Document of
The World Bank

Report No: ICR00004030

IMPLEMENTATION COMPLETION AND RESULTS REPORT

(TF-23346, TF-57033)

ON A

GRANT FROM THE GLOBAL ENVIRONMENT FACILITY TRUST FUND

IN THE AMOUNT OF

US$49.35 MILLION

TO THE

UNITED MEXICAN STATES

FOR A

SOLAR THERMAL AGUA PRIETA II PROJECT

May 30, 2017

Energy and Extractives Global Practice
Latin America and Caribbean Region

CURRENCY EQUIVALENTS
(Exchange Rate Effective April 2017)

Currency Unit = Mexican Peso (MXN)
US$1.00 = MXN 18.56

FISCAL YEAR
January 1 – December 31

ABBREVIATIONS AND ACRONYMS

CAT	Construct Lease Transfer (*Construcción Arrendamiento Transferencia*)
CCGT	Combined Cycle Gas Turbine
CFE	Federal Electricity Commission (*Comisión Federal de Electricidad*)
CO2e	Carbon Emissions (Carbon Dioxide Equivalent)
CPS	Country Partnership Strategy
CRE	Energy Regulatory Commission (*Comisión Reguladora de Energía)*
CSP	Concentrating Solar Power
EPC	Engineering, Procurement, and Construction
FM	Financial Management
FMR	Financial Management Report
FMSM	Financial Management Supervision Mission
GEF	Global Environment Facility
GEO	Global Environment Objective
GHG	Greenhouse Gas
GoM	Government of Mexico
HRSG	Heat Recovery Steam Generator
HTF	Heat Transfer Fluid
ICB	International Competitive Bidding
ICR	Implementation Completion and Results Report
IP	Implementation Progress
IPP	Independent Power Producer
ISCCS	Integrated Solar Combined Cycle System
ISR	Implementation Status and Results Report
LAERFTE	Law for the Use of Renewable Energy and the Energy Transition Financing (*Ley para el Aprovechamiento de las Energías Renovables y el Financiamiento para la Transición Energética*)
LyFC	Mexican Light & Power Company *(Luz y Fuerza del Centro)*
M&E	Monitoring and Evaluation
MPSA	Mitsubishi Power Systems Americas, Inc.
MTR	Midterm Review
NAFIN	Mexican Development Bank (*Nacional Financiera, S.N.C.I.B.D.*)
NGO	Nongovernmental Organization
O&M	Operation and Maintenance
OM	Operational Manual

OPF	Finance Build Transfer Scheme (*Obra Pública Financiada*)
OPRC	Operations Procurement Review Committee
PAD	Project Appraisal Document
PCN	Project Concept Note
PDO	Project Development Objective
PEF	Federal Expenditures Budget (*Presupuesto de Egresos de la Federación*)
PV	Photovoltaic
R&D	Research and Development
SEMARNAT	Ministry of Environment and Natural Resources (*Secretaría de Medio Ambiente y Recursos Naturales*)
SENER	Ministry of Energy (*Secretaría de Energía*)
SFP	Ministry of Public Administration (*Secretaría de la Función Pública*)
SHCP	Ministry of Finance and Public Credit (*Secretaría de Hacienda y Crédito Público*)
STP	Solar Thermal Project
STAP	Scientific and Technical Advisory Panel
TES	Thermal Energy Storage
TTL	Task Team Leader
UNFCCC	United Nations Framework Convention on Climate Change

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MEXICO
Solar Thermal Agua Prieta II Project

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A. Basic Information

Country:	Mexico	Project Name:	Solar Thermal Agua Prieta II Project
Project ID:	P066426	L/C/TF Number(s):	TF-23346, TF-57033
ICR Date:	05/31/2017	ICR Type:	Core ICR
Lending Instrument:	Specific Investment Loan	Borrower:	GOVERNMENT OF MEXICO
Original Total Commitment:	US$49.35 million	Disbursed Amount:	US$46.39 million
Revised Amount:	US$49.35 million		
Environmental Category: B		**Global Focal Area: C**	
Implementing Agencies: Federal Electricity Commission (*Comisión Federal de Electricidad, CFE*)			
Cofinanciers and Other External Partners:			

B. Key Dates

Process	Date	Process	Original Date	Revised / Actual Date(s)
Concept Review:	06/15/1999	Effectiveness:	07/03/2008	07/01/2008
Appraisal:	06/20/2006	Restructuring(s):		08/31/2009 05/11/2010 04/05/2011 05/12/2011 06/28/2013 12/27/2013 12/21/2015
Approval:	10/05/2006	Mid-term Review:		
		Closing:	10/31/2009	05/31/2016

C. Ratings Summary

C.1 Performance Rating by ICR

Outcomes:	Unsatisfactory
Risk to Global Environment Outcome	Substantial
Bank Performance:	Moderately Unsatisfactory
Borrower Performance:	Moderately Unsatisfactory

C.2 Detailed Ratings of Bank and Borrower Performance			
Bank	**Ratings**	**Borrower**	**Ratings**
Quality at Entry:	Moderately Satisfactory	Government:	Moderately Satisfactory
Quality of Supervision:	Moderately Unsatisfactory	Implementing Agency/Agencies:	Unsatisfactory
Overall Bank Performance:	Moderately Unsatisfactory	**Overall Borrower Performance:**	Moderately Unsatisfactory

C.3 Quality at Entry and Implementation Performance Indicators			
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):	None
GEO rating before Closing/Inactive status	Moderately Unsatisfactory		

D. Sector and Theme Codes

	Original	**Actual**
Sector Code (as percentage of total Bank financing)		
Other Renewable Energy	100	100

Theme Code (as percentage of total Bank financing)		
Climate change	40	40
Infrastructure services for private sector development	40	40
Pollution management and environmental health	20	20

E. Bank Staff

Positions	**At ICR**	**At Approval**
Vice President:	Jorge Familiar	Pamela Cox
Country Director:	Gerardo M. Corrochano	Isabel M. Guerrero
Practice Manager/Manager:	Antonio Barbalho	Susan G. Goldmark
Project Team Leader:	Guillermo Hernández González	Gabriela Elizondo Azuela
ICR Team Leader:	Guillermo Hernández González	
ICR Primary Author:	Luis M. Vaca-Soto	

F. Results Framework Analysis

Project Development Objective (PDO) and Key Indicators (as approved)

The PDO of the project was to demonstrate and encourage replication of the Integrated Solar Combined Cycle Systems (ISCCS) power generation technology in Mexico and elsewhere, thereby contributing to the reduction of global GHG emissions.

The approved PDO indicators were the following:
1. Total electricity generated from the solar thermal hybrid plant (GWh per year)
2. Solar output as a percentage of total energy produced by the hybrid plant (GWh per year)

Revised Project Development Objective (as approved by original approving authority) and Key Indicators and reasons/justifications

The PDO was not revised. However, the target of PDO indicator 1 was revised from 3,700 GWh per year to 2,935 GWh per year, to reflect the decrease in the size of the solar field from 31 MW to 12–15 MW. Also, the installed capacity of the combined-cycle component was decreased from 485 MW to 394 MW. These adjustments were processed through a restructuring in June 2013. Also, two core indicators were added to the results framework in the ISR Seq. 15, in October 2014: (a) generation capacity of renewable energy—other than hydropower—constructed, in MW, and (b) generation capacity of renewable energy constructed—solar—also in MW. The final set of key PDO indicators is the following:

(a) PDO Indicator(s)

PDO Indicator	Baseline Value	Original Target Values (from approval documents)	Formally Revised Target Values	Actual Value Achieved at Completion or Target Years
Indicator 1:	Total electricity generated from the solar hybrid project (GWh per year)			
Value (quantitative or qualitative)	0	3,700	2,935	1,167.37
Date achieved	11/22/2006	11/22/2006	06/28/2013	04/17/2017
Comments (incl. percentage of achievement)	Achievement: 39.77 percent (partial). The target for this indicator was adjusted upon the restructuring process in June 2013, to reflect the reduction of the size of the solar field from 31 MW to 12–15 MW. The installed capacity of the combined-cycle component was also reduced from 485 MW to 394 MW. The reported value for this indicator is based only on five months of operation for the thermal component (which was commissioned in October 2016). As of May 29, 2017, the solar field had been physically connected to the thermal plant but had not supplied any steam to the thermal component.			
Indicator 2:	Annual average efficiency of solar input to electric output (percent)			
Value (quantitative or qualitative)	0	>12 percent	n.a.	0
Date achieved	11/22/2006	11/22/2006	06/28/2013	04/17/2017
Comments (incl. percentage of achievement)	Achievement: 0 percent. The target for this indicator remained unchanged. As of May 29, 2017, the solar field is completed and physically connected to the thermal plant but had not supplied any steam to the thermal component. Therefore, it was not possible to estimate the annual average efficiency of solar input to electric output.			

Indicator 3:	Generation capacity of renewable energy (other than hydropower) constructed (MW)			
Value (quantitative or qualitative)	n.a.	n.a.	14	14
Date achieved	n.a	n.a.	10/18/2014	04/17/2017
Comments (incl. percentage of achievement)	Achievement: 100 percent. This indicator was added to the Results Framework in the ISR Seq. 15, in October 2014. As of May 29, 2017, the solar field had been completed (hence the updated value of 14 MW) but had not sent any steam to the thermal component. CFE estimates that the solar field will start supplying steam for the thermal component by mid-2017.			
Indicator 4:	Generation capacity of renewable energy constructed - solar (MW)			
Value (quantitative or qualitative)	n.a.	n.a.	14	14
Date achieved	n.a.	n.a.	10/18/2014	04/17/2017
Comments (incl. percentage of achievement)	Achievement: 100 percent. This indicator was added to the Results Framework in the ISR Seq. 15, in October 2014. As of May 29, 2017, the solar field had been completed (hence the updated value of 14 MW) but had not supplied any steam to the thermal component. CFE estimates that the solar field will start supplying steam for the thermal component by mid-2017.			

Global Environment Objectives (GEO) and Key Indicators (as approved)
The global benefits associated with the project include the following: (i) demonstrate the operational viability and value added of integrating a solar field with a large conventional thermal facility (ISCCS using solar parabolic trough technology); (ii) contribute to reduce the long-term costs of the technology; and (iii) reduce global GHG emissions.

Key performance indicators associated with the GEO include:
1. Cost of solar thermal power (US cents per kWh)
2. Reduction of CO_2 emissions (tons per year)

Revised Global Environment Objectives (as approved by original approving authority) and Key Indicators and reasons/justifications

The GEO was not revised. However, the target of GEO indicator 1 was revised from 15,500 tCO_2e per year to 11,833 tCO_2e per year, to reflect the decrease in the size of the solar field from 31 MW to 12–15 MW. This adjustment was processed through a restructuring in June 2013. The final set of key GEO indicators was the following:

(b) GEO Indicator(s)

GEO Indicator	Baseline Value	Original Target Values (from approval documents)	Formally Revised Target Values	Actual Value Achieved at Completion or Target Years
Indicator 1:	Reduction of annual CO_2 emissions			
Value (quantitative or qualitative)	0	15,500	11,833	0
Date achieved	11/22/2006	11/22/2006	06/28/2013	03/31/2017

Comments (incl. percentage of achievement)	Achievement: 0 percent. The target for this indicator was adjusted following the restructuring in June 2013, to reflect the reduction of the size of the solar field from 31 MW to 12–15 MW. As of May 29, 2017, the solar field had been completed but had not supplied any steam to the thermal component. CFE estimates that the solar field will start supplying steam for the thermal component by mid-2017 and only then can the reduction of annual CO_2 emissions be estimated (as of May 29, 2017, the steam from the solar field had not displaced any steam from fossil-fuel sources).

(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:	Yearly global production of electricity of the ISCCS plant (GWh)			
Value (quantitative or qualitative)	0	3,700	2,935	1,167.37
Date achieved	11/22/2006	11/22/2006	06/28/2013	03/31/2017
Comments (incl. percentage of achievement)	Achievement: 39.77 percent (partial). The target for this indicator was adjusted following the restructuring in June 2013, to reflect the reduction in the size of the solar field from 31 MW to 12–15 MW and the reduction in the installed capacity of the combined-cycle component from 485 MW to 394 MW. The reported value for this indicator corresponds to five months of operation for the thermal component only (which was commissioned in October 2016). As of May 29, 2017, the solar field had not supplied any steam to the thermal component.			
Indicator 2:	Yearly contribution of solar electricity (GWh)			
Value (quantitative or qualitative)	0	70	31	0
Date achieved	11/22/2006	11/22/2006	06/28/2013	03/31/2017
Comments (incl. percentage of achievement)	Achievement: 0 percent. The target for this indicator was adjusted during the restructuring process in June 2013, to reflect the reduction of the size of the solar field from 31 MW to 12–15 MW. As of May 29, 2017, the solar field had been completed but had not supplied any steam to the thermal component, and therefore the yearly contribution of solar electricity is zero. CFE estimates that the solar field will start supplying steam for the thermal component by mid-2017.			

