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

(Draft under Consideration by the World Bank)

In May 2004, the World Bank submitted a status report on the GEF co-financed solar thermal portfolio to the GEF Council. In response to Council comments, the Bank subsequently commissioned an external assessment of the World Bank/GEF's strategy for the market development of concentrating solar thermal power.

The consultant was selected through a competitive procurement process, following World Bank procedures. The selected consortium, the Global Research Alliance, is led by CSIR-South Africa, and includes the Fraunhofer Institute for Systems and Innovation Research, Fraunhofer Institute for Solar Energy Systems, and CSIRO-Australia.

The report's findings and recommendations are now under consideration by the World Bank. Council Members are invited to comment on the report, by July 15, 2005. Comments may be sent to Mr. Steve Gorman, GEF Executive Coordinator, World Bank (sgorman@worldbank.org), copied to Mr. Rohit Khanna, Senior Operations Officer (rkhanna2@worldbank.org).

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

May 31, 2005

Prepared for The World Bank

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List of Abbreviations / Definitions

ADB	African Development Bank
CC	Combined Cycle
CCGT	Combined Cycle Gas Turbine
CEA	Central Electricity Authority (India)
CFE	Comisión Federal de Electricidad (Mexico)
CSP	Concentrating Solar Thermal Power
DNI	Direct Normal Irradiance
DoE	US Department of Energy
EEHC	Egyptian Electricity Holding Company (national power utility)
EPC	Engineering, Procurement & Construction contract (turnkey contract)
ESCOM	South Africa's main utility
FERC	US 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
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	German Investment Bank
KSC	Key success criteria
LEC	Levelised Electricity Costs
LNG	Liquefied Natural Gas
MMBTU	Million British Thermal Units
MNES	(Indian) Ministry of Non-Conventional Energy Sources
NEAL	New Energy Algeria (Company in charge of the development of renewable energy projects in Algeria).
NREA	New and Renewable Energy Authority (NREA)
O&M	Operation and Maintenance

ONE	Office National de l'Electricité (National electricity supply company of Morocco)
OP 5	Operational Programme 5 of the GEF (promotes the deployment of near-commercial energy efficient technologies by assisting the removal of barriers)
OP 6	Operational Programme 6 of the GEF (promotes the deployment of near-commercial renewable energy technologies by assisting the removal of barriers)
OP 7	Operational Programme 7 of the GEF (supports technological development, and aims to increase the market share of low greenhouse gas-emitting technologies not yet commercial, but showing promise of becoming so in future)
ORC	Organic Rankine Cycle
PCAST	USA President's Committee of Advisors on Science and Technology
PIU	Project Implementation Unit
PPA	Power Purchasing Agreement
PR	Progress Ratio (of learning curves)
PV	Photovoltaics
RES	Renewable Energy Sources
RfP	Request for Proposals
RREC	Rajasthan Renewable Energy Corporation (State Nodal Agency for promotion of renewable energy programs in the State of Rajasthan
RVPN	Rajasthan Rajya Vidyut Prasaran Nigam Limited
SEGS	Solar Electricity Generating Systems (Californian trough plants. Term is often used for CSP plants with solar live steam production and little fossil co-firing.)
SF	Solar field
SolarPACES	International Energy Agency implementing agreement on Concentrating Solar Power and Chemical Energy Systems for the development of CSP
ST	Steam Turbine
STAP	GEF's Scientific and Technical Advisory Panel
STEG	Solar Thermal Electricity Generation
STPP	Solar Thermal Power Plant
TEC	Techno-economic Clearance
UNFCCC	United Nations Convention on Climate Change
WB	The World Bank

EXECUTIVE SUMMARY

Global warming has been identified as a very significant poverty and security issue. The associated detrimental effects are likely to particularly manifest themselves in many of the developing countries. Though most of the anthropogenic emissions thought to be contributing to the effect have historically come from the OECD countries, modelling shows that in the future the bulk of emissions will come from countries such as India and China. It is therefore in the interest, and within the gambit of, the World Bank to contribute to the identification and support of solutions to GHG emission reduction.

The Operational Programme 7 (OP 7) of the GEF supports the technological development and aims to increase the market share of low greenhouse gas-emitting technologies that are not yet commercial, but which show promise of becoming so in 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 of converting solar radiation into electricity, and it had been operationally proven in California since the mid-1980s. Successively, four projects in Egypt, India, Mexico and Morocco entered the GEF CSP portfolio with a grant volume of US$ 194.2 million in total, managed by the World Bank.

Each project has encountered significant delays. Apart from an unsuccessful attempt for the Indian project in 2003, no Requests for Proposals have yet been issued from any of the four client countries. This suggests the difficulties encountered have been predominantly associated with the relevant authorities in each country reaching necessary agreement.

While there was a strong rollout of solar thermal electricity plants in California in the 1980's, no new commercial scale solar thermal electricity plant has been commissioned in the last 12 years. In that time, research and development has led to improved solar field components, new thermal storage concepts, and 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 of 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, no critical mass of projects has yet been reached such that the industry would be self-sustaining. The industry is presently fragile. There is presently less than 300MW of "firm" projects, whereas something of the order of several thousand MW would be required for the industry to approach commercial competitiveness. To put this in context, the most successful renewable technology in recent times, wind energy, now has over 40,000MW of installations worldwide.

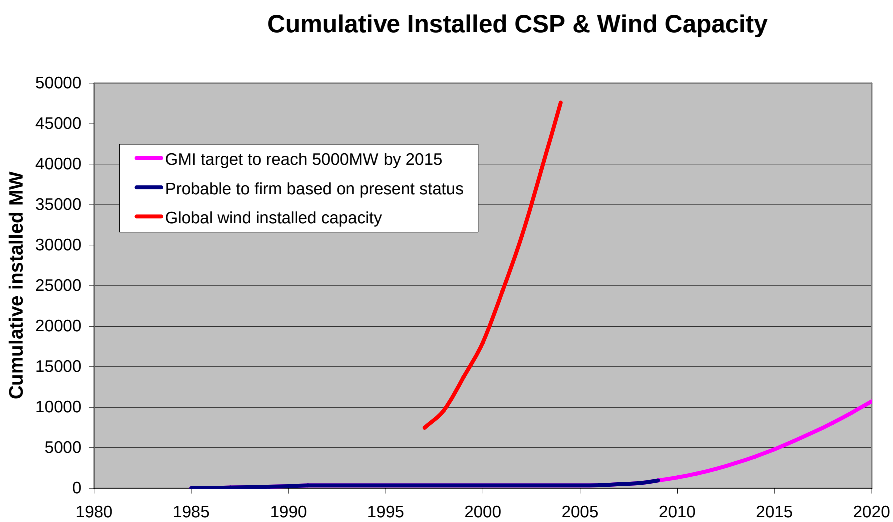
Solar thermal electricity offers a number of advantages when considered as part of a country or region's energy generation options mix. Solar energy is the world's most abundant sustainable resource. It represents an even large resource due to the geography of many of the world's developing countries. Solar thermal, based on a hot fluid, can integrate well with conventional thermodynamic cycles and power generation equipment, and with advanced, emerging technology. It offers dispatchable power when integrated with thermal storage, and thus good load matching between solar insolation and the strong growth (in many countries) in electrical demand during summer. The collector technology itself is constructed of predomi-

nantly 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 components. This however also raises perhaps the major barrier for the technology at present. The cost of electricity for a one-off plant is presently around US16-20c/kWh (depending on solar radiation levels), which might be acceptable for some kW or small MW applications, 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 GW (similar to wind capacity today), not including allowance for any cost of carbon. This would represent approximately 1 % of the global installed power generation capacity and require subsidies of the order of 12 billion €. An allowance for a carbon cost beginning at 7.5 €/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 (i. e. larger plants), increased production volume and technological innovation.

The figure below shows that the required growth rates for solar thermal electricity to achieve cost-competitiveness are quite mild 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 GMI (Global Market Initiative) is a proposed industry target to reach 5000 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 with financial closure purportedly imminent.



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

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**	**Full commissioned and operating**
Algeria 25 MW trough, ISCCS	✓	✓	This year	Original expectation Sep 2005	
Arizona 1 MW trough ORC	✓	✓	✓	✓	
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	✓	✓	✓	✓	Early 2006
Italy/ Empoli (2x 80 kW solar gas turbine with waste-heat usage for air-conditioning)	✓	✓	✓	✓	
India/ Solar Heat and Power Pty Ltd, 5 MW, Fresnel	✓	✓			
Iran 67 MW trough, ISCCS	✓				
Israel 100 MW trough	✓	✓			
Jordan 135 MW trough	✓	✓ (RfP 2001)			
Nevada 50 MW trough	✓	✓	Next two months	Aug/Sep 05	Estimate 2007
Portugal/ Solar Heat and Power Pty Ltd, 5 MW with potential to upgrade to 50 MW, linear Fresnel	✓	✓	Financial close shortly		
Spain/ ACS + SMAG, Andasol 1 50 MW trough	✓	✓	Next few months	Late 2005	Around late 2007
Spain/ ACS + SMAG, Andasol 2x50 MW trough	✓	✓	This year		
Spain/ Abengoa, PS10 11 MW tower (sat steam)	✓	✓	✓	✓	Estimated 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 Extre-maSol 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	✓				

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

- Targets specific to CSP
- Appropriate financial support, 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:

- Encourage competition - over time as costs drop, the level of mandated support should be correspondingly reduced.
- Provide 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.

Country/ project	**Status of project**	**Project structure**	**Expected schedule**
India, 140 MW ISCCS incl. 35 MW solar trough, site approx 2240 kWh/m2/yr DNI	World Bank waiting on letter of commitment from Govt of India, after which already drafted RfP (revised) could be released. Government of Rajasthan very enthusiastic	Single EPC cum O&M (5yrs). PPA with RVPN. Project owner RREC.	RREC expects GoI and MNES sign-off "any day". RfP can then be finalised. Some issues require updating such as source of gas.
Egypt/ Kuraymat, 151 MW ISCCS incl. 25 MW solar	NREA awaiting final approval from JBIC for financing balance of foreign project investment cost ($97M)	Two EPC contracts, one to cover each of CC and solar field.	Bid documents planned to be issued Oct 2005; WB non-objection Nov 2006; Issue contract to commence construction mid 2007.
Mexico / El Fresnal near Agua Prieta, Sonora State (site decision in March 2005, plant Agua	CFE have asked WB/GEF if still willing to provide the grant for a larger (560 MW) ISCC plant. CFE requires a	The final owner of the plant will be CFE. They will undertake to provide the O&M. (Previously, unsuccessful project	At this stage, bidding is expected for 2006, construction is to begin 2007, operation 2009.

Prieta II), originally 285 MW ISCCS but looking to in-crease CC to 560 MWe; Solar trough field 25-40 MW; Excellent solar site conditions (however exact solar data not available).	firm commitment in order to complete technical and economical evaluation to submit to Treasury Ministry for approval in June 2005.	development under IPP scheme.)	
Morocco/ Ain Beni Mathar 240 MW ISCCS, incl 30 MW trough. Expected production from ISCCS 1590 GWh/yr, of which approx 55 GWh/yr solar (3.5 % solar contribution).	EPC cum O&M (5 yrs). Option exists to renew O&M contract after 5yrs. Bid document completed by Fichtner Solar and reviewed with client (ONE). In March 2005, lodged with World Bank for "Non Objection".	Owner of plant will be ONE. Total cost expected approx €213M, incl connection to infrastructure. €43M from GEF, and €34M from ONE. Balance of €136.45M from African Development Bank as soft loan.	When "Non Objection" approval received, can issue to pre-qualified bidders. EPC cum O&M contract could be signed by end of 2005, with expected start of operation mid 2008-early 2009.

At this point in time, CSP technology does not suffer 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, and 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 centralised 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 OP7. Given the delays to date, and quite likely some more hurdles to come, this would appear an attractive option. However the goals of OP7 are worthy, and it is important that an organisation such as the World Bank is seen to be taking a lead in such issues. Of the zero GHG technologies that are technically feasible yet not yet commercial, CSP is a lead candidate. If the goals of OP7 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 MW 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 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 MW, 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:

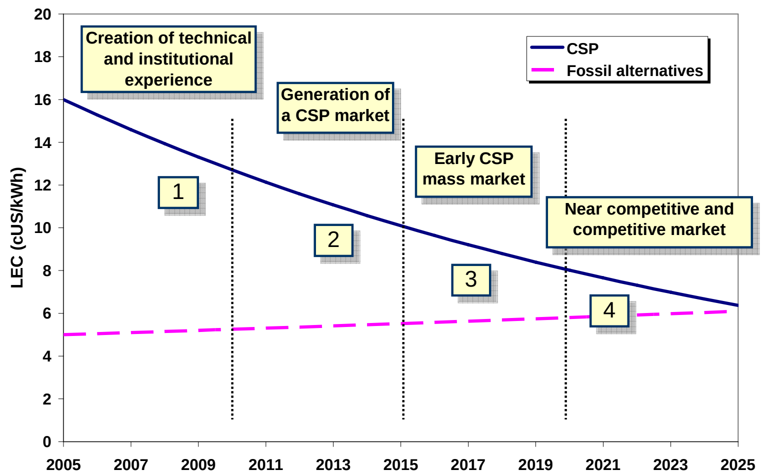
- They are important to the global CSP industry as they constitute a significant percentage of planned projects at present, especially if 3 or 4 proceed. Inevitably, some will not proceed, so the more that are planned the more robust will be the early implementation phase. They provide momentum and continuum to the global industry, which in turn will provide benefits to the developing countries when future projects are developed.
- The developing countries, with good 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 OECD countrys' resources.
- 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 towards supporting more projects, and work pro-actively to promote the technology globally, with the idea that global progress benefits the WB 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, however with appropriate exit strategies if various milestones are not met.

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.



	Key Success Criteria (KSC)	Comment	Importance
Phase 1	Response to RfP's	Critical that a good number of bids are received from robust consortia	Crucial
	Contracts signed for at least 2 projects	Having less than 2 projects proceed to contract signature would represent a relative failure of the portfolio. More than 2 would indicate a healthy CSP portfolio and good reasons to continue.	High
	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)
	Reallocation of balance of GEF funds	If 1 or 2 of the 4 projects are not successful (based on missing key deadlines without due cause), and the above 3 KSC's 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 would already have significantly progressed their projects, for e. g. Algeria, Iran, Jordan, China.	Medium
Phase 2	Continuing emergence of CSP projects in other countries	CSP market development is a long term process. It will be of the order of 1 year before construction commences on the first WB/GEF project, a further 2 yrs till operation commences - realistically a minimum of 4 yrs from now till there is a good level of operational data. This affords a good opportunity for the WB to assess CSP progress internationally.	High
	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
	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
	New portfolio of WB projects successfully commenced	If the above KSC's have been satisfactorily met, a new competitive call for proposals should be launched. The timing will be dependent on the above KSC's.	High
	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
	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 mobilisation 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
	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

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 ISCCS vs 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 O&M experience to be gained in these countries, and a 200,000m^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 EPC (engineer, procure, construct) 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, i. e. 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 any engineering design problems occurring between the solar field and the steam turbine/ HRSG will rest with the owner and designer.
- How best to fund CSP beyond these projects? World bank/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 PPA through the fund. The WB/GEF funds could be partitioned such that they were only available to the developing country projects. By that time, particular regions may be emerging as the most attractive upon which to concentrate.

SUMMARY OF CHAPTERS

The Operational Programme 7 (OP 7) of the GEF supports the technological development and aims to increase the market share of low greenhouse gas-emitting technologies that are not yet commercial, but which show promise of becoming so in 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 of converting solar radiation into electricity, and it had been operationally proven in California since the mid-1980s. Successively, four projects in Egypt, India, Mexico and Morocco entered the GEF CSP portfolio with a grant volume of US$ 200 million in total, managed by the World Bank. The main technology route considered is the ISCC technology which links solar thermal technology and gas combined cycle technology, providing thus larger power capacities for the needs of the developing countries at affordable prices but at the price of a low solar share (5-10 %) and a complex relationship between the two parts of a project.

Each of the four projects is at a different stage of delivery, and all have encountered various obstacles along the way. The first project to receive approval in principle from GEF was the Indian Mathania project. The Mexican, Moroccan and Egyptian projects have perhaps benefited from the prior experiences 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 institutionalised routes through government.

With this background in mind, the main objective of the present study was to assess the strategy being followed by the Bank/GEF for solar thermal power technology in light of:

- The current state of market development, technology and costs of CSP (chapter 2);
- Risks with respect to technical, financial/commercial, regulatory/institutional and strategic issues faced by the GEF/WB portfolio and possible mitigation options (chapter 2.3.3);
- The status of the current GEF/WB portfolio (chapter 4);
- Scenarios for possible short and long-term choices for the GEF/WB (with respect to the present portfolio and beyond (chapter 3).

