WORLD BANK GEF

Assessment of the World Bank/GEF Strategy for the Market Development of Concentrating Solar Thermal Power

A WORLD BANK GROUP GLOBAL ENVIRONMENT FACILITY PROGRAM PUBLICATION

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ASSESSMENT OF THE WORLD BANK GROUP/GEF STRATEGY FOR THE MARKET DEVELOPMENT OF CONCENTRATING SOLAR THERMAL POWER

GLOBAL ENVIRONMENT FACILITY PROGRAM
THE WORLD BANK

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Foreword

In many of the World Bank's client countries, solar energy is available in abundance and could play a key role in meeting the electricity needs of these countries. Although pioneering work in the area of solar thermal electricity generation took place in the United States and Europe during the 1980s, in the developing countries such work accelerated rapidly with the launch of the World Bank/GEF solar thermal projects.

The World Bank/GEF program is currently supporting solar thermal projects in Morocco, Egypt, and Mexico. In view of the cost considerations associated with solar thermal technology, these projects use the integrated solar combined cycle (ISCC) configuration, which combines the benefits of renewable energy with conventional fossil-fuel-based power plants.

This study presents an independent review of the implementation progress for these projects in the context of the long-term strategy for solar thermal development. The study team undertook extensive consultations with stakeholders and made some specific recommendations with regard to project implementation. In particular, they emphasized the need for flexibility in technology choice and implementation approach, given the changing nature of this industry worldwide and the availability of more suppliers.

There is now a renewed enthusiasm for solar energy development around the world. Project development and implementation is moving at a fast pace, especially in Europe. The new-found enthusiasm is largely built around strong national policy commitments that reduce the revenue risks faced by developers. This study also recognizes the need for a solid policy platform to sustain solar-thermal-based electricity generation efforts. However, in order to reach commercial competitiveness, this industry would need a significantly higher order of capacity additions, which can be realized only through large national programs in both the developed and developing worlds.

The solar thermal projects supported under the World Bank/GEF program played a catalytic role in the development of the industry during a period when there was a low level of activity globally. We hope that our partners can benefit from this independent review and successfully implement the first set of solar thermal electricity generation projects in the developing world.

Warren Evans
Sector Director
Environment Department

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List of Abbreviations

ADB	African Development Bank
AU	Australia
BMU	Bundesumweltministerium fuer Umwelt, Naturschutz und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)
c/kWh	cents per kilowatt-hour
CC	combined cycle
CCGT	combined cycle gas turbine
CEA	Central Electricity Authority
CER	certified emissions reductions
CFE	Comisión Federal de Electricidad (Federal Commision of Electricity)
CSP	Concentrating Solar Thermal Power
DNI	direct normal irradiance
DoE	U.S. Department of Energy
EEHC	Egyptian Electricity Holding Company
EPC	engineering, procurement & construction contract
ESCOM	South Africa Electricity Supply Commission
FERC	U.S. Federal Energy Regulatory Commission
GAIL	Gas Authority of India Limited
GDP	gross domestic product
GEF	Global Environment Facility
GHG	greenhouse gases
GMI	Global Market Initiative (for Concentrating Solar Power)
GoI	Government of India
GoR	Government of Rajasthan
GT	gas turbine
GW	gigawatts
GWh	gigawatt-hours
GWh_e	gigawatt-hours electric
HRSG	heat recovery steam generator
HTF	high temperature fluid
IEA	International Energy Agency
INR	Indian rupee
IPP	independent power producer
IREDA	Indian Renewable Energy Development Agency
IRR	internal rate of return
ISCC	Integrated Solar Combined Cycle
ISCCS	Integrated Solar Combined Cycle System
JBIC	Japan Bank for International Cooperation
KfW	Kreditanstalt für Wiederaufbau (German Development Bank)
kWh	kilowatt-hour
kWh_{th}	kilowatt-hour thermal
KSC	Key success criteria
LEC	levelized electricity costs
LNG	liquefied natural gas
MMBTU	million British thermal units
MNES	Ministry of Non-Conventional Energy Sources
MSP	medium-sized project
MT	million tons
MToe	million tons oil equivalent
MW	megawatt
MWe	megawatt electric
MW_{th}	megawatt thermal
NEAL	New Energy Algeria

NREA	New and Renewable Energy Authority
OECD	Organisation for Economic Co-operation and Development
O&M	operation and maintenance
ONE	Office National de l'Electricité/National Office of Electricity
OP	Operational Program
ORC	organic Rankine cycle
PCAST	U.S. President's Committee of Advisors on Science and Technology
PEF	Programa de Egresos de la Federación (Planning of Expenses of the Federal State [of Mexico])
PIU	project implementation unit
PPA	power purchasing agreement
ppmv	parts per million by volume
PR	progress ratio (of learning curves)
PV	photovoltaics
R&D	research and development
RECs	renewable energy certificates
RES	renewable energy sources
RfP	request for proposals
RPS	Renewable Portfolio Standard
RREC	Rajasthan Renewable Energy Corporation
RVPN	Rajasthan Rajya Vidyut Prasaran Nigam Limited
SEGS	solar electricity generating systems
SF	solar field
SolarPACES	International Energy Agency Implementing Agreement for Solar Power and Chemical Energy Systems
ST	steam turbine
STAP	GEF's Scientific and Technical Advisory Panel
STEG	solar thermal electricity generation
STPP	solar thermal power plant
TCF	trillion cubic feet
TEC	techno-economic clearance
TWh	terawatt-hours
UNFCCC	United Nations Convention on Climate Change
WB	The World Bank

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Executive Summary

Global warming is now widely considered a very significant poverty and security issue. The associated detrimental effects are likely to particularly manifest themselves in many developing countries. Though most of the anthropogenic emissions thought to be contributing to the effect have historically come from the countries of the Organisation for Economic Co-operation and Development (OECD), modeling shows that in the future the bulk of emissions will come from countries such as India and China. It is therefore in the World Bank's interest to contribute to the identification and support of solutions to GHG emission reduction.

The GEF's Operational Program 7 (OP 7) supports the development of technologies with low greenhouse gas emissions that are not yet commercial, but which show promise of becoming so in the future. In 1996, the GEF's Scientific and Technical Advisory Panel (STAP) recommended high-temperature solar thermal power technology as one of the renewable energy technologies that had very significant cost reduction potential and potentially a high demand from countries in the world's solar belt. Concentrating solar power (CSP) was viewed as the most cost-effective option to convert solar radiation into electricity, and has been operationally proven in California since the mid-1980s. Successively, four solar thermal projects entered the GEF CSP portfolio with a grant volume of $194.2 million in total managed by the World Bank: (1) the Egypt Solar Thermal Hybrid Project in Kuraymat, Egypt; (2) the India Solar Thermal Project in Mathania, India; (3) the Mexico Hybrid Solar Thermal Power Plant Project in Agua Prieta, Mexico; and (4) the Morocco Integrated Solar Combined Cycle Power Project in Ain Beni Matar, Morocco.

Each project has encountered significant delays. Apart from an unsuccessful attempt on behalf of the Indian project in 2003, no requests for proposals (RfPs) have yet been issued from any of the four projects until very recently. This suggests the difficulties encountered have been predominantly associated with non-technical issues, which are examined in this study.

Solar thermal electricity plants were introduced in California in the 1980s, but no new commercial-scale solar thermal electricity plant has been commissioned in the last 12 years. This was primarily due to insufficient financial incentives. Research and development (R&D) has since led to improved solar field components and new thermal storage concepts. In addition, operation and maintenance experience has continued to emerge through the existing California plants. However, past construction experience has been lost, and there is a feeling outside the solar thermal industry that this is still a relatively new technology with associated risk.

Over the last 12 months, the industry has been reinvigorated. Several projects are presently under construction around the world. Nonetheless, these projects have not reached the kind of critical mass to suggest that the industry is now self-sustaining. In fact, the industry is presently nascent, and as a result fragile. "Firm" projects presently total less than 300 megawatts (MW), whereas several thousand megawatts would be required for the industry to approach commercial competitiveness. By comparison, wind energy—the most successful renewable technology in recent times—is now exceeding 60,000 MW of global installed capacity.

Solar thermal electricity offers a number of advantages when considered as part of a country or region's energy generation options mix. Solar energy is the world's most abundant sustainable resource. It represents an even larger resource because of the favorable geography of many of the world's developing countries. Solar thermal, based on a hot fluid, can integrate well with conventional thermodynamic cycles and power generation equipment, as well as with advanced, emerging technology. It offers dispatchable power when integrated with thermal storage, and thus good load matching between solar insolation (exposure to sunlight) and the strong growth (in many countries) in electrical demand during summer. The collector technology itself is constructed of predominantly conventional materials—glass, steel, and concrete, and no fundamental scientific breakthroughs are required for the cost to continue to drop. There is also the advantage that at a time when deep cuts to greenhouse gas emissions are being called for, solar thermal can be installed in large capacities, yet constructed of modular, repeated, well-known components. However, this also raises perhaps the major barrier for the technology at present. Depending on solar radiation levels, the cost of electricity for a one-off plant is presently around 16 to 20 cents per kilowatt-hour (c/kWh), which might be acceptable for some small applications (kilowatts or a few megawatts), but difficult to justify for larger multi-MW installations.

This report determines that solar thermal electricity technology is worthy of continued support. The benefits of a successful industry, particularly for developing countries, are significant. The technology is not new, but stalled in its development path. All required technology elements are essentially already in place. The major outstanding issue is the need for cost reduction, and this study concludes that there is no fundamental reason why the technology could not follow a similar cost reduction curve to wind energy and eventually be cost-competitive. However robust, long-term support mechanisms will be required.

The major studies associated with cost reduction potential of solar thermal electricity technology were reviewed in this study, with some inconsistencies noted in a couple of them. The most detailed and conservative of the recent studies predicts that commercial competitiveness could be achieved with installations of around 42 gigawatts (GW) (similar to wind capacity today), not including allowance for any cost of carbon. This would represent approximately 1 percent of the global installed power generation capacity and require subsidies of about €12 billion. An allowance for a carbon cost beginning at €7.50 per ton of carbon dioxide (/t CO_2) would decrease this capacity to 22 GW, and reduce required subsidies to €2.5 billion. Cost reductions are expected to come from a combination of plant scale-up (larger plants), increased production volume, and technological innovation.

The figure below plots the required CSP installation rate required to achieve cost-effectiveness by 2020. It shows that the required growth rates for solar thermal electricity to achieve cost-competitiveness are quite moderate compared to what wind, the fastest growing energy technology in the world, has achieved. The "probable to firm" represents a prediction based on an analysis of the status of global CSP projects at present. The Global Market Initiative (GMI) is a proposed industry target to reach 5,000 MW of installed CSP by 2015. The growth from 2005 until 2009 is a prediction based on those projects beyond the stage of formed consortia, and with financial closure either in hand or imminent.

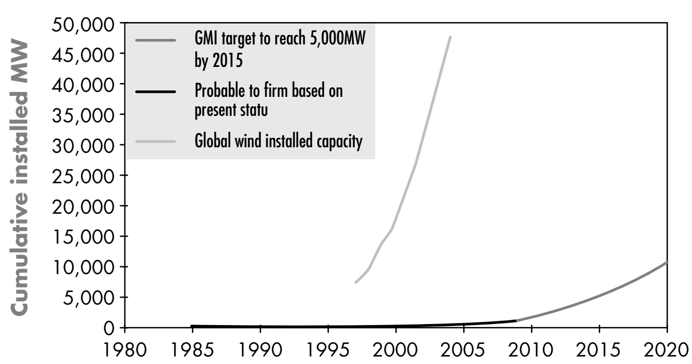
The table below lists known projects in progress (excluding WB/GEF projects).

The major success factors required to create a sustainable solar thermal electricity market are:

- *Targets*, initially specific to CSP
- *Appropriate financial support*, again initially specific to CSP, including a mix of both investment and production credits
- *Supporting legislation and regulation*

In all the above, it is important that two things are maintained within the support framework:

Cumulative installed CSP & Wind Capacity



Known projects in progress

Country and plant details (not including GEF projects)	Concept formally floated and pre-liminary assess-ment conducted	Consortia formed—ready to bid or RfP ready to release	Financial closure	Construction commenced	Fully commissioned and operating
Algeria 25 MW trough, ISCCS	⇨	⇨	⇨	2006/7 (Original expectation Sep 2005)	Possibly 2009
Arizona 1 MW trough ORC	⇨	⇨	⇨	⇨	⇨ (since April 2006)
Australia/Solar Heat and Power Pty Ltd, 38 MW Fresnel into coal-fired power station	⇨	⇨	⇨	⇨ (of first stage)	First stage under commissioning
Australia/Solar Heat and Power Pty Ltd, 250 MW Fresnel, stand-alone with thermal storage	⇨				
Australia 120 kW tower providing solar-reformed natural gas to a heat engine	⇨	⇨	⇨	⇨	2006
China/Ordos 50 MW trough	⇨				
India/Solar Heat and Power Pty Ltd, 5 MW, Fresnel	⇨	⇨			
Iran 67 MW trough, ISCCS	⇨				
Israel 100 MW trough	⇨	⇨			
Italy/Empoli (2x 80 kW solar gas turbine with waste-heat usage for air-conditioning)	⇨	⇨	⇨	⇨	
Jordan 135 MW trough	⇨	⇨ (RfP 2001)			
Nevada 64 MW trough	⇨	⇨	⇨	⇨ (February 2006)	Estimate March 2007
Portugal/Solar Heat and Power Pty Ltd, 5 MW with potential to upgrade to 50 MW, linear Fresnel	⇨	⇨			
Spain/ACS + SMAG, Andasol-1 50 MW trough	⇨	⇨	⇨ (June 2006)	Expected July 2006	Around late 2007
Spain/ACS + SMAG, Andasol-2 50 MW trough	⇨	⇨	2006	Expected 2006	Around early 2008
Spain/Abengoa, PS10 11 MW tower (saturated steam)	⇨	⇨	⇨	⇨	Estimate July 2006
Spain/SENER, Solar Tres 15 MW tower (molten salt)	⇨	⇨			
Spain/EHN+SolarGenix, 15 MW trough (HTF)	⇨	⇨			
Spain/Iberdrola, 7x50 MW Trough (HTF)	⇨	⇨			
Spain/HC, 2x50 MW Trough (HTF)	⇨	⇨			
Spain/Abengoa, 2x 20 MW Tower, 1x 50 MW Trough	⇨	⇨			
Spain/SMAG,50 MW ExtremaSol 1	⇨	⇨			
Spain/5 MW trough with direct steam generation (INDITEP)	⇨	⇨			
Spain/Solar Heat and Power Pty Ltd, 5 MW, Fresnel	⇨	⇨			
South Africa/100 MW Molten salt tower	⇨				

- *Encouraging competition.* As costs drop over time, the level of mandated support should be correspondingly reduced.

- *Providing certainty for investors. This technology requires not only long-term price security, but also an assurance that rollout can continue through subsequent plants if stated targets are met.*

The following table shows the present status of the existing GEF portfolio.

CSP technology does not currently contend with significant threats from other zero emission technologies. In the case of other renewables, their present contribution to global electricity supply is small, and there is room for new technologies to emerge. In particular, renewable resources are, by their very nature, geographically diverse. This tends to support rather than diminish the principle of encouraging a mix of energy options. Even in a particular region, different technologies tend to fit different parts of the electricity market. For example, photovoltaics can act ideally as distributed generation, whereas CSP fits centralized generation. Of the dispatchable non-hydro renewables, geothermal and bioenergy are quite site-specific, and thus resource-constrained, in the same way that CSP is resource-constrained in some climates.

We can see three options for the World Bank at this point. They are:

1. Pull out of CSP altogether and perhaps support a different, zero GHG technology path under OP 7. Given the delays to date, and quite likely some more hurdles to come, this would appear an attractive option. However, the goals of OP 7 are worthy, and it is important that a visible organization such as the World Bank takes the lead in such issues. Of the zero GHG technologies that are technically feasible yet not yet commercial, CSP

PRESENT STATUS OF THE EXISTING GEF PORTFOLIO

Country/project	Status of project	Project structure	Expected schedule
India, 140 MW ISCCS incl. 35 MW solar trough, site approximately 2,240 kWh/m^2/year DNI.	WB waited on letter of commitment from GOI, after which the already drafted RfP (revised) could be released.	Single EPC with O&M (5yrs). PPA with RVPN. Project owner RREC.	Eventually, the project could not be timely implemented due to inappropriate design and location.
Egypt/Kuraymat, 151 MW ISCCS incl. 25 MW solar.	Financial closure agreed. Solar thermal part and CC at bidding stage.	Two EPC contracts. The solar island will be an EPC with O&M contract; the CC island will be an EPC contract with local O&M to be bid separately financed by NREA.	Delays due to the splitting of the packages to be funded by GEF, NREA, and JBIC. Contract signature expected for early 2007. Construction might begin late 2007. Possible begin of operation late 2009.
Mexico/El Fresnal near Agua Prieta, Sonora State (site decision in March 2005, plant Agua Prieta II), originally 285 MW ISCCS but finally increase CC to 560 MWe; Solar trough field 25–40 MW; Excellent solar site conditions (exact solar data not available).	November/December 2005: Approval by the Treasury Ministry. The hybrid plant has been included in the PEF (Programa de Egresos de la Federación) and approved by Congress. Acceptance of the doubling of fossil capacity by the WB task team after technical economic assessment by Sargent and Lundy (May 2006) and a consultancy by Spencer Management.	The final owner of the plant will be CFE. They will undertake to provide the O&M. (Previously, unsuccessful project development under IPP scheme.)	At this stage, bidding is expected for 2006, construction to begin 2007, operation 2009.
Morocco/Ain Beni Mathar 240 MW ISCCS, including 30 MW trough. Expected production from ISCCS 1,590 GWh/year, of which approx 55 GWh/year solar (3.5 percent solar contribution).	EPC with O&M (5 years). Option exists to renew O&M contract after 5 years. Bids received May 2006. Ongoing evaluation process.	Owner of plant will be ONE. Total cost expected approx €213M, including connection to infrastructure. €43M from GEF, and €34M from ONE. Balance of €136.45M from African Development Bank as soft loan.	EPC with O&M contract for the project expected to be signed by the end of 2006, and at the latest in January 2007. Expected start of operation of the plant is mid 2009 (construction time 30 months).

is a lead candidate. If the goals of OP 7 are to be pursued, as they should, other technology paths may prove more frustrating, and ultimately less rewarding, than CSP.

2. Provide minimalist support to the present portfolio and "wait and see." The CSP industry, beginning again in earnest, is presently fragile. Against the thousands of megawatts needed for CSP to reach cost-effectiveness, the 120 MW of WB/GEF projects will not, of themselves, lead to any significant reduction in the underlying cost of the technology. Wind technology grew in the OECD countries before it was cheap enough to be used on a large scale in the developing countries. The same could be done for CSP. This would be an easy solution, but with the industry on a cusp, such a decision could be responsible for tipping the industry toward a demise. Though 120 MW is small against thousands of megawatts, it is quite large against the present 300 MW or so of possible-to-firm projects in OECD countries. These four projects are instrumental for the following reasons:

   - They are important to the global CSP industry as they constitute a significant percentage of planned projects at present, especially if three or four proceed. Inevitably, some will not proceed, so the more that are planned, the more robust will be the early implementation phase. They provide momentum and continuum to the global industry, which in turn will provide benefits to the developing countries when future projects are developed.

   - The developing countries with good exposure to sunlight (insolation) could play a more significant role in CSP than in wind. We have not conducted a quantitative analysis, but there is at least anecdotal evidence to suggest that direct beam solar radiation is a larger ratio than wind when compared to the resources of the OECD countries.

   - They will reveal at an early stage any major impediments to successive plants. Some of these have already been revealed and are discussed in this report.

3. Provide strong support to the present portfolio, embark on parallel paths toward supporting more projects, and work pro-actively to promote the technology globally, with the idea that global progress benefits the World Bank portfolio.

This study suggests a combination of 2 and 3 above as the recommended path. This essentially allows a prudent, active support of the technology, but with appropriate exit strategies if various milestones are not met. We do not advocate that the developing countries take a lead share of the risk in developing the CSP market. But the strong solar resource in many of the developing countries, and the relative simplicity of CSP technology, suggests developing countries should take a more proactive role than other emerging energy technologies. However, we do advocate a role in parallel with present global developments.

A strategy first requires a vision. The following is proposed—*"CSP should be supported to encourage a rapid growth phase to the point that it plays a key role in the electricity supply mix of developing countries where there is a good solar resource."*

The table below recommends a phased strategy for the World Bank to pursue, with inherent exit paths. The four phases are explained in the CSP cost reduction curve below.

The key issues and recommendations are:

- ❑ Make the request for proposal (RfP) specifications concerning the solar field more flexible. They should allow bids from alternative collector types and encourage storage.

- ❑ We would strongly recommend that the bid not specify a particular solar field capacity, but rather a minimum threshold, with the capacity offered an assessment criteria. The resulting competition will ensure the maximum capacity possible is offered for the finance available.

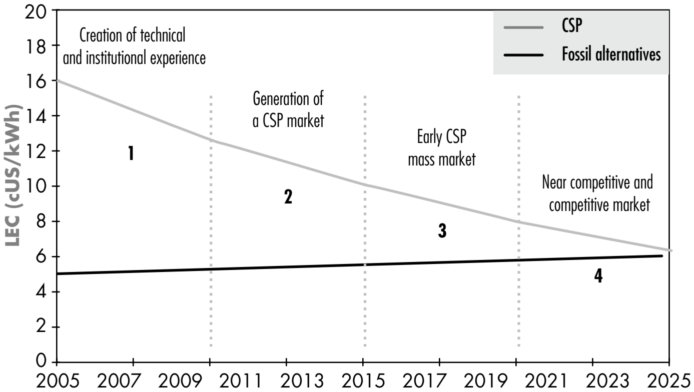
- ❑ The issue of integrated solar combined cycle systems (ISCCS) versus stand-alone solar is not critical from a technical basis. Ultimately, larger solar contributions are desirable, but in these early days, it is important for operation & maintenance (O&M) experience to be gained in these countries, and a 200,000 m^2 field will yield similar levels of O&M expertise whether it is attached to a stand-alone Rankine cycle or to a Rankine cycle as part of a combined cycle plant. There are likely to be some early "teething' problems with ISCCS, simply because it hasn't been done before, but should present no problem with good engineering.

- The single engineer, procure, construct (EPC) approach presented some issues when these projects were first mooted, but with strong consortia now in place as a result of activities in other countries such as Spain, the handling of liabilities within the consortium should be possible.
- The two-EPC approach in Egypt—that is, a solar field EPC contract and a combined-cycle EPC contract—is not new in the power industry. Many power stations are constructed with multiple parallel contracts. However, it will tend to limit the flexibility of the technologies that can be offered. The liability for

Phased strategy for the World Bank to pursue

	Key Success Criteria (KSC)	Comment	Importance
Phase 1	Response to RfPs	Critical that a good number of bids are received from robust consortia.	Crucial
Phase 1	Contracts signed for at least two projects	Having less than two projects proceed to contract signature would represent a relative failure of the portfolio. More than two would indicate a healthy CSP portfolio and a good reason to continue.	High
Phase 1	Continuing CSP project activity in other countries and first plant installations	Though the WB has no control over projects in other countries, it would be prudent to maintain a watching brief to ensure the WB/GEF portfolio is not advancing in isolation. This is not so crucial to the existing portfolio, but failure of this criteria would prevent movement to Phase 2.	Medium to high (unless global CSP activity ceases)
Phase 1	Reallocation of balance of GEF funds	If one or two of the four projects are not successful (based on missing key deadlines without due cause), and the above three KSCs have been met, it is recommended that the balance of funds be reallocated by a competitive call for proposals. It is likely that bidding countries—such as Algeria, Iran, Jordan, and China—would already have significant progress on their projects.	Medium
Phase 2	Continuing emergence of CSP projects in other countries	CSP market development is a long-term process. It will be on the order of 1 year before construction commences on the first WB/GEF project, a further 2 years until operation commences—realistically a minimum of 4 years from now until there is a good level of operational data. This affords a good opportunity for the WB to assess CSP progress internationally.	High
Phase 2	Successful operational performance of Phase 1 WB/GEF projects	By this time, some good operational data will be emerging from the GEF portfolio, as well as a number of plants in other countries.	High
Phase 2	Evidence of legislated financial support mechanisms for CSP	Many countries have renewable energy policies and targets, but only financial incentives that have the backing of legislation are useful for bankable documentation. Given that in Phase 2 there is still a considerable financial gap to be filled, it is desirable that target countries are showing commitment to a domestic CSP industry.	Medium to high
Phase 2	New portfolio of WB projects successfully commenced	If the above KSCs have been satisfactorily met, a new competitive call for proposals should be launched. The timing will be dependent on the above KSCs.	High
Phase 2	Emergence of key countries/regions	By this time, key countries or regions will have begun to emerge. It is important that countries are taking the initiative to the World Bank rather than what has to this point tended to be the other way round. If this interest is not shown, it would be a moot point as to whether the WB should be pursuing them.	High
Phase 2	Contribute to development of local manufacturing and operating experience	As more plants are destined for developing countries, local solar component manufacturing expertise should emerge. It is not, for example, a very expensive matter to set up a tube manufacturing facility. In addition, if a region such as the Mediterranean emerges, a Mediterranean team (cross-country) of expertise in construction could make sense.	Medium to high
Phases 3 & 4	WB/GEF part of a global CSP fund	If the CSP market has reached this stage, a huge mobilization of funds will be in progress. A global CSP fund would be an attractive means of helping to leverage WB/GEF funds. The GEF contributions could be partitioned within the fund to remain with developing countries.	Medium to high
Phases 3 & 4	Contribute to the sustainable development of a country/region	Economic (employment, manufacturing) and environmental (international recognition for spurring a new renewable technology) benefits should have begun to emerge.	Medium to high

CSP COST REDUCTION CURVE



any engineering design problems occurring between the solar field and the heat recovery steam generator (HRSG) will rest with the owner and designer.

- WB/GEF funds could be leveraged most usefully through participation in a global CSP fund. Project proposals would be bid on a competitive basis for funds. Awarded proposals could combine a mix of up-front grant monies, and a longer-term power purchasing agreement (PPA) through the fund. The WB/GEF funds could be partitioned such that they were only available to developing country projects. By that time, particular regions may be emerging as the most attractive opportunities.

1
Setting the Context

1.1 Operational Programs of the Global Environment Facility

Mitigating climate change and achieving stabilization of atmospheric concentrations of greenhouse gases—the objective of the United Nations Convention on Climate Change (UNFCCC)—will require deep reductions in global emissions of energy-related carbon dioxide emissions. Developing and deploying new, low-carbon energy technologies will thus be needed, in particular in developing countries where the largest growth in emissions is expected to occur.

The Global Environment Facility (GEF) has operational programs that promote the deployment of renewable energy (Operational Program 6, or OP 6) and energy efficiency (Operational Program 5, or OP 5) by assisting in the removal of barriers to the use of energy efficient technologies and commercial or near-commercial renewable energy technologies. The objective of these programs is to lay the foundation for increased public and private investments in renewable energy and energy efficient technologies (STAP, 2003; Mariyappan and Anderson, 2001). An operational program is a "conceptual planning framework for the design, implementation, and coordination of a set of projects to achieve a global environment (that) organizes the development of country-driven projects and ensures systematic coordination between the implementing agencies and other actors."

Operational Program 7 (OP 7) is devoted to "reducing the long-term costs of low greenhouse gas-emitting energy technologies." Its objective is to reduce greenhouse gas emissions by accelerating technological development and increasing the market share of low greenhouse gas-emitting technologies that have not yet become commercial, but which show promise of becoming so in the future. To achieve this objective, GEF promotes technologies through financing demonstration projects with a view to bringing down energy costs to commercially competitive levels, through technological learning and economies of scale.

Under Operational Programs 5 and 6, the GEF funds the incremental cost of barrier removal; under Operational Program 7, it funds the incremental cost of the technology.

1.2 CSP funding within Operational Program 7

The GEF's Scientific and Technical Advisory Panel (STAP) believes that OP 7 should be an important element in GEF operations. In particular, two technologies—grid-connected photovoltaics and solar thermal technologies—are thought to have comparative cost advantages because of high solar insolation in developing countries.

Solar thermal technology has been demonstrated in the state of California over the past 15 to 20 years. However, the integration of solar thermal technology with a combined cycle gas turbine (ISCCS)—the choice to date for a hybrid system in the WB/GEF solar thermal portfolio—has not been demonstrated. Such integration has advantages and disadvantages, which are discussed more fully in Chapters 2 and 3.

In 1996, GEF's Scientific and Technical Advisory Panel (STAP) recommended high temperature solar thermal power technology as one of the renewable energy technologies that had very significant cost reduction potential and potentially a high demand from countries in the world's solar belt. Concentrating solar power

(CSP) was considered the most cost-effective option of converting solar radiation into electricity; it had been operationally proven in California since the mid-1980s. However, no follow-up investments were made when California terminated a favorable tax policy, and the industrial development slowed down considerably. Any activity that did continue consisted mostly of research and development programs in Europe and the United States and considerable efforts to revive the technology on the part of the solar industry.

The Mathania solar thermal power plant in India was the first to enter GEF's Operational Program 7 in 1996 as part of a larger strategy. In this larger strategy, the proposed project in India was expected to be the first in a series of multi-country investments that together would facilitate the commercialization of solar thermal technology. Similar projects in Mexico, Morocco, and the United States were in advanced stages of preparation. Additional solar thermal projects were under consideration in Egypt, Tunisia, Israel, Jordan, Spain, Italy, and Greece (Crete). Other countries in the high insolation regions of Africa had also shown interest. While not all of these projects were expected to materialize in the near term, up to four projects, including the initiative in India, were anticipated to be developed by 2001. The combined effects of these projects, it had been concluded, would be to accelerate the process of cost reduction, demonstrate the technical performance of the technology in a wider range of climate and market conditions, and create a sustainable market for parabolic trough solar thermal technology. Subsequently, the GEF approved two more projects for OP 7, namely those under development in Mexico and Morocco, with a fourth project in Egypt. Presently, the WB/GEF solar thermal portfolio consists of projects in four countries—Egypt, Morocco, India, and Mexico—with a total solar capacity of approximately 120 MW and a total WB/GEF commitment of around $200 million. It is expected that these projects would help benchmark the costs of technology and contribute to an understanding of the institutional and regulatory requirements for this and other advanced renewable energy technologies in developing countries.

Apart from these four projects, GEF-supported project preparations exist in Brazil and South Africa. South Africa's utility ESCOM has undertaken a feasibility study for a 100 MW solar tower. Other countries have shown interest in receiving GEF support for similar plants, including Algeria, Iran, Jordan, and China.

To date, the number of OP 7 projects supported has been small (not just CSP) and the achievements limited. OP 7 has proven to be a difficult portfolio to develop.

1.3 Lessons from past studies on the GEF solar thermal portfolio

All four solar thermal projects in Mexico, Morocco, Egypt, and India have experienced implementation problems. These four projects were reviewed in 2001 by Mariyappan and Andersen. Apart from highlighting common implementation problems (power sector restructuring, general difficulties of IPP projects in emerging markets) as a reason for delay, the report alluded to three OP 7 specific issues:

i. The contradiction between the drivers of economic development in developing countries, i.e. poverty alleviation, and those of the developed world, i.e. environmental concerns, generates a mismatch of global expectations and local willingness-to-support these projects.

ii. There has been insufficient dialogue between GEF and the CSP industry during project design, adoption of the CSP strategy, and project implementation.

iii. GEF has remained the only significant funding source[1] for these CSP plants.

These issues continue to be at the center of the strategic discussion on CSP.

In May 2004, GEF published a status report on the solar thermal portfolio (World Bank, 2004) and argued that the portfolio offers a variety of lessons related to project preparation, co-financing, procurement, and progress toward cost reduction.

- *Project preparation:* Initially the four projects were prepared as independent power projects (IPPs), but have since been

[1] We note that international funding organizations such as KfW, JBIC, and ADB have offered soft loans, and that national bodies such as the Government of India or ONE in Morocco have offered smaller grants.

changed and are now being developed as public sector power projects. This lack of success of the IPP approach appears to be not only the result of risk aversion to integrated solar thermal and combined cycle technology in the private sector, but also a general global decline in IPP interest in developing countries.

- *Co-financing:* Securing full co-financing is a key feature, as the four projects are now being developed as public sector power plants.

- *Procurement:* There are a limited number of global consulting firms and suppliers in the solar thermal industry. In the WB/GEF projects, the solar contribution of the integrated solar combined cycle technology is in the 5 percent range, and consequently the lead for these hybrid projects would be taken by mainstream power generation firms. Risk perception by the bidders and risk reduction strategies would be a major barrier to overcome.

- *Progress toward cost reduction: Experience to date has certainly helped identify the issues in preparing and structuring solar thermal projects in developing countries, but progress toward cost-reduction can only be evaluated with a fair degree of confidence after contracts have been negotiated and awarded to selected bidders, and particularly after operation has commenced.*

Further lessons learned have been put forward by Cédric Philibert (2004) of the International Energy Agency:

- *Lesson 1:* International collaboration may help, but domestic policy decisions remain decisive.

- *Lessons 2&3:* In technology transfer, non-financial barriers must not be underestimated; developing new, large-scale technologies in developing countries only may not work.

- *Lesson 4: Sharing the necessary "learning investments" might be a good idea.*

An interpretation of these four lessons, as well as those lessons presented earlier in this section, is that technology transfer in developed countries has its own set of challenges. However, technology transfer into developing countries is very likely to face even further challenges, including a lack of appropriate policy, legislation, institutional structures, human resources, (venture) capital resources, and industrial partners willing to consider new technologies. In general, economic and institutional barriers rather than technology availability are more apt to be the cause of failure to transfer technology (see the brief review of definitions related to technology transfer in Box 1).

1.4 Aims of the Study

The main objective of this assignment was to assess the strategy being followed by the Bank/GEF for solar thermal power technology in light of:

1. The current state of technology, costs, and market development;

2. The difficulties experienced by the GEF co-financed projects, assessing the three primary risks facing the Bank/GEF portfolio:

    a. Limited industry response,

    b. Uncertainty of meeting the cost and performance targets, and

    c. Uncertainty of sustainability and replicability arising from the absence of long-term country or international commitments;

3. The original objectives of the portfolio.

1.5 Scope of Work

According to the aims of the investigation, the following three tasks were carried out and are presented in the following chapters:

- *Task 1—Summary of Solar Thermal Technology Growth:* Brief summary of the development of the CSP technology thus far (including the current international experience in the implementation of solar thermal power projects), the technological improvements and cost forecast scenarios (results described in Chapter 2 and Annexes 1–3).

Box 1: What is technology transfer?

The term "technology transfer" tends to mean different things to different entities, generally giving flexibility to individuals and organizations within their practices. However, most broad definitions include (Lawrence-Pfleeger et al, 2003):

- technology—as an idea, practice or object resulting from research, as well as an embodiment of the technology;
- the movement of technology into a setting where it can improve a product or process in some way; and
- an entire process involving facilitators at different steps, including those who create the technology, those who incorporate the technology into a useful product, service, tool or practice, and those who further develop the technology for commercialization and use.

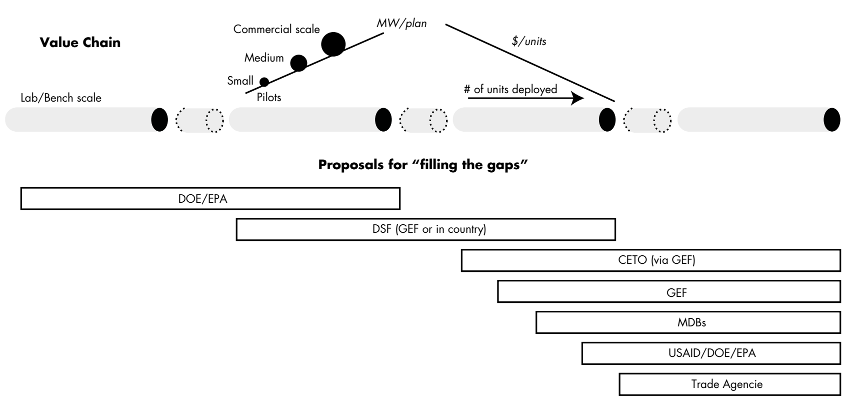
In the context of the above definition, the WB/GEF can be viewed as a facilitator in the transfer of technology.

The United Nations Environmental Programme's (UNEP) Intergovernmental Panel on Climate Change (IPCC, 2000) defines the term "technology transfer" as a broad set of processes covering the flows of know-how, experience, and equipment for mitigating and adapting to climate change among different stakeholders such as governments, private sector entities, financial institutions, and NGOs. The broad and inclusive term "transfer" encompasses diffusion of technologies and technological cooperation across and within countries. It covers technology transfer processes among developed countries, developing countries, and countries with economies in transition. It comprises the process of learning to understand, utilize, and replicate the technology, including the capacity to choose and adapt to local conditions and integrate it with indigenous technologies.

The transfer of technology may be limited because of existing barriers, barriers that may arise at each and any stage of the process of technology transfer. These barriers vary according to the specific context, for example from sector to sector, and can manifest themselves differently in developed countries, developing countries, and countries with economies in transition.

The U.S. President's Committee of Advisors on Science and Technology (PCAST, 2003) investigated the processes associated with the transfer of technologies. Based on their investigations, a diagram describing this process of technology transfer via a value chain has been developed (Figure 1).

Figure 1: "Gap" identification in technology transfer



Source: PCAST (2003).

The PCAST depiction of the technology transfer process highlights the gaps or barriers that need to be overcome before a technology is deployed successfully on a widespread scale. Included in the PCAST value chain technology transfer process are the potential sources of funding that can be accessed to cover the various stages of the value chain. It should be noted that GEF funding is viewed as a possible source of funds from demonstration, through buy-down, and into the widespread deployment of a technology. The value chain process as depicted in Figure 1 can readily be broadened to include the developing countries and countries with economies in transition. Also worthy of note is PCAST's view of the role that GEF could play in technology transfer.

- *Task 2—Risk Assessment and Mitigation:* Assessment of risks and the adequacy of risk mitigation measures provided in project design in the WB/GEF portfolio. This assessment included technological performance risk, financial/commercial risks, regulatory/institutional risks, and strategy risks (results described in Chapter 3).

- *Task 3—Market Development Strategy: Following on Tasks 1 and 2, the report considers the chances of realization and the bottlenecks of each of the four projects in the WB/GEF portfolio (results described in Chapter 4 and Annex 4). Chapter 5 discusses the importance of the WB/GEF portfolio in the future development of CSP technology and strategies beyond the current portfolio, including projected market impacts of partial or full implementation of the current portfolio; the extent to which WB/GEF projects will contribute to the development of this technology; conditions necessary for further technology development; and commercialization following the implementation of the projects in the WB/GEF portfolio.*

This report integrates lessons from previous reports (see references) and personal surveys/interviews with key stockholders in the four GEF projects: the World Bank, GEF, target country decision makers on the WB/GEF CSP projects, financing institutions, industry (combined cycle & solar field) and consultants. A list of interviewed organizations/persons is provided in Annex 5.

2
Concentrating Solar Thermal Power (CSP) Development

This chapter describes ongoing CSP developments worldwide; the technological paths of concentrating solar thermal power plants; and projected cost reductions for CSP technology due to recent technology improvements, scale effects (larger plant size), and volume effects (accumulated capacity). This provides the necessary background for the evaluation of the WB/GEF CSP portfolio and the future development of CSP.

2.1 Ongoing CSP market development worldwide

The solar electricity generation systems (SEGS) plants of Southern California are well-known for their many successes, not the least of which was their ability to be constructed relatively quickly and to meet the constraints associated with various financial incentives. It is also well-known that no significant commercial plants have been built since the last SEGS plant in 1990.

Since that time, developers and researchers have been busy improving the various components of the technology, not only in solar research institutions but also importantly in the field, making use of the SEGS plants themselves. In fact, the SEGS V field was used for the purpose of testing an improved collector for the Andasol project in Spain (SKALET loop) under real conditions. Operation and maintenance costs have dropped through improved components and practices. Importantly, these improvements have been measured in the field, not just in desktop studies. The nine SEGS plants were constructed with an investment cost of $1.2 billion, all private capital. More than 13 TWh of solar electricity were produced from these plants by 2005, with electricity sales of over $2 billion. These projects were successful as a result of favorable Federal Energy Regulatory Commission (FERC) regulations, tax credits, and attractive time-of-use tariffs (14 c/kWh on average and up to 36 c/kWh during summer peak).

The sudden loss of all of the favorable conditions in the early 1990s left no incentives in either the OECD or developing countries. A shortcoming of that period is that no legacy or supporting framework was left behind despite all the investment activity. This meant that the only CSP players left to further the CSP technology after the SEGS plants had been built were the component manufacturers themselves. The SEGS operating companies were mainly concerned with operating what was there, not expansion.

The power manufacturing industry was facing stiff competition at the time, so margins were very tight, with no room to support the development of CSP, especially when there were no incentives in place. Deregulation was occurring in the power industry all over the world, and the resulting competition, along with only a fledgling green power market at the time, meant that utilities could no longer afford to support projects that promised long-term strategic value but uncompetitive short-term returns. Wind power began to grow at this time, as units could be installed in small manageable capacities with a limited financial risk.

Up until a couple of years ago—as interest in Spain, Arizona, and the GEF projects emerged—there were about two to three times more CSP researchers than industry personnel. This strong R&D interest has kept the technology progressing during the hiatus period; however, the industry is likely to stagnate unless the technological advances that have emerged since 1990 are put into practice.

The industry also has developed a much better understanding of real-world project finance, as well as other project factors such as

Table 1. Overview and status of CSP projects worldwide (excluding WB/GEF projects)

Country and plant details (not including GEF projects)	Concept formally floated and preliminary assessment conducted	Consortia formed—ready to bid or RfP ready to release	Financial closure	Construction commenced	Fully commissioned and operating
Algeria 25 MW trough, ISCCS	⇨	⇨	⇨	2006/7 (Original expectation Sep 2005)	Possibly 2009
Arizona 1 MW trough ORC	⇨	⇨	⇨	⇨	⇨ (since April 2006)
Australia/Solar Heat and Power Pty Ltd, 38 MW Fresnel into coal-fired power station	⇨	⇨	⇨	⇨ (of first stage)	First stage under commissioning
Australia/Solar Heat and Power Pty Ltd, 250 MW Fresnel, stand-alone with thermal storage	⇨				
Australia 120 kW tower providing solar-reformed natural gas to a heat engine	⇨	⇨	⇨	⇨	2006
China/Ordos 50 MW trough	⇨				
India/Solar Heat and Power Pty Ltd, 5 MW, Fresnel	⇨	⇨			
Iran 67 MW trough, ISCCS	⇨				
Israel 100 MW trough	⇨	⇨			
Italy/Empoli (2x 80 kW solar gas turbine with waste-heat usage for air-conditioning)	⇨	⇨	⇨	⇨	
Jordan 135 MW trough	⇨	⇨ (RfP 2001)			
Nevada 64 MW trough	⇨	⇨	⇨	⇨ (February 2006)	Estimate March 2007
Portugal/Solar Heat and Power Pty Ltd, 5 MW with potential to upgrade to 50 MW, linear Fresnel	⇨	⇨			
Spain/ACS + SMAG, Andasol-1 50 MW trough	⇨	⇨	⇨ (June 2006)	Expected July 2006	Around late 2007
Spain/ACS + SMAG, Andasol-2 50 MW trough	⇨	⇨	2006	Expected 2006	Around early 2008
Spain/Abengoa, PS10 11 MW tower (saturated steam)	⇨	⇨	⇨	⇨	Estimate July 2006
Spain/SENER, Solar Tres 15 MW tower (molten salt)	⇨	⇨			
Spain/EHN+SolarGenix, 15 MW trough (HTF)	⇨	⇨			
Spain/Iberdrola, 7x50 MW Trough (HTF)	⇨	⇨			
Spain/HC, 2x50 MW Trough (HTF)	⇨	⇨			
Spain/Abengoa, 2x 20 MW Tower, 1x 50 MW Trough	⇨	⇨			
Spain/SMAG,50 MW ExtremaSol 1	⇨	⇨			
Spain/5 MW trough with direct steam generation (INDITEP)	⇨	⇨			
Spain/Solar Heat and Power Pty Ltd, 5 MW, Fresnel	⇨	⇨			
South Africa/100 MW Molten salt tower	⇨				

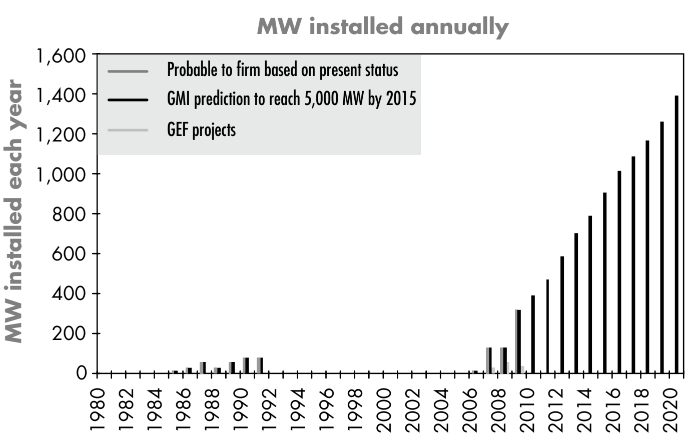
regulatory regimes, permitting requirements, performance warranties, risk factors, liabilities, and tender documentation.

There are today significant bankable projects emerging around the world (see Table 1).

The following plots can be established from Table 1. The projects considered „possible to firm" are those projects that are beyond the „consortia formed, ready to bid" stage, plus the GEF projects. Beyond those known projects, the best that can be done is predictive. Perhaps the most advanced long-term program presently in place that aims to progress CSP technology is the Global Market Initiative (GMI) (see Chapter 6, section 6.3).

