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The World Bank

Report No: ICR2693

IMPLEMENTATION COMPLETION AND RESULTS REPORT
(TF-58314)

ON A

GRANT

IN THE AMOUNT OF US$ 43.2 MILLION
FROM THE GLOBAL ENVIRONMENT FACILITY TRUST FUND

TO THE

OFFICE NATIONAL DE L'ELECTRICITE ET DE L'EAU POTABLE (ONEE)

OF THE KINGDOM OF MOROCCO

FOR AN

INTEGRATED SOLAR COMBINED CYCLE POWER PROJECT

June 25, 2013

Sustainable Development department
Energy and Environment unit
Middle East and North Africa region

CURRENCY EQUIVALENTS

(Exchange Rate Effective April 19, 2013)
Currency Unit = Morocco Dirham (MAD)
MAD 8.52 = US$ 1
Euro 1 = US$ 1.29

FISCAL YEAR

January 1 – December 31

ABBREVIATIONS AND ACRONYMS

ABM	Ain Beni Mathar
AfDB	African Development Bank
ASME	American Society of Mechanical Engineers
CC	Combined-Cycle
CSP	Concentrated Solar Power
DLR	German Aerospace Center
DNI	Direct Normal Irradiation
DPL	Development Policy Loan
DSM	Demand Side Management
EPC	Engineering Procurement Construction
GEF	Global Environment Facility
GEO	Global Environmental Objective
GT	Gas Turbine
GWh	Gigawatt hour
HRSG	Heat recovery steam generator
HTF	Heat Transfer Fluid
IBRD	International Bank for Reconstruction and Development
ICR	Implementation Completion Report
IPP	Independent Power Producer
ISCC	Integrated Solar Combined Cycle
kV	Kilovolt
kWh	Kilowatt hour
LCOE	Levelized Cost of Electricity
MASEN	Moroccan Agency for Solar Energy
MMBtu	Million British Thermal Unit
MNA	Middle-East and North Africa
MWh	Megawatt hour
NPV	Net Present Value
NREL	National Renewable Energy Laboratory
O&M	Operations and Maintenance
ONEE	Office National de l'Electricité et de l'Eau Potable (Morocco National Electricity and Water Utility)
PAD	Project Appraisal Document
PDO	Project Development Objective
PIU	Project Implementation Unit
PPA	Power Purchase Agreement
STAP	Scientific and Technical Advisory Panel
ST	Steam Turbine
UNFCCC	United Nations Framework Convention on Climate Change
US	United States

Vice President:	Inger Andersen
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Project Team Leader:	Roger Coma-Cunill
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MOROCCO
Integrated Solar Combined Cycle Project

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Data Sheet

A. Basic Information			
Country:	Morocco	Project Name:	INTEGRATED SOLAR COMBINED CYCLE POWER PROJECT
Project ID:	P041396	L/C/TF Number(s):	TF-58314
ICR Date:	06/25/2013	ICR Type:	Core ICR
Lending Instrument:	SIL	Borrower:	GOVERNMENT OF MOROCCO
Original Total Commitment:	USD 43.20M	Disbursed Amount:	USD 43.20M
Revised Amount:	USD 43.20M		
Environmental Category: B		**Global Focal Area: C**	
Implementing Agencies:			
Cofinanciers and Other External Partners:			

B. Key Dates				
Process	**Date**	**Process**	**Original Date**	**Revised / Actual Date(s)**
Concept Review:	08/05/1998	Effectiveness:	12/31/2007	03/31/2008
Appraisal:	06/26/2006	Restructuring(s):		
Approval:	04/19/2007	Mid-term Review:	04/10/2010	
		Closing:	12/31/2012	12/31/2012

C. Ratings Summary	
C.1 Performance Rating by ICR	
Outcomes:	Satisfactory
Risk to Global Environment Outcome	Moderate
Bank Performance:	Satisfactory
Borrower Performance:	Satisfactory

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

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):	Satisfactory
Problem Project at any time (Yes/No):	No	Quality of Supervision (QSA):	None
GEO rating before Closing/Inactive status	Satisfactory		

D. Sector and Theme Codes

	Original	Actual
Sector Code (as % of total Bank financing)		
Other Renewable Energy	100	100
Theme Code (as % of total Bank financing)		
Climate change	40	40
Infrastructure services for private sector development	20	20
Technology diffusion	40	40

E. Bank Staff

Positions	At ICR	At Approval
Vice President:	Inger Andersen	Daniela Gressani
Country Director:	Simon Gray	Theodore O. Ahlers
Sector Manager:	Charles J. Cormier	Jonathan D. Walters
Project Team Leader:	Roger Coma-Cunill	Noureddine Bouzaher
ICR Team Leader:	Roger Coma-Cunill	
ICR Primary Author:	Roger Coma-Cunill	

F. Results Framework Analysis

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

The global environmental objective is to reduce greenhouse gas emissions from anthropogenic sources by increasing the market share of low greenhouse gas emitting technologies. The project will also demonstrate the operational viability of hybrid solar thermal power generation technology and contribute to replication of integrated solar combined cycle (ISCC) power generation technology in Morocco and elsewhere through the learning effects provided by its construction and operation, and through economies of scale as use of the technology spreads. It is one of a number of similar projects in the world supported by the Global Environment Facility (GEF), and by other financing sources, as part of a global programmatic effort to accelerate cost reduction and commercial adoption of large-scale low greenhouse emitting generation technologies.

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

(a) GEO Indicator(s)

Indicator	Baseline Value	Original Target Values (from approval documents)	Formally Revised Target Values	Actual Value Achieved at Completion or Target Years
Reductions in CO_2 emission (tons/year)	**0**	**24,300**	**24,300**	**22,988**[1]
Solar Thermal Power Plant costs in ¢/kWh	**0**	**17.4**	**17.4**	**24.4**[2]
Number of visitors to and information requests about plant	**0**	-	-	**440**
Number of workshops and conferences in which experience of plant is presented	**0**	-	-	**91**
Information about the plant posted on ONEE's website	**No**	**Yes**	**Yes**	**Yes**

[1] This value corresponds to the reductions of CO_2 emissions (tons) in 2012, i.e. 0.59 (emissions coefficient) * 38,963 MWhe (solar field generation). This value is slightly lower than target because energy production from solar field was lower than the projected value (cf. footnote 4).

[2] The calculation methodology of this outcome indicator was not provided in the Project Appraisal Document (PAD), so it was assumed to be the levelized cost of electricity (see Annex 2).

(b) 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
ISCC's yearly generation of electricity (GWh)	**0**	**3,538**	**3,538**	**3,370**[3]
ISCC's yearly generation of solar electricity (GWh)	**0**	**40**	**40**	**39**[4]
ONEE staff trained in various aspects of ISCC technology	**0**	**20**	**20**	**20**
Solar output as percentage of total electricity produced by ISCC power plant	**0**	**1.13**	**1.13**	**1.16**
Share of ISCC energy in total electricity production (%)	**0**	**16.8**	**16.8**	**10.85**

G. Ratings of Project Performance in ISRs

No.	Date ISR Archived	GEO	IP	Actual Disbursements (USD millions)
1	06/18/2007	Satisfactory	Satisfactory	0.00
2	11/27/2007	Satisfactory	Satisfactory	0.00
3	07/09/2008	Satisfactory	Satisfactory	43.20
4	12/18/2008	Satisfactory	Satisfactory	43.20
5	09/29/2009	Satisfactory	Satisfactory	43.20
6	09/25/2012	Satisfactory	Satisfactory	43.20

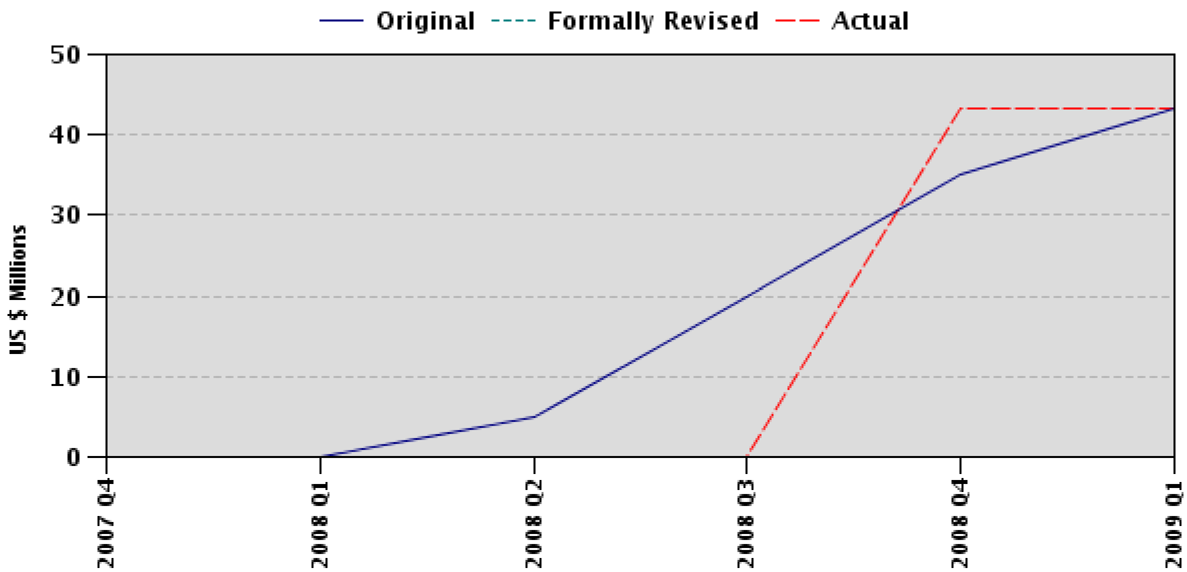
H. Restructuring (if any)

Not Applicable

[3] It should be noted that the ISCC plant guaranteed an electricity production of 3,781 GWh, well above the 3,370 GWh corresponding to the actual electricity demand from the system operator.

[4] The Direct Normal Irradiation (DNI) for 2012 is about 12% lower than the reference year. Since the solar field was sized based on the reference year, it would be expected that the annual solar field thermal output would be lower accordingly.

I. Disbursement Profile



1. Project Context, Global Environment Objectives and Design

1.1 Context at Appraisal

1. At appraisal, Morocco's electricity demand was increasing rapidly at 8% per year due to strong economic growth[5], a growing population and successful policies for increasing electricity access. Despite intensified electricity conservation and demand side management (DSM) efforts, electricity demand was expected to continue growing at that rate for the foreseeable future. Moreover, the country was largely dependent on imported fossil fuels for power generation due to lack of endogenous resources. Morocco's total energy bill had increased from US$ 3 billion in 2004 to US$ 4.2 billion in 2005 due to the rise in the prices of oil and coal. To reduce this dependence, the Government of Morocco had actively been seeking to diversify the country's energy mix with a larger use of natural gas and renewable energies. Morocco had already commissioned its first gas-fired combined cycle power plant at Tahaddart[6] in 2005 and had a few wind and hydro projects, but did not have any experience on utility-scale solar technology.

2. On the international scene, the Government of Morocco was deeply committed with the global efforts to combat climate change. In 1995, Morocco ratified the United Nations Framework Convention on Climate Change (UNFCCC) and hosted its seventh Conference of the Parties in November 2001. On January 25, 2002, Morocco ratified the Kyoto Protocol.

3. The Global Environment Facility (GEF) had identified solar thermal power technology as one of its priorities because of the technology's significant cost reduction potential. The GEF and the Bank built a portfolio of four demonstration projects to facilitate the commercialization of solar thermal technology under GEF's Operational Program 7 "Reducing the long-term costs of low greenhouse-gas emitting technologies". The objective was to contribute to the global learning of the technology in order to drive-down its costs to commercially competitive levels through economies of scale and innovation. By appraisal, the GEF pipeline using this technology consisted of a project in India (later dropped) from 1996, the Morocco-Ain Beni Mathar and Mexico-Agua Prieta from 1999 and the Egypt-Kureimat project from 2004. The Moroccan government seized the opportunity offered by the GEF support program to cover the incremental cost of an expensive solar thermal technology[7] to access the country's unexploited solar resources.

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[5] 5.4% per year due to reforms introduced to increase the economy's overall productivity. Source: International Monetary Fund, Morocco: Article IV Consultation Discussions, June 2007.

[6] The 385 MW combined-cycle power plant at Tahaddart was commissioned in March 26, 2005. The gas for the plant was supplied from the Maghreb-Europe pipeline, sharing the same gas with the Ain Beni Mathar ISCC plant. Morocco benefited from an arrangement whereby the country could extract up to 7% of all gas wheeled from Algeria via Morocco to Spain and Portugal.

[7] The 9 solar plants with a total of 354 MW composing the Solar Energy Generating Systems (SEGS) in California's Mojave desert were the only CSP plants in operation in the world at that time.

4. The configuration integrating solar and combined cycle (ISCC) technology was chosen in these projects because it offered several cost and operational advantages over independent solar thermal plants that made them more suitable for introducing solar-generated electricity in developing countries.

5. The Bank fully supported GEF's strategic objective to reduce, over the long term, the costs of low-carbon energy technologies. The Bank had engaged in an intensive policy dialogue with the Government of Morocco and ONEE on energy issues after years of inaction in the country's energy sector. The Bank was in an advanced stage of preparation of an energy development policy loan (DPL), which had synergies with the proposed ISCC project in Ain Beni Mathar.

1.2 Original Global Environment Objectives (GEO) and Key Indicators

6. The Project Appraisal Document (PAD) states that the project development objective (PDO) was "to increase the contribution of renewable energy sources in Morocco's energy mix and add capacity to the power grid to help cope with the sustained growth in electricity demand".

7. The project's global environmental objective (GEO) was to "reduce greenhouse gas emissions from anthropogenic sources by increasing the market share of low greenhouse gas emitting technologies". As part of the GEO, the PAD also stated that "the project will demonstrate the operational viability of hybrid solar thermal power generation technology and contribute to replication of integrated solar combined cycle (ISCC) power generation technology in Morocco and elsewhere through the learning effect provided by its construction and operation, and through economies of scale as use of the technology spreads. It is one of a number of similar projects in the world to be supported by GEF, and by other financing sources, as part of a global programmatic effort to accelerate cost reduction and commercial adoption of large-scale low greenhouse emitting generation technologies. Secondarily, the project will make a modest direct contribution to the reduction of greenhouse gas emissions".

8. The Grant Agreement (Schedule 1) combined the PDO and GEO and stated that the project objective was "to support the Recipient in increasing its power generation capacity, reducing greenhouse gas emissions and promoting renewable energy sources in the Kingdom of Morocco through the development of an integrated solar combined cycle power plant in Ain Beni Mathar".