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

Market Development (Chapter 2.1)

The main message from the market development is ***that the GEF/WB 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 due to emerging programmes

and legal frameworks. Particularly strong initiatives have been legislated in Spain: (1) a tariff suitable to cover the risk premiums of the first projects, (2) a sensible allowance for gas backup for transient and start-up purposes, (3) tariffs assured for a bankable period, (4) an element of "stretch" to ensure the technology does not become comfortable, but that after 200 MW has been deployed, the tariff will be revised in light of cost-reduction.

A list of CSP projects and their status is provided in S-Table 1. It shows that in the last 12 months a considerable variety of CSP projects have emerged, with interest over a wide part of the globe.

S-Table 1: Overview and status of CSP projects world-wide (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	Full commissioned and operating
Algeria 25 MW trough, ISCCS	✓	✓	This year	Original expectation Sep 2005	
Arizona 1 MW trough ORC	✓	✓	✓	✓	
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	✓	✓	✓	✓	Early 2006
Italy/ Empoli (2x 80 kW solar gas turbine with waste-heat usage for air-conditioning)	✓	✓	✓	✓	
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Iran 67 MW trough, ISCCS	✓				
Israel 100 MW trough	✓	✓			
Jordan 135 MW trough	✓	✓ (RfP 2001)			
Nevada 50 MW trough	✓	✓	Next two months	Aug/Sep 05	Estimate 2007

(Table 1 continued)

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	Full commissioned and operating
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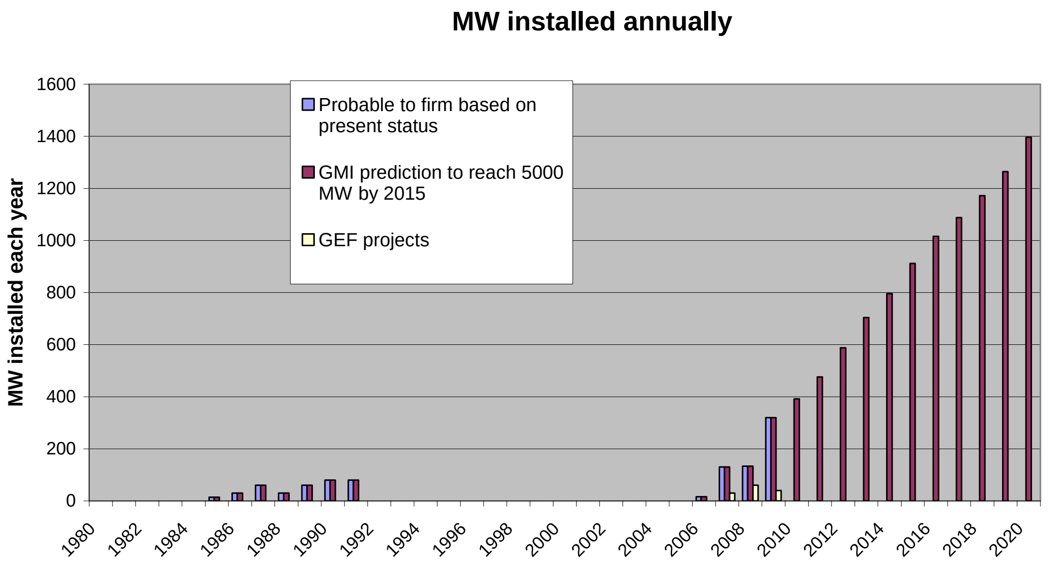
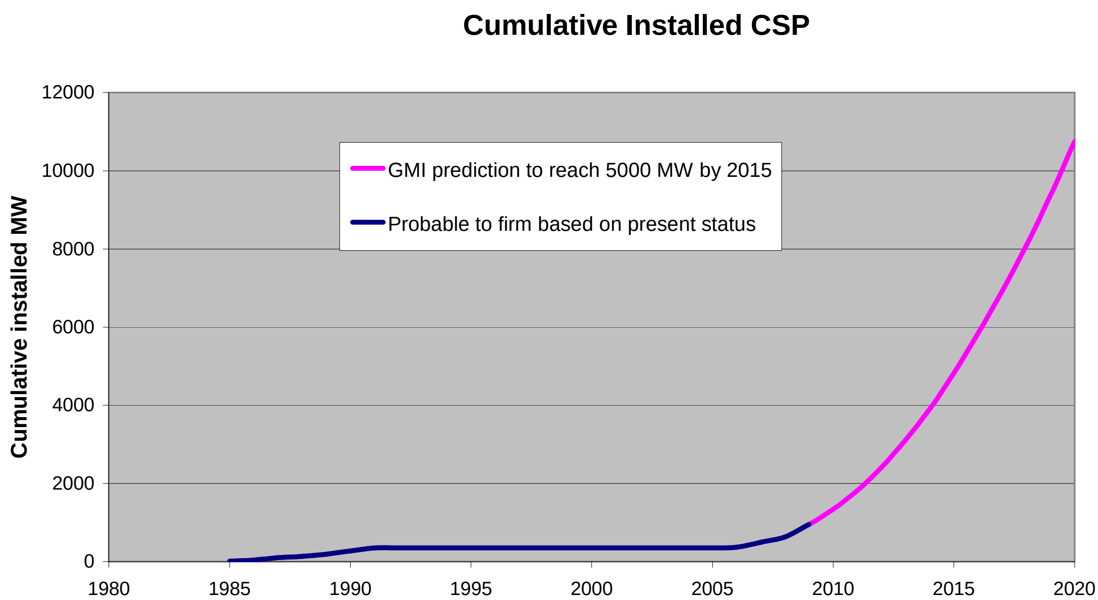
Spain/ ACS + SMAG, Andasol 2x50 MW trough	✓	✓	This year		
Spain/ Abengoa, PS10 11 MW tower (sat steam)	✓	✓	✓	✓	Estimated 2006
Spain/ SENER, Solar Tres 15 MW tower (molten salt)	✓	✓			
Spain/ EHN+SolarGenix, 15 MW trough (HTF)	✓	✓			
Spain/ Iberdrola, 7x50 MW Trough (HTF)	✓	✓			
Spain/ HC, 2x50 MW Trough (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	✓				

The following plots can be established from S-Table 1. The projects considered "possible to firm" are those projects above 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 based on a vision established by the Global Market Initiative GMI (see chapter 6.3).

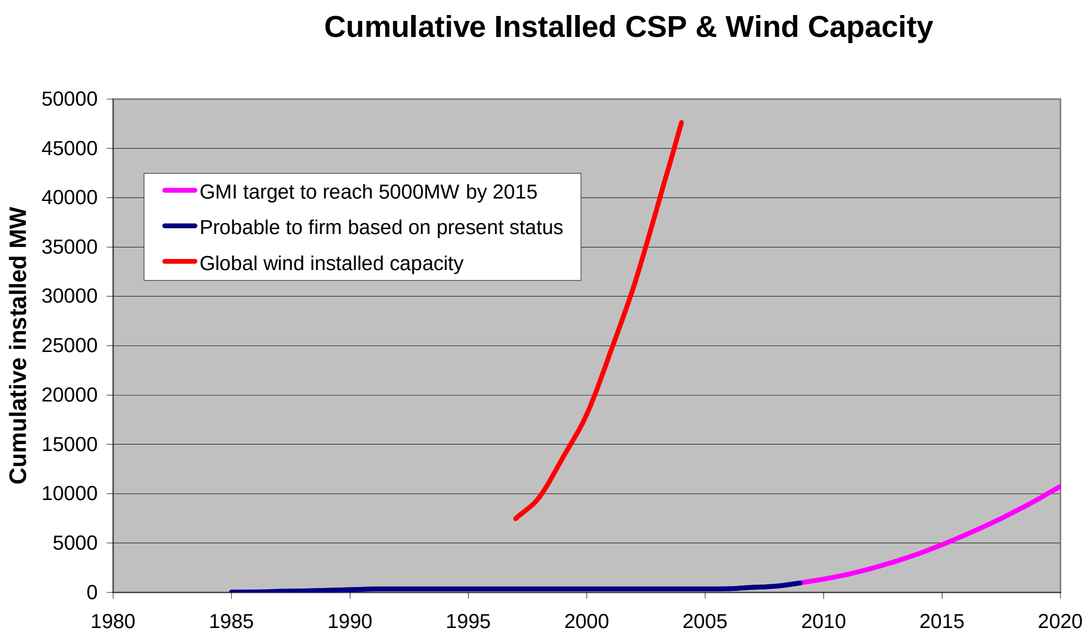
S-Figure 1: Short-term and possible medium to long-term development of CSP technology world-wide (yearly installed MW_e). In 2007 for example, it is probable that an additional 130MW will begin operation, of which 30MW are GEF projects. It is noted that GMI is a target of 5000MW within 10 years – we have chosen to break this up into annual steps for illustrative purposes.



S-Figure 2: Short-term and possible medium to long-term development of CSP technology world-wide (cumulative installed MW_e).



S-Figure 3: Short-term and possible medium to long-term development of CSP technology world-wide (cumulative installed MW_e) compared to global wind installed capacity.



S-Figure 3 shows that the market deployment path assumed for CSP is much more conservative than that which has taken place for wind. This indicates the CSP curve is not unrealistically optimistic, and indeed has room for increased aggressiveness.

Technological paths (Chapter 2.2)

According to Sargent&Lundy (2003), 54 % of anticipated CSP cost reduction is likely to be attributable to technological innovations with the balance attributable to plant scale-up and increasing production volume. There are a number of collector concepts which are technically viable, and a number of ways of integrating these into both conventional and future power cycles. The prospects for a number of these combinations are attractive, yet without firm data from multiple working plants (apart from troughs using a heat transfer fluid), it is not possible to predict a future winner. In fact different combinations will tend to suit different markets, and it will be the specific markets which will decide. If a hybrid concept is selected (i. e. the solar contribution is less than a nominal 50% of the total plant electrical output), it is crucial that the solar contribution be capable of being increased over time. Even where the solar field is supplying part of the energy required to drive the turbine, the solar contribution should be able to be increased in a modular fashion when, for example, collector costs drop or fuel prices increase.

This study primarily considered the SEGS-type concept (solar steam into a stand-alone Rankine cycle) as evidenced in the SEGS plants in California, and the Integrated Solar Com-

bined Cycle System (ISCCS), as proposed for the GEF projects to date. However all major collector types have been reviewed and recommendations are made to allow opportunity for alternative collectors and cycle configurations to be bid.

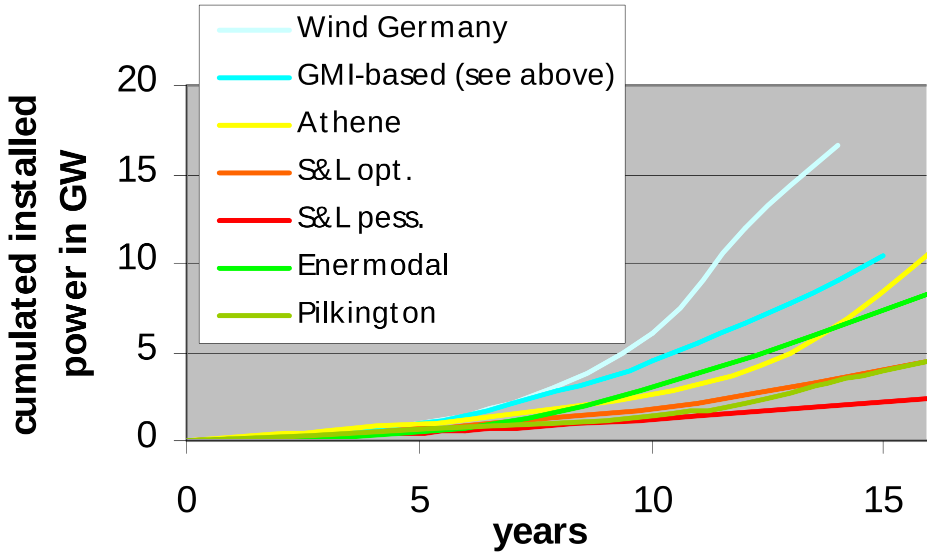
From a long term perspective the solar contribution of the "ISCCS" (and "Solar feed water preheating") cannot be extended beyond a certain level. However, as long as countries build fossil CC or Rankine plants anyway, equipping these plants with a solar field is a significant contribution to GHG emission reduction. ISCCS and solar feed-water preheating are well suited for market introduction of new solar collectors because the marginal investment in conventional plant components required to support the solar field is lower than for a stand-alone solar plant. There are also cost benefits through sharing some components of plant infrastructure, project implementation costs and plant O&M . In developing countries where the primary need is for electricity (not necessarily green electricity), the combination of solar energy together with a large scale fossil power plant tends to have more attraction than stand-alone solar plants.

Once the solar field is in place, ISCCS offers as much potential for learning how to operate and maintain a solar field as would SEGS-type plants.

Cost Reduction (Chapter 2.3)

All cost-reduction studies reviewed for this report assumed a conservative global CSP market development compared to the past technology deployment of wind energy. It is also noted that many of the countries in the world's sunbelt lack the financial resources to presently finance solar energy on a large scale. The large rollout of wind energy began as a result of significant financial support tariffs in a single country, which then spread through other OECD countries. It is as a result of cost reduction in OECD countries that the developing countries can now take on this technology. With the present global CSP activity, strong technology growth similar to wind energy would appear feasible.

S-Figure 4: Comparison of the different market development assumptions of the CSP studies in comparison with the German wind market development and the GMI (goal of cost competitiveness after cumulative installed power of 5 GW in 10 years).



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

- ➢ The technology has the potential to be cost competitive within 10-25 years and will then be one major electrical power option for developing countries, which often are located in the sunniest parts of the world. Due to the possibility of hybridisation and thermal energy storage solar thermal power is dispatchable power that helps to support grid stability, as opposed to many other renewable energy sources.
- ➢ Should GEF promote CSP investments in developing countries now rather than wait till the technology has moved further down the learning curve?
  We believe that the four GEF projects would be an important contribution to OP7's goal of "Reducing the long-term costs of low greenhouse gas-emitting energy technologies". However, they will not of themselves be sufficient to reduce the CSP costs down to a competitive level, and in fact it would be beyond the financial capability of any single programme. It is difficult to quantify the cost reduction effect of the four projects: In the beginning of the portfolio's history it appeared that it would be one of the GEF plants that would be the next one built following the Californian SEGS plants. However today, with other commercial CSP activities evolving, other projects have already commenced. Therefore the question is which four sections of the cost reduction curve will be occupied by the GEF projects. Certainly, as the projects are early in the cost-reduction process, the GEF projects will have a larger percentage effect on technology cost-reduction than if they came later. It is likely that much of the cost-reduction in these early plants will result

from a reduction in the risk premium as operational and investor confidence is gained. Subsequent to this cost reductions will result from a combination of economies of scale (i. e. bigger plants), mass production, and improved component performance.

It is important that actions towards reducing GHG emissions occurs early. This is particularly the case with CSP where delay means fossil-fuelled plants with lifetimes of 25-30 years or more lock in GHG emissions, considerably limiting the option to shift to more sustainable generation options. Whereas the OECD-countries generally have the means to subsidize new, clean power technologies on a large scale, developing countries usually do not have these resources. It is important to note that if the GEF grants are withdrawn, it is highly unlikely these four CSP projects will proceed. By supporting the implementation of the first CSP pilot plants GEF/World Bank will help to create technology trust and institutional learning and thereby reduce the hurdle for subsequent market entry. The large solar fields of solar thermal power plants contain many components that can be locally manufactured, e.g. concrete foundations, 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 macro-economic aspects of value creation in the countries of destination were not quantified in this study)

CSP Risk Analysis (Chapter 3)

From the discussion in Chapter 3 of the various risks and barriers that the GEF/WB portfolio and CSP more generally are facing, it appears that the regulatory/institutional risks are at present the highest barrier/risk, while financial/commercial risks and in particular technological risks are less of an impediment at this point. Strategic risks are also high but only in the longer term, and could be mitigated by a more diverse development of the general CSP market as compared to the WB/GEF portfolio relying only on the ISCC technology route.

The S-Table 2 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) as well as the main level of impact (project success; GEF/WB programme success; global technology evolution).

