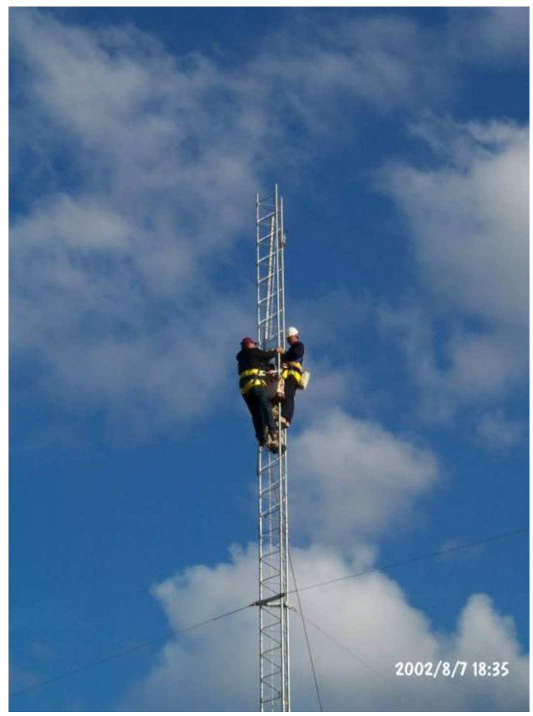
Phase I—Project Preparation

Long Yuan organized a team of domestic and international experts to carry out from July to September 2002 an investigation at each selected site and prepare a micro-siting report for each, determining the specific installation position for all the towers. The former State Power Corporation organized a micro-siting evaluation meeting to approve of this micro-siting work. Under the guidance of SPC, Long Yuan determined the local organization that would manage installation of equipment and be responsible for data collection, backup, and transfer for every site. Long Yuan signed an agreement with each of these local organizations.

The training courses were held in July 2002 in Huitengxile, Inner Mongolia, and in March 2003 in Beijing. The trainees in the first course were all persons responsible for installation and maintenance of wind measurement equipment. The main content of the first training was equipment installation, maintenance, and standard procedure for collecting data and filling in forms, and this training event was organized and managed by Long Yuan. The main content of the second training was data collection and data analysis. The trainers were experts from Hydropower and experts retained by the UNDP.

The wind equipment arrived in China in six batches during the second half of 2002. After customs clearance and inspection, the equipment was repacked and sent to each of the wind farm sites, all managed by Long Yuan. There are nominally four towers at each site, three of 40 meters in height and one of 70 meters.

Phase II—Project Implementation



During the second half of 2002, Long Yuan sent technical experts to provide technical support for wind tower installation and adjustment at those sites for which the responsible organizations were having trouble with installation.

Although data collection began in succession at the various sites from the end of 2002, the formal starting time was March 2003. Each month, the staff at every wind measurement site would carry out routine inspection, data collection, and data transfer. Aside from a few exceptions—in which the data recovery rate was 90 percent (because of natural disasters)—the recovery rate achieved was over 95 percent at most sites.

After the equipment had been up and running for one year, some of the sensors (anemometers) became damaged. In order to ensure the high quality of the wind measurement data, Long Yuan conducted an investigation and made a report on the damaged equipment. By August 2004, with UNDP's approval to purchase supplemental parts, all of the damaged sensors had been replaced.

In 2004, Long Yuan organized Chinese and foreign experts to carry out an inspection tour of the operational situation of the wind measurement towers. Though the assessment was generally favorable, some problems were identified; these were made key topics of discussion at the third training session.
The third training session was held at Putian Windfarm, Fujian Province, in March of 2004. The main topics of the training were filling in forms in a standardized way and on-site replacement of the sensors (anemometers). Anemometer replacement was taught first by on-site replacement of a sensor by a trainer, followed by the trainees themselves being asked to replace the sensors.

At the Lichuan wind farm site in Hubei, one tower was sited at a location at which the wind resources were relatively weak. At the Xuwen site in Guangdong, one tower could not operate properly because of typhoon damage at the beginning of 2004. According to the requirements of the UNDP Project, both of these towers were moved (in May and July 2004, respectively) and the wind resource measurement for them was started again from scratch.

Capacity building was an important focus of the wind resources work. If the only goal had been to provide good wind resource assessment data to develop specific projects, the most efficient approach would have been to hire a professional company experienced in this area. However, because the goal was broader, the Project Team worked with local organizations emphasizing the chance to give them experience and build their capacity. For this reason the training sessions were especially important.

Textbox 3. Hydropower ECG's Role and Impact

In the 1990s, the former State Power Corporation evolved into some smaller companies below the parent company and appointed Hydropower ECG in 1995 as a technical service provider for renewables, including hydropower and wind. When State Power disappeared and NDRC took over energy planning work, they also appointed Hydropower as a national technical wind service provider. Since then, Hydropower has formulated almost all wind technical standards published by NDRC. Hydropower itself reorganized and now has

Hydropower Engineering Consulting Group

Hydropower's work for the Project included several key components: (1) development of the data acquisition and management system; (2) development of quality control and data validation procedures; (3) analysis and preparation of monthly reports on data acquisition and quality control; (4) organization of wind site inspection tours; and (5) preparation of data summaries and conducting of wind flow modeling. The activities associated with each of these components are elaborated below.

Development of data acquisition and management system: Hydropower developed the data management systems, which included management of the wind measurement equipment at the field sites, the measurement tower equipment and configurations, and data from nearby meteorological stations and existing wind farms. The data was submitted by the field organizations to Long Yuan, which provided initial processing and checking of the data and then submitted the data to Hydropower.

Development of quality control and data validation procedures: According to requirements of the bidding document, Hydropower had developed software for the quality control and validation of the site measurement data. Hydropower now has about 10 clients nationwide using this software. This includes management of site wind measurement data, data reading, data editing, data check and validation, and data correction. The type of data in the model includes that designated as raw data, erroneous data, updated data, corrected data, time-selected data, etc. Based on results, a data recovery rate is computed.

Analysis and preparation of monthly report on data acquisition and quality control: During the Project, Hydropower conducted comprehensive analyses for the Monthly Wind Site Quality Control Report. This report listed all the un-addressed problems and all issues that needed to be addressed immediately and jointly by Long Yuan, Hydropower, and the international consulting experts. The report focused on the various processes of data management and quality control and included decisions made on modification, change, and replacement of sensors and wind towers.

Organization of wind site inspection tours: Hydropower organized inspection tours of the wind sites, which included inspection of the equipment operation, wind site management by the field organizations, and the activities of verification and modification. Hydropower investigated the need to move the 40 meter wind towers and was responsible for selecting the new site. The international consulting experts joined these wind site inspection tours and certified that the wind towers were erected, the sensors configured, and data acquisition procedures conducted in line with the requirements of the Project.

Preparation of data summaries and conducting of wind flow modeling: The software developed by Hydropower includes a portion that prepares statistics on the wind measurement data. This portion of the software includes data reading, data input, data output, and conversion of 10 minute average data to hourly average data. A representative data set is developed and compared to long-term wind data from a nearby meteorological station, if available. Various standard figures, including wind speed, wind power density distribution, wind direction, and wind energy are displayed in charts. Turbulence, wind shear, and power production, as well as other parameters, are modeled. The wind flow modeling makes use of selected analysis techniques and modeling tools, mainly the Wind Atlas Analysis and Application Program (WASP) from Risø and WindFarmer from Garrad Hassan. With such methods, Hydropower processed the data from all 10 wind farms for an entire year to get wind resource site maps, wind speeds in complex terrains, estimates of wind energy potential of the sites, and other data. Hydropower prepared a wind site characterization report after these activities were concluded.

Long Yuan

Since the Project began in 2002 many changes have occurred, including restructuring in the government. As previously mentioned, the Project was transferred from the SETC to the NDRC. The original organizing company on the Chinese side was the State Power Corporation (SPC), which no longer exists. Its contract was passed on to Long Yuan after government restructuring, as Long Yuan was an offshoot of SPC, and Long Yuan retained the implementation responsibilities. Long Yuan's role in the Project's wind resource assessment work was to: (1) accept equipment, (2) train field organizations, and (3) act as the central organization for collecting data.

According to Long Yuan, most of the wind measurement equipment associated with the UNDP Project is under the control of the local institutions. In the past, Long Yuan paid some of them to keep up the equipment, but none have been paid for more than a year. Most of the sites have stopped collecting data, though Ningxia is still collecting data for its own purposes. It should be noted that as the Project is coming to a close, there is a need for the equipment ownership to be formally transferred from UNDP.

Textbox 4. Long Yuan's Role and Impact

Long Yuan's parent company is Guodian, one of China's five big power companies post-SPC. Long Yuan is the only Beijing-based wholly-owned subsidiary of Guodian, and is focused on renewables, primarily wind, but also some biomass. In the wind sector, Long Yuan is well known, having in the past accounted for one-half of China's installed wind capacity. The company's wind capacity doubled from 2002 (224 MW) to 2005 (416 MW) and rose rapidly in 2006 to 760 MW. In 2007, Long Yuan expects to surpass 1 GW of installed wind ca-

Results

At the close of the Project, the achievements of the wind component are evidenced by the following: two of the wind projects have been included in the national wind concession program; the Project resource assessment standards and measurement protocols have been adopted as the national resource assessment standards; and the 10 sites assessed under the Project achieved 70% of the nominal wind development capacity potential in aggregate for the sites. Importantly, the Chinese Government now acknowledges the importance of resource assessments and the accompanying standardization of this process, and capacity building was accomplished within key organizations and Government partners.

The key Project accomplishments of the wind component include:

- An established and documented basic wind profile for China;
- The introduction of advanced technology and management standards for equipment, field installations, data acquisition/quality control, validation, evaluation, and assessment;
- Establishment of a Chinese wind measurement program;
- Development of a national database for wind data that has been very useful for monitoring the performance of all installed systems and for future planning. Also, established national technical codes for wind farm development, and standardized analytic procedures consistent with international best practices;
- Characterization of sites at 10 locations in 8 provinces in China, for which data collection spanned 2 full years;
- Promotion of commercial wind development at Project sites, resulting in development of 283 MW at 4 of the sites by end-2005;
- Thirteen (13) organizations involved in capacity building:
    - Multiple training courses held in field installation and data acquisition;
    - Nine (9) training documents and >10 siting reports generated.

These accomplishments will be elaborated in the below section.

It is of national importance that the 10 sites developed under the Project have been included in NDRC's list of projects for large-scale wind farm development. Huitengxile, one of the Project sites, now has two 100 MW wind farms under construction as a national concession project. Other sites have been developed at the provincial level, including Helan (112.2 MW), Yumen (77.7 W), and Datong (49.3 MW installed, 49.5 MW under construction).

Wind Measurement

Prior to the UNDP Project, measurement and wind resource assessment in China was rather rough and done with low quality anemometers. Now, all the wind developers in China recognize the importance of wind measurement and pay more attention to it. It is also notable that 70-meter anemometer towers can now be found throughout China as a result of the Project. The towers used prior to the UNDP Project mainly consisted of 10-meter meteorological towers with only one anemometer at weather stations located throughout China. Wind farm operators and project developers used an assorted array of measurement towers and sensor configurations that with few exceptions met international best practice criteria. Many of these configurations are not qualified under current national standards, for example, at many sites it was not possible to analyze wind shear. It is also important to separate wind speed and wind direction, so having two devices at least one meter from each other is necessary.

Standard National Resource Assessment Protocols

Hydropower was asked by the NDRC to prepare a guidebook for wind resource assessment protocol standards; Hydropower used the UNDP Project protocols in carrying out this task. The standards have been adopted and published by NDRC as the national standards for wind resource assessment. In the future, NDRC will use these standards to ensure those wishing to establish a wind farm have met requirements. The wind resource assessment must be included in the feasibility study for wind farms. This outcome, in which the Project's output serves as the basis for NDRC's standardization of its national wind development program, is one of the key accomplishments of the Project's wind component.

Textbox 5. Impacts Beyond China

In 2006, a Hydropower delegation traveled to Cuba to help with wind resource assessments. Cuba is interested in buying equipment from Goldwind, China's top fully-domestic turbine producer. The delegation met with Fidel Castro and learned that Cuba wants to conserve energy and develop new energy resources. Cuba is also included in SWERA wind mapping and work is being done with WASP in cooperation with Risø. This provides a good example of how concentrating on capacity building in the larger developing countries can. through

Impacts on National Wind Plan

When the NDRC was evaluating the concession concept, including writing of the concession bidding documents, the Project was influential in introducing options for feed-in tariffs. In 2003, NDRC held a meeting in Xinjiang to discuss strategic planning for wind and came up with the 2010 and 2020 targets. They also came up with the idea of regional planning at this meeting. NDRC sent out an order to all the provinces to begin the planning and resource assessment process in each potential project area at a certain level. In effect, this made all provinces in China responsible for developing resource assessment data. Because Hydropower was commissioned by NDRC to do the training in each province that they had done under the UNDP Project, it has therefore become the basis for continued development of wind resource assessment capacity in China. In addition, the Project's protocols for wind resource assessment have been adopted as the national standard, so the Project also serves as the standard by which the expanded NDRC mandate for assessment must be carried out.

Development at Project Wind Assessment Sites

Four of the sites at which the UNDP Project supported wind resource assessments had developed 283 MW of wind farms by the end of 2005. These included:

(1) 68.5 MW in Huitengxile, Inner Mongolia, developed by Beijing International Electric New Energy Co. and Huadian Inner Mongolia Wind Power Co.;
(2) 52.5 MW at Yumen, Gansu, developed by Gansu Jieyuan Wind Power Co.;

(3) 112.2 MW in Helan Shan, Ningxia, developed Ningxia Power Group;
(4) 50 MW at Taonan, Jilin, developed by Datang Jilin Power Generation Co.

Most project development has been promoted at the provincial level, except for Huitengxile, which was included in the NDRC's 2002 national wind concession program. Another 430 MW was in various stages of development in project pipelines, including 100 MW at Yumen, 50 MW at Taonan, 50 MW at Gulei, 50 MW at Putian, 50 MW at Poyang Hu, 50 MW at Xuwen, and 80 MW at Lichuan. Therefore, during the course of the Project, approximately 700 MW of wind development has occurred at fully constructed wind farms or in project pipelines.

One of the Project's original aims was to encourage 1,000 MW of installed capacity (10 x 100 MW per site) through the investment provided by the Project's local partners at each site. The Project did not directly participate in commercial wind farm development in the measurement activities. Nevertheless, during the course of the Project, development has occurred or is occurring at most sites so that at the end of 2005, 700 MW (or 70% of the target) was completed or in development.

The Project also assisted Hydropower in developing wind resource assessment software that is internationally acclaimed. At present, almost all of the large wind power developers are applying this software.

Policy Impact

The Project was heavily involved in the development of the Renewable Energy Law, which will further spur on development of the wind sector. In addition, the Project has played a role in the execution of the *National Action Plan for Wind Energy Development* for NDRC, which applies to wind farms and the wind industry, and also provided input to a *Wind Roadmap* in preparation for China by the Renewable Energy and Energy Efficiency Partnership (REEEP).

Popularization of Quality Control and Analysis Software

Hydropower's software, developed for fast validation of the wind measurement data at the Project's 10 sites, is a world class software package that incorporates a high degree of automation for raw data processing. It also incorporates data quality control, parameter analysis, and the measure-correlate-predict method for wind resource assessment. Hydropower has organized two training courses on its software, one in 2005 and one in 2006. The trainees include all stakeholders interested in wind resource measurement and assessment. Hydropower has about ten clients in China that have purchased the software for use as a tool when compiling site reports.

Hydropower has provided training on use of its quality control software two times. It has also provided training on the national technical standards it developed. This latter training has been provided to local DRCs, officials and developers, also two times. These trainings helped to promote Hydropower's software product.

It is clear that the Project played an important role in making Hydropower an important actor in China's wind sector. In addition to the popularization of its software (the best such software in China and also superior to many similar international software packages), the protocols developed by Hydropower under the Project have now been adopted by NDRC as standards for the industry, further raising the company's stature in the field.

Impact on Quality of Wind Resource Assessment

Before the Project, there were no detailed standards to follow in wind resource assessment, including both measurement and analysis. At that time, only one 10-meter tower was used and the data indicated low wind speeds not suitable for commercial wind farms. Wind resource measurements need to be conducted at the hub heights of modern large wind turbines (megawatt-scale), and measurements at two heights (at least) are required to obtain an indication of wind sheer, which is the rate with which wind velocity increases with height above the ground. Megawatt-scale wind turbines have hub heights typically in the range of 60-70 meters. The Project introduced a set of one 70-meter tower and three 40-meter towers along with new standards. The new tower set-up and standards are being used across China, so the impact is significant. Overall, the Project resulted in a great upgrade in wind resource assessment work in China, with a heightened awareness of its importance among officials and investors alike.

High Quality Wind Data

Very detailed wind data was obtained from the 10 sites, providing the basis for future steps in the development of wind farms at the sites. Altogether, 60 million data points were collected. The wind resource data from five sites is already being used as the basis for construction of five wind farms, thus providing strong support to the development of wind power in China:

(a) Huitengxile Wind Farm in Inner Mongolia has already been chosen to be a national concession project of 100 MW. There will also be a second phase project at the site of another 100 MW.
(b) A 50 MW installation at Yumen Wind Farm in Gansu has been completed. The installed capacity today has reached 110 MW.
(c) The Lichuan site in Hubei has become the province's first concession project, with a capacity of 50 MW.
(d) The data from the Helanshan site in Ningxia were used in the design of a 112

MW wind farm. This year an additional 30 MW is being constructed, and in 2008 an additional 40 MW will come on line.

(e) Plans are underway for bidding for a provincial concession project at Duchang in Jiangxi.

The timing of the Project was opportune, as the rapid growth of China's wind sector was made more sustainable by the improved quality of resource assessments. When the UNDP Project started, China had only a few hundred megawatts of installed wind electric power capacity. In 2006 alone, China added 1,330 MW, doubling its wind capacity to 2,600 MW. The wind farms constructed since 2004 have most likely used the new wind resource assessment standards formulated through the Project. Since the concession program started in 2003, calling for up to 300 MW for the largest projects, China is seeing more and more frequent initiation of wind farm projects. In addition, the NDRC has issued orders to all the provinces to carry out resource assessments looking at several sites. The government, via the Ministry of Finance, intends to support wind resource assessments to find new sites for a total of 50,000 MW. To date, however, most wind resource assessment has been paid for by developers.

Some of the Project results are already in use in the National Wind Concession Plan. A few sites, including Ningxia and Gansu, have already become national wind concession projects. For two of the sites, the wind resources data obtained through the Project were used for development of wind farms at those sites.

Achievements in Wind Site Selection

The wind assessment sites selected cover the zones in China rich in wind energy resources, including the southeast coastal area, North China, Northeast China, and Northwest China. The sites also include two sites (Lichuan, Hubei and Duchuan, Jiangxi) that have the typically complex terrain found in some parts of China. Given the distribution of sites, the wind measurements obtained provide an overall profile of the wind resources in China. Expert opinion was widely sought and adhered to in determining sites for the towers, so that the sites are, to a certain degree, representative.

Technical Capacity Building

The Project has trained and given practice to a large contingent of wind resource measurement personnel. It has raised their specialization level and capabilities. Focusing on the different characteristics of each phase in the work, the team organized three trainings with different content and different key areas of attention. The capabilities of trainees were raised in the areas of theory and the application of wind resource management software and hardware.

Information Dissemination

Reports and documents completed by Long Yuan and/or its subcontractors as a part of the UNDP Project are as follows:

(a) Training materials: *Wind Resource Fundamentals, Site Monitoring Plan, Site Specific Resource Assessment, Data Validation Examples, Energy Estimates, General Implementation Guidelines of Wind farm Renewable Resources Assessment Project, NRG Tower and Anemometer Installation, Installation Direction (on Land) for ROHN Tower, and Handbook for Maintenance for ROHN Tower*.

(b) Micro-siting reports: general report (*Site Investigation Report for UNDP China Wind Resources Assessment*) and sub-reports for each site (*UNDP Wind Resources Assessment Project Site Selection Report for Lichuan-Laoyeiao-Xuwen, Fujian Wind Measurement Site Selection Report, Yumen, Gansu Wind farm in Wind Measurement Site Selection Evaluation Report, Jilin Wind Measurement Site Selection Report, Huitengxili and Dali Site Selection Report, and Ningxi Wind Measurement Site Selection Report*).

(c) Periodic reports: *Materials Reporting on Installation, Management, and Data Collection* (altogether four volumes), *Report on Implementation of Wind Measurement Equipment Installation Equipment at Each Site for UNDP Project,* and *UNDP Project Mid-Term Report*.

Impact of Variable Wind Power on the Grid

The need to evaluate the impact of variable wind resources on the power grid is included in the national wind plan. At present the approach is to limit the maximum share of wind power in each province to five percent. However, many stakeholders in the wind field believe this could be increased to 10%, similar to that suggested for the U.S. in the past. A possible area for future international support could include: (1) determination of the economically reliable and developable resources and (2) determination of how much wind power each provincial grid can accept. The precursor to this work is in the final completion stage starting with a project conducted in Zhangbei in northern Hebei Province in cooperation with the NDRC, Hydropower, and the National Renewable Energy Laboratory in the USA.

Impacts on Hydropower

According to Hydropower principals, the greatest impacts of the Project were: improved detail and accuracy of standards; contact with international experts; and lowered financial risk. In the absence of the Project, according to Mr. Shi Pengfei of Hydropower, the company would not likely have developed such detailed and accurate standards, and there would have been much less international contact. In addition, had Hydropower pursued the same goals with the lower quality wind resource assessment standards that existed before the Project, there would have been considerable more financial risk in project development.

In terms of capacity building, Hydropower benefited from the Project in four main areas: (1) organizational accomplishments; (2) training; (3) data management and analysis; and (4) site visits and coordination of international consultants. Each of these areas is elaborated below.

Organizational accomplishments: During Project preparations, Hydropower was involved in organizing different committees and organizations as well as three conferences in Beijing. Through this work a closer relationship with high-level organizations—the central government, the local government, and domestic and international consulting organizations—was developed.

Training: In 2003 and 2004, Hydropower participated in two training courses, one held in Huitengxile, Inner Mongolia and the other held in Putian, Fujian. Training course participants were the persons responsible for data collection and the engineers from each of the ten field organizations. Hydropower experts provided instruction on how to make professional site visits, how to keep a good site log, how to maintain the sensors in good condition, and how to gather data that meets requirements.

Textbox 5: Long Yuan's View of Project

The key principal of Long Yuan, Mr. Yang, remarked that the Project made an important contribution to the nation as a whole. Before the Project, there was only one company in China involved in wind development, and the government was unsure as to whether wind power should be pursued or not. Looking at the wind sector today, with multiple companies active in wind development in a commercial environment, the government has clearly taken a keen interest in wind.

Data management and analysis: In order to achieve international best practices in wind resource assessment, Hydropower kept in close contact with the best wind resource assessment organizations in the world during the Project. In 2004, an engineer from Hydropower went to Risø Lab and worked closely with Risø senior scientists; in addition, in the same year Hydropower sent an engineer to Madrid to attend a course on wind resource assessment and wind farm optimization held jointly by Risø and Garrad Hassan. As a key accomplishment, Hydropower has developed software focused mainly on quality control, validation, and analysis of wind data. The software is based on international best practices and recommendations from Risø and Garrad Hassan. The software

achieved a leading edge standing in the field and passed examination by the Chinese Academy of Meteorological Sciences (CMA) as well as Risø certification.

Site visits and coordination of international consultants: Hydropower was responsible for organization of Risø and Garrad Hassan site visits. Hydropower was also responsible for providing comments to local organizations to improve wind measurement and data acquisition. For example, in Inner Mongolia, they recommended a separate measurement of wind direction and wind speed. They also developed a procedure to deal with the tower "shadow effect" by using two anemometers.

Impacts on Long Yuan

The key impacts the Project had on Long Yuan were capacity building and international cooperation. Company staff became more familiar with the procedures of wind measurement, including installation of sensors and technical specification. Ten staff members were directly involved in the Project. The training provided through international cooperation to these staff can be passed on to others within the company. Long Yuan also won the bid to develop the Yumen, Gansu, wind farm.

Along with China Guangdong Nuclear Power Company, Long Yuan has a national training center in Suzhou, which is open to the entire country. The center is supported by GTZ, and focuses on wind technology and practicum. It is assumed that indirectly, the Project has had an impact on the curriculum at this center.

Lessons Learned

Over the course of the Project period, the wind component generated some useful lessons learned as a result of the problems encountered. Some of these problems were caused by unavoidable external reasons, such as government restructuring, problems coordinating with local level organizations, and problems from natural hazards like the blizzard at Lichuan (such as towers falling over and breaking due to weather). In the end, the data collection period had to be extended by one year to address such problems.

Some of the main delays, however, came from the UNDP side as the ordering of equipment was very slow as was the bidding for data analysis. The PMO found that it takes a minimum of six months to get procurement issued and then three more months to get equipment—a total of almost a year to get equipment in the field. In addition, the fact that close to 30 organizations were involved in the Project, including nine field organizations, three international groups, and two high level government agencies, created challenges and delays. However, the positive side of the high number is the much larger base for diffusion.

Capacity Building

The first lesson learned is that for China's wind sector and installed capacity to develop, it must have domestic capacity and minimize dependence on external expertise. This was especially true in terms of the resource assessment, and looking ahead, it will be true in terms of grid integration. In order to integrate wind power to the provincial grids, a similar process will be required whereby external experts undertake training and capacity building to instill the necessary analytical capability, management capacity, and tools.

In order to minimize dependence on external expertise, international cooperation is a must. In the wind component of the Project, the team found the international cooperation aspects of the project very helpful and worthwhile. It helped in terms of quality control and validation procedures—to make the data more reliable. It also helped China employ more accurate and sophisticated techniques in using the WASP model for wind flow analysis and site characterization. During collaboration with Risø, Hydropower gained more skills with the WASP model, including an understanding of what kind of parameters to think about. The result was a more accurate wind flow model application to China.

Similarly, the Project found that in commercial development of the sector the choices are either to build the capacity of already experienced organizations or hire a professional team immediately. Capacity building from the ground up with inexperienced organizations will slow down the project and may compromise project quality. A delicate compromise is required between the two, as capacity building is necessary to ensure the sustainability of the project, but ensuring quality is equally important for the same reason.

Contracting and Procurement

The above lessons learned were generated from the wind component but apply in general to all sectors. Another such general finding was that procurement and contracting processes need to be streamlined. Bureaucratic contracting procedures can result in significant delays, and these must be accounted for in the project plan. In addition, procurement can also require set-backs and delays. International procurement is more time-consuming, expensive, and complicated than domestic, but domestic procurement requires an external review, which also causes delays.

Flexibility

During the course of the Project, China's electric power industry was restructured and deregulated, which required the Project to adapt both its structure and affiliation. This presented an enormous challenge to the Project. Originally, the Project was under the SETC, and the implementation organization was the former State Power Corporation. Before the power sector was restructured, the State Power Corporation had control of the power companies at the local level. After restructuring, however, the various local utilities did not have higher level organizations to answer to. So Long Yuan, which took over implementation after the State Power Corporation was dissolved, had trouble getting the provincial-level organizations to cooperate. There was only a commercial relationship between Long Yuan and these local companies. Quite often Long Yuan was not able to get the data in a timely manner, and this prolonged the data acquisition period. Increasing negotiation was needed just to acquire the data. Therefore, the only solution was to sub-contract the local organizations to do the work. This required considerable flexibility within the PMO to maximize project success.

Management and Protocols

As mentioned previously, the data collection task resulted in 60 million data points. It was very challenging to collect this data and keep it straight. The PMO had to fill the gap, developing data protocols, beyond the capacity of Hydropower and Long Yuan. While the PMO's strategy is one of minimal staffing, using local field persons to do most things, the wind assessment work required special management and oversight. Eventually Jorge Aryaza was hired to devote more than 80% of his time exclusively to the wind component of the Project

Data Acquisition

The Project aimed to collect two years of data at all sites, but data collection required three years to populate the two-year database. In the end, just one year of data was validated. When the TOR was written for Hydropower, it included just one year of data as the feasibility of collecting and validating two years of data was uncertain. The contract could not be changed.

The biggest problem in data acquisition was the data-loggers, of which there were 93. They had very limited storage capacity and required a problematic transfer of data through a special card. In the second year of data acquisition, a new type of storage capability became available, which was more user friendly and did not require a card reader, and this improved the situation somewhat.

Another problem was that the cost per data point collected was high, at about 0.6 RMB (about US$0.08) per data point. This was another reason for the reduced time period of data collection/validation. Some of the sites were very difficult to reach—in some cases, downloading data required a full day's walk. In Huitengxile, Inner Mongolia, extremely heavy snow resulted in a ten-hour trip for data collection and hospitalization of the engineer. Given these constraints, it was impossible to ensure good data for two years at all sites.

International Cooperation

The Project experimented with international cooperation. Usually, the PMO contracted with domestic institutions and international institutions, but often found it difficult to get them to work together. In the wind assessment component, the PMO involved a domestic organization as the prime contractor, with international content included in the contract. The idea was that the domestic contractor would choose an international organization they would like to work with. This approach did eliminate some problems, as the PMO did not have to coordinate with Risø and Garrad Hassan; however, there were issues with regard to contracting conditions.

Recommendations

As noted from the above, development of indigenous capacities is key; it is therefore important that training be a continual process. Recommendations going forward have been touched on regarding facilitation of international cooperation for capacity building on the grid integration of wind power, as well as additional capacity building across the board. The small number of trained staff and the turnover at key organizations hampers the indigenous capacity for continual training within organizations.

Future work in the sector should continue to support policy, planning, certification, testing, and training, to build on the accomplishments made during the project period. Going forward, UNDP should focus on the macro perspective of resource assessment and training, as the domestic industry will carry on the micro-siting work. In terms of policy, support for regional planning should continue as well as support of policy development in general. Capacity building is still needed in this regard as well.

Specific recommendations follow.

Improve Analysis

China needs more accurate and creative analysis for its wind sites, some of which have completely different terrain from Europe. The WASP simulation is perfectly good for Europe but should be tailored to account for these differences. It is suggested that some capacity building work be done in this area. In addition, there is a need to combine the assessment results of the ten sites with results from NREL to get meso-scale maps.

Hydropower suggested areas for future work that would build on the UNDP Project's analytical work, including: (1) defining the economic capacity of the wind sites, and (2) developing a way to combine all the information gathered into a GIS system. Defining the economic capacity of the wind sites could be very important for the government in facilitating its planning work. Hydropower is now completing work with NREL as a partner, which is cost shared with U.S. EPA funds, that combines all information into a GIS system for a test case in Zhangbei in northern Hebei Province. This activity also is directed as building a supply curve for sequential installations of wind capacity based on economic value of wind sites. This activity is being closely monitored by the NDRC for expansion to other provinces.

Ensure Sound Bidding

During the Project period, problems were encountered with the price of power bid in wind concession projects. Bidding was focused overwhelmingly on the lowest price bid rather than the soundness of the technical proposal. The result was prices that were too low. Going forward there is a great need to determine how to make the competition more rational to ensure that the bidding process also considers technical issues in addition to cost.

Need for Quality-Control in Manufacturing

The manufacturing sector would benefit from work in testing and certification. China has 40 enterprises that would like to produce turbines but no mechanism for quality control. There is a corresponding need to certify the quality of new production.

Offshore Wind Development

Offshore wind is of strong interest to China, particularly because offshore resources are located near China's load center in the east. Yet, there are many issues to resolve. First, there is a need to understand resources including measurement and the selection of appropriate sites. There is also a need to learn how to set up a tower foundation underwater. NREL has been involved in offshore wind resource modeling for China, but the country also requires on-site measurement offshore. The country's offshore wind resources are about three times its onshore resources—the area of potential sites is less, but the wind power density is much greater.

Load versus Resource Location

Clearly the best sites for development are those located near both the high load centers and the best resources. However, this is rarely the case. There are exceptions, such as northern Inner Mongolia where a growing mining industry could benefit from wind power. However, on the east coast where the loads are the greatest, there is a problem of available land, in addition to difficulties in land acquisition. This problem could be considered from the German approach of dispersed turbines and high feed-in tariffs. This should be investigated further.

Focus on Macro Support

Changes that occurred in the power sector since the Project's initiation have shifted the need to macro support from the detailed type of site support that was more appropriate when the Project began. Given the rapid development of the wind sector and the strengthening of the industry, the needs now are country-wide rather than project-specific. This includes work in policy, planning, certification, testing, and training. The resources for wind appear to be vast, and do not represent a constraint; similarly, investment appears promising. The main challenges, therefore, are (1) policy and planning and (2) upgrading the grid, which is largely an economic rather than a technical issue. Lastly, though technology is maturing, there remains a need to improve upon it, which would benefit from a standards and certification system and continued international technology transfer. The fact is that the pace of development in the market (including investment) is occurring much more quickly than the technology and policy support. As has been seen in rural village electrification, the consequence of speed is a lack of quality. Though turbines continue to improve, many issues remain with wind turbine components. Wind farm management is also not yet up to the task.

Need for Training

In the latter regard, training is an important area in which international cooperation could help. China's installed wind capacity is doubling each year. There are over 30 companies now involved in wind manufacturing, and ten in other aspects of the sector. To both sustain and support the pace of development, training must be widespread and consistent. The lack of experienced personnel is a serious challenge to expansion of wind electric power. Current managers of Long Yuan's wind farms were managers of coal-fired plants. Most of the maintenance workers of the wind farms were previously farmers. Because of the serious shortage of expertise in the wind sector, companies tend to steal staff from each other. This results in high turn-over and disruptions in capacity building within the companies.

In summary, the wind project component has been highly successful. In the future, key needs of China's wind sector include: (1) advanced technology development for wind turbines and components; (2) enhanced wind turbine integration and expansion of component manufacturing; (3) expansion of the project developer and investment base; (4) ramping up of scale of project development; (5) support for regional planning for wind penetration of >1,000 MW; (6) continued policy development (e.g., feed-in tariffs, etc.); (7) continued work in macro wind resource assessment, and (8) ongoing training of wind plant operators, managers, and technicians.
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5. Hybrid Village Power Development

Background

Through large-scale and ambitious national rural electrification programs, China has been expanding the use of decentralized renewable energy systems in its rural regions since about 1995. These efforts began as the Brightness Program, which came about during the 1996 World Solar Summit Conference in Zimbabwe, and was implemented in China in 1998. The next phase of this was Song Dian Dao Xiang (SDDX) or the National Township Electrification program, launched in 2001. In just 20 months, SDDX electrified more than 1,000 townships in seven western provinces—Xinjiang, Qinghai, Gansu, Inner Mongolia, Shaanxi, Sichuan, and Tibet—bringing power to about 1.3 million people and providing the basis for rural economic development. Installation was completed in June 2003 and consisted of 268 mini-hydro and 721 solar or wind/solar hybrid village power systems with a total of approximately 275 MW of mini-hydro and 16 MW of PV installed capacity. Total capital investment was the equivalent of about US$600 million.

The follow-on phase of this initiative, Song Dian Dao Cun (SDDC), or the National Village Electrification program, was intended to electrify another 25,000 villages in China's off-grid western region—including the provinces of Qinghai, Gansu, Inner Mongolia, Xinjiang, Tibet, and Sichuan—using mainly solar and wind/solar systems. In early 2007, the Chinese Government undertook a strategic design phase for SDDC based on the lessons learned from SDDX and with the aim of securing the program's sustainability. As of the end of December 2007, the central government has not yet formerly announced an official schedule and budget for the program.

In the year 2000, work was begun on the statistics of electrification in China. At that time, it was estimated that about 30 million people were without electricity. As of 2006, it is estimated that the unelectrified population equals about 12 million people in 2.7 million households. The government's target is to have provided electricity to 100% of the population by 2015. Recently a new program, Huhu Tong, or Every Household Connected, was announced. The State Grid Corporation is to have responsibility for this program, and much of the program will comprise grid extension. It is slated to begin in Gansu.

The Government's national programs have been ambitious and rapid. SDDX comprises the largest renewable energy-based electrification program in the world. With the scale of the programs have arisen challenges, however. The focus of the Government was on hardware procurement; it neglected planning for training and a management and service structure. When the systems were installed there was no standardized tariff system in place and no mechanism for funding upkeep and maintenance, not to mention battery and other parts replacement. Some locales collected no tariff, while others charged six times the national average. Each township decided its own tariff structure, and this resulted in inequities within provinces. Additionally, the people on the ground in charge of the systems were not adequately trained. Finally, it was not clear who owned or had responsibility for the systems. Because of these issues, the Government learned an expensive lesson on the necessary components of a long-term national electrification program.

SDDX represented an opportunity for the UNDP Project to influence a major capital procurement and development activity by transferring the Project's experience and sustainable development principles to the program through cooperation with the NDRC. For one aspect, the national program provided a significant regional off-grid electrification density that made it feasible to test some of the Project's rural electrification business development and management concepts based on a RESCO type model. In this concept, a single RESCO would be responsible for the operation and management of multiple village power systems in a manageable service territory, thereby creating the critical mass that would allow creation of a business to provide O&M services.

The national program also offered the opportunity to use regional development approaches for rural energy project development that included power for significant economic development opportunities beyond the single-village principle. Therefore, the UNDP Project had sufficient flexibility to take advantage of the unique opportunity created by the implementation of SDDX and adapted its original activities in the village power component to expand the Project's village power work to a national scale, with a resultant national impact. The UNDP Project played an important role during the Government's phases of learning, evaluation, and consideration of solutions.

In recent years the Government worked with the German technical cooperation agency GTZ to set up a training program that began at the central level and was diffused to the provinces. Individuals trained at the provincial level carried out training of local technicians at the village level. This was useful but there were challenges as well. Due to poor pay of local technicians the turnover was high. Also, to ensure that training was consistent and ongoing, it needs to be brought under the formal Chinese vocational system.

To combat the issues of management and funding, the government worked with international agencies and donors to look at different models of rural energy service companies. Shifting from a government-run to a commercial model has been considered. The role UNDP played was to organize the response to issues that emerged after installation of the Township Program's systems. The Project helped mobilize the international community to address these issues in a systematic way.