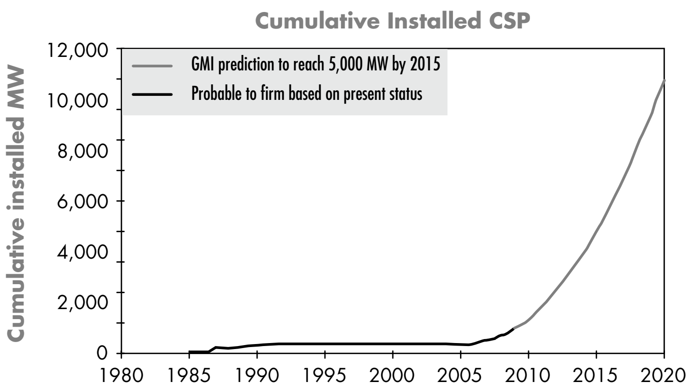
The objective of the GMI is to facilitate and expedite the building of 5,000 MWe of CSP worldwide over the next 10 years. This initiative represents the world's largest, coordinated action in history for the deployment of solar electricity. It aims to do this by, among other things, promoting the introduction of incentives and schemes in participating countries to provide the necessary framework for projects to proceed. This projection was also integrated into the plots, assuming linear growth in installed capacities up to 2015.

Figure 2: Short-term and possible medium- to long-term development of CSP technology worldwide (yearly installed MWe)



Source: Authors.

Figure 3: Short-term and possible medium- to long-term development of CSP technology worldwide (cumulative installed MWe)



Source: Authors.

Table 1 shows that over 700 MW of solar thermal projects are under differing degrees of development in Spain. This is a direct result of the new Royal Decree 436/2004, which provides the following:

- Grants same tariffs for PV and CSP from 100 kW to 50 MW.
- A premium on top of the electricity pool price of €0.18/kWh, which roughly equates to a total price of €0.21/kWh.
- Bankable with 25 year guarantee.
- Annual adaptation to electricity price escalation.
- 12 to 15 percent natural gas backup allowed to grant dispatchability and firm capacity.
- After implementation of first 200 MW, tariff will be revised for subsequent plants to achieve cost reduction.

Algeria has implemented a feed-in tariff that provides a premium of up to 200 percent (based on a scale linked to solar contribution) for CSP plants backed by natural gas. For example, if the solar share is greater than 25 percent, the price that would be received for all electricity generated by the plant would be three times the market price (see Algeria country sheet in Annex 1 for more detail). The introduction of this feed-in law has led to the development of the Algeria CSP project.

In the United States, the DoE has a goal to deploy significant CSP plants in the Southwest. This is known as the 1,000 MW CSP Southwest Initiative. In June 2004, the Western Governors' Association at their annual meeting in Santa Fe resolved to diversify their energy resources by developing 30 GW of clean energy in the West, including a declaration to "establish a stakeholder working group to develop options for consideration by the governors in furtherance of the 1,000 MW Initiative. The 64 MW Nevada plant is already under construction and the 1 MW Arizona ORC is producing electricity since April 2006.

The main conclusion from this project activity is that the WB/GEF portfolio is not evolving in isolation, but is part of increasingly interconnected developments in both OECD and developing countries that might trigger the take-off of the solar thermal technology. This nascent global solar thermal power market is evolving through programs and legal frameworks. The quick response of project developers to these market signals makes it clear the technology is ready to proceed.

2.2 Technological paths of Concentrating Solar Thermal Power plants

Like conventional power plants, a solar thermal power plant consists of a heat generating unit and a unit that converts heat into electricity. Whereas in conventional power plants the heat is being provided by burning fossil fuels or by nuclear decomposition processes, a solar thermal power plant uses large mirror fields to concentrate the sunlight onto a focal line (e.g. parabolic trough collectors) or a focal point (e.g. solar tower). Annex 2 provides an overview of solar collector technologies.

In this section, the technological developments and improvements will be described for the different collector technologies, and different power cycle integration variants will be presented and discussed.

2.2.1 Solar collector improvements

A number of important studies have been carried out recently that describe and evaluate the technical improvements of collector concepts and components, including Sargent and Lundy (2003), DLR and others (ECOSTAR, 2005), and Kearney and Price (forthcoming).

These studies have examined the cost reduction potential for solar thermal power plants that will result from technical innovations. Improvements of component and system efficiencies of CSP technologies and their potential cost reduction effect have been taken into consideration. Whereas the ECOSTAR study was carried out by European R&D institutions with the objective to set guidelines for public R&D funding for CSP technology and to streamline R&D efforts in the European countries, the Sargent and Lundy study has a more U.S.-like perspective and is primarily aimed at predicting future cost reduction of solar thermal power technology based on an engineering approach (as opposed to learning curve approaches; see Chapter 2, section 2.3.1). Kearney and Price have conducted a more detailed and specific analysis of the particular components contributing to a solar field.

The Sargent and Lundy study analyzes the parabolic trough and solar tower technologies, and bases its cost reduction forecasts on the existing cost and performance experience from the nine California trough plants (SEGS) and the two pilot tower plants (Solar One, Solar Two). In a long-term perspective, the study predicts lower costs for the tower technology.

The ECOSTAR study analyzes trough, tower, Fresnel, and dish technologies in different configurations. The objective of the ECOSTAR study is not to compare different technologies. It believes that market forces will decide if one technology will rule out other technologies. The objective of the study was to elaborate which technical improvements (materials, components, system integration) will lead to which cost reduction effect for each technological path.

The Sargent and Lundy study distinguishes the development goals according to technical improvements that have already been realized over the last decade due to continuous R&D in CSP, and future technical development forecasts until 2020. The main technical improvements as seen by Sargent and Lundy are given in Table 3.

Table 2: ECOSTAR study – cost reduction potentials due to technical improvements

Parabolic Trough [1]	Tower	Linear Fresnel [2]	Dish [3]
Innovative structures (up to 28 percent)	Larger heliostats above 200 m^2 (up to 12 percent)	Linear Fresnel collector field (up to 3 percent)	Mass production for 50 MW (38 percent)
Front surface mirrors (up to 19 percent)	Larger module size (up to 15 percent)	Thermal storage (up to 15 percent)	Brayton instead of Stirling cycle (up to 12 percent)
Advanced storage (up to 18 percent)	Ganged heliostats (up to 8 percent)	Reduced pressure losses (up to 7 percent)	Improved availability and O&M (up to 11 percent)
Reduced pressure losses (up to 16 percent)	Advanced storage (up to 10 percent)	Dust repellent mirrors (up to 7 percent)	Increased unit size (up to 9 percent)
Dust repellent mirrors (up to 16 percent)		Increased fluid temperature (up to 6 percent)	Reduced engine costs (up to 6 percent)
Increased solar field outlet temperature (up to 15 percent)			Increased engine efficiency (up to 6 percent)

[1] with thermal oil as heat transfer fluid and direct steam generation (DSG)
[2] reference: Trough with DSG
[3] parabolic dish concentrators in combination with a Stirling engine today realize the highest LEC compared to the other collector concepts.

Source: Authors based on DLR and others (2005).

Table 3: Sargent and Lundy—technical improvements for the trough and the tower technology

Parabolic Trough[1]	Tower[2]
Receiver coating (solar absorptance, infrared/heat irradiance)	Increasing heliostat size (up to 148 m^2)
Receiver glass envelope transmittance	New primary mirror technology with thin glass or thin films
New front surface reflectors	Cost-effective support structure
Receiver reliability	Self-cleaning glass
Reduced parasitics (SF pumping etc.)	Drives for mirror tracking
Heat storage (up to 12 hrs)	Solar flux monitoring in the receiver
Solar field support structure (main solar field cost driver)	Improved receiver design
Higher operating temperature (up to 500°C)	Reduced start-up time and improved operation strategies
Self-cleaning glass	Improved heat transfer fluid and storage
Larger plant sizes	Larger plant sizes
Reduced operation and maintenance costs	Reduced operation and maintenance costs

[1] with thermal oil as heat transfer fluid. No direct steam generation (DSG) considered
[2] only molten salt technology considered.

Source: Authors based on Sargent and Lundy (2003).

The drawback of cost forecasts based on the assessment of future technological innovations and improvements is the fact that only today's technological know-how can be considered. New technological trends may come up and replace a current technology. In this context, Fresnel collectors as a technological simplification of parabolic trough plants are not considered in the S&L study, nor are other receiver technologies in the tower technology like the pressurized air receiver, which in the future might produce lower LEC due to very high solar efficiencies (thus smaller solar fields) by feeding the solar heat directly into a gas turbine.

Besides the difficulty of predicting long-term technological paths, it is not clear which technologies will be accepted by the market; that is, whether investors will progressively implement technical innovations or be more prudent and use proven technology. In Chapter 2 (section 2.3.2), the CSP cost reduction potential will be analyzed applying the learning curve concept.

2.2.2 Power Cycle integration concepts

The heat generated in the solar absorbers is subsequently used for electric power generation. In this section, different concepts for the integration of solar collectors into conventional power cycles are presented. On the technical side, the difference between these concepts is the collector integration within the thermodynamic cycle and the degree of hybridization with fossil power generation (the solar share). From a strategic point of view, each concept is suitable for different goals, such as market introduction of solar collector technologies or long-term options. The different concepts for collector usage can be subdivided into the following categories:

Solar Live Steam in hybrid Rankine plants (Option 1)

In this arrangement, the solar field provides superheated steam for use in a Rankine cycle. These plants can be operated in hybrid mode with any type of steam plant for fuel saving. Depending on plant operation mode and solar field size, the solar share of such hybrid systems can vary over a wide range. The SEGS plants in California are examples of this configuration (they are able to use up to 25 percent natural gas). Coupling a solar field with a conventional coal-fired power plant can lead to even higher environmental benefits, because a carbon-intensive fuel being converted at relatively low efficiencies (compared to a CC plant) can be saved whenever solar steam is available.

"Solar-Only" Rankine plant (Option 2)

A "solar-only" Rankine plant has the same underlying power-block concept as the hybrid Rankine plant, but without a fossil-fuel steam generator. It is noted that there may be an argument for small levels of fossil back-up used only for keeping the turbines available for a "hot start" following short insolation reductions and for pre-heating prior to start-up. Preferably, such plants would be equipped with heat storage of a few to several hours in order to increase the full load operating hours of the plant. Storage can not only lead to lower electricity generation costs, but improved dispatchability, which provides benefits to the grid. Although this concept is environmentally the most desirable plant configuration, storage costs need to be reduced further.

Solar Gas turbine combined cycle (Option 3)

Due to the high concentration factors, solar towers (central receivers) and dishes can produce very high temperatures (above 1,000°C) for use directly in gas turbines or to complement the gas turbine combustion chamber. This offers the possibility of a solar-driven combined-cycle with correspondingly high efficiencies. In the medium to long term, this technology has very promising prospects because of the high efficiencies and the related savings in solar field investment.

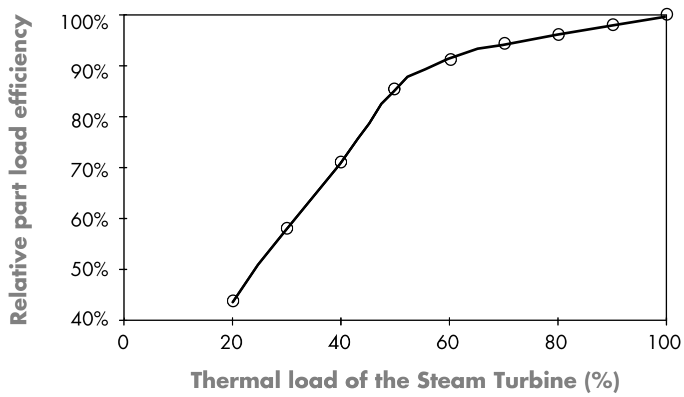
Combined Heat and Power solar plant (Option 4)

Similar to conventional combined heat and power, in this option a solar thermal electricity plant is combined with a lower temperature thermal application such as sea water desalination or air conditioning. Co-firing is also possible. Due to the double use of the solar heat for power and heat generation, total efficiencies of up to 80 percent can be achieved. Generally, any kind of thermal power plant (also CC, ISCCS, or fossil steam plants) can in general be designed such that subsequent heat-driven processes can benefit from the plant's waste heat. In order to supply reasonable temperatures to these processes, a certain power drop on the electric power side has to be accepted. In the long run, this concept will be a very attractive solution where cooling applications are beneficial (e.g. in hotels) and especially for locations where drinking water is scarce—a problem many hot countries are suffering from, and which in many cases will be further exacerbated by global warming.

Integrated solar combined cycle (ISCC) (Option 5)

The Integrated Solar Combined Cycle System (ISCC) was initially proposed as a way of integrating a parabolic trough solar plant with modern combined-cycle power plants. The basis of this plant type is a combined cycle plant consisting of a high-temperature gas turbine and a bottoming steam turbine. The steam for the steam turbine in an ISCCS plant is provided by two heat sources: the heat recovery steam generator using the exhaust gas of the gas turbine and the solar field. It is important to note that in this configuration the solar is used at the steam turbine cycle efficiency, not the higher combined cycle efficiency as with Option 3. The size of the steam turbine in an ISCCS is larger than it would be in a conventional combined cycle.

FIGURE 4: EXAMPLE OF PART LOAD BEHAVIOR OF A STEAM TURBINE



Source: E.ON Engineering (modified original data).

The three main advantages of this concept are:

- higher solar shares than in solar feed water preheating
- no solar energy losses due to daily plant start-up and shut-down
- the incremental costs for a larger steam turbine are less than the overall unit cost in a solar-only plant.

The main drawback of the technology is the part load losses during operating hours when there is no solar energy input (see Figure 4). Therefore the interdependencies of steam turbine oversizing, steam turbine part-load behavior, solar field size, solar irradiance, plant site, plant operation mode, and possibly solar heat storage or duct burner have to be carefully considered in a project-specific overall system analysis in order to ensure that the solar field will provide its full economic and environmental benefits.

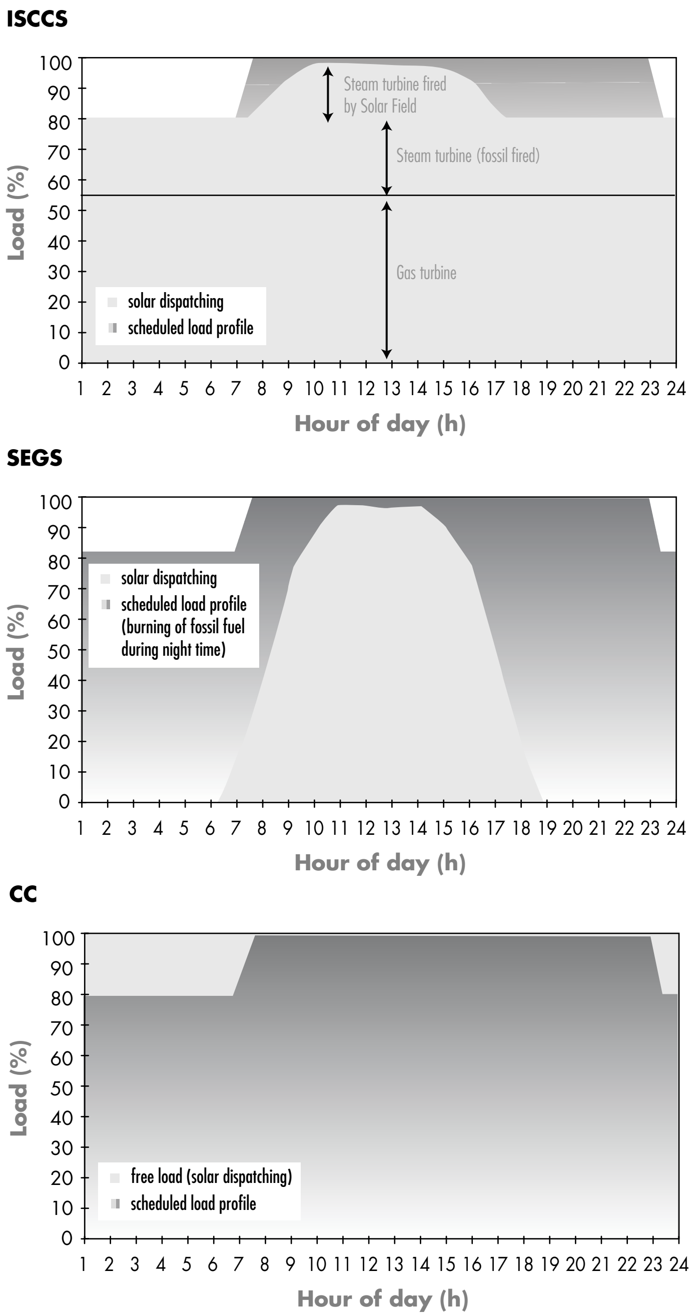
Solar Feed Water Preheating (Option 6)

In this option, solar thermal heat is used for preheating feed-water in large-scale conventional Rankine plants, substituting steam that would otherwise be bled from the turbine. Additional electricity can be generated, or fossil fuel saved, depending on the operation mode. This concept is well-suited for market introduction of new collector types, since it reduces the risk by lowering the investment costs that would otherwise be needed for a new steam cycle (approximately $10 million for a 5–10 MWe solar field). Further advantages are the possibility of using existing plant infrastructure and good solar heat conversion efficiencies from solar irradiation to net solar electricity (Morin and others, 2004). The solar field can also be installed in phases. The drawbacks include its small solar share (around 1 percent), which is why this concept is only attractive for market introduction.

Solar Process Heat Applications (Option 7)

The slow pace of CSP market introduction is mainly related to the very large investments related to this type of renewable energy technology. Solar process heat applications are one way to lower this hurdle, since the initial investment will decrease by a factor of 10 to100. Typical process heat applications are in the range of 200–1,000 kWth for the cooling of buildings or refrigerators. CHP applications are a wise market introduction strategy for new collector types and suppliers, since such applications can be considered as the first step toward large-scale solar thermal power applications. This concept might be attractive to the GEF and the

Figure 5: Load curves used for the annual performance calculation[2]



Source: Dersch et al. (2002).

[2] For the scheduled load: if no solar energy is available the fossil back-up-burner is used (ISCCS and SEGS plant). In the solar dispatching mode no fossil back-up is used.

World Bank if future CSP funding sources significantly decrease. By promoting such projects, WB/GEF could spur the competition in the CSP sector, because under current conditions (e.g. in Spain) it is very difficult for any new players to enter the CSP market.

These concepts will be further discussed and compared in section 2.2.4.

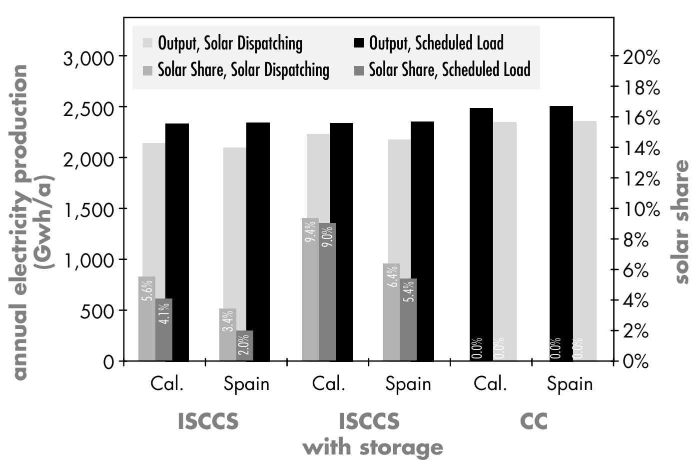
2.2.3 ISCCS—evaluation of performance, cost, and CO_2 benefits

The ISCCS concept has been of interest to the solar community for some time, and has been the subject of a number of studies (Stein, 2000; Dersch, 2002). In 2002, the International Energy Agency's SolarPACES implementing agreement carried out a study (Dersch et al., 2002) on thermodynamic modeling of ISCCS plants in comparison with combined cycle as well as SEGS-type (hybrid) plants in order to evaluate the performance, cost, and CO_2 effects of the ISCCS concept. Its main results are presented here.

Assumptions

A base solar field size corresponding to a 50 MW SEGS plant in Barstow, California, was used for the calculations (270,000 m^2).

Figure 6: Results of annual performance calculation for ISCCS and CC



Source: Dersch et al. (2002).

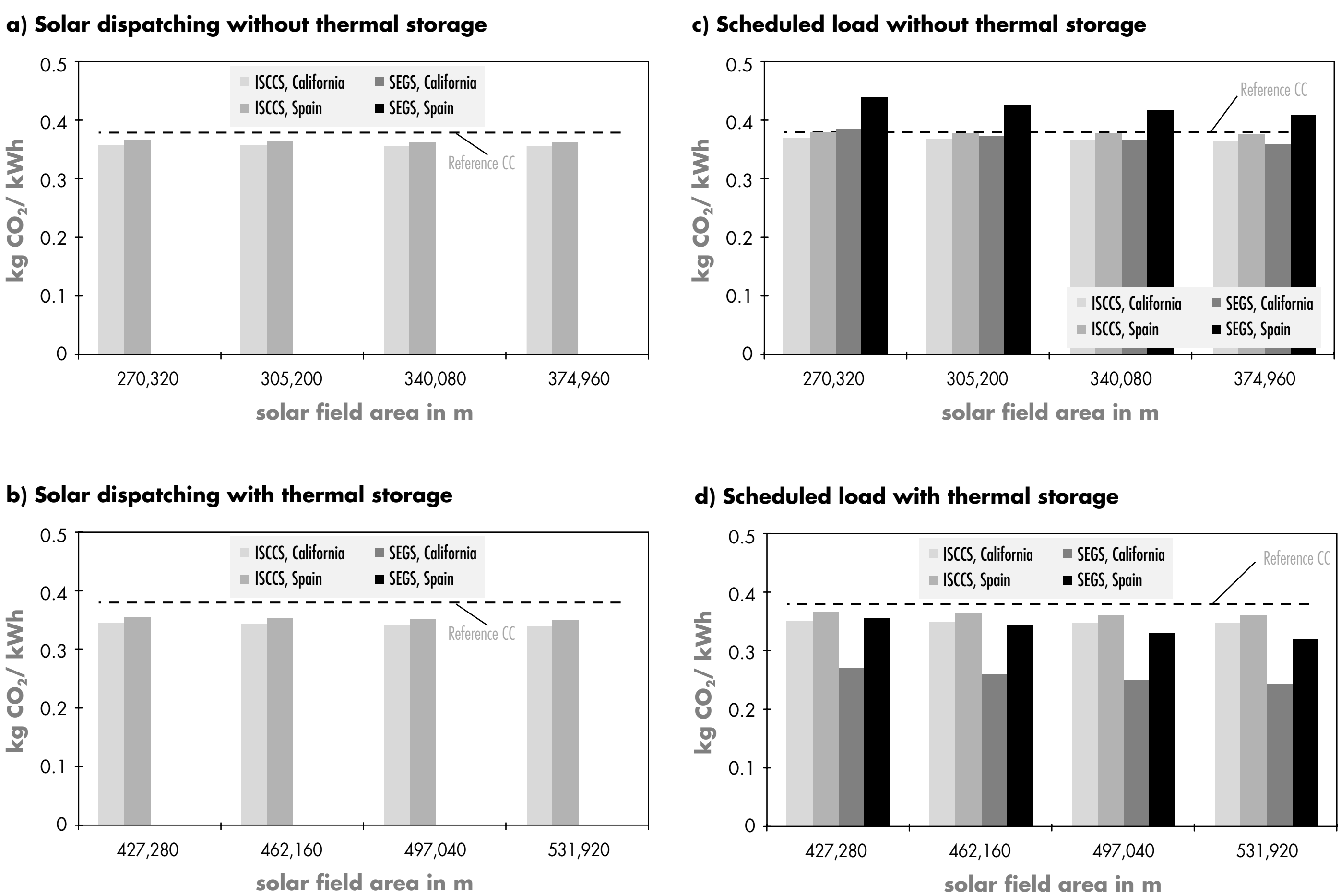
The load curves of all plants were assumed to be identical in the first scenario. The second scenario considered solar dispatching load (see Figure 5). All three investigated plant concepts are sized such that the annual electricity output remains the same for the scheduled operation. As a consequence, the sizing of the gas and steam turbine capacities are different for the pure CC and the ISCCS plant (CC: GT has 201 MW, ST has 109 MW; ISCCS: GT has 162 MW, ST has 148 MW). The calculations have been carried out for a site in Spain (DNI: 2,023 kWh/(m^2a)) and the Californian site in Barstow (DNI: 2,717 kWh/(m^2a).

Results

The main results of the annual electricity calculations were that without solar heat storage the solar share ranges between two and six percent depending on plant site and operation mode (solar dispatching or scheduled load). With storage, the solar share can be increased up to almost 10 percent.

Figure 7 shows CO_2 emissions of all analyzed plant concepts. All analyzed ISCCS concepts (regardless of sites, storage, duct

Figure 7: Specific CO_2 emissions for different sites, plant configurations, operation modes and solar field sizes



Source: Dersch et al. (2002).

burning, load scheduling) show lower CO_2 emissions than the reference CC plant. However, the CO_2 emission difference of an ISCCS plant compared to a CC plant is small due to the relatively small contribution of the solar field. The calculations were carried out under the same constraints, including the use of a reference plant site. Different ambient conditions can have a considerable impact on the total plant performance.

Lower ambient humidity, higher ambient temperature, and the use of dry cooling instead of wet cooling (if sufficient cooling water was unavailable) lead to a decrease of the total plant efficiency such that the beneficial solar impact can be outweighed by the less favorable plant site conditions. A poor site or poorly designed plant can result in higher CO_2 emissions from the ISCCS plant than from a pure CC plant. Lower ambient pressure (due to higher altitude) also has a negative effect on the total plant output, but the plant efficiency and thereby the CO_2 emissions will not be negatively affected.

In this study, the calculated performance of the SEGS plants show that when operated under load scheduling mode, the specific CO_2 emissions rise because of the use of gas in a lower efficiency steam cycle. However this modeling was carried out merely for the purposes of illustrating a point in the study concerning operational modes under similar constraints. In practice, a SEGS plant with gas co-firing would under real conditions not be used for 24 hour-operation. Intermediate load operation or solar dispatching mode would considerably improve the CO_2.balance of the SEGS concept. When operated in solar dispatching mode, the SEGS plants of course show zero CO_2 emissions.

In most cases, the ISCCS configurations showed lower LEC than the SEGS plants (under comparable economic constraints[3], see Figure 8). The reason for this is that the incremental cost of a larger steam turbine is much lower than building a stand-alone power block for a SEGS plant.

2.2.4 Summary—technological paths

The description of collector innovations (in section 2.2.1) is intended to provide an insight into CSP technology developments and to provide a basis for the technology-related cost reduction forecasts that contribute significantly to overall cost reduction. According to Sargent and Lundy (2003), 54 percent of the future CSP cost reduction is attributable to technological innovations, with the balance attributable to plant scale-up and increasing production volume. It is not the intention to pick the winning technology or development path.

Looking at the potential of the different power cycle integration concepts (sections 2.2.2 and 2.2.3), in the mid- to long term, higher solar shares are obtained via the options where solar heat directly drives a turbine (options 1, 2, 3, and 4). Even if the plants are designed for hybrid operation, the solar share can be increased later during the plant's lifetime, e.g. when collector costs will have decreased or fuel prices increase.

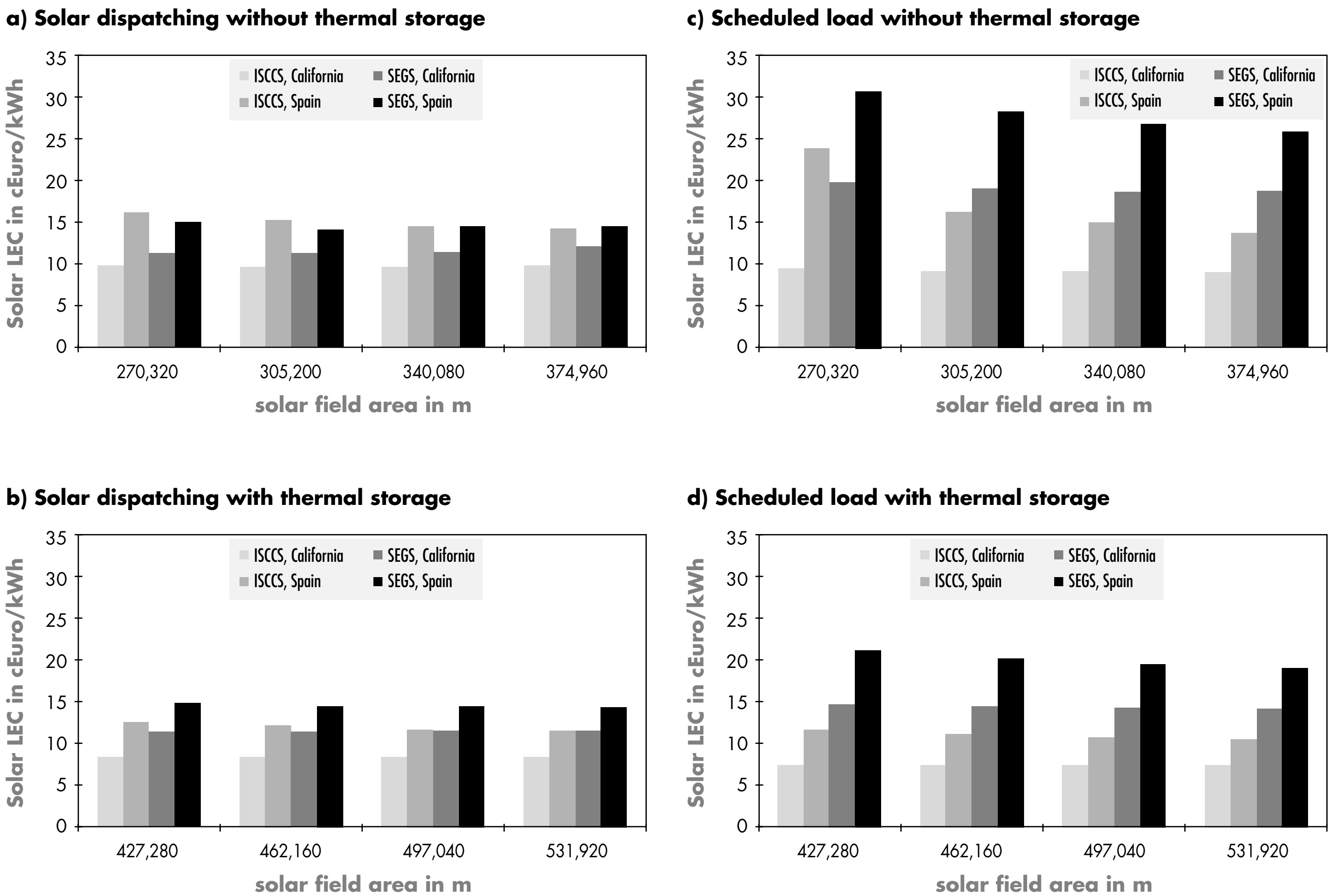
From a longer-term perspective, the solar contribution of the ISCC (and solar feed water preheating) cannot be extended beyond a certain level. However, as long as countries build fossil CC or Rankine plants anyway, equipping these plants with a solar field is a significant contribution to GHG emission reduction. On the one hand ISCCS and solar feed-water preheating are well-suited for market introduction of new solar collectors because the additional marginal investment for the conventional plant components is relatively low (or zero). There are also areas of overlap, and thus cost reduction potential, with the plant infrastructure and project implementation costs. For developing countries especially, where the primary need is electricity (not necessarily green electricity), the combination of solar energy together with a large-scale fossil power plant can, in the technology introduction stages, be much more attractive than stand-alone solar plants. ISCCS is a good configuration for creating experience with the CSP technology under the same operating conditions as in solar-only plants.

2.3 Cost reduction comparison of CSP technology

The aim of any electricity producing technology must be to realize competitive electricity generation costs. Several studies have ex-

[3] Constant real discount rate: 6.5 percent, plant lifetime: 25 years, fuel price 1.26 USc/kWh, annual fuel price escalation: 2 percent, annual inflation 2.5 percent, SF + heat exchanger \$220/m^2, CC specific investment cost: \$550/kW, additional power block costs due to SF: \$600/kW.

FIGURE 8: SOLAR LEC FOR DIFFERENT SIZES, PLANT CONFIGURATIONS, OPERATION MODES AND SOLAR FIELD AREAS



Source: Dersch et al. (2002).

amined the future cost reduction potentials for solar thermal power generation technology. The most important studies in this context are Enermodal (1999), DLR (2004), Sargent and Lundy (2003), DLR and others (2005), and Kearney and Price.

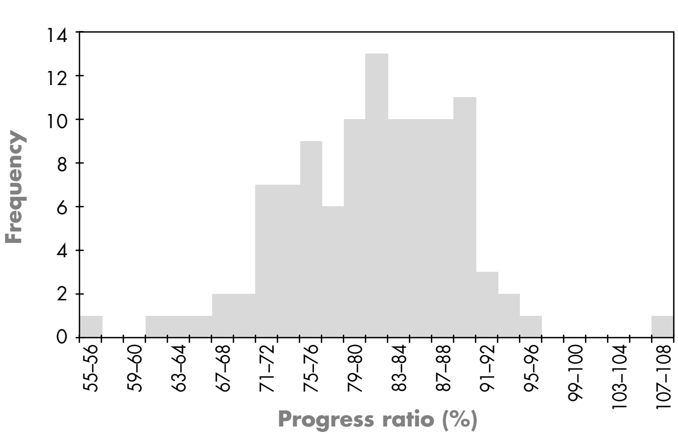
Whereas section 2.2.1 the studies using engineering approaches were discussed, this section evaluates the studies applying the learning curve concept.

The experience curve approach developed by T.P. Wright (1936) and the Boston Consulting Group (1960) assumes that each doubling of the cumulated production of any kind of product results in a specific cost reduction by a so-called learning factor (typically 20 to 30 percent).

The progress ratios[4] of a large variety of products from the electronics, mechanical engineering, paper, steel, aviation, and automotive sectors were analyzed in a study by the IEA (2000):

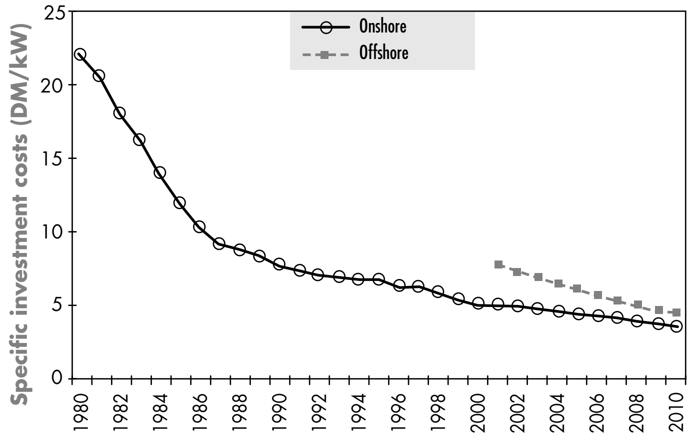
[4] The progress ratio r is defined as the complementary to the learning factor l, that is: r=100 percent-l

Figure 9: Progress ratio for different producing branches. The height of the columns reflects the number of occurrences (distribution)



Source: OECD/IEA, 2000, Experience Curves for Energy Technology Policy, Figure 1.3, p. 14.

Figure 10: Specific investment costs of wind energy converters over time



Source: Ragwitz (2005).

2.3.1 Cost reduction and growth rates of other renewable energy technologies

In order to narrow down the perspective from general technology cost reduction to renewable energy technologies, wind energy and photovoltaics are analyzed with respect to two main implicit assumptions of learning curves: (1) the specific cost reduction; and (2) market development.

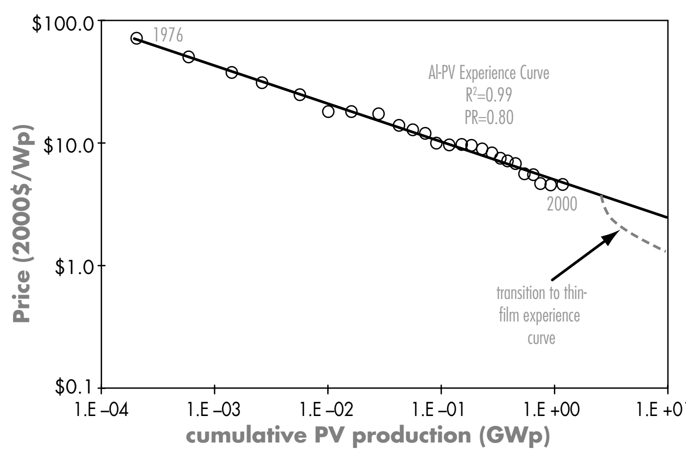
The next two graphs show the specific cost reduction curves experienced by wind energy converters and photovoltaics.

The next two graphs show the experienced market growth for wind energy converters and photovoltaics:

2.3.2 Experience curve concept applied to Solar Thermal Power Generation

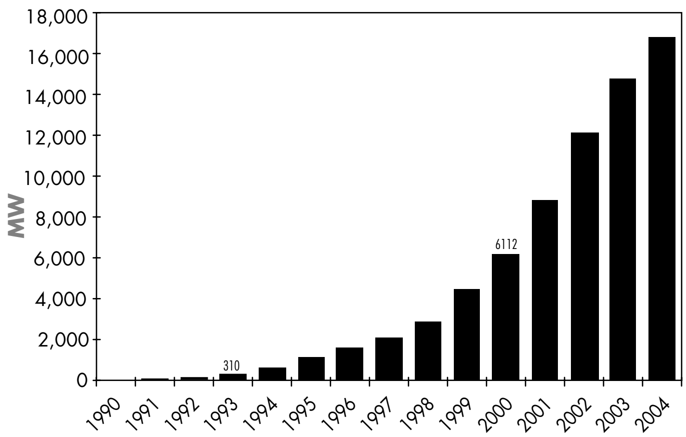
Of the above-mentioned studies, the Enermodal study and the Athene model use experience curve approaches to assess the future costs of solar thermal power generation.

Figure 11: Specific investment costs of photovoltaics (in Dollar per watt peak power) as a function of cumulative production volume (in gigawatt peak power GWp)



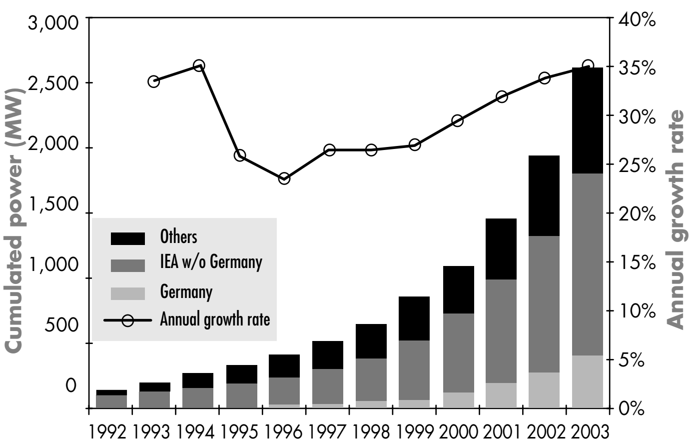
Source: Duke (2002).

Figure 12: Development of installed wind capacity in Germany



Source: BMU (2004).

Figure 13: Development of the worldwide installed PV capacity and annual growth rate

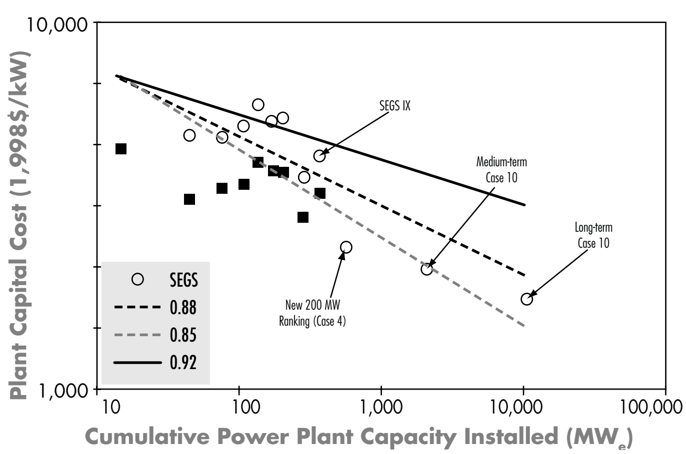


Source: Quaschning (2004).

Enermodal (1999): Cost Reduction Study for Solar Thermal Power Plants

The Enermodal study uses the specific investment costs per installed capacity ($/kW) as a reference measure. This reference number does not seem appropriate to forecast cost reduction for solar thermal power plants because larger solar fields in combination with heat storage can lead to lower levelized electricity costs due to a higher plant capacity factor, even though the specific investment costs increase. The second point of note in the approach used by the Enermodal study is the fact that it uses the cost of the first plant out of the nine existing parabolic trough plants as the starting point of the learning curve instead of using a linear regression function of all reference plants (see Figure 14). Therefore the cost of the first plant determines strongly the cost forecast for future technology deployment. The third point of note in the methodology is the fact that the numbers used for the experience curve differ strongly from the numbers given in the text, which correspond exactly to the values given in the Pilkington study (1996).

Figure 14: Enermodal Study—Experience curves for different assumptions on the progress ratio (red crosses represent values given in the text of the studies for the nine Californian SEGS plants)



Source: Enermodal (1999): Cost Reduction Study for Solar Thermal Power Plants.

DLR (2004): Scenario model "Athene"

This study assumes as a starting point the empirical values from the existing parabolic trough plants. But for the future cost reductions, it is explicitly mentioned that all solar thermal power technologies are included. Technological variants and improvements as well as competition are essential preconditions of the experience curve model.

Cost reduction in this study is split into four categories:

- Improving efficiency (from 13.2 percent today to 17.0 percent in 2025)
- Learning effects due to volume production
  - collector costs, surface-specific progress ration (PR) is 0.9
  - thermal energy storage (up to 12 hrs), capacity-specific PR=0.88
  - steam cycle components from 850 €/kW down to today's conventional plant costs of 740 €/kW, PR=0.94
- Economies of scale due to larger units (up to 200 MWe): doubling capacity leads to 15 percent cost reduction
- The annual operation and maintenance costs will decrease proportionally to the reduction of investment costs (2.5 percent of investment).

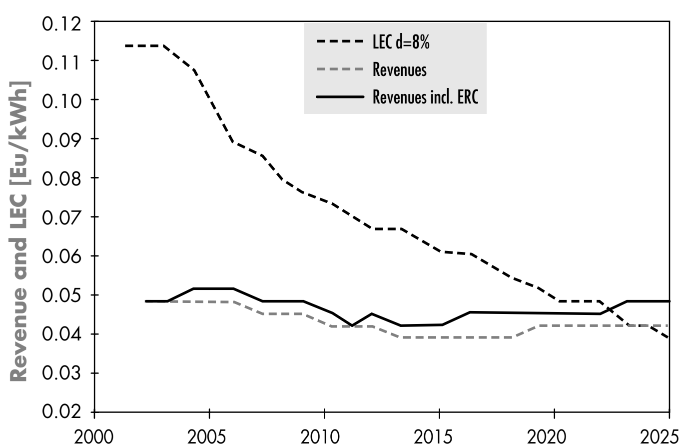
Further assumptions of this model are:

- No CO_2-allowances considered, respectively carbon price increasing from initially 7.5€/t CO_2 to 30€/t CO_2 in 2050
- Plant life time: 25 years
- Internal plant project interest rate: 8 percent (in real terms)
- Solar Resource DNI=2350 kWh/(m^2a) (favorable sites for solar thermal power generation range between 1,800 and 2,900 kWh/(m^2a).
- Market growth of 23 percent p.a. (IEA references: wind (1971–2000) 52 percent p.a., PV 32 percent), (implementation of 5,000 MW till 2015 corresponds to GMI goal).
- Fossil Reference LEC (IEA) with same number of annual operating hours as STPPs
- Fuel prices increasing by 0.52 percent p.a. (IEA)

As a result of the assumptions given above, the cost reduction forecasts of the Athene study are given in the following graph:

According to the Athene study, the cost competitiveness of solar thermal power generation will be reached in 2025. The total necessary subsidies account to 12 billion €, which corresponds to a total installed capacity of 42 GW_e, not taking into account CO_2 trading. If the above-mentioned carbon prices are included, cost competitiveness will be reached in 2023. The total necessary

Figure 15: Development of levelized electricity costs and revenues from the power exchange market referred to by LEC of fossil power plants (plant project interest rate 8 percent)



Source: Economic model from DLR (2004), authors'assumptions.

Note: The continuous line includes Emission Reduction Credits (ERC) of initially 7.5€/t CO_2 increasing to 30€/t CO_2 in 2050.

investment will thereby be significantly reduced to €2.5 billion, respectively 22 GW_e.

The implicit assumption is that the number of full-load hours is constantly increased due to larger thermal energy storages (see also the "steps" in fossil reference price) up to 6,500 hours per annum (12 hours thermal storage). However, in some cases it may be more economical to aim at producing only peaking to mid-load-power for the period when power tariffs on the electricity market are highest (smaller energy storage), which in turn could justify lower thermal storage.

The Athene model is a very thorough assessment using many validation points from experienced facts and developments. The assumptions used are generally conservative. In this context, the Athene scenario may be considered as a very conservative scenario for CSP cost and market development.

2.3.3 Cost Reduction—Summary

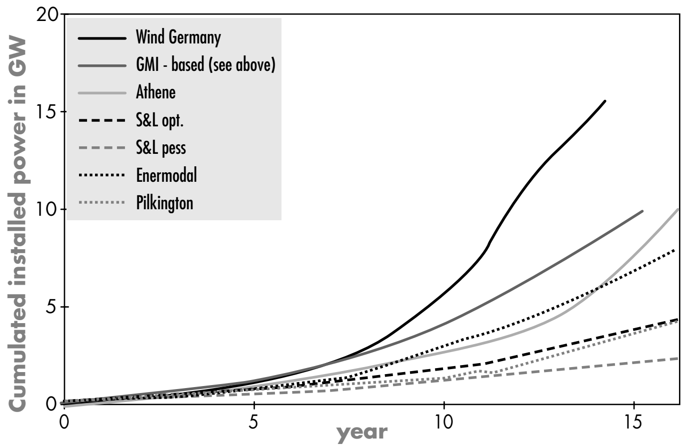
All studies referenced, including the GMI-based market development in Chapter 2 (section 2.1), assumed a conservative global CSP market development compared to the actual deployment of wind energy, even in a single country (Germany).[5] It has to be stated as well that many of the countries in the world's sunbelts lack the financial resources to finance solar energy. With present global CSP market movements re-emerging, there is no fundamental reason why technology growth similar to wind energy is not feasible.[6]

The main messages from the comparison of cost projection studies are:

- The technology has the potential to be cost-competitive within 10 to 25 years, and has the potential to be a significant electrical power option for developing countries, which often have abundant solar resources. With hybridization and thermal energy storage, solar thermal power is dispatchable power that helps to support grid stability.

