Document of
The World Bank

Report No: ICR0000880

IMPLEMENTATION COMPLETION AND RESULTS REPORT
(IBRD-44880 TF-22642)

ON A

LOAN

IN THE AMOUNT OF US$13 MILLION

AND A

GLOBAL ENVIRONMENTAL FACILITY GRANT

IN THE AMOUNT OF US$27 MILLION

TO THE

PEOPLE'S REPUBLIC OF CHINA

FOR A

RENEWABLE ENERGY DEVELOPMENT PROJECT

May 2, 2009

China and Mongolia Sustainable Development Unit
Sustainable Development Department
East Asia and Pacific Region

CURRENCY EQUIVALENTS

(Exchange Rate Effective June 30, 2008)

Currency Unit = RMB Yuan (Y)
Y 1.00 = US$0.1457
US$1.00 = Y 6.8657

FISCAL YEAR
January 1 – December 31

UNITS OF MEASURE

GW	Gigawatt	MW	Megawatt (1,000 kilowatts)
GWh	Gigawatt hour	MWh	Megawatt hour (1,000 kilowatt hours)
klmh	Kilolumen hour	MVA	Megavolt Ampere (1,000 kVA)
km	Kilometer (0.62 statute mile)	TW	Terawatt (1,000 Gigawatts)
kV	Kilovolt (1000 Volts)	TWh	Terawatt hour (1,000 Gigawatt hours)
kVA	Kilovolt Ampere (1,000 Volt Amperes)	Wh	Watt hour
kW	Kilowatt (1,000 Watts)	W	Watt
kWh	Kilowatt hour (1,000 Watt hours)	Wp	Watt peak
lm	lumen		

Vice President: James Adams

Country Director: David Dollar

Sector Manager: Ede Ijjasz-Vasquez

Project Team Leader: Richard Spencer

ICR Team Leader: Richard Spencer

ABBREVIATIONS AND ACRONYMS

CAS	Country Assistance Strategy	O&M	Operation and maintenance
CGF	Competitive Grant Facility	PAD	Project Appraisal Document
CO_2	Carbon dioxide	PDO	Project development objective
CPS	Country Partnership Strategy	PMO	Project Management Office
CRESP	China Renewable Energy Scale-up Program	PPA	Power purchase agreement
DC	Direct current	PTPIC	Post and Telecommunication Industry Products Quality Surveillance and Inspection Center
DSCR	Debt service cover ratio	PV	Photovoltaic
EAP	East Asia and Pacific region	QAG	Quality Assurance Group
EIRR	Economic internal rate of return	QRF	Quick Response Facility
EA/EMP	Environment assessment and environmental management plan	REDP	Renewable Energy Development Project
EVA	Ethylene vinyl acetate	RP	Resettlement plan
FMR	Financial management report	SARS	Severe Acute Respiratory Syndrome
FIRR	Financial internal rate of return	SDPC	State Development Planning Commission
GDP	Gross domestic product	SDR	Special Drawing Right
GEF	Global Environment Facility	SETC	State Economic and Trade Commission
GEO	Global environment objective	SFR	Self financing ratio
GoC	Government of China	SHS	Solar Home System
IBRD	International Bank for Reconstruction and Development	SMEPC	Shanghai Municipal Electric Power Company
ICR	Implementation Completion and Results Report	SO_2	Sulfur dioxide
IDC	Interest during construction	SPCC	State Power Corporation of China
ISR	Implementation Status Report	SWPC	Shanghai Wind Power Company
LRMC	Long-run marginal cost	TA	Technical assistance
MDSF	Market Development Support Facility	TI	Technology improvement
M&E	Monitoring and evaluation	TIPS	Tianjin Institute of Power Sources
MIS	Management information system	TSP	Total suspended particulates
MoST	Ministry of Science and Technology	UL	Underwriters' Laboratories
MTR	Mid term review	VAT	Value-added tax
NDRC	National Development and Reform Commission	WTP	Willingness to pay
NO_x	Oxides of nitrogen	Y	Chinese Renminbi Yuan

CHINA
RENEWABLE ENERGY DEVELOPMENT PROJECT

CONTENTS

A. Basic Information			
Country:	China	Project Name:	CN-Renewable Energy Development
Project ID:	P046829,P038121	L/C/TF Number(s):	IBRD-44880,TF-22642
ICR Date:	04/30/2009	ICR Type:	Core ICR
Lending Instrument:	SIL,SIL	Borrower:	GOVERNMENT OF CHINA
Original Total Commitment:	USD 13.0M,USD 27.0M	Disbursed Amount:	USD 12.9M,USD 26.9M
Environmental Category: B,B		**Focal Area**: C	
Implementing Agencies: National Development and Reform Commission Shanghai Wind Power Company			
Cofinanciers and Other External Partners:			

B. Key Dates

CN-Renewable Energy Development - P046829

Process	Date	Process	Original Date	Revised / Actual Date(s)
Concept Review:	04/02/1998	Effectiveness:		12/12/2001
Appraisal:	06/28/1998	Restructuring(s):		05/17/2001
Approval:	06/08/1999	Mid-term Review:		04/23/2004
		Closing:	06/30/2007	06/30/2007

CN-GEF-Renewable Energy Development - P038121

Process	Date	Process	Original Date	Revised / Actual Date(s)
Concept Review:	01/30/1998	Effectiveness:		12/12/2001
Appraisal:	10/15/1998	Restructuring(s):		06/14/2001 06/20/2003 11/24/2003 05/23/2005 09/27/2006
Approval:	06/08/1999	Mid-term Review:		04/23/2004
		Closing:	06/30/2007	06/30/2008

C. Ratings Summary

C.1 Performance Rating by ICR	
Outcomes	Satisfactory
GEO Outcomes	Moderately Satisfactory
Risk to Development Outcome	Low or Negligible
Risk to GEO Outcome	Low or Negligible
Bank Performance	Satisfactory
Borrower Performance	Satisfactory

C.2 Detailed Ratings of Bank and Borrower Performance (by ICR)

Bank	Ratings	Borrower	Ratings
Quality at Entry	Satisfactory	Government:	Moderately Satisfactory
Quality of Supervision:	Highly Satisfactory	Implementing Agency/Agencies:	Satisfactory
Overall Bank Performance	Satisfactory	Overall Borrower Performance	Satisfactory

C.3 Quality at Entry and Implementation Performance Indicators

CN-Renewable Energy Development - P046829

Implementation Performance	Indicators	QAG Assessments (if any)	Rating:
Potential Problem Project at any time (Yes/No):	No	Quality at Entry (QEA)	None
Problem Project at any time (Yes/No):	Yes	Quality of Supervision (QSA)	Highly Satisfactory
DO rating before Closing/Inactive status	Satisfactory		

CN-GEF-Renewable Energy Development - P038121

Implementation Performance	Indicators	QAG Assessments (if any)	Rating:
Potential Problem Project at any time (Yes/No):	No	Quality at Entry (QEA)	Highly Satisfactory
Problem Project at any time (Yes/No):	Yes	Quality of Supervision (QSA)	Satisfactory
GEO rating before Closing/Inactive Status	Satisfactory		

D. Sector and Theme Codes

CN-Renewable Energy Development - P046829		
	Original	Actual
Sector Code (as % of total Bank financing)		
Renewable energy	100	100
Theme Code (Primary/Secondary)		
Climate change	Primary	Primary
Rural services and infrastructure	Primary	Primary

CN-GEF-Renewable Energy Development - P038121		
	Original	Actual
Sector Code (as % of total Bank financing)		
Renewable energy	100	100
Theme Code (Primary/Secondary)		
Climate change	Primary	Primary
Other financial and private sector development	Primary	Primary
Rural services and infrastructure	Primary	Primary
Trade facilitation and market access	Primary	Primary

E. Bank Staff

CN-Renewable Energy Development - P046829		
Positions	At ICR	At Approval
Vice President:	James W. Adams	Jean-Michel Severino
Country Director:	David R. Dollar	Yukon Huang
Sector Manager:	Ede Jorge Ijjasz-Vasquez	Yoshihiko Sumi
Project Team Leader:	Richard Jeremy Spencer	Noureddine Berrah
ICR Team Leader:	Richard Jeremy Spencer	
ICR Primary Author:	Richard Jeremy Spencer	
	Noureddine Berrah	

CN-GEF-Renewable Energy Development - P038121		
Positions	**At ICR**	**At Approval**
Vice President:	James W. Adams	Jean-Michel Severino
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Project Team Leader:	Richard Jeremy Spencer	Noureddine Berrah
ICR Team Leader:	Richard Jeremy Spencer	
ICR Primary Author:	Richard Jeremy Spencer	
	Noureddine Berrah	

F. Results Framework Analysis

Project Development Objectives (from Project Appraisal Document)
Development of sustainable markets for wind and photovoltaic (PV) technologies, in order to increase supply of electricity in an environmentally sustainable way and improve access of isolated rural populations to electricity services.

Revised Project Development Objectives (as approved by original approving authority)
Development of a sustainable market for PV technologies and demonstration of the viability of commercial wind development in the coastal regions.

Global Environment Objectives (from Project Appraisal Document)
The project's global objectives are 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.

Revised Global Environment Objectives (as approved by original approving authority)

(a) PDO Indicator(s)

Indicator	Baseline Value	Original Target Values (from approval documents)	Formally Revised Target Values	Actual Value Achieved at Completion or Target Years
Indicator 1 :	Avoided emissions of SO2, NOx, TSP (million tons)			
Value (quantitative or Qualitative)	SO2 0 NOx 0 TSP 0	SO2 0.7 NOx 0.2 TSP 3.3	SO2 4.41 NOx 0.119 TSP 0.213	SO2 0.746 NOx 0.912 TSP 0.204
Date achieved	01/01/1998	12/31/2007	06/30/2008	06/30/2008
Comments (incl. % achievement)	SO2 17%, NOx 766%, TSP 96%. Calculations based on 2006 emissions values for thermal power sector and data from other target s. Based on all wind farms in China. Revised target and timing on restructuring was projected for 2009 in PDS.			

Indicator 2 :	Generation of wind electricity (GWh/yr)			
Value (quantitative or Qualitative)	416	2,618	1,478	103,400
Date achieved	01/01/1998	12/31/2007	06/30/2008	06/30/2008
Comments (incl. % achievement)	700%. Estimated based on installed capacity of 5,900MW and 20% wind farm capacity factor. Revised target and timing on res tructuring was projected for 2009 in Project Design Summary (PDS). Source: Wind Power Monthly.			
Indicator 3 :	Number of PV systems sold			
Value (quantitative or Qualitative)	90,000	585,000	600,000	625,000
Date achieved	01/01/1998	12/31/2007	06/30/2008	06/30/2008
Comments (incl. % achievement)	104%. Based on sales reported by participating PV companies of 500,000 units. Particpating companies estimated to have 80% of market. Revised target and timing on restructuring was projected for 2009 in PDS. Source: PMO database and ICR.			
Indicator 4 :	Installed Capacity			
Value (quantitative or Qualitative)	Wind 168 MW PV 1.8 MW	Wind 1,058 MW PV 17.6 MW	Wind 750 MW PV 20 MW	Wind 5900 MW PV 80 MW (at end 2006)
Date achieved	01/01/1998	12/31/2007	06/30/2008	06/30/2008
Comments (incl. % achievement)	Wind 350%. Source: China Wind Energy Association. PV 400%. Source: China PV Industry Association. Revised target and timi ng on restructuring was projected for 2009 in PDS.			
Indicator 5 :	Number of component manufacturers that reach quality standards			
Value (quantitative or Qualitative)	Wind 0 PV 0	Wind 20 PV 30	Wind 0 PV 30	74
Date achieved	10/01/1998	12/31/2007	06/30/2008	06/30/2008
Comments (incl. % achievement)	247%. Source: PMO records. Revised target and timing on restructuring was projected for 2009 in PDS.			

(b) GEO Indicator(s)

Indicator	Baseline Value	Original Target Values (from approval documents)	Formally Revised Target Values	Actual Value Achieved at Completion or Target Years
Indicator 1 :	Avoided CO2 emissions (million tons)			
Value (quantitative or Qualitative)	7.6	55.9	38.6	140
Date achieved	01/01/1998	12/31/2007	06/30/2008	06/30/2008
Comments	363%. Calculations based on 2006 emissions values for thermal power sector and			

(incl. % achievement)	data from all wind farms in China. Revised t arget and timing on restructuring was projected for 2009 in PDS			
Indicator 2 :	Installed cost of wind farms ($/kW)			
Value (quantitative or Qualitative)	1,300	1,000 by 2004 950 by 2007	950 by 2006 900 by 2009	1,300
Date achieved	01/01/1998	12/31/2007	06/30/2008	06/30/2008
Comments (incl. % achievement)	No net change in installed cost, because of rapid growth in installed capacity creating worldwide shortages of turbines. So urce: ICR team estimates. Revised target and timing on restructuring was projected for 2009 in PDS.			
Indicator 3 :	Installed cost of PV systems ($/Wp)			
Value (quantitative or Qualitative)	16	13 by 2004 11 by 2007	13 by 2006 11 by 2009	9
Date achieved	01/01/1998	12/31/2007	06/30/2008	12/31/2007
Comments (incl. % achievement)	Price reduced by 18% more than expected. Source: PMO data from participating PV companies. Revised target and timing on res tructuring was projected for 2009 in PDS.			

(c) Intermediate Outcome Indicator(s)

Indicator	Baseline Value	Original Target Values (from approval documents)	Formally Revised Target Values	Actual Value Achieved at Completion or Target Years
Indicator 1 :	Installed wind farm capacity			
Value (quantitative or Qualitative)	0 MW	190 MW	20 MW	21 MW
Date achieved	01/01/2000	12/31/2004	12/31/2003	12/01/2006
Comments (incl. % achievement)	105% but wind farms delayed by nearly 3 years. Revisions made on restructuring.			
Indicator 2 :	Number of PV systems sold and operating			
Value (quantitative or Qualitative)	50,000	100,000 by 2002 300,000 by 2004	100,000 by 2004 300,000 by 2006	175,000 by 2004 401,908 by 2007
Date achieved	05/05/1999	12/31/2004	12/31/2006	12/31/2007
Comments (incl. % achievement)	Systems verified as eligible to receive GEF grants; 115% of target but delayed by one year. Revisions made on restructuring .			
Indicator 3 :	Capacity of PV systems sold and operating			
Value (quantitative or Qualitative)	0	2.0MW by 2002 10,0 MW by 2004	2.0 MW by 2004 10,0 MW by 2006	3.4 MW by 2004 11.1 MW by 2007

Date achieved	05/05/1999	12/31/2004	12/31/2006	12/31/2007
Comments (incl. % achievement)	Capacity verified as eligible to receive GEF grants; 111% of target but delayed by one year. Revisions made on restructurin g.			
Indicator 4 :	Wind farm staff trained in financial management, engineering, construction management, O&M and private sector development			
Value (quantitative or Qualitative)	0	30		22
Date achieved	05/05/1999	12/31/2003		06/30/2007
Comments (incl. % achievement)	100% of staff of Shanghai Wind Power Company (SWPC) trained. 73% of target, but staff of SWPC smaller than expected. Revisi ons made on restructuring.			
Indicator 5 :	Preparation of private sector investment packages for 200MW of wind capacity by 2001			
Value (quantitative or Qualitative)	0	200MW of packages prepared by 2001 and promotion of packages to investors by 2003	Undertaking technical preparatory work for large coastal wind farms by 2005	Wind farm plan for 200 MW by 2010 and 310 MW by 2020, including 100MW offshore, prepared
Date achieved	05/05/1999	12/31/2003	12/31/2005	06/30/2007
Comments (incl. % achievement)	100% achieved, but later than expected. Revisions made on restructuring.			
Indicator 6 :	Quality control mechanisms in place at PV companies			
Value (quantitative or Qualitative)	No quality control mechanisms	In place by 2004	In place by 2005	All participating companies signed quality guarantee agreements, which included sanctions, with PMO by end 2004.
Date achieved	05/05/1999	12/31/2004	12/31/2005	12/31/2004
Comments (incl. % achievement)	100% achieved, one year earlier than forecast. Revisions made on restructuring.			
Indicator 7 :	Capabilities of three accredited PV testing institutes strengthened to international standards.			
Value (quantitative or Qualitative)	No PV testing institutes with international accreditation	Three institutes accredited	Three institutes accredited	Four institutes upgraded to ISO 17025 for testing
Date achieved	05/05/1999	12/31/2001	12/31/2003	12/31/2006
Comments (incl. % achievement)	133% of target achieved, one center (for modules) in 2005, three in 2006 (balance of system, batteries and PV systems) three years later than expected. Revisions made on restructuring.			
Indicator 8 :	Project PV standards adopted as national standards			
Value	No national standards	Project standards	Project	Project standards

(quantitative or Qualitative)		adopted	standards adopted	adopted as GB/T 19064 in 2003. International standard IEC 61215 adopted in 2005
Date achieved	05/05/1999	12/31/2001	12/31/2003	12/31/2005
Comments (incl. % achievement)	Original aim 100% achieved by expected date. Additional standard exceeds original objective. Revisions made on restructuri ng.			
Indicator 9 :	Number of cost-shared projects for technology improvement carried out			
Value (quantitative or Qualitative)	0	500	200	197
Date achieved	05/05/1999	12/31/2004	12/31/2006	06/30/2008
Comments (incl. % achievement)	99% achieved, with about 18 months delay.			
Indicator 10 :	Proportion of cost-shared technology improvement contracts meeting targets			
Value (quantitative or Qualitative)	0	80%	80%	95%
Date achieved	05/05/1999	12/31/2004	12/31/2006	06/30/2008
Comments (incl. % achievement)	120% achieved, with about 18 months delay.			
Indicator 11 :	Value of loans to companies for technology improvement projects			
Value (quantitative or Qualitative)	0	$50 million	$15 million	$187.75 million
Date achieved	05/05/1999	06/30/2005	06/30/2007	04/30/2004
Comments (incl. % achievement)	By mid term it was evident that capital for technology improvement - originally intended to be supported by SETC - was widel y available and since by this stage the indicator had been exceeded more than 12 times was not monitored thereafter.			

G. Ratings of Project Performance in ISRs

-						
No.	Date ISR Archived	DO	GEO	IP	Actual Disbursements (USD millions)	
					Project 1	Project 2
1	07/02/1999	S	S	S	0.00	0.00
2	12/28/1999	S	S	S	0.00	0.00
3	06/15/2000	S	S	S	0.00	0.00
4	12/27/2000	U	U	U	0.00	0.00
5	06/26/2001	S	S	S	0.00	0.00
6	10/09/2001	U	U	U	0.00	0.00
7	12/21/2001	S	S	S	0.13	0.00
8	06/06/2002	S	S	S	0.13	0.00
9	12/23/2002	S	S	S	0.13	1.35
10	06/13/2003	S	S	S	0.13	2.08
11	11/07/2003	S	S	S	0.13	2.08
12	06/19/2004	S	S	S	0.13	3.91
13	12/29/2004	S	S	S	9.02	5.86
14	05/07/2005	S	S	S	10.38	6.91
15	05/05/2006	S	S	S	10.38	11.32
16	12/18/2006	S	S	S	12.94	16.89
17	05/20/2007	S	S	S	12.94	18.29
18	06/25/2007	S	S	S	12.94	19.86
19	12/17/2007	S	S	S	12.94	22.73

H. Restructuring (if any)

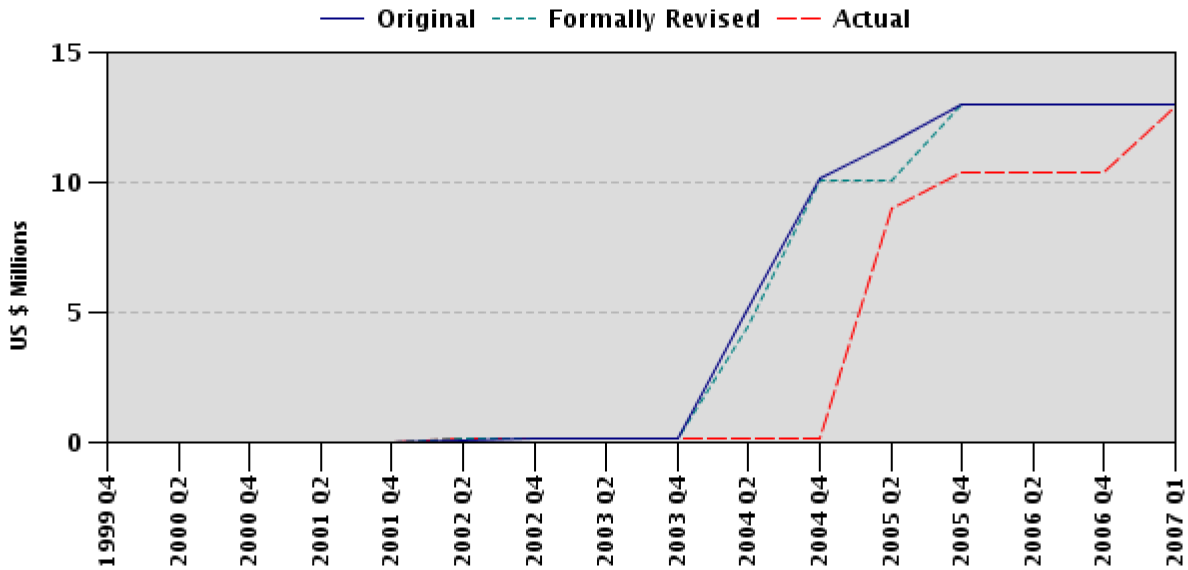
Restructuring Date(s)	Board Approved		ISR Ratings at Restructuring			Amount Disbursed at Restructuring in USD millions		Reason for Restructuring & Key Changes Made
	PDO Change	GEO Change	DO	GEO	IP	Project1	Project 2	
05/17/2001	Y		U		U	0.00		To delete planned investments in 170MW of wind farms in Huitengxile, Zhangbei and Pingtan, and to change the implementing age ncy for the wind component. Loan amount reduced from $100 million to $13 million.
06/14/2001		N			S		0.00	To reduce planned GEF grant support for wind development and to change implementing agency.

06/20/2003		N			S		2.08	To widen the scope of support to participating PV companies, by the introduction of the Market Development Support Facility (MDSF) which, analagous to the technology improvement component, was aimed at providing cost-shared grants to participating PV compan ies to assist them to improve their commercial skills and develop their markets. There was also a reallocation of amounts between e xpenditure categories and procurement arrangements for wind and PV components to allow procurement of goods and to create an Increme ntal Operating Costs category.
11/24/2003					S		2.08	To change denomination of GEF grant from SDR to US Dollars, in line with Bankwide requirements.
05/23/2005		N			S		6.91	To extend PV project area to include two additional provinces: Yunnan and Sha'anxi; and one additional autonomous region : Ningxia. Increased PV subgrant for modules meeting international standard to $2/Wp.

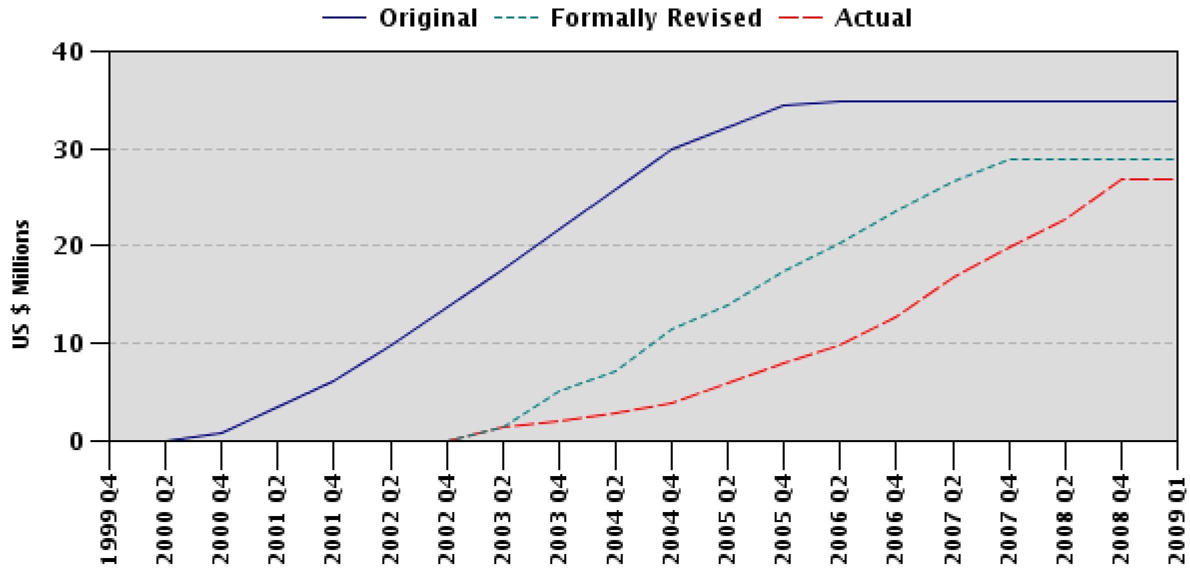
09/27/2006		N			S		14.85	To extend the implementation of the PV and TI components by one year and to reallocate proceeds.