With the rapid growth of the Chinese economy, standards of living, and foreign reserves, many questions remain as to whether development funding is still needed in the country. In many rural areas the conditions do not yet exist to rely on commercial and market principles. Development funding has been instrumental in devising ways to improve the quality of life in these areas. The Project has demonstrated that a relatively small amount of funding and technical support from UNDP/GEF can leverage the international technical expertise needed to support accelerated and expanded commercialization of wind electric power and other renewable energy technologies, including the development of village power systems and the supportive infrastructure required for their sustainable operation.

Project Overview

The main focus of the hybrid village power component has been the establishment of village power pilot projects with an emphasis on sustainable delivery of modern electricity services. This has included new approaches in managing system operation, capacity building for project developers, and productive use applications for local economic development. The Project originally had three sites for the pilots—Gansu, Zhejiang, and Shandong Provinces. Due to the anticipated SDDX program, it was withdrawn from Gansu and moved to Xinjiang, where co-financing was available. One set of five hybrid village installations was therefore installed in Bulunkou, a remote area of Xinjiang, in 2002. One additional hybrid installation was initiated in the beginning of 2003 on the coastal island of Bei Long Dao off Zhejiang and several additional project sites were investigated on islands along the south coast of Shandong, but the conditions militated against project development. In 2001, the project established a rolling program of resource assessment, and set up wind and solar measurement equipment in 30 villages across China, including western China and Zhejiang and Fujian islands.

Under the Project, a Village Power Project Development Guidebook was produced that has received wide distribution and use internationally. Close collaboration with the Poverty Alleviation Office (PAO) in Beijing and in local provinces has led to inclusion of renewable energy projects in PAO's program for rural development. In addition, several workshops, including the Village Hybrid System Design and Integration Workshop (2000), were held to further capacity building in village power. The project helped to create a business model for the commercial operation and management of village power systems which is also linked to strategies for economic development. This was demonstrated in the Bulunkou (Xinjiang) pilot project. Because of the Project's cooperation with NDRC on SDDX, the pilot projects were able to be used to support the NDRC in this endeavor. Finally, the UNDP project undertook an extensive baseline survey of village power systems installed under SDDX, and capacity building for the energy service structure of SDDX. These project activities are described in more detail below.

Bulunkou Pilot Project: Modeling Energy Service Companies

The Bulunkou Village Power Project began in 2002. Its objective was to demonstrate a mechanism for managing renewable energy-based village power systems in rural China using business development principles based on a RESCO model and in a way that was sustainable and replicable, and that fostered productive applications of electricity as well as micro-enterprise development. It was essentially an experiment in management models for village power.

Bulunkou Township is in a high-elevation, remote area (pictured at right from the highway in), and covers an area of approximately 84 kilometers (km) by 112 km. Its average elevation is 2,400 meters (over 7,800 feet), with one of the project systems at 3,800 meters. The nearest cities are about 120 km away at the foot of the Pamir Mountains along the historic Silk Road. The Project consisted of five hybrid wind-PV-diesel or wind-diesel systems that were designed to meet basic needs and provide power 24 hours per day, as well as afford the capacity for productive uses. The systems ranged in size from 22 – 24 kW for three of the five systems, which are double-turbine wind-PV-diesel hybrids, to 10 kW for two of the systems, which are single-turbine wind-diesel hybrids. At the time of installation, the Bulunkou Project systems supplied power to 34% of the Township population. For the most part, day-to-day project financing was to come from tariffs collected from Bulunkou residents on a monthly basis.

Management took the form of a Rural Energy Service Entity (RESE), which assumed management of the systems in August 2003 as a non-profit entity and part of the local Bulunkou government. This arrangement was a compromise between the Chinese government's preference and the original intention to establish a private management company, while still allowing for business incentives to improve the performance of the management company. The PMO worked with the Kezuo District Government, the County Poverty Alleviation Office, and the Xinjiang DRC in developing the management structure. Non-profit status had some financial advantages in terms of taxes and salaries.

The chief officer in the RESE was a Township government official. The RESE was responsible for overseeing the daily operation and maintenance of all five systems, as well as supervising tariff collection. Additional responsibilities included overseeing training of the system operators, and ensuring that payment of their salaries was feasible from the money collected in tariffs. Altogether, the RESE included a manager, a financial officer, and four technicians, with oversight from the Village Secretariat. In addition to the five Bulunkou systems, the RESE assumed responsibility for five SDDX systems. This allowed for a comparison of the two approaches. The system at Bulunkou proper is pictured at right.

The pilot project provided valuable lessons learned in the obstacles to instilling commercial principles in the management of village power projects. The initiation of SDDX shortly after the Bulunkou pilot began increased these challenges, because SDDX systems were provided free of charge and with no tariff structure to rural residents in the same region. Nonetheless, the accomplishments of the pilot are significant. The PMO commissioned an assessment of the project in mid-2006 that highlighted the results in terms of technical performance, management, and socio-economic impacts. The impacts and lessons learned are described below.

Bei Long Dao Pilot Project

The Bei Long Dao island electrification system, a wind-diesel hybrid, faced equipment procurement difficulties due to the bankruptcy of two suppliers. First, the Zhejiang Institute for Mechanical and Electrical Engineering (ZIMEE—the primary contractor) attempted to procure suitable turbines from the Atlantic Orient Corporation (AOC) in the United States. This company went bankrupt before the turbines could be delivered through a third party intermediary. However, the diesel genset, battery bank, and control system were successfully procured and commissioned from AES in Australia in early 2003. The system was subsequently operated as a diesel power system and provided 22 hours of power per day while the wind turbines were to be procured and delivered using an alternative supplier. ZIMEE then worked through AES to contract Vergnet in France to provide a 60 kW turbine. The turbine was contracted by AES and delivered to Bei Long Dao; However, AES went bankrupt before the turbine could be commissioned and although ZIMEE made full payment by letter of credit to AES for the turbine, AES defaulted in its payment to Vergnet during bankruptcy proceedings. Following this, Vergnet was uncooperative.

As of early 2007, the battery bank needed replacement and the system was running only on diesel. Final agreement was reached in November 2007 with ZIMEE, the Windey Wind Power Company (a subcontractor to ZIMEE), and the Zhejiang Development and Reform Commission to recommission the system using two alternative 10 kWe Bergey wind turbines in addition to a new battery bank. The wind turbine from Vergnet will be used by ZIMEE and the Windey Wind Power Company for research purposes as a grid-connected turbine, since it cannot be installed by the parties as a stand-alone system. The use of primarily domestic equipment will also help ensure that future operation and maintenance of the Bei Long Dao power system can be easily handled by domestic operators. The Rui'an Electric Utility Company by agreement with the Zhejiang Development and Reform Commission has formerly accepted the Bei Long Dao system with agreement to operate, maintain, and manage the system.

Nonetheless, a key achievement in Bei Long Dao was the agreement by the local power bureau to operate, maintain, and manage the system as part of their normal power portfolio. The tariffs under the battery-diesel hybrid system were approximately half of the former tariffs of the diesel-only system.

Village Power Project Development Guidebook

The Village Power Project Development Guidebook was published by the Project in August 2002. Significantly, this guidebook was used as a training guide for SDDX. It was later published on two Web sites and is used as a resource in the World Bank's Toolkit for Renewable Energy in Developing Villages.[6] The guidebook provides information on China's historical approaches to rural electrification and resource potentials; technology and distribution options for village power; how to evaluate the options in terms of cost-effectiveness, load, technology quality, capacity, and other variables; options for financing, managing, and servicing village power systems; and mechanisms for determining tariff levels. The guidebook also contains numerous case studies, and a series of lessons learned. The step-by-step guide provided as an annex makes this a complete tool for project developers and policy makers, with global application. As such, it has helped to change the perspective on village power not only within China but worldwide. The guidebook was widely distributed and promoted through public events and the media, and disseminated through both domestic and international channels. It has become popular, and copies are snapped up quickly. (Some 2,000 hard copies and 2,000 CD-Rom versions have been disseminated by UNDP/Beijing.)

Village Wind/Solar Resource Measurement Program

In 2003 the Project initiated a village wind/solar resource measurement program with 30 meteorological towers installed at 20 sites in villages in western China and on Zhejiang and Fujian islands. Four companies were involved: Beijing Jike Co. Ltd. (Jike), Jikedian Renewable Energy Development Center (Jikedian), Beijing Bergey Windpower (Bergey), and Qinghai Energy Research Institute One year of data was collected from the 30 towers, measuring both wind and solar resources. A small workshop was held during the first half of 2003 to continue training of field operators of the meteorological towers and to assess the status of the data collection program. An additional workshop was held after data collection was completed to assess the results of the measurement program. The aim of the program was to contribute to the planning of the SDDC program, and the results of the work were used in the SDDX program as well.

Baseline Survey of SDDX

In order to provide the Government with feedback on the implementation of SDDX, UNDP/GEF, along with the NDRC, provincial DRCs, system integrators, and Wang

[6] Available at http://go.worldbank.org/HJCU6ZFIQ0.

Sicheng of Jike, the lead consultant on the project, undertook a survey of village power systems installed under SDDX. This survey is one of the major accomplishments of the Project. The goals of the survey were to address the issues of ownership of the power systems; tariff levels and their collection; funding battery and other parts replacement; how to fund operation and maintenance, and technical services; and how to assess the requirements for continued operation and maintenance of the systems 15 years into the future. The survey also investigated how and whether the power systems might be made more efficient through productive applications. As village power systems have more operational and economic challenges than solar home systems, the greater focus was on the former.

To address these questions, the survey team—composed of both domestic and international experts—conducted field surveys to collect basic socioeconomic information from village households (pictured above); operation and maintenance information from the system managers and operators; and comments from other stakeholders. Questionnaires were developed for basic information collection; interviewing provincial governments, DRCs, and utilities; talking with system integrators; visits to the villagers, township government, and system operators; the micro-hydro stations (about 5% of the surveyed SDDX systems were hydro); and collecting cost data. The field methodology was a random sample approach. In all, the survey team visited 66 villages in 7 provinces. They recorded technical issues involving the inverters, transmission lines, and controllers in almost all provinces; in a few instances the wind turbines were reported with issues. The team determined that these issues were inevitable; serious technical issues occurred 1.5 times per village during the two years the systems had been operational. In these instances, 47% of the troubles had been solved by trained operators; in 53% of the troubles, professional engineers were required. This supported the conclusion that continued training of operators is a crucial step.

Tariff levels were also recorded. In almost 14% of the villages surveyed, no tariff was collected. The most common amount, seen in 24% of the villages, was RMB 2.00/kWh, but the amounts ranged from RMB 0.42/kWh – RMB 3.0/kWh. In two provinces, a local utility served as manager and tariff collector; in the other 4 provinces this role was filled by the Township Government. In each province potential future RESCOs identified included system integrators, utilities, and private companies.

The projected budget from 2006 – 2020 ranged over the 7 provinces, and was based on the costs recorded for the first two years of operation. The highest forecast total cost for 15 years of operation was in Qinghai, which has 112 systems equaling 2.7 MW capacity, at RMB 192,406,500 (about US$26 million). This equals a cost of RMB 4725/kW (about US$641/kW). The lowest total cost was in Shaanxi, which for 9 systems and 100 kW capacity, equaled RMB 9,597,000 (about US$1.3 million) or RMB 6398/kW (about US$868/kW). The total estimated amount for operating the 490 systems surveyed over 15 years equaled RMB 845,664,000 (about US$115 million). Half of this cost was accounted for by battery replacement, followed by daily operation and maintenance, technical support, and other costs.

In most cases, the survey found that the capacity was too limited to power productive loads; in addition, most villagers were unable to pay a tariff high enough to contribute to operating costs (over RMB 2/kWh). In contrast, the Rural Power Company under the provincial Hydro Power Bureau can run commercially on a tariff of RMB 0.4 – 0.5/kWh. Because the capacity of hydro systems is much greater than that of the village power systems (and, incidentally, allow for productive uses), the annual income is nearly 40 times that of PV systems.

Recommendations from the survey were to select the provincial utilities as the owner of systems, with the power to set the tariff level, collect tariffs, select the RESCOs, and ensure equity of the village power systems. Where the local utility was not interested in assuming ownership, it was recommended that the Brightness Company take over. It was further recommended that RESCOs be selected through a bidding process.

The Renewable Energy Law—which was approved in 2005 before the survey data collection was completed—stipulates that the price of operating off-grid renewable energy systems should be charged at the same tariff level as the grid, and that the difference in cost between that tariff and the actual cost will be supplemented by a systems benefit charge. In other words, grid users in China pay an additional small amount that goes toward operation of the off-grid systems. On average, the subsidy required was determined to be RMB 4.64/kWh.

Capacity Building for the SDDX Service Structure

The activity "Capacity Building for Service for SDDX" was carried out over 2005 and included production of one report on potential RESCO models for village power in China, as well as two training sessions and development of a training curriculum and video. The outputs included an overview of the status of service at SDDX stations in seven provinces (along with proposed RESCO models); training materials; and two pilot training workshops. The final report on the Baseline Survey included both the baseline survey results as above and the analysis of potential RESCO models for consideration, along with their training needs.

For the second output, the training program, a list of training requirements was identified, and a training curriculum developed. In addition, a list of trainee candidates was compiled. These candidates included local government officials engaged in the management of the village power systems, system integrators who had installed systems under SDDX, and key people involved in management work for potential RESCOs.

<u>Training and Workshops</u>
The UNDP Project developed a module on business management and contracted Jikedian to carry out training on managerial topics, in a train-the-trainers venue. GTZ conducted technical training. Under the

project, Jikedian held two pilot training sessions, one in Beijing and one in Qinghai, and trained a total of 39 people to be in turn provincial level trainers. The training sessions were carried out over four days. The first training was held in July of 2005 at Jikedian in Beijing, and included 2 trainees from each province under SDDX, for a total of 14 trainees. The training was recorded on DVD. Feedback was collected from trainees to better meet needs in the future.

The second training was held in September 2005 in Qinghai, with support from the Qinghai New Energy Research Institute. A total of 10 trainees from the provinces attended while 15 trainees were from the Qinghai New Energy Research Institute. One trainee from Qinghai, who participated in the first pilot training, served as one of the chief trainers at the second pilot training. This can be considered an indication of the success of the training component.

The key content of the curriculum included: (1) challenges and opportunities for providing rural energy services; (2) fundamental tasks for rural renewable energy systems; (3) models, experiences, and case studies of international rural renewable energy systems; and (4) China's current models and experiences in rural renewable energy systems. The training included a combination of lectures, case studies, and discussion. The trainees' feedback on the training was positive. An interest in extending the training to the prefectural and county levels, to build the capacity of the local owners and operators, was indicated. The responsibility for maintaining an ongoing RESCO training program was shifted to the provincial DRC offices.

Originally the PMO had planned an International Sustainable Village Power Development Conference in Xinjiang for 2005 or 2006. However, since this conference event has been postponed several times by the NDRC, the UNDP instead made the decision to execute the International Conference on China Rural Energy Development for the benefit of the Office of the National Energy Leading Group, which is in the process of drafting a new Energy Law that will support China's rural energy development initiatives, in addition to other renewable energy and energy efficiency initiatives. The conference was held in Beijing on November 23, 2007.

The UNDP used the Conference as a forum for presenting domestic and international experience for sustainable development based on renewable energy technologies and systems. For rural energy development specifically, the results of the Project's pilot sustainable village power program centered in Bulunkou in the Xinjiang Autonomous Region of western China and the Project's support of the Song Dian Dao Xiang activities of the National Development and Reform Commission were successful presentation highlights at the Conference. Energy Leading Group participants were clearly impressed especially with insights related to productive use applications and village enterprise development, and the impacts of electrification on rural family income generation and improvements in quality of life. Key examples given were dramatic cases of educational achievements (e.g., village students attending universities for the first time in village history after the introduction of computers, lighting, and other technology), and advances in health services. As a result of the conference information, Xu Dingming, Vice Chairman of the Office of the National Energy Leading Group, made a renewed commitment to accelerate government support of rural electrification programs in the near term.

Textbox 6. The World Bank's REDP Project

The Renewable Energy Development Project (REDP) is a World Bank project that began in December 2001 and will conclude in June 2008. REDP is focused predominantly on the use of PV in China's remote western regions, and includes mainly household systems. Solar home systems (SHS) are more commercial than village systems, and the main goals of REDP in this work have been to: (1) expand sales by supporting the PV enterprises; and (2) resolve the problem of lack of electricity in remote areas. The project activities include sales grants, capacity building for enterprises, and support for technology research and development through grants and awards. Though the overarching aims of the project are similar to the UNDP Project, with the village power work being the key area of synergy, the scope is much narrower.

<u>Coordination with Other Stakeholders and Projects</u>

The UNDP Project coordinated with a number of system integrators (SIs) in carrying out the village power work. Some of the SIs involved included Jike, the Institute of Electrical Engineering at the Chinese Academy of Sciences, Huade (Inner Mongolia), and a few others. In addition, the UNDP Project coordinated with other projects. To avoid duplication in project activities, a subgroup was formed in Beijing for donor information exchange. This sub-group included the World Bank's Renewable Energy Development Project (REDP), UNDP, GTZ, the European Union's Program, the Energy Research Institute at the Center for Renewable Energy Development (ERI-CRED), Jikedian, and Beijing Bergey Windpower. These people and organizations worked together to support the government's rural electrification program, and coordination among programs was enhanced. One key example was the cooperation between REDP and UNDP—REDP used the UNDP Project's Baseline Survey to design their own work, instead of replicating the information gathering effort. REDP is currently involved in helping the government consider strategies and options for SDDC. The textbox above provides a short brief on REDP.

Results

The focus of the village power component was to demonstrate a service-based approach for operation and maintenance of rural village power systems and to build capacity of the stakeholders involved. The Bulunkou pilot project was very successful in this regard. In addition, the close collaboration with NDRC on the SDDX program, as well as the group collaboration with REDP, GTZ, and other Beijing-based donors working in rural electrification, helped to expand the impact of this Project component to a national level. The various workshops and trainings helped contribute to this impact along with building capacity, as did the SDDX Baseline Survey.

It is of note that the Project's original plan was to work on pilot projects for five years, as this was the proposed instrument of demonstration. However, it was fortunate that both the PMO and the Project principals were capable of flexibility—as this capability was built into the Project—for the opportunity arose with SDDX to have an impact on 1,000 systems instead of a small handful, and the Project was able to shift direction and seize the opportunity. There had already been 10 years of experience with U.S. and European donor agencies working in China through rural pilot projects with the aim of affecting national rural electrification policy, and the influence was small in scope. Having just completed the Project Development Guidebook, the UNDP Project PMO approached NDRC immediately to propose assisting with the design of the program. The Government declined because of budgetary issues and time constraints, and went ahead to complete installation of the systems in less than two years. Once installation was complete and the inevitable problems of technical and financial sustainability began to arise, the Government became more receptive to assistance from the Project.

The Government's budget was designed to cover the hardware and installation of SDDX, little else. Without the UNDP Project's contribution, an assessment of needs and quality control would not have been possible. The UNDP Project, by identifying the issues that would determine the sustainability of both the monumental investment and the initial achievement—ownership, post-installation servicing, battery replacement, etc.—provided the Government with a key base of information from which it could initiate the process of formulating remedial policy actions to avoid the embarrassment of a failed rural system. In this effort the UNDP Project participated in a coordinated international support effort to assist the NDRC in taking corrective actions for the SDDX program. This is no small accomplishment. Through the rapport established between the UNDP PMO and Chinese Government in all of the various sectors, a synergy was established that allowed the UNDP Project to assist the Government to a significant extent. SDDX is the largest hybrid system-based rural electrification program in the world, and the Project was able to play a significant role, if not in its design or implementation, then in working to identify the requirements for the program's sustainability and to provide pilot project examples to illustrate how this can be accomplished.

Introducing to NDRC the importance of considering system operation and management as well as hardware in design of village power programs was therefore the first area of impact in this Project component. Productive applications were the second area of important contribution. Productive applications in rural village power might be considered active poverty alleviation, as opposed to the traditional approach of giving away money and services. In China the traditional approach has been to give money away, but this money is not always used for poverty alleviation (at least not in the traditional sense). Therefore, the UNDP project provided a good counter-example to income generation for the Chinese Government.

When people in rural villages are asked about their daily life after electrification, the most important impact they tend to mention is improved quality of life (through increased convenience and leisure time and being provided "windows to the world" through radio and television). The second most important mentioned is income generation. Examples of productive uses leading to income generation in rural areas include retail stores and hotels. In addition, clinics are able to take in more patients, and therefore increase their income. Other benefits from electrification are included in the Bulunkou Impacts sub-section below.

According to the Project partners, about five years ago most Chinese officials believed that rural electrification in the remaining unelectrified regions of the country were very difficult. The difficulties reflected the low population densities, remoteness, and low incomes of the communities in these regions. In recent years, because of the activities supported by the UNDP Project, Government officials have come to learn about the best practices applied and have also been able to hear Chinese experts' ideas, findings, and recommendations. Their exposure to these alternate approaches and perspectives has had a significant impact on the Government's approach to rural electrification— a real success of the Project.

The following sub-sections provide detail on the impacts of individual Project activities.

The Baseline Survey of SDDX Systems

The Baseline Survey was a major accomplishment of the Project in the village power area. Based on survey results, the Project developed a GIS database covering all SDDX projects, including their geographic locations, technological configuration, load requirement, installed capacity, management structure, etc. This database has proven to be very useful not only for monitoring the performance of installed systems but for planning of future rural electrification projects. Examples of the benefits of the survey are provided below.

- The survey played an important role in developing awareness among Government officials of the issues that must be considered in rural electrification both for SDDX and follow-on programs. Together with the pilot projects and the Guidebook, the Baseline Survey had a profound impact on the Chinese Government because it did not have an accurate understanding of the reality on the ground in the rural areas. This included the often limited competence of the local technicians; the reality of the existing tariff structures, where they existed; the importance of spare parts replacement and the lack of methods to deal with replacement; and other institutional issues which needed resolution.

- The survey team had a formal meeting with Government officials to present results, and the officials expressed satisfaction with the study. It was clear that the officials paid attention, but there was a need to continue to push them—both at the Central and the Provincial levels. In early 2007, the Government asked the World Bank, through REDP, to consider the issue of management models and issue a call for proposals to identify a design team for SDDC, with the aim of avoiding the pitfalls encountered in SDDX. Prior to the work carried out by UNDP, the Government would not have looked to outside help for a national program. Direct evidence that the UNDP Project activities helped create a sea change in thinking in regard to rural development in China can be derived from statements and discussions with key government officials in the Energy Bureau of the NDRC. Though evaluations of specific projects had been carried out by various donors and foreign governments, the Baseline Survey represented the first analysis in which the NDRC was provided with a "big-picture" view of the reality of the Township Program, not to mention the continuing needs of the country's rural areas.

- Wang Sicheng, General Manager and Senior Engineer of Jike, submitted a document to the Chinese Government that provided suggestions for the post-installation management of the Township Electrification Program. This document provided very detailed comments on post-installation service, including an overall evaluation of the Township Electrification Program; suggestions regarding owners, everyday operation and maintenance, tariff collection and management, and after-installation technical support; possibilities for selection of the RESCOs; calculation of operation and management costs for 15 years out; implications for implementation of the renewable energy law, including cash flow; how to manage the subsidy for rural tariffs; and suggestions for the next phase, SDDC. This document and its contents were made possible because of the UNDP project's Baseline Survey.

- Finally, because Wang Sicheng as well as Lu Fang, the Director Assistant and Economist for Jikedian, were part of the expert team involved in designing the Renewable Energy Law and its implementing regulations, they made sure that the allocation of a subsidy to rural systems was included in the Law. This was an indirect but powerful consequence of the Project. According to Mr. Wang, if it had not been for the UNDP Project, he and the other experts would not have had these valuable comments to share with the Government. For example, the term "RESCO" was only a vague concept for Jikedian before the Project began. Now there are experts on the ground who can bring information about the RESCO approach through the proper channels to an audience of Government officials.

Leveraging Collaboration

International experts, not unlike in the other Project sectors, contributed to the village power component by bringing to the table alternative viewpoints and experiences, as well as international case studies, which proved influential in workshops, the development of the Guidebook, and high-level discussions. This was true in regard to data analysis, practical know-how, and comparing different models and technologies (e.g., hydro vs. solar for village power applications). Such international contribution refers not only to the consultants brought on board by the Project but also by the PMO principals themselves. The Senior Technical Advisor, William Wallace, was expert at information dissemination as well as bringing his experience and connections to bear for the benefit of the UNDP Project and the Chinese Government in general.

It also bears mention that the ability and long-standing reputation of William Wallace allowed him to bridge the gap with Chinese colleagues. In China, information is a valuable commodity and access to it is not straightforward. In addition, it is generally true that Chinese Government officials are more likely to listen to and accept the recommendations of Chinese experts over international experts. Collaboration with other stakeholders, and within and among projects, can be a determining factor for success in national-scale work.

Because the UNDP Project shared office space with REDP, the collaboration between these two projects was immediate and highly beneficial. The UNDP Project was initiated somewhat earlier than REDP, so REDP was able to capitalize on the lessons learned and accomplishments of UNDP—especially in terms of the Baseline Survey and training activities—as well as carry on the work begun by UNDP after the Project closed. A prime example is working with the NDRC on SDDC, as described above. In addition, because CREIA is also located in the same office, it is able to collaborate with REDP as well. Because both projects adopted the principle of maximizing impact by avoiding overlap, the achievements of one project were extended by the other. REDP is also carrying on the work on RESCO business models that was begun under UNDP.

The REDP/UNDP collaboration, along with others within the international community, has demonstrated on the canvas of rural electrification how leveraging resources extends impacts. UNDP initiated a semi-annual event— a donor information exchange meeting— and co-sponsored the first of these meetings with the World Bank. This contributed to the launch of the donor sub-group for SDDX. Prior to this, each donor organization was working independently of its peer organizations, and the result was inefficiency of investment as well as time. That the sub-group was able to achieve actual coordination and cooperation—as opposed to simple information exchange—is a significant accomplishment.

Introducing the Concept of RESCOs

As mentioned previously, prior to the work carried out by UNDP the Chinese Government had only a very vague idea of the meaning of a RESCO. According to Lu Fang, Assistant to the Director at Jikedian, the UNDP Project can be credited with having pushed RESCO research into the limelight in China. Charlie Dou of Bergey Windpower is of the opinion that the UNDP Project was the first to introduce a RESCO management model into China. With the Bulunkou pilot, for the first time, the Project brought the energy service business model and related international experiences to Western China, enlightening people's thinking on the topic and demonstrating its application. Simultaneously, the Project brought the RESCO model to NDRC and was able to obtain their support and interest. Traditionally, management had always been associated with the government—local, provincial, or Central—and therefore not questioned in lieu of focusing on hardware and social impact.

Further, the Bulunkou RESCO project has stimulated further work and publicly guided projects of the World Bank (projects "Design of Rural Energy Services Company Models" in 2006 and "Design of Technically and Financially Viable Business Models for Long Term Sustainable Operation of PV and PV Hybrid Facilities Installed under the Township Electrification Program" in 2007), REEEP (Mongolia project "Dissemination of Best Practice of Village Power to East Asian Countries"), and others. In addition, the work has been highlighted at international conferences such as the International Photovoltaic Science and Engineering Conference (PVSEC) in Shanghai and the Great Wall Renewable Energy Forum in Beijing, both in 2006.

Wang Sicheng, of Jike, expresses the opinion that the Bulunkou pilot project has been more successful than the SDDX sites, and this was supported by the independent evaluation of the Bulunkou systems undertaken in 2006,[7] among other more informal observations. Mr. Wang also suggested that the pilot could be offered as an example of best practices in East Asia.

Impacts of the Bulunkou Pilot Project

The socioeconomic impact assessment of the Bulunkou pilot commissioned by the UNDP Project in 2006 found that the pilot has had profound impacts on the village populations as a result of electrification. One of the major impacts was the introduction of television as a window to information from the outside world, which included entertainment and culture as well as access to information for occupational improvement; satellite phones helped to facilitate social and business communication outside villages; and education and health services were greatly impacted. The major findings of the study included the following.

<u>Technical Performance of the Systems</u>

Overall, the assessment found that though none of the five village systems had been error-free since installation, the problems encountered were not unexpected. In two of the villages, major disruptions were experienced due to lightning strikes that burned out turbine alternators. In addition to alternator damage, power shortages were experienced in one of these sites due inappropriate (suboptimal) siting of the wind turbines. In Bulunkou proper, problems were experienced with the battery string, which was improperly arranged. Poor manufacturing quality of other batteries required a number at each site to be replaced.

Most of these problems were resolved in 2006. The re-siting of turbines was carried out in that same year at the one site (Gaizi), and all systems were operating at full capacity by the publication of the assessment. Replacement of batteries will continue over the life of the systems.

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[7] Stroup, Kristin. "Renewable Energy for Village Power in Bulunkou Township," report of the NDRC/UNDP/GEF Project, September 2006.

Socioeconomic Impacts

The introduction of electricity to Bulunkou Township has had profound effects on the population. One of the most obvious effects has occurred because of television, which has brought information about the outside world, educational programs, and entertainment into village homes. In addition, the opportunity for group leisure has fostered community cohesion. Programs targeted at occupational improvement (such as on veterinary care for livestock) has improved income capacity. Cultural programs, that feature stories of other families belonging to the predominantly Muslim Kyrgis minority population of the area, as well as foreigners, have heralded a shift in worldview and perhaps a redefinition of self.

Two of the most important effects have occurred at the Bulunkou school and health clinic, both of which have been able to acquire new equipment and as a result attract more students and patients, respectively, as well as professional staff. At the school, 34 new computers with Internet access were introduced in 2006—a rare occurrence in rural China—and are destined to have already had a radical impact on the community. Other electronic equipment in the schools contributes to an increase in teaching capacity for the local educators, including allowing use of educational videos and reception of satellite educational programs. The Bulunkou Township health clinic has acquired new medical equipment, including an x-ray machine (powered by a separate dedicated diesel genset) and EKG machines, and has expanded services for women and children. The clinic doctor and nursing staff have also increased and at the time of the assessment an in-patient facility was being constructed to improve services and expand capacity at the clinic. All of these improvements allow Township residents to receive treatment locally rather than traveling long distances for healthcare.

Another of the major impacts came about because of high-quality electric light, which replaced candles and kerosene lamps and has allowed students to study during evening hours while women produce carpets and handicrafts. In addition, one family in Bulunkou was able to acquire a personal computer (the housemaster is pictured above using Microsoft Word) for use in lesson planning and education. Further, satellite telephones have facilitated communication outside the village and have allowed for doing business with more convenience and calculation.

Satellite phones are only one example of the productive uses that had resulted from the introduction of renewable energy to the Township as of mid-2006. In addition, there were about 35 daily use stores and restaurants in the Township, and these make use of primarily lighting and secondarily television to operate during evening hours and attract customers. A few repair shops had also opened, and while they were not permitted to use electrical equipment due to the load requirement, these shops did utilize lighting to operate in the evening. Other productive uses occurred because of increased tourism to the area, and included sale of handicrafts and other goods to tourists. Ka Lake, pictured here, is a popular destination for the area and its hotel and restaurant, which originally received power through the Project, has been able to expand its facilities and draw in more tourists. Local townspeople capitalize on the foot traffic to sell gemstones, offer overnight stays in yurts (pictured at right), and produce other handicrafts.

The general trend observed in Bulunkou indicated an increase in income, with a slight decrease in the percentage of lower income families and a somewhat large increase in the percentage of upper income families. In general, it was the families who were well-off before electrification whose incomes increased the most. Regardless, any increase in income improves the standard of living, which includes increased convenience due to lighting and appliance ownership, and improved infrastructure and services. In addition to the stores and restaurants that had popped up in Bulunkou, access to a cellular signal and the Internet was slated for mid to late 2006, along with improved drinking water. Though cellular access and drinking water are not direct results of the renewable energy systems, these systems were the catalyst for the improvement in services overall. The choices available to people have expanded in myriad ways since the introduction of the village power systems, and this is the main indication of socioeconomic development.

<u>Management Assessment</u>
The RESE, in overseeing the five UNDP systems as well as five SDDX systems in the Township, demonstrated that the management of multiple systems allows for higher management efficiency. However, because the SDDX program (which was implemented immediately following the beginning of the Bulunkou Project) included no tariff requirements, Bulunkou residents challenged the payment of their own tariffs. This made the RESE's fiscal responsibilities more difficult and consequently, the system operators as well as the managers of the RESE were not entirely steadfast in tariff collection, and at one point stopped collecting tariffs altogether. The RESE managed to keep the systems mostly operational by applying for subsidies from the County government. But by the time of the 2006 assessment, they had realized a new paradigm was needed.

At the time of the 2006 assessment, the RESE management team (of which only one member remained from the original team), had devised a plan to recoup the losses in revenue by installing new pre-payment meters in each household. The RESE management was competent and demonstrated a strong level of commitment to their fiscal responsibility and the future of electrification in the Township. They had proven their capacity for self-correction and growth over the life of the project, and because of this, full ownership of the five Bulunkou Project systems was transferred to the RESE. This important step was expected to improve the business model of the RESE from that point forward.

One area that was identified as needing resolution was training of system operators as well as end-users, in terms of both daily operation and maintenance (system operators) and load management (end-users). The RESE was aware that encouraging the use of electricity generates tariffs, while limiting the use protects the system, and navigating between these two mission areas requires skill. Because the systems differ in terms of configuration and size, however, it is important that training focus on the specific system design as well as a general technical overview. Financial resources are required to ensure ongoing training in the future, to account for the turnover in systems operators and RESE supervisors.

Conclusion and Outcomes

For having been in operation for only four years, the Bulunkou Project achievements are remarkable. As of the assessment in 2006, Bulunkou had already experienced profound changes since the systems were installed in December 2002. It was significant that an overwhelming number of people interviewed expressed enthusiasm for contributing their income to improving village power.

What was accomplished in Bulunkou compared to SDDX was pioneering in many ways. The Bulunkou Project was able to show that productive applications of small-scale renewable energy are viable, and they do impact the socioeconomic wellbeing of rural populations. It also showed that shifts in perspective are indeed possible, and that people are willing to become accountable for the service of their electricity. These changes were brought about because of a new perspective on the management structure of rural energy.

Lessons Learned

While the village power component of the UNDP Project made many gains in bringing the issues of management to the forefront, the macro-environment created some barriers. One lesson learned was that it is practically impossible to do anything without Central Government support. The UNDP Project realized early on that they would not be able to carry out the project exactly as they wanted, but would have to compromise to ensure Government support.

The Government now recognizes several problems, including that the scale of the PV used in SDDX is perhaps not the best choice, because the capital costs are so high. They also now recognize that a plan (and a budget) must be in place for management and post-installation service. However, at present there is no solution to address these issues. Not only the Government but also most of the international projects in China's village power sector have erroneously placed the majority of the emphasis on hardware. The UNDP Project and the GTZ village power pilot projects are exceptions to this rule. Because funding is usually finite, it goes toward supporting the equipment and neglects putting in place contracts for follow-up monitoring. Without follow-up assessments, the issues go unnoticed and the same mistakes continue to be made.

The UNDP Project learned that to set up successful village power projects in China, it is necessary to include the following inputs: (1) business development (very little of which is done in China); (2) project financing (mostly government and international grants to date); (3) performance monitoring (done at a low level by system technicians); (4) higher levels of data acquisition and logging (often neglected); (5) marketing/education; (6) and cost recovery (this is a recurring problem). Because of the work under the UNDP Project, the Government is now cognizant of these issues, but they remain ongoing challenges.

The Renewable Energy Law has set up a cross-subsidy fund to cover costs that are not covered by tariffs. This has been a significant achievement since it is impossible to cover the costs of rural village power systems with a tariff alone. The highest documented tariff is 2 RMB, which is a challenge for most villagers. If rural systems charge only grid prices (0.4 or 0.5 RMB), RESCOs find it difficult to even cover the basic expenses of salaries and routine maintenance. Such tariffs will not allow for capital recovery, major repairs, or replacement of batteries.

Even in Bulunkou the higher tariffs charged (an average of RMB 1.2/kWh) could not fully cover costs or make a business out of the RESCO operation. Therefore, a challenge remains in terms of fully commercializing village power systems. Generally the government has accepted a principle that the capital cost of systems is essentially non-recoverable and a responsibility of the central and provincial governments, and a government subsidy fund is also needed to support equipment replacement costs and ongoing O&M, particularly if parity of tariffs with grid-customers is established.

While many think the path of government subsidizing is not correct in village power, the PMO does not see an alternative path in China and views public-private partnerships for village power as essential. There have been cases in China and elsewhere where SHSs thrive without subsidies, but renewable energy-based village power systems cannot. A role for the private sector in managing the systems is therefore necessary. However, these private enterprises cannot survive on tariffs alone. This issue needs further consideration.

The Bulunkou pilot sought to incorporate productive uses as a way of raising the income level of the system users, and therefore the amount of tariff they would be able to pay. The more electricity is consumed, the more is paid, and the better off the RESCO. However, it is now clear that a strict RESCO model is not feasible in China due to the heavy influence of the government, which controls tariffs and sometimes owns the systems. It is also clear that putting utilities in charge of renewable energy systems is not a better solution—previous surveys have found that the systems transferred to the utility companies have universally failed. Therefore, a mixed system will need to be devised. An effective public-power partnership for village power will be required for real financial and technical sustainability of such systems; it is not yet clear that such an approach will be possible in China.

Bulunkou Pilot Project

It was fortunate that the Bulunkou systems were installed in the same county as the SDDX systems, and with a single energy service organization overseeing them, as this allowed for comparison of the two approaches. Practically speaking, the biggest difference is that the UNDP systems provide a higher level of service and allow for limited productive uses and 24 hours of power. In contrast, the SDDX systems provide power only a few hours per day and applications are limited to basic needs. This cannot be a basis for social and economic development. There is growing international agreement that full-time, high-quality electricity services are essential for such development. The Bulunkou pilot and the RESE, in effect, provided for a laboratory of sorts for the UNDP project, and the lessons learned were used to refine the village power training curriculum that was developed to support capacity building of SDDX.

