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PROJECT PERFORMANCE ASSESSMENT REPORT

PEOPLE'S REPUBLIC OF CHINA

RENEWABLE ENERGY DEVELOPMENT PROJECT

(IBRD-44880; TF-22642)

June 1, 2010

*Sector Evaluations (IEGSE)
Independent Evaluation Group (World Bank)*

Currency Equivalents (annual averages)

Currency Unit = Chinese Yuan Renminbi (CNY)

1999	US\$1.00	CNY 8.28	2004	US\$1.00	CNY 8.28
2000	US\$1.00	CNY 8.28	2005	US\$1.00	CNY 8.19
2001	US\$1.00	CNY 8.28	2006	US\$1.00	CNY 7.99
2002	US\$1.00	CNY 8.28	2007	US\$1.00	CNY 7.99
2003	US\$1.00	CNY 8.28	2008	US\$1.00	CNY 6.87

Abbreviations and Acronyms

CRESP	China Renewable Energy Scale-up Project
ERR	Economic rate of return
GEF	Global Environment Facility
GEO	Global environment objective
GW	Gigawatt
FRR	Financial rate of return
ICR	Implementation Completion Report
IEG	Independent Evaluation Group
IEGWB	Independent Evaluation Group (World Bank)
klmh	Kilolumen hour
kW	Kilowatt
MDSF	Market Development Support Facility
M&E	Monitoring and evaluation
MW	Megawatt
MWp	Megawatt peak
NCPG	North China Power Grid
PMO	Project Management Office
PPAR	Project Performance Assessment Report
PV	Photovoltaic
QRF	Quick Response Facility
RE	Renewable energy
REDP	Renewable Energy Development Project
SHS	Solar home system
SMEPC	Shanghai Municipal Electric Power Corporation
SWPC	Shanghai Wind Power Company
TI	Technology improvement
Wp	Watt peak

Fiscal Year

Government: January 1 to December 31

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The Independent Evaluation Group assesses the programs and activities of the World Bank for two purposes: first, to ensure the integrity of the Bank's self-evaluation process and to verify that the Bank's work is producing the expected results, and second, to help develop improved directions, policies, and procedures through the dissemination of lessons drawn from experience. As part of this work, IEGWB annually assesses about 25 percent of the Bank's lending operations through field work. In selecting operations for assessment, preference is given to those that are innovative, large, or complex; those that are relevant to upcoming studies or country evaluations; those for which Executive Directors or Bank management have requested assessments; and those that are likely to generate important lessons.

To prepare a Project Performance Assessment Report (PPAR), IEGWB staff examine project files and other documents, interview operational staff, visit the borrowing country to discuss the operation with the government, and other in-country stakeholders, and interview Bank staff and other donor agency staff both at headquarters and in local offices as appropriate.

Each PPAR is subject to internal IEGWB peer review, Panel review, and management approval. Once cleared internally, the PPAR is commented on by the responsible Bank department. IEGWB incorporates the comments as relevant. The completed PPAR is then sent to the borrower for review; the borrowers' comments are attached to the document that is sent to the Bank's Board of Executive Directors. After an assessment report has been sent to the Board, it is disclosed to the public.

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Outcome: The extent to which the operation's major relevant objectives were achieved, or are expected to be achieved, efficiently. The rating has three dimensions: relevance, efficacy, and efficiency. *Relevance* includes relevance of objectives and relevance of design. *Relevance of objectives* is the extent to which the project's objectives are consistent with the country's current development priorities and with current Bank country and sectoral assistance strategies and corporate goals (expressed in Poverty Reduction Strategy Papers, Country Assistance Strategies, Sector Strategy Papers, Operational Policies). *Relevance of design* is the extent to which the project's design is consistent with the stated objectives. *Efficacy* is the extent to which the project's objectives were achieved, or are expected to be achieved, taking into account their relative importance. *Efficiency* is the extent to which the project achieved, or is expected to achieve, a return higher than the opportunity cost of capital and benefits at least cost compared to alternatives. The efficiency dimension generally is not applied to adjustment operations. *Possible ratings for Outcome:* Highly Satisfactory, Satisfactory, Moderately Satisfactory, Moderately Unsatisfactory, Unsatisfactory, Highly Unsatisfactory.

Risk to Development Outcome: The risk, at the time of evaluation, that development outcomes (or expected outcomes) will not be maintained (or realized). *Possible ratings for Risk to Development Outcome:* High Significant, Moderate, Negligible to Low, Not Evaluable.

Bank Performance: The extent to which services provided by the Bank ensured quality at entry of the operation and supported effective implementation through appropriate supervision (including ensuring adequate transition arrangements for regular operation of supported activities after loan/credit closing, toward the achievement of development outcomes. The rating has two dimensions: quality at entry and quality of supervision. *Possible ratings for Bank Performance:* Highly Satisfactory, Satisfactory, Moderately Satisfactory, Moderately Unsatisfactory, Unsatisfactory, Highly Unsatisfactory.

Borrower Performance: The extent to which the borrower (including the government and implementing agency or agencies) ensured quality of preparation and implementation, and complied with covenants and agreements, toward the achievement of development outcomes. The rating has two dimensions: government performance and implementing agency(ies) performance. *Possible ratings for Borrower Performance:* Highly Satisfactory, Satisfactory, Moderately Satisfactory, Moderately Unsatisfactory, Unsatisfactory, Highly Unsatisfactory.

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Principal Ratings

	<i>ICR*</i>	<i>ICR Review*</i>	<i>PPAR</i>
Outcome	Satisfactory	Satisfactory	Satisfactory
Risk to Development Outcome	Negligible to Low	Negligible to Low	Negligible to Low
Bank Performance	Satisfactory	Satisfactory	Satisfactory
Borrower Performance	Satisfactory	Moderately Satisfactory	Moderately Satisfactory

* The Implementation Completion Report (ICR) is a self-evaluation by the responsible Bank department. The ICR Review is an intermediate IEGWB product that seeks to independently verify the findings of the ICR.

Key Staff Responsible

<i>Project</i>	<i>Task Manager/Leader</i>	<i>Division Chief/ Sector Director</i>	<i>Country Director</i>
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Preface

This is the Project Performance Assessment Report (PPAR) on the China Renewable Energy Development Project. This project was financed through IBRD Loan No. 44880 in the amount of US\$13 million, and co-financing of Trust Fund No. 22642 in the amount of US\$27.0 million from the Global Environment Facility. The loan was approved on June 8, 1999. The signature of the legal agreements was delayed until June 26, 2001, by which time the project had been restructured and downscaled. The project became effective on December 21, 2001, and closed one year after the originally scheduled closing date on June 30, 2008. The loan was 99.5 percent disbursed.

This PPAR was based on a review of project documents, including the Implementation Completion Report (Report No. ICR0000880), the Project Appraisal Document (Report No. 18479-CHA), loan documents, mid-term review reports and other project files, as well as discussions held with Bank staff involved in the project. An Independent Evaluation Group (IEG) mission visited China in April 2009 to discuss the project's development effectiveness with the government, the project implementing agencies, research institutes, semi-nomadic households, and other stakeholders. Their cooperation and assistance are gratefully acknowledged.

Following standard IEG procedures, copies of the draft PPAR were sent to government officials and agencies for their review, but no comments were received.

Summary

As the Chinese Government increased its commitment to the development of renewable energy in the 1990s, the World Bank began collaboration with the government to expand and accelerate the development of electricity generation based on renewable resources. These partnership efforts between China and the World Bank led to the China Renewable Energy Development Project (REDP), which was approved by the World Bank on June 8, 1999. REDP was among the first instances of international assistance to China aimed at accelerating the commercialization of renewable power generation. REDP also marked the beginning of a long-term programmatic approach that the Bank has adopted to create the enabling environment, build capacity, mobilize resources and catalyze investments in the renewable energy sector in China.

The signing of the legal documents of the REDP was delayed by two years because the restructuring of China's power sector subsequent to appraisal created difficulties for reaching power purchase agreements. Since the original targets were no longer viable, the project was restructured by cancelling three wind farms under the wind power component. The restructuring was approved by the Board on an absence of objection basis. The legal documents were signed on June 26, 2001, and the project became effective on December 21, 2001, two and one half years after approval of the original project.

As a result of the restructuring, the wind power component of the project was reduced from 190 megawatts (MW) to 21 MW. The World Bank's financing was reduced from US\$100 million to US\$13 million, the Global Environment Facility grant from US\$35 million to US\$27 million, and the total project cost from US\$445 million to US\$205 million. The loan and grant were 99.5 percent disbursed. Due to considerably expanded local counterpart investments, the actual project cost was \$317.27 million. The project was completed on June 30, 2008, one year after the originally scheduled closing date.

The project development objective (PDO) was to establish sustainable markets for wind and photovoltaic (PV) energy technologies in order to: (a) supply electricity in an environmentally sustainable manner; and (b) increase access of isolated rural populations to electricity services. The global environment objectives (GEOs) were to: (a) reduce greenhouse gas emissions by producing electricity from renewable energy; (b) reduce costs of renewable energy to permit long-term financial sustainability; and (c) remove barriers to the large-scale commercialization of the technologies. The PDO and the GEOs were not revised in the legal agreements during project restructuring.

The **outcome** of the project is rated **satisfactory**, given substantial ratings for relevance, efficacy, and efficiency. The REDP was successful in promoting the rapid growth of a sustainable off-grid PV market in China. There were more than 400,000 PV systems sold under the project, exceeding the target of 350,000. More than 2 million people in isolated rural areas have been provided with access to PV-generated electricity thanks to the project. The project could have achieved even higher sales volumes had there not been any market inroads by highly subsidized government and donor PV projects.

The project was effective in removing barriers to the large-scale commercialization of PV technology. It helped reduce PV prices, improve quality, and establish a thriving network of suppliers, wholesalers, and retailers. The project also contributed to the development of national capacity in PV product specifications, testing, and certification.