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

9. The objective and key indicators were not revised.

1.4 Main Beneficiaries

10. The main target beneficiaries were the citizens of Morocco who would reduce the risk of blackouts with the addition of the ISCC plant in the system and would benefit

from a more affordable non-carbon technology in the long term. The citizens of the city of Ain Beni Mathar, Oujda and the Oriental region were expected to benefit in particular from the project due to direct and indirect employment opportunities and increased reliability of power supply.

1.5 Original Components

11. The project was primarily designed to demonstrate the operational viability of hybrid solar thermal power generation technology and contribute to its replication in Morocco and throughout the world through the learning effect provided by its construction and operation. Thus, the original components of the project were:

Component 1 – Design, construction and Operation of an Integrated Solar Combined Cycle Power Plant

12. This component was aimed at financing the construction and operation of a pioneer hybrid Integrated Solar Combined Cycle Power Plant through an Engineering Procurement Construction (EPC) contract and a 5-year Operations and Maintenance (O&M) contract. The plant, with a net capacity of 472 Megawatts (MWe), consisted of two gas turbines, two heat recovery steam generators (HRSG), one steam turbine and a 20 MWe parabolic trough solar field (see Annex 4 for details). There were no similar plants (see Figure 1 below) in the world. Integrated Solar Combined Cycle (ISCC) technology aimed to draw the environmental benefits of solar energy together with the operational advantages of a 'conventional' gas turbine-steam turbine combined cycle plant, a mature technology that was widely used worldwide. While the solar resource partially substituted fossil fuels, the plant could also supply energy to the grid whenever it was required.

13. The development of parabolic trough concentrated solar power (CSP) technology had stalled after the construction of nine plants with a total of 354 MW in the United States (US) in the 80s. Hence, CSP technology did not exist in developing countries and the integration of a solar field with a combined cycle island had not been built anywhere yet. The US$ 43.2 million GEF grant was allocated to cover the incremental cost of the plant arising from the addition of the solar field.

14. From October 2010 (commissioning date) until November 2011, the plant performed below expectations[8] due to insufficient gas supply, an issue beyond ONEE’s control. Since then, the plant has been performing satisfactorily and meeting almost all performance targets (see Annexes 2 and 4 for details). Further evaluations will be

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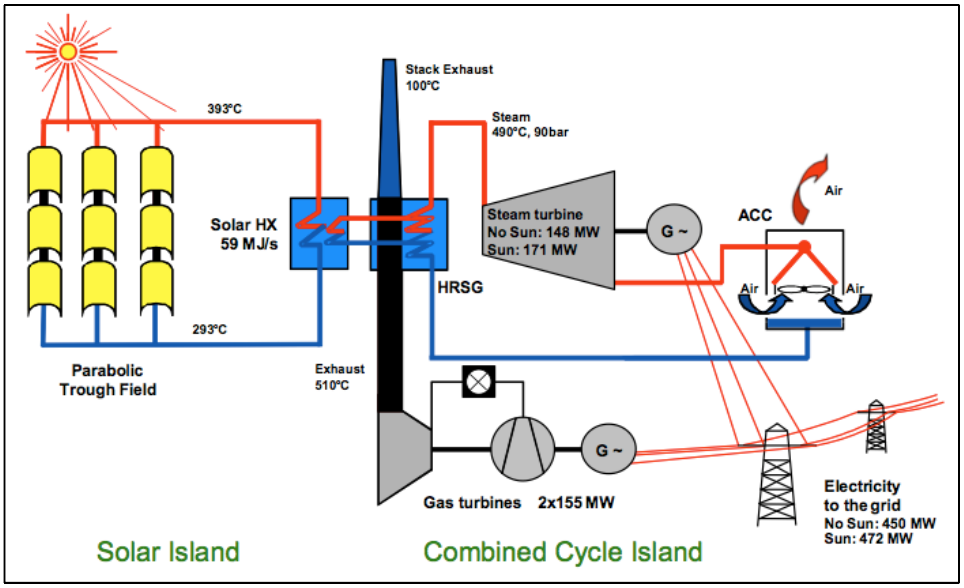
[8] In ISCC technology, the solar field can only operate when the gas-fired combined cycle island is operating at least partially. When the combined cycle island is not operating, e.g. due to fuel shortage, the solar field lies idle as well. If the solar island drives substantially less than 50% of the steam turbine, which is the case in the Ain Beni Mathar ISCC, the solar energy alone is not enough to keep the steam turbine operational. Steam turbine manufacturers recommend not to operate the turbine below a certain minimum capacity (in general around 25% of the nameplate capacity) for performance and reliability reasons, i.e. governor systems can be less stable at very low loads, risk of corrosion of blades and vibrations.

required in the future since complete performance data are only available for one year (2012) at this point in time.

Figure 1- The ISCC plant in Ain Beni Mathar[9]



Component 2 – Construction of 225 kV and 60 kV power lines

15. This component was aimed at financing two 225 Kilovolt (kV) transmission lines that carry the power generated by the ISCC plant and one 60 kV back up transmission line. The first 225 kV transmission line was planned to carry power to the existing Oujda substation (110 km). The second 225 kV transmission line was to evacuate power to the Bourdim substation (70 km). The 60 kV line (10 km) was conceived to provide a backup power supply to the auxiliaries of the ISCC plant in case of emergency by connecting the existing 60/225 kV substation of Ain Beni Mathar city to the plant.

Component 3 – Construction of a 225 kV substation

16. This component was aimed at financing the construction of one 225 kV substation. The substation was expected to be constructed next to the power plant to dispatch the generated power via two 225 kV transmission lines, the first connecting the power plant to the Oujda substation and the second to the Bourdim substation.

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[9] Brakmann G., Badaoui N-E. (ONEE), Dolejsi M., Klingler R., "Construction of ISCC Ain Béni Mathar in Morocco", Fichtner/ONEE, 2010 SolarPACES, Perpignan, France.

Component 4 – Construction of an access road

17. This component was aimed at financing a 6 km access road to link the ISCC plant to the main road (Main road 19). Two bridges over the Charef and Tabouda rivers were also constructed.

Component 5 – Boreholes

18. This component was aimed at financing the drilling of two boreholes to pump required groundwater from the aquifer located below the Ain Beni Mathar site for the operation and maintenance of the plant, i.e., replenishment of the closed steam cycle, human consumption and mirror cleaning. ONEE had received authorization to pump 3.1 million m^3/year of water based on consumption estimates of a wet-cooling system. However, ONEE chose a dry-cooling system, which reduced dramatically the plant's impact on the aquifer. The water consumption in 2012 has been 334,112 m^3/year only.

Component 6 – Land acquisition

19. This component was aimed at financing the acquisition of 203 hectares (ha) for the project, including 160 ha for the ISCC plant (88 ha for the solar field), 6 ha for the boreholes and water distribution, 31 ha for the gas spur from the Maghreb-Europe pipeline to supply the power plant, and 6 ha for the access road.

Component 7 – Gas pipeline

20. This component was aimed at financing the construction of a 13 km gas spur from the Maghreb-Europe gas pipeline to the plant.

Component 8 – Environmental and Social Development and Management

21. This component was aimed at financing a comprehensive monitoring and evaluation program to disseminate the results and the lessons learned from the project, the implementation of the Environmental Management Plan (EMP) and a capacity building program to strengthen the capacity of ONEE to monitor EMP implementation. This component was expected to support ONEE in the dissemination of lessons learned about the project, which was key in the achievement of the project's outcomes.

Component 9 – Consulting services for project management and supervision

22. This component was aimed at financing the services of a consulting engineer to support ONEE during the construction, testing and operation of the plant for the two-year guarantee period.

1.6 Revised Components

23. The project components were not revised.

1.7 Other significant changes

24. The construction of the plant suffered from a 6-month delay due to force majeure events such as severe flooding of project site, damage to collectors due to strong winds, total loss of one transformer and fire in one turbine filter. All damages were financially covered by the contractor's insurance and were repaired or compensated within a few weeks. Despite these incidents, the ISCC plant was constructed in 34 months.

The Ain Beni Mathar ISCC solar field – June 2012

2. Key Factors Affecting Implementation and Outcomes

2.1 Project Preparation, Design and Quality at Entry

25. **Despite the long preparation process (over eight years[10]), the ISCC project in Ain Beni Mathar was the first plant of its kind in operation in the world.** As explained in section 5.1, the pioneering nature of the project justified these delays. The strong government and ONEE commitment and the determination of the Bank's project team led to a successful project design. The main reasons for project preparation delays were the following:

- Change in project design: the project experienced two major changes affecting its design: (i) First, the project was originally proposed to be implemented by a project-financed Independent Power Producer (IPP). The GEF grant was planned to be disbursed in two-tranches, the first tranche to reimburse the IPP for some expenses incurred during the construction of the solar field, and the second, through an escrow account against agreed solar thermal output (kWh) during the life of the project[11]. In 2002, two calls for expressions of interest did not attract interest from the private sector due to market uncertainties and the lack of a long-term PPA. Interested parties were asked to bid for what was called "merchant plants". They were supposed to build the plants first and look for buyers of the electricity later at a price to be negotiated after the plants would have been built. This scheme could work in a large and open market like the US, but it proved too risky for a project in Morocco, where there were very few potential buyers of electricity. Consequently no IPP company showed any interest. Following the unsatisfactory response to the bidding of an IPP, ONEE decided to finance the project itself and to launch a tender for an EPC (Engineering, Procurement and Construction, i.e. Turnkey contract) and a 5-year O&M contract in 2005; (ii) Second, ONEE decided to raise the capacity of the combined cycle island from 207 MW to 452 MW on May 2006 after the first phase of the two-stage bidding process to meet increasing electricity demand in view of unexpected serious delays in another planned combined cycle plant.

Table 1 – Overview of changes in project design

	1998	2005	2006	2007-present
ISCC total capacity (MW)	150	200-250	472	472
Solar thermal capacity (MW)	45	20-30	20-30	20
GEF grant (million)	50	50	49.6	43.2

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[10] From Project Concept Note review meeting in August 5, 1998 until Board approval in April 19, 2007

[11] World Bank, "Project Concept Document, Morocco: Solar Based Thermal Power Plant", July 22, 1998.

- Cancellation risk of GEF contribution: the possible cancellation of GEF financing for the solar component was taken into consideration in 2004 and 2007 causing further delays in project preparation. In 2004, the Bank commissioned an independent assessment on the Bank/GEF strategy for developing CSP in response to GEF's concerns over the slow progress in project preparation. The review underlined the strategic importance of World Bank/GEF support to this technology due to its large demonstration effect. In early 2007, the GEF Secretariat expressed concern about insufficient quality of the submitted Project Appraisal Document and about the reduction of solar field capacity from an initial 38-45 MW estimated in 1999 to 20 MW in 2007 as a result of bid award. The project team reviewed the Project Appraisal Document and justified the reduction in the solar field capacity based on sound technical data. The GEF approved the requested US$ 43.2 million grant one month prior to the Bank's Board approval on April 2007, in keeping with normal GEF practice.

- Re-bidding of contract for ONEE's engineering consultant: The recruitment of an engineering firm to assist ONEE in supervising project implementation was one of the effectiveness conditions of the GEF grant. The only shortlisted firm in the first bid was found to be ineligible to be awarded a World Bank-financed contract, so ONEE was requested to rebid the tender. The second attempt was successful and the contract was signed with the Fichtner consortium on March 24, 2008. However, the re-bidding process delayed the project by ten months because it required two extensions of the grant effectiveness' deadline, from May 20, 2007 to March 31, 2008.

26. **The project objectives were well aligned with GEF's strategy and Morocco's priorities.** The project was part of a larger program financed by the Global Environment Facility (GEF) to allocate grants up to $50 million to four Integrated Solar Combined Cycle (ISCC) projects in Egypt, Morocco, Mexico and India with a total solar CSP capacity of 150 MW, which represented over 40% of the total CSP installed capacity at the time[12]. In doing so, the GEF[13] and the World Bank saw an opportunity to encourage global deployment of CSP, a nascent carbon-free technology with potential for significant cost reductions through economies of scale and innovation. In addition to the cancellation of the India project, the solar components of the projects in Egypt (from 30 to 20 MWe, operational), Mexico (from 40 to 14 MWe, under construction) and Morocco (from 45 to 20 MWe, operational) were reduced during their preparation time for different reasons. The reduction of the GEF CSP portfolio to a total of 54 MWe (Egypt, Mexico and Morocco) together with the rapid growth of CSP technology worldwide, reduced the weight of the GEF portfolio over global CSP

[12] The 9 solar plants with a total of 354 MW composing the Solar Energy Generating Systems (SEGS) in California's Mojave desert were the only CSP plants in operation in the world.
[13] The project supported GEF's objective OP7 which focused on the promotion of technologies which had the potential to achieve "levelized energy costs to commercially competitive levels" through learning and economies of scale.

installed capacity to around 2.7%. Despite this reduction, GEF-financed ISCC projects in Egypt and Morocco had a strong demonstration effect for national and international stakeholders through visits on-site and exchange of information, which contributed to the development of the technology (see section 3.2 below). For Morocco, the ISCC design allowed the country to take a measured risk and test the feasibility of CSP in its generation system without hampering its twin objective of ensuring reliable electricity supply[14].

Table 2 – Chronology of key solar CSP events

Year		Facts
1990	-	9 CSP plants are deployed in California, US 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, US 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
	-	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 US marked the beginning of CSP scale-up worldwide
Jan. 2008	-	Construction of the GEF ISCC plant starts (472 MW, including 20 MW solar CSP) on site in Ain Beni Mathar, Morocco.
	-	Construction of the GEF ISCC plant (140 MW, including 20 MW solar CSP) starts on site in Kureimat, Egypt. _
2008	-	Commissioning of the Andasol I plant (50MW) 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 (20MW), three 50 MW parabolic trough plants (Puertollano, Andasol II and La Risca) and in the US, such as the 5MW Sierra Sun Tower.
Oct. 2010	-	Commissioning of Ain Beni Mathar ISCC plant in Morocco
June 2011	-	Commissioning of Kureimat ISCC plant in Egypt
2012	-	CSP installed capacity worldwide reaches 1.8 GW, mostly in Spain (1,331 MW) and the US (518 MW). 94% of installed capacity is with parabolic trough technology. An additional 6 - 20 GW of CSP capacity is under construction or development.