There were a few problems with the Bulunkou pilot. It was designed both for: (1) demonstration of renewable village power, and (2) demonstration of sustainable management. UNDP took responsibility for the system development, and gave the task of management responsibility to the local government through the model RESE, but that task was not carried out well in all respects. The local government was told to develop a sustainable management system, but was not provided with specific assistance, though informally they did receive guidance. In retrospect, this was an oversight. A formal monthly follow-up and training component would have been useful to build the management capacity and business practices of the RESE.

According to the PMO, the problem was that the UNDP Project's village power component had a budget only for equipment. Supporting the investment beyond hardware was not included in the project document. Therefore, pulling together a training program required them to be creative. For productive applications, the project partnered with IT Power. Bergey assisted with training, and in some cases at their own rather considerable expense.

Another problem with the pilot was retaining operators. The challenge with keeping the operator's position staffed is seen around the world. Sustaining village power programs therefore requires constant training to account for high turnover. Because the skills that operators receive in their position can result in them being able to command higher wages, they often leave in search of greater opportunities and incomes in urban areas.

Finally, the issue of system ownership in Bulunkou—a topic of discussion for several years now—remains unresolved. According to village leaders, ownership by the village would be best—more efficient and more economical. There is no incentive to safeguard the systems much when there is no accountability. However, government officials are wary of this idea.

One final observation is that the impact of the Bulunkou pilot could have been greater if the location were less remote. The Baseline Survey and the Guidebook, as well as village power workshops, were accessible to officials in Beijing. To visit Bulunkou, however, one must take a six-hour flight and spend nearly as many hours in a car to reach the Township. As the saying goes, "seeing is believing," so the impact could have been greater had a visit from NDRC been more easily undertaken.

Bei Long Dao Pilot Project

The Bei Long Dao pilot project was one of the greater challenges of the Project and therefore generated several important lessons. The two international bankruptcies cost the Project about $30,000, but the real issue was that the PMO staff had little power to combat the situation. AES was the subcontractor of ZIMEE and not legally accountable to PMO and UNDESA. Though the PMO/UNDESA sent in technical requests and put great political pressure on AES, unfortunately they had no legal influence. Further, AES was under Chapter 11. After the AES bankruptcy, the PMO attempted to work directly with Vergnet and with the former AES engineers on a private consulting basis to resolve the problem; however, this required more money. Although funding could be obtained, an acceptable arrangement with either Vergnet or with private consultants could not be successfully concluded.

While the use of international procurement of high quality equipment is generally considered an attractive option for transferring technology and expertise to developing countries, the case of Bei Long Dao demonstrated that more important compensating benefits can be achieved with domestic equipment, where suitable equipment and support can be procured in country. For rural energy development applications in China at present, the domestic manufacture, installation, and operation of rural electrification systems has reached an approximate level of international parity during the past five years. It has been demonstrated unequivocally that now there is no need to import international equipment in support of China's rural electrification programs, and there are compelling benefits to procuring domestic equipment and expertise in order to increase the reliable operation of such systems.

Recommendations

The village power component achieved good results in regard to influencing the Government perspective on rural electrification. This occurred through the Baseline Survey, the Guidebook, and the pilot projects. However, the key problem was getting the attention of high-level officials, who continue to think of electrification in terms of achieving Government targets—e.g., 100% electrification in the next 15 years—as opposed to sustaining the infrastructure already on the ground. Therefore, the next step needed is to find the opportunity to report on the Project's findings to high-level officials. This has been achieved to some extent by working-level officials sharing with their bosses the principles and guidance provided by the experts. There have been good results attained already in this sense. Progress is achieved step by step.

As described above, Jikedian provided the Government with a plan, a budget, and a proposed operation plan for the SDDX systems. The key outstanding issue, though, is funding. Although the high-level officials believe the experts' work is very important, they have said that the associated budget is too large. These high-level officials have a different idea of how to operate the program. At the level of the division chief, the officials agree with the assessment of the experts. They recognize that the Government must provide the lion's share of the financing for rural electrification, but the high-level officials have not made a final decision on this. This is not only a problem for the upcoming SDDC, but also for the existing systems installed under SDDX. For the latter, there is still a need to determine who will own and repair systems. Thus, it is recommended that the key stakeholders continue to work to influence the high-level officials, on ensuring funding as well as taking the next steps in training. One recommendation from Jikedian was that more pilot projects like Bulunkou be established.

At present, the government has initiated a program called Electrification of Unelectrified Areas, which is different from SDDC. The size of the newly-initiated program is about 1 billion RMB, including local government contributions. About half, 500 million RMB, will go towards grid extension. Whether or not the rest will be used for solar home systems (SHSs) or off-grid village systems will depend on what the individual provinces apply for. However, Wang Sicheng of Jikedian expects that SHSs will be chosen for at least half of the off-grid population as they avoid a lot of the problems of village systems. It is possible that the renewable energy component of this program will be quite small. Either way, the requirements for supporting this program along with upkeep of SDDX and the potential launch of SDDC include the following.

- **Technical Assistance**. Future training should include both technical training and training on the management of renewable energy systems. Both are important to ensure sustainability. Because of frequent turnover of operators, a training program to certify new operators is needed to ensure sustainability. Guaranteeing the salaries of system operators will also go a long way toward staff retention and return on investment from training activities. Jikedian plans to carry out technical training as well as promote its renewable energy systems management program, the latter of which will include training program accreditation and curriculum development. They hope to get more support from NDRC and international organizations to do this. Jikedian will also have the opportunity to continue the RESCO modeling developed under the UNDP Project, through the World Bank's REDP project.

- **Rural Electrification Research**. The Government is also supporting research for next steps in rural electrification. Several research topics are being pursued by the Chinese Academy of Engineering and CAS, which is supported by MOST and the Energy Office under the State Council. Work supported by MOST in this area is focused on renewable energy research—what the target should be, how to reach it (i.e. policies), PV technology, and stand-alone wind technology. Other next steps needed are continued research on RESCOs and more training of trainers and officials. Future training should also encompass end-users. In other countries the use of cartoons to illustrate best practices has been very successful in instilling the principles of efficiency and load management in rural dwellers with limited literacy—both through individual booklets and national campaigns. This might be considered in China going forward.

- **Cross Subsidy for Grid Applications**. The grid cross-subsidy that is included in the Renewable Energy Law looks promising, but it will need to be implemented carefully. To date, there is no plan on how to manage the funds. The issues for consideration include: (1) how to decide the funding level per system type; (2) when to provide the funding—before issues arise or after (if before, some mechanism will have to be put in place to ensure the funds are not spent on other purposes; if after, the lengthy and bureaucratic application process currently in place will have to be accelerated significantly); and finally, (3) how to verify that the funds are really required, e.g. that a part has failed. The grid-financed subsidy could make possible the sustainability of rural village systems. However, actually monitoring, enforcing, and implementing it is a monumental endeavor. At present very little work has been done to map this out, and therefore the project could be a very useful and high-profile one, not to mention being of use to many other countries, including the Philippines and North Korea.

- **Socioeconomic Impact Assessment for Rural Energy**. Finally, though there have been useful studies on the socioeconomic impact of rural energy projects, more work should be done in this area, especially in terms of economic impact. The Baseline Survey was extremely useful because of its coverage of the issues of technical management, tariffs, and projected funding for continued upkeep. However, its coverage of socioeconomic impacts was not comprehensive. To support a future for renewable energy-based rural energy systems, the benefits of existing systems must be highlighted, and for a wide audience. A very useful project would be to fund a study that would measure the impacts of SDDX based on the extensive database that already exists, just adding in new variables such an income growth, changes in healthcare, and changes in educational achievement. Such a study could help to balance the plethora of 'issues' and 'lessons learned' with some very concrete reasons for why carrying out rural electrification is a worthwhile endeavor.

6. Industrial-Scale Biogas Development

Background

The use of biogas began in rural China during the 1970s and has made considerable progress since then; biogas is now widely used in small-scale household production (8 – 10 m^3 tanks) across the country, and a population of 80 million benefits from this fuel for cooking and, to a lesser degree, lighting. Biogas development is backed by the central government through strong fiscal incentives as well as investment subsidies, including to rural households. Accordingly, as of 2005, 17 million household biogas digesters, 140,000 municipal waste treatment facilities, and over 3,500 industry sewage biogas facilities had been installed; biogas production from these sources is estimated at 8 billion m^3 per year.

Apart from rural use, in 2006 the installed power generation capacity operating from biogas amounted to just 500 MW. The estimated resource potential, according to a 2002 estimate of feedstock, includes 2.5 billion tons of wastewater from industry, and 49 million tons of solid excrement from feed lots. There is an estimated potential of 14.5 billion m^3 per year of industrial-scale biogas, of which 10.6 billion m^3 comes from industry, 2.7 billion m^3 comes from large feedlots, and 1.2 billion m^3 comes from small livestock farms. It is estimated that the above could be used to generate 3.8 GW of base load electricity with 23 TWh of electricity production potential, or could be used like natural gas for supporting peak load periods. The estimated potential for 2020 is vastly higher, including 41.5 billion m^3 of industrial-scale biogas, comprised of 21.5 billion m^3 from industry and 20 billion m^3 from livestock farms. This would amount, in 2020, to an installed capacity potential of 13.8 GW, assuming an increase in conversion efficiency.

Based on this estimated potential, NDRC's targets for biogas development include: 19 billion m^3 from industry, livestock farms, and land fill methane by 2010; and 80 billion m^3 by 2020 if landfill methane is included. This latter figure would be reduced to 40 billion if landfill methane were to be excluded. Both figures exclude household production. The power generation targets are 800 MW from industry and livestock farms by 2010, and 3,000 MW by 2020. Only 1.2 billion m^3 out of 14 billion m^3 industrial-scale biogas potential is currently being used; most of the gas produced is vented since the industry focus is on waste treatment and not energy production. Therefore, the potential for the industrial biogas industry is huge and with only about 10% being exploited, largely untapped. The size of the market grows annually, in concert with the increase in the standard of living. For example, as fewer rural households are willing to find employment in raising pigs, the demand for large farms will rise, increasing the nation's total pig stock. There will be a corresponding rise in biogas potential.

Project Overview

The Project's biogas activities had the following components: (1) use of the biogas pilot plants to promote advanced technology solutions to wastewater treatment of organic effluents (using available domestic technology as well as some advanced foreign technology); (2) use of the pilot plants to promote solutions to some of the institutional issues of management and financing associated with biogas projects; (3) increase in the commercialization potential of biogas projects by transferring European experience for technology deployment, business development, and commercialization support to China; (4) regional workshop forums that had a specific focus on business development between bioengineering companies and their customers; (5) building capacity within bioengineering companies to increase their business; and (6) facilitating linkages between bioengineering companies, biogas projects, and the investment community

The biogas component of the UNDP project was distinct in that it focused on industrial-scale biogas projects; in contrast, most work in China to date, particularly the large-scale programs of the Chinese Ministry of Agriculture (MOA), has been devoted to small-scale household biogas digesters. MOA combines its household work with other agricultural approaches, such as greenhouse cultivation. The UNDP project promoted multiple outputs on the industrial scale, including both biogas and fertilizer. Though to date gas is usually burned for heating purposes, the UNDP project supported use of the gas for electricity generation.

The biogas sector work was designed with three industrial-scale pilot plants as one of three crucial components. The other two components comprised workshops and policy design work. These are described in more detail below.

Biogas Workshops

The PMO organized five regional industrial biogas workshops that were very effective in facilitating technical and commercial exchange and new business. This is demonstrated by the significant number of biogas project development deals that emerged directly from the workshops' business development sessions, which brought together end-users and developers. The goal of the workshops was to provide potential industrial-scale biogas end-users with the information they needed to make informed investment decisions.

The workshops were based on a standard format and approach. They opened with government representatives (e.g., NDRC, SEPA, local officials, etc.), who presented the environmental management standards for liquid effluents and explained what the end-users needed to do to meet these standards. They also explained that by a certain date, the construction of new facilities would not be allowed unless there was adequate treatment of the effluent stream. This helped to reinforce a perceived need for the technologies to livestock farm and industry owners. Both international and domestic experts then explained that there were solutions for these challenges. This helped to create a vision of a way forward.

In technical sessions, experts presented the technical and financial characteristics of the treatment plants to process waste effluents, generate electricity and useful heat, and to produce fertilizer. Following the technical sessions the business development break-out sessions were held. In those sessions groups of farm owners met with bioengineering companies. The biogas plants in most cases are financed by the industrial users themselves, so the essential parties were all at these sessions. This provided the basis for investment and implementation. Altogether, the workshop approach was successful and helped guarantee the outcomes of the project.

Policy Support

On the policy side, the project supported the development of the *National Biogas Action Plan* (NAP), a key output of the biogas component. A multiple stakeholder steering group consisting of the relevant government officials, research institutes, and key national experts was created to guide the working group of expert consultants, focused on providing key information as a basis for subsequent specific actions that were needed. This information included: case studies and regional development approaches; a review of international best practices; identification of priority actions and target regions for development; and the appropriate applications for anaerobic digestion for livestock farms and industrial wastewater. As part of the project's support for the NAP, a series of six detailed background reports on the emerging biogas industry were prepared.

The operational component of the plan is still being expanded and refined, but it constitutes the basis of the government's strategic planning and policy efforts in the sector, and is closely linked to the Renewable Energy Law. The Plan establishes biogas development targets, priority actions for the sector, and key priority regions. Some of the priorities include resource assessment; policy and institutional development; strengthening the enforcement of environmental laws; development of investment and financing mechanisms; and expanded scientific research and technical innovation. The focal regions identified are: (1) those with sensitive ecological environments and a low capacity for absorbing environmental disruptions from commercial biomass operation, and key river and lake environmental watersheds that have been identified by SEPA as high priority regions for regulatory enforcement; and (2) economically-developed regions with huge biogas reserves. Principal industrial operations targeted by the NAP are those with significant organic wastewater discharge (both actual and potential). The priorities include alcohol industry facilities that produce more than 30,000 tons per year and biogas plants serving farms with more than 30,000 pigs.

Pilot Projects

Under the biogas component, three demonstration projects were constructed: two at pig farms in Hangzhou (Zhejiang province) and Shunyi (Beijing), and one at a distillery in Qingdao (Shandong Province). The pilot plants were constructed in different climatic zones and demonstrated different technologies, including the best of available Chinese technology—considered of good quality by the PMO—as well as some European technology. Part of the project strategy was to take advantage of the opportunities presented by environmental imperatives in China. This meant that timing was important, and some compromise was required in order to demonstrate the appropriate model through an environmental lens.

Though one objective of the UNDP Project was to promote biogas power generation, none of the demonstration projects were initially interested in this. Originally, there had been a plan to generate power at Dengta Pig Farm, but the farm was moved and plans shifted. The same occurred at the Shunyi Pig Farm, so the generators were diverted to the Qingdao Distillery. The distillery, at first opposed to power generation, was receptive to the idea after carrying out a cost/benefit calculation. It is very unlikely that the distillery would have carried out biomass power generation without the project.

The following sub-sections provide more detailed information on the three pilot projects.

The Qingdao Distillery. The Qingdao Distillery was established in 1958. It produces *baijiu*, a clear alcoholic spirit made by fermenting local and imported biomass feedstocks such as sorghum, cassava, various grains, etc. The distillery also manufactures plastics and mineral water. Relative to China's distilleries, Qingdao is small.

The biogas installation supported by the project is associated with edible ethanol production. Edible ethanol has a number of applications, including use as a chemical feedstock, in industry, in low quality alcoholic beverages, and in hospitals. At 96%, the purity of edible ethanol is high, though not sufficient for fuel ethanol. Qingdao's edible ethanol is made from cassava, imported from Vietnam, which could be considered bio-ethanol.

The company set up a small biogas installation in the 1980s, but its effectiveness was poor due to leaks in the cement construction and inability to control the temperature. This is quite different from the project installation in which the temperature is kept at between 52 and 54 degrees Celsius, which is very beneficial to biogas production. At present the biogas is used in combination with coal to fire the boiler used for ethanol distillation, spirits production, and space heating. The biogas power generation equipment has been commissioned and is being used starting in late 2007.

Biogas processing is accomplished by running the slurry (half solid, half liquid) through two first-phase anaerobic digesters. It is then trucked to agricultural users to be used as a liquid fertilizer for saplings. The value of the fertilizer is estimated at 1 million RMB (about US$135,500) per year, but at present the distillery gives it away free in an effort to help create a market for liquid fertilizers. However, the distillery spends about 300,000 RMB per year on trucks and the salaries of drivers to ship the fertilizer to users. This is not perceived as a loss since the distillery saves on disposal costs. As the market further develops, the distillery plans to start selling the liquid fertilizer under contract. In addition, by disposing of the anaerobic effluent as a liquid fertilizer, the distillery's ethanol and biogas installations have zero wastewater discharge, which allows the company to meet environmental regulations and demonstrate environmental responsibility.

The distillery is currently operating its diesel generators using biogas for power generation and also using excess biogas for boiler co-firing with coal. In addition, the biogas generators were constructed with heat exchangers so that engine heat can be used to heat factory buildings. The CHP equipment is entirely of domestic manufacture. At present, the distillery pays 0.78 to 0.80 yuan per kWh (the industrial price) for electricity, whereas their additional costs of generating electricity from the biogas will be 0.20 RMB/kWh, representing a considerable offset for the retail price of electricity.

Hangzhou Dengta and Shunyi Pig Farm. The Hangzhou Energy and Environmental Engineering Co. (HEEEC) was the general contractor for the Dengta and Shunyi pig farms, comprising design, equipment, and installation responsibilities, and built the equipment for the third. It also supplied some of the equipment for the Qingdao Distillery. It is a private, nongovernmental company that grew out of a small research institute. With considerable support from the UNDP/GEF project over the duration of the project period, HEEEC has emerged as a leader in the field of biomass conversion and cleanup, and biogas-based cogeneration of heat and electricity.

The initial motivation for UNDP/GEF project assistance in this area was to support and facilitate the development and application of biogas technology that would significantly reduce the liquid effluent from China's huge livestock industry, especially from pig farms and dairy farms and other polluting industrial processes. In order to increase the viability of this technology dissemination it was necessary to increase the commercial potential for the deployment of biogas systems for industrial wastewater effluent treatment. The European model for biogas development heavily influenced the Project's approach in China, which necessitated a sea change in the thinking for how to use advanced technology in China of domestic manufacture. The scope of adjustments necessary were enormous and involved: 1) changes in biogas plant design and technology options, especially shifting from the ubiquitous UASB reactors common in China to digesters of CSTR designs; 2) change in emphasis from clean-up of liquid plant effluents to meet national discharge standards, to emphasizing production of biogas as the primary product and designing plants for zero discharge of water into the environment; 3) creation of new markets for solid and especially for new liquid organic fertilizers produced directly as digestants from the anaerobic reactors; 4) change in land use practices and farming practices (such as using less wash water to concentrate wastes, eliminating rain water from waste collection, regional control of fertilizer loading on crop land, etc.); and 5) production of electricity and sale to utilities using standardized power purchase agreements as a major output of the product value stream of plants. Following the Project's recommendations for zero discharge plant designs helped reduce plant construction and operating costs by 40–60% of costs based on traditional high efficiency Chinese designs

What emerged was a commercial technology that converts wastewater effluents into biogas and fertilizer, with the consequence that extremely low effluent systems are now in place in China, and zero discharge effluent systems are technically and commercially feasible. Widespread use of this innovative technology in China has the potential to influence environmental monitoring engineers to improve the effluent systems of other livestock farms and industries.

HEEEC, under the leadership of Chairman CAI Changda, has worked closely with the UNDP project and by adopting the project's approach has established a new paradigm for the productive use of biomass residues on livestock farms. It has been a mutually beneficial relationship. As a result of its participation in the UNDP/GEF project, HEEEC has implemented projects across the country in such places as Guangdong, Fujian, and Inner Mongolia. Table 2 displays the list of projects that have resulted from the UNDP project. The company is also expanding internationally, including three plants constructed overseas; in addition, it is exporting the Chinese technology supported by the project.

Through 2006 the company had been responsible for:

- The design and construction of more than 50 large-scale biogas projects.
- Preparation of 18 feasibility study reports for biogas projects.
- The design and construction proposal for 25 additional biogas projects.
- Major contributions to the development of China's *National Biogas Action Plan*.

At the start of the UNDP/GEF project, the Dengta facility was the largest pig farm in China, with about 200,000 pigs. The biogas produced at the facility as a result of the project was used for the production of process heat for several of the farms operations (pig houses as well as turtle ponds, etc.) and for cooking in the staff dining hall. The farm also purchased a 500 kWe biogas-powered genset for electricity generation, but the farm site was relocated before the generator could be installed and commissioned. The water discharged following installation of the biogas facility met national environmental effluent discharge standards finalized in 2002 and published by SEPA. When the farm had to move in 2005 due to the dramatic expansion of the city of Hangzhou, the Dengta pig farm's biogas plant was replicated soon afterwards. In this replication, the design and construction teams were able to learn from the first installation and design, and constructed the second installation in half the time, just 6 months. The Dengta pig farm was able to finance the Project partly through the UNDP's 10% contribution and partly through a larger low-interest business loan for the company.

The Dengta installation made important contributions in its role as a demonstration project. It helped to generate interest in biogas by other pig farms, as well as raising the awareness of government officials and other industry sectors. The Energy and Environment Committee of the National People's Congress was one of the many groups that toured these pilots. There were over 900 person-visits to the installation, including a prominent CPPCC member and officials from MOST, SETC, MOA, and SEPA; visitors came from Vietnam, Thailand, Indonesia, and Japan. A workshop was held nearby with a visit to the Dengta facility as well. Overall, HEEEC participated in four international biogas forums with support from the project (at Hangzhou twice, as well as Zhaoqing and Qingdao).

HEEEC developed sixteen biogas-based combined heat, power, and fertilizer production (CHPF) projects around Taihu Lake. These projects demonstrate the zero discharge liquid effluent large-scale livestock farms, combined with enhanced revenue from production of electricity, heat (for internal use on the livestock farms), and fertilizer. The environmental path-forging role of these facilities is especially important in this location because Taihu Lake, the third largest freshwater lake in China, has become severely polluted from industrial effluent.

This pollution has resulted in spectacular algae blooms and the despoliation of the lake water, rendering it unsuitable for human use (drinking, bathing, cooking, etc.) and choking off fish life. The national government led by SEPA has declared the current situation as a national environmental emergency and the Taihu Lake has been placed in the central government's "Three Lakes-Three Rivers" list of important watersheds in China slated for special and high priority attention for clean up. The central government and governments of Zhejiang and Jiangsu are reported to be preparing expenditures of as much as $14 billion for clean-up of the lake and clean-up or closure of the worst polluting source industries. The problem of Taihu Lake's pollution has attracted the attention of both Chinese media and the international press including the BBC, the New York Times, and the Christian Science Monitor.

Table 2: Selected Industrial-Scale Biogas Projects of HEEEC

Project Owner	Location	Project scale	Timing	Biogas m^3/day	Power generation	Other output	Service provided
Dengta Pig Farm	Hangzhou, Zhejiang	200,000 pigs	1999-2000	8,500	500 kW (?)	CERs (>20k?) fertilizer	contracting
Shunyi Pig Farm	Beijing	60,000 pigs	2000-2001	2,200	--------	--------	contracting
Jiaozhou Brewery	Qingdao	10,000 tpy ethanol	2001-2002	10,000	300 kW expected	Liquid fertilizer	Supplied equipment
Tianyuan Farm	Hangzhou, Zhejiang	100,000 pigs	2001-2002	2,800	-------	---------	contracting
Lu Jiayuan Pig Farm	Jiaxing, Zhejiang	20,000 pigs	2004	800	50 kW	---------	--------
First Brewery (yellow wine)	Xiaoshan, Zhejiang	120 t/d alcohol ww	2004	550	----------	---------	--------
Yellow Wine Group	Shaoxing, Zhejiang	10,000 t/a rataffee	2004	500	----------	---------	--------
Yongjia Pig Farm	Wenzhou, Zhejiang	8,000 pigs	2005	400	24 kW	---------	--------
Changxing First Pig Farm	Yixing, Zhejiang	15,000 pigs	2005	500	24 kW	-----------	--------
Xingwang Breeding Farm	Yixing, Zhejiang	10,000 pigs	2006	1,000	80 kW	Fertilizer	---------
Kunshan Pig Farm	Kunshan, Jiangsu	5,000 pigs	2006	500	30 kW	------	----------
Nongchuang Pig Farm	Wujiang, Jangxu	10,000 pigs	2006	1,000	50 kW	------	---------
Weiwei Dairy Farm	Xuzhou, Jiangsu	2,500 cows to be 10k	2006	2,500	500 kW	----	--------
Kunxing Dairy Farm	Yixing, Jiangsu	2,500 cows	2006	550	24 kW	----	-------
Kangle Farm	Changzhou, Jiangsu	15,000 pigs	2006	1,200	80 kW	----	-------
Nanyang Breeding Farm	Wuxi, Jiangsu	10,000 pigs	2006	1,000	50 kW	----	-------
Sanli Breeding Farm	Wuhu, Anhui	10,000 pigs	2006	1,000	80 kW	----	-----
Chuantian Dairy Farm	Nanjing, Jiangsu	1,000 cows	2006	1,000	80 kW	----	-----
Yongkang Breeding Farm	Jintan, Jiangsu	8,200 pigs	2006	1,000	80 kW	-----	-----
Changxing 2nd Pig Farm	Yixing, Jiangsu	25,000 pigs	2006	2,000	180 kW	-----	-----

Project Owner	Location	Project scale	Timing	Biogas m^3/day	Power generation	Other output	Service provided
Mengniu Aoya Pasture	Inner Mongolia	10,000 cows	Under const.	--------	1 MW (grid)	------	-----
Deqinguan	Beijing	2.6 M hens	Under constr.	--------	2 MW (grid)	Fertilizer	-----
Minhe Animal Husbandry Co.	Minhe, Shandong	30 M (?) chicken/y	Seeking investment	30,000	3 MW	Fertilizer	-----

Note: Projects indicated in bold are UNDP demonstrations, plus Tianyuan, which is the reconstruction of the Dengta Farm after it was moved out of Hangzhou. Source: Hangzhou Energy & Environmental Engineering Co., Ltd (March 2007).

There are perhaps over 1,000 companies in China doing industrial biogas projects of various scales. However there are only 10 companies in China with similar experience and expertise comparable to HEEEC that can do very large projects with power generation equal to or greater than 1 MW. HEEEC is currently discussing a cooperation project with IFC to include investment in a large-scale project as well as capacity building. The many impacts of the project on HEEEC's business development are detailed in the Results section.

Other Project Activities to Support Commercialization

Other project activities that supported the commercialization of biogas technologies included production of an international best practices report; production of project development guidelines—one each for livestock farms (large feedlot operations and breeding farms) and for industrial plants producing high organic content wastewater effluents (such as distilleries, breweries, slaughterhouses, food processing companies, etc.). The Project also provided support for development of a commercial power project that would be the first centralized biogas power plant project in China serving a farming region that produces 600,000 pigs per year. This latter activity consisted of conducting a feasibility study for the biogas plant, which was located in Nahhu, Zhejiang Province, and had a production capacity of 2 MW. The plant included combined heat and power (CHP) applications. Financing for the plant is currently being sought by local officials in Zhejiang.

The project's transition to a regional development approach also contributed to the commercialization of the sector, and this was supported by a regional workshop held at Taihu Lake. The idea behind the regional approach is to pursue a broad view of a complete watershed, taking into account the aggregate of pollution sources in a given region and constructing policies to promote pollution mitigation through the commercialization of biogas facilities, including building power plants near the power grid and bringing in the resource from multiple polluters in the area in centralized facilities. This approach also has the advantage of utilizing private investment capital to solve pollution control issues, since it is impossible for the government alone to provide enough grant assistance to effectively address pollution on the scale that exists in China. As a result of this workshop, SEPA is now looking at how to manage the wastewater from hundreds of plants around the lake by using a regional planning approach, instead of considering dispersed plants in isolation. Single plants serving multiple farms and providing new investment incentives could also be a part of this regional approach.

Results

The large-scale biogas activities of the Project have been perhaps the most successful due to the combination of project tools and results. The project was effective in improving technology, especially for power generation; capacity building; generating direct results and additional projects from the pilot plants; and removing institutional barriers through policy development. These activities together created synergies that resulted in a whole greater than the sum of its parts. Further, the approach for the successful regional biogas workshops served as a model for developing markets, and these workshops had concrete results—45 contracts for biogas projects were generated by the first three workshops alone. While the number of projects stimulated by secondary and tertiary effects is unknown, it is certainly a multiple of the original results based on bioengineering company feedback. Further, CDM projects in the biogas sector are now being pursued, whereas in the past landfill methane was of the highest priority.

In sum, the three key areas of impact can be summed up as follows. First, the project achieved a paradigm shift for China's biogas industry by using an early adopter/champion strategy. Second, strong scale-up effects from the project have been observed. The UNDP project had quantitative targets of what it wanted to achieve in this regard, including stimulating projects with the workshop series, and enhancing industry growth by promoting technology for power production. Third, while the *Biogas Action Plan* has not yet been fully completed, the project played an important role in getting the Renewable Energy Law drafted and passed, and in securing the associated biomass feed-in tariff and grid connection guarantee for small, independent biogas power producers.

The specific impacts of the project are detailed below.

Promotion of the European Model

While the first two demonstration projects in Hangzhou and Shunyi used contemporary two-stage plants, the Qingdao plant, despite having equipment for two stages installed, is now only operating the first stage. Qingdao is producing liquid fertilizer as a byproduct and is in the process of working toward development of a business model and a market in which to sell the fertilizer. While it is in some sense a waste that Qingdao's second phase reactors were never put into production, it is also a major success of the project because the paradigm was changed in China to an appreciation of the benefits of single-stage treatment. In addition, while the first two demonstration projects only burned the biogas, the Qingdao plant has installed power generators supplied by the project.

Improved Power Generation Equipment

At the time of project inception, the only biogas generators available in China were modified diesel engines of poor quality, available from three or four manufacturers. At the present time, there are four manufacturers (including Shengli Shengdong and Sichuan Hongyan) that manufacture generators specially designed for biogas fuels. The quality has progressed and now 24 to 700 kW generators are available from these domestic manufacturers, with 1 MW generators in the development stage. For the time being, generators from foreign manufacturers are still used in landfill methane projects and in the MW-scale projects in which HEEEC is involved, and at a higher price.

Media Coverage and Information Dissemination

One very positive aspect of the project was the number of visitors to the pilot plants and the resultant media coverage. Hundreds of visitors went to the Shunyi plant, including domestic print and television media, and international media. The BBC produced two programs on the demonstration projects, and CCTV produced a feature program. Other stations covering the demonstration included Beijing TV, Zhejiang TV, and some German television stations.

In the role of facilitator of innovation, the PMO used an understanding of the mechanisms of the diffusion of innovation.[8] This was essential in designing an approach to facilitate a paradigm shift and commercial and environmental breakthrough in the biogas area, as well as in other project areas. In short, the mechanism of diffusion involves communicating innovation through certain channels so that individuals make choices through awareness, persuasion, and informed evaluation rather than by authoritative or collective influence. The key to this was finding an influential leading-edge innovator, and for this component that innovator was HEEEC, and Mr. Cai. Also important was the support from experts in the European community, including Stephen Etheridge from the UK.

In terms of publications, HEEEC prepared the *Guidebook for Biogas Projects on Livestock and Poultry Farms* under contract to the UNDP project. This was given to Tanzania and Namibia.

Workshop Approach

One of the principal successes of the project, and a strategy to be replicated in the future, was the inclusion of business promotion and business discussion in the workshops. In addition, the breakout sessions were very dynamic, sometimes with two to three hours of questions. Altogether, over 700 individuals from industrial plants and livestock farms (almost 500 organizations) attended the five workshops. The multi-stakeholder model and the paradigm change model adopted were also very important. The former—which involves making sure that all key stakeholders

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[8] For explanation, see Everett Rogers (2003). *Diffusion of Innovations – 5th Edition*. New York: Free Press.550 pp.

are in one place at the same time with a common vision—was adopted by the Chinese government and can be credited directly to the PMO and the leadership of William Wallace.

New Investment Opportunities

In the past, most biogas projects were paid for by the livestock owner, with frequent supplementation by a bank loan. In the future it appears the situation will be different, and represents a new opportunity for investors. For example, the Tianjin Taida Group is a listed company that plans to invest in biogas installations at Yili Dairy's ten 5,000-cow dairy farms. Taida has retained HEEEC to carry out the design and construction of the biogas installations.

Grid Connection for Biogas

It has been confirmed, because of the project work in policy and commercial development, that the large biogas projects (>500 kW) will be connected to China's grid in the near future. This is remarkable and a major achievement because: (1) biogas power generation projects are relatively new; and (2) just one year ago this was not considered a likely possibility. Mr. Cai confirmed that for the megawatt-scale biogas projects HEEEC is developing, approval has been issued by the Huabei grid and the Shandong grid and that, conforming to the implementing regulations of the Renewable Energy Law, a tariff increment of 0.25 yuan over the price of coal-fired power will be paid.

Industrial-scale biogas is still not fully commercial on its own; for this reason, an increment to the grid price of electricity is offered for biogas power generation. Typical prices for coal generated power are 0.4 yuan/kWh if de-sulfurization is carried out, or 0.3 yuan/kWh if not. Producing electricity instead of using the gas directly increases the opportunities for biogas to become commercial. However, evidence that biogas power production lowers net costs can be gathered from the fact that the end-users of large projects are all generating power. Though biogas in China is still not as commercial as in Europe and still depends on the Renewable Energy Law, this situation is likely to change in future.

Pilot Plants

It is considered very unlikely that the distillery would have carried out biomass power generation without the UNDP project. In contrast, it is interesting to note that just about every project that HEEEC is doing now has a power generation component.

As a result of HEEEC's achievements under the UNDP project, other companies with the same business model have developed, including one based in Beijing. The emergence of these competitors demonstrates that there is a robust market for the industrial-scale biomass sector. The private sector is very much driving the growth of the industrial-scale biogas industry.

Each of the pilot plants had a significant impact on the sector in its own way. These are detailed below.

Achievements of HEEEC under the Project

In the view of Mr. CAI, Chairman of HEEEC, the UNDP project had a huge impact on the company, facilitating its rapid growth and capacity development. Though the industry and HEEEC would have continued developing and inevitably have improved the technology in the absence of the project, t*he UNDP project provided the company with an important and effective shortcut to a new technical approach*.

Workshop impacts: Detailed introductions to the demonstration projects built by HEEEC were made at the UNDP project's exchange forums held in Hangzhou (2001) and Zhaoqing (2003). Face-to-face discussions between developers and project owners of the pig farms were a key aspect of these forums. These face-to-face discussions were crucial in promoting the development of biogas conversion projects through commercial deals resulting from them. HEEEC participated in four international biogas forums with support from the project (at Hangzhou twice as well as Zhaoqing and Qingdao).

International cooperation during the project*:* International cooperation facilitated by the project helped bring advanced technology to HEEEC. Early on, the PMO invited three European experts to China: Steven Etheridge, UK; Rick Waser, Ecofys (Netherlands); and Jens-Bo Holm Neilsen, University of Southern Denmark. These foreign experts provided guidance, new concepts, and key information about new technology to HEEEC. In particular, the Danish expert brought the concept of CHP generation and composting to the company. Consequently the Chinese technology

Textbox 7. HEEEC Projects under the UNDP Project.

The projects that were undertaken by HEEEC since its involvement in the UNDP project are summarized in Table 2. Select additional details are presented below:

- Wenzhou Yongjia Pig Farm: Yongjia is a private entrepreneur's farm, with the biogas project supported jointly by the owner and the government. The biogas is distributed by pipeline to 125 households.
- Kangle Pig Farm: This farm has CHP and composting. The waste heat from the power generator can be used throughout the year.
- Jiangsu Jintan Yongkang Breeding Farm: The holder at this farm's biogas installation is integrated into the aerobic tank, a design newly developed by HEEEC.
- Jiangsu Yixing Changxing No. 2 Pig Farm: Because HEEEC's first pig farm biogas installation for Changxing operates very well, the

and concepts improved significantly. In 1999, Mr. Cai went with William Wallace to Amsterdam and London to visit pig, cow, and chicken farms and biogas production and conversion technologies. In 2001 Mr. Lin went to the Sustain conference in Amsterdam. The technology HEEEP uses today is based on experience and technology from Germany, Denmark, and other European countries.

HEEEC's International Work*:* The strong growth in the capabilities of HEEEC is reflected in their growing transfer of advanced biomass conversion technology to other countries. HEEEC's anaerobic digesters comprise a new technology similar to continuous stirred tank reactors (CSTR) but is more aptly described as "improved CSTR"; it is the most technologically advanced internationally. They have transferred their technology to Japan and Taiwan, and have also designed plants for customers in Malaysia and Thailand. In 2001 Tanzania, Namibia, and South Africa invited Mr. Cai to give lectures at Tanzania University, Namibia University, and a company in South Africa, respectively. UNDP Namibia was aware of the China biogas demonstration projects. HEEEC has developed cooperative relationships with organizations in 15 countries in Africa, Asia, Australia, and the U.S., as well as in Russia.

Business Development: The company's ability to develop commercial projects grew substantially through involvement with the project, which facilitated new concepts and technologies as well as management skills. In addition to enabling HEEEC to grow its capabilities, the UNDP project provided an effective platform for developing new business and building the company's reputation. When HEEEC started getting involved with the project, there were 12 technical staff members. There are now 32 technical staff and 3 project installation teams.

Perhaps the most obvious impact of the project is the speed at which the company's biogas project work has developed. In 2001, the company had 4 biogas projects with a total contract value of 5.26 million RMB (about US$713,000). In 2006, they had 21 biogas projects with a total contract value of 42.8 million RMB (about US$5.8 million). Thus, the annual biogas project value is now 8.1 times what it was in 2001. Altogether, since 2001 and up to the end of 2006 they have conducted over 50 large-scale turnkey biogas projects. They have also conducted 18 feasibility studies and, separately, 25 project designs. *More than half of the projects accomplished resulted from the UNDP project workshops*, which included business development sessions. In terms of technical level, HEEEC is now approaching the level of biogas technology in Europe, although their services are much cheaper than those of European providers.