S-Table 2: Overall risk evaluation for the WB/GEF solar thermal portfolio

	Risk	**Importance**	**Main level of impact**	**Main actor 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	✶	(❷) / ❸	Plant designer

	ISCC concept			/ 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-optimised operation of the ISCC 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	WB/GEF National level
9.	Insufficient financing secured for the GEF/WB projects	✦/✶	❶	WB/GEF National level
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
	Regulatory/institutional risks related to the WB/GEF portfolio	✶/❋	❷ / ❸	
18.	Lack of incentives to maximise operation of the solar field	❋	❶	National level WB/GEF
19.	Loss of confidence in potential project developers due to lengthy bidding procedures	❋	❷	WB/GEF National level
20.	Loss of confidence in project developers due to missing long-term assurance of CSP market growth	✶	❷ / ❸	WB/GEF National level
21.	Lack of supportive-framework for renewables, in particular CSP	❋	(❷) / ❸	WB/GEF National level
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 ISCC and its future impact	❋	❸	WB/GEF National level
24.	Risk in mandating the trough technology compared to tower, dishes or Fresnel collectors for future developments	✶	❸	WB/GEF National level
25.	CSP might take up market shares more slowly than.	✶	❷ / ❸	WB/GEF

	other renewables (incl. PV and wind)			National level
26.	Concepts chosen not flexible enough with respect to future plant extensions	❋	❸	
27.	Dependency 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 GEF/WB programme success; ❸ global technology evolution

Status of the GEF/WB portfolio and possible development (Chapter 4)

The team has carried out 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 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 - are contained in Annex 4. Each project is at a different stage of delivery, and all have encountered various obstacles along the way (see S-Table 3).

S-Table 3: 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 2240 kWh/m2/yr DNI	World Bank waiting on letter of commitment from Govt of India, after which already drafted RfP (revised) could be released. Government of Rajasthan very enthusiastic	Single EPC cum O&M (5yrs). PPA with RVPN. Project owner RREC.	RREC expects GoI and MNES sign-off "any day". RfP can then be finalised. Some issues require updating such as source of gas.
Egypt/ Kuraymat, 151 MW ISCCS incl. 25 MW solar	NREA awaiting final approval from JBIC for financing balance of foreign project investment cost ($97M)	Two EPC contracts, one to cover each of CC and solar field.	Bid documents planned to be issued Oct 2005; WB non-objection Nov 2006; Issue contract to commence construction mid 2007.
Mexico / El Fresnal near Agua Prieta, Sonora State (site decision in March 2005, plant Agua Prieta II), originally 285 MW ISCCS but looking to increase CC to 560 MWe; Solar trough	CFE have asked WB/GEF if still willing to provide the grant for a larger (560 MW) ISCC plant. CFE requires a firm commitment in order to complete technical and economical evaluation to submit to Treasury	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 is to begin 2007, operation 2009.

field 25-40 MW; Excellent solar site conditions (however exact solar data not available).	Ministry for approval in June 2005.		
Mexico / El Fresnal near Agua Prieta, Sonora State (site decision in March 2005, plant Agua Prieta II), originally 285 MW ISCCS but looking to increase CC to 560 MWe; Solar trough field 25-40 MW; Excellent solar site conditions (however exact solar data not available).	CFE have asked WB/GEF if still willing to provide the grant for a 500 MW instead of 250 MW ISCCS. CFE require a firm commitment in order to complete technical and economical evaluation to submit to Treasury Ministry for approval in June 2005.	The final owner of the plant will be CFE. They will undertake to provide the O&M.	At this stage, bidding is expected for 2006, construction is to begin 2007, operation 2009.
Morocco/ Ain Beni Mathar 240 MW ISCCS, incl 30 MW trough. Expected production from ISCCS 1590 GWh/yr, of which approx 55 GWh/yr solar (3.5 % solar contribution).	EPC cum O&M (5 yrs). Options exists to renew O&M contract after 5yrs. Bid document completed by Fichtner Solar and reviewed with client (ONE). In March 2005, lodged with World Bank for "Non Objection".	Owner of plant will be ONE. Total cost expected approx €213M, incl connection to infrastructure. €43M from GEF, and €34M from ONE. Balance of €136.45M from African Development Bank as soft loan.	When "Non Objection" approval received, can issue to pre-qualified bidders. EPC cum O&M contract could be signed by end of 2005, with expected start of operation mid 2008-early 2009.

The first project to receive approval in principle from GEF was the Indian Mathania project. The Mexican, Moroccan and Egyptian projects have perhaps benefited from the prior experiences 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 institutionalised routes through government, and the specific issues and difficulties of each are dealt with in Annex 4. Overall though, each country is purporting a high level of enthusiasm to progress their projects. The following views are pertinent to the overall portfolio.

It is probable that an element of over-optimism surrounded the projects of this portfolio early on. When the detailed feasibility assessments were carried out, with all the local factors such as risk factors on performance, finance and insurance included the final price went up instead of down. In the mind of decision-makers, this made things more difficult. This, however, is not a unique scenario for a new or emerging technology.

In addition, the projects were initially predicated on the basis of an IPP structure where all the difficulties and risks of raising finance and ensuring performance were to be borne by

large organisations. When this approach had to be revised to EPC cum O&M contracts, many more institutional and governmental factors came into play, which has led to delays.

The delays in the four GEF/WB projects are due to a complex mixture of reasons which involve all parties, including

- lack of interest from the side of the hosting countries, possibly due to priorities concerning environmental issues and/or slow/complex decision procedures at the national levels;
- the GEF/WB (slow response in different project steps, lower internal priority than expected for projects of such size);
- lack of flexibility or additional requests for modifications from the side of co-financiers as in the case of the JBIC which requested delays for reflection and the separation of the bidding documents into two separate bids for the solar component and the combined cycle.

It would be naive to believe there will not be more delays of some form or other affecting one or more projects. However it is believed that firm dates now need to be set in place for each project after consultation with each country.

CSP development options for the WB/GEF (Chapter 3)

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. The cost reduction studies analysed for this report suggest CSP deployment of between 5000-42,000MW[1] would be required for commercial competitiveness, so against that figure the 120MW of the GEF portfolio will not of itself produce a significant cost reduction. However the institutional learning aspects, which are not so easily quantified as Levelised Electricity Costs (LEC), will play a large role in possible cost reduction. It is also important to underline the commitment that the GEF has been prepared to make toward CSP technology - the GEF funds for the project portfolio represent roughly one third of its annual budget for climate change issues in recent years. Given this considerable commitment, it is important to assess the level of impact it is likely to have. It is clear that a complex issue such as the introduction of CSP technology in developing countries needs more time than just the realisation of a portfolio of four projects. *It is therefore not astonishing that the portfolio encountered the difficulties and delays which have been observed so far.*

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[1] S-Figure 4 shows that for the first 10 years or so, the various models are generally in broad agreement (apart from GMI which is a target rather than a model). The large discrepancies in MW required before commercial competitiveness arise from assumptions on the point of commercial competitiveness (e. g. predictions concerning conventional electricity prices, carbon prices, etc. over the next 25 years). As the cost curve begins to plateau over time, small changes on the vertical axis (LEC) have pronounced effects on the horizontal axis (time or MW).

The main question for the GEF/WB today is whether it is worthwhile continuing the support for the joint development of CSP technology the current portfolio is "successful". The following is a presentation of the different scenarios for action, both short and long-term. For the purpose of representing short and long-term aspects, the scenarios are divided into two groups:

- **The "First Round":** this group of scenarios deals with short-term aspects (in particular the current GEF/WB 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:
  - *"The First Round" - "Falling Dominos":* This scenario assumes that the GEF/WB portfolio would be cancelled as a whole due to the delays accumulated so far as well as the recognition that there may have been an underestimation of the time it takes to get the technology to the market in the developing world where there are inadequate structures to promote renewables. It also assumes no parallel efforts in industrialised countries.
  - *"The First Round" - "Getting to the harbour":* This scenario assumes that the GEF/WB portfolio would be partially or totally realised during the next 2 years.
- **The "Second Round"** assumes a (more or less) successful "First Round" and considers options for GEF/WB 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.
  - *"The Second Round" - "Wait and See":* This scenario is based on the recognition by GEF/WB 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 likely not to have much impact.
  - *"The Second Round" - "2-Track approach" (CSP in industrialised + developing countries):* This scenario is based on CSP contiuing to develop in OECD countries, but requiring further support and development at the international level in order to open up "the second track" (i. e. the developing countries).
  - *"The Second Round" - "Specialising":* This scenario is based on one hand on the recognition by GEF/WB that the large scale promotion of CSP might exceed its financial and institutional capacities, and on the other hand of the recognition of the fact that CSP is to play an important role in the power mix of developing countries. This requires specialisation of the GEF/WB support on particularly sensitive issues for the future development of CSP in those countries.

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

A strategy comprises a vision, a rationale, an understanding of the key issues, and subsequent recommendations.

The final chapter draws the above material together into the key issues formulating the CSP strategy, critical success factors for the World Bank, and recommendations for each of the countries in the existing portfolio. We start with the premise that we see no reason to change the existing OP7 objectives. They form a suitable foundation for the introduction of emerging technologies such as 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 sits well with other more global visions/scenarios that have been formulated in recent years:

- The Global Market Initiative for CSP, with the objective "to facilitate and expedite the building of 5,000 MW_e 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 %. 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 % in developing countries), for 2020 around 21,500 MW (of which 30 % in developing countries).
- The ATHENE scenarios in the SOKRATES project (DLR, 2004) which envisages 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 here higher (at around 50 % already in 2025) due to a lower installed capacity in the US as compared to Greenpeace/ESTIA.

From a general perspective, the rationale for CSP is based on the following:

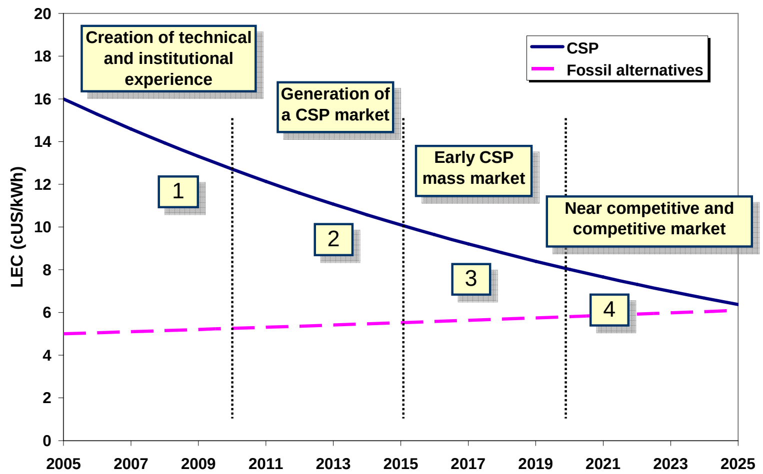
- Solar energy is the world’s largest sustainable energy resource
- Solar energy is abundant in many developing countries
- Solar thermal sits favourably in terms of technology development – no exotic material breakthroughs are required, it comprises thermal processes which are well-understood
- Solar 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 are able to be undertaken relatively easily and without too much dependence upon 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

The following strategy is founded on three observations: (1) CSP power plants must early on displace fossil fuel, but increasingly replace fossil-fuelled plants which would otherwise lock-in GHG emissions for at least three decades; (2) A mix of renewable technologies is needed to turn resource variability into resource diversification. However CSP has the inherent advantage of being able to be deployed in large dispatchable "chunks". (3) Two regions, the Mediterranean/Near East area and Mexico have – in the short term - the potential to export additional solar electricity to the Northern industrialised countries (US and Europe) in order to lower GHG emissions and benefit from their green electricity tariffs.

For simplicity, we discuss the proposed strategy in terms of the CSP industry and market development path as indicated in S-Figure 5.

S-Figure 5: Four phases in the development of CSP



The four phases are as follows. The curve assumes cost competitiveness around 20 years from now in 2025, which represents a midpoint of the predictions by various cost-reduction models.

- ***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 realisation of a few

plants in Spain, US 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 500-2000 MW). Diversification in technologies, certain degree of cost reduction but still far away from economic margins. Target of perhaps 15-20 % of capacities installed in developing countries. Financing driven in industrialised 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 2000-7000 MW). Substantial decrease in costs due to scale and volume effects, costs approaching competitive ranges but not yet generally cost effective. Target of perhaps 20-25 % of capacities installed in developing countries. In some applications, however, even without subsidies interesting, 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 30-40 % of capacities installed in developing countries. This is a stage that is currently reached by wind, however, with a still comparatively low share of the developing world (by the end of 2004 around 47 GW of wind were installed world-wide, of which around 8.5 % in the developing world).

A successful strategy must further take into account that the main purpose is not to realise 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***.

The market introduction strategy must also cope with the ***main barriers to the technology***. For CSP in developing countries these barriers are:

- Insufficient financial means to support more expensive renewables in the early phase in order to cover their rapidly growing electricity demand;
- Inadequate institutional framework for renewable energy and insufficient competition in electricity markets;
- Suspicion of a technology "that is only just emerging even in the developed world".

Key Issues and Recommendations (Chapter 6)

The report discusses, in the light of a vision for CSP and criteria for a successful realisation of a strategy towards that vision, a variety of questions linked to the short-term (questions 1-9 below) and the long-term engagement (questions 10-16 below) of WB/GEF in CSP. The an-

swers contain also the major recommendations from the report. In this executive summary some of the arguments are considerably shortened. For a more detailed discussion, the reader is referred to Chapter 6.

(1) Can the rational to include CSP in the OP7 objectives be confirmed ?

From an overall perspective, we believe CSP is a technology worth pursuing under the objectives of OP7 as it meets all important criteria: (i) Solar energy is abundant in many developing countries; (ii) Solar thermal sits favourably in terms of technology development – no exotic material breakthroughs are required, it comprises thermal processes which are well-understood; (iii) Solar thermal integrates well with other thermal processes, thermodynamic cycles and conventional power generation equipment; (iv) 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; (iv) Solar plants can be designed to be dispatchable unlike wind or PV currently.

(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, one because we believe they are crucial to building momentum in the solar thermal industry, and two because by proceeding future projects in those countries are likely to benefit from the leverage applied now. 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 to release of 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 the writing of this report the question has been raised whether the present portfolio context is not similar to a few years ago where hopes were high for an immediate realisation of the WB/GEF projects which have not materialised so far. However, there are substantial differences in the context now, as there are: considerably higher energy price context; concrete CSP projects coming up in the developed world; stabilisation of the business model (move from the IPP approach to public EPC).

(3) Are there particular conditions for the continuation of the portfolio ?

However, given the time elapsed for the project portfolio, the country itself needs to 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:

1. Release of RfP (i. e. must have passed "non-objection")
2. Assessment of bids and presentation of preferred bidders to WB
3. Signing of contracts

Such timelines need to be discussed and fixed with each of the four countries individually. From the current perspective it appears as realistic that by the end of 2006 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 ?

In the case of the revision/cancellation of 1-2 projects, and the wish of the GEF/WB to support further this important technology in the given country without looking for alternative sites, the following alternative technology lines to the ISCC concept might be considered: (i) market introduction for industrial process heat applications based on concentrator solar; (ii) small-scale solar combined heat&power plants (heat for absorption chillers, process heat or sea water desalination: water scarcity is a seriously upcoming problem in the countries of the solar belt, this problem is much more serious than energy scarcity. CSP offers an economic solution to this problem, namely seawater desalination from waste heat of the condenser); (iii) 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.

(5) Was the ISCC/Solar Trough technology the right selection for the WB/GEF portfolio ?

The answer is not a frank yes but there are some arguments that point to **ISCC** (i. e. the integration with a fossil combined cycle plant) as a suitable solution for the current phase of market introduction. ISCC makes particularly sense in the following context: (i) if the country aims at exporting gas through the combination with clean solar energy (e.g. Algeria); (ii) if the country wants to build fossil plants in areas suitable for solar thermal plants (e.g. Morocco); (iii) if the country can save on old inefficient coal-fired power plants by the combination with solar thermal (e.g. Mexico); (iv) 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 case of Egypt but delays were caused by the contractual separation of the two plants while technically they are combined). Nevertheless, the ISCC choice has introduced a variety of additional problems that have delayed project realisation (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 **trough technology** 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. 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.

(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 2 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, and willing to take on the

whole project, the single EPC approach appears favoured. There is no fundamental reason why the 2 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 very well defined in the specifications, requiring a detailed design and optimization study. In the single EPC, the consortium carries out the optimisation 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.

(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?

If the bidding documents specify a fixed solar field aperture size for the troughs and given that the grant from GEF is also a fixed amount, there is no flexibility should costs come in higher than was originally anticipated when these projects were originally developed. As 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). 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.

(8) How are the opportunities for successive plants ?

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 US$50M projects if the chance of follow-up plants is slim? 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 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, the economic conditions by then will dominate the decisions.

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 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 –. 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 of the order of 10-20 years. Also at this point in time the development in OECD countries still appears fragile. 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. Perhaps the most reasonable chance of subsequent plants is some combination of grants, renewable portfolio standards, renewable feed-in laws, etc in a suitable CSP fund starting in a given region such as the Mediterranean / Middle East region.

(9) What are the chances/risks of each of the four GEF/WB projects to reach realisation ?