G. Ratings of Project Performance in ISRs

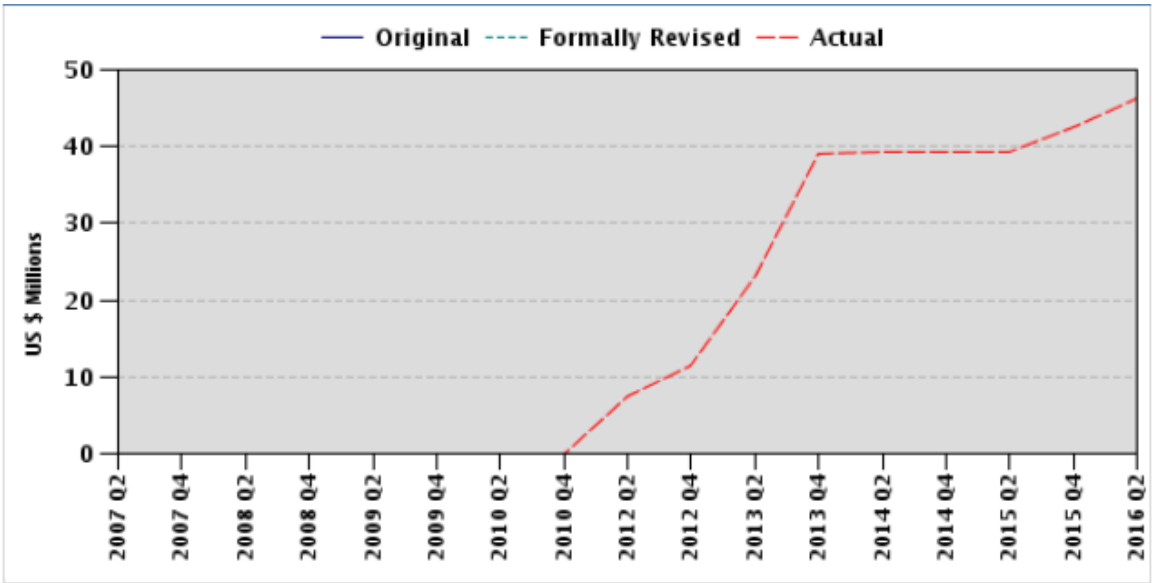
No.	Date ISR Archived	GEO	IP	Actual Disbursements (US$, millions)
1	02/15/2007	Satisfactory	Satisfactory	0.00
2	06/06/2007	Satisfactory	Satisfactory	0.00
3	12/11/2007	Moderately Unsatisfactory	Moderately Unsatisfactory	0.00
4	06/26/2008	Moderately Unsatisfactory	Moderately Unsatisfactory	0.00
5	12/16/2008	Moderately Unsatisfactory	Moderately Unsatisfactory	0.00

6	05/22/2009	Moderately Satisfactory	Moderately Unsatisfactory	0.00
7	11/14/2009	Moderately Satisfactory	Moderately Unsatisfactory	0.00
8	04/05/2010	Moderately Satisfactory	Moderately Satisfactory	0.00
9	02/21/2011	Moderately Satisfactory	Moderately Satisfactory	0.00
10	08/10/2011	Moderately Satisfactory	Moderately Satisfactory	0.00
11	04/14/2012	Moderately Satisfactory	Moderately Satisfactory	8.02
12	11/03/2012	Moderately Unsatisfactory	Moderately Unsatisfactory	18.84
13	06/25/2013	Moderately Unsatisfactory	Moderately Unsatisfactory	38.99
14	01/04/2014	Moderately Satisfactory	Moderately Satisfactory	39.31
15	10/18/2014	Moderately Satisfactory	Moderately Satisfactory	39.31
16	06/23/2015	Moderately Satisfactory	Moderately Unsatisfactory	42.63
17	12/17/2015	Moderately Satisfactory	Moderately Satisfactory	42.75
18	05/31/2016	Moderately Unsatisfactory	Moderately Unsatisfactory	46.39

H. Restructuring (if any)

Restructuring Date(s)	Board Approved GEO Change	ISR Ratings at Restructuring		Amount Disbursed at Restructuring in US$, millions	Reason for Restructuring and Key Changes Made
		GEO	IP		
08/31/2009		MS	MU	0.00	Extension of closing date from October 30, 2009 to April 30, 2010.
05/11/2010		MS	MS	0.00	Extension of closing date from April 30, 2010 to April 30, 2011.
04/05/2011		MS	MS	0.00	Extension of closing date from April 30, 2011 to July 31, 2011.
05/12/2011		MS	MS	0.00	Extension of closing date from July 31, 2011 to January 31, 2014.
06/28/2013		MU	MU	38.99	Amendment of grant agreement to reduce the size of the solar plant and adjust the target values of the outcome and results indicators accordingly.
12/27/2013		MU	MU	39.31	Extension of closing date from January 31, 2014 to December 31, 2015.
12/21/2015		MS	MS	42.75	Extension of closing date from December 31, 2015 to May 31, 2016.

I. Disbursement Profile



1. Project Context, Global Environment Objectives and Design

1.1 Context at Appraisal

1. **Country context.** Mexico's energy sector has been of strategic importance to the economy and is also an important driver of economic growth. Mexico has also been a major oil exporting country for many decades, with crude oil production being an important source of foreign exchange earnings and an important contributor to fiscal revenues. However, starting in 2004, oil production, as well as oil reserves, started to decline. The decline in domestic oil production gave rise to increasing pressures on Government fiscal policy. It also started to focus attention on the need to diversify the country's energy resources away from oil towards an increased use of natural gas and the development of the country's renewable energy potential[1]. Demand for electricity, natural gas, and oil products was projected to rise by 75 percent, 69 percent, and 35, percent, respectively, within the next ten years.

2. At the time of appraisal, in 2006, Mexico was the ninth largest greenhouse gas (GHG) emitter in the world, and the main sources of emissions (excluding land use-related emissions) were fossil-fuel combustion for energy generation and industrial processes.

3. **Sector context (electricity).** The electricity sector in Mexico included 8,250 MW of natural gas-based independent power production (IPP), 10,268 MW of hydroelectric capacity, 22,691 MW of thermoelectric capacity (including fuel oil and diesel), 2,600 MW of coal-based power plants, 1,365 MW of nuclear capacity, 960 MW of geothermal capacity, and 2.18 MW of wind generation for a total installed capacity of 46,137 MW as of 2005. Solar off-grid photovoltaic (PV) capacity was 26 MW. The national interconnected system had about 45,000 km of transmission and distribution lines.

4. In 2006, the main sector institutions with responsibility for the development of Mexico's electricity sector were (a) the Ministry of Energy (*Secretaría de Energía*, SENER), which was responsible for energy sector planning as well as for policy formulation in the sector, and (b) the state-owned utility Federal Electricity Commission (*Comisión Federal de Electricidad*, CFE), which was responsible for generation, transmission, and distribution of electricity.[2] In addition, the Energy Regulatory Commission (*Comisión Reguladora de Energía*, CRE) was responsible for regulation and oversight of the electricity subsector.[3] Despite the strong technical capabilities of CFE, one of the largest state-owned utilities in Latin America, the electricity sector presented several challenges, in particular the technical efficiency and quality of service areas. CFE's interdependence with the Ministry of Finance and Public Credit (*Secretaría de Hacienda y Crédito Público*, SHCP) affected its decision-making process regarding investments and financial

[1] World Bank (2016). Implementation Completion and Results Report – Large-Scale Renewable Energy Development Project. Report No. ICR 00003965. Washington D.C.

[2] At the time of appraisal, a smaller utility, the Mexican Light & Power Company (*Luz y Fuerza del Centro,* LyFC), served the Mexico City metropolitan area and small portions of neighbor states (roughly 5 million users). LyFC ceased operations in October 2009 and all of its assets were taken over by CFE.

[3] The entire Mexican energy sector was reshaped by a major reform supported by the Federal Administration in 2013. The legislation reform package, passed in August 2014, facilitated greater investment in power generation, and allowed for more private participation in the maintenance and construction of distribution and transmission networks. Also, it created a wholesale electricity market where power generators can sell electricity to distributors and end users.

management (FM).

5. **Renewable energy.** At the time of appraisal and despite Mexico's high renewable energy potential[4], the country had only a small share of generation capacity based on wind, solar, small hydro, or geothermal (approximately 3 percent of installed capacity). The Government Energy Sector Program established the increased use of renewable energy resources as a sector priority and defined several strategic actions, including (a) developing programs, projects, and actions to increase the use of renewable energy; (b) increasing the capacity share of renewable energy in the electricity sector; (c) strengthening research and technology development activities on renewable energy; and (d) promoting education on renewable energy.

6. Mexico was making substantial progress in the development of policies and measures to increase the market share of renewable energy. These included (a) a provision for accelerated depreciation, which made 100 percent investment in renewable energy technologies after January 2005, eligible for depreciation in the first year, and (b) a proposed Renewable Energy Law (passed by the lower House of Congress in late 2005 and eventually published in 2008) that specified a range of methodologies and dispatch conditions to better capture the value of contributions of renewables. The Renewable Energy Law established (a) the creation of a trust fund to support the development of emerging technologies based on renewable energy sources and (b) the implementation of a second trust fund to support research and development (R&D) activities focused on those renewable energy technologies that were considered promising for the future development of national energy and other industries.[5]

7. Although the potential for renewable energy development in the country was considerable, it had been constrained by CFE's use of narrowly defined least-cost criteria to prioritize its investment options with the consequent development of large-scale generation projects based on natural gas. This had resulted in the installation of only 2 MW of grid-connected wind power by CFE at the time of project preparation.[6]

8. In March 2006, the former Institute of Electrical Research (IIE- Mexico)[7] issued a report that identified the research and technology development priorities for the Mexican energy industry in the 21st century. The report emphasized that given the abundant solar resources in Mexico, research and technology development activities would have to focus on (a) heat production for industrial applications using solar resources, (b) concentrating solar power technology (and specifically parabolic-trough technology), and (c) PV solar panels.

9. Mexico had a well-developed industrial base and had the potential to locally manufacture up to 40 percent of components for an Integrated Solar Combined Cycle Systems (ISCCS) plant using parabolic trough technology. Mexican companies had already manufactured parabolic collectors for ongoing projects in California at that time.[8]

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[4] Mexico is located within the world's solar belt where high solar insolation allows for the efficient operation of grid-connected solar-based power generation.

[5] The Law for the Use of Renewable Energy and the Energy Transition Financing (*Ley para el Aprovechamiento de las Energías Renovables y el Financiamiento para la Transición Energética*, LAERFTE) was approved in 2008 and later replaced by the Electric Industry Law, which was published in 2014 after the major energy reform of 2013.

[6] La Venta I, a CFE grid-connected wind demonstration project.

[7] By presidential decree dated June 24, 2006, the Institute of Electrical Research became the National Institute of Electricity and Clean Energy (INEL).

[8] SMA (Spencer Management Associates), Report. 1994.

Rationale for Bank Involvement

10. Global warming had been identified as a very significant poverty and security issue. The associated detrimental effects were (and still are) likely to manifest themselves in many developing countries.

11. The Global Environment Facility (GEF) Operational Program 7 supported technology development initiatives aimed at increasing the market share of low GHGs-emitting technologies that were not yet commercial, but promised to become competitive in the future.

12. In 1996, the GEF Scientific and Technical Advisory Panel (STAP) recommended high-temperature solar thermal power technology as one of the renewable energy technologies with significant potential for cost reduction and for meeting the expected high demand from countries located in the world's solar belt. Concentrating Solar Power (CSP), viewed as one of the most cost-effective option for transforming solar radiation into electricity, had been operationally proven in California since the mid-l980s. In 1999, the GEF launched a portfolio of four projects (located in India, Mexico, Morocco, and Egypt) to promote the introduction of ISCCS projects.

13. In 2005, the GEF sponsored an updated review of the status of the technology and its potential for replication[9]. The review concluded that (a) solar thermal electricity technology was worthy of continued support; (b) the potential benefits of a successful industry, particularly for developing countries, were significant; (c) the technology was not new and had been proven; however, it was still in the process of becoming competitive; and (d) the technology had the potential to follow a similar cost reduction curve as wind energy.

14. The World Bank and GEF, together with other bi-lateral agencies, engaged with a broad array of Mexican policy, technical, financial, and environmental agencies and actors on the topic. These discussions were aimed at building a consensus on the need for energy sector diversification, the potential benefits of developing in-country renewable energy resources to achieve such diversification, and the technical assistance and program approaches required to stimulate and sustain long-term renewable energy development.

15. The World Bank, GEF, SENER, CFE, and other agencies worked together by (a) collecting information on international experience and tailoring it to Mexican circumstances; (b) identifying and collaborating with a range of technical, financial, and policy experts within and outside of Mexico; and (c) carrying out key analyses required to inform decisions. This collaboration contributed to strengthening national institutional capacity to plan, integrate, and develop renewable energy with various projects supported either through carbon finance or by the GEF.

16. Given the entry into force of the Kyoto Protocol in February 2005, the World Bank's engagement with Mexico (both through the GEF and several projects under development through the World Bank's Carbon Finance Business) strengthened the country's position in the context of the emerging international agreements aimed at mitigating GHGs.[10]

17. Mexico ratified the United Nations Climate Change Convention in 1993 and the Kyoto

[9] Assessment of the World Bank/GEF Strategy for the Market Development of Concentrating Solar Thermal Power, May 31, 2005, prepared by a group of experts from Global Research Alliance; Fraunhofer Institute for Solar Energy Systems; Commonwealth Scientific and Industrial Research Organisation, Australia; and Council for Scientific and Industrial Research, South Africa.

[10] At the time, Mexico was the ninth largest emitter of GHG while CO_2 emissions increased by 23 percent between 1990 and 2000.

Protocol on September 7, 2000. With the presentation of the Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) at the end of 2006, the Mexican Government confirmed its commitment to report on progress achieved in mitigating GHG emissions.

18. As a non-Annex I country, Mexico was eligible for financing from the GEF through the mechanism established by the Convention. The Agua Prieta ISCCS Project received the endorsement of the GEF Operational Focal Point and was formulated in accordance with national priorities.

19. The Agua Prieta ISCCS Project was included in the Federal Expenditures Budget (*Presupuesto de Egresos de la Federación*, *PEF*) for 2006 by SHCP, which was subsequently approved by the Congress.

High Level Objectives to which the Project Contributes

20. The Agua Prieta II Solar Thermal Project (STP) was consistent with the Country Partnership Strategy (CPS) (Report No. 28141-ME, March 18, 2004) which proposed promoting environmental sustainability as one of its four strategic pillars. In particular, the CPS acknowledged the threat of climate change (paragraph 54, pp 21) and agreed "to support on-going programs to address the problems of GHG emissions and promote the introduction of clean energy technologies" (paragraph 119, pp 44). At appraisal, this project represented Mexico's and Latin America's first pilot application of the ISCCS technology, which was particularly promising as it combined the advantages of both solar and thermal sources of energy: while the use of solar resources partially substituted fossil fuels, the system could also supply energy to the grid whenever it was required due to the operation of a conventional combined cycle system. The technology could also be integrated into an existing thermal system, and could therefore be widely replicated. Although the ISCCS technology did not evolve into a mainstream power generation technology, it was a promising alternative with broad positive implications for global climate change mitigation at the time of appraisal. Nonetheless, the Agua Prieta II STP remains aligned with the 2014–2018 CPS, specifically to Theme 4 (Promoting Green and Inclusive Growth) by supporting efforts to (a) reduce the footprint of growth, (b) promote a low-carbon economy, (c) contribute to the reduction of GHG emissions, and (d) contribute to energy security by diversifying the energy matrix composition.