Since the work on the demonstration projects, HEEEC has prepared the Jiaxing Nanhu feasibility study for the UNDP Project, which included 2 MW of power generated from the manure of several pig farms. This experience was helpful in their obtaining and designing the three large grid-connected projects they are now working on. All three projects carried out international bidding; and HEEEC won because of its experience with the UNDP project. In addition, the power generated at the Jiaxing plant will be accomplished on an independent power producer (IPP) basis, which is a model that is not yet established in China and could therefore have far-reaching effects.

Feedback from End-Users: HEEEC has gotten very positive feedback from end-users, suggesting that biogas installations resulting from business development sessions at the UNDP Project's biogas forums (or subsequent multiplier effects) have had a positive impact. In general, end-users have a very high level of satisfaction with HEEEC's biogas installations because these both improve their economic returns and provide the capability of meeting environmental regulations. Many of the end-users have recommended HEEEC's biogas project services to other end-users and these have become HEEEC's new customers. The China Pig Farm Association has also promoted HEEEC's work at meetings.

Achievements of the Qingdao Distillery under the Project

According to Mr. Wang, the production manager of the distillery, the primary contributions of the UNDP project include economic and social/environmental benefits. Overall, the project improved the quality of their biogas installation. With the expansion of their facility in 1999, their biggest challenge was meeting environmental regulations for the waste slurry. The UNDP Project guaranteed that the technology operated at international quality levels, which in turn guaranteed that the distillery received approval and met the national environmental standards for their production of edible ethanol. (China has strict environmental regulations for edible ethanol production.) It is a significant achievement for the distillery compared to pre-project capability that they have zero wastewater emissions.

The introduction of improved technology also afforded the distillery staff the opportunity for acquiring new knowledge. The concept of biogas shifted from being solely a treatment to being an environmental and economic opportunity. In this way, the conceptual approach of the distillery was broadened significantly.

Secondly, without the support of UNDP it would have been very difficult for the distillery to fully recover costs. Other enterprises that install and self-fund such biogas facilities may never recoup on their investment. Distillery principals also feel that the project was instrumental in connecting the distillery with the right experts for designing and installing the biogas equipment, which includes the services of HEEEC.

Significantly, the distillery's costs of ethanol production have declined substantially because of the biogas project. This is because biogas has replaced some of the coal used in the boiler, which is used for the edible ethanol production, alcoholic beverage production, and heating. For example, Qingdao's processing costs for edible ethanol production are 500 to 520 yuan per ton, which is much less than the costs of other producers, which generally range from 650 to 700 yuan per ton. Qingdao saves at least 4 to 5 tons of coal per day and at best 8 to 10 tons, depending on environmental conditions.

It should be noted that the revenues of the distillery will be further improved if the fertilizer is sold on the market rather than given away. To do this, it will be necessary to develop technology for solidifying or concentrating the fertilizer at low cost.

In sum, the social benefits of the project surpass the economic benefits, in terms of their environmental and demonstration impacts. The environmental improvement brought by the project is significant—prior to the project, the distillery emitted all of its wastewater (400 to 500 m^3 per day) from ethanol production and the chemical oxygen demand (COD) was greater than 40,000 mg per liter. The negative environmental consequences from this scenario were serious. Now the anaerobic fermentation produces fertilizer, all of which is taken away and used in forestry and agriculture, which eliminates wastewater.

Because of its being a demonstration project, the distillery has been named a "Model Work Unit for the Recyclable Economy" by Shandong Province. *Recyclable Economy* is now an important theme that the GOC is promoting to reduce waste. The distillery's biogas installation has received many visitors, organized by the Environmental Protection Bureau of Zhaozhou City, and have included manufacturers from other sectors. In addition, the facility has been visited by large groups of students from the Qingdao Science and Technology University.

Lessons Learned

At the project's inception, the state of the biogas industry posed some challenges for the project. In 2002, SEPA developed and promulgated a set of environmental standards to control the wastewater emitter. The country's focus at that time was solely on environmental protection, and biogas plants were only built in response to SEPA requirements. However, the project goals included promoting the use of biogas installations for energy generation as well as environmental protection. In order to produce energy and to meet wastewater standards at the same time it is necessary to build a two-stage plant, which is expensive.

The project was successful in promoting the European model, which is zero discharge, although it was difficult initially to shift from the accepted biogas processing design. However, because there is no discharge, this model is economically advantageous. Success in promoting the European model is reflected in the recent projects and perspective of HEEEC. The company is currently building biogas plants of the type promoted by the project, with no affiliation with the project.

In China, the barriers to taking this more economically and environmentally desirable European approach are two-fold: (1) the SEPA regulations have not kept up with the technology, and (2) there is no market for liquid fertilizer because few people have experience using it. The SEPA regulations allow discharge of clean water, but restrict using liquid fertilizer directly from the plant. In China, the liquid material is separated from the solid before the aerobic step. The solid is made into a solid fertilizer (for which there is a domestic market), while the liquid must still be treated in a second (aerobic) phase. The commonly used Upflow Anaerobic Sludge Blanket (or Bed) (UASB) reactors in China require separating the solid from liquid to remove large particulates that could disrupt the sludge bed. This is an efficient process for achieving clean water, but by removing the solids the gas output potential of the plant is reduced. The UASB process also uses a large quantity of water, which tends to dilute the liquid fertilizer as well.

At the time of project inception an additional barrier to the European, energy-focused biogas approach was difficulty in selling electricity to the grid. Before the Renewable Energy Law was issued, this it was not possible. Now, some MW-scale biogas projects have recently received grid connection agreements from grid companies, so China has begun to accumulate experience in grid-connected biogas.

The crux of the challenge in shifting to the European approach was a difference in paradigm. In Europe, everything goes into the digester—solids, liquids, and garbage—to generate as much biogas power as possible; environmental benefits are secondary. In China, pollution control is the goal, with energy production secondary. Changing this paradigm was difficult. Though the project promoted the European model, all three demonstration projects installed the two-stage pollution control technology.

The project experience illustrates that facilitating paradigm change is neither simple nor obvious. In this case the goal was to change fundamentally, how industrial biogas technology is used in China. The impact has been significant, in that one prominent bioengineering company changed its business model, and this has had ripple effects on the industry that continue after the project's closure.

In this instance, the paradigm shift could not likely have been achieved by working from the policy angle. Instead, industry led the way and has had an effect on policy, namely the fact that power generated from biogas can now be connected to the grid. To gain the support of SEPA, rather than focus on the benefits of power generation, the UNDP project promoted the benefits of a market for liquid fertilizer. Capitalizing on the output value of fertilizer eliminates wastewater, reduces the cost of operating plants, and makes facilities more affordable for industry. This in turn benefits the government, as subsidies are not required to deal with the wastewater—SEPA's current practice. Once plants become commercially feasible, government support is not necessary. This requires a change in thinking, but it is more likely to occur due to the fact that it is couched in terms of cost savings.

Finally, the project faced some challenges in the form of technical issues. The greatest technical difficulty encountered was with the distillery's second treatment phase, the aerobic as opposed to anaerobic phase. The process was water-intensive, difficult to operate, and it is unclear whether it met the 300 mg per liter COD regulation. Since the distillery decided to give up on the second phase and instead turn the effluent into fertilizer, the investment in the SBR reactors (about two-fifths of total equipment costs) was wasted. However, the distillery's single-phase approach could turn out to be more ideal for subsequent plants in terms of biogas production and power generation. Since the facilities would have zero emissions, the aerobic treatment could focus on CSTR (which produces more biogas) rather than USB (which had been utilized at the distillery for more complete treatment). Therefore, what began as a challenge produced a valuable lessons learned. All of these decisions at the distillery were made by the distillery owner and manager on the basis of business criteria and based on their own operating experience with the plant, the ultimate in effective transfer of new operational concepts.

Other technical issues included some mixing difficulties with the 2,200 m^3 CSTR, because the cassava contains dirt and as a result can cause high acid content, which reduces the amount of biogas produced and can cause problem with blocked pipes. To remedy this, calcium carbonate, an alkaline material, is added.

Recommendations

There are three main areas in which future UNDP projects should consider focusing biogas efforts. The first is fuel ethanol, utilizing cassava, sweet potato, and sugarcane. The wastes from processing of these feedstocks have very high potential for biogas. In addition, because cassava waste after bio-ethanol production contains mostly cellulose with little protein, which does not make good material for feed production as in the case of corn, biogas is a higher return option for the waste than animal feed. Mr. Cai, of HEEEC, sees biogas installations for bio-ethanol plants as one of the next big areas for his company's development beyond its work in livestock farms. However, it should be noted that this requires Central Government approval as the Government, which subsidizes ethanol, is strictly limiting new projects.

The second main area for potential focus is municipal waste, such as the solid wastes from big hotels and restaurants. To date, this is an unexplored resource in China. Third, small and medium-sized livestock farms have received little focus to date. There is a need to determine the best use of electricity generated by biogas installations on these farms. Typically too low to meet China's grid-connection requirement of 500 kW, the question is how best to make use of this electricity for new activities such as animal feed production.

Biomass-based power generation is now underway with the MW-scale plants, and is supported by the Renewable Energy Law. However, the implementation rules are still being worked out and there remain challenges. While experience is gained by the provinces accepting biogas energy on the grid, there may be a role for CREIA to play to promote information sharing and to educate the utilities and provincial authorities not yet exposed to biomass-based grid power.

As for the needs of the existing installations, the general manager of the Qingdao distillery has emphasized the need for a cost-effective technology to solidify the liquid fertilizer. Further research in this area is needed, and there does not appear to be any underway at present. The market prospects for solid fertilizer are there, and were it to be developed, could influence other distilleries to install biogas facilities for the extra revenue from production. Other needs include investigating the efficiency of the existing biogas production facilities, and looking for ways to improve. Additional uses of the biogas might also be investigated, such as compression or sale to consumers as a cooking fuel.

7. Solar Water Heating Development

Background

Solar thermal energy for water-heating is one of the most advanced renewable energy technologies in China, with a mature commercial domestic market. China is the world's largest producer of solar water heating (SWH) systems. Notably, there are over 1,000 SWH manufacturers—with about 10 operating on a large scale—and 95% of the intellectual property rights (IPR) for solar thermal technologies used in China are domestically owned.[9] In the past 10 years, the growth rate for SWH installation has reached 15% per year. NDRC's strategic planning targets for SWH development call for an installed capacity of 150 million m^2 in 2010 and 300 million m^2 in 2020.

Currently in 2006, China's cumulative installed capacity of solar water heaters is around 90 million m^2, for 80% of the world's total. [10] By contrast the entire cumulative installed capacity for Europe at the end of 2005 was about 15 million m^2. In 2006 alone, China installed approximately 20 million m^2 of solar water heating systems based on collector surface area. However, the increase in installed solar thermal systems lags behind the equipment production capacity, which has an annual increase rate of 28%.[11] In 2006, the domestic production capacity stood at 6 million m^2. The excess production is currently exported to Europe and South-East Asia. There is substantial potential internationally for the best of the Chinese solar water heating products, provided that these can meet the stringent quality and performance standards of the international marketplace.

Therefore, China's SWH market still has a lot of room for growth in coming years. There remains a very large domestic rural market which is largely untapped, while the urban market should continue to focus on improvement in the quality of products. These are two very different markets. The SWH industry has been compared to the Chinese air conditioner industry in terms of scope and scale. However, the SWH industry is potentially more profitable than the latter since the raw materials and basic inputs for air conditioners cost much more. Yet, the products sell for the same price.

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[9] NDRC, Mid and Long-term Renewable Energy Development Plan, August of 2007

[10] Scheme on Promoting Solar Thermal in China, International energy Net; GTZ, wind Energy Country Study, September 2007

[11] GTZ, Wind Energy Country Study, September 2007

China's SWH industry faces many challenges in the quest to become a world-class industry, which requires high-quality, durable products that can meet high standards of production, performance, and longevity. Overall, the market is constrained by widespread dissemination of poor products, and after-sales service is an ongoing problem. A decade ago the industry was made up of as many as 2,000 SWH companies, with most producers being very small and many products of poor quality, poor performance, and short lifetime. Though SWH standards development work began in China in 1982, and by 1990 had achieved 10 standards for the industry—by then China was the world's largest producer of SWHs—there were still inadequate standards for SWH design, production, or performance. Further, there was no system of testing, evaluation, and certification. Consumers were often stuck with poor products and lacked recourse. The work of the UNDP Project has helped to facilitate the rationalization of the industry through establishment of standards, a national testing system, a certification and product labeling process, and technical advances, and this has resulted in new levels of consumer confidence and market growth.

Project Overview

From the outset, the SWH market sector was one of the most promising for the UNDP Project to have a great impact. UNDP's partners had similar goals and approaches, and the absence of top-down-driven pilot projects removed a layer of political battles. Additionally, these activities, with a focus on testing and certification, were elevated to a national level for a greater impact. The broad objectives of the Project support for China's solar water heating industry included:

- To create a more orderly market for high quality solar water heating products in China;
- To ensure future expansion of the SWH market; and
- To develop consumer confidence and awareness by identifying quality products that have been certified and tested.

The UNDP project's SWH program was designed in direct response to a request of the Government of China. After implementation of the UNDP project began, the State Economic and Trade Commission (SETC) requested involvement in standards and certification issues. The original project document had not integrated these issues, but the UNDP project was flexible enough to do so.

At the request of UNDESA, SETC, and UNDP, and with the concurrence of the Project Management Office of the Project, a two-year work plan[12] for the calendar years 2003 and 2004 was prepared to map activities during the final stage of the Project. At the time the project was expected to be extended by one year and to be completed by May 2005. (This was subsequently extended by two more years to permit achievement of the major project goals and to accommodate the time impacts of the

[12] UNDP/GEF Project Two-Year Work Plan for 2003 and 2004 (Feb 2003). Project Report for CPR97/G31

Chinese Government restructuring that was underway in 2003). The two-year work plan was necessary in order for the PMO and its principal stakeholders to obtain a sense of the probability of achieving the outputs and major objectives as mandated by the Project Document. That document established criteria at the inception of the Project, and as determined during the Project's Advisory Group Meetings and intermediate reviews. During the then current restructuring of the Chinese Government, the functions of the State Economic and Trade Commission were redistributed within the Government. The UNDP/GEF Project was reassigned to the new National Development and Reform Commission, formerly the State Development and Planning Commission.

The basic capacity building objectives of the Project were consolidated as much as possible to create national programs that would maximize the Project's leverage and take advantage of synergies through cooperation with other groups to achieve concrete outcomes. The capacity building associated with solar water heating testing and certification was executed in the context of a National SWH Standards, Testing, and Certification Program. That program contains the following components:

1. Development of new national standards for SHW product component and system testing to complete the current standards framework in China, consistent with international standards in the field.
2. Selection of three national testing centers and procurement of equipment to develop test facilities at these centers.
3. Establishment of a certification center and program for solar water heating products.

This approach reflects the guiding principle of the Project's overall cooperation with China—ensuring that what the project does becomes part of China's national program.

Textbox 8. The Wuhan National Solar Water Heater Test Center—the First National Testing Center.

The Wuhan National Solar Water Heater Test Center was chosen to be one of the UNDP project SWH test centers shortly after its start-up of operations in 2001. The principals of the Center were also part of the UNDP-sponsored study tour to four European countries to learn from international labs. This was very useful since it coincided with the setting up of their lab.

The center passed the CNAL requirements for certification in November 2002, and in May 2003, SAQSIQ and the State Certification and Accreditation Supervision Management Committee jointly issued a document approving establishment of the center. The Center began testing work shortly thereafter. Under the leadership of SAQSIQ, the Hubei Production Quality Supervision and Testing Research Institute is responsible for the center.

The center has developed many manuals on quality, procedures, operation, inspection, calibration, and guidance. It has also jointly developed with Huazhong University of Science and Technology a fully automatic system for testing SWH collectors. When the testing center was first established, China had no regular system for testing collectors and could not carry out testing of performance of collectors in a consistent way. The work for developing a fully automatic system was supported by the UNDP project, and the system meets or surpasses both the national and ISO standards.

Standards and Testing

The SETC established a partnership with the China National Institute of Standardization (CNIS—described in Textbox 9) and the China National Laboratory Accreditation Committee (CNAL) to cooperate in the process of developing new standards for the SWH industry and to provide laboratory accreditation for the three new national testing centers. The CNIS was contracted to provide consultant services for the development of the new national standards. CNAL and initially three separate research institutes worked to develop the testing center functions of the National SWH Testing and Certification Program.

Three research institutes were selected in a competition to become the National SWH Testing Centers in China, including:

- The Solar Research Institute of Yunnan Normal University in Kunming, Yunnan Province.
- Hubei Product Quality Testing and Supervision Institute in Wuhan, Hubei Province (Textbox 10).
- Institute of Air Conditioning in the China Academy of Building Research in Beijing.

Through coordination with the CNAL, the State Quality Technical Supervision Bureau (SQTSB) for laboratory accreditation, and with CNIS, the Wuhan and Beijing Test Centers were accredited as national test centers.

The Jiangsu Provincial Supervisory and Testing Institute in Nanjing, Jiangsu Province was later established as a national testing center independently of the Project. There may be additional such testing centers established in the future based on need and the qualifications of

Testbox 9. China National Institute of Standardization (CNIS)

CNIS is the largest institute for standardization in China and is affiliated with the General Administration of Quality Supervision and Inspection and Quarantine (AQSIQ). CNIS conducts research on national policies and development strategy for standardization, researches and develops standards, and provides standards information services.

There are six research institutes under CNIS: Sub-Institute of Resources and Environment; Standardization Theory and Strategy Research Institute; General Standardization Research Institute; High Tech and Information Standardization Research Institute; Research Institute for Standardization of Quality Safety for Industrial and Consumer Products; and Research Institute for Food and Agriculture Standardization. CNIS also houses China's largest standardization library. Finally, CNIS has under its purview the China Standard Certification Center, which implements certification for energy efficient, water conserving, and environmentally-friendly products.

The objectives of CNIS's involvement in the UNDP project were, in association with CREIA, SETC, and the PMO, to: (1) assess the current status of standards and certification procedures for SWH in China; (2) perform a needs assessment for a national standards, testing, and certification program; (3) develop a consensus process for establishing national standards for SWH; (4) assist in identifying and selecting national test and certification centers; and (5) organize two workshops to solicit broad input and promote information dissemination.

institutes applying for national testing center status. The China General Certification Center (CGCC), which was competitively selected to house the China National Solar Water Heating Certification Center, has also established a formal process that allows for an increase in the number of national testing centers based on national needs.

Following competitive selection of the test centers, stakeholders visited five test centers in Europe. European experts later came to China to continue the knowledge exchange. After the first study tour, a group was formed of the three test centers, national experts, and two international experts. The group determined what equipment to procure and what special custom equipment to design and then split up the tasks. The UNDP PMO undertook the task of supervising the preparation of the specifications and procurement of the equipment. The group collaborated during the establishment of the test facilities and worked with the certification program to develop the certification procedures.

The Project emphasized the need for a competitive process in selecting the test centers. The SETC developed a rigorous process with an evaluation committee and scoring system. Proposals from 10 organizations were accepted and each organization was interviewed and asked to make a presentation. It is worth mentioning that no test facilities affiliated with a manufacturer could be chosen. This was in spite of the fact that some of the best facilities were technically associated with manufacturers; however, the technical experts and major companies in the field insisted on this provision to avoid conflict of interest between test centers and their industry customers. In addition, the original Project Document called for a budget of US$1 million to support an indoor solar simulator. Early on in the Project, the Senior Technical Advisor insisted that this was an inappropriate use of these equipment funds and instead developed a plan to leverage these funds on a 50/50 cost-shared basis to provide the equipment base for three national test centers.

Prior to the Project, China had 10 standards for SWH. An additional four were developed as part of the Project over 2002 – 2003, including:

- GB/T18708-2002—Test methods for thermal performance of domestic solar water heating systems.
- GB/T18713-2002—Solar water heating system design, installation, and engineering acceptance.
- GB/T18674-2003—Indoor test methods for the thermal performance of solar collectors.
- GB/T 19141-2003—Specification of domestic solar water heating systems.

Three of the four standards form the foundation for the product testing program developed in the test centers and used by the certification center as the basis for the product certification and labeling system.

In theory, China's SWH manufacturers are not required to meet these standards, which are classified as "voluntary." However, those companies that can meet the national standards and display the CGCC product label have a significant marketing advantage over those companies whose products cannot be shown to meet the standards through the testing system. The nation also randomly samples 50 enterprises annually to see if they are meeting the standards. Those among the 50 that fail to meet the standards are asked to improve. What is helpful to the enterprises is that the testing centers can point out what needs improvement with the technology, so the manufacturers have the opportunity by testing to improve the quality of their products.

At each testing center, there are eight test stations (expandable to others) for system thermal performance. Testing procedures for single-day and multi-day tests have also been developed. The single-day test gives a snapshot of system performance, while the multi-day test provides a series of test conditions and data points that can be translated to performance data for any climatic conditions existing throughout China. Currently only the single day testing is routinely done, but the test centers have the capability to do the multi-day testing at the request of their corporate customers. Multi-day testing will become important when the certification shifts from simple pass-fail to energy labeling. The areas tested include:

- System thermal performance: multiple (eight) test stations (expandable), testing thermal performance and heat loss coefficient of the SWH tanks; single and multi-day testing.
- Solar collector thermal performance testing: two-axis tracking test bed tests two units at a time; thermal efficiency and parameters for collectors tested.
- System qualification testing: durability and reliability testing for systems; environmental testing and testing of mechanical integrity.
- Collector qualification testing: two loop test system; internal and external thermal shock testing, pressure testing, and rain resistance testing.
- All-glass evacuated tube thermal and qualification testing: measurement of solar exposure parameter, heat loss coefficient, and vacuum performance; thermal and mechanical stressing of single evacuated glass tubes.
- Materials testing: testing of thermal and optical properties of solar water heater materials.

Protocols and standards for product testing were developed in a multiple stakeholder process that developed consensus between technical experts, industrial participants, institutional participants and appropriate government officials.

Certification

Certification serves as the bridge between standards and testing. Standards might be seen as a basic foundation for a sound SWH industry, with product review and testing capability as the next floor. Standards cover both manufacturing processes and product performance; in addition to standards, there are certification requirements for manufacturing processes.

The Beijing Jian Heng Certification Center (China General Certification Center – CGCC) was competitively selected as the National SWH Certification Center in the national program. The certification program is linked to the testing of the national test centers. The Center was very proactive in developing the SWH certification program for China, developing the test procedures for the national testing program, and exercising coordination control over the National Testing Centers. By early 2004, the Center had developed the draft version of the *Implementation Rules for Solar Water Heating Certification*, which was reviewed and formally approved in mid-2004. These rules form the basic structure and requirements of the SWH certification program in China.

Textbox 10. The China General Certification Center (CGCC)

The CGCC was organized by the National Institute of Metallurgy (NIM) with authorization of the Certification and Accreditation Administration of China (CNCA). The center is a non-profit organization committed to investigation of product standards and product certification. At present, the center is the only third-party certification institute authorized by CNCA to carry out certification of new energy and renewable energy products, including SWHs, PV cells, and wind turbine generator systems. CGCC operates according to the requirements of IEC/ISO guideline 65 and received accreditation from the China National Accreditation Board for Certifiers (CNAB) in April 2004.

The China General Certification Center (CGCC) is in charge of the UNDP's SWH component. CGCC's Golden Sun Certification program has had a strong and positive impact on China's SWH industry. As of early 2007, 620 types of SWH systems had been certified at the CGCC, amounting to 2,168,330 products total; 11 types of collector tubes had been certified, amounting to 22,045,700 total.

The CGCC's contributions to the UNDP project were to establish and implement an effective National Certification Program for SWH products, associated voluntary certification procedures, and a labeling program; and to promote the program and its label to consumers so it would become a decision-making factor. The CGCC also coordinated and unified test procedures and methods, organized round robin testing, and implemented training activities. The CGCC's work has enjoyed widespread support from the SWH industry as well as local and national policy makers in China.

The Center also submitted for review the initial design for certification certificates and labeling in early 2004, in accordance with the procedures of the China National Certification and Accreditation Administration. In mid-2005 the Center established a Web site for publicizing the certification procedures for review and public dissemination.[13] Further, detailed test procedures were developed in the form of: (1) *Inspection Provisions for Solar Collectors;* (2) *Inspection Provisions for All-Glass Evacuated Solar Collectors;* (3) *Operating Regulations for Domestic Solar Water Heating Systems;* and (4) *Inspection Provisions for Domestic Solar Water Heating Systems*. These documents were reviewed in an expert workshop in mid-2004 in Beijing, which included both Chinese and European experts.

[13] See http://www.cgc.org.cn.

The Project also established a steering committee and expert working group to guide the work. Another key aspect of the project's national certification program was the development of a promotion and media campaign to support the program. The promotion campaign includes education of consumers and the public, and promotion of the Golden Sun Certificate product labeling system, which is for products that pass certification. The Golden Sun label is shown above.

Seventeen solar water heater manufacturing companies received citations as the first group of companies to qualify for the certification process with the right to display the "Golden Sun" label on their products in March 2006. These companies had to pass a rigorous set of procedures to obtain certification, including detailed inspections of their product assembly lines, adherence to rigorous sampling and testing procedures, and product testing at a certified national testing center. In the initial pilot program over 2000 of the Golden Sun labels were issued to participating companies, and subsequently the volume has been increasing rapidly. The China General Certification Center (CGCC—described in Textbox 10) is in the process of developing a tracking system to account for the total number of labels issued in the certification program.

Textbox 11. The Beijing Test Center.

The National Center for Quality Supervision and Testing of Solar Heating Systems (CTS)[1] in Beijing was established in 1999. CTS operates with the support of the NDRC, the Ministry of Construction (MOC), and the AQSIQ. Since 2002 the Center has received technical and financial support from the UNDP/GEF project. They were authorized to operate as a test center in February 2005 and were certified by CMA, CAL, and CNAL in July 2005. At present the Center has about 40% of the national-level testing market.

The CTS is one of three national SWH test centers in China that has the capacity to conduct comprehensive testing of solar water heaters, solar collectors, evacuated solar collector tubes, and solar water heating systems according to China's national standards. The principal activities and responsibilities of the test center are: (1) national supervision and testing for solar thermal products and applications; (2) testing tasks as organized by the relevant government departments; (3) appraisal testing for scientific research results and new products; (4) daily testing to which the center is entrusted; (5) compilation of national standards; (6) design and construction of national test laboratories; and (7) tests for scientific research projects. The center has developed software for test and evaluation of SWH systems.

The center conducts research and testing related to building-integrated solar water heating and has been responsible for national research projects issued by NDRC, MOST, and MOC as well as cooperative international solar thermal energy projects supported by UNDP and the United Nations Foundation. For China's National Scientific Research Projects under the 11th Five-year Plan, the center has been awarded grants for four areas of work, with total funding of RMB 10 million.

In response to the UNDP Project objective to stimulate the market, the Center organizes meetings to encourage industry to use solar water heating systems. According to Center principals, the UNDP Project has four key impacts: (1) manufacturers attach more importance to product quality after the establishment of the testing center; (2) measures have been taken to encourage consumers to use SWHs; (3) the Beijing Test Center has been designated a key lab for national scientific projects; and (4) as a result of product testing, solar thermal products on the market are at a higher level than before.

Capacity Building

There were several activities carried out by the Project that accomplished capacity building of the certification and testing bodies, industry, and the general public. First, CNIS helped to organize and conduct a Standards Orientation Workshop in Beijing in 2000) that provided a forum for discussion of key issues associated with the development of a standards and certification program for SWH technology. CNIS organized input from participating experts and other stakeholders on the planning process for the standards and certification program. On the basis of the results of the workshop, CNIS prepared an initial plan outlining activities and schedule for development of the standards program.

For the Project, CNIS also developed a *Needs Assessment Report*, which covered: (1) needs for SWH standards (including organization of the standards system, identification of standards that urgently needed to be formulated or revised, and areas in which to strengthen international cooperation in standardization); (2) needs for SWH testing (including current status of SWH testing, need for establishing a test center at the national level, and requirements for establishing such a test center); and (3) needs for SWH certification (including certification for energy conservation products in China and the urgent need to implement SWH certification).

In December 2003 in Beijing, CNIS, the Chinese Renewable Energy Industries Association (CREIA) and the Chinese Industry Association for Rural Energy (CIARE) jointly held a news conference on national standards for solar water heating systems, followed by a workshop on standards, testing, and certification for SWH systems. About 120 participants, including journalists from 15 media organizations, attended the news conference, at which the four newly developed national SWH standards were announced to the public. After the news conference, about 110 participants attended the Standards, Testing, and Certification Workshop. The workshop consisted of three sessions for presentations, discussions, and on-site visits related to SWH standards, testing, and certification.

A training book *Standards Training for SWH* was published and training conducted with 50 SWH enterprises during the Third China International Solar Energy Technology & Product Exposition in July 2005 in Nanjing. During the Exposition, a review meeting was conducted with industry and experts for the certification implementation program, and a Web site was established for the program on the general site of the Jian Heng Certification Center.

In March 2006 the China General Certification Center held a workshop on "Summarizing the National Solar Water Heating Standards, Testing, and Certification

Program in China." The workshop was associated with the CREIA Annual Meeting held the day before in the International Science and Technology Center, and was attended by about 80 people. The workshop topics comprehensively covered the broad scope of SWH activities for standards, testing, certification, market development, commercialization, emerging applications, and future trends and needs for the continued development of the sector in China. In addition to presentations from the PMO and UNDP partners, presentations were given by each of the national testing centers. The one day workshop represented the very successful conclusion to the Project's SWH program.

Information Dissemination and Outreach

In March 2006 the China General Certification Center executed a Press Conference to announce the initiation of the National SWH Certification and Product Labeling program for solar water heating products in China. The Press Conference was attended by about 100 people held over from the CREIA Annual Meeting and was covered by more than 40 media outlets, including CCTV, Beijing TV, People's Daily,

Textbox 12. Shandong Sangle Solar Energy Co., Ltd.

Solar water heating companies in Shandong province, both in sales volume and in collector area, accounted for 25% of national production in 2006. Sangle Solar has the largest market share in Shandong province. One factor that distinguishes Sangle from other SWH companies is that a key shareholder is the Shandong Academy of Science. This provides the company with access to very strong technical resources. All the other major SWH manufacturers are private enterprises.

Sangle was one of the earliest major companies in the industry; its parent organization, the Energy Research Institute, began marketing SWHs in 1987. They are one of the largest SWH manufacturers in China. Sangle exports products to Europe, Africa, Southeast Asia, and North America (although U.S. and Canadian sales are limited). Europe is their most attractive export market. They have recently talked with some U.S.-based Taiwanese intermediaries about establishing a cooperative venture with Wal-mart.

In 2006, Sangle's sales were 300,000 units with roughly 750,000 m^2 of collector area. For 2007 they expect to sell between 400,000 and 500,000 units. Cumulatively the company has produced about 4 million m^2 of collectors since 1987. Sales in 2006 were 500 million RMB, of which 200 million RMB were in Shandong alone. Production volume grew by 70 percent in 2006. Sangle has 60 percent of the provincial market in Shandong and 40 percent of the market in Henan, two of the provinces in China with the largest population.

In 2006 the Shandong Provincial Government approved Sangle setting up two research centers, including the Solar Controller Research Center (the first in China) and the Enterprise R&D Center. Sangle was one of the earliest SWH manufacturers to have a control system. This system makes it very convenient to use the SWH all year around, allows for adjustment in water amount, and can be integrated with electricity. The company has several certifications, including ISO 9001, granted in the year 2000. Others include China Compulsory Certification (3C) and Drinking Water Sanitary Conformity Assessment from the Shandong Department of Health, which means their product can be used for potable water uses as well—they use stainless steel, which passes the standards for food. Sangle is the first and only manufacturer that has been able to get this kind of certificate. Further, they have European certification (CEN-KEYMARK, which is equivalent to SOLARMARK), so they can sell in Europe. They obtained this from a German certification center (ISFH Lab provided the testing certificate). Lastly, they have both Russian industry certification and certification from CGCC, the certification body set up by the UNDP project.

China Daily, Jinghua Times, Beijing Evening, Sina Internet, and Sohu Internet. The event was broadcast on CCTV news on the Sunday evening news program. The Press Conference included speeches from several experts and organizations including the China Jian Heng Certification Center, CREIA, and various experts. William Wallace gave a presentation at the Press Conference on behalf of UNDP.

Results

The UNDP project has played a key role in helping the Chinese SWH industry to greatly improve the quality of manufacture and final products. It has established a National Testing and Certification Program for SWH products in China; it has completed the national standards framework to support the program; three National SWH Test Centers have been established and continue to improve and develop their capabilities; the certification program has been established along with an energy labeling system that will continue to evolve; and the National Testing and Certification Program has been created as a flexible structure that will support the current SWH market as well as future new applications, such as building-integrated systems and advanced technologies. All of these results have played a very important role in enhancing the quality of SWH products, strengthening the orderliness of the SWH market, and promoting the development of China's SWH industry.

Integrating standards, testing, and certification into the national solar water heating program was a major accomplishment. The development of standards was essential in developing test and certification procedures; the certification program has been widely acknowledged as building confidence to the consumer market. Further, UNDP support shortened the time to develop the national standards and testing/certification procedures by at least 5 – 7 years, according to companies interviewed during the evaluation mission. With the national testing program tied to national standards, the limitations of the previous patchwork system of provincial test centers and differing local regulations are being overcome. The provinces have to accept the national standards and this will minimize local protectionism. In addition, the institutional infrastructure that was established by the Project is well integrated into the existing government infrastructure responsible for solar water heating issues, which forms the basis for transparency as well as ongoing improvement, development, and capacity.

Consolidation of project resources and focusing on an integrated national program of standards development, testing, and certification has led to a maximum impact. This consolidation and focus was not in the original project design, but was also the approach applied to the wind and village power Project components. In addition, the use of a multi-stakeholder process was very effective in the development of national standards and getting government and industry support and cooperation. Many aspects of the project's work are just now coming into effect. For example, the European study tour had a big impact and now the industry has kicked off a series of study tours that it is taking on its own.

The following sections highlight specific impacts of the UNDP project's SWH component.

Shift to Systems-Based and Industry-Driven Standards

One key impact of the project is the standards for SWHs have shifted from being based on components and single devices to being based on complete SWH systems. This shift, which continues to evolve with standards now under development, has enhanced the production of high quality SWHs and promotes the growth of the industry in China. A key accomplishment of the project was bringing industry and the standards designers together so that industry lets the designers know what their needs are. This has encouraged manufacturers to actively seek to improve their products, and in so doing expand capacity. The workshops played an important role in bringing the various players together.

Impact of Improved Product Quality

The improvement in product quality resulting from Project work has resulted in significant growth in production of SWHs in China over the last several years. CNIS principals have suggested that this growth has also promoted other solar energy related industries. Increasing consumer confidence has played a role, whether directly or indirectly, in boosting the industry—especially in the long term. The higher quality manufacturers are producing more volume, and the poor quality ones less.

> **Textbox 13. Shandong Linuo Paradigma Co., Ltd.**
> Located in Jinan, capital of Shandong province, Linuo Paradigma is one of the best known suppliers of solar thermal systems in China. It is also one of the largest and fastest growing producers of solar energy technology worldwide. It is a Sino-German joint venture, established between the Linuo Group and Paradigma Gmbh & Co. KG in 2001, and is the largest manufacturer of evacuated solar tubes in China. The company has over 10,000 employees and more than 16 different subsidiaries in China.
>
> The Linuo Group was established in 1994, specializing in solar products, glass products, pharmacy and automotive coatings; it has been honored as a Shandong Provincial Outstanding Private Enterprise, National High and New Tech Enterprise, National High Tech Private Enterprise, and Top 1,000 Greatest Industrial Enterprises of China in 2005.

Providing a Foundation for Legislation

The establishment of the national standards, testing, and certification program for SWH also provided a solid foundation for the SWH-related portion of China's Renewable Energy Law. Huang Ming, president of the Huangming Solar Energy Group, China's top SWH producer, and also a member of the National People's Congress, has also presented a legislative proposal to the National People's Congress as he and others in the industry would like to see more specific regulations to accompany Article 17 (the portion related to SWH and solar energy) in the RE Law.

Impact of International Cooperation

The Project has played an important role, through international cooperation, in bringing positive international influence to the production of SWHs in China and in promoting the connection between Chinese standardization research organizations and international standardization units. The European study tour helped the testing and certification centers to get information about advanced international technology on a first-hand basis, and therefore helped to improve their technical level. Local industry also welcomes the influence of international cooperation. The connection with international standardization units helps to integrate China into international standards affairs, promote information exchange, and include the nation in the international standards expert base. The SWH partner team also benefited from learning-by-doing in the implementation and design of the test centers.

Impact on Manufacturers

Manufacturers are very happy with the results of the Project, as testimonials in this document illustrate. For many years, there was no testing center at which they could test their products. Therefore it was a practice of imitating the technology of the biggest producers like Tsinghua and Huangming, as they have had some limited internal testing capabilities. Now that other manufacturers have access to testing, they have been afforded the opportunity to design and upgrade their own products. This has had an important effect on the industry as it encourages innovation and technological improvement.

Impact on Consumers

Product quality has risen substantially. Part of this is due to the fact that manufacturers now display the results of their testing and certification, and their sales targets, as part of product sales. With no testing, it is difficult to differentiate good from bad products. In this way, the standards program has become a marketing tool. The Golden Sun label helps a lot in this regard. The more the manufacturers that have failed testing or not undergone it are weeded out, the more mature the market becomes. Jian Heng, which houses the certification center, has done well in consumer education. When 17 companies passed the first certification program, Jian Heng publicized this not only nationally, but at the local level as well. They used newspaper announcements and other methods.

Without the UNDP project there was considerable risk for loss of confidence by the consumers. The establishment of a highly publicized certification process and labeling of products that have earned the golden seal of approval has helped companies with these products to expand their markets and sales. Some within the industry have indicated that restructuring has already occurred from the Project.

Impact on Project Partners

During the review of the Project on which this document is based, the testing and certification centers, as well as top manufacturers, were visited and asked to share their impressions of the Project as well as the impacts the Project had on them. The following section presents these perspectives.