Source: World Bank based on AT Kearney, ESTELA, "Solar Thermal Electricity 2025", June 2010; and IRENA, "Concentrating Solar Power", Renewable Energy Technologies: cost analysis series, June 2012

27. **The project was a partnership between the Bank (IBRD), Global Environment Facility (GEF), African Development Bank (AfDB) and ONEE, which required strong coordination.** All co-financiers participated in the financing of one single contract for the design, construction, operations and maintenance of the 472 MW ISCC plant, where the US$ 43.2 million GEF grant mobilized by the Bank (2007) covered the incremental cost of the solar field. During the procurement process, a close

[14] Audinet P., März T., "Lessons for Solar Power Development from the World's First Integrated Solar Combined Cycle Project", 2011.

coordination between the Bank, AfDB and ONEE was required. AfDB was the main co-financier with one loan of Euro 136.45 million (2005) and another of Euro 151.14 million (2008), totaling Euro 287.8 million. In 2009, ONEE obtained a loan of Euro 100 million from Spain's State financial agency, "Instituto de Crédito Official (ICO)" to finance its contribution to the project.

28. **Key risks were identified and mitigation measures introduced properly in the project design.** The contribution of the solar CSP field to the total power generation of the plant in Megawatt hours (MWh) was less than 1%. This small contribution posed the risk that the plant operator could not maximize the solar island output while neglecting its operations and maintenance. A mechanism composed of acceptance tests and penalties based on guaranteed performance was introduced in the EPC and O&M contracts to maximize the solar contribution and minimize performance risk. The fact of having only one contractor for the solar field and the combined cycle island (and not two as in Egypt) avoided potential differences between contractors related to key equipment that could have an impact on the solar field performance[15]. Furthermore, ONEE's inexperience in this technology was addressed by hiring a reputable engineering company, Fichtner Solar, as technical advisor, which ensured a sound technical design and on-the-job training for ONEE staff.

29. On October 2007, the Bank had an internal review to assess project preparation and design in the framework of the Eighth Quality at Entry Assessment[16]. As explained in section 5.1, the project was rated "Satisfactory" overall.

2.2 Implementation

30. **The technical advisor, Fichtner Solar, enhanced ONEE's capacity during project implementation by providing assistance in supervising the construction of the plant and during acceptance tests at commissioning**[17]. Fichtner Solar was present on-site throughout the construction phase with a team of 3 to 7 engineers reinforced by engineers from the German Aerospace Center (DLR) during tests of the solar field. This implementation arrangement worked well and ensured the resolution of technical issues whenever they arose.

31. **The establishment of a small Project Implementation Unit (PIU) led by an experienced project manager based on-site with support from financial, procurement and safeguards specialists based at ONEE's headquarters facilitated project implementation**. The long distance between ONEE's headquarters and the

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[15] In Kureimat, Egypt, the solar field could not generate at design steam levels because the solar heat exchanger (low pressure HTF on one side / high pressure water-steam on the other) had leaks, and the resulting water in the oil caused cavitation problems in the HTF pumps in the solar field. Discrepancies between the power block EPC and the solar system EPC/O&M contractor made the problem resolution difficult. This equipment-type of problem was not identified in Ain Beni Mathar, Morocco.

[16] World Bank, "Eighth Quality at Entry Assessment (QEA8), Fiscal Year 2006-2007", 2008

[17] From start of construction on January 19, 2008 until commissioning on October 19, 2010.

project site, over 500 km, motivated this arrangement which proved highly positive for the successful implementation of this complex project.

32. **The bidding process did not set a particular solar field capacity but rather requested bidders to submit two options: 20 MW and 30 MW.** Pre-bidding cost estimates were subject to a high degree of uncertainty due to the small solar CSP market worldwide and limited number of suppliers. Since the GEF grant was allocated to cover the cost of the solar field and its amount was pre-determined at US$ 43.2 million, this arrangement reduced the risk of receiving bids far in excess of the available funding.

33. **The unexpected shortage of gas for the combined-cycle island hindered the maximization of solar-generated electricity for thirteen months.** Initially, the plant relied on gas transiting through the Maghreb-Europe pipeline from which Morocco had the right to consume around 7%. Starting in 2008, a lower-than-expected gas demand in Spain and Portugal due to the economic crisis reduced the available gas in the pipeline. After commissioning, the plant could only operate intermittently to cover the evening peak electricity demand. The solar field was available, but steam was not produced due mainly to cost-efficiency reasons. This problem was solved in November 2011 after ONEE's signature of a dedicated gas-supply contract with Algeria.

34. **The project was originally conceived to be implemented on independent power producer (IPP) basis, but it was redesigned as public project with turnkey contract during preparation.** The Mexico ISCC project was similarly restructured. The Egypt Kureimat project was designed as a public project from the start and did not experience any changes in this regard. The Ain Beni Mathar project awarded through international competitive bidding a single turnkey contract, i.e. EPC and a 5-year O&M contract to the Abengoa consortium for the design, construction, operation and maintenance of the ISCC plant. The Egypt Kureimat project, instead, awarded one EPC contract for the combined cycle island and another EPC contract for the solar island.

2.3 Monitoring and Evaluation Design, Implementation and Utilization

35. **M&E design**: The stated PDO in the PAD and in the Grant Agreement shows some nuanced differences, but they do not affect the overall objectives in substance. While it is common for the PDO and GEO to be different, especially if the GEO refers to mitigation of greenhouse gas emissions such as in this case, the PDOs in both the PAD and the Grant Agreement should always be the same. The overarching objective is to test the viability of solar thermal technology and contribute to replication of integrated solar combined cycle (ISCC) technology in Morocco and elsewhere, while the project development objective is to increase the contribution of renewable energy sources in Morocco's energy mix and add capacity to the power grid to help cope with the sustained growth in electricity demand as stated in the PAD.

36. An appropriate results framework was designed as described in Annex 3 of the PAD. The outcome indicator "solar thermal power plant costs in ¢/kWh" was not

defined[18], but it has been assumed to be US$ 24.4 ¢/kWh, the levelized cost of electricity from the solar field. The targets of the related outcome indicator "solar thermal power plant costs as a % of natural gas price" were not specified in the PAD.

37. **M&E implementation:** ONEE provided data to evaluate project implementation after the Bank's project closing date. However, a systematic and comprehensive plan to compile lessons learned and disseminate knowledge resulting from the ISCC plant needs to be further pursued when more operational data becomes available.

2.4 Safeguard and Fiduciary Compliance

38. **The project did not pose major environmental risks and was classified as category B by the Bank**. The operational policies OP4.01 on environmental assessment and OP4.12 on involuntary resettlement were triggered. Appropriate safeguards documents were completed and disclosed, including (i) Environmental Impacts Assessment (EIA) for the ISCC plant, the gas spur and access road, and high voltage lines (three reports), (ii) Environmental Management Plan (EMP), (iii) Resettlement Policy Framework (RPF) and (iv) Resettlement Action Plan (RAP).

39. **The main potential environmental impacts identified during construction and operation, i.e. site contamination by thermal fluid leakage, excessive water pumping and generation of large quantities of solid waste during construction, have been satisfactorily prevented** so far by the plant operator, Abengoa, and ONEE. At the beginning of construction (2008), though, the environmental mitigation and monitoring measures were not adequately conducted nor thoroughly reported. ONEE staff on-site was not aware, for example, of the existence of an EMP. Hence, several measures required in the EMP such as noise and air quality monitoring, proper waste management, preparation of an occupational, health, and safety plan by the plant operator had not been done. But ONEE rapidly remediated these issues. Despite the absence of major environmental impacts, improvements could be introduced in the management of environmental issues to ensure satisfactory implementation of mitigation measures on all project components in the future. Regarding social issues, all measures put forward by ONEE to be in compliance with Bank's policies, e.g. compensation to landowners for loss of agricultural productivity, were considered satisfactory and no particular issues arose.

2.5 Post-completion Operation/Next Phase

40. **Several post-completion operation options were discussed but not implemented due to technical and institutional reasons.** The creation of a pure solar CSP plant next to the ISCC plant in Ain Beni Mathar seemed the most feasible option[19],

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[18] PAD, "Annex 17: Scientific and Technical Advisory Panel (STAP) Review", p. 94. STAP technical reviewer requested clarification of the calculation methodology of this indicator in his point 6.3 "solar thermal power plant costs", but the Bank team did not seem to address this remark in the PAD.

[19] World Bank, "Aide Memoire – Supervision mission of Ain Beni Mathar ISCC plant", July 13-16 of 2009 (in French)

but ONEE preferred not to take any step towards project preparation due to the changing institutional environment. Indeed, Morocco reinforced the legal and institutional framework for the large-scale development of solar energy by the adoption of a law on renewable energies and the creation of a specialized solar agency, the Moroccan Agency for Solar Energy (MASEN), in 2010.

41. **The operation & maintenance (O&M) of the plant has been entrusted to a private company, Abengoa, under a 5-year contract**. The contractor submits monthly reports to ONEE with details on the performance of the plant and a list of maintenance actions. In 2015, the contract will expire and ONEE will have to either operate and maintain the plant with its own staff, renew the private company's contract or find another contractor. The advantages and disadvantages of each option need to be carefully assessed over the next year. For the purpose of this project, the important issue is to ensure that the expertise acquired during the O&M of the pilot ISCC plant remains in Morocco. At present, 90% of the 60 staff employed by the private company in O&M are Moroccans, which already ensures this goal is met.

42. **The monitoring of performance indicators needs to continue and be more systematic in the future.** The O&M private contractor (Abengoa) already monitors and reports basic indicators such as total ISCC's annual electricity generation (GWh) and ISCC's annual electricity generation from the solar field (GWh). However, it is recommended that ONEE's strengthens its monitoring system for the other indicators of the PAD's Annex 3, in particular those related to the dissemination and lessons learned during pre-construction, construction and operation of the plant.

43. **A continued monitoring of the performance of the ISCC plant by the Government of Morocco is recommended in three years.** Due to the shortage of gas supply from commissioning (October 2010) until November 2011, the Bank could only evaluate the performance of the solar field and its integration with the combined cycle island (see Annex 4 for details) based on a single full-year of data (2012). The availability of more data in the future could contribute to confirm that the satisfactory performance has been sustained. The Government of Morocco could monitor and report the results to the Global Environment Facility (GEF).

3. Assessment of Outcomes

3.1 Relevance of Objectives, Design and Implementation

44. Relevance is rated as **High** because:

(i) Demonstration and learning of CSP technology from the project remains highly valuable at global level despite the growth of installed CSP capacity. Lessons learned and operational data from the project can be very valuable for the deployment of the technology particularly in developing countries. The hybrid gas-solar ISCC configuration is a viable future technology when countries have ready access to gas. ISCC plants have several advantages over stand-alone CSP plants such as increased efficiency and stable plant operation.

(ii) The objective of the GEF project continues to be highly relevant to the country's current development priorities and the Country Partnership Strategy (CPS)[20]
(iii) Project implementation contributed to raise awareness of CSP technology in Morocco and to create in-country expertise, which has been key for designing the Moroccan Solar Plan and launching utility-scale pure solar CSP projects Ouarzazate I and II; and
(iv) The Clean Technology Fund is providing support to the scale-up of the technology in MNA countries, including Morocco, since 2009 to further support cost-reductions through economies of scale and learning effects.

45. Since project appraisal, the total CSP installed capacity worldwide has increased from 354 MW to approximately 2 GW mainly because of favorable incentive mechanisms in Spain and the US. CSP technology has experienced cost reductions due to economies of scale and innovation, but remains expensive. The CSP levelized cost of electricity (LCOE) of Ain Beni Mathar was US$ 24.4 ¢/kWh (see Annex 3). The LCOE comparison with stand-alone "pure" CSP plants requires caution though because of differences in size and configuration. Solar fields in ISCC plants are generally smaller, which do not allow them to reach the economies of scale of larger stand-alone CSP plants. Also, the integration of the combined cycle and the solar CSP technologies makes it difficult to attribute precise cost figures on major shared components, e.g. HRSG and steam turbine. Further, the solar integration benefits from existing power side services.

3.2 Achievement of Global Environmental Objectives

46. The project's main global environmental objective was to demonstrate the operational viability of concentrated solar power (CSP) technology in a hybrid solar-gas configuration and to foster replication. As part of a GEF-financed portfolio of similar projects, the project would contribute to the global learning effects that would accelerate cost-reduction and commercial adoption of the technology. A secondary objective was the reduction in CO_2 emissions. The contribution to the global learning effects was expected to materialize through dissemination of experiences and lessons learned during site-visits of national and international citizens, participation in workshops and conferences and publication of technical information on ONEE's website. Since October 2010, 440 visitors have travelled on-site to learn from the project and ONEE staff has participated in 91 national and international events to showcase the project, which has appeared in 41 television reports (see Annex 2 for details).

47. In 2012, the Bank facilitated the visit of a Chinese delegation composed of high-ranked government and business representatives to the project site. One of the participants expressed that "this is very unique opportunity for us to learn how to carry out resource assessment, project design, construction and operation from real

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[20] International Bank for Reconstruction and Development and International Finance Corporation, "Country Partnership Strategy for the Kingdom of Morocco for the period FY10-13", Report No. 50316-MA.

practitioners"[21]. The Bank is providing technical and financial support to develop the first CSP project in the province of Inner Mongolia. China envisages developing 1,000 MW CSP projects by 2015 and to reach a total installed CSP capacity of 3,000 MW by 2020. Several countries have announced ambitious targets. A pipeline of projects worldwide in the range of 6-20 GW has been announced, including CSP plants in Australia, South Africa, the United States and India[22]. The latter plans to develop 20 GW of solar energy by 2022. This increase in global CSP installed capacity could dramatically contribute to drive-down the cost of the technology for global benefit.

48. Also, the Bank facilitated the visit of a US delegation composed of US Treasury and Environmental Protection Agency staff.

49. Regarding the reduction in CO_2 emissions, the Ain Beni Mathar project achieved a reduction of 22,988 tons in 2012, only 5.4% lower than target value. This value is explained by the lower energy production from the solar field due to a 12% lower Direct Normal Irradiation (DNI) than the reference year (see Annex 4), which might not be constant until the end of the project lifetime.

50. For the above reasons, the achievement of Global Environmental Objectives is considered **Satisfactory**.

3.3 Efficiency

51. The net present value (NPV) and economic rate of return of the project have been recalculated based on actual values, including the cost of investment which was reduced from US$ 556 million at appraisal to $543.60 million in this ICR and the average selling price (2012) which increased[23] from US$ 8 ¢/kWh to US$ 9.15 ¢/kWh (see Annex 3). The resulting project NPV is US$ 305 million and the economic rate of return is 16.55% (GEF grant has been deducted from total costs). As mentioned in the PAD, fuel costs are the most critical variable. It should be noted that it has not been possible to obtain the actual price of gas supplied by Algeria to ONEE for the project. Hence, the price US$ 6/MMBtu used in the PAD has been taken as reference. The project NPV would become negative for a price of natural gas exceeding $7.7/MMBtu.