- Should GEF promote CSP investments now in developing countries and not once the technology has moved further down the learning curve?

FIGURE 16: COMPARISON OF THE DIFFERENT MARKET DEVELOPMENT ASSUMPTIONS OF THE CSP STUDIES IN COMPARISON WITH THE GERMAN WIND MARKET DEVELOPMENT AND THE GMI-GOAL (TARGET OF CUMULATIVE INSTALLED POWER OF 5 GW IN 10 YEARS TO ACHIEVE COST-COMPETITIVENESS)



Source: Authors.

The GEF projects will contribute to OP 7's goal of "reducing the long-term costs of low greenhouse gas-emitting energy technologies" if at least two or three are successfully deployed and operated. However, the projects in the current portfolio will not have a significant cost-reduction impact on the underlying cost of the technology. It is difficult to quantify the cost reduction effect of the four projects: In the beginning of the portfolio's history, it seemed that it would be one of the GEF plants that would be the first to be built after the California SEGS plants. However today, with other commercial CSP activities evolving, other projects

[5] Another comparison basis of the necessary effort would be the required subsidies on the basis of the reference LEC by correcting the GW-numbers by the specific investment ($/kW), equivalent full-load hours (h/a), and O&M costs ($/a). The result would remain in the same order of magnitude.

[6] In this context it has to be mentioned that the global wind market corresponds to approximately three times the German installations.

will come in first. Therefore the question is, which part of the cost reduction curve will the GEF projects influence? In theory, the cost reduction effect will be largest for the first plants built. In practice, much of the early cost reduction will result from a reduction of the risk premium as design, construction, and O&M experience is gained. The developing countries in particular experience an additional premium due to the perceived added difficulties of carrying out large projects using new technology. This is another cost reduction area that the GEF projects can impact in a positive manner.

Affordable technology and climate protection are goals officially supported by many developing countries with good solar resources. In order to meet these goals, GEF and the World Bank should support the implementation of climate-protecting renewable energy in developing countries. Whereas the OECD countries can afford subsidizing power technologies on a large scale, developing countries usually are not able to do so. By supporting the implementation of the first CSP pilot plants, WB/GEF will help create technology trust and institutional learning and thereby reduce the hurdle for subsequent market entry. The solar fields of solar thermal power plants contain many components that can be locally manufactured, such as concrete foundations or standard steel components or, depending on the solar technology and the project country, mirrors. Last, but not least, the erection of the plants—as well as operation and maintenance—represent sustainable development aid through job creation. These macroeconomic aspects of value creation in the countries of destination are not considered in the above cost studies.

3
CSP Risk Analysis

This chapter assesses risks in the project design of the WB/GEF portfolio and discusses adequate risk mitigation measures. This assessment includes:

- Technological performance risk
- Financial/commercial risks
- Regulatory/institutional risks
- Strategy risks

The different risks relate either directly to the different projects in the four GEF countries or more indirectly via the technology choices, the business model, and the institutional settings made for the portfolio.

The last group of risks concern the medium- and long-term consequences of the choices made for the current portfolio, such as the choice of the ISCCS concept for all four projects in the portfolio.

The risks are evaluated in a qualitative way by presenting their main impacts. In addition, they are also evaluated in a semi-quantitative way by categorizing them according to the following characteristics:

♦: low risk

■: medium risk

✸: high risk

In the final section of this chapter, an aggregate assessment of the risks is provided for the four risk groups mentioned above. This table also shows the main level at which the risk operates: project success, WB/GEF program success, and global technology evolution.

3.1: Technological risks related to the WB/GEF portfolio

	Risk		Valuation	Mitigation
1.	Non-optimal choice of location	■	❑ If the hybrid plant site is to be adapted for a solar field, risk results from additional costs (e.g. constructing gas pipeline) or a drop in total plant electricity due to poorer plant cooling, reduced air density at higher locations, or hotter sites (lower gas turbine output). As a consequence, these electricity losses may outweigh the energy yield of the solar field.	❑ This risk can be mitigated by careful plant and site evaluation. ❑ To a certain degree additional costs can be justified by the market introduction of a technology (gaining experience in technology, institutions, industry, O&M are considered to be superior goals).
		■	❑ Morocco: good insolation levels. Losses in power plant output due to height of location (900 m). Infrastructure for water/natural gas available.	❑ India: examine other revenue streams for potential use of the gas pipeline. Investigate nearby recent oil discovery for gas. Investigate alternative nearby locations.
		♦	❑ Egypt: good insolation levels. Infrastructure for water/natural gas and transmission is available	
		♦	❑ Mexico: the two currently discussed plant sites in Sonora offer ideal conditions for the solar field.	
		✸	❑ India: flat site and transmission available. Some infra-structural work needed to provide water. Current non-availability of gas infrastructure (gas pipeline). Reasonable insolation levels.	
2.	Environmental benefit low or non-existing due to the ISCCS concept	■	❑ The CO_2 emission reduction actually achieved is rather low compared to a combined cycle reference: 5 to 10 percent solar share in the overall production; decreased efficiency of the steam generator.	❑ Not very important issue at the current stage of early market introduction. However, once detailed project design is known, detailed environmental calculations should evaluate weaknesses (including sensitivity calculations for non-optimized plant operation).
3.	Insufficient experience with CSP technology	♦	❑ Key technologies most likely to be used for the WB/GEF portfolio (solar trough technology, combined cycle, no thermal storage) are very well known and have a long track record (only concerning operation, however, not new construction and development). ❑ Parabolic reflectors have been tracing the sun for 20 years at the Californian SEGS plants (from 1986 to 2005 they have generated nearly 13 TWh). ❑ Steam cycle is conventional Rankine cycle. ❑ Heat exchanger is the interface between solar field and combined cycle –> proven technology).	❑ Analyzing on-field efficiency etc. in order to convince investors of the technical feasibility (e.g. 4,360 m^2 test loop SKAL-ET at Kramer Junction in California to convince the Spanish company ACS to invest in the AndaSol 1 and 2 plants in Spain). ❑ Secure valid warranties from manufacturers and EPC (in practice one of the most critical points in real project development).
4.	Thermal storage new and non-experienced technology in the required size	■	❑ Most likely no storage in any of the WB/GEF plants, although for the Indian project a bonus was to be awarded for a thermal storage proposal. ❑ Thermal storage known in chemistry and in smaller dimensions from the "Solar Two" project (power tower in the U.S.).	❑ Thermal storage can improve the efficiency and the solar share of the ISCCS. Storage technology based on molten salt (7.5 hours) is part of the new Andasol 1 and 2 plants ((2x50 MW) starting operation in Spain in 2006/2007. ❑ Another layout with an extra steam turbine or buffer heat storage may be worth analyzing.

5.	Problems arising at the technical interface between the solar component and the fossil component	♦	❑ The WB/GEF plants would be the first ISCCS plants; the Spanish plants (maximum 15 percent solar) as well as possible plants in the US are not ISCCS plants.	❑ Interface occurs at the steam generator in a standard configuration through a heat exchanger. Major complications are unlikely.
		■	❑ In the ISCCS, determining the exact electrical contribution (gas or solar) is quite complex. Especially in the shared responsibility model (solar field – CC), responsibility questions might arise if the plant does not meet its forecasted output.	❑ One method is to determine the actual (rather than design) performance during commissioning tests, so that an accurate set of offset curves can be generated for each off-design parameter (such as ambient temp., relative humidity, steam inlet conditions, condenser pressure, etc). Any additional MW generated above the calculated output at a given set of conditions is attributable to the solar field.
		■	❑ Power plants degrade over time, heat exchanger fouling coefficients increase over time, operational parameters change over time, such as feed water heaters going out of service.	❑ There are probably enough periods of time when the solar field is not contributing (night, clouds), to be able to periodically reconfirm the CC performance.
6.	Non-optimized operation of the ISCCS plant	■	❑ Possible in the case of Egypt given the fact that there will be no turnkey supplier but two separate suppliers for the solar and the fossil parts.	❑ The solar portion will be done through one stage bidding while the CC portion will be done in two stages. The selected bidder and its design for the solar portion will feed into the second stage of bidding for the CC portion as a way to ensure that the interface is optimized. In addition, a consultant will be hired to ensure that the design and implementation of the project as a whole will run smoothly, especially when it comes to the interface.
7.	Complete failure of the solar plant	♦	❑ Complete failure of the solar field might occur at several points during construction (e.g. due to bankruptcy of the solar supplier) or during operation (e.g. due to damage to the mirrors by hail etc., but this is unlikely).	❑ In order to cope with non-compliance in power purchasing agreements, the gap must be made up by firing a duct burner to avoid penalties. The duct burner (also called supplementary firing) is a well-known addition to combined cycles, enabling a boost during periods of high electricity prices. Given the fact that the solar share is small, the loss is limited. Without a power purchasing agreement, there would only be a commercial loss. If there is a single plant owner, the attributable loss would be calculated for accounting purposes more than penalty purposes.

3.2: Financial/commercial risks related to the WB/GEF portfolio

	Risk		Valuation	Mitigation
8.	Low interest in bidding by industry	✸	❑ In case bidding conditions are too restrictive and unattractive to companies, the industry response to the call for bids might be very limited (e.g. India, Mexico in the first round).	❑ Greater integration of industry in the bidding process, both CC and solar suppliers.
9.	Insufficient financing secured for the WB/GEF projects	♦	❑ Morocco: preferential loan from the ADB, the GEF grant and equity from ONE should fully cover the financing required. An unresolved issue is how to compensate the power loss due to a sub-optimal plant site, possibly by smaller dimensioning of the solar field so that the excess costs due to the solar field are fully covered by the GEF grant.	❑ Downward adjustment of the required solar capacity in case of cost over-runs during the bidding procedure.

(continued on next page)

	Risk		Valuation	Mitigation
		♦	❑ Egypt: Financing settled so far by JBIC, NREA to finance local costs, with a potential for IBRD funding for any gaps that may arise.	
		♦	❑ Mexico: financing (besides the GEF grant) is to be provided by CFE or the Mexican Treasury ministry. The rated power will be fixed. The company offering least-cost-LEC will win the bid. This leaves the question of exact investment costs open.	
		■	❑ India: preferential loan from KfW and the GEF grant is not sufficient to cover the required capital cost, nor the local LEC to cover the gas and O&M price. Additional financing required.	❑ For India, gap in capital cost could be minimized by allowing solar component of ISCCS to receive same tariff as wind Indian Rupee (INR3.3). A cost gap would still remain, which would have to be filled by, e.g. government subsidization. This could be justified by the other benefits gas supply could bring to the region.
10.	Exposure to fossil fuel price increases (in particular gas price increases)	♦	❑ If a combined cycle plant is to be installed, the ISCCS approach helps to reduce exposure to gas price fluctuations on a per MWh produced basis. Compared to a solar-only plant, disadvantage of the ISCCS approach. ❑ Morocco: risk low due to long-term nature of contracts ("droit de passage"). However, the Moroccan government could levy part of the financial advantage on ONE. ❑ Mexico has strong gas-CC expansion strategy. ISCCS helps to mitigate risk. ❑ India: gas use for electricity generation is expected to increase here; however indigenous gas resources are not strong. In addition, India has a strong commitment to hydro. Solar can help reduce the exposure to high gas prices and low water flows during drought.	❑ Storage technology can significantly increase the solar share. Storage (based on molten salt; 7.5 hours) will be part of the new Andasol 1 and 2 plants (2x50 MW) starting operation in Spain in 2006/2007.
11.	Non-guaranteed power purchase (relevant for IPP approach)	■	❑ Increasingly, due to the electricity market liberalization, no long-term power purchasing agreements are granted to the company that runs the ISCCS plant in concession, increasing the risk to companies.	❑ Frame for preferential feed-in of renewable electricity (for hybrid electricity from ISCCS above a certain share). ❑ Risk comparatively small in markets with growing electricity demand. ❑ Longer periods of bankable tariff support for CSP so that, as in Spain, the upfront capital is underwritten by the revenue stream.
12.	Weak financial position of off-taker	■	❑ Higher financial risks for banks (e.g. case of Nevada – now overcome; case of Algeria where the off-taker is Sonatrach, the strong national hydrocarbon company, who will sell on to the financially weaker electricity supply company).	❑ In the Nevada case, recent legislation changes made it possible for the renewable contracts signed by the utility to be protected. This solution is difficult to provide on a wider basis. ❑ Back-to-back guarantees from state/WB
13.	Additional financial risk for the solar supplier (but also the main EPC contractor) due to combined EPC and O&M contracts	■	❑ The reason for combining the O&M contract with the EPC contract is to instill the final owners with confidence that the field will perform as desired prior to them taking ownership.	❑ It is considered prudent that the final owner of the plant receives some assurance as to performance over a period of time. There may be an opportunity to minimize the risk for the solar supplier by having the owner (if a utility) carry out the O&M, if the owner is prepared to bear the associated risk.

			❑ The EPC contractor will generally have built in a factor for technical risk. There is also a factor built in for O&M risk, which increases the overall price. ❑ Generally, the O&M contract is smaller in volume than the EPC contract. Often the O&M and EPC contractors are different companies. In the case of combined EPC + O&M, the liability of the O&M contractor is then for the overall project volume.	❑ (Consider separate O&M contracts if confidence in the performance of the plants allows it.)
14.	Unusually high level of guarantees required from the national side	✸	❑ In the case of India, up to 20 percent of the investment was required as a guarantee until the end of the O&M contract because the technology involved was new. This forces companies either to raise their margins or to wait five years before they can expect the return.	❑ Discuss the required amount of security at an early stage. ❑ Risk sharing among turnkey contractor, financing organizations, and at national level.
15.	Full liability for the contractor of the solar thermal component for the whole ISCC	✸	❑ Despite the fact that the technical risk of the solar plant not performing is limited (see above), the financial risk is high for the smaller solar supplier but also for the turnkey provider if the failure of the solar plant is considered a reason to reject the combined cycle plant. Civil work and the combined cycle by far the largest share in the investment.	❑ Careful study of limited liability requirements of the turnkey provider and the solar provider. ❑ Investigation of replacement solutions and cost. ❑ Demonstration of critical components.
16.	Risk pricing by bidders	■	❑ Risk pricing by bidders might occur at an early stage of CSP development when there are a lot of uncertainties.	❑ Reduction in the size of the solar component. ❑ Ensure competition (possibly including solar tower).
17.	Insufficient protection of intellectual property	■	❑ Concern has been raised that in a single EPC arrangement, there would have to be significant sharing of know-how and experience both from the CC supplier to the solar field supplier, and vice versa to enable the overall plant to run optimally. There was a concern that either party could deal with other partners in future projects and share the information acquired. This brings up the issue of the contractual relationship (confidentiality agreements) and clauses on future freedom to operate. ❑ It is important that the overall plant run optimally and reliably to benefit the reputation of both the CC supplier and the solar field supplier.	❑ This will need to be dealt with using conventional legal mechanisms—this situation is commonplace in collaborative relationships.

3.3: Regulatory/institutional risks related to the WB/GEF portfolio

	Risk		Valuation	Mitigation
18.	Lack of incentives to maximize operation of the solar field	✸	❑ Since the plant operator gets an initial grant; from his short-term perspective, the operation of the solar field only makes sense if O&M costs are below the selling price of the electricity. If the solar field causes (unexpected) problems with respect to the CC operation, non-usage of the solar field might be the consequence.	❑ Ensure incentives/obligations to operate the solar field in the form of penalties on a kWh-basis (below design operation).

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	Risk		Valuation	Mitigation
19.	Loss of confidence in potential project developers due to lengthy bidding procedures	✸	❑ In principle, difficulties with the WB/GEF portfolio and delays were to be expected as a new technology is combined here with the more difficult environment of developing countries. Therefore, the time frame is not really a surprise. Several years were lost with the unsuccessful IPP approach. ❑ Frame conditions have changed (higher general energy prices, ongoing projects in Spain and the U.S.), which advocates pushing through the current portfolio.	❑ The WB/GEF portfolio needs one rapid success in order to restore confidence of investors and companies who have participated in bids in the past. ❑ The portfolio requires higher priority and shorter decision lines in the WB/GEF hierarchies. It represents one third of GEF's climate change budget. ❑ Concentrate efforts to convince investors and financial institutions.
20.	Loss of confidence in project developers due to missing long-term assurance of CSP market growth	■	❑ Pushing a new technology is a hurdle companies only take if the related risks are adequately compensated and/or long-term perspectives of the market are attractive. ❑ Due to today's favorable conditions in other parts of the world (e.g. Spain, U.S., Algeria), this problem seems less dramatic than it did a few years ago.	❑ Rapid implementation of at least the first of the WB/GEF projects. ❑ Common discussion and development of a long-term view of CSP (including information, dissemination, and public discussions in strategy workshops).
21.	Lack of supportive-framework for renewables, in particular CSP	✸	❑ All of the WB/GEF countries have a certain frame for renewables with ambitious targets, R&D etc. However , in general, national financial support is limited to the provision of own funds for the main electricity, which limits the further expansion of the renewables technology until it is competitive with the main market technology.	❑ Investigate suitable mixes of financing and support structures for future promotion of CSP technology such as soft loans + renewable portfolios, (low-level) feed-in tariffs adapted to the financial context of developing countries, Clean Development Mechanisms. ❑ For future projects, national RES goals and frameworks should be a primary criterion for choosing a country to support in order to increase the likelihood of a multiplication effect of the first plant. ❑ Consider market barriers ("OP6 –type barriers") also in technology simulation projects such as under OP 7.
22.	Lack of competitive electricity market structures	■	❑ Opening electricity markets can have negative and positive impacts on the development of new technologies such as CSP: on one hand, it might squeeze out the surplus of the main market operators that is needed to embark on such a technology. It might also lead to higher uncertainties (e.g. during market transitions or when PPAs are no longer available). On the other hand, within the framework of interlinked markets, CSP might have a better chance (e.g. electricity exports from Algeria, or the whole of Northern Africa to Europe).	❑ This is a bigger issue than that just facing CSP. The issue for CSP is to create a framework in which it can compete against fossil fuels and other renewable technologies. ❑ Create security in tariffs and allow for attractive returns.

3.4: Strategic risks related to the WB/GEF portfolio

	Risk		Valuation	Mitigation
23.	Risk in mandating a particular integration configuration such as ISCCS and its future impact	✸	*Opportunities* ❑ In the short run, it is more important to get the first WB/GEF plants running than to achieve a maximum CO_2 reduction. ❑ Even though ISCCS may only have around 5 percent or less of solar contribution, this is still 30 MW (around 200,000 m^2), and the same amount of solar field O&M experience and know-how will be gained either way. ❑ A prime requirement for developing countries is the additional capacity, rather than a specific need for peak power as in many developed countries. Most of the developing countries are suffering from low reserve margins in available power (e.g. 6 percent in Mexico). The advantage of ISCCS is that a one-off project results in both significant additional capacity plus the solar contribution, whereas STR + CC requires the planning complexity of two projects with the chance that one will fail. *Constraints* ❑ Limited overall GHG benefits compared to a solution involving stand-alone solar thermal Rankine (STR) + conventional combined cycle (CC), especially if the ISCC's design is not optimized for low CO_2 emissions. Limited public acceptance in developed countries and international funding organizations. ❑ ISCCS might require compromises between the solar and the fossil parts, which hamper the performance of one or the other and result in a sub-optimal overall performance (e.g. dry and sunny location versus lower performance of the CC due to high outside temperatures and lack of cooling water; location constraints due to the availability of natural gas, power losses etc.). ❑ Upgrading the low solar share in an ISCCS plant later during the plant's lifetime is not possible from today's technological perspective. ❑ Moving from the ISCCS technology route with a low share of solar to a solar thermal technology with a larger share of solar or a solar-only technology route is not a gradual process but represents a technology change (otherwise the steam generator has an increasingly degraded performance).	❑ Accurate and comprehensive instrumentation is required to measure the contribution to electricity generation in an ISCC, which may not be available in all plants. ❑ ISCCS is, in the medium to long-term, not the first choice, but for further developments in the short term, it mightt be the only acceptable option for solar thermal power from a developing country's perspective. However, thermal and financial calculations should carefully consider whether the ISCCS option really has the lowest cost, or whether the compromises to be made between the solar and the fossil parts increase costs to a point where options with larger solar fractions become comparable in costs. Environmental benefits are to be checked ex-post for the first plants.
24.	Risk in mandating the trough technology compared to tower, dishes, or Fresnel collectors for future developments	■	❑ According to the Sargent and Lundy study (2003), tower technology has the larger potential for cost reduction in the longer term. On the other hand, there may be a limit to the size of the plant due to the difficulties of focalizing the light on the tower over large distances.	❑ As much freedom as possible should be left to the bidders. Competition speeds up cost reduction. Therefore the bidding should not be focused on the trough technology but be technology-independent (CSP). A security criterion might be bidding companies/consortia financially strong enough to bear the risk of non-operation.

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	Risk		Valuation	Mitigation
25.	CSP might take up market shares more slowly than other renewables options (incl. PV and wind)	■	❑ Other renewable energy sources allow an incremental growth in contrast to CSP with generally large steps of several tens of MW so they can be more easily adapted to financing constraints and small investments. This reduces the overall risk exposure of an investor.	❑ Storage technology should be introduced, perhaps only in future project developments. In the current round of WB/GEF, introducing project storage might cause additional delays in the realization of the projects.
			❑ Compared to PV and wind, CSP has a storage possibility.	
			❑ Levelized electricity costs for most CSP technology routes are (still) very much below those of PV.	❑ Solar dish technology is similar to other renewables as it allows incremental add-ons in the kW range compared to the main CSP technologies of trough and tower. Although levelized electricity costs are highest with this technology (dishes are hardly competitive today with PV[7]), it could be worthwhile investigating its potential in smaller projects in developing countries given the incremental nature of this technology.
26.	Concepts chosen not flexible enough with respect to future plant extensions	✸	❑ If financing constraints are an issue, one solution might be to construct a solar power plant over a number of years. With the ISCCS concept this is more difficult to implement and more costly: with an ISCCS, any delays in the solar field do not have to delay the combined cycle, even though the combined cycle will operate less efficiently using duct burning or a partly loaded steam turbine until the solar field is fully installed. The solar contribution could be extended over time by adding mirrors with corresponding storage.	❑ Investigate modular concepts that allow additional capacities to be added once additional financing is available without increasing costs considerably. This is not possible with ISCCS given the fact that the steam turbine needs to be designed to an optimal point of use.
27.	Dependency on single supplier of key elements	■	❑ Currently only Flabeg manufactures such mirrors.	❑ Evaluate bottlenecks that might occur if construction of a number of plants coincides. However, Flagsol believes two 50 MW plants of the Andasol type with 500,000 m^2 can be fabricated in a year, with a third being possible with a new furnace within six months.
			❑ With financial support by the German Ministry for the Environment, Solar Millenium and Schott have successfully developed improved receiver tubes (now there are globally two commercial tube suppliers).	❑ Bending is the time consuming process rather than the glass production (glass production takes only 9 days for the Andasol plant). In principle, mirror bending could be offered by other companies too and is a question of CSP market development (motivation for competitors to enter the market).
			❑ All other elements are more or less standard.	❑ Guarantee access to fabrication train for mirrors.

[7] On the other hand the Ecostar study (DLR, 2005) shows that this technology has a considerable future cost reduction potential (see Table 2).

3.5 Overall risk evaluation

The following table presents the compilation of the different risks and their evaluation across the four risk categories (technological risks, financial/commercial risks, regulatory/institutional risks, and strategic risks), the main level of impact (project success; WB/GEF program success; global technology evolution) and the main actors for risk mitigation.

Table 4: Overall risk evaluation for the WB/GEF solar thermal portfolio

	Risk	Risk Level	Main level of impact	Main body for risk mitigation
Technological risks related to the WB/GEF portfolio		♦/■	❶	
1.	Non-optimal choice of location	♦/■/✸	❶	National level
2.	Environmental benefit low or non-existing due to the ISCCS concept	■	❷/❸	Plant designer/operator
3.	Insufficient experience with CSP technology	♦	❶/❷	Equipment suppliers
4.	Thermal storage in the required size new and non-experienced technology	■	❶/❸	Equipment suppliers
5.	Problems at the technical interface between the solar component and the fossil component	♦/■	❶	Plant designer/operator
6.	Non-optimized operation of the ISCCS plant	■	❶	Plant designer/operator
7.	Complete failure of the solar plant	♦	❶	Plant designer/operator
Financial/commercial risks related to the WB/GEF portfolio		■	❶/❷	
8.	Low interest in bidding by industry	✸	❷	National level – WB/GEF
9.	Insufficient financing secured for the WB/GEF projects	♦/■	❶	National level – WB/GEF
10.	Exposure to fossil fuel price increases (in particular gas price increases)	♦	❷	National level
11.	Non-guaranteed power purchase	■	❸	National level
12.	Weak financial position of off-taker	■	❶	National level
13.	Additional financial risk for the solar supplier (but also the main EPC contractor) due to combined EPC and O&M contracts	■	❷	National level – WB/GEF
14.	Unusually high level of guarantees required from the national side	✸	❶	National level
15.	Full liability for the contractor of the solar thermal component for the whole ISCC	✸	❷	National level – WB/GEF
16.	Risk pricing by bidders	■	❷	Bidders – National level
17.	Insufficient protection of intellectual property	■	❶	Bidders
Reglatory/institutional risks related to the WB/GEF portfolio		■/✸	❷/❸	
18.	Lack of incentives to maximize operation of the solar field	✸	❶	National level – WB/GEF
19.	Loss of confidence in potential project developers due to lengthy bidding procedures	✸	❷	National level – WB/GEF
20.	Loss of confidence in project developers due to missing long-term assurance of CSP market growth	■	❷/❸	National level – WB/GEF
21.	Lack of supportive-framework for renewables, in particular CSP	✸	❷/❸	National level – WB/GEF
22.	Lack of competitive electricity market structures	■	❷/❸	National level
Strategic risks related to the WB/GEF portfolio		■/✸	❸	
23.	Risk in mandating a particular integration configuration such as ISCCS and its future impact	✸	❸	National level – WB/GEF
24.	Risk in mandating the trough technology compared to tower, dishes, or Fresnel c ollectors for future developments	■	❸	National level – WB/GEF
25.	CSP might take up market shares more slowly than. other renewables (incl. PV and wind)	■	❷/❸	National level – WB/GEF
26.	Concepts chosen not flexible enough with respect to future plant extensions	✸	❸	
27.	Dependence on single supplier of key elements	■	❷/❸	Equipment suppliers

Legend:

Importance of risk: ♦: low risk; ■: medium risk; ✸: high risk

Main level of impact: ❶ project success; ❷ WB/GEF programme success; ❸ global technology evolution

An overall impression of the risk is provided for each of the four risk categories. It appears that the regulatory/institutional risks present the highest risk level for the portfolio as a whole. Technological risks are less relevant for the overall portfolio (but might have an impact at the level of individual projects), while financial/commercial risks might be relevant both at the level of the individual projects and to some degree for the WB/GEF portfolio as a whole. Strategic risks are equally high but only relevant in the longer term, and may be mitigated by a more diverse development of the general CSP market compared to the WB/GEF portfolio, which relies solely on the ISCCS technology route. Strategy risks, by definition, mainly affect the global technology evolution.

Table 5 shows where the most critical points are in the project development trees. While project delay is the general consequence in the pre-bidding stages, the bidding process itself accumulates the most critical short-term risks. These result either in further substantial project delays if the whole process has to be redesigned (shift from the IPP approach to a public EPC/O&M financing), or in project abortion in the worst case.

Table 5: The critical points in the project development tree

Step in project development tree	Risk	Damage in case of risk event
Project idea and first evaluation	19	❑ project delay
Feasibility study	19	❑ project delay
Prequalification of bidders	19	❑ project delay
Development of detailed bidding procedure (EPC, O&M)	19	❑ donors/national bodies damaged in credibility
Financial close	9, 19	❑ project delay
Bidding process	8, 11 (IPP), 12, 13, 14, 15, 16 19	❑ project abort/project delay ❑ donors/national bodies damaged in credibility
Contract	17	❑ project delay
Construction	27	❑ project delay
Operation	1, 2, 3, 4, 5, 6, 7 18	❑ technology line (e.g. ISCC) and possibly whole CSP line damaged in credibility ❑ De facto project abort; technology line (e.g. ISCC) and possibly whole CSP line damaged in credibility
Technology replication	10, 20, 21, 22, 23, 24, 25, 26	❑ Replication endangered

4
The Status of the WB/GEF CSP Portfolio

This chapter briefly describes the status of the WB/GEF portfolio and its possible development. For more details, see Annex 4.

4.1 Status of the WB/GEF portfolio and possible development

The team made personal visits to each of the GEF project countries, interviewing key players and decision makers, as well as conducting follow-up interviews and discussions by phone/email to clarify the points and issues raised. The interviewed people are listed in Annex 5. A detailed assessment of each project—status, key issues and recommendations, energy infrastructure, and institutional framework—is contained in Annex 4. This section summarizes some of the key findings and issues relating to the projects.

Each project is at a different stage of delivery, and all have encountered various obstacles along the way (see Table 6). The Indian Mathania project was the first to receive approval in principle from GEF. The Mexican, Moroccan, and Egyptian projects benefited perhaps from the prior experience of India in terms of the bid documents and bidding procedure, and the dealings with the World Bank and GEF. However, each country has its own institutionalized routes through government. Specific issues and difficulties are dealt with in Annex 4. Overall though, each country shows a high level of enthusiasm and desire to progress with their projects. The following views are pertinent to the overall portfolio.

A certain amount of confusion has arisen from the wealth of LEC figures that appear around the world in papers, at conferences, and independent evaluations. Quite often, the LEC figure is discussed with little regard to the assumptions and robustness of the underlying calculation. For example, figures of 12–14 c/kWh are often purported to be the benchmark LEC set by the SEGS plants, when in reality the agreed energy price for those SEGS plants depended on maximizing return with due regard to time-of-use tariffs, the various incentive schemes in place at the time, and the specific requirements of the investors. They do not necessarily equate with the conventional method of calculating LEC—put simply, cost of capital + O&M (with or without tax, depreciation, etc. included). The other significant factors are the level of insolation under which they were calculated, and the currency upon which they were based. It is not appropriate, for example, to apply the exchange rate between the euro and the Indian rupee to the whole of the LEC and expect to have an accurate idea of LEC in India. Different parts of the capital are sourced at different rates, and some of the labor will be at local rates.

Individual techno-economic feasibility studies are needed and have been conducted for these four projects (including a very recent one for Mexico). These ensure that all factors are considered. They also take local factors into account. For example, the Indian RfP set specific limits on the levels of euro and dollar that could be used toward the EPC financing.

It is possible that an element of over-optimism surrounded the projects of this portfolio at an early stage. When the detailed feasibility assessments were carried out, including all the local factors plus risk factors of performance, finance and insurance, the final price went up instead of down, which made things more difficult for the decision makers at the political level. However, this is not a unique scenario for a new, or relatively new, technology.

In addition, the projects were initially predicated on the basis of an IPP structure, where all the difficulties and risks of raising finance

Table 6: Summary of GEF project status

Country/project	Status of project	Project structure	Expected schedule
India, 140 MW ISCCS incl. 35 MW solar trough, site approx 2,240 kWh/m^2/year DNI.	WB waited on letter of commitment from Govt of India, after which the already-drafted RfP (revised) could be released.	Single EPC with O&M (5 years). PPA with RVPN. Project owner RREC.	Eventually, the project could not be timely implemented due to inappropriate design and location.
Egypt/Kuraymat, 151 MW ISCCS incl. 25 MW solar.	Financial closure agreed. Solar thermal part and CC at bidding stage.	Two EPC contracts. The solar island will be an EPC with O&M contract; the CC island will be an EPC contract with local O&M to be bid separately financed by NREA.	Delays due to the splitting of the packages to be funded by GEF, NREA and JBIC. Contract signature expected for early 2007. Construction might begin late 2007. Possible begin of operation late 2009.
Mexico/El Fresnal near Agua Prieta, Sonora State (site decision in March 2005, plant Agua Prieta II), originally 285 MW ISCCS but finally increase CC to 560 MWe; Solar trough field 25–40 MW; Excellent solar site conditions (exact solar data not available).	November/December 2005: Approval by the Treasury Ministry. The hybrid plant has been included in the PEF (Programa de Egresos de la Federación) and approved by Congress. Acceptance of the doubling of fossil capacity by the WB task team after technical economic assessment by Sargent and Lundy (May 2006) and a consultancy by Spencer Management.	The final owner of the plant will be CFE. They will undertake to provide the O&M. (Previously, unsuccessful project development under IPP scheme.)	At this stage, bidding is expected for 2006, construction to begin 2007, operation 2009.
Morocco/Ain Beni Mathar 240 MW ISCCS, including 30 MW trough. Expected production from ISCCS 1,590 GWh/year, of which approx 55 GWh/year solar (3.5 percent solar contribution).	EPC with O&M (5 years). Option exists to renew O&M contract after 5 years. Bids received May 2006. Ongoing evaluation process.	Owner of plant will be ONE. Total cost expected approx €213M, including connection to infrastructure. €43M from GEF, and €34M from ONE. Balance of €136.45M from African Development Bank as soft loan.	EPC with O&M contract for the project expected to be signed by the end of 2006, and at the latest in January 2007. Expected start of operation of the plant is mid 2009 (construction time 30 months).

and ensuring performance were to be borne by large organizations. When this had to be revised for EPC with O&M contracts, many more institutional and governmental factors came into play, which has resulted in delays.

It would be naive to believe that additional delays of some form or other affecting one or more projects will no longer occur. We believe firm dates now need to be set for each project after consultation with each country.

4.2 Status of the WB/GEF portfolio by country

4.2.1 WB/GEF project in Egypt (Kuraymat)

Project history

The chronology of the Egypt/Kuraymat project is as follows:

April 2004	Pre-qualification and bidding documents completed. In parallel, NREA was investigating potential sources of financing, including JBIC.
June 2004	Government of Egypt makes official request to JBIC to finance the project.

August 2004	JBIC sends fact-finding mission, shows interest, but requests the splitting of the CC and solar packages as well as a halt of 5 months on the procurement process to allow for JBIC's processing and approval of the financing. World Bank team expresses its reservations on the two-package approach, given the significant additional risks (integration, management and accountability) it poses to the client.
March 2005	Government of Egypt decides to split the CC and solar packages in order to obtain JBIC financing.
March 2006	The prequalification process for the solar thermal part (March 2006) resulted in four prequalified bidders.

Future development according to current planning:

The project experienced delays due to the splitting of the packages to be funded by GEF and JBIC, which required a certain change in scope.

February 2007	Contract signature expected.
Late 2007	Construction might begin.
Late 2009	Possible beginning of operation (assuming 30 months construction time).

4.2.2 WB/GEF project in Mexico (Sonora)

Project history

The chronology of the Mexico/Sonora (previously Mexicali) project is as follows:

1986[8]	The Mexican electricity sector was opened to competition in a limited way. New types of projects emerged: financed built-transfer projects OPF corresponding to EPC, CAT and Independent Power Producers (PIE Productores Independientes de Electricidad).
1995–96	Spencer Management Associates (SMA) undertook an evaluation of ISCCS plants under IPP financing scheme in cooperation with CFE.
Oct. 1998	Meeting on "solar thermal dissemination mission" sponsored by IEA SolarPACES, CFE and others. Interest was shown by all sides for a possible solar thermal project as part of CFE's expansion plan.
Aug.–Nov. 1999[9]	Technical and economical feasibility study carried out by SMA for integrating parabolic trough solar field into a gas turbine combined cycle plant at Cerro Prieto near Mexicali, Baja California Norte.
Dec. 1999	Mexico solar thermal hybrid project entered the GEF program (with GEF grant of $49.3 million) as an IPP project at a specific site in Mexicali, Baja California Norte, to be procured in conjunction with the planned Mexicali II Combined Cycle Gas Turbine (CCGT) Project IPP.[10]
March 2002	"Call for Bids" on an IPP basis was published. The solar field was an option for the combination with a CC plant.
April–March 2003	After several postponements of the deadline for the "call for bids," the bidding process was halted after the visit of Laris Alanís (CFE director) to the World Bank. It became clear that there was an irresolvable "the hen or the egg" problem: the

[8] http://gaceta.diputados.gob.mx/Gaceta/58/2002/feb/20020213.html

[9] Thematic Review of GEF-financed solar thermal projects, October 2001.

[10] World Bank to GEF Council, April 2004.

World Bank could not commit its grant funding before knowing the identity of the winning bidder, while CFE could not finalize the bidding process before the financing was secured. It also has to be stated that there were not only problems on the financing side, but also the industry response to the published bidding was very limited.

For the further ISCCS project development, it was decided that an EPC scheme with CFE as WB grant recipient should be pursued. The solar field would no longer be an option but compulsory.

Oct. 2004	Finalizing of a feasibility study for Mexicali II (Baja California Norte) including Sargent and Lundy as the World Bank's consultants and social and environmental specialists.
Nov. 2004	The plant location was changed to Sonora state (Agua Prieta Site). CFE's explanation was that the power sector expansion plan would not allow further delays related to the implementation of the solar field.
March 2005	Inquiry from CFE to the World Bank if the Bank would still support an ISCCS plant with a solar field integrated into a 500 MW instead of a 250 MW plant.
May 2006	A technical economic study by Sargent and Lundy and a consultancy by Spencer Management, of the 500 MW CCGT concluded that "the bigger the host of CCGT is, the greater the conversion efficiency and the solar energy collected" and explained that "the reasons for the outstanding output is due to two factors i) higher efficiency of the thermal 2x2x1 arrangement and ii) the 500 MW thermal plant results in a lower drop in efficiency during night hours, when the solar field is not operating."
By June 2005	Completion of technical and economical evaluation by CFE.
June 2005	Presentation to the Treasury Ministry.
Nov.–Dec. 2005	Approval by Treasury ministry.
Jan. 2006	The hybrid plant has been included in the PEF (Programa de Egresos de la Federación) and approved by Congress.

Future development according to current planning:

June 2006	Invitation for tenders (published).
Sept. 2006–Jan. 2007	Start construction.
April 2009	Grid connection of the plant.

4.2.3 World Bank/GEF/KfW project in India (Mathania)

Project history

The chronology of the India/Mathania project is as follows:

1988	Project report to the Government of India (GoI) on a 30 MW solar thermal power plant. GoI approved India for a demonstration project.
1989	Land allocated.
1990	Working group finalized the parabolic trough preference for design.
1991	Revised feasibility study report in view of cost escalations and tariff revision to Central Electricity Authority (CEA) for techno-economic clearance (TEC).
1992	CEA dropped project, finding it techno-economically non-viable.

1993 Prime Minister's Office intervened, steering committee was constituted.

1994 BHEL and Solel prepare detailed project report for 35 MW solar.

1995 Proposed to GEF and KfW for funding; comprehensive feasibility report prepared by Engineers of India and Fichtner; found 140 MW CC with 35 MW solar most viable.

1996 Possibility of implementation by IPP with private equity explored; GEF grant of $49 million agreed to in principle.

1997 Rajasthan State Power Corporation Ltd formed especially for the Mathania ISCCS project.

1998 Detailed project report (with naphtha as fuel) submitted to CEA for TEC.

1999 CEA approved, KfW appraised, EPC with O&M approach decided on.

2000 GoI decision facilitates grant funding; Fichtner Solar appointed as consultant.

2001 Pre-qualification process completed; high price volatility of naphtha results in changeover to R-LNG; revised pre-qualification process initiated.

2002 Pre-qualification finalized with LNG as fuel; RfP document finalized; project agreement and separate agreement signed; heads of agreement for gas supply signed with GAIL; RfP issued.

2003 Protracted negotiation with potential bidders fails to secure a bid.

2004 Fichtner redrafts RfP ready for release mid-2004, but prior to release World Bank requests a letter of commitment to the project from Government of India.

Letter from GAIL (India Ltd) to Rajasthan Renewable Energy Corporation (RREC) (March 16 2004) stating that the agreed gas price would be INR270.47/MMbtu, including transmission, and escalating at 5 percent per year (note RREC modeling assumes 5 percent per year for first 5 years, then fixed).

Principles and terms and conditions for PPA agreed upon by Discoms and RREC on 16th August 2004.

Letter from CEA to Government of Rajasthan confirming LEC of INR2.62/kWh (current modeling shows 2.82) and suggesting that it would be "desirable that the concerted efforts be made to implement the project at its earliest" (September 3, 2004).

2005 MNES informed of new large gas/oil find near Mathania.

Future development according to current planning:

At the time of the study, the consultants had recommended that (i) the GoI needed to reply to the World Bank letter of 2004 stating the government's commitment to the project proceeding and to meeting the requirements stated therein, and that (ii) there be a resolution of the balance of funding from KfW. Eventually, the project could not be implemented in a timely manner due to inappropriate design and location.

Additional information/discussion of the Indian project

In March 2003, the STAP Brainstorming Session on OP 7 (STAP 2003) reported that the likelihood of success for the Indian project was 30 percent, due partly to the complicated process to that date, and the risk to industry players. In the intervening period, we believe the chance of success has risen.

- gas and PPA agreement principles, terms and conditions have been agreed to;

- a modified bid document has been prepared in draft form (we have been unable to view this document);

- all clearances are now in place;

- the CEA, which dropped the project on the grounds it was "techno-economically nonviable" in 1992, has recently (September 3, 2004) written to the Government of Rajasthan stating that it would be "desirable that the concerted efforts be made to implement the project at its earliest".

The document "principles of PPA" dated September 16, 2004, has been modified from that agreed to in June 2001. It includes the following:

- The determination that there will be "no financial burden on the Discoms (distribution companies) because the tariff is well below the cost of generation compared to new coal-based power plants and within the price-band of procurement of power by the utilities."

- States that the risk involved with a "take or pay" gas contract will be covered by a back-to-back arrangement under the PPA. Furthermore, if the plant load needs to be reduced on request from Discoms, there will be compensation paid for fixed charges and take or pay obligations of the gas supply contract. The problem was exacerbated when the GoR directed in 2001 that the ISCCS plant would be outside the purview of merit order dispatch.

- Notwithstanding occasions when there will be no choice but to ask the plant to shut down, every effort will be made to keep the solar part going when radiation is available by ensuring the part load of the CC remains high enough to enable the solar field to operate (albeit at part-load conditions).

The latest costing spreadsheet (June 2004) shows a first year energy cost of INR 2.49/kWh, and 20 year average LEC of INR 2.82/kWh (taking into account: $45 million GEF grant, INR 500 million GoI grant, and INR 500 million GoR grant). The total project cost, including IDC, is INR 8,226.87 million. This is based on a gas price of INR 270.47/Mmbtu, a water price of INR 20/1,000 Cuft, and O&M at 1 percent of total project cost for first 2 years, then 2.5 percent in year 3 with 4 percent escalation following. These costs have been worked out on the basis of a total plant output of 155 MW, with 30 MW solar block. The annual electrical output of the plant is 916 GWh, including 63 GWh estimated from the solar block.

Note that it was conveyed to us that the present pool price is INR2.1–2.2/kWh, depending on the hydro situation, but imported electricity to the State of Rajasthan is around INR4–5/kWh. Currently, Rajasthan imports much more electricity from other states than would be generated by the Mathania plant. The electricity generated by Mathania will essentially be a cheaper substitute for currently imported electricity.

Based on these figures, the solar electrical capacity factor is 24 percent. This seems high for an insolation regime of 2,240 kWh/m^2/yr DNI, even allowing for the advantages of ISCCS in terms of start-up and transients. However, even if a 20 percent capacity factor were assumed to allow for field availability, the LEC only goes from 2.82 to 2.85. This is another of the effects of ISCCS—it desensitizes the overall LEC to solar performance (in both directions).

With regard to gas supply, RREC has informed MNES about the biggest inland gas and oil reserve found in Jaisalmere and Barmer, which is about 150–170 km from the Mathania site. Cairns Energy, UK, will operate oil and gas rigs. This is closer than the present 425 km, and if supplies are confirmed, should result in a cheaper gas price. However, it is understood that the "GoR has entered into a gas cooperation agreement with GAIL for assessment of potential demand in the industrial sector, transport sector and domestic sector on the pipeline route, which will further bring down the transport charges to Mathania project on progressive development of demand potential." There is also potential for the possibility of further extension of the pipeline from Kota-Mathania to Ramgarh (Ramgarh Gas and Power) due to the potential for industrial towns along the way.

Though these gas options provide the possibility for cheaper gas, they also give rise to further project delay while the optimum option is being sought. A preferred route needs to be established as soon as possible. The study could be conducted while bids were being assessed. Then construction of the new pipeline needs to be started so that gas flows will have been established prior to construction completion of the ISCCS. This completion date will need to be enforced by penalties for late delivery.

There seems to have been a differing view over time as to the capacity of the solar portion. Figures up to 35–40 MW of solar have been circulated, but the latest cost spreadsheet was based on 30 MW. This seems a sensible choice if the reluctance of the GoI to sign off is due to cost. It makes the technical integration easier, with less manipulation of an otherwise optimized combined cycle required. It also improves the overall GHG performance of the ISCCS as off-design operation is closer to the ideal (the steam turbine is better dimensioned so duct-firing or the level of part-load operation is reduced). The arguments by RREC appear to make this capacity quite competitive in terms of LEC versus the imported price of electricity. However, we would recommend consideration of the following option for the next RfP.