Textbox 14. Huangming Solar Energy Group

Huangming Solar Energy Group is a leading enterprise in the Chinese solar and SWH industries. In 2006 the company produced nearly 2 million m^2 of solar water heating systems, equivalent to slightly more than a ten percent share of China's domestic market, more than any other producer. Huangming has twenty patents for its products, which have passed the "Great Wall Certification" and ISO9002 Quality System Certification, as well as winning many national awards. While solar water heaters are the dominant product of Huangming, the company also has PV products (particularly PV lamps) and some demonstrations of solar thermal power generation. The PV lamps are exported to France, Germany, Spain, Italy, and the United States.

Huangming's Solar City is an extensive complex including its solar products manufacturing, international meeting center (under construction), solar education center, and tour center. The World Solar Cities Congress will be held at Huangming's Solar City's international meeting center in 2010. The building will have 60% solar cooling, 80% solar heating, and a little PV. There are plans for developing a solar university in five to ten years.

Huangming cooperates with the German Fraunhoffer research institute in some of its research and development; the company also has cooperation with a Greek lab for testing (the UNDP project's study tour found that the Greek SWH testing system was the closest in Europe to the Chinese testing conditions, as it was the most pragmatic and cost-efficient). This cooperation is through a group under the Chinese Academy of Sciences (CAS) in Beijing. The CAS group has been to visit the Greek lab.

Huangming has world-class production technology for vacuum tubes, a relatively new but very dynamic industry in China. Huangming developed its own vacuum tube technology. In 2006 the company produced over 10 million vacuum tubes; and eventually plans to develop a manufacturing capacity of 36 million tubes per year.

Project Impacts on the China National Institute of Standardization[14]

Mr. Wang Ruohong, Vice Director of the Sub-Institute of Resources and Environment Standardization within CNIS, noted that the project has enabled China to make substantial progress in the development of standards, testing, and certification of SWHs. Particularly, the CNIS team indicated that the biggest impact of the project was that quality in the industry has become more stable. The results are definitive and the market has grown. The project also helped CNIS develop management skills in this area; and they are now going on to do more SWH standards. The

[14] Visit was to the Sub-institute of Resource and Environment Standardization at China National Institute of Standardization (13 March 2007).

international cooperation was important to CNIS, including both the study tour to European countries and the opportunity to make connections with international consultants.

The NDRC/UNDP/GEF/UNDESA Project established the basis from which CNIS is pursuing future post-project work on standards. So far they have developed two additional national standards, which include:

- GB/T 19775-2005: Glass-Metal Sealed Heat-Pipe Evacuated Solar Collector Tubes.
- GB/T 20095-2006: Assessment Code for Performance of Solar Water Heating Systems.

There is a large market for the evacuated solar collector tubes in Europe. CNIS is also working on the revision and combination of four collector standards (GB/T17581-1998, GB/T18974-2003, GB/T4271-2000, and GB/T6424-1997) and revising a standard on solar thermal applications terminology (GB/T12936.1-2). This work is supported by AQSIQ and other government agencies. CNIS is also doing work in standards for PV systems.

Recently, CNIS has also been working on SWH-related energy efficiency and energy labeling. This is motivated by their desire to connect their SWH work with their other work in energy labeling. This work covers the areas of product classification, evaluating parameters of energy conservation, energy grading, test methods, and checking and inspection rules.

Project Impacts on the China General Certification Center

The CGCC team noted that prior to the Project few consumers could distinguish among manufacturers in terms of product quality. In 2005, the ten largest manufacturers had 28% of the market. After certification, the share of the top 10 rose to 40%. While no investigation has been carried out, the CGCC team expressed certainty that some of the small manufacturers of poor quality products have gone out of business. At the same time, products with the Golden Sun Certification labels have been disseminated widely.

Through the Project, CGCC was able to develop and perfect China's certification procedure, including pilot certification and review. In June 2005, CGCC conducted pilot certification, in which about 17 enterprises participated, including all the larger ones such as Huangming and Tsinghua. The team conducted factory inspections at manufacturers like Huangming and Linuo. During pilot certification, CGCC found some problems. In the national standards, there are four optional testing topics (such as resistance to freezing). It was found that the four topics are not suitable to products. This was a flaw of the testing centers; and the team found a good way to solve this problem. This was a direct result of the Project.

In addition to the press conference mentioned previously, CGCC also made a lot of progress in carrying out various types of publicity and thereby expanding the impact of certification. They prepared a series of brochures and posters with the approved models and gave these to the SWH enterprises. CGCC also arranged for certified enterprises to be listed in People's Daily. As a result of all the publicity work, CGCC has found that manufacturers find the label to be an honor and, as a result, place it in large size on their products.

CGCC has also carried out training activities in the areas of standards, testing, and certification. In the beginning of 2004, CGCC worked with the Jiangsu Provincial Supervision and Testing Institute to organize a workshop on standards, testing, and certification. On March 27, 2006, CGCC organized a workshop on solar thermal applications.

The CGCC team noted that through the certification testing process, companies have been improving their quality. In the initial inspection, the average per company of items not meeting standards was 10.4. In the follow-up inspection, the rate fell to 3.7 items per company. Of course, companies must fix all of these items before getting certification. In the process of fulfilling Project tasks and objectives, CGCC overcame many difficulties in terms of testing, standards, and certification, moving the process from birth to growth to maturity, thus bringing very positive outcomes.

The CGCC team indicated that they could not have accomplished these outcomes in the absence of the UNDP project. There are three main reasons: (1) the UNDP Project facilitated the funding needed for CGCC to do its work; (2) the Project provided international experience; and (3) the Project facilitated name recognition—use of the NDRC/UNDP/GEF "name" conveyed a sense of reliability and status to the CGCC. The team also estimated that, without the UNDP project, the whole process might have been delayed by about five years.

The team indicated that the Project has had an impact not only on the SWH industry but potentially on the whole certification business in China. Before the Project, there were no other successful examples of voluntary certification in China. Many other certification centers in China have shown an interest in learning from CGCC. This is partially because CGCC worked hard to get stakeholders involved and obtain the consensus of experts. This is not a common practice in China, and represents a process that could be replicated.

Project Impacts on the Beijing Test Center

The Beijing Test Center team listed four key impacts of the project: (1) manufacturers attach more importance to product quality after the establishment of the testing center; (2) measures have been taken to encourage consumers to use SWHs; (3) the Beijing Test Center has been designated a key lab for national scientific projects (during the period 2006 to 2010); and (4) as a result of product testing, solar thermal products on the market are at a higher level than before.

The center's work has expanded as a result of the Project. The center's growth in testing work is shown in Table 3, which presents the number of collectors, systems, collector tubes, and materials tested at the Center in 2005 and 2006. The Center's finances have also improved, as shown in Table 4.

Table 3: Numbers of Items Tested by the Beijing Test Center

Items	# of Items	
	2005	2006
Solar collectors	14	28
SWH systems	39	130
Solar collector tubes	10	21
Solar materials (coating)	4	17

Table 4. Financial Flows at the Center

Year	2005 (RMB)	2006 (RMB)
Income	250,000	800,000
Profit	-450,000	100,000

After the UNDP Project was completed, the center's scope of work and responsibilities related to SWHs expanded to cover the following areas:

- Product quality and supervision work issued by the national and local governments;

- Production licensing work and product certification work issued by the relevant government departments;
- As requested by the relevant departments, new product inspection and evaluation of high quality products;
- Testing services on performance and quality for manufacturers and others;
- Testing for citizens, legal persons, and other organizations;
- R&D for the development of new SWH testing technology, methodology, and testing equipment;
- Technical exchange, exhibitions, and training activities carried out jointly with other relevant organizations;
- Consulting services in developing new solar energy and other new energy testing technologies, quality control, and systems certification; and
- Product quality diagnosis, production technology verification, research on new production technologies, new product testing, and technical service work for manufacturers.

The number of product categories the center is authorized by the government to test has risen steadily from 6 products in 2002, to 10 products in 2004, to 34 products in 2006.

The team noted that had the UNDP project not undertaken the SWH component in testing and certification, it is unlikely that national quality supervision could have been carried out in Beijing, and not with such advanced equipment. The Project helped to ensure that both the Center's operations and the SWH technology achieved international quality levels. The guidance of international experts has allowed the Center to gain a higher technical skill level, as well as improvements in organization and procedure.

Because the Center is under the Ministry of Construction, it has much contact with those in the building industry. This affords the Center the opportunity to introduce SWHs to architects and designers in the building industry. This has perhaps had an influence on the Chinese Government's current promotion of building integrated SWHs. In addition, every year, based on evaluation and testing, the Center prepares lists of good quality enterprises and bad quality enterprises. They provide these lists to the building industry, so that the latter knows who to use.

The Center has been awarded RMB 10 million to carry out National Scientific Research Projects under the 11th Five-Year Plan. These projects include: scale-up research of solar heating, large-scale systems, solar air conditioning, and seasonal (long-term) storage technology.

Project Impacts on the Wuhan Test Center

Mr. Zhang Xiaoli, Chief Engineer of the Wuhan Testing Center, mentioned several areas in which the Project has stimulated the Center's work and the industry's improvement. First, the Center has developed a role in supporting the Government's supervision work. It has participated in the Government's last three annual random-sample SWH product testings—the government chooses 50 or 60 manufacturers randomly and the testing centers in turn go to the manufacturers to randomly select units to test.

Secondly, the Center is now carrying out certification work for several domestic SWH certification organizations (including China Quality Certification Center, Jian Heng Certification Center, and Guangdong Zhongcheng Certification Center). At present, there are 20 manufacturers that are certified, and Wuhan has taken responsibility for testing 12 of them. Altogether there are 26 different certification parameters; and the Center has been responsible for developing the tests for 18 of them.

Third, the number of products and components tested by the Center rises annually as does the number of manufacturers tested. In 2003, the Center tested the products of 30 manufacturers. In 2006, the number of manufacturers had risen to 200.

Fourth, the Center has continuously developed new capabilities in testing SWH components, such as testing the deterioration of plastic seals and experiments to test the resistance to freezing of household SWHs. Fifth, since June 2002, the Center has published over 10 articles in the nation's SWH journals. And finally, the Center has expanded its work in quality control and system certification services. It has helped numerous manufacturers perfect their quality control systems, improve the level of their production processes, and improve product quality. These manufacturers include the 10 largest, such as Huangming, Tsinghua Sunshine, and Linuo.

The Wuhan team noted that the Project has promoted the healthy and systematic development of the SWH industry in China. In particular, it has put an end to the longstanding situation in which SWH products could enter the market without testing; provided testing services so that certification could be realized in China; guided manufacturers in improving product quality, thus promoting improvement in the quality of SWHs in China overall; provided leadership and structure to the SWH market and industry, improving the reputation of name-brand products; and set a good basis for the perfection of national product standards and processes for production.

Similar to the other testing centers, the Wuhan team noted that the European study tour had helped improve the Center's technical capacity. Ideally, Mr. Zhang noted, Center staff should go abroad every two years to see what is happening in the international solar water heater industry. He also noted that the study tour had much more of an impact for the Center than visits by international experts, though the latter was also helpful.

Project Impacts on Shandong Sangle Solar Energy Co.

The Sangle team noted that, with the help of the national test centers, the quality of Sangle's products has increased greatly. The same year that Beijing and Wuhan test centers were launched, in 2005, Sangle signed its first full-year contract with Wuhan for technical services. It signed a similar contract with the Beijing center in 2006. These testing services help Sangle to develop new products and improve the quality of existing ones. All of Sangle's technical staff visit the test centers periodically for training. The team also noted that CREIA, with its industry meetings, has had a very positive impact.

In the past, Sangle marketed its products mainly in Shandong. Now, with the unified standards promoted by the Project, they can sell outside their home province and across the country. Before the Project, Sangle's market base was limited by the fact that the test report from Shandong was not accepted by other provinces. The Project has therefore led to an exponential growth in the company's sales. Three years ago the company's growth in revenues was 30% – 50%; last year it was 70%.

The team also emphasized that, under the influence of the project, the Chinese Government—from the central to the local levels—began to pay lots of attention to the SWH industry and renewable energy as a result of the Project, and has been holding many workshops. Over the last three years, the NDRC and also the Ministry of Construction and Ministry of Agriculture frequently have held meetings on renewable energy. Originally, Sangle and other companies operated without Government support; this situation is now changing. It is notable that the Renewable Energy Law was one of the fastest laws in China ever to be passed.

Project Impacts on Shandong Linuo Paradigma Co., Ltd.

Mr. Ren, the General Manager of Linuo, noted that the national testing centers have been very helpful and useful to the company's business. He explained that Linuo has all of its products tested at the centers. In doing so, they learn what the merits and shortcomings of their products are and can decide what to do next. It is a great help to their research and development, and production.

The test centers help them in two areas. First, in design; with full test results, they can improve their design. Without such data, this would not be possible. Second, the test data allows them to identify problems they have with their SWHs. An example is high heat loss, which points to the need for improvements in the vacuum tubes and water tank. Now they can pursue improvements efficiently; the test centers have helped them shorten the time needed for making such improvements.


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Mr. Ren noted that the staff of the Beijing testing center has been very helpful and supportive in helping the company to understand the test results. Linuo has its own testing center and it is useful to compare its results to the Beijing test center. The Beijing center has also helped the company to improve the testing capabilities of its own staff.

Project Impacts on Huangming Solar Energy Group

The Huangming team notes the company has benefited greatly from the project in the areas of training, meetings, knowledge exchange, and the testing center. The national testing centers have been the most important benefit of the project for Huangming. Before their establishment, Huangming was vulnerable to every local quality and technical bureau that could test and fine Huangming (not necessarily legitimately) and essentially, had the power to keep the company from entering the local market. Now that the company has a testing certificate from a national center, this has ceased to be an issue. Mr. Huang Ming believes that the establishment of national testing centers by the project is very important and sets a good basis for further progress in the industry.

Though Huangming was not directly supported by the Project, they often talk to people from the Wuhan Center. Zhang Xiaoli, Wuhan's chief engineer, has been very helpful and often comes to Huangming. The company has benefited substantially from this collaboration, especially in the area of materials.

With the existence of the national testing centers, Huangming has also benefited by being able to achieve the national title of "China Famous Brand" from the State Administration Quality Supervision and Quarantine. They have received this status on the basis of the national test center results. The title allows them to be free from the random sample SWH testing carried out by the government.

Lessons Learned

The opportunity to visit with test centers as well as manufacturers, not to mention Project principals, during the review process allowed for an assessment of lessons learned in addition to the many impacts described above. An overview of the key lessons learned is provided below.

International Standards

According to the PMO, the most difficult aspect of the project was negotiating with industry on the standards. The challenge was to get 100 people to build consensus. The international standards were used as guidance, but there was conflict over whether to take the Chinese standards fully to the international level. In the end, there was compromise, so that the standards are not quite up to the international level. This has been criticized by some in the industry, including Mr. Huangming.

Project Budget

At first the plan was to support general equipment acquisition with US$1 million, focusing on procurement of one major piece of equipment that had doubtful use to the industry's development. The alternative use of equipment funds was subsequently development to provide direct support for equipping testing centers with the available funding on a cost-shared basis. The SETC played a significant role in the decision to have three national testing centers as opposed to one, which was the focus of initial discussions. As a result, the NDRC/UNDP/GEF Project provided US$300,000 to establish each center, matched by an additional US$300,000 provided as cost-sharing from each center's own budget. While this funding level was sufficient to develop the basic testing functions necessary to the national program at each center, it is not adequate to bring the test centers up to a true international level of expertise. The continued development of the testing centers in China to true international capacity will be a multi-year and highly interactive process with the international testing community.

There were some specific equipment related problems that are still in the process of being resolved; for example, software issues affecting the level of automation achieved with the two-axis collector testing platform, some problems with the system test beds at one test center traceable to software problems and lack of operator training, and some system design issues that required retrofitting solutions. The equipment and testing systems have been inspected several times by the international experts who have provided valuable feedback in a continuous improvement process during the course of the Project.

Compromising in Dealing with Local Institutions

The PMO learned from this Project component that it could persuade and advise, but not impose solutions. For example, the Wuhan testing center had a good solar tracker, but poor software. The PMO offered to issue a separate contract for the software work, but could not impose its management system on the testing center. Similarly, though the PMO had wanted some aspects of the design for equipment that had to be built to be controlled by the international consultants, this was not a politically possible move. Had it been pursued, it would have added another year on the project. Sometimes, international expert advice is just not acceptable to the Chinese. It is important to remember that international input is only advisory.

Another trade-off that UNDP made with regard to the centers was that the Project personnel and experts had initially insisted on not having the Beijing testing center located in the urban area of the city, in favor of having more space in the suburbs. However, the project could not have moved ahead if they had continued to insist, so instead the PMO had to give in. The way the UNDP has run this project has been an approach of compromise, and in general, the UNDP Project has found that it can get further this way.

Financial Sustainability of Testing Centers

Before the UNDP Project, testing centers ran at an economic loss. At present they are financially self-sustainable but do not anticipate making a profit in the near future. This is in contrast to the food and beverage testing programs in China, which operate at a profit. An attempt was made to force the testing centers to develop solid business plans and fully think through the business aspects of operating the test centers in order to achieve financial sustainability in center operations; however, all of the centers found it difficult to focus on this aspect of institutional development. While the centers charge fees for doing the tests, these fees are nominal and provide only a minimal operating profit once a critical capacity of customer base and testing is achieved. One of the principal ways they do make money is to do research for the manufacturers, and this is a common procedure in all testing facilities in China, though there are occasional conflicts with the core purpose and business of the institutes. However, the testing centers insisted on getting advanced spectrophotometer equipment (which cost about $50,000 each) under the Project, specifically because these allow the centers to conduct research for the manufacturers, enhance their marketing capacity, and therefore earn some profit. Spectrophotometers also increase the status of the centers and give them a market distinction.

It should be noted that high expense of the testing equipment is a barrier in some of the testing standards work. Industry may be able to purchase some equipment that CNIS and other centers cannot afford.

Technical Issue Areas

The SWH industry has developed very rapidly in China. When the UNDP project undertook the plan to develop standards at the start of the project, they based the plan on the state of the industry at that time (2000/2001). Thus, some relatively newer products and technologies were not included. Additionally, the design and construction of the two-axis tracker for the solar collector thermal performance testing did not achieve the quality the PMO had designed for, especially the software system. In the future, the software really needs to be redone.

Mr. He Tao at the Beijing Test Center reported that the Center's equipment for data collection and control has been the biggest problem they encountered. At first they purchased one system, but they had to take it down because it did not meet the standards of accuracy that were promised. They therefore had to install a new one, and there were issues with adjusting this one as well.

Finally, procurement was slow in this sector as in the others market sectors, as was noted by some of the Project partners.

Cooperation among Test/Certification Centers, and Industry

Since the testing centers are equal and therefore natural competitors, there was some trouble in getting them to cooperate. Thus, there is a need for an "umpire" of sorts among them. To some extent, the certification center has this authority, but not to the extent originally hoped. The PMO has spent considerable time promoting concepts to improve interaction and cooperation between the testing centers, such as regular meetings between technical staff on noncompetitive and general testing issues, sharing staff to solve common problems, etc. These ideas have met with only limited success. Setting up a joint engineering team among them will be important for development, but this remains a task for the future.

Mr. Wang Zong of the CGCC pointed out that there is a need to further coordinate, unify, and improve the standards and testing procedures among the centers. There is also a need to determine how to integrate and simultaneously promote the certification system and the Chinese SWH industry. He also noted a challenge with getting the industry to fully accept the voluntary Golden Sun certification scheme.

Mr. Ren of Linuo also suggested that there is some room for improvement in the certification system. In particular, it needs to be strengthened. Consumers must be made to realize there is a difference between certified and uncertified products. There is a need for further promotion not just to consumers but to local officials as well. Linuo has found that they are barred by the local bureaus of industry and commerce from using the "Golden Sun" certification emblem in their advertising. While they can use the seal on their products, the local bureaus would only allow them to use the "CGCC" name (the name of the certification organization) rather than the "Golden Sun" name in advertisements, because the latter is not the real name of the certification organization. This is a problem specifically in Shandong Province.

It should be noted that establishing a voluntary certification program is very difficult. The Solar Keymark certification program in Europe has been successful in getting the whole European industry to accept it. In order to achieve this, however, it was necessary to get the logo accepted first by the consumers, so that then the enterprises would accept it. Under the Project, CGCC used newspapers as their main method to connect with consumers on the label, and cooperated with CREIA to pressure the manufacturers to accept it. Though there have been good strides made in this direction in China, additional work (and time) is required in this area.

Recommendations

There is tremendous momentum in the SWH market now, and it is worth considering additional international support for increasingly rigorous and comprehensive standards, testing, and certification. There are also new opportunities for international involvement such as the SWH building integration market, and working with the Government's recently launched initiative for "new countryside establishments" (new urban and village development). Moving SWH into the rural areas is a necessary next step. Finally, development of trade school, university curricula, and other training programs for solar thermal systems could be an area of consideration. Other recommendations are included below.

Need for Stricter Testing, Standards, and Mandatory Certification

Based on the above section, one obvious area for continued support is moving the SWH industry up the final notch to meet international standards. Although in some areas the Chinese products are close to international standards, overall there is still a significant measure to go to achieve parity in product quality with many European products. Mr. Huang Ming is afraid that if this is not carried out, the Chinese SWH industry is in danger of getting a reputation for being a "garbage industry." He drew a parallel to China's auto industry which, because it wants to eventually export, has now adopted international standards. The electronics industry has similarly adopted international standards. Huang Ming believes that the lower standards may have been adopted by officials in charge because they are not aware of the great danger in how this will affect the industry in the future.

To move toward the goal of international standards, a next step would be to have SWH test centers in the U.S. and Europe test independently what is tested in China and see if the results are very close. This round robin approach would validate what the Chinese test centers have accomplished. For now, the centers could start some collaboration with U.S. and European test centers, such as round robin and more general communication. China should become more aggressive in its contact with international testing/standards organizations.

Huang Ming emphasized that the most important priority for the industry at present should be to raise the quality level and protect the reputation of SWHs in China's domestic market. Last year, within the great achievement of SWH sales in China equaling 20 million m^2, lies a potential time bomb—there remain safety issues, including accidents with leakage, freezing in the winter, and flooding of users' homes. Electric heating devices may cause fires. After-sales service continues to be weak. Mr. Huang Ming noted that a recent newspaper article offered the statistic that only 53% of consumers are satisfied with their SWHs. Consumers are used to the quality control of electric appliances and feel they are entitled to the same quality in SWHs.

One of the issues, which was highlighted by Mr. Zhang of the Wuhan test center, is that there are no standards for the materials used to seal SWHs. He thinks that these standards should be addressed in the future. The equipment of some manufacturers when used in the Northeast has problems at low temperature. The elasticity of the sealant may go down with the low temperate and the equipment leaks. Mr. Zhang also noted that there is a need for strengthening PV testing in future.

Testing in the areas of system lifetime, component lifetime, stability of performance, and corrosion, and addressing specific "disaster points" of the industry, would help to move the testing and certification program more toward the needs of the market. Mr. Huang Ming currently carries out such tests within his company but it would be of benefit to the entire industry. He suggested that some new tests or advanced tests need to be developed around an important practical problem in the industry that needs to be solved. For example, corrosion of stainless steel is a problem, particularly in the countryside, where the water is not good. Plastic tanks could be the solution to this problem, but will require some lifetime and corrosion testing. Another specific problem to address is how to prevent lightning from striking the SWHs.

Technology testing standards in particular should be strengthened. The focus was originally on product standards, but there is a need for testing standards to guide research and development. These require higher technology and investment. For example, currently there are challenges with measuring the absorption/reflection ratio of collector tubes because the surface is not flat. In the view of the CNIS team, there is an urgent need to get equipment (which does now exist at the testing centers with purchase of the advanced spectrophotometer equipment) and funding for work in this area. While technical standards exist, they do not have the relevant design standards. To be comprehensive, the standards also need to be linked.

The hardware in testing laboratories is one issue. The software used in lab management and quality control systems is another. There is a need for improvement in this software as well as in the capacity of people to use it. Formal education programs may be one avenue.

On the good basis of the two national testing centers established, the testing infrastructure should be expanded in the future to a larger space, higher level, and more comprehensive scope. A follow-on project to the UNDP work might include working to persuade the government to accept the idea of compulsory standards and certification for SWHs. Further public education is also important and could be a component of a new SWH project.

It must be stated that for the Project to achieve positive outcomes, it had to begin the standards and certification work on a realistic scale. For this reason, the standards developed were limited to the most important focal areas. In the future, standards should be expanded to cover related areas. International standards for solar thermal devices are connected to standards for their components, such as valves. For another example, because SWHs so commonly integrate electrical water heating systems, standards should be developed for these and made mandatory—a part of “3C” (China Compulsory Certification). In general, products in China with electrical parts require 3C certification, but this has not carried over to the SWH field to date.

Integrating SWH in New Building Construction

Though integrating SWH in new building construction was not included specifically in the Renewable Energy Law, the Ministry of Construction has set up a separate code for SWHs in new building construction—“Technical code for solar water heating systems for civil buildings.” It is anticipated that there will also be new building construction requirements to accommodate SWHs. In some cases, this may be in municipal codes. For example, buildings under construction need to include pipes for SWHs, making the buildings SWH-friendly. NDRC is also said to be developing guidelines for SWHs in new building construction. There will be an advisory role for international experts in this area; in particular, certification for integrated SWH will need to be developed. In addition, policy work will be critical. Demonstration projects in building design might be a good approach.

UNDESA, with UN Foundation support, operated a path-breaking program to integrate solar hot water heaters into residential buildings in China. This initiative promoted solar thermal technology as an alternative to coal combustion for the production of hot water in China's residential sector, expanding the use of solar energy for heating water by integrating high-quality solar technology into attractive and cost-effective building designs. The project focused on strengthening capacity within the building industry for integration of solar water heating technology into new residential construction. It also conducted consumer outreach on the benefits of solar technology and explored opportunities for creating financial incentives for real estate developers and home buyers to use solar systems.

Energy Savings Labels

Similar to the development of the EnergyStar label of the U.S. Environmental Protection Agency and Department of Energy, a follow-on project for China could include development of a labeling program for different levels of energy savings. This would obviously apply to SWHs as well as other products.

Targeting the Rural Market

There are already rural households in places like Henan that have SWHs, but in other remote areas, such as Xinjiang Province, they have not yet arrived. So far none of the national rural electrification programs has provided SWHs to remote areas, but this is needed. He Tao of the Beijing Test Center noted that he had received a call from a Tsingdao manufacturer about a solar space heating project in Tibet. He added that for Western China, solar space heating is a big potential market, requiring much more energy than supplied for domestic water heating. At present there are two manufacturers of solar air heaters. One uses solar tube collectors, while the other uses flat plate solar collectors. It was mentioned that in Pinggu County of Beijing more than 100 villages had installed solar space heating and that there is also such a project in Ningxia.

Mr. Gao Jingping, the General Manager of Sangle, recommended a project focusing on the countryside in Shandong as a commercial model for promotion of SWHs. He believes that rural areas represent China's largest market for SWHs and will drive growth of the industry. In addition, the promotion of SWHs in the countryside fits in well with the government's policy for "establishing a new countryside." Shandong would be a good place to demonstrate widespread installation of SWHs in the countryside, because it is relatively rich compared to other provinces and because the Shandong Government has plans for making piped water available in all rural areas within three years. Once the water target is met, the major barrier to SWHs in rural areas will have been removed.

It bears mentioning that at present SWHs are still too expensive for many rural people to afford. The energy used per rural household is much less than in urban areas, so it is not clear that the rural areas represent a larger SWH market than urban areas. The benefit of urban areas is that households are much more concentrated, use more energy, and bathe much more often. Linuo has begun getting involved in the rural market. They have found that the market requirements are low price, low functionality, and low amount of hot water. A market assessment for rural areas might be useful as a follow-on project.

Building Prohibitions on Installation of SWHs

One of the most important barriers to development of the SWH industry is that property managers of more than half of the urban residential complexes in China prohibit their residents from installing SWHs. There have even been some cases in which the Renewable Energy Law was used, counter to its original intention, to block home owners from installing SWHs or even force them to take down SWHs that have been installed. The Renewable Energy Law states that no one should prohibit the installation of qualified SWHs unless the property manager's contract with the homeowner has a clause stipulating that none are to be installed. Many contracts do stipulate that no SWHs (or often, more generally, no equipment) be installed on the roof. There is now a law that all new residential buildings be equipped with a roof and plumbing system that will accommodate SWHs. Yet, even though these new buildings will have the appropriate pipes, if the contract stipulates no SWHs or rooftop additions, there is no way to add them. Follow-on work is therefore merited in this area, and could include developing a new law or implementing regulation. This work might be based on study of international examples, such as that in Germany.

Targeting Large-Scale Users

Another area worth future attention is the market for large-scale users of SWHs, such as hotels, schools, and hospitals. For every 1,000 hotels in which hot water is needed, only 3 or 4 have installed SWH systems. Even old hotels have the roof and space for SWHs, and schools are especially appropriate end-users. The problem is that the decision-makers are often not aware of the economic benefits of SWH. In 2003, the U.S. Department of Energy estimated that the average cost of energy from SWHs was the equivalent of US$0.04/kWh.

In China the energy cost is much lower, and lower than the price of electricity. Given the large amount of hot water used for cleaning sheets and for baths in hotels, hospitals, and schools, these organizations could substantially lower their annualized costs for heat by using SWHs. Follow-on work might include supporting an outreach campaign, or creating a demonstration project in a large city where hotel, school, and hospital principles can get a first-hand example of the benefits. Another possibility is combining a business development forum for hotels with the energy efficiency workshops planned under the UNDP-GEF Energy Efficiency Program (EUEEP). The Solar City Congress that will be held in Dezhou at Huangming's Solar City in 2010 could also be a launching pad for increased public awareness. On the one hand, the meeting could be small-scale and low level, but it could also be implemented as a big campaign to promote the solar city movement.

In conclusion, it is indicative of the huge impact the SWH component of the UNDP project has had that there are so many ideas for follow-on work. More than any of the other market sectors, the Project partners in the SWH sector—the test and certification centers, and industry leaders—were fully engaged in discussion and clear on the profound impacts the Project has had and the resultant opportunities for further work. It has been said that the UNDP Project has changed the landscape of the renewable energy technology market in China, and this is especially so for the SHW industry. The industry has been a stronghold in China for many years, but the introduction of a standards and certification program has been revolutionary for those involved. The potential for a ripple effect of continuing impacts appears promising.

8. Bagasse Co-Generation

Background

China has a vast bio-energy potential with recent average biomass resources utilization estimated at above 500 million tons of coal equivalent (tce). Of this, straw and stalk resources are estimated at around 150 million tce.[15] Such resources could be utilized for power generation and biofuels. In regard to the former, it is estimated that bagasse co-generation power in the sugar industry alone has the potential to supply 700 – 900 MW in China. In regard to the latter, China has an important bio-ethanol potential relying on sugarcane, cassava, corn, and broomcorn cultures.

In southern China, the sugar industry is one of the main economic activities. Sugar consumption is low in China compared to the rest of the world, but the output is significant. In 2002, the total planted area of sugarcane was 1.09 million hectares, with an output of 73.1 million tons of sugarcane. Used as raw material for the production of sugar, this cane could produce 18.3 million tons of bagasse equal to 4.58 million tce when used as fuel for a boiler.[16]

Although the Chinese sugar industry had already established the practice of burning bagasse (sugar cane residue) for heat and power production prior to the initiation of the UNDP Project, the energy produced was almost all consumed on-site. Therefore, the Project sought to promote the introduction and commercialization of modern bagasse co-generation technology, capable of supplying plant requirements, while at the same time creating a surplus which could be sold to the national grid.

Project Overview

The bagasse component of the UNDP Project was originally designed to have a significant focus on bagasse co-generation in the sugar industry with installation of two pilot projects, establishment of best practices, and international business exchanges. The project undertook feasibility studies and constructed a state of the art bagasse demonstration facility with the Guangxi Guitang Group in Guangxi Province. Lessons learned from the operation of this plant were to be communicated through a series of workshops and training sessions in order to facilitate commercial replication. Promising business exchanges occurred between bagasse co-generation companies in China and Australia through an international study tour.

[15] NDRC, Mid and Long-term Renewable Energy Development Plan, August 2006.

[16] From final pilot project assessment document of the Guangzhou Engineering and Design Company of Light Industry.

However, due to the restructuring of the sugar industry in China, which made viable projects more difficult in this sector, the bagasse component was deemphasized in the overall Project, to focus more resources on higher priority sectors. Because of this, the reviewers of this final evaluation did not include bagasse organizations or field visits in their review activities. A short overview of the outcomes of efforts in this area will be provided based on review of Project documentation.

Pilot projects

After investigations at various sugar facilities in southern China, The Guangxi Guitang Group in Guangxi Province was selected as the partner for the bagasse co-generation project. The project was designed to consist of two components, including an energy efficiency boiler retrofit financed by Guitang, and a 12 MW advanced steam turbine generator acquisition, cost shared by the Project. The heat and power usage in the plant, installation of an advanced control system, and emphasis on integrated manufacturing operations made the undertaking very appropriate for the UNDP project.

Guangxi Guitang Group performed a feasibility study and the Guangzhou Design Institute of Light Industry provided assistance in design of the project. The Qingdao Jieneng Steam Turbine Company, Ltd. was selected by competitive procurement to provide the 12 MW steam turbine using an advanced double extraction design for increased heat and power efficiency. The Guitang pilot was installed in late 2003 and commissioned in early 2004. System performance was monitored for 9 months in 2004.

Although the PMO and its domestic partners executed the procurement process for the Guangxi Guitang Group bagasse co-generation project in record time, subsequent delays in the project were experienced related to plant civil engineering design and construction and turbine construction. Further, negotiations with additional project candidates, including the final rejection of the Da Shui Qiao sugar mill after four attempts to create a viable project, failed to produce a second viable bagasse project due to lack of a viable partner.

Business Development

Despite difficulties with the pilot projects, business development activities proved fruitful. An international study tour was undertaken in 2002 to Australia and Hawaii to visit state-of-the-art co-generation facilities, obtain information about government co-generation programs and policies, and meet other manufacturers and related businesses. This led to a partnership with the Sustainable Energy Development Authority in New South Wales in Australia, to hold a joint bagasse cogeneration workshop in southern China in 2004.

The Bagasse Cogeneration Study Tour to Australia and Hawaii was conducted with CREIA's support and was designed to promote the development of bagasse co-generation in China and assist in the restructuring of the sugar industry in China. Another goal was to draw lessons learned in respect to management of co-generation plants and development of policies to promote technology dissemination and commercialization. The study tour was designed to accomplish the following objectives:

- Visit co-generation facilities at sugar mills in Australia representing state-of-the-art use of advanced equipment, plant management techniques, and efficient use of steam, electricity, and sales of electricity to local grids.
- Obtain information about government programs and policies used to provide incentives for co-generation development.
- Meet manufacturers of co-generation and CHP equipment, project developers, sugar mill owners, and the R&D community to explore business development opportunities.

The study tour was hailed as a success and contributed to a beneficial relationship between China and Australia for knowledge exchange.

Other Activities

Another activity planned in the bagasse component of the Project was a market study to identify the potential for bagasse co-generation power production in the sugar industry in China. This was initiated but then cancelled since the NDRC announced plans to support such a market study in its general biomass program activities.

The Project was also pursuing discussions with the Sustainable Energy Development Authority in New South Wales in Australia for a joint bagasse co-generation workshop. The workshop was to focus on business development between Australian and Chinese companies. Consistent with the Mid-Term Evaluation Report recommendations for the Project, this activity was also cancelled as other activities were deemed to be of higher benefit with potential for generating greater return on investment.

Results

To assess the usefulness of the Guitang pilot project, Mr. He Wei Cai of the Guangzhou Engineering and Design Company of Light Industry conducted a final assessment and prepared a final report for the Project's 13 MW co-generation pilot project at the Guitang Sugar Processing Plant in Guangxi Province. The report was finalized in mid-2005. The findings of this report are summarized here.

The report notes that the milling capacity of sugar mills in China is small, and therefore the efficiency of energy is low while the costs are high. It is for this reason that the SETC closed many small sugar mills, to facilitate the development of the larger mills. The justification for the pilot project was to build the technical and management capacity of such an operation to obtain higher energy efficiency as well as more effective management. This was to serve as a demonstration for the rest of the industry.

Guitang Group is the largest sugar refining enterprise in China, and was established in 1956. The milling capacity grew from 1,500 tons/day then to 10,000 tons/day at present, producing greater than 1 million tons of sugarcane annually and about a quarter of a million tons of bagasse. The bagasse is used as raw material for making paper, with the remaining pith being used as boiler fuel for power generation. The pith accounts for about 40% of the bagasse.

The target of the project was to replace the existing three boilers of 20 t/h steam output, and small turbine generator, with the 12 MW turbine generator and one 75 t/h boiler for utilization of bagasse and pulverized coal. The three 20 t/h boilers of the Guitang power station had a generating capacity of 24 MW, which was about 7500 kW short of the demand. The new configuration was structured to meet the full demand of Guitang as well as connect to the existing electrical supply network. The technical specification was completed in September 2001, the tender completed in November 2001, and the generator contracted from Qingdao Jieneng in March 2002. The generator arrived in early 2003, and during this time construction began on the electrical room, equipment building, and peripheral water supply and drainage system. The generator was then installed, and commissioned in October of 2004. Electricity was generated in December 2004, and performance evaluation began shortly thereafter.

Guitang was short on electricity in December 2004, so the generator immediately rectified this problem as well as carrying out the goal of environmental responsibility. The new generator required less coal (401 g/kWh compared to 560 g/kWh for the old generator), and the efficiency of the generator was far better than the previous set-up—overall efficiency improvement equaled 28.4%. Needless to say, this had an economic benefit for Guitang. Previous to the Project, the company had to buy power from the grid at a cost of RMB 0.50/kWh. This is no longer necessary. The cost of the new set-up was equal to RMB 0.274/kWh. Altogether, Guitang calculated that it will save RMB 18,790,000 per year from the UNDP Project activities.