52. In view of the above results, the Efficiency of the project is rated **Satisfactory**.

3.4 Justification of Overall Outcome Rating

53. The project was the first of its kind in the world and contributed to the demonstration of a new non-carbon emitting technology in Morocco coupled to a gas-fired combined cycle system to fulfill the rapidly increasing electricity demand in the

[21] Song, Y. "China visits Morocco, Egypt & finds the light of the future", October 1, 2012. Blog: http://menablog.worldbank.org/closer-sun-china%E2%80%99s-vision-solar-future

[22] Climate Investment Funds, "CTF Investment Plan for Concentrated Solar Power in the Middle East and North Africa region – Supplemental document". October 28, 2010

[23] The increase reflects changes introduced by the government for some categories of consumers in 2009.

country at least cost. The integration of the solar field and the combined cycle islands was the most difficult challenge technically, but it was overcome (see Annex 4). After a difficult start due to unavailability of sufficient gas, the ISCC plant is performing satisfactorily. While little can be learned about economics of CSP technology from this experience given the small size of the solar field, useful lessons can be drawn in the areas of development, procurement, contractual structure and performance testing of the solar island components. O&M planning and optimization of future solar projects will benefit from the lessons learned in this facility.

54. The project provided ONEE staff with invaluable experience during the different phases of the project. This learning experience had a positive influence in the preparation of the Moroccan Solar Plan (2009) and the preparation of a 160 MW pure solar CSP project in Ouarzazate, which the Bank also supports. For example, ONEE staff in charge of purchasing meteorological stations for Ouarzazate chose the same firm and equipment used for Ain Beni Mathar based on the same terms and contract. ONEE staff involved in the ISCC project was also in charge of preparing the tender for selecting the owner's engineer for the Ouarzazate project. Moreover, numerous site visits to the project allowed national and international professionals to learn from it.

Rating: **Satisfactory**, based on High relevance of objectives, Satisfactory achievement of development objectives and Satisfactory efficiency.

3.5 Overarching Themes, Other Outcomes and Impacts

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

55. Overall, the project has had very positive social development impact on the neighboring communities and the local economy. These impacts have been larger during construction than during operation. The project has: (i) provided further electricity supply to the local community, (ii) stimulated local economy, (iii) improved the standard of living in the community, (iv) opened up several hamlets near the plant that did not have road access, and (v) created jobs. Moreover, the town of Ain Beni Mathar near the project site has benefited from tax revenues paid by ONEE to the municipality in concept of licenses.

56. The project's direct benefits included:

- Community projects for one hundred neighboring families, e.g. construction of latrines in three schools and reinforcement of irrigation system. These projects were financed with the funds corresponding to the expropriation of collective land for the project.
- 740 direct jobs during construction (240 non-qualified workers of the nearby town of Ain Beni Mathar and nearly 500 qualified workers from other parts of Morocco) and 50 after commissioning (October 2010) for O&M work.

57. The project's indirect benefits included:

- Greater dynamism of the local economy during construction of the plant due to increased demand for goods and services (accommodation, restaurants, cafes).
- Benefits for women derived from the community projects that were implemented around Ain Beni Mathar as compensation for use of collective land, which improved their quality of life through: (a) improving access to schools and (b) improving irrigation systems[24].

(b) Institutional Change/Strengthening

58. The 20 MW CSP solar field of the ISCC plant has provided a unique opportunity to ONEE staff and other Moroccan professionals to get familiar with a new technology. The learning effects of this experience have had a positive impact on the scaling-up of CSP technology in the country, which is positioning itself at the forefront of the global agenda on climate change and green technologies[25].

(c) Other Unintended Outcomes and Impacts

59. The small size of the solar field did not provide the appropriate incentives for the development of a local solar industry. Only 5% of the components where produced locally. The EPC contractor, Abengoa, preferred to mitigate the construction risks by using European suppliers that the company normally utilized. Furthermore, waivers on import taxes granted for this project led to very limited price advantages for national suppliers[26]. Also, the pipeline of CSP projects worldwide was significantly smaller six years ago and many of the CSP components were only available from a smaller number of companies from Europe and the US.

60. After the construction of the plant, the new legal and institutional framework to support the implementation of the 2,000 MW Moroccan Solar Plan put, however, a stronger emphasis on the development of a local solar industry to diversify the economy and create jobs. To maximize the impact of the project in the long term, the possibility to create a research center on the site involving nearby universities and other partners could be explored.

61. At the time of project preparation, Morocco's government and the Bank were not planning future CSP engagement and market momentum was slow globally. In fact, GEF's support to the project –as well as to the other three similar projects worldwide-

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[24] World Bank, "Aide Memoire – Supervision mission of Ain Beni Mathar ISCC plant", July 13-16 of 2009 (in French)

[25] Morocco is increasingly drawing the attention of the renewable energy community as proven by the number of international and regional conferences held in the country such as SolarPACES and MENAREC in 2012.

[26]Audinet P., März T., "Lessons for Solar Power Development from the World's First Integrated Solar Combined Cycle Project", 2011.

helped keep global momentum for CSP technology at a time when there was a slow down because of limited government support in US and Europe. Since 2009, the Bank and the Clean Technology Fund (CTF) are supporting a larger CSP program to scale-up the technology in the MNA region in a context of revived global interest in CSP. The CTF MNA CSP scale-up program has benefited from lessons learned during project design and implementation.

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

62. Not applicable.

4. Assessment of Risk to Development Outcome

63. *Technical:* The ISCC plant completed a one year of operation (2012) with highly satisfactory performance values (see Annex 4). The initial acute problem related to gas supply shortages was resolved after ONEE signed a gas supply agreement with Algeria, therefore ensuring an adequate and continuous fuel supply to the plant. The risk of further supply problems is considered to be low to moderate. Integration of the solar island with the combined cycle island has been functioning as designed, meeting the primary objective of the ISCC configuration. The risk of not being able to maintain normal operation is low to moderate. Mitigation is ensured by provisions included in the O&M contract to incentivize the O&M contractor to maximize the electrical output of the plant. The 5-year O&M contract also includes performance tests after expiration. The solar island is performing well. However, a mirror-soiling phenomenon, created by sand and dust wet with morning dew, has been noticed during the summer which can reduce mirror reflectivity by 20-40% and hence decrease the solar island performance in the long run. ONEE has recently started using manual mirror washing to complement the work of the contractors' mirror washing truck. The risk of lower performance of the solar island is **moderate**.

64. Government commitment and institutional framework: The government is deeply committed to scale-up solar technology in Morocco to fulfill the target of 2,000 MW installed by 2020. Hence, the contribution to the cost-reduction of CSP technology for the global benefit through economies of scale and learning effects will continue. A newly-created specialized agency, MASEN, has taken over ONEE on the leadership role to implement solar technology in the future. MASEN will start shortly the construction of the first phase of the Ouarzazate solar complex, a 160 MW parabolic trough CSP, and recently announced the development of three additional large CSP projects in the same site. The second site to host the next large CSP complex is the town of Ain Beni Mathar at 5 km from the ISCC plant. MASEN and ONEE have frequent informal contacts through which experiences are shared. However, the solar island in Ain Beni Mathar remains the only CSP plant in operation in Morocco so far. Hence, the dissemination of lessons learned needs to continue through on-site study-tours for national and international visitors, participation in regional and international conferences and divulgation in several media formats.

Rating: In view of the above reasons, the overall Risk to Development Outcome is **Moderate**.

5. Assessment of Bank and Borrower Performance

5.1 Bank
(a) Bank Performance in Ensuring Quality at Entry

65. The PAD was approved by the Bank's Board on April 19, 2007 after a lengthy preparation time (over 8 years). This long preparation time is justified by (i) the change in the design of the project, from an IPP to a public sector project; (ii) the inexperience inside and outside the Bank in developing Concentrated Solar Power (CSP) projects; and (ii) the coordination required among partners, i.e. GEF, AfDB, ONEE and IBRD, which were also inexperienced in preparing projects of this nature. In particular, the main causes of this long preparation time were:

- General global decline in IPP interest in developing countries. The 9/11 events and the collapse of the energy company Enron in 2001, the largest bankruptcy in US history, reduced private sector's appetite for such projects. This changing environment was part of the reason behind two unsuccessful bids in 2002 and the subsequent re-bid as a public sector project in 2005. Also, the initially proposed "merchant plant" structure was not well adapted to the embryonic private energy market in Morocco, i.e. the winning bidder was supposed to build the plant first and look for buyers of electricity later at a price to be negotiated after the plant would have been built.
- In 2004, the Bank commissioned an independent assessment of the GEF-financed ISCC portfolio[27] – in close collaboration with the GEF Secretariat, client countries and industry - to respond to concerns from some GEF council members regarding the slow pace of implementation. The cancellation of the solar component of the Ain Beni Mathar project was raised. As a result of this assessment, the cancellation was rejected but further delays were incurred
- During the bidding process (2005-2007), ONEE needed to completely redesign the bidding documents and the project scope to accommodate a doubling of the conventional generation capacity (because another generation plant in its capacity expansion plan was delayed).

  When the solar field component of the bidding documents was being designed there was virtually no global experience (inside or outside the Bank) in bidding CSP plants. Moreover, there was no global experience in developing CSP projects in a developing country, or in a ISCC configuration anywhere, or bidding it as an IPP.The project was a partnership between GEF, AfDB, ONEE and IBRD. The

[27] World Bank, GEF, "Assessment of the World Bank/GEF strategy for the Market Development of Concentrating Solar Thermal Power", 2006

required coordination between partners without experience in developing CSP projects also contributed to the delays.

66. A Bank's internal assessment on the project's quality at entry carried out in October 2007, stated that "delays appear to have been largely outside the control of the project team" and highlighted that the "GEF Council Approval was not obtained until October 2004, more than 6 years after Concept Review". The Bank's assessment at that time rated the project "Satisfactory" overall, which coincides with the rating of the ICR team. The evaluation did not identify any significant shortcoming, other than the very long preparation time previously explained, and highlighted the procurement arrangements among its strong aspects.

67. The Bank team designed a sound two-stage procurement process, technical and financial, to select one contractor to design, construct, operate and maintain the plant through international competitive bidding. In contrast with the experience of Egypt's Kureimat ISCC plant, the award of a single contract to one company responsible to erect, operate and maintain for five years the whole plant (EPC and 5-year O&M contracts), facilitated the integration of the combined cycle and the solar field islands.

Rating: **Satisfactory**.

(b) Quality of Supervision

68. In general, the Bank team's supervision was thorough and proactive on issues related to the solar field financed by the Global Environment Facility (GEF). The Bank carried out six supervision missions with teams composed of technical and safeguards policy experts. The Bank team monitored closely the compliance with the effectiveness conditions of the grant agreement. The effectiveness deadline was adequately extended from August 19, 2007 to March 31, 2008 to allow time to ONEE to complete the recruitment of the engineering consultant, which was one of the effectiveness conditions. During construction of the plant, the Bank supervised adequately environmental and social issues. In December 2008, the Bank team reported to management that the progress report received from ONEE "contained limited information on the component 8 of the project (Environmental and Social Development and Management and lessons learnt from constructing integrated solar thermal power plant) and on the implementation of the Environmental Management Plan", but it is unclear if there was an immediate follow-up with ONEE to address this issue.

69. The Bank team contributed to the dissemination of lessons learned by, for example, presenting a paper about the project[28] at the international Solar Paces Conference in 2011[29], which was published in its proceedings. The Bank and ONEE need to continue their respective dissemination efforts in national, regional and international

[28] Audinet P., Marz T., "Lessons for Solar Power Development from the World's First Integrated Solar Combined Cycle Project", SolarPACES, 2011.
[29] http://www.solarpaces2011.org/cms/fileadmin/user_upload/Dokumente/Complete-program.pdf

events. The creation of a dedicated project website with detailed technical and operational data could be considered by ONEE once more operational data are gathered in the next few years.

Rating: **Satisfactory**

(c) Justification of Rating for Overall Bank Performance

70. The Bank's team designed and supervised a hybrid technology, ISCC, which was a first of its kind in the world and a solar technology, CSP, which did not exist in any developing country. The risks of such an operation were high. The plant has been performing satisfactory during all the year 2012 after the problem of gas supply was resolved. Hence, the performance data is limited and further evaluations should be carried out in the future to draw conclusions. One could argue that gas availability for the ISCC plant could have been analyzed further during preparation, but it should also be noted that gas-related issues are highly-sensitive issues in Morocco and information is often not available.

Rating: **Satisfactory**

5.2 Borrower

(a) Government Performance

71. The Moroccan government was a major driving force behind the project, which was expected to reduce the risk of blackouts due to a fast-growing electricity demand in the country. The GEF grant provided the government with the opportunity to diversify its energy mix and to contribute to the demonstration and replication of the technology through learning effects. In 2006, the Moroccan government sent a letter to the Bank expressing its commitment to these objectives while reiterating the importance of the GEF contribution.

Rating: **Satisfactory**

(b) Implementing Agency or Agencies Performance

72. After bid evaluation, ONEE knew that the GEF grant could not cover the total cost of the solar field. ONEE, however, showed strong commitment to the project by covering the difference[30]. ONEE went the extra mile on environmental protection issues by choosing a cooling system in the plant design which dramatically reduced the project's water consumption, but with a higher price tag. ONEE had requested bidders to submit offers with two cooling options (wet and dry), which allowed ONEE to take an informed decision based on operational and cost criteria. The implementation of the environmental management plan for the ISCC plant was adequate, but the overall

[30] ONEE paid US$ 23.8 million, the difference between the US$ 66 million of the lowest evaluated bid and the US$ 43.2 million of the GEF grant. Project Appraisal Document (PAD), 2007, p.12.

monitoring of environmental impacts could have been improved –including impact on groundwater and impacts related to transmission lines – with the appointment of an environmental manager with competences on all components of the project as suggested by the Bank. Similarly, the monitoring of indicators needs to be more systematic and not only limited to few output indicators reported by the EPC and O&M contractor.

73. Nevertheless, ONEE deserves credit to have successfully implemented a unique project worldwide involving high uncertainties and risks. During construction, ONEE's project implementation unit (PIU) was confronted to: (i) extreme weather events in 2008 and 2009 (wind and storms), which affected equipment in the solar field; (ii) incidents during construction, such as fire in the air filter of one gas turbine (May 2009); and (iii) lack of sufficient gas for testing. Despite these adversities, ONEE's project team reacted swiftly and construction only suffered from a 6-month delay. The establishment of a working environment based on trust and dialogue with the EPC and O&M contractor was part of the reason for the timely resolution of these incidents. In addition, the support provided by an experienced advisor to the PIU ensured the quality of the ISCC plant.