Egypt: Issues that need to be resolved before the first project can progress further are (i) that an agreement being reached between NREA and the World Bank with regard to incremental costs not only covering capital costs but also operation and maintenance costs; (ii) 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. Fichtner Solar is currently preparing the two bid documents. Although this approach has many unknowns, it is an occasion to learn on a different institutional arrangement for the contract. To stimulate Egyptian interest in implementing further solar thermal power projects it is recommended that the World Bank seriously consider a role in facilitating: (i) Egypt establish 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; (ii) the 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; (iii) 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; (iv) 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; (v) how best Egypt can secure any benefits from mechanisms such as the Clean Development Mechanism

India: There are 2 prime outstanding issues for India before the project can progress further: (i) a reply from the GoI to the World Bank letter of 2004 stating they are committed to the project proceeding and meeting the requirements stated therein; (ii) a resolution of the balance of funding from KfW, which is the subject of a meeting understood to be planned for May 2005. Without these issues resolved, it is difficult to see the Indian project proceeding further. 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 underway. 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 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.

Mexico: 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 % of its original contribution, should not be grounds 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. 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. High solar shares anyway are not among the advantages of the ISCC concept. ISCCS is a good concept to boost a CC that would anyway be built with a comparatively huge amount of renewable energy (com-

pared to other forms of solar energy usage). In any case it is also recommended that CFE, 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. 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.

Morocco: The Moroccan project appears from the current perspective the most advanced of the four GEF/WB projects. It is therefore a key project in the portfolio and important for the whole GEF programme 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 a particular attention to the Morocco project so that delays are cut down to a minimum and the deadlines as proposed currently, with contract signature by January 2006 are respected.

(10) Which strategy choice should be adopted in case of successful/unsuccessful termination of the current portfolio ?

The report discusses the impact of various options for the future strategy of WB/GEF: "Wait and See" (waiting for cost reductions in developed countries), "2-Track-Approach" (pushing the technology in developing and developed countries in parallel), "Specialisation" on less costly niche developments. These options assume that the current portfolio has some reasonable implementation success (at least 2 projects). The "Wait and See" strategy 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. It is also unlikely that a strategy based on small scale promotion of CSP technology would be able to lower the cost sufficiently fast in order to allow for a stronger penetration of the bulk electricity market. 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. 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 GEF/WB strategy concentrate on regions with best chances to create volume markets ?

The second phase of efforts along the cost reduction curve (creating markets) should concentrate on regions with best chances to create volume markets in the shortest time and should not disperse efforts. Such countries/regions are from the current perspective: (i) the Mediterranean area and the Middle East (precedent of supposed previously successful WB/GEF projects in Egypt and Morocco, supposed success of currently ongoing efforts in Algeria; efforts in Jordan and Iran; CSP developments in Spain, Italy and Israel). If the Mexican project succeeds and other projects, currently underway, continue to go ahead in the South-West of the US, these region has similar good arguments. (ii) China: due to the sheer volume of demand including for renewable energy sources, the exemplary recent approach to create an institutional frame for renewables combined with the nascent efforts to create an 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.

(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 the report.

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 efforts along the CSP cost curve it can be estimated that for the developing countries about 200-300 MW of solar thermal power are to be installed by say 2015. Of this about 90 MW might have been provided in phase 1, the institutional and technical learning phase currently ongoing (at least two WB/GEF projects and Algeria succeeding). The second phase should consist of at the minimum another four projects in the regions discussed above. Out of these projects, each one in the range of 30-50 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 financing but at small amounts 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 200-300 million Euro up to 2015.

(13) Should a future engagement continue to promote ISCC/Solar trough? Should it promote a broader range of technologies, if yes which?

The ISCC 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 the promoted technology options should be wider, in order to spur further competition and to adapt to individual needs/inquiries of the countries of destination (see criteria for technology selection below).

S-Table 4: 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, especially Fresnel collectors because of high local value creation (due to larger share of simple collector components)
Environmental protection	Spain, Italy, US	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, US	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; ISCC 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	ISCC 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

(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?

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 emphasised 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. In the report different mechanisms are discussed to provide such a structure, including support from a renewables scheme in the developing countries themselves (see the case of Algeria) as well as from an appropriate international fund. In this context it should also be discussed to operate future CSP plants under the IPP scheme in sufficiently liberalised markets. The commitment of the plant operator would also be leveraged by the fact that the total plant financing has to provide for. The plant operator would get its electricity remuneration in a strong currency (e.g. US$/MWh), potentially with a GEF implementing agency (e.g. WB) 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.

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

Necessary GEF (and other donor) CSP engagement accounts to US$ 44 million on an annual average for a full support of CSP up to competitiveness (around 2025): Under the assumption that 35 % of the CSP installations by 2025 will be installed and operated in developing countries, the cumulated subsidies would account to 875 million €[2], respectively US$ 1.12 billion[3]. If it is further assumed that 30 % of this amount will be borne by countries like Algeria from own national means, an amount of 610 million €, respectively US$ 786 million has to be financed by international funding. If the GEF is supposed to finance this part, on an average US$ 44 million of annual CSP funding would be necessary. This includes CO_2 emission trade (through CDM). In case the CO_2 emission trade is not taken into account, the necessary annual average CSP-funding accounts to US$ 189 million.

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

In case the required large scale funding exceeds the financial perspectives of the GEF, the following two alternatives are being suggested: (i) The GEF should try to join forces in the field of renewable energy deployment in developing countries in order to establish the above mentioned fund with the participation of different stakeholders. Potential co-funding organisations 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. (ii) In the case of significantly reduced financial means for future CSP projects in combination with the wish of the GEF/WB to support further this important technology, similar technology lines as discussed in (4) should be envisaged.

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2 Under the assumption of a project IRR of 8% without revolving fee of 21 million €.

3 Exchange rate (May 10, 2005) 1€ = 1.2835 US$

S-Table 5: Key success criteria for the World Bank/GEF CSP portfolio (Phases pertain to S-Figure 5).

	Key Success Criteria (KSC)	**Comment**	**Importance**
Phase 1	Response to RfP's	Critical that a good number of bids are received from robust consortia	Crucial
	Contracts signed for at least 2 projects	Having less than 2 projects proceed to contract signature would represent a relative failure of the portfolio. More than 2 would indicate a healthy CSP portfolio and good reasons to continue.	High
	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)
	Reallocation of balance of GEF funds	If 1 or 2 of the 4 projects are not successful (based on missing key deadlines without due cause), and the above 3 KSC's 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 would already have significantly progressed their projects, for e. g. Algeria, Iran, Jordan, China.	Medium
Phase 2	Continuing emergence of CSP projects in other countries	CSP market development is a long term process. It will be of the order of 1 year before construction commences on the first WB/GEF project, a further 2 yrs till operation commences - realistically a minimum of 4 yrs from now till there is a good level of operational data. This affords a good opportunity for the WB to assess CSP progress internationally.	High
	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
	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
	New portfolio of WB projects successfully commenced	If the above KSC's have been satisfactorily met, a new competitive call for proposals should be launched. The timing will be dependent on the above KSC's.	High
	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

	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 mobilisation 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
	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

1 Setting the Context

1.1 Operational Programmes of the Global Environment Facility (GEF)

Mitigating climate change and achieving stabilization of greenhouse gas atmospheric concentrations – 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 will occur.

The Global Environmental Facility (GEF) has operational programmes that promote the deployment of renewable energy, Operational Programme 6 (OP 6), and energy efficiency, Operational Programme 5 (OP 5), by assisting the removal of barriers to the use of energy efficient technologies and commercial or near-commercial renewable energy technologies. The objective of these programmes 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 Programme 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".

A third operational programme, Operational Programme 7 (OP 7), "Reducing the long-term costs of low greenhouse gas-emitting energy technologies" has the objective 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 future. To achieve this objective, the 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 Programmes 5 and 6 the GEF funds the incremental cost of barrier removal, and under Operational Programme 7 it funds the incremental cost of the technology.

1.2 CSP funding within Operational Programme 7

The GEF's Scientific and Technical Advisory Panel (STAP) has a view that OP 7 should be an important element in GEF operations. Two technologies in particular, grid-connected photovoltaics and solar thermal technologies, are viewed as likely to have comparative cost advantages because of high solar insolations in developing countries.

Solar thermal technology has been demonstrated, for example in California in the USA, over the past 15-20 years. However, the integration of solar thermal technology with a combined cycle gas turbine (CCGT) – the preferred choice for a hybrid system in the World Bank/GEF solar thermal portfolio – has not been demonstrated. Such integration is commercially important as it enables continuous operation of the hybrid integrated solar combined cycle (ISCC) system regardless of solar radiation conditions. In difference to solar-only op-

tions this occurs in the ISCC concept, in principle, at lower costs while providing at the same time higher capacities, which makes the concept more acceptable in developing countries.

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 of converting solar radiation into electricity, and it had been operationally proven in California since the mid-1980s. However, no follow-up investments were made when California terminated a favourable 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 US and considerable efforts to revive the technology from the side of the solar industrial actors.

The Mathania Solar Thermal Power Plant in India was the first to enter the GEF Operational Programme 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 commercialisation 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 being under development in Mexico and Morocco with a fourth project being from Egypt. Presently, the World Bank-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 World Bank-GEF commitment of around US$ 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-funded project preparations exist in Brazil and South Africa. South Africa's utility ESKOM 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), the achievements limited and 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 a "Thematic Review" 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[4] for these CSP plants of additional funding sources from within the country.

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

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

- *Project preparation:* Initially the four projects were prepared as Independent Power Project (IPP's) but have been 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 coupled with 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 GEF/WB projects the solar contribution of the integrated solar combined cycle technology is in the 5 % 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 towards 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.

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

Further lessons that have been learnt have been put forward by Cédric Philibert (2004) of the International Energy Agency and are listed as follows (the lessons are self explanatory):

- *Lesson 1:* International collaboration may help, but domestic policy decisions remain decisive.
- *Lesson 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 are very likely to face even further challenges, challenges due to a lack of appropriate policy, legislation, institutional structures, human resources, (venture) capital resources, industrial partners willing to consider new technologies etc. 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 some basic definitions related to technology transfer is given in the following box).

What is technology transfer?

The term "technology transfer" tends to mean different things to different entities, generally giving flexibility to individuals and organisations 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 embodi ment 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 World Bank/GEF can be viewed as a facilitator in the transfer of technology.

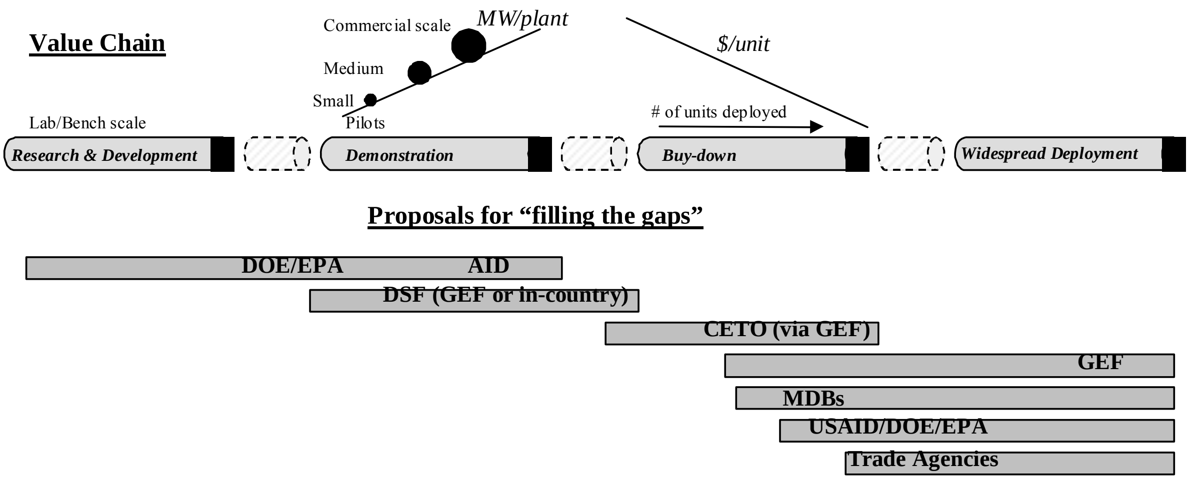
The United Nations Environmental Programme’s (UNEP) Intergovernmental Panel on Climate Change (IPCC, 2000) defines the term "technology transfer" as a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders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

cate 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 USA's President's Committee of Advisors on Science and Technology (PCAST, 2003) investigated the processes associated with the transfer of technologies and based on their investigations a diagram describing this process of technology transfer via a value chain has been developed. PCAST's technology transfer, via a value chain process, is depicted in the Figure 1 below.

Figure 1: "Gap" identification in technology transfer



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 should be noted is the role that GEF can potentially play in technology transfer.

1.4 Aims of the Study

Within the background as described in the sections 1.1 to 1.3, 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).
- *Task 2 - Risk Assessment and Mitigation:* Assessment of risks and the adequacy of risk mitigation measures provided in project design in the Bank/GEF portfolio. This assessment included technological performance risk, financial/commercial risks, regulatory/institutional risks, strategy risks (Results described in Chapter 3).
- *Task 3 - Market Development Strategy:* Following on Tasks 1 and 2, the report considers the chances of realisation and the bottlenecks of each of the four projects in the GEF/WB portfolio (Results described in Chapter 4 and Annex 4). Chapter 5 discusses the importance of the GEF/WB portfolio in the future development of CSP technology and strategies beyond the current portfolio: projected market impacts of partial or full implementation of the current portfolio, extent to which the Bank/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 Bank/GEF portfolio etc.

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 GEF/WB CSP projects, financing institutions, industry (combined Cycle & Solar Field) and consultants. A list of interviewed organisations/persons is given in Annex 5.

2 Concentrating Solar Thermal Power (CSP) Development

The main purpose of this chapter is to present on one hand the ongoing CSP developments worldwide (chapter 2.1), and on the other hand technological paths of Concentrating Solar Thermal Power Plants (chapter 2.2) as well as projected cost reductions for CSP technology due to recent technology improvements, scale effects (larger plant size) as well as volume effects (accumulated capacity) (chapter 2.3). This provides the necessary background for the evaluation of the GEF/WB CSP portfolio and the future development of CSP.

2.1 Ongoing CSP market development worldwide

The SEGS plants of Southern California are well-known for their many successes, not the least of which was their ability to be constructed in short periods of time meeting the constraints associated with the 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 able to be 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 US$ 1.2 billion, all private capital. More than 13 TWh of solar electricity has been produced from these plants by 2005, with electricity sales of over US$ 2 billion. These projects were successful as a result of favourable FERC (Federal Energy Regulatory Commission) regulation, 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 favourable conditions in the early 1990's left no incentives in either the OECD or developing countries. A shortcoming of that period is that no legacy of 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 the 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 was something like 2-3 times more CSP researchers than industry personnel. This string

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 other progress that has been made is the industry's much better understanding of real-world project finance, and other project factors such as regulatory regimes, permitting requirements, performance warranties, risk factors, liabilities and tender documentation.

There are today significant bankable projects emerging around the world. A list of these and their status is provided in Table 1.

Table 1: Overview and status of CSP projects world-wide (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	Full commissioned and operating
Algeria 25 MW trough, ISCCS	✓	✓	This year	Original expectation Sep 2005	
Arizona 1 MW trough ORC	✓	✓	✓	✓	
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 120kW tower providing solar-reformed natural gas to a heat engine	✓	✓	✓	✓	Early 2006
Italy/ Empoli (2x 80 kW solar gas turbine with waste-heat usage for air-conditioning)	✓	✓	✓	✓	
India/ Solar Heat and Power Pty Ltd, 5 MW, Fresnel	✓	✓			
Iran 67 MW trough, ISCCS	✓				
Israel 100 MW trough	✓	✓			
Jordan 135 MW trough	✓	✓ (RfP 2001)			
Nevada 50 MW trough	✓	✓	Next two months	Aug/Sep 05	Estimate 2007

(Table 1 continued)

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	Full commissioned and operating
Portugal/ Solar Heat and Power Pty Ltd, 5 MW with potential to upgrade to 50 MW, linear Fresnel	✓	✓	Financial close shortly		
Spain/ ACS + SMAG, Andasol 1 50 MW trough	✓	✓	Next few months	Late 2005	Around late 2007
Spain/ ACS + SMAG, Andasol 2x50 MW trough	✓	✓	This year		
Spain/ Abengoa, PS10 11 MW tower (sat steam)	✓	✓	✓	✓	Estimated 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	✓				

The following plots can be established from Table 1. The projects considered "possible to firm" are those projects above 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 programme presently in place that aims to progress CSP technology is the Global Market Initiative GMI (see chapter 6.3).