The REDP supported the construction of two wind farms in Shanghai totaling 21 MW. The investment proved to be a major learning-by-doing activity for local utilities that built considerably greater capacity for wind farm design, procurement, construction management, and operations than originally expected. However, the project's direct contribution to the establishment of a sustainable wind market in China was modest, as could be expected from the substantially reduced scale of the project after restructuring.

Although the impact of wind energy development was limited, the project's **overall efficacy** is rated **substantial**, taking into consideration the substantial achievements on the PV market development, and the fact that the 88 percent of the total project costs were related to PV technology development. The project's **efficiency** is rated **high**. With the exception of the wind farm component, the REDP achieved very high financial and economic returns.

The **risk to development outcome** is rated **negligible to low**. The government continues to show strong commitment to the development of renewable energy, and a series of Bank follow-up projects has been developed to scale up the achievements of the project. The market is promising for larger household PV systems with more end-use applications, as well as for PV-based street lighting and grid-connected PV systems sponsored by the government.

The **Bank's performance** is rated **satisfactory**. Quality at entry was satisfactory. Although the project's scope was substantially reduced following a delay of two and a half years in signing the legal documents, the factors leading to the delay and restructuring of the project appear to have been out of the control of the project team. The quality of supervision was also satisfactory. The Bank team delivered high-quality advice and showed good judgment, persistence, and flexibility in resolving important issues during project implementation.

Borrower performance was **moderately satisfactory**. The government has shown strong support for renewable energy and rural electrification. However, during implementation it was weak in supporting the rationalization of the wind power tariff and in coordinating various agencies involved. The transparent and proactive performance of the implementing agencies contributed greatly to establishing the conditions that led to the success of this market development project.

The lessons emerging from the assessment are as follows:

- For interventions in rural PV markets, it is important to conduct a rigorous and extensive market study early in the preparation stage to provide information on market characteristics and barriers and to lay a solid foundation for effective project design.

- Linking subsidies to quality improvements can be effective in situations where consumer perception of and feedback on quality are limited.
- A technology-neutral and bottom-up approach that avoids prescribing designs and sizes can be critical in unleashing the creativity of businesses in developing products that meet local needs.
- Clear policies supporting development, access to the grid and mechanisms for cost recovery are critical preconditions for private sector-led renewable energy development.
- A market-based approach to PV dissemination requires a consistent and well-coordinated approach by all PV project supporters. Market-based approaches risk limited uptake if they compete with heavily subsidized approaches.

Vinod Thomas
Director-General
Evaluation

1. Introduction

Country and Sector Background

1.1 With rapid growth over the past few decades, China found itself in a dilemma between the country's soaring energy demand and accelerating air pollution driven by fossil fuel use. In recent years, China's electricity demand has grown on average at 12% per year. About three-quarters of the power generation is coal fired, the dirtiest form of energy use. China's heavy dependence on coal has taken a heavy toll on the environment and led to serious pollution-related human health issues. Sixteen Chinese cities are among the world's top 20 polluted cities (Stockholm Environment Institute 2002). The International Energy Agency (IEA) projects that China will overtake the United States as the world's largest carbon emitter before 2010 (IEA 2006).

1.2 In the 1970s and 1980s, China's energy development strategy was characterized as "walking on two legs": centralized large-scale projects and decentralized rural electrification. Renewable electricity—such as hydropower, biogas, fuel wood, and, to a lesser extent, solar and wind energy systems—were considered a decentralized solution to increase energy access in remote villages. During this period, with the exception of small hydro, the development of renewable energy (RE) remained, for the most part, in a research and pilot demonstration stage.

1.3 By the mid-1990s, with increased attention to the emission problems arising from burning coal, the government increased its commitment to RE development, as outlined in its New and Renewable Energy Development Program: 1996-2010 (World Bank Report No. 15592, 1996). The program, approved by the State Council in 1994, sought to improve the efficiency of RE technology, lower production costs, and enlarge the contribution of renewables in the total energy portfolio. It called for the creation of a modern industrial base and market infrastructure for mature RE technologies such as wind and solar power by 2000. RE programs launched since the mid-1990s also shifted emphasis from being centrally managed and supply driven to an approach based on commercializing proven technologies.

1.4 In recent years, China's RE, especially wind, experienced unprecedented growth. China had about 135 gigawatts (GW) of RE power capacity in 2006 (including large hydro), accounting for 17% of overall generation capacity and 22.18% of the overall power generated.¹ China has now become the world's third largest installer of wind turbines, with total grid-connected capacity of wind power reaching 5.89 GW.² China is also the world's third largest producer of solar PV modules, although most are exported to Europe and the United States.

1. SER 2006.

2. China Wind Association, 2008

The World Bank's Assistance

1.5 In 1995, the World Bank began collaborating with China to expand and accelerate the development of RE-based electricity as part of China's 10th Five-Year Plan (2001-06). To have a lasting impact on the fast-growing energy sector, the Bank's approach sought to create an enabling environment, build capacity, mobilize resources, and catalyze investments in both the power and end-use sectors. These efforts led directly to the China Renewable Energy Development Project (REDP), which at the time was the second largest RE project the World Bank had approved. REDP was also among the first instances of international assistance to China that aimed to accelerate RE development.

1.6 The project concept was based on a major Global Environment Facility (GEF)-financed study in 1994 (NEPA and others, 1994) and analytical and advisory assistance on China's environment in 1997 (Johnson and others, 1997). The Bank had undertaken a number of key studies of renewable energy in China, including "China: Renewable Energy for Electric Power" (World Bank Report No. 15592-CHA 1996) and "China: A Strategy for International Assistance for Accelerating Renewable Energy Development" (Taylor and Bogach, 1997). These studies identified the need for major investments and technical assistance efforts to support RE development in China and the priority areas for such assistance. Based on the studies, solar photovoltaic (PV) and grid-connected wind farms were identified as at or closest to commercial viability.

1.7 Since REDP, two additional RE programs have been approved and implemented. These are the first phase of the China Renewable Energy Scale-up Program (CRESP) and the follow-up of the Renewable Energy Scale-up Program. The dates and brief description of these programs are discussed in Annex B.

Other Donor Assistance

1.8 Many other multilateral and bilateral donor agencies, including the United Nations Development Program and the Asian Development Bank, have been and continue to be involved in supporting China's solar and wind energy development. The agencies, brief descriptions of the projects, and the amount of loans and grants provided by each are summarized in Annex C.

2. Project Objectives, Components, Implementation, and Financing Mechanisms

Objectives

2.1 The project appraisal document and Loan Agreement stated that the objective of REDP was to establish sustainable markets for wind and PV energy technologies in order to supply electricity in an environmentally sustainable manner and increase access of isolated rural populations to electricity services.

2.2 The objectives of the GEF cofinancing grant were to reduce greenhouse gas emissions by producing electricity from renewable energy; reduce costs of renewable energy to permit long-term financial sustainability; and remove barriers to the large-scale commercialization of the technologies.

Components

2.3 The project's original components are discussed below. The percentage of total project cost is in parentheses.

- **Wind farm component (47 percent of project costs) for on-grid electricity production.** The component consisted of an investment subcomponent (45 percent of project costs) to finance 190 megawatts (MW) of wind capacity at five sites: Huitingxile in Inner Mongolia (100 MW), Zhangbei in Hebei (50 MW), Pingtan in Fujian (20 MW), and Chongming Island and Nanhui (20 MW) in Shanghai. There was also an institutional strengthening subcomponent (2 percent) to overcome barriers to wind farm development and to promote private sector investment.
- **PV component (35 percent of project costs) for off-grid electrification.** The component had several elements:
 - a) Grants for 10 megawatts-peak (MWp)³ systems to households and institutions in Qinghai, Gansu, Inner Mongolia, Xinjiang, Tibet, and Sichuan. Subsidies of US\$1.50 per watt-peak (Wp) of PV capacity per system (with a capacity of 10 Wp or greater) would be provided to participating PV companies to improve PV product quality, warranties, and after-sale services, and to strengthen business capabilities and marketing efforts.
 - b) Market development to overcome barriers and develop PV markets through public information campaigns, capacity-building for PV companies, and so forth.
 - c) Institutional strengthening to improve product quality, certification and standards, and project management and monitoring.
- **Technology improvement (TI) component (20 percent of project costs) for wind and solar technology to improve quality and reduce costs.** The component consisted of:
 - a) Cost-shared grants were available to participating TI companies. A competitive grant facility was set up to improve quality or reduce costs of products. Grants for small and urgent cost-shared projects were provided through a quick response facility (QRF). A production investment fund provided commercial loans to companies to purchase production equipment, follow-up investment to grant-financed activities, or other investment activities.
 - b) Institutional strengthening to support program management, improve the staff capacity in manufacturing companies, and carry out special studies to facilitate project implementation.

3. A peak watt is a unit used to rate the performance of solar cells, modules, or arrays and is equivalent to the maximum nominal output of a photovoltaic device, in watts (W) under standardized test conditions, usually 1,000 watts per square meter of sunlight with other conditions, such as specific temperature.

2.4 The project was restructured between Board approval and the signing of the loan, grant and project agreements, as explained below, but the project development objective remained unchanged. The restructured project had the following components:

- **The wind farm component (12 percent of project costs)** was scaled down to include only the two wind farms in Shanghai totaling 21 MW and to provide technical assistance to support the management of the wind farms and preparatory work on large coastal sites.
- **PV component (76 percent of project costs)** remained unchanged.
- **TI component (12 percent of project costs).** The design of the investment subcomponent remained unchanged, but supported only PV manufacturers. The institutional strengthening subcomponent remained unchanged.

2.5 During implementation, the project also introduced two significant changes:

2.6 In June 2003, the Market Development Support Facility (MDSF) was introduced to provide cost-shared grants to participating PV companies to help them improve their commercial skills and develop markets. Companies were eligible to apply for up to US\$10,000 annually for business and market development in 2003 and 2004, and up to US\$20,000 annually for 2005 and 2006.

2.7 In May 2005, the project increased the number of target provinces to include Yunnan and Sha'anxi Provinces and Ningxia Autonomous Region. It increased the PV subsidies from US\$1.50/Wp for PV modules meeting the project standards to US\$2.0/Wp for modules meeting the higher performance requirement of the international standard and the new Chinese national standard.⁴ As of July 2007, only sales of systems with modules conforming to the higher standard were accepted.