I. Disbursement Profile

P046829



P038121


Original
Formally Revised
Actual
US $ Millions
40
30
20
10
0
1999 Q4
2000 Q2
2000 Q4
2001 Q2
2001 Q4
2002 Q2
2002 Q4
2003 Q2
2003 Q4
2004 Q2
2004 Q4
2005 Q2
2005 Q4
2006 Q2
2006 Q4
2007 Q2
2007 Q4
2008 Q2
2008 Q4
2009 Q1

1. Project Context, Development and Global Environment Objectives Design

1.1 Context at Appraisal

The project focused on an aspect of the World Bank Country Assistance Strategy (CAS) presented to the Board in early 1997: meeting infrastructure demand in an environmentally sustainable way to support continued economic growth. The project concept was based on a substantial body of Bank work, including *China: Issues and Options in Greenhouse Gas Emissions Control*, a joint report of the Chinese Government, UNDP, and the World Bank issued in December 1994 and *Clear Water, Blue Skies: China's Environment in the 21st Century*, published by East Asia and Pacific (EAP) region in 1997.

Power demand was increasing by an estimated 17-20 Gigawatts (GW) per year and, based on past experience, about 80 percent of this incremental demand was expected be met by coal-fired generation. *Clear Water, Blue Skies* had estimated the cost of health and agricultural damage from coal-related air pollution at six percent of GDP. Reducing local environment damage from coal use became a priority for the Government of China (GoC) which created interest in renewable energy and energy conservation as two promising, but still relatively untested, options.

The Bank had undertaken a number of key studies of renewable energy in China, including *China: Renewable Energy for Electric Power*, published in 1996, (World Bank Report No. 15592-CHA), *China: Renewable Energy Development for Thermal Applications*, and *China: A Strategy for International Assistance for Accelerating Renewable Energy Development*, the latter two being published in 1997. These concluded that biomass, small hydro, photovoltaics (PV) and wind were the renewable energy technologies with the greatest medium term potential in China. Of these, wind was close to, but not yet at, commercial viability for electricity production in grid applications and PV was the least-cost option for off-grid electricity.

1.2 Original Project Development Objectives (PDO) and Key Indicators (as approved)

The original PDO was development of sustainable markets for wind and photovoltaic (PV) technologies in order to increase supply of electricity in an environmentally sustainable way and improve access of isolated rural populations to electricity services. Key performance indicators were:

- Avoided emissions of sulfur dioxide (SO_2), oxides of nitrogen (NO_x) and total suspended particulates (TSP) as a result of thermal power generation replaced.
- Electricity generation from wind farms.
- Number of PV systems installed in households/institutions under the project.
- Installed capacity of wind and PV systems.
- Number of local manufacturers with components that are certified to meet international/industry standards.

1.3 Original Global Environment Objectives (GEO) and Key Indicators (as approved)

The GEO was 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. Key performance indicators were:

- Avoided emissions of carbon dioxide (CO_2).
- Installed costs of wind farms and PV systems.
- Remove barriers to large-scale commercialization of the technologies.

1.4 Revised PDO (as approved by original approving authority) and Key Indicators, and reasons/justification

The project was restructured between approval by the Board and signature of the Loan, Grant and Project Agreements, because three of the originally-planned four wind farms did not obtain their final approvals from Government of China, thus making the sustainable market objective for wind unrealistic. The restructuring was approved by the Board on May 17, 2001 and the changes to the GEF financing were made in June, 2001.

The PDO was revised to: development of a sustainable market for PV technologies and demonstration of the viability of commercial wind development in the coastal regions. Key performance indicators were not changed, but their values were reduced.

1.5 Revised GEO (as approved by original approving authority) and Key Indicators, and reasons/justification

The GEO was not revised on restructuring because it was considered that the same objectives were achievable. The GEO indicators were modified at the time of restructuring before signature, to reflect the reduced scope of the wind component.

1.6 Main Beneficiaries

The beneficiaries identified at appraisal and after restructuring remained (a) nomads and rural households in isolated areas of northwest China benefiting from increased access to electricity; (b) participating PV companies which would gain commercial skills and business opportunities; and (c) PV manufacturers which would be supported in their efforts to improve quality and reduce cost.

Beneficiaries identified at appraisal but which as a result of the project's restructuring did not receive either as substantial a benefit as expected, or none at all were: (a) people living in areas with wind potential particularly those in northwestern regions; (b) people living in areas where harmful emissions from coal fired power plant would have been avoided; and (c) wind manufacturers which did not receive support for technology upgrading.

1.7 Original Components (as approved)

The project consisted of three components:

- **A wind farm component**, consisting of an investment subcomponent to finance 190 megawatts (MW) of wind capacity at five sites (Huitengxile, Zhangbei, Pingtan and two in Shanghai), and an institutional development subcomponent aimed at overcoming barriers to wind farm development. Total cost of this component at appraisal was estimated at $208.9 million, of which Bank financing was to be $100 million and Global Environment Facility (GEF) financing was to be $3 million.

- **A PV component**, consisting of an investment subcomponent that provided sub-grants for sales of 10 MW peak (MWp) of PV systems, a PV market development subcomponent to overcome PV market barriers and an institutional strengthening subcomponent focusing on improving quality of PV equipment, certification and standards and project management and monitoring. Total cost of this component was estimated at $155.9 million, of which $22 million was to be financed by the GEF.

- **A technology improvement (TI) component,** consisting of an investment subcomponent under which wind and PV manufacturers were to be provided cost-shared grants to foster innovation, cost reduction and quality improvement and an institutional strengthening subcomponent for program management and monitoring. Total cost of this component was estimated at $79.6 million, of which $10 million was to be financed by the GEF.

1.8 Revised Components

The restructured project consisted of the same three components, with the wind farm and TI components being modified as follows:

- **The wind farm component**, consisting of an investment subcomponent financing 20 MW of wind capacity at two sites in Shanghai, and a technical assistance subcomponent to support management of the planned wind farms and preparatory work on large coastal sites. Total cost of this modified component was estimated at $24.7 million, of which Bank financing was to be $13 million and GEF financing was to be $1.5 million.

- **The TI component,** consisting of an investment subcomponent only for PV manufacturers, but with similar design as before. The institutional strengthening subcomponent remained unchanged. Total cost of this component was estimated at $24.8 million, of which $3.5 million was to be financed by the GEF.

1.9 Other significant changes

A number of changes were made in the course of implementation:

- **In June 2003**, the Market Development Support Facility (MDSF) was introduced, at the suggestion of the PMO and participating PV companies, aimed at providing cost-shared grants to participating PV companies to assist them to improve their commercial skills and develop their markets. There was also a reallocation of amounts between expenditure categories and procurement arrangements for wind and PV components to allow procurement of goods and to create an Incremental Operating Costs category.

- **In November 2003**, to change the denomination of the GEF grant from Special Drawing Rights (SDR) to US Dollars, in line with a Bank wide reform.

- **In May 2005,** following the mid-term review (MTR), to extend the PV project area to include two additional provinces: Yunnan and Sha'anxi; and one additional autonomous region: Ningxia. It also increased the PV sub-grant from $1.50 for modules meeting the project standards to $2/Wp for modules meeting international standards, namely IEC 61215-1993, and the Chinese equivalent, GB 9535-1998, which by this time could be met by a number of Chinese PV module manufacturers.

- **In September 2005,** it was agreed to drop the credit pilot; no amendment to the legal agreements was made for this change.

- **In September 2006,** to extend the implementation period for the PV and TI components by one year, to compensate for delays that had accumulated during implementation and to allow full achievement of the development objective.

2. Key Factors Affecting Implementation and Outcomes

2.1 Project Preparation, Design and Quality at Entry

The choice of areas for support – wind and PV – was based on thorough analysis. The project design was based on analysis of the Chinese context in addition to the work mentioned in Section 1.1. The Bank's extensive engagement in the conventional power sector in both investment and in policy over many years and specific Bank experience of wind projects (primarily in India) informed the work on the wind farms. Design of the PV component was based on an assessment of the market for renewable energy in rural areas of northwestern China and took into account lessons learned from PV projects in Argentina, Indonesia and Sri Lanka. The first hand experience of team members who had managed similar programs in the Netherlands and UK was used to design the TI component.

Project design focused on market development for renewable energy, relying on a traditional method for wind, but on innovative output based and cost sharing mechanisms for PV and TI. In this context, the PDO was appropriate given the size of the markets at the time. The separation of the wind and PV components was sound, considering the different implementing agencies, approach and purposes. Government commitment to the design and approach were strong.

The project was acknowledged to be a high-risk, high-payoff operation, using novel designs and techniques, particularly in its emphasis on technology development and in its reliance on the market and individual companies operating in the sub-sectors addressed. The process of what would now be called adaptive management was recognized in the project documentation and in the structures set up to manage the project.

The novelty of the design of the PV and TI components led to a number of implementation issues. No amount of preparation could have anticipated all of them and there was limited, if any, experience worldwide on which to draw. These issues are discussed in more detail in the implementation section below.

Quality Assurance Group (QAG) reviewed quality at entry and found the project to be highly satisfactory.

2.2 Implementation

Implementation took some time to get under way and was assessed, twice, as unsatisfactory during the period between Board approval and signing of the loan and grant agreements.

The risk that power purchase agreements (PPAs) would not be agreed or maintained was identified during preparation and was considered manageable based on the experience of the task team with other power sector projects in China. Uncertainties about the ownership of the wind farms to be developed and about how to share the incremental cost of wind generated electricity from the Huitengxile and Pingtan wind farms led to a delay in signing the PPAs, first noted in December 1999. Differing views among government departments created an impasse around which it proved difficult to find a way.

Eventually, in March 2001 Ministry of Finance (MoF) requested that the wind farm component consist only of the Shanghai wind farms. The Pingtan wind farm was also dropped at this point for unconnected reasons: a government instruction that no trees were to be cut down for any project development was being strictly enforced at the time. After the subsequent restructuring the move to implementation went smoothly, with effectiveness being declared in December 2001.

Implementation progress was generally satisfactory although it was disrupted by the SARS epidemic in 2003, which restricted travel to and within China.

Wind Component

Institutional and procurement issues caused delay. After the restructuring, Shanghai Municipal Electric Power Company (SMEPC) and its subsidiary special-purpose wind farm company (Shanghai Wind Power Company – SWPC) became responsible for implementation. Neither had experience of wind farm development or of single-responsibility contracting for wind farms under which one contractor – in this case the wind turbine supplier – took responsibility for the supply of the turbines and the design and supervision of the construction of the foundations and the design and layout of the balance of plant but with these latter two carried out by other contractors. The project financed a study tour to European wind farms for managers of SMEPC and SWPC followed by face to face discussions with the regional procurement staff. The study tour was effective in clearing up doubts about the merits of using a single-responsibility contract.

Site changes caused delays to one wind farm. There was a delay caused by the decision to move the Nanhui wind farm some kilometers south of its original site, to increase the safety distance from the new Pudong International Airport. A change of the capacities of the wind farm sites such that the wind farm in Chongming was reduced to 4.5 MW and the Nanhui wind farm was increased to 15.5 MW (for a total of 21MW) did not affect implementation.

Finalization of the power purchase agreement took longer than expected. Under Chinese rules, the price and quantity of electricity can only be provisionally agreed following commissioning of the power plant, and firmed up one year after the start of commercial operation. Both wind farms entered commercial operation on December 1, 2005. Production was slightly below forecast in 2006 but within expected variations due to lower wind conditions.

The institutional strengthening component was implemented satisfactorily. Tasks were generally performed according to priority, for example ensuring that the work to support physical implementation was done before longer-term scaling-up issues were addressed. The mid term review (MTR) noted that two major tasks, the wind resource measurement and the development of an education center had not yet been started but these were completed by the close of the wind component in June 2006.

PV Component

The PMO was formed before effectiveness and its staff had started working with participating PV companies during preparation. The PMO monitored participating companies, their performance and the market well throughout the lifetime of the project. PMO staff felt it would have been helpful to have an initial training and organizational period rather than launching straight into implementation.

More effort than expected was needed for project start-up. Signing up an initial 16 participating companies, and initiating the procedures by which PV sub-grants could be claimed, verified, and paid required substantial effort. Teething problems that emerged and resolved early in implementation included refining system eligibility criteria, ensuring that the management information system (MIS) captured all relevant information and preparing a labeling system so that components could be tracked.

Slow system sales were an initial problem. Caused in part by project delays resulting from the creation of NDRC and the SARS epidemic companies had difficulty scaling up sales. Average system size did not grow as expected either. Several participating PV companies did not make high levels of eligible sales. The response included recruiting additional participating PV companies, widening the project area to cover additional provinces and autonomous regions and increasing the sub-grant for systems using modules that met international standards. Dropping under-performing companies was considered but not pursued on the grounds that they could still contribute to market development.

Increasing competition and the Market Development Support Facility (MDSF) improved sales. These had positive impacts particularly in the last two years as participating companies became more competitive and component shortages eased. The competitive approach and technology neutrality were important factors. Several other restructurings were undertaken to introduce improvements, including the MDSF aimed at helping participating companies improve their commercial skills and build the market.

There was no pilot of credit mechanisms as originally planned. This was for two reasons. First, and possibly unique to the western provinces of China, the cash market for PV systems is large and the participating companies concentrated on these. Second, following extensive study of the credit markets, the PMO and task team concluded that the time needed to introduce the changes into the project would leave insufficient time for a satisfactory pilot.

TI Component

The competitive grant facility (CGF) went smoothly. The use of a CGF, in which participating TI companies could apply for cost-shared grants to improve quality or reduce cost of PV components, was implemented in a series of four annual rounds. In each round about half of all proposals were funded at a rate of between 25 and 30 percent of the total activity cost. After the first year, the calls for proposals covered focal areas which had been identified as quality and cost bottlenecks for PV systems.

The parallel quick-response facility (QRF) did not work as expected. Originally conceived to shorten processing time to meet urgent financing needs of the grantees, it turned out to be incompatible with the approval procedures of GoC and the Bank. It ended up funding similar projects to the CGF. The mid-term review noted these shortcomings; with hindsight, it may have been more effective to eliminate the QRF to free up scarce GEF funds and PMO resources to concentrate on other aspects of the component.

PMO-managed work to support quality improvement was effective. By providing testing services, developing standards and mechanisms to ensure compliance with them, and improving capacity to test and certify PV components and systems the support worked as intended. This task was initiated during preparation and continued throughout implementation. Timing and adapting this work to the needs of the market proved to be difficult but the step by step approach was appreciated by stakeholders.

An initial disconnect between PV and TI quality improvement had to be solved. Initially there was a disconnect between general quality improvement initiatives supported by the TI component and ensuring quality for the PV systems receiving a PV subgrant. Earlier development of testing and certification capacity might have benefited overall efforts to improve quality in the industry at large and among participating PV companies alike. Whether this would have resolved the disconnect is difficult to know even with hindsight, because success would have been dependent on the PV companies' readiness and capacity to make improvements in quality.

Two QAG assessments took place: one in the first year after approval but before effectiveness, which rated supervision satisfactory; and the second shortly after mid-term which rated supervision highly satisfactory.

2.3 Monitoring and Evaluation (M&E) Design, Implementation and Utilization

M&E Design

Some of the indicators at the PDO and GEO level were not well connected to the project or global objectives and were not easy to collect. The PDO indicators were, with one exception covering quality, forecasts for the growth of wind and PV across the whole of China and were based on, in the restructured project, figures for 2009. One PDO indicator and one GEO indicator used forecasts of avoided pollutant emissions, also for the whole of China.

Attribution of the project's contribution to these indicators is not possible other than the direct reductions, primarily from the wind farm, which forms only a small proportion of the total. This consequently creates difficulties in evaluating the project against the PDO and GEO indicators. As practised today now that the start of the art of M&E has further developed, more focused indicators may have been useful, particularly those focused on the impacts of the project itself rather than sector-wide effects.

M&E Implementation

M&E implementation was carried out thoroughly. Relatively simple indicators for the wind component were easily collected and provided for each supervision mission by SWPC. Monitoring of the PV component depended mainly on information generated by the MIS. Initially the PMO did not pay sufficient attention to this aspect, resulting in an ISR rating of unsatisfactory for M&E in late 2003. This proved to be effective in focusing efforts on timely tracking and reporting. Following the MTR PV and TI components were monitored at each supervision, particularly system sales, and system capacity and progress in CGF and technology support activities.

M&E Utilization

The M&E design was based on the earlier logical framework approach which makes use of outputs rather than intermediate indicators. Hence intermediate indicators were relevant to measurement of the project's implementation progress and used for that purpose. For the wind farm component progress in construction of the wind farm and subsequent electricity production were easy to monitor and well linked to planned project outputs. Enabling environment indicators for the wind sector were also measurable and easy to monitor through normal supervision processes.

Similarly, the output measures for the PV and TI components were useful for gauging project progress and helping the PMO and the Bank to focus on areas of implementation that were lagging. PDO indicators were used at MTR to evaluate likelihood of achievement of the project and global objectives.

At mid-term the possibility of adjusting the M&E indicator values was considered by the PMO, task team and Bank management but was rejected.

2.4 Safeguard and Fiduciary Compliance

Safeguards

There was one temporary problem with environmental safeguards. The ISR rating for safeguards compliance was downgraded to unsatisfactory and brought to the attention of the executing agency and concerned government departments when SMEPC/SWPC failed to undertake the environmental assessment after the decision to change the wind farm site at Nanhui. The approach was effective in ensuring full compliance with all environmental requirements before the start of construction.

Fiduciary

Fiduciary compliance was satisfactory, with all procurement following Bank policies. All audits and financial management reports were provided on time, with the exception of the accounts for SMEPC and SWPC and project accounts for the wind farm component in 2003, which were delayed as a result of the SARS epidemic.

The main fiduciary challenge was in the PV component in ensuring that PV sub-grants claimed were for eligible systems. Initial verification plans relied on a combination of physical checks with purchasers of PV systems and physically tracking PV systems through the manufacturing and distribution process. Physical verification by field visits proved to be impractical. The main purchasers of systems are semi-nomadic, live in extremely remote areas and speak different languages and dialects from those selling systems. Consequently finding a system once it had been sold was near impossible and in any event extremely costly; after two attempts at physical verification, it was abandoned.

Following the decision to abandon physical investigation, the verification system was overhauled and reviewed by a consultant. In addition to the physical tracking by serial number of the PV module from start of manufacture through to completion of retail sales, the PMO improved tracking of stock records and financial monitoring. It worked well, since the verification process was able to detect and weed out ineligible systems. It also detected one apparent case of fraud by a participating PV company which falsified bank statements used as part of the financial verification process. Subsequent investigation by forensic accountants found no evidence that any payments had been made that were not due to the company but that the fraudulent claim had been detected and payment prevented, suggesting that the verification was working as needed. The company was removed from participation in REDP by the PMO.

2.5 Post-completion Operation/Next Phase

Wind Component

TA during preparation and implementation supported formal training and on the job experience in operations and maintenance for the wind farm. Combined with a 'green electricity' pilot program in Shanghai, which pays a premium for wind generated electricity funded by consumers which want to demonstrate their commitment to the environment, the cost of electricity supplied to SMEPC is fully recovered. The PPA is for a term of 20 years, which is the planned lifetime of the wind farms. Based on the financial analysis of the wind farms and SWPC in Annex 3 the company appears to be financially sound and sustainable.

Recognition of the difficulties encountered in putting in place the power purchase arrangements for the wind farms was one of the reasons for the development of the GoC/GEF/World Bank China Renewable Energy Scale-up Program (CRESP) which started in 2000. Throughout preparation and since its approval in FY05, CRESP has built on the lessons learned from REDP and is contributing to the sustained scale up of renewable energy in China, as well as financing further wind power capacity.

As both SWPC and SMEPC have an interest in output from the wind farms, this is monitored carefully and suitable data about wind farm performance are available from both parties. Such is the worldwide interest in the wind sector in China that several specialized consultants and journals regularly monitor and report on sector performance.

PV Component

The transition for participating PV companies receiving output-based assistance in REDP to fully commercial operations was started in the closing two years of the project. From about mid-2006 communications and support to participating PV companies began to focus on post-REDP sustainability. PV companies' requests for MDSF support increasingly centered on developing their markets, extending and improving their distribution networks and improving their products with a corresponding reduction in their efforts to improve their commercial skills. The supporting programs also shifted focus on supporting, for example, the development of a Chinese quality mark, the 'Golden Sun' for PV systems and components which enjoyed considerable take up by market participants.

Monitoring of the market prices of systems showed that most of the participating companies began to increase prices by five to ten percent in 2007. The output-based support in REDP was about 10-15 percent of the cost of systems but companies were able to limit the increase to this level as the PV module and battery price rises that took place in 2005-06 began to moderate or decline. The strengthening of the Yuan against the US dollar also helped to limit the influence of the subsidy in Yuan terms.

The GoC has continued to support off-grid rural electrification, and is expected to continue to do so as it strives towards its 2020 goal of universal electrification in which PV will play an increasing role. The market is now self-sustaining, and thus further additional support is not required.

With the increasing maturity of the market, several commercial firms have started to monitor and report on it. Indicators of volume, prices and profitability of firms are available from a number of sources, obviating the need for a formal monitoring program.

TI Component

The TI component provided one-off gains to PV equipment suppliers, which incorporated the improvements funded in new products of higher quality and lower price which have now entered the marketplace.

3. Assessment of Outcomes

Because the project was restructured before signing, and therefore before any disbursements were made, outcomes have been rated by applying a weight of zero to pre-restructuring outcomes and full weight to post-restructuring outcomes.

3.1 Relevance of Objectives, Design and Implementation

Climate change is today one of the (if not the) major global priorities and China's ability to contribute to its mitigation both as an emitter and as a supplier of mitigation is increasingly recognized domestically and internationally. Few question that renewable energy will play an increasing role in climate change mitigation, and there is consensus that market driven renewable energy development is most sorely needed.

Most importantly, development of renewable energy is unquestioned in China: the country has committed to the development of 30 GW of wind and biomass capacity each and 1.8 GW of PV capacity, all by 2020. Following REDP's success, China has used PV for its own large-scale rural electrification program, including for mini-grids in towns and villages, and is now exploring ways to develop grid connected PV. Market based approaches and competition are now recognized in China as the best means to achieve sustained renewables development and reduce costs.

One of the pillars of the Bank's Country Partnership Strategy (CPS) for China during 2006-10 is to manage resource scarcity and environmental constraints to the country's future growth. The Bank also committed during the Bonn renewable energy conference (in 2004) to increase its lending for energy efficiency and renewable energy by 20 percent each year between 2005 and 2009. Development of renewable energy remains one of GEF's strategic objectives to reduce GHG emissions and mitigate climate change threats.

The Bank continues its engagement in the renewable energy sector in China. The government developed a comprehensive Renewable Energy Law with Bank assistance, among others, during the preparation of CRESP. CRESP also financed 200 MW of grid connected wind-farms on two of the sites originally planned under REDP, a 25 MW pilot biomass project and rehabilitation of small hydropower units. A GEF grant is being used for supporting technical assistance which has adapted the TI approach to lower construction costs for state-of-the-art wind farms and biomass.

3.2 Achievement of Project Development Objectives and Global Environment Objectives

As an innovative project from both the Chinese and World Bank perspective, some problems in launch and implementation were to have been expected. Notwithstanding the difficult start, the impact of the project has been considerable.

Wind Component

The Shanghai wind farms, despite their small size, demonstrated the commercial viability of well designed, procured and constructed wind farms. By the construction of 21 MW of capacity and its subsequent operation, the outputs were as forecast (Intermediate Indicator 1, Annex 2 part A). SWPC is now trained and effective (Intermediate Indicator 4), evidence for which is that it has further developed one of the Shanghai sites. Shanghai municipal government has developed plans for 200MW of additional capacity by 2010 (Intermediate Indicator 5 and Annex 7). The wind farms have became a model for procurement and operation of wind farms by Long Yuan, a shareholder in SWPC and the developer of the 100 MW wind-farm in Pingtan (Fujian Province) financed by the Bank in CRESP, and at least one other non-Bank financed project of 150MW in the coastal areas of Jiangsu province.

The contribution of wind farms to avoided emissions has been substantial with them exceeding the target for NO_x, and meeting it for TSP. By contrast the amount of SO_2 avoided is substantially below expectations (PDO Indicator 1) possibly because of enforcement of tough SO_2 emissions regulations introduced during the project lifetime. By the end of 2008, wind capacity installed in China had reached 10GW, about 12 times forecast and generation about 103TWh, or 7 times that forecast (PDO Indicators 2 and 4) and China had the fourth largest installed capacity in the world, accounting for about ten percent of the total.

PV Component

The PV Component achieved its expected outputs and development objectives with REDP verified sales exceeding 400,000 units with an aggregate capacity of 11.1MWp compared with the objective of 350,000 systems and a capacity of 10MWp (Intermediate Indicators 2 and 3). The project helped establishing a sustainable PV market in the north western region of China. Drawing from the discussion in Annex 2 part B on the PV component, indications of the vibrancy and sustainability of the market are as follows:

- *Size*. Sales of verified systems have grown during the project, indicating a strong market with no signs of saturation. Compared with the situation at appraisal when the market was thought to be about a quarter of the size it is today, there is evidence of strong market growth.
- *Concentration*. Of the 18 most active PV companies, the four-firm concentration ratio (the market share held by the top four companies and a proxy for competition) is about 37 percent. PV module suppliers have a lower ratio of about 29 percent. In 1997, one year before appraisal, the four-firm concentration ratio was 51 percent. In other words, competition has increased.
- *Price competition*. Price competition remains intense, with wholesale to retail markups in the range of nine to 13 percent.
- *Innovation and Quality.* The range of product offering – while difficult to measure quantitatively – appears to have increased over the project lifetime, with a wider range of sizes of system, innovative products tailored to consumer needs, and a wide range of viable business models.
- *New Segments.* With Government support, the Chinese market has broadened to include mini-grid and grid-connected systems, especially in remoter areas which increases both the scope of the market and its size, while also providing further incentives for innovation and quality improvement.