The next RfP should include additional assessment criteria with a significant weighting that considers the size of the field (or solar GWh_e) offered. There should still be a minimum required field size (in the original RfP this cut-off was 50 GWh_e below which the bid would not be considered). But this should be a lower figure, to be determined through consultation. This would mean that bids could be differentiated on the basis of the solar field size, prompting competition on both the quality and quantity of solar offered.

Paradoxically perhaps, the ultimate outcome for GEF is likely to improve if the solar expectation is reduced. The solar field, which is modular in design, will generate as much experience and know-how as a larger one. And though the solar capacity would be less, the number of solar MW is to some extent arbitrary. In the broad scheme of things, which is ultimately what OP 7 is concerned with, the technology and the industry would be better served by a successful project. There is more chance of a successful industry being spawned by a successful 25 MW than by a risky 30 MW, or even by a proposed 35 MW that never proceeds because it is too expensive. By 2015, no one will be concerned that the very first project was a few MW less than originally intended.

One of the delays in 2003 when no bids were received was due to the fact that there was no clear definition of who would bear the risk liability. We were informed the risk issues have since been resolved and tender documents revised. Currently risk is being shared by the whole consortium of contractors. The second issue raised by MNES was involvement of very few contractors in the project and the revised proposal has a consortium of contractors/participants to address this issue. The Department of Economic Affairs fully supports this project and will ultimately approve it. Currently, the decision for this project rests with MNES.

The original project was approved by the central government, but there was a change of government after the last election in late 2004. The new central government revised the whole project again and approved it in principle, but the formal decision is still outstanding. The final decision is to be made by MNES (Ministry of Non-conventional Energy Sources). Officials from the MNES have personally visited the Mathania site and approved the project in principle. The chief minister of Rajasthan wrote to the prime minister (around February 2005) to speed up the process, but no reply has been received as yet. RREC believe formal approval could be gained any day.

Officials from the Rajstahan Vidyut Vitran Nigam stated that they fully support the project and will purchase electricity subject to the Rajasthan Regulatory Commission setting the price.

4.2.4 World Bank/GEF project in Morocco (Ain Beni Mathar)

Project history

The chronology of the Morocco/Ain Beni Mathar project is as follows:

1999	Idea for the Moroccan project started in 1999. The Morocco project entered the GEF work program in May 1999.
2000	Assistance by Fichtner Solar for the design of bidding documents under an IPP scheme. Feasibility study report (while IPP scheme intended).
2002	The Moroccan electricity sector started to open to competition in a limited way (smaller con-

	sumers remain captive). Process still ongoing in 2005.
2003	Publication of the IPP call in 2003; organization of a workshop with interested companies. But not enough consortia interested in the bid (possible reasons: technology uncertainties, market uncertainties, lack of long-term PPA).
2003	Change to public financing as public EPC with O&M the same year.
	Revised feasibility study report according the public EPC scheme.
2004	Prequalification procedure in 2004, bidding and evaluation in 2005.
2005	Fichtner Solar redrafts RfP ready for release mid-2005.
May 2006	Two out of four pre-qualified bidders submitted a technical and a commercial proposal and the bids were open on May 10, 2006. Faced by a shortage of capacity, ONE is considering asking the bidders for an increase in the size of the combined cycle power plant. No decision has been reached yet.

Future development according to current planning:

Dec. 2006	Bidding and evaluation of the bids.
Jan. 2007	Contract signature.
Feb. 2007	Construction is to begin
Dec. 2008–Jan. 2009	Plant starts operation.

5

Long-term CSP development scenarios for the World Bank/GEF

The original interest of the World Bank and the Global Environment Facility in CSP technology was due to the significant contribution that CSP could potentially make toward meeting the rapidly increasing energy demands of the developing world. It is evident that the WB/GEF portfolio in itself—with at best around 120 MW solar thermal power capacity at the end—is not able to significantly reduce the costs of CSP technology, and was never intended to do so, although this issue is mentioned as an aim for the WB/GEF portfolio. The institutional learning aspects, which cannot be so easily measured quantitatively as levelized electricity costs (LEC), have by far been more important than the possible cost reduction. It is also important to underline that the commitment of the GEF on the CSP technology was important in financial terms given that the GEF funds for the project portfolio represent roughly one-third of its annual budget for climate change issues in recent years.

Given this important engagement and the stated objectives of the WB/GEF portfolio, it is legitimate to consider the long-term contribution of the CSP portfolio and possible evolution of a long-term strategy by the WB/GEF, independent of any shorter-term focus of large organizations. Short-term focus may yield premature responses, driven by failures, pressure from alternative development routes, or up-coming issues "à la mode." Nevertheless, it is clear also that a complex issue[11] such as the introduction of CSP technology in developing countries needs more time than just the time of the realization of a portfolio of four projects. It is therefore not surprising that the portfolio encountered the difficulties and delays that have been observed so far.

The main question for the WB/GEF today is whether the effort necessary to continue the support for the joint development of technology and structures is worthwhile, or whether the exceedingly slow progress of the portfolio thus far makes it difficult for the WB/GEF to further pursue CSP technology, quite apart from the short-term aspect of bringing the currently existing portfolio to a successful end.

With such heterogeneous interests, it is valuable to consider the implications of different scenarios, both in the short and the long term, before providing recommendations on a market strategy within and beyond the currently existing portfolio in Chapter 6.

5.1 "Scenario" discussion of strategic aspects for WB/GEF in the development of CSP

This section explores, in the form of different scenarios, the possible consequences and impacts of decisions made at the WB/GEF for CSP technology. It is not the intention to provide a judgment on one or the other option, but to simply depart from the present situation and explore the likely impact of other choices.

[11] Not so much complex from the technological side, given the fact that the components for CSP technology are already well-proven, including in large projects, but from the fact that one combines the development of a new technology of a certain scale with the inadequacy of existing structures in the developing world to try to bring the technology to a more mature stage. The scale of the CSP technology is an important aspect in this, and proper to CSP, as is the aspect that CSP development in industrialized countries has so far not contributed to introduce sufficient amounts of power capacity to reduce costs and to establish an industry. With smaller scale technologies such as PV or wind, similar problems exist for the combined development of technology and structures in the developing world, but the two aspects previously mentioned have greatly reduced the importance of these technologies.

For the purpose of representing short- and long-term aspects, the scenarios are divided into two groups:

- The "First Round." This group of scenarios treats short-term aspects and in particular the current WB/GEF portfolio and the impact of decisions on the portfolio on the ongoing CSP developments around the world. Within the first round, the following two scenarios are considered:
  - *"Falling Dominos."* This scenario assumes that the WB/GEF portfolio would be canceled as a whole due to the delays accumulated so far, as well as the recognition that WB/GEF might have underestimated the time it takes to get the technology to the market in the developing world with inadequate structures to promote renewables and without parallel efforts in industrialized countries.
  - *"Getting to the harbor."* This scenario assumes that the WB/GEF portfolio would be partially or totally realized during the next two years.
- The "Second Round" assumes a (more or less) successful termination of the first round and considers options for WB/GEF for further activities. This is inscribed in a longer term vision of CSP development, including both the development of the technology and of suitable structures.
  - *"Wait and See."* This scenario is based on the recognition by WB/GEF that as long as the costs for CSP have not come down to levels close to being competitive with fossil power generation, and as long as the political frame for renewables and CSP in developing countries is not advanced enough, further support to CSP is not likely to have much impact.
  - *"2-Track approach" (CSP in industrialized + developing countries).* This scenario is based on the recognition by WB/GEF that CSP will not develop simply in regions other than industrialized Southern countries, at least not on the short term, but requires further support and development at the international level in order to open up rapidly the second track.
  - *"Specialising."* This scenario is based first on the recognition by WB/GEF that the large scale promotion of CSP might exceed its financial and institutional capacities, and second on the recognition of the fact that CSP is to play an important role in the power mix of developing countries. This requires specialization of the WB/GEF support on particularly sensitive issues for the future development of CSP in those countries.

It is also suitable for such scenario development to classify the countries according to their possible interests in CSP technology into three groups:[12]

- *Group 1 countries*. Industrialized countries with suitable climatic resources for CSP technology and highly developed economies that have already set up a comprehensive framework to promote renewables or that could potentially do so (southern Europe, southwestern United States, Israel)
- *Group 2 countries.* Countries that are or will sooner or later be connected to Group 1 countries, and among themselves, for power exchange (Northern Africa and Mexico[13]). Figure 17 clearly illustrates the importance of this issue with the example of the Mediterranean rim. There are a variety of developments going on that make this „ring" more likely to happen in the future than in previous times. Such aspects concern the opening of electricity markets, although to various degrees in North African countries, the establishment of physical links for power exchange among North African countries themselves as well as toward Spain and Italy. CSP can potentially play an important role in this power exchange. However, the implication

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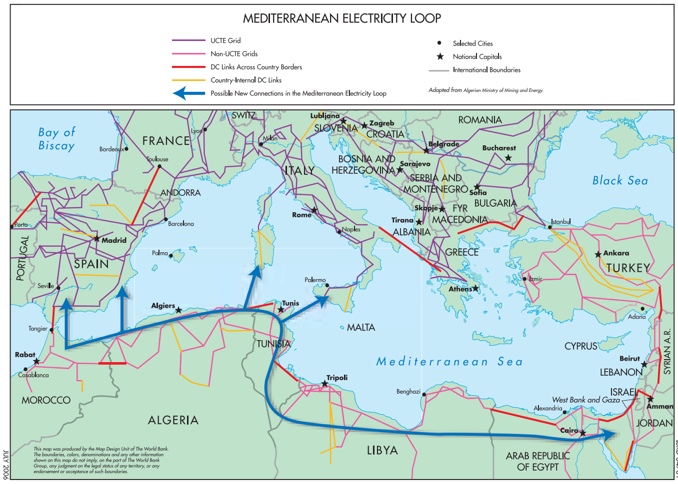
[12] This grouping is derived from a similar classification proposed in the Global Market Initiative (GMI). There was an intensive debate at one of the workshops organized in the course of this project regarding whether the distinction between Group 2 and Group 3 is not too artificial. However, looking at the map presented on the interlinkage of the Mediterranean area and its potential large impact, it appears useful to consider these two groups separately.

[13] Mexico is an OECD country, but still has some characteristics of a developing country caused in part by the large split in wealth within the population.

of such a power ring goes well beyond the mere importance of electricity exchange: it contains elements of political[14] and societal development around a project of common interest, as well as economic development by setting up local production structures for important components of technologies and products, such as for CSP technologies. Structures of this type exist with the so-called "maquiladoras," manufacturing companies of small to large size along the Mexico-United States border, cooperating intensively with companies in the United States.[15] Depending on the success or failure of the first round of CSP development, this group of countries appears as strategic in the future development of CSP. For the moment, given the somewhat more hesitant development of CSP in the Southwest United States as compared to the development in Spain; the impression that the North African WB/GEF CSP projects have the highest chance of being realized; and the stage of the ISCCS project proposed outside the WB/GEF portfolio in Algeria, as well as the CSP activities in Jordan, Iran, and Israel suggest that the Mediterranean area is a key region for future CSP development, given the institutional learning accumulated so far for CSP in these countries as well as in the international funding organizations.

- *Group 3 countries.* These developing countries are not close to the electricity grids of Group 1 countries. This comprises important countries like India, China, Brazil, and South Africa, where the driving force is essentially the tremendous need for new electricity generation capacity. The motivation to invest in CSP might be different and focused on the national context rather than on the interaction with other countries.

FIGURE 17: THE STRATEGIC POSITION OF GROUP 2 COUNTRIES FOR THE DEVELOPMENT OF CSP TECHNOLOGY (EXAMPLE OF THE MEDITERRANEAN AREA)



which has a solid policy framework for CSP in place, it appears less likely that there would be an impact of a WB/GEF decision to phase out the portfolio, although in the longer term (Spain has a decision point concerning the continuation of its favorable support frame for CSP once 500 WM are reached), some impact cannot be excluded.

5.2 THE FIRST ROUND: "FALLING DOMINOS"

This scenario, dealing with shorter term aspects, assumes that the WB/GEF portfolio would be canceled as a whole in a short frame of time due to the delays accumulated so far as well as the recognition that WB/GEF might have underestimated the time it takes to get the technology to the market in the developing world with inadequate structures to promote renewables and without parallel efforts in industrialized countries. As a consequence, there could be negative impacts on all three groups of countries, though with different degrees. In some countries, such as Spain,

[14] Political relationships among countries in North Africa, for example among Morocco and Algeria, continue to be difficult for a variety of historic reasons. However, there are encouraging efforts and symbols to overcome these divisions. Potentially, in the longer term North Africa can parallel the European Union.

[15] The development of such structures is not without problems for the Group 1 countries, given the high levels of unemployment in some of them and the pressure from the population to protect national employment; see for example the recent discussion in Europe after the opening of the EU toward the Eastern countries and the subsequent transfer of production plants to these regions and the social consequences in the old EU. On the other hand, it is unlikely that the development of a North African Union would not present in some stage of its development such features.

The First Round: Fallling Dominos

All WB/GEF CSP projects canceled → **Negative Impacts on all groups of countries (delay; projects canceled)**

Comments:

- Critical moment in time for CSP: a variety of projects are in a phase of consolidation Other projects in a phase of stabilization.
- The WB/GEF portfolio represents a relatively small installed solar capacity of around 120 MW; nevertheless important amount of solar technology, given the early stage of the industry and the few plants under construction.
- The WB/GEF projects represent with Algeria, the only ISCCS plants currently in some advanced stage.

Possible Impacts:

- Strong impact on Group 1 countries partially unlikely: solid policy frame in Spain; Arizona quite advanced. But further developments, e.g. in Nevada, California, Israel slowed down. The CSP market loses the chance to get a broader base to be less dependent on promising but early-stage market developments in Spain and other countries.
- Impact in Group 2 countries (Algeria) and Group 3 countries larger: "If even the countries supported by WB/GEF cannot do it, we can't do it either". CSP technology—being a very important technology for GHG reduction in the countries of the world's sunbelts—might not at all or only after 20 years be applied in de-veloping countries. ISCCS technology particularly threatened.
- No realization of important learning effects with the solar suppliers, and in particular the consortia (comprising solar suppliers and suppliers of conventional CC technology) that propose ISCCS technology. This could have negative consequences for the future cooperation of such consortia on plants with larger share of solar thermal generated electricity.
- Credibility/reliability of GEF and World Bank at stake, at least within the CSP community.
- By 2010 at best 500 MW installed CSP

5.3 The First Round: "Getting to the harbor"

This scenario, also dealing with shorter term aspects, assumes that the WB/GEF portfolio would be partially or totally realized[16] during the next two years. The timeframe of two years appears reasonable in order to provide enough time for the projects to progress. It is difficult to conceive that the WB/GEF portfolio should exceed this time frame up to contract signature given the fact that the catalyser

The First Round: Getting to the Harbor

All 4 WB/GEF CSP passing in next 2 years ↔ **Projects passing in Group 1 and 2 countries, and some projects in Group 3 countries by 2010**

2–3 WB/GEF CSP passing in next 2 years ↔ **Projects passing in Group 1 and 2 countries, and some projects in Group 3 countries by 2010**

Comments:

- The frame for CSP technology take-off is currently the most favorable in years (development in Spain; international energy price environment).
- "Psychological" impact of 4 or only 2–3 WB/GEF projects realized probably quite similar on the different groups of countries. Realizing only one project out of four would not be sufficient to characterize the portfolio as a success; it would at best be perceived as "saving face".
- Revision/cancellation of 1–2 projects: Question of alternatives? Alternative technology lines to ISCCS concept, see next page (time delay?) Support to more motivated countries (preferentially in Group 2) with good projects and the willingness to set up suitable support structures.
- Environmental impact (CO_2) of the WB/GEF portfolio small (ISCCS plants). Success aspect more important than environmental expectations.

Possible Impacts:

- In total about 1,000 MWe CSP installed or in construction by around 2010 (Spain 500 MW, Nevada 50 MW, California, Israel 100 MW, Algeria 25 MW in ISCC, South-Africa: 100 MW, Iran, Jordan,…, WB/GEF 120 MW in ISCC).
- Progress on cost curve not yet enough but noticeable
- Successful examples of projects in Group 2 and possibly Group 3 countries.
- Different technology lines in the phase of realization (including the ISCCS technology line in the WB/GEF portfolio and in Algeria), opening up options for future choices.

[16] The expression "has been realized" means in this context that the signature of the EPC contract with the successfully bidding consortium has occurred, not the fact that the plants have been built. This takes typically another 2–3 years.

function in a now more favorable environment for CSP might have passed, either due to sufficient progress in Group 1 or due to a slowing down of CSP activities worldwide once again. One possibility to speed up the operations could be a transfer of the CSP portfolio to the IFC.

It is important to underline that the environment for CSP development is currently indeed different from the one a few years ago: sometimes, while reading statements made a few years ago by supporters of the CSP technology, some critics of the engagement on CSP have the impression of "déjà vu," when it comes to current statements on development of CSP in industrialized countries as well as the imminence of the WB/GEF portfolio and other projects in developing countries being realized.

Although it is clear that even today it is not unlikely that there is a part of "principle hope" with respect to the speed with which changes occur, it is undeniable that two important frame elements for CSP have changed in the last two years: (1) the general energy price environment is one of strong tensions on prices; and (2) the development and the policy frame in Spain is a hard fact, although even for these two elements reverses or delays are not fully excluded (short-term collapses of energy prices due to recession in important countries or speculation; delays in the realization of current projects and the starting of new projects in Spain). As a consequence there could be positive impacts on all three groups of countries, with most impact on Group 2 countries. The basic requirement for the realization of this scenario is that the WB/GEF promotes very actively at the conclusion of the contracts for the next months. Otherwise, keeping contract signature within a delay of two years will not be possible.

In the case of the revision/cancellation of one or two projects, and the wish of the WB/GEF to support further this important technology, the following alternative technology lines to the ISCCS concept might be considered:

- Market introduction for industrial process heat applications based on concentrator solar

- Small-scale solar combined heat & power plants (heat for absorption chillers (e.g. air conditioning), process heat or sea water desalination (the latter one becoming an increasingly important in some cases dramatic issue in many countries with good solar resource).

- Feed-water preheating in fossil steam plants: promoting also other than parabolic trough collector types (e.g. tower, dish, Fresnel) by a technology-unspecific bidding procedure, feed-water preheating leads to good solar efficiencies, good ratio of funding and solar-MWh because of reduced investment. Existing plant (infrastructure) might be used.

The Second Round: Wait and See

No WB/GEF activities in Group 2 or Group 3 countries until costs for CSP are lowered ←–––	Group 1 countries going ahead; realization of projects in Group 2 and 3 countries left to the market and possibly other international funding organizations
Comments: ❑ CSP electricity cost reduction continues toward break-even with fossil generation by 2015–20. ❑ Competition from other renewables in Group 2 and 3 countries (wind, PV, concentrating PV, geothermal). But CSP has some advantages: 1) dispatchability (due to storage and/or hybrid firing) 2) local industry promotion/job creation 3) sea water desalination. ❑ WB/GEF working on improvement of the policy frame for CSP in some countries.	Possible Impacts: ❑ Little impact in Group 1 countries ❑ Delays in the replication of projects in Group 2 and 3 countries from the first round. ❑ CSP will loose market shares to other renewables in Group 2 and 3 countries, perhaps even to more expensive renewables such as PV. ❑ ISCCS technology line abandoned except for Algeria. ❑ By 2015 not more than 2,000 MW installed.

5.4 The Second Round: "Wait and See"

This scenario, dealing with longer term aspects, is based on the recognition by WB/GEF that as long as the costs for CSP have not come down to levels close to being competitive with fossil power generation,[17] and as long as the political frame for renewables

[17] Considering nevertheless that gas prices are on the rise for power generation even if contracts for gas delivery tend to have very long running times.

and CSP in developing countries is not advanced enough, further support to CSP is not likely to have much impact. This means essentially taking a break on the technology for the next five years and reconsider activities in the light of the development occurred by then. This attitude raises a variety of questions:

- with respect to the long-term requirements as well as the constancy needed from the side of a funding organisation like the GEF to promote such a large scale technology as CSP in the developing world;
- the relevance of this technology in the future power generation mix of the developing world in general, and in comparison to other renewable energy sources in particular
- the necessary preparation of the policy frame in developing countries before such a large-scale technology can be taken up

The Second Round: 2-Track Approach

WB/GEF supports further motivated Group 2 and 3 countries ⟷ **Group 1 countries going ahead, Group 2 and 3 countries taking up in parallel**

Comments:

- Question of the technology choice, if any choice to be made „...(ISCCS plants may be excluded because of low and unexpendable solar shares (<20 percent)".
- More critical on environmental performance? (ISCCS technology).
- Revision of the bidding procedures (complexity, liability issues: e.g. what is an adequate liability for the solar component in the case of ISCCS technology).
- Question of the most successful business model (public EPC versus private IPP investments).
- Type of financing instrument (GEF grants, soft loans, Clean Development Mechanism)?
- Requests on the policy frame for renewables/CSP of the hosting country?
- Requests on the structure of the electricity sector in the hosting country?
- Question of the focus on Group 2 countries given the prominent role of these countries for CSP at an intermediate stage of technology take-off.
- Linking up with the Global Market Initiative.

Possible Impacts:

- Realistically ~4 projects (perhaps ~8 if continued cost reduction from first round).
- Strong CSP development in Group 1 countries as a basic requirement for the justification of such an important commitment. Possibly stronger signs of development from countries such as Italy, Israel, and the U.S. where development is still slower or nonexistent compared to Spain.
- Concentration on Group 2 countries as a key group at the intermediate stage of development of the CSP technology (previously successful WB/GEF group 2 countries and new countries such as Algeria, Jordan, Iran).
- Mitigation of the risk that the few CSP market nations might fail to successfully make the CSP market run (see above).
- Concentrate on technologies that allow a flexible extension of solar capacities as financial means become available. ISCCS continues depending on the interest of the host country, but more technology options realized in developing countries.
- By 2015, more than 2,000 MW installed, in case of a very favorable development up to 5,000 MW.

The Second Round: Specializing

WB/GEF supports further motivated Group 2 and 3 countries but only in a specialized way

Comments:

- Support technologies particularly well adapted to some of the Group 3 countries.
- Enhancing the application of smaller scale CSP (dishes?) to alleviate the problem of the large initial steps to enter CSP, even if specific costs higher. Small direct impact on the overall installed MW.
- Concentrating on other technology routes such as a larger market introduction of CSP technology for small-scale CHP in industrial and other ap-plications.
- Concentrating on countries with problematic water supply (not all CSP technologies equally suitable).
- Concentrating on regions with weaker grids.
- Activities to improve the frame for CSP (non-technical) and to reduce liability problems in particular cases by suitable guarantees.
- Linking CDM activities and CSP support (carbon pricing alone cannot bring sufficient support unless costs of CSP have fallen further).

Group 1 countries going ahead, Group 2 and 3 countries taking up in parallel

Possible Impacts:

- Longer-term "preparation of grounds" for the faster take-off of the CSP technology thereafter.
- No large-scale CSP projects with WB/GEF involvement. Projects in Group 2 and Group 3 countries mainly market driven or driven from the national level / other in-ternational financing sources.
- ISCCS technology line abandoned except for countries with specific interests such as Algeria.
- Impact on installed MW com-paratively small.
- By 2015, not more than 2,000 MW installed.

5.5 The Second Round: "2-Track Approach"

This scenario, also dealing with longer term aspects, is based on the recognition by WB/GEF that CSP will not develop simply in regions other than industrialized Southern countries, at least not on the short term, but requires further support and development at the international level in order to open up rapidly "the second track." Such a second track raises inevitably the question whether the GEF can raise again a substantial fraction of its climate change budget and justify this internally as well as to the GEF donors. In turn, this question can only be answered once the GEF has reflected on the importance of the development of CSP for the power supply of developing countries. It also raises the question of lessons learned from the first round with respect to the institutional settings and the long-term interest in the countries taking up the technology, questions of technology choices, etc.

5.6 The Second Round: "Specializing"

This scenario, dealing with longer term aspects, is based on one hand on the same assumptions as the "wait-and-see" scenario described previously (that is, the recognition by WB/GEF that the large-scale promotion of CSP might exceed its financial and institutional capacities), and on the other hand on the recognition of the facts described in the "2-Track Scenario;" that is, the important role that CSP is to play in the power mix of developing countries. This requires specialization of the WB/GEF support on particularly sensitive issues for the future development of CSP in developing countries.

6
Short- and long-term recommendations for the WB/GEF strategy for CSP in the context of a long-term vision for CSP

This chapter tries to narrow the different scenarios considered in the previous chapter. It starts with the statement of the central objective of a long-term vision for solar thermal power and develops a set of success criteria for the establishment of such a long-term vision. This vision does not imply a unique strategy and a unique actor to realize it, but (possibly harmonized) efforts from different actors, including WB/GEF, in both developed and developing countries. The chapter then provides answers for a variety of questions aiming et the role and consistency of WB/GEF actions on CSP departing from the present portfolio up to long-term aspects of WB/GEF involvement in CSP.

6.1 Long-term vision for CSP

Proposed long-term vision for solar thermal power in developing countries:

CSP should be supported to encourage a rapid growth phase to the point that it plays a key role in the electricity supply mix of developing countries where there is a good solar resource.

This vision is based on the following observations. A more detailed rationale for these reasons is provided below in the form of hypotheses. The corresponding hypotheses are mentioned in brackets.

1. In order to maintain climate change within acceptable limits, CSP power plants must, in combination with other renewable power options, increasingly replace fossil infrastructure in developing countries that would build up in those countries and create a lock-in for at least three decades (*Hypothesis 1*). Promoting CSP first through small-scale applications in order to lower cost and then return to the bulk power market with a more competitive CSP technology cannot fulfil this target given the time frame involved (*Hypothesis 2).*
2. *Due to promising cost-reduction prospects (Hypothesis 3*), dispatchability and local industry benefits, CSP is considered one of the most promising technologies for deep cuts in GHG emissions in countries of the world's sunbelt. Other renewables except geothermal, which appears complementary to CSP, and potentially wind energy, cannot fill in the gap rapidly enough (however, wind suffers from the problem of dispatchability) (*Hypothesis 4).*
3. *Although today the economic perspective is prevailing in many developing countries, and although the way will certainly be long toward general acceptance of the fact that, despite the historic emissions of the developed world, a large contribution to the GHG problem will growingly come from the developing world, developing countries start to realize that climate change will threaten their development before they can reach the level of the developed world. Correspondingly, many of them take first steps toward renewable targets and frameworks, which will help to promote CSP in suitable countries and in a suitable mix with other renewables (Hypothesis 5).*
4. *Exporting electricity from renewables from the sunbelt may constitute an important incentive for some developing countries to introduce CSP plants. This is, however, not to be promoted without precaution: Given the strong growth in electricity demand in developing countries mentioned under (1), renewable power must first be directed toward reducing GHG emissions from power generation in their own country. Two regions, the Mediterranean/Near East area and Mexico have—in the longer term—the potential to export additional solar electricity to the Northern industrialized countries (United States and Europe) in order to replace fossil*

fuel generated electricity there, to lower GHG emissions, and to develop a common project narrowing the development gap between both the participating parties (Hypothesis 6).

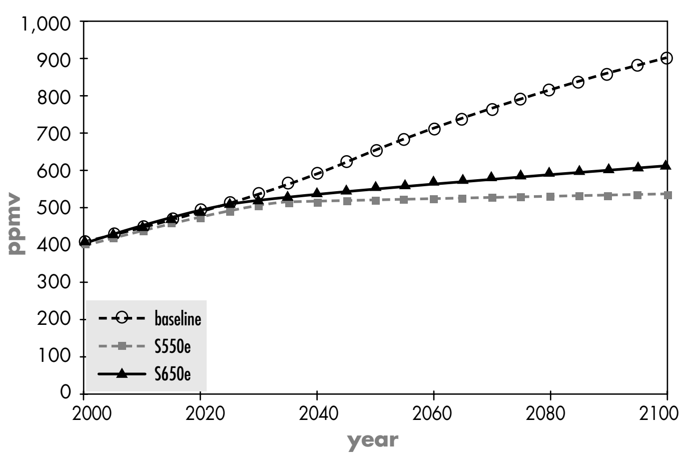
The central objective is underpinned by the following accompanying hypotheses:

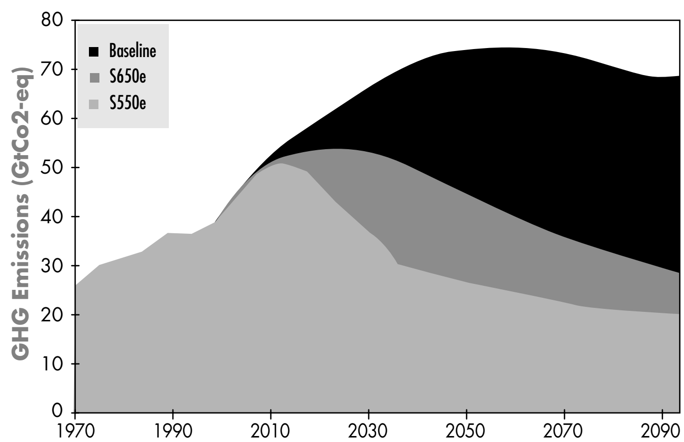
- ***Hypothesis 1: Now is the right time for CSP to increasingly replace new installations of large centralized fossil power stations***

Electricity demand is currently growing in many countries of the sunbelt at a rate of 6 to 7 percent annually, especially in developing countries. Even considering the strong necessity for electricity saving measures in these countries, which are often not considered, large new electric capacities are required (IEA, 2003 and 2004). These capacities will be built in the next 20 years and will remain for at least 30 years—until the middle of this century—which will create a technology lock-in in the developing world. What is problematic about such a technology lock-in? According to current science, it is important to stabilize GHG concentrations in the atmosphere at levels of 550 parts per million by volume (ppmv) in order to not exceed a 2° C global temperature increase. This level requires a peaking of world GHG emissions in the middle of the next decade (Figure 18). Other emission paths allow an increase of concentration levels to 650 ppmv. Even if there are doubts whether this concentration level is not already far too high, this is still a considerable distance from the baseline development with levels close to 1,000 ppmv, increasing well into the next century. Also in the 650 ppmv scenario world emissions need to peak in 2030, requiring considerable efforts up to then. It follows from this reasoning that if the occasion is not used to replace at least part of the fossil power plants to be built in the next 25 years with CSP power, they will still be an important source of greenhouse gases up to the middle of this century.[18]

[18] See the Policy Recommendations for Renewable Energies of the Bonn International Conference for Renewables (2004): "As developing countries work to expand and modernize their energy systems, and industrialized countries work to replace their ageing systems and meet rising demand, societies face a unique opportunity over the next few decades to increase investments in renewable energies. Over the next 30 years, global investments in energy-supply infrastructure are projected to be $16 trillion. The opportunity is to orient a large and increasing share of these investments toward renewable energy, in order to advance the transition to a global energy system for sustainable development. On the other hand, if these investments continue as business as usual, mostly in conventional energy, societies will be further locked into an energy system that is incompatible with sustainable development and that further increases the risks of climate change."

Figure 18: Global GHG concentration stabilization profiles (left) and emission profiles for stabilizing greenhouse gas concentrations at 550 ppmv and 650 ppmv versus baseline emissions (curves labelled S550e and S650e in the graph)





Source: Criqui *et al.*, 2003.

In this case, even the 650 ppmv level is very unlikely to be reached. The importance of developing countries in climate change stems from the fact that their share in energy-related carbon dioxide emissions will increase from 37 percent in 1995 to 45 percent in 2025 and 66 percent in 2050 (Criqui *et al.*, 2003). In addition, a delay of institutional and technology learning for the implementation of solar thermal power plants in the coming years in developing countries could hamper a stronger growth of solar capacities even in the second generation of power plants beyond 2030.

- ❑ ***Hypothesis 2: Small-scale CSP applications do not correspond to strongly growing electricity needs in developing countries***

Niche or small-scale applications for solar thermal power will certainly contribute to develop the market in the longer term and are also necessary to contribute to the diversification of technologies (e.g. development of solar dishes or Fresnel collectors), but would not develop fast enough to introduce solar thermal power on the market in a time when the electricity infrastructures in the developing countries are essentially built up. In addition, they would rather satisfy different target groups as compared to the bulk power generators, in particular industrial CHP applications or solar thermal applications in remote areas.

- ❑ ***Hypothesis 3: After many years of technology improvement through R&D, now CSP markets are needed***

Electricity generation costs from CSP have been at a level comparable to wind energy in the late 1980s. This is one of the reasons why the technology was considered interesting for developing countries, as it was expected that costs could be brought down quite soon to competitive levels. The costs of CSP have potentially been brought down in the last decade since the first plants in California by further R&D, but now steady and sustainable implementation is needed to establish optimized fabrication infrastructure as well as institutional and business procedures.

- ❑ ***Hypothesis 4: CSP is the most promising renewable energy source for developing countries in the world's sunbelt***

There are no serious renewables alternatives to solar thermal power in the developing countries in the sunbelt. Wind energy is in principle a competitor for solar thermal power, due to its advanced maturity among the renewable energy sources together with hydropower, but needs a "stabilizing partner" in the power mix in particular as long as countries are not well interconnected. Technical progress,[19] power network interconnection on a larger scale, improved information/communication technologies for distributed power generation, improved weather forecasts and a well-balanced power mix with renewables that compensate each other's weaknesses in a given country constitute important strategies to reduce the non-dispatchability of wind, but will need considerable time to be implemented. In addition, hot summers with extended dry periods impact strongly on the power generation from wind converters, as experienced for example in Spain in the dry summer months of 2003. Hydropower often has a similar trend to fail in hot summers, similar to wind. Increasing temperatures due to the greenhouse effect will further aggravate this problem. In principle, biomass generated electricity as well as PV (including hydrogen generated from PV at the longer term) could be such a partner for wind. However, in the sunbelt, biomass is not abundant and PV is, in the short run, still too expensive and mainly an option for rural electrification, hence a complement to bulk generation of solar thermal electricity. Like wind energy, PV also suffers from a lack of dispatchability. This might be strongly reduced in the combination of both technologies, but PV still has a way down the cost curve before it can fulfil the role of complementing wind in the power mix. Geothermal energy is an already well-proven technology with comparatively low electricity generation costs. Geothermal energy is mainly available at economic levels in the "ring of fire," which includes most countries of the Pacific Rim (Figure 19). Given this occurrence, geothermal energy is in many

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[19] This statement should not shadow the tremendous progress going on in the dispatchability of wind. Wind energy has made considerable progress with respect to availability in the past ten years: even in sites with wind speeds of 22 km/h, the charge factor (number of full operation hours per year) has passed from 1,600 (18 percent) to 2,400 hours (27 percent) per year. On average, in the European Union, the wind converters produce during 3,000 h/year (34 percent) as compared to 20 percent in 1995, and the newest 5 MW machines approach 40 percent. Wind speeds to be used extend now from 9 to 100–120 km/h as compared to 14–79 km/h a decade ago (Science and Vie, 2005).

respects, on a worldwide level, complementary to CSP, although in some countries the technologies could be in competition (in particular for example in Mexico, which has already installed several geothermal power plants). Tidal and wave energy is in a more early stage of development as compared to CSP.

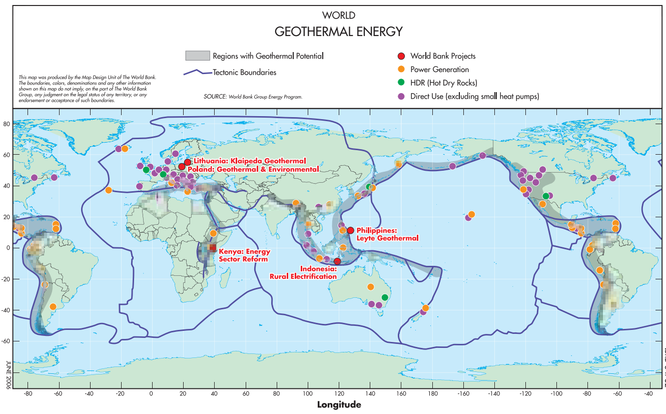
- *Hypothesis 5: Developing countries are increasingly favoring RES due to increasing fossil fuel prices and climate change*

Power plants that are built in the coming years and decades will face a changing environment as compared to the last 20 years, such as growing fossil fuel prices in particular for natural gas. Partly this will be compensated for by increased exploration efforts for fossil fuels and better exploitation of existing resources, but access to cheap gas will be a central element of competition among all countries. There will also be an increasing attitude of developing countries to consider climate change seriously because it constitutes a threat to their existence, at least their development, and in particular for regions in the sunbelt that are close to desert areas with a tendency to expand due to climate change (see the declarations of a variety of developing countries at the Bonn International Conference for Renewables, 2004).

- *Hypothesis 6: CSP electricity export represents an important long-term option for some developing countries*

Industrialized countries have also important resources for solar thermal power, however, less than the developing countries in the solar belt. This varies between the countries. While the United States and Australia have in principle enough of their own solar thermal resources to cover larger needs for electricity in their own country (see for example Price, 2005), Europe might only cover a few percentage points of its own electricity needs with solar thermal power. Japan has even more limited domestic solar thermal power potential. In such cases, importing clean electricity from the sunbelt region can be an important reduction option for industrialized countries. Hence the need to develop electricity exchange based on CSP. However, this should not occur at the expense of covering a country's own needs and/or should contribute to regional development and cooperation. As long as a country's own needs are not covered by clean electricity, tradable solutions[20] could constitute a suitable approach also. This supposes, however, the installation of an international trading system,

Figure 19: Implementation of geothermal power plants worldwide



Source: World Bank (http://www.worldbank.org/html/fpd/energy/geothermal/markets.htm)

which currently is only the case with CDM. Physical exchange of electricity between adjacent developed and developing regions can also generate additional benefits as compared to tradable

[20] Tradable solutions constitute an alternative to physical export of green electricity by unbundling the environmental attributes of a unit of renewable energy from the underlying electricity. Possible trading solutions are in particular renewable energy certificates (RECs) and certified emission reductions (CERs) (under the CDM). The development of tradable certificate programs is driven by the implementation of legislation known as renewable portfolio standards (RPS). RPS typically mandate that each retail power supplier obtain a certain percentage of its total annual energy sales from renewable sources. An important issue in developing a robust international market for renewable certificates is the ability to track both the certificates and greenhouse gas emission reduction credits. For RECs, electronic issuing and tracking systems have been developed in parts of North America, the European Union, and Australia to support the development of RECs as a compliance and market tool. A pilot project has also been carried out to develop RECs to finance renewable energy projects in Brazil, China, and South Africa (http://www.reeep.org/groups/TRECS). In the European Union, there is currently a discussion to link Mediterranean countries to the EU Renewables Directive from 2001 which could imply a trading solution but also a feed-in tariff for those countries. RPS have so far shown much less impact on the development of renewables as they make investments in renewable electricity plants more risky. Therefore, the emergence of additional investments in the renewable market may take more time with this system than with other systems that guarantee a fixed premium price for the renewable electricity.

solutions, such as increased network stability (allowing larger amounts of renewable electricity in the respective countries) or the contribution to interregional stability, which can be an important element in the Mediterranean/Near East area.

Several global visions for CSP have been formulated quantitatively in recent years, in particular (see also the discussion in Chapter 2, section 2.1):

- The Global Market Initiative, with the objective "to facilitate and expedite the building of 5,000 MWe of CSP worldwide over the next ten years" (GMI, 2003).

- The Greenpeace/ESTIA study (2003) that projects "that by 2040 the proportion of global electricity demand which could be satisfied by solar thermal power will have reached a share of 5 percent. This is on the assumption that global electricity demand doubles by that time, as projected by the International Energy Agency." For 2015 the study projects around 6,000 MW (of which 25 percent in developing countries), for 2020 around 21,500 MW (of which 30 percent in developing countries).

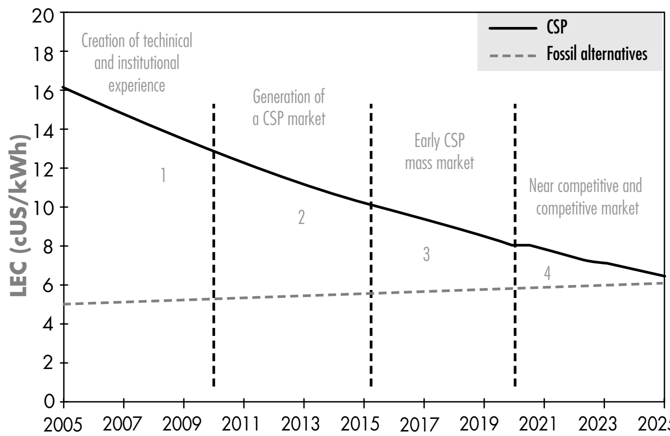
- The ATHENE scenarios in the SOKRATES project (DLR, 2004), which envisage the installation of around 5,000 MW by 2015, 15,000 MW by 2020, and 42,000 MW by 2025. The share of developing countries is higher in this study (at around 50 percent already in 2025) due to a lower installed capacity in the United States as compared to Greenpeace/ESTIA.

6.2 Criteria describing the success of a long-term CSP strategy

Any successful strategy aimed at the realization of the above-described vision should accompany the various stages of the development of CSP along the cost reduction curve (see Figure 20) with different elements of support adapted to the advancement of the market for the technology.

The four parts in the cost reduction curve are briefly described as follows. The curve assumes cost competitiveness around 20 years from now in 2025, which appears a realistic target.

Figure 20: Four stages in the development of CSP



Source: Authors.

- *Part 1 of the cost reduction curve*: Creation of technical and institutional experience. Small number of new units (in addition to the Californian SEGS plants), a few hundred MW. Creation of confidence, lowering of risk factors applied to first plants, first "pilots" in developing countries. Corresponds to the realization of a few plants in Spain, the United States, and some of the WB/GEF projects as well as of the first Algerian plant by 2010.

- *Part 2 of the cost reduction curve*: Generation of a market (total installations of 500–2,000 MW). Diversification in technologies, certain degree of cost reduction, but still far away from economic margins. Target of perhaps 15–20 percent of capacities installed in developing countries. Financing driven in industrialized countries by feed-in tariffs and renewable portfolios, in developing countries by a mixture of grants, preferential loans and national financing as well as a dedicated CSP fund (see below).

- *Part 3 of the cost reduction curve*: Early phase of a growing mass market (total installations of 2,000–7,000 MW). Substantial decrease in costs due to scale and volume effects, costs approaching competitive ranges but not yet generally cost-effective. Target of perhaps 20 to 25 percent of capacity installed in developing countries. In some applications, however, even without subsidies, financing in developing countries through carbon pricing and (premiums from exports), national financing, private investors.

- *Part 4 of the cost reduction curve*: Development of a mass market (near competitive and competitive market). Installed capacities: 7,000–25,000 MW. Further decrease in costs due to volume effects and R&D. Target of 30 to 40 percent of capacity installed in developing countries. This is a stage that is currently reached by wind, but with a still comparatively low share of the developing world (by the end of 2004 around 47 GW of wind were installed worldwide, of which around 8.5 percent in the developing world).

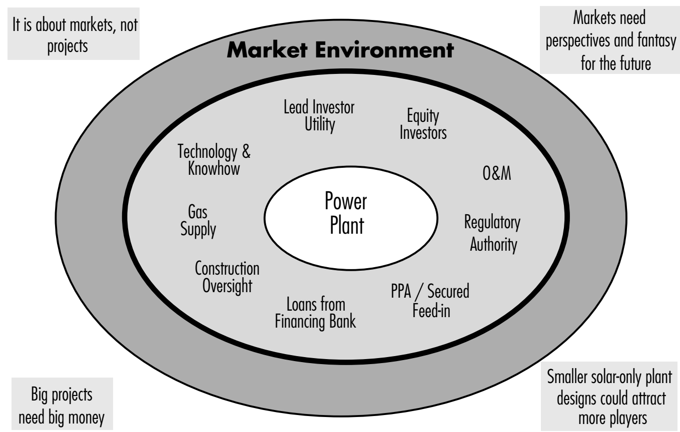
A successful strategy must further take into account that the main purpose is not to realize individual projects but to secure the development of a market. For this, the strategy must integrate the expectations of important market players that constitute the market environment for the CSP technology (Figure 21).

The third major issue is that a market introduction strategy must cope with the main barriers to the technology. For CSP, barriers in the developing countries are relevant, such as:

- Lacking financial means to support more expensive renewables in an early phase in order to cover the rapidly growing electricity demand;
- Lacking institutional frames for renewable energy sources and lacking competition on electricity markets;
- Suspicion toward a technology "that is even not used in the developed world."

Table 7 translates these general requirements in a list of success criteria for a suitable CSP strategy that may realize the vision described in section 6.1. The criteria are further described according to the phase of the cost reduction curve where they mainly act, possible OP 7 objective to which they are linked (see the following box), the scenarios of the second round described in Chapter 3 to which they are relevant, as well as the importance of the criteria in an early stage of market development.

Figure 21: Market environment for the introduction of CSP technology



Source: Haeussermann (2005).

Table 8 describes the different roles that CSP could take in the power system of the different countries/regions (where solar thermal energy is most promising) according to criteria 3 described above. This role is important for the economics of CSP in the shorter term and for the acceptance of the whole technology line in the longer term. It also might determine the choice of the technology. Solar-only technologies might be preferred in principle, but there are various functions that might favour ISCCS as the preferred technology in a country.

6.3 New market initiatives and their relevance in a long-term strategy for CSP

The following briefly describes two important new market initiatives, which have in common that they try to integrate the different stakeholders relevant for the development of a technology and take into account the regulatory/institutional framework, thus meeting

Box 2: OP 7 objectives

The main OP 7 objective is "to reduce greenhouse gas emissions from anthropogenic sources by increasing the market share of low greenhouse gas emitting technologies that have not yet become widespread least-cost alternatives in recipient countries for specified applications." Underlying this objective is the basic aim of the GEF, which is to promote technologies directed to non-Annex I countries. The GEF document describing OP 7 objectives assumes that "the objective will be achieved by GEF's promotion of such technologies so that, through learning and economies of scale, the levelized energy costs will decline to commercially competitive levels." However, it also admits that "programmatic benefits also can result from structured learning from projects implemented." This major objective is accompanied by a variety of other requirements laid on the GEF by the Conference of the Parties of the UNFCCC. For example, projects:

a) are country driven and in conformity with, and supportive of, national development priorities;

b) are consistent with and supportive of internationally agreed programs of action for sustainable development;

c) transfer technology that is environmentally sound and adapted to suit local conditions;

d) are sustainable and lead to wider application;

e) are cost-effective (not relevant for OP 7 technologies at the beginning);

f) strive to leverage other funds; and

g) mitigate climate change.