Project Implementation

2.8 The project was approved on June 8, 1999. However, the signature of the legal documents was delayed until June 26, 2001, and the project only became effective two and a half years after the approval date on December 21, 2001. This was caused by several events that led to the restructuring of the project. First, the reform of China's power sector broke up large regional grids such as the North China Power Grid (NCPG) into provincial grids. The impact of high prices for wind power was greater on the smaller provincial grids than on NCPG, which would have been the original buyer of the wind power from Huitingxile and Zhangbei wind farms. Because the provincial grids were unwilling to share the incremental costs of wind power, no power purchase agreements were made. Uncertainties over the power purchase price also deterred local counterpart financing for the two wind farms. Second, the Chinese authorities raised concerns about the environmental impact of the Pingtan wind farm under new and more stringent regulations, which prohibited trees from being removed for any project development. In a letter to the World Bank Country Director on March 26, 2001, the

4. These are IEC 61215 and GB 9535-1998.

Ministry of Finance requested that the wind farms at Huitingxile, Zhangbei, and Pingtan be dropped from the project. Consequently, the project was restructured.

2.9 After project restructuring, the Shanghai Municipal Electric Power Corporation (SMEPC) became the implementing agency for the wind farm component. SMEPC formed a special purpose wind farm company, Shanghai Wind Power Company (SWPC) to carry out the investment. SWPC is owned by several entities: SMEPC, 35%; State Power Corporation of China, 33 percent; and Shanghai Power Investment Corporation, a subsidiary of SMEPC, 32 percent. The Ministry of Finance on-loaned the \$13 million Bank loan to SMEPC, which were then on-lent it to SWPC. The technical assistance and technical preparation work were implemented by SMEPC and were supported by local and international consultants.

2.10 The implementing agency for the PV and TI components was the State Economic and Trade Commission. A project management office (PMO) was established under the Commission to oversee project implementation. The Commission was abolished in 2003 and relevant departments were merged into the National Development and Reform Commission. This organizational restructuring partially contributed to the slow start of the PV component.

2.11 For the PV component, considerable capacity building supported by REDP had taken place during project preparation. In 1996, 17 PV companies with sales of solar home systems (SHS)⁵ were selected and received technical assistance in business development and internal controls before the start of the project.⁶ These companies joined REDP in December 2001. Nineteen more companies joined in two batches in 2003 and 2005.⁷

2.12 The closing date of REDP was extended for one year to June 30, 2008, to allow full achievement of the development objectives of the PV and TI components.

Financing

2.13 The project's total costs were estimated during appraisal at US\$444.2 million. The World Bank was only financing the wind power component of the project. After three wind farms were cancelled and the wind component was reduced from 190 MW to 21 MW, World Bank financing was reduced from US\$100 million to US\$13 million in

5. In areas where grid extensions were not feasible because of low population densities, long distances from the existing grid, and the rugged terrain, a stand-alone SHS often represents the least-cost option to supply of modern electricity. A SHS typically consists of a PV module, a rechargeable battery, a charge controller, wiring, fluorescent direct current lights, an inverter and outlets for other DC appliances (such as radio and TV). See a picture of an SHS in Annex B.

6. Several companies were spinoffs of Qinghai New Energy Research Institute in Xining. Companies based in Xining have led the rural market for PV over 1997-2007.

7. REDP PV participating companies are different from PV manufacturing companies, which are located in more developed areas. PV manufacturing companies produce PV modules and export 90% of the products to international markets. REDP companies sell SHSs in unelectrified rural markets. These companies purchased modules and batteries, made one or more of the other main components – controllers, lamps and in some cases inverters—and were engaged at some level in distribution and retailing.

June 2001. The total GEF grant was reduced from US\$35 million to US\$27 million and the estimated total project cost from \$445 million to \$205 million. Because of the substantially increased counterpart investment in the PV market, actual project costs amounted to US\$317.27 million, as shown in Table 1.

Table 1. Project Components, Sources of Financing, and Costs (US\$ millions)

COMPONENT	SUBCOMPONENT/ SOURCES OF FINANCING	APPRAISAL COST ESTIMATE	REVISED COST ESTIMATE	ACTUAL/LATEST COST ESTIMATE
Wind Farm	Investment	202.70	22.40	25.58
	Institutional strengthening	6.00	2.30	1.50
PV	Investment	145.00	145.00	91.60
	Market Development	7.00	7.00	3.34
	Institutional Strengthening	4.00	4.00	1.96
TI	Investment	78.00	23.40	190.00
	Institutional Strengthening	1.60	1.40	1.95
TOTALS	IBRD	100.00	13.00	12.94
	GEF	35.00	27.00	26.86
	Local	309.20	165.40	277.47
	Total	444.20	205.40	317.27

Source: Project appraisal document and ICR

Note: The numbers include taxes, duties, and physical and price contingencies. Local counterpart financing came from a combination of domestic banks, participating companies, and end users.

3. Monitoring and Evaluation

3.1 *Design.* The key performance indicators of REDP included: (a) avoided emissions from replaced thermal power generation; (b) installed wind and PV capacities; (c) increased wind power generation; (d) increased PV systems sold to households and institutions; (e) decreased capital cost of windfarms (US\$/kilowatt [kW]) and PV systems (\$/Wp), and number of qualified PV component suppliers. These indicators were defined at the country level rather than the project level; they reflect emission reduction, capacity expansion, and cost decline resulting from all RE programs in the nation (first three indicators). The first four indicators also included forecast data for 2009.

3.2 The causal chain in the design of the monitoring and evaluation (M&E) system was not clearly formulated. Given the large presence of other RE programs in China, the link between achievements at the country level and intervention of this project is not clear. Country-level and forecasting indicators are also too broad or inexplicit to be used to measure progress and achievements.

3.3 Disaggregated cost indicators would have been needed to verify the links between project inputs and the outcome for decreased capital costs. The cost of a PV system is largely determined by exogenous factors, including the world silicon price (which is around 56 percent of the PV module price), metal plumbum price for battery production (24 percent of the whole system price), and world demand for solar PV modules (52 percent of the whole system price) etc. The project's monitoring evaluation (M&E) did not provide adequate evidence of the connection between REDP and the reduction of cost and therefore was not able to convincingly demonstrate the logic of project design.

3.4 For TI, project M&E focused on the number of proposals selected for support and the number of approved TI grants. Less attention was given to whether TI activities have led to actual cost reductions or quality improvements.

3.5 **Implementation.** Although the weakness in the M&E design was not addressed during project implementation, the M&E on PV system price and quality and on PV companies' financial management was timely and rigorous. The PMO developed management information system software to cross-check company sales reports for completeness and internal consistency. It also contracted with consultants to regularly review the accounting systems and records of purchases, inventory, sales, and cash movements at company offices. The PMO also commissioned reviews on the cash sale model, MDSF and TI grants, and impacts in areas such as jobs, education, health, and quality of life. For the wind farm component, progress in construction of the wind farms and subsequent electricity production were monitored and reported regularly.

3.6 **Utilization.** The comprehensive and strict market monitoring administered by the PMO provided the incentive for companies to improve financial management and product quality and supported quality audits and transparent grant release. It also informed decision making, for example, on determining the best time to toughen quality requirements. The two wind farms themselves generated valuable data on the performance of the installed turbines; these data were used to inform the development of wind farms in the follow-up projects.

3.7 **The overall quality of project M&E is rated substantial.** That rating is based on a modest rating for design, and substantial ratings for implementation and utilization.

4. Relevance

4.1 **The project's objectives were and remain substantially relevant.** The stated objectives of the project were well embedded in both the government and the Country Assistance Strategies (1997-2005), which emphasize meeting infrastructure demand in an environmentally sustainable way.

4.2 REDP also addressed three of the four core goals of the Bank's 2001 Energy Business Renewable Strategy: help the poor directly through improved access; promote private sector development; and protect the environment. REDP also addressed the

government objectives of economic development in western provinces, where much of the renewable resources are located.

4.3 The project development objectives remain substantially relevant at the time of evaluation. It supports the current Bank Country Partnership Strategy (2006-10), one pillar of which is to manage resource scarcity and environmental constraints to the country's future growth. In addition, the project objectives are fully consistent with GEF's strategic objectives to reduce greenhouse gas emissions and mitigate climate change, and GEF's Operational Program 6 to support the promotion of RE by removing barriers and reducing implementation costs.

4.4 The project objectives were aligned with the country's mid- and long-term energy development policies. China has set a target of obtaining 10 percent of the country's primary energy from renewables by 2010 (expected 60 GW) and 15 percent by 2020 (totaling 120 GW, including 30GW of wind power and 1 GW of grid-tied PV). In the long term, China has set an objective of having 30 percent or more of its total energy requirements satisfied by renewable sources by 2050.

4.5 **The overall relevance of project design is rated substantial.** The subsidy instrument adopted by the project was innovative, so it effectively addressed some of the key barriers in the pre-REDP PV market. By design, a company was qualified for sales subsidies/grants, if the company (a) met REDP quality standards, (b) maintained sales and service outlets with trained staff and stocks of spare parts in the area, and (c) kept adequate sales and financial records and complied with the normal REDP verification requirements. Clearly, such performance- and output-based subsidies provided incentives and direct grants to companies to achieve economies of scale (by expanding output and extending sales and service networks), improve product and service quality, and strengthen their financial and business capabilities. The subsidies were partially passed onto consumers and partially retained by producers, thus spurring both demand and investment.

4.6 Furthermore, because the subsidy approach was technologically neutral (the grant is based on per Wp of capacity) without specific restrictions on system size or design, it encouraged innovation and allowed business decisions to be made in line with market demand.