Rating: **Highly Satisfactory**

(c) Justification of Rating for Overall Borrower Performance

74. The overall borrower's performance was rated **Satisfactory** due to the reasons explained above.

6. Lessons Learned

75. **The use of integrated solar-combined cycle (ISCC) technology can be a stepping stone for scaling-up concentrated solar power (CSP), provided that fossil-fuel supply is guaranteed.** The hybrid solar-gas ISCC power plant addressed the need for additional power-generating capacity while contributing to the global learning curve of CSP technology. The ISCC design allowed ONEE to take a measured risk and test the feasibility of CSP in its generation system without hampering its objective of ensuring reliable electricity supply. The parabolic trough solar field could only generate thermal energy as planned thirteen months after the plant's commissioning (October 2010) once a guaranteed supply of Algerian gas was secured. Morocco had the right, as royalty, to consume 7% of the gas volumes transiting in the Maghreb-Europe gas pipeline, which was used to supply the combined cycle plant of Tahaddart and the hybrid solar-gas plant of Ain Beni Mathar. However, the reduction of transiting gas volumes due to decline in gas consumption in Spanish and Portuguese markets reduced the gas supply available for the project.

76. **ISCC plants offer a unique solution to build small capacity solar fields to substitute fossil fuel in larger conventional plants.** However, ISCC plants are only one of several options for the development of concentrated solar power, and probably a

secondary one when fast and large-scale deployment of solar energy in a specific power system is desired[31].

77. **The choice of an optimal site is key to the development of an Integrated Solar Combined Cycle (ISCC) plant.** The selection of Ain Beni Mathar as project site was a compromise between weather conditions, water and gas availability and social factors. If the project would have been a gas-fired combined cycle (CC) plant (without solar field), the site location would have probably been closer to the sea to maximize performance due to lower pressures and lower ambient temperatures. However, the integration of a CC plant with a parabolic trough CSP plant required a higher solar irradiation such as in Ain Beni Mathar. The solar irradiation (DNI) at the site was measured at 2,290 kWh/m² annually during preparation of the project (higher than the 2,100-2,200 average in Spain, but lower than 2,700 in southwestern United States). Also, the site was located on one of the largest ground-water tables in North Africa and only 12 km from the Maghreb-Europe gas pipeline. Moreover, the project was expected to reduce unemployment in a region deeply affected by the closure of the neighboring Jerada coal mine in 2005.

78. **Request cooling technology options to bidders.** Due to high cost uncertainties, ONEE requested bidders to submit a proposal with wet cooling technology and another with dry cooling, while indicating a threshold of water consumption. This procurement arrangement allowed ONEE to know actual costs of both options and take an informed decision, which yielded the best technical solution at a lower cost.

79. **Bid the project with single contract for the construction, operation and maintenance of the ISCC plant to achieve smooth operation of the plant.** The Ain Beni Mathar project involved the financing of only one contract, jointly financed by ONEE, the Bank (IBRD) and AfDB, under international competitive bidding and had its procurement actions advanced and completed before the Bank's Board approval of the grant. ONEE, with the support of its technical advisor Fichtner Solar, dealt with only one contractor, Abengoa, which introduced simplicity in an already complex project. This was not the case in Egypt where the Kureimat project was tendered in two separate contracts for the solar field and the combined cycle island. After problems with a piece of equipment emerged, e.g. leakage of solar heat exchanger (low pressure HTF on one side / high pressure water-steam on the other), differences arose between the EPC contractor of the combined-cycle island and the solar field EPC/O&M contractor regarding who had the responsibility of solving the problem. This problem did not occur at Ain Beni Mathar.

80. **Extend the operations and maintenance (O&M) period from two to five years.** Due to ONEE's inexperience with CSP technology, three years without guarantee were added to the standard O&M contract (2-year with guarantee). This procurement arrangement lowered ONEE's operational risks by transferring it to the contractor and allowed the plant's satisfactory performance so far. The Egypt's Kureimat project, instead, bid a contract for a 2-year O&M.

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[31] Audinet P., Marz T., "Lessons for Solar Power Development from the World's First Integrated Solar Combined Cycle Project", 2011

81. **Suppliers of key ISCC plant components need to be members of the EPC consortium.** At Ain Beni Mathar, the supplier of the steam turbine was not a member of the consortium that was awarded the turnkey contract for the design, construction, operation and maintenance of the plant. The inclusion of the steam turbine supplier in the consortium would probably have reduced unnecessary delays during construction because of the risk-sharing with other members of the consortium and increased involvement in the project.

82. **Encourage independent solar irradiation measurements in order to ensure a correct application of penalties.** A number of capable firms have developed excellent tools to provide such data in most parts of the world. Further, installation of accurate measurement stations at solar plant sites should take place early to obtain several years of solar data prior to plant design.

83. **Plan the tender to satisfy both utility and bidder needs.** The initial IPP tenders in 2002 for the Ain Beni Mathar plant failed, in part, because the request was for IPP tenders without a PPA. Rather, interested parties were asked to bid on the basis of a "merchant plant”. This approach was considered too risky by potential bidders for a project in Morocco, where there were very few potential buyers of electricity. The subsequent tender for a turnkey contract for the design, construction, operation and maintenance of the ISCC plant resolved those problems and attracted quality responses.

84. **Place particular attention on operational ISCC issues in the detailed design.** While conceptually straightforward, the detailed design of the ISCC integration can negatively impact operational flexibility under certain circumstances. At Ain Beni Mathar, certain aspects related to the integration of the solar steam generator and HRSG require special attention by the operator to achieve smooth operation in the solar mode. This added complexity could have an impact on obtaining optimum performance and maximum utilization of the integrated system.

85. **Develop and use standardized acceptance tests for CSP and ISCC plants would be an additional advancement.** The National Renewable Energy Laboratory (NREL) in the US has issued preliminary Guidelines for large solar systems that can be combined with existing standards for power systems, and institutions like the American Society of Mechanical Engineers (ASME) are working on issuing official Performance Test Codes for utility-scale solar systems.

86. **Set mirror soiling goals and meet them by an appropriate frequency for mirror panel washing**. New cost-effective mirror washing techniques should be developed to obtain clean mirrors using less water and less labor. Improved instrumentation to monitor reflectivity would provide important operational data, preferably at reduced cost and improved accuracy for readings in a large solar field.

87. **Establish a framework of open partnership with the EPC contractor to resolve any potential incident as soon as possible**. A relationship of trust between the

implementing agency/PIU and the EPC contractor is paramount to avoid unnecessary contractual disputes and overcome all technical challenges posed by such project.

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

(a) Borrower/implementing agencies

(b) Cofinanciers

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

Annex 1. Project Costs and Financing

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

Components	Appraisal Estimate (US$ millions)	Actual/Latest Estimate		Percentage of Appraisal
		MAD	US$	
1- Design, Construction and Operation of an Integrated Solar Combined Cycle Power Plant	462.58	4 366.81	508.36	110%
2- Transmission Lines	15.75	134.14	15.62	99%
3- Substations	8.04	36.27	4.22	53%
4- Access Road	3.37	33.55	3.91	116%
5- Boreholes	0.31	4.90	0.57	184%
6- Land acquisition	0.84	9.00	1.05	125%
7- Gas pipeline	8.21	17.10[32]	1.99	24%
8- Environmental and Social Development and Management	2.24	0.81[33]	0.09	4%
9- Consultancy services	4.98	66.90	7.79	156%
Total Baseline Cost	**506.32**	**4669.48**	**543.60**	107%
Physical Contingencies	49.83	0	0	
Price Contingencies	11.65	0	0	
Total Project Costs	**567.80**	**4669.48**	**543.60**	
Project Preparation Facility (PPF)	0	0	0	
Front-end fee IBRD	0	0	0	
Total Financing Required	**567.80**	**4669.48**	**543.60**	

[32] Only supply of equipment and construction of the interconnection facility with the pipeline Maghreb-Europe are covered in this price. Supply of equipment and construction of the 12.5 km gas pipeline are included in cost n° 1 (Design and Construction of the Power Plant).

[33] Only the cost of updating findings and results of the Environmental Impact Assessment is included in this figure. All costs related to other environmental and social development and management are included cost n° 1.

(b) Financing

Source of Funds	Type of Cofinancing	Appraisal Estimate (US$ millions)	Actual/Latest Estimate (US$ millions)	Percentage of Appraisal
African Development Bank		390	371.8[34]	95%
Borrower		136.27	0.00	0.00%
Global Environment Facility (GEF)		43.20	43.20	100%
Instituto de Credito Oficial (ICO)		0.00	129.19[35]	0.00%

[34] Loan of Euro 287.8 million.
[35] Loan of Euro 100 million.

Annex 2. Outputs by Component

Project Component 1: Design, Construction and Operation of an Integrated Solar Combined Cycle Power Plant

88. The plant was built and operated through an Engineering, Procurement and Construction (EPC) with Operation and Maintenance (O&M) contract. ONEE is the owner of the plant. The O&M contract will last 5 years and includes appropriate incentives to ensure an efficient operation of the plant, particularly the solar field.

89. The Solar Island consists of a parabolic trough solar field, the heat transfer fluid (HTF) system up to the HTF inlet and outlet flanges of the Solar Heat Exchangers, associated control systems and control and service buildings. The contractor for the Project (ABENGOA) guarantees the supply of solar heat to the solar heat exchangers as a function of direct normal irradiation (DNI) and sun incident angle.

90. The Combined Cycle Island consists of two gas turbines, two heat recovery steam generators (HRSG), one steam turbine, solar heat exchangers plus all associated control and balance of plant equipment and installations. The dry-cooling option was implemented for cooling of the steam cycle. The Contractor guarantees the generation of electricity and the heat rate as a function of ambient temperature and supply of solar heat from the Solar Island.

91. The EPC contractor started in July 2007, with time to plant commissioning scheduled for 22 months for the first gas turbine and for 34 months for the ISCC plant. The EPC contractor did not meet the target commercial operation dates due to different reasons. The work was delayed mainly for the following reasons:

1. Exceptional bad weather especially in 2008 and 2009, heavy rain and flooding of the site
2. Lack of a reliable natural gas supply impeded testing
3. Fire accident which damaged the air filter for a gas turbine (no extra costs was incurred as a result of the incident)

92. The small size of the solar field, representing around 1% of the ISCC plant total energy production (MWh) in the form of steam to the ST, can only operate during normal steam turbine operation. But steam turbine operation was severely limited due to insufficient availability of gas from October 2010 (commissioning date) until November 2011. For the purpose of this evaluation, only values corresponding to the year 2012 have been considered. As can be observed in Table 2 below, the plant achieved almost all its targets and in some cases even exceeded them. The solar field, for example, generated 39 MWh instead of 40 MWh, a remarkable result in its first year of “normal” operations. Further performance data is provided in Technical Annex 4.

Table 2 – Results Framework: PAD target vs. achieved

	2010		2011		2012	
Outcome Indicators	Target	Achieved	Target	Achieved	Target	Achieved
Reductions in main air pollutants emissions (tons/year) for CO_2	10,800	0	23,780	3,040	24,300	22,988
Solar Thermal Power Plant costs in ¢/kWh	21.8	-	18.7	-	17.4	24.4[36]
As a % of natural gas price	-	-	-	-	-	-
Dissemination :						
- Number of Visitors to and information requests about the plant	-	8	-	150	-	282
- Number of workshops and conferences in which the experience about the construction and operation of the plant is presented	-	26	-	34	-	31
- Information about the plant posted on ONE's website	yes	yes	yes	yes	yes	yes
Results Indicators for Component 1						
ISCC's yearly production of electricity in GWh	1,556	270	3,360	1,719	3,538	3,370
ISCC's yearly generation of solar electricity in GWh	17	0	37	5	40	39
ONE staff trained in various aspects of ISCC power technology	4	8	4	10	2	2
Solar output as a percentage of total energy produced by ISCC power plant (%)	0.5	0	1	0.31	1.13	1.16
Share of ISCC energy in total energy production (%)	8.7		15.6		16.8	10.85

Project Component 2: The construction of 225kV and 60kV transmission lines

93. This component covers the construction of two 225kV and one 60kV transmission lines. The power produced by the ISCC plant is evacuated by two 225kV transmission lines to the Oujda (110 km) and Bourdim (70 km) substations. The two lines have been constructed by contractors ELCOTRAM and SEMI MAROC.

[36] This value corresponds to the LCOE of the solar field (assuming 10% discount rate and 25-year plant lifetime). The actual capital expenditures are US$ 73,954,680, including US$ 67,957,000 for the solar island and 5,997,680 for the cost of solar heat exchangers. The actual operations and maintenance (O&M) costs are US$ 1,611,000 per year, including variable costs specific to the solar field and planned maintenance (US$ 431,000 per year), and fixed O&M costs shared with the combined cycle island (US$ 1,180,000 per year), e.g. cost of services, maintenance of the steam turbine and auxiliary equipment.

94. The 60kV line is constructed to provide a backup power supply to the auxiliaries of the ISCC plant in case of emergency. This line, of about 10 km, will connect the 60/225 kV substation of Ain Beni Mathar to the ISCC power plant 60/6.6 kV emergency substation.

Project Component 3: The construction of High Voltage and Very High Voltage substations

95. This component covers the construction of one 225 kV substation. Design, procurement and construction works were carried by the contractor COL GIOVANNI.

Project Component 4: The construction of an access road

96. To link the power plant to the main road (Route principale 19), which links Oujda to Bouarfa, an access road of about 6km was constructed. As part of the access road, two bridges over the Charef and Tabouda rivers were also constructed. The infrastructures were designed to support the heavy equipment necessary for the construction of the ISCC power plant.

Project Component 5: The drilling of boreholes

97. Three boreholes were drilled by be the Agence de Bassin de Moulouya (the Moulouya Watershed Agency) which is legally mandated to undertake this work. Water is pumped from the aquifer located below the site of Ain Beni Mathar. Only two boreholes are used to pump quantities of water necessary for operation and maintenance of the power plant, in particular the cleaning of the solar collectors and operating of the steam cycle. Water reserves equivalent to one day consumption are stored. The site wastewater is collected and treated in a two-hectare stabilization pond.

Project Component 6: Land acquisition

98. 203 hectares of land were acquired by ONEE for the construction and operation of the plant. 160 hectares are for the power plant (including 88 ha for the solar field), 6 hectares for the boreholes and water distribution, 31 hectares for the gas spur from the Maghreb-Europe pipeline to supply the power plant and the transmission lines, and 6 hectares for the access road.

Project Component 7: The construction of a gas pipeline to supply the plant

99. The gas supply was ensured via the construction of a 13 km gas spur from the Maghreb-Europe gas pipeline. Works related to the pipe construction were included in the EPC contract of the ISCC power plant awarded to ABENGOA.

100. An agreement was signed between ONEE and EMPL (Europe Maghreb Pipeline Limited) for the construction of the interconnection facility of the supply pipe with the main pipeline. Contractors for civil, mechanical and electrical works were EMMSA and SIEMENS.