With respect to CSP, OP 7 emphasizes "the proven parabolic trough variant for electric power generation" but leaves open the choice of other technologies for support in the future.

With respect to resources, the GEF concludes that "given the long lead times for the development and deployment of highly capital intensive backstop technologies, as well as the time required to move down learning curves, time horizons for the achievement of program objectives will typically be on the order of decades. The technologies identified under this program will require the security of funding and long-term commitment of GEF support. Analysis of indicative project pipelines and estimates of minimum "critical mass" of support for the various technologies under this program suggest an initial requirement of $100 million per year in GEF grant resources, gradually rising to $200 million per year over five to ten years as investment demand and absorptive capacity grow. One analysis of the median amount of resources required to induce cost reductions in just one of the technology applications listed in the operational program (for large-scale electricity production using PV cells) is around $3.3 billion,[21] about half of which would be for applications in developing countries. It is therefore clear that the GEF should choose technologies for this operational program where it can leverage resources of other players as well.

some of the most important criteria for successful market creation mentioned previously. The first, the Global Market Initiative (GMI) is specifically directed toward CSP; the second, EM Power, addresses renewable electricity (RE) more broadly.

6.3.1 Global Market Initiative (GMI)[22]

The goal of this coordinated action, called the CSP Global Market Initiative (GMI), is to facilitate and expedite the building of 5,000 MWe of CSP power worldwide over the next ten years up to 2015. Furthermore, the GMI claims that by then full competitiveness with conventional power generation will be reached. For this purpose, a visible, reliable, and growing market for solar

[21] This is in good compliance with the Athene cost reduction forecast (see chapter 2.3.2): 2.5 million € (under the assumptions of an internal project revenue rate of 8 percent and CO_2-trading)

[22] Section based on " The Concentrating Solar Power Global Market Initiative"

Table 7: Main success criteria for CSP strategy

	Main success criteria for CSP strategy	Criteria most important for position 1–4 [4] in cost reduction curve	OP 7 objective linked to criteria	Criteria relevant for Chapter 5 scenario	Ranking of criteria from an early market perspective
1	Ensure increasing participation of developing countries in CSP development	1-3	Main objective	"Two-Tracks"	very important
2	Spur CSP market deployment in industrialized countries	1,2		"Two-Tracks" Wait and See"	
3	Make sense for the country's power market (see Table 8)	1,2	a)	"Two-Tracks" "Wait and See"	
4	Include successful market creation policy measures	2,3	Main objective	all	
5	Serve economic development of countries/region	1-4	a)	all	
6	Contribute to building up of local institutional experience	1	Main objective	all	
7	Create renewables frame in developing countries	2,3	a)	"Two-Tracks"	
8	Mobilize sufficiently large funds	2	f)	"Two-Tracks"	
9	Promote CSP electricity production instead of CSP investments	1-4	a) b) e) f) g)	all	
10	Mobilize private investment	2-4	f)	"Two-Tracks"	
11	Promote technology diversity	2	-	"Two-Tracks"	
12	Enhance previous country experience with CSP	2,3	-	"Two-Tracks"	
13	Contribute to building of local manufacturing experience	3,4	c)	all	
14	Contribute to the sustainable development of a country/region [1] (note see below)	3,4	c) d)	all	
15	Reduce environmental impact [2]	2-4	g)	"Two-Tracks"	
16	Assure acceptability of technology in regions to which CSP electricity is exported	3,4	d) g)	"Two-Tracks"	
17	Promote small- and large-scale applications of the technology [3]	3,4	-	"Specializing"	less important

Notes:

1 including social and economic dimensions in addition to the environmental dimension. Enhance capacity of the country/region to integrate different aspects

2 In developing countries only relevant for phases 2-4 in the cost reduction curve, in industrialized countries also for 1

3 Small-scale development alone is not sufficient to achieve the goal in a sufficiently short time to lower costs for CSP. Targeted rather at specific applications. Volume is needed.

4 See Figure 20

Table 8: Possible role of CSP in different countries/regions with suitable solar resources

Function	Country/Region	Technology selection criteria	Technology implications
Local industry promotion	Spain, Italy, Greece, Egypt	Share of local manufacturing (foundations, steel, glass industry)	CSP in general, espe-cially Fresnel collectors because of high local value creation (due to larger share of simple collector components)
Environmental protection	Spain, Italy, U.S.	Environmental impact	Solar only or SEGS
Noon peaker	Israel, Egypt, Jordan	Local daily power load characteristics	Solar only or SEGS
Evening peaker	North Africa, South Africa	Local daily power load characteristics	Storage technology or ISCC
Summer noon peaker	Spain, U.S.	Local yearly power load characteristics; power mix (wind; hydro)	Solar-only options (including storage) or SEGS
Diversification of power mix	Morocco, China, Mexico	Fit to power generation mix	Solar only or SEGS; ISCCS technology (if own gas resources or large amount of MW needed)
Fuel Saver	Mexico (to prolong national gas resources or to reduce inefficient coal use), South Africa	Combination with natural gas or coal	Feed-water preheating but also ISCC
Exporter of Gas/Green Electricity	Algeria, Iran	Combination with natural gas	ISCCS technology
Remote Power Producer	Remote regions with larger electricity demand that cannot be satisfied by PV	Quality of energy service	Small-scale CSP
Transmission Stabilizer	Crete	Quality of energy service	Storage technology

Source: Geyer (2005); authors' own additions.

thermal power with normal risk levels must be established in order for project developers and CSP equipment suppliers to make the needed long-term investments to achieve acceptable investment costs, and hence competitive rates. The following policy areas will have the greatest impact on the use of concentrating solar power. Each country or state participating in the CSP GMI will contribute with the following policy measures:

- *Targets*: As the overall goal of the CSP GMI is 5,000 MWe to reach cost competitiveness by 2015, national and/or regional targets will be set for CSP capacity. These targets may be a specific number of MW over a certain period of time, or may be a percentage of CSP within the new capacity to be built over a certain period of time, as in Renewable Portfolio Standards.

- *Tariffs*: The level of revenue for CSP projects needs to be adequate to encourage private sector investment and provide a stable investment climate. This can be achieved by feed-in tariffs, production tax credits, or public benefit charges specific for CSP. These supports will be designed to reduce over time as the CSP technology becomes competitive in the power market after 5,000 MWe of CSP has been built by 2015. Coordination with participating neighboring countries, states, or regions with preferential tariff schemes will allow CSP-based electricity imports from high solar radiation areas (and therefore lower electricity costs). The use of long-term power purchase agreements or similar long-term contracts with creditworthy off-takers, or equity ownership by public organizations will build the confidence of investors and financial institutions.

- *Financing*: Cooperating bilateral and/or multilateral financial institutions will ensure that project-related flexible Kyoto instruments such as Clean Development Mechanisms and Joint Implementation Actions become applicable to CSP and ensure that the mechanisms are bankable. The establishment of national or regional loan guarantee programs via existing windows at multilateral banks, national lending programs, and global environmental programs (such as GEF, UNEP, and UNDP) will further reduce the inherent risk of introducing new technology for private sector banking institutions. Investment tax credits, which stimulated the first 354 MWe of CSP plants in the United States, should be maintained, and production tax credits similar to those that have stimulated the growth of wind power in the United States should be made available to CSP plants. Cost-shared development of transmission lines between regions with excellent solar resources and urban load centers, even across borders of participating countries and regions, will optimize the development and exploitation of all regional resources.

- Regulation: Limitations on CSP plant capacity or operating strategies that make the technology introduction more costly need to be avoided. Legal restrictions and barriers to allow more cost-effective connections of CSP plants to the electric grid at the end user (customer), distribution, and/or transmission points shall be identified and eliminated.

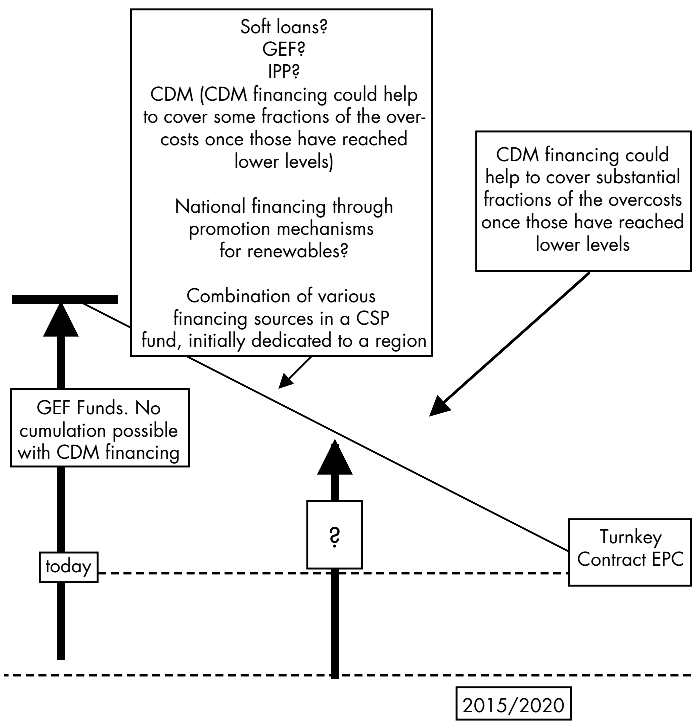
6.3.2 EM Power: A new approach to OP 7?[23]

An initiative is under development, involving UNEP and KfW, that could be a new model for support to near-commercial energy technologies. The proposal is technology neutral, and looks at how markets function. It started with PV-hydro applications, and now also includes distributed PV and CSP. The aim is to facilitate collaborative market development and transformation on a regional level. It is a partnership project that will explore market aggregation tools and identify investment opportunities. The idea is to work with the industry and OECD countries and try to bring partners together, and build regional capacity (in financing, contracting etc.). GEF could facilitate market aggregation for a specific RE (renewable electricity) or technology application. The problem, though, is not being able to spend money in developed countries and to get the motivation of OECD countries. Information is being collected on market aggregation tools, such as forward procurement and dual betting (bundling of financing for RE and conventional, which lowers the transaction costs). Firstly, a market has to be created before it can be aggregated. The proposal is that GEF sponsors a few pilot medium-sized projects (MSPs), and links them up with investment, scaling up the effects.

6.4 The possible role of the Clean Development Mechanism in project financing: How to cross the bridge toward competitiveness

As mentioned in the previous section, the Clean Development Mechanism can play an important role in the further development of CSP (although currently there is no easy way to combine GEF and CDM), in particular once costs have come to a level where

Figure 22: Various financing mechanisms to cross the bridge toward competitiveness and the role of carbon financing in such a financing strategy



Source: Authors.

[23] Section based on the Report of the STAP Brainstorming Session on Operational Program 7, Washington, D.C., March 10–11, 2003. Information from a presentation by Peter Hilliges, GEF Secretariat.

Table 9: Example of CDM financing for CSP

Project	
Investment:	$250 million
Installed capacity:	100 MW solar only power station
Generation	430 GWh electricity/year
CDM component	
Baseline:	Coal-fired power plant (1.1 t CO_2/MWh)
CER generation	475,000 t CO_2/year
Additional revenues	$4.7 million/year (over crediting life of 20 years, $10[24]/t CO_2)
Split up of revenues	Conventional electricity sale 6 cents/kWh CER sale

Source: Authors, based on Sutter (2002)

the additional financing expected from CDM projects could contribute substantial fractions to the project financing. Currently, the contribution would be typically several million dollars with a need for additional financing of around $50 million, corresponding to the amount of the grants in the current GEF portfolio.

6.5 Central questions for determining the role of the WB/GEF in the realization of the CSP vision

In view of the vision formulated previously and the criteria describing a successful strategy for the realization of such a vision, the World Bank has to answer a variety of questions addressing its implications for CSP and technology choices at different time horizons. The long-term questions concern both strategic questions as well as operational questions.

6.6 Answers to the questions addressing the short-term development of the WB/GEF CSP portfolio

After having reviewed the current WB/GEF portfolio in the frame of the long-term vision and the corresponding success criteria developed in Chapter 6 (sections 6.1 and 6.2), the current chapter provides answers to the questions addressing the short-term development of the WB/GEF CSP portfolio raised in section 6.5. A third section then addresses in detail the chances/risks of each of the four WB/GEF projects to reach realization (question (9)).

6.6.1 The current WB/GEF portfolio in the frame of the long-term vision

This section investigates the extent to which the current WB/GEF portfolio is "in line" with the long-term vision and the criteria for a successful overall long-term strategy developed in sections 6.1 and 6.2, or whether there are individual characteristics of the current portfolio that contradict the development of a long-term strategy. For this purpose, the current portfolio is evaluated below against the list of criteria set up previously.

From the comparison with the list of success criteria it follows that:

- The present portfolio is to a satisfactory degree in line with the requirements for the further development of a successful promotion strategy for CSP along the cost reduction curve. The strategy has certainly helped to keep the CSP technology up during the past years; it has contributed considerable funding to the initial stage of the cost reduction curve (however, conclusion of this stage is necessary with at least a partial success of the portfolio), and it has generated considerable institutional learning. As such, it can be considered a partial success (under condition of finalization).

- The weakest point seems to be the fact that currently no incentives are given to actually operate the installed solar fields in the ISCCS plants. In case the solar field causes unexpected trouble or the O&M costs of the solar field exceed the remuneration from the solar electricity sales, it seems quite possible that the solar field will not be operated. Penalties on a kWh_{th}-basis for the solar field might be a possibility to mitigate that weak point.

[24] The value of $10 used by this author appears as high. Typical CER prices are on average rather $5 than $10, although it must be emphasized that present CDM projects might be the most profitable ones. On the other hand, there is also scope for system learning, which would mitigate increasing CER prices.

Table 10: Questions addressed to the short- and long-term CSP strategy by the WB/GEF

Questions addressing the short-term development of the WB/GEF CSP portfolio

1. Can the rationale to include CSP in the OP 7 objectives be confirmed?
2. Should the WB/GEF portfolio of CSP plants be continued as a whole, in parts, or should it be stopped?
3. Are there particular conditions for the continuation of the portfolio?
4. Are there alternative possibilities for disbursement of the WB/GEF grants to promote CSP in one or two of the four selected countries, in particular in case of project failure?
5. Was the ISCC/solar trough technology the right selection for the WB/GEF portfolio?
6. Should there rather be a single or a two-EPC approach (combined or separate EPC for the fossil combined cycle and the solar part of the plant)?
7. Should the pending bidding procedures show flexibility with respect to the size of the solar field in order to be flexible with respect to cost uncertainties?
8. What are the opportunities for successive plants?
9. What are the chances/risks of each of the four WB/GEF projects to reach realization?

Questions addressing the long-term development of the WB/GEF CSP portfolio

Strategic questions

10. Which strategy choice as discussed in Chapter 5 (sections 5.4 to 5.6) ("Wait and See", "2-Track-Approach", "Specialization") should be adopted in case of successful/unsuccessful termination of the current portfolio? What would be the outcome of such an engagement?
11. Should a future WB/GEF strategy concentrate on regions with the best chance to create volume markets ?
12. What are the requirements on the composition of any future portfolio for CSP in order to fit the development toward the realization of the CSP vision described in Chapter 6 (section 6.1)?

Operational questions

13. Should a future engagement continue to promote ISCC? Should it promote a broader range of technologies; if yes, which?
14. Which funding mechanisms appear as most suitable to promote CSP in the future? Should WB/GEF bundle forces with more actors to reach a critical mass? In particular, how can the technology best be promoted in developing countries?
15. What amount of support is necessary for any following step?
16. What could be the potential GEF engagement in case of reduced available CSP funding?

- Another weak point is to generate a stronger link between the development of a frame for renewables in the countries and the evolution of CSP technology. Both are largely disconnected in the WB/GEF portfolio countries, whereas in Algeria, for example, the connection is explicitly made. This point is linked to the previous one.

- One other weak point in the comparison appears to be the interface from the currently ongoing activities in the phase of institutional and technical learning to a full-fledged market development strategy as necessary for the next phase where a market has to be generated.

- Private sector investment was not present in the first phase of market development, although a suitable replacement was found with the public EPC approach. However, the next phase must involve more private investment.

6.6.2 Short-term recommendations for the WB/GEF Portfolio

This section provides answers to the questions raised in section 6.5 addressing the short-term development of the WB/GEF CSP portfolio. It gives general and project-specific recommendations for the WB/GEF portfolio and looks at implications for the CSP strategy.

Table 11: Evaluation of the current WB/GEF portfolio against the set of success criteria for a long-term strategy for CSP

	Criteria	Relevance in the current WB/GEF portfolio	Strong/weak/medium point in portfolio
1.	Ensure increasing participation of developing countries in CSP development	Important issue in current portfolio. However, weak point in so far as no mechanism in place that generates further interest. Successful termination of the larger part of the WB/GEF portfolio will generate confidence for other developing countries to enter at part 2 of the cost reduction curve or to continue the experience from part 1.	Medium
2.	Spur CSP Market Deployment in industrialized countries	Not taken into account. Only indirectly accessible to WB/GEF; can be influenced through a parallel development of the market in developing countries.	Medium
3.	Better understand the country's power market	Given to a certain degree, but limited.	Medium
4.	Include successful market creation policy measures	Only partially taken into account through grants and preferential loan. Lack of a strategy extending in particular from part 1 to part 2 of the cost reduction curve. Originally this strategy was there in the form of larger amounts of grants, but it is questionable whether grants would be the best means to move on to the next phase. For the future, it will be more effective to fund MWh instead of MW (see also description of a CSP fund in section 6.3).	Weak
5.	Serve economic development of countries/region	In the frame of the size of the WB/GEF projects, once realized they will certainly have an economic impact on the region concerned (even considering the solar part alone).	Medium
6.	Contribute to building up of local institutional experience	Important issue of the current WB/GEF portfolio.	Strong
7.	Create renewables frame in developing countries	The current strategy provides for little incentives for the current to consider a wider frame for CSP. The frame for renewables is also developing in parallel, but there is no straight link between the renewables frame and the CSP strategy in the countries, as for example established in Algeria.	Weak
8.	Mobilize sufficiently large funds	GEF funds provided are considerable. However, no strategy discussed so far how to move from part of 1 of the cost curve to part 2 (Figure 20)	Strong
9.	Mobilize private investment	Not successful so far (failure of the IPP approach). However, so far a fairly successful replacement solution was found with the public EPC approach.	Weak
10.	Promote technology diversity	Not considered so far. The main focus was right from the beginning on troughs as the most experienced technology by the time. The selection of four ISCCS plants might have been determined by the country choice for large capacity increase. Important issue for part 2 of the cost reduction curve.	Medium
11.	Enhance previous country experience with CSP	Not an issue in Part 1 of the cost reduction curve.	—
12.	Contribute to building of local manufacturing experience	Larger fractions of the plants will be built by local companies, in particular all construction work. Concerning solar components, given the small volumes involved so far, the presence of suppliers in industrialized countries, no local manufacturer has arisen so far	Medium

(continued on next page)

Criteria	Relevance in the current WB/GEF portfolio	Strong/weak/medium point in portfolio
13.Contribute to the sustainable development of a country/region	The contribution to the overall sustainable development of the current portfolio is limited to the direct economic and environmental impact (see below). Criteria less important in Part 1 of the cost reduction curve.	Medium
14. Reduce environmental impact	Is in principle the case but depends on the quality of the plants realized (issue of the larger steam boiler with larger partial load losses in ISCC). Criteria of less importance in Part 1 of the cost reduction curve.	Unclear at present
15. Ensure acceptability of technology in regions to which CSP electricity is exported	So far no export of electricity is foreseen for any of the 4 WB/GEF projects given that this is essentially an interesting option for gas suppliers such as Algeria who want to sell electricity from combined cycles in combination with solar thermal power. Criteria of less importance in Part 1 of the cost reduction curve.	—
16. Promote small and large-scale applications of the technology [3]	Criteria of less importance in Part 1 of the cost reduction curve given that the technological diversification is more an issue of part 2 of the cost curve	—

1. Can the rationale to include CSP in the OP 7 objectives be confirmed?

The context for the recommendations in this section is the original objective of OP 7—to increase the market share of low greenhouse gas-emitting technologies that are not yet commercial, but which show promise of becoming so in the future. In view of strongly growing energy demand in the developing world, increasing global environmental concerns regarding energy provision, fuel security issues including domestic supply constraints, and an increasing likelihood of some form of global trade on carbon emissions (including targets in all countries also in the developing world), we strongly believe the OP 7 objectives are responsible, timely, and necessary.

There are numerous avenues for manifesting these objectives, some of which have already been pursued under OP 7 such as biomass and fuel cells. From an overall perspective, we believe CSP is a technology worth pursuing under the objectives of OP 7 as it meets all important criteria:

- Solar energy is the world's largest sustainable energy resource
- Solar energy is abundant in many developing countries
- Solar thermal is positioned favorably in terms of technology development—no exotic material breakthroughs are required, and it comprises thermal processes that are well-understood
- Solar thermal integrates well with other thermal processes, thermodynamic cycles, and conventional power generation equipment
- There remains room to "stretch" the technology
- Operation and maintenance issues can be undertaken relatively easily and without too much dependence on an incumbent supplier
- Solar thermal electricity plants can be installed in large "chunks," which means it is one of relatively few renewable technologies that can make the necessary deep cuts in GHG emissions.
- Solar plants can be designed to be dispatchable

We see that solar thermal electricity offers prospects that have much strategic value for the countries that take up the technology, and thus forms an important part of the technology mix to be pursued under OP 7, which itself is a critical element toward the worldwide deployment of low GHG-emitting technologies. The rationale is discussed below.

2.Should the WB/GEF portfolio of CSP plants be continued as a whole, in parts, or should it be stopped?

We would encourage the World Bank and GEF to proceed with each of the present projects. First, we believe they are crucial to building momentum in the solar thermal industry. Second, by proceeding, future projects in those countries are likely to benefit from the leverage applied now. It is likely that by the time these GEF projects begin operation, and any subsequent projects are formulated, new projects will have commenced around the world, leading to cost reductions. These cost reductions won't be enough to avoid the need for gap funding (whether in OECD or developing countries), but the gap will be less, and perhaps acceptable.

We would liken the process to falling dominoes. It only takes one domino to "miss the mark" and halt the flow. Multiple, well-designed projects with gaps that are not stretched to their limits are more likely to give rise to a continuous stream of new projects.

At the very least, each project should be given the opportunity to proceed the release of the RfP, as the cost to get to this point will be relatively small against the opportunity it affords to discern the level of interest.

In the course of writing this report, the question has been raised whether the present portfolio context is not similar to a few years ago, when hopes were high for an immediate realization of WB/GEF projects that have not materialized so far. However, there are substantial differences in the context now, such as a considerably higher energy price context, concrete CSP projects coming up in the developed world, and stabilization of the business model (move from the IPP approach to public EPC).

3. Are there particular conditions for the continuation of the portfolio?

Given the time elapsed for the project portfolio, the countries with pending projects must commit to firm timelines that it must meet in order to keep the GEF grant available. The key dates for the countries to adhere to are (a) release of RfP (i.e. must have passed "non-objection"); (b) assessment of bids and presentation of preferred bidders to WB; and (c) signing of contracts.

Such timelines need to be discussed and fixed with each of the four countries individually. From the current perspective, it appears realistic that by the end of 2007 the Moroccan project—as well as the projects in Egypt and Mexico—could have reached the contract signature stage.

4. Are there alternative possibilities for disbursement of the WB/GEF grants to promote CSP in one of the four selected countries, in particular in case of project failure?

The team has considered alternative possibilities for disbursement of the GEF grants, in particular providing a smaller contribution toward the capital cost of the project and maintaining some for "other activities to promote CSP in the country." Other activities could help to improve the chances of subsequent projects in those countries, and might include setting up in-country fabrication facilities for mirrors or tubes and the establishment of "expert teams" of local skilled labor. However, we don't believe this money will be well-spent given the tenuous chance of immediate subsequent projects in those countries.

There was also the possibility of splitting the grant into two smaller grants to fund two smaller projects, but, as discussed above, there are fixed costs that are relatively independent of capacity associated with such power projects, and it would be likely that instead of one 25 MW solar field one would end up with two 10 MW solar fields (or two 12.5 MW solar fields with higher LEC's) without the benefit of contributing to a cost reduction in the technology. There would also be the risk that one of them would not proceed.

In the case of the revision/cancellation of one to two projects, and the wish of the WB/GEF to support further this important technology in the given country without looking for alternative sites, the following alternative technology lines to the ISCCS concept might be considered:

- ❑ Market introduction for industrial process heat applications based on concentrator solar.
- ❑ Small-scale solar combined heat & power plants (heat for absorption chillers (e.g. air conditioning), or process heat or sea water desalination (the latter becoming increasingly important in many countries with good solar resources).
- ❑ Feed-water preheating in fossil steam plants: promoting technologies other than parabolic trough collector types (e.g. tower, dish, Fresnel) by a technology unspecific bidding procedure. Feed-water preheating leads to good solar efficiencies, good

ratio of funding and solar-MWh because of reduced investment. Existing plant (infrastructure) might be used.

5. Was the ISCC/solar trough technology the right selection for the WB/GEF portfolio?

The question has arisen as to which is the better configuration—SEGS or ISCCS? Our contention is that it is a matter of "horses for courses." Technically, both options are feasible, as is the option of integration into a coal-fired Rankine cycle. One of the major issues that arise is one of perception—that in an ISCCS plant there may only be a solar contribution of some 6 percent. In reality, a 30 MW solar field in either configuration will still generate approximately the same GWh/yr of solar electricity, and bequeath the same level of O&M experience, through having to maintain some 200,000 m^2 of solar array.

There is a more pressing need for MW than for solar plants in the developing countries of this portfolio. There is also a significant non-technical lead time associated with any new project—permits, authorities, contract administration, etc.—regardless of the project capacity. Given that there is less than a 100 percent chance that all proposed power generation projects will proceed, the hybridization of solar with combined cycle both helps to meet the power needs of that country while simultaneously deploying a solar field, a field that may just have been deemed "too hard" if for the sake of only a 25–30 MW plant.

The ISCCS configuration has not been tried before, and thus it is probably inevitable that some teething troubles will emerge. If sound engineering is applied, we believe that enough is known about solar field operation, and enough about combined cycle operation, that any problems that may arise are not likely to be fundamental in nature, but rather to do with optimizing energy flows, particularly under transient solar conditions.

ISCCS makes particularly good sense in the following context:

- if the country aims at exporting gas through the combination with clean solar energy (e.g. Algeria);
- if the country wants to build fossil plants in areas suitable for solar thermal plants (e.g. Morocco); however, one should carefully consider hampering the performance of the combined cycle plant in the case of a non-optimal location due to the solar plant;
- if the country can save on old inefficient coal-fired power plants by the combination with solar thermal (e.g. Mexico);
- if the country has a strong need for increasing the installed MW due to strongly increasing demand and combination of solar and combined cycle does not create additional delay (in principle Egypt, but delays were caused by the contractual separation of the two plants while technically they are combined).

So the answer to the question posed on the ISCCS technology is not a frank yes, but there are some arguments that point to ISCCS as a suitable solution for the current phase of market introduction. Nevertheless, the ISCCS choice has introduced a variety of additional problems that have delayed project realization (e.g. the question of a single or two EPC contracts for the fossil and the solar part, see below; the question of mutual liability between the two project parts etc.)

The other technology issue is that of the solar field—trough, tower, Fresnel, dish? The trough using a heat transfer fluid is certainly the most advanced, and for the most advanced projects in the portfolio, particularly Morocco, we would advocate staying with the existing project as formulated. However given that these projects are early in the cycle for the technology, it is important that the best options be given the opportunity to emerge.

We would strongly suggest that consideration be given to not specifying troughs for the remaining projects (presently it is not specified for Egypt), but rather leaving the technology selection up to the bidders. We believe this will lead to a greater number of bids, improving the competition. Though the tower technology providers would probably balk at installations greater than 50 MW, 25–30 MW should be within their capacity.

6. Should there rather be a single or a 2-EPC approach (combined or separate EPC for the fossil combined cycle and the solar part of the plant)?

In the absence of IPP approaches to this portfolio, the issue of single EPC (to cover the whole ISCCS turnkey project) versus two

EPC (one contract to cover the combined cycle, and the other to cover the solar field) has arisen. In power projects, single turnkey projects (made up of multiple sub-contracts) are common, but power projects comprising multiple EPC contracts (boiler, turbine, cooling, etc) are not uncommon either. An ISCCS project combines a well-known technology (combined cycle) with the less well-known solar field. There are a number of large well-established combined cycle suppliers, but few solar suppliers. The resulting imbalance led, in the past, to some conflicts over the balance of risk. However, with larger consortia now emerging (as a result of the Spanish activities) that are willing to take on the whole project, the single EPC approach appears favored.

There is no fundamental reason why the two-EPC approach is unworkable, however it does raise some difficulties. In particular, the design of the cycle, particularly the interface between the solar and the heat recovery steam generator (HRSG), needs to be well defined in the specifications, requiring a detailed design and optimization study. In the single EPC, the consortium carries out the optimization as part of the bid. The issue that arises, however, is if the project is built as specified and does not perform, the liability must rest with the designer of the specifications.

This approach also limits the flexibility of the solar field offers. This is because the specifications for the HRSG (steam generator) will need to know the thermal contributions and the temperatures that will come from the external heat source (solar field). These will need to be specified so the various heat exchangers in the HRSG can be sized appropriately. For example, the superheater will need to be oversized to accommodate the additional superheating required (given that troughs using heat transfer fluid are limited to around 370°C steam temperature, yet the steam turbine requires perhaps 500°C). However, when the solar field is not operating, the superheater area is too great, and thus significant desuperheating is needed (an efficiency loss). Superheater area is a fixed parameter defined by the operating temperature of the solar field. For example, if the superheater area was designed for 370°C to enable troughs using htf to comply, it would be an excessive area for a tower that could supply the full 500°C. The end result is that the HRSG ends up being designed to suit a particular solar temperature, and thus is optimized for a particular collector.

7. Should the pending bidding procedures show flexibility with respect to the size of the solar field in order to be flexible with respect to cost uncertainties?

The team has only been able to view one set of RfP documents—the original ones from the aborted bid process for India. Those documents specified a fixed solar field aperture size (220,000 m^2 ± 3 percent) for the troughs. Given that the grant from GEF is also a fixed amount, there is no flexibility should costs come in higher than originally anticipated when these projects were originally developed. Given these are first-off projects in developing countries, the risk margin is likely to be high, resulting in the possible situation where all the bids come in either too expensive for the finance available, or non-conforming (reduced field size).

The capacity of these first projects is to some extent arbitrary. It is unlikely that in ten years time the issue of whether the first ISCCS project comprised 25 or 28 MW of solar will be an issue. What will be an issue, however, is whether the GEF projects failed to get past the RfP process as a result of overly restrictive bidding requirements, and, if they did proceed, whether they operated successfully.

We suggest the bid documents allow for a minimum threshold capacity requirement for the solar field, but make the offered solar capacity one of the assessment criteria. The resulting competition will help ensure the maximum capacity possible is offered for the finance available. Most importantly, it would allow the bidders to develop, and feel comfortable with, their own risk profile.

It does raise additional complications as to how the bids are assessed. The documents would need to provide clear guidance as to the weightings given to different assessment criteria—overall LEC, peak solar capacity, solar $/MWh_{th}$, etc., in much the same way as the 2002 Indian bid documents gave priority to thermal storage, etc.

In single EPC contracts where one turnkey price is offered, the break-out cost of the solar field itself will not be known, and even were it requested, there would be the tendency to offload some of the solar field cost against the combined cycle power block cost to make the solar field appear more attractive on a $/MWh_{th}$ basis. The dual-EPC approach has the advantage that each component is bid separately and competitively.

8. How are the opportunities for successive plants?

The World Bank has asked "what is the likelihood of these four plants contributing to the development of a momentum that sees subsequent plants being installed?" And as a corollary, why pursue this GEF portfolio of 4 x $50 million[25] projects if the chance of follow-up plants is slim? There are a number of factors impacting on this issue, but perhaps the key one is the expected cost reduction curve. Depending on the particular model and assumptions used (see section 2.2) some thousands of MWs are required before the technology is competitive with conventional fuels. This means that subsequent plants are only likely to be built if some other form of financial incentive is available—grants, renewable portfolio standards, renewable feed-in laws, etc. The other possibility is that the necessary cost reductions occur as a result of a significant rollout in the OECD countries, the benefits eventually feeding through to the World Bank countries. The latter is quite possible, but could take on the order of ten to twenty years. Perhaps the most reasonable chance of subsequent plants is some combination of the above in a suitable CSP fund starting in a given region such as the Mediterranean/Middle East region (see discussion below).

The rollout in the OECD countries is still in its infancy, although there are in particular robust incentives in Spain, and emerging activity in the United States, to help underwrite significant deployment activity. Nonetheless, at this point in time, there are less than 300 megawatts of what we would regard as relatively firm project prospects. Arguably, technology and industry maturity could be said to have been reached before commercial competitiveness was achieved—perhaps after a couple of thousand MW—and there would be a greater degree of certainty that competition and corresponding momentum would help to roll the industry forward to commercial competitiveness. Once 2–3,000 MW was installed, much as for wind, there would be much more data available to plot the cost reduction curve and provide a degree of certainty for investors. At this point, the industry is totally reliant on external financial incentives; if existing ones were to be removed for any reason, the industry would stop, just as the removal of incentives in California halted the continued progression of the SEGS plants.

The most attractive financial incentives are in Spain. However, these presently only apply to the first 200 MW. Beyond that, there is an expectation they would reduce in line with a (to-be-specified) cost reduction target. However, given that the Royal Decree was essentially put in place to support Spanish industry, and at this point Spanish industry has taken the lead role in the projects proposed, there would appear to be a good chance of continued support. The only other strong support in OECD countries for solar technology is via a small number of Renewable Portfolio Standards (RPS)'s in the United States, although we feel that something like the Southwest United States CSP Initiative needs to be confirmed with strong financial incentives attached for a robust CSP market to develop there.

At this point, the industry still appears fragile. However, once construction is well under way for a few projects in Spain and the Nevada project, a cusp will have been reached. It is more the number of projects than the total MW under construction that will help to move the industry beyond the cusp (part 1 of the cost reduction curve, see Figure 20) and into the beginnings of a more robust rollout (part 2 of the cost reduction curve). In other words, six 30 MW projects are deemed to be of more value than a single 360 MW project. More projects spread over more countries will ameliorate the risk associated with reliance on one country's incentive, and also the risk of one or more projects not proceeding. It will also help build the profile and the perception of widespread activity.

From this point of view, an announcement of at least 1 or 2 GEF projects in the next 12 months becomes quite crucial. We do not feel that the existing portfolio would benefit from any significant change to the way the funding is made available to the projects. The best chance of success is to make the funding available as an upfront grant, as is presently the case. Holding a retainer until certain performance milestones are met would not be necessary, as performance penalties are covered in the bid documents.

From the overview of the mid-term expansion plans for the electricity sector, it appears that with the exception of Egypt none of the other countries in the portfolio have concretely integrated further CSP plants into their expansion plan. Morocco has established a certain number of sites that are suitable for further CSP plants. This

[25] the exact amount is $194.2 million

is understandable to a certain degree given the awaiting for the first plant. Most likely, with the experience of the first plant, and the experiences in countries like Spain, further CSP plants would be considered in a few years as options. However, by then economic conditions will dominate the decisions.

6.6.3 Specific recommendations on the four WB/GEF projects

9. What are the chances/risks of each of the four WB/GEF projects to reach realization?

Egypt

Egypt is currently a net exporter of energy through its reserves of oil and natural gas, which provides valuable foreign income. However, the Egyptian Government does recognize that these reserves of oil and gas do have a finite life. The Egyptian Government further recognizes that it has good renewable energy resources such as wind and solar insolation that can be exploited. Additionally, the Egyptian Government has as one its primary objectives the expansion of its manufacturing industry, which includes the manufacture of components for its energy sector. The government recognizes that expansion of the manufacturing sector is dependent on the development of local know-how and intellectual capital. Finally, the Egyptian demand for electricity is growing and new generation capacity has to be continuously installed.

Importantly, the government recognizes that the GEF grant has provided the catalyst to explore the application of solar thermal technologies.

Two issues that had introduced delays in the project course over the last year were:

- ❑ An agreement had to be reached between NREA and the World Bank with regard to incremental costs not only covering capital costs but also operation and maintenance costs (agreement was reached mid-May 2005 that the GEF financing will cover the incremental O&M costs).
- ❑ Resolution of concerns regarding the JBIC request to split the existing bid documents into two, one for the solar island and the other for the combined cycle island. This issue was finally accepted by the World Bank and Fichtner Solar prepared the two bid documents.

It is within this context that the following is recommended for Egypt:

1. The RfP does allow bids for a broad range of collector technologies (trough, dish, tower, Fresnel). This will stimulate the level of interest in the Egyptian project and reduce the probability of no successful bidders being found.

2. Flexibility must be allowed to explore the consequences of JBIC's request for two bid documents; careful management of timelines to execute the project must be maintained. Although this approach has many unknowns (see the discussion in section 6.6.2), it is an occasion to learn about a different institutional arrangement for the contract.

3. To stimulate Egyptian interest in implementing further solar thermal power projects, we recommend that the World Bank seriously consider a role in facilitating:

   - ◆ Egypt's establishing a renewable energy fund to finance future solar thermal project. Such a renewable energy fund could be financed through a small levy on oil and gas that is exported, similar to the procedure in Algeria.

   - ◆ Surveying local equipment suppliers/contractors to establish what components may be provided locally and to inform such suppliers and contractors of the opportunity of further projects.

   - ◆ Establishing how best to develop local know-know and intellectual capital. Local know-how enables wider choices to be made and increases the probability of new technologies being accepted by all stakeholders, in particular local stakeholders.

   - ◆ How best to integrate any Egyptian solar thermal project into a Mediterranean basin power pool. Such a power pool has the potential to provide Egypt with foreign income and allows Egypt to retain its position of being a net energy exporter.

- How best Egypt can secure any benefits from mechanisms such as the Clean Development Mechanism.

(4) It was specifically requested by those interviewed in Egypt that the World Bank keep the ISCCS stakeholders in Egypt, Morocco, Mexico, and India informed of developments in the various countries through regular newsletters, and seriously consider facilitating an international meeting at a convenient venue where the four countries and other interested countries can compare experiences and developments. Such an international meeting will facilitate future dialogue among the four countries and reduce the communications load off of the WB.

India

At the time of the study, the consultants had recommended that (i) the GoI needed to reply to the World Bank letter of 2004 stating the government's commitment to the project proceeding and to meeting the requirements stated therein, and that (ii) there be a resolution of the balance of funding from KfW. Eventually, the project could not be implemented in a timely fashion due to inappropriate design and location. In case the project is brought forward again, the following remarks might be considered:

- The RfP should be modified to allow a broad range of collector technologies to be bid (trough, dish, tower, Fresnel) to supply steam to the steam cycle. This will help improve the level of interest in the Indian project, and make less likely the situation where no successful bidders can be found.

- The RfP should be modified such that there is a minimum threshold of required solar capacity (perhaps around 23 MW), but which encourages bidders to compete to offer the most solar MW (or better still GWh) for the available grant. This will help reduce the possible situation where no bids are received because the fixed grant is not enough to cover the mandated field size.

- A timeline with specific dates will depend on the above issues being resolved. However it is suggested that the Moroccan project be given time to release RfP's first to at least get one project successfully under way. Given the significant time gap in this project, a new call to pre-qualify bidders will be needed.

- The gas supply issue has plagued this Mathania project from the outset. Discussions in India suggested an alternative supply point requiring a much shorter pipeline; this is now the new preferred option. In addition, some preparatory work has been carried out to investigate alternative uses for the gas and revenue possibilities along the pipeline. This situation needs to be clarified and confirmed in a letter to the World Bank.

- We have seen little technical evidence to support Mathania's selection as the preferred site for this first Indian project. However, various stakeholders suggested it might be unwise to open up this issue to any significant degree as it could lead to further procrastination, and thus quash any project altogether. In any case, it was pointed out, the permits are in place and most of the infrastructural and resource requirements are now starting to come together for Mathania. However, other stakeholders considered there were better sites available and that these should be explored. Integration with the Jaiselmer 110 MW combined cycle was mentioned, but the existing steam turbine would need resizing to accommodate a 30 MW solar field, or a smaller solar field. The Mathania solar resource of 2,240 $kWh/m^2/yr$ is only an average site by world standards. We would be reluctant to recommend a detailed investigation of alternative sites, however there could be value in ensuring that in the last decade—since Mathania was selected—a better site has not emerged. We would suggest a short assessment with very tight deadlines of no more than two or three other sites that might host such a plant. The onus would need to be on the other sites to prove themselves more attractive than Mathania's present status, and also that they could make up the lost time. This could perhaps form part of the required response to the World Bank. One advantage this would have is to effectively lay the groundwork for a more flexible technology response, as recommended above.

Mexico

Long-term prospects of CSP in Mexico

Mexico has excellent solar insolation conditions, a growing electricity demand, and a growing dependence on natural gas imports. Solar thermal power plants can help mitigate the country's risk related to volatile fuel prices. Further arguments to introduce CSP in Mexico are the fact that CSP can be used to substitute Mexico's expensive peaking power plants, which would justify higher solar LEC. Furthermore, the local industry will profit from the CSP market. A Mexican company has already provided structures for the Californian SEGS collectors. In the future, over 50 percent of the solar field investment and O&M can be provided by the Mexican national economy (Spencer Management Associates, 2000).

Near-term prospects of CSP in Mexico

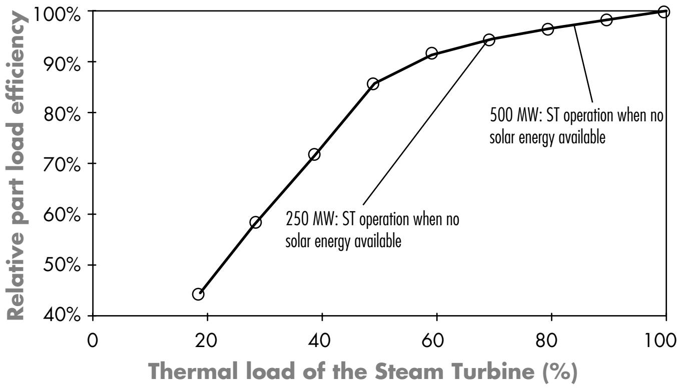
The country has in place legislation mandating a least-cost obligation for electricity generation technologies. The arguments as to why Mexico would profit from CSP technology would have to be recognized by Mexican political authorities with the consequence of developing a legal framework that fosters CSP deployment in the country (ideally in the form of feed-in-tariffs). Currently, a new law for the promotion of renewable energies in the country is in preparation. According to CFE, it might take one to two years before this law is approved. This law will foster solar and wind projects in the future. It is not yet clear how this law will comply with the least-cost requirement, which is also fixed by law. As a consequence the question of whether, in the near term, Mexico will be able to invest domestic capital into further multiple solar thermal power projects is not yet known.

Recommendations on the Mexican project

Given the fact that in the long run, the country will profit from CSP technology and that CFE shows strong interest in the current ISCCS project, it is recommended to maintain the WB/GEF support of the project. CFE will gain valuable construction and especially operational experience with such a plant. With this CSP experience, the country would be much more likely to invest in this technology at a later point.

Mexico's new plan to equip a 560 MW CC instead of a 250 MW plant with a solar field, thereby diluting the solar share to approximately 50 percent of its original contribution, should not be grounds (from an energy, ecological, or economic point of view) to cancel project support. The 560 MW CC would be built anyway and, with the same solar field size, more solar electricity is actually generated (Figure 23). This is because during the hours when the solar field is not operating, there are thermodynamic advantages due to the solar field now representing less of an off-design imposition.

Figure 23: Relative part load losses of the steam turbine for the daytimes when solar field is not providing solar steam for different ISCCS plant sizes



Source: part load characteristics: E.ON Engineering (see figure 4); interpretation and transfer to ISCCS: Gabriel Morin.

Recent further developments for this plant and the recent Sargent and Lundy study (2006) have shown that the doubling in size of the fossil component is not a decisive argument against this plant.

We are unsure if the same methodology has been used to model annual output in both the Sargent and Lundy (2003) feasibility study and the earlier Spencer (2000) study, and for clarification suggest this be reviewed.

The dilution of the solar share of the plant does not appear to be a decisive argument against the 500 MW plant because high solar shares are not among the advantages of the ISCCS concept anyway. ISCCS is a good concept to boost a CC that would anyway be built with a comparatively huge amount of renewable energy (compared to other forms of solar energy usage).

One critical point with respect to the ISCCS concept in general, but especially in combination with a larger combined cycle, is the fact that sufficient incentives will be in place in order to ensure that the solar field will actually be operated. Such motivation is especially strong when the remuneration of the solar electricity occurs on a kWh basis. However, in this case, an upfront grant covers the excess solar costs. Possibly such incentives might be provided in the form of penalties if the solar field is not working according to the design conditions (penalties on kWh_{th} basis for the solar field).

A different plant concept was discussed at the World Bank CSP Workshop (April 20, 2005)—the integration of a solar field into an existing coal-fired Rankine plant owned by CFE. Such a combination will have a much higher CO_2-emission benefit by displacing coal rather than natural gas, when the solar field is used as a fuel saver. Technically/thermodynamically, the solar field would fit well into the Rankine cycle. If the GEF, the World Bank, and CFE are flexible enough to change to this non-ISCC concept, further examination of this hybrid concept is strongly recommended.

In any case, we recommend that CFE, the World Bank, and GEF agree upon a common project plan for further project implementation, including meetings and/or reporting after each milestone to avoid institutional problems encountered in the past (delays due to low project priority, unclear procurement guidelines).