Figure 2: Short-term and possible medium to long-term development of CSP technology world-wide (yearly installed MW_e)

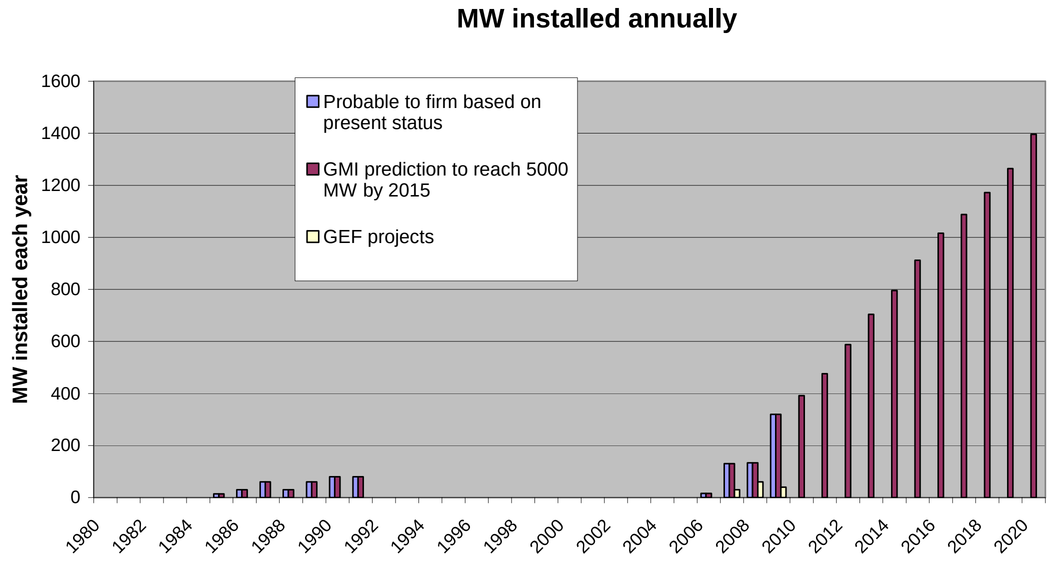
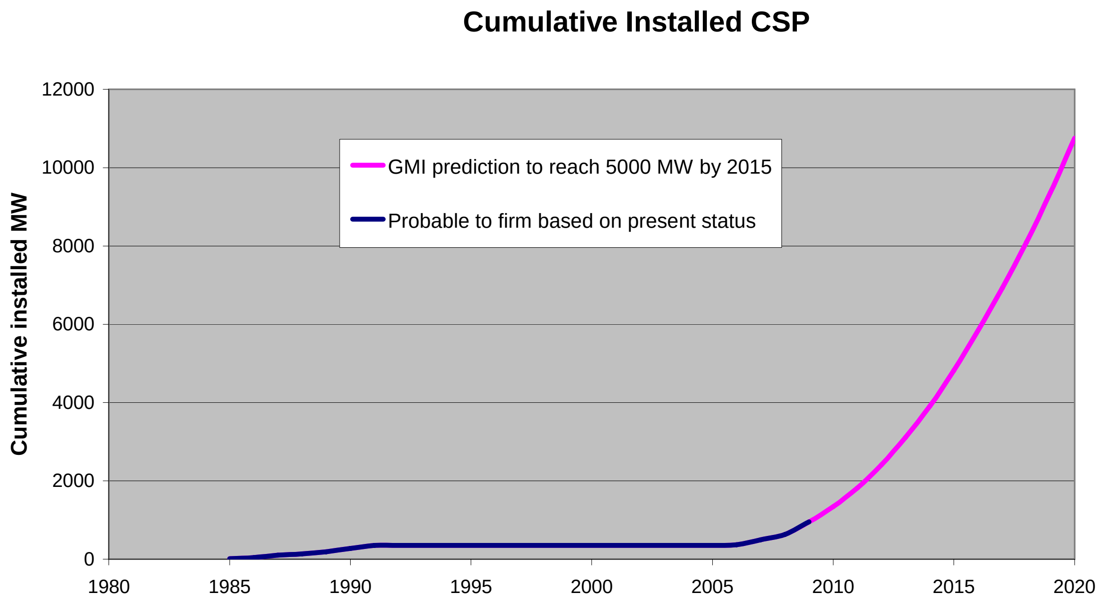


Figure 3: Short-term and possible medium to long-term development of CSP technology world-wide (cumulative installed MW_e)



The objective of the GMI is to facilitate and expedite the building of 5,000 MW_e of CSP worldwide over the next ten 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.

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 Euro/kWh, which roughly equates to a total price of 0.21 Euro/kWh
- Bankable with 25 year guarantee
- Annual adaptation to electricity price escalation
- 12-15 % 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 % (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 %, 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 US, the DoE has a goal to deploy significant CSP plants in the South West of the country. This is known as the 1000 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 50 MW Nevada plant and the 1 MW Arizona ORC are already under development.

The main conclusion from this project activity is that the GEF/WB 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 programmes 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). An overview of the solar collector technologies is given in Annex 2.

In this chapter 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 which describe and evaluate the technical improvements of collector concepts and components, including Sargent & Lundy (2003), DLR et al. (ECOSTAR-study, 2005), and Kearney and Price (Recent Advances in Parabolic Trough Solar Power Plant Technology, Chapter 6 of book yet to be published).

These studies have examined the cost reduction potential for solar thermal power plants which 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 the R&D-efforts in the European countries, the perspective of the Sargent&Lundy-study has (technologically) a rather US-American perspective and has the purpose to predict future cost reduction of solar thermal power technology based on an engineering approach (as opposed to learning curve approaches see chapter 2.3). Kearney and Price have conducted a more detailed and specific analysis of the particular components contributing to a solar field.

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

The ECOSTAR-study analyses Trough, Tower, Fresnel and Dish technologies in different configurations. The objective of the ECOSTAR-study is not to compare different technologies. It says that market forces will decide if one technology will rule out other technologies. All examined technologies show the cost reduction potential down to competitiveness. 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.

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

Parabolic Trough[5]	Tower	Linear Fresnel[6]	Dish[7]
Innovative structures (up to 28 %)	Larger heliostats above 200 m^2 (up to 12 %)	Linear Fresnel collector field (up to 3 %)	Mass production for 50 MW (38%)
Front surface mirrors (up to 19 %)	Larger module size (up to 15 %)	Thermal Storage (up to 15 %)	Brayton instead of Stirling cycle (up to 12 %)
Advanced Storage (up to 18 %)	Ganged heliostats (up to 8 %)	Reduced pressure losses (up to 7 %)	Improve availability and O&M (up to 11 %)
Reduced pressure losses (up to 16 %)	Advanced storage (up to 10 %)	Dust Repellent mirrors (up to 7 %)	Increased unit size (up to 9 %)
Dust repellent mirrors (up to 16 %)		Increased Fluid Tempera-ture (up to 6 %)	Reduced engine costs (up to 6 %)
Increased solar field outlet temperature (up to 15 %)			Increased engine efficiency (up to 6 %)

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

Parabolic Trough[8]	Tower[9]
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)	Reduce start-up time and improve operation strategies
Self-cleaning glass	Improve heat transfer fluid and storage
Larger plant sizes	Larger plant sizes
Reduced Operation and Maintenance Costs	Reduced Operation and Maintenance Costs

5 with Thermal Oil as heat transfer fluid and Direct Steam Generation (DSG)

6 reference: Trough with DSG

7 parabolic Dish concentrators in combination with a Stirling engine today realize the highest LEC compared to the other collector concepts.

8 with Thermal Oil as heat transfer fluid. No Direct Steam Generation (DSG) considered

9 only molten salt technology considered.

The Sargent&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&Lundy are given in Table 3.

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 it has to be criticized that e.g. 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 e.g. 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 technological paths on long term it is not clear which technologies will be accepted by the market, e.g. if the investors will progressively implement technical innovations or be more prudent and use proven technology. In chapter 2.3 the CSP cost reduction potential will be analyzed applying the learning curve concept.

2.2.2 Power Cycle integration concepts

The heat produced in the solar absorbers is subsequently used for electric power generation. In the following paragraph, different concepts for the integration of solar collectors into conventional power cycles are being presented. On the technical side, the difference among these concepts is the collector usage within the thermodynamic cycle and the degree of hybridization with fossil power generation, i.e. the solar share. From a strategic point of view, each concept is suitable in order to pursue different goals, e.g. 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)

The solar field is providing superheated steam for the use in a Rankine plant. These plants can be operated in hybrid operation 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 varies in a wide range. Typical system configurations are the one of the SEGS plants in California with 25 % fossil share. Coupling a solar field with a conventional power plant (e.g. hard-coal) can lead to high 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, however without a fossil steam generator. Preferably, such plants are equipped

with heat storage of several hours in order to increase the amount of full load hours of the plant. Storage does not only lead to lower electricity generation costs but will also lead to a greater availability for the sake of the grid-operator. Although this concept is ecologically the most desirable plant configuration, today it has the highest LEC and is therefore rather considered to be a long-term option.

Solar Gas turbine combined cycle (Option 3)

Due to the high concentration factors, solar towers can produce very high temperatures up to above 1000°C to be used directly in gas turbines in addition or as a substitute to the gas burning chamber. This offers the possibility of a solar-driven combined-cycle with the related very high efficiencies. In Italy, currently the first solar tower feeding directly a gas turbine is being constructed by an Italian-German consortium. The plant consists of two towers each having a gas turbine of 80 kWe. The waste heat is used to provide air. The project has rather R&D character, however is used to provide a hospital in Empoli with electricity and cooling applications. In the long run this technology has very promising prospects because of the high efficiencies and the related savings in solar field invest.

Combined Heat and Power solar plant (Option 4)

In this option a 5-100 MW_e solar plant is combined with a subsequent heat-driven process, e. g. sea water desalination or air-conditioning. The possibility of co-firing is also given. Due to the double use of the solar heat for power and heat generation, efficiencies of up to 80 % can be achieved. Generally, it has to be stated that any kind of thermal power plant (also CC, ISCC or fossil steam plants) can in general be designed in a way 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 sunny developing countries are increasingly suffering from.

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 ISCC plant is provided by two heat sources: the heat recovery steam generator using the exhaust gas of the gas turbine and the solar field. Therefore the size of the steam turbine in an ISCCS is larger than it would be in classical combined cycle.

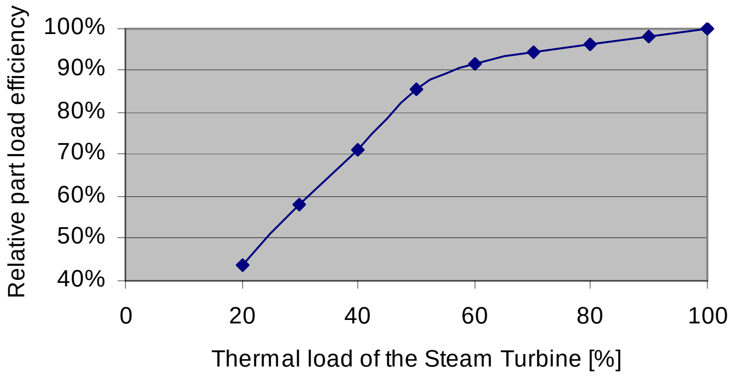
The three main advantages of this concept are:

- 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 with no solar energy input (see Figure 4). Therefore the interdependencies of steam turbine oversizing, steam turbine part-load behaviour, solar field size, solar irradiance, plant site, plant operation mode and possibly solar heat storage or duct burner have to be considered carefully in a project-specific overall-system-analysis, in order to assure that the solar field will provide its desired economic and ecological impact.

Figure 4: Example of part load behaviour of a steam turbine



Source: E.ON Engineering

Solar Feed Water Preheating (Option 6)

Solar thermal heat is being used for preheating feed-water in large-scale conventional Rankine plants and thus, substituting bled steam from the turbine. Thereby additional electricity can be generated or fossil fuel can be saved, depending on the chosen operation mode. This concept is very well suited for market introduction of new collector types, since it reduces the risk due to low investment (approximately US\$ 10 million for a 5-10 MW_e solar field). Further advantages are the possibility of using existing plant infrastructure and good solar heat converting efficiencies (solar irradiation → net solar electricity) (Morin et al., 2004). The drawbacks are its small solar share (around 1 %) 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 possibility to lower this hurdle, since the initial investment will decrease by a factor of 10-100. Typical process heat applications are in the range of 200-1000 kW_{th} 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 towards large-scale solar thermal power applications. This concept might become attractive to GEF and WB in case the future CSP funding sources will significantly decrease. By promoting such projects, GEF/WB could spur the competition in the CSP sector, because under current conditions (e. g. in Spain) it is very difficult for new players to enter the CSP market.

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

2.2.3 ISCC – evaluation of performance, cost and CO_2-benefits

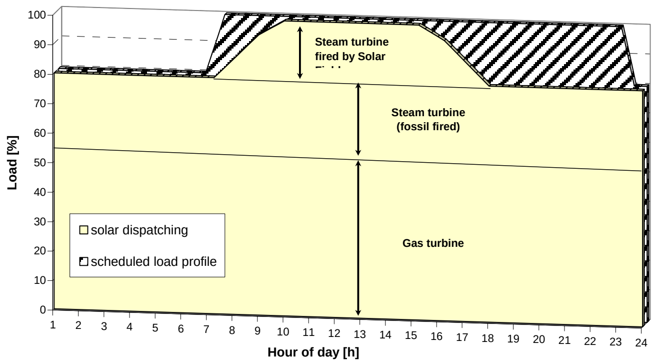
In 2002, the International Energy Agency's SolarPACES implementing agreement carried out a study (Dersch et al.) on thermodynamic modelling of ISCC plants in comparison with Combined Cycle as well as SEGS-type (hybrid) plants in order to evaluate the performance, cost and CO_2 effects of the ISCCS concept. Its main results will be presented here.

Assumptions

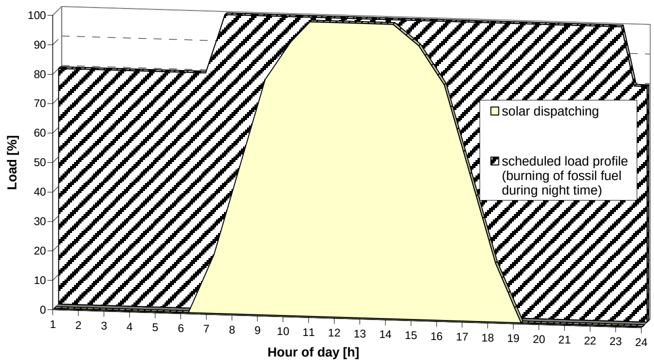
A base solar field size corresponding to a 50 MW SEGS plant in Barstow, California, was used for the calculations (270,000 m^2). The load curves of all plants were assumed to be identical in the first scenario. The second scenario considered solar dispatching load, see Figure 5. All three investigated plant concepts are sized in a way that the annual electricity output will be the same for the scheduled operation. As a consequence, the dimensioning of the gas and steam turbines are different for the pure CC and the ISCC 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: 2023 kWh/(m^2a)) and the Californian site Barstow (DNI: 2717 kWh/(m^2a).