21. The project was consistent with GEF Operational Program 7 "Reducing the Long-Term Costs of Low Greenhouse Gas Emitting Technologies". The GEF approved the proposed ISCCS plant (originally to be located at Mexicali, Baja California) under Operational Program OP 7 as part of its work program in December 1999. This GEF program was aimed at accelerating market penetration of several large-scale backstop technologies, such as solar thermal power, that were constrained by high capital costs and high commercial risks. A GEF Grant of US$49.3 million would support the construction of the solar field (31 MW) while the investment costs for the combined cycle component (270 MW) would be borne by an Independent Power Producer (IPP).

22. The Agua Prieta II STP was a demonstration project expected to reduce GHG emissions from anthropogenic sources through the installation of an ISCCS plant using solar parabolic trough technology. The project was located in the Municipality of Agua Prieta, State of Sonora, close to the Agua Prieta City and 2 km from the border with the United States, within the world's solar belt (where direct normal insolation is highest and the potential to develop solar energy is best). At the

time of appraisal, it was (and still is) the first project of its kind in the electricity markets of Mexico and Latin America.

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

23. The Project Development Objective (PDO) was to demonstrate and encourage replication of ISCCS power generation technology in Mexico and elsewhere, thereby contributing to the reduction of global GHG emissions.

24. Key performance indicators associated with the PDO included the following:

- Total electricity generated from the solar thermal hybrid project (3,700 GWh per year)
- Solar output as a percentage of total energy produced by the hybrid plant (12 percent)

25. The Global Environment Objectives (GEOs) included the following: (a) demonstrate the operational viability and value added of integrating a solar field with a large conventional thermal facility (ISCCS using solar parabolic trough technology), (b) contribute to reduce the long-term costs of the technology, and (c) reduce global GHG emissions. Key performance indicators associated with the GEO included the following:

- Cost of solar thermal power (US cents per KWh)
- Reduction of CO_2 emissions (15,500 tons per year)

26. The carbon emissions reduction was estimated in 391,270 tons of CO_2 over the 25-year economic life of the plant.

27. The key outcome indicators associated with the GEO were the following:

- Reductions in main air pollutants emissions (tons per year) for CO_2
- Annual average efficiency of solar input to electric output (percent)

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

28. **The PDO was not revised.** However, the target of PDO indicator 1 was reduced from 3,700 GWh per year to 2,935 GWh per year, to reflect the decrease in the size of the solar field from 31 MW to 12–15 MW. Also, the installed capacity of the combined-cycle component was decreased from 485 MW to 394 MW. These adjustments were processed through a restructuring in June 2013. Also, two core indicators were added to the results framework in the Implementation Status and Results Report (ISR) Seq. 15, in October 2014: (a) generation capacity of renewable energy—other than hydropower—constructed, in MW, and (b) generation capacity of renewable energy constructed—solar—also in MW.

29. **The GEO was not revised.** However, the target of GEO Indicator 1 was reduced from 15,500 tCO_2e per year to 11,833 tCO_2e per year, to reflect the decrease in the size of the solar field from 31 MW to 14 MW. This adjustment was processed through the restructuring of June 2013.

1.4 Main Beneficiaries

30. The direct beneficiary of the project was CFE, which gained access to a new technology

and whose technical capacity benefitted from its active participation at all stages of project implementation, including its close coordination with the contractor during the construction, commissioning and initial operation of the solar field and its integration to the ISCCS. CFE technical staff also participated in a technical visit sponsored by the World Bank to the Ain Beni Mathar ISCCS power plant (470 MWe), in eastern Morocco (also financed by the GEF) as well as ISCCS plants in Spain. Indirect beneficiaries are electricity consumers in the northern part of Mexico, since the Agua Prieta Project is expected to alleviate power scarcity in the region.

31. At the time the ICR was prepared, the solar field had been completed, but had not supplied any steam to the thermal component. Once the solar field is interconnected and operational, the Agua Prieta Project will contribute to a more diverse and less fossil-fuel dependent energy matrix for power generation. The global benefit will be the abated emissions of GHGs due to the steam contribution from the solar field to the combined cycle, which might be replicated at a later stage in other thermal plants around the world.

1.5 Original Components (*as approved*)

32. The project comprised two main components:

- Component 1: Design and construction of a 31 MW (peak) solar field. This consisted of a large field of single-axis tracking parabolic trough solar collectors.
- Component 2: Design and construction of a 480 MW (net) gas based thermal plant. This component consisted of a power plant based on a standard configuration that included two industrial frame combustion turbines, each associated with a heat recovery steam generator (HRSG), and a steam turbine.

33. The GEF Grant only financed Component 1. Table 1 below shows the indicative costs and the original financing arrangement.

34. Originally, the entire project (thermal component plus the solar field) was to be bid under the Finance Build Transfer scheme (*Obra Pública Financiada*, OPF). The winning bidder would design and construct the plant and CFE would operate and maintain it. The project would ultimately be a state-owned initiative. As described in Section 2.2, the project was divided into three components with three different contracts: one for the procurement of the turbines, another for the construction of the solar field, and a third contract for the construction of the combined cycle plant and the interconnection between the thermal and solar components. The delayed acquisition of the turbines had a substantial impact on the implementation schedule, and resulted in significant delays in the full commissioning of the project.[11]

[11] As of May 29, 2017, only the combined cycle part of the project had been commissioned; the solar field had been completed but had not sent any steam to the combined cycle.

Table 1. Design and Construction of a 485.5 MW (net) ISCCS Plant[a]

Component	Indicative Cost (US$, millions)	GEF Financing (US$, millions)	GEF Financing (percent)	GoM Financing (US$, millions)	GoM Financing (percent)
Component 1: Design and construction of a 31 MW (peak) solar field					
Solar field 118,500–120,000 m^2	43.518	43.518	100.00	—	—
Fence (land of solar field)	0.241	0.241	100.00	—	—
Land purchase	1.500	—	—	1.50	100.00
Wastewater treatment plant	1.860	0.420[b]	22.58	1.43	76.90
Incremental Cost due to Integration[c]	5.171	5.171	100.00	—	—
Total (Component 1)	**52.290**	**49.350**	**94.38**	**2.93**	**5.60**
Component 2: Design and construction of a 480 MW (net) gas based thermal plant					
Combustion Turbine	79.900	—	—	79.90	100.00
HRSG (no duct firing)	36.700	—	—	36.70	100.00
Steam Turbine and Auxiliaries	26.500	—	—	26.50	100.00
Mechanical Equipment	56.000	—	—	56.00	100.00
Electrical Equipment	18.900	—	—	18.90	100.00
Civil and Structural Work	13.300	—	—	13.30	100.00
Construction	65.000	—	—	65.00	100.00
Total (Component 2)	**296.300[d]**	**0.000**	**0.00**	**296.30**	**100.00**
TOTAL	**348.590**	**49.350**	**14.16**	**299.23**	**85.84**

Note: a. The operation of the integrated ISCCS is responsibility of CFE; b. Includes only the expansion required for the maintenance of the solar field (that is, cleaning of mirrors, and so on); c. The integration of solar field requires modifications in the design of the thermal components: (i) major equipment expansion, (ii) modifications in the power block (based on the configuration selected during the cycle optimization phase of the project), and (iii) the addition of duct firing; d. This is an indicative cost of the thermal component that was specified before the bidding has been awarded.

1.6 Revised Components

35. None of the original project components, or subcomponents, were revised or dropped from the project scope, but their size was reduced. Since the preparation of the project in 2005, the power industry was significantly impacted by an increase in equipment costs. The lack of response to the bidding launched by CFE in 2006 and 2007, respectively, led the utility to reduce the requested capacity of the solar field, from 31 MW to the 12–15 MW range, to ensure that the GEF resources could still be used to finance this component. The budget originally allocated to the solar component (25–31 MW) was equivalent to about US$1,600 to US$2,000 per kW, substantially lower than the cost of about US$3,300 and US$4,500 per kW, respectively, that was observed in the bid award for the solar components of the Ain Beni Mathar (Morocco) and Kureimat (Egypt) plants, which were being built around the same time. The installed capacity of the combined cycle component was also reduced from 485 MW to 394 MW, due to local climatic conditions.[12]

1.7 Other significant changes

36. The project underwent six Level-II restructurings, aimed at extending the closing date due to implementation delays, and one Level-II restructuring (in June 2013) which effectively reduced the size of both the solar and thermal components; these are described in detail in Section 2.2. The

[12] The original installed capacity of 485 MW had been determined for local conditions during summer season.

cost of the solar field (Component 1) and the thermal plant (Component 2) significantly increased due to the suspension of works caused by the delays in procuring and installing the gas and steam turbines. CFE estimated the following overruns: 19 percent for the turbines, 31 percent for the solar field, and 31 percent for the thermal plant. The overrun for the entire project, as of April 2017, was 27.37 percent.[13]

2. Key Factors Affecting Implementation and Outcomes

2.1 Project Preparation, Design and Quality at Entry

37. **Project preparation history and main reasons for delays.** Project preparation started in 1999. The Project Concept Note (PCN) was prepared in September 1999 and the Project Appraisal Document (PAD) was completed in September 2006. The project was approved on October 5, 2006, and became effective on July 3, 2008. Project preparation, namely, from concept review to effectiveness, took about 9 years, compared with almost 11 years for the Ain Beni Mathar project in Morocco and 10 years for the Kureimat project in Egypt. The Mathania project, in India, was cancelled in 2005, nine years after the GEF Grant had been approved, in principle, in 1996.

38. The main reasons for the lengthy preparation period were: (a) federal administration changes, (b) lack of interest of the private sector in participating in ISCCS projects under IPP contracts due to the financial risks and incentives perceived as insufficient, (c) a reduction of the expected power demand that moved CFE to postpone the construction of the ISCCS plant twice, (d) the need to coordinate the procurement procedures of CFE and the World Bank and the unsuccessful first three bidding processes, and (e) the need to coordinate the sequence of the bidding process and the approval of the GEF Grant because: (i) the GEF could not approve the proposed Grant unless the wining proposal complied with the World Bank/GEF requirements related to the ISCCS plant, and (ii) CFE could not go ahead with a bidding process that included the solar component if the project was not first approved by the World Bank.

39. In 1999, an international consulting firm completed a feasibility study for integrating a parabolic trough solar field into a natural gas combined cycle plant at Mexicali, Baja California. The GEF approved the proposed ISCCS plant at Mexicali under Operational Program OP 7 as part of its work program in December 1999.

40. In March 2002, CFE called for bids on an IPP basis, and the integration of the solar field with the combined cycle plant was optional. In April 2003, after several postponements of the deadline for bid submissions, the bidding process was halted to resolve a particular issue: the World Bank could not commit GEF Grant funding before knowing the identity of the winning bidder, while CFE could not finalize the bidding process before the financing was secured.

41. Other issues were also affecting the progress of the CSP projects in other regions of the world. In May 2004, the GEF published a status report on the GEF solar thermal portfolio in Egypt, Morocco, India, and Mexico,[14] offering several lessons related to project preparation, cofinancing, procurement, and progress toward cost reduction.

[13] As of April 2017, the solar thermal plant had not been fully commissioned (that is, the solar field was not supplying any steam to the combined cycle yet), and final costs could still increase further. The overrun of the entire project has been covered by CFE.

[14] Solar Thermal Portfolio: A GEF Council Status Report. 2004. GEF/C.23/Inf.9.

42. In the case of Mexico, the GEF Status Report stated that the CSP project suffered significant delays due to (a) Mexico's constitutional least-cost requirement prohibiting ex ante commitment to procuring a solar-thermal hybrid, (b) incompatibilities between the CFE bidding procedures for IPPs and the World Bank procurement guidelines, (c) delays in the need for the Mexicali II project due to lower than anticipated power demand growth, and (d) Mexico's legal requirement that CFE cannot put a package out for bid until there were assurances that the required financing (including the GEF Grant) had been committed.

43. The Bank's procurement policies and the Mexican legislation (*Ley de Obras Públicas y Servicios Relacionados con la Mismas*) were not aligned and the GoM was not willing to make adjustments. However, given previous positive experiences and the solid track record of CFE with IPPs, in June 2004 the Operations Procurement Review Committee (OPRC) authorized, on an exceptional basis, the use of international bidding practices under Mexican law and CFE procedures for the implementation of the CSP project. The Operational Manual (OM), dated November 2007, stated that the procurement method to be used by the project would be the one established by the Mexican legislation (*Ley de Obras Públicas y Servicios Relacionados con la Mismas*).

44. In November 2004, the plant location was changed to Agua Prieta, in the northeastern corner of the Mexican state of Sonora, to avoid further delays in the implementation of the solar field and to comply with the power sector expansion plan.

45. Around that time, CFE inquired about the viability of increasing the size of the combined cycle component (CCGT) of the project to 500 MW. In response to such inquiries, two international consultancy firms concluded in May 2005 that "the bigger the CCGT is, the greater the conversion efficiency and the solar energy collected" and that "the reasons for the outstanding output is due to two factors, i) higher efficiency of the thermal 2x2x1 arrangement and ii) the 500 MW thermal plant results in a lower drop in efficiency during night hours, when the solar field is not operating."

46. On May 25, 2005, the GEF Council accepted the implementation of the Mexican CSP Project under the OPF modality by which CFE would ultimately own and operate the plant. The GEF Grant would be made available upon successful installation of the solar thermal facility.

47. On August 28, 2006, CFE launched the first bidding process under the OPF implementation modality for the combined cycle component (536 MW), while the solar field (24 MW) would be financed by the GEF Grant. The provision of solar field was now compulsory. Sixteen companies participated in the bidding process but none of them presented proposals at the bid opening ceremony, which was held on August 6, 2007. The main reason for the lack of proposals was the budgetary ceiling imposed on the thermal portion of the hybrid project, that is, the CCGTs. Also, some participants argued that the amount of the GEF Grant was not enough to cover the cost of the requested 24 MW solar field. In August 2007, the SHCP (*Subsecretaría de Egresos*) approved an increase to the budget (capital cost) of the project and CFE relaunched the bidding process in September 2007. This bidding process was again unsuccessful, since no proposals were received.

48. The PAD, dated September 2, 2006, included the design, construction, and operation of an ISCCS with a 31 MW solar field and a 480 MW natural gas combined cycle, as approved by the GEF (instead of the original 31 MW solar field and 270 MW natural gas combined cycle). The PAD also stated, "The only procurement method under the project consists of ICB under Mexican national law and CFE procedures."