The evidence of a link between the PV component and market development is strong. The 18 most active PV companies all grew significantly during the project period and are now thought to share a market in northwestern China worth about $22 million per year (100,000-135,000 systems per year), strong evidence that the 625,000 systems sold forecast for end of project (PDO Indicator 3), has been achieved by participating PV companies alone, given that they reported verified and unverified sales of 500,000 systems up to the end of 2007.

The total installed capacity of PV in China is estimated to be 80MWp, compared with 20MWp (PDO Indicator 4) forecast at the start of the project, of which participating PV companies are known to have supplied at least 12 percent. In aggregate they doubled the number of employees and sales revenues more than trebled. REDP-compliant sales form a significant proportion of the total sales reported by companies, suggesting that the market growth was linked to the improved quality, availability and suitability of the systems fostered under REDP.

TI Component

The TI component exceeded its output indicators. Seventy-four component manufacturers meet quality standards, compared with the 30 expected, and 18 companies offer PV systems that meet international standards (PDO Indicator 5). It contributed to the achievement of the PDO by improving the quality of a significant number of PV system components, by developing the capacity to test to international standards and by ensuring standards are enforced (Intermediate Indicators 6 and 7). Project PV standards were adopted as national standards (Intermediate Indicator 8) and then higher, international standards were adopted.

Of a planned 200 technology improvement activities, 197 were carried out (Intermediate Indicator 9) and 95 percent met or exceeded their aim compared with the target of 80 percent meeting their aim (Intermediate Indicator 10), resulting in an estimated $187 million investment in production of the improvements, 12 times the original target (Intermediate Indicator 11).

Measuring the direct impact of these activities is difficult but it is notable that several of the companies supported by the project have enjoyed substantial growth and increasing market share as the worldwide demand for PV systems has expanded. China now exports PV systems, proof that many companies are now meeting international standards; several of these companies were beneficiaries of the TI component.

Global Environment Objectives

The global environment objective to reduce greenhouse gases (which with other pollutants was also a sector-related CAS goal) was more than fully achieved primarily as a result of the rapid growth in wind farm capacity in China over the period of the project with avoided CO_2 emissions estimated to be 130 million tonnes, compared with an expected 38.6 million tonnes (GEO Indicator 1). The direct contribution of the Shanghai wind farms to the achievement of the target was modest at an estimated 33,700 tonnes per year or about 700,000 tonnes over the project lifetime. The question of attribution of the demonstration effects of the project to the wider achievement of the target cannot be effectively answered in a report of this nature.

Cost reductions in the renewable energy technologies were mixed. The installed cost of wind capacity (GEO Indicator 2) was the same at the end of the project as at the start, at $1,300/kW compared with a target of $900/kW for the end of project. Installed cost of the Shanghai wind farm was $1,264/kW, however estimates suggest that in 2002-2003 installed cost of a typical wind farm probably fell to about $860/kW before climbing again as a result of turbine shortages and the rise in the value of the Euro.

PV systems costs (GEO Indicator 3) started at about $16/Wp and had fallen to $9 by project close, well below the target of $11/Wp (Annex 2, Figure A2.5) despite materials shortages caused by the worldwide increase in demand. Because this is based on data from participating PV companies, the project linkage is strong since it is clear that these companies collectively dominate the market for off-grid PV. In turn, these companies attribute cost reductions to their own efforts, part financed by the project to compete and innovate.

No separate indicator was established for the fourth GEO objective of removing barriers to the large-scale commercialization of wind and PV technologies. It would, nonetheless, be hard to argue other than that both wind and PV are fully commercial in China, based on the analysis of the PDO indicators together. In both technologies there are large and growing markets in which genuinely commercial transactions take place. In the PV market this is wholly unsubsidized. In the wind sector, market support – including for example mandated market shares – have been introduced through the Renewable Energy Law, which ensure that turbine suppliers and developers operate under strongly competitive conditions and respond to commercial incentives.

These different cost outcomes underline the consequences of choosing a cost target as an indicator of impact when market conditions are exogenous to the project. It also illustrates how, in far exceeding expected installed capacity, a PDO indicator and in consequence GEO Indicator 1, there has been a shortfall in GEO indicator 2.

3.3 Efficiency

Wind Farms

The wind farm component covers the full loan amount of $13 million. Economic and performance at appraisal and completion and financial performance at completion are compared in Table 1.

Table 1: Comparison of Economic and Financial Rates of Return – Wind Farms

	Appraisal		Completion	
	IRR, %	NPV @ 12%, $M	IRR, %	NPV @ 12%, $M
Economic with local environmental externalities	7.6	-4.7	12.9[1]	1.1
Economic with local+ global environment al externalities[3]	8.4	-3.9	15.2	4.1
Economic without environment externalities	5.0	-7.4	0.7[2]	-12.0
Financial	n/a	n/a	9.5	-3.0

1 Assumes consumer willingness to pay at the Jade Green Tariff and at the buyers PPA for non-green energy.
2 Assumes wind farm output is valued at the avoided cost of coal generation.
3 CO_2 valued at $15/ton.

The justification at appraisal for proceeding with the wind farms was for the demonstration effects, even though they were not economic; this was formalized at restructuring by assuming a willingness to pay for the demonstration benefits by the Shanghai authorities that made the project economically viable.

The improvement to economic and financial returns ex post are the result of a higher than anticipated 'regular' tariff being agreed for the project by SMEPC, of Y0.897/kWh (taken in the economic analysis to represent willingness to pay). In addition, a 'green' electricity scheme was introduced during implementation, with Bank support though under separate funding. In the scheme, environmentally-conscious firms and households can voluntarily pay a premium for wind-generated electricity, which accounts for about 25 percent of total wind farm output. The premium sets the tariff at approximately Y1.15/kWh. Only if the avoided cost of coal is taken as the economic benefit of the generation, implicitly not taking into account actual willingness to pay for wind electricity or any environment externalities, is the project not efficient. This is discussed in more detail in Annex 3.

The NPV is presented at 12 percent discount rate for *ex-ante* and *ex-post* comparison purposes. It should be noted, however, that the current discount rate applied by NDRC for national projects is eight percent; the NPV would be commensurately higher at this lower discount rate.

Actual costs were nearly identical to forecast, despite some delays in procurement and higher than expected turbine foundation costs. The benefits of the demonstration effect – which include the learning about foundations – cannot be assessed in financial or economic terms, but as discussed elsewhere have been positive, given the plans for further development of wind in Shanghai.

Of the TA associated with the wind farms component, a total of $600,000 which was directly attributable to the wind farms themselves has been included in the analysis. The balance (of $900,000) has not been included in this analysis because the activities financed were not associated with the wind farms, but aimed at supporting further development of wind in Shanghai.

PV and TI Component

No economic or financial analysis was carried out at appraisal, because it was considered at the time that the PV systems were to be sold in areas where there were no viable alternatives.

About 60 percent of the total GEF financing was for the direct PV grant support; most of the rest was for indirect support of market development and technology improvement activities, and for project management. The ex post analysis covers the full amount of the grant allocated to the PV and TI components, totaling $25.5 million. All TI expenditures were allocated against the verified PV systems sold under the project. This conservative assumption did not take into account any systems sold during the last six months of the project, sales by companies participating in the project which were not eligible (such as domestic sales to non-project provinces, or exports). Nor were spillover effects – whereby other companies benefit from TI and market development – included in the analysis.

With these conservative assumptions, the economic rate of return on the systems sold is estimated at 93.4% including global environment externalities using the willingness to pay method. The corresponding financial return to the purchases is 88%. The returns are robust to PV system life, levels of carbon emission reduction, and assumptions about willingness to pay. These high returns are supported by three observations from the market. First, systems are bought for cash, which suggests a high benefit perceived by households. Second, the cost of the PV system is modest compared with income. Third, the initial cost of a PV system in China is much lower than in other countries.

The economic analysis is presented in depth in Annex 3, and in turn relies on information in Annex 5, drawn from beneficiary surveys.

3.4 Justification of Overall Outcome and Global Environment Outcome Rating

Rating: Achievement of PDO is rated Satisfactory

All the PDO indicators have been achieved except the abatement of SO_2 emissions which was less than expected. Intermediate indicators have also all been achieved or exceeded though in some cases late – the wind farm entry into service, preparation of wind farm plans, the PV testing facilities and some minor shortfalls in wind farm staff training and TI projects. The project was economically and financially efficient and the objectives of the project are today of *higher* relevance to global priorities, GoC's sustainable development objectives, the Bank's assistance strategy for China and its corporate goals.

Given that there are minor shortcomings, balanced by other achievements above expectations, good efficiency and relevance, a rating of Satisfactory is justified.

Achievement of GEO is rated Moderately Satisfactory

Two of the three GEO objectives, avoided CO_2 emissions and cost reduction for PV, have been exceeded by a considerable margin, but that for wind was not. Barriers to commercialization have been demonstrably reduced. These were accomplished in an efficient way, while focus on global environment and climate change has grown in China, the Bank and the wider global community in the lifetime of the project, with a strong emphasis on mitigation. Efforts to reduce greenhouse gas emissions and to bring down the long term costs of renewable energy technologies continue, with increased focus on those which are commercially ready.

Given that all but one of the objectives has been exceeded by a wide margin, but that one objective has not been achieved, the project was Moderately Satisfactory in achieving its global objective.

3.5 Overarching Themes, Other Outcomes and Impacts

(a) Poverty Impacts, Gender Aspects, and Social Development

The project did not have a poverty alleviation objective and so poverty impacts were not monitored. Nonetheless, the surveys reported in Annex 5 indicates that on average purchasers of SHS have only slightly higher incomes on the population as a whole (median income of SHS purchasing households of Y13,000 per year compared with a median for the population as a whole of Y12,000). Moreover even the poorest quintile of households reported purchasing SHS.

Hence many of the more than two million people in western China who benefited from access to modern electricity through PV systems delivered under the project were poor. The survey reports that 95 percent of SHS users claim that the system has increased their incomes, though only 15 percent claim the increase is significant. Although further quantitative analysis of this unexpected finding is not possible with the survey data available, there are strong indications that poverty impacts have been achieved among a considerable number of people.

(b) Institutional Change/Strengthening

During project implementation, China's interest in scaling up renewable energy grew stronger. REDP was followed by CRESP which focused on institutional issues and long term sustainability of grid-connected renewable energy in China. The renewable energy law took effect in 2006 and was followed by several regulations promoting the development of renewable energy with a major focus on wind, including onshore wind farms of one GW or more and plans for offshore development. Several lessons drawn from REDP informed these institutional changes.

(c) Other Unintended Outcomes and Impacts (positive or negative)

While the Project Appraisal Document (PAD) noted that the project, if successful, could affect PV prices globally, the Chinese PV sector has undergone a transformation in the past ten years:

- Some of beneficiaries of the TI grant have become major players in the international market. Some are listed on stock exchanges in Europe and the US and are operating in markets the Europe, Japan and the US. China is now the second largest producer of PV equipment in the world, and the third largest exporter.
- At the 2007 European PV Industry Exhibition, Chinese companies were the third largest cohort of exhibitors, and at the May 2008 Lighting Africa Conference in Accra Ghana, 30 Chinese companies exhibited off-grid lighting products.
- Some REDP supported companies have won competitive bids for World Bank financed PV systems in Lao PDR, Mongolia and Papua New Guinea.

Attribution is difficult to assess; these companies would likely have succeeded without the small grants provided by the TI component. However, it is clear that their exposure through REDP to international industry experts and the incentives provided to focus on quality contributed to, and most probably accelerated, their success. Many of the unintended positive impacts of REDP are documented in a paper prepared at the request of the MoF entitled "Photovoltaics, An Innovation Success Story."

A two-tier market for wind equipment has developed in China. One follows best international practice, but the second tier relies on local suppliers of turbines using older technology which do not meet international standards. Some developers use these to maximize installed capacity rather than power generation. As with any new and fast-growing market this is to some extent unavoidable, but to the extent that the wind component helped foster a general interest in wind it has contributed to this.

3.6 Summary of Findings of Beneficiary Survey and/or Stakeholder Workshops

PV and TI Components

Because of the innovative nature of the PV and TI components, the closing stages of the project sought feedback from participating PV companies, TI companies, buyers of SHS and others to draw out lessons for future projects of this kind. While not required for a core ICR, the findings are recorded, for future projects of this kind.

Beneficiaries are mostly animal herders or farmers, having paid Y700 – 1,000 for an 18-25Wp system within the past five years. They report that:

- Over 60 percent are satisfied or moderately satisfied with their systems.
- The systems provide either great or some improvement to their lives and incomes.
- Over 90 percent of those who have given up systems did so because the gained access to the grid or otherwise no longer need them

Stakeholder discussions find that:

- Project participants – PV and TI companies alike – found that the design and implementation of those parts of the project relevant to them met their needs, were fair, transparent and well administered.
- Slowness in verification and disbursement was a common problem.
- The work of the PMO was highly rated.

More detail may be found in Annex 5 which describes the beneficiary surveys and Annex 6 which describes the stakeholder discussions.

4. Assessment of Risk to Development Outcome and Global Environment Outcome

Rating: Negligible to Low

The risks to sustaining the development outcomes are minimal and longer term sustainability of the achievements of REDP are highly likely.

Development of wind based electricity is now among the highest priorities of the Chinese government. The industry is growing strongly and challenging targets have been set by the government for on-shore wind and interest for off-shore wind is growing. Pricing arrangements for wind are covered by the renewable energy law and the government is developing policies to encourage local manufacturing capabilities, reduce cost and increase the competitiveness of wind-based electricity.

The policy and market frameworks for PV are in place: demand growth is strong and stable, technology and business capabilities have been substantially strengthened, investments are being sustained by the private sector, and quality products are available. The high number of suppliers ensures sustained competition and downward pressure on price.

5. Assessment of Bank and Borrower Performance

5.1 Bank Performance

(a) Bank Performance in Ensuring Quality at Entry

Rating: Satisfactory

The QAG Quality at Entry Panel noted that "while the project approach is audacious, the Bank team is well aware of the risks, and has worked hard to devise strategies to manage risks to the extent possible. The Panel commended the team for its creativity, openness to outside ideas, and above all its candor in the process of developing the project. The quality of project documentation and technical analysis is excellent…" The Panel rated quality at entry Highly Satisfactory and considered preparation to have been best practice.

The QAG review took place after Board approval but before project restructuring – in other words when the PPA issue was known. Preparation had estimated the chance of the PPA risk materializing as low, which was judicious and well flagged and consciously accepted. The reaction of the corporate entities at the central, regional and provincial levels of SPCC was stronger, and government willingness to intervene weaker, than expected. The Bank was proactive in its efforts to find ways around the impasse, developed an effective contingency plan which was implemented through restructuring.

The Bank overestimated the power companies' understanding of the specific characteristics of wind projects. The original project design relied on goods and works procurement and the use of SPCC's expertise to integrate the wind farms. This was not in line with wind industry practice, but was felt during preparation to be manageable given SPCC's extensive engineering skills and experience, albeit limited, of wind farm development. The more usual single responsibility approach was adopted following the restructuring.

During implementation of the PV component, two minor shortcomings that might have been given more attention and addressed during preparation became apparent:

- The excessive effort and cost of the physical verification of PV systems was presaged when the market survey was conducted in the winter. This should have alerted the team that verification through physical visits, as used in similar bank projects in other countries, was not appropriate for trying to reach people in northwestern China who were by and large semi-nomadic, living in some of the most remote least populated parts of the planet.

- The level of support needed for participating PV companies so that they could become effective commercial entities proved to be significantly more difficult than expected.

Taking into account the project's innovative profile these shortcomings are considered minor especially in view of all the other dimensions of identification, preparation and of appraisal and hence the overall rating of quality at entry is assessed as Satisfactory.

(b) Quality of Supervision

Rating: Highly Satisfactory

A QAG panel judged the quality of supervision in FY 03-04 to be "…Highly Satisfactory overall, with the focus on development effectiveness and the supervision inputs and processes being the strongest aspects of the assessment." The panel also judged the supervision of fiduciary and safeguard aspects of the project as well as project reporting to be fully satisfactory.

The supervision team was adequately staffed and established excellent working relations with all parties involved in the project implementation. Budgets were adequate and benefited from additional TF support.

A pragmatic and flexible approach towards supervision was adopted. Faced with events, unforeseen during preparation, that delayed the signing of the project, the team proposed and Bank management approved the restructuring of the project to adapt it to the changed institutional environment without compromising the development and global objectives. The Bank continued to fine tune the project to changing conditions and to address implementation issues based on feedback from stakeholders, especially participating companies.

At the same time, the Bank was firm and persuasive when arrangements proposed by the executing agencies threatened the quality of the project and/or the achievement of the PDO or GEO. The change of the verification system is illustrative of the former and the adoption of the single responsibility contract for procuring the wind farms in Shanghai is illustrative of the latter. The Bank also maintained strong fiduciary oversight throughout project implementation.

(c) Justification of Rating for Overall Bank Performance

Rating: Satisfactory

Given a satisfactory performance during preparation and a highly satisfactory performance during supervision, overall performance is rated Satisfactory.

5.2 Borrower Performance

(a) Government Performance

Rating: Moderately Satisfactory

The GoC's commitment to renewable energy started strongly and grew throughout preparation and implementation. It remained committed to the project concept and objectives even during the institutional rearrangements before restructuring and the transition of the project from SETC to NDRC. Nonetheless, it could have done more to avoid the need to restructure in the first place, especially had there been better cooperation between all the parties and could have reacted more quickly to the changed circumstances. The slow transition to NDRC delayed implementation of the PV and TI components. It coordinated and supported project closing well. Overall rating of government performance is judged to be just within the Moderately Satisfactory range.

(b) Implementing Agency or Agencies Performance

Rating: Satisfactory

Performance by SMEPC and SWPC was satisfactory. SWPC was established before project start. The transfer of the wind farm implementation responsibilities from SMEPC to SWPC after the separation of generation from transmission and distribution was carried out smoothly without delaying the procurement and construction of the wind farms. Both showed strong commitment to the project and cooperated with the Bank to identify and address the issues hindering implementation in a timely manner. Monitoring was carried out regularly and reported to the Bank. Transition to regular operations was smooth

The PMO's performance was satisfactory. It was established and started working before project signature. It quickly formed good working relations with and was highly rated by participating PV and TI companies and other concerned agencies. It made commendable efforts to develop a culture of quality and good service, established service standards and monitored those standards. It made good use of management tools including the MIS and its website for monitoring, guiding and managing the program. Fiduciary management was satisfactory. It disseminated knowledge through periodic newsletters, a website, numerous training and dissemination workshops and published two books: under REDP: “The Sun and Us” in early 2005 and “Run with the Sun” mid-2008. It managed the transition and closing of REDP well.

Participating PV companies were quite open to change, worked well with the small business expert to improve their management practices and were involved and proactive in adapting the TA components to meet their needs. TI companies were also proactive and inventive, and took well to the cost-shared approach to TI. Their performance was satisfactory.

(c) Justification of Rating for Overall Borrower Performance

Rating: Moderately Satisfactory

Taking into consideration the satisfactory ratings for all the implementing agencies, and that the performance of the Government falls within the moderately satisfactory range, a moderately satisfactory rating overall is warranted.

6. Lessons Learned

Take specific country circumstances into account when designing off-grid electrification. Lessons learned in other countries should be applied with caution. Analytical work conducted during the early stages of preparation should not be confined to market conditions, prices and affordability but should extend to technology options, market and growth analysis, the need for credit and implementation arrangements. Design of monitoring and evaluation should take into account practical implementation issues (Sections 2.2. 2.3 and 2.4).

Foster synergies between market and technology development. Empower the market participants through decision making; cost shared grants are particularly effective whether for technology development or market development. Ensure fair and transparent allocations in designing cost shared programs (Sections 2.2 and 3.2).

Adapt procurement method to implementing agency capacity and technology and provide adequate support. For wind farms, especially when knowledge of the technology has not taken root, single responsibility contracting methods are preferable. Include support from consultants well versed in international best practice in procurement and implementation (Sections 2.2 and 3.2).

Design TA programs to be flexible and responsive to changing circumstances. Consideration should be given to adapting TA as the project implementing agency skills and experience grows. Design the TA program so that changes can be implemented quickly. Avoid designs which require frequent amendment of legal agreements (Sections 1.8, 1.9, 2.2, 2.5 and 3.2).

7. Comments on Issues Raised by Borrower/Implementing Agencies/Partners

(a) Borrower/implementing agencies

Borrower has provided a completion report which for the wind component is summarized at Annex 7 and reproduced in full for the PV and TI component. The Borrower has had an opportunity to comment on the final draft version of this report and has no further comments.

(b) Cofinanciers

Not applicable.

(c) Other partners and stakeholders
(e.g. NGOs/private sector/civil society)

Not applicable

Annex 1. Project Costs and Financing

(a) Project Cost by Component (in USD Million equivalent)

Fully Blended Project				
Components[1]	**Appraisal Estimate (USD millions)**	**Estimate on Restructuring (USD millions)**	**Actual/Latest Estimate (USD millions)**	**Actual/Restructuring (%)**
Windfarm Investment	180.80	17.80	25.58[2]	144
Windfarm Institutional Strengthening	6.00	2.30	1.50	65
PV System Investment	106.50	106.60	91.60[2]	86
PV Market Development Program	7.00	7.00	3.34	48
PV Institutional Strengthening	4.00	4.00	1.96	49
Technology Improvement Investment	78.00	23.40	190.00[2]	812
Technology Improvement Institutional Strengthening	1.60	1.40	1.95	139
Total Baseline Cost	383.90	162.50	316.83	195
Taxes and Duties	26.40	22.82	-	
Physical Contingencies	10.40	1.22	-	
Price Contingencies	18.80	17.36	-	
Total Project Costs	439.50	203.90	316.83	155
IDC	3.70	1.42	0.31	22
Front-end fee IBRD	1.00	0.13	0.13	100
Total Financing Required	444.20	205.45	317.27	154

[1] Cost categories based on the PAD breakdown.

[2] Includes taxes, duties and contingencies

(b) Financing

Fully Blended Project

Source of Funds	Type of Financing	Appraisal Estimate (USD millions)	Estimate on Restructuring (USD millions)	Actual/Latest Estimate (USD millions)	Actual/Restructuring (%)
IBRD	Lending	100.00	13.00	12.94	100
GEF	Grant	35.00	27.00	26.86.	99
Sub-borrower (SPCC/Power Cos)	Equity	43.50	10.20	5.31	52
Borrowing Country's Financial Intermediaries	Lending	112.10	-	8.21	-
PV, TI Companies and End Users	Equity	151.50	137.25	263.95	192
GoC (SETC)	Lending	2.00	18.00	-	-
Total		444.20	205.45	317.27	154

Note: financing components based on the categories used on restructuring.

Annex 2. Outputs by Component

A. WIND COMPONENT

Wind Farms

The component financed a total of 21MW of wind generation capacity, on two sites. On the Nanhui site, 11, 1.5MW wind turbines including their towers and foundations were installed, together with wind farm electrical and control cabling, a control room, offices and accommodation for wind farm staff and a switchyard and connection to the local electricity grid. The Chongming wind farm of 3, 1.5MW wind turbines consisted of a similar installation to that at Nanhui.

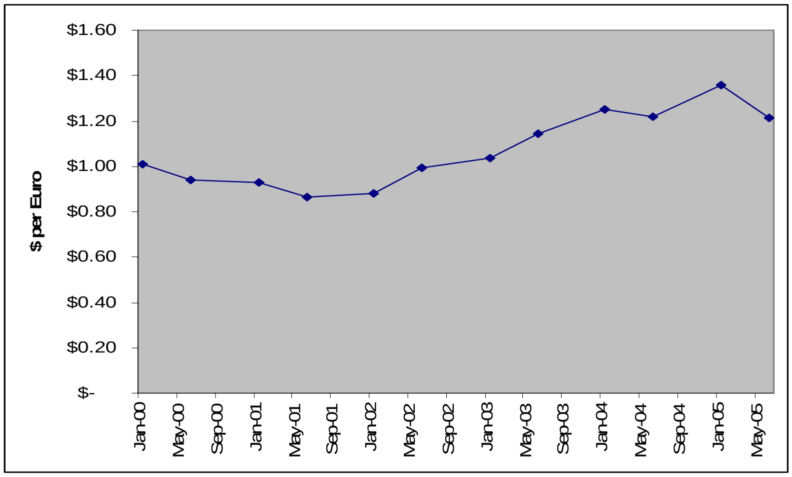
Following rolling commissioning of each turbine as soon as it was installed and connected, the wind farms entered commercial operation on December 1, 2005. Some teething troubles were encountered with the wind turbines, with one suffering from misalignment of the gearbox and generator which necessitated remanufacturing the generator. All gearbox oil cooling systems were retrofitted with extra heat exchangers following initial gearbox overheating.

In the first year of operation (to November 2006), the wind farms produced 39.9 GWh. Because of year-on-year variations in wind, it is too early to tell whether the long term average annual production will equal the planned level of 42GWh. Wind turbine availability was 98.3 percent (compared with the warranty value of 97 percent) and at 99 percent of the theoretical power curve (compared with a warranty value of 97 percent).

Installed cost was $1,264/kW, almost exactly half way between that estimated at appraisal ($1,350/kW) and the estimate at restructuring ($1,160). Wind farm costs varied significantly over the project period as the combined effects of the increase in demand worldwide for wind turbines created shortages of supply. In China wind turbine prices increased by about 50 percent between 2004 and 2007[1] while the Euro: US dollar exchange rate fluctuated markedly between 2001 and 2003 (see figure A2.1), of significance given that cost estimates were made in US Dollars and Chinese Yuan (which was pegged to the US Dollars) while wind turbines are largely produced in the Euro zone and priced in Euros.