Figure 5: Load curves used for the annual performance calculation[10]

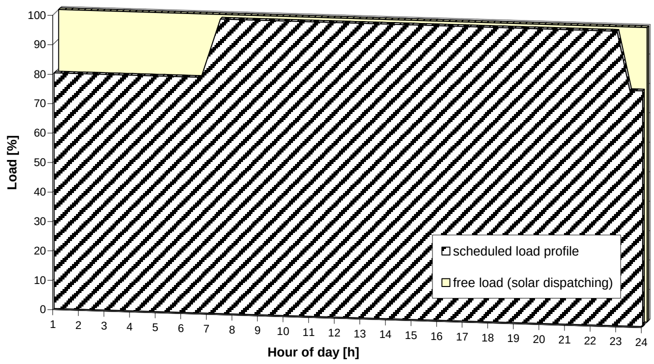
ISCCS



SEGS



CC



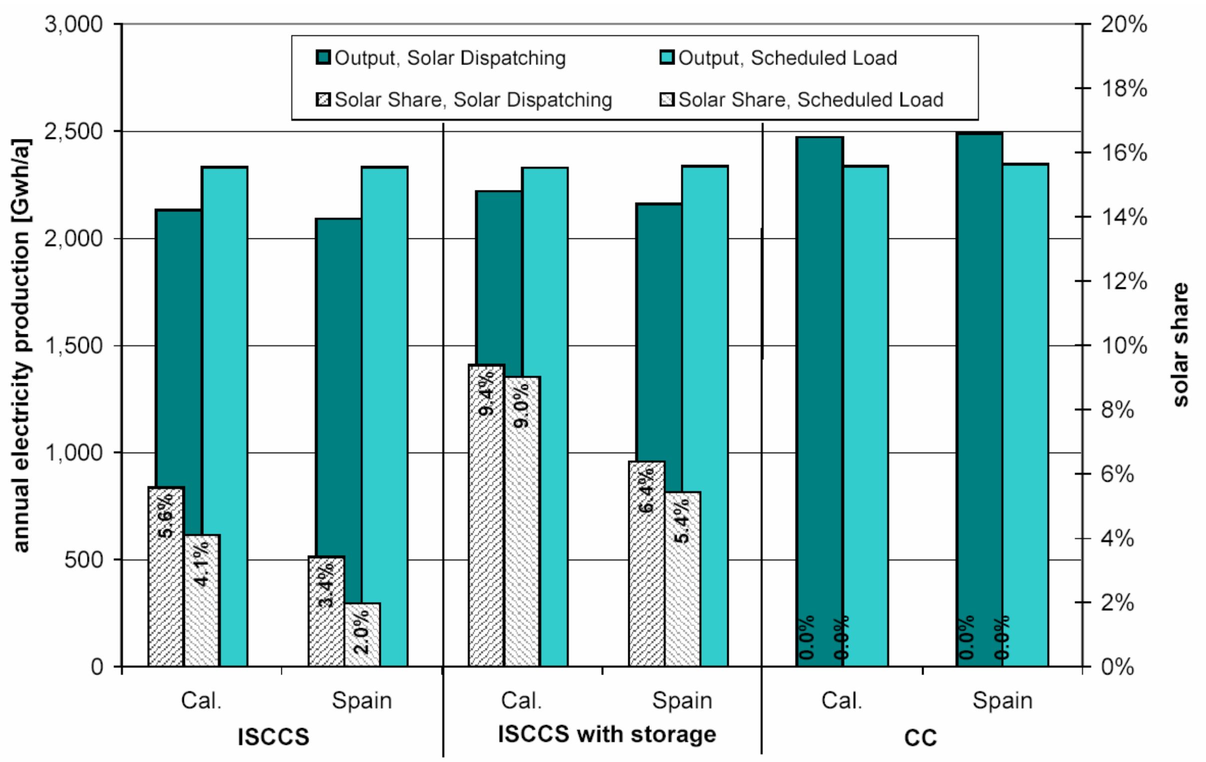
Source: Dersch et al. (2002)

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

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 %.

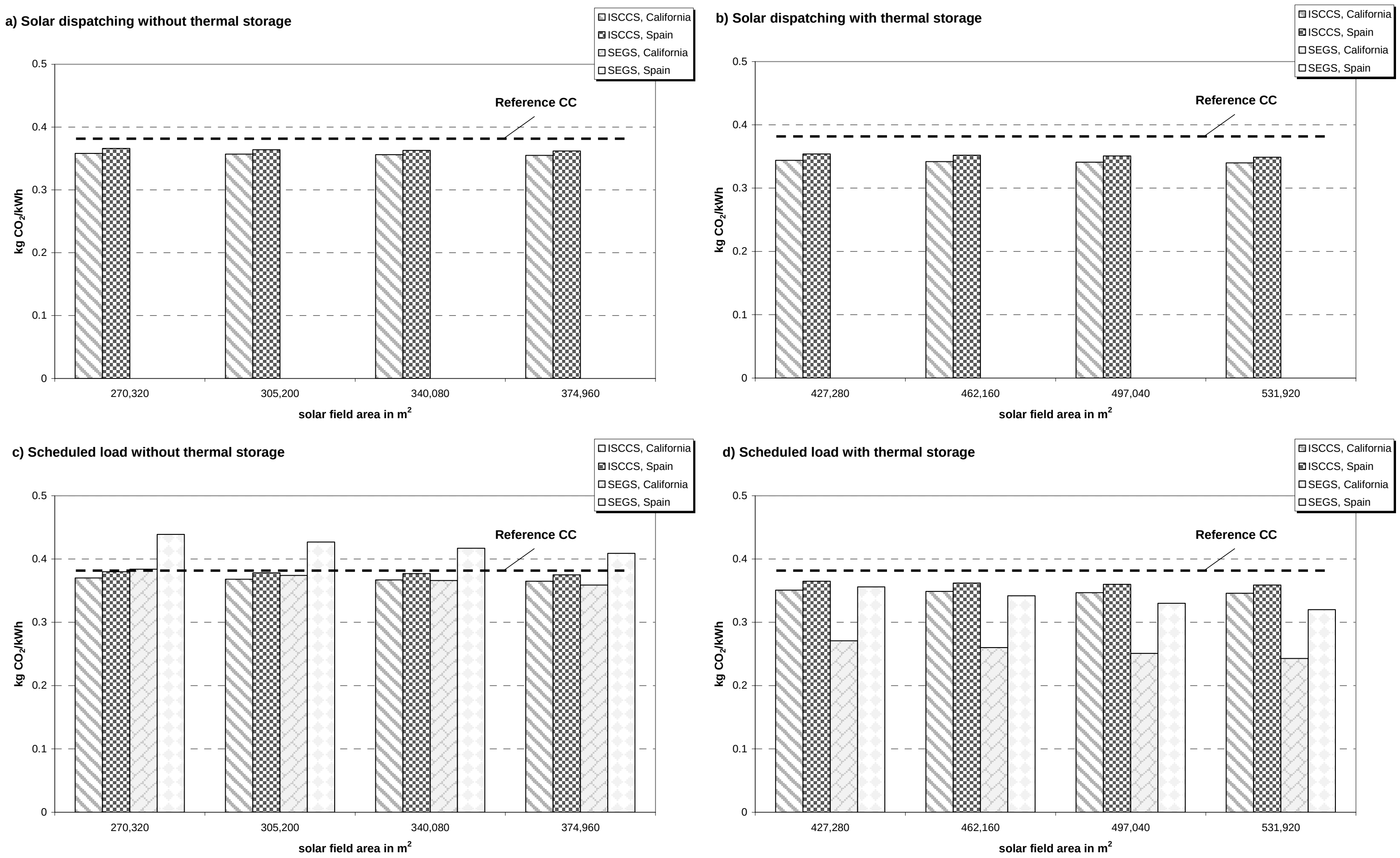
Figure 6: Results of annual performance calculation for ISCC and CC



Source: Dersch et al. (2002)

In Figure 7 the CO_2-emissions of all analyzed plant concepts are given. All analyzed ISCC concepts (regardless of sites, storage, duct burning, load scheduling) show lower CO_2 emissions than the reference CC plant. However, the CO_2 emission difference of an ISCC 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 side restrictions, especially concerning the plant site. If, under real conditions, the plant location of a CC plant would be changed in favor of the solar field (e.g. solar irradiance, space for solar field), different ambient conditions will have a considerable impact on the total plant performance.

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



Source: Dersch et al. (2002)

Especially lower ambient humidity and higher ambient temperature and a less favorable dry cooling concept (instead of wet cooling) lead to a decrease of the total plant efficiency in a way that the beneficial solar impact can easily be overcompensated by the worse total plant site conditions with the consequence of even higher CO_2-emissions of an ISCC plant compared to 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.

The SEGS show under load schedule mode relatively high CO_2 emissions because the gas – in this case being the main primary energy source – is being fired in a low-efficiency steam cycle. In this context it has to be stated that the assumed operation modes were chosen to allow comparison under equal side restrictions (especially load management). However, a SEGS plant with gas co-firing would under real conditions not be used for 24 hour-operation. Mid-load-operation or solar dispatching mode would considerably improve the CO_2.balance of the SEGS concept. When being operated in solar dispatching mode, the SEGS plants show zero CO_2-emission.

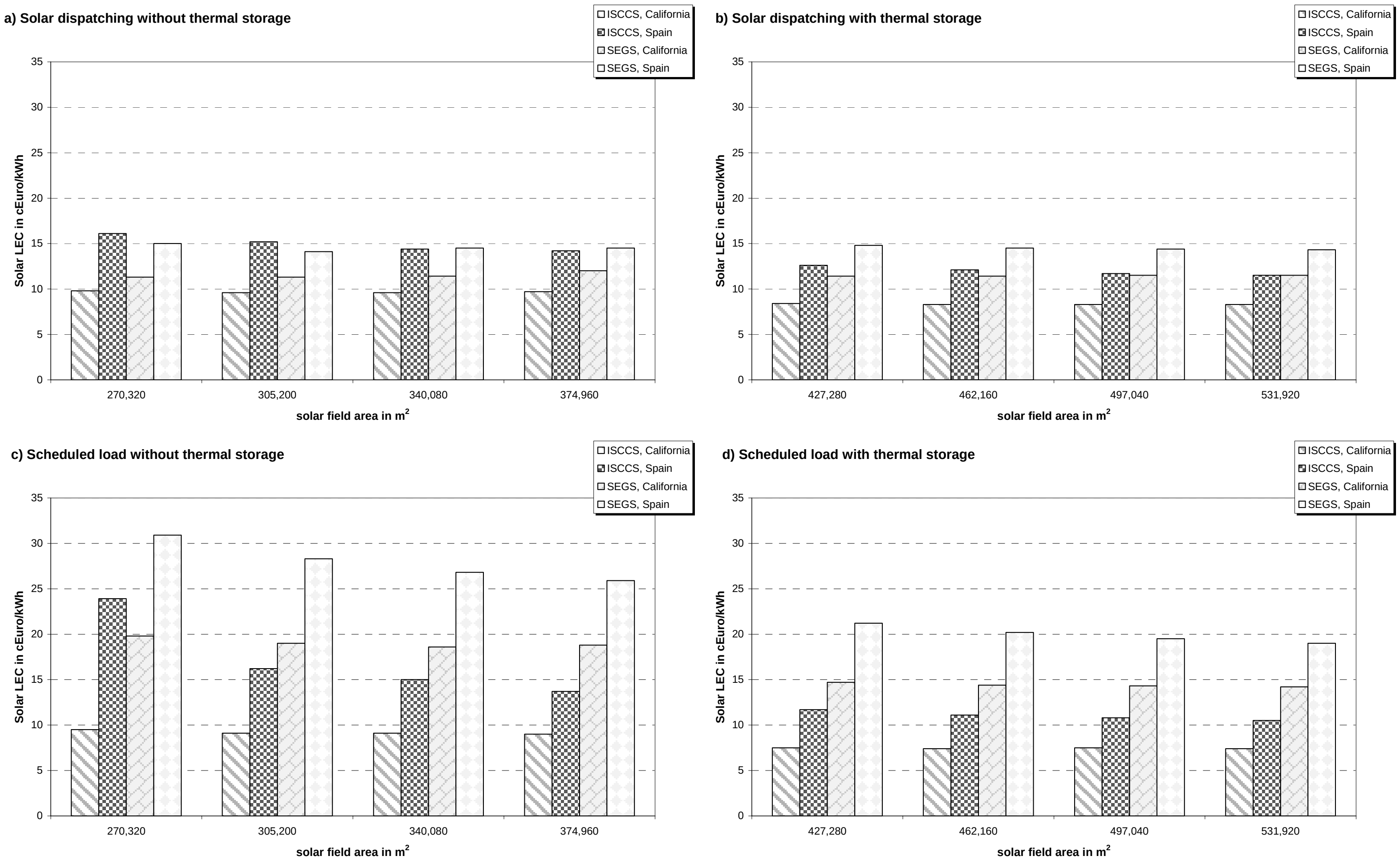
Concerning the levelised electricity cost for the solar share, in most cases, the ISCC configurations showed lower LEC than the SEGS plants (under comparable economic side restrictions[11], see Figure 8). The reason for this is that the incremental cost of a larger steam turbine is much lower than building a stand-alone power block for a SEGS plant.

2.2.4 Summary – technological paths

The purpose of the description of collector innovations (chapter 2.2.1) is rather to give an insight into the technological developments and to provide a technological back-up to cost reduction forecasts which contribute significantly to future cost reduction. According to Sargent&Lundy (2003) 54 % of the future CSP cost reduction is attributable to technological innovations whereas the remaining part is attributable to plant scale-up and increasing production volume. The purpose of this chapter is not to show some technologies or development paths being superior to others. The market should play the decisive role on technology success.

[11] Constant real discount rate: 6.5 %, plant lifetime: 25 years, fuel price 1.26 US$c/kWh, annual fuel price escala-tion: 2 %, annual inflation 2.5 %, SF + heat exchanger 220 US$/m2, CC specific investment cost: 550 US$/kW, additional power block costs due to SF: 600 US$/kW

Figure 8: Solar LEC for different sizes, plant configurations, operation modes and solar field areas



Source: Dersch et al. (2002)

Looking at the potential of the different power cycle integration concepts (chapters 2.2.2, 2.2.3), in the mid to long term, higher solar shares must be 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.

On a long 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 on GHG emission reduction. In this context one has also to look at the solar capacities and MWh, reaching very high values in comparison with other renewable energy technologies. On the other hand ISCC and solar feed-water preheating are very well suited for market introduction of new solar collectors because the (supplementary) investment for the conventional plant components is relatively low (or zero). On the other hand, strong synergies concerning the plant infrastructure and project implementation costs are given. Especially for developing countries needing primarily electricity (not necessarily green electricity), the combination of solar energy together with a large scale fossil power plant is much more attractive than stand-alone solar plants. The GEF funding will also be more effectively used in hybrid (ISCC) than in SEGS plants against the background that a lower amount of solar electricity would be generated if plants with considerably higher solar shares were pursued, because the power block investment and the project implementation costs for a separate solar plant would be considerably higher.

Especially ISCC is a good technology to create experience for the CSP technology under the same operating conditions as in Solar-Only-Plants, being the only long-term perspective for solar thermal power generation.

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

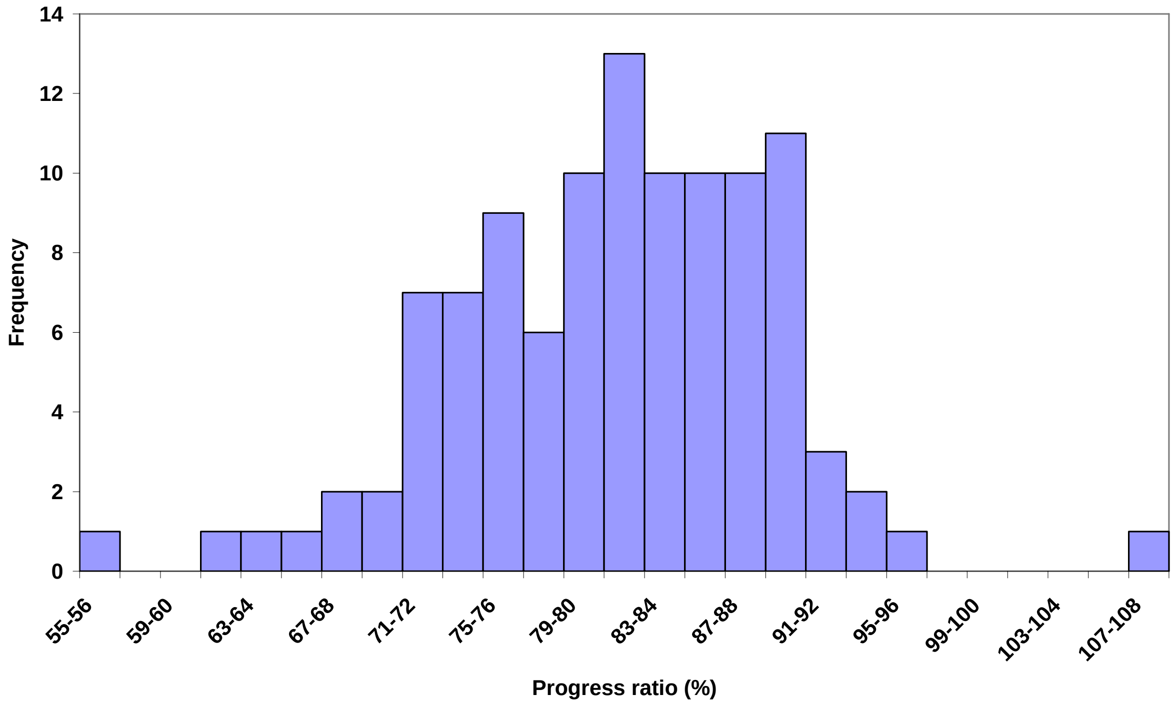
Whereas in chapter 2.2.1 the studies using engineering approaches were discussed, this chapter evaluates the studies applying the learning curve concept.

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 20-30 %).