49. The GEF Trust Fund Grant Agreement, signed on November 22, 2006, stated that "*The solar field (which is part of an integrated combined cycle solar system) shall be awarded on the basis of International Competitive Bidding procedures of the Recipient as contemplated in paragraph 3.13 (a) of the Procurement Guidelines.*"

50. The GEF Grant had two conditions of effectiveness: (a) signature of the subsidiary agreement (*Contrato de Apoyo Financiero No Reembolsable*) between SENER, CFE, and the National Development Bank *Nacional Financiera*, NAFIN, and (b) the purchase of the land where the project would be implemented. According to local regulations, this last condition could only be processed once the project bidding was completed and successful.

51. In August 2007, the World Bank received and approved a request from NAFIN to extend the effectiveness date of the GEF Grant for the third time, to April 4, 2008. The original effectiveness date was July 9, 2007. The signature of the subsidiary agreement among the parties, one of the effectiveness conditions, was fulfilled on October 31, 2007. The second condition of effectiveness of the GEF Grant—the acquisition of the land necessary to accommodate the solar field—was waived by the World Bank and the Grant was declared effective on July 1, 2008.

52. The extended project preparation period strengthened the relationship between the GEF, the participating agencies of the Government and the World Bank, and facilitated coordination throughout implementation.

53. **Soundness of the background analysis.** During project preparation, a close working relationship with the GoM in general, and with CFE in particular, was established. Mexico was preparing a strategy to promote the utilization of its renewable energy potential and CFE was designing a plan to participate in the GEF initiative, aimed at developing the ISCCS technology. Mexico was one of the countries selected by the GEF to implement one of four ISCCS projects, together with India, Morocco, and Egypt.

54. An assessment of the GEF strategy for the market development of concentrating solar thermal power technology sponsored by the GEF in 2005 concluded that the major outstanding issue for full-scale development of solar thermal electricity technology was the need for cost reduction, and that long-term support mechanisms were going to be required.

55. A STAP review of the GEF's portfolio in 2004 concluded that low GHGs emitting technologies were not only exposed to the barriers typical of innovation and technology market development but also to the common barriers that affect conventional projects (for example, transactional, informational, institutional, and capacity related). These common barriers affected the first phase of the project implementation but were removed before the last bidding process was launched.

56. Mexico, as the world's ninth largest emitter of GHGs, had made commitments to mitigate its GHG emissions under the Kyoto Protocol. These commitments, the inclusion of the project in the PEF (the ISCCS project was included by the SHCP in the PEF for 2006 and later approved by Congress), the GEF support, and the careful consideration of the above-mentioned issues and barriers formed the sector background for the preparation and implementation of the ISCCS project.

57. **Project design.** The ISCCS Project included two components: (a) Component 1: Design and construction of a 31 MW (net) solar field and (b) Component 2: Design and construction of a 485.5 MW (net) gas based thermal plant.

58. Lessons learned with the GEF portfolio, as indicated by the STAP review and incorporated in the project design, included the following:

- Considering the difficulty in adapting emerging technologies to the originally proposed IPP scheme, the GEF accepted and CFE changed the IPP approach to an OPF where the project would be owned, operated, and maintained by CFE.
- As securing full cofinancing is frequently a slow and difficult process for capital-intensive projects in developing countries, three projects in the GEF portfolio, originally programmed to operate under the scheme of IPP, switched to a different modality with a more limited participation of the private sector. In the case of India and Morocco, the scheme switched to the Engineering, Procurement and Construction (EPC) model with contracts for operation and maintenance (O&M). In Mexico, the project was switched to an OPF model.
- There were a limited number of consulting firms and suppliers in the solar thermal technology industry, but since the solar contribution in the GEF portfolio of hybrid projects was in the 6–10 percent range, it was expected that the lead in the bids for these projects would be taken by mainstream power generation firms.
- The potential for ISCCS cost reductions looked promising. At the time, the Assessment of the World Bank/GEF Strategy for the Market Development of Concentrating Solar Thermal Power (2005) concluded that the solar thermal electricity technology was worthy of continued support, the required technology elements were essentially already in place, the major outstanding issue was the need for cost reduction, and there was no fundamental reason why the technology could not follow a similar cost reduction curve to that of wind energy and eventually be cost-competitive. However, long-term support mechanisms would be required. It turned out that, by mid-2017, the ISCCS had not become a mainstream technology for power generation.

59. The Agua Prieta ISCCS plant was based on a standard configuration that included two industrial frame combustion turbines, each associated with a heat recovery steam generator (HRSG), and a steam turbine. The solar component consists of large field of single-axis tracking parabolic trough solar collectors, and the solar collector field is composed of parallel rows of solar collectors aligned on north-south horizontal axis. Each solar collector has a linear parabolic-shaped reflector that focuses the sun's direct beam radiation on a linear receiver filled with a heat transfer fluid (HTF), located at the focus of the parabola. The collectors track the sun from east to west during daytime to ensure that the sun is continuously focused on the linear receiver. The HFT is heated as it circulates through the receiver and returns to a series or heat exchangers in the power block where the HFT is used to generate high-pressure, superheated steam. The superheated steam supplements steam from the HRSG to a conventional reheat steam turbine generator to produce electricity. The spent steam from the turbine is condensed in a standard condenser and returned to the heat exchanger via condensate and feed water pumps, to be finally transformed back into steam. After passing through the HTF side of the solar heat exchangers, the cooled HTF is recirculated through the solar field. An additional natural gas duct burner allows a similar production of 14 MW when the solar field is not in operation.

60. **Government commitment.** The Government was strongly committed to all project objectives, including the demonstration of the operational viability and value added of integrating a solar field with a large conventional thermal plant (ISCCS) using solar parabolic trough technology. The country's energy development strategy included (a) energy diversification away

from fossil fuels and (b) development of the country's significant renewable energy potential. This strategy was in line with the Government commitment to reduce Mexico's GHG emissions beyond its obligations under the UNCCC.

61. **Assessment of risks.** The overall project risk was rated as Substantial, an appropriate rating given the untested market for investing in the development of Mexico's solar energy potential using ISCCS technology, the limited development of the country's renewable energy potential at the time, and political uncertainty regarding the longer-term sustainability of Government commitment. Six risks to the development objectives were identified and solar market, technological, and operational mitigation measures were proposed to manage them. These risks were: (a) insufficient and/or noncompetitive bid responses, (b) failed bid, (c) insufficient experience with CSP technology, (d) technological or design problems during operation, (e) poor maintenance of solar field due to constraints in budgetary resources approved by the SHCP (*Subsecretaría de Egresos*) for O&M and (f) change in government and potential changes in SENER.

62. **Monitoring and Evaluation (M&E).** The set of indicators included in the results framework represented –at least theoretically– an adequate choice for assessing achievement of the PDO and GEO, under the assumption that the plant was going to be commissioned and fully operational within the implementation period, which was not the case for the Agua Prieta Project. The M&E design did not provide an adequate measure of progress over time, and the use of broad terms in PDO formulation (such as *"elsewhere"* and "*[…] encourage replication […]"*), posed a challenge for assessing PDO achievement, since encouraging replication is only possible once the project is successfully implemented and lessons learned are disseminated.

63. **Quality at entry.** No Quality at Entry Review was carried out by the Bank for this GEF operation.

2.2 Implementation

64. After three failed bidding processes in 2002,[15] 2006, and 2007, attributed—among other factors—to the mismatch between the available budget and the required capacity of the hybrid plant, in particular the capacity of the solar component, and the amount of the GEF Grant, the following crucial decisions were made: (a) at the request of CFE, the World Bank supported (and the GEF authorized) a reduction in the size of the solar field from 31 MW to 12–15 MW to align the available budget with the market prices for concentrating solar plants, (b) the CFE budget for the project was increased, and (c) the original contract bidding documents for the hybrid ISCCS plant were split to award three contracts instead of one:

- the construction of a 394 MW combined cycle power plant and its integration with the solar field (financed by CFE),
- the provision of the gas and steam turbines (financed by CFE), and
- the construction of the solar field (financed by the GEF Grant).

65. The solar field contract would follow World Bank standard bidding procedures, whereas

[15] The bid process that was launched in 2002 involved an ISCCS plant in Mexicali, Baja California. The project location was changed to Agua Prieta, Sonora, in 2004. The unsuccessful bids in 2006 and 2007 correspond to this new location, that is, the Agua Prieta Project.

the first two contracts (financed entirely by CFE) followed national procedures. As a result of these decisions, the fourth bidding process was successful: the contract of the combined cycle plant was signed in September 2011, the contract for the provision of the turbines was signed in January 2011, and the contract for the construction of the solar field was signed in July 2011.

66. With regards to the solar field bidding process, the bidding documents for the fourth call for bids provided flexibility for the size of the solar field. The bidders were asked to submit offers for the construction of a 12-MW solar field and capacity additions of 1 MW each. Based on the available Grant resources, a contract for a 14-MW solar field was awarded to an international consortium. The members of this consortium had extensive experience in CSP in Spain, the United States, South Africa, India, Poland, and other countries and later participated in the implementation of two ISCCS plants located in Morocco (470 MW, 20 MW from solar field, and supported by the GEF) and Algeria (150 MW, 20 MW from solar field) in 2010 and 2011, respectively. CFE submitted to the World Bank the request to award the contract to develop, design, test, and commission the solar component to an international consortium. This proposal was cleared by the World Bank's OPRC on April 27, 2011.

67. Implementation of the Agua Prieta II project was supposed to start after Board approval, in October 2006, and was expected to be completed by April 2009. However, the implementation of the overall project experienced significant delays (as described above) and construction only started until 2011.

68. A critical negative development in project implementation was the failure of the contractor in charge of the provision of the gas and steam turbines to meet the contract requirements (the contractor was an intermediary, rather than a turbine manufacturer). The contract (which had been signed early 2011) had to be canceled by CFE, causing a significant delay of almost two years in project implementation. The bidding process for the provision of the turbines had to be retendered and as a result, CFE temporarily suspended the works for the project in April 2013. On December 13, 2013, CFE and an experienced international turbine supplier (which was the manufacturer of the turbines originally offered to CFE by the intermediary contractor) concluded and signed an agreement by which the originally committed turbines would be delivered to CFE. This negotiation involved a lengthy legal process since immediately after CFE realized that the intermediary was not going to be able to honor the contract clauses, the utility claimed ownership of the turbines, which had been included as a guarantee in the contract. Therefore, an agreement between CFE and the turbine manufacturer was not immediately feasible, since the three turbines were being subject of a legal dispute. Finally, the turbines arrived at the construction site in April and May 2014, and the ongoing bidding process for the turbines (which had been running in parallel with the negotiation between CFE and the turbine manufacturer as a backup plan in case the negotiations failed) was cancelled.

69. The total delay in the acquisition of the turbines had a significant impact on (a) the completion of the solar field, as final works and commissioning could only be carried out once the combined cycle was completed and connected to the thermal plant (the works in the solar field were suspended temporarily on April 12, 2013 and restarted in August 2014), and (b) increasing costs of both the solar field and the combined cycle plant.

70. As a result of the numerous unsuccessful bidding processes, the observed delays between approval and effectiveness, and the delays during implementation (mostly due to the delay in the acquisition of the turbines, the project's closing date was extended six times: the first three

extensions (from October 30, 2009 to April 30, 2010; from April 30, 2010 to April 30, 2011; and from April 30, 2011 to July 31, 2011) were needed to allow time to launch the fourth bidding process. The fourth extension (from July 31, 2011 to January 31, 2014) was needed to allow for the additional time required to complete the last bidding process and build the plant. A fifth extension to the closing date (from January 31, 2014 to December 31, 2015) was approved by the World Bank with the objective of allowing time to complete the construction of the solar field, and its interconnection with the combined cycle power plant. At that time, CFE was committed to commission the hybrid plant by May 2015, but this date was later postponed, first to August 2015, then November 2015, and ultimately April 2016, which resulted in a sixth (and final) extension to the closing date, from December 2015 to May 2016 (for a cumulative extension of 6 years and 7 months from the original closing date of October 2009). On April 22, 2016, CFE informed the World Bank of an additional delay in the commissioning date (from April 9, 2016, to mid-July 2016), and the Government and World Bank agreed to maintain World Bank technical and fiduciary support for CFE until the ISCCS plant was fully commissioned, instead of extending the closing date again (given CFE's track record of not maintaining previous commitments).

71. The final project ISR, dated May 31, 2016, rated the progress toward achievement of PDO and overall implementation progress (IP) as Moderately Unsatisfactory, as the commissioning date had been postponed several times during 2015–2016.

72. The thermal component was commissioned in October 2016 and has produced approximately 1,170 GWh since then. As of April 2017, the solar field has been completed but has not yet supplied any steam to the thermal component. CFE estimates that the solar field will be finally supplying steam to the thermal component by mid-2017.

73. **Midterm review (MTR).** The team carried out a MTR mission in October 2013. The main topics discussed were: (a) general progress of the project; (b) the status of the provision of the gas and steam turbines; (c) an extension to the closing date of the project. The main findings of the MTR were reported in ISR Seq. No. 15 (January 2014), including the fact that CFE had reached an agreement for the supply of the turbines. As a consequence, the project's PDO and Implementation Progress ratings were raised to Moderately Satisfactory.

74. **Supervision reporting.** Over the implementation period, supervision missions visited Mexico and the project site, Agua Prieta, in the State of Sonora, about twice a year (on average), starting in 2007, with the final 'formal' supervision mission taking place in December 2015. During the last few missions, the focus was on (a) the tasks required to accelerate completion of the thermal plant and its interconnection with the solar field and (b) the processing of the modifications of the solar field contract caused by the suspension of works from April 2013 to August 2014. A final, 'informal' supervision mission (after the GEF Grant closed), was originally scheduled to take place in March 2017 for the purpose of verifying the successful interconnection of the solar field with the thermal plant. Even though this interconnection was physically completed, the solar field had not supplied steam to the thermal component by May 2017, so the team decided to postpone this final mission until the plant is fully commissioned.