[1] Windpower Monthly May 2008

Figure A2.1: US $: Euro Exchange Rate January 2000 – June 2005



At its lowest point, when turbine costs were about $600/kW in China in 2002-2003, an 'average' wind farm cost would have been about $860/kW, taking the normal benchmark of turbine costs being 70 percent of total wind farm costs. That the Shanghai wind farms did not reach this low point is in part due to the timing of the procurement – prices had started to increase as a result of the increase in the value of the Euro – and in part because of the unusual soil conditions in Shanghai, causing turbine foundation costs to be higher than for normal wind farms.

Technical Assistance

Eight discrete technical assistance activities were planned, of which four were fully completed and three partially completed. One activity was dropped.

Development of financial management system. It was planned to support the development of a financial management system for SWPC. SWPC financed this activity itself, so this activity was dropped and the budget was reallocated to the communications and outreach package.

Operations and management support. The purpose of this activity was to help SWPC develop its operations and management systems and standardize them. The technical assistance supported visits to other wind farms in China and hiring consultants to assist in the compilation of procedures. The procedures were prepared and adopted by SWPC.

Wind resource assessment in Shanghai. The technical assistance supported rehabilitation of existing wind measurement equipment or the procurement of new equipment sufficient for eight sites. Consultants were hired to collect and analyze the data, establish which sites were suitable for wind farms, and prepare optimization studies for those sites where wind farms were feasible. Based on this work, Shanghai municipal government adopted a plan to develop 310MW of wind by 2010.

Effects of windpower on the grid. This activity aimed to establish the maximum level of wind power that could be accepted by the grid without jeopardizing system stability. The evaluation demonstrated that in the short term 300MW could be accepted, and that up to 1,000MW would be possible by 2020.

Communications and outreach. The purpose of this package was to broaden knowledge of wind energy, particularly among school and university students. It financed several of the exhibits at a visitor and education center constructed at the Nanhui site. By project closing, some 46,000 people had visited the center, including nearly 30,000 school and university students, and the center had won an award in 2006 for the best specialist education center. Linked to the education center was funding for information dissemination and the establishment of a website. The website had not been completed at project closing.

Study tour. Early in the project implementation phase, senior staff from SMEPC and SWPC attended a study tour in Europe and the US, which focused on best practices in procurement and construction of wind farms. This was particularly valuable as SWPC subsequently adopted a procurement approach based on supply and installation and bid evaluation using whole life costs which has been replicated for two other wind farms financed by the Bank.

Project management. One part of this was to provide international consultant assistance to SWPC during procurement, and to support its supervision of the contractor during construction and commissioning of the Nanhui and Chongming wind farms. This activity was successfully completed. The second part was intended to support a scoping study for offshore wind in the Shanghai area, but although terms of reference were agreed and a consultant selected, the study was never carried out.

Optimization of foundations. Soil conditions in Shanghai are particularly difficult and the foundations for the wind farms at Chongming and Nanhui had cost considerably more than budgeted. A study was thus conducted to review the foundation options, with particular emphasis on more economical designs.

B. PV COMPONENT

More than two million people in western China have been provided with access to modern electricity services through PV systems. Sales are concentrated in Tibet, Qinghai, Sichuan and Xinjiang (Figure A2.2). Total PV systems sales reported by the PV companies exceeded 500,000 with REDP-verified sales exceeding 400,000 units with an aggregate capacity of 11.1 MWp compared with a goal of 350,000 units with a capacity of 10 MWp (Figures A2.3 and A2.4).

Figure A2.2: Regional distribution of PV sales

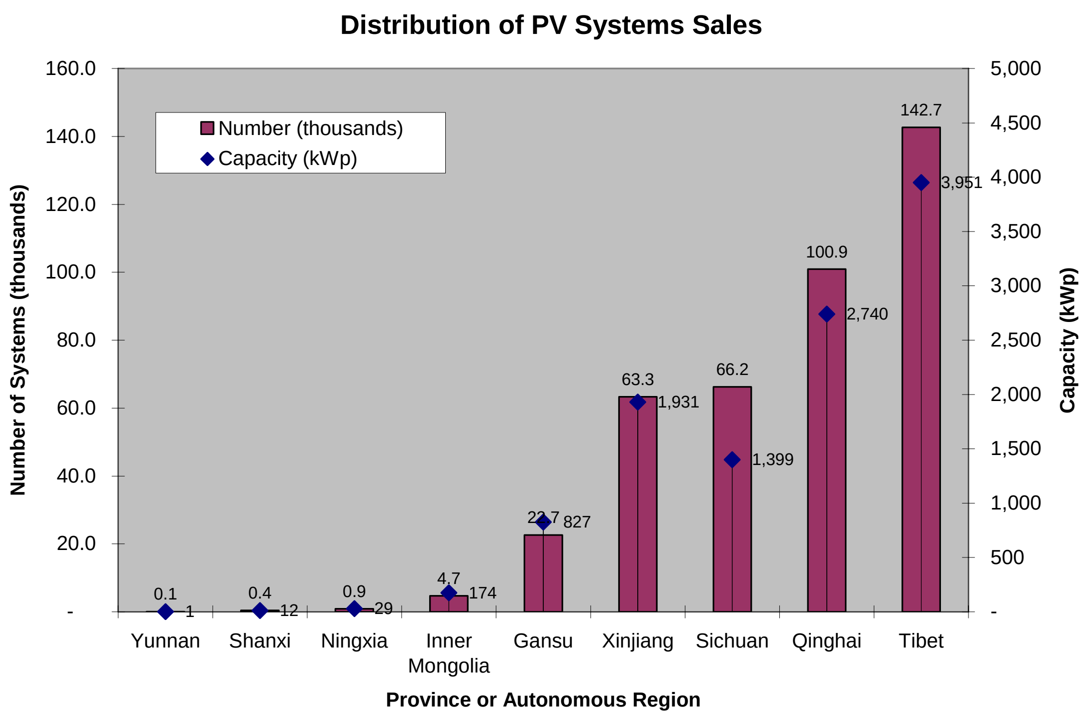


Figure A2.3: Cumulative PV Sales by Number

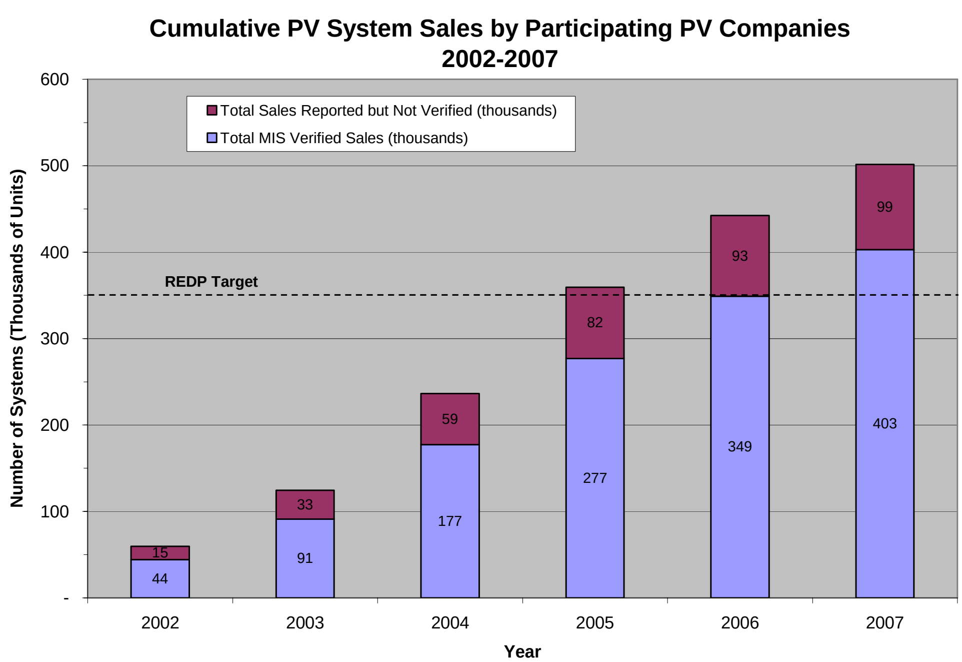
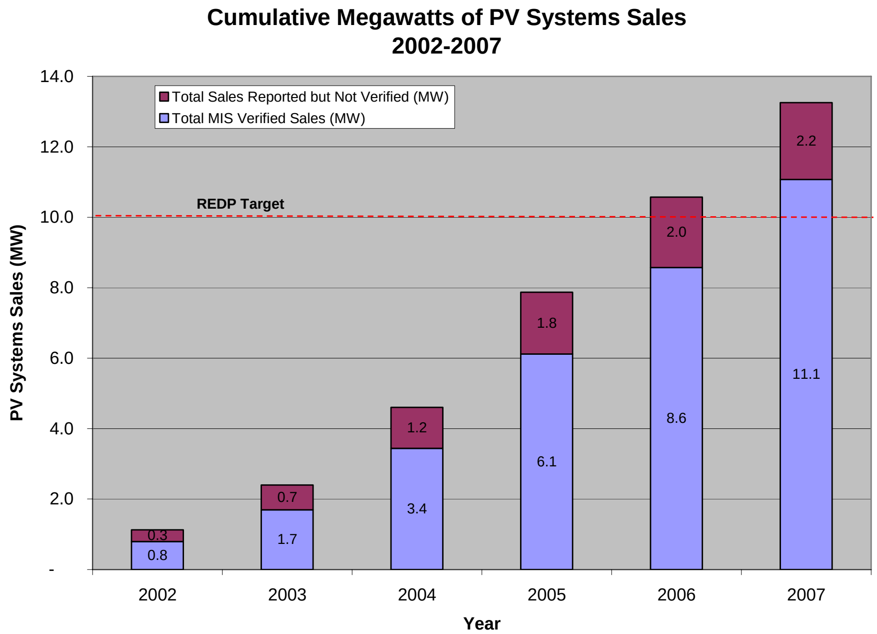


Figure A2.4: Cumulative PV Sales by Capacity



Twenty eight PV companies actively participated as retailers of PV systems with manufacturing and systems integration facilities and extensive distribution networks reaching to the remotest parts of north western China. PV sales revenues by company estimates grew more than four-fold; employment and distribution networks doubled. Annual sales grew from about 40,000 units in the first year of the project, peaking at 100,000 by mid-term and declining to 80,000 in 2007 (due to PV module supply constraints). Total sales of systems and average costs by year is shown in Table A2.1

Table A2.1: Annual PV System Sales and Costs

	Sales		PV system costs	
	annual Wp	cumulative MWp	per year US$	cumulative US$
2002	0.80	0.80	6.6	6.6
2003	0.90	1.70	7.5	14.1
2004	1.73	3.43	14.3	28.4
2005	2.68	6.11	22.2	50.6
2006	2.45	8.57	20.3	70.9
2007	2.50	11.07	20.7	91.6

An examination of seventeen of the most active participating PV companies found that:

- Revenues grew 363 percent from 2002 to 2007 to Y225 million while sales in MWp expanded 651 percent from 0.9 MW to 6.6 MWp (indicating a significant reduction in costs or reluctance of companies to share actual revenue data);
- Employees more than doubled from 378 to 843 and number of retail outlets tripled from 266 to 721;
- High competition (market share of the top four companies was 37 percent), continues to keep margins low at about 13 percent and innovations high; and

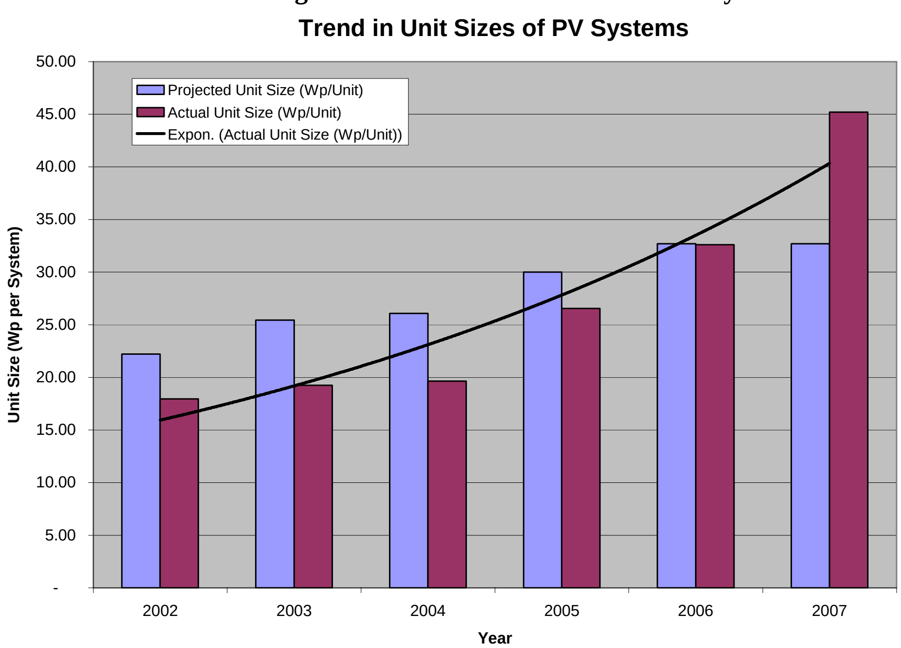
- 14 companies invested in new and expanded factories and offices with factory premises more than doubling to 12,000 m^2 and office space increasing 50% to 6,000 m^2.
- At least 13 of the 28 companies have invested in small PV module laminating plants as a way to secure access to module supplies, control costs and capture more margins along the supply chain. However, as PV module manufacturing is now a commodity business with significant economies of scale, the viability of these small module lines is questionable.

China is the world's third largest manufacturer of PV modules with production capacity of over 2,800 MWp a year compared with 10 MWp in 2000. Actual production in 2007 was 1,088 MWp of PV. Ten of the Chinese PV companies are listed on the New York and London stock exchanges with a market capitalization of over US$24.4 billion on May 15, 2008.

Exports of modules and systems are growing. Companies are undertaking aggressive international marketing (at the 2007 European PV Industry Exhibition, Chinese companies had the third highest number of exhibitors, and at the May 2008 Lighting Africa Conference in Accra Ghana, 30 companies exhibited their off-grid lighting products). They have so far, won Bank financed procurements in, Lao PDR Mongolia and Papua New Guinea.

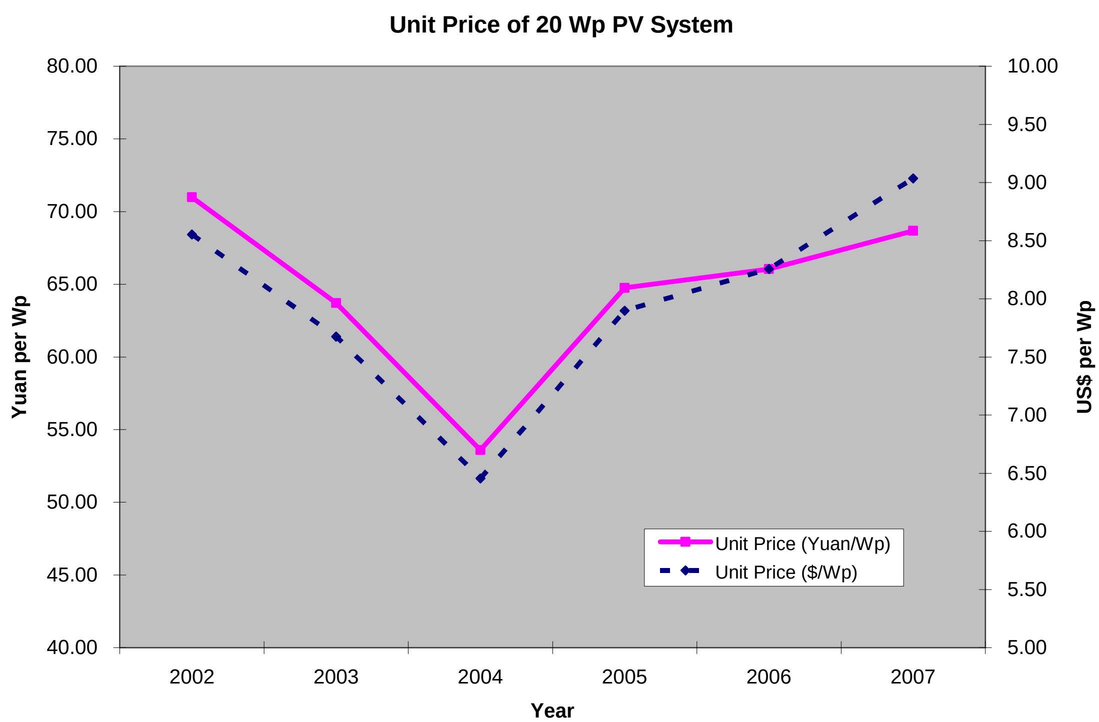
Consumer confidence coupled with increasing incomes and higher expectations is reflected in the steady rise of the average size of PV systems purchased. After the first three years of REDP where the average system size hovered around 20 Wp, it has steadily risen to 45 Wp in 2007 Figure A2.5). For details of user responses, see Beneficiary Survey Results section, later.

Figure A2.5: Trend in Unit Size of PV System



Average unit cost in Yuan declined up to 2004 and then rose due to PV module supply constraints and price increases of batteries and other components due to *the global surge in commodity prices*, as well as companies beginning to supply PV modules that meet the higher quality standard (which was expected to add about $0.50/Wp or about a 12% increase in module prices or 6% system price increase). The unit cost of a representative 20 Wp system declined to Y54/Wp in 2004 and then rose 30 percent to Y69/Wp. The 2007 unit price in dollar terms is $9/Wp, compared with $16/Wp before the project, partly due to dollar depreciation (Figure A2.6).

Figure A2.6: Trend in Unit Retail Price of 20 Wp PV System



C. TI COMPONENT

The TI Component included:

- Providing grants, on a cost sharing basis, from the Competitive Grant Facility (CGF) and the Quick Response Facility (QRF) for technology improvement investments proposed by PV component and system manufacturers to improve the quality of their products.
- Funding activities initiated by the PMO for training, awareness, advisory activities, information dissemination, and comparative performance tests of components and systems. These activities were funded through the TI Program Support Facility.

The CGF and QRF

The CGF issued a request for proposals each year specifying (i) the type of priority projects targeted that year; (ii) the available budget; (iii) the standard proposal format; and (iv) the eligibility and the evaluation criteria. Proposals were evaluated, ranked and funded top-down up to the available budget.

The Quick Response Facility (QRF) used a similar approach without request for proposals. Interested manufacturers could submit proposals at any time, using a simplified standard application form. Proposals were evaluated in the order in which they were received.

The indicators to measure the success of the TI subgrants, as mentioned in the revised PAD, are given in Table A2.2. The number of cost shared TI projects carried out was slightly less than projected. The number of projects that met the contract targets, as assessed by the PMO, was substantially higher that projected.

Table A2.2: Revised PAD Indicators

	End of Project Projected	End of Project Actual
Number of cost shared projects for technology improvement	200	197
Share of proposals of which contract targets have been met	80%	95%

The CGF was competitive and selective. Table A2.3 shows that only 48.6 percent of the submitted proposals were selected for support and that only 28.5 percent of the requested TI grant amounts were approved. The CGF was by far the most competitive sub-grant facility.

Table A2.3: Approval Rates CGF Projects

Tender Round	Number of Proposals Received	Total TI Grant Requested ($)	Number of Projects Approved	Share (%)	Total TI Grant Approved ($)	Share (%)
CG 2002	28	1,188,706	14	50.0	314,286	26.4
CG 2003	43	1,723,385	30	69.8	707,071	41.2
CG 2004	118	4,667,900	47	39.8	1,076,429	23,1
CG 2005	101	3,155,514	50	49.5	961,484	30.5
Total	290	10,735,505	141	48.6	3,059,270	28.5

The TI grant disbursements are given in Table A2.4. The actual numbers are marginally different from the projected numbers as mentioned in the grant agreements. The actual proven eligible total project cost is 4.5 percent lower than the estimated project cost and the actual TI grant paid is 3.0 percent lower than the approved TI grant. The REDP cost share was about 30 percent, well below the allowable maximum of 50 percent. For every $1 TI grant, beneficiaries invested $2.32 in technology improvement.

Table A2.4: TI Grant Disbursements

	Number of Projects	Total Project Cost Planned $	Total TI Grant Approved $	Share	Actual Proven Eligible Total Project Cost $	Actual TI Grant Paid $	Share
CGF-2002	14	1,236,571	314,286	25.42%	852,379	304,286	35.70%
CGF-2003	30	3,065,771	707,071	23.06%	2,943,026	696,904	23.46%
CGF-2004	47	3,390,027	1,076,429	31.75%	3,204,938	1,019,486	31.81%
CGF-2005	50	2,707,396	961,484	35.51%	2,999,903	941,989	31.40%
CGF-Total	141	10,399,765	3,059,270	29.42%	10,000,246	2,962,665	29.63%
QRF-2002	11	350,286	117,943	33.67%	369,646	112,836	30.53%
QRF-2003	2	48,671	22,857	46.96%	37,219	18,592	49.95%
QRF-2004	11	353,167	108,504	30.72%	346,960	108,504	31.27%
QRF-2005	11	320,883	96,487	30.07%	250,867	96,487	38.46%
QRF-2006	21	508,137	146,974	28.92%	436,655	146,817	33.62%
QRF-Total	56	1,581,144	492,765	31.17%	1,441,347	483,236	33.53%
TI-Total	197	11,980,909	3,552,035	29.65%	11,441,593	3,445,901	30.12%

(Exchange Rate: 7 RMB/$)

Based on disbursement data, average project size is given in Table A2.5.

Table A2.5: Average Project Size

	Number of Projects	Average Actual Total Project Cos ($)t	Average Actual TI Grant Paid ($)
CGF-2002	14	60,900	21,700
CGF-2003	30	98,100	23,200
CGF-2004	47	68,200	21,700
CGF-2005	50	60,000	18,800
CGF-Total	***141***	***70,900***	***21,000***
QRF-2002	11	33,600	10,300
QRF-2003	2	18,600	9,300
QRF-2004	11	31,500	9,900
QRF-2005	11	22,800	8,800
QRF-2006	21	20,800	7,000
QRF-Total	***56***	***25,700***	***8,600***
TI-Total	**197**	**58,100**	**17,500**

The participating TI companies can be divided into three groups:

- Provincial market driven companies. Usually located in the western provinces and close to the rural PV market, they used the TI grants to improve the design and the quality of their products to meet the more stringent standards and adapt them to the needs of more demanding customers in the market.

- National technology driven companies. Located in the eastern provinces around Beijing, Shanghai and other major cities, they used the grants to bring the quality of their products up to national standards and participate in government and bilateral donor supported programs.
- Export oriented companies. These companies used the TI grants to introduce innovation and bring their products up to international standards with focus on exports to fast growing PV markets in Europe, Japan and the US.

Based on analysis of the 81 TI supported projects for which fact sheets have been produced and for which sales data was available[2], ninety-five percent of the projects produced the intended outputs. Sales of a selection of products developed under the TI grants are:

- 3.2 million DC lights.
- 21,000 PV systems of various sizes.
- 75,000 PV controllers for systems of various sizes.
- 18,000 integrated controller and inverter systems.
- 550 Wind/PV hybrid systems.
- 9500 improved small wind turbines.
- 900,000 m^2/year EVA, 1 ton aluminum paste, and 1.4 ton silver paste for module manufacturing.
- 115 PV module laminators.
- 45 solar simulators.
- 1500 monitoring devices for wind/PV hybrid systems.
- 3 PV array testers.
- 25,000 LED systems.
- 200 kWp PV concentrator cells.

The TI subgrants also supported 23 testing and certification projects and contributed to increasing awareness on the importance of quality and on the need to provide consumers information on quality aspects.

Many QRF projects contributed to technology improvement. Still, the QRF did not work as intended. Projects proposed were not always urgent with short term impacts and the evaluation and contracting process and implementation time were lengthier than envisaged. The QRF ended up supporting small size projects but similar in nature to the ones funded by the CGF.

Loans to Support Technology Improvement Projects

A concern during preparation was that TI companies would not be able to obtain capital to invest in production of the innovations financed by the TI cost shared grants. Consequently, an SETC financing facility was agreed but never implemented. Although no financing was available under REDP, at mid term, it was found that at least $187

[2] Some sales data is from 2005, and so final numbers are probably higher

million had been invested by TI subgrant beneficiaries (from their own resources or bank loans), which was over 12 times the amount originally targeted. The indicator was not subsequently monitored.

TI Program Support and Institutional Strengthening

Other quality improvement activities under REDP were carried out both under the TI Program Support Facility and the Institutional Strengthening sub-component of the PV component. They were initiated and managed by the PMO to assure the quality of PV systems eligible for the GEF subsidy while the quality improvement activities under the TI component were intended to improve the quality of all PV components and systems available in the Chinese market, with special focus on those manufactured in China.

There were four groups of activities under REDP to guarantee the quality of systems supported by the project. These were (i) standards; (ii) approved components list; (iii) enforcement of standards; and (iv) training and awareness creation.

Standards

REDP project standards were discussed and prepared during preparation and agreed during negotiations. They were based on standards used in other World Bank projects and national standards and international standards. The quality level chosen was high enough to guarantee a minimum quality without excluding suppliers with potential for improvement. The Standards Committee established during the project preparation continued to work during implementation and was instrumental in modifying existing and developing new standards. Certified testing laboratories were selected to ensure compliance with project standards. Technical assistance was provided to these laboratories to further strengthen their capabilities.