The difference was the demonstration project used a medium-temperature and medium-pressure boiler and turbine generator instead of low-temperature and low-pressure ones. The latter is the set-up used in most sugar refineries in China, creating inefficiencies on a vast scale. If other sugar mills could adopt the improved technology of Guitang, the energy savings would be significant.

Lessons Learned

In terms of specific lessons learned, it should be noted that the Guitang project was implemented on a very compressed time scale, due to the demands of the Guitang sugar mill to complete the project in time for the 2002 crushing season. As expected, in the end it was impossible to meet the compressed schedule, and the project had to revert back to a schedule that was more consistent with international experience.

This is also a recurring theme. In several ways the implementation and design of the UNDP project did not accurately account for the amount of time and amount of support required to carry out its very ambitious goals and its large budget. It is important to be realistic with the timeframes for such undertakings. As the Chinese Government learned with its national Township Electrification Program, it is more important to be deliberate and patient to ensure the optimum quality and sustainable impact, than to focus on quick impacts and short turnaround.

It has been acknowledged that the Project's support of bagasse co-generation commercialization in southern China met with difficulties due to the 2002 and continuing restructuring of the Chinese sugar industry, particularly in Guangdong and Guangxi. This was the main constraint. That the Project was able to evaluate the usefulness of the project component, and move to focus on higher priority areas, once again highlights the benefits of designing the UNDP project with inherent flexibility. What the Project was able to achieve in its other focus areas is proof that the correct decision was made.

Recommendations

The Guitang project achieved promising results especially in terms of gains in efficiency. In the future this project should be publicized within the sugar industry, to make mill owners aware of the benefits of investing in new, higher-efficiency co-generation equipment. The potential for reduced power consumption and the environmental benefits make this a worthwhile endeavor for China, and the cost savings make it worthwhile for the sugar industry.

Future investigations might consider using the leaves and other parts of the sugarcane as fuel for power generation, in addition to the bagasse, based on international case studies. Typically the tops and leaves of the sugarcane plant are burned off in the field before harvest, or removed at harvest and left in the field to decompose. In Brazil, the use of these "trash" components has been investigated for power production using biomass-gasifier/gas turbine technology. Results have shown that using the cane trash to supplement the bagasse could increase the production of electricity at a sugarcane mill by 500%. This could be a worthwhile investigation for China.

9. Institutional Development

Background

At Project inception there were growing concerns over environmental issues in China resulting from the country's heavy dominance on coal. Recognizing the potential that renewable energy could play in the country, and the burgeoning industrial base in this area, there was a need for development of an industry trade group that could facilitate the mainstreaming of clean energy options in the country. Renewable energy trade associations in countries such as the US, Europe, and Japan had been instrumental in educating decision makers and the public on the attributes of renewable energy technology, supporting the development of effective policies at the national and sub-national levels, mobilizing industry and providing networking opportunities, promoting technology standards, and identifying and providing outreach on project and investment opportunities, among other activities. Under the Project it was deemed useful to create a similar association in China that could accelerate scale up of environmentally beneficial renewable energy technologies in the country.

Project Overview

The Chinese Renewable Energy Industries Association (CREIA) was set up in 2000 under the support of SETC/UNDP/GEF Project of Capacity Building for Rapid Commercialization of Renewable Energy in China. It obtained the formal registration from the Ministry of Civil Affairs, China in March 2002 as a branch of China Comprehensive Resource Utilization Association (CCRUA).

The Project assisted CREIA to establish objectives and activities, and to create links with key stakeholders, both within China (public and private sector) and internationally. It also assisted CREIA in setting up a formal governance structure consisting of a Board of Directors, an Advisory Group, and a dedicated staff team of technology and market experts.

CREIA's objectives are threefold:

(1) Serve as a window bringing together national and international project developers and investors.

(2) Operate as a bridge between regulatory authorities and the industry.

(3) Provide a platform for domestic industries to link up with each other.

Activities have included:

- Policy analysis and recommendation for related governmental departments.
- Market development and market regulation.
- International cooperation between the industry and foreign investors.
- Workshops, training, education, and outreach to raise both the professional level and public awareness.
- Technology development and industrialization.
- Environmental support to mitigate the pressure caused by climate change, including support on carbon finance and the Clean Development Mechanism (CDM).
- Regular consultation and guidance in terms of technology, policy, market, investment and export/import for the industries, research institutions, and the governmental officials.

The Project encouraged CREIA to forge international cooperation with a range of entities worldwide, including the US and European wind, PV, and biomass associations. CREIA has also worked in cooperation with a number of international organizations including the World Bank, UNDP, the United Nations Foundation, the Energy Foundation, and a variety of bilateral organizations. These activities have required CREIA and its members to operate according to international standards and requirements thus increasing the quality and level of work conducted.

Results

CREIA was borne out of the UNDP-GEF Project. CREIA has had a significant impact on renewable energy in China, whether it is from the perspective of the market, technology, commercialization, or policy. Further, it is globally recognized as one of the leading NGOs in renewable energy worldwide. To date, CREIA has attracted over 200 corporate members and about 40 experts covering all the sub-sectors of Renewable Energy in China—Solar Thermal, Solar PV, Wind, Biomass, Bagasse, Hybrids, Geothermal, Small Hydro and Ocean energy. Project results are outlined below.

Self-sufficiency

At its initiation, the Project provided support to CREIA through staff and office space, as well as project and program assistance. This support continued for approximately four years. At present, the UNDP Project no longer subsidizes CREIA; it only provides contracts for work performed such as policy studies or holding workshops. CREIA is financially independent, operating on revenues from a number of sources. These include membership fees, conference and workshop fees, CDM support, and contracting activities with a range of entities such as Chinese government agencies, the private sector, bilateral and multilateral organizations, foundations, etc.

CREIA as a Window to the Outside World

Although CREIA has not been in existence for very long, it is internationally recognized as a leader in the renewable energy field. CREIA brings together national and international project developers and investors. It promotes technology transfer and raises awareness of renewable energy investment opportunities through an online Investment Opportunity Facility (IOF) and through regional networking and training activities. Over the past six years, CREIA has set up relationships with up to 70 countries, serving as the premier Chinese non-government organization involved in bilateral and multilateral cooperative relations on renewable energy worldwide. In this way, it plays a major role in promoting business for China's renewable energy development, as well as advancing trade and investment opportunities between its members and foreign players.

CREIA is a primary source for information on the Chinese renewable energy market and is host to organizations from around the world, including delegations from Europe, North America, Russia, and Australia. CREIA also serves as an ambassador for China's renewable energy activities overseas, by organizing, hosting, and supporting trade missions and events that bring Chinese firms to foreign countries to explore a range of market and commercial opportunities. Further, CREIA has worked with a number of developing countries that are interested in how China has increased its renewable energy activities through policy, regulatory, and other activities. Examples include Cuba, North Korea, Sri Lanka, and Pakistan. CREIA has been extremely open to partnering with entities worldwide on the scale up of renewable energy both for China and globally and always engages in a professional and responsive manner.

CREIA as a Bridge between Local Companies and Government

CREIA serves as a bridge between regulatory authorities, research institutes, and industry professionals in China, providing a platform to discuss renewable energy development at the national level and subsequently advise the Government of China on strategic policy formulation. In this regard CREIA has hosted and/or participated in numerous conferences and workshops on renewable energy, and has been key in the design of renewable energy policies, regulations, and standards involving biomass, biogas, PV, geothermal, wind, and hydropower. Most notable were CREIA's contribution to the Beijing International Renewable Energy Conference in 2005, and organization of CREIA's own annual membership conferences which grew to over 250 participants in 2007. CREIA was also selected to serve as the East Asia Regional Secretariat for the world renowned Renewable Energy and Energy Efficiency Partnership (REEEP).

Additionally, CREIA has developed numerous publications on technical, finance, policy, and market issues related to renewable energy development in China. Further, CREIA's website, which undergoes routine revisions and upgrades to better meet member needs, is considered one of the best sources in the country for information on renewable energy in China. This includes the IOF which provides a platform for CREIA members to publish information on their products and services and link with potential partners. *It is important to note that both within China, and externally, CREIA is often considered the "go to" organization for support in policy and regulatory development, training and technical assistance, technology and market assessments, and education and outreach.*

Particularly key was CREIA's support in development of the Chinese Renewable Energy Law of 2005. This law was created and passed in an extremely short time frame (approximately 2 years from inception to approval) and would not have been possible, particularly in this time horizon, without the involvement of CREIA. The UNDP-GEF Project first supported CREIA in developing this law, then provided outreach support to help secure its passage. CREIA also brought in organizations such as the Energy Foundation to provide policy cooperation and alliance building. Further, CREIA worked with NDRC in preparation of the country's Long and Mid-term Renewable Energy Plan and supported MOST in a number of key projects.

Through its activities under the UNDP-GEF Project, CREIA has become a leader in CDM development. This includes helping to secure the successful registration of the Huitengxile Windfarm Project which has become China's first registered CDM project, and the first registered CDM project in wind energy in the world. In its CDM activities, CREIA often works with a number of internationally-recognized players in this field including EcoSecurities, the Institute for Global Environmental Studies, and CAMCO International.

One of the most demonstrative examples of CREIA's dominance and respect in the renewable energy field in China is the fact that its Director, Mr. Zhu, is on every important committee formed to advise the government on strategic planning in renewable energy. This includes work for NDRC, MOA, and MOST. CREIA has served as a vital intermediary between the government and other key players (industry, research community, financiers, etc) in helping to influence renewable energy development in China.

CREIA as a Cross-Sector Contributor to Renewable Energy in China

CREIA provides a network for its members from the Chinese renewable energy business community, which in the past has lacked a medium to communicate across their respective sub-sectors, and provides a stage to voice their concerns collectively. The project has contributed significantly across various sectors in China and played a very important function in the field. China's renewable energy sector development is at a high peak, and CREIA, with support from the UNDP-GEF Project has played a vital role in making this happen. Before, CREIA, the players and activities in renewable energy in China were dispersed and did not communicate with each other. CREIA has brought the key stakeholders together, including across the various government agencies, and helped to streamline information flow much more quickly than was possible before. The textbox shows some of the agencies with which CREIA has collaborated.

Efficiency and Spirit of Services

CREIA keeps its cost low and operates on an efficient and effective basis. With a small staff base, CREIA has managed to develop a solid reputation in renewable energy both domestically and overseas. CREIA has a motto of “Service First: and a policy that states we “cannot **not** receive people.” The organization’s enthusiasm is catching and a variety of players including industry, government, academia, investors, multilateral and bilateral organizations seek their support and input.

Textbox 15. CREIA’s Cross Sector Agency Focus

CREIA is working across a variety of Chinese government agencies on the development and promotion of renewable energy. These include:

- Ministry of Science and Technology
- National Development and Reform Commission
- Ministry of Agriculture
- Ministry of Science and Technology
- Ministry of Construc-

Industrialization Promotion

CREIA has played an important role in helping to advance and improve the availability, costs, quality, and performance of renewable energy technologies in the country. CREIA works with industry members and its government counterparts to expand the market through a range of policy, financing, training and technical workshops, report preparation, and market conditioning activities, as well as helping to facilitate business alliances both with Chinese and global partners. CREIA also maintains the Project’s Geographic Information System (GIS) data base which is a useful important tool for tracking, mapping, and monitoring renewable energy resources in the country.

For example, CREIA has contributed continuous support to the development of national standards for solar integrated building design and construction, supported photovoltaic development in the country, and helped to establish the National Certification Center network for SWH systems. Already 20 companies have passed the certification requirements, including all of the top 15 companies active in the market. CREIA has also developed a number of industrial reports to support specific technology interventions; developed the National Action Plan for Industrial Biogas Development; and prepared the Strategic Report for SWH and Wind Energy. This work has lead to improved product quality and technology performance and demonstrated that these technologies can deliver reliable energy services at competitive prices, helping to accelerate market development. CREIA was an early player and leader in this area; more details on CREIA’s work in support of technology industrialization and promotion are provided in the technology sections of this report.

Textbox 16. CREIA, UNDP, and Broader International Collaboration

Mr. Zhu Junsheng, CREIA Director, believes that the development of renewable energy in China has made great progress and that this cannot be separated from the contributions of international cooperation efforts, such as those of UNDP. China has received significant help from international experts and Bill Wallace is a prime example of this. Mr. Wallace has contributed significantly and has been recognized for these efforts at the highest levels in the country, most notably by the Premier (Zhu Rongji). Mr. Zhu noted about international cooperation projects that they have "a small amount of investment, but a big impact!" The special role played by these projects and the UNDP project in particular is that of bringing people and different groups together. Mr. Zhu indicated this is much more important than the demonstration projects. As an example is the bridge between the UNDP and World Bank projects. "It's very important to have this kind of bridge."

Mr. Zhu stated that the UNDP project has had a very big impact. Before, the players and activities in renewable energy in China were very dispersed. The Project brought these people together – including various government departments. Having this sort of central base of knowledge management has encouraged better sharing of information and enabled renewable energy to develop more quickly than before.

Lessons Learned

CREIA has been a major success of the UNDP/GEF/UNDESA Project: it is pervasive in coordinating national renewable energy development with government, industry and academia; it has promoted broad based international collaboration with the Chinese renewable energy industry; and it is a pioneer in CDM project development in China. It is recognized in China and globally for its work in all aspects of renewable energy policy, market, financing, and technology promotion. And, CREIA is the leading NGO and consultant of choice by a host of public and private sector organizations on these issues in the China marketplace.

CREIA was initiated under the UNDP-GEF Project and required initial grant funding to develop and operate the organization. The UNDP PMO and staff were instrumental in guiding the CREIA team and encouraging them to always think about self sufficiency, which they have now achieved. This early stage hand-holding was vital to CREIA's success and has been recognized by CREIA management. UNDP also brought in experts from the US and Europe to assist CREIA in setting up and running a successful renewable energy industry trade association. Moreover, CREIA benefited from the cost-sharing of space and staff with the PMO, on-going information flow between these entities, and contractual support.

CREIA also had the advantage of a Director in Mr. Zhu, who formerly held a high-level position with at SETC, and from the CREIA Advisory Group, which includes senior government officers, leading renewable energy experts, and corporate leaders in the renewable energy industry. The Advisory Board connection helps to ensure that CREIA has strong links to the government and puts the Association in a good position to provide input and feedback on policies and programs. Further, CREIA's Board of Directors is made up of the leading and most influential renewable energy companies in China. This is a variance from trade associations in the US and Europe where the lines between government and industry are more distinct.

Lastly, from the UNDP perspective, creation of CREIA gave the organization access to business participation and enhanced networking opportunities which could that could not have been achieved by the PMO alone.

Recommendations

CREIA will need to continue to emphasize fund raising to ensure self sufficiency and finance growth and expansion for the organization. This will require expanding the number of members and providing quality member services. On-going engagement with current and prospective members will be important to satisfy member needs. Additionally, as CREIA continues to provide contracting and consulting services with government agencies, multilateral and bilateral organizations and other clients, it will need to ensure superior products and services. The dual objectives of *meeting member needs and providing quality contract deliverables* can necessitate different staff skill sets and may affect future staffing plans.

Managing CREIA's growth will be important as renewable energy continues to expand in China. A strong business plan will be useful, as will effective leadership. With the prospective retirement of Mr. Zhu, it will be important to put in place a Director with a proven management track record, knowledge of the renewable energy industry, and strong linkages to government and the private sector in China, and worldwide

In the near future, CREIA's role will be most valuable in continuing to deepen and expand in the areas of policy and regulatory support, technology promotion, industry assistance, provision of services to enterprises, and market outreach and development. CREIA will also need to focus on strengthening of domestic and international communications and cooperation, particularly in the areas of investment and financing, and furthering of its CDM activities.

10. Policy and Planning Support

Background

The Chinese Government has been attaching great importance to the development and utilization of renewable energy for many years. In the 1980s, the State Council issued Several Recommendations on Promoting the Development of Rural Energy, which made renewable energy a part of the plans for the development of rural energy and rural electrification. With the maturation of renewable energy power generation technologies, particularly wind power technologies, in 1994, the then Ministry of Power issued Several Recommendations on the Construction and Management of Wind Farms, establishing a firm foundation for wind power in China. In 1999, the Chinese Government issued Several Policy Recommendations on Promoting the Development of Renewable Energy, making further progress in removing barriers to the development of renewable energy. In 2003, the Government began to set about formulating its Promotion Law for Renewable Energy Development and Utilization. Since its inception CREIA, with the support of the UNDP-GEF Project, has been instrumental in providing policy advice and support, and helping to make China into one of the world's leaders in renewable energy policy development and implementation.

Project Activities

Project activities in the policy area have included the following:

- Tracking and monitoring of renewable energy policy activities globally (national, state, and local), including what has worked, what has not worked, and why, to provide up-to-date information and guidance to senior Chinese policy makers.
- Developed and disseminated information through numerous studies, surveys, and workshops for use in developing industrial guidelines and regulations and providing policy recommendations to the Government. Also developed a series of renewable energy guidebooks that have helped decision makers in policy design (e.g., industrial biogas guidebook, village power guidebook, etc.); National Biomass and Wind Development Roadmaps; and other strategic planning documents. Further, the Project organized a national policy conference and included policy issues as an integral component of its general workshop series.
- Organized expert group sessions in China on renewable energy policies and implementing strategies.
- Provided advice during the development and execution of China's wind energy concession program.
- Mobilized the Chinese renewable energy industry to provide input on policy formation activities.
- Showcased Chinese renewable energy policy and market development activities at the Bonn International Renewable Energy Conference in 2004, including organizing a special China Day side event.

- Assisted in the organization and implementation of the Beijing International Renewable Energy Conference in 2005, the follow up to the Bonn conference.
- Raised funding and secured technical assistance from a range of donors for renewable policy support activities in the country.
- Very importantly, the above activities led to crucial support to NRDC in the development of the Chinese Renewable Energy Law of 2005 and the formulation of associated implementing regulations. Project advocacy activities included national conferences/workshops, construction of showcase demonstration projects, and broad coverage by the mass media. The Project also provided assistance in the direct formulation of the law including organization of workshops and brainstorming with participation of different stakeholders; project support of study tours to US, Europe, Australia, and Japan to learn about country experience and lessons learned in the development of renewable energy laws, regulations, and policies; provision by the PMO of key personnel (Wang Zhongying, etc) to aid in the development of the draft RE law; and administrative support services.

Textbox 17. Provisions of the Renewable Energy Law of 2005

- Established national targets for renewable energy
- Set grid connection priorities
- Classified tariffs for renewable energy
- Shared costs at the national level
- Created a dedicated renewable energy fund
- Established policies on favourable credits and tax incentives.

Results

The Project helped to move China from the margins to the mainstream in terms of international renewable energy policy development. Today, China is the lead developer and supplier of SHW, and one of the fastest growing markets for PV and wind technologies. Policy and planning support of the Project has helped to seed these activities.

The Project has also contributed to the dramatic change in social and political perceptions with regard to renewable energy in the country. For example, at the early stage of the Project it was almost impossible to get attention on renewables at vice-ministerial level. Today, everyone from China's President and Premier, down to government officials (national and subnational), the private sector, investors, NGOs, and civil society are talking about renewable energy and its important role in China's energy future.

Technology Specific Policy and Planning Results

Policy and related activities in wind, PV, biogas, and solar thermal have lead to significant commercial activity of these technologies in the country. For example, support on wind standards and measurement has had a major impact on the NRDC wind concession program and has helped introduce more commercial approaches to wind development in the country. NRDC has also highlighted the work of the Project in advancing industrial scale biogas through support of Biogas National Action Plan which provides a strategy for introducing commercially viable operations of biogas for large farms and industrial processes. Work on solar water heating test centers and the related certification program have opened markets for these technologies. The policy review conducted for the National Township Electrification Program has also been important in improving rural energy access in the country. All of these sectoral initiatives have provided valuable input and feedback to the Renewable Energy Law discussed below.

Renewable Energy Law

China's Renewable Energy Law marked a milestone in the development of renewable energy in China. The UNDP-GEF Project played an important role in assisting the process, especially in the early stages, leading to the passage of the legislation. The UNDP and the Project also helped to mobilize additional international support from multilateral and bilateral donor agencies in Beijing for the law and to provide coordination for these efforts through a sub-group of the Donor Information Exchange Group.

At the start of 2004, the National Peoples' Congress (NPC) of the Government of China made the decision to develop legislation leading to the adoption of a renewable energy law for China. In February 2005 the NPC passed national legislation – the Renewable Energy Law (RE Law) – that for the first time established a national framework for the development of all sectors of the renewable energy industry. The RE Law also specified time-bound targets for the evolving shares of the overall electricity market and the primary energy market to be held by a mix of renewable energy options (see Table 5). It includes mandates for the provincial governments to develop feed-in tariffs for RE-based electricity and other energy (fuels, heat) as well as quotas for the purchase of RE-based energy. The Law establishes cost-sharing mechanisms so the incremental cost will be shared among utility consumers, and creates a grid-financed renewable energy fund that will be used to provide subsidies to power generators based on energy delivered. It also creates new financing mechanisms and supports rural uses of renewable energy. Further, the law provides for a long-term development plan, R&D, geographic resource surveys, technology standards, and building codes for integrating solar water heating systems in new construction.

On January 1, 2006, the law went into effect after a comparatively short process from the decision by Government to proceed with the drafting of an RE law to the law officially coming into effect. This is one of the shortest time intervals of any major law in China, illustrating the priority given to renewable energy development in the country at the highest levels. The law is a landmark in national renewable energy legislation, and provides a framework within which government and industry can expand the scale and diversity of RE applications in China. It is a comprehensive law designed to accelerate growth and investment of renewable energy markets in China and has attracted significant worldwide attention.

Table 5: China RE Installed Capacity and Targets			
Renewable Energy Option	**2005**	**2010**	**2020**
Hydro power	115 GWe	180 GWe	300 GWe
Wind power	1.3 GWe	5 GWe	30 GWe
Biomass power	2 GWe	5.5 GWe	30 GWe
Solar PV	0.07 GW(peak)	0.3 GW(peak)	1.8 GW(peak)
Solar hot water	80 million m^2	150 million m^2	300 million m^2
Ethanol	0.8 million tons	2 million tons	10 million tons
Biodiesel	0.05 million tons	0.2 million tons	2 million tons
Biomass pellets	~ 0	1 million tons	50 million tons
Biogas and biomass gasification	8 billion m^3/year	19 billion m^3/year	44 billion m^3/year
Share of total primary energy (including large hydropower)	~7.5%	10%	16%
Share of electric power capacity (excluding large hydropower)	~8%	10%	20%
Sources: Preliminary development planning targets provided by China Energy Research Institute, Energy Bureau of NDRC, and conference presentations by others. Current figures: REN21 Renewables 2005 Global Status Report and 2006 Update.			

As with many such umbrella documents, the devil is truly in the details, and 20+ months after the law went into effect there remain many implementing regulations to be drafted, and issues to be worked out.

Impacts of the UNDP Project in Renewable Energy Law Development and Implementation

The UNDP-GEF Project was involved at all stages of the preparation of the Renewable Energy Law. A number of people interviewed during the evaluation mission undertaken in March 2007 indicated that the UNDP Project played an important role in all aspects of the design and development of the Renewable Energy Law. In particular:

- UNDESA and the PMO helped move China to a central stage in the international renewable energy arena with the special China Day side event at the June 2004 Bonn International Renewable Energy Conference (shown in the photo). Participation in the Bonn conference led to China hosting the follow-on conference (Beijing International Renewable Energy Conference) in 2005, resulting in broad exposure of Chinese officials and industry leaders to many of the leading policy makers, international RE experts, private firms, and international agencies active in renewable energy across the globe.

- The Project's advocacy, particularly in the early stage (1999-2001), contributed a great deal to the change of attitude by senior policy-makers and planners toward renewable energy in the country.

- The UNDP Project's crucial and timely input regarding the importance of the Law, facilitated the initial decision to start the legislative process. In October 2003, the Environmental Protection and Resource Conservation Committee of the NPC organized a workshop and contacted He Ping in the UNDP about organizing a site visit to the project's biogas pilot plant in Shunyi. Committee members indicated that they were considering preparation of RE legislation, but were unsure whether or not to proceed. The site visit was arranged and created a very positive atmosphere for the development of a renewable energy law. A subsequent presentation to and follow on consultations with committee members by Wang Zhongying of the Center for Renewable Energy Development (CRED), under the Energy Research Institute (ERI), appears to have been crucial in influencing the committee to pursue the development of the law.

- The NDRC/UNDP/GEF/UNDESA Project succeeded in opening the legislative process to a range of stakeholders, increasing transparency, and ultimately increasing the impact of the legislation. In particular, the NPC originally arranged for the drafting of the law by commissioning two competing groups to prepare separate versions. These were Tsinghua University and NDRC. During the Government restructuring in 2002, the UNDP project was transferred from the State Economic and Trade Commission to the responsibility of the Energy Bureau within the newly renamed NDRC, as the domestic implementing agency for the project. NDRC's Energy Research Institute was assigned the task of preparing one of the two drafts of the legislation. Wang Zhongying, as the Director of the Center for Renewable Energy Development in the Energy Research Institute and the National Project Coordinator for the UNDP project, was given the responsibility by the NDRC to help manage process for drafting the Renewable Energy Law. The two approaches to developing the draft legislation were quite different, with ERI/NDRC pursuing an *open multi-stakeholder process* to prepare its version. ERI convened three major public workshops and widely circulated their draft for comment. By contrast, Tsinghua University convened a small internal group to prepare the draft and pursued a much more limited circulation for review and discussion. The NDRC version was ultimately selected and the Project supported the multi-stakeholder process for developing the Renewable Energy Law. Through the NDRC multi-stakeholder process a wide consensus emerged for the NDRC version. While there is some experience in China with multi-stakeholder approaches to policy and legislation development, it is uncommon to convene open meetings and to invite criticism of current policies. It appears that the UNDP project along with support within the NDRC and other members of the international community promoted and influenced the NDRC in their decision to take a more open multi-stakeholder process for the development of draft legislation. *The UNDP project facilitated an important innovation in Chinese policy making that led, in this case, to the crafting of the RE Law.*

- The NDRC/UNDP/GEF/UNDESA Project, in cooperation with NDRC, helped to establish a collaborative of multilateral and bilateral donor agencies in Beijing to provide financial and expert support in the legislative process. These entities included the UNDP, GTZ, the Energy Foundation, WWF, World Bank, and several others. The Project also attracted the attention of renewable energy experts—both within China and internationally— who encouraged the central government to create the Renewable Energy Law.

- 2004 was the period of intensive UNDP support for the law. In this year the Environmental Protection and Resource Conservation Committee of the NPC looked to international organizations for support and contacted the UNDP and World Bank. UNDP organized several donor coordination meetings and several other supportive activities. These included a study tour to the US, Australia, and Europe for the committee members and others in government and industry to learn about renewable energy legislation in other countries. Additionally, in the case of the US, the tour also highlighted activities to create a national laboratory system for renewable energy. A final dissemination workshop on the Renewable Energy Law was held in the fourth quarter of 2004; UNDP took the lead in facilitating and supporting this.

- UNDP played a key role in coordinating donor support and in leading the international response to supporting the development of the RE legislation. Total donor support was about $250,000, with major financial contributions from the UNDP, the World Bank, and the Energy Foundation. The UK through the Department for International Development (DFID) and GTZ also provided support for the European study tour. Further, UNDP arranged for the involvement of RE industry experts to advise on the design of the law and the requirements for effective implementation.

- CREIA in turn has been an important player in the establishment and development of the RE Law, and is presently active in defining detailed implementation procedures. With support of the UNDP, CREIA has prepared books and other publications on renewable energy technology and policy, and sent these to key officials, industry, and others to promote RE in China. CREIA is working with NDRC, MOST, and other government agencies, and with the RE industry, and acts as an effective intermediary between government and the RE industry. CREIA is collecting information from the RE industry regarding concerns and needs for the implementation details, and is providing this information to the government.

- UNDP has been able to demonstrate the importance of a multi-stakeholder approach to project development. UNDP was able to quickly respond to policy maker needs on a quick turnaround basis which enabled the legal process to move more swiftly and relatively smoothly as needs arose. For example, UNDP was able to quickly program funds to support the renewable energy policy tours when this was determined to be a priority.

Lessons Learned

- The open, participatory nature of the Renewable Energy Law development achieved broad based buy in and enabled the approval process to be accelerated.
- International support was instrumental in demonstrating effective policies used elsewhere, providing financial and technical support to fill in gaps, and encouraging Chinese decision makers to move forward with legislative development.
- The right "institutional champion" is key. It was extremely timely that the UNDP-Project management was shifted to NDRC leadership.
- China is now viewed as a world leader in renewable energy policy and the world is waiting and watching to see the results. A number of other companies, particularly those in the developing world, are interested in China's results particularly as they pertain to poverty alleviation, energy access, and economic and social development.
- Capacity building to develop local skills for all aspects of policy development has been instrumental. This experience base can now be transferred to the subnational levels in China as well as regionally.

Recommendations

Recommended next steps include the following:

- The current Renewable Energy Law in China is fairly general, and many implementation details have yet to be worked out. Priorities include: developing national general targets; preparing a national renewable plan; establishing grid-connected pricing mechanisms; determining cost sharing measures; arranging financial back-up measures in rural areas; preparing renewable energy development specifications; establishing technical criteria for solar integration, renewable energy resource assessments, grid connection and other national standards; and clarifying the role of hydropower in the Renewable Energy Law. The key next step in the policy area is to assist in the development of implementing regulations; CREIA will continue to support this activity. Additionally, assistance will be needed in development and implementation of the National Middle and Long Term Plan for Renewable Energy; the 11th Five Year Renewable Energy Development Plan; and the Solar Building Economic Policy.

- The approach used to support renewable energy policy and law development in China can be applied in other developing countries supported by UNDP, GEF, and other donors.

- UNDP/Beijing is working with the Financial and Economic Committee of the NPC, providing US$500,000 for revision of China's Energy Conservation Law. This activity can benefit from the documented experiences of the UNDP-GEF Project.

- The UNDP/Beijing is now currently assisting the Energy Leading Group of the State Council during preparation of the new "Energy Law," which is more general legislation covering energy policy, but which includes renewable energy and energy efficiency issues. Some of the adjustments to be made to the Renewable Energy Law will be made in the Energy Law legislation.

11. Project Management

This section provides an evaluation of the Project management and staffing. Please note that the evaluators were unable to assess the quality of the financial management of the Project as the meetings and discussions focused on the technical and policy aspects of the Project. Periodic audits have been performed by the UN and this is assumed to be adequate in assessing the financial management of the Project.

Background

- **Project Management and Execution**. For this effort, UNDP is the GEF-implementing or funding agency. UNDESA is the executing agency, that is technically, managerially, and financially accountable to UNDP/GEF. Since UNDESA has no field representation, it authorized UNDP to disburse funds on their behalf.
- **Project Staffing**. The Project Management team was comprised of the Beijing-based Project Management Office and the NY-based UNDESA office. William Wallace was the Senior Technical Advisor (STA) of the PMO, and Li Shaoyi the manager from the UNDESA office. In early years of the project there were six staff members in Beijing, which subsequently dropped to 1-3 in the later years. Professional Chinese staff, United Nations Volunteers (UNVs), and administrative Chinese staff in the PMO conducted many of the activities.
- **Project Donors.** None of the donors have been actively engaged in the project—GEF, AusAID, nor the Netherlands. In 2004, the Netherlands decided not to complete their commitment 100 percent because of a government decision to decrease the level of international commitments. This resulted in a decrease of about US$300,000 to the project budget.
- **Chinese partners:** On the Chinese side, the project started with SETC (the State Economic and Trade Commission) and SEPA (the State Environmental Protection Agency) as co-implementing agencies, the latter of which played a subordinate role. The project might have been even stronger if SEPA had asserted itself more. Later, with restructuring, responsibility moved from SETC to NDRC (the National Development and Reform Commission); and the project was managed by NDRC's Energy Bureau. At that time, the project gained a much higher level of influence with its policy activities. This resulted in more NPC and State Council exposure. In effect, the project moved over to NDRC before the Energy Bureau formed. So, at first it was unclear whether the project would be under the purview of the NDRC Resource Utilization Department (staffed by former SETC staffers) or by the Energy Bureau (staffed by former SDPC staffers). Administratively the former was not the appropriate place. In the end, the Energy Bureau people also turned out to be strong advocates and managers for the project.
- **Project Redesign:** The original project document focused on cross-cutting areas, such as standards, commercialization, and investment. Technology/market sectors were addressed in an inconsistent manner. From the project manage-

ment perspective, it was not clear how to manage the project or be held accountable for results. Thus, a project redesign was necessary, with a refocusing on the basis of five well-defined technology/application sectors (industrial scale biogas, wind for large scale grid connection, SHW, bagasse co-generation, and village power for rural electrification). For each of these technology/application sectors, a comprehensive and integrated set of activities was constructed to pursue specific commercialization objectives, including technology and infrastructure development and deployment, business development, policy formulation, financing, information dissemination, and others. For each technology/application sector, the Project designed a specific commercialization strategy. Differentiation by technology and application sector was necessary as the commercialization strategy varied by each sector.

For a project the size and scope of this one, redesign and refocus were natural. Though the Project Document did not specify where to redesign (as this was impossible to foresee), it did provide a management mechanism to make it possible and viable—that is by means of a semi-annual review by the Project Advisory Group and Tripartite Review Committee, which consisted of the PMO, UNDP, UNDESA, the Project's co-investors, and GOC representatives. The Project Advisory Group provided timely and responsive guidance on project implementation, making project success possible.

Textbox 18. Project Management Responsibilities

- Project management and oversight.
- Preparation and management of subcontractor contracts.
- Liaison with UNDESA and donors.
- Coordination with government counterparts.
- Development of Project Management Plan.
- Tracking of Project deliverables, schedules, and budgets.
- Preparation of technical and financial reporting.
- Hiring, management, and oversight of project staff.
- Development/update of project management documentation and data base.

Impacts

- The effective and efficient Project Management team, consisting of the Beijing-based Project Management Office and the New York-based Li Shaoyi of UNDESA, were critical to the implementation of this project. The number of components of this project and the tremendous number of activities planned, including more than 88 workshops over 5 years, were incredibly ambitious for a PMO staff of 6 (in the early years; subsequently dropped to 2-3 staff members) and UNDESA staff of 1. The dedication and long hours can be attributed to the following personnel:

- o Wang Zhongying, the National Project Coordinator, provided overall coordination between project components and with other Chinese programs, and Wu Haiou, Project Assistant, provided invaluable assistance in implementation of activities and monitoring of subcontractors.

- o William Wallace, the STA (shown at right with Premier Zhu), performed a yeoman's effort in managing activities in China, preparing Terms of References (TORs), directing subcontractors, liaising with UNDESA and the donors and providing the interface with the international components of the Project.
- o Li Shaoyi, the UNDESA project manager and Deputy Director of the PMO, directed the Project activities, kept the Project on schedule, dealt with administrative issues, and facilitated the UN procurements, which were identified early on as a difficulty.
- o Professional Chinese staff, UNVs, and administrative Chinese staff in the PMO were essential to carrying out many of the activities, including a tremendous number of workshops. However, the initial two UNVs (Fred Asseline and James Graham) left after two years and after some time were replaced with only one UNV (Jorge Ayarza). The Project was fortunate in having the services of outstanding UNVs, which were essential to maintaining a high professional level for many of the Project's key activities and responsibilities. The Chinese domestic staff were also of high quality, but because of the highly dynamic nature of the modern job market in China, turnover of domestic staff throughout the course of the Project was very high (50–100% per year).
- o While CREIA is nominally a separate organization, the overlap of staff, juxtaposition of office space, and sharing of information led to CREIA providing significant support to the PMO in executing the Project.

- The Management team provided timely and high quality performance reports; timely and accurate financial statements in conformance with UNDP financial practices; and smooth and coordinated implementation of different Project Activities reflected in a high delivery rate.
- The UNDP and other donors have been very impressed with the PMO and consider it to be one of the best they have ever supported. This is measured by the following: reporting has been timely and of high quality; the Project Implementation Reports are used as models at UNDP; financial statements are timely and accurate; and implementation of Project activities have been coordinated and conducted at a reasonably high delivery rate.
- Issues that have led to less than smooth implementation include difficulties with pilot projects and political selection processes. Issues that have slowed the de-

livery rate of activities include inadequate PMO staffing, lack of contractual timeliness at UN procurement, SARS, and government restructuring.

- One issue affecting the close-out phase of the Project was a change in management philosophy at UNDESA during the final year, which prevented the UNDESA project manager, Li Shaoyi, from making his normal and regular trips to China for direct management meetings with the PMO, government, and contractors. As a consequence, some especially difficult issues existing as residual problems at the end of the Project could not be dealt with in a timely and efficient manner. These types of problems required the combined efforts of the PMO, UNDESA, and the government to resolve. (Examples include the completion of the Bei Long Dao village power project, coordination of the final contracting phase of the Project, and protracted staffing problems in the PMO at the end of the Project.) As a result, there were further delays in the close-out phase of the Project. .

Lessons Learned

- When the project is initiated, it should be structured to ensure that the PMO reports to the strongest government agency responsible for areas addressed by the project.
- In project design, the team needs to think through what kind of management structure can help best achieve objectives. In retrospect, it would have made sense for the project to work with the SPC (former State Planning Commission) from the start. The problem at the time, however, was that SETC was more comfortable and skilled at working with international organizations, while the SPC was somewhat hostile to foreign cooperation. When SPC evolved into NDRC, it became more willing to work with international organizations.
- To have impact, it is important to work with the highest level policy making body possible. This is important to make sure the project is working at (or going to get through to) the senior levels so that sustainability can be ensured once the project is over. It is also useful to work with government entities that can help to mobilize resources and make co-financing arrangements work.
- The project may have a pilot or demonstration components, however, if they are to impact national policy, this aspect needs to be integrated into project management activities from the beginning.
- Over the course of a multi-year program, particularly in a rapidly changing environment such as renewable energy, it is important for the project management team and local government counterparts to be flexible in terms of management operations. If a desirable opportunity arises to switch to another organization, as occurred with the UNDP-GEF Project in the move to NDRC, the team must be prepared and willing to do so.
- Inadequate staffing by the PMO has been an issue over the course of the Project. The Project was understaffed over the life of the project. One of the major issues was low staff salaries provided by the project. In this case, UNDP provided some staffing resources, with the remainder to be provided by government counterparts. Initially, four positions were specified. The salaries were not pre-

specified but were handled according to domestic practices, with the problem being that domestic practices vary widely. Though the team was able to deliver significant results, it was at the expense of the few staff members who supported the effort. Given the sound project management it is anticipated that even more could have been accomplished with 10 staff members. Early on the project had about six staff, and in the final few years they had the equivalent of only two to three people. It was mentioned that UNDP and UNDESA take a very different approach to staffing than the World Bank, which tends to staff with many more people.