4.7 The Market Development Support Facility grants under REDP gave companies flexibility to identify capacity weaknesses and improve business and market development. This bottom-up approach was different than the common practice in rural PV projects, which predetermined the capacity-building needs and offered standardized packages of training and promotion. Similarly, the cost-shared grants under the TI component provided broad scope for the entire PV sector to explore TI opportunities. The cost-shared scheme also leveraged additional private investments, as the companies typically self-financed 50-60 percent of the incremental costs of MDSF activities and 70% of the TI costs.

4.8 Notwithstanding the project's innovative design, there were some shortcomings:

- a. At the time of project preparation, there was no consistent national policy to support the development of RE by spreading the incremental costs broadly across regional grids. The project underestimated the institutional and policy barriers that led to the restructuring of the project and originally set overambitious targets which were revised before loan signing. Although the delays and subsequent cancellation of the wind farms were largely out of the Bank's control, in retrospect, the project could have made a larger contribution by focusing on a longer-term policy-oriented approach. Ultimately, a conducive policy environment is a key precondition for commercializing RE development.

It is commendable that this shortcoming was recognized early and addressed during REDP restructuring. A policy-oriented approach was immediately built into the design of the follow-up project (CRESP) during its preparation in 2000. CRESP is a 10-year program aimed at supporting the implementation of a national policy framework for RE to address market barriers that hinder large-scale commercial energy markets in China.

- b. The project did not develop financing mechanisms for rural consumers and private companies.⁸ Until now, retail SHS sales in China have been primarily cash based. The absence of consumer financing prohibited program benefits from reaching the poorer segment of the community and the non-herder's market and constrained the increase in the size of the systems.⁹ Private PV projects also had difficulties in obtaining bank credits, which may have limited sales growth.
- c. No mechanism was built into the TI component to ensure information sharing. If the knowledge produced by firms is exclusive and competitive, subsidies are not justified.¹⁰ Otherwise, to stimulate a socially optimal level of TI, knowledge spillover methods should be incorporated in the project design.
- d. The project focused on a supply-side approach to improve product quality. Less attention was given to consumer education to drive demand for quality.
- e. Functions of the subcomponents are somewhat overlapping. As reported by the Implementation Completion Report (ICR), the parallel QRF facility ended up funding similar projects to the competitive grant facility. And it may have been more effective to eliminate QRF to release scarce PMO resources for other aspects of the components.

8. Due to time pressures for project completion, consumer finance pilots and a partial credit guarantee facility were developed but not implemented.

9. PV systems were primarily sold to herders, who can sell yaks to get extra cash. Yaks are worth about \$1,000 each. Thus, herders can fund a SHS without a loan.

10. Chinese firms are inclined to focus on expanding production capacity; technology innovation typically takes a lower priority. In that sense, the TI grants provide some necessary incentives to improve technology.

5. Efficacy

5.1 The efficacy of the project is assessed against the achievement the project development objectives as outlined in paragraph 2.1. The attainment of the global environment objectives outlined in para 2.2 is also discussed, though not included in the efficacy rating. The objectives related to PV market development and provision of increased access of isolated rural populations to electricity services were substantially achieved. The objective of establishing sustainable markets for wind energy was modestly achieved. Taking into account that 88 percent of the project costs correspond to PV development and the related increase in access, **overall efficacy** is rated **substantial**.

5.2 The achievements and issues of REDP are discussed in detail objective by objective. Since removal of barriers to PV and wind energy technology markets was an essential intermediate outcome and hence ingredient to establishing sustainable markets for these technologies, the discussion of the achievement of the first two GEOs is subsumed under the discussion of the related project development objectives. Three additional GEOs are discussed at the end of the efficacy section. The overall efficacy rating is based on achievement of project development objectives only.

Establishing sustainable markets for PV energy technologies.

Rating: Substantial

5.3 At appraisal three key barriers to the establishment of sustainable markets for PV energy technologies were identified and the project effectively helped overcome these, thus contributing to the rapid growth of China's PV manufacturing sector as discussed below.

PV Barrier 1: Small-scale and relatively inexperienced companies

5.4 The combination of financial mechanisms, capacity building, and strict monitoring and internal controls helped small companies in the rural SHS market expand output, deepen distribution networks, and improve financial practices. There is currently a well-established sector of companies operating in the production, integration, and distribution of PV systems in the target market areas, as shown below.

5.5 Verified sales of PV systems under REDP have dramatically increased to more than 11 MWp, compared with the target of 10MWp. Figure 2 shows the year-by-year verified and reported sales. The average size of PV systems has also increased steadily, from 18 Wp in 2002 to 45 Wp in 2007 as shown in Figure 3.

5.6 To be noted, sales increased sharply from 2002 to 2005, but declined in 2006 and 2007. According to project documents and interviews with PV companies, the decline was partially caused by market inroads by highly subsidized government and donor PV projects.¹¹ The competitiveness of commercial SHS had been lowered by these

11. Silk Road Brightness Project under a Shell-Netherlands government program in Xinjiang.

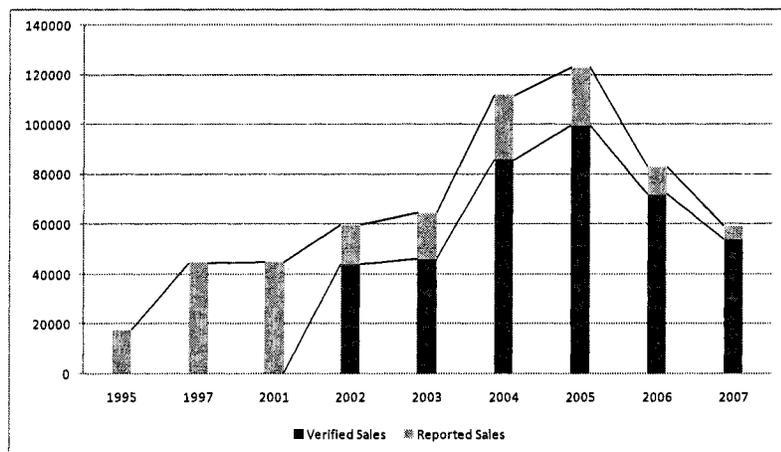
government- or donor-funded programs, which supplied SHS with 90-100 percent subsidies, effectively crowding out commercial sales. Highly subsidized systems can undermine the development of local ownership and undercut market-based projects. This highlighted that it is important to have proper coordination with parallel solar PV programs to avoid potential overlaps and conflicts; project arrangements should actively promote the adoption of a sustainable, market-based approach in government- and donor-supported PV projects.

5.7 For the 17 REDP-supported SHS companies whose data are available, employees more than doubled from an estimated 378 in 2002 to 843 in 2007, and the outlets increased from 266 to 721 during the same period of time. The rural sales revenue expanded 363 percent, from RMB 48.7 million yuan in 2002 to RMB 225.1 million yuan in 2007.

5.8 The PV companies also upgraded their financial management during REDP. Companies computerized their accounting systems and introduced standardized documentation and controls to comply with the eligibility requirements of REDP. The steadily rising rate at which the companies' report of sales was verified by the PMO is an indication of the improvement (Figure 2).

5.9 REDP also helped the start-up of some PV manufacturing companies by providing financial resources under the TI component. With lack of access to credits, small and new companies view the TI component as crucial for conducting R&D. Some of the beneficiaries of the TI grant have become major players in the international market and are listed on stock exchanges in Europe and the United States.

Figure 1. Annual Sale of PV Units



Sources: PMO data, March 2008.

Note: The data do not include sales, which were not eligible for REDP sales grants.

PV Barrier 2: Poor-quality products and service

5.10 REDP used the “carrots and sticks” principle to motivate companies to improve product and service quality. Companies that met REDP standards were eligible for subsidies; companies whose product quality fell short of standards were subject to

financial penalties. Tests were conducted on products sampled at outlets and warehouses to ensure compliance. By the end of the project, all but two PV participating companies become ISO-9001 certified for quality management.¹²

5.11 The project also introduced steadily higher technical specifications and strengthened domestic capacity in testing and certification. REDP also led to the establishment of a quality seal—Golden Sun—which has been recognized by the government and World Bank financed-PV projects. However, the Golden Sun mark is still mostly unknown among rural consumers.

5.12 The PMO maintained lists of the suppliers of certified components – panels, batteries, lights and controllers. By requiring PV companies to use only certified components, REDP also motivated PV manufacturing companies to improve quality. In the end, there were 74 component suppliers that were certified as meeting the REDP standards, compared to the original target of 30.

5.13 The IEG mission was informed that before REDP, low-performing products damaged the reputation of both PV products in the domestic market and Chinese brands in the international market. By improving product quality, REDP provided critical help for China to become an international manufacturing center for PV modules.

PV Barrier 3: High cost/lack of mechanism to increase affordability

5.14 The retail *prices* as quoted by the solar companies showed significant reduction between 2002 and 2004; there was a slight increase in the following years largely caused by shortage of PV modules in the international market. Overall, after adjusting for inflation, the average market prices of all PV systems declined by the end of REDP. Table 2 summarizes the average prices of different PV systems.

Table 2. Average Prices of PV Systems (RMB yuan) (2002 real price)

	<i>Inflation Rate</i>	<i>10 Wp</i>	<i>18 Wp</i>	<i>20 Wp</i>	<i>40 Wp</i>	<i>50Wp</i>
2002		572.5	1,065	1,175	2,550	3,500
2003	0.012	529	963	1,038	2,421	3,211
2004	0.04	444	906	803	1,653	2,216
2005	0.018	516	833	988	1,565	2,364
2006 first half	0.015	521	854	1,001	1,514	2,401
2006 second half		531	868	1,016	1,526	2,522
2007	0.032	566	838	1,050	1,659	2,652

Source: PMO 2008.

Note: Inflation rates are based on PMO report, economic and financial analysis of PV component.

12. ISO-9001 certification is awarded to firms that have put in place the systems, procedures, and record keeping to ensure consistently high-quality products and services and customer satisfaction. ISO-9001 certification is a standard quality assurance requirement of international supply chain management.

5.15 REDP contributed to PV system price reduction in three ways: output-based subsidies were directly transferred to consumers, the profit margins were kept low as REDP helped the market remain competitive, and the price was reduced in parallel with cost reduction. (see paragraph 5.4).