The Standards Committee also worked on the development of national standards for PV systems and components, adopted by China in 2003 as GB9535-1998. The new national standards were more stringent than those of REDP. REDP adopted them, with some small exceptions, for disbursement of the grant.

Approved Components List

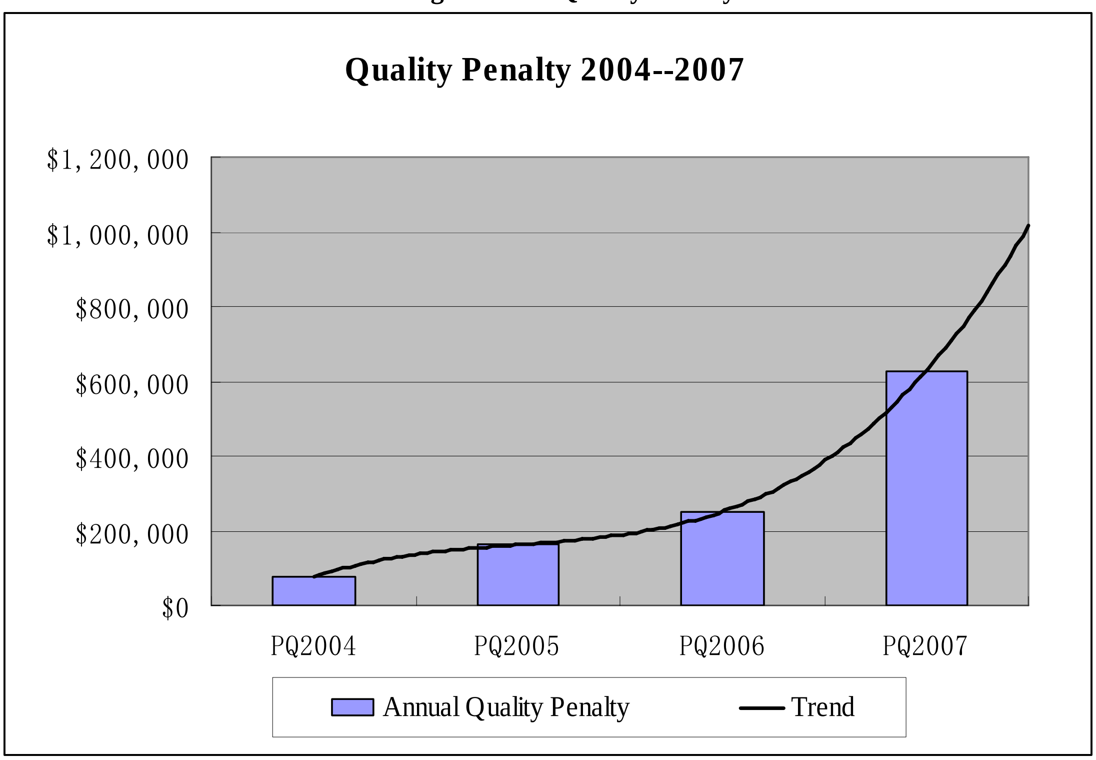
To control the quality of PV components used in systems supported by REDP, the PMO established and maintained an Approved Components List based on quality tests carried out by the selected testing laboratories. REDP participating PV companies could access the GEF subsidy only for PV systems using components from on the Approved Components List. Eligibility to the subsidy was later extended to components with recognized international certification such as ISO9000 certification. Components that were found not to meet project requirements during one of the many component tests conducted during the implementation of REDP (especially the last three years) were taken from the Approved Components List.

Enforcement of Standards

To enforce the standards and quality related rules, the PMO tested samples of the systems for which a GEF subsidy was paid. The inspection of systems sold to the end users proved significantly more difficult than expected. It was very costly and time-consuming, especially for nomadic end-users and those living in remote and sparsely-populated areas. After a number of trials with disappointing results this approach had to be abandoned and replaced by an inspection during unannounced visits to sales agents and factories and testing of randomly chosen samples in the selected laboratories to ensure compliance with the required technical and quality standards. Over the implementation period, the PMO conducted five of these surveys. Based on the surveys PV companies and PV component manufacturers, the PV companies were penalized by reducing their PV subgrant. PV component manufacturers were penalized by removing their components from the REDP approved components list.

A total of $1,118,000 was deducted from the PV subgrant entitlement because of quality control problems. Figure A2.7 depicts the financial penalties imposed on participating PV companies from 2004 to 2007. The system component with most problems was the charge controller.

Figure A2.7: Quality Penalty



Training and Awareness Creation

The results of the REDP quality surveys conducted by the PMO in 2004 and 2005 showed that some participating PV companies and component manufacturers did not completely understand the REDP and national SHS technical standards. In some cases, the tests conducted in the laboratories gave results quite different from the companies own test results because of inadequate calibration of testing equipment and insufficient knowledge on PV quality control and testing processes.

To address this, the PMO organized a PV Component Testing training seminar for the companies which products did not to meet the REDP quality standards. In addition to the seminars, the PMO sought to increase quality awareness through quarterly newsletters, hand-outs and the REDP website. For instance, the approved component list was printed on the back page of the newsletters to assist PV companies decide where to buy components. To increase awareness among end-users and other stakeholders, the PMO published brochures and reports on PV technology, systems and components and on quality related issues.

The PMO and World Bank staff and consultants carried out field visits to the project provinces throughout the implementation of REDP. They visited PV companies, PV component and system manufacturers, markets, trade fairs, testing institutions and end-users.

Quality related issues were discussed during the annual REDP summary meetings at a dedicated session which participating PV companies were required to attend. During the discussion, the results of tests and measures taken by the PMO were presented. The companies provided feedback which was used to improve quality supervision.

Upgrading Testing Laboratories

Upgrading of PV component testing laboratories was started during preparation of REDP and continued during implementation. During project preparation, four testing laboratories were identified to undertake tests according to the project technical requirements. Two of them were PV module testing laboratories, one battery, controllers and inverters testing laboratory and one DC lights testing laboratory. During implementation, the PMO supported capacity building of the testing laboratories through training, access to international best practice and in some case state of the art hardware. In addition, testing laboratories could apply, on a competitive basis, for CGF funding to strengthen their capabilities

Testing laboratories which received support from the project include:

- PV Module Testing Laboratory
- Testing Laboratory for Controllers and Inverters
- PV System Testing Laboratory
- DC Light Testing Laboratory
- PV Battery Testing Laboratory

Two cases illustrate the support provided by the project for testing laboratories.

The main PV Module Testing Laboratory supported by the project was the Tianjin Institute of Power Source (TIPS) which received testing equipment and training. TIPS was accredited by the national accreditation organization, according to ISO/IEC 17025, to perform the tests according to GB9535-1998, which is equivalent to IEC 61215-1993. In addition, in September 2006 TIPS was accepted by Underwriters Laboratories (UL) of the US as a third party to perform tests according to IEC61215-2005. TIPS has thus been established as a PV module testing laboratory of international caliber, able to perform tests according to UL 1703, IEC 61730-1 and IEC 61730-2.

> Quote from TIPS: Before 2005, there were only a few module manufacturers in China. Our testing capacity was quite limited, and we could only conduct electrical performance tests. With the support of REDP we have, since 2006, conducted tests not only for more than 200 domestic module manufacturers but also for foreign manufacturers. Well-known manufacturers such as Wuxi Suntech, NEPV, Changzhou Trina, and Solarfun are now our customers.

During preparation of REDP, the Post and Telecommunication Industry Products Quality Surveillance and Inspection Center under the Ministry of Information Industry (PTPIC) was selected for testing controllers and inverters according to the project standard. In 2006, the PMO supported PTPIC through the Competitive Grant Facility to further strengthen its testing capabilities. The impact of the REDP support, according to PTPIC is given in the Table below.

Before upgrading	**After upgrading**
1. Unable to perform tests on the maximum power point tracking (MPPT) characteristics of charge controllers. 2. Unable to perform tests on system efficiency and power generation. 3. Unable to perform tests on batteries operating in a PV system. 4. Unable to perform tests on controllers for small wind turbines or PV-wind hybrid systems.	1. Equipment installed to test controllers and inverters in stand-alone and grid-connected PV systems, wind turbines and PV-wind hybrid systems. 2. Test procedures in place, in accordance with national and international standards, for controllers and inverters installed in the above systems. 3. Able to test any type of controller, inverter or integrated controller and inverter. 4. Obtained ISO/IEC 17025-2005 accreditation for controller, inverter and system tests.

Annex 3. Economic and Financial Analysis

This Annex summarizes analyses undertaken upon completion of the two components. The wind farm component was completed in mid-2006 while the PV component was completed in early 2008.

WIND FARMS

After restructuring only the two wind farms in Shanghai were financed: one at Nanhui (11 x 1.5MW), the other on Chongming Island (3 x 1.5MW). Key assumptions for appraisal and completion are shown in Table A3.1. TA financed by the GEF grant has not been included in this analysis on the grounds of its relatively small size ($1.5 million, or 5% of total cost). The benefits from the TA not related directly to the Shanghai wind farms are widely dispersed, so making analysis quite infeasible.

Table A3.1: Key Assumptions, Appraisal v. Completion

		At appraisal	At completion	
Exchange rate	Y/$US	**8.3**	8.28	
Nanhui				
Annual average wind speed @50m	[m/s]	7.8	5.46	actual 2006
Number of turbines	[ ]	10	11	
Turbine size	kW	600	1.5	
Installed capacity	MW	6	16.5	
Capital cost (1)	Y million	63.29		
	$/kW	1271		
Chongming				
Annual average wind speed @50m	[m/s]	7.8	6.34	actual 2006
Number of turbines	[ ]	24	3	
Turbine size	kW	600	1.5	
Installed capacity	MW	14.4	4.5	
Capital cost (1)	Y million	150.55		
	$/kW	1260		
Combined				
Total energy	[GWh]	44.6	39.9	
Load factor	[GWh]	25.0%	21.7%	
Total MW	[MW]	20.4	21	
Total	Y million	213.84	211.8	BCR June 20076
Less taxes	Y million	4.26	[?]	
Total economic cost (overnight)(2)	Y million	209.6	197	
Fixed O&M cost – percent of capital cost	[ ]	1.5%	3.9%	calculated
Fixed O&M cost - value	Y million	3.1	8.49	June 2006
Total $/kW (completed cost, including taxes)	[$/kW]	1263	1264	
Tariff	Y/kWh		0.897	

(1) financial cost, as per feasibility study
(2) as stated by BERI for the economic analysis

Economic Analysis

The economic analysis at appraisal was conducted in two steps: (a) a least-cost study to determine under what conditions wind farms were part of the optimal generation mix; and (b) a cost-benefit analysis and risk assessment. In both steps, the analysis was done with and without estimated local and global environmental costs of thermal power development.

The Shanghai wind farms were *not* selected as least-cost alternatives, even with consideration of both local and global externalities. As shown in Table A3.2, even when local and global externalities were included as benefits, the ERR was below the hurdle rate of 12%.

Table A3.2: Economic Rates of Return at Appraisal

	ERR	NPV $ (1998)Million
Base case (no externalities)	5.0%	-7.4
With local externalities	7.6%	-4.7
With local and global externalities	8.4%	-3.9

Source: PAD, Annex 6, p.59

At appraisal the benefits of wind power were assessed at the average generation tariff, plus estimates of the avoided local and global environmental damage costs. Now that the Jade 'green' electricity scheme is in place, the economic analysis can make use of the best possible indicator of economic benefits, namely the consumer's *actual* willingness-to-pay (WTP) for wind electricity. Total sales under the Jade electricity scheme are shown in Table A3.3.

Table A3.3: Jade Electricity Sales

Consumer Category	Total sales	Green sales	
	[GWh]	[GWh]	[ ]
Residential	11222	0.9	0.01%
Commercial	14666		
Industrial	46997	8.6	0.02%
Total	72885	9.5	0.01%
Wind farm		39.9	
Green Sales as % of wind farm		23.8%	

It follows that the WTP of consumers purchasing green electricity is the sum of the green tariff and the non-green tariff (Table A3.4).

Table A3.4: WTP, Y/kWh

	Non-green average tariff	Green tariff	total WTP
Residential	0.67	0.53	1.20
Industrial	0.60	0.53	1.15

Adjustment of this benefit estimate for incremental network capacity costs is not required. There is no reason to suppose that the Nanhui and Chongming wind farms incur higher transmission capacity costs than if an equivalent fossil plant were built elsewhere. Indeed, the wind farms are closer to the load centers than several of the other generating plants that serve Shanghai, and may therefore even warrant a network capacity credit. Any such network capacity credit would be offset by a generation capacity penalty, given the non-dispatchability of wind power. These may be assumed to offset each other, and are not therefore considered in the economic analysis.

On the other hand the analysis should adjust for the energy losses in transmission and distribution. In the absence of estimates of the LRMC and losses by voltage level, the following assumptions are made:

- Average transmission losses to high voltage industrial consumers: 4%
- Average transmission & distribution losses to low voltage residential consumers: 11%

The detailed breakdown of project expenditures does not identify the sources and uses of funds during construction, including breakdown of local and foreign costs, IDC and VAT on construction outlays. Consequently it is difficult to estimate the economic cost of the project (i.e., excluding taxes and IDC). Nominal rates of VAT are rarely incurred in practice, and the terms and conditions of the domestic loan are not known. As a result, it is assumed that taxes and duties, VAT and IDC make up 7.5% of the total financial investment cost of Y211.8 million. This makes the estimated *economic* capital cost Y197 million.

Table A3.5 shows operating costs as stated in the 2006 financial report as compared with the June rolling financial plan which underlines that actual operating costs in 2006 were significantly greater than forecast in the rolling plan. The extent to which some of the operating costs were incurred in connection with an ongoing wind farm expansion at Chongming is not clear.

Table A3.5: Operating Costs, Y million

	June 2006 financial plan	2006 actuals (from financial report)
Salary and welfare	1.7	
Cash paid to and behalf of employees		2.8
Miscellaneous	3.5	

General and administrative expenses		3.52
Cash paid for goods and services		4.62
Taxes paid		5.75
Income tax	8.9	

The resulting economic analysis in shown in Table A3.6, under the assumption that the energy production in 2006, 39.9 GWh, is representative of the long-term average.[3] The economic rate of return, without consideration of avoided carbon externalities, is 12.9%, substantially better than the corresponding figure at appraisal of 7.6%. On the other hand, if the wind farm output is valued at the avoided cost of coal generation (estimated at about Y0.5/kWh), the ERR falls to 0.7%, worse than the appraisal estimate of 5%. With the additional benefit of avoided GHG emissions (estimated to be 37,150 tons per year at $15/ton CO_2 – See Annex 7), and under the plausible assumption that wind energy displaces coal generation, the ERR increases to 15.2%.

Since the project output is valued at the Jade tariff (for green sales) and the PPA for non-green sales, the economic returns may be argued to be internalizing the avoided local environmental damage costs of coal generation, so the use of a further environmental damage cost adder (for example using the data taken from the appraisal analysis) would double count.

Financial Analysis

The classic World Bank methodology for estimating financial returns is to add to the economic flows taxes, duties and transfer payments, but maintaining the cost of capital at the discount rate, i.e., estimate a financial return independent of the capital financing structure (the so-called project return, rather than the investors return to equity). As shown in Table A3.7, the financial returns are slightly lower than the economic returns, at 9.5 percent.

This analysis assumes the figures from the rolling financial forecast made in the last year of the project (2006 for the following eight years). That forecast assumed production of 42 GWh/year, as determined by the feasibility study. Limited information about SWPC's debts and restructuring (the World Bank loan was refinanced in 2005-2006) makes comparison of the project financial return with the weighted average cost of capital difficult. However, that this restructuring was successfully achieved in the face of further wind farm expansion suggests that the project is financially feasible. The borrower's completion report also notes that SWPC will seek CER sales to further enhance revenues.

3 If one uses the long term average of 42 GWh as estimated in the feasibility studies, the ERR increases by about 1.4%.

Table A3.6: Summary of Economic Analysis

			NPV	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Costs														
Capital costs		[Ymillion]	*157*	197.0										
Operating costs		[Ymillion]			8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7
GEF TA		[Ymillion]		4.9										
Total costs		[Ymillion]	*213*	201.9	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7
Energy balance														
Energy @windfarm		[GWh]	*236*		39.6	39.6	39.6	39.6	39.6	39.6	39.6	39.6	39.6	39.6
green sales		[GWh]	*56*		9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
of which Industrial consumers		[ ]			91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%
		[GWh]	*51*		8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6
adjusted for transm. loss	4.0%	[GWh]	*53*		9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
residential		[GWh]	*5*		0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
adjusted for transm. loss	11.0%	[GWh]	*6*		0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
hence sales at PPA		[GWh]	*177*		29.7	29.7	29.7	29.7	29.7	29.7	29.7	29.7	29.7	29.7
Benefits														
industrial sales@green tariff	1.15	[Y/kWh]												
		[Ymillion]	*59*		9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9
residential @green tariff	1.20	[Y/kWh]												
		[Ymillion]	*6*		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
benefits at PPA	0.897	[Y/kWh]												
		[Ymillion]	*157*		26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4
total benefits		[Ymillion]	*222*		37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
net economic flows		**[Ymillion]**	***9***	**-201.9**	**28.5**	**28.5**	**28.5**	**28.5**	**28.5**	**28.5**	**28.5**	**28.5**	**28.5**	**28.5**
ERR		[ ]		12.9%										
Carbon	15	[$/ton]												
KgC/kWh	0.85	[millionKg]			33.7	33.7	33.7	33.7	33.7	33.7	33.7	33.7	33.7	33.7
		[USmillion]			0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
avoided carbon benefits		[Ymillion]			4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
economic flows (incl.GHGbenefit)		**[Ymillion]**		**-201.9**	**32.7**	**32.7**	**32.7**	**32.7**	**32.7**	**32.7**	**32.7**	**32.7**	**32.7**	**32.7**
ERR		[ ]		15.2%										

Table A3.7: Financial returns (based on Rolling Plan, 42 GWh)

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Benefits at tariff									
Revenue from sales		3154	3154	3154	3154	3154	3154	3154	3154
Allowance		268	268	268	268	268	268	268	268
Total revenue		3422	3422	3422	3422	3422	3422	3422	3422
Costs									
Maintenance costs		0	0	0	329	329	329	329	329
Salary and welfare		170	170	170	170	170	170	170	170
Sales surtax		13	13	13	13	13	13	13	13
Income tax		89	93	110	78	90	104	114	121
Miscellaneous expenses		350	350	350	350	350	350	350	350
Total expenses		622	626	643	940	953	967	977	983
Capital cost	21790								
Financial flows	-21970	2800	2795	2779	2482	2469	2455	2445	2439
FIRR	9.5%								

The entry for “allowance” is in fact a rebate of VAT, namely 50% of the VAT levied on sales, which the Government provides as an incentive to renewable energy producers (this is a transfer payment, and does not therefore appear in the *economic* analysis). The revenue entries from sales shown in Table A3.7 (as well as other tables in this annex) are net of VAT

PV AND TI COMPONENTS

The allocation of REDP funds to the various project activities is shown in Table A3.8. From the perspective of economic analysis, the PV sub-grants ($15million) are a pure transfer payment (from GEF to the PV system companies).[4] However, all of the remaining ("non-grant") expenditures represent real economic costs that need to be accounted for in the economic analysis.

Table A3.8: Allocation of Funds

	Budget	
	$USm	
1 Investment		
1.1 PV Sub grants	15.00	59%
2 Market Development Activities		
2.1 MDSF	0.93	4%
2.2 Public information, Market monitoring and specific market activities	1.88	7%
2.3 Development operational links with main government programs		
2.3.1 RESCO	0.22	1%
2.3.2 Review Rural Electrification plans	0.20	1%
3 Institutional Strengthening		
3.1 Project management	1.46	6%
3.2 IOE	0.48	2%
TI Component		
1 Investment		
1.1 Competitive Grant	2.80	11%
1.2 Quick response Facility	0.46	2%
2 Institutional Strengthening		
2.1 Program Support/Product quality assurance	1.65	6%
2.2 Program Management	0.42	2%
TOTAL	25.50	100%

Source: Aide-memoire April 2007.

Economic analysis at Appraisal

A formal economic analysis was completed for only the wind component of REDP at appraisal. The justification for not presenting a formal economic analysis for the PV component was that the PV systems were to be sold in areas where there were no viable alternatives. Subsequent development of economic analysis techniques for such

[4] Households surveyed in one of the Gansu counties also received grants for PV system purchase from the provincial Government.

circumstances do now permit analysis (and may have been able to demonstrate the lack of viable alternatives had they been available at the time)

Methodology for economic analysis at ICR

The lower bound of economic benefits can be measured from the avoided costs of the alternative: if a PV system replaces the expenditure on kerosene and other fuels for lighting, dry cells for radio listening and other portable uses, then the benefits of the PV system must be at least as great as those avoided costs. Very often, however, the *quantity* of the corresponding energy service provided by the PV system – e.g. the quantity of lighting measured in lumen-hours – is much larger than that previously provided from kerosene, as is the *quality* of light (PV-provided lighting is free of smoke and smells, largely free of fire dangers and provides better color light). Hence avoided costs are often negative

It has been shown that many consumers are willing to pay more – i.e. spend a larger share of their disposable income - for a PV system than for kerosene and dry cells. This behavior is captured by the consumer's demand curves for lighting and other services, and economic theory provides the basis for measuring the total benefits of a given level of consumption of the service as the area under the demand curve. The methodology presented here compares results from the avoided cost and the consumer surplus methods. A more detailed explanation of the theory of the consumer surplus method is in the attachment to this Annex.

Environment benefits

The calculation of global environmental benefits that arise from avoided emissions of carbon is straightforward. Estimating the *local* environmental benefits that arise from the reduction in emissions of particulates, NO_x and SO_x associated with fossil fuel electricity generation (or from kerosene or ghee combustion to provide lighting in wick lamps) is much more difficult. They are likely to be quite small in the case of the northwestern provinces of China since consumption is quite low. Consequently the analysis does not attempt to quantify these benefits.

Indirect social benefits

The indirect social benefits of electrification are well recognized, and include improved educational outcomes for children, higher household incomes made possible by home businesses (and better educational outcomes), and the improvements in quality of life provided by access to modern telecommunications, TV, radio, and music players. These *indirect* benefits are often distinguished from the *direct* benefits of cheaper and better quality lighting, and power for appliances such as TV and radio and, in northwest China, milk separators. The perception of potential consumers that modern lighting brings a range of social benefits – from better fire safety in the home to improved outcomes of child education – is already expressed in their WTP for a more expensive PV system. An attempt to estimate these indirect social benefits and add them to the direct benefits (of more and better lighting, radio use and productive purposes) may well double-count and has not been undertaken in this analysis.

Technology improvement and market development

Only 60 percent of the total GEF financing was for the direct PV grant support: most of the rest was for indirect support of market development and technology improvement activities, and for project management. Whatever may be the benefit of the TI component to the costs and quality of systems sold under REDP, the technology improvements will benefit all PV system sales, including exports not only of complete systems, but also of components.

Industry-wide benefits cannot be easily estimated, hence the only reliable method of capturing the economic benefits of the TI and market development outlays is to treat them as one of the input costs, to be balanced against the consumer benefits. For the economic analysis, the allocation of the TA expenditures to each PV system is simply the total non-grant funding ($10.5million, Y75.5million) divided by the number of (verified) PV systems sold (401,908 as of end November 2007) = Y 187.9. This is likely to be a conservative assumption: not only are systems sold during the last six months of REDP in January-July 2008 excluded, but also reporting companies participating in REDP have sales not eligible for the REDP grant, domestic sales in provinces not covered by REDP, and, in some cases, export sales.

Data Collection

Data drawn from a survey conducted in Gansu and Tibet has been used for the purposes of the economic analysis. A more comprehensive survey of all areas in which participating PV companies were active during the project would have been desirable, but given the difficulties of reaching consumers in the more remote area, these four counties were chosen as reasonably representative of consumers as a whole. This tends to be supported by the findings of the beneficiary survey reported in Annex 5, where the Gansu and Tibet survey is also reported in more detail.

In general, the use of expenditure data is preferred for classifying households. In the survey of Gansu and Tibet, the differences between income and expenditure are unusually large, with average expenditure only 41% of average income. In this analysis income rather than expenditure quintiles have been used, which is also consistent with the 1998 survey of four REDP provinces[5].

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[5] See *Assessing Markets for Renewable Energy in Rural Areas of Northwest China,* World Bank Technical Paper 492

Household energy use

Table A3.9 shows household energy quantities before and after PV system purchase, by income quintile. The most unusual feature (compared with other countries) is that consumption of ghee for lighting – on average some 4.4 liters per month before PV system purchase, and still 3.5 litters afterwards – exceeds consumption of kerosene. This is a reflection of the significant proportion of the sampled households that are semi-nomadic herdsmen. For many households, ghee is not a purchased fuel, and continues to be available after PV system purchase. As expected, once SHS were acquired, the number of households using candles and kerosene falls considerably.

The observed changes are consistent with earlier surveys conducted by REDP. For example, while the 2007 survey showed a reduction of kerosene users from 19 to 4.3% of households, a 2004 survey of Dingqing county in Tibet showed a decline of kerosene users from 12.9% of households before PV system purchase to zero after purchase.