The progress ratio[12] of a big variety of products from the sectors Electronics, Mechanical Engineering, Paper, Steel, Aviation and Automotive was analysed in a study of IEA (2000):

[12] the progress ratio r is being defined as the complementary to the learning factor l, that is: r=100 %-l

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



Source: IEA (2000)

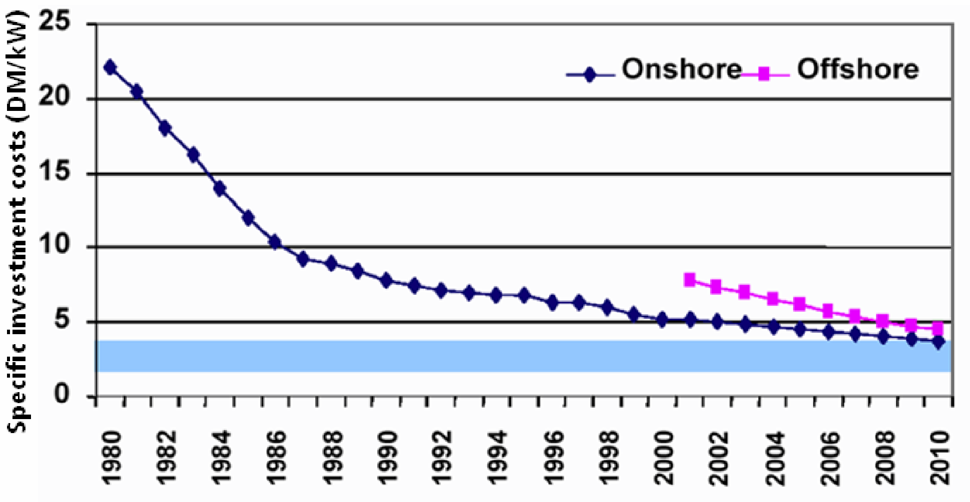
2.3.1 Cost reduction and growth rates of other renewable energy technologies

In order to narrow down the perspective from general technology cost reduction to renewable energy technologies wind energy and photovoltaics are analysed with respect to two main implicit assumptions of learning curves:

1. the specific cost reduction and
2. the market development of these.

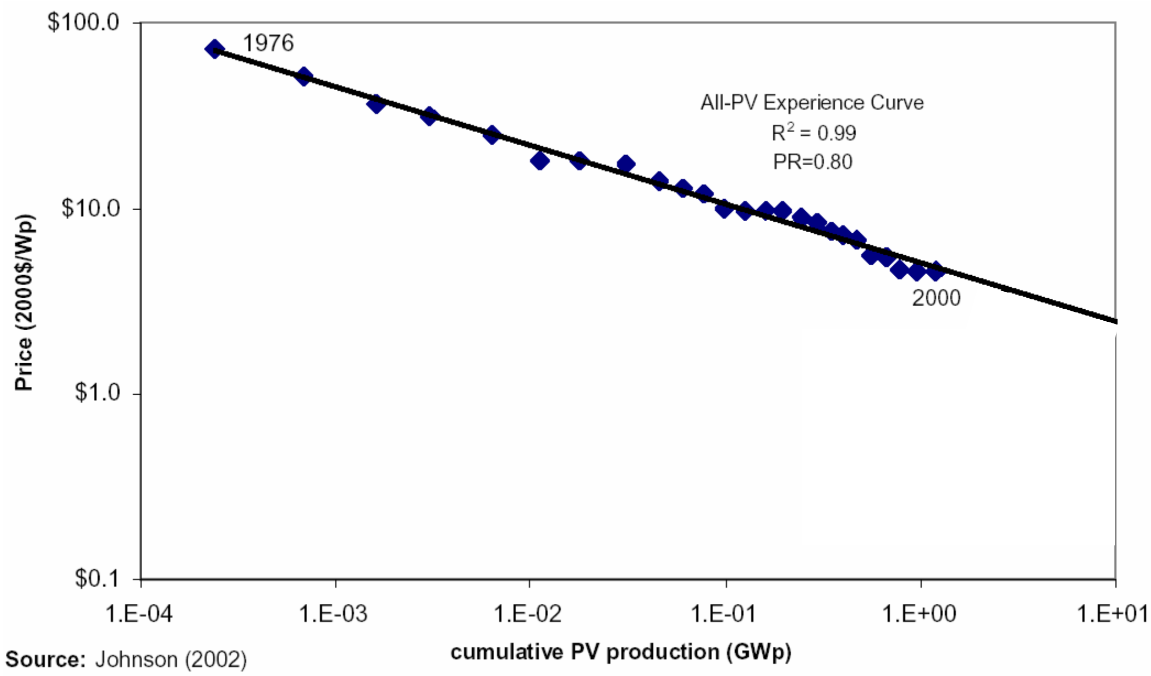
In the next two graphs show the experienced specific cost reduction for wind energy converters and photovoltaics.

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



Source: Ragwitz (2005)

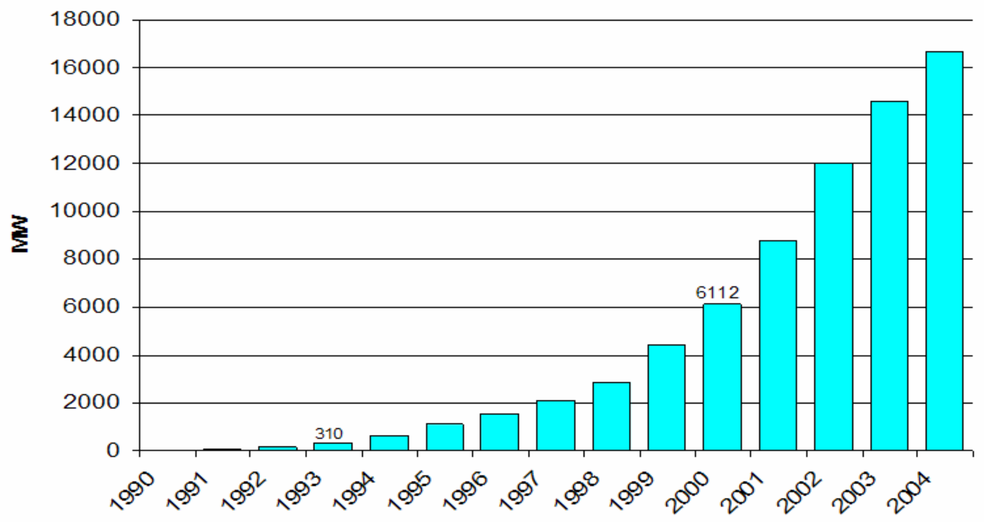
Figure 11: Specific investment costs of photovoltaics as a function of cumulated production volume



Source: Duke (2002)

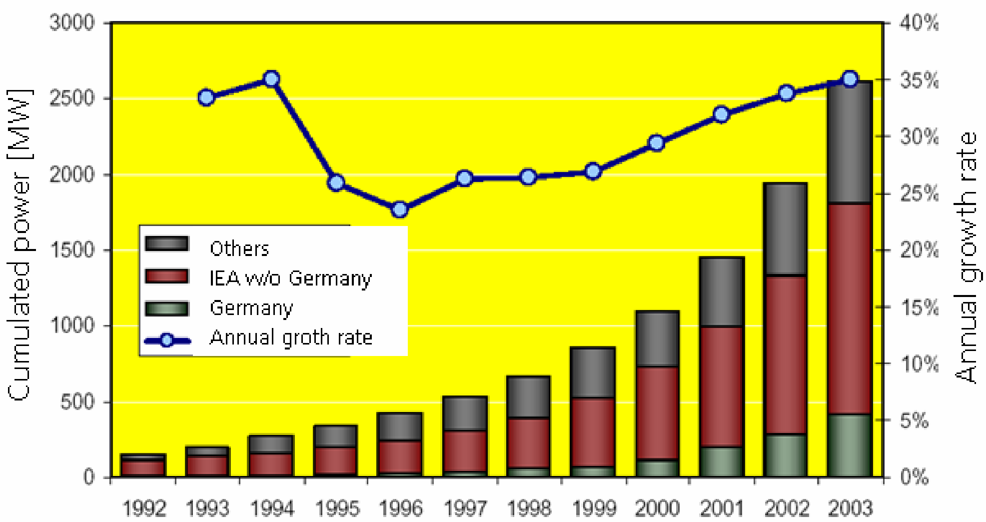
The next two graphs show the experienced market growth for wind energy converters and photovoltaics:

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)

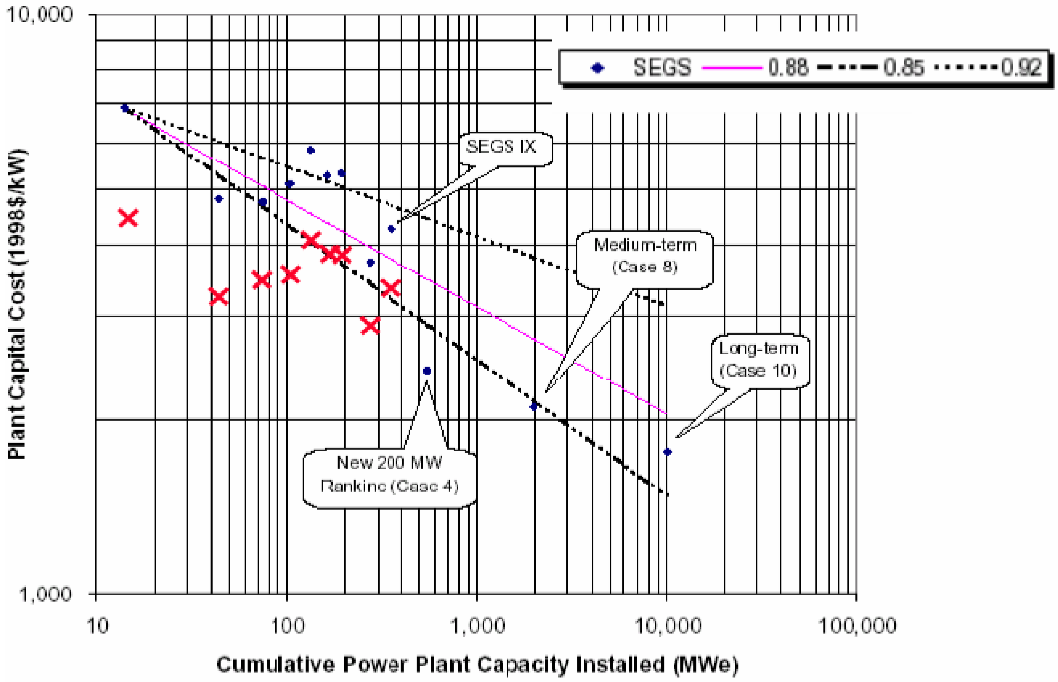
2.3.2 Experience curve concept applied to Solar Thermal Power Generation

Out 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.

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

As often used for the comparison of energy technologies, the Enermodal-study uses the specific investment costs per installed capacity (US$/kW) as a reference measure. This reference number does not seem appropriate to forecast cost reduction for solar thermal power plants because greater solar fields in combination with heat storage will lead to better levelised electricity costs due to more full-load hours of the plant. However the specific investment costs will increase by these measures. The second criticism 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 criticism 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 Pilkington-study (1996). Because of the severity of these criticisms, the cost reduction forecasts of the Enermodal-study were not further considered.

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 9 Californian SEGS-plants)



DLR (2004): Scenario-model "Athene"

As starting point this study uses the experimental values of 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 4 categories:

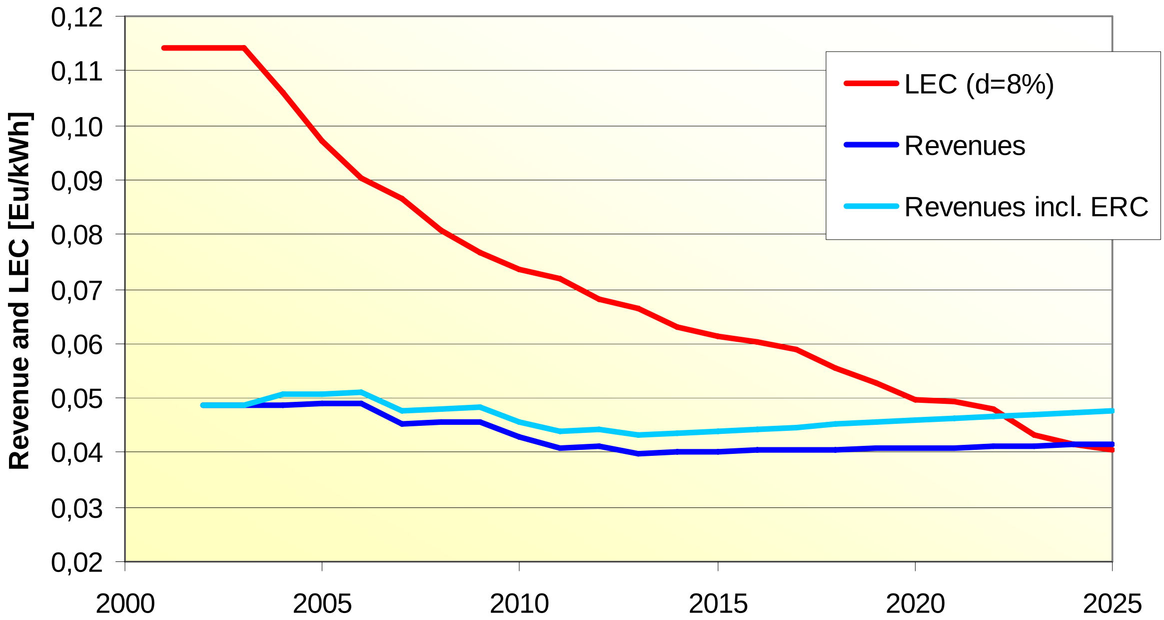
- Improving efficiency (from 13.2 % today to 17.0 % in 2025)
- Learning effects due to volume production
  - collector costs, surface-specific progress ration (PR) is 0.9
  - thermal energy storage (up to 12 hrs), capacity-specific PR=0.88
  - steam cycle components from 850 €/kW down to today's conventional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

Further assumptions of this model are:

- No CO_2-allowances considered, respectively carbon price increasing from initially 7.5 Euro/t CO_2 to 30 Euro/t CO_2 in 2050
- Plant life time: 25 years
- Internal plant project interest rate: 8 % (in real terms)
- Solar Resource DNI=2350 kWh/(m^2a) (favourable sites for solar thermal power generation range between 1800 and 2900 kWh/(m^2a).
- Market growth of 23 % p.a. (IEA references: wind (1971-2000) 52 % p.a., PV 32 %), (implementation of 5000 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 % 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:

Figure 15: Development of levelised electricity costs and revenues from the power exchange market referred to by LEC of fossil power plants (plant project interest rate 8 %), the bright blue line includes Emission Reduction Credits (ERC) of initially 7.5 Euro/t CO_2 increasing to 30 Euro/t CO_2 in 2050



Source: DLR (2004)

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

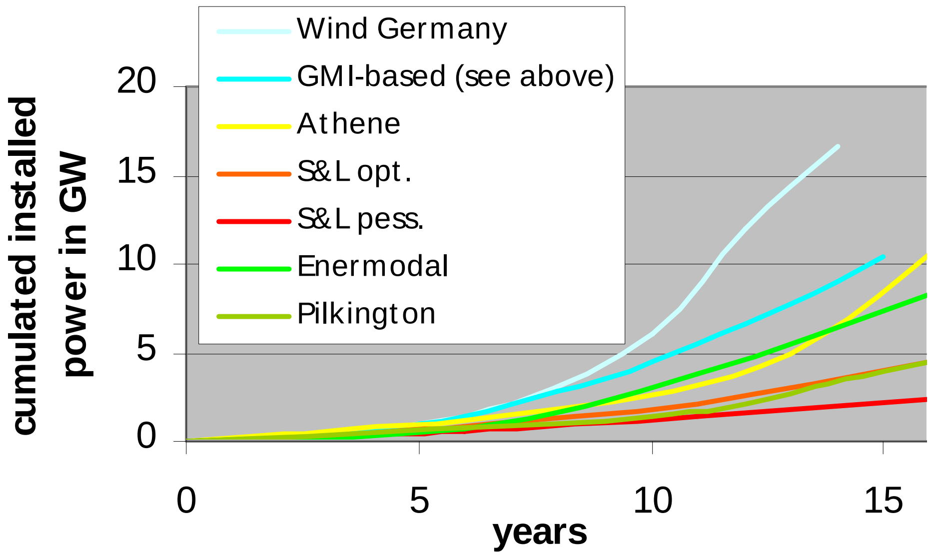
The implicit assumption is that the number of full load hours is constantly increased due to bigger thermal energy storages (see also the "steps" in fossil reference price) up to 6500 hrs/a (12 hrs thermal storage). However from a business perspective it might be economically optimal to produce only peaking to mid-load-power while the power tariffs on the electricity market are highest (smaller energy storage), which in turn will justify higher solar LEC to be competitive.

The scenario-model Athene is a very thorough assessment using many validation points from experienced facts and developments. The used assumptions are conservative, though. In this context the Athene scenario may be considered as a very conservative if not worst case scenario for CSP cost and market development.