75. Overall, there were 18 ISRs completed during project implementation. Staff responsibility for supervision was shared between Washington, DC, and Mexico City. The key GEO and IP ratings were rated 'Satisfactory' for the first two ISRs. Following a delay in complying with the Grant effectiveness conditions and the failure of the first three bidding processes, both the GEO and IP ratings were downgraded to Moderately Unsatisfactory. In May 2009 and April 2010, the

GEO and the IP were rated Moderately Satisfactory, respectively, following improvements in the preparation for the fourth bidding process. In November 2012, both the GEO and the IP ratings were downgraded to Moderately Unsatisfactory. In December 2013, the PDO and IP ratings were raised to Moderately Satisfactory to reflect the progress achieved in the implementation of the project's thermal component. Later, in 2015 and 2016, the PDO and IP ratings were downgraded to Moderately Unsatisfactory to reflect the delays in achieving the PDO due to the numerous times the commissioning date had to be postponed.

76. **Project restructurings.** Six Level-II restructurings took place during implementation, to extend the closing date. In total, the closing date was extended from October 2009 to May 2016 due to the delays in the implementation of the thermal plant. In June 2013, the Grant Agreement was amended (through a Level-II restructuring) to reduce the size of the solar plant and adjust the target values of the outcome and results indicators accordingly. Overall, the project underwent seven Level-II restructuring processes. The main reason for project restructurings were delays related to (a) the effectiveness condition of acquisition of land for the solar field (which was later waived to reach effectiveness), (b) unsuccessful bidding processes, and (c) construction of the plant. The first three extensions to the closing date were short-term (6 months, 12 months and 3 months, respectively), and were needed to complete the three different bidding processes for the project. Longer extensions to provide financing for implementation as agreed under the Grant Agreement would then be assessed (which was the case for the subsequent 30-month extension that was processed in May 2011).

77. As mentioned above, the combined cycle plant was commissioned in October 2016, whereas the solar field had not supplied steam to the thermal plant (as of May 2017). After five months of operation, the production of the thermal plant component seems to be on track to meet its target (almost 40 percent of energy production target). However, in the absence of a full commissioning, the Implementation Completion and Results Report (ICR) team could not assess the contributions of the solar field toward the PDO and GEO. However, these contributions are expected to materialize in the short or medium term, since the required infrastructure is in place and only a few remaining tests are still needed. Based on the above considerations, the ICR team is assessing progress toward the PDO and GEO as Moderately Unsatisfactory.

78. Overall, an initial project implementation timeframe of 3 years for a construction project, including the natural gas-based thermal plant and the solar field, was impractical and not realistic from the start (typical construction projects tend to have an implementation duration of up to 6 to 9 years). During the timeframe of project implementation, the project experienced at least three changes in TTLs, which may have also contributed to some of the observed delays.

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

79. **Monitoring and evaluation (M&E) design.** The set of indicators included in the results framework represented –at least theoretically– an adequate choice for assessing achievement of the PDO and GEO, under the assumption that the plant was going to be commissioned and fully operational within the implementation period, which was not the case for the Agua Prieta Project. The ICR team could only assess partially the progress toward PDO through monitoring energy production from the combined cycle, which only reached 40 percent of the expected annual production during a 5-month operations period. However, the key indicators related to the operation of the solar field (annual average efficiency of solar input to electric output, cost of solar

thermal power, reduction of CO_2 emissions, global production of electricity of the ISCCS plant, and yearly contribution of solar electricity) could not be assessed since the solar field is not yet operational.

80. As it turned out, the M&E design did not provide an adequate measure of progress over time. Additionally, the use of broad terms in PDO formulation (such as *"elsewhere"* and "*[…] encourage replication […]"*), posed a challenge for assessing PDO achievement, since encouraging replication is only possible once the project is successfully implemented and lessons learned are disseminated. Furthermore, the PAD results indicators are not fully aligned with the PDO, notably "Total electricity generated from the solar thermal hybrid project (GWh/year) and solar output as a percentage of total energy produced by the hybrid plant (GWh/year)." In retrospect, the project M&E could have benefited from a set of indicators that could have shown progress over time.

81. **M&E implementation.** Monitoring and evaluation of outcomes are the responsibility of CFE. Since the solar field is not yet operational, preliminary arrangements were made with CFE and NAFIN for the collection of the required information once the plant is fully commissioned (including the operation of the solar field). However, since full commissioning is only expected until mid-2017, such data gathering will not be available for the ICR (only the energy dispatched by the combined cycle alone was available at the time of ICR preparation). The choice of a set of indicators that would only allow for assessing PDO achievement until project commissioning prevented the supervision team from adequately managing project risks and bringing unforeseen circumstances (such as the delay in the acquisition of the turbines) to management attention.

82. **M&E utilization.** The monitored data to be obtained during the first year of operation of the ISCCS plant are expected to be used to estimate the costs and benefits of Concentrating Solar Power (CSP) systems based on parabolic trough collectors in the north of Mexico. However, it should be noted that the choice of indicators led to lack of data collection and thus lack of M&E utilization, hence not serving the purpose of monitoring progress towards achievement of the PDO.

2.4 Safeguard and Fiduciary Compliance

Environmental

83. The project was defined as a Category B given that its potential adverse environmental impact on human populations or environmentally protected areas are considered very small. During preparation, it was expected that the project would trigger Environmental Assessment (OP/BP/GP 4.01) safeguard policy, with the potential environmental impact confined to the project site. Appropriate mitigation measures were identified and included in the Environmental Management Plan, which followed the World Bank guidelines, notably OP 4.01.

84. The project carried out a mandatory Environmental Impact Assessment and obtained the required resolution from the Mexican Ministry of Environment (SEMARNAT), including the conditions to be complied with during the project's preparation, construction, and operation phases. At least once a year, the World Bank carried out field visits during which CFE provided a full documentation package as evidence of compliance with the environmental authority, which was later confirmed during the supervision activities. Environmental safeguards were consistently rated as Satisfactory.

Social

85. The project did not trigger any social safeguard policy. During the preparation of the project, a social screening was conducted. It showed that the construction and operation of the project would not cause any adverse social impacts. The installation and operation of the plant required an area of about 118–120 hectares, and the land where the project is installed did not have any productive or social use and was the property of one legal private owner, who sold the land to CFE.

86. The project was included in the Municipal Development Plan and did not create any conflict with other future development plans and/or proposed land uses. A public consultation was held by CFE on May 4, 2006, with the attendance of representatives of local authorities, associations, mass media, nongovernmental organizations (NGOs), labor unions, and community members. The results of the consultation were positive. In general terms, the participants welcomed the construction and operation of this innovative technological arrangement.

Fiduciary

Financial

87. A Financial Management Assessment undertaken before Board approval concluded that the ISCCS project design allowed for an appropriate level of transparency that would facilitate oversight and control while also supporting smooth implementation. Based on this analysis, the regional FM team determined that the project risk was Moderate and concluded the following: (a) CFE had an adequate internal control environment, capable human resources, a well-organized office, and good separation of responsibilities; (b) although the project would only involve a small number of payments (approximately three) from CFE to the bid winner, it would involve large sums of resources, so the inherent risk was moderate; (c) before project implementation, certain actions were required to strengthen program FM, for example, implementation of the project's OM, fine-tuning of agreed audit arrangements, and the final format of the Disbursement Report; (d) NAFIN (as the project's financial agent appointed by the SHCP) would provide implementation support and oversight based on its many years of experience with World Bank-financed projects; (e) for disbursement purposes, the recognition of expenditures was going to be based on the payments from CFE to the winning bidder; and (f) considering the project's characteristics, at least two financial management supervision missions (FMSMs) would be carried out during the first implementing year and one FMSM during the following years, and a World Bank FM specialist would review the annual audit reports.

88. Through most of the implementation period, project FM performance remained mostly Moderately Satisfactory. Toward the final implementation period (2016), FM performance was rated Moderately Unsatisfactory, mainly because the appointment of the independent auditor to conduct the project's Financial Statements audits for the periods ending on December 31, 2015, and May 31, 2016 (closing), was delayed. The project's Financial Management Reports (FMRs) were consistently submitted to the World Bank with delays; in some cases, minor inconsistencies were observed.

89. According to reforms on the legal framework governing CFE as an autonomous state-owned enterprise ('*Ley de la Comisión Federal de Electricidad*', issued on August 11, 2014), effective February 16, 2015, CFE Directive Board was instituted and began to act as the governing

body for CFE. Under this legal framework, the appointment of the external auditor for CFE corresponds to its Board of Directors. Consequently, the Ministry of Public Administration (*Secretaría de la Función Pública*, SFP) no longer had the responsibility to appoint the auditor to carry out the external audit for the project under the Memorandum of Understanding agreed between the World Band and SFP on November 2012, through which the World Bank had accepted that the SFP was responsible for appointing the auditor to conduct the independent audit for World Bank-financed projects in Mexico.

90. Since no funds were utilized nor disbursements made during 2014, the World Bank approved an audit period extension to cover from January 1, 2014, to December 31, 2015. CFE appointed an independent auditor for the audits covering the 2014–2015 and 2016 (closing) periods, and the World Bank approved the appointed auditor and accepted the terms of reference prepared and submitted by CFE for these audits. The audit reports for these last two audits (both included an unmodified -or clean- opinion) were received and accepted by the World Bank. The scope of these audits covered both Grant and CFE funds provided for the project. No findings were issued by the auditor and all disbursed expenses complied with the eligibility criteria.

Procurement

91. During project preparation, CFE's performance in procurement was reviewed against international standards, and it was concluded that CFE's experience, capacity, and organization was adequate to carry out complex procurement procedures, such as those required for the project. The World Bank and CFE agreed on a schedule of reviews including the bidding documents, advertisement, and the bid evaluation report under special arrangements that would ensure confidentiality of the award until it was final. In June 2004, the OPRC authorized, on an exceptional basis, the use of international bidding practices under the Mexican law and CFE procedures for the implementation of the CSP project. Due to several unsuccessful bidding processes, the project was split into three different contracts: one for the procurement of the turbines, one for the construction of the combined cycle and the interconnection with the solar field, and a third one for the construction of the solar field itself. The last (and successful) bidding process for the construction of the solar field was carried out using the World Bank standard bidding documents for International Competitive Bidding (ICB).

92. Progress on the solar field construction (originally fully funded by GEF resources) was satisfactory until it had to be halted in April 2013 due to the delay in the provision of the natural gas and steam turbines for the thermal plant. When the works restarted in August 2014, the solar field contractor had the right to terminate the contract since final works could not be completed due to CFE's responsibility for the delay in the provisioning of the gas and steam turbines, and since the solar field contract was at risk of being cancelled (without the works being completed), CFE agreed, after a very difficult negotiation, to compensate the contractor for the higher cost of the affected works and goods on a current, demonstrable value basis (*costo real demostrable*). Consequently, the solar field contract had to be amended several times to adjust both its amount and its termination date. CFE made significant progress in submitting to the World Bank different modifications for the solar field contract in December 2015 (to extend contract's validity to April 9, 2016, and to increase the contract amount by approximately US$2.8 million or 6 percent of the original amount). However, despite the significant support of the World Bank, CFE did not submit all the required supporting evidence for a final amendment in a timely manner and, consequently, the Grant was not fully disbursed, and approximately US$3 million, or 6 percent of Grant proceeds,

were cancelled.[16]

93. Procurement was rated as Satisfactory for ISR Seq. 01 and Seq. 02, and was downgraded to Moderately Satisfactory for ISR Seq. No. 03 due to the unsuccessful bidding process launched in September 2006 (the first for the Agua Prieta location). The Procurement rating remained as MS until it was downgraded to Moderately Unsatisfactory in ISR Seq. 12 due to the first signs of delays in the acquisition of the turbines. The rating was later upgraded to MS in ISR Seq. No. 13 to acknowledge that the solar field contract had been awarded. The procurement rating was downgraded to Unsatisfactory for ISR Seq. 18 to reflect the fact that CFE could not manage to submit the final amendment for the solar field contract in a timely manner, which in turn resulted in the cancellation of approximately US$3 million from the GEF Grant. It should be noted that throughout implementation, the procurement rating was based on those aspects related to the GEF-financed solar field (with the exemption of the MU rating in ISR Seq. 12 as explained above), since that was the only component over which the Bank had a fiduciary responsibility (as opposed to social and environmental safeguards, whose enforcement was supervised for the entire ISCCS project).

2.5 Post-completion Operation/Next Phase

94. The O&M of the ISCCS is the responsibility of CFE. To monitor the plant performance indicators and the achievement of the PDO and the GEO, a reporting system for the next few years will have to be agreed with the SHCP, SENER, and CFE. Although the ISCCS has a very high replicability potential in Mexico (50 percent of the energy matrix for power generation is natural gas combined cycle-based), a subsequent operation had not been discussed with CFE at the time of ICR preparation. It will take a few years after the project is fully commissioned to effectively assess whether the benefits of the ISCCS technology can and should be replicated in Mexico and elsewhere.

95. In the meantime, Chile is the first country in Latin America to incorporate the CSP technology to its energy matrix. Several CSP projects are under development, including Atacama 1 (power tower with storage—110 MW—under construction); Copiapó (power tower with storage—240 MW—under development); and Pedro de Valdivia (parabolic trough with storage—360 MW—under development). Another nine CSP projects are in different states of preparation in Chile (see Annex 10 for details).

3. Assessment of Outcomes

3.1 Relevance of Objectives, Design and Implementation

Relevance Rating: Substantial

96. **Relevance of project objectives.** The project was part of a larger program financed by the GEF to allocate Grants up to US$50 million to four ISCCS projects in Egypt, Morocco, India, and Mexico, with a total solar CSP capacity of 150 MW, to encourage global deployment of the nascent

[16] Even during the six-month grace period after the Grant was closed (the grace period was extended by two months), the World Bank and CFE worked hard on gathering evidence for potential eligible expenses, that is, those incurred before the closing date. However, a difficult and tense relationship between CFE and the solar field contractor because of the discussed delays prevented CFE from submitting all the required information by the corresponding deadline.

carbon-free CSP technology with potential for cost reductions through innovation and economies of scale.

97. Owing to higher costs than originally expected and the cancellation of the India project, the final CSP capacity installed with GEF support was only 54 MW. However, public information about the projects, the commissioning of the ISCCS projects of Egypt and Morocco, cost reductions, and the increased use of thermal energy storage (TES) helped expand the market for the CSP technologies from 354 MW in 1990 to 6,996 MW in 2017. Also, the technology was expanded geographically from Spain and the United States to Algeria, Australia, Canada, Chile, China, France, Germany, India, Israel, Italy, Kuwait, Saudi Arabia, South Africa, Thailand, and Turkey, in addition to Egypt, Mexico, and Morocco. The new generation facilities represent a mix of parabolic trough and tower technologies, and almost all incorporate TES. Annex 10 presents a chronology of key CSP technology events and recent developments.