Table 3.9: Energy Consumption by Quintile (Users Only)

		Quintile					
	units	1	2	3	4	5	all
Before SHS							
kerosene	liters/month	5.6	2.8	3.4	3.0	5.6	3.5
ghee light	Kg/month	9.2	1.8	4.7	4.1	4.0	4.4
candles	per month	8.0	24.4	23.8	26.4	53.5	31.0
dry cells	per month	1.7	1.7	2.7	3.1	3.7	2.7
After SHS							
kerosene	liters/month	3.0	1.0	1.6	2.0	2.0	1.8
ghee light	Kg/month	1.7	2.0	3.8	4.0	2.3	3.5
candles	per month	4.7	11.7	2.9	5.0	3.7	5.5
dry cells	per month	3.2	2.8	3.3	3.8	2.9	3.2
Change							
kerosene	liters/month	-2.6	-1.8	-1.8	-0.9	-3.6	-1.7
ghee light	Kg/month	-7.5	0.2	-0.9	-0.1	-1.7	-0.8
Candles	Per month	-3.2	-12.7	-20.9	-21.4	-49.9	-25.5
Dry cells	Per month	1.5	1.1	0.5	0.6	-0.8	0.5

Table A3.10 shows the average monthly energy expenditures, by income decile, before the PV system was acquired.

Table A3.10: Monthly Energy Expenditure Before SHS

	Quintile					
	1=poorest	2	3	4	5=richest	all
Kerosene	24.0	11.1	12.7	11.6	35.9	15.2
Ghee light	163.8	12.6	60.4	60.1	64.7	63.6
Candles	7.7	9.4	10.0	12.9	21.1	13.5
Charcoal	11.0		8.7			9.3
Firewood	12.0				2.0	7.0
Dry Cells	3.5	2.8	5.2	6.7	5.8	5.0

Total	24.0	11.4	24.7	36.6	30.9	26.6
Average expenditure, Y /month	344	373	466	570	711	494
Fraction	7.0%	3.1%	5.3%	6.4%	4.3%	5.4%

Number of households reporting

	Quintile					
	1=poorest	2	3	4	5=richest	all
Kerosene	14	39	63	32	15	163
Ghee light	7	7	37	70	26	147
Candles	62	93	122	123	161	561
Charcoal	1	0	3	0	0	4
Firewood	1	0	0	0	1	2
DryCells	63	71	111	108	63	416
Total	92	140	197	188	194	811

Note: The expenditures shown for individual fuels are for users of that fuel only, and therefore the column entries do not sum to the total expenditure row, which is for all households

Table A3.11 shows energy expenditures after acquisition of SHS.

Table A3.11: Household Energy Expenditure, With SHS

	Quintile					
	1=poorest	2	3	4	5=richest	all
Kerosene	3.0	4.0	4.7	5.5	4.0	4.9
Ghee light	24.3	3.3	61.1	53.3	36.9	49.7
Candles	5.7	10.2	3.8	7.5	4.6	6.5
Charcoal	3.0					3.0
Firewood	5.3		9.0			6.3
Dry Cells	4.6	3.5	6.1	7.2	3.6	5.2
PV O&M	1.5	2.0	2.6	3.0	2.8	2.4
Total	9.2	5.9	19.8	37.7	12.5	19.2
Average expenditure, Y /month	344	373	466	570	711	494
Fraction	2.7%	1.6%	4.3%	6.6%	1.8%	3.9%

Number of households reporting

	Quintile					
	1=poorest	2	3	4	5=richest	all
Kerosene	1	2	16	16	1	36
Ghee light	5	3	23	60	17	108
Candles	47	17	18	33	7	122
Charcoal	2	0	0	0	0	2
Firewood	3	0	1	0	0	4
Dry Cells	71	64	98	90	68	391
PV O&M	143	120	160	181	174	778
Total	73	69	107	110	71	430

Operation and maintenance costs of SHS

Among operating costs for PV systems, the most widely reported cost was for lights, with 699 of 948 households incurring an annual average expense of 27.4 Y (Table A3.12). When averaged across all households with PV systems, the total average operating cost was Y23.7/year.

Table A3.12: Annual SHS Operating Costs

	maintenance &repairs	controller	battery	wiring	lights	total
number reporting	162	4	22	10	651	720
expenditure of reporting households	4.3	79.0	34.7	16.9	27.4	34.4
average for all SHS	0.8	0.4	0.9	0.2	21.3	23.7

Appliances and their use

For the calculation of economic benefits, usage of appliances is the critical variable and is set out in Table A3.13. The predominant appliance in use after purchase of a PV system is lighting (91%), followed by radio (80% of all SHS), and flashlight (recharging) (40%). Most households have one or two lamps, with an average total wattage of 23W (median 15W). Significant TV use was found only in Naqu County, which is the least remote of the counties surveyed: whether there is reception at all in the other counties (other than with satellite dishes) is unknown.

Table A3.13: Appliances Present in SHS (numbers of households reporting use)

	Gansu		Tibet		All	
	Tianzhu	Minqin	Naqu	Bange	n	as%
kerosene light	88		18	5	111	13%
ghee light	32		112	2	146	17%
Flashlight	101		200	34	335	40%
Candles	8		57	25	90	11%
other(fill in)			3	2	5	1%
fluorescent light	136	190	212	226	764	91%
Black & white TV			9		9	1%
color TV			21		21	3%
Radio	118	190	155	204	667	80%
VCD			14		14	2%
Recorder	4	1	28	2	35	4%
washing machine			1		1	0%
refrigerator			2		2	0%
butter separator	3		7		10	1%

Kerosene and electricity consumption

For the 164 users of kerosene before purchase of a PV system, the average reduction in consumption is 3.17 liters/month. 128 PV system users eliminated their entire previous kerosene consumption. The estimated annual electricity consumption using PV systems when averaged across all households is presented in Table A3.14.

Table A3.14: Average kWh Consumption in PV Systems

	Gansu		Tibet		All
	Tianzhu	Minqin	Naqu	Bange	
Lighting	7.4	3.7	21.9	0.1	9.1
Radio	5.0	3.9	11.8	11.0	8.4
Appliance	0.3	0.0	13.0	0.1	4.1
All	12.7	7.6	46.8	11.2	21.6

GHG emissions

The PAD estimates of CO_2 emissions were based on the assumption that a 20Wp PV system would replace two kerosene pressure lanterns per household, each used four hours per day, with a consumption of 0.05Kg/hour – equivalent to 14.8 liters of kerosene per household per month. This was consistent with findings in other countries: for example, in Indonesia, kerosene consumption fell from 25.9 liters/month before PV system purchase to 6.3 liters/month after purchase, a saving of 19.6 liters per household per month.

Not only is this consumption significantly greater than that found in the survey, the proportion of households using kerosene lighting before PV system purchase (19.5%) was found to be significantly lower than in the corresponding 1998 survey which showed 98.5% of Gansu households reporting use of kerosene. Details are compared in Table A3.15.

Table A3.15: Comparison of Survey Results: Percentage of HH Using Kerosene

	1998 Survey	2007 Survey
Gansu	98.5%	19.5%
Inner Mongolia	35.8%	
Xinjiang	87.2%	
Qinghai	44.0%	
Tibet		19.5%

Thus the benefit of PV systems in reducing GHG emissions based on the survey results is considerably lower than that estimated at appraisal, given that the actual displacement of kerosene is only 3.2 liters/household/month. The 19,426 tons of lifetime avoided CO_2 (Table A3.16), when valued at $15/ton CO_2, represents a benefit of $US0.29 million. Neither ghee lamps nor candles are included for lack of detailed information on which to base calculations but given the relatively small benefit from kerosene reduction, carbon emission reductions benefits are also likely to be small for these two sources.

Table A3.16: Carbon Emission Reductions

Households using kerosene	[ ]	164
Savings per month	[liters/HH/month]	3.17
Liters/year	[million liters/year]	0.006
Lifetime kerosene consumption	[million liters]	0.094
Density	[liters/kg]	1.3
Lifetime kerosene consumption	[tons]	72.0
Carbon emissions	[tons C/TJ]	19.6
Heat value	[TJ/103 tons]	44.8
Carbon emissions	[Tons C/ton Kerosene]	0.877
	[tons Carbon]	63.1
	[Tons CO_2]	231.5
Fraction kerosene users	[ ] = 164/827	0.198
Averaged across all 827 PV systems in the survey	[Tons CO_2]	45.9
For the REDP target (350,000 systems)	[Tons CO_2]	19,425
\$/ton CO_2	[\$/tonCO_2]	15
global benefit	[\$US]	291,384

Economic costs of a PV system compared with alternatives

To calculate the lifetime costs of a PV system, the following (conservative) assumptions have been made. Prices are assumed to include 17% VAT, so for the *economic* analysis the VAT is deducted:

- System life is 15 years.
- Battery replacement is assumed to be necessary every two years, costing 300 Y.
- Controllers are assumed to be replaced every five years, costing 27 Y.
- The annual kWh produced by the PV system requires an assumption about the average number of hours per day at peak output, taken here as 5.5 hours. A 20Wp system therefore produces 20 x 5.5 x 365 = 40.15 kWh/year.
- Financial cost of system: 1200 Y (average system price in the survey). For the economic cost we deduct 17% VAT =930Y.
- Discount rate of 10%
- General O&M costs, including replacement of lights, Y22.3/year, as found in the survey.

The cost of electricity from a 20Wp PV system then calculates as shown in Table A3.17 with a levelized cost of $0.99/kWh (Y7.19/kWh).

Table A3.17 shows the lumen-flux provided by different fuel-based lighting devices. There is little in the literature on Ghee lights, so the same flux as for a candle is assumed.

Table A3.17: Lumen-Output by Lighting Device

Type of Lighting	Lumen-Flux (lm)
incandescent lamp	
10 watts	50
15 watts	100
25 watts	230
50 watts	580
75 watts	1080
100 watts	1,280
fluorescent lamp	
10 watts (straight)	600
20 watts (straight)	1,200
40 watts (straight)	1,613
22 watts (circular)	1,480
32 watts (circular)	1,506
compact fluorescent lamp	
10 watts	600
12 watts	1200
18 watts	1613
20 watts	1,480
25 watts	1,506
kerosene Lamp	
1 kerosene simple wick lamp	12
1 hurricane lantern	40
1 pressurized kerosene lamp (Petromax)	2040
Candle	12
ghee light	12

Sources: The Netherlands Energy Research Foundation (ECN), *Rural Lighting Services: A Comparison of Lamps for Domestic Lighting in Developing Countries*, ECN-CX—98-032, July 1998; R. van der Plas and A. de Graff, *A Comparison of Lamps for Domestic Lighting in Developing Countries*, World Bank, Industry and Energy Department Working Paper, Energy Series Paper No.6, Washington DC, 1988.

With these assumptions one may calculate the cost of lighting for the different lighting sources as shown in Table A3.18.

Table A3.18: (Financial) Cost of Lighting (Y/kLmh)

		Kerosene	Ghee light	Candle	PV system
Flux	lumen	40	12	12	600
Average price	Y/liter	4.35	15.4	2.08	
	Y/kWh				16.2
Average consumption	liter/month	3.53	4.36	29.8	
	kWh/month				1.06
Monthly expenditure	Y/month	15.4	67.1	62.0	17.2
Hours of use/day	[hours]	3.4	5.5	1.6	2.0
Hours of use/month	[hours]	103	166	49	61
Lighting/month	kiloLumenhours	4.1	2.0	0.6	60.8
Fuel consumption/hour	liter/hour	0.034	0.026	0.609	

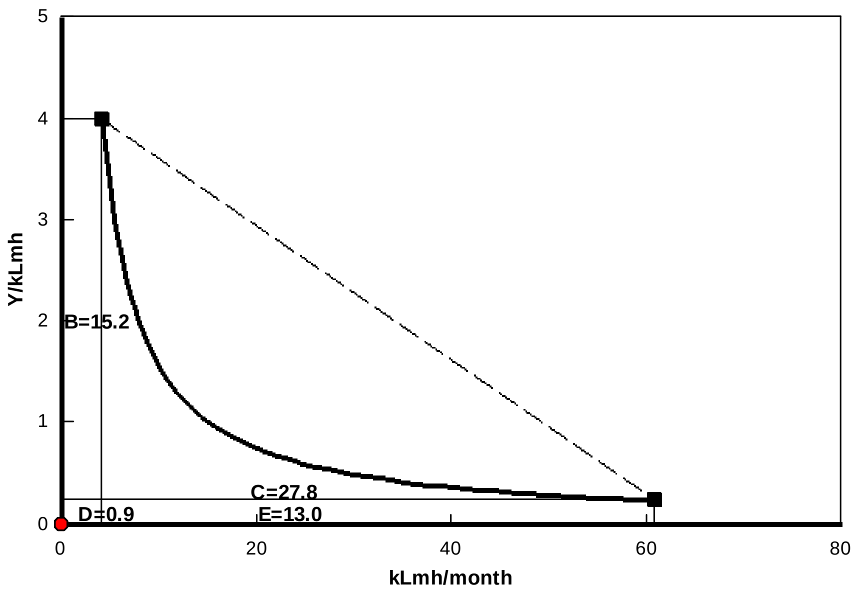
	kWh/hour				0.017
Cost/klmh	**Y/klmh**	**4**	**34**	**106**	**0.3**
	$/klmh	0.52	4.67	14.67	0.04
Literature values (2)	$/klmh	0.4-0.8		5-10	

1 From Table 5.3, assuming 58% of kWh and 58% of cost is attributed to lighting
2 ECN, *op.cit*.

Demand Curve for Lighting

The demand curve for lighting can be derived based on the foregoing analysis and assumptions using the methodology described in the Attachment to this Annex. The demand curve for kerosene lighting is shown in Figure A3.1. The net economic benefit per month is the increase in consumer surplus, calculated at 43Y (areas B+C).

Figure A3.1 Demand Curve for Kerosene Lighting



Since there are no data for the number of radio/TV listening hours *before* the SHS was acquired, we cannot derive a demand curve for this service.[6] However, it is reasonable to assume that the value ascribed to using PV-generated electricity to radio listening hours is at least equal to the value given to lighting, so the total willingness to pay can be scaled up from the above lighting value using a scale factor of 0.58, the proportion of lighting in total consumption; the total monthly benefit per household is Y43/0.58=Y74.1 (or $10.24)[7]

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6 Radio listening prior to the PV system would necessarily have been provided from dry cells, the costs of which range from 880$/kWh for AAA cells to 80$/kWh for D cells. This reflects the high willingness-to-pay for stored electricity for high value uses such as flashlights and radios.

7 In comparison, the Philippines, using a comparable methodology, the average monthly benefit was $9.90/month

Economic Returns

Avoided cost method

In most other countries, the lower bound to the economic benefit of a PV system could be estimated based on the avoided energy cost. In Tibet and Gansu, before the PV system, monthly energy expenditure is 26.6Y. After PV system purchase, expenditure on fossil fuels decreases to Y16.8/month, so the avoided cost is only Y10/month (Y120/year). Since the cost of the PV system – including amortization of the capital cost over 15 years at 10%) is estimated at Y30/month, total energy expenditure *increases* by Y20.6/month, and the avoided cost calculation becomes meaningless (showing a negative economic return).

In most countries where significant amounts of fossil fuels are used before PV system purchase, the total expenditure on energy *decreases* rather than increases, because many households in other countries use expensive car battery charging, or have access to diesel generators (or, as in Vietnam, make extensive use of pico hydro generators). The consumption of kerosene in unelectrified Tibet and Gansu households is particularly low by international standards, a difference that in large part is explained by lifestyle differences rather than poverty *per se*.

Consumer surplus method

The total area under the lighting demand curve (ignoring the initial consumer surplus area ***A***) is the area ***B***+***C***+***D***+***E*** = Y58.8/month. Table A3.19 estimates the total benefit. Note the previously discussed allocation of non-grant REDP expenditures (for TI, Market development and instruction strengthening activities) of Y188 per system.

TableA3.19: Economic Returns

		NPV	2002	2003	2004	2005	2006	2007	2008	2009	2010
Systems sold	[ ]		59.7	64.7	85.9	99.8	72.1	54.0			
Cumulative	[ ]		59.7	124.3	210.3	310.1	382.2	436.1	436.1	436.1	436.1
Net economic flows											
2002 Systems	Ym	367	-70.64	71.262	56.404	69.925	56.4	71.26	55.07	71.26	56.4
2003 Systems	Ym	361		-76.56	77.233	61.13	75.78	61.13	77.23	59.68	77.23
2004 Systems	Ym	436			-101.7	102.62	81.22	100.7	81.22	102.6	79.3
2005 Systems	Ym	461				-118.2	119.2	94.36	117	94.36	119.2
2006 Systems	Ym	302					-85.3	86.06	68.12	84.45	68.12
2007 Systems	Ym	0									
Aggregate flows	Ym	1928	-70.64	-5.302	31.906	115.5	247.3	413.5	398.6	412.4	400.3
	$m	267.74									
ERR	[ ]	93.4%									

Note: Calculations done for an assumed 15 year lifetime: for sake of legibility, only the first 8 years are shown here. The reported capital cost includes 17% VAT, which is subtracted from the average retail price to obtain the economic cost. Batteries and controllers have been adjusted for VAT but O&M have been left at their reported financial costs.

The resulting economic rate of return (ERR) calculates to 93.4 percent. The corresponding financial return to the purchases is 88 percent. This implies that the users perceived a payback of expenditure within a little more than a year. Evidence supports very high values of willingness-to-pay and high economic returns. First, systems are bought for cash, which suggests a high benefit perceived by households. Second, the cost of the PV system is modest compared with income. Third, the initial cost of the PV system in China is low; much lower than that reported elsewhere (Table A3.20).

Table A3.20: Comparisons of System Costs, 20Wp

	Consumer cost
China	$166 (2007)
Indonesia	$396 (in 2003)
Sri Lanka	$302 (in 2001)
Philippines	$490 (2007)

Sensitivities

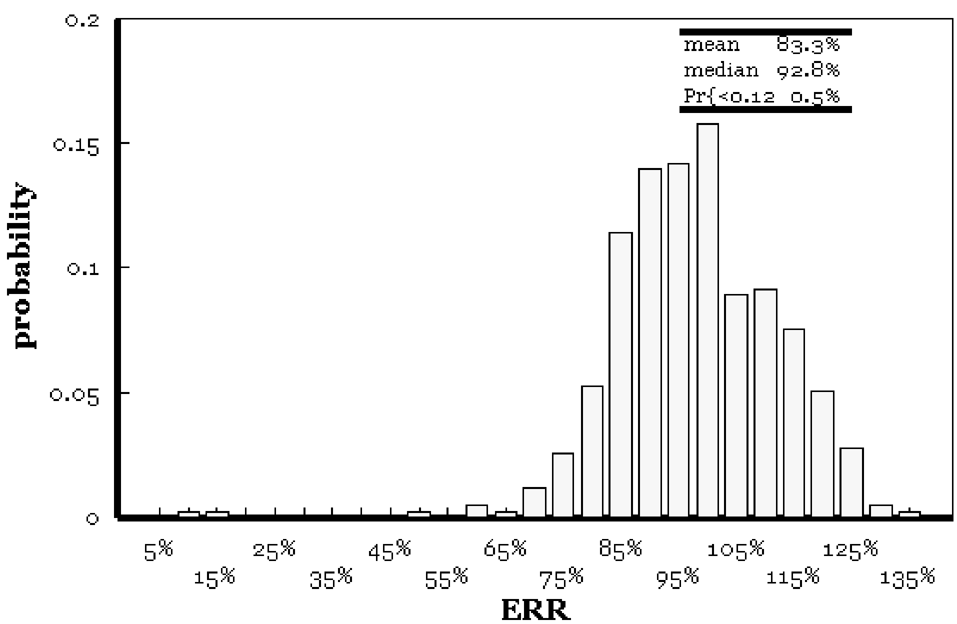
Based on earlier surveys, much higher kerosene displacement is achieved in the other project provinces, and thus it can be argued that the Tibet/Gansu results should not therefore be extrapolated to REDP as a whole as above. Nonetheless, the calculation at appraisal of the kerosene displacement of 14.8 liters of kerosene per household per month seems to have been an over- estimate. To investigate the impact, 78% of households – as found in the 1998 survey – have been assumed to stop using two liters of kerosene per month as found in Gansu and Tibet surveys. Under these conditions, the benefits of GHG reduction are $5 million, with a modest increase on the ERR, to 93.8 percent. Even inclusion of the original assumptions from appraisal would only increase the ERR by just over three percentage points to 97.8 percent.

Robustness of the project returns to system life was tested over a range of lives from one to 15 years. At an average system life of two years, returns are 71%. Monte Carlo simulation of the following multiple variables was also carried out:

- Proportion of households using kerosene and candles
- Actual displacement of kerosene and candles
- Price of kerosene and candles
- Battery replacement frequency (1-4 years, median two years)
- PV system life

The resulting distribution of ERR is shown in Figure A3.2. The biggest level of uncertainty is in the WTP estimation itself, both with respect to the methodology as well as the high level of uncertainty in survey estimates of lighting demand. Using Monte Carlo analysis and assuming an asymmetrical distribution for the WTP estimate of benefits (small probability of higher WTP than the baseline estimate, large probability of lower WTP than the baseline estimate), with a median WTP of Y0.60, then the mean estimate of returns is still 51 percent, with a 3.7 percent probability of not meeting the hurdle rate of 12 percent economic rate of return.

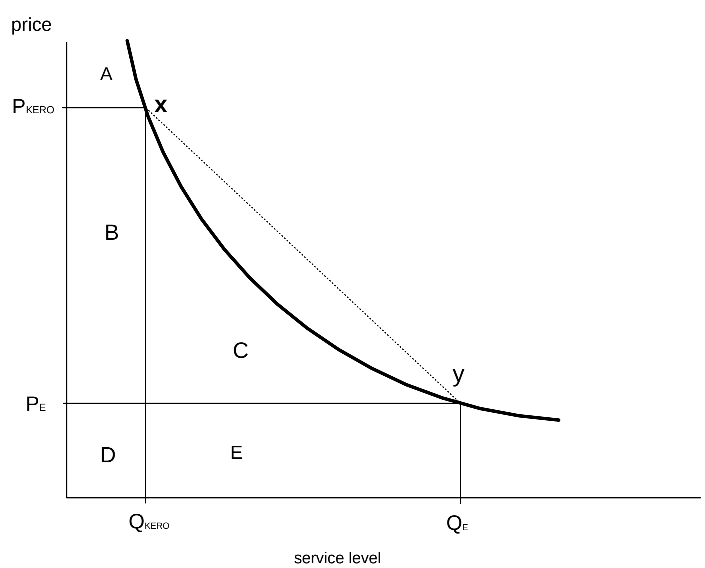
Figure A3.2: Probability Distribution of ERR



ATTACHMENT TO ANNEX 3
METHODOLOGY FOR ESTIMATING CONSUMER BENEFITS FROM DEMAND CURVES

The methodology adopted here to establish the benefits of rural electrification follows that used in a number of other countries for rural electrification projects (Philippines, Bolivia, and Vietnam, among others). Economic theory holds that the benefit of consuming a given quantity of a good, at some given price, is equal to the area under the demand curve. Such a demand curve is illustrated in Figure A3.1.1 for the case of lighting: the x-axis represents the quantity of lighting service consumed (say as kiloLumen-hours/year), and Y shows the price, in Yuan/kilolumen-hour).

Figure A3.1.1: Demand curve for lighting



The demand curve is drawn as downward sloping, and typically has a shape that is concave (with respect to the origin). This shape frequently emerges where more than two points on the curve can be plotted (here only the points ***x*** and ***y*** are assumed known). The concave shape also follows from the (convenient) assumption of constant elasticity (an assumption often made in econometric models).

For simplicity, assume that the lighting service is provided by kerosene lamps only: the quantity of services so consumed is Q_{KERO}, at the price P_{KERO}. Thus the total household expenditure on lighting is $Q_{KERO} \times P_{KERO}$, equal to the area ***B + D***.

The total willingness-to-pay (WTP) for the service at level Q_{KERO} is the total area under the demand curve to that level of consumption, i.e. areas ***A + B + D.*** This is the total *benefit* to the consumer. However, the *cost* is area ***B + D,*** and therefore the *net benefit* consuming Q_{KERO}, also called the consumer surplus, is the difference between the two, namely the area ***A***.

After electrification, the level of service (in the case of lighting, the number of lumen-hours) typically increases substantially; consumption increases from $\boldsymbol{Q_{KERO}}$ to $\boldsymbol{Q_E}$, but the price paid for the electrified service also falls (typically) from $\boldsymbol{P_{KERO}}$ to $\boldsymbol{P_E}$. Now the household's expenditure for electricity is $\boldsymbol{P_E}$ x $\boldsymbol{Q_E}$, equal to the area ***D+E***. At this level of consumption, the total area under the demand curve to $\boldsymbol{Q_E}$, i.e. the total benefit, is now the area ***A + B + C + D + E***. Therefore the net benefit, or consumer surplus, after subtracting the cost ***D + E,*** is ***A + B + C***. Thus it follows that the net economic benefit of electrification is the *increase* in consumer surplus, which is the area ***B + C***.

Areas ***B, D*** and ***E*** are readily calculated from knowledge of consumption before and after electrification, from the household budget for kerosene (and battery charging), and from the tariff of electrified service: i.e. given knowledge of the two points on the demand curve ***x*** and ***y***, the areas ***B, D*** and ***E*** are immediately calculable. But area ***C*** is more difficult to estimate, since it requires knowledge of the *shape* of the demand curve between points ***x*** and ***y***. The most convenient assumption – and therefore the one most frequently encountered – is that the demand curve is linear.

Such an assumption will usually lead to an overestimate of the area ***C***, and of the net benefits of electrification, because the empirical evidence is that in fact the demand curve is much more likely to have a concave shape of the type shown in Figure A3.1.1. Given some functional form for such a demand curve, the area ***C*** is readily calculated as the definite integral: here we use a standard functional specification with constant elasticity β.

$$Q = Q_0 \left[\frac{P}{P_0} \right]^{\beta}$$

whose corresponding area ***C*** (e.g. between $\boldsymbol{Q_{KERO}}$ and $\boldsymbol{Q_E}$) easily calculates from the corresponding definite integral.