Morocco

The Morocco project appears from the current perspective the most advanced of the four WB/GEF projects, although the Moroccan request to increase the CC capacity due to power shortage could introduce further delay. It is therefore a key project in the portfolio and important for the whole GEF program that this project is strongly promoted and supported, even in the most difficult phase still ahead, the bidding process. The World Bank should therefore pay particular attention to the Morocco project so that delays are kept to a minimum and the deadlines as proposed currently, with contract signature by January 2007, are respected. This could set a sign for the other projects in the portfolio (lead function). Internally, this requires for the World Bank a tough follow-up of procedures. Problems arising in the bidding procedure might arise from the fact that bidding companies, not yet trusting the establishment of a market, might add risk factors to the price that could bring the price beyond the currently foreseen financing. From the current perspective, this risk appears limited (larger share of well-known conventional components with known costs due to the ISCCS approach, financial calculations taking into account such a risk to some degree, the development in Spain that might share the "risk of the first plant"), but not fully excluded. In case of substantial cost overdraw, a rapid compromise should be discussed with the participating companies.

6.7 Answers to the questions addressing the long-term development of the WB/GEF CSP portfolio

This section provides answers to the questions addressing the long-term development of the WB/GEF CSP portfolio raised in section 6.5 (both questions related to strategy and operational questions). From the previous description of a long-term vision for CSP and of the success criteria for a strategy to introduce CSP in developing countries in particular, one can deduce several recommendations that are important for the future development of the WB/GEF CSP portfolio in order to fit such a successful strategy:

6.7.1 Strategy recommendation

The options discussed here for part 2 of the cost reduction curve assume that the current portfolio has some reasonable implementation success (at least 2 projects).

10. Which strategy choice as discussed in Chapter 5 (sections 5.4 to 5.6) ("Wait and See", "2-Track-Approach", Specialization") should be adopted in case of successful/unsuccessful termination of the current portfolio ? What would be the outcome of such an engagement?

The "Wait and See" strategy (see Chapter 5, section 5.4) is incompatible with the success criteria and OP 7 main objective: The "Wait and See" strategy described in section 5.4 does not fulfil Criteria 1 in that it delays the introduction of solar thermal technology beyond the point when a lot of the power generation infrastructure of developing countries will be in place. It is also in contradiction to the main objective of the OP 7 to promote GHG technologies that will make a major contribution to the reduction of greenhouse gas emissions in developing countries. This objective remains entirely valid in the light of the arguments provided at the beginning of this chapter.

Pursuing the "Specialization" strategy now will for some decades only lead to a limited contribution to a path toward reduced CO_2 emissions: It is unlikely that a strategy based on small-scale promotion of CSP technology would be able to lower the cost sufficiently rapidly in order to allow for a stronger penetration of the bulk electricity market. Hence the "Specialization" strategy considered in the previous chapter cannot replace the "2-Track-Aproach" in order to promote quickly enough the penetration of CSP power before fossil alternatives lock down the path toward reduced CO_2 emissions for some decades. However, in the absence of a more ambitious strategy, it can constitute a suitable means to keep interest in CSP at a minimum level or to complement possible more comprehensive strategies from other actors (for more details see answer to Question (16)).

Future GEF Strategies must rely on a 2-Track-Approach: It follows that the main strategy must rely on a 2-Track-Approach promoting the technology in both the developing and the developed countries and to accompany it along the cost reduction curve with different strategies.

11. Should a future WB/GEF strategy concentrate on regions with the best chances to create volume markets?

For the *first phase* of the cost reduction curve (in which we are currently and which establishes technical and institutional experience), it appears as adequate that there was a broad consideration of countries/regions, as the main aspect was the creation of technical and institutional experience. The second phase of the cost reduction curve should concentrate on regions with the best chance to create volume markets (Criteria 4) in the shortest time and should not disperse efforts. However, technology promotion might mean, at a given point of the cost curve, to focus on a given region. Such countries/regions are from the current perspective:

- The *Mediterranean area and the Middle East.*[26] *The main reason for this conclusion is this region fulfils partially or fully a variety of the above-mentioned criteria such as Criteria 1 (if the current WB/GEF portfolio and the ISCCS project in Algeria are successful), Criteria 2 (recent development in Spain and partially Italy and Israel; to be enhanced in Greece), Criteria 3 (in particular for example in Algeria but for the whole of the North African region up to Iran due to the nascent power interconnection of those countries with Europe and among themselves as well as the growing electricity demand at noon and power technology diversification issues), Criteria 7 (currently only in Algeria), and Criteria 12 (if the current WB/GEF portfolio is successful). A successful strategy in this area must enhance the partially fulfilled criteria in other countries and in particular (1) stabilize and increase the participation of the European Mediterranean countries and Israel; (2) replicate the current WB/GEF portfolio in Morocco and Egypt; (3) support the current efforts in Algeria; (4) activate stronger support for the CSP efforts in Jordan and Iran; and (5) investigate for other countries in the region without current CSP strategy but suitable solar resources the possibility to develop a CSP strategy (e.g. Libya or possibly African countries further to the South, see Trieb, 2005). According to Criteria 3, the technology chosen must best fit the requirements of power sector development. In some or all cases, this might be ISCCS technology, either because it best fits the needs of the economy (Algeria) or because it ensures the largest solar capacity installed at the lowest price combined with an overall large fossil capacity covering the rapidly growing demand in the region. Diversification of technologies (Criteria 11) appears, nevertheless, also relevant for the developing countries in the region, although initially it can be assured by the developed countries such as Spain, which have a different weighting of the criteria in the early stage of the cost reduction curve, in particular Criteria 15 (environmental impact).*
- *China. Due to the sheer volume of demand including for renewable energy sources, the exemplary recent approach to create an institutional frame for renewables, and the nascent efforts to create its own manufacturing base for the technology. This region appears interesting despite not having the most optimal solar resources and a larger distance between consumers and suitable areas in the country (Huang, 2005).*

Other countries/regions as compared to the previous two markets (Mediterranean/Middle East and China) might have also their logic to develop CSP, but they require additional arguments to concentrate on in the second phase: Mexico[27] could gain interest from a strong

[26] A detailed scenario analysis of the renewables needs and CSP needs, in particular for the Mediterranean area and the Middle East, is carried out by Trieb (2004).

[27] Mexico's long-term-prospects of solar electricity export (to the U.S.) are less promising compared to North Africa and Middle East (to Europe)—because the U.S. itself has huge solar resources (irradiation and land) in contrast to Europe.

uptake of CSP in the Southwest United States or from a strong national strategy for CSP. India, like China, is a market of its own, but is hampered by the complexity of the decision levels that are manifested in the current WB/GEF portfolio. A minimum requirement for this market to be considered is a successful implementation of the corresponding current WB/GEF project. South Africa is for the moment an isolated market and has little real interest to develop CSP given the strong role of coal. Possibly feed-water preheating in combination with coal could be a viable strategy for this country, as well as combination of existing low-efficiency coal plants with solar.

12. What are the requirements on the composition of any future portfolio for CSP in order to fit the development towards the realisation of the CSP vision described in Chapter 6 (section 6.1)?

At a minimum four CSP plants should be promoted by the GEF within the second phase of the cost reduction curve: For the second phase of the cost curve, it can be estimated from the above that for the developing countries about 200 to 300 MW of solar thermal power are to be installed by about 2015. Of this, about 90 MW might be provided in phase 1 (at least two WB/GEF projects and Algeria succeeding). The second phase should consist of—at a minimum—another four projects in the Mediterranean/Middle East region. Out of these projects, each one in the range of 30 to 50 MW, two might concentrate on the countries of phase 1, which have most advanced in the development of the frame for renewables and developed further their power sector expansion strategy to include CSP. Another two projects might be built in Jordan and Iran, which are to some degree advanced with their strategy, although the interest of CSP for their power sector must be demonstrated in detail. Additional small amounts of financing would be required to investigate CSP and prepare the grounds for further implementation in other countries in the region. The total funding required for the second phase of the cost reduction curve (developing countries only) might be around €200 to €300 million.

6.7.2 Operational recommendations

13. Should a future engagement continue to promote ISCC? Should it promote a broader range of technologies; if yes, which?

Promote a broader range of technologies (power cycle integration and solar thermal collectors): The ISCCS concept is an attractive option for developing countries to include solar energy into the existing power market expansion plans. On the other hand, it is also reasonable to focus on parabolic trough technology, being the most experienced CSP technology so far. However, in the long run,[28] the promoted technology options should be wider (see power cycle integration options in section 2.2.2 and solar collector types in Annex 3), in order to spur further competition and to adapt to individual needs/inquiries of the countries of destination.

14. Which funding mechanisms appear as most suitable to promote CSP in future? Should WB/GEF bundle forces with more actors to reach a critical mass. In particular, how can the technology best be promoted in developing countries?

Provide future grants for production (MWh) instead of investments (MW): It is also questioned whether an investment grant strategy might provide the right frame for the market (see also financing mechanisms below). In particular, it must be emphasized that in the current portfolio grants are given for investments and not for production. It is therefore not assured that the solar plants effectively produce over a larger number of years. Therefore feed-in-tariffs with MWh instead of MW as funding basis should be considered (criteria 12). In this context, we favor a discussion about operating future CSP plants under the IPP scheme in sufficiently liberalized markets. The commitment of the plant operator would also be leveraged by the fact that the total plant financing has to be provided. The plant operator would get its electricity remuneration in a strong currency (e.g. $/MWh), potentially with a GEF implementing agency (e.g. the World Bank) as the electricity buyer. The GEF implementing agency would in turn place a contract with the local electricity supplier, reducing its financing risk by paying a premium on top of the local market price. This again would motivate the IPP contractor to produce electricity in accordance with the electricity price/demand.

In particular for the Mediterranean region funding mechanisms based on electricity production are discussed:

[28] And partially even for the short term (current portfolio) by including solar tower or potentially a solar hybrid steam plant in the case of Mexico.

- *Global Market Initiative for Concentrating Solar Power (GMI):* GMI (2003)[29] describes an initiative to formulate a fair scheme that accounts for both improved tariffs for clean energy generated in the developing countries and to allow a benefit from enhanced feed-in tariffs for energy that is imported into close-by industrialized countries. According to GMI (2003), the financial cost gap can be further reduced through a blend of clean development mechanisms (CDM such as carbon tax credits, if bankable), and preferential financing, such as the European Union's infrastructural support program, the Mediterranean Development Aid (MEDA) Programme.

- *Financing Instruments for the Market Introduction of Solar Thermal Power Plants—the Scenario Model Athene (DLR 2004):* DLR (2004) describes with their ATHENE model a comprehensive approach regarding how project financing can be assured through the development of a fund for the market introduction of CSP. Such a fund could be developed further later on to accompany the introduction of phase 3 and 4 of the cost reduction curve. This approach can provide guidance on how to develop, for example, a Mediterranean/Middle East-centered fund. The aim of the vision developed by DLR (2004) is, as described above, to implement 5,000 MW CSP worldwide by 2015 and more than 40 GW by 2025. Several funding mechanisms are combined in order to lower considerably the additional costs of initially €145 billion (required with a 15 percent internal rate of return). Such a fund could provide, in analogy to feed-in tariffs such as in Spain (for CSP) or Germany (for other types of renewables), long-term power purchasing agreements in hard currency in such a way that the risk perception due to the reliable PPA could be significantly reduced. As a consequence, the investors' expected internal rate of return of the projects will be reduced from 15 percent down to 8 percent.[30] Through such a mechanism alone, the additional costs of the market introduction are calculated to be lowered to about €12 billion. Comprehensive risk reduction is provided in the form of government export and credit guarantees as well as machine insurance and insurance against natural disasters through the re-insurance branch. According to the fund idea developed with the ATHENE model, the additional market introduction costs are lowered to about €2.5 billion if the carbon pricing is added, with a carbon price increasing from initially 7.5€/t CO_2 to 30€/t CO_2 in 2050. If every project receiving financing from the fund revolves a unique fee of €21 million to the fund, the market introduction cost is lowered to €1.75 million. Under these conditions by 2015 and with 5,000 MW installed power a price can be achieved that can be covered from the electricity sales and carbon financing. Starting in 2023 with an installed power of 20 GW, a cost level is reached that covers cost also with conventional project financing and carbon financing. Starting in 2030, solar power plants would also be, according to the calculations, cost-competitive without carbon financing. It must be emphasized that the ATHENE approach is a rather conservative approach to estimate cost competitiveness (see also Chapter 2, section 2.1.2). If the market introduction is realized according to the calculations of the ATHENE model, the €1.75 billion in initial market financing flows back to the fund with an internal rate of return of 4 percent and will achieve a surplus between 2020 and 2050 of about €8 billion. Such revenues could be used to pay the initial market financing back or to increase, as an ex-post dividend, the internal rate of return of the individual projects. If the carbon price would be only 30 percent of the model estimates, the fund would still revolve but without interest. For the implementation of the CSP strategic goals, it is recommended that the GEF in the future organize its CSP funding according to the above-mentioned fund in order to reduce risk and thereby significantly reduce the technology's market introduction costs. On the other hand, the environmental and economic benefit of the funding will be significantly enhanced by motivating the power producers to produce MWh instead of MW.

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[29] GMI (2003) emphasizes that to some extent, the large tariff differences between ostensibly cheap fossil-based bulk power and solar-generated power are due to subsidies granted implicitly or explicitly for fossil fuel in some countries. This inflates the subsidies needed to cover the apparently higher cost of CSP power. Therefore, access to favorable tariffs from solar thermal electricity importers could be offered while reducing subsidies on fossil power production in solar thermal electricity exporters to minimize net funding.

[30] Given the fact that this is not equity interest but project IRR with mixed financing (debt and equity), the used interest rate of 15 percent appears rather high. Nevertheless, the financiers' expectations on the IRR directly depends on risk perception. All mentioned financing risks can significantly be reduced by such a fund in a way that 8 percent (in real terms) appears as a realistic if not conservative assumption.

15. What amount of support is necessary for any following step?

Necessary GEF (and other donor) CSP engagement accounts to $44 million on an annual average up to around 2025: Under the assumption that 35 percent of the CSP installations by 2025 will be installed and operated in developing countries, the cumulative subsidies would account to €875 million[31], or $1.12 billion.[32] If it is further assumed that 30 percent of this amount will be borne by countries like Algeria from its own national means, an amount of €610 million ($786 million) has to be financed by international funding. If the GEF is supposed to finance this part, on an average $44 million of annual CSP funding would be necessary. This includes CO_2 emission trading (through CDM). In case the CO_2 emission trade is not taken into account, the necessary annual average CSP funding amounts to $189 million.

16. What could be the potential GEF engagement in case of reduced available CSP funding means?

Potential GEF engagement in case of reduced available CSP funding means: Although the original OP 7 objectives consider as likely decades for the promotion of the target technologies with a considerable annual funding, all-in-all the grants really available from the GEF fund for future CSP development stay behind initial expectations and the estimated requirements. In case the required large-scale funding (Criteria 8) exceeds the financial perspectives of the GEF, we suggest the following two alternatives:

- ❑ The GEF should try to join forces in the field of renewable energy deployment in developing countries in order to establish such an above-mentioned fund with the participation of different stakeholders. Potential co-funding organizations are export and development banks like KfW, JBIC, African Development Bank, Asian Development Bank, and national development aid programs, especially if allowing for the promotion of RES.[33]

- ❑ In the case of significantly reduced financial means for future CSP projects in combination with the wish of the WB/GEF to support further this important technology, the following technology lines (alternative to the ISCC) concept might be considered (see also Chapter 2, section 2.2):

  - o Feed-water preheating in fossil steam plants (approximate invest: $10 million for 10 MWe): also promoting other than parabolic trough collector types (e.g. tower, dish, Fresnel) by a technology-unspecific bidding procedure. Feed-water preheating leads to good solar efficiencies, good ratio of funding and solar-MWh because of reduced investment. Existing plant (infrastructure) might be used.

  - o Small-scale solar combined heat and power plants (heat for absorption chillers (e.g. air conditioning), process heat or sea water desalination (the latter becoming increasingly important in many countries with good solar resources).

  - o Industrial process heat applications of 200–1,000 kW_{th} (based solar concentrators).

For the implementation of such small-scale CSP projects, the following tendering strategy might be interesting. Preliminarily, a set of criteria (compare also criteria in Table 7) to be met by the projects have to be defined by the WB/GEF. For example:

- o Multiplication effect (the project suggestion should make clear that it is a pilot project that will induce several successors of its kind)

- o Environmental benefit

- o Cost-effective use of GEF-funding (possibly based on a criterion like solar MWh per $)

- o Social benefit (the project should prove that it will have a positive impact on social and economic aspects)

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[31] Under the assumption of a project IRR of 8 percent without revolving fee of 21 million €.

[32] Exchange rate (May 10, 2005) €1 = $1.2835.

[33] German Federal Ministry for Economic Cooperation and Development (BMZ)/KfW Entwicklungsbank *Special Facility for Renewable Energies and Energy Efficiency* (budget of €500 million over five years for soft loans for RES projects in developing countries.)

Based on such criteria, bidders are invited to present their project ideas, without limitations concerning the collector technology or the heat usage (power, heat, cooling etc.), without limitations concerning countries, and possibly even without limitations concerning the budget.[34] Possible technology options are given in Chapter 2 (section 2.2) and with respect to collector technologies in Annex 2. Possible candidate countries might be any country with a long-term interest in CSP technology, e.g. Mediterranean countries or China.

This type of business concept could also be applied based on the currently available funding if one or two projects of the current ISCCS portfolio might not come to successful implementation.

[34] Depending on the available budget, more capital-intensive power options like SEGS plants could be favored.

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Annex 1
Characterization of the Status of Important Ongoing CSP Projects Worldwide
(Description of each project according to a set of criteria)

Algeria (Hassi R'mel)

Australia(Liddell)

Iran(Yazd)

Israel (Asharim)

South Africa (Upington)

Spain (Andasol 1 & 2)

Spain (PS10)

USA (Nevada)

USA (Arizona)

Country/Location	**Algeria/Hassi R'mel**
Type of technology	Parabolic trough integrated with a combined cycle plant
Technical parameters	130 MW combined cycle, with a gas turbine power on the order of 80 MW and a 75 MW steam turbine. 25 MW solar field, requiring a surface of around 180,000 m^2 of parabolic mirrors. Addition of a desalination plant fore-seen. Originally the following configurations were considered: Size 150 MW (combined cycle 107 MW net, solar field 43.6 MW net).
Business model	BEA-NEAL partnership guaranteeing one-third of the capital, beyond which the remainder would be guaranteed by a foreign investor at a minimum of 51 percent and the EIB with a profit-sharing loan (QUASI EQUITY). BUILD OWN OPERATE contract or BOO/BOT, "non-recourse." Sonatrach will buy the electricity (NEAL: a company set up by SONATRACH, SONELGAZ and SIM to carry out projects that make use of renewable en-ergy. Sonatrach: National company for the production, transport and commercializa tion of hydrocarbons. Sonel-gaz: Electricity and Gas Company of Algeria. BEA: Banque Extérieure d'Algérie).
Liability provisions	
Status of plant	Invitation for expressions of interest launched on June 8, 2004. The publication of the bidding was originally planned for September 2004, with contract award December 2004 and project start by September 2005. A Request for Proposals was issued in May 2005 by the New Energy Algeria (NEAL) to construct, finance, exploit, and maintain a hybrid solar/gas power plant of 150 MW at the site of Hassi R'mel. A visit to the site and the data room took place on July 4, 2005. The interested consortia have (until October 5, 2005) been invited to submit a technical proposal. An investor has been retained for construction, exploitation, and commercialization.
Expected project time schedule	Expected start of construction 2006/2007.
Project developer/Prequalified devel-opers	NEAL is the project developer. Following the invitation for expressions of interest, the following companies declared their interest: CME and General Electric (USA), ACS COBRA (Spain), LAVALLIN (Canada), SIEMENS and Solar Millennium (Germany), MITSUI-JGC (Japan), ALSTOM (France), BLACK & VEATCH (Great Britain) and BRC (Algeria).
Financing structure	Aggregate investment: $177 million (of which EPC $143.9M, intercalary interests $12M, preliminary costs $0.5M, contingency $4.3M, customs taxes $5.3M). Investments of nearly $140 million will be contributed by the German investment bank KFW in preferential rate loans and the European Investment Bank (EIB). The BEA will syndicate with the EIB the portion in Dinars.
Final owner of plant	Foreign investor or consortium
Institutional frame for renewables in host	❑ Algeria has set up a national program for the promotion of renewable energy sources in the frame of a sus-tainable development up to 2020 (5-years program) (Law N° country 04-09 of 14 August 2004 relative to the Promo-tion of Renewable Energy Sources in the frame of Sustainable Development). ❑ Quota system for renewable energy sources with a tender procedure (The promotion shall occur "in coherence with the principle of competitiveness"). Later on, green certificates for renewable energy sources are envisaged but no structure for Green certificates is in place so far. ❑ The decree N° 04-92 of 25 March 2004 "on the costs of diversification" aims at bringing the share of electricity produced by the renewable energies to 5 percent of the total electricity to be produced by 2010, by introducing incentive measures for all the branches of energy used to produce electricity. Premiums for each kWh from renew ables and cogeneration (see below), including an obligation to the network operator to connect renewable energy sources to the grid within economic acceptable limits. In accordance with the law N° 02- 01 of February 5, 2002 (art. 98), the costs of diversification are integrated in the tariffs. In addition: creation of a "national observatory for the promotion of renewable energy sources."

Type of renewables	**Premiums** (expressed as a percentage of the electricity price per kWh defined by the market operator)
Electricity from solar thermal – natural gas hybrid plants	200 percent if the contribution of solar energy represents a minimum of 25 percent of the total primary energy,180 percent if the solar share is 20 to 25 percent, 160 percent if the solar share is 15 to 20 percent, 140 percent if the solar share is 10 to 15 percent,100 percent if the solar share is 5 to percent, no premium below 5 percent.
Electricity from solar only (PV or solar thermal)	300 percent
Electricity from wastes	200 percent
Hydropower	100 percent
Wind power	300 percent
CHP	160 percent (the production capacities should not exceed 50 MW).

Source: Executive Decree N° 04-92 of 25 March 2004 relative to the diversification costs of electricity production (Articles 12–17).

In the case of the presently planned plant at Hassi R'mel, the solar output is expected to be 11 percent of the total plant output: This would lead to a production premium of 140 percent on the conventional price estimated at 2.2 c/kWh.

Institutional frame in host country for the electricity market

Electricity is currently growing at around 4 percent a year. The additional requirements in production capacity are estimated at 6,000 MW for the period mentioned. The law 02-01 on electricity and distribution of gas from February 2002 has liberalized the electricity sector by opening production and distribution to competition. This law is in the perspective of an interconnected and liberalized Euro-Maghreb market comprising the neighbors of Algeria and the closest European countries (signature of the Rome agree ment in December 2003 by three Maghreb countries and the European Commission in view of a common electricity market starting 2006). This law also foresees the integration of renewable energy sources in the energy mix of the country.

In this perspective, Algeria is following up a "Project 2000 MW" comprised of three elements:

- ❑ a first set of power plants destined to the internal market with a capacity of 800 MW;
- ❑ a second set of power plants destined to the export market with a capacity of 1,200 MW;
- ❑ under-sea connection cables with a minimum capacity of 2,000 MW linking Algeria to Spain to reach the European markets.

IIn addition, Algeria investigates the possibility of a second project of 500 to 1,000 MW destined also to electricity export via an under-sea cable that links Algeria to Italy (Sardinia).

Key governmental institutions and their interests

The contribution of revenues from oil and natural gas was 55 percent of the state budget, 97 percent of foreign currency inflow, and about 40 percent of GDP. Algeria has an interest to export gas, but also a need to diversify the economy. Ninety-five percent of Algeria's exports go to Europe.

One main objective for Algeria, being a producer for gas, is to export this energy carrier, in particular to Europe (Algeria envisages increasing gas exports to 100 billion m^3

in 2010 and to 120 billion m^3 in 2020. As Europe, for diversification reasons has set limits on gas imports from Algeria, exporting gas through the generation of electricity constitutes a second road to exporting gas. Combining with solar helps to make the electricity exports more acceptable to Europe in the view of Algeria.

During the last two decades, Algeria has been suffering from droughts and a lack in water due to both the droughts and the increase in the Northern population, living standards, and its industrialization. For this reason, water desalination becomes an important issue to which solar thermal power plants could provide solutions.

Tariff structure in country

The tariffs are administered in the expectation of the electricity market liberalization.

Near-term strategy for CSP in the country

Algeria has considered, in addition to the presently planned ISCCS plant, the following two options, but no con-crete plans exist for the moment: (1) Size 306 MW (com bined cycle 258.8 MW net, solar field 54.1 MW net. (2) Size 400 MW (combined cycle 363.4 MW net, solar field 71 MW net).

Otherwise, since the launch of the electricity market reform in 2002, the following two IPP projects are in the phase of realization:

- ❑ Project Kahrama at Arzew 321 MW: combined cycle unit coupled to a seawater desalination unit of 90,000 m^3/day. Total project cost is $400 million. Financing is assured to 80 percent by the company Black & Veatch and to 20 percent by the Algerian Energy Company (AEC), a mixed Algerian company between Sonatrach and Sonelgaz.
- ❑ Project Sharikat Kahraba Skikda (SKS) 824 MW: combined cycle unit. Total project cost is $460 million. Financing is assured to 20 percent by the company SNC Lavallin and to 80 percent by the Algerian Energy Company (AEC).

The operation for the two projects is expected for 2005. In addition, for the following project a call for a joint venture has been launched:

- ❑ Project de Hadjerat Nouss – bidding call – 1,400 MW: interest was manifested from two main international groups, the Canadian group SNS Lavallin and the German company Siemens, which have been prequalified on a technical level. Financing shall be assured through a minimum foreign investment of 51 percent and the remain der from public Algerian companies (SONELGAZ, SONATRACH and AEC).

Project Sharikat Kahraba Berrouaghia 400–500 MW (EPC won by Siemens).

View of the country on a mid-term strategy for CSP with possible future options (5–10 years)

Algeria envisages 500 MW generating power from renewables for local use in 2010 and further strongly in-creasing power generation both for local use and for export from 2010 to 2020. The first electric cables linking Algeria and Europe are currently investigated or in the starting phase.

Year	Renewable Energy Capacities (MW)	
	Local	Export
2010	500	200
2015	1,000	400
2020	1,500	6,000

The first 500 MW for local production are supposed to be 400 MW solar thermal capacity (corresponding to 2,200 MW hybrid plants, and to 100 MW wind energy and other renewable energy sources. Investment costs will be of the order of $2 billion. After 2015, Algeria believes that it will be possible to construct solar-only CSP, as they will be competitive with the combined cycle plants.

Country/Location	**Australia, Liddell**
Type of technology	Linear Fresnel preheating feedwater for large coal-fired power station
Technical parameters	A staged project with up to 135,000 m^2 to provide 285°C/70 bar steam to the feedwater cycle of a 500 MW steam turbine. Solar Heat and Power Pty Ltd. (SHP) calculates this is equivalent to 38 MWe.
Business model	EPC for solar field
Liability provisions	
Status of plant	First 1 MW_{th} completed, and contract for 2nd stage in process of being signed
Expected project time schedule	38 MWe operating by 2007
Project developer/Prequalified developers	Solar Heat and Power Pty Ltd. (SHP)
Financing structure	Grants from Australian Govt. where available plus capital raised through semi-public offering
Final owner of plant	Macquarie Generation
Institutional frame in host country	The State of New South Wales (NSW)—where this project is located—has a deregulated electricity structure, with generation supply bid competitively into a pool. Generators are separate organizations to the retailers, distributors, and transmission companies, so power purchase agreements for the generated electricity are required. The country has in place a mandatory renewable energy target (MRET), which requires electricity retailers to purchase renewable energy certificates equivalent to a small proportion of their sales each year. These are purchased competitively; certificate prices are presently around the AU3.5c/kWh level. With pool prices around the same level, the maximum price available to renewables projects from this scheme is around AU7-8c/kWh. In the state of NSW, there is also the opportunity to gain NGACs on top of the RECs worth approximately AU1c/kWh. An energy white paper was released by the Australian Government in late 2004 that offers support through grants for both renewables R&D and large-scale energy projects, which have a significantly reduced GHG signature.
Key governmental institutions and their interests	Australian Greenhouse Office; Office of the Renewable Energy Regulator; NSW Department of Energy, Utilities and Sustainability.
Tariff structure in country	For most of the country, electricity is sold into a pool with successful bidders receiving the price of the last successful bid. In the main electricity markets, this means pool prices of around AU3.5c/kWh for most of the year. Most organizations use a combination of pool and contract pricing.
Near-term strategy for CSP in the country	There is no specific target or goal for CSP in the country. Renewables are presently bid against each other, so it is the cheapest renewable project that proceeds. Over the three years of operation so far, the main winners have been wind, solar hot water, and hydro, and to a lesser extent landfill biogas.
View of the country on a mid-term strategy for CSP with possible future options (5-10 years)	The abundant availability of cheap good quality coal, followed by natural gas, makes it very difficult for renewables to compete in Australia without a renewables program such as MRET. Because MRET essentially means only the cheapest renewable project will proceed, CSP will have a difficult time until it can meet the price of wind, which is presently around AU7-8c/kWh. There still appears to be availability of good wind sites. Good solar sites are abundant, and hybridizing with coal-fired plants (and to a lesser extent gas-fired plants) seems the most attractive proposition in the near term. Long-term thermal storage is being actively investigated, which could then open up many opportunities as the reliance on nearby fossil fuel would no longer be a limitation.

Country/Location	Iran/Yazd
Type of technology	ISCCS
Technical parameters	Total plant capacity proposed 430 MWe; Peak solar input 67 MWe; air cooled condenser; Annual DNI 2,500kWh/m^2/yr
Business model (as per 2002 pro-posal when GEF funding had been anticipated)	Intended to repower existing gas turbines with extension owned by IPP
Status of plant	Feasibility study undertaken; Consultancy Services let to Moshanir Power Engineering Consultants January 2001 for upgrading 2 GT's to a combined cycle power plant and adding a solar field with aperture area of 366,240 m^2. At this stage, tender documents have been prepared.
Expected project time schedule	Would like to progress asap
Project developer	*Information not supplied*
Financing structure	Total project cost of $322 million (incl existing GT's $67 million) comprising $150 million Iranian Ministry of Energy, $50 million GEF (note this is not a GEF project), $55 million balance from soft loans (note $10 million imbalance)
Final owner of plant	*Information not supplied*
Key governmental institutions and their interests	The Islamic Republic of Iran is interested in large-scale exploitation of its solar resource by CSP. The principle rationale is the government's strategic goal of diversification of its power production base and the promulgation of the country's oil and gas reserves. The Iranian Power Development Company (IPDC) has and will play a key role in any CSP plant in Iran.
Tariff structure in country	*Information not supplied*
Near-term strategy for CSP in the country	The country has indicated its strong interest by initiating preparatory work toward a large CSP plant. Previously Iran has helped sponsor (by the Energy Ministry and the Electric Power Research Center, now named NIROO Research Institute) and organize the "First German-Iranian Seminar on Solar Thermal Power Plants" (1993), a joint Iranian-German Expert Group on Solar Thermal Power conducted a concept study for a 100 MW Solar Thermal Power Plant. In 1996. IPDC contacted GEF to investigate the possibility of support. GEF responded that a more thorough feasibility study was needed as the basis for potential commitment of grant support. This study was carried out by NIROO, FLABEG Solar, and Fichtner Solar. Of a number of sites, it determined Yazd to be preferred with 2511kWh/m^2/yr DNI. Approximately 9km^2 of land has already been purchased by the Yazd utility. Water is limited and thus dry cooling was selected. Three older 64 MW gas turbines (KWU V93.1) and two new Alstom gas turbines (PG9171E) have already been installed and put into operation in 2000. A consultancy has been awarded to convert 2 GT's into an ISCCS. The feasibility study showed an investment of $115 million would result in an additional net electricity generation of 964 GWh/yr and upgrade the plant efficiency from 32.2 percent to 50.2 percent. The solar field, costing around $138 million, would further improve annual average efficiency to 53.1 percent.
View of the country on a mid-term strategy for CSP with possible future options (5–10 years)	Iran is one of the world's largest players in the petroleum market. With global concern over medium-term supplies of petroleum, prices on the world market are high. It is in the national interest to conserve domestic supplies so more is available for export. CSP offers a large opportunity to reduce domestic consumption of petroleum products, as well as diversifying the resource base. There is interest in the job creation possibilities resulting from CSP plants and a local CSP industry.

Country/Location	Israel, Asharim
Type of technology	Trough (oil) Rankine cycle
Technical parameters	100 MW initially, up to 500 MW if first successful.
Business model	IPP in a BOO arrangement; PPA with IEC.
Status of plant	Preferred site selected.
Expected project time schedule	*Information not supplied.*
Project responsibility	Israel Electric Company
Financing structure	$250 million for 100 MW, expected to yield LEC of 9c/kWh
Final owner of plant	IPP
Key governmental institutions and	Public Utilities Authority (Electricity) responsible for setting strategic targets such as the national need for CSP to be developed. Israel Electric their interests Authority (IEA) is a special commission that has responsibility for approving market price. When a new technology such as CSP is suggested to be integrated for strategic reasons, the cost of CSP must be included in the total cost mix, and the marginal additional cost spread over the generation mix with only a small price increase to the public. The National Council for Planning and Construction provides authority for plants such as this to proceed.
Tariff structure in country	The Public Utilities Authority has decided to issue premiums for the production of renewable electricity.
Near-term strategy for CSP in the country	It is reported that the IEC approved in principle the construction of a 100 MW CSP plant with a $250 million investment cost. The IEC approved this on the basis that IEA approves additional higher cost to the public.
View of the country on a mid-term strategy for CSP with possible future options (5–10 years)	*Information not supplied*

Country/Location	**South Africa, near Upington in the Northern Cape Province**
Type of technology	Solar tower
Technical parameters (installed MW, etc.)	Gross electrical rating: 110 MWe Net output approximately 100 MWe Plant design life 35 years Annual DNI = 2.95 MWh/m^2
Business model (EPC, separate EPC for solar and fossil, IPP)	Not yet determined.
Liability provisions (in particular for hybrid)	Not yet determined.
Status of plant	ESCOM undertook a prefeasibility study on CSP technologies. In the first task, fourteen CSP technologies and/or variations were to be studied further. Information on the technologies was compiled from published literature and where possible from demonstration facilities or operational plants. The technologies were screened in terms of a list of selection criteria. The screening process identified two technologies, solar trough and central receiver technologies, as possible near-term options to be evaluated further. The second task comprised the compilation of a typical meteorological year (TMY) data file for a reference site, as well conducting a strategic environmental assessment (SEA) for the Northern Cape Province of South Africa as the most suitable location for possible CSP plants. Using Upington as a reference site for the plant locations, annual simulation models were developed to predict the performance and costs of the two CSP technologies, identified through the screening process as task 3. Pilot plant designs were developed around 100 MWe systems and optimized to provide the lowest levelized energy cost (LEC) for the location. Long-term cases were also evaluated to provide an indication of the lowest possible energy costs that could be expected with future development. ESCOM also investigated what industry, mainly South African and to some extent international, could supply on a cost-effective basis toward the construction of a solar ther mal plant. One of the major findings that emerged was that SA industry was not geared to manufacture troughs for a one-off plant and with no guarantees of further plants industry felt it far to risky to invest in production facilities for a one-off plant. However, it emerged that there were less risks associated with the local manufacture of a central receiver. This influenced ESCOM's decision toward the further investigation into central receiver option. ESCOM furthermore undertook a full technical engineering study, based on conditions for the Upington region.
Expected project time schedule	To be established.
Project developer/Prequalified developers	Likely to be ESCOM.
Financing structure	To be established.
Final owner of plant	To be established.
Institutional frame in host country	With the adoption of the white paper on energy policy of 1998, the SA government has sought to integrate its broad policy frameworks, with the need to provide policy stability for investors, suppliers, and consumers in the sector. Recognizing the potential role that the energy sector could play in achieving national growth and development aims, the following five key objectives are identified in the white paper: ❑ Increasing access to affordable energy services; ❑ Improving energy governance; ❑ Stimulating economic development;

- Managing energy-related environmental impacts;
- Securing supply through diversity.

These objectives reflect the need for achieving a balance between sustainable development, economic growth, environmental management, and security of supply issues in the energy sector. Fundamental to achieving these objectives is the creation of a suitable environment for encouraging competition, coupled with focused regulation to ensure a self-sustaining industry ultimately serving to benefit the broader economy and energy consumers.

In September 2004, the updated National Integrated Resource Plan (NIRP) was published by the National Electricity Regulator (NER). This is a process of planning that is revised every year based on the projected demand.

Capacity needs: South Africa is expected to experience sustained growth in electricity demand under-pinned by growth in industrial, mining, and commercial sectors. The NIRP has estimated that about 2,640 MW of new peaking generation capacity will be required between 2006 and 2010. These require-ments for new capacity are over and above the need to return to service the mothballed coal-fired power plants as currently planned by ESCOM.

The key strategic objectives of the SA government pertaining to meeting the new peaking generating capacity are:

- Meeting new generation capacity requirements;
- Introducing private sector participation in the generation sector;
- Enhancing security of supply through fuel diversity;
- Accessing private sector financing and informing policy decisions on public versus private sector procurement;
- Enhancing black economic empowerment (BEE) in the energy sector; and
- Maintaining low-cost electricity.

The white paper on renewable energy was approved in November 2003 by the SA cabinet. The aim of the policy is to create the conditions for the development and com mercial implementation of renewable energy. This includes:

- Ensuring that economically feasible technologies and applications are implemented through the development and implementation of an appropriate program.
- Ensuring that an equitable level of national resources are invested in renewable technologies given their potential and compared to investments in other energy supply options.
- Addressing constraints on the development of the renewable energy industry.

The Department of Minerals and Energy has translated this white paper on renewable energy into a practical strategy with clear implementation plans for 2004–13. Renew able energy will be used for power generation to the grid and for water heating. Non-grid applications will be integrated in the electrification program and research and development. Bio-fuel technologies will be initiated as part of the strategy.

It is in this context that the SA government is committed to this renewable energy policy document, which is intended to give much needed thrust to renewable energy. This policy envisages a range of measures to bring about integration of renewable energies into the mainstream energy economy.

To achieve this aim, the government is setting as its target 10,000 GWh (0.8 Mtoe) renewable energy contribution to final energy consumption by 2013, to be produced mainly from biomass, wind, solar, and small-scale hydro. The renewable energy is to be utilized for power generation and non-electric technologies such as solar water heating and bio-fuels. This is approximately 4 percent (1,667 MW) of the projected electricity demand for 2013 (41,539 MW).

Country/Location	South Africa, near Upington in the Northern Cape Province *(cont.)*
	Some of the main benefits of the renewable energy white paper will be renewable energy for rural com-munities, far from the national electricity grid, remote schools and clinics, energy for rural water supply and desalination, and solar passive-designed housing and solar water heating for households in urban and rural settings and commercial applications. Large-scale utilization of renewable energy will also reduce the emissions of carbon dioxide, thus contributing to an improved environment both locally and worldwide.
Key governmental institutions and their interests	The key institutions that influence the electricity sector, including ESCOM in adopting new technologies such as solar thermal systems are: The Department of Minerals and Energy (DME). The DME establishes energy policy and legislation as well as provides direction, through planning processes, as to what course of action is needed to meet energy policy objectives. The Department of Science & Technology (DST). The DST together with DME has formulated an energy research and development strategy for SA. One of the areas identi-fied for R&D is renewable energy. Department of Public Enterprises. ESCOM, as a public enterprise, reports directly to this department. The National Electricity Regulator (NER). The NER sets tariff prices as well as granting licenses for electricity production. Any new electricity generation facility will need to ensure that it complies with regulations as managed by the NER.
Expected LEC (in SA Rands)	In the prefeasability study, full component costs & maintenance cost figures were determined for the base case plants. These figures were used to calculate the cost of production over the plants' lifetimes. A com-parison was done for the trough and tower technologies

Parameter	Trough	Tower
Capacity, MWe	100	100
Annual capacity factor	0.4	0.51
Winter Peak Capacity Factor	0.87	0.98
Summer peak capacity factor	0.86	0.86
Capital cost (1000 Rand/kW)	22.5	22.2
Annual O&M costs (million Rands)	24.2	19.0
LEC (Rand/kWh)	0.5	0.39

Near-term strategy for the country	CSP will cost more than ESCOM's current price of coal-based power for the foreseeable future, but could still represent an attractive power source because of environmental and economic benefits.
Mid-term strategy for the country with possi-ble future options (maybe 10 years)	See above.
Suggested approach to improve chances of CSP success in South Africa	**Coal Resource/Reserve** South Africa's current coal resource/reserve information (of 55 billion tons of reserves and 115 billion tons of resources) is based on the Bredell report of 1987. In the light of South Africa being a major producer, user, and exporter of coal in the world, and therefore largely reliant on coal for its medium- to long-term economic development, it is essential that the potential of the remainder of the country's coal resources and reserves be evaluated. The major question that needs to be answered is: "To what extent are the current coal resources and reserves sufficient to supply the future needs of the various coal-consumption sectors, of which the coal export sector is one of the most important?" In this light it is important to establish a national inventory on coal resources and reserves.

It is the responsibility of the government (as is the case throughout the world), and particularly that of the Department of Minerals and Energy, not only to reevaluate the amount of coal available in the national coal resource/reserve base, but also the amount of coal that has already been mined out, as well as the rate at which future exploitation will take place. For this purpose, the Department of Minerals and Energy has awarded a contract to Miningtek (a division of the Council for Scientific and Industrial Research) to un-dertake the investigation.

Coal is the second largest earner of foreign exchange in South Africa today. Coal energy is used by dif-ferent sectors of the South African economy. Coal composition is a complex structure of organic and inorganic components, which determine its specific characteristics. The efficient utilization of coal reserves demands the production of different but very specific saleable products to satisfy market requirements.

The outcome of this study is very likely to influence decisions on how the remainder of SA's coal reserves will be utilized.

Coal Discards

South Africa generates approximately 60 million tons per annum of discard coal, which is estimated to have already accumulated to more than 1 billion tons. These large amounts of carbonaceous material impact negatively on the environment; in addition, they contain significant amounts of usable coal. Discard coal is therefore a major concern to the Department of Minerals and Energy regarding potential future environmental impacts. It poses the challenge of being a major resource that provides an economic op-portunity through its utilization.

In 2001, the Department of Minerals and Energy commissioned a survey to establish an inventory of dis-card and duff coal in South Africa. This resulted in the publishing of the National Inventory on Discard and Duff Coal.

In the context of this project, the primary stakeholders interviewed were:

- Dept of Minerals and Energy - DME
- Dept of Science & Technology - DST
- ESCOM (South Africa Electricity Supply Commission)

The primary objective of the SA government is to alleviate poverty by creating an enabling environment for socioeconomic development. This is primarily to be achieved through promoting local manufacturing enterprises and through the expansion of local expertise.

A major barrier to the implementation of new technologies is the lack of knowledge and awareness of the technology in the host country. Here a "critical mass" of knowledge and expertise is required.

Key issues to be considered in developing local knowledge and expertise are:

(a) Knowledge transfer precedes technology transfer;

(b) Knowledge enables wider choices to be made and increases the probability of new technologies being accepted by all stakeholders;

(c) Complete technology transfer is sensitive to the sociological dimension and ensures complete "owner-ship;" and

(d) Human pride and dignity need to be taken into account.

Regarding barriers to solar thermal technologies in developing countries, technology transfer is made up of two legs, technology push and market-pull. As far as technology push is concerned, this is well-established, understood, well-resourced, and well-organized. This issue has been heavily influenced by stakeholders, who are mostly from the developed world.

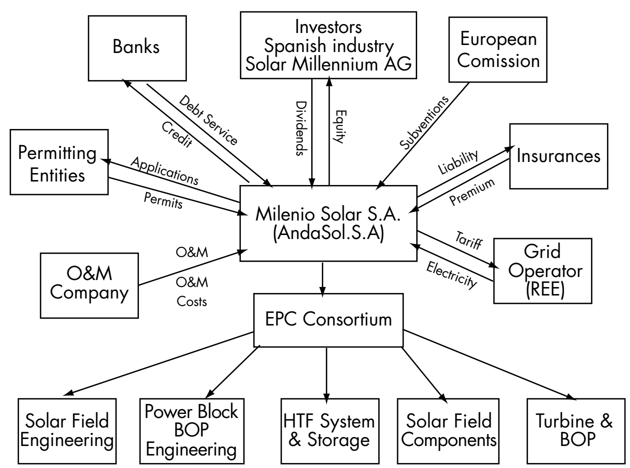
Country/Location	South Africa, near Upington in the Northern Cape Province *(cont.)*

A shortcoming with the stakeholders from the developing world is that, having a sound technology-push strategy, they do not have a sound market-pull strategy. A market-pull strategy has to be formulated with stakeholders from the developing world. Without active participation and "champions" from the developing world, the transfer of solar thermal technology into this environment will be difficult.

Critical success factors for SA in the field of solar thermal energy

- ❑ Establish how solar thermal technologies can contribute toward meeting the objectives of the Millennium Development goals;
- ❑ Implement SA's energy policy, taking into account that SA's coal reserves have a limited life;
- ❑ Implement the energy efficiency policy with encouragement on the utilization of clean coal tech-nologies;
- ❑ Within the context of the renewable energy and energy efficiency policy, encourage the exploita-tion of SA's renewable energy resource to meet the targets that have been established by govern-ment;
- ❑ Develop local expertise, know-how, and intellectual capital; and
- ❑ Establish local manufacturing enterprises to take advantage of solar thermal projects.