98. Industrial capacity continued to expand in developing regions, supported in part by local content requirements associated with CSP procurement programs. Large facilities (greater than 100 MW) are increasingly the norm, as is the incorporation of TES and dry cooling technologies. Several R&D programs around the world that focus on cost reduction and increased thermal efficiency are contributing to the reduction of CSP bid prices.

99. The PDO and the GEO supported Mexico's commitment to developing its renewable energy potential and reducing its emissions of GHGs. During implementation, a renewable energy law was approved in 2008 (LAERFTE), which facilitated the creation of financing instruments (such as the Fund for the Energy Transition and the Sustainable Use of Energy, FOTEASE) to support renewable energy research and promotion. In 2012, the Government published the Climate Change Law (*Ley General de Cambio Climático, LGCC*) and committed itself to a National Climate Change Strategy (*Estrategia Nacional de Cambio Climático, ENACC*), which is now an integral component of its national development policy. In addition, the Government set several emission reduction targets, including an electricity-related emissions reduction goal of 14 to 28 $MtCO_2$ by 2012. Finally, it set the objective of reducing GHGs by 50 percent by 2050 against a 2000 baseline. LAERFTE was replaced by the Energy Transition Law (LTE, 2015), which sets minimum targets for clean energy in the Mexican energy matrix (participation of 25 percent by 2018, 30 percent by 2021, and 35 percent by 2024). Notwithstanding this, the project could have benefited from a less broad PDO formulation and a from a results framework that could have better shown progress over time. Nonetheless, the relevance of project objectives is Substantial.

100. **Relevance of project design.** The design of this demonstration project was in line with the ongoing World Bank's CPS at appraisal (April 2004), where the World Bank's main value added was in "helping Mexico achieve better development effectiveness … through improved policy and project design," and it remained aligned with the World Bank's recent 2014–2018 CPS for Mexico, specifically to Theme 4 (Promoting Green and Inclusive Growth). The project design incorporated lessons from the GEF experience in developing ISCCS-based systems as well from similar projects in other countries and was adapted, as needed, to take into consideration updated costs of the CSP technology. Overall, the project design was relevant and targeted and provided an essential Grant incentive for the development of Mexico's solar energy potential, and hence project design is rated as Substantial.

101. **Relevance of project implementation.** The overall project implementation arrangements were sound. Mexico was the Grant recipient and two Government entities were involved in these

arrangements: (a) NAFIN was the recipient's financial agent, which also provided overall FM for the project, and (b) CFE, which was in charge of project construction and O&M. During project implementation, a team within CFE was responsible for overall planning, coordination, implementation, supervision, and M&E of the project, including the preparation of the financial statements and FMRs and maintenance of records and accounts. The CFE team was staffed with a project coordinator, a full-time on-site environmental specialist, a procurement specialist, and an FM specialist among other professionals. The World Bank acted as a GEF implementing agency.

102. CFE was able to adapt the original project procurement and implementation arrangements to the changing characteristic of the CSP market, as evidenced by other CSP projects that were implemented in parallel. However, the substantial delay in the implementation of the thermal plant (due to the delay in the procurement process for the acquisition of the gas and steam turbines) caused a serious disruption in the execution of the solar field and the need to incorporate numerous modification to its construction contract. As CFE had to focus on the resolution of the technical aspects of the project and the repeated delays in the commissioning of the solar field, the administration of the contract deteriorated, causing delays and errors in the preparation of financial and technical reports and in the processing of the construction contract modifications. This affected the quality of project implementation and caused the downgrade of several project indicators. Hence, project implementation is rated as Modest.

103. Finally, the substantial delays in the implementation of the Agua Prieta Project reduced the benefits of its demonstration effect, one of the key objectives.

3.2 Achievement of Global Environmental Objectives

Rating: Modest

104. The main GEOs (reduce GHG emissions and remove barriers to the development of renewable energy technologies) are expected to be achieved, once the ISCCS plant is fully commissioned and demonstrate its performance and sustainability. However, significant delays in the implementation of the ISCCS plant postponed the evaluation of the indicators. The solar field is expected to be fully operational by mid-2017.

105. Table 2 summarizes progress made toward the most important GEOs and PDOs.

Table 2. Achievement of the GEO and the PDO

Project Outcome Indicator	Baseline	2017	End Project Target	Percentage of achievement
PDO 1. Total electricity generated from the solar hybrid project (GWh per year)	0	1,167.37	2,935	39.77
PDO 2. Annual average efficiency of solar input to electric output (percent)	0	n.a.	>12 percent	0
PDO 3. Generation capacity of renewable energy (other than hydropower) constructed (MW)	n.a.	14	14	100
PDO 4. Generation capacity of renewable energy constructed - solar (MW)	n.a.	14	14	100
GEO 1. Reduction of CO_2 emissions (tCO_2e per year)	0	0	11,833	0

3.3 Efficiency

Rating: Low to Negligible

106. An ex post economic analysis of the project was carried out to evaluate the efficiency of the project and verify its economic viability as presented in the PAD. The economic analysis looked at the costs and benefits accruing to Mexico, including not only the actual values related to capital equipment and operating costs but also the monetized environmental benefits.

107. **Economic benefits.** The main economic benefits of the STP are (a) the production of electricity and (b) the reduction of GHG emissions in the global atmosphere. The economic benefits of electricity generation are set, for the purposes of this analysis, at the level of the avoided cost of generating electricity using other options, especially fossil fuels. During appraisal, the estimated avoided costs of generation was US$0.052 per kWh based on an estimated crude oil price of US$50–US$54 per barrel. Although the oil price dropped significantly in recent years to as low as US$43 per barrel in 2016, due to the increase of the oil price between 2012 and 2014 (above US$100 in these three years), the average actual oil price since the plant's operation in 2011 is US$80.30 per barrel. Environmental benefits are valued at US$30 per tCO_2e, increasing by 1 percent a year.

108. **Project economic costs.** The main economic costs of project are (a) the investment necessary for the construction of the project (US$531.291 million compared to the estimated cost during appraisal of US$418.837 million) and (b) the costs of O&M of US$12,891,891 annual fixed O&M costs and US$103,754,684 annual variable O&M costs.

109. **Results.** The cost-benefit analysis for the Agua Prieta Project shows that the project has a negative net present value for a discount rate of 12 percent. (see Annex 3). At the adopted social discount rate of 6 percent, the project NPV is US$ 227.0 million.

3.4 Justification of Overall Outcome Rating

Rating: Unsatisfactory

110. The overall outcome rating is Unsatisfactory. This rating is based on the following considerations:

(a) **The continuing substantial relevance of the project objectives for the Government as well as for the World Bank.** As noted earlier, Government commitment to the project objectives strengthened during implementation, reflected in the passing of a renewable energy law and a national commitment to specific climate change goals; for the World Bank, providing support to the Government's 'green growth' strategy is an integral component of the latest Country Partnership Framework.

(b) **A modest achievement of the GEO.** The combined cycle was commissioned in October 2016 and since then is performing in line with expectations, achieving approximately 40 percent of the annual target with only five months of operations. Although the solar field is not yet operational, by April 2017, all the infrastructure was in place and only minor civil and electrical works were pending, as well as several operating tests, and CFE is confident that once the solar field is in operation, it will perform in line with expectations.

(c) **A low to negligible rating for the project efficiency**, which was derived mostly from the

delay in the acquisition of the gas and steam turbines and the consequent cost overruns for each of the project contracts, that is, the solar field, the turbines, and the construction of the combined cycle plant (including the interconnection between the solar field and the thermal component).

3.5 Overarching Themes, Other Outcomes and Impacts

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

111. The project was not expected to have any significant social impacts, and did not trigger any social safeguards policies. As part of the implementation, CFE contributed to the social municipal programs of Agua Prieta on a yearly basis, and is paying for municipal services, including the wastewater used for the plant processes. In terms of local employment, the project employed about 800 temporary workers during construction.

112. During the implementation period, CFE supported the following social projects in the Municipality of Agua Prieta: (a) medium-voltage wiring and public lighting works in a municipal sports facility; (b) low- and medium-voltage wiring in a housing complex; (c) lighting works in a church; (d) donation of electrical equipment (wiring and connectors) in low-income neighborhoods; (e) installation of a 75 kVA transformer in a municipal sports facility; and (f) electrification and lighting works in a public baseball facility. By April 2017, CFE had allocated approximately US$250,000 to social projects. The team monitored both social and environmental safeguards for the entire ISCCS project (and not only for the GEF-financed solar field). The overall safeguards rating was consistently rated as Satisfactory throughout project implementation.

(b) Institutional Change/Strengthening

113. Mexico already had a well-developed and experienced institutional framework in place at the time of project preparation. CFE has several decades of experience in developing Mexico's electricity network and was familiar with procurement processes to expand Mexico's power generation pool through the use of IPPs. However, development of novel technologies has proven to be a challenge for seasoned CFE procurement officials (the bidding process for the first IPP wind plant, that is, la Venta III, took almost three years), and Agua Prieta was not the exception. Early development during project implementation led the utility to split the project into three different contracts, which in turn increased the required efforts in contract management and supervision. The unfortunate delays in the provision of the gas and steam turbines, which resulted in an overall delay for the project, forced the utility to enter into technical and legal disputes with the solar field contractor which were eventually, and successfully, resolved. The World Bank team provided a strong and timely support throughout the entire re-negotiation process, specifically advising the utility on the reasonableness of the additional costs claimed by the contractor, and thus resulting in significant savings for CFE.

114. The implementation of the Agua Prieta Project and the constant support from World Bank teams have resulted in a more-knowledgeable and better-prepared utility to be able to handle (and even to prevent) difficult technical and contractual challenges.

115. The overarching theme is CFE's enhanced capability to incorporate a novel technology for the Mexican energy matrix, thus enabling the utility to be better prepared for the competition scenario that will result from the implementation of a wholesale market, derived from the major

energy reform that was passed in 2013.

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

116. No beneficiary surveys or stakeholder workshops were carried out. During the preparation of the project, a social screening was conducted and showed that the construction and operation of the project would not cause any adverse social impacts. A public consultation held by CFE in 2006, with the presence of representatives from local authorities, associations, mass media, NGOs, labor unions, and community members, was positive and the participants welcomed, in general terms, the construction and operation of this innovative technological arrangement. During implementation, the project supported social projects which benefitted a significant portion of the Agua Prieta municipality population.

4. Assessment of Risk to Development Outcome

Rating: Substantial

117. At the time of project appraisal in 2006, the critical risks to the development objective that had been identified were (a) insufficient and/or noncompetitive bid responses, (b) a failed bid, (c) insufficient experience with CSP technology, (d) technological or design problems during operation, (e) poor maintenance of solar field due to constraints in budgetary resources approved by the SHCP for O&M, and (f) risk due to change in Government and potential changes in SENER. Regarding risks (a) and (b), there were three failed calls for bids at the start of project implementation. Changes in the procurement strategy contributed to a successful fourth bid. Risks (c), (d), and (e) will be evaluated during a period to be defined once the ISCCS plant starts operation. Risk (f) did not materialize during the ISCCS plant construction and the Government remained committed to reduce GHG emissions and develop its renewable energy potential through two changes of federal administration. However, the significant delays observed in the project commissioning (by April 2017 the solar field was not yet operational) represent a major risk for the combined cycle to remain operating as a stand-alone project (which is effectively happening at the time of ICR preparation). Although CFE has confirmed its commitment to eventually interconnect the solar field to the combined cycle, the utility's poor track record on maintaining previous commitments with regard to the commissioning date poses a substantial risk for the GHG mitigation potential of the project to never materialize. The Government and the World Bank have maintained close collaboration and constant communication to monitor CFE's progress on the final steps of the solar field construction and its eventual interconnection with the combined cycle. However, budgetary constraints with CFE have caused additional delays. There would be implications for the utility to leave the solar field incomplete, in terms of contractual obligations and reputational risks for the GoM and for the utility.

118. Based on the above circumstances, the current assessment of risk to development outcome is Substantial.

5. Assessment of Bank and Borrower Performance

5.1 Bank Performance

(a) Bank Performance in Ensuring Quality at Entry

Rating: Moderately Satisfactory

119. At the beginning of project preparation, the World Bank fully researched the relatively new ISCCS technology, its technical characteristics, available sources of main project components, harmonization of local and procurement rules, operational and dispatching alternatives, and viable private sector participation, among other relevant issues.

120. The contract modality selected for project implementation was IPP, as in Morocco and India, but as the amount of the GEF Grant was considered insufficient to cover the cost of the solar field, the potential contractors were unwilling to participate under the IPP modality. When the EPC model—or, in the case of Mexico, the OPF model—were adopted and the required size of the solar field was reduced during project implementation to accommodate its cost to the amount of the GEF Grant, the calls for bids were successful. A feasibility study prepared in November 2004 by an international firm provided preliminary information to be adjusted once the final project site had been selected. An update was prepared in May 2006 by the same consultancy firm, once the Agua Prieta site was confirmed. This update provided accurate costs estimates, technical suggestions as for the combined cycle configuration, and tentative schedule. Overall, the World Bank team completed a thorough due diligence and devoted sufficient economic and human resources for project preparation. Risks were accurately identified in general, except for the one that materialized: delays in one of the contracts (for the provision of the turbines) after which CFE decided to split the project into three contracts (a decision with which the World Bank concurred).

121. In retrospect, the project M&E could have benefited from a set of indicators that could have shown progress over time. The use of broad terms in PDO formulation posed a challenge for assessing PDO achievement.

(b) Quality of Supervision

Rating: Moderately Unsatisfactory

122. World Bank supervision of the ISCCS Project covered the period from 2006 to 2016, due to the initial delays in awarding the construction contracts and due to the suspension of works caused by the critical failure to deliver the gas and steam turbines by the initial provider of these equipment.

123. World Bank supervision missions, staffed with the needed expertise and skills, made frequent visits to CFE headquarters and the project site during the 10-year period from Board approval in October 2006 until the GEF Grant closing on May 31, 2016. The focus of World Bank supervision during the early years was in supporting the bidding process for the solar field plant, that is, the GEF's financed project's component. During the last two years, the supervision team focused on the modifications of the solar field contract caused by the suspension of works during 2013 and 2014 and the works required for the interconnection with the combined cycle component. Throughout the entire implementation stage, the team adequately supervised social and

environmental safeguards enforcement for the ISCCS project.