This approach of estimating changes in welfare by consumer surplus has a number of issues and limitations. One must recognize that the demand curve shifts outwards with increases in income (for a so-called *normal* good, for a given price higher income implies a greater demand). However in the case of an *inferior* good – of which radio listening is a good example, as discussed below – consumption *decreases* with increase of income. In addition, the implication of such curve is that at zero price, the quantity consumed would be infinitely large. Yet in fact, even in face of very dramatic electricity price decreases (as are achieved by gird-connection as against car battery use), in the short run consumption will be constrained by the (limited) stock of appliances required to actually use larger quantities of electricity.

Annex 4. Bank Lending and Implementation Support/Supervision Processes

(a) Task Team members

Names	Title	Unit	Responsibility/ Specialty
Lending			
Noureddine Berrah	Principal Energy Specialist	EASEG	TTL and Economist
Susan Bogach	Senior Energy Specialist	EASEG	Economist
Anil Cabraal	Senior Energy Specialist	EASEG	PV Specialist
Enno Heijndermans	Alternative Energy Expert	EASEG	TI Specialist
Scott Piscitello	Renewable Energy Engineer	EASEG	Wind Specialist
Jianping Zhao	Senior Energy Specialist	EACCF	GoC Liaison
Elaine Sun	Senior Financial Analyst	EASEG	Financial Analysis
Todd Johnson	Senior Economist	EASES	Economist
Jan Post	Senior Ecologist	LCSEN	Environment Specialist
Chaohua Zhang	Senior Social Sector Specialist	EASSD	Resettlement Specialist
Cliff Garstang	Senior Counsel	LEGEA	Lawyer
Chau-Ching Shen	Financial Management Specialist	EACCF	Financial Management
Aldo Baietti	Senior Financial Analyst	EASPS	Quality Assurance
Richard Hansen	PV Business Development	Consultant	Quality Assurance
Richard Spencer	Renewable Energy Specialist	EMTEG	Quality Assurance
Supervision/ICR			
Richard Spencer	Senior Energy Specialist	EASVS	TTL
Anil Cabraal	Lead Energy Specialist	ETWEN	PV Component
Ximing Peng	Energy Specialist	EASCS	GoC Liaison
Xiaoping Li	Senior Procurement Specialist	AFTPC	Procurement
Haixia Li	Financial Management Specialist	EAPCO	Financial Management
Enno Heijndermans	Consultant	EASVS	TI Component
Noureddine Berrah	Consultant	EASTE	Economist
Youxuan Zhu	Consultant	EASTE	Resettlement
Cristina Hernandez	Program Assistant	EASTE	Project Processing

(b) Staff Time and Cost

Stage of Project Cycle	Staff Time and Cost (Bank Budget Only)	
	No. of staff weeks	USD Thousands (including travel and consultant costs)
Lending		
FY95	1	8
FY96	8	45
FY97	14	100
FY98	39	374
FY99	34	326
FY00	3	15
FY01	0	5
Total:	99	872
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

Note: Staff weeks are estimates based on staff and consultant budgets not including TF

Annex 5. Beneficiary Survey Results

This Annex reports on two surveys that were undertaken on behalf of the PMO at project completion. One was conducted in one province, Qinghai, and two autonomous regions, Tibet and Xinjiang (also reported as Sinkiang); it is referred to here as the Qinghai, Tibet and Xinjiang survey. The second was conducted in two counties each in Gansu and Tibet and is referred to here as the Gansu and Tibet survey.

During project preparation, a survey was carried out in Gansu, Inner Mongolia, Qinghai and Xinjiang, all of which became part of the project area[8]. Field investigations were also carried out during project implementation in Inner Mongolia, Qinghai, Sichuan, Tibet and Xinjiang.

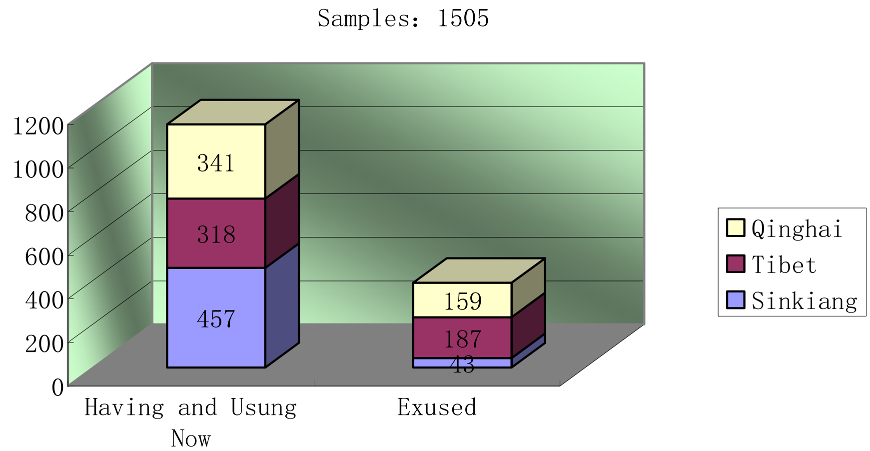
A comprehensive survey of all project areas would have been desirable but the remoteness of some of the areas, the low population density and people's semi-nomadic lifestyle combine to make any survey of actual beneficiaries of project-provided PV systems impractical, as was discovered early in project implementation. Necessarily, given their different purposes, these surveys have different emphasis and the quantitative combination of the Qinghai, Tibet and Xingjiang and Gansu and Tibet surveys would be statistically unsound, nonetheless, the qualitative information that can be gained is useful. It also adds further to the confidence in the findings of the economic analysis reported in Annex 3.

Qinghai, Tibet and Xinjiang Survey

A total of 1505 people were surveyed in the Qinghai, Tibet and Xinjiang survey, equal numbers being drawn from Xining, Lhasa and Urumqi. Interviewees were drawn randomly at bus stations and markets where rural people from remote areas of the provinces gather. Based on the sample about 75 percent of respondents were owners and users of SHS, while 25 percent either had never owned or had owned but given up using systems. The province/autonomous region (AR) breakdown is in Figure A5.1

8 *Assessing Markets for Renewable Energy in Rural Areas of Northwestern China,* World Bank Technical Paper 492.

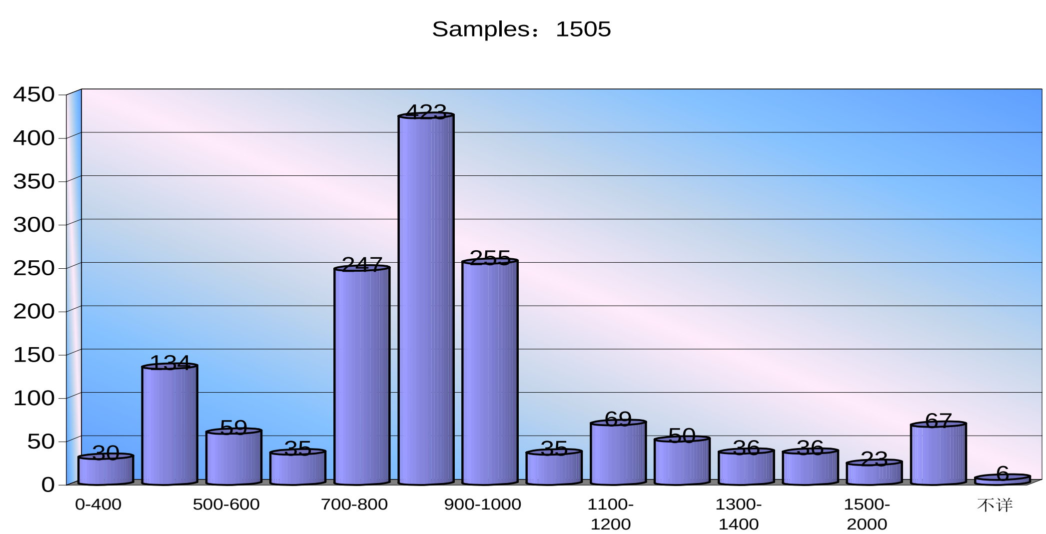
Figure A5.1: Users and Non-users of SHS in Qinghai, Tibet and Xinjiang



About 95 percent of respondents had one SHS in the household but some had two and three reported having three systems. Multiple systems in one household reflects the nomadic lifestyle in which households are often split between different locations, especially during the summer months. Brand awareness among respondents was strong with only about 15 percent not knowing the make of their system. Six companies represented just over 50 percent of all sales.

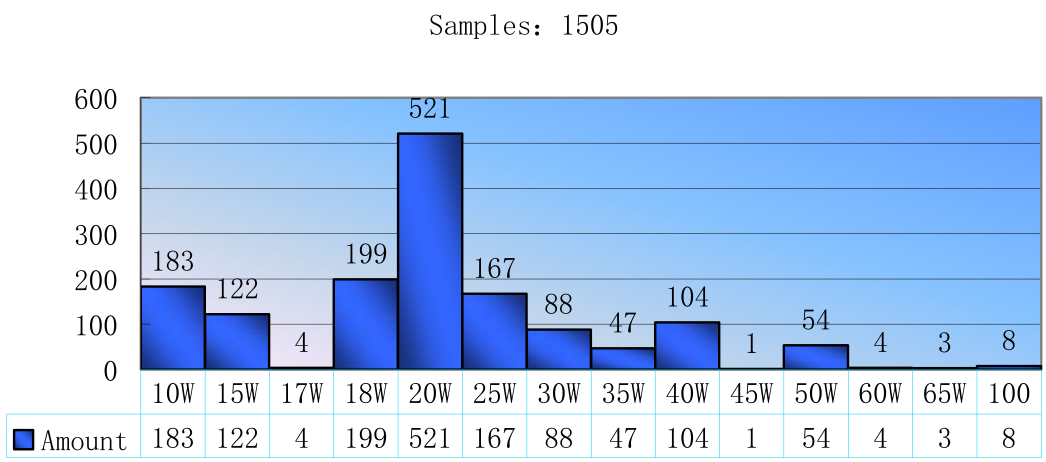
Systems cost between Y500-1500, with most being in the range of Y700-1000, as shown in Figure A5.2. Systems in Xinjiang tended to be somewhat cheaper than those in Qinghai and Tibet, which may correspond with the apparently rather larger market.

Figure A5.2: System Cost in Qinghai, Tibet and Xinjiang



The bulk of systems owned were in the range of 18-25Wp (Figure A5.3) taken together with system cost, this corresponds to buyers paying about Y38-40/Wp, on the assumption that smaller systems cost less. This is somewhat lower than the prices reported by participating PV companies, but may be distorted by incentives paid to purchasers by local governments.

Figure A5.3: System Size in Qinghai, Tibet and Xinjiang

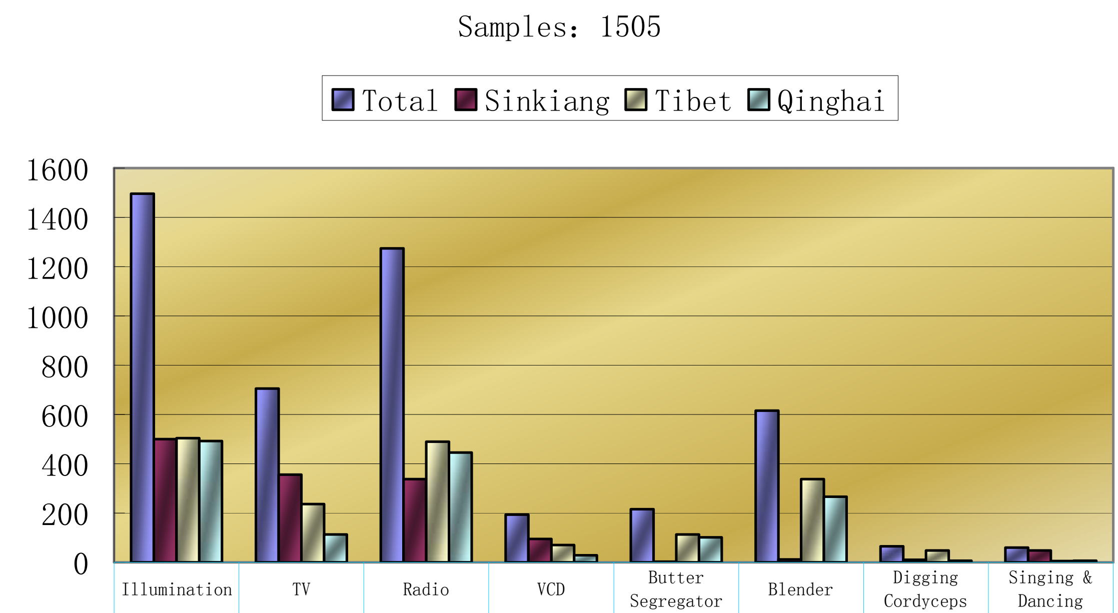


Buyers purchased their first PV system as early as 1998, and about 58% of systems are more than six years old. A small subset of respondents – 65 in all – reported replacing their systems with new ones. The main reason for doing so was because the systems had faults (20%), the systems had been lost (23%) or because a higher power system was needed.

Systems appear to be reliable. About 80 percent of systems do not need repair during the warranty period, and 65 percent of all owners have not yet replaced the battery, although those with smaller batteries are more likely to need replacement sooner.

Almost everyone uses their systems for lighting (99.4%), and the second most popular use is radio (85%), followed by the use of blenders (about 40%) and milk separators (15%). Uses by province are shown in Figure A5.4.

Figure A5.4: System Use in Qinghai, Tibet and Xinjiang



	Illumination	TV	Radio	VCD	Butter Segregator	Blender	Digging Cordyceps	Singing & Dancing
Total	1496	705	1274	193	216	616	65	60
Sinkiang	500	356	338	95	2	12	10	48
Tibet	504	236	490	70	113	338	48	5
Qinghai	492	113	446	28	101	266	7	7

People are broadly satisfied with their PV systems with those feeling satisfied or relatively satisfied comprising about 65 percent of all users. Only 5% feel dissatisfied or relatively dissatisfied.

Of the whole sample of 1505 respondents, 389 reported having a system but had given up using it. Most had bought the system in the period 2002 – 2005, and most had given up using them in 2005 – 2007. Interviewees overwhelmingly (97%) reported that their village had now gained access to grid electricity (probably mini grids). Those who gave up their systems for other reasons cited unstable power and lack of reliability or difficulties in getting the system repaired.

Gansu and Tibet Survey

As a starting point for the economic analysis, a household survey was undertaken in 2007 in Gansu province and Tibet Autonomous Region. The four sampled counties were:

- *Naqu county, Tibet*. Naqu prefecture is one of the most important centers of animal production and carries about 7 million head of various livestock on native grasslands, mainly yak and ovines.
- *Bange county, Tibet:* Also in Naqu prefecture, but much more remote.
- *Tianzhu Tibetan Autonomous region*: although located in Gansu, it is quite similar to the two Tibet provinces.

- *Minqin county, Gansu*: This is the only county among the four sampled where the predominant occupation is farming.

Table A5.1 shows the occupations of respondents.

Table A5.1: Households by Occupation

	Gansu				Tibet					
	Tianzhu		Minqin		Naqu		Bange		All	
	N	%	N	%	N	%	N	%	N	%
Herding	190	95	24	10	272	78	103	30	589	52
Farming	7	4	223	89	15	4	70	20	315	28
Transportation	0	0	0	0	8	2	11	3	19	2
Forest	0	0	0	0	4	1	32	9	36	3
Service industry	0	0	0	0	8	2	34	10	42	4
Construction	0	0	0	0	5	1	31	9	36	3
Handicrafts	0	0	0	0	6	2	6	2	12	1
Not sure	0	0	0	0	0	0	18	5	18	2
Manufacture	0	0	0	0	3	1	3	1	6	1
Other	0	0	0	0	0	0	3	1	3	0
All	199	100	250	100	347	100	347	100	1143	100

Tibet and Gansu are among the poorest parts of China and also stand at the bottom of the provinces targeted by the REDP PV component (Table A5.2). Shaanxi rural income stands between those of Tibet and Gansu.

Table A5.2: 2003 Per Capita Incomes in the REDP Provinces Y

	Urban	Rural
Tibet	8200	1861
Sampled counties		
Naqu		4139
Bange		3886
Gansu	8087	1980
Sampled counties		
Tianzhu		3306
Minqin		4086
Inner Mongolia	6229	2446
Ningxia		
Qinghai	8058	2165
Shaanxi		
Sichuan	7710	2589
Xinjiang	7503	2245
Yunnan		

Source: Gansu and Tibet Survey and G. K. Heilig, Zhang Ming, Long Hualou, Li Xiubin and Wu Xiuqin, *Poverty Alleviation in China: A Lesson for the Developing World?* International Conference on the West Development and Sustainable Development, August 2-4, 2005 Urumqi, China

Income and expenditure

Annual household income is shown in Table A5.3. In three of the four sampled counties, farmers had higher income than herders (the exception being Bange county in Tibet, where herders had higher incomes). This finding is in contradiction to that of the 1998 survey which found that in general, farmers were poorer than herders (in Gansu, Inner Mongolia, Xinjiang and Qinghai).

Table A5.3: Annual Household Income, Y

	Gansu		Tibet		
	Tianzhu	Minqin	Naqu	Bange	All
Herding	12,866	13,367	13,074	18,830	14,025
Farming	13,571	16,876	14,867	12,871	15,817
Transportation			31,000	11,727	19,842
Forest			14,000	9,875	10,333
Service industry			15,875	9,824	10,976
Construction			16,200	8,997	9,997
Handicrafts			14,167	9,167	11,667
Not sure				9,111	9,111
Manufacture			16,667	11,333	14,000
Other				9,000	9,000
Average	12,l892	16,515	13,895	13,066	14,042

For the sample as a whole, the distributions of incomes of households with and without SHS are quite similar. The most reliable inference one can draw is that households with higher incomes have more savings, and are therefore more likely to be able to purchase PV systems than households on lower incomes. Rural incomes in China have been steadily increasing over the past five years, so the ability to separate out the effect of the PV system from the overall growth in household incomes is limited.

One explanation for the high income of Bange county herders is income from Cordyceps harvesting (*dong chong xia cao* or "summer grass- winter worm", (*Cordyceps Sinensis*). It is a product that has long been used in traditional Chinese medicine, and more recently recognized as prophylaxis against cancer. Ten years ago, retail prices were around Y3,000/kg; five years ago Y10,000/kg, and presently as much as Y60,000-100,000/kg. The Tibetan plateau (including areas in Qinghai and western Sichuan) is the main area of supply: reports are that herdsmen (and others) adept at spotting winter-worm can easily make Y1,000-2,000/month selling this in urban markets. PV systems have a role to play in that they are used by the herdsmen when on winter-worm collecting expeditions.

Energy use across all fuels, prior to PV system purchase in Tibet and Gansu is low, and significantly lower than in other counties: only 19.5% of unelectrified households report use of kerosene in Gansu and Tibet, compared with 57% in rural Peru, and 67% in the Philippines. These differences appear to be a consequence of lifestyle rather than income: rural households in Gansu and Tibet are no poorer than those in other countries.

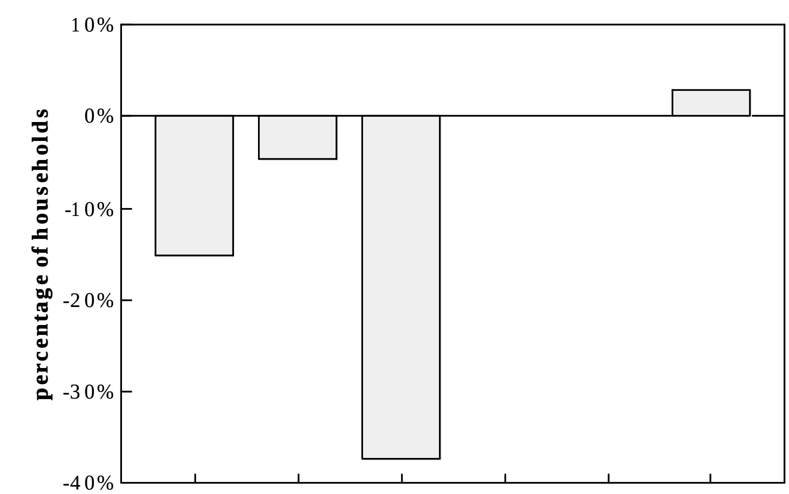
Table A5.4: Percentage of households using energy sources (before SHS)

	Tibet & Gansu	Peru (1)	Philippines (2)	Indonesia (3)
Kerosene	19.5%	57.0%	67%	94%
Ghee light	17.6%			
Candles	50.4%	60.0%	35%	
Dry Cells	40.7%	74.0%	48%	
Car Battery		11.0%	4%	51%
LPG		14.0%		
Generators		0.6%		

Sources:
(1) World Bank: *Peru Rural Electrification Survey*, May 2007
(2) *Rural Electrification and Development in the Philippines: Measuring the Social and Economic benefits*, ESMAP Report 255/02, May 2002
(3) World Bank *Implementation Completion report, Indonesia Solar Homes Project: Economic Analysis,* April 2004

As expected, once SHS were acquired, the number of households using these fuels falls considerably, notably candles and kerosene but the percentage of households that use dry cells slightly increases. The observed changes, illustrated in Figure A5.5 are consistent with earlier surveys conducted during project implementation. For example, while the Gansu and Tibet survey showed a reduction of kerosene users from 19 to 4.3% of households a field survey in 2004 in Dingqing county Tibet showed a decline of kerosene users from 12.9% of households before PV system purchase to zero after purchase.

Figure A5.5: Change in Households Using Fuels Following SHS Installation



	Kerosene	Ghee light	Candle	Charcoal	Firewood	Dry Cells
before SHS	19%	18%	50%	0%	0%	41%
after SHS	4.3%	12.9%	13.2%			43.5%
change	-15.2%	-4.7%	-37.2%			2.9%

Conclusions From Beneficiary Survey

The correlation between the findings of the two surveys, where they overlap, appears to be quite strong and tends to be supported by the evidence from other sources, particularly that provided by participating PV companies. This engenders a reasonable level of confidence about the market characteristics, and the way in which people in the target provinces are benefiting from the project.

One particularly striking finding is the 75% take up of PV systems among the respondents to the Qinghai, Tibet and Xinjiang survey. Major growth in ownership appears to have started in about 2003, which coincides with the period in which the project started to support substantial market development efforts in the target provinces and when system sales started to grow. There is strong evidence that the project reached its intended beneficiaries.

It is also noteworthy that the prices paid and the system sizes are quite close on average to those reported by participating PV companies. This suggests that the cost reductions resulting from increased competition and technical progress have been passed on to end users. Moreover, market-driven system designs, particularly relating to system size appears to have been important, and vindicates project design which avoided prescribing designs or sizes and encouraged innovation.

The finding that people will only discard their systems in favor of upgrading it for a more powerful one, or the arrival of their grid also indicates that the market is likely to continue to thrive for some years to come as does indications that households purchase a second or even third system. There remain large tracts of western China inhabited by semi-nomadic people that simply cannot be reached by static systems such as grids.

The evidence of the poverty reduction resulting from the project is unexpected. Median income of PV purchasers is little more than non PV purchasers and people in the lowest income quintile have purchased SHS. Combined with the finding that 95 percent consider that their income has increased as a result shows that access to modern energy is perceived by beneficiaries to improve their incomes. Further analysis of the survey data is not possible to quantify this finding.

Other Components (Wind and TI)

Beneficiary surveys were not carried out for the Wind and TI components.

Annex 6. Stakeholder Workshop Report and Results

Six stakeholder workshops were held during the closing stages of the project. All related to the PV and TI component. Of these, four were for PV and TI companies alone, one was for the PMO and one was a closing workshop in which the findings were reported to the Government of China.

Workshops for PV and TI Companies

The four workshops were held in Beijing (December 21, 2007), Shanghai (January 15, 2008), Xining (January 22, 2008) and Urumqi (January 23, 2008). A total of 54 stakeholders attended the workshops. In Beijing and Shanghai participants were mainly TI only companies (73%), while in Xining and Urumqi the majority was PV only companies (52%). The workshops discussed individual actions of the project, the PV subgrant, the Market Development Support Facility (MDSF), the Competitive Grant Facility (CGF), the Quick Response Facility (QRF), the quality actions and supporting activities for quality, capacity building and the PMO's performance.

Reactions at each workshop were mixed: in general participating PV companies expressed strong support for PV related activities, while TI companies expressed similar sentiments for the TI related activities. Views of the more affected party are reflected in the summaries that follow.

The PV Subgrant

PV companies were positive about the PV subgrant, considering that it was a successful mechanism by which to develop the SHS market and the PV companies, particularly supporting their ability to compete in the market, improving the capacity of their management and the quality of their products. With clear and detailed principles and procedures set out it was easy to operate. Some considered that the mechanism was becoming outdated but that the principles could be applied to other projects.

Asked what they would have done to improve the design of the PV subgrant, participating companies would have liked to extend it to demonstration systems, extend it to all China and to support exports. They also thought that increased differentiation between different quality standards would be useful.

In implementation, PV companies felt that the approved supplier list changed too often, that there were too many PV companies, and more companies could have been allowed to join, and more companies removed if they failed to meet performance standards. PV companies generally appreciated the verification system but considered that it was slow, complex, did not adequately foster competition, and created delays in disbursement of the grant. PV companies considered it unfair to punish PV companies for product quality of qualified suppliers (which in the majority of cases were the PV companies themselves). They also were of the opinion that penalties for non compliance with quality standards should have kept the same for each batch and not as practiced by REDP increase over time.