- UN procurement has been slow, hampering financial and administrative management. From submission of the TOR to signing of the contract the time elapsed was never less than 6 months and the average time was usually in the range of 7–9 months. There are no clear UN policies or guidelines for how local resources can be used in procurement, so the Project management staff had to develop such mechanisms on their own. The PMO is now able to utilize a local agent, China Green Enterprises Ltd., which has been approved by the UN. They can complete a competitive solicitation in significantly less time than UNDESA or the UNDP. However documents still need to be sent to NY for approval. Local procurement cannot be used if the UN Procurement Division decides that a particular procurement requires international bidding.
- One of the concerns for all projects, and amplified with this one due to its size, is the need to make provisions for continuity of support once the project is completed.
- Creation of strong management records and documentation is important to have a permanent record of the Project activities and accomplishments, as well as meeting all reporting requirements imposed by the Project's co-financiers.
- This Project is complex in that it had multiple donors from countries such as the Netherlands and Australia, as well as the GEF. This was beneficial in that there was more funding, a greater network, and more power. However, there were also multiple bureaucracies that slowed the typical fast-moving Chinese pace, multiple agendas, and a large amount of reporting and planning.
- For example, the UNDP and UNDESA as well as the donors required the preparation of a semi-annual and annual project report with annexes. However, the GEF itself required the preparation of a separate annual Project Implementation Report (PIR) in a completely different format (i.e. a distinctly different type of report). In addition to the semiannual Advisory Group and Tripartite Review Meetings and annual project audit, UNDESA conducted detailed bimonthly project review meetings. These latter meetings were especially effective for the implementation of the Project, but were also very time consuming.

Recommendations

- Project managers and key personnel need to have the requisite skills to assume the position. Terms of reference for these positions should be clear and well thought, and specify eligibility criteria. In the case of the UNDP-GEF project, William Wallace brought proven management capabilities, familiarity and experience with China and many of the key stakeholders, and strong renewable energy experience. His background and experience were invaluable to the success of the project. The trend for the UN and some other donor agencies is to move away from the use of full time senior technical advisors (or chief technical advisors) for project management offices, but this proposition needs more critical consideration when the benefits of such positions are factored in.
- Staff salary compensations will need to be competitive with what is happening in the marketplace. It will be important in negotiating staffing with donors and government counterparts that competitive salaries are included in the contract agreements.
- On contractual issues, since little can be done regarding the UN procurement process in NY, it will be important for the PMO to use locally qualified bidding agents to the extent possible as these contracting processes for these entities can be performed in a more timely and efficient manner.
- In the future, donors should use more coordinated with streamlined reporting requirements.

12. Conclusions

Overall Impacts

The Project by both its design and implementation has produced a highly *effective* mix of policy and planning, institutional development, capacity building, investment, and dissemination. The Project has taken an intelligent approach in seeking to fill gaps that needed attention, rather than duplicating efforts that were already being addressed by other programs or donors. Impacts have been greatest in the way of building capacity, followed by institutional development, policy and planning support, hardware investment, and finally information dissemination. The impact of the Renewable Energy Law and follow on implementing regulations will likely lead the longest term impacts into the future.

Mr. Shi Lishan, at the final Advisory Group meeting and review of the Project, offered the following perspective on the Project from the position of the National Implementation Agency:

The Project design was an appropriate fit for the development of renewable energy in China during the period of time in which the Project was implemented. The Project closely complemented the strengths and weaknesses of renewable energy technology development and correctly anticipated the needs and demands for renewable energy development during the past seven years.

Examples of the complementarity of the Project with national renewable energy development needs include: 1) the wind component has become crucial to the support of industry development and accelerated commercialization of wind in China; 2) the SWH component has been able to serve and strengthen the market during a critical stage of market development; 3) the industrial biogas component was able to accelerate and change the market and the nature of technology deployment to move to a true commercial development model, and promote regulations to support commercialization and business development; and 4) the Village Power application component has also had significant and important impacts on the national Song Dian Dao Xiang program.

The Project has provided and continues to provide support for the renewable energy development infrastructure in China. Some significant impacts of the project from the point of view of the National Development and Reform Commission include:

(1) The Project resulted in the formal initiation of the long-term wind resource assessment national project in China, which secured a total of RMB 300 million (about US$40.7 million) of financial support from the national budget;
(2) The results of the Project prompted the government to establish a national target for building 100 biogas power plants in China, and the Project helped to

promote the use of biomass pelletization technologies for practical applications in rural areas to increase the convenience of gathering and utilizing biomass feedstock. The technologies are easy to deal with, and the decentralized characteristics also fit well with the realities of rural conditions;

(3) The Project was directly responsible for mandating SWH installation regulations, which are now in place, and also helped to develop regulations that mandate the installation of SWH systems in hospitals, department stores, schools, etc,. that can now be seen in many areas of China;

(4) The Project helped to convince the national government to decide to build solar PV grid-connected demonstrations as concessions, using competitive public bidding to select the project developers and investors; and these concessions are expected to help China to achieve its national target for installed solar power.

The Project has been implemented in parallel with the development of renewable energy in China, and, with its support, many of the policies that now support renewable energy have been established through the Renewable Energy Law, its implementing regulations, and the national standards and certification system. Many more such policies are expected to be established even after the Project has reached its conclusion.

With the foundation that this Project has constructed to assist the government in its support of renewable energy, the future is bright for the continued trend of policy development in the central government, and in renewable energy investment and commercial development. The Project has done what it was designed to do, and has even exceeded expectations.

Key impacts achieved in each of the main focus areas are outlined below.

Capacity Building

A significant success of the project has been in the capacity building area, including strengthening the professional level and expertise of Chinese stakeholders (industries, government officials, financial sector, etc.) in the renewable energy sector. The Project by its design and implementation has been very effective in trying to push the envelope in a number of well-selected niche areas and has had a considerable impact on a national level through discussions with the GOC on more market-based approaches to RE deployment. The areas with the greatest impact are industrial-scale biogas, using both international and national expertise and experiences, SWH testing and certification, the business-oriented approaches in village power, and improved resource assessment and site characterization practices for wind development. International study tours, expert exchanges, and training and technical assistance have also contributed to technology, market, and policy development activities.

Institutional Development

One of the most striking impacts of the Project has been in institutional development, to include the advancement of local institutions that can continue activities beyond the Project, including networking activities and cooperation. In this regard, CREIA, China's only Renewable Energy Industries Association, has been a huge success. Its mission is to promote the adoption of RETs in China and it actively develops capacity for rapid industrialization of the RE sector.

CREIA is now a credible organization with over 200 members from industry and a board of top experts from industry and research and development institutes in China. It has developed a large portfolio of activities, some of which generate income to support the other non-paying activities. It organizes workshops, conferences, and training sessions, provides policy guidance and analysis, organizes outreach and education, provides consultancy services, and assists with exports, among other activities. CREIA hosts a Web site and aims to further develop e-commerce activities with the IOF, presently being developed. The IOF contains a large database of investment projects, resources, investment costs and price levels.

CREIA has led numerous activities including policy studies, standards and certification dissemination efforts, support of industrialization, international cooperation, workshops and exhibitions, information dissemination, and training programs. CREIA has been very effective in coordinating national RE development among government, industry, and academia and for promoting international collaboration with the China renewable energy industry. CREIA has also been a major player with identification and facilitation of projects under the Clean Development Mechanism (CDM) in China, with much of the recent CDM initiatives being led by major corporations.

Apart from the direct impact through the establishment of CREIA, the Project also contributed to institutional development through subcontracts and collaborations with organizations that previously may have had little RE experience. These partnerships built their RE understanding and expertise, creating an enhanced knowledge base and expanding the network of RE organizations. Through the establishment of donor coordination meetings on RE, the Project has built a credible voice from the donor community in policy and strategy support to the GOC. Finally, through close coordination with local, provincial, and central government officials, the Project has advanced their understanding of technologies and best practices in standards and institutional and policy approaches in renewable energy.

Policy Support

A third important effect has been on policy development, to include policy, planning and strategic activities that have influenced the GOC authorities in their thinking and approach to renewable energy commercialization. In this regard, the Project has become a partner to the GOC in policy and planning through the expertise it has built in the fields of industrial-scale biogas, off-grid village power systems, wind farm development, and solar water heating standards and certification. Through the wind concessions program and the Biogas NAP, the Project has provided policy and strategy assistance.

Most notably, the Project has built upon sectoral policy activities to assist in the design and development of the Renewable Energy Law. This law has high-level support of the government and was instituted in a very short time horizon for the country. It sets key targets and activities to accelerate scale-up of renewable energy across the country and is globally recognized by countries and policy-makers throughout the world. The Project has also assisted in developing the detailed implementing regulations supporting this law.

Demonstration Projects

The Project supported a number of pilot projects to demonstrate the costs, benefits, and applications of various renewable energy technologies with the goal of leveraging investment in larger scale projects. The hardware investments in industrial-scale biogas pilots changed the paradigm of the biogas industry from one of environmental compliance to generating economic benefits and increased efficiency; SWH testing and certification work created three national testing centers and one certification center, as well as the Golden Sun label, changing the structure and enhancing the quality of the SWH industry. Wind resource assessment and site characterization efforts have resulted in Project standards become the new national resource assessment standards; in addition, two of the wind projects have been included in the national wind concession program. The five hybrid systems in Bulunkou Township have provided the government with a tangible example of alternative approaches to village electrification, especially as these systems are located in the same vicinity as SDDX systems. From this example and the extensive Baseline Survey carried out by the Project, the Government now recognizes the need to address issues of management, training, sustainable funding, and productive uses in its national programs for rural electrification, thus changing the canvas on which it will now work toward lighting the countryside.

Outreach and Dissemination

A key focus of the Project was to enhance the knowledge and understanding of renewable energy by a broader range of stakeholders and the general public. The large outreach and dissemination efforts documenting the results and impacts of the Project have generated support from the Chinese government, stakeholders, and the general public. Key examples of successful outreach efforts include the Village Power Development Guidebook, employed by project developers in China and worldwide; the Baseline Survey of SDDX, which has been used by the Government to rethink the next phase of national electrification, SDDC; the project development guidebook for biogas projects; and the many workshops organized by CREIA, Jikedian, and the PMO to conduct trainings, promote knowledge exchange, share the results and lessons learned of the Project, and engage government stakeholders in meaningful discussions.

International Cooperation

The Project has had an open approach to other international and national donors and stakeholders involved in renewable energy. It has initiated cooperation and collaboration and has supported joint efforts with organizations such as WWF, Econergy, Energy Foundation, UN Foundation, bilateral and multilateral donors, and others. In-house cooperation has been intensive with CREIA, REDP, CRED, and ERI.

Project Management

In spite of the highly complex project design, the shear breadth of activities, the time consuming procedures for subcontracting and site selection, the Project has managed to fulfill its objectives in a reasonable amount of time and with high quality, with an understaffed project office. The staff is highly qualified, extraordinarily dedicated, and extremely hardworking.

This Project is path-breaking in that it had multiple donors from the Netherlands and Australia, which was beneficial in that there was more funding, a greater network, and more power. However, there were also multiple bureaucracies that slowed the typical fast-moving Chinese pace; multiple agendas, and a large amount of reporting and planning. In the future, donors could be more coordinated with streamlined reporting requirements.

Sustainability

The Project can be assessed against sustainability criteria including economic, social/political and environmental/technical aspects.

- In the field of industrial-scale biogas, multiple feedstock and somewhat centralized systems have been shown to be financially and economically viable. Due to environmental regulations, biogas system deployment will continue to grow even after the Project ends. The infrastructure (expertise, manpower, domestic manufacturing) has been built and this sector will continue to thrive.

- In the SWH sector, manufacturing is already commercial and China's SWH industry is the largest in the world. The market flourishes in the absence of subsidies and has surpassed that of the EU. A major issue hindering the market is the inconsistent quality of systems and lack of after-sales service. The focus on testing and certification was urgently needed in this sector. In principle, the certification system can be sustained via applicant fees and/or government support. In this way, the testing and certification can be sustainable as can the SWH market, through higher and more consistent quality levels. The dedication of leading industry players will help to ensure that the rigor and scope of the national testing facilities will continue to grow and in turn, strengthen the market in the long term.

- Wind resource assessment and site characterization activities of the Project were designed to raise the existing levels of site characterization to international standards and to increase investment in the wind farm sector. Whether such site characterization and pre-feasibility is sustainable depends on a number of factors: would Chinese investors be interested in high quality information to lower their risks or would they see such systems as too expensive in the future? Who will own and manage the measurement systems in the future and will developers and investors be willing to pay for the site characterization service? Such questions will need to be resolved for this process to be sustainable. It is thought that by setting a high standard, at least these sites can be well-characterized, and the measurement systems can later be moved to other sites. Once a market exists for this equipment, the wind measurement equipment will likely be manufactured in China. The Project has helped make the concessions program sustainable and commercially viable, thus directly contributing toward the long term staying power of the wind power industry.

- For the village power sector, the capacity building efforts have focused on viable rural energy service delivery models for China. Timing and political drivers did not allow the Project to influence the design of NDRC's Township program and installation of 1,000 village power systems. On the other hand, the Project was able to assess the GOC's program, provide the government with lessons learned, and make recommendations for future such work. In this way the Project was able to change the perspective toward village power of many officials directly involved with the systems. The lessons learned and recommendations generated by the Project are all geared toward ensuring the sustainability of the GOC's massive investment in RE hardware for rural areas. These recommendations have made their way into the design for the follow-on phase, SDDC. Such an impact demonstrates the credibility of the Project with the NDRC in playing this role.

- Project work in bagasse co-generation resulted in one pilot project within the sugar industry that successfully demonstrated the benefits of increasing the efficiency of co-firing boilers and generators. Replacing inefficient equipment generated an 28% increase in efficiency and a significant cost savings for the sugar mill. In addition, international cooperation between China and Australia in this field generated positive information exchange and capacity building.

- From an institutional perspective, CREIA was designed with sustainability in mind and has been a huge success. Today CREIA is a self-sustaining entity solidly grounded in the Chinese RE industry, with international visibility and financing from a number of domestic and international sources.

Technology

A project that handles five renewable energy technology application areas in all aspects from policies to pilot demonstrations is highly complex, and demands intensive managerial skills. The fact that most activities were carried out in a reasonable amount of time and with high quality demonstrates that the Project staff has performed an exceptional job. The industrial-scale biogas sector clearly has had one of the most significant and wide-reaching impacts, followed by solar hot water heating, large-scale wind, and rural village power systems. Each of the sectors was characterized by its own set of challenges and opportunities, and in each of these sectors the Project has overwhelmingly achieved its objectives. The inevitable challenges and set-backs, when encountered, were dealt with in the best way possible and did not impact the overall results of the Project. Following are specific impacts of each market sector.

Greenhouse Gas Reduction Benefits

With a particular emphasis on capacity-building, the Project did **not** have any requirement, back in the mid-90s at Project inception, to address greenhouse gas (GHG) reductions. Calculating the impacts of the Project on GHG emissions can be difficult; however, calculations of the CO_2 emissions avoided through the wind and SWH activities of the Project were calculated during the last three years of Project operation, and for the period of 01-07-2005 to 30-06-2006 it was calculated that wind project installations (200 MW) led to the avoidance of 0.4 million tons of CO_2 emissions per year in 2004 and 2005. Similarly, the Project estimated the CO_2 emissions that are avoided per year due to displacing electric water heaters with SWH. In 2005 if 70% of urban electric water heaters were displaced, the off-set CO_2 was equal to 7.75 million tons. If 35% were displaced, the emissions avoidance was 3.87 million tons.

Table 6: Estimates for tCO_2e avoided per year for wind generated electricity.

Source	Capacity MW	Year	Capacity Factor (%)	GWh Per Year	Conversion Factor Ton CO_2e/ GWh	tCO_2e per Year (Million t)
China New Capacity	67	2002	25	146	915	0.13
China Cumulative Capacity	468	2002	25	1,024	915	0.94
China New Capacity	98	2003	25	214	915	0.20
China Cumulative Capacity	567	2003	25	1,241	915	1.13
Project Installation	200	2004	25	438	915	0.4
China New Capacity	197	2004	25	431	915	0.39
China Cumulative Capacity	764	2004	25	1,673	915	1.53
Project In-	200	2005	25	438	915	0.4

stallation						
China New Capacity	503	2005	25	1,101	915	1.01
China Cumulative Capacity	1267	2005	25	2,774	915	2.54

Table 7: Estimates for tCO_2e avoided per year for displacing electric water heaters.

Capacity Mm^2	Year	Replacement of Electric Heaters (%)	MWh Per Year	Conversion Factor 0.96 Ton CO_2e/ MWh	tCO_2e per Year (Million t)
10	2002	100 Baseline	7,210,000	0.96	6.92
10	2002	70 Urban	5,047,000	0.96	4.84
10	2002	35 ½ of Urban Systems	2,523,500	0.96	2.42
12	2003	100 Baseline	8,652,000	0.96	8.31
12	2003	70 Urban	6,056,400	0.96	5.81
12	2003	35 ½ of Urban Systems	3,028,200	0.96	2.91
14	2004	100 Baseline	10,094,000	0.96	9.69
14	2004	70 Urban	7,065,800	0.96	6.78
14	2004	35 ½ of Urban Systems	3,532,900	0.96	3.40
16	2005	100 Baseline	11,536,000	0.96	11.1
16	2005	70 Urban	8,075,200	0.96	7.75
16	2005	35 ½ of Urban Systems	4,037,600	0.96	3.87

The Project has led to *accelerated and expanded commercialization* of wind electric power (grid-connected wind farms), solar water heating, and biogas-based cogeneration. The project has also laid the groundwork that will help the industry to achieve larger overall long-term market penetration than might have otherwise occurred. Further, over the longer term (the next three to five decades) the impact of the project, through technical assistance and through providing a new enlarged vision of possibility for the renewable energy industry, will have facilitated a much larger role for these technologies than might have occurred. Areas in which the Project is contributing to GHG reductions include the following:

- Directly through demonstration projects that result in the reduction or avoidance of GHG emissions (carbon dioxide, methane, and nitrous oxide).
- Downstream commercial renewable energy installations that replicate and/or leverage the Project demonstrations.
- Indirectly through policy promotion that is instrumental to the promulgation of policy, incentives, and particularly through the establishment of national targets for renewable energy.

Renewable Energy Linkages and Leadership in the International Community

One of the key activities of the Project was to expose Chinese decision makers and policy advisors to the latest development trends of the international renewable energy community. This was accomplished through numerous conferences, overseas study tours, and high level dialogues with senior policy makers in Europe, the US, Australia, and others. These activities culminated in China Day at the Bonn International Renewable Energies Conference (Bonn 2004), and hosting of the follow-on Beijing International Renewable Energy Conference (BIREC 2005) in November 2005. At the Bonn Meeting the GOC made its ambitious commitment to a 16% renewable energy target by 2020 (later dropped to 15% in the action plan) and at BIREC 2005 and beyond the Government, in partnership with industry, has been striving to reach this impressive goal. The Renewable Energy Law has been a cornerstone of China's efforts and serves as a model for other countries interested in expanding renewable energy commercialization, particularly developing countries.

The UNDP/GEF Project, working in close cooperation with NDRC, played an important role in: exposing Chinese decision makers to international experiences and players in renewable energy; helping to put in place the policies and regulations that are making this one of the most rapidly growing markets worldwide; stimulating a rapidly growing industry base for domestic applications and export; and accelerating the country up the renewable energy learning curve. China's presence in the global marketplace has become a model for other countries worldwide, particularly those in the developing world. These countries are benefiting from the Chinese experience base, and from the South-South support that it offers. It has also contributed to moving clean energy to the forefront in global fora such as the 14^{th} and 15^{th} sessions of the Commission on Sustainable Development (CSD-14, 15) and the UN Framework Convention on Climate Change (UNFCC).

Dynamic Track Record of Growth

Since making its renewable energy commitments in Bonn, China has realized tremendous growth in renewable energy and emerged as one of the leading countries in the field. The booming market for renewable energy was catalyzed by the vision and leadership of NDRC, with substantial support by the NDRC/UNDP/GEF Project Team, the AG management structure, and the flexibility in Project design and implementation. The significant advancement of renewable energy in just a few short years was stimulated and made possible by the foundation of activities supported over the Project duration—from legislative training and technical assistance, to policy support, to industrial capacity development and pilot projects, through public awareness and outreach. The Project operated at the right place and at the right time; had a management team that could move from vision to action; worked in close coordination and cooperation with the GOC leadership; helped to strengthen an industrial base and supporting institutions (e.g., CREIA) that today is producing world class products and services; and made critical ties to the global community.

Technology Specific Findings

Industrial Biogas

Major Impacts

- The UNDP Project contributed directly to the growth of the biogas industry through the establishment of a new commercial paradigm for the biogas field by shifting the focus from environmental management alone to environmental management combined with power generation and fertilizer production.
- The new RE Law provides the basis for grid-connected biomass-derived power and for full-scale commercialization of integrated biogas co-generation and environmental management initiatives.
- With the initiative of and direct support from the Project, the *National Action Plan for Industrial-Scale Biogas Development in China* was developed.
- The Project's principal commercial partner in the industrial biogas field, Hangzhou Energy & Environmental Engineer Company, was a key participant in the conceptualization and preparation of the biogas NAP, and provided further support with publication of two major guidebooks on industrial scale biogas projects.
- The project facilitated commercial industrial-scale biogas projects through the organization and support of regional workshops that brought together industry leaders with potential clients and relevant government officials.

Capacity Building Using International Experts and Study Tours

- The Project activities resulted in demonstrable and measurable improvements in technical and business capabilities in bioengineering companies such as Hangzhou Energy & Environmental Engineering Co. and industrial users.

- The Project facilitated industrial biogas technology diffusion to other regions and countries (Taiwan, Japan, and potentially Malaysia and South Africa).

Lessons Learned

- To have an impact on the commercialization of new biogas technology (and any other innovative technology), it is essential to identify and work with the leading edge industry and private sector innovators (HEEEC) and early adopters of the technology.
- The Project-supported pilot projects were especially effective in promoting technology adoption and commercial deployment, including attracting enormous government, customer, and media attention and interest.
- The combination of successful pilot projects and regional workshops focused on business development are very effective in promoting commercialization. The regional workshops for the customer base resulted in many commercial contracts for industrial biogas plants.
- A focused and consistent approach affected a paradigm shift in the industrial biogas field within the lifetime of the UNDP Project.
- It is essential to speak the institutional language and to address the needs of each key stakeholder (government, industry, customers, international development support agencies, etc.).

Implications/Actions for the Future

- While the momentum towards full commercialization is high now, it will be important to continue support for the biogas field; full commercialization is not yet a reality.
- Provide ongoing support for the paradigm shift until the new technology approaches pioneered by the Project are “mainstream” and widely embraced by government (both national and provincial levels), industry, and customers.
- Protect the gains made by the Project.
- Continue the business development workshops.
- Biogas should be incorporated in the renewable energy fund project (UNDP pipeline proposal).
- Standardization of plant design and component integration will speed commercial diffusion and reduce costs of design, construction, operation, and maintenance of the plants.
- To achieve NDRC biogas targets, especially for power generation from biogas, NDRC and SEPA need to continue to work with the industry to promote true commercialization and industrial-scale power generation projects on the megawatt scale. SEPA is focused on environmental management but is still not fully behind biogas power generation commercialization and has not fully adopted the zero-discharge concept of operating biogas plants.

- There is a need to integrate rural development with biomass power generation, especially where the local biogas power generation component can support rural development.

Village Power

Major Impacts

- The Project has worked as an important partner with NDRC in trying to improve the sustainability of the national government's village power programs.
- The Project introduced the Rural Energy Service Company (RESCO) model to China.
- The village power system at Bulunkou provides a demonstration of a sustainable approach to village power with renewable energy technologies, including socially and economically productive uses of electricity.
- UNDP has taken a leadership role in promotion of productive uses for village power systems, to move beyond the narrow and unsustainable focus on provision of consumptive uses of electricity.
- Co-supported by the Project and by the World Bank PMO (WB Renewable Energy Development Project in China), the extensive and challenging village power Baseline Survey (2005) and the associated policy recommendations now form the basis of NDRC framework for village power. The NDRC Energy Bureau was a full partner and beneficiary of this work.
- Project support including the Baseline Survey and economic analysis permitted NDRC assessment of new regulations.
- The Village Power Development Guidebook has had an influence in China and internationally. Over 2,000 hard copies and CDs have been distributed in dozens of countries as well as within China. There have been many requests to UNDP/Beijing from other UNDP offices and UN agencies for the guidebook.
- The Project-supported training program has helped promote new management models for the Government village power programs.

Lessons Learned

- When presented with a major opportunity, the international community has to respond (e.g., the magnitude of the government SDDX program).
- The international community, in providing effective support to the government, needs to work in coordination.
- Having flexibility and the capacity for rapid response provides the ability to take advantage of major opportunities that were not anticipated in the early stages of project design and initiation. This can result in far greater impacts than originally contemplated. This is essential for GEF projects that "overdesign" the initial approach.

- Be careful of what you ask for! The international community had been asking for village power in China. When it came (State Council to NDRC), the scale was unprecedented and no one was prepared for implementation.
- The UNDP Project was not able to work in the Village Power project design and development phase. The Project was able to work in the subsequent design and development stage. UNDP/GEF has to be a major player from the beginning.
- To achieve sustainability in village power systems, it is essential to establish funds and mechanisms for developing the O&M infrastructure, revenue collection and management, training for technicians and managers, development of productive applications, tariffs, etc.
- It is essential to conduct baseline surveys and periodic surveys during the course of the Project to monitor and assess social and economic project impacts as well as management performance.
- Concentrate on domestic systems integration and supplier base: major dependence on international suppliers and systems integrators is not a sustainable or affordable approach.
- There is a need to establish standards for village power systems components, system design approach, and systems performance. For example, the NREL hybrid power test facility is a good model for similar facilities that should be developed in China.

Implications for the Future

- Execute the pipeline proposal (which takes into account the lessons learned).

Solar Water Heating (SWH)

Major Impacts

- Integrating standards, testing, and certification into the national SWH program was a major accomplishment.
- Standards development was essential in creating test and certification procedures, but more work is needed for the industry to expand internationally.
- Industry acknowledges the importance of the certification centers, uses them for testing their products, for establishing their own test facilities, and for improving their products.
- The SWH certification program is widely acknowledged as building confidence in the consumer market, but certification is not universally used among the major suppliers, and some oppose it.
- UNDP support shortened the time to develop the national standards and testing and certification procedures by 5 – 7 years.
- Without the UNDP Project there was considerable risk for loss of confidence by the consumers.

- Industry said that only one center would have been built (Wuhan) had there not been a project. (Wuhan had separate funding; the other centers would not have).
- A sub-sector of the industry thinks that restructuring has already occurred as a result of the UNDP Project.
- With the national testing program tied to national standards, limitations of provincial testing barriers can be overcome. The provinces have to accept the national standards and stop local protectionism.

<u>Lessons Learned</u>

- By working at the national level and with the appropriate government agencies, it is possible to enhance project outcomes through development of a national program.
- Consolidating Project resources and focusing on an integrated national program of standards development, testing, and certification allowed for maximum impact. This was not in the original Project design. (This was also done for wind and for VP systems.)
- The use of a multi-stakeholder process is very effective in development of national standards and getting government and industry support.
- International standards cannot be forced on China, but these standards serve as important guideposts for the standards design and development process.

<u>Implications for the Future</u>

- There is tremendous momentum in the SWH market, and it is worth considering additional international support for increasingly rigorous and comprehensive standards, testing, and certification procedures. This is essential if the Chinese SWH industry is to be successful competing in international markets, although for the near future the global SWH market is dominated by China's domestic market.
- There are new opportunities for international involvement such as the integrated SWH building market and integration with the government support for "new countryside establishments" (new urban and village development). Because many residential building designers oppose adding solar water heating units to their buildings, architectural integration of solar water heating will be important to maintaining market momentum.
- China needs development of trade school and university curricula and training programs for solar thermal systems, to provide the SWH industry with the skilled mechanics, technicians, engineers, and designers that it needs.

Wind

<u>Major Impacts</u>

- The Project had a strong contribution to the national wind energy resource assessment program in China.

- Resource assessment sites have already achieved 70% (700 MWe installed and in pipeline) of UNDP wind development targets.
- Two of the UNDP projects were incorporated in the national wind concession program.
- Project resource assessment standards and measurement protocols have been adopted as the national resource assessment standards and influenced wind measurement procedures throughout China (70m anemometer towers throughout China with similar sensor configurations influenced by Project).
- UNDP made a contribution to the recognition by government of the importance of wind energy resource assessment and standardization of this process.
- Capacity building within key organizations, especially Hydropower (key government partner), was critical.

Lessons Learned

- China must have its own wind resource assessment capacity and cannot depend solely on external expertise. However, ongoing international collaboration with leading wind resource assessment organizations is essential in order for China to establish its own world-class assessment capacity.
- For the wind measurement program, the Project had to achieve a fine balance between working with a professional team immediately or building capacity in experienced organizations. The latter may slow down the Project and compromise project quality. Capacity building should be integrated with professional execution.
- UNDP Project flexibility is required in order to adapt effectively to unexpected events such as the restructuring/deregulation of the Chinese electric power industry
- Bureaucratic contracting procedures can result in significant delays. It is easier to deal with domestic procurement than international procurement, but this requires an external review.
- Procurement and contracting procedures need to be streamlined.

Implications for the Future

- Grid integration of wind electric power requires analysis and tools not yet used in China. This capacity needs to be developed in China through international collaboration.
- Efforts should refocus now on macro resource assessment and on training, letting the domestic wind industry do the micro-siting work.
- Work should continue on wind energy policy development and support for regional planning.
- Future work should support policy, planning, certification, testing, and training. Trained staff is too rare and they often change jobs. There is a huge need for capacity development in the wind electric power industry in China.

Project Management

<u>Lessons Learned</u>

- Support the multiple stakeholder process with workshops and other information and with data exchange.
- Project management has been effective but overburdened, and could have achieved even more with more effective staffing levels, in line with other multilateral staffing levels. The World Bank REDP PMO, which managed a project similar in size to the UNDP Project, but had a more narrow focus, operated with 10 staff during the entire lifetime of the project.!
- UNDP PMOs need to have the resources and mechanisms to hire and retain top people. Otherwise the huge investments in time, training, and networking with the key PMO staff are lost as these staff leave for better paying positions.
- The UNDP Project Document was not an operational plan, and a separate management plan had to be developed in order to implement the project.

In summary, the project was extremely successful in achieving its objectives of building national capacity for the rapid commercialization of renewable energy systems in China and eliminating barriers to renewable energy technology development in the areas of village power hybrid systems, wind farm commercialization, biogas for industrial power generation, solar water heating, and bagasse co-generation. It also contributed to cross cutting objectives of building local institutional capacity at CREIA and fostering technology specific and broader policy development through the Renewable Energy Law of 2005 and follow on implementing regulations. The Project provides a model for expansion in China as well as for replication in other developing countries.

Textbox 19. Future Needs for Renewable Energy Projects in China

Biomass: The real problems in biomass are not agricultural, but technology and market promotion, which happen to be two areas of CREIA's strength. Biomass areas with needs include direct combustion for power generation. Work needs to be done on the collection, storage use, equipment, and market. None of these has a good mechanism at present.

Work is also needed in liquid biofuels. In bio-ethanol, for example, it is necessary to determine how much China should target, how big of a scale, and how to solve the problem of competition with agricultural land. So, there is a need to research: (1) scale, (2) where the best potential is in terms of resources, and (3) once the best feedstock is known, how to develop it.

Off-Grid PV: China needs to resolve the poverty problem of the West. Lots of work has been done to date, but the management mechanism still needs to be worked out. The country has made a large amount of investment, but doesn't have time to figure out a good management mechanism. Work also needs to be done on investment and scale—that is, how big should the systems be and should they be household-scale or village systems?

Grid-Connected PV: Work needs to be done on what kind of policy the government needs. This policy will have to attract both the investment and the end-user.

SWH: The outstanding needs on SWHs are to evaluate the possibility of a mandatory policy that would require SWHs in new buildings; for existing buildings, how should the policy work? There are some problems with building management. There is also the conundrum of making SWH affordable for the rural poor. Evaluation of subsidies should be undertaken. In sum, research is still needed on policy and economic aspects.

Wind: Details are needed in the following areas: certification systems, standard setting, regional planning (how big; how much; and integration with the grid).

Training: Need to make more people understand the industry, including basic principles, R&D, and manufacturers.

If China is able to carry out effective development programs (such as rural electrification) in-country, then they will also be successful with their growing aid programs elsewhere in the world, such as Africa. Therefore, influencing these programs in China could potentially benefit other countries.

Annex I. Project Documentation and Outputs

The project produced extensive documentation, including (1) internal semi-annual and annual reports, (2) external short publications, (3) presentations at conferences and workshops, including both PowerPoint-illustrated live presentations and associated written papers, (4) and extensive documents by project participants, stakeholders, and contractors. Some of the principal project participants prepared extensive briefing materials, primarily as PowerPoint (PPT) presentation, for the project evaluation team meetings with them in March 2007. Many other documents and presentations were prepared by various project stakeholders as a consequence of their work under the project.

Workshops convened by the PMO served to engage both the public and private sectors, and in some areas (e.g., biogas co-generation and power generation) some of those workshops directly facilitated major contracts for private companies working with the PMO to commercialize new RE technologies.

The UNDP/GEF PMO, working with stakeholders, convened a side event at the 2004 Renewable Energies Conference in Bonn in June 2004 and supported participation at the conference by leading Chinese renewable energy experts from both the public and private sector. The commitments made at the Bonn conference to expanded renewable energy development by the Government of China put China at the center state in the global renewable energy marketplace. China also hosted the follow-on conference—the Beijing International Renewable Energy Conference (BIREC). Many UNDP/GEF project-related presentations were made at BIREC. In Bonn 2004 and Beijing 2005 the project-related presentations did more than document the work supported by the project. They served to inform and educate many in the Chinese public sector and helped build commitment of the Government of China to significant expansion of China's development of renewable energy policy and technology.

This list of documents includes many produced by or for the project and others indirectly related to the project. Presentations prepared by the PMO are indicated with **PMO** after the citation. While this list is extensive, it is not comprehensive.

Industrial-Scale Biogas

Documents prepared by the PMO

Wallace, W.L.; H.O. Wu; and Z.Y. Wang (2006). *Boosting the Market for the Commercialization of Industrial Scale Biogas Projects in China*. 6 pages. PDF. NDRC/UNDP/GEF PMO.

Wu Haiou and William Wallace (2006). *NDRC/UNDP/GEF Support for Industrial Scale Biogas Development in China.* 21 pages. PPT. Presentation at the Zhejiang and Jiangsu Regional Industrial Scale Biogas Development Workshop November 29, 2006, Hangzhou, Zhejiang. **PMO**

Documents prepared for the UNDP/GEF Project

Hangzhou Energy & Environmental Engineering Co., Ltd (March 2007). *The Achievements of Hangzhou Energy & Environmental Engineering Co., Ltd since Taking on the UNDP/GEF "Capacity Building for the Rapid Commercialization of Renewable Energy in China" Project.* 57 pages. PPT presentation prepared for the evaluation team in March 2007.

Hangzhou Energy & Environmental Engineering Co., Ltd (January 2006). Guidebook of Livestock and Poultry Farm Biogas Project. Prepared for UNDP/GEF Project Management Office. 174 pp.

Hangzhou Energy & Environmental Engineering Co., Ltd (January 2006). Guidebook of Light Industry Project. Prepared for UNDP/GEF Project Management Office. 126 pp.

Formulation Team of National Action Plan on Biogas Development (2007). National Action Plan for Industrial Scale Biogas Development in China. 92 pp.

Village Power

Documents prepared by the PMO

UNDP/GEF and World Bank/GEF (December 2005). *SDDX Program Survey and Recommendation*. 70 pp. PDF format.

The *Baseline Survey* and RESCO (Rural Energy Service Company) Training for SDDX (Song Dian Dao Xiang) program were conducted by the UNDP/GEF PMO and the PMO of World Bank/GEF/ Renewable Energy Development Project (REDP). The team also conducted RESCO training for about 120 trainees. This work established the first comprehensive base of data and information on the SDDX.

Wallace, W.L.; H. Wu; and Z.Y. Wang (2006). *Experience for Sustainable Development of Rural Energy in China.* 8 pages. PDF.

Documents prepared for the UNDP/GEF Project

Beijing JKD Renewable Energy Development Center, Electrical Engineering Institute (2007). *Field survey & Capacity building of Rural Energy Service for "SDDX" Program.* 29 pages. PPT.

(2007). *RESCO Model in Bulunkou.* 47 pages. PDF.

Kristin K. Stroup (Sept. 2006). *Capacity Building for the Rapid Commercialization of Renewable Energy in China: Renewable Energy for Village Power in Bulunkou Township*. 99 pages. Prepared by Energy and Security Group for the UNDP PMO.

C. Dou and J. Graham, eds. (August 2005). Authors Charlie Dou, Sicheng WANG, Luying DONG, Winfried Rijssenbeck, Zhizhang LIU, E. Ian Baring-Gould, Zhongying WANG, and Jingli SHI. *China Village Power Project Development Guidebook. A Practical Guidebook for the Development of Renewable Energy Systems for Village Power Projects*. 116 pp. PDF. Available from UNDP/Beijing in both hard copy as a CD-ROM (both in Chinese and English).