Project Component 8: Environmental and Social Development and Management

101. The implementation Environmental Management Plan (EMP) for all the project components, e.g. construction and operation of the ISCC plant, the substations, the access road, the transmission lines and the gas pipeline, was carried out adequately for the ISCC plant. However, ONEE did not carry out: (i) a capacity building program to strengthen capacities for the follow-up and monitoring of the implementation of the overall EMP, and (ii) a comprehensive monitoring and evaluation program to disseminate the results and lessons learned from the project in all its phases.

Project Component 9: Consulting services for project management and supervision

102. An "owner's engineer" company, Fichtner Solar, was recruited to support ONEE in the development of the project. This company had already been involved in the project by preparing the feasibility study and tender documents including the performance acceptance criteria. Fichtner Solar was present throughout the construction phase with a team of 3 to 7 engineers and sub-contracted CSP specialists from the DLR (German Aerospace Center) to be on site on a short-term basis to support its work, in particular during tests of the solar field.

Annex 3. Economic analysis and Incremental Cost analysis

I. Economic analysis

103. The ISCC plant is an integral part of ONEE's least-cost expansion plan. Incremental capital costs, operation and maintenance costs, and benefit streams of the project (all in 2013 prices) are shown in Table 3. Assumptions underlying these figures are detailed below. Each assumption is discussed and analyzed on the basis of exchanges the Bank team had with ONEE during the implementation completion (ICR) mission.

- The total installed cost of the plant was about US$543.60 million instead of the appraised US$ 567.18 million (Annex 1).
- Annual fixed operation and maintenance (O&M) costs were US$ 12 million instead US$ 14.4 million.
- Transmission and distribution costs increased from US$ 0.6 ¢/kWh at appraisal to US$ 0.9 ¢/kWh. This value was calculated based on the cost charged by ONEE in 2012 to private power producers within the framework of the Renewable Energy Law 13-09.
- Fuel costs have been estimated on the basis of the economic cost of gas for Morocco of US$ 6/MMBtu. While official figures on the actual cost of natural gas for the plant were not readily available, figures collected informally from different sources in Morocco for this evaluation seem to indicate that ONEE paid more than US$ 6/MMBtu in 2011 and 2012.
- Gross generation (excluding solar generation) was estimated at 3,538 GWh/year in the PAD while the guaranteed production in 2012 was 3,741 GWh/year.

Economic Benefits

104. Economic benefits associated with incremental electricity supply to consumers were calculated using average tariffs. The PAD explained that benefits in this case are more a reflection of the adequacy of tariffs than the true value of the benefits of the project because tariffs, particularly for domestic consumers, are subsidized. The tariff at appraisal was estimated at US$ 8 ¢/kWh. The average selling price for 2012[37] was around US$ 9.15 US ¢/kWh. The increase reflects upward changes introduced in 2009 by the government for some categories of consumers.

Results of the Analysis

105. The calculations in the PAD showed that the expected NPV of the project was equal to US$48 million and the economic rate of return equal to 11.4%.

[37] Source: ONEE, Sales and Marketing Division.

106. Using new and actual values for the following parameters:

- Cost of investment US$ 543.6 million instead of the estimated US$ 556 million
- Gross generation (excluding solar generation) was estimated at 3538 GWh/year while the guaranteed production in 2012 was 3741 GWh
- Cost of operating and maintenance was estimated at US$ 14 million, while in 2012 the cost was US$ 12 million.
- Cost of transmission increased from US$ 0.6 ¢/kWh to US$ 0.9 ¢/kWh
- Average selling price increased from US$ 8 ¢/kWh to US$ 9.15 ¢/kWh

The calculated new NPV of the project is $305 million dollars and the rate of return is 16.55%. (GEF grant has been deducted from total costs)

107. Sensitivities: It was indicated in the PAD that fuel costs for the ISCC plant are the most critical variable. The project NPV becomes negative for a price of natural gas exceeding US$ 7.7/MMBtu. While the switching value for fuel cost was improved from US$ 7.2/MMBtu as appraised to $7.7/MMBtu, this variable is still of great concern and is still beyond control of ONEE. As suggested in the PAD, should fuel prices increase, tariffs would have to be adjusted accordingly. In other words, when the price paid by ONEE for gas imports is above the threshold of US$ 7.7/MMBtu, the economics of the plant are no longer viable and an increase of electricity tariffs might be required to offset the cost of fuel.

Table 3 – Updated Economic Analysis

Fixed Operating Costs	12	US$ million/year
Trans & Dist Cost	0.9	US¢/kWh
Gross Generation	3701	GWh/year
Fuel Cost	6	US$/MMBtu
Average Tariff	0.0915	US$/kWh
Average T & D Losses	12%	
Life of the Plant	25	years
Discount rate	10%	
Heat Rate	6,626	MMBtu/MWh

US$ Million

	Invest Cost	**Fixed O&M Cost**	**Trans & Dist Cost**	**Fuel Cost**	**Total costs**	**Energy Sales**	**Total Revenues**	**Net Revenues**
2007	250	0	0	0	250	0	0	-250
2008	250	0	0	0	250	0	0	-250
2009	44	12	33	147	236	3303	302	66
2010		12	33	147	192	3303	302	110

2011	12	33	147	192	3303	302	110
2012	12	33	147	192	3303	302	110
2013	12	33	147	192	3303	302	110
2014	12	33	147	192	3303	302	110
2015	12	33	147	192	3303	302	110
2016	12	33	147	192	3303	302	110
2017	12	33	147	192	3303	302	110
2018	12	33	147	192	3303	302	110
2019	12	33	147	192	3303	302	110
2020	12	33	147	192	3303	302	110
2021	12	33	147	192	3303	302	110
2022	12	33	147	192	3303	302	110
2023	12	33	147	192	3303	302	110
2024	12	33	147	192	3303	302	110
2025	12	33	147	192	3303	302	110
2026	12	33	147	192	3303	302	110
2027	12	33	147	192	3303	302	110
2028	12	33	147	192	3303	302	110
2029	12	33	147	192	3303	302	110
2030	12	33	147	192	3303	302	110
2031	12	33	147	192	3303	302	110
2032	12	33	147	192	3303	302	110

NPV (US$ Million): 305
IRR: 16.55%

108. The large increase of the NPV of the project, from US$ 48 million to US$ 305 million is mainly explained by the 14.4% increase of the average selling tariff of electricity, it accounts for 92.5% of the additional gains. The remaining part of the increase is explained by the higher than yearly projected guaranteed production from the power plant.

II. Incremental Cost Analysis

109. An Updated Incremental Cost Analysis is presented in Table 4 below. The Levelized Cost of Electricity for the solar field is US$¢ 24.4/ kWh.

Table 4 – Investment, O&M and incremental costs (US$ million)

	Appraisal NPV (discounted)	**Latest NPV estimate**	**Percentage of Appraisal**
Baseline CCGT (Costs not updated)			
Capital Costs	414	414	100%
Fuel Costs	1171	1171	100%
O&M Costs	93	93	100%
Total	1678	1678	100%
Levelized Electricity Cost (US$/MWh)	57.2	57.2	100%
Alternative ISCC			
Capital Costs	476	518	109%
Fuel Costs	1158	1158	100%
O&M Costs	107	107	100%
Total	1741	1783	102%
Levelized Electricity Cost (US$/MWh)	59.6	61.04	102%
Increment			
Incremental Capital Costs	62.51	104	166%
Incremental fuel Costs	-13.39	-13.00	97%
Incremental O&M Costs	14.04	14.00	100%
Total Incremental Costs	63.16	105.00	166%
Incremental Electricity Cost (US$/MWh)	2.1	3.84	183%

Table 5 - Sensitivity Analysis for Incremental Cost Estimate

		Total Incremental Cost (US$ million)	Percentage Change with base case (%)
Gas Price	$7/MMBtu	102.83	-2.1%
	$6/MMBtu	105	Base Case
	$5/MMBtu	107.17	2.1%
Discount Rate	15%	104.68	-0.3%
	10%	105	Base Case
	5%	105.61	0.6%
Plant life time (years)	30	105.04	0.0%
	25	105	Base Case
	20	104.93	-0.1%

Table 6 – Incremental Costs Calculations – Technical Data

	Appraisal Technical Data	Actual Values
Available Grant (US$ million)	43.2	43.2
LEC of total generation (US$/MWh)	62.16	61.10
Solar Generation (GWh/year)	40	39[38]
Solar Generation as percent of design value	1.1	1.1
LEC of solar generation (US$/MWh)	247	244
Solar field size (1,000 m^2)	183.12	183.12
DNI (Annual direct normal irradiation, $kWh/m^2/a$)	2,290	2,036[39]
Power plant gross capacity (av. temp., max solar heat, MW)	478	478
Power plant net capacity (day, av. temp., max solar heat, MW)	472	472
Power plant net capacity (night, av. temp., max solar heat, MW)	450	450
Specific $C0_2$ emissions of comparable generation (kg CO_2/kWh)	0.6	0.6
Annual CO_2 emission reduction (kt/CO_2/a)	24.3	22.9[40]
Total $C0_2$ emission reduction (mln t/CO_2/25 years)	0.61	0.57
Incremental cost per ton of C02 avoided (US$/ton)	104	111.5

[38] This is the actual value for the year 2012 only, which might have variations over the 25-year project lifetime. Hence, the design value of 40 GWh/year has been used for calculating, for example, the levelized cost of electricity.

[39] This is the actual value for the year 2012 only.

[40] This value corresponds to the reductions of CO2 emissions (tons) in 2012, i.e. 0.59 (emissions coefficient) * 38,963 MWhe (solar field generation). This value is slightly lower than target because energy production from solar field was lower than projected value

Annex 4. Technical Analysis

Introduction

110. ISCC *Concept*: The Ain Beni Mathar (ABM) power plant is a gas-fired combined cycle (CC) configuration supplemented by solar-generated steam to produce additional power using solar energy. This so-called ISCC (integrated solar combined-cycle) approach serves to increase the overall plant electrical output while offering certain advantages with regard to solar thermal implementation. The plant's general concept is depicted in Figure 1.

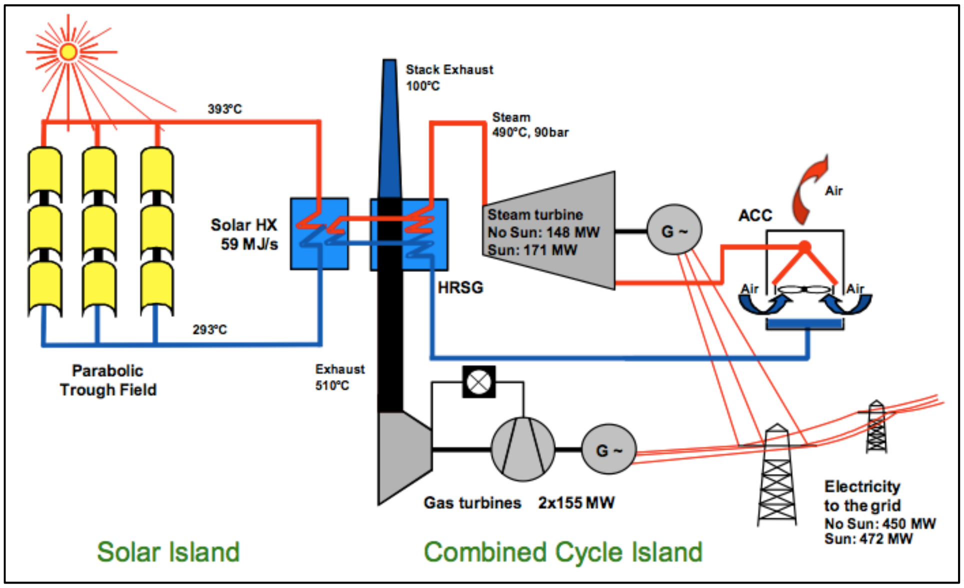


Figure 2 – The ISCC Plant in Ain Beni Mathar
(Source: Fichtner Solar GmbH[41])

111. The ISCC integrates solar steam into the Rankine steam "bottoming cycle" of a combined-cycle power plant. The gas turbine (GT) constitutes the "topping cycle". The hot exhaust air of the GT is used to generate steam in a Heat Recovery Steam Generator (HRSG), which then drives the steam turbine (ST). The general concept in an ISCC is to oversize the ST to handle the increased steam capacity. At ABM, the solar field produces steam in solar heat exchangers that is sent to the high pressure steam drum of the HRSG to supplement the steam being generated by the exhaust air of the gas turbine. At ABM the solar-generated electricity adds a modest 4% to the total plant power

[41] Georg Brakmann, Nour-Eddine Badaoui (ONEE), Miroslav Dolejsi, Roland Klingler, "Construction of ISCC Ain Béni Mathar in Morocco", Fichtner/ONEE, 2010 SolarPACES, Perpignan France.

output (MWe), with an annual energy contribution (MWh) closer to 1%. Heat rejection from the turbines is accomplished with an air-cooled condenser (ACC), greatly reducing the water usage for the plant.

112. The ISCC approach in general improves the economics of trough solar technology because the incremental cost to the CC plant requires no or minimal ancillary costs in the power block, electrical transformers, substation and other plant facilities to accommodate the solar addition. In addition, the solar steam energy may, in some cases, be converted to electricity at a higher efficiency. Also, the incremental cost of ancillary equipment in the plant is relatively small.

The Ain Beni Mathar ISCC plant configuration

113. The layout at ABM contains two Alstom gas turbines (Model GT13E) of 155 MWe net capacity each and a single Alstom steam turbine-generator (Model DKYZ2-1N41B COMAX) of 171 MWe net capacity. Without solar integration, e.g. in the evening, the design plant output of the plant is about 450 MWe. At the times that solar steam is integrated into the HRSG at design capacity, the design plant output increases to 472 MWe. Thus, the solar system adds approximately 20 MWe to the plant output (or 4.2%).

114. Table 7 shows the key technical design data for the solar field and CC at Ain Beni Mathar. This is based on a typical weather year[42] for which the solar radiation totals 2,350 MWh/m2-a. A more complete description of the major power plant subsystems is given in Exhibit 1.

Table 7 - Key Technical Data for Ain Beni Mathar ISCC plant

Key Technical Data	Units	Value
Solar Field total aperture area	sq. m	183,200
Number of collectors	--	224
Number of collector loops	--	56
Design direct normal irradiance	W/sq. m	700
Solar Field design thermal power	MW	58.7
Hot outlet HTF temperature	°C	393
Cold inlet HTF temperature	°C	293
GT rated power (each)	MWe	155
ST rated power	MWe	171
Solar electric power	MWe	20

(Source: ONEE)

Operation and Performance

[42] For purposes of commercial solar field design, an appropriate solar radiation file is assembled from limited historical data or extensive radiation estimates using satellite data to provide a typical or reference weather file. This serves as a placeholder for actual long-term radiation measurements at the site which are normally not available prior to plant design.