5.16 However, the project did not overcome one important barrier identified at project appraisal: the lack of financing mechanism to improve system affordability. REDP sales were concentrated in Tibet, Qinghai, Sichuan, and Xinjiang and were relatively weak in the other six provinces. The IEG mission was informed that partly because of the absence of consumer financing, it was difficult for PV companies to penetrate into a non-herders market, where consumers typically cannot afford the high upfront costs of the system.

5.17 In summary, REDP contributed to the rapid growth of the Chinese off-grid PV market. The project was effective in reducing prices, improving quality, and supporting the development of a marketing and distribution network for the sustainable development of the technology, thus substantially meeting the first development objective, as well as the related global environment objective or removing barriers to large-scale commercialization of PV technology.

Establish sustainable markets for wind energy technology

Rating: Modest

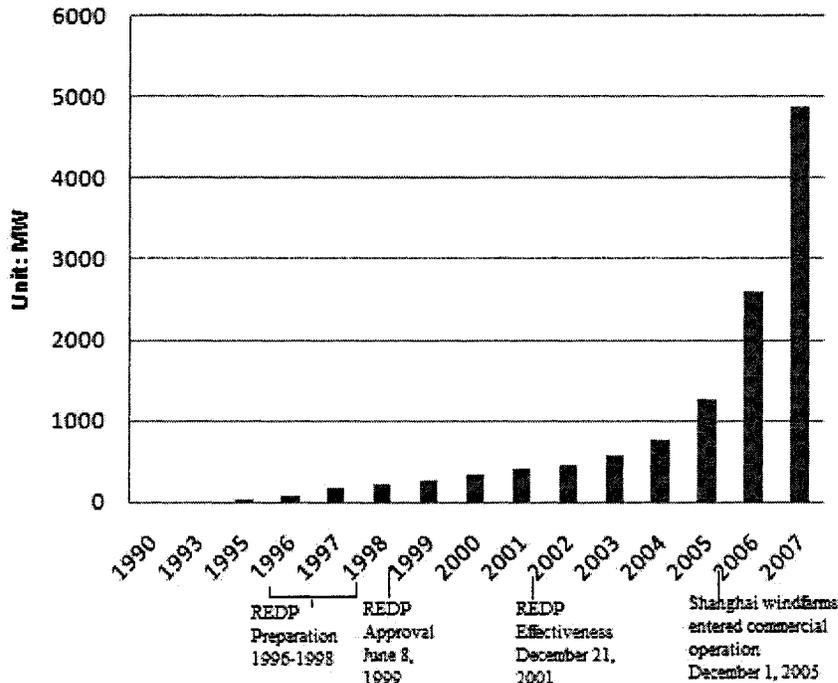
5.18 At appraisal, four barriers were identified in the pre-REDP wind market that needed to be overcome to establish sustainable markets for wind energy technology. As could be expected from the substantially reduced scale of the wind component, the project's impact on removing these barriers and hence establishing a sustainable market for wind energy technology was mostly at the local level. However, REDP had achieved an unintended impact on the creation of a regulatory framework for the development of RE in China.

Wind Barrier 1: Higher generation costs than coal-fired thermal power plants

5.19 REDP's support for scaling up investments as a way to reduce wind power costs no longer appears to be essential, because China's wind power capacity, including in less-developed provinces, has been growing at more than 100% per year in each of the last three years. Figure 4 indicates the development of wind power in China in comparison with the timeline of REDP wind component.

5.20 REDP also intended to lower wind farm costs by introducing international competitive bidding. However, as discussed in paragraph 5.3, there was no net change in installed cost at the end of the project.

Figure 2. Cumulative Installed Wind Capacity in China and the Timeline of REDP



Wind Barrier 2: Lack of a legal framework for wind farm projects

5.21 REDP had a major, albeit unintended, impact on establishing a regulatory framework for RE in China. The difficulties encountered in establishing the power purchase arrangements of the wind farms to be supported by the projects highlighted the need for a stable pricing framework and a basis for the subsidization of wind power. The follow-up Bank projects contributed to the design and development of a new regulatory framework. These included a range of studies, workshops, and study tours, most actively during the extended CRESPP preparation activities from 2000-07. Bank-supported studies analyzed the pros and cons of different policy options. IEG mission was informed that Project staff involved in preparation of REDP also strongly advocated for a mandated market share policy during the drafting of China's Renewable Energy Law.

5.22 The Renewable Energy Law, which became effective January 1, 2006, provided an overarching framework for the development of renewable energy in China. One of its key provisions required power utilities to produce a share of the electricity from renewable sources or to purchase power from RE generators at a government-determined price. The law also stipulated a national cost-sharing mechanism whereby consumers must pay for the extra (incremental) costs of renewable power. And the law establishes fixed premium prices (feed-in tariffs) and pricing mechanisms for wind power and biomass.

Wind Barrier 3: Lack of institutional capacity

5.23 The project improved the technical, financial and legal capacity of local utilities (SMEPC and SWPC) to initiate or participate in wind project development. SWPC pointed out that through REDP, the company obtained ample experience in wind turbine operating and maintenance, and procedures and methods for public bidding.

5.24 The experience from the Shanghai wind farms also informed the developer, Long Yuan Company and made the implementation of the CRESF-funded Pingtan wind farm (from 2004-07) easier. The Pingtan wind farm had been successfully completed and had produced 11% more energy than planned in 2008.

Wind Barrier 4: Inadequate information on wind resources, site characteristics, and equipment performance

5.25 The project generated valuable data on the performance of installed wind turbines. Through REDP, local utilities learned about constructing foundations in soft soils and conducting wind resource measurement. That knowledge contributed directly to the adoption of 310-MW government wind project in Shanghai.

5.26 Overall, REDP effectively helped establish a sustainable market for wind energy technology in Shanghai. However, it fell short of meeting its intended impact at the national level.

Increasing access of isolated populations to electricity services

Rating: Substantial

5.27 REDP exceeded its targets of increasing access to modern energy through distribution of SHSs. There were more than 400,000 SHS systems sold under the project, exceeding the targets of 350,000. More than 2 million people in isolated rural areas in western China have received electricity service through the project. The REDP has also supported PV village systems (and a few with wind and PV) to provide electricity for public facilities such as schools and health centers and for village satellite telephones, and Buddhist temples.

5.28 At the sector level, REDP played a key role in the momentum in China's solar energy industry. It increased awareness of PV technology among government and energy company officials and contributed to the increased deployment of PV systems in government rural programs. The government now has a target of 300 MWp for rural PV systems (including both off-grid home systems and local PV grids) by 2020. The major PV-based rural electrification programs are summarized in Annex C.

Alleviating poverty

5.29 Although REDP did not explicitly spell out a poverty alleviation objective, by providing electricity services to rural areas, it did promote local economic development

and improve living conditions for households without electricity. This was supported by an end-user survey covering 1,203 households in 6 villages in 2007.¹³ The survey reported that 95 percent of SHS users claimed that the system increased their incomes; 15 percent claimed that the increase was significant. In addition, about 1,500 permanent and 3,000 temporary jobs have been created in the participating companies as a result of this program.

Global Environment Objective: Reducing greenhouse gas emissions by producing electricity from renewable energy

5.30 The weakness in the design of project's M&E makes assessment of the emissions reduction objective difficult, because emission baseline values were not provided, and there were no outcome target indicators to directly measure CO₂ emissions resulting from the project.

5.31 The avoided CO₂ emission from Shanghai wind farms was estimated to be 33,700 tons per year. For the PV component, it was estimated that for a 20-Wp system, 550 kilograms of CO₂ are avoided, assuming 15 years of system lifetime. The calculation was based on kerosene usage surveys conducted in four counties in Gansu and Tibet in 2007. Results from the survey may not represent the actual project benefits because (a) kerosene use in other target provinces was much higher than in Gansu and Tibet; (b) emissions from candles, ghee lamps, and the substituted production of dry cells were ignored because of a lack of reliable data; and (c) the calculation did not take into account the carbon cost of manufacturing PV systems. In sum, this global development objective was only modestly achieved.

Global Environment Objective: Reducing costs of renewable energy to permit long-term financial sustainability

5.32 The project aimed at lower wind farm costs in China by allowing international competitive bidding and large-scale development. During 2002-03, wind turbine costs in China went down dramatically to about US\$860/kW, as compared to US\$1,300/kW at the start of the project. However, wind turbine costs climbed up again by the end of the project, mainly because of foreign exchange rate change and the rapid growth in installed wind power worldwide which created shortages of wind turbines and pushed up wind turbine prices. Installed cost of the Shanghai wind farm was \$1,264/kW.

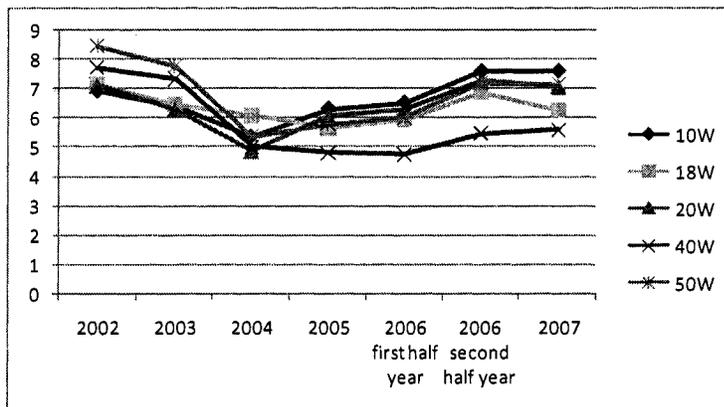
5.33 The PV system costs started at about US\$16/Wp and had fallen to US\$9/Wp by the end of the project, well below the target of \$11/Wp. However, no detailed indicators were developed to measure how much of the cost reduction was attributable to REDP, and how much was related to exogenous factors such as worldwide price reduction of silicon feedstock. Note that when insufficient information is provided by the Bank for IEG to arrive at a clear rating, IEG will downgrade the relevant ratings as warranted. Nonetheless, the IEG mission identified at least two mechanisms through which the project invention contributed to cost decline.