Beijing JKD Renewable Energy Development Center, Electrical Engineering Institute (2007). *Field survey & Capacity building of Rural Energy Service for "SDDX" Program.* 29 pages. PPT.

Conference and Workshop Presentations

Wallace, William; Sicheng Wang; Lu Fang; and Zhongying Wang (2005). *UNDP/GEF Support for China's National Rural Electrification Programs*. 13 pages. PPT. Presented at 15th PV SEC Conference, October 12, 2005, Shanghai, China. **PMO**

Ma Shenghong (2004). *The Brightness and Township Electrification Program in China.* 24 pages. PPT. Beijing Jikedian Renewable Energy Development Center. Presented at Renewables 2004, Bonn, Germany.

Dou, Charlie (March 2006). *Wind Power Technology and China Rural Electrification.* 8 pages. PDF. Presented at CTI/Industry Joint Seminar Successful Cases of Technology Transfer in Asian Countries Hanoi, Vietnam.

Dou, Charlie (March 2006). *Wind Power Technology and China Rural Electrification.* 48 pages. PPT. Presented at CTI/Industry Joint Seminar Successful Cases of Technology Transfer in Asian Countries, March 8-9. Hanoi, Vietnam. . www.bergey.com

Haugwitz, Frank (Sept. 6, 2006). *Socio-Economic Impact Monitoring of Rural Electrification Projects in Yunnan and Tibet Autonomous Region: A China Case Study*. 14 pages. PDF. Presented at 21st EU PV Solar Energy Conference and Exhibition. Frank.Haugwitz@gtz.de.

Klinghammer, Winfried; Ma Shenghong; and Noerenberg, Konstantin (2005). *First Experiences with the Implementation of a Large-Scale Program on PV Hybrid Village Power Plants in Western China.* 4 pages. PDF. Presented at PVSEC 15, Shanghai. Winfried.Klinghammer@projekt-consult.de

External Documents (Village Power)

PMO of NDRC/UNDP/GEF Speed-up of Chinese Renewable Energy Commercialization and Capacity Building PMO of NDRC/GEF/World Bank Renewable Energy Development Project in China (Dec. 2005). *SDDX PROGRAM Survey and Recommendation.* 71 pages. PDF.

Shi Jingli (Oct. 20, 2004). *Setting up Renewable Energy Service Companies (RESCOs) for Maintenance and Operation of Village Renewable Energy Systems.* 4 pages. PDF. Asia-Pacific Environmental Innovation Strategies (APEIS) Research on Innovative and Strategic Policy Options (RISPO) Good Practices Inventory. shjingli@163bj.com.

Voravate, Tuntivate; Douglas F. Barnes; and V. Susan Bogach (2003). *Assessing Markets for Renewable Energy in Rural Areas of Northwestern China*. 135 pages. PDF. Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP).

Project Group of Energy Research Institute (Dec. 2005). *Investigation Report of Typical Regions for the Study on Modes Access to Electric Power in Small Villages and Dispersed Households.* 26 pages. Study for project on Modes Access to Electric Power in Small Villages and Dispersed Households of Energy Research Institute (ERI) of the National Development and Reform Commission (NDRC).

China Solar Water Heating

Documents prepared by the PMO

Wallace, W.L.; S.J. Liu; and Z.Y. Wang (2006). *Development of a Standards, Testing, and Certification Program to Support the Domestic Solar Water Heating Market in China*. 8 pages. PDF.

Wallace, W.; S.J. Liu; and Z.Y. Wang (2006). *Development of a Standards, Testing, and Certification Program to Support the Domestic Solar Water Heating Market in China*. 15 pages. PPT. Presented at Great Wall Renewable Energy Forum, October 26, 2006, Beijing P.R.C. **PMO**

Documents prepared for the PMO

CTS (March 16, 2007). *National Center for Quality Supervision and Testing of Solar Heating Systems (Beijing)*. 51 pages. PPT. **Prepared for March 2007 assessment mission**

National Solar Heater Supervision and Inspection Center (Wuhan) (2007). *为中国太阳能热利用产业发展服务.* 42 pages. PPT. United Nations Development Programme. **Prepared for March 2007 assessment mission**

Shandong Sangle Solar Energy (March 2007). *Welcome to Shandong Sangle Solar Energy Co., LTD*. 119 pages. PPT. **Prepared for March 2007 assessment mission**

Sub-institute of Resource and Environment Standardization China National Institute of Standardization (2007). *SWH Product Standards, Testing, and Certification in China Project Report*. 31 pages. PPT.

United Nations Development Programme (Oct. 15, 2003). *Capacity Building for the Rapid Commercialization of Renewable Energy*. 52 pages. PPT. http://www.ccre.com.cn.

Wang Zong (March 13, 2007). *Endeavor to be the Authority Certification Brand in the SWH Industry*. 56 pages. PPT. Presentation at China General Certification Center.

China Wind

Documents prepared by the PMO

Wallace, W.L.; Z.Y. Wang; and S.J. Liu (2006). *Support for Wind Resource Assessment and Wind Farm Development in China*. 7 pages. PDF. NDRC/UNDP/GEF Project Management Office.

Wallace, W.; Z.Y. Wang; and S.J. Liu (Oct. 23, 2006). *Support for Wind Resource Assessment and Wind Farm Development in China*. 21 pages. PPT. Presented at the Wind Resource Assessment and Site Characterization Workshop October 23, 2006, Beijing, China. **PMO**

Documents prepared for the PMO

Chinese Renewable Energy Industries Association (CREIA); Greenpeace; and the Global Wind Energy Council (GWEC) (Oct. 26, 2006). *The Wind Pricing Policy in China is yet to be Improved.* 2 pages. PDF. Press Release.

Li Junfeng; Shi Jingli; Xie Hongwen; Song Yangqin; Shi Pengfei (Oct. 2006). *A Study on the Pricing Policy of Wind Power in China*. 78 pages. PDF. Chinese Renewable Energy Industries Association (CREIA); Greenpeace; and the Global Wind Energy Council (GWEC).

China Long Yuan Electric Power Group (March 2007). *Achievement Report of UNDP Wind Resource Research & Evaluation Project in China.* 45 pages. PPT. United Nations Development Programme.

Shi Pengfei (Oct. 16, 2003). *Capacity Building for the Rapid Commercialization of Renewable Energy in China: Wind Resource Measurement, Data Management and Analysis Project*. 48 pages. PPT. NDRC(SETC)/UNDP/GEF Project (CPR/97/G31).

Shi Pengfei (Oct. 23, 2006). *Introduction of the Management and Execution of Wind Data Acquisition and Site Characterization Program.* 20 pages. PPT. Presented at the Wind Resource Assessment and Site Characterization Workshop, Beijing, China, 23 October 2006.

Shi Pengfei (Oct. 2006). *Positive and Negative Impacts of Wind Power Concession Projects in China*. 21 pages. PDF. Presentation at Great Wall Renewable Energy Forum, Beijing, China, October 26, 2006. shi-pengfei@263.net.

External Documents

Raufer, Roger; Xu Litong; and Wang Shujuan (June 2003). *Steps towards a Wind Resource Concession Approach in China.* 101 pages. PDF. United Nations Development Program and United Nations Department of Economic and Social Affairs.

CREIA (China Renewable Energy Industries Association)

CREIA (2005). *2005 CREIA Annual Report*. 17 pages. (English version Revised by William Wallace)

Xiuhua Zhang (2004). *The CRIEA Project: Potential Applications for CDM Projects?* 19 pages. PDF. Presented at Workshop on CMD and ICT, Oslo, March 9, 2004.

Chinese Renewable Energy Industries Association (2003). *Mid-term Review of CREIA*. 14 pages. PPT. http://www.creia.net.

Chinese Renewable Energy Industries Association (CREIA) (2001). *Two Year Project Impact Evaluation of CPR97/G31 Capacity Building for the Rapid Commercialization of Renewable Energy in China*. 21 pages.

Project Mid-Term Review and Associated Documents

Wallace, William L. (2003). *Capacity Building for the Rapid Commercialization of Renewable Energy in China*. 80 pages. UNDP/GEF Project Management Office for Mid-Term Project Review, October 15, 2003.

Lew, D. and W. Rijssenbeek (Jan. 2004). *Capacity Building for the Rapid Commercialization of Renewable Energy in China. Report of the Mid-Term Evaluation* Mission. 95 pp. United Nations Development Programme Project Number CPR /97/G31.

Porter, Gareth; Shi Han; and Zhao Shidong (2003). *Energy and Environment Outcome Evaluation: UNDP China*. 36 pages. United Nations Development Programme.

Martinot, Eric and William Wallace (2003). *Case Study: UNDP/GEF Project for Commercialization of Renewable Energy in China.* 5 pages. PDF.

Project Documents, Work Plans, and Semi-Annual and Annual Reports

United Nations Development Programme Project of the Government of the People's Republic of China (1999). *Capacity Building for the Rapid Commercialization of Renewable Energy.* 74 pages. Project CPR/97/G31/A/1G/01. Project Document

Capacity Building for the Rapid Commercialization of Renewable Energy in China (Feb. 2003). *UNDP/GEF Project Two-Year Work Plan 2003 and 2004*. 27 pages. Project Report for CPR/97/G31.

United Nations Development Programme Project of the Government of the People's Republic of China (2000). *First Annual Report for Capacity Building for the Rapid Commercialization of Renewable Energy*. 72 pages. Project CPR/97/G31.

United Nations Development Programme Project of the Government of the People's Republic of China (2001). *Second Annual Report for Capacity building for the Rapid Commercialization of Renewable Energy*. 39 pages. Project CPR/97/G31.

United Nations Development Programme Project of the Government of the People's Republic of China (2002). *Third Annual Report for Capacity building for the Rapid Commercialization of Renewable Energy*. 16 pages. Project CPR/97/G31.

United Nations Development Programme Project of the Government of the People's Republic of China (2003). *Fourth Annual Report for Capacity building for the Rapid Commercialization of Renewable Energy*. 33 pages. Project CPR/97/G31.

United Nations Development Programme Project of the Government of the People's Republic of China (24 Aug 2004). *Fifth Year Annual Report for Capacity building for the Rapid Commercialization of Renewable Energy*. 46 pages. Project CPR/97/G31.

United Nations Development Programme Project of the Government of the People's Republic of China (15 Aug 2005). *Sixth Year Annual Report for Capacity building for the Rapid Commercialization of Renewable Energy*. 53 pages. Project CPR/97/G31.

United Nations Development Programme Project of the Government of the People's Republic of China (25 Sept. 2006). *Seventh Year Annual Report for Capacity building for the Rapid Commercialization of Renewable Energy*. 69 pages. Project CPR/97/G31.

China Renewable Energy and Environment

(Feb. 28, 2005). *The Renewable Energy Law of the People's Republic of China*. 7 pages. PDF. Adopted at the 14th Session of the Standing Committee of the 10th National People's Congress on February 28th, 2005. Beijing Review No. 29, July 21, 2005.

UNDESA (2005). *Case Studies of Market Transformation: Energy Efficiency and Renewable Energy.* 63 pages. PDF. United Nations.

Expert Group on Renewable Energy Convened by UNDESA (2005). *Increasing Global Renewable Energy Market Share: Recent Trends and Perspectives, Final Report.* 104 pages. PDF. Prepared for the Beijing International Renewable Energy Conference 2005.

Ku, Jean; Debra Lew; Shi Pengfei; and William Wallace (July 2005). *The Future is Now: Accelerating Wind Development in China*. 12 pages. PDF. From Renewable Energy World Magazine; July – August 2005 Issue.

LI Jun Feng and GAO Hu (2006). *China Policy Framework to Support Renewable Energy Development.* Energy Research Institute of National Development and Reform Commission. 23 pages. PDF. Presented at GWREF Oct. 26th, 2006, Beijing.

National Development and Reform Commission People's Republic of China (June 2007). *China's National Climate Change Program*. 63 pages. PDF.

United Nations Development Programme (2006). *United Nations Development Programme at work in China: Annual Report 2006.* 19 pages. PDF.

United Nations Development Programme (2005). *UNDP Country Programme for the People's Republic of China 2006 – 2010.* 8 pages. PDF.

Wang Zhongying (2004). *Present Status and Future Prospects for the Development of Renewable Energy in China*. 35 pages. PDF. Presented April 17, 2004.

Annex II. Documentation Used in Review

Industrial-Scale Biogas

Wallace, W.L.; H.O. Wu; and Z.Y. Wang (2006). *Boosting the Market for the Commercialization of Industrial Scale Biogas Projects in China*. 6 pages. PDF. NDRC/UNDP/GEF PMO.

Hangzhou Energy & Environmental Engineering Co., Ltd (March 2007). *The Achievements of Hangzhou Energy & Environmental Engineering Co., Ltd since Taking on the UNDP/GEF "Capacity Building for the Rapid Commercialization of Renewable Energy in China" Project.* 57 pages. PPT.

Hangzhou Energy & Environmental Engineering Co., Ltd (January 2006). *Guidebook of Livestock and Poultry Farm Biogas Project.* Prepared for UNDP/GEF Project Management Office. 174 pp.

Hangzhou Energy & Environmental Engineering Co., Ltd (January 2006). *Guidebook of Light Industry Project.* Prepared for UNDP/GEF Project Management Office. 126 pp.

Wu Haiou and William Wallace (2006). *NDRC/UNDP/GEF Support for Industrial Scale Biogas Development in China.* 21 pages. PPT. Presentation at the Zhejiang and Jiangsu Regional Industrial Scale Biogas Development Workshop November 29, 2006, Hangzhou, Zhejiang.

Formulation Team of National Action Plan on Biogas Development (2007). *National Action Plan for Industrial Scale Biogas Development in China.* 92 pp.

Village Power

C. Dou and J. Graham, eds. (August 2005). Authors Charlie Dou, Sicheng WANG, Luying DONG, Winfried Rijssenbeck, Zhizhang LIU, E. Ian Baring-Gould, Zhongying WANG, and Jingli SHI. *China Village Power Project Development Guidebook. A Practical Guidebook for the Development of Renewable Energy Systems for Village Power Projects.* 116 pp. PDF Available in both hard copy as a CD-ROM (both in Chinese and English).

(2007). *RESCO Model in Bulunkou.* 47 pages. PDF.

Beijing Jike Energy New Tech Development Co. (2006). *Dissemination of Best Practice of Village Power to East Asia Countries.* 46 pages. PDF. Renewable Energy and Energy Efficiency Partnership (REEEP).

Beijing Jike Energy New Technology Development Company (April 2006). *Study Report on Village Power in Mongolia.* 36 pages. PDF. Dissemination of Best Practice of Village Power to East Asia Countries Contract Number of the Project: 10303046: REEEP Project.

Dou, Charlie (March 2006). *Wind Power Technology and China Rural Electrification.* 48 pages. PDF. Presented at CTI/Industry Joint Seminar Successful Cases of Technology Transfer in Asian Countries Hanoi, Vietnam.

Haugwitz, Frank (Sept. 6, 2006). *Socio-Economic Impact Monitoring of Rural Electrification Projects in Yunnan and Tibet Autonomous Region: A China Case Study*. 14 pages. PDF. Presented at 21st EU PV Solar Energy Conference and Exhibition. Frank.Haugwitz@gtz.de.

Janzing, Bernward (March 2006). *Energie von kleinen Inseln.* Energie in Entwicklung. 4 pages. PDF.

Klinghammer, Winfried; Ma Shenghong; and Noerenberg, Konstantin (2005). *First Experiences with the Implementation of a Large-Scale Program on PV Hybrid Village Power Plants in Western China.* 4 pages. PDF. Presented at PVSEC 15, Shanghai. Winfried.Klinghammer@projekt-consult.de

Ku, J.; E.I. Baring-Gould; and K. Stroup (Jan. 2005). *Renewable Energy Applications for Rural Development in China*. 5 pages. PDF. Presented at 2004 DOE Solar Energy Technologies Program Review Meeting October 25-28, 2004 Denver, Colorado. NREL/CP-710-37605.

National Renewable Energy Center (NREC) of Mongolia Team (Enebishi, Dr. Namjil; Mr. SH Tumurbaatar; Peng Luming; Chixun; Liu HaiTao) (March 2006). *Field Trip to Village Power in Mongolia.* 12 pages. PDF. REEEP Project Team Report for Project 10303046: Dissemination of Best Practice of Village Power to East Asia Countries.

National Renewable Energy Laboratory (April 2004). *Renewable Energy in China: WB/GEF Renewable Energy Development Project*. 2 pages. PDF. NREL file: NREL/FS-710-33067. www.nrel.gov/international.

PMO of NDRC/UNDP/GEF Speed-up of Chinese Renewable Energy Commercialization and Capacity Building PMO of NDRC/GEF/World Bank Renewable Energy Development Project in China (Dec. 2005). *SDDX PROGRAM Survey and Recommendation.* 71 pages. PDF.

Shi Jingli (Oct. 20, 2004). *Setting up Renewable Energy Service Companies (RESCOs) for Maintenance and Operation of Village Renewable Energy Systems.* 4 pages. PDF. Asia-Pacific Environmental Innovation Strategies (APEIS) Research on Innovative and Strategic Policy Options (RISPO) Good Practices Inventory. shjingli@163bj.com.

Voravate, Tuntivate; Douglas F. Barnes; and V. Susan Bogach (2003). *Assessing Markets for Renewable Energy in Rural Areas of Northwestern China*. 135 pages. PDF. Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP).

Wallace, W.L.; H. Wu; and Z.Y. Wang (2006). *Experience for Sustainable Development of Rural Energy in China.* 8 pages. PDF.

Beijing JKD Renewable Energy Development Center, Electrical Engineering Institute (2007). *Field survey & Capacity building of Rural Energy Service for "SDDX" Program.* 29 pages. PPT.

Ma Shenghong (2004). *The Brightness and Township Electrification Program in China.* 24 pages. PPT. Beijing Jikedian Renewable Energy Development Center. Presented at Renewables 2004, Bonn, Germany.

Wallace, William; Sicheng Wang; Lu Fang; and Zhongying Wang (2005). *UNDP/GEF Support for China's National Rural Electrification Programs*. 13 pages. PPT. Presented at 15th PV SEC Conference, October 12, 2005, Shanghai, China.

Kristin K. Stroup (Sept. 2006). *Capacity Building for the Rapid Commercialization of Renewable Energy in China: Renewable Energy for Village Power in Bulunkou Township.* 99 pages. Prepared by Energy and Security Group for the UNDP PMO.

Project Group of Energy Research Institute (Dec. 2005). *Investigation Report of Typical Regions for the Study on Modes Access to Electric Power in Small Villages and Dispersed Households.* 26 pages. Study for project on Modes Access to Electric Power in Small Villages and Dispersed Households of Energy Research Institute (ERI) of the National Development and Reform Commission (NDRC).

China Renewable Energy and Environment

(2005). *Beijing Declaration on Renewable Energy for Sustainable Development*. 3 pages. PDF.

(Feb. 28, 2005). *The Renewable Energy Law of the People's Republic of China*. 7 pages. PDF. Adopted at the 14th Session of the Standing Committee of the 10th National People's Congress on February 28th, 2005. Beijing Review No. 29, July 21, 2005.

Berrah, Noureddine; Fei Feng; Roland Priddle; and Leiping Wang (2007). *Sustainable Energy in China: The Closing Window of Opportunity.* 331 pages. PDF. The World Bank Publication.

Department of Economic and Social Affairs Division for Sustainable Development (2005). *Case Studies of Market Transformation: Energy Efficiency and Renewable Energy.* 63 pages. PDF. United Nations.

Expert Group on Renewable Energy Convened by the United Nations Department of Economic and Social Affairs (2005). *Increasing Global Renewable Energy Market Share: Recent Trends and Perspectives, Final Report.* 104 pages. PDF. Prepared for the Beijing International Renewable Energy Conference 2005.

Ku, Jean; Debra Lew; Shi Pengfei; and William Wallace (July 2005). *The Future is Now: Accelerating Wind Development in China*. 12 pages. PDF. From Renewable Energy World Magazine; July – August 2005 Issue.

LI Jun Feng and GAO Hu (2006). *China Policy Framework to Support Renewable Energy Development.* Energy Research Institute of National Development and Reform Commission. 23 pages. PDF. Presented at GWREF Oct. 26th, 2006, Beijing.

National Development and Reform Commission People's Republic of China (June 2007). *China's National Climate Change Program*. 63 pages. PDF.

REN 21 (Renewable Energy Policy Network for the 21st Century) (2006). *Renewables: Global Status Report: 2006 Update*. 35 pages. PDF. www.ren21.net.

United Nations Development Programme (2006). *United Nations Development Programme at work in China: Annual Report 2006.* 19 pages. PDF.

United Nations Development Programme (2005). *UNDP Country Programme for the People's Republic of China 2006 – 2010.* 8 pages. PDF.

United Nations Environment Programme and New Energy Finance Ltd (2007). *Global Trends in Sustainable Energy Investment 2007: Analysis of Trends and Issues in the Financing of Renewable Energy and Energy Efficiency in OECD and Developing Countries.* 54 pages. PDF. ISBN: 978-

92-807-2859-0, DTI/0985/PA.

Wang Zhongying (2004). *Present Status and Future Prospects for the Development of Renewable Energy in China*. 35 pages. PDF. Presented April 17, 2004.

Wohlgemuth, Norbert and Jyoti Painuly (2007). *Promoting Private Sector Financing of Commercial Investments in Renewable Energy Technologies*. 18 pages. PDF.

World Bank Office, Beijing (May 2007). *China Quarterly Update May 2007*. 22 pages. PDF.

China Solar Water Heating

Wallace, W.L.; S.J. Liu; and Z.Y. Wang (2006). *Development of a Standards, Testing, and Certification Program to Support the Domestic Solar Water Heating Market in China*. 8 pages. PDF.

CTS (March 16, 2007). *National Center for Quality Supervision and Testing of Solar Heating Systems (Beijing)*. 51 pages. PPT.

National Solar Heater Supervision and Inspection Center (Wuhan) (2007). *为中国太阳能热利用产业发展服务*. 42 pages. PPT. United Nations Development Programme.

Shandong Sangle Solar Energy (March 2007). *Welcome to Shandong Sangle Solar Energy Co., LTD*. 119 pages. PPT.

Sub-institute of Resource and Environment Standardization China National Institute of Standardization (2007). *SWH Product Standards, Testing, and Certification in China Project Report*. 31 pages. PPT.

Sub-institute of Resource and Environment Standardization China National Institute of Standardization (2007). *SWH Product Standards, Testing, and Certification in China Project Report*. 30 pages. PPT.

United Nations Development Programme (Oct. 15, 2003). *Capacity Building for the Rapid Commercialization of Renewable Energy*. 52 pages. PPT. http://www.ccre.com.cn.

Wallace, W.; S.J. Liu; and Z.Y. Wang (2006). *Development of a Standards, Testing, and Certification Program to Support the Domestic Solar Water Heating Market in China*. 15 pages. PPT. Presented at Great Wall Renewable Energy Forum, October 26, 2006, Beijing P.R.C.

Wallace, W.; S.J. Liu; and Z.Y. Wang (2006). *Development of a Standards, Testing, and Certification Program to Support the Domestic Solar Water Heating Market in China*. 17 pages. PPT. Presented at Great Wall Renewable Energy Forum, October 26, 2006, Beijing P.R.C.

Wang Zong (March 13, 2007). *Endeavor to be the Authority Certification Brand in the SWH Industry*. 56 pages. PPT. Presentation at China General Certification Center.

Wang Zong (March 13, 2007). *Endeavor to be the Authority Certification Brand in the SWH Industry*. 52 pages. PPT. Presentation at China General Certification Center.

China Wind

Chinese Renewable Energy Industries Association (CREIA); Greenpeace; and the Global Wind Energy Council (GWEC) (Oct. 26, 2006). *The Wind Pricing Policy in China is yet to be Improved.* 2 pages. PDF. Press Release.

Division Environment and Infrastructure TERNA Wind Energy Programme (Sept. 2005). *Energy Policy Framework for Electricity Markets and Renewable Energies in the PR China.* 25 pages. PDF. Eschborn, Germany

Dou, Charlie (March 2006). *Wind Power Technology and China Rural Electrification*. 9 pages. PDF. CTI/Industry Joint Seminar Successful Cases of Technology Transfer in Asian Counties, March 8 – 9, Hanoi Vietnam. www.bergey.com.

Lan Yu (Sept. 2006). *The Way Forward for the Wind Industry in China*. 109 pages. PDF. Imperial College London Faculty of Life Sciences (University of London) Centre of Environmental Policy.

Lewis, Joanna (2006). *A Review of the Potential International Trade Implications of Key Wind Power Industry Policies in China*. 13 pages. PDF. Prepared for the Energy Foundation China Sustainable Energy Program.

Li Junfeng; Shi Jingli; Xie Hongwen; Song Yangqin; Shi Pengfei (Oct. 2006). *A Study on the Pricing Policy of Wind Power in China*. 78 pages. PDF. Chinese Renewable Energy Industries Association (CREIA); Greenpeace; and the Global Wind Energy Council (GWEC).

Meyer, Sebastian (Sept. 15, 2006). *China Wind Concession Projects Awarded*. 3 pages. PDF. Azure International. Sebastian.meyer@azure-international.com.

Raufer, Roger; Xu Litong; and Wang Shujuan (June 2003). *Steps towards a Wind Resource Concession Approach in China.* 101 pages. PDF. United Nations Development Program and United Nations Department of Economic and Social Affairs.

Shi Pengfei (Oct. 2006). *Positive and Negative Impacts of Wind Power Concession Projects in China*. 21 pages. PDF. Presentation at Great Wall Renewable Energy Forum, Beijing, China, October 26, 2006. shi-pengfei@263.net.

Wallace, W.L.; Z.Y. Wang; and S.J. Liu (2006). *Support for Wind Resource Assessment and Wind Farm Development in China*. 7 pages. PDF. NDRC/UNDP/GEF Project Management Office.

Wilkinson, Anthony; Rajesh Panjwani; and Debra Lui (Feb. 2006). *Wind Power Sector Outlook: Blowing Hard Across Asia*. 40 pages. PDF. CLSA Research: Asia-Pacific.

Xinhuanet (Oct. 6, 2006). *Four SOEs Awarded Wind Power Projects in China*. 1 page. PDF.

Yingling Liu (May 19, 2006). *Made in China, or Made by China? Chinese Wind Turbine Manufacturers Struggle to Enter Own Market*. 2 pages. PDF.

China Long Yuan Electric Power Group (March 2007). *Achievement Report of UNDP Wind Resource Research & Evaluation Project in China.* 45 pages. PPT. United Nations Development Programme.

Shi Pengfei (Oct. 16, 2003). *Capacity Building for the Rapid Commercialization of Renewable Energy in China: Wind Resource Measurement, Data Management and Analysis Project*. 48 pages. PPT. NDRC(SETC)/UNDP/GEF Project (CPR/97/G31).

Shi Pengfei (Oct. 23, 2006). *Introduction of the Management and Execution of Wind Data Acquisition and Site Characterization Program.* 20 pages. PPT. Presented at the Wind Resource Assessment and Site Characterization Workshop, Beijing, China, 23 October 2006.

Wallace, W.; Z.Y. Wang; and S.J. Liu (Oct. 23, 2006). *Support for Wind Resource Assessment and Wind Farm Development in China*. 21 pages. PPT. Presented at the Wind Resource Assessment and Site Characterization Workshop October 23, 2006, Beijing, China.

CREIA

Xiuhua Zhang (2004). *The CRIEA Project: Potential Applications for CDM Projects?* 19 pages. PDF. Presented at Workshop on CMD and ICT, Oslo, March 9, 2004.

Chinese Renewable Energy Industries Association (2003). *Mid-term Review of CREIA*. 14 pages. PPT. http://www.creia.net.

CREIA (2005). *2005 CREIA Annual Report*. 17 pages.

UNDP Project Reports

Global Environment Facility (2001). *Memorandum Regarding Proposed Restructuring of China: Renewable Energy Development Project*. 18 pages. PDF.

Martinot, Eric and William Wallace (2003). *Case Study: UNDP/GEF Project for Commercialization of Renewable Energy in China.* 5 pages. PDF.

Wallace, William L. (2003). *Capacity Building for the Rapid Commercialization of Renewable Energy in China*. 80 pages. PPT. UNDP/GEF Project Management Office for Mid-Term Project Review, October 15, 2003.

Capacity Building for the Rapid Commercialization of Renewable Energy in China (Feb. 2003). *UNDP/GEF Project Two-Year Work Plan 2003 and 2004*. 27 pages. Project Report for CPR/97/G31.

Chinese Renewable Energy Industries Association (CREIA) (2001). *Two Year Project Impact Evaluation of CPR97/G31 Capacity Building for the Rapid Commercialization of Renewable Energy in China*. 21 pages.

Lew, D. and W. Rijssenbeek (2004). *Capacity Building for the Rapid Commercialization of Renewable Energy*. 27 pages. United Nations Development Programme Project Number CPR /97/G31.

Porter, Gareth; Shi Han; and Zhao Shidong (2003). *Energy and Environment Outcome Evaluation: UNDP China*. 36 pages. United Nations Development Programme.

United Nations Development Programme Project of the Government of the People's Republic of China (1999). *Capacity Building for the Rapid Commercialization of Renewable Energy.* 74 pages. Project CPR/97/G31/A/1G/01. Project Document

United Nations Development Programme Project of the Government of the People's Republic of China (2000). *First Annual Report for Capacity Building for the Rapid Commercialization of Renewable Energy.* 72 pages. Project CPR/97/G31.

United Nations Development Programme Project of the Government of the People's Republic of China (2001). *Second Annual Report for Capacity building for the Rapid Commercialization of Renewable Energy*. 39 pages. Project CPR/97/G31.

United Nations Development Programme Project of the Government of the People's Republic of China (2002). *Third Annual Report for Capacity building for the Rapid Commercialization of Renewable Energy*. 16 pages. Project CPR/97/G31.

United Nations Development Programme Project of the Government of the People's Republic of China (2003). *Fourth Annual Report for Capacity building for the Rapid Commercialization of Renewable Energy*. 33 pages. Project CPR/97/G31.

United Nations Development Programme Project of the Government of the People's Republic of China (24 Aug 2004). *Fifth Year Annual Report for Capacity building for the Rapid Commercialization of Renewable Energy*. 46 pages. Project CPR/97/G31.

United Nations Development Programme Project of the Government of the People's Republic of China (15 Aug 2005). *Sixth Year Annual Report for Capacity building for the Rapid Commercialization of Renewable Energy*. 53 pages. Project CPR/97/G31.

United Nations Development Programme Project of the Government of the People's Republic of China (25 Sept. 2006). *Seventh Year Annual Report for Capacity building for the Rapid Commercialization of Renewable Energy*. 69 pages. Project CPR/97/G31.

Annex III. Review Schedule

Mission Timetable and Activities in China (2007)

Day/Date	Locale	Time	Events	Organization / Principals
3/09 Fri	Beijing	15:30	JMW arrive PEK	
3/10 Sat	Beijing	22:00		Review of China project documents
3/11 Sun	Beijing	12:00-15:00	Initial project meeting	Bill Wallace (WW), Eugenia Katsigris (EK)
3/12 Mon	Beijing	All day	Meetings at the PMO	Morning: Briefing by WW, meeting with CRED – WANG Zhongying: project director and Senior Energy Economist Afternoon: ZHU Junsheng, President of CREIA
3/13 Tue	Beijing	10:00 - noon	Meetings, tour of facilities after lunch	China National Institute of Standardization Sub-Institute of Resource and Environment Standardization
		Noon	Hosted lunch	Institute of Standardization (host)
		14:00 – 16:00	UNDP/Beijing meeting	Dr. Yiyang SHEN, Dep Res Rep KHODAY
		16:50 - 20:30	Meeting and tour, hosted dinner	SWH certification center
3/14 Wed	Beijing	Morning	PMO village power briefing	WW Village Power briefing
		14:15 – 18:00	Meeting [team, Dr. Shen]	Beijing Jike New Energy Technology Company (Wang Sicheng)
		19:00 – 20:30	Dinner	PMO team, Dr. Shen (UNDP), Wang Sicheng, others
3/15 Thu	Beijing	09:45 – 11:45	Meeting	China Hydropower Engineering Consulting Group, Inc.
		12:00 – 13:30	Hosted lunch	China Hydropower Engineering Consulting Group, Inc.
		14:15 – 16:30	Meeting	China Long Yuan Electric Power Corporation
3/16 Fri	Beijng	09:30 – 12:30	Meeting and tour	National Center of Quality Supervision and Testing for Solar Water Heating Systems (Beijing)
		13:00 – 15:00	Hosted lunch	National Center (host)
		>15:30	At hotel	Review and discussion with Bill and EK
3/17 Sat	Beijing	10:30 – 12:15	PMO biogas briefing	Bill, EK, JMW
		12:30 – 13:15	Lunch	Charlie DOU (Bergey Windpower), JMW, Bill, EK, Shijun

Day/Date	Locale	Time	Events	Organization / Principals
		13:30 – 19:00	PMO biogas briefing	Bill, EK, JMW
3/18 Sun	Wuhan	16:10 – 18:00	PEK/WUH	Fly to WUH
3/19 Mon		09:15	Meeting, tour of center	Solar thermal test center
		Noon – 13:15	Hosted lunch	Solar thermal test center
		15:30 – 16:35	WUH/HGH	Fly from Wuhan to Hangzhou, check into hotel, no-host dinner
3/20 Tue	Hangzhou	09:10 – 12:10	Meeting on large-scale biogas / cogen systems	Hangzhou Energy and Environmental Engineering Co., Ltd.
		12:20 – 13:20	Hosted lunch	Hangzhou Energy and Environmental Engineering Co., Ltd.
		16:00 – 17:00	Meeting and facilities tour after 2+ hour drive to pig farm and biogas facility	
		19:30 -	Hosted dinner	Hangzhou Energy and Environmental Engineering Co., Ltd.
3/21 Wed	Hangzhou	09:10 – 10:40	HGH/TAO	Fly from Hangzhou to Qingdao
	Qingdao	12:30 – 17:00	Lunch at the distillery followed by a meeting	Qingdao Jiuchang Distillery Wastewater Treatment Project (biogas project)
3/22 Thu	Qingdao	07:30 – 08:10	TAO/TNA	Fly from Qingdao to Jinan
	Jinan	10:00 – 12:30	Meetings and facility tours	Shandong Energy Research Institute Shandong Sangle Solar Energy Co. Ltd.
		12:30 – 14:00	Hosted lunch	Shandong Energy Research Institute Shandong Sangle Solar Energy Co. Ltd.
		14:00 – 15:00	Facilities tour, short road tour	Toured sales office with many solar water heaters on display; went to outskirts of town to see new residential apartment buildings with solar water heaters
		15:45 – 16:50	Tour of factory	Linuo Paradigma SWH company
3/23 Fri	Jinan	10:00 - evening	Tour of exposition hall, lunch, meeting, factory tour	Huang Ming – Himin Solar Energy Group [Ca. 2+ hours drive between hotel and Himin Solar Energy Group facilities]
3/24 Sat	Jinan	12:15 – 13:05	TNA/PEK	Fly from Jinan to Beijing
3/25 Sun	Beijing	All day	Hotel	Write up notes
3/26 Mon	Beijing	AM	Hotel	Write up notes

Day/Date	Locale	Time	Events	Organization / Principals
		12:30 – 15:00	Lunch	Meeting with Frank Haugwitz (GTZ) JMW and EK
		> 16:00	Hotel	Write up notes
3/27 Tue	Beijing	19:00 – 21:00	Dinner meeting	Prof. Eric Martinot (Tsinghua University and WRI) JMW
3/28 Wed	Beijing			JMW and EK meeting to prepare notes
3/29 Thu	Beijing	All day into evening	Internal working meetings at JMW hotel	JMW and EK at hotel, brainstorming and preparation of draft project overview in PPT format
3/30 Fri	Beijing	11:00 – 12:30	UNDP Beijing offices	Project meeting and debriefing on initial findings and conclusions
		18:00	Dinner	Informal dinner (PMO team, UNDP, guests)
3/31 Sat	Beijing	12:00 – 15:00	Final project meeting	WW, EK, and JMW
	Beijing	>15:00	Beijing to IAD	Hotel to PEK, PEK to IAD

Annex IV. Key Interviews

Beijing

UNDP/GEF Project Management Office
National Development and Reform Commission (NDRC)

United Nations Development Program

GEF/The World Bank China Renewable Energy Development Project
National Development and Reform Commission (NDRC)

Chinese Renewable Energy Industries Association (CREIA)

China General Certification Center

Sub-Institute of Resource and Environment Standardization
China National Institute of Standardization

Beijing Jikedian Renewable Energy Development Center

Beijing Jike Energy New Technology Development Company

China Hydropower Engineering Consulting Group Co. (Hydropower Planning General Institute)

China Guodian Corporation- China Long Yuan Electric Power Group Corp.

Beijing Solar Energy Research Institute

Center for Renewable Energy Development (CRED)
Energy Research Institute
National Development and Reform Commission (NDRC)

Institute of Air Conditioning
China Academy of Building Research
National Center for Quality Supervision and Testing of Solar Heating Systems (Beijing)
National Center of Quality Supervision and Testing for Air Conditioning Equipment

Renewable Energy & Rural Power Division
Energy Bureau
National Development and Reform Commission

German Technical Cooperation (GTZ)
Renewable Energies in Rural Areas program

Wuhan (Capital of Hubei Province)

Hubei Provincial Supervision and Inspection Institute of Product Quality
National Solar Water Heater Supervision and Enspection Center of Product Quality
National Drink and Provisions Oil Product Supervision and Inspection Center of Product Quality

Hangzhou (Capital of Zhejiang Province)

Hangzhou Energy & Environmental Engineering Co., Ltd. (HEEEC)

Xingwang Pig farm / industrial biogas facility

Shandong province

Shandong Academy of Sciences
Jinan

China-Himin Solar Energy Group
Dezhou City

Shandong Sangle Solar Energy Co., Ltd.
Jinan

Shandong Linuo Paradigma Co., Ltd.
Sino-German Joint Venture
Jinan

Shandong Energy Research Institute
Shandong Sangle Solar Energy Co., Ltd.
Jinan

Qingdao Jiuchang Distillery Wastewater Treatment Project (biogas project)