124. The presence of procurement, FM, and environmental specialists in the Mexico Country Office during project implementation, as well as the appointment of a local task team leader (TTL), provided continuity to the World Bank supervision effort and additional support to the Mexican counterparts, which allowed for a much-needed financial support to CFE in the amount of US$2.8 million through contract amendments. Despite all efforts made by the World Bank team, the final amendment was not submitted on time by CFE and consequently, US$3 million were cancelled.

125. During project implementation, the World Bank maintained an active dialogue with the Mexican counterparts to coordinate changes to the project design and the procurement strategy, including efforts by the technical-procurement team to improve bidding documents and reach a successful bidding for the World Bank-financed component (solar field), after the failure of several bidding processes. The relationship and trust between the World Bank and CFE improved markedly during implementation, which helped pave the way for deeper engagement with Mexico on energy. World Bank's sponsored visits to the CFE's technical staff to other ISCCS plants in Morocco and Spain helped make design changes to improve operational efficiency.

126. The continued coordination with the Mexican counterparts is expected to facilitate the monitoring of the ISCCS operation in the near future, which is required to assess whether the PDO was achieved.

127. Despite the intense supervision support by the Bank team, the fact that the solar field was not fully operational by the time of ICR preparation cannot be overlooked. While major delays in project implementation were caused by the provision of the turbines (that is, a contract that was not financed by the World Bank), the lack of progress toward achievement of the GEO is the main consideration determining this rating as Moderately Unsatisfactory. Also a long overdue MTR (which only took place until October 2013, this is, seven years after approval and five years after effectiveness), the numerous project restructurings to extend the closing date that could have been processed differently (fewer restructurings with longer extensions), and finally the lack of a level-I restructuring to revise the PDO and the indicators included in the results framework, support the assigned Moderately Unsatisfactory rating for World Bank performance during supervision.

(c) Justification of Rating for Overall Bank Performance

Rating: Moderately Unsatisfactory

128. Based on the Moderately Satisfactory rating for the project preparation stage, and the Moderately Unsatisfactory rating during supervision, in addition to the fact that by the time of ICR preparation the solar field was not yet operational, as well as the difficulties to get CFE to submit all solar field contract amendments in a timely manner, the rating for overall Bank performance is considered Moderately Unsatisfactory.

5.2 Borrower

(a) Government Performance

Rating: Moderately Satisfactory

129. Government commitment to the development objective was maintained throughout

preparation and implementation of the GEF Grant and was a critical factor in the decision to complete it, even when several obstacles caused substantial delays and additional costs. Technical issues during the final stages of construction and testing have forced CFE to again postpone the commissioning of the solar field to mid-2017, beyond the closing date of May 31, 2016. The GoM showed strong political and financial support for the project, which resulted in a negotiation with the World Bank to extend the World Bank's technical and fiduciary support beyond the Grant's closing date, in an effort to successfully complete the project. However, financial, technical, procurement, and construction aspects, outside of SHCP's and NAFIN's control, resulted in significant delays for project commissioning and resulted in substantial cost overruns. Based on the above considerations, the rating for Government performance is Moderately Satisfactory.

(b) Implementing Agency or Agencies Performance

Rating: Unsatisfactory

130. CFE was responsible for project implementation, and also had overall responsibility for the management of the international bidding process for the ISCCS plant. Implementation of the solar field was satisfactory until works had to stop due to the delay in the provision of the turbines. Consequently, CFE team had to devote much of its attention toward the end of implementation on difficult negotiations with contractors both for the thermal plant and the solar field to be able to complete the project. Unfortunately, the solid progress on the solar field was overshadowed by the poor handling on the thermal component and, consequently, performance of CFE as implementing agency is rated as Unsatisfactory.

(c) Justification of Rating for Overall Borrower Performance

Rating: Moderately Unsatisfactory

131. The overall borrower's performance is rated Moderately Unsatisfactory due to the reasons explained above.

6. Lessons Learned

132. Innovative, groundbreaking technology projects cannot be treated as conventional infrastructure projects. The World Bank should consider additional time for completing this type of projects to account for all the complications that could be encountered along the way, even for sophisticated client countries, such as Mexico, and sufficient Bank budget should also be allocated since specialized staff would spend a significant amount of time dealing with revision of procurement-related matters.

133. The difficulties faced by CFE for the provision of the gas and steam turbines were unexpected considering, as indicated in the PAD, that "the experience, capacity and organization of CFE is more than adequate to carry out highly complex procurement procedures, such as that required for the Project." However, when the difficulties materialized, CFE continued firmly committed to the project, financed a substantial amount of the additional costs caused by the delay in the provision of the turbines, and is now completing the last stages of the project. This capacity of CFE to overcome the difficulties indicates the convenience of selecting capable and committed entities to implement complex projects. The experience gained with this project indicates that

capacity building through technical assistance in procurement and implementation of "modular" projects, including those components or "modules" not financed by the World Bank, is needed both for World Bank and Borrower tasks teams.

134. The World Bank might want to consider earlier deployment of dedicated local staff for closer supervision as soon as project ratings become unsatisfactory, without waiting for the project to be considered a 'problem project'.

135. The World Bank should carefully weigh operational guidelines and procedures against maintaining solid relationship with sophisticated countries. In the case of the Agua Prieta Project, the decision to close the Grant without the complete project being commissioned, but at the same time agreeing to maintain the World Bank's technical and fiduciary support beyond the closing date, resulted in an unorthodox situation where both supervision and closing activities had to be performed in parallel with very limited budget.

136. Demonstration projects carry very high implementation risks. They must be supported to overcome technological and economic barriers and lessons learned must be incorporated at every stage of the project, not only during preparation. The GEF approach, which consisted in the simultaneous implementation of four similar demonstration projects around the world, proved to be successful if viewed as a portfolio: even if one project was cancelled (which was the case of India) and another was delayed (in the case of Mexico), the other two projects were completed as scheduled (Morocco and Egypt), demonstrated the ISCCS concept, and helped move the market toward the acceptance of the CSP technologies. The World Bank and the GEF would benefit from commissioning a study to assess the impact of this ISCCS portfolio of four projects on worldwide CSP deployment. Also, the World Bank and the GEF would benefit from commissioning a study to assess the impact of GEF support for renewable energy technologies (off-grid solar PV, wind, and CSP) in Mexico.

137. The World Bank, along with country clients, should carefully analyze potential, unintended consequences of splitting a large infrastructure project into several bids. In the case of Agua Prieta, the significant delay in the acquisition of the gas and steam turbines resulted in a suspension of works for the entire project, including the solar field. Consequently, CFE had to renegotiate the solar field contract under unfavorable terms. The experience gained with this project indicates that, independently of the procurement delays, every effort should be made to award the entire project to a single EPC contractor. Even if the decision of splitting a project into several contracts is made in the future, the Bank and the Borrower should clearly agree on the level of fiduciary supervision by the Bank to be applied not only to the Bank-financed contract, but to the totality of the contracts involved.

138. Innovative, groundbreaking technology projects impose additional challenges when defining the PDO and the results framework. The use of broad terms in the PDO could result in successful projects being rated as Unsatisfactory. Moreover, an appropriate selection of project indicators that could clearly show progress over time, could contribute to identifying early signs of issues for management attention.

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

(a) Borrower/implementing agencies

139. The Government (SHCP, CFE and NAFIN) sent the draft ICR document with edits, which are reflected in the final ICR.

(b) Cofinanciers

Not applicable.

(c) Other partners and stakeholders

Not applicable.

Annex 1. Project Costs and Financing

(a) Project Cost by Component (in US$, millions equivalent)

Components	Appraisal Estimate (US$, millions)	Actual/Latest Estimate (US$, millions)	Percentage of Appraisal
Component 1: Design and construction of a 14 MW (peak) solar field	52.29[a]	52.25	99.93
Component 2: Design and construction of a 394 MW (net) gas based thermal plant	296.30[b]	473.10	159.67
Total Baseline Cost	—	—	—
Physical Contingencies	0.00	0.00	—
Price Contingencies	0.00	0.00	—
Total Project Costs	—	—	—
Project Preparation Facility	0.00	0.00	—
Front-end fee IBRD	0.00	0.00	—
Total Financing Required	**348.59**	**525.35**	**150.71**

Note: a. The total cost at appraisal included the solar field itself, the fence, the land purchase, the wastewater treatment plant, and the incremental cost due to integration; b. The total cost at appraisal included the provision of the combustion and steam turbines. Notice that the original estimates correspond to a 31-MW solar field and a 480-MW thermal plant, whereas the actual costs correspond to a 14-MW solar field and a 394-MW thermal plant (excluding taxes).

The overruns reported in Section 1.7 differ from those reported in the table above, since those reported by CFE (Section 1.7) are estimated with respect to the original amounts of the three different contracts, whereas those reported in the table above are estimated with respect to the appraisal estimate.

Overruns Reported by CFE (reported figures include 16% value added tax)

	Original Estimate (as per Original Contract) in US$, millions	Actual Cost in US$, millions	Overrun Percentage
Gas and steam turbines	140.36	167.04	119.01
Solar field	46.16	60.61	131.31
Combined cycle plant	291.95	381.76	130.76
Total	**478.47**	**609.41**	**127.37**

(b) Financing[a]

Source of Funds	Type of Cofinancing	Appraisal Estimate (US$, millions)	Actual/Latest Estimate (US$, millions)	Percentage of Appraisal
Borrower	—	299.24	502.41	167.9
GEF	—	49.35	46.39	94
Foreign Private Commercial Sources (unidentified)	—	0.00	0.00	—
Total	**—**	**348.59**	**548.80**	**157.43**

Note: a. CFE absorbed all the overrun costs for the turbines, the solar field, and the combined cycle plant, using a combination of CFE's own budget and commercial loans. Also, actual/latest estimations include 16% value added tax.

Annex 2. Outputs by Component

Table 2.1 Achievement of the GEO and the PDO

Project Outcome Indicator	Baseline	2017	End Project Target	Percentage of Achievement
PDO 1. Total electricity generated from the solar hybrid project (GWh per year)	0	1,167.37	2,935	39.77
PDO 2. Annual average efficiency of solar input to electric output (percent)	0	Pending	>12 percent	0
PDO 3. Generation capacity of renewable energy (other than hydropower) constructed (MW)	n.a.	14	14	100
PDO 4. Generation capacity of renewable energy constructed - solar (MW)	n.a.	14	14	100
GEO 1. Reduction of CO_2 emissions (tCO_2e per year)	0	0	11,833	0

The following energy production from the combined cycle has been reported by CFE since commissioning in October 2016:

Table 2.2 Energy production since commissioning (for the thermal component only)

Month	MWh	Capacity Factor (percent)
October 2016	202,453.36	62.56
November 2016	234,542.37	74.89
December 2016	257,961.11	79.71
January 2017	259,758.86	80.26
February 2017	212,652.99	72.75
Accumulated	**1,167,368.69**	

Annex 3. Economic and Financial Analysis

1. The combined cycle plant that is part of the ISCCS plant started operation in October 2016. The construction of the solar field is already completed and CFE is in the process of integrating it to the combined cycle. The estimated capital and operation and maintenance costs and the benefit streams of the project, in 2017 prices, are shown in Table 3.1. This information is based on the exchanges the Bank team had with CFE and Mexican authorities during project implementation. No ICR mission was performed because the project still must be completed and the solar field is not operational yet.

- The total installed capacity of the ISCCC is 394.0 MW, instead of the 485.5 MW estimated at appraisal. The installed capacity of the solar field is 14 MW, instead of the appraised 31MW.
- The total cost of the ISCCS plant is expected to reach about US$525.4 million instead of the appraised US$348.0 million.
- Annual fixed operation and maintenance (O&M) costs are estimated at US$ 16.8 million instead of US$ 15.8 million estimated at appraisal.
- Current natural gas cost has been estimated as US$3.41/MMBtu, compared to US$4.90 during appraisal.
- Gross generation (excluding solar generation) was estimated at 3,402 GWh/year in the PAD while the current estimate is 2,802 GWh/year. Solar generation is estimated at 31 GWh/year, compared with 70 GWh/year at appraisal.

Economic Benefits

2. The economic benefits of the electricity generated by Agua Prieta II were estimated considering an annual average price of $53.3/MWh, as projected by CFE after the first months of operation. This price is in line with the avoided cost estimated in the base case of the PAD: $52.0/MWh and in the range of the current average marginal prices at the local node of the National Interconnected System, in the northern state of Sonora. Since marginal prices experienced a certain degree of variability during the final months of 2016 and the first months of 2017, a sensibility analysis was performed to evaluate the effect of higher electricity marginal prices on the economic benefits.

Results of the Economic Analysis

3. During project preparation, expected NPV of the project in the base case was equal to US$49.6 million and the economic rate of return equal to 14.4%. Using new and actual values, as indicated above, the current calculated NPV of the project is $227.0 million and the rate of return is 10.7%. The higher investment cost of the project was compensated by higher electricity prices, lower natural gas prices and an updated lower social discount rate (6%) that reflects the recent evolution and prospects of the Mexican economy. [17]

4. Sensitivity analysis: The project NPV becomes negative for a price of natural gas exceeding US$ 4.29/MMBtu, a price of electricity below 4.66 US$ cents/kWh, or a social discount rate higher

[17] Discounting Costs and Benefits in Economic Analysis of World Bank Projects. 2016

than 10.7%.