115. The ABM ISCC operates day and night as dictated by the ONEE's grid demand requirements. The high temperature exhaust gas from the gas turbine (GT) generates steam in the HRSG, which is then supplied to the steam turbine (ST).

116. The ABM ISCC plant did not operate on a sustained normal schedule until November 2011 when security of the natural gas supply was achieved. Operation during most of the year 2011 was below projected plant output for the sole reason of shortage in the gas supply due to a lower than expected availability of transit gas from the Algeria-Spain pipeline. The plant operated only in an intermittent manner in 2011, frequently for peak purposes after sunset, reducing the contribution of solar energy. The solar field was available throughout the year when ONEE chose to operate the plant as an ISCC.

117. Nevertheless, it was indicated by ONEE that the flexibility offered by the power plant in terms of the range of configurations and power at which the plant can be operated was beneficial and contributed to overcoming the overall capacity shortage in the Moroccan power system in 2011. The following discussion primarily reflects information from data collected over the continuous 12 months of 2012.

118. The general appearance of the Ain Beni Mathar ISCC site and equipment is good, leading to the conclusion that the maintenance at the plant in these initial years is performed following industry standards.

Actual DNI vs. Reference Year

119. Parabolic troughs collect the direct beam radiation from the sun (termed "Direct Normal Irradiance", also known as DNI). After a thorough evaluation by Fichtner Solar of applicable solar resource databases from NASA, NREL, METEONORM and S@tel-Light, Fichtner provided to ONEE in 2001 a DNI Reference year of hourly meteo data for Ain Beni Mathar calculated with the METEONORM Version 4 Year 2000 software. The cumulative annual DNI for the reference year is 2290 kWh/m²-year. The pattern for the year 2012 is compared to the Reference (or Design) year in the plot below. The 2012 annual value is about 12% lower than the reference year, spread relatively evenly throughout the year. Since the solar field sizing is based on the Reference Year, it would be expected that the annual solar field thermal output would be accordingly lower.

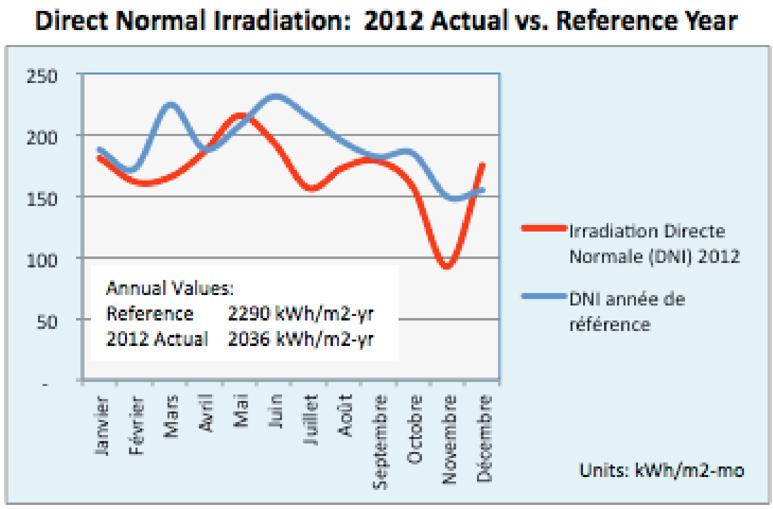


Figure 3 – Direct Normal Irradiation: 2012 Actual vs. Reference Year (source: ONEE)

<u>Monthly Plant Capacity Factor</u>

120. The Ain Beni Mathar ISSC plant is a base-load CC plant on the ONEE grid. The grid demand often calls for high production, but is sometimes constrained below full capacity, i.e. 100% capacity factor, due to a reduced demand from the grid operator, or by operating issues at the plant itself. The graphic below illustrates that the Ain Beni Mathar plant operated at a high base-load level in 2012, after the gas supply was stabilized in late 2011, with capacity factors up to 95%. The output units are MWhe. Note that the lower limit of the scale in each plot is at a high level. The dip in October is due to scheduled maintenance of one of the gas turbines.

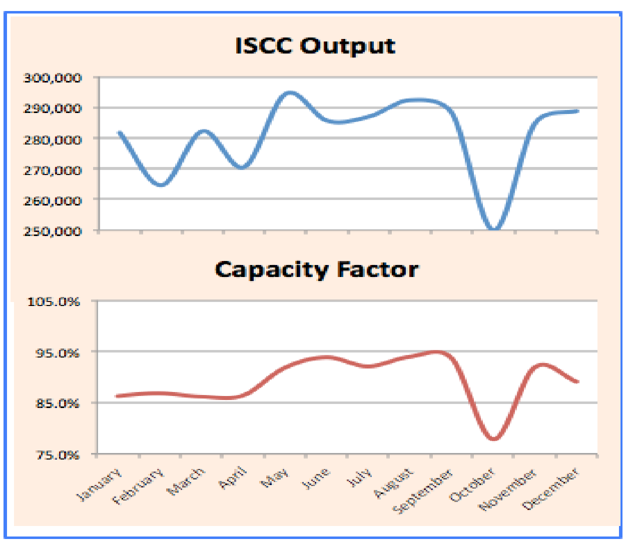


Figure 4 – ISCC output (MWhe) and Capacity Factor (%) (source: ONEE)

Integration of Solar Energy

121. For illustration purposes only, the graphic below shows typical performance on a summer day for the cases of solar input (blue) and without solar input (red). The solar contribution peaks in midday, just when the gas turbine output is degraded due to high ambient air inlet temperatures. The high solar output reduces the level of gas use during this midday period, lowering plant greenhouse gas emissions.

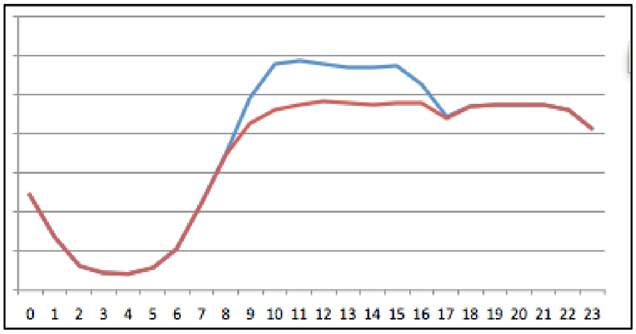


Figure 5 - Hourly Plant Output vs. Time for Summer Day (Source: ONEE)

Solar Contribution to Total Electrical Output

122. Due to the size of the solar system compared to the total ABM plant capacity the average annual solar contribution is low, on the order of 1% annually, while reaching approximately 2% during peak months. Data on the monthly solar contribution over the year 2012 is shown in the following table. The contribution is low in winter when solar production is lowest, and peaks in the May through September period.

Solar System Electrical Contribution			
2012	CC MWe	SF MWe	SF Addition
January	281,852	73,282	0.8%
February	264,628	68,803	0.8%
March	282,221	73,377	1.2%
April	270,587	70,353	1.4%
May	294,359	76,533	2.0%
June	285,632	74,264	1.8%
July	286,942	74,605	1.2%
August	292,366	76,015	1.1%
September	288,089	74,903	1.4%
October	249,683	64,918	0.9%
November	284,766	74,039	0.4%
December	288,752	75,076	0.7%

(Source: ONEE)

123. The performance of the solar system in 2012 appears to be functioning satisfactorily, though output in this initial full calendar year of operation was limited by low insolation, excessive soiling due to weather and limitations in mirror cleaning, and perhaps solar field efficiency.

Solar Field Thermal Output (Actual vs. Warranted)

124. The measured thermal output of the solar field is compared to the projected solar field output obtained using a sophisticated performance model for the solar field. Input to the model consists of the actual weather data and warranted solar field performance parameters. In addition, the solar field warranty takes into account a lowered solar field output, or none, during periods of high winds. Such periods are excluded from the solar field output requirement, reducing the warranted requirement.

125. Table 8 below shows actual performance as reported by ONEE in 2012 vs. warranted values. The solar system output exceeds or is close to warranty performance in the periods January –June, September, and November-December. The output falls short in July and August, due a reduction in radiation and excessing soiling as discussed later, and in October. July-August are of particular importance, as these are important solar months. Other metrics of the solar system performance are provided in Table 9.

Table 8 – Solar system Actual vs. Warranted performance

Solar System Warranted Peformance			
2012	Qsf, act	Qsf,war	Act/War
January	8,668	8,330	104%
February	8,633	9,090	95%
March	13,364	12,488	107%
April	14,986	14,234	105%
May	23,178	20,949	111%
June	19,680	19,969	99%
July	13,465	15,239	88%
August	12,567	16,542	76%
September	15,399	15,610	99%
October	8,662	10,593	82%
November	4,032	4,254	95%
December	7,222	7,197	100%

Table 9 – Performance of the solar field

PARAMETER Units Description Source	DNI kWh/m2-mo Measured DNI O.N.E.	SF MWht output MWht MWht to HRSG O.N.E.	SF MWhe output MWhe MWhe to ISC Col E*0.26	SF Thermal Effic re DNI % Col E/Col M Calc	SF Elec Effic re DNI % Col N*0.26 Calc
		Solar Field Outputs		Solar Field Efficiencies	
	DNI	Qsf	MWsf	Effsf,t	Effsf,e
January	182	8,668	2,254	26%	7%
February	162	8,633	2,244	29%	8%
March	165	13,364	3,475	44%	11%
April	186	14,986	3,896	44%	11%
May	215	23,178	6,026	59%	15%
June	194	19,680	5,117	55%	14%
July	156	13,465	3,501	47%	12%
August	173	12,567	3,267	40%	10%
September	179	15,399	4,004	47%	12%
October	157	8,662	2,252	30%	8%
November	93	4,032	1,048	24%	6%
December	175	7,222	1,878	23%	6%
Annual	2,036	149,857	38,963	40%	10%

Conclusions – Ain Beni Mathar (ABM) solar system performance in 2012

126. The performance is good but falls short of excellent. More detailed evaluation of data would be necessary to quantify the contributing factors to performance, both positive and negative.

127. Reliability issues in solar trough systems at other trough CSP projects have generally focused on the solar heat exchanger tube sheet leaks, HTF pump seal replacement rate, and ball joint operation (not leaks). ONEE has not reported any difficulties in these areas, which would generally occur, if present, after a longer operating period.

128. The GEF-financed ISCC Kureimat project in Egypt has had some unusual corrosion problems in the solar field due to a high sulfuric acid content in the local air environment, but that would be highly unlikely at ABM due to the clean ambient atmosphere. Solar field soiling has been a problem at ABM, however, and is discussed below.

129. *Average Solar Field Reflectivity:* Solar field performance is almost directly proportional to the mirror panel reflectivity. According to Fichtner, ONEE's engineer for the project, a mirror-soiling phenomenon that occurs especially in summer at ABM consists of a small amount of precipitation in combination with dusty mirrors, forming a hard film that can reduce the solar

field reflectivity by 20 to 40%. Cleaning all the mirrors in this condition takes several days, which is not an adequate solution.

130. Some additional information comes from daily data on mirror reflectivity readings for the months May 2012 through January 2013 provided by ONEE. The daily readings were taken in a consistent pattern of 12 measurements distributed throughout the solar field. It is possible from the data to calculate the reported monthly solar field average reflectivities, shown in the table to the left. The data is indicative but should be viewed with caution as there are numerous indicators that suggest the data contains a number of internal inconsistencies.

Month	Average daily reflectivity
May	89.8 %
June	88.2
July	81.5
August	77.3
September	82.6
October	83.5
November	86.0
December	86.2
January	87.8

A further point is that the average reflectivities seem low, though that is a subjective observation. New glass mirror panel reflectivities are about 0.94. In the US, mirror washing in summer is carried out to maintain an average field reflectivity in the 0.90 to 0.91 range; this is an economic goal set by the cost of washing compared to the gain in performance, and the impact on the plant economics. The goal for an ISCC plant like Ain Beni Mathar could be quite different. But note that the average monthly reflectivities shown are quite low compared to 0.90, especially for such a small field with a semi-automated mirror washing machine. Finally, the months of July through October show particularly low values, likely due to excessive sandstorms plus rain or morning dew.

Exhibit 1 - Ain Beni Mathar ISCC Power Plant Technical Description

- *Gas Turbine*: The plant includes two ALSTOM type GT13E gas turbines with generators of rated electric power capacities of 155 MWe at 15°C ambient dry bulb temperature. The gas turbines will combust about 9.6 kg of natural gas per second each, and therefore require about 490 kg of combustion air per second. Inlet air filters clean the air of dust and other particulates.
- *Steam Turbine*: The plant includes an ALSTOM steam turbine with generator. At rated conditions of the gas turbines and HRSGs full load operation, plus a solar heat input of 58.7 MJ/s and 15°C ambient dry bulb temperature the steam turbine generator output will be 171 MWe. The turbine has a high pressure section that receives steam from the high pressure superheaters, an intermediate pressure section that receives reheat steam from the intermediate pressure reheaters and a low pressure section that receives steam from the low pressure superheaters and the high pressure turbine section.
- *HRSG*: At full load operation of the gas turbines the two Heat Recovery Steam Generators will each receive about 504 kg/s flue gas from the gas turbines at temperatures of about 510°C. The flue gas leaves the HRSGs at about 100°C. Each HRSG includes one low pressure economizer, low pressure evaporator, deaerator and low pressure superheater for feed off the steam turbine low pressure section; one intermediate pressure economizer, intermediate pressure evaporator, intermediate pressure steam drum, two intermediate pressure re-heaters and one intermediate pressure superheater for feed off the steam turbine intermediate pressure section; and two high pressure economizers, one high pressure

evaporator, high pressure steam drum, and three high pressure super-heaters for feed of the high pressure section of the steam turbine. The HRSG is designed and delivered by CERREY of Mexico. The solar generated steam will be injected into the high pressure steam drum at about 93 bar pressure.