Country	Spain/Andasol 1 & 2	Spain/PS10
Type of technology	Solar only trough (oil htf)	Central receiver (tower) with saturated steam receiver
Technical parameters	2 x 50 MWe oil troughs with 7.7 full load hrs molten salt storage; 2 x 179.1 GWh/a	11 MWe gross; 23 GWh_e (gross)/yr; 15 MWh sat steam thermal storage (25 min at full load)
Business model	EPC Consortium	EPC
Status of plants	SKAL-ET loop tested in SEGS V; all permitting applica-tions submitted; nearly all land secured (problem with needing to acquire many small allotments; tenders called for loans, strong response, final deal being considered	Abengoa (Inabensa), CIEMAT, DLR, Fichtner re-ceived €5M for preparatory work; construction under way
Expected project time schedule	Commence construction mid- to-late 2006, commence operation approximately 24 months later	Expected to be operational by July 2006
Project developer & owner	Milenio Solar S.A., AndaSol-2 S.A. (now held 70 percent by ACS Cobra, 30 percent by Solar Millenium)	IPP Sanlucar Solar S.A. EPC led by Solucar Energia S.A.
Financing and project structure	EPC price 2 x €260 million	Total capital investment cost €33 million

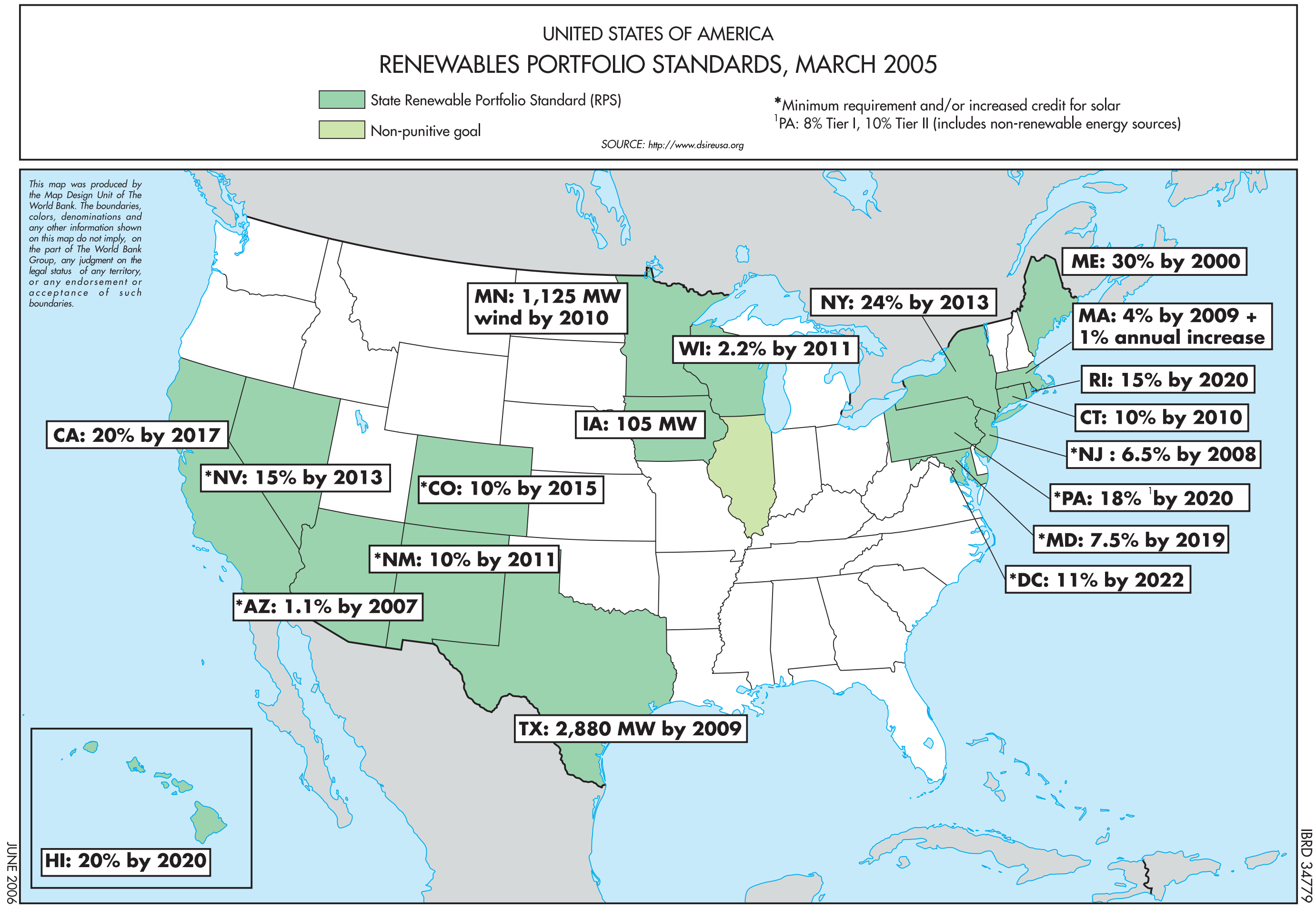


Solar 2004, Paul Nava, Flagsol

Country	Spain/Solar Tres	Spain/EuroSEGS
Type of technology	Tower with molten salt	Trough (oil htf)
Technical parameters	15 MWe, approx 240,000 m^2 (heliostats) considering 16hrs full load thermal storage, 78.8 GWh_e/yr	15 MWe, 95,880 m^2, originally proposed to use two different types of solar collector, solar radiation at this site poor compared to other sites in Spain
Business model	IPP	IPP

Country	**Spain/Andasol 1 & 2**	**Spain/PS10** *(cont.)*
Status of plants	Activity in this project has recommenced with the an-nouncement of the new tariffs in Spain	Prefeasibility study, site assessment, pre-engineering of power block and solar field all completed
Expected project time schedule	Operational in 2006	Not known
Project developer & owner	Ghersa, assisted in technical design by Boeing and Nexant (these three companies have formed Solar Tres)	EHN
Financing and project structure	2002 estimate: $72 million	2002 estimate: $45 million
Key governmental institutions and their interests		
Tariff structure in country	Spain has introduced the most attractive tariffs for CSP in the world. The Royal Decree 436-2004 allows for tariffs up to €0.21/kWh, allows 12 to 15 percent gas backup for purposes of dispatchability and firm capacity, is secure for 25 years (to provide necessary bankable guarantees), and allows for annual inflation escalation. The tariff is in place for the first 200 MW, after which the tariff will be reviewed downward to follow the expected cost-reduction curve.	
Near-term strategy for CSP in the country	Spain has set in place a suite of support mechanisms that will help support a range of renewable energy technologies. It is understood that the increase in tariffs from €12 to 18cents/kWh and other associated changes has helped to provide the necessary financial cover for the risk premium on these first projects. The specific tariffs to support CSP, including the associated support of bankable timeframes and sensible allowance of gas, sees Spain as one of the leaders in promoting CSP projects.	
View of the country on a mid-term strategy for CSP with possible fu-ture options (5–10 years)	As various capacity points for CSP are achieved, the tariff premium will drop to suit a cost reduction path. This is a sensible approach; however, the technologies that miss out on the first 200 MW installment will have to accept a lower premium.	

Country/Location	**USA, Nevada**	**USA, Arizona**
Type of technology	trough + Rankine cycle	trough + organic Rankine cycle
Technical parameters	64 MWe (net) (increased from originally 50 MW)	1 MWe, 2,000 MWh annual generation, O&M 2.91c/kWh, 95 percent plant availability, 10,346m^2 aperture
Business model	EPC	
Status of plant	Construction commenced February 2006, start-up expected March 2007	Construction commenced March 2004, start-up April 2006
Project developer/Prequalified developers	Solargenix is project developer; four large compa-nies bidding for EPC contract	Project team is APS as the utility, Ormat for the turbine, and Solargenix for the solar field
Financing structure **Final owner of plant**		
Key governmental institutions and their interests	Much of the renewable energy policy drive and framework is being provided by the individual states. There are a variety of incentives available for renewable energy driven by consumer demand and renewable energy portfolio standards (see U.S. map below). In Arizona, the standard goes further to specify that 60 percent of the RPS must be solar electric.	
Tariff structure in country	The retailing of electricity in the U.S. is increasingly being carried out by companies that stretch across the traditional state boundaries, with significant interstate wheeling of electricity and gas. The market is highly competitive, with many green energy schemes available on a voluntary basis to consumers.	
Near-term strategy for CSP in the country	Continued development of renewables in the U.S. will be influenced largely by statutory requirements based on regulation or legislation. The major policy driver at pres ent for CSP in the U.S. is the "1,000 MW CSP South West Initiative" as part of the Western Governors' Association resolution to diversify energy resources by developing 30 GW of clean energy in the U.S. West. A comprehensive study of CSP options for New Mexico has just been completed. The Southwest is a rapidly growing area with a corresponding need for increased power. As this is also the country's sunbelt, there are good opportunities for CSP if appropriate incentives are available.	
View of the country on a mid-term strategy for CSP with possible future options (5–10 years)	The U.S. has a long history in CSP development, and since the last SEGS plant was built has continued with R&D and O&M cost reduction programs. The next stage for CSP in the U.S. will depend on the technical success of the Nevada and Arizona plants, the continued activity in Spain and elsewhere, the success of the Global Market Initiative for CSP, and the emergence of mandated requirements to specifically support solar electric technologies. Under the present RPS of the four states (NM, CA, AR, NV), there would be a total of 4,926 MW of renewable capacity required by 2008 and 7,297 MW required by 2015. There are 37,099 MW of additional power genera tion required in these four states over the net three to five years, of which 87.6 percent is natural gas. There is an estimated 7,858,560 MW of solar capacity potential from these four states based on available land area near to infrastructure. The combination of sun, gas, sites, and power demand, particularly summer demand, ensures there are strong opportunities available for CSP in the Southwest.	


UNITED STATES OF AMERICA
RENEWABLES PORTFOLIO STANDARDS, MARCH 2005
State Renewable Portfolio Standard (RPS)
Non-punitive goal
*Minimum requirement and/or increased credit for solar
[1]PA: 8% Tier I, 10% Tier II (includes non-renewable energy sources)
SOURCE: http://www.dsireusa.org
This map was produced by the Map Design Unit of The World Bank. The boundaries, colors, denominations and any other information shown on this map do not imply, on the part of The World Bank Group, any judgment on the legal status of any territory, or any endorsement or acceptance of such boundaries.
ME: 30% by 2000
NY: 24% by 2013
MA: 4% by 2009 + 1% annual increase
MN: 1,125 MW wind by 2010
WI: 2.2% by 2011
RI: 15% by 2020
CT: 10% by 2010
IA: 105 MW
CA: 20% by 2017
*NJ : 6.5% by 2008
*NV: 15% by 2013
*CO: 10% by 2015
*PA: 18% [1]by 2020
*MD: 7.5% by 2019
*NM: 10% by 2011
*DC: 11% by 2022
*AZ: 1.1% by 2007
TX: 2,880 MW by 2009
HI: 20% by 2020
JUNE 2006
IBRD 34779

Annex 2
The Framework for CSP in China

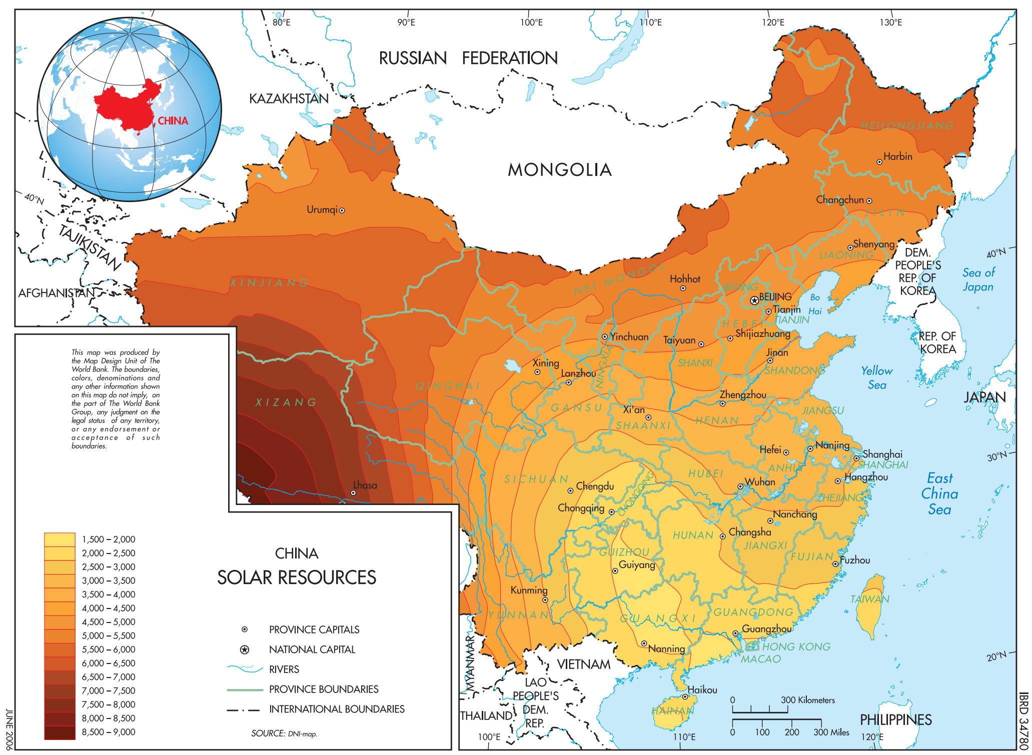
Country	China
Business model	Feb 28, 2005 – National Congress of China endorsed the Renewable Energy Law in the form of feed-in-tariffs.
Institutional frame in country	Thermoelectric power accounts for 75 percent of China's electrical energy generation, and coal represents the bulk of the primary raw material. Growing electricity needs, energy shortage, Kyoto Protocol and air pollution in metropolitan areas have led to electricity strategies based on nuclear energy and RES.
Near-term strategy for Renewables in the country	At the Renewables2004 Conference in Bonn, Germany, China committed itself to build up renewable energy, aiming for: (1) 60 GW_e by 2010 RES; (2) 121 GW_e by 2020 RES; and (3) RES for heat supply and biofuels. China's RES goals are also implemented in national frameworks on a five- and fifteen-year basis in the "New and renewable energy industry development." As an instrument to implement these ambitious goals, a "Feed-In-Law for Renewables" was endorsed on Feb 28, 2005. The goals of this law are to: (1) Confirm the important role of renewable energy in China´s national energy strategy; (2) Remove barriers to the development of the renewable energy market; (3) Create market space for renewable energy; (4) Set up a financial guarantee system for renewable energy; and (5) Create a social atmosphere conducive to renewable energy. This law is considered as a strategic investment not only in clean energy, but also as a strong future business opportunity for China. The utility companies will surcharge the extra cost to the end users. The law has not yet come into force. The State Council will set the feed-in-tariffs at the beginning of 2006 according to different regions and different types of renewable energy resources.
Near- and long-term strategy for CSP in the country	Especially in the Southwest of the country, solar conditions are favorable to CSP. The Chinese Academy of Science is developing different types of solar collectors for use in solar thermal power collectors. China already is the largest producer of low-temperature solar collectors for water heating in the world. and has interested companies to start CSP activities in China for the local and the export market. It is not yet clear if and how CSP will be considered in the Renewable Energy Law. A first—possibly GEF-co-financed—commercial pilot project would increase awareness of CSP technology in China. Under China's favorable RES conditions, a pilot project could induce a significant

Country	**China (cont.)**

multiplication effect for CSP market development. In the long term, CSP as a dispatchable power source can to some extent be a safe and clean alternative to nuclear energy.

The Solar Millenium AG, Germany, announced in May 2006 the development of solar thermal power plants for the Chinese market. For this purpose, a framework agreement for the realisation of solar thermal power plants with a total power of 1,000 MW up to 2020 was signed with regional companies (total investment $2.5 billion). The first plant (50 MW) will be completed soon in Inner Mongolia (estimated costs $1,62.5 million). Solar Millenium, with the Inner Mongolia Ruyi Industry Co Ltd, is conducting a feasibility study for the project in Ordos of the northern Inner Mongolia Autonomous Region. Preparatory work will be completed for construction to begin by the end of the year 2006. About 20 to 30 per cent of the total spending will be financed by investors, with the remaining coming from bank loans. Chinese experts estimate that the Ordos solar plant would sell its electricity for 18.8-20c/kWh to the grid companies. During the next four years, 200 MW solar thermal power plants will be constructed. Prior to the framework agreement, investigations on possible locations were carried out in three Chinese provinces in cooperation with the Ministry of Energy (autumn 2005). China has also integrated solar thermal power plants in the new Five-Year-Plan. Since January 2006, a new law will promote the implementation of renewables (10 percent renewables electricity by 2010, or 100,000 MW).

Solar Resources in China (DNI-map, Source):



Annex 3
CSP Technology Options

Solar collector technologies

Parabolic Trough Systems

Steam cycle power plants with up to 80 MW capacity using parabolic trough collectors have been in commercial operation for more than 15 years. Nine plants with a total of 354 MW of installed power are feeding the Californian electric grid with 800 million kWh/year at a cost of about 10–12ct/kWh. The plants have proven a maximum efficiency of 21 percent for the conversion of direct solar radiation into grid electricity. While the plants in California use a synthetic oil as heat transfer fluid in the collectors, efforts to achieve direct steam generation within the absorber tubes are under way in order to reduce the costs further.

Linear Fresnel Collectors

Another option under investigation is the approximation of the parabolic troughs by segmented mirrors according to the principle of Fresnel. Although this will reduce efficiency, it shows a considerable potential for cost reduction. The close arrangement of the mirrors requires less land and provides a partially shaded, useful space below.

Solar Tower Systems

Concentrating the sunlight by up to 600 times, solar towers are capable of heating a heat transfer fluid up to 1,200 °C and higher. Today, molten salt, air or water is used to absorb the heat in the receiver. The heat may be used for steam generation or—making use of the full potential of this high-temperature technology in the future—to drive gas turbines. The PS10 project in Sanlucar, Spain, being the first commercial solar tower project currently under construction aims to build a steam cycle pilot plant with 11 MW of power. For gas turbine operation, the air to be heated must pass through a pressurized solar receiver with a solar window. Combined cycle power plants using this method will require 30 percent less collector area than equivalent steam cycles.

Parabolic Dish

Parabolic dish concentrators are typically relatively small units that have a motor-generator in the focal point of the reflector. The motor-generator unit may be based on a Stirling engine or a small gas turbine. Their size typically ranges from 5 to 15 m of diameter or 5 to 25 kW of power. Like all concentrating systems, they can additionally be powered by fossil fuel or biomass, providing firm capacity at any time. Because of their size, they are particularly well-suited for decentralized power supply and remote, stand-alone power systems. Dishes up to 400 m^2 have been built, with this size being used for direct steam generation.

Country/Location	**Egypt/Kuraymat**
Type of technology	Conventional combined-cycle plant with solar thermal power collector (not trough-specified)
Technical parameters (installed MW, etc.)	Located about 90 km south of Cairo. The project site is characterized by an uninhabited flat desert landscape, high intensity direct solar radiation that reaches 2,400 kWh/m^2/annum, an extended unified power grid, and extended natural gas pipeline, and is near a source of water. The conceptual design of the project is as follows: **Power Block** Typical combined-cycle power plant consists of: ❑ Two gas turbines of about 41.5 MWe, each firing natural gas as fuel to generate electricity, in addition to the capability of using fuel oil distillate No.2 as an alternate fuel for emergency; ❑ Two heat recovery steam generators – (HRSG) will use the exhaust gases from the gas turbine to produce superheated steam; ❑ One steam turbine of about 68 MW; ❑ Cooling system in which the steam turbine exhaust will be condensed in the condenser and pumped to the HRSG. **Solar field** ❑ The solar field comprises parallel rows of solar collector arrays (SCAs), sets of typical mirrors—which are curved in only one dimension—forming parabolic troughs. The trough focuses the sun's energy on an absorber pipe located along its focal line (Heat Collection Element "HCE"). ❑ The total area of the solar collectors is about 220,000 m^2, connected in series and parallel to produce the required heat energy by tracking the sun from east to west while rotating on a north-south axis. ❑ The heat transfer fluid (HTF), (typically synthetic oil) is circulated through the receiver heated to a temperature up to 4000C. The fluid is pumped to a heat exchanger to generate steam that can be superheated in the HRSGs and integrated with the steam generated from the combined cycle (CC) before introducing it to the steam turbine (ST) to generate electricity.

Country/Location	Egypt/Kuraymat

Summary of Technical Parameters of Baseline Design

Capacity of Solar portion (MWe)	30
Capacity of gas turbine (MWe)	2 X 41.5
Capacity of steam turbine (MWe)	68
Net electricity generated (GWh_e/annum)	985
Exegetic solar generation (GWh_e/annum)	65
Solar share	6.6 percent
Fuel saving due to solar portion (toe/annum)	14,000
CO_2 reduction (Tonnes/annum)	38,000

Source: Information provided by NREA.

Business model (EPC, separate EPC for solar and fossil, IPP)	The Government of Egypt put in place regulations that are not attractive to the BOOT approach concept, which resulted in the adoption of the EPC with O&M project by NREA. The current structure of the Egyptian electricity sector is vertically integrated where the generation, transmission, and distribution companies form part of the Egyptian Electricity Holding Company. The holding company is obliged to purchase electricity from the generation companies. This potentially simplifies the purchasing of electricity from any new generation facility, including that from any ISCCS plant. Business models that will be applied will depend to a large extent on future investment policies as presented by the government. Furthermore, international investment organizations such as the World Bank, JBIC, and KfW should also facilitate investments in the Egyptian manufacturing industry. Egypt derives much of its foreign exchange through exporting crude oil and natural gas. Solar thermal, as well as other renewable energy technologies, has the potential to save Egyptian natural gas, which could then be exported at a premium price, with a small margin (profit), possibly Piasters 2/kWh, going into a renewable energy fund.
Liability provisions (in particular for hybrid) exceed five years.	NREA will be the owner of the project and the recipient of the GEF grant. The private sector can participate in the O&M through contracts of limited time frame that will not Two separate contracts are planned for the combined cycle (CC) island and the solar thermal island. This arrangement is at the request of JBIC. No major problems are foreseen by NREA with this two-island arrangement. Bidding documents will be designed to be very specific as to how to manage this two island approach.
Status of project	At bidding stage (see below)

Expected project time schedule

	Solar Island	C.C. Island
Conceptual Design Report	March 11, 2003	
Prequalification Document issued for Solar & CC	August 30, 2005	December 26, 2005
WB non-objection of evaluation of PQD	March 14, 2006	June 28, 2006
Financing secured (letter of intent from JBIC)		
Issue Bid Documents (two packages)	May 30, 2006	July 17, 2006
Bidding (first stage)	August 5, 2006	
Evaluation by Consultant	August 28, 2006	
Clarification with bidders (solar + CC)	September 25-28, 2006	September 25-28, 2006
Bidding (second stage)	November 30, 2006	November 15, 2006
Evaluation by Consultant	December 21, 2006	December 25, 2006
Review by NREA	15 days end October 2006	
WB/JBIC non-objection	January 10, 2007	January 10, 2007
Negotiation & Draft Contract	January 15, 2007	January 22, 2007
WB/JBIC Approval	January 30, 2007	January 30, 2007
Egyptian Authorities Approval	February 15, 2007	February 15, 2007
Contract Sign	February 20, 2007	February 20, 2007
Completion of Construction	July 2009	July 2009
WB/NREA sign grant agreement	End April 2007	
WB non-objection on draft contract	2 weeks mid-May 2007	
Egyptian Authority approval & ratification (including financing)	mid-April 2007	
Consulting contract for project management in place	End May 2007	
Contract signature	End May 2007	
Contract effectiveness	Mid-June 2007	
Completion of EPC works	30 months mid-December 2009	

Financing structure	JBIC to finance the CC island with the GEF grant to cover the incremental cost of the solar power plant. NREA to participate in both the solar part and the CC. The total project cost is estimated at $199.3 million, including taxes and duties and contingencies, but excluding interest during construction. The total project cost includes the 5-year O&M estimated at $13.93 million for the solar and combined cycle islands. The total project cost of $199.3 million will be financed as follows: $49.9 million from the GEF as a grant; $92.3 million from the Japanese International Bank of Japan (JBIC); and the remaining $57.1 million equivalent from NREA. The discount rate is assumed to be 6 percent.
Final owner of plant	NREA

Country/Location	Egypt/Kuraymat

Institutional frame in host country for electricity generation

The Egyptian energy policy depends on three main pillars, namely (1) diversifying energy resources; (2) improving energy efficiency and enhancing energy conservation programs; and (3) maximizing the share of renewable energy (RE) in the energy mix.

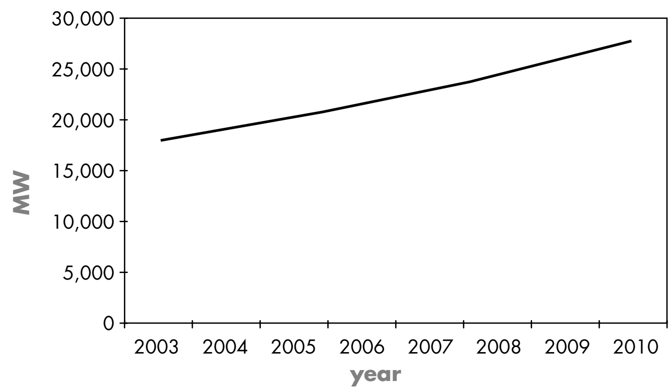
Fossil fuels (oil, natural gas, limited deposits of coal) contribute 85.3 percent to the energy mix. Hydro (Nile River), contributes 13.7 percent to the energy mix. Renewable energy (RE), mainly from wind, contributes nearly 1 percent to the energy mix.

Currently, the growing demand rate for electric energy to satisfy Egypt's socioeconomic plans ranges from 6.5 to 7.5 percent annually during this decade. The target is to increase installed capacity from 18,600 MW in 2004 to about 27,000 MW by 2010. Consequently, Egypt is required to add about 2,000 MW/year, as an average, to secure the needed energy supplies. Such expansion provides room for a considerable share of electricity generation from renewable sources.

Securing energy demand on a continuous basis is a vital element for sustained development plans, in view of the nation's limited fossil fuel reserves. Egypt has given due consideration to the promotion of its indigenous renewable energy resources, mainly solar, wind, and biomass.

The evolution and expected increase in generation capacity can be seen in the following graph:

Evolution of electricity installed capacity in Egypt



Source: Information provided by NREA.

Institutional framework in host country for renewable energy

In 1982, a renewable energy strategy was formulated as an integral part of national energy planning in Egypt. Currently, the strategy aims to cover 3 percent of Egypt's electric energy demand with renewable energy resources, mainly from solar, wind, and biomass applications by the year 2010, with additional contributions from other renewable energy applications.

The growing demand of electric energy to satisfy economic and social development plans reaches about 6 percent annually up to 2010. Such expansion plans provide room for a considerable share of electricity generation from renewable energy resources.

The strategy calls for the development of renewable energy resources, particularly solar, wind, and biomass, through specific measures for development activities, including:

- ❑ Renewable energy resource assessment and planning;
- ❑ Research, development, demonstration, and testing of the different technologies;

	❑ Transfer of technology, development of local industry, and application of mature technologies; ❑ Establishment of testing and certification facilities and development of local standards and codes; and ❑ Education, training, and information dissemination programs. Renewable energy's environmental benefits allow for financial support through various mechanisms such as the Clean Development Mechanism (CDM), financing RE incremental costs, soft loans, and mixed credits.
Key governmental institutions and their interests	Ministry of Electricity & Energy New and Renewable Energy Authority (NREA) The national power utility, the Egyptian Electricity Holding Company (EEHC).
Tariff structure in country	The average cost of electricity at generation for Egypt is Piasters 15/kWh (approximately 2.63 cents/kWh as of April 2005). It has been calculated that for the ISCCS the cost of generation will be 4.9 cents/kWh. It should be noted that Egypt's installed generation capacity at 2003/2004 was 18,119 MW. With the planned ISCCS capacity of 150 MW, the size of the project is small in comparison to Egypt's total generation capacity and the initial high generation costs can easily be absorbed by the total generation capacity.
Expected LEC (c/kWh)	The LEC for kWh price of the ISCCS plant is still uncompetitive compared to other schemes of power generation. (See previous note).
Overall energy situation of Egypt	**Energy policies** Egypt's energy policies are formulated basically in the two main energy sectors; the oil and gas sector, and the electricity sector. The oil and gas sector has the following objectives: ❑ To achieve national self-sufficiency of petroleum products and natural gas; ❑ To increase Egypt's hydrocarbon reserves. The oil reserves had slightly increased from 3.46 billion barrels (1990/91) to 3.68 billion barrels (2000/01). Gas reserves have increased nearly six times in the same period to reach about 57 trillion cubic feet (TCF); ❑ To maintain oil export revenues as one of the major sources of foreign exchange needed for development; ❑ To undertake oil and gas operations using environmentally sound practices to protect human health and the environment; and ❑ To promote energy utilization efficiency in all consuming sectors. The electricity sector aims to achieve the following objectives: ❑ To maximize the exploitation of all feasible hydro resources, including mini-hydro; ❑ To maximize the use of natural gas for existing and new generating facilities; ❑ To develop and promote the use of renewable energy resources, especially wind, solar, and biomass; ❑ To improve energy efficiency in both sides of supply and demand; and ❑ To develop regional electricity interconnection with the neighboring countries.

Country/Location	Egypt/Kuraymat
	Primary Energy Resources Egypt's main energy resources are oil, natural gas, hydropower, and coal, in addition to good potential for renewable energy resources. Oil and gas accounts for 93.5 per cent of total commercial energy consumption. Current oil reserves total 3.68 billion barrels, mostly located in the Gulf of Suez. The present annual production level of oil is nearly 32.3 million tons (MT), of which 23.4 MT are consumed domestically (representing 73 percent of that production). The balance is exported. Current reserves of natural gas are about 57 TCF. Most of the gas resources are located in the north coast, Nile Delta, and western desert. The development of proven natural gas reserves is a result of the country's intensive efforts to attract foreign investment in gas exploration and production. The Government of Egypt has allowed for sharing gas production and more flexibility in gas pricing; these incentives have attracted more foreign investment in oil and gas exploration. With an annual production level of 796.4 TCF in 2000/01, natural gas could play an important role in the country's future energy scene. A gas substitution policy has been adopted and is being implemented to promote the use of natural gas in electricity generation, industry, transport, and residential and commercial utilizations. Hydropower is the third major energy resource in Egypt. Most of the Nile's hydro potential has already been exploited to generate about 13.7 TWh of electricity annually. Some assessment studies revealed the feasibility of using mini-hydro-generating facilities to make use of some small hydro potential along the river's main streams. Currently it is planned to develop four small hydropower stations with total installed capacity of nearly 60 MW. Pumped storage potential has also been assessed in "Algalala" and "Ataka" sites to be used as peak load pump storage stations. In addition to oil, natural gas, and hydro, Egypt has limited coal reserves estimated at about 27 MT. The only commercial mining is in Maghara, Sinai, producing about 600,000 tons per year. However, the current production is 58,000 tons per year. About 1.8 million tons of coal are being imported now as feedstock for the steel industry.
Near-term strategy for CSP for the Egypt	NREA expects a successful pilot project in Egypt that leads the CSP technology and may create new industries related to solar fields. In the near term, the project schedule as presented earlier will be followed to implement the pilot project. Additionally, the transfer of know-how and learning into Egypt is expected to take place. As part of the overall project, additional activities will include: ❑ Training of NREA/EEHC and regulatory staff in solar thermal power plant operations, with particular respect to dispatching and integration into the power system; ❑ Monitoring/evaluation and dissemination of performance results from the project, both domestically and internationally. The purpose of this activity is to support future replication; and ❑ Consulting services for project management and support to NREA's PIU. NREA also is planning to survey local equipment suppliers/contractors to establish what components may be provided locally and to inform such suppliers and contractors of the opportunity for future projects.
Mid-term strategy for the country with possible future options (maybe 10 years)	NREA developed an ambitious program for large-scale electricity generation using an integrated solar combined cycle ower plant. In this field, NREA has completed a study on "Technical Development of Solar Thermal Electric Power Generation and its Potential Utilization both in Egypt and Mediterranean Countries," including evaluation of the application status of the solar thermal generation technologies and systems developed worldwide along with a study specifying predictions of the construction and operation development capacities. The long vision for STEG targets the installation of 750 MW by 2017 producing 7 TWh/year of electricity for local consumption and export through the interconnected electricity grid to Europe. Such a plan envisages a fuel saving of 64,000 TOE at 2017. In addition, it will create valuable chances for technology transfer and job creation opportunities in Egypt and the region

5 year development plans	Annual Energy Generation at the end of the period GWh/year	Installed plant rate: No. of plants	Installed plant rate: Power Capacity (MW)	Installed plant rate: Total Capacity (MW)	Cumulative Capacity	Accessible Potentials
1997–2002						
2002–2007	0.95	1	150	150	150	70
2007–2012	3.98	1	300	300	450	74
2012–2017	7	1	300	300	750	80

Source: Information provided by NREA.

Accessible potentials and installation plants for solar thermal electricity generation

1. Accessible potential: Total capacity that can be installed on 50 percent of the lands that are sunny and available at less than 5 km from electric and gas networks.

2. The first plant is anticipated to be ISCCS.

Suggested approach to improve chances of CSP success in Egypt

NREA has gained significant experience in designing and implementing wind energy projects with international loan and grant financing. Important lessons drawn from that experience include the importance of a transparent and well-managed competitive bidding process. Another important lesson from the development of the wind projects is that they have attracted major international suppliers of wind technology, demonstrating the interest and comfort of major suppliers with business transactions in Egypt.

Furthermore, through the development of these projects, NREA has operated under PPAs with the national utility and has gained significant experience in structuring and negotiating such agreements. This experience will be very useful in the competitive bidding approach adopted for the solar thermal project, in which a power purchase agree ment will need to be put in place as well as a gas purchase agreement

Egypt has a large oil and gas sector and provides valuable foreign exchange. However, one of the objectives of the oil and gas sector is to promote energy efficiency in this sector. A barrel saved is a barrel produced, and considering Egypt's energy situation, which is characterized by a growing energy requirement and depleting energy resources, energy conservation becomes of paramount importance. The upward adjustment of oil prices is driving the need for energy conservation. How pressing such a need may be may differ from one country to another, depending on the impact of imported energy prices on the economy and the balance of payments. Energy-producing countries, which were lucky enough to attain self-sufficiency, are least hit by the energy shocks and tended to deal complacently with it.

Egypt was one of the countries that experienced these mixed-blessing events. Egypt has concluded a large number of oil exploration agreements with many international companies, and consequently, oil production has steadily been on the rise since the mid-1970s. Starting in 1976, Egypt has been able not only to meet its own needs of energy, but also to export some oil. Consequently, the urge for energy conservation was given a lower profile in the Egyptian energy policy. The growing production of oil and gas since 1975 has stimulated a period of fast economic growth. With little or negligible effort at energy conservation, domestic energy consumption went hand in hand with domestic oil and gas production since the mid-1970s. The availability of domestic oil and gas, which were priced at historically very low prices, encouraged unrestrained uses of energy. This distorted pricing system was justified, at the time, on the basis of prevailing social and political reasons, but this does not change the fact that a great deal of precious resources have been wasted over a long period of time. Now, with increased awareness of the limitation of oil and gas reserves, and a valid expectation of higher future prices of imported energy, the call for energy conservation should take a more serious dimension.

The process of energy conservation usually begins with efforts to change certain behavioral attitudes and practices acquired under a period of low energy costs. At a second stage, emphasis should shift to investment in retrofitting activities whose energy savings would be quick and attractive. Finally, in the longer run, the process would aim at replacing obsolete technologies with new and more efficient ones. Therefore, energy conservation should not be considered as a one-time process, but rather as an ongoing process that extends over the short, medium, and long terms. Moreover, the overall target should not be limited to the enhancement of energy efficiency, as represented by reduced energy intensity, but it should also aim at attaining a higher level of GNP and a faster rate of economic growth. Generally, energy saved as a result of energy

Country/Location	Egypt/Kuraymat
	conservation could be redirected either to feed larger and more efficient domestic production, or exported to generate foreign receipts that support investment plans and the balance of payments. A policy recommendation to delay Egypt from becoming a net importer of energy is to retain all or most of the limited oil and gas reserves to meet future domestic energy requirement. NREA has indicated that the solar thermal project, as well as other renewable energy projects, can save Egyptian natural gas, which could be exported at a premium price, with a small margin (profit), possibly Piasters 2/kWh, going into a renewable energy fund Such a renewable energy fund can make a major contribution toward the establishment of a solar thermal industry. If an integrated and holistic approach is adopted to the use of such a fund, it can be argued that such a fund can find strategic application in the development of Egyptian know-how and intellectual capacity. Locally based knowledge enables wider choices to be made and increases the probability of new technologies being accepted by all stakeholders. Furthermore, locally based knowledge is sensitive to local issues. One such issue may be poverty alleviation, which would benefit from an expansion of the manufacturing sector—manufacturing sector that could be expanded to support an Egyptian solar thermal industry. As indicated by NREA, one of the first sets of activities to be undertaken in this regard is to: ❑ Survey local suppliers/contractors to establish what components can be sourced locally' ❑ Train NREA/EEHC and regulatory staff in solar thermal plant operations, in particular in dispatching and integration into the power system; and ❑ Monitor, evaluate and disseminate performance results both locally and internationally with a view to support future replicability. **Critical success factors for Egypt in the field of solar thermal energy** ❑ Implement Egypt's energy policy, taking into account that Egypt's oil and gas reserves have a limited life; ❑ Implement energy efficiency policy to encourage retention of oil & gas reserves for local consumption; ❑ Within the context of the energy efficiency policy, encourage the exploitation of Egypt's renewable energy resources; ❑ Develop the renewable energy fund, financed through a levy on exported oil and gas; ❑ Develop local expertise, know-how, and intellectual capital; and ❑ Develop local manufacturing enterprises to take advantage of solar thermal projects.

Additional Information for Egypt

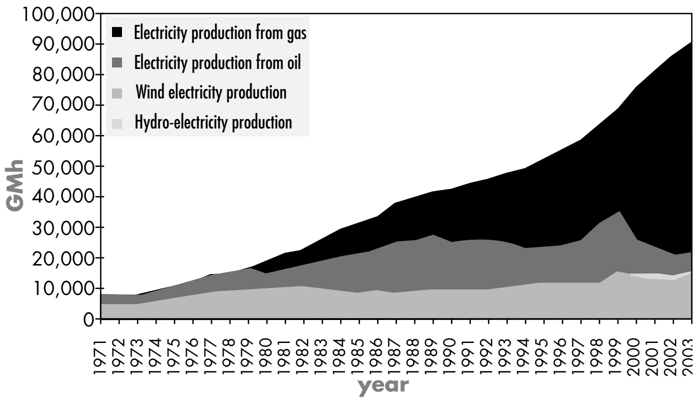
An overview of the Egyptian energy situation is outlined by Gelil (2002). The following table provides a description and an overview of the characteristics of Egypt's electricity sector:

Description		2003/2004	2002/2003	Variance (%)
Peak Load	MW	14,735	14,401	2.3
Total power generated	GWh	94,913	88,951	6.7
Hydro	GWh	13,019	12,859	1.2
Thermal	GWh	67,948	68,204	(0.4)
Power purchased from wind	GWh	368	204	80.4
Power purchased from (IPPs)*	GWh	77.4	76.7	0.9
Power gen. from private sector (BOOT)	GWh	13,501	7,607	77.5
Net exported power	GWh	918	827	11
Sent energy from connected power plants	GWh	78,029	78,065	(0.5)
Generated energy from isolated plants	GWh	269.7	239	12.8
Total fuel consumption	ktoe	15,261	15,267	–
H.F.O	ktoe	1,213	1,642	(26.1)
N.G	ktoe	14,006	13,579	3.1
L.F.O	ktoe	42	46	(8.7)
Fuel consumption (private sector BOOT)	ktoe	2,735	1,400	95.4
Fuel consumption rate	gm/kWh gen.	224.6	223.5	(0.5)
Fuel consumption rate	kcal/kWh	2,201	2,190	(0.5)
Thermal efficiency	%	39.1	39.2	(0.3)
N.G ratio to total fuel	%	92	89.2	3.1
N.G ratio from power plants connected to gas grids	%	98.1	97.1	1
Installed	capacity MW	18,119	17,671	2.5
Hydro		2,745	2,745	–
Thermal		13,186.5	13,498	2.3
Wind		140	63	122.2
Private sector		2,047.5	1,365	50
Transmission	lines km			
50	kV	2,263	2,263	–
400	kV	33	33	–
220	kV	13,711	13,711	–
132	kV	2,466	2,466	–
66	kV	15,731	14,855	5.9
33kV		2,749	2,526	8.8
Transforme	Capacities MVA			
500	kV	10,155	10,155	–
220	kV	29,208	24,605	18.7
132	kV	3,641	3,591	1.4
66	kV	29,362	27,917	5.2
33	kV	1,851	1,801	

Source: Authors based on information provided by NREA.

The following figure describes the evolution of the Egyptian electricity sector 1971–2003.

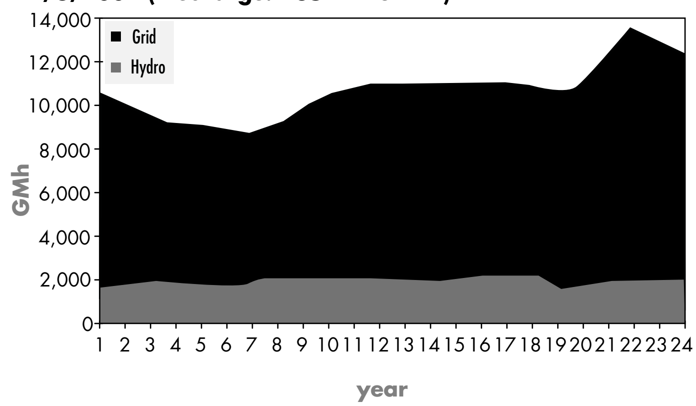
Evolution of electricity installed capacity in Egypt



Source: Autors based on ENERDATA Database.

Below is the daily load curve for Saturday, June 19, 2004. This provides a perspective on the daily load curve in the middle of the Egyptian summer. Prominent is the maximum demand at about 10:00 pm in the evening.

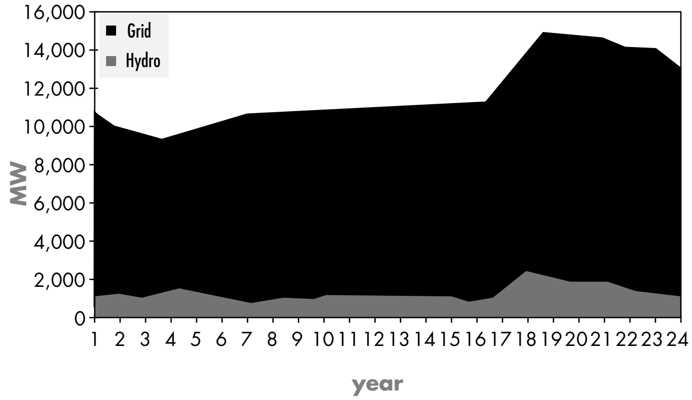
Daily Load Curve (Maximum Discharge) on Saturday 19/6/2004 (Discharge: 235 Million m³)



Source: Information provided by NREA.

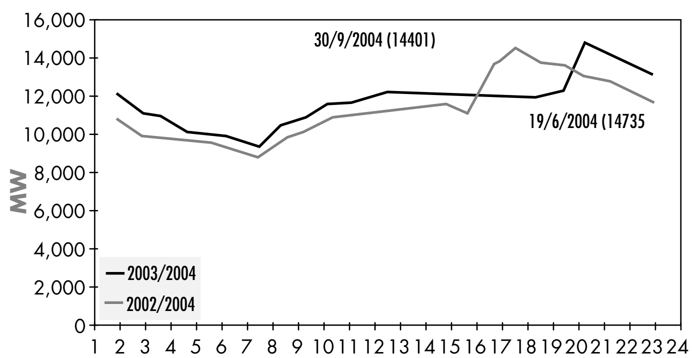
Below is the daily load curve for Wednesday, December 31, 2003. This provides a perspective of the daily load curve in the middle of the Egyptian winter. Prominent is the maximum demand at about 7:00 pm in the evening, as expected for winter, the demand is higher than for summer.

Daily Load Curve (Minimum Discharge) on Wednesday 31/12/2003 (Discharge: 75 Million m³)



Source: Information provided by NREA.

The diagram below presents the daily load curve for two days, June 19, 2004, and September 30, 2004. Peak demand is similar, but with differing times of occurrences.



Source: Information provided by NREA.