The Market Development Support Facility

Medium and small sized participating PV companies most appreciated the MDSF as it had helped to improve their capacity. The design was sound and flexible, allowing it to cover a large number of different areas of company business and the evaluation procedure was considered reasonable. It was particularly helpful for financial management, market development and internal quality control.

Some considered that the MDSF should have been open to non-participating PV companies, and that the amount of the grant should have been increased for good projects providing an incentive to improve project quality. Additional checking during implementation would have been appreciated by recipients of cost shared grants, and feedback from experts could have been more prompt.

The Competitive Grant Facility

TI companies liked the CGF mechanism and considered it strict but fair, open and transparent in the way projects were selected for grants. It reached its aim of helping to develop the Chinese PV industry and was considered to be efficient. It was particularly appreciated given that R&D investment funds were difficult to obtain from other sources at the time.

Weaknesses included poor monitoring of progress during implementation of the CGF, and a complicated closing procedure which would also have benefited from a more objective basis on which success could have been evaluated. The amount of support for each grant should be increased, and the upfront costs met through a higher first payment (more than 30% of approved support). Disbursement could have been quicker.

The Quick Response Facility

In all workshops the QRF was rated lower than the CGF. Still the QRF was considered important because by design it was quicker and closer to requirements of the market. Further, participants regarded it flexible and able to help companies achieve results. It was considered not to be quick enough in deciding whether to support a proposal or not, few applicants received support, and both disbursement and the closure procedures were slow.

Quality Actions Through TI Program Support and Capacity Building

Nearly all participants evaluated positively the quality actions undertaken by REDP, in particular the introduction of the SHS standards, and the promotion of the Golden Sun mark, and quality checking actions directly with the participating PV companies. Participating PV companies also considered that the qualification of suppliers help protect the market and their customers. Checking could have been more frequent and more often unannounced. Participating PV companies wanted to see the continuation of the mechanism after the end of the project.

Capacity building for PV quality, particularly upgrading testing centers and helping PV companies to have their equipment tested was appreciated as a means of improving product quality and also creating the link with international standards. The main criticism stakeholders had was that more could have been done: continued support to increase acceptance as an international testing organization and to create competition in China to avoid monopoly.

Conferences, workshops, exhibitions study tours and international training were among the most highly appreciated areas of support. Most participants wanted more such activities (the reader may wish to note that most of these activities were cost shared with participants). More could have been done to help communications within the industry, particularly through providing data, and through providing market intelligence.

The PMO was held in high esteem by participants, considered to be a good bridge between government and the companies, and to be fair and open. It was considered to be understaffed, and contract and project checking and disbursement speeds could have been better.

Workshop for PMO

In November 2007, PMO and Bank staff conducted a workshop on the implementation of the project.

Implementation Generally

Implementation of REDP without a full time PMO would have been impossible. The PMO's operation could have been improved by increased capacity building for PMO staff and by reducing the high staff turnover during REDP implementation (3 component managers resigned during REDP implementation). The latter may have been achieved by better incentives (net payments, training, etc.).

PV Component

PMO staff considered that the provision of output and quality based grant support directly to the PV companies worked well and that financial verification and the MDSF worked as intended. By far the main difficulty the PMO experienced in implementing the PV component was the verification of PV system sales (first field verification and later financial verification). Implementation of the PV component could have been improved in particular by conducting bi-annual quality verification from the start and not just after the problems with quality of REDP supported systems became apparent.

TI Component

The PMO considered the TI component vital for improving the quality of PV components and systems, both those supported by REDP PV subgrants and more generally. The CGF and upgrading of testing laboratories worked well. The main difficulty faced by PMO staff in implementing the TI Component was the management, monitoring and closing of the TI grant facilities (CGF and QRF) projects. The PMO was of the opinion that these facilities could have been improved by simplifying the calculation of eligible grant payments. The PMO would further have liked more resources allocated for the establishment and maintenance of the REDP approved components list.

Bank Supervision

In general the supervision was considered crucial for achieving the REDP objectives, but better mutual understanding would have made implementation easier and less stressful. The PMO considered the World Bank supervision team dedicated, efficient, creative and helpful. The supervision team provided suggestions for improvement of REDP implementation and solutions to problems encountered. The PMO appreciated the frequent supervision missions and found the detailed Aide Memoires prepared by the supervision team helpful to follow-up agreed actions. The supervision team diligently monitored implementation of the agreed activities.

The PMO appreciated in particular the capacity building conducted by the supervision team. Especially the junior staff learned a lot from the supervision team. Although the assistance from the supervision team was appreciated, the PMO felt that the supervision team was at times too impatient and listened too little, insisting too often on its view being carried forward. This could have been improved by more frequent field visits to better understand Chinese culture and actual problems faced and the PMO's position. The PMO was also too often caught between the supervision team and NDRC. In these cases, a better dialogue between the parties would have made the PMO's work easier.

Closing Workshop with GoC

The closing workshop hosted by the Government of China, with attendance from most project participants, several donors and, the PMO and World Bank staff focused mainly on project outcomes. Of these three main ones were noted by several participants.

Energy Development As Part of Rural Development

One of the outcomes of the project had been the Government's growing recognition of the role of energy development as a contributor to rural development, in particular under the 'New Socialist Countryside' policy. PV had a particular role to play, as it had been demonstrated to be suitable not only for small, individual applications, but also for mini-grid applications, electrifying remote villages and townships. Further scale-up is needed to make PV cost effective for this kind of application, which may result in the industry having to understand the trade-offs between mini-grid and off grid applications.

Industrialization of the PV Sector

Workshop participants highlighted the growing industrialization of PV, turning from a relatively small industry dominated by small and medium enterprises, into one in which industrial sized companies were required. Several companies noted China's role as a producer in the world, and that further growth would be beneficial to China itself, as it scaled up its electrification efforts, as well as to the world at large. For this to be a realistic objective, however, further focus on sustainability and quality was required

Technology improvement was seen as a particularly important dimension of the industrialization process, and the kind of capital provided by REDP – essentially first-stage equity – was particularly welcome. The Golden Sun program was highlighted as an important part of this effort as well.

The Importance of Financing

A number of speakers mentioned that the importance of system financing had not been tested. Some noted that the PV component had relied on cash sales, and the absence of financing had not appeared to be a hindrance to sales. Others noted that the absence of formal financing for some of the participating PV companies had been an issue, both for their own growth and to help them make additional sales.

Annex 7. Summary of Borrower's ICR and/or Comments on Draft ICR

Because the project was implemented by two separate implementing agencies working independently of one another, they each prepared a completion report. Both were long and have been summarized; the one on the wind component by Bank staff, and the one on the PV and TI Components by PMO staff which has been lightly formatted for easier reading.

Wind Component

The project followed a 1998 feasibility study that eventually chose the Nanhui and Chongming sites. The project was completed in 2005 by SWPC, a special-purposes company established by SMEPC in November 2001. In general, the operating results are satisfactory, with wind production of 40GWh lower than estimated but within the actual variation caused by annual variations in wind speeds.

Implementation progress compared with plan is shown in Table A7.1.

Table A7.1: Implementation Progress

Step Progress of Project	Plan Progress				Actual Progress			
	Beginning		Ending		Beginning		Ending	
	Y	M	Y	M	Y	M	Y	M
Preparation of Invite Bid Documents	2003	1	2003	2	2003	1	2003	2
Bid Documents for No Objection	2003	2	2003	4	2003	2	2003	7
Evaluation of Bid Documents	2003	5	2003	9	2003	7	2003	9
Evaluation Report for No Objection	2003	9	2003	9	2004	2	2004	2
Negotiation for Contract with GE	2003	9	2003	10	2004	2	2004	4
Equipment Made and Delivered	2003	10	2004	3	2004	4	2004	12
Civil Works	2003	10	2004	4	2004	2	2005	6
Installation and Adjusting	2004	4	2004	10	2004	12	2005	6
Testing and Commissioning	2004	10	2004	11	2005	6	2005	11
Acceptance	2004	11	2004	12	2005	11	2005	12

Delays in implementation were caused by SWPC inexperience in procurement of wind farms, and particularly of World Bank procedures, SARS, and inexperience of the contractor in construction of wind farms on the shoreline. In addition one turbine suffered a major fault on installation, necessitating the remanufacturing of the generator and thus delay in its commissioning.

Total planned cost was Y219,701,700 ($26.53 million) compared with the actual project costs of Y211,773,711 ($25.58 million). Cost savings were attributed to local manufacture of the towers (compared with the original estimate which expected towers to be imported), and lower installation cost, especially of the switchyard and network connection. Costs were higher as a result of high civil work costs and domestic price inflation.

Environment impacts were expected to be dust, vehicle movements and noise during construction and noise and effects on birds during operation. Construction impacts were modest because the wind farms are on newly reclaimed land, with few residents in the area and none in the immediate vicinity.

Wind turbine noise effects during operation are mitigated by siting the wind farm away from residential areas and requiring the wind turbines to meet IEC 61400-14; monitoring after construction is continuing. Effects on birds have been extensively studied. Only one migratory cycle had been observed between the start of operations in June 2005 and writing the completion report. Long term observations continue but no bird strikes have been observed.

The wind farm is estimated to avoid emissions of about 37,150 tonnes of CO_2 per year given installed capacity of 21MW and the feasibility study assumptions of production of 42GWh per year and a capacity factor of 22.8 percent.

Land occupation is shown in Table A7.2. No houses were demolished or permanent residents displaced. In Chongming, land had been rented to fishermen and for seasonal planting. In Nanhui the area outside the berm was unused state owned land, and an area designated for a forest park.

Table A7.2: Land Occupation by Wind Farms

	Land occupation (m^2)	
	Permanent	Temporary
Chongming		
Berm	3000	26000
Reclaimed land	4830	6667
Total	7830	32667
Nanhui		
Berm	1350	16000
Forest park	6335	9335
Total	7685	25335

Total land costs, including purchase, compensation and transfer fees amounted to Y1,401,148 in Chongming ($169,221) and Y645,491 ($77,958) in Nanhui. Positive social impacts include commercialization of renewable technologies and development of wind power markets in China. Some local job opportunities during construction and operation have been created.

A visitor center has been set up adjacent to the Nanhui wind farm, and between April 2006 and April 2007 about 46,000 people visited the center. Of these, about 29,900 are school and university students. The education center has received a positive response.

The technical assistance component played an important part in the project, enriching the experience of SMEPC and SWPC, and providing support for future project development. The activities included: financial management; operations and management support; planning of wind resources (as a result of which SMEPC plans to develop 200MW by 2010 and Shanghai government plans to reach 310 by then and 1,000MW by 2020); investigation of the impacts on the grid of wind power; support for the wind power visitor center; study tours abroad; international consultant support during procurement, construction and commissioning; and design research into wind turbine foundations.

The project is considered sustainable with a calculated FIRR of 6.28 percent. Clean Development Mechanism (CDM) funding at $13/ton would improve the FIRR to 10.2 percent and will be applied for.

SMEPC and SWPC assess Bank performance positively, noting its support in financial management, procurement and technical assistance. Regular supervision helped SWPC understand international project management.

Borrower performance is assessed positively, particularly in procurement, contract management, construction and operations and maintenance. Cost control was good. Liaison between SMEPC and SWPC was good. Communications with Bank staff and GE was difficult so improved language skills are needed. Frequent changes of management affected consistency of working. More data collection would have helped government decision making to start with. The positive experience has positioned SWPC well for procurement of further wind farms, including the planned Donghai offshore project.

PV and TI Components

REDP is a project of the National Development and Reform Commission (NDRC) and the World Bank (WB) in order to establish sustainable markets for wind and PV technologies, with international grant financing provided by the GEF. It has had two main components: (1) PV component; (2) TI component. A third component for institutional strengthening supported activities to eliminate barriers to market development and promote technology commercialization.

During implementation, there are some issues happened which affected the implementation outcomes and results: (1) Delayed project start; (2) Strong sector growth; (3) Low domestic inflation and stable currency; (4) Strong official support for PV and development of western China; (5) No consumer finance and no bank credits for private PV companies; (6) SARS – 2003; (7) Polysilicon shortage and increasing module prices, 2004 – 06; (8) Renewable Energy Law – 2006.

And based on the external context, the design was also improved and changed: (1) MDSF was shifted to demand driven; (2) Addition of three provinces; (3) Extension of project closing date by one year; (4) Increased direct REDP cooperation with official programs; (5) Raised subsidy for systems with higher standard modules; (6) Permitted larger systems; (7) Imposed penalties on PV companies and suppliers; (8) Introduced multiple sales verification methods; (9) Assisted PV companies to enter international markets; (10) Did not implement SHS customer and PV company credit pilots.

These improvements and changes helped REDP to realized its objectives and targets, although it faced some challenges before implementation, such as REDP's large scale, uncompetitive China PV sector, low affordability of last consumers, low product quality / high cost.

The main achievements of REDP are:

(1) Contribution to rural electrification. More than two million people in western China have been provided with access to modern energy through PV systems, solving the basic electricity needs of households.

(2) Promotion of rural PV businesses and service networks. 28 companies have developed and expanded their rural PV businesses, establishing sustainable access to PV based electricity services in remote communities in western China. The companies have established commercially sustainable sales and service networks that reach the deepest rural areas in China and increasingly they are selling in world markets with certified products.

(3) Establishment of market frameworks for PV standards, tests, certification. REDP supported the establishment of a comprehensive market framework of standards, testing, and quality verification and certification capacities for PV components and SHS that will contribute to the long term sustainability of product quality and consumer protection in China's rural PV markets. This framework is now being used in other projects in China and is being drawn upon in the design of PV projects in other countries. REDP supported the establishment of a quality seal – China Golden Sun – that can be the basis for continued growth of domestic and international markets for China's quality PV products.

(4) Step by step improvements to product quality. REDP supported companies to upgrade their technology capabilities and products, including improved modules, lights, controllers, inverters and other components. 74 companies now offer products that meet REDP requirements. Also, 24 SHS systems have been certified as meeting IEC 62124 and 25 companies have products or systems that have received the Golden Sun quality seal.

(5) Gradual lowering costs and prices. REDP's parallel support for market development and technology improvement resulted in better quality PV products and at the same time reductions to the costs. Through market competition and technology improvement, REDP contributed to 30% to 40% reductions in the costs/prices of PV products. Before 1997, the cost of off-grid PV stations was about RMB120-140/Wp, while now it is RMB80-100/Wp; the price of SHS was reduced from RMB80-100/Wp to RMB50-60/Wp.

(6) Maintain competitive market. The commercial SHS market has remained competitive with the top firms having little if any market control.

(7) Mobilizing private financing. The companies succeeded in accessing private financing to support sales growth and investments. While the private firms in interviews report continuing not to have access to bank financing, they also report raising loans and investments from family, friends, employees and investors to finance multiple expansions of the businesses. Several owners referred to a rough standard of paying 1% per month on private loans. The companies have reinvested profits as a main source of growth financing. After improvements in management, business skills and financial systems, some companies have received access to commercial bank credits and financial support of other institutions.

(8) Neutral product / business model; demand driven capacity building. REDP's approach was open to a full range of types and permutations of business models, allowing the business to make their decisions in line with market signals. The project established the technical specifications of the systems, the broad potential market areas and basic consumer protection requirements covering warranties, truth in advertising and similar. While all the companies depended on cash sales as their revenue model in the commercial market, each developed its own supply chain and distribution arrangements, product line, pricing and other elements of their business plans. The performance based subsidy covered PV systems from small portable systems to larger, professionally installed ones, from 10 Wp up to 500 Wp, This allowed the companies to size and procure their products to fit their target customers' affordability and preferences. REDP's main business and market development support was the cost share grants of the MDSF. Each company applied individually based on their own assessment of their shortcomings and needs.

(9) Increased use of PV in official programs for western China development.

(10) Development of China's PV sector.

(11) Level playing field and transparent, professional project management.

From REDP, there are also some lessons that should be learned:

(1) The absence of consumer finance for SHS purchasers is typically viewed as a barrier that limits affordability and hence restricts sales and rural market development and penetration.

(2) Lack of access to formal financial institution credit services for small and medium enterprises is frequently assessed as a constraint on market development. All of the private SHS companies participating in REDP were SMEs; in practice, during REDP none had access to formal financial institution credit services.

(3) Before the start of PMO implementation, there was no opportunity to organize the PMO and conduct PMO staff training. There was no significant pre-start up capacity building for the PMO staff in the best practices and guidelines for project management in accordance with the World Bank's procurement or other requirements. This learning-by-doing approach, while eventually effective, contributed to a slower than expected pace during the start up of implementation.

(4) When establishing the PMO and when replacing staff, it was often difficult to recruit qualified staff due to the temporary nature of the positions, the salary levels and the long time required by the process of contracting a staff person. This problem grew as the time remaining in the project grew shorter.

(5) Also, the nature of the remote PV rural market and the fiduciary responsibility of the PMO for the grant funds required caution and due diligence in disbursements of grant funds, which led to delays in disbursing sales performance grants and cash flow problems for the PV companies. These delays led to negative feedback at times from PV companies.

(6) The QRF did not work well. It was never quick as it took the PMO a long time to evaluate the proposals, to obtain the required approvals and to sign the sub-grant agreements. Furthermore, the projects often ended up not being for the intended purpose and not meeting the criteria of being urgent and small. To be effective, QRF proposals would have to have been evaluated, approved and contracted within three weeks and this did not happen. The QRF should also not have been used by companies who wished to by-pass the CGF competitive process. Except these, QRF still was very successful.

Overall, the project was implemented very satisfactorily. The NDRC maintained the project's results oriented focus, while encouraging flexibility to adjust to changing market conditions, the learning being generated while implementing the project and international best practices.

The World Bank management and staff also encouraged flexibility while maintaining a focus on achieving results and the project objectives. The World Bank supervision teams operated professionally, visiting PMO periodically, suggesting actions to improve project performance. The World Bank staff and consultants had rich knowledge and worked hard, which contributed to the successful implementation of REDP. The Chinese participants learned about many project management experiences from them. In linking REDP with international PV expertise and best practices for PV market development projects, World Bank staff ensured that REDP benefited significantly from international as well as Chinese knowledge and experience. They carried out their fiduciary responsibilities effectively. The World Bank staff and consultants of the Washington and Beijing offices maintained good relations with the PMO.

Annex 8. Comments of Cofinanciers and Other Partners/Stakeholders

Not applicable.

Annex 9. List of Supporting Documents

The ICR was prepared in part based on the following reports which are available on the project files:

Borrower Completion Report Shanghai (Chongming, Nanhui) Wind Power Project. Shanghai Wind Power Company, June 8, 2007

REDP Borrower's Report (for PV and TI Components). REDP PMO. May 2008.

REDP PV sales grant analysis report. Wang Wei. May 2008

REDP PV companies sales grant analysis. Wang Wei. May 2008.

REDP Economic and Financial Analysis of the PV Component. Peter Meier. May 5, 2008.

2007 Solar Home System End User Investigation Report. SwellB. December 16, 2007.

2008 PV Field Investigation Report of Overall Sample. SwellB. May 6, 2008.

The Market Development Support Investment Appraisal Report. GaoDe Investment Advisory. May 2008.

Photovoltaic Technology Improvement in China – A selection of 81 Technology Improvement Projects in China REDP. REDP PMO. May 2008.

Final Evaluation Report on REDP TI Component. Results and Impacts (of the China REDP TIC). Emil ter Horst. May 2008.

2007 TI investment survey report. REDP PMO. May 2008

Summary Report REDP Technical Committee. REDP Standards Committee. May 2008.

REDP Quality Improvement Report. Zhang Cheng, Luo Xinlian and Enno Heijndermans. May 2008.

Market Price Research On China Solar Home System. SwellB. March 8, 2008.

PMO operation report. REDP PMO. May 2008.

REDP cash sales model lessons report. James R. Finucane. April 2008.

REDP promotion and outreach report. Ge Chun. March 14, 2008.

REDP PV Companies Development Report. James R. Finucane. April 2008.

Workshops - Stakeholder Participatory Workshop reports

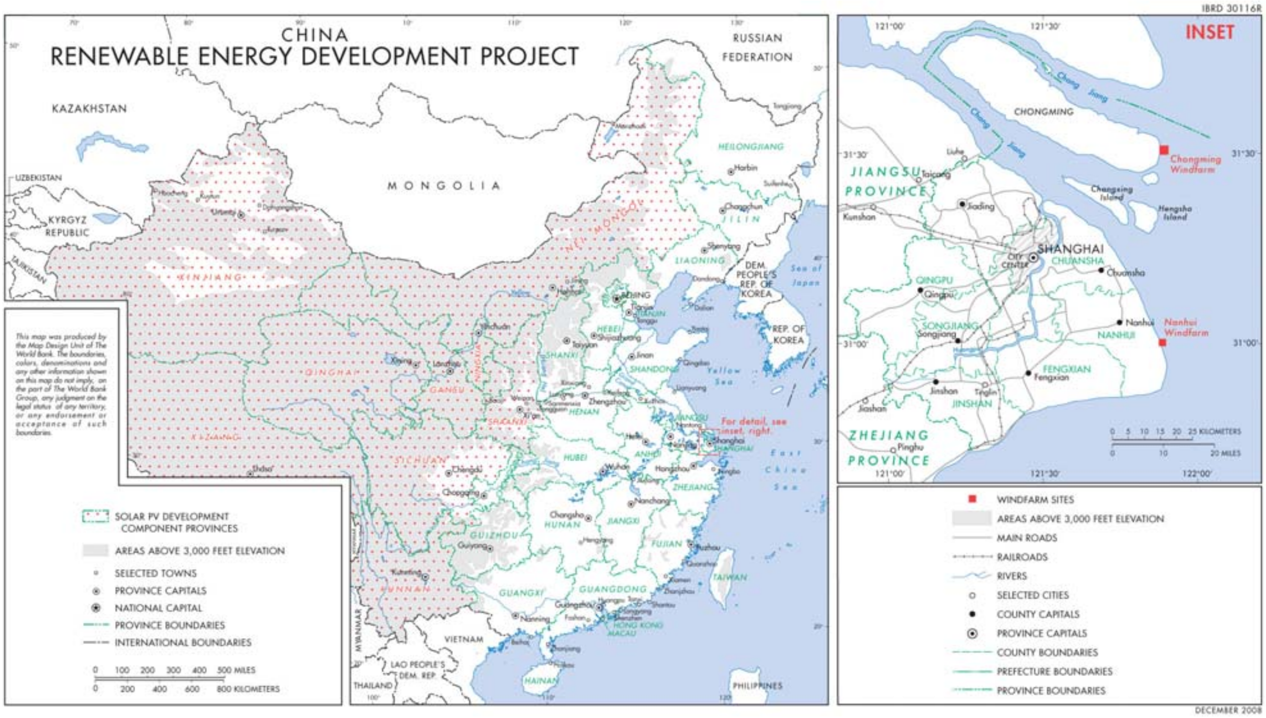
- Records of REDP Evaluation Meeting by PMO Staff
- December 21, 2007 Beijing meeting records
- January 15, 2008 Shanghai meeting records
- January 22, 2008 Xining meeting records
- January 23, 2008 Urumqi meeting records

• Questionnaire PMO staff evaluation on REDP

China Photovoltaic Industry Development Research Report (2006-2007). REDP PMO. February 2008.

Run with the Sun. REDP Achievement Album. REDP PMO. May 2008.

MAP


CHINA
RENEWABLE ENERGY DEVELOPMENT PROJECT
RUSSIAN FEDERATION
KAZAKHSTAN
MONGOLIA
UZBEKISTAN
KYRGYZ REPUBLIC
TAJIKISTAN
DEM. PEOPLE'S REP. OF KOREA
REP. OF KOREA
Sea of Japan
Yellow Sea
East China Sea
MYANMAR
VIETNAM
LAO PEOPLE'S DEM. REP.
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XINJIANG
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SICHUAN
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GUIZHOU
FUJIAN
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Urumqi
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Shijiazhuang
Jinan
Zhengzhou
Xi'an
Chengdu
Chongqing
Lhasa
Guiyang
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Nanning
Guangzhou
Changsha
Wuhan
Nanchang
Hefei
Nanjing
Hangzhou
Fuzhou
Shanghai
For detail, see inset, right.
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SOLAR PV DEVELOPMENT COMPONENT PROVINCES
AREAS ABOVE 3,000 FEET ELEVATION
SELECTED TOWNS
PROVINCE CAPITALS
NATIONAL CAPITAL
PROVINCE BOUNDARIES
INTERNATIONAL BOUNDARIES
0 100 200 300 400 500 MILES
0 200 400 600 800 KILOMETERS
IBRD 30116R
INSET
CHONGMING
Chang Jiang
Chongming Windfarm
Changxing Island
Hengsha Island
JIANGSU PROVINCE
Liuhe
Taicang
Jiading
Kunshan
SHANGHAI
CITY CENTER
CHUANSHA
Chuansha
QINGPU
Qingpu
SONGJIANG
Songjiang
Nanhui
NANHUI
Nanhui Windfarm
FENGXIAN
Fengxian
Jinshan
Tinglin
JINSHAN
Jiashan
ZHEJIANG PROVINCE
Pinghu
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122°00'
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0 5 10 15 20 25 KILOMETERS
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WINDFARM SITES
AREAS ABOVE 3,000 FEET ELEVATION
MAIN ROADS
RAILROADS
RIVERS
SELECTED CITIES
COUNTY CAPITALS
PROVINCE CAPITALS
COUNTY BOUNDARIES
PREFECTURE BOUNDARIES
PROVINCE BOUNDARIES
DECEMBER 2008