- *Solar Field*: The parabolic trough collector design installed at ABM utilizes the Abengoa first generation improvement of the EuroTrough collector. Each collector has an aperture area of 818 m^2. The collectors exposed to higher wind loads due to their position in the outer rows of the solar field are structurally reinforced. The EuroTrough collector structure is assembled in a hall close to the site from pre-fabricated low cost steel elements that can often be manufactured locally all over the world[43]. The pre-fabricated steel parts of torque box frames and plates, cantilever arms and HCE supports are then delivered locally by a sub-supplier and assembled by local workers under supervision at the site. The assembly is organized in one line using several fixed jigs for accuracy. Quality control of the assembled SCE steel structure is done on a photogrammetric measuring station. Final steps in the assembly hall are mirror mounting and SCE balancing.
- The collector design uses two different pylon designs: the regular pylon at the end and between two collector elements and drive pylon at the center of a full solar collector assembly (SCA). Similar to the collector steel structure and the pylon foundation, the pylons are designed as reinforced or regular according to the position in the solar field. Solar mirrors for the plant are of tempered glass supplied by the Abengoa subsidiary Rioglass. The collector absorber tubes (or "receivers") installed at the plant are from Schott Solar.
- *Mirror washing*: A mirror-washing truck of Abengoa design is used to wash the mirrors on a scheduled basis. The machine used demineralized water (of an intermediate demineralization level) sprayed on mirrors while being scrubbed with soft rotating brushes. A separate spray also impacts the receiver. As presently understood, the truck makes 4 passes on each individual collector (2 each way) or row before moving to the next. Each mirror panel is washed on approximately a 30-day interval. The washing is conducted during the long day shift, and not confined to night-time hours as adopted in U.S. plants.
- *HTF System*: The Heat Transfer Fluid system is designed for a HTF mass flow of Solutia's VP1 of 440 kg/s at 100% load. The solar field is divided by a main header which leaves the power block area at the southern end, splits into an east and a west section and separates the solar field into a northern collector loops area with the power block in the middle and a southern collector loops area. The northern part comprises 25 loops of four collectors per loop, and the southern part 31 loops. The HTF is pumped into the solar field by 3x50% HTF main pumps, the HTF flow is separated by control valves between the east and the west section, HTF flow through the loops is controlled per individual adjusting automatic valves. The HTF system of the plant includes an ullage and regeneration system. The ullage system consists of one ullage vessel, one ullage heat exchanger, one closed cooling cycle with the required coolers and pumps. Furthermore the HTF system includes one expansion vessel and two overflow vessels with overflow pumps, a HTF filter, a HTF storage vessel with storage pumps and a freeze protection unit with natural-gas-fired freeze protection heater and freeze protection pumps.
- *Solar Steam Generators*: Enthalpy received by the HTF from the solar field is used for steam generation in two trains each consisting of one tube and shell economizer and two evaporators, also in tube and shell design. Saturated steam is produced and fed into the high

[43] At ABM the steel structural elements were imported by Abengoa.

pressure steam drum of each train from where it is forwarded to the HRSGs for further superheating.

- *Water Supply System*: About 140 m^3/h of raw water will be pumped to the plant from the three different wells that exist in the proximity of the plant. In the water treatment system the water is treated by clarification, filtration, reverse-osmosis (RO) and ion exchange. The auxiliary cooling system uses clarified water; the mirror washing water is from RO water and the steam cycle make-up is be from demineralized water. The plant includes a water treatment plant which treats HRSG blow down before discharge to the evaporation pond.
- *Cooling System*: Exhaust steam is condensed by an air-cooled steam condenser. The air-cooled steam condenser is implemented with 24 ventilators blowing ambient air through the heat transfer surfaces which is used as the heat sink. This technology was applied to save about 80% of the water that would otherwise be needed for heat rejection for the plant.
- *Other*: The power block area is located in the middle of the northern part of the solar field with collector loops in the east and the west. The HV-switchyard as well as the effluent water treatment, the administration building and the evaporation pond are located in the north of the plant outside the power block area. The power generation voltage level at steam turbine generator and gas turbine generators is 14.5 kV and power evacuation voltage level is 225 kV. Station loads will be fed from the 6.6 kV medium voltage switchgear. Emergency power supply is designed with uninterruptible power supply units and diesel generators.

Annex 5. Bank Lending and Implementation Support/Supervision Processes

(a) Task Team members

Names	Title	Unit	Responsibility/ Specialty
Lending			
Noureddine Bouzaher	Senior Energy Economist	MNSSD	TTL
Charles Rachid Bouhamidi	Financial Analyst	MNSSD	
Lizmara Kirchner Sterling	Financial Analyst	MNSSD	
Rene Mendonca	Power Engineer	MNSSD	Consultant
Siaka Meryem Benchemsi	Financial Management Specialist	MNACS	
Moez Bakayoko	Financial Management Specialist	MNACS	
Samia Msadek Makhlouf	Financial Management Specialist	MNACS	
Armando Araujo Ribeiro	Procurement Specialist	MNSSD	Consultant
Dominique Bichara	Senior Counsel	LEGMS	
Khalid Boukantar	Program Assistant	MNSSD	
Sophie Jablonsky	Junior Professional Associate	MNSIF	
Dahlia Lotayef	Environmental Specialist	MNSSD	
Yaa Oppong	Social Safeguards Specialist	MNSSD	
Tiguist Fisseha	Social Safeguards Specialist	MNSSD	
Fanny Missfeldt-Ringius	Environmental Economist	AFTEG	
Rohit Khanna	Bank GEF Coordinator	ENVGC	Adviser/reviewer
Chandrasekar Govindarajalu	Bank GEF Coordinator	ENVGC	Adviser/reviewer
Silvia Pariente-Dvaid	Senior Energy Specialist	MNSSD	reviewer
Supervision/ICR			
Anas Abou El Mikias	Financial Management Specialist	CICBR	Consultant
Armando Ribeiro Araujo	Procurement Specialist	LCSTR	Consultant
Pierre Audinet	Senior Energy Economist	SEGES	TTL supervision
Khalid Boukantar	Program Assistant	MNSSD	
Mariana T. Felicio	Social Development Specialist	MNSSO	
Rene Mendonca	Power Engineer	MNSED	Consultant
Adnane Benabdelkrim	Environmental Specialist	MNSSD	Consultant
Silvia Pariente-David	Senior Energy Specialist	MNSEG	
Roger Coma-Cunill	Energy Specialist	MNSSD	TTL supervision/ICR
David Kearney	CSP Specialist	MNSSD	Consultant
Tayeb Amegroud	Power Engineer	MNSSD	Consultant

(b) Staff Time and Cost

Stage of Project Cycle	Staff Time and Cost (Bank Budget Only)	
	No. of staff weeks	USD Thousands (including travel and consultant costs)
Lending		
FY96		2.02
FY97		12.67
FY98		18.14
FY99		72.87

FY00		43.09
FY01		25.19
FY02		52.67
FY03		16.96
FY04		12.16
FY05		76.17
FY06		127.24
FY07		89.63
FY08		0.00
Total:		548.81
Supervision/ICR		
FY96		0.00
FY97		0.00
FY98		0.00
FY99		0.00
FY00		0.00
FY01		0.00
FY02		0.00
FY03		0.00
FY04		0.00
FY05		0.00
FY06		0.00
FY07		0.00
FY08		54.51
FY09		28.49
FY10		42.34
FY11		20.48
FY12		41.27
FY13		57.56
Total:		244.65

Annex 6. Beneficiary Survey Results

Not applicable

Annex 7. Stakeholder Workshop Report and Results

Not applicable

Annex 8. Summary of Borrower's ICR and Comments on Draft ICR

I. Summary of Borrower's ICR

The following corresponds to the conclusions of the ONEE's evaluation report sent to the Bank on February 2013 *(translated from the original French version):*

"The project has achieved its objectives in its entirety despite the difficulties encountered during design and operation of the plant. The difficulties can be summarized as follows:

- High technological risks during project development
- Managing multiple design options of the project: 250 MW and 472 MW configurations, 20MW and 30 MW solar field capacities, wet cooling, dry cooling…
- Exceptional Severe Weather: difficulty of transporting equipment, restricted access to the site, work stoppages due to the difficulties of access to work areas
- Strong wind storms
- Accidents during transport of heavy equipment: Module of Gas Turbine No. 2 ("TG 2"), main transformer of Gas Turbine No.1 ("TG1").
- Fire occurred in the air filter of the gas turbine No. 2
- Incident of the starting system static (SSD) of the gas turbine No. 1;
- High vibration in the stator generator of Gas Turbine No.2 before commissioning and within guarantee period
- Insufficient gas questioned the project and construction issues have dominated operational issues before commissioning of the plant.

Regarding the lessons learned from the project, we believe that the anticipation spirit in such a project is the key to success. In the case of Ain Beni Mathar, we can mention:

- Site selection
- EPC turnkey contract
- Mitigation of risk by the addition [to the O&M contract] of 3 more years operating without construction guarantee
- Choice of dry cooling with an alternative wet cooling option
- Adoption of hourly guarantees and establishment of a monitoring system in accordance with the contract.

In conclusion, the operational stakes of the ISCC plant are high and several challenges still need to be overcome to:

- Maintain the equipment and keep performance during the remaining life of the project
- Capitalize on industrial experience regarding the integrated solar combined cycle technology."

II. Borrower's comments on draft ICR

After consideration by the team of the Ain Beni Mathar project draft completion report transmitted on June 4, 2013, we inform you that we have no specific comments on the said report except for the map on page 60 [French translated version] which shows the project site. We will send you another map shortly for your consideration.

Annex 9. Comments of Cofinanciers and Other Partners/Stakeholders

Annex 10. List of Supporting Documents

- Audinet P., Marz T., "Lessons for Solar Power Development from the World's First Integrated Solar Combined Cycle Project", 2011.

AT Kearney, ESTELA, "Solar Thermal Electricity 2025", June 2010

- Brakmann G., Badaoui N-E. (ONEE), Dolejsi M., Klingler R., "Construction of ISCC Ain Béni Mathar in Morocco", 2010 SolarPACES, Perpignan, France.

- Climate Investment Funds, "CTF Investment Plan for Concentrated Solar Power in the Middle East and North Africa region – Supplemental document". October 28, 2010

- IRENA, "Concentrating Solar Power", Renewable Energy Technologies: cost analysis series, June 2012

- International Bank for Reconstruction and Development and International Finance Corporation, "Country Partnership Strategy for the Kingdom of Morocco for the period FY10-13", Report No. 50316-MA.

- SolarPACES 2006, "ISCC Ain Beni Mathar□Integrated Solar Combined Cycle Power Plant in Morocco", Brakmann, Georg (Fichtner Solar), Berrehili, Mohammed (ONEE), Filali, Khalid (ONEE).

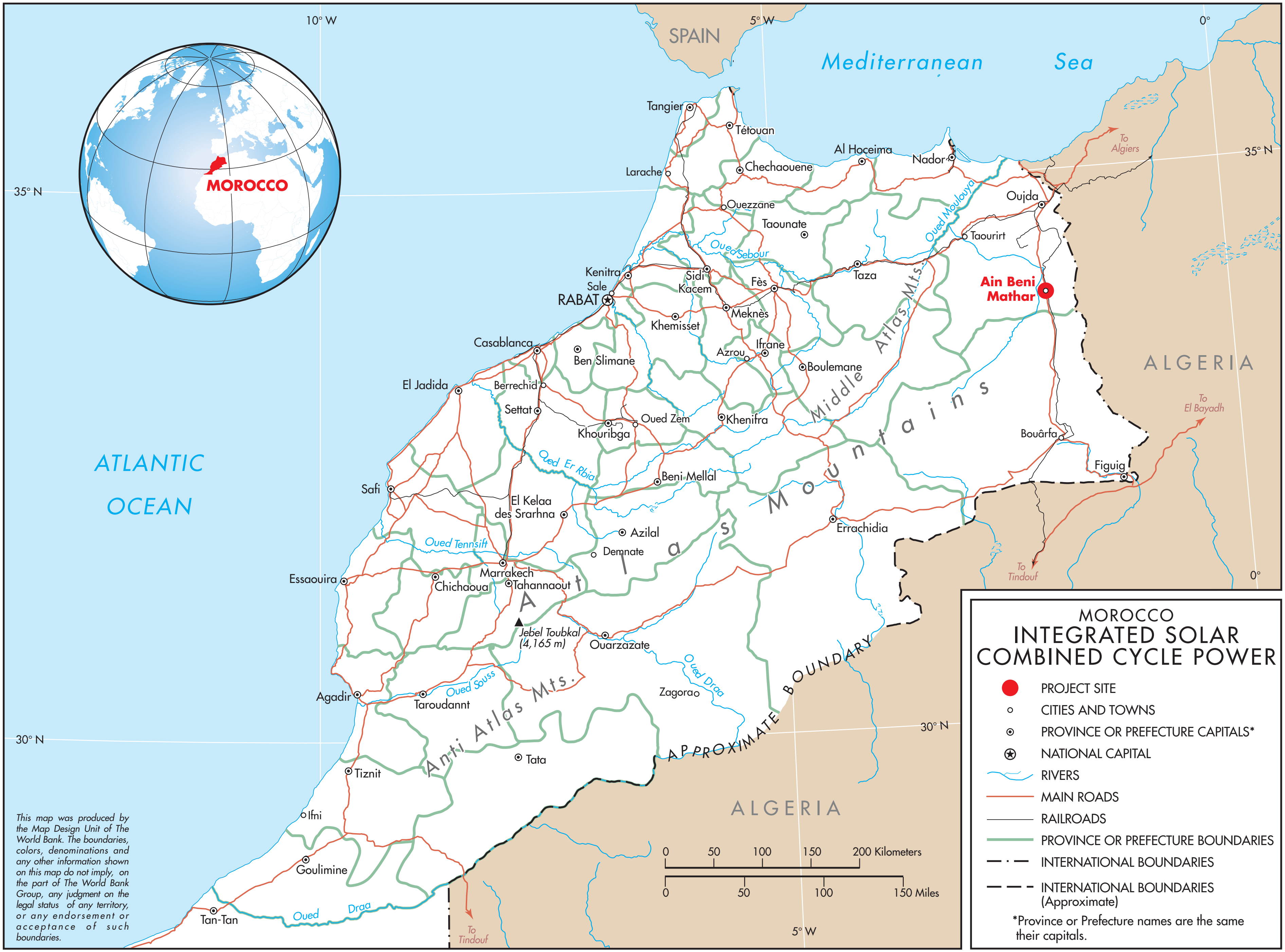
- SolarPACES 2010, "Construction of ISCC Ain Béni Mathar in Morocco", Brakmann, Georg (Fichtner Solar), Badaoui, Nour-Eddine (ONEE), Doleisi, Miroslav (Fichtner Solar), Klingler, Roland (Fichtner Solar)

- World Bank, GEF, "Assessment of the World Bank/GEF strategy for the Market Development of Concentrating Solar Thermal Power", 2006.

- World Bank, "Project Appraisal Document on a Proposed Grant from the Global Environment Facility Trust Fund in the Amount of US$ 43.2 million to the Office National de l'Electricité of the Kingdom of Morocco for an Integrated Solar Combined Cycle Power Project", Report No: 36485-MO, February 20, 2007.

- World Bank, "Eighth Quality at Entry Assessment (QEA8), Fiscal Year 2006-2007", 2008

- World Bank, "Aide Memoire – Supervision mission of Ain Beni Mathar ISCC plant", July 13-16 of 2009 (in French)



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