Country/Location	India/Mathania
Type of technology	Parabolic trough integrated with a combined cycle plant
Technical parameters (based on Sep 2004 RREC spreadsheet)	Capacity of the plant is 155 MW_e, of which 30 MW are solar (original was 35 MW using 220,000±3 percent m^2 parabolic trough field). Expected annual net production from the ISCCS of 916 GWh per year. The solar output is estimated at 63 GWh_e (depending on the level of thermal storage included) representing 6.9 percent of the annual production. Solar radiation for the region has been quoted as around 2240 $kWh/m^2/yr$ (DNI). The inclusion of thermal storage has been encouraged, with the 2002 RfP document stating that 5 percent of the bid assessment weighting criteria would be devoted to storage (bids with no storage would receive a score of 0 for this parameter). The site is relatively flat, with access to water and transmission. The source of fossil fuel for the gas turbine has proved problematic. Supply of cost-effective fuel to the project has been one of the critical issues to be resolved. There is a letter from GAIL stating gas price of INR 270.47/MMBTU, with possibility of cheaper gas from a new, nearby oil/gas field.
Business model (based on 2002 RfP)	Pre-qualified bidders submit a proposal for an EPC with O&M contract to build the plant on a turnkey basis and operate it for a period of five years. The plant will be owned by the Rajasthan Renewable Energy Corporation (merger of REDA and RSPSL). The EPC part of the contract is a fixed lump sum. The power purchase agreement is intended to be with Rajasthan Rajya Vidyut Prasaran Nigam Limited (RVPN).
Liability provisions (based on 2002RfP)	Bids with less than 50 GWh_e of solar production will not be accepted. For the purpose of tests on completion, rejection criteria (i.e. plant not accepted) apply to net electric power (if 5 percent below performance model), net heat rate (if 2 percent above performance model), and the solar field (if 5 percent below performance model). Penal ties for performance deficiencies apply to a number of parameters. In relation to the solar field, a penalty of 100,000 INRs is payable per kW_{th} of deficiency (2002 RfP). A second acceptance test applies at the end of the five-year O&M period whereby penalties amounting to 80 percent of the first acceptance test penalties apply. An agreed level of degradation is permitted.
Status of project	The project could not be implemented in a timely fashion because it had serious flaws in design due to the proposed technology and aggravated by inappropriate location. The capital cost of the project was about $200 million, and the resulting subsidies were in the range of $112 million to $136 million. After many extensions, an ICB failed in September 2003 due to lack of bidders. Subsequently, the Bank requested a commitment from the Government of India for additional measures to improve the project's economics, including additional subsidies. Finally, the Ministry of Finance sent a letter stating that the Ministry of Environment and Forest had decided to close the project.
Expected project time schedule	The project has been dropped and is no longer part of the WB/GEF pipeline. The Government of India and other donors (such as KfW) might consider other opportunities for taking the project forward.
Project developer/Prequalified developers	Prequalification was completed in February 2002. Initially three consortia were involved; however, one pulled out, leaving two consortia, both from India, using the same solar field supplier.
Financing structure	The present funding arrangement (according to RREC) is: ❑ Loan from KfW (revised) €92.16 million (this figure is from the RREC 2004 financial spreadsheet, however KfW advise their loan at present is €125.7 million). ❑ Grant from GEF — $45 million ❑ Grant from GoI — $10.86 million ❑ Grant from GoR — $10.86 million ❑ Total — INR 8,226 million

Capital cost breakdown (including IDC) is solar block (INR 3,557.2) and CC block (INR 4,669.6).

Country/Location	India/Mathania
Owner of plant RREC	
Institutional framework in host country for electricity generation	Generation and distribution throughout the country is controlled by state-owned bodies, apart from several private sector licensees catering to such cities as Mumbai, Ahmedabad, Surat, and Calcutta, and in the state of Orissa where distribution of power has been privatized.

India requires significant power generation installation over the coming years. Its tremendous growth rates make it a power-starved nation, even after 50 years of planning and the experience of putting up a 90,000 MW generating capacity with associated transmission and distribution systems. Power shortages have resulted from insufficient capital investment in the sector and from a need for improved efficiency in delivery (the country has high T&D losses and low plant utilization). The national average energy shortage in FY99 was 5.9 percent, and the peak deficit was as high as 14 percent. In Rajasthan, the shortages were a little less than average. According to estimates of Central Electricity Authority (CEA), India needs an additional 100,000 MW at an estimated investment of nearly $100 billion to meet its power requirements in the next 15 years. Participation of private/foreign capital would appear inevitable.

Installed Power Generation Capacity (MW) as on 02/28/2005

			Thermal						
Sl. No.	**Region**	**Hydro**	**Coal**	**Gas**	**DSL**	**Total**	**Wind**	**Nuclear**	**Total**
1	Northern	10,596.6	16,914.5	3,213.2	15.0	20,142.7	178.5	1,180.0	32,097.8
2	Western	5,702.1	20,791.5	5,035.7	17.5	25,844.7	632.5	760.0	32,939.3
3	Southern	10,437.8	13,892.5	2,720.4	939.3	17,552.2	1,671.7	780.0	30,441.7
4	Eastern	2459.5	15737.4	190	17.2	15944.6	5.2	0.0	18409.3
5	N. Eastern	1,133.9	330.0	750.5	142.7	1,223.2	0.3	0.0	2,357.5
6	Island	5.3	0.0	0.0	70.0	70.0	0.0	0.0	75.3
7	All India	30,335.2	67,665.9	11,909.8	1,201.8	80,777.5	2,488.1	2,720.0	116,320.8

Source: CEA National Electricity Plan, Appendix 4.3.

Year	Electricity Consumption (GWh)	Annual compounded growth rate (%)
1950	4,157	–
1960–61	13,841	11.6
1970–71	43,724	12.2
1980–81	82,367	6.5
1990–91	190,357	8.7
2000–01	316,600	5.2

Source: General Review, CEA.

Summary of All-India long-term forecast

Year	Energy Requirement (GWh)	Peal Load (MW)
2006–07	719,097	115,705
2011–12	975,222	157,107
2016–17	1,318.644	212,725

Source: 16th EPS Report.

11th Plan Capacity Addition (Tentative) – Sector Wise

Sector	Hydro	Thermal	Nuclear	Total
Central	15,828	4,328	2,264	22,420
State	11,740	12,523	9,273	33,536
Private	4,940	0	0	4,940
Total	32,508	16,851	11,537	60,896

Source: 16th EPS Report

Institutional frame in host country for renewables	India is keen to promote and develop its renewable energy resources. There is apparently a goal (administered by the MNES) to have 10 percent of new power come from renewables by 2012. The technologies pursued are mainly solar PVs, solar thermal, wind, many forms of biomass, and also associated new and emerging technologies. The Ministry of Non-Conventional Energy Sources (MNES) provides financial incentives, such as interest subsidy and capital subsidy. In addition, soft loans are provided through the Indian Renewable Energy Development Agency (IREDA), a public sector company of the ministry and also through some of the nationalized banks and other financial Institutions for identified technologies/systems. The government also provides various types of fiscal incentives for the renewable energy sector, which include direct taxes (100 percent depreciation in the first year of the installation of the project), exemption/reduction in excise duty, exemption from central sales tax, and customs duty concessions on the import of material, components, and equipment used in renewable energy projects. The ministry has also suggested that states should announce general policies for purchase, wheeling, and banking of electrical energy generated from all renewable energy sources. Fourteen states have so far announced such policies in respect of various renewable energy sources.1 We heard of a 10 percent target for renewables, but can't confirm its status at this time.
Key governmental institutions and their interests	The key institutions for renewables in India are the Government of India itself, the Ministry of Non-Conventional Energy Sources (MNES), the Renewable Energy Develop Agency (IREDA). In the state of Rajasthan, the state government formed a new company—Rajasthan Renewable Energy Corporation (RREC)—on August 9, 2002 by merging the activities of REDA and RSPCL. RREC is the state nodal agency for promotion of renewable energy programs in the state. Main Activities of RREC are: ❑ Extending electricity in remote rural areas through solar photovoltaic (SPV) lighting systems; ❑ Execution of 140 MW integrated solar combined cycle power project at Mathania; ❑ Development of wind energy power projects; ❑ Development of biomass power projects;

Country/Location	India/Mathania

- Development of mini-hydropower projects; and
- Designated agency under Energy Conservation Act.

The state government announced a wind policy in April 2003, which is valid up to 2009 for additional capacity creation. The following incentives apply to this Wind Policy

- Sale of power to RVPN for 2003–04 Rs. 3.3/unit;
- Annual escalation at 2 percent;
- Wheeling charges fixed at 10 percent;
- Provision for third party sale/captive consumption;
- Exemption of electricity duty for five years; and
- Allotment of sites at concessional rate.

200 MW commissioned/application for 500–600 MW registered with RREC.

Electricity data for the State of Rajasthan

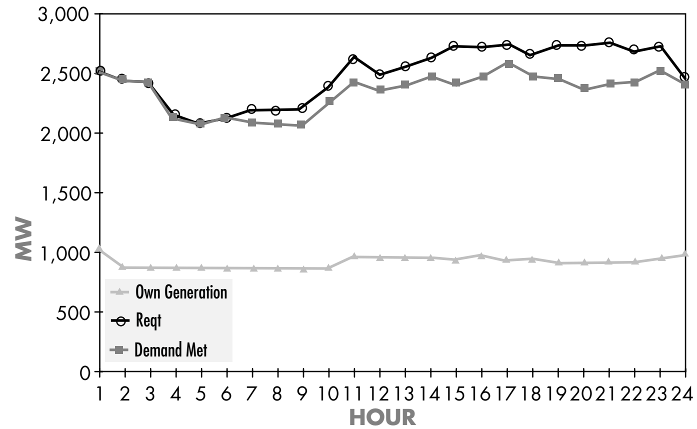
PARAMETER	JODHPUR DISCOM	RAJASTHAN
GENERAL		
Population	15,317,007	53,523,388
Area (km^2)	182,509	242,239
Population Density(Persons/km^2)	84	156
District.	10	32
Employees	9,249	40,223
ELECTRICAL		
Total connected load (MW)	2,614	9,902
33KV lines (kms)	10,000	25,718
33/11KV S/S (Nos./Capacity in MVA)	581/2,140 MVA	1,650/6,490 MVA
Domestic Connected Load (MW)	725	2,181
Agriculture Connected Load	793	3,110
Ind.Connected Load (MW)	714	3,382
Domestic Electrification	47 percent	42 percent
Villages/Towns Electrified	83 percent	92 percent
T&D Losses (percent)	39 percent	38 percent
Revenue from sale of electricity (Rs.Crores)	785	2948
Energy Sold (MU)	3,463	12,716
Average Tariff (Rs./unit)	2.11	2.18

CONSUMER		
Total Consumers	1,520,871	5,082,743
Domestic Consumers	1,174,897	3,703,259
Agricultural Consumers	104,813	577,443
Industrial Consumers	35,172	134,084
HT Consumers	600	2,505
Domestic Consumers as percent of total consumers	77 percent	73 percent

Source: http://www.rajenergy.com/JodDiscom.htm#

Near-term strategy for CSP in India

India, being the first ISCCS and first GEF project, suffered from a lack of competitive interest. While India has become mired, other projects have benefited from the early difficulties identified as a result of the Mathania process. India could now stand to benefit from the renewed interest shown in CSP and ISCCS. Thus it would probably be premature to drop the Indian project from GEF funding until the near future for Morocco and Egypt in particular are established. There does not appear to be, however, a stated plan for CSP at the government level beyond the existing project. The Central Electricity Authority's draft National Electricity Plan [http://www.cea.nic.in/nep/nep.htm] considers a wide range of energy technologies and potential, but essentially expects most of the contribution over the next 15 years to come from fossil fuel, hydro, and nuclear. Certainly India is well aware of the technical potential for the technology, and the solar resource is available. It is noted in the draft plan that just 1 percent of the Raj desert could provide up to 6,000 MW of solar power. In addition, there is interest from Indian private industry to advance CSP technology, whether troughs, Fresnel, towers, or dishes. The summer demand and supply curve for Delhi shown below indicates a significant power shortage during solar hours in the summer months. This gap would be well-matched by a solar technology such as CSP, especially as thermal storage could also help supply the demand into the evening.



Source: http://www.ndplonline.com/index.jsp

India also has a strong R&D base, which could help to provide a good scientific resource, not only for technical development of the components but also for performance monitoring and thermodynamic cycle improvements. The strong knowledge and familiarity that Indian power engineers have with thermal technologies (based on fossil fuel) provides a good foundation for integration of solar thermal, which essentially uses the same power cycles and power blocks.

Country/Location	India/Mathania
View of the country on a mid-term strategy for CSP with possible future options (5–10 years)	India has huge power capacity additions planned over the next decade. At the end of 2002 (end of the 9th Plan), the country had a peaking shortage of 12.7 percent and energy shortage of 7.5 percent. The 10th Plan (2002–07) recommended an additional 46,000 MW to be installed by 2007, and the 11th Plan is likely to suggest a fur ther 60,896 MW required by 2012. The modeled break-up by fuel type is shown below. For the longer term, a further 69,500 MW is expected to be required during the 12th Plan (2012–17). The 12th Plan continues with the same expected trend of hydro, thermal, and nuclear. The plans also consider various scenarios. In particular, gas is a limited resource in the country, and it is likely that gas will have to be sourced outside of India. Hydro also is a resource that can produce significant seasonal variability, particularly if climate change becomes more pronounced. Solar thermal fits well with other fossil fuels, as it is based on the same thermodynamic cycles and power generation equipment. Thus it could be a strategic move to incorporate solar thermal into the mix to help offset any unplanned shortfalls in gas resources. With hydro expecting to contribute approximately ??? of the installed capacity by 2017, solar is likely to be a strategic hedge here also because, if there is a reduction in water flows due to drought, there is a good chance that levels of solar insolation will be high. It has possibly already been carried out, but with climate models improving it would be interesting to consider the complementarity of solar and hydro under various climate change scenarios.
Suggested approach to improve chances of CSP success in India	There seems to have been a differing view over time as to the capacity of the solar portion. Figures up to 35 to 40 MW of solar have been circulated. The latest cost spreadsheet (June 2004) has been based on 30 MW. This seems a sensible choice, in fact, if the reluctance of the GoI to sign off is due to the cost. It makes the technical integration easier, with less manipulation of an otherwise optimized combined cycle required. It also improves the overall GHG performance of the ISCCS as off-design operation is less removed from ideal (the steam turbine is less-oversized, thus duct-firing or the level of part load operation is reduced). The arguments by RREC appear to make this capacity quite competitive in terms of LEC versus imported price of electricity. However we would recommend consideration that the next RfP include additional assessment criteria with a significant weighting that considers the size of the field (or solar GWh_e) offered. There should still be a minimum required field size (in the original RfP this cut-off was 50 GWh_e, below which the bid would not be considered). However, this should now be a lower figure, to be determined through consultation This would mean that bids could be differentiated on the basis of the solar field size, prompting competition on both the quality and quantity of solar offered. Paradoxically perhaps, the ultimate outcome for GEF is likely to be improved if the solar expectation is reduced. The solar field, being modular, will generate as much experi ence and know-how as a larger one. And though the solar capacity would be less, the number of solar MW is to some extent arbitrary. In the broad scheme of things, which is ultimately what OP 7 is concerned with, the technology and the industry would be better served by a successful project. There is more chance of a successful industry being spawned by a successful 25 MW than by a risky 30 MW, or even by a proposed 35 MW that never proceeds because it is too expensive. By 2015, no one will be concerned that the very first project was a few MW less than originally intended. In addition for the India case, we would recommend that the specified CSP technology be broadened to enable alternative collector technologies to be offered. There is already a study under way for a 5 MW linear Fresnel plant in India, and strong interest in a dish-based solar steam plant.

Country/Location	Mexico/Sonora State, Aqua Prieta
Type of technology	Parabolic trough integrated with a combined cycle plant
Technical parameters	For the former site Cerro Prieto near Mexicali in Baja California Norte (source: SMA study, June 2000): 285 MWe plant with a 39.6 MW_e parabolic trough solar field, 14 percent of plant capacity is solar corresponding to 4 percent of annual electricity yield (site has an average DNI of 2,600kWh/(m^2a)). Plant site was changed to Sonora state in November 2004, irradiation data there even seems to have slightly higher values. Latest inquiry from CFE to the WB: increase the ISCCS total plant size from 250 MW to 500 MW. The solar field capacity is not yet determined (in between 25 MW_e and 40 MW_e). A new study by Sargent and Lundy (May 2006) determined that the increase in capacity of the thermal component in fact increases the conversion efficiency of the solar energy collected.
Business model	"Obra Pública Financiada OPF" corresponds to a Finance Build Transfer scheme, similar to an EPC contract (Engineering, Procurement & Construction = Turnkey contract). The operation will be performed by CFE (by law). Flexibility about maintenance. Previously IPP was pursued and a tender was already published in March 2002. But due to the fact that WB/GEF could/would not commit to its funding before the win ning bidder was chosen, the bidding process had to be stopped. After a visit of Mr. Laris Alanís (one of the 5 CFE directors) at the World Bank in Spring 2003, the business concept was changed to an EPC contract with CFE getting the WB fund. The former hen-egg-problem (CFE could not put out a conditional bid while the WB could not grant the funding previous to knowing who would receive it) is resolved now.
Liability provisions	The EPC contractor will be responsible for the construction financing, engineering, procurement, and construction, selling the turnkey hybrid plant to CFE. CFE will operate it, maybe maintenance contractor.
Status of plant	June 2005: presentation to the Treasury Ministry. November/December 2005: Approval by the Treasury Ministry. The hybrid plant has been included in the PEF (Programa de Egresos de la Federación) and approved by Congress. The site for the 500 MW facility has been selected at Agua Prieta, State of Sonora. After a technical economic assessment by Sargent and Lundy (May 2006) and a consultancy by Spencer Management, the World Bank task team has concluded that "the 500 MW 2x2x1 CCGT arrangement enhances the contribution and efficiency of the solar component". In addition, the larger size of the thermal component does not affect the contribution of the project to reduce either the long term cost of the technology or the amount of GHG emissions. In fact, the installation of the solar field in Mexico will build local technical capacity with the potential to trigger replication in the country with either gas or coal based power facilities. The chances for this are particularly high for Mexico, given the culture of entrepreneurship exhibited by CFE engineers with other technologies such as geothermal.
Expected project time schedule	June 2006: invitation for tenders (published). September 2006–January 2007: start construction. April 2009: Grid connection.
Project developer/Prequalified developers	In the IPP bidding procedure in 2002, several companies were submitting bids. However, there was very little interest for offering the solar field because the solar-field-only was an option for the CC plant. The bidding was stopped by CFE when it became clear that the above-mentioned hen-egg-problem could not be resolved. According to current planning, the next bidding will occur in 2006. According to Mexican law, no prequalification of bidders occurs.

Country/Location	Mexico/Sonora State, Aqua Prieta
Financing structure	CFE is paying for the combined cycle, for the land (CC+SF), and for O&M. WB is paying for the solar field investment and the excess power block investment. (CFE financing procedure: CFE is applying for the investment financing within its annual investment plan at the Mexican Treasury, which has to approve the investment in agreement with the Congress.) The investment for the thermal portion of the Solar Thermal Hybrid Plant Agua Prieta II has been approved by Treasury and Congress.
Final owner of plant	Comisión Federal de Electricidad (CFE)
Institutional frame in host country for the electricity market	The main electricity company in Mexico is CFE, a state-owned utility. CFE is responsible for the whole country, except for the central area of Mexico City, which is served by a CFE-owned daughter (Luz y Fuerza del Centro – LFC). CFE has a similar structure and spirit as EDF in France who contributed to set up CFE. The revenue of CFE is part of the federal budget (same as the oil company Pemex). Subsidies and profits must balance (requirement from Ministry of Treasure) but currently subsidies to CFE are higher (source: Gabriela Elizondo, Feb05). It seems difficult to compensate this with the tariffs (subsidized tariffs for the residential and agricultural sector, the subsidies are planned to be reduced (POISE – Programa de Obras e Inversiones del Sector Eléctrico 2004–13). CFE has a legally fixed least-cost expansion plan (law: LSPEE); investments have to be justified in compliance with the objective to provide the least-cost electricity. The Mexican power sector is open to competition in a limited way. There are three types of projects: ❑ Build-lease-transfer (CAT): the acceptor of the bid provides the financing, the detailed engineering, and the construction. These projects are operated by CFE and use financial means belonging to a trusteeship until the investment is covered by CFE, when CFE acquires plant ownership. ❑ Financed-built-transfer projects (OPF): same as CAT with the only difference that the financing is provided by CFE. ❑ Independent Power Producers (PIE): the acceptor of the bid provides the financing, builds the plant, operates it, and owns it.
Institutional frame in host country for renewables	Currently no green tariffs exist in Mexico, but a new law on renewables is in preparation looking at these issues. It is not yet clear how or if this law will justify excess costs related to current status of CSP technology, especially against the background of the least-cost-obligation. In the past, CFE has been more reluctant to invest in renewables plants. Mexico has a capacity payment for generation capacities (subsidy for availability); hydroelectric power is considered as intermittent and does not receive this subsidy. The current CFE plant portfolio contains the following renewable energy sources: ❑ **Hydroelectric power plants** These are considered cost-competitive during the demand peak. ❑ **Geothermal power plants** These are cost-effective. ❑ **Wind energy** According to CFE calculations, wind energy (LEC 4-7c/kWh) cannot compete with CC technology, however it can compete with coal-fired power stations. Furthermore, wind energy is considered useful to help diversification (fuel) and is considered environmentally friendly. (It has not become clear how strictly the least-cost-obligation is being applied against other criteria (as e.g. fuel diversification). Apparently, wind energy does not fully meet the least-cost requirement. However, approximately 400 MW of wind turbines will be installed over the next 10 years.)

- **Photovoltaics**
  In Mexico, 5 percent of the 103 million inhabitants are not connected to the grid. During the last nine years, 42,000 small solar modules have been installed to serve the same amount of houses. This will be a widely applied technology in the future for populations pending electrification in rural areas.

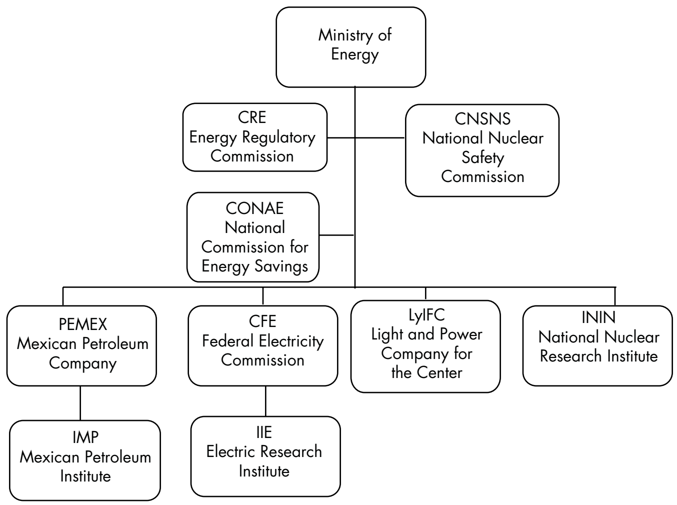
Key governmental institutions and their interests

CFE: Mexico's main electricity company

Mexico's Ministry or Energy (SENER)

Mexico's Treasury Ministry, to approve the financing of new plants

Structure of the Mexican energy sector:



Source: Information provided by CFE.

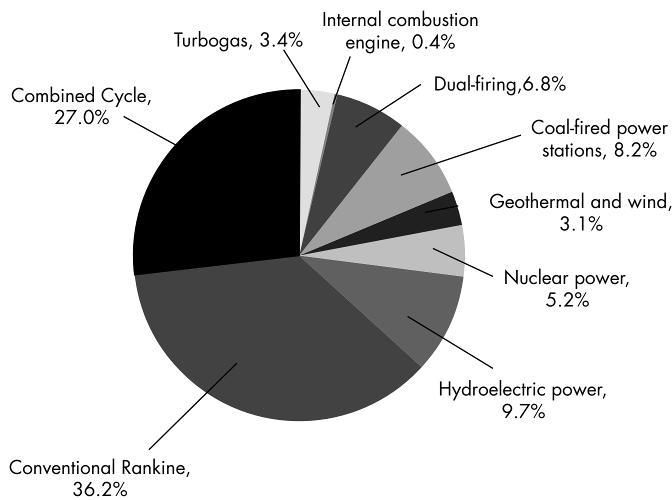
Energy Policy Objectives (SENER):

- Increase the quality of life of the Mexican people;
- Promote a rational use of resources in the context of sustainable development and intergenerational equity;
- Promote investment in productive and feasible projects for Mexico;
- Generate an elastic supply of hydrocarbons;
- Increase productivity in the sector; and
- Achieve a competitive pricing policy.

Country/Location	Mexico/Sonora State, Aqua Prieta
Tariff structure in country	The large-scale industry (high and medium voltage customers), companies and high-level consuming households (low level voltage customers) are paying a price calculated from the fuel price development and a price component depending on the indices of the producing branches: machinery and equipment, basic metallurgy, and other manufacturers. The residential and agricultural sectors pay subsidized tariffs.
Description of the electric power system	Concerning gas and oil reserves, Mexico ranks (worldwide):

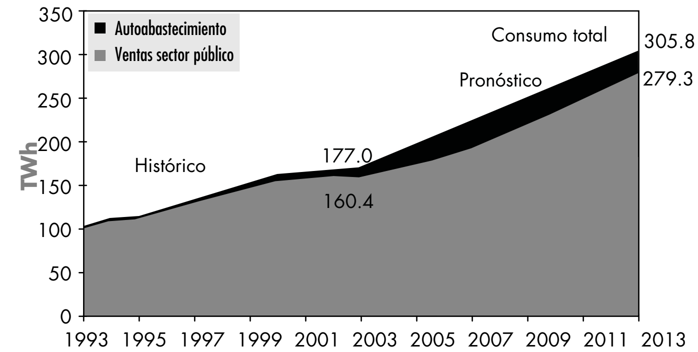
- ❑ 9th in crude oil proven reserves;
- ❑ 21st in natural gas proven reserves;
- ❑ 7th in crude oil production; and
- ❑ 8th in natural gas production.

Despite these promising numbers, Mexico is a net importer of natural gas; about 30 to 40 percent of total gas consumption is imported.
The country has 45 GW installed capacity (gross capacity in 2003). The power generation system of CFE by produced amount of energy is given in the following graph (only grid-connected plants).



Source: Information provided by CFE.

Accordingly, the use of fossil energy sources accounts for 82 percent of annual energy production.
Self-producing (autonomous) units account for 9.4 percent of national electricity production. The past and future (forecasted) electricity consumption are given in the following graph:



Source: Information provided by CFE.

For the years 2004–13 (being the reporting period of the latest CFE electrification plan POISE), CFE predominantly plans to build combined cycle plants, with a total capacity of 13.0 GW. The arguments are high efficiency, and thereby air cleanliness for critical zones. According to POISE, combined cycles offer the flexibility to use alternative (future) fuels like gasification of other energy sources (e.g. from PEMEX refineries, gasified coal, or waste).

The electricity production from heavy fuel oil becomes less attractive because its production in Mexico is decreasing. Nuclear energy is not considered to be practicable (Mexico already has one nuclear power plant). The utilization of coal is limited due to necessary infrastructure (e.g. port), environmental aspects, and importation of this fuel.

In the face of possibly future high natural gas prices or possible future limitations of gas procurement by PEMEX (Petróleos Mexicanos) or limitations from US-American importations, CFE has taken action such as gas drilling (Altamira and another drilling in the Pacific Ocean). For the future, CFE permanently studies other generation technologies like renewable energies or combined cycles with gasification of coal and waste. Beyond the planned 13.0 GW of CC plants, 3.2 GW hydroelectric, 0.7 GW coal-fired Rankine, 1.0 GW gas turbine, 0.1 GW internal combustion (e.g. Diesel), and 0.4 GW wind and 6.7 GW of not yet defined plant types are being planned.

CFE has many old plants with low efficiencies and high costs that are only used for peaking power generation. In the forecasted period (2004–13) 4.2 GW of these plants will be taken off the grid to improve the competitiveness of CFE's power plant assembly.

In 2003, Mexico exported 765 GWh_{el} to California and 188 GWh_{el} to Belize; the cumulative imports amounted to 71 GWh_{el}.

Near-term strategy for CSP in the country	Besides one 25 MW_{el} solar field (to be integrated into the CC plant "Baja California III") no other solar thermal power projects are mentioned in Mexico's electrification plan for the years 2004–13.
View of the country on a mid-term strategy for CSP with possible future options (5–10 years)	Once successful experiences have been completed with a first solar thermal power plant (i.e. the ISCCS plant), a further expansion of CSP technology is likely, esp. in the face of rising fossil fuel prices and favorable solar conditions in Mexico (personal communication of Juan Granados, CFE). This has happened with wind energy: After 10 years of successful operation of a first wind turbine, several wind parks with a total capacity of several 100 MW are now being projected.

Country/Location	Morocco/Ain Beni Mathar
Type of technology	Parabolic Trough integrated with a combined cycle plant
Technical parameters	200–250 MW_{el}, of which 20–30 MW solar, 220,000 m^2 parabolic trough field. Expected annual net production of 1,590 GWh per year. The solar output is estimated at 3.5 percent of the annual production representing 55 GWh per year. Link to the gas pipeline Maghreb-Europe (Algeria to Spain) (12 km connection). Morocco is entitled to about 10 percent from the gas transited through this pipeline. So far, it has not used all its entitlement.
Business model	EPC (Engineering, Procurement & Construction = Turnkey contract) with O&M. Following an unsatisfactory response to an original competitive bidding of an IPP, Morocco's public power utility ONE has decided to finance the solar thermal plant itself. Contract common for the solar and the fossil part. 5-year O&M contract. This contract can be renewed for another 5-year period. The O&M contract will ensure appropriate incentives for the operation of the plant, including to the full capacity utilization of the solar field..
Liability provisions	(in particular for hybrid)
Status of plant	The bid document has been completed by Fichtner Solar and reviewed with the client (Office National d'Électricité). Beginning March 2005, the bid document has been submitted to the World Bank for "Non-Objection." The two-stage bid documents were issued to the prequalified bidders in July 2005. The technical and financial proposals were opened May 2006.
Expected project time schedule	Allowing for normal time span for bid evaluation, and contract negotiations, it is expected that the EPC with O&M contract for the project can be signed by the end of 2006, and at the latest in January 2007; expected start of operation of the plant is mid-2009 (construction time 30 months).
Project developer/Prequalified developers	The prequalification of potential contractors had been completed in 2004. There were applications from seven international consortia, out of which four have been prequalified.
Financing structure	Total cost of plant is expected be around $243 million. This includes transmission lines and substations, connection to gas pipeline, land acquisition, boreholes, access road and engineering and supervision. GEF grant (20 percent): $50 million (incremental cost due to solar thermal component). O.N.E. will bear about 16 percent of the total cost of the project. Remaining from African Development Bank as a loan (The Board of the ADB has already approved the co-financing for this project in March 2005): about $156 million.
Final owner of plant	Office National de l'Electricité ONE
Institutional frame in host country for the electricity market	The Moroccan electricity market is being structured into a competitive part of the market (for industrial consumers) and a regulated single-buyer market (for residential consumers). Both parts are expected to converge towards a fully open whole sale market for electricity. Morocco is interconnected with Spain and Algeria. ONE will continue to be solely responsible for transmission . The program by ONE for the development of its transmission network (3 billion Dirham, €270 million) has the objective to enforce the reliability and the security of its functioning, as well as the exchange with the neighbours in view of the opening of the national electricity market to competition and its integration into a vaster European-Maghreb market. This programme foresees notably: (1) the doubling of the interconnection with Spain, already done in December 2005 ; (2) the reinforcement of the interconnection with Algeria; (3) the development of the 400 kV grid towards the centre (Mediouna) and the East (Oujda) with the construction of 3 400 kV/225 kV stations; (4) The extension of the 225 kV grid; and (5) the modernisation of the national dispatching.

Institutional frame in host country for renewables	Objective to increase the share of (new) renewables from 0.24 percent in 2003 to 10 percent in 2011 and close to 20 percent in 2020. Since June 2004, Morocco has a national plan for the development of renewables and for the improvement of energy efficiency (EE). This is an indication of the political will to integrate renewables into the national energy landscape with quantified objectives. The plan shall contribute to the national objectives of supply security at the lowest cost, general access to energy, the preservation of the environment, and more generally to sustainable development. It foresees the production of electric power of 600 MW from wind parks and thermo-solar hybrid plants; the exploitation of biomass and cogeneration; and a program for the creation of 1,000 micro enterprises for energy services close to the user, and decentralized electrification of about 150,000 rural households under the rural electrification program.
Key governmental institutions and their interests	ONE: Morocco has a strong need for new capacity: peak power in July was 3,190 MW, which is only 12 percent above the available capacity (available capacity is less than installed capacity). Government of Morocco/Ministry of Energy: enabling Morocco to embark on a path of sustainable development in accordance with its commitments under the 2002 Johan nesburg World Summit for Sustainable Development and the 1997 Kyoto Protocol to the Climate Change Convention. Centre de Développement des Energies Renouvelables (CDER)
Tariff structure in country	Electricity tariffs to consumers are high in Morocco due to the taxes: 7–8c/kWh. This is pressure to lower the costs, especially to industry (tariffs have been lowered by 36 percent)
Description of the electric power system	As of September 2004, the power plants owned by ONE are 26 hydropower plants (total installed power 1,265 MW), 5 thermal power plants based on steam generation (2,574 MW), 7 power plants based on gas turbines and several diesel plants (784 MW), wind turbines (54 MW), or in total an installed power of 4,508 MW). 40 percent of the capacity is working less than 5 hours a day. The vast majority of Morocco's electricity is generated in thermal power plants that burn oil and coal. All of the oil is imported, and most of the coal comes from South Africa (the United States and Columbia are also key suppliers). The country's two largest electricity power station are located at Mohammedia and Jorf Lasfar. Sixty percent of the hydropower is concentrated in the five largest hydro plants: Bine el Ouidane in Azilal (capacity 1.38 billion m^3), Idriss 1er on the Oued Sebou (1.186 billion m^3), Al Massira at Settat (2.76 billion m^3), al Wahda (3.8 billion m^3) and Ahmed el Hansali in Zaouiyat Echeikh (0.74 billion m^3). The year 2004 registered a strong increase in electricity demand of 7 percent and this for the second year in a row; demand has now reached 17,946 GWh. Some 56.4 percent of demand was met by IPPs, 35 percent by the power plants exploited directly by ONE, and 8.6 percent by imports through the interconnection with Spain. Hydroelectricity production reached 1,591 GWh (a 10.4 percent increase compared to 2003) and represents 8.9 percent of electricity demand.
Near-term strategy for CSP in the country	Power projects near finalization: ❑ First gas-fired combined cycle plant of Tahaddart: Power 385 MW, Owner: E.E.T (Energie Electrique de Tahaddart, created for this purpose. 48 percent of the capital is owned by ONE, 32 percent by Endesa Europa and 20 percent by Siemens Project Ventures), Operator: Siemens O&M, Cost €285 million, Start: April 2005. 20 years Power Purchasing Agreement E.E.T – ONE. Financing: 25 percent of the investment is financed by the provision of capital, the remainder by two loans raised on the Moroccan market at the Banque Centrale Populaire BCP and a consortium constituted by the BCP, the BMCE Bank and the CA. ❑ Hydro pumping station of Afourer, Power 463 MW, Owner and operator ONE, Cost 1,700 million Dirham (about €155 million), Financing: European Investment Bank and Arab Fund for Economic and Social Development. Start: 2005. ❑ Wind park of Essaouira, Power 60 MW, mean annual production 210 GWh, Owner and operator ONE, Cost 650 million Dirham (about €60 million), Financing: Loan €50 million from KfW. Start of operation: end of 2006. ❑ Wind park of Tanger, Power 140 MW, mean annual production 510 GWh, Owner and operator ONE, Cost 1,800 million Dirham (about €165 million), Financing: Loan €80 million from the European Investment Bank, €50 million from KfW, Agence Française de Développement, ONE. Start of operation: beginning 2007.

Country/Location	Morocco/Ain Beni Mathar

- ❑ Hydropower plant Tanafnit-El Borj, Power 2 x 9 MW MW, mean annual production 100 GWh, Owner and operator ONE, Cost €61 million, Financing: Loan €61 million from KfW. Start of operation: second half of 2007.

Short term projects	Installed Power MW	Installed Power Start
Combined cycle plant Tahaddart	385	2005
Pumping station Afourer	463	2005
Transfer of 3 gas turbines from Tan Tan to Laâyoune	100	2005
Wind Park Essaouira	60	2006
Wind Park Tanger	140	2007
Solar thermal plant Ain Beni Mathar	200–250 MW	2009
Hydroelectric complex Tanafnit El Borj	2x9 MW et 2x13 MW	2007
Performance boost for the thermal power plant of Mohammedia	600	2007

Source: Authors based on internet data from ONE.

Rural electrification: The PERG global program for rural electrification was approved in the Government Council in August 1995 and put into practice starting 1996. ONE, which is responsible for carrying out the program of rural electrification, has accelerated the pace since 2002 to generalize the access to electricity by 2007 rather than 2010 as originally foreseen. At the end of 2007, the PERG will have contributed to electrify 34,400 villages, of which more than 28,000 are linked to the national grid, thus providing access to electricity for 12 million people for a global budget of around 20 billion Dirham (close to €2 billion). This objective will be realized to 91 percent by linking the consumers to the grid and by 7 percent through decentralized electricity generation with PV installations. At the end of 2003, a budget of about 12.3 billion Dirham (more than €1 billion) was engaged by ONE to electrify 13,235 villages (989,946 homes, 6,434,000 rural inhabitants). The rural electrification level, which was 18 percent in 1995, reached 62 percent at the end of 2003, and 72 percent at the end of 2004 with the connection of 187,000 homes to the electric grid. ONE projects to connect 4,000 villages in 2005, with 200,000 homes. The investment will reach €420 million, of which part is used for solar energy equipment for 22,000 houses.

Conclusion: The hybrid solar thermal plant of Ain Beni Mathar is a firm part of the short to medium strategy for the expansion plans of the electric sector in Morocco. Together with the recent commitment of the African Development Bank to engage financing, the chances for the project taking up operation by 2009 appear high.

View of the country on a mid-term strategy for CSP with possible future options (5–10 years)

The new 5-years plan (2005–2010) of ONE foresees investments of the order of 30 billion Dirham (€2.7 billion).
Longer-term power projects:

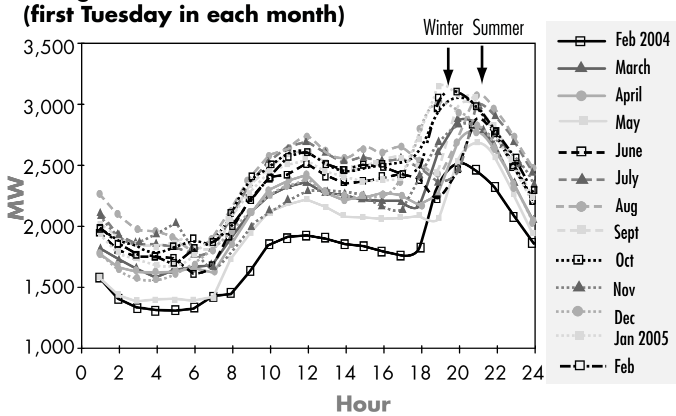
- ❑ Second gas-fired combined cycle plant of Tahaddart: Power 400 MW. Start of operation: 2008–2009
- ❑ Combined cycle plant de Al Wahda (Province de Sidi Kacem): 800 MW. Start of operation: 2008–2009. Invitation for the expression of interest launched March 2005 in view of the prequalification of companies.

Conclusion: New solar thermal plants are so far not part of the mid-term strategy for the expansion of the electricity sector in Morocco (time horizon 2005–2010). However, ONE plans to consider solar thermal option further in an early stage of realization of the first plan at Ain Beni Mathar.

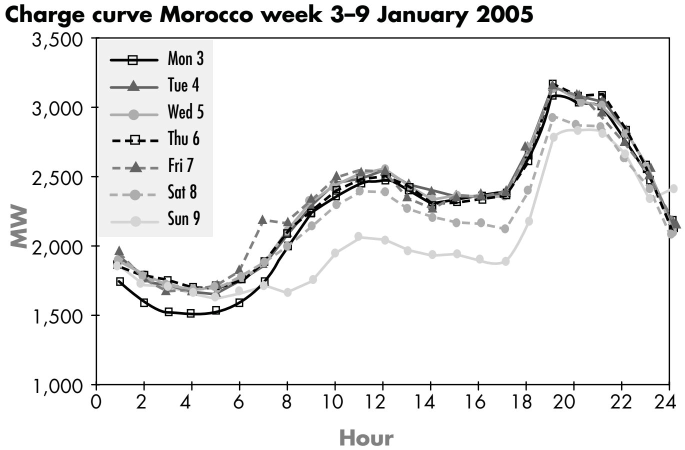
Additional information for Morocco:

Figure 24: Daily load curve of the Moroccan electricity system (over the year and over the week)

Charge curve Morocco Feb 2004–Feb 2005 (first Tuesday in each month)



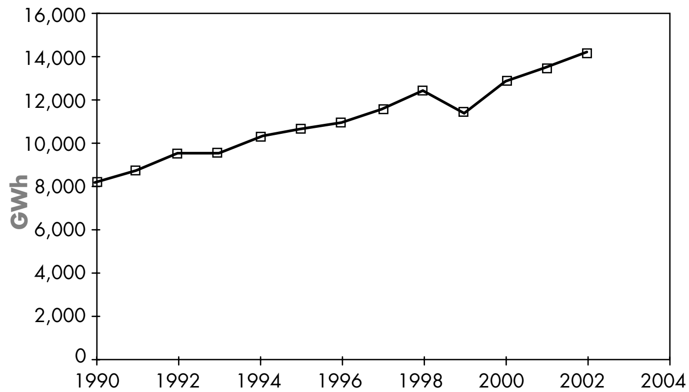
Charge curve Morocco week 3–9 January 2005



Source: Authors, based on ONE.

Figure 25: Growth in electricity demand

Growth in final electricity demand in Morocco 1990–2002



Source: Authors based on ENERDATA Database.

Table 12: Overview of power plants owned by ONE in Morocco (2004)

	Installed Power in MW
26 hydropower stations	**1,265**
Pumping station and turbines of Afourer	**233**
5 thermal power stations (steam)	2,385
Coal-fired	1,665
Oil-fired	720
6 gas turbines	615
Diesel	69
Total thermal plants	**3,069**
Wind (of which 50 MW from the CED*)	**54**
Total ONE	**4,621**

Source: Authors based on internet data from ONE.

Table 13: Electricity produced by type of power plant in Morocco (2004)

	(GWh)	Part (%)
Thermal ONE	**4,648**	**25.9**
Hydro	**1,600**	**8.9**
Wind	**13**	**0.1**
Concession	**10,122**	**56.4**
JLEC: Jorf Lasfar Energy Compagny JLEC	9,936	55.4
Compagnie Eolienne de Détroit CED (Wind)	186	1.0
Contributions from third	**72**	**0.4**
Balance of exchange	**1,535**	**8.6**
Morocco – Spain	1,554	8.7
Morocco – Algeria	–19	–0.1
Auxiliary consumption and compensators	–33	–0.2
STEP (Energy absorbed by the pumping)	–10	–0.1
Total electricity called	**17,945**	**100**

Source: Authors based on internet data from ONE.

Table 14: Thermal power production in Morocco (2004)

Fuel	Net production in GWh	Part (%) *
Coal	12,520	85.8
Jorf Lasfar	9,936	68.1
Mohammedia	1,571	10.8
Jérada	1,012	6.9
Fuel oil	2,061	14.1
Mohammedia	1,113	7.6
Kénitra	768	5.3
Gas turbines	126	0.9
Laâyoune + Dakhla	53	0.4
Gas oil	4	0.0
Total thermal	14,584	100

* in relation to the total thermal production

Source: Authors based on internet data from ONE.

Table 15: Hydropower production in Morocco (2004)

	Installed Power *	Net production	
	MW	GWh	Part (%)
Bine El Ouidane	135	130,302	8.1
Afourer	94	304,594	19.0
Step Afourer	233	10,329	0.6
Hassan 1er	67	55,414	3.5
Moulay Youssef	24	43,351	2.7
Al Massira	128	66,784	4.2
Imfout	31	17,735	1.1
Lalla Takerkoust	12	14,544	0.9
M. Eddahbi	10	13,194	0.8
El Kansera	14	17,044	1.1
Oued El Makhazine	36	67,992	4.2
Lau	14	33,155	2.1
Idriss 1er	41	110,417	6.9
Allal El Fassi	240	162,432	10.1
Al Wahda	240	319,948	20.0
Mohammed El Khamis	23	46,477	2.9
Ahmed El Hansali	92	136,661	8.5
Ait Messouad	6	23,338	1.5
Other	58	26,619	1.7
Total hydro	**1,498**	**1,600,330**	**100.0**

* At the maximum slope of the dams

Source: Authors based on internet data from ONE.

Annex 5
List of interviewed persons

- African Development Bank: Nono J.S. Matondo-Fundani
- Ajmer Vidyut Vitran Nigam Limited: Rajeev Agarwal
- BMU – German Ministry of Environment: Joachim Nick-Leptin, Ralf Christmann
- Comisión Federal de Electricidad CFE (Mexico): Ing. Juan Granados, Ing. Alberto Ramos
- DLR (German Aerospace Center): Robert Pitz-Paal, Jürgen Dersch, Franz Trieb
- Fichtner Solar GmbH: Georg Brakmann
- FlagSol GmbH: Paul Nava, Michael Geyer
- Global Environment Facility GEF: Christine Woerlen
- Imperial College Centre for Energy Policy and Technology: Dennis Anderson
- International Energy Agency SolarPACES: Thomas Mancini, Michael Geyer
- Kearney & Associates: David Kearney
- KfW (Kreditanstalt für Wiederaufbau): Klaus-Peter Pischke
- New & Renewable Energy Authority NREA (Solar Thermal Department): Eng. Salah El Desouky, Eng. Ayman M Fayek, Eng. Khaled M Fekry
- National Renewable Energy Laboratory NREL: Henry Price, Mark Mehos, Tom Wil-liams
- Office National de l'Electricité: Omar Benlamlih, Abdallah Mdarhri, AbdelazizMr. Houachmi, Azzedine Khatami
- Rajasthan Renewable Energy Corporation RREC: Shri Rakesh Verma (Chairman and Managing Director) and S.L. Surana
- Rajasthanstahan Vidyut Vitran Nigam: Shri Salauddin Ahmed
- Sandia National Laboratories: Thomas Mancini
- Schott-Rohrglas GmbH: Nikolaus Benz
- Siemens Financial Services: Jürgen Ratzinger
- Siemens Power Generation: Thomas Engelmann
- Solargenix: Gilbert Cohen
- Solel, Inc.: David Saul
- US Department of Energy DoE: Thomas Rueckert
- VDI/VDE (Verein Deutscher Ingenieure/Verband der Elektrotechnik Elektronik Informationstechnik e.V.): Ludger Lorych
- World Bank: Gabriela Azuela, Anne Bjerde, Chandrasekar Govindarajalu, Charles Feinstein, Rohit Khanna, Todd Johnson, Rene Mendonca, Pedro Sanchez

World Bank Global Environment Facility
Coordination Team Environment Department

THE WORLD BANK
1818 H Street, NW
Washington, D.C. 20433, USA
Telephone: 202.473.1816
Fax: 202.522.3256
Email: GEOnline@worldbank.org
Web: www.worldbank.org/gef