13. PMO, 2007 Solar Home System End User Investigation Report.

- a) One PV company reported that by improving internal management and quality control, product failure rate was decreased; this resulted in cost reduction.
- b) REDP helped the SHS market remain competitive if not become more competitive. The gross margins including sales subsidies were estimated to be as low as around 13 percent in 2007.¹⁴ By comparison, the margins were about 50% in the Philippine SHS market and 100 percent in Sri Lanka.¹⁵ There was evidence linking competition with increased efficiency and reduced cost.

As shown in Figure 1, the unit *price* of larger systems came down more dramatically than smaller systems. Research commissioned by the PMO¹⁶ found that solar modules of different capacities (10W, 18W, 25W, 40W, and 50W) had the same unit prices (yuan/Wp) if they were produced by the same manufacturer. Therefore, the difference in price trends among different systems may be explained by the increased competition for larger SHSs: as larger systems gained popularity among users, more efficient suppliers were attracted to produce bigger systems¹⁷, which led to increased competition and reduced cost.

Figure 3. Unit Wp Price of PV Systems (US\$/Wp)



Source: PMO, market price research on China SHSs. March 2008.

Note: Inflation rates are based on PMO report, economic and financial analysis of PV component.

5.34 Cost of SHSs may also have come down because of increased economy of scale (paragraph 5.9) and the support from TI grants, which have the objective of lowering cost and improving quality (if necessary) of PV systems or hybrid PV wind systems. More detailed cost indicators could have helped confirm the impacts.

11. Finucane 2008.

12. World Bank project documents.

16. PMO, market price research on China SHSs. March 2008.

17. Supported by PMO, Table 26.

6. Efficiency

6.1 With the exception of the wind farm component, which accounted for just 12 percent of project costs, the project delivered high financial and economic rates of return. **The overall project efficiency is therefore rated high.**

6.2 According to the ICR, the economic rate of return for wind farm investments exceeded the appraisal estimate. This was the result of a larger estimated willingness to pay. The consumer willingness to pay is assumed to be the wind power purchase price plus a premium of RMB 0.253/kWh that was actually paid by environmentally conscious consumers under a “green” electricity program. One concern is that the green tariff may already have reflected consumer willingness to pay to avoid greenhouse gas emissions. If this is the case, the economic rate of return (ERR) calculation for the wind component is overestimated through double-counting.

6.3 The wind farms had a poor financial rate of return (FRR) because of low capacity utilization (around 20 percent). The poor wind resources in Shanghai presented a formidable barrier to improving the wind farm performance.

Table 3. Economic and Financial Rates of Return – Wind Farm

	<i>Appraisal</i>	<i>Completion</i>
ERR with local environmental externalities	7.6	12.9
ERR with local and global environmental externalities	8.4	15.2
ERR without environmental externalities	5.0	0.7
FRR	NA	9.5

6.4 According to the ICR, the PV and TI components jointly delivered exceptionally high ERR. At the PV subproject level, the ERR for PV market development including CO₂ emissions reduction benefits and considering consumer willingness to pay was estimated to be 93.4 percent. The FRR was 88 percent.

6.5 As shown in Table 5, the economic returns of REDP are much higher than comparable ERRs of similar projects in other countries. This is mainly attributable to the apparently lower costs of Chinese PV systems, relative to those produced outside China.

**Table 4. ERR of World Bank Solar PV Projects
(Without GEF Subsidy)**

Project	ERR based on consumer willingness to pay (%)
China REDP	93.4
Indonesia	30.6
Sri Lanka Energy Services Delivery	31
Philippines Rural Energy Project	32-47 (20-Wp-75-Wp systems)
Bolivia Renewable Energy Project	27-40

Sources: World Bank project documents.

6.6 For economic analysis, the project carried out a detailed energy survey covering 1,203 households in four counties. The study then estimated a log linear demand curve of a representative household (a weighted average across five different income groups) based on its energy demand for different lighting sources before and after the project. The change in consumer willingness to pay is measured by the change in consumer surplus corresponding to lumen consumption from kerosene and from a compact fluorescent lamp. The project effort should be commended since few Bank projects attempt an analysis of consumer surplus change as rigorous as this one.

6.7 Nonetheless, the economic analysis was potentially biased in several ways discussed below.

- a. This analysis seems to attribute REDP-subsidized PV system adoption to REDP. But households were already adopting PV systems before REDP and would have continued to do so even in REDP's absence. REDP seems to have brought about a reduction in the relative price of 40-W and 50-W systems and thus may have pushed some people from a 20-W system to a 40-W system. Improvements in quality may have tipped the balance from kerosene for others. But if the increased solar system sales relative to a counterfactual are smaller than those from comparing before-and-after adoption, then the gains would be overestimated.
- b. The study estimated the project welfare gains as the change in consumer surplus by moving from total kerosene consumption to total reliance on a 20-W compact fluorescent lamp. However, as the survey indicated, consumers used a mix of lighting sources both before and after electrification, including kerosene, ghee, and candles. Therefore, the welfare change is not a straightforward comparison between kerosene and SHS.
- c. The current survey was conducted in Tibet and Gansu provinces. Among the targeted six provinces, the two rank the lowest in terms of per capita income. There is also large heterogeneity in lifestyle and energy supply conditions across the regions. Hence, results from the survey may not represent the conditions of the whole project. The survey could have covered a larger geographical area with a wider variety of fuel consumption patterns, incomes, and system sizes and prices.

- d. Household incomes are not static. In some cases, electrification directly contributed to the growth of income. As income increases over time, households are willing to pay more for their lumens at all levels of consumption. Therefore, a demand curve based on a one-time survey may not capture the entire benefit gains.
- e. The study spreads total TI costs over all verified sales and takes the average number as an incremental cost for each system sold. Such an approach may be misleading because TI funds were disbursed over many years. The stream of costs should be discounted to express them in present-value terms.

6.8 In Annex F, a demand curve for lighting is re-estimated based on consumption for lumens from two observable bundles of fuel used before and after a SHS. The welfare gain based on the “bundle” approach is larger than the ICR estimate. And the corresponding ERR from the consumers’ perspective is 115 percent versus the ICR estimate of 35 percent. Some of the fuels (ghee and candles) that were substituted by a SHS may have been omitted under the simplified ICR assumption that a consumer switched from total kerosene use to total reliance on a SHS.

7. Outcome

7.1 **The project outcome rating is satisfactory**, based on project subratings of substantial for relevance, efficacy, and high for efficiency (taking into account the much greater weight in project costs of the PV and TI components), as summarized in Table 6 below.

Table 5. Project Outcome Based on the Achievement of Project Objectives

OBJECTIVES	RELEVANCE	EFFICACY	EFFICIENCY	OUTCOME
Establish sustainable markets for wind energy technology		Modest		
Establish sustainable markets for PV energy technology		Substantial		
Increase access of isolated rural populations to electricity services		Substantial		
Overall Rating	Substantial	Substantial	High	Satisfactory

8. Risk to Development Outcome

8.1 **REDP’s risk to development outcome is rated negligible to low**. The market is promising for larger household PV systems with more end-use applications,¹⁸ and also in the government-sponsored contract market for street lighting and grid-connected PV

18. The market for small SHS systems is now largely saturated in many areas, notably much of Qinghai.

systems. Given the continued government commitment to developing RE, the contract market is likely to grow in strength. In fact, by 2007 all members of the leading group of 18 SHS companies were engaged to some extent in contracting, with contracting sales accounting for almost half of the sales on average.

8.2 The REDP SHS companies also began to make sales in export markets. At least two of the companies have made contract exports for an estimated US\$2.0-3.0 million over 2006-07, including for World Bank-supported projects in Lao PDR, Mongolia, and Papua New Guinea. By the companies' estimates, exports have reached an average of 7 percent of sales.

8.3 Regarding the wind component, at the policy level, the government has shown strong commitment to the development of wind energy. The 2006 Renewable Energy Law was enacted specifically to address the institutional and policy barriers that led to the restructuring of REDP. At the project level, the satisfactory technical and financial capacity of SWTP ensures that the wind farms will continue being maintained and operated in a safe and efficient way.

8.4 In addition, a series of Bank follow-up projects, including CRESF and the follow-up to CRESF, has been developed to scale up grid-connected wind power, including the development of Huitingxile and Pingtan wind farms from the original REDP.

8.5 At the same time, there is some concern about the future growth of the PV market. Profit margins of the rural market have remained too low because competition was based too much on price rather than a price: quality ratio. Without the subsidies, the average net revenue on sales for the PV companies was less than 1 percent, and seven of the 18 companies would be operating at a loss in 2007.¹⁹ Given such a low profit margin, companies may find it challenging to improve or even maintain product quality, especially after the completion of REDP. In fact, high-tech companies in other developed regions have reportedly been unwilling to introduce improved but more expensive products to the rural market because the price competition in rural market is too intense.²⁰

9. Bank Performance

9.1 **Quality at entry was satisfactory.** The Bank team conducted a rigorous and holistic market study early in the preparation stage. The study identified pre-existing barriers in the PV market and provided information on potential market size and characteristics. It proved to be important for the Bank team in adopting effective instruments to achieve the project development objective and global environment objectives. The project used novel designs and techniques, particularly in its emphasis on market-driven approach. Considerable capacity building for PV companies during project preparation prepared future development of the market.

19. Finucane 2008.

20. Ter Horst 2008.

9.2 Although the scale of the project was substantially reduced after a two and one-half year postponement in the signing of the legal documents, factors leading to the delay and restructuring of the project appear to have been out of the control of the project team. A wind tariff covenant that would allow cost recovery was agreed upon at project appraisal and included in the Project Agreement. Therefore, risks related to power tariffs were to be mitigated by a covenanted action on the part of the Borrower should tariff disagreements arise.