Table 3.1 – Updated Economic Analysis

Operation and Maintenance Costs	16.8	US$ Million
Net Generation	2833	GWh per year
Fuel Cost	3.41	US$ per Million Btu
Average Tariff	5.33	US$cents per kWh
Net Electricity to Grid	2833	GWh per year
Life of the Plant	25	years
Discount Rate	6.0	%

Calendar year	Investment Cost	Fuel Cost	Operation & Maintenance	Total Costs	Total Revenues Energy Sales	Net Revenues
	US$ million	US$ million	US$ million	US$ million	US$ million	US$ million
2016	525.4	13.4	4.2	542.9	37.0	-505.9
2017	-	73.1	16.8	89.8	149.3	59.5
2018	-	73.1	16.8	89.8	149.3	59.5
2019	-	73.1	16.8	89.8	149.3	59.5
2020	-	73.1	16.8	89.8	149.3	59.5
2021	-	73.1	16.8	89.8	149.3	59.5
2022	-	73.1	16.8	89.8	149.3	59.5
2023	-	73.1	16.8	89.8	149.3	59.5
2024	-	73.1	16.8	89.8	149.3	59.5
2025	-	73.1	16.8	89.8	149.3	59.5
2026	-	73.1	16.8	89.8	149.3	59.5
2027	-	73.1	16.8	89.8	149.3	59.5
2028	-	73.1	16.8	89.8	149.3	59.5
2029	-	73.1	16.8	89.8	149.3	59.5
2030	-	73.1	16.8	89.8	149.3	59.5
2031	-	73.1	16.8	89.8	149.3	59.5
2032	-	73.1	16.8	89.8	149.3	59.5
2033	-	73.1	16.8	89.8	149.3	59.5
2034	-	73.1	16.8	89.8	149.3	59.5
2035	-	73.1	16.8	89.8	149.3	59.5
2036	-	73.1	16.8	89.8	149.3	59.5
2037	-	73.1	16.8	89.8	149.3	59.5
2038	-	73.1	16.8	89.8	149.3	59.5
2039	-	73.1	16.8	89.8	149.3	59.5
2040	-	73.1	16.8	89.8	149.3	59.5

5. Tables 3.2 to 3.4 tables show the estimated NPV under various scenario of social discount rates, electricity prices and fuel cost. The base case is indicated in **bold**.

Table 3.2

Social Discount Rate	NPV US$ million
6.0%	**227.0**
8.0%	111.5
10.0%	25.9
10.7%	0.0
12.0%	(38.3)

Table 3.3

Electricity Price USD cents/kWh	NPV US$ million
4.66	0.0
5.3	**227.0**
6.0	453.6
7.0	791.9

Table 3.4

Fuel cost USD/million Btu	NPV US$ million
3.41	**227.0**
4.00	73.8
4.29	0.0
5.00	(183.8)

6. Table 3.5 shows the updated financial under the assumptions indicated above.

Table 3.5 – Updated Financial Analysis

Calendar year	CAPEX	Grant	Revenue Energy Sales	Fuel costs	Variable O&M	Operating Income	Interest on loans	Depreciation	Income tax paid	Loan principal	Net Revenue
					USD million						
2016	525.4	46.4	37.0	13.4	4.2	19.5	0.0	0.0	0.0	0.0	-505.9
2017			149.3	73.1	16.8	59.5	21.7	21.0	1.5	41.6	15.7
2018			149.3	73.1	16.8	59.5	19.9	21.0	1.7	43.4	15.6
2019			149.3	73.1	16.8	59.5	18.0	21.0	1.8	45.2	15.4
2020			149.3	73.1	16.8	59.5	16.1	21.0	2.0	47.2	15.2
2021			149.3	73.1	16.8	59.5	14.1	21.0	2.2	49.2	15.0
2022			149.3	73.1	16.8	59.5	12.0	21.0	2.4	51.3	14.8
2023			149.3	73.1	16.8	59.5	9.8	21.0	2.6	53.5	14.6
2024			149.3	73.1	16.8	59.5	7.5	21.0	2.8	55.8	14.4
2025			149.3	73.1	16.8	59.5	5.1	21.0	3.0	58.2	14.2
2026			149.3	73.1	16.8	59.5	2.6	21.0	3.2	60.7	14.0
2027			149.3	73.1	16.8	59.5	0.0	21.0	3.5	0.0	77.0
2028			149.3	73.1	16.8	59.5	0.0	21.0	3.5	0.0	77.0
2029			149.3	73.1	16.8	59.5	0.0	21.0	3.5	0.0	77.0
2030			149.3	73.1	16.8	59.5	0.0	21.0	3.5	0.0	77.0
2031			149.3	73.1	16.8	59.5	0.0	21.0	3.5	0.0	77.0
2032			149.3	73.1	16.8	59.5	0.0	21.0	3.5	0.0	77.0
2033			149.3	73.1	16.8	59.5	0.0	21.0	3.5	0.0	77.0
2034			149.3	73.1	16.8	59.5	0.0	21.0	3.5	0.0	77.0
2035			149.3	73.1	16.8	59.5	0.0	21.0	3.5	0.0	77.0
2036			149.3	73.1	16.8	59.5	0.0	21.0	3.5	0.0	77.0
2037			149.3	73.1	16.8	59.5	0.0	21.0	3.5	0.0	77.0
2038			149.3	73.1	16.8	59.5	0.0	21.0	3.5	0.0	77.0
2039			149.3	73.1	16.8	59.5	0.0	21.0	3.5	0.0	77.0
2040			149.3	73.1	16.8	59.5	0.0	21.0	3.5	0.0	77.0

7. Tables 3.6 to 3.8 show the estimated NPV under various scenario of social discount rates, electricity prices and fuel cost. The base case is indicated in **bold**.

8. Sensitivity analysis: The updated financial projections indicate that the project NPV becomes negative for a price of natural gas exceeding US$ 3.42/MMBtu, a price of electricity below 5.32 US$ cents/kWh, or a social discount rate higher than 6.1%.

Table 3.6

Social Discount Rate	NPV USD million
6.0%	**4.1**
6.1%	0.0
8.0%	(102.7)
10.0%	(176.9)
12.0%	(228.8)

Table 3.7

Electricity Price USD cents/kWh	NPV USD million
5.32	0.0
5.33	**4.1**
6.00	214.7
7.00	529.0

Table 3.8

Fuel cost USD/million Btu	NPV USD million
3.41	**4.1**
3.42	0.0
4.00	(137.6)
5.00	(375.7)

Annex 4. Bank Lending and Implementation Support/Supervision Processes

(a) Task Team members

Names	Title	Unit	Responsibility/Specialty
Lending			
Gabriela Elizondo	Senior Energy Specialist	LCSFE	TTL
Ernesto Terrado	Senior Energy Specialist, Consultant	LCSFE	
Enrique Crousillat	Lead Energy Specialist	LCSFE	
Juan David Quintero	Lead Environmental Specialist	ESSD	
Elena Correa	Senior Social Specialist	ESSD	
Efraim Jimenez	Lead Procurement Specialist	LCOAA	
Juan Carlos Alvarez	Legal Counsel	LCOAA	
Victor Ordonez	Senior FM Specialist	LCOAA	
Juan Carlos Serrano	ET Consultant	LCOAA	
Hernan Gonzalez	ET Consultant	ESSD	
Georg Caspary	ST Consultant	LCSFE	
Supervision/ICR			
Guillermo Hernandez	TTL, Energy Specialist	GEE04	
Karen Bazex	Senior Energy Specialist	GEE01	Former TTL
Roberto Gabriel Aiello	Senior Energy Specialist		Former TTL
Gabriela Elizondo	Senior Energy Specialist	GEE04	Former TTL
Ernesto Terrado	Consultant		
Enrique Crousillat	Consultant	GEE04	
Juan David Quintero	Consultant	GENDR	
Efraim Jimenez	Consultant	OPSPF	
Elena Correa	Consultant	GSU10	
Hernan Gonzalez	ET Consultant	LCSPS - HIS	
Juan Carlos Alvarez	Senior Counsel	LEGES	
Juan Carlos Serrano-Machorro	Senior Financial Management Specialist	GG022	FM
Georg Caspary	Consultant	GENGE	
Victor Manuel Ordonez Conde	Senior Finance Officer	WFALA	
Demetrios Papathanasiou	Practice Manager	GEE06	
Felix Prieto Arbelaez	Senior Procurement Specialist		
Armando Ribeiro Araujo	Consultant		
Luis M. Vaca-Soto	Consultant	GSU10	Senior Power Engineer/ICR main author
Tomas Socias	Senior Procurement Specialist		
Alonso Zarzar Casis	Senior Social Scientist		Social Safeguards
Diomedes Berroa	Senior Operations Officer	OPSPF	Procurement
Jose Luis Calderon Bartheneuf	Consultant		Environmental Safeguards
Laura Wendell Berman	Energy Specialist	GEE04	
Gabriel Penaloza	Senior Procurement Specialist	GGO04	Procurement
Cesar Adrian Arreola Croda	Consultant	GEE04	
Jeannette Estupinan	Senior FM Specialist	GGO22	FM
Luis Barajas Gonzalez	Financial Specialist	GGO22	FM
Farah Mohammadzadeh	Consultant	GTI11	
Karla Olguin Hernandez	Consultant		

McCarthy, Eugene D.	Consultant	GEEES	
Elisabeth Maier	Operations Officer	GEE05	
Juliana Victor	Senior Monitoring & Evaluation Specialist	GEESO	
Richard Hosier	Senior Energy Specialist	GEE08	ICR Peer Reviewer
Silvia Martinez Romero	Senior Renewable Energy Specialist	GEEES	ICR Peer Reviewer
Andrea Castro	Consultant	GEE04	
Elena Segura	Senior Counsel	LEGLE	
Gabriela Vidals	Operations Officer	LCC1C	
Alexandra Ortiz	Program Leader	LCC1C	
Nancy Montes de Oca	Team Assistant	LCC1C	
Diana Gabriela Jimenez Cruz	Program Assistant	LCC1C	
Karina Kashiwamoto	Language Program Assistant	LCC1C	
Megan Meyer	Energy Specialist	GEE04	Ex post economic analysis
Bipul Singh	Energy Economist	GEE06	Ex post economic analysis
Lara Born	Energy Specialist	GEE01	Ex post economic analysis

(b) Staff Time and Cost

Stage of Project Cycle	Staff Time and Cost (World Bank Budget Only)	
	No. of Staff Weeks	US$, thousands (Including Travel and Consultant Costs)
Lending		
FY05	5.63	58.11
FY06	13.26	120.08
FY07	10.83	35.52
Total (lending):	**29.72**	**213.71**
Supervision/ICR		
FY07	9.56	34.52
FY08	4.18	26.70
FY09	18.71	71.92
FY10	19.55	103.20
FY11	16.83	44.40
FY12	7.28	36.55
FY13	3.19	14.47
FY14	12.58	63.46
FY15	10.98	68.24
FY16	10.95	58.96
FY17	17.10	58.73
Total (supervision/ICR):	**130.91**	**581.16**

Annex 5. Beneficiary Survey Results

Not applicable.

Annex 6. Stakeholder Workshop Report and Results

Not applicable.

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

The Government (SHCP, CFE and NAFIN) sent the draft ICR document with edits, which are reflected in the final ICR.

Annex 8. Comments of Cofinanciers and Other Partners/Stakeholders

Not applicable.

Annex 9. List of Supporting Documents

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Annex 10. Chronology of Significant CSP Technology Events

1990 - Nine CSP plants are deployed in California, United States, with a total capacity of 354MW.

1991 - Bankruptcy of the sole developer of parabolic trough technology slows down CSP technology development.

2004 - Construction of the first 150 kW Dish Stirling pilot plant at Sandia Labs, United States, and deployment of pilot molten salt solar towers, Solar One and Solar Two.

2007 - Introduction of feed-in tariff mechanisms in several European Union countries contributes to foster deployment of CSP technology.

2007 - Deployment of the first commercial solar tower plant (PS10) in Spain (10 MW) and the large Nevada Solar One (64 MW) parabolic trough plant in the United States marked the beginning of CSP scale-up worldwide.

2008 - Construction of the GEF ISCCS plant starts (472 MW, including 20 MW solar CSP) on site in Ain Beni Mathar, Morocco.

2008 - Construction of the GEF ISCCS plant (140 MW, including 20 MW solar CSP) starts on site in Kureimat, Egypt.

2008 - Commissioning of the Andasol I plant (50 MW) in Spain proving commercial viability of CSP thermal storage system.

2009 - CSP installed capacity worldwide reaches 600 MW with the commissioning of further plants in Spain such as the solar tower PS20 (20 MW) and seven 50 MW parabolic trough plants (Puertollano, Andasol II, Ibersol, Solnova 1, 3, and 4, and La Risca) and in the United States, such as the 5 MW Sierra Sun Tower.

2010 - Commissioning of Ain Beni Mathar ISCCS plant (472 MW) in Morocco.

2010 - Commissioning of La Florida, Majadas I, and Palma del Río 2 plants (150 MW) in Spain.

2011 - Commissioning of Kureimat ISCCS plant (20 MW) in Egypt.

2011 - Commissioning of the Andasol III, Arcosol 50, Extresol-2, Helioenergy 1, La Deheza. Lebrija, Manchasol 1 and 2, Palma del Río, and Termesol plants (450 MW in total) in Spain.

2012 - Commissioning of the Aste 1A, Aste 1B, Astexol II, Borges Termosolar, Gemasolar, Guzman, Helioenergy 2, Helios 1 and II, La Africana, Morón, Olivenza 1, Orellana, Puerto Solar II, Solaben 2 and 3, and Solacor 1 and 2 plants (825 MW in total) in Spain.

2013 - Commissioning of the Arenales, Casablanca, Enerstar, Solaben 1and 6, and Termosol 1 and 2 plants (350 MW) in Spain.

2013 - Commissioning of the Diwakar and Godawari plants (150 MW in total) in India.

2014 - Ongoing construction of Gujarat Plant (25 MW) in India.

2014 - Commissioning of the Dhursar and Megha plants (175 MW in total) in India.

2015 - Commissioning of Noor 1 ISCCS plant in Quarzazate, Morocco.

2015 - Ongoing construction of the Noor II and III plants in Morocco.

2015 - Launching of the Midelt project in Morocco.

2016 - Ongoing construction of Dadri plant (14 MW) in India.

2016 - Capital cost of the solar thermal field of the Duba I project in Saudi Arabia will be less than US$1,600 per kW according to the awarded bid.

2017- In Chile's last auction for dispatchable 24-hour solar power, in March 2017, the winning proposal offered a price of US$0.63 per kWh. The project will comprise two 120 MW solar thermal towers with up to 14-hour thermal storage, combined with 150 MW of PV.

2017 - Total capacity of CSP plants in operation worldwide reaches 6,996 MW (94 plants). In addition, 26 CSP plants are under construction (1,797 MW), 3 plants under contract (60 MW), and 48 plants under development (8,857 MW).

2017- Total capacity of ISCCS plants in operation worldwide reaches 1,945 MW.

2017- Total capacity of ISCCS plants under construction worldwide reaches 2.608 MW.

MAP
(Provided by the Cartography Unit of the World Bank Group)