9.3 **Quality of supervision was satisfactory.** In linking REDP with international PV expertise and best practices for PV market development projects, the Bank team ensured that REDP benefited significantly from international as well as Chinese knowledge and experience. The core team remained the same throughout the project design, appraisal, and implementation period, facilitating consistency of dialogue. The Bank has also shown good judgment, persistence, and flexibility in resolving important issues raised during project implementation. For example, after the delay in securing power purchase agreements, the Bank team effectively adjusted the design of REDP and the follow-up projects to continue to achieve the main development objective and global environmental benefits. After discovering that the use of SWPC's expertise to integrate the wind farms was not in line with wind industry practice, the Bank team successfully convinced the implementing agency to adopt the single responsibility procurement approach. Finally, the Bank team changed the verification method of PV sales that was adopted originally at appraisal after realizing its inappropriateness to the semi-nomadic local market.

9.4 **The overall Bank performance is rated satisfactory** given satisfactory ratings for quality at entry and quality of supervision.

10. Borrower Performance

10.1 **The government performance is rated moderately satisfactory.** Project records show that, in the face of difficulties of reaching power purchase agreements subsequent to the restructuring of China's power sector, the government was weak in supporting the rationalization of the wind power tariff and in coordinating various agencies involved to address the challenge. The inability to finalize power purchase agreements led to the cancellation of three wind farms in the original project design. The unsatisfactory performance on wind power was tempered by the government's strong support for RE and rural electrification. The Renewable Energy Law ensured a sustainable commercialization of RE based on cost-recovery principles and on ensuring greater access for the poor. The opportunities presented by the government policy in the western rural market encouraged the entry of many new companies during 2004-06.

10.2 **The implementing agency performance is rated satisfactory.** During the early stages of project implementation, the PMO effectively explained to stakeholders the project design and their role in it and mobilized their interest and cooperation. PMO staff also undertook frequent field visits and other monitoring responsibilities to verify physical progress. They managed to finalize a large number of contracts for subprojects scattered in mountainous rural areas with difficult access. PV companies interviewed

considered the dedicated support from the PMO as being crucial to the project success and have expressed their appreciation.

10.3 Overall, borrower performance covering government and implementation agency performance is **moderately satisfactory** in line with the harmonized evaluation criteria calling for a moderately satisfactory rating when either government or implementing agency rating or both are moderately satisfactory.

11. Lessons

11.1 The lessons emerging from the assessment are as follows:

- For interventions in rural PV markets, it is important to conduct a rigorous and extensive market study early in the preparation stage to provide information on market characteristics and barriers and to lay a solid foundation for effective project design.
- Linking subsidies to quality improvements can be effective in situations where consumer perception of and feedback on quality are limited.
- A technology-neutral and bottom-up approach that avoids prescribing designs and sizes can be critical in unleashing the creativity of businesses in developing products that meet local needs.
- Clear policies supporting development, access to the grid, and mechanisms for cost recovery are critical preconditions for private sector-led renewable energy development.
- A market-based approach to PV dissemination requires a consistent and well-coordinated approach by all PV project supporters. Market-based approaches risk limited uptake if they compete with heavily subsidized approaches.

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Annex A. Basic Data Sheet

China Renewable Energy Development Project
(IBRD-44880; TF-22642)

Key Project Data (US\$ million)

	<i>Appraisal estimate</i>	<i>Actual or current estimate</i>	<i>Actual as % of appraisal estimate</i>
Total project costs	444.20	317.27	71.4
Loan amount	100.00	12.94	12.9
Cofinancing	35.00	27.00	77.1
Cancellation	--	87.06*	--

* Cancelled amounts are in terms of loan amount at appraisal.

Cumulative and Actual Disbursements (US\$ million)

	<i>FY02</i>	<i>FY03</i>	<i>FY04</i>	<i>FY05</i>	<i>FY06</i>	<i>FY07</i>	<i>FY08</i>	<i>FY09</i>
Loan 44880								
Actual	0.13	0	0	10/25	0	2.56	0	0
Cumulative	0.13	0.13	0.13	10.38	10.38	12.94	12.94	12.94
Grant 22642								
Actual	0	2.08	1.84	4.15	4.71	7.08	7.08	-0.80
Cumulative	0	2.08	3.91	8.07	12.77	19.86	26.94	26.86

Project Dates

	<i>Original</i>	<i>Actual</i>
Concept Review for Loan, 44880	--	04/02/1998
Concept Review for Grant, 22642	--	01/30/1998
Appraisal for Loan, 44880	--	06/28/1998
Appraisal for Grant, 22642	--	10/15/1998
Board approval	--	06/08/1999
Signing	N/A	06/26/2001
Loan Effectiveness	N/A	12/12/2001
Closing date	06/30/2007	06/30/2008

Staff Inputs (staff weeks)

Stage of Project Cycle	Staff Time and Cost (Bank Budget Only)	
	Number of Staff Weeks	US\$ ('000)
Lending		
FY95	1	8
FY96	8	45
FY97	14	100
FY98	39	374
FY99	34	326
FY00	3	15
FY01	0	5
Total:	99	186.10
Supervision/ICR		
FY00	29	182
FY01	27	172
FY02	19	122
FY03	12	78
FY04	17	131
FY05	20	111
FY06	12	95
FY07	8	67
FY08	16	95
Total:	160	1,053

Mission Data

Ratings of Project Performance in Implementation Status and Results (ISRs)

No	Date ISR Archived	Performance rating: Development Objective	Performance rating: Global Environment Objective	Performance rating: Implementation Progress
1	07/02/1999	Satisfactory	Satisfactory	Satisfactory
2	12/28/1999	Satisfactory	Satisfactory	Satisfactory
3	06/15/2000	Satisfactory	Satisfactory	Satisfactory
4	12/27/2000	Unsatisfactory	Unsatisfactory	Unsatisfactory
5	06/26/2001	Satisfactory	Satisfactory	Satisfactory
6	10/09/2001	Unsatisfactory	Unsatisfactory	Unsatisfactory
7	12/21/2001	Satisfactory	Satisfactory	Satisfactory
8	06/06/2002	Satisfactory	Satisfactory	Satisfactory
9	12/23/2002	Satisfactory	Satisfactory	Satisfactory
10	06/13/2003	Satisfactory	Satisfactory	Satisfactory
11	11/07/2003	Satisfactory	Satisfactory	Satisfactory
12	06/19/2004	Satisfactory	Satisfactory	Satisfactory
13	12/29/2004	Satisfactory	Satisfactory	Satisfactory
14	05/07/2005	Satisfactory	Satisfactory	Satisfactory
15	05/05/2006	Satisfactory	Satisfactory	Satisfactory
16	12/18/2006	Satisfactory	Satisfactory	Satisfactory
17	05/02/2007	Satisfactory	Satisfactory	Satisfactory
18	06/25/2007	Satisfactory	Satisfactory	Satisfactory
19	12/17/2007	Satisfactory	Satisfactory	Satisfactory

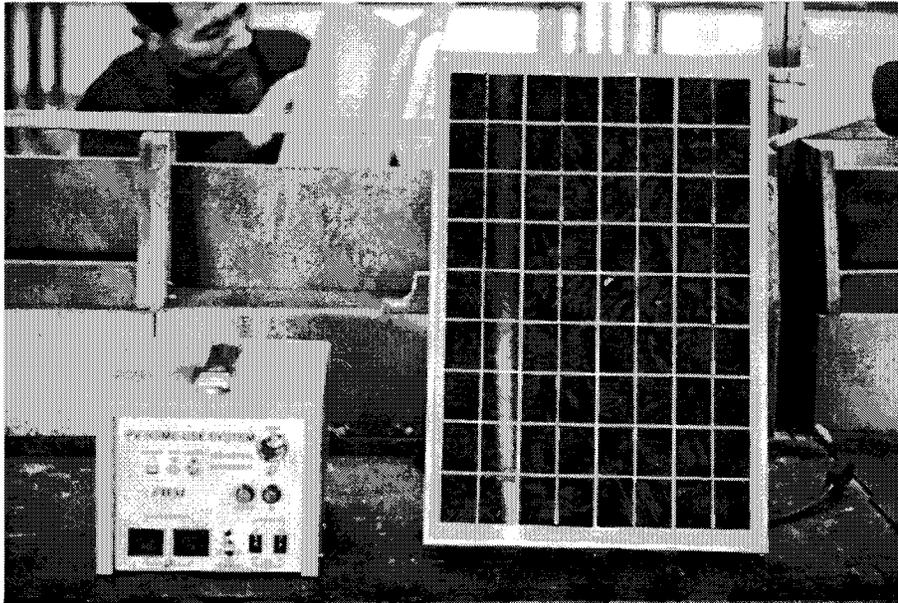
Other Project Data

Borrower/Executing Agency:

FOLLOW-ON OPERATIONS

Operation	Loan no.	Amount (US\$ million)	Board date
The First Phase of the China Renewable Energy Scale-up Program (CRESP)	IBRD-47920	87.00	06/16/2005
The Follow-Up Project to the First Phase of the China Renewable Energy Scale-up Program	IBRD-48160	86.33	02/07/2006

Annex B. Solar Home System



Annex C. Major Rural Electrification Programs Sponsored by the Chinese Government

Project	Cost	Duration	Description
Building Project for Unelectrified Counties	NA	1989-1999	The program installed seven PV stations previously unelectrified counties in Qingtang Plateau. The total installed PV capacity was 425 kW.
Brightness Program	RMB 20 millions	2000-2010	The program aimed at providing wind and solar energy to 23 million unelectrified people in remote areas in China by 2010. At the initial phase, pilot projects were launched in Inner Mongolia, Gansu and Tibet where about 30,000 household-scale solar PV systems and 40 village-scale solar PV systems were installed.
Township Electrification Program (SDDX)	RMB 2.6 billions	2002-2005	The program provided PV and small-scale wind generated electricity to un-electrified areas in seven western provinces (Tibet, Xinjiang, Qinghai, Gansu, Inner Mongolia, Shanxi and Sichuan). The program served about 900,000 people in 270 townships with small hydro, and another 350,000 people in 720 townships with PV-only and PV-wind village-scale systems (typically 30-150 kW in size). Total PV installation was 15.5 MWp.
Village Electrification Program (SDDC)	US\$5 billions	By 2010	The program is a scheme to provide renewable electricity to 3.5 million households in 10,000 villages by 2010. Solar PV is expected to play a major role, while small hydro and wind power are also likely to be employed.

Sources: REDP Chinese PV Industry Development Report, National Renewable Energy Laboratory.

Annex D. Other World Bank-Financed Renewable Energy Programs in China

<i>Project Name</i>	<i>IBRD Financing (US\$ million)</i>	<i>GEF Grant (US\$ million)</i>	<i>Approval Date</i>	<i>Expected Closing Date</i>	<i>Description</i>
Renewable Energy Scale-up Program Phase I (CRESP)	87	40.22	17-June-2005	30-Sep-2010	The program objective is to enable commercial renewable energy suppliers to provide energy to the electricity market efficiently, cost-effectively and on a large scale. The other objectives of CRESP included (a) preparation of a medium- to long-term plan for RE development; (b) establishment of a National Wind Resource Assessment Center, and a testing center; (c) provincial renewable energy resource assessments; (d) the development of Power Purchasing Agreements for IPP's to further develop China's Mandated Market Policy that requires 10% from RE; (e) through TA on tariff-setting, a policy shift from being price-based to quantity-based; (f) preparation of plans and financial incentive policies, and (g) to test renewable energy promotion models.
Follow-Up to Renewable Energy Scale-up Program Phase I	86.33	0.00	7-Feb-2006	30-Sep-2010	The project objective is to follow-up on the Renewable Energy Scale-Up Program to demonstrate early success in large-scale renewable energy investments with participating local developers in one pilot autonomous region and one pilot province. The project comprises two components: a 100 MW wind farm at Huitingxile in the Inner Mongolia Autonomous Region and small hydro construction and rehabilitation projects in Zhejiang Province (rehabilitation of eleven small hydropower plants and construction of seven new small hydropower plants).

Sources: World Bank Project Documents

Annex E. Other Internationally Financed Renewable Energy Projects

Project	Cost	Duration	Description
Silk Road Brightness Project (Shell-Netherlands Government Program in Xinjiang)	€25 millions	2001-2005	To provide 78,777 sets of 25 Wp SHS for unelectrified communities in Xinjiang. The program supported system assembly, installation, training for dealers and users, and the development of sales and service network.
UNDP/GEF Renewable Energy Project (Australian Government)	US\$4.5 millions	1998-2003	The program 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 RE technologies. The program focused on four specific technologies – wind/solar PV hybrid systems for rural electrification, solar water heaters, bagasse cogeneration and biogas systems.
German Government-Aided Program	RMB 30 millions	2003-2005	The program focused on developing R&D strategy, increasing management efficiency, controlling product quality, and building-up local sales and services network. A few PV power stations would be built for demonstration. The program was executed in Qinghai and Yunnan.
CIDA Solar Energy for Rural Electrification (Canadian Government)	CDN\$3.42 millions	2003-2005	This program is to establish PV power station and provide relevant training in Inner Mongolia region. The program is also to conduct an awareness and outreach program, assist in developing a sustainable demand-driven market of solar and introduced DMC techniques as related to solar technology.
NEDO PV Program (Japanese Government)	US\$38.53 millions	1998-2002	The program established a PV module testing center in Beijing and PV power stations in several provinces.
The Kyoto Protocol's Clean Development Mechanism (CDM)			China has 17 Clean Development Mechanism (CDM) projects for wind power, registered under the United Nations Framework Convention on Climate Change. Azure International estimates that carbon credits add approximately 0.06 RMB (0.8 US cents) per kWh to the revenue from such projects.

Sources: REDP Chinese PV Industry Development Report, Report on the Development of The Photovoltaic Industry in China (2006-2007), The Overseas Aid Program and the Challenge of Global Warming (The Australian Government's Overseas Aid Program).

Annex F. Estimated Consumer Economic Rate of Return

As discussed in the main report, ICR ERR analysis is likely to be biased due to simplified assumption about consumer energy consumption behavior. In this annex, a consumer demand curve and corresponding consumer surplus change were re-estimated using a “bundle” approach.

Based on the household survey conducted in 2007, a representative household’s (the weighted average of 5 income groups) consumption of kerosene, ghee light and candle before the purchase of a SHS and the lumen consumption of a SHS is shown in Table 6.

Table 6. Monthly Consumption for Lighting from Different Energy Sources

Fuel	Price (yuan/kiloLumenhours)	Quantity (kilolumenhours)
Kerosene	4	4.1
Ghee light	34	2.0
Candle	106	0.6
PV	0.3	60.8

Source: ICR.

Assuming a log linear demand functional form, the demand function can be estimated based on the above observations:

$$P = 51.31Q^{-1.29}$$

or in Figure 6 labeled as ICR.

The ICR assumes that this representative consumer shifts from using only kerosene before SHS to using only PV for lighting, then the monthly change in consumer surplus, as measured by the areas below demand function and above price, equals to 46.7 yuan/month. The consumer ERR is 35 percent as shown in Table 9.

Next, consider that the representative household in fact consumes a mix of fuel before and after SHS as reported by the 1997 household survey and is summarized in Tables 7 and 8.

Table 7. Energy Consumption before SHS

Fuel	Quantity	KiloLumen hours (klmh) per month	Expenditure (yuan)	Price (yuan/klmh)
Kerosene	3.5 (liters/month)	4.1	15.2	3.71
Ghee light	4.4 (Kg/month)	2.0	63.6	31.8
Candles	31.0 (per month)	0.6	13.5	22.5
All		6.7	92.3	13.78

Source: ICR, PPAR Calculation.

Table 8. Energy Consumption after SHS

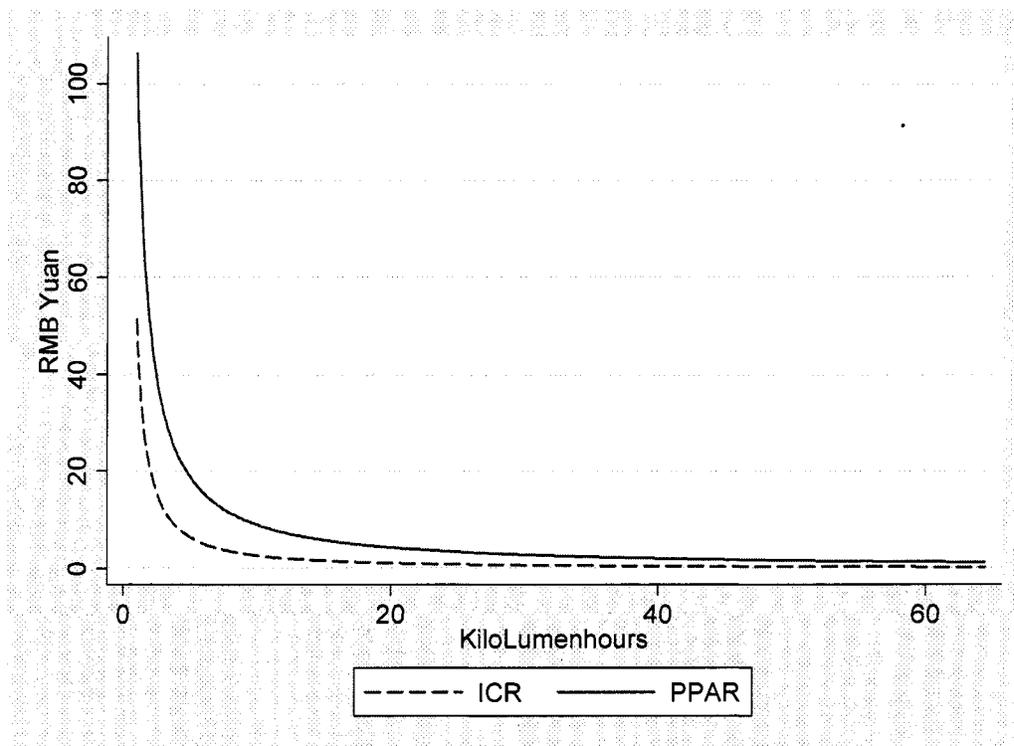
Fuel	Quantity	KiloLumen hours (klmh) per month	Expenditure (yuan)	Price (yuan/klmh)
Kerosene	1.8 (liters/month)	2.1	4.9	2.32
Ghee light	3.5 (kilograms/month)	1.59	49.7	31.24
Candles	5.5 (per month)	0.11	6.5	61.06
Solar PV	10 (wp/system)	60.8	17.2	0.28
All		64.6	78.3	1.21

Source: ICR, PPAR Calculation.

Based on the two observations highlighted in Tables 7 and 8, the demand function was re-estimated as:

$$P = 106.14Q - 1.07$$

Or in Figure 6 labeled as PPAR. The consumer surplus change is 122.88 yuan/month. The consumer ERR is 114.6% as shown in Table 9.

Figure 4. Demand Function Under Different Assumptions

The consumer ERR is estimated based on the assumptions made in the ICR: A SHS lasts for 15 years, battery is replaced every two years, costing 300 yuan; controllers are assumed to be replaced every five years, costing 27 yuan; the average operation and maintenance costs is 23.7/year including replacement of lights; and the system cost is 1200 yuan.

Table 9. Consumer ERR

**Consumer
ERR**

ICR 35%

PPAR 115%

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Calculation of Consumer EIRR																
System Cost	1,200															
Bulbs and other O&M costs	0	0	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Battery			300		300		300		300		300		300		300	
Controller						27					27					27
Consumer surplus increase (ICR)		560	560	560	560	560	560	560	560	560	560	560	560	560	560	560
Consumer surplus increase (PPAR)		1,475	1,475	1,475	1,475	1,475	1,475	1,475	1,475	1,475	1,475	1,475	1,475	1,475	1,475	1,475
Consumer cashflow (ICR)	1,200	560	254	554	254	527	254	554	254	554	227	554	254	554	254	527
Consumer cashflow (PPAR)	1,200	1,475	1,169	1,469	1,169	1,442	1,169	1,469	856	1,469	1146	1,469	1,169	1,469	1,169	1,444