2.3.3 Cost Reduction – Summary

All quoted studies including the GMI-based market development in chapter 2.1 assumed a conservative global CSP market development compared to the past technology deployment of wind energy in one single county (Germany).[13] It has to be stated as well that many of the countries in the world's sunbelts lack the financial resources to finance presently still relatively expensive solar energy. But with the present CSP market movements in Spain and the USA strong technology growth similar to wind energy seems feasible.[14]

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 (cost competitiveness after cumulative installed power of 5 GW in 10 years).



Main messages from the comparison of cost projection studies are:

- ➢ The technology has the potential to be cost competitive within 10-25 years and will then be one major electrical power option for developing countries, which often are located in the sunniest parts of the world. Due to the possibility of hybridisation

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13 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.

14 In this context it has to be mentioned that the global wind market corresponds to approximately 3 times the German installations.

and thermal energy storage solar thermal power is dispatchable power that helps to support grid stability, as opposed to many other renewable energy sources.

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

  It is clear that the four GEF projects will significantly contribute to OP7's goal of "Reducing the long-term costs of low greenhouse gas-emitting energy technologies". However, it became clear too that the current portfolio will by far not be sufficient to reduce the CSP costs down to a competitive level. It is difficult to quantify the cost reduction effect of the four projects: In the beginning of the portfolio's history it seemed to be clear that it would be one of the GEF plants to be the first one's to be built after the Californian SEGS plants. However today, with other commercial CSP activities evolving, other projects are already being built before. Therefore the question is, which extract four sections of the cost reduction curve will be borne by the GEF projects. According to the theory, the cost reduction effect will be largest for the first plants, that will be built. In practice, the first noticeable cost reduction effect will be the one of the added risk premium for the first offer.

  Cheap technology is one goal, climate protection is another goal officially supported by many developing countries with good solar resource. In order to meet these goals, GEF and the World Bank have to support the implementation of climate protecting renewable energy in developing countries now. Whereas the OECD-countries can afford subsidizing power technologies on a large scale, developing countries usually are not willing or able to do so. By the implementation of the first CSP pilot plants GEF/World Bank will help creating technology trust and institutional learning and thereby reduce the hurdle for subsequent market entrance. The huge solar fields of solar thermal power plants contain many components that can be locally manufactured, e.g. concrete foundations, standard steel components or – depending on the solar technology and the project country – mirrors. Last not least the erection of the plants as well as operation and maintenance represent sustainable development aid through job creation. These macro-economic aspects of value creation in the countries of destination are not considered on the above discussed cost studies.

3 CSP Risk Analysis

This chapter assesses risks in the project design of the GEF/World Bank 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, the institutional settings etc. made for the portfolio.

The last group of risks concern the medium and long-term consequences of the choices made for the current portfolio, in particular for example the choice of the ISCC 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 categorising 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; GEF/WB program success; 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 (900m). Infrastructure for water/natural gas available. ➢ Egypt: ➢ Mexico: the 2 currently discussed plant sites in Sonora State offer ideal conditions for the solar field. ➢ India: flat site and transmission available. Some infrastructural work needed to provide water. Current non-availability of gas infrastructure (gas pipeline). Reasonable insolation levels.	➢ India: examine other revenue streams for potential use of the gas pipeline. Investigate nearby recent oil discovery for gas. Investigate alternative nearby locations.
2.	Environmental benefit low or non-existing due to the ISCC concept		➢ The CO_2 emission reduction actually achieved is rather low compared to a combined cycle reference: 5-10 % 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-optimised plant operation).

	Risk		Valuation	Mitigation
3.	Insufficient experience with CSP technology	✦	➢ Key technologies most likely to be used for the GEF/WB 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).	➢ Analysing on-field efficiency etc. in order to convince investors of the technical feasibility (e.g. 4360 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 GEF/WB plants, although for the Indian project a bonus was to be awarded if thermal storage were proposed. ➢ Thermal storage known in chemistry and in smaller dimensions from the "Solar Two" project (power tower in the US).	➢ 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 analysing.
5.	Problems arising at the technical interface between the solar component and the fossil component	✦	➢ The GEF/WB plants would be the first ISCC plants; the Spanish plants (maximum 15 % solar) as well as possible plants in the US are not ISCC plants.	➢ Interface occurs at the steam generator in a standard configuration through a heat exchanger. Major complications are unlikely.

	Risk		Valuation	Mitigation
	(continued)	★	➢ 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-optimised operation of the ISCC 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. Procedure for the optimisation of the interface unclear in Egypt.	➢ If two separate bids appear necessary in Egypt, make sure the interface is optimised in co-operation with the combined cycle supplier and the solar supplier.
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 GEF/WB 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 overcosts during the bidding procedure. ➢ For India, gap in capital cost could be minimised by allowing solar component of ISCCS to receive same tariff as wind (INR3.3). A cost gap would still remain, which would have to be filled by, e. g. government subsidisation. This could be justified by the other benefits gas supply could bring to the region.
			➢ Egypt:	
			➢ 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. World Bank awaiting letter of commitment from Indian Government.	

	Risk		**Valuation**	**Mitigation**
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 ISCC 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. ISCC 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 liberalisation, no long-term power purchasing agreements are granted to the company that runs the ISCC plant in concession, increasing the risk to companies. ➢ Risk comparatively small in markets with growing electricity demand.	➢ Frame for preferential feed-in of renewable electricity (for hybrid electricity from ISCC above a certain share). ➢ 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

	Risk		Valuation	Mitigation
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 instil the final owners with confidence that the field will perform as desired prior to them taking ownership. ➢ 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.	➢ 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 minimise 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. ➢ (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 % 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 organisations 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).

	Risk		Valuation	Mitigation
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 maximise 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).
19.	Loss of confidence in potential project developers due to lengthy bidding procedures		➢ In principle, difficulties with the GEF/WB 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 US), which advocates pushing through the current portfolio.	➢ The GEF/WB 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 favourable conditions in other parts of the world (e.g. Spain, US, Algeria), this problem seems less dramatic than it did a few years ago.	➢ Rapid implementation of at least the first of the GEF/WB projects. ➢ Common discussion and development of a long-term view of CSP (including information, dissemination and public discussions in strategy workshops).

	Risk		Valuation	Mitigation
21.	Lack of supportive-framework for re-newables, in particu-lar CSP		➢ All of the GEF/WB 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 technol-ogy until it is competitive with the main market tech-nology.	➢ Investigate suitable mixes of financing and support structures for future promotion of CSP technology such as soft loans + re-newable portfolios, (low-level) feed-in tar-iffs adapted to the financial context of de-veloping 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 multiplica-tion effect of the first plant. ➢ Consider market barriers ("OP6 –type barriers") also in technology simulation projects such as under OP7.
22.	Lack of competitive electricity market structures		➢ Opening electricity markets can have negative and posi-tive impacts on the development of new technologies such as CSP: on one hand, it might squeeze out the sur-plus of the main market operators that is needed to em-bark 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 ISCC and its future impact		*The pros* ➢ In the short run, it is more important to get the first GEF/WB plants running than to achieve a maximum CO_2 reduction. ➢ Even though ISCC may only have around 5 % 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 % in Mexico). The advantage of ISCC 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. *The cons* ➢ 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 optimised for low CO_2 emissions. Limited public acceptance in developed countries and international funding organisations.	➢ Accurate and comprehensive instrumentation is required to measure the contribution to electricity generation in an ISCC, which may not be available in all plants. ➢ ISCC is, in the medium to long-term, not the first choice, but for further developments in the short term, it might 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 ISCC 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.

	Risk		Valuation	Mitigation
	(continued from previous table)		➢ ISCC 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 ISCC plant later during the plant's lifetime is not possible from today's technological perspective. ➢ Moving from the ISCC 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).	
24.	Risk in mandating the trough technology compared to tower, dishes or Fresnel collectors for future developments	✶	➢ According to the Sargent&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 focalising 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.

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. ➢ Compared to PV and wind, CSP has a storage possibility. ➢ Levelised electricity costs for most CSP technology routes are (still) very much below those of PV.	➢ Storage technology should be introduced, perhaps only in future project developments. In the current round of GEF/WB, introducing project storage might cause additional delays in the realisation of the projects. ➢ 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 levelised electricity costs are highest with this technology (dishes are hardly competitive today with PV[15]), 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 ISCC 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 ISCC given the fact that the steam turbine needs to be designed to an optimal point of use.

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

	Risk		Valuation	Mitigation
27.	Dependency on single supplier of key elements	★	➢ Currently only Flabeg manufactures such mirrors. ➢ 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). ➢ All other elements are more or less standard.	➢ Evaluate bottlenecks which 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. ➢ 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). ➢ Guarantee access to fabrication train for mirrors.

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; GEF/WB programme success; global technology evolution) and the main actors for risk mitigation.

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

	Risk	Importance	Main level of impact	Main actor for risk mitigation
	Technological risks related to the WB/GEF portfolio	✦/✶	❶	
28.	Non-optimal choice of location	✦/✶/❋	❶	National level
29.	Environmental benefit low or non-existing due to the ISCC concept	✶	(❷) / ❸	Plant designer / operator
30.	Insufficient experience with CSP technology	✦	❶ / (❷)	Equipment suppliers
31.	Thermal storage in the required size new and non-experienced technology	✶	(❶) / ❸	Equipment suppliers
32.	Problems at the technical interface between the solar component and the fossil component	✦/✶	❶	Plant designer / operator
33.	Non-optimised operation of the ISCC plant	✶	❶	Plant designer / operator
34.	Complete failure of the solar plant	✦	❶	Plant designer / operator
	Financial/commercial risks related to the WB/GEF portfolio	✶	❶ / ❷	
35.	Low interest in bidding by industry	❋	❷	WB/GEF National level
36.	Insufficient financing secured for the GEF/WB projects	✦/✶	❶	WB/GEF National level
37.	Exposure to fossil fuel price increases (in particular gas price increases)	✦	❷	National level
38.	Non-guaranteed power purchase	✶	❸	National level
39.	Weak financial position of off-taker	✶	❶	National level
40.	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
41.	Unusually high level of guarantees required from the national side	❋	❶	National level
42.	Full liability for the contractor of the solar thermal component for the whole ISCC	❋	❷	National level WB/GEF
43.	Risk pricing by bidders	✶	❷	Bidders National level
44.	Insufficient protection of intellectual property	✶	❶	Bidders

	Regulatory/institutional risks related to the WB/GEF portfolio	✶/❋	❷ / ❸	
45.	Lack of incentives to maximise operation of the solar field	❋	❶	National level WB/GEF
46.	Loss of confidence in potential project developers due to lengthy bidding procedures	❋	❷	WB/GEF National level
47.	Loss of confidence in project developers due to missing long-term assurance of CSP market growth	✶	❷ / ❸	WB/GEF National level
48.	Lack of supportive-framework for renewables, in particular CSP	❋	(❷) / ❸	WB/GEF National level
49.	Lack of competitive electricity market structures	✶	(❷) / ❸	National level
	Strategic risks related to the WB/GEF portfolio	✶/❋	❸	
50.	Risk in mandating a particular integration configuration such as ISCC and its future impact	❋	❸	WB/GEF National level
51.	Risk in mandating the trough technology compared to tower, dishes or Fresnel collectors for future developments	✶	❸	WB/GEF National level
52.	CSP might take up market shares more slowly than. other renewables (incl. PV and wind)	✶	❷ / ❸	WB/GEF National level
53.	Concepts chosen not flexible enough with respect to future plant extensions	❋	❸	
54.	Dependency 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 GEF/WB 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 ISCC 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 GEF/WB portfolio and its possible development. For more details, see Annex 4.

4.1 Status of the GEF/WB 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 summarises 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 experiences 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 institutionalised routes through government, and the specific respective 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, through papers, conferences, independent evaluations, etc. Quite often the LEC figure is bandied around with little regard to the assumptions and robustness of the underlying calculation. For example, figures of 12-14 US$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 maximising 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 labour will be at local rates.

Individual techno-economic feasibility studies are needed (and have been conducted for these 4 projects, although a new one may be needed 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 US$ that could be used toward the EPC financing.

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 2240 kWh/m2/yr DNI	World Bank waiting for letter of commitment from Govt of India, after which already drafted (revised) RfP could be released. Government of Rajasthan very enthusiastic.	Single EPC cum O&M (5yrs). PPA with RVPN. Project owner RREC.	RREC expects GoI and MNES to sign "any day". RfP can then be finalised. Some issues require updating such as source of gas.
Egypt/ Kuraymat, 151 MW ISCCS incl. 25 MW solar	NREA awaiting final approval from JBIC for financing balance of foreign project investment cost ($97M)	Two EPC contracts, one each to cover CC and solar field.	
Mexico / El Fresnal near Agua Prieta, Sonora State (site decision in March 2005, plant Agua Prieta II), originally 285 MW ISCCS but looking to increase CC to 560 MWe; Solar trough field 25-40 MW; Excellent solar site conditions (however exact solar data not available).	CFE have asked WB/GEF if still willing to provide the grant for a larger (560 MW) ISCC plant. CFE requires a firm commitment in order to complete technical and economical evaluation to submit to Treasury Ministry for approval in June 2005.	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 is to begin 2007, operation 2009.
Mexico/ Aqua Prieta (2 sites in discussion changed from original Baja California Norte to Sonora State), originally 285 MW ISCCS but looking to increase CC to 500 MW_e; solar trough field 25-40 MW; excellent solar site 2600 $kWh/m^2/yr$ DNI	CFE have asked WB/GEF if still willing to provide the grant for 500 MW instead of 250 MW ISCCS. CFE require a firm commitment in order to complete technical and economical evaluation to submit to Treasury Ministry for approval in June 2005.	The final owner of the plant will be CFE. They will undertake to provide the O&M.	At this stage, bidding is expected for 2006, construction is to begin 2007, operation 2009.

Morocco/ Ain Beni Mathar 240 MW ISCCS, incl. 30 MW trough. Expected production from ISCCS 1590 GWh/yr, of which approx 55 GWh/yr solar (3.5 % solar contribution).	EPC cum O&M (5 yrs). Options exist to renew O&M contract after 5 yrs. Bid document completed by Fichtner Solar and reviewed with client (ONE). In March 2005 lodged with World Bank as "non objection".	Owner of plant will be ONE. Total cost expected approx €213M, incl. connection to infrastructure. €43M from GEF, and €34M from ONE. Balance of €136.45M from African Development Bank as soft loan.	When "non objection" approval received can be issued to pre-qualified bidders. EPC cum O&M contract could be signed by end of 2005; expected start of operation mid 2008-early 2009.

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 and ensuring performance were to be borne by large organisations. When this had to be revised for EPC cum 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. However we believe firm dates now need to be set for each project after consultation with each country.

4.2 Status of the GEF/WB portfolio by country

4.2.1 GEF/WB project in Egypt (Kuraymat)

Project history

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

2004 August — Prequalification and bid document completed. In parallel NREA investigated potential sources of co-financing. The JBIC (Japan Bank for International Co-operation) showed interest but requested a halt of 5 months in further project activities in order for the JBIC to decide on the financing. Time schedule by that time:
Co-financing in place October 31, 2004
Selection of Bidder October 15, 2005
GEF Board Date December 31, 2005

2005?	The decision by the JBIC was made but JBIC requested to split the existing bid documents into two: one for the solar part and another for the combined cycle part. Fichtner Solar is currently preparing the two bid Documents.

Future development according to current planning:

2005 June	Bid documents scheduled for "non-objection" by the World Bank bidding and evaluation of the bids
2006 June	Contract signature
2006	Construction is to begin
2008 Dec.	Plant starts operation towards the end of 2008

4.2.2 GEF/WB project in Mexico (Sonora)

Project history

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

1986[16]	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).
1995-1996	Spencer Management Associates (SMA) undertook an evaluation of ISCC plants under IPP financing scheme in cooperation with CFE.
1998 October	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.
1999 Aug.-Nov.[17]	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.
1999 December	Mexico solar thermal hybrid project entered the GEF program (with GEF grant of US$ 49 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.[18]

16 http://gaceta.diputados.gob.mx/Gaceta/58/2002/feb/20020213.html

17 Thematic Review of GEF financed solar thermal projects, October 2001

18 World Bank to GEF Council, April 2004

2002 March	"Call for Bids" on an IPP basis was published. The solar field was an option for the combination with a CC plant.
2003 Apr./March	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 WB 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 ISCC 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.
2004 October	Finalizing of a feasibility study for Mexicali II (Baja California Norte) including Sargent&Lundy as the WB's consultants and social and environmental specialists from WB.
2004 November	The plant location was changed to Sonora state. CFE's explanation was that the power sector expansion plan would not allow further delays related to the implementation of the solar field.
2005 March	Inquiry from CFE to the WB if WB would still support an ISCC plant with a solar field integrated into a 500 MW instead of a 250 MW plant.

Future development according to current planning:

By May 05:	Get feedback from GEF/WB on 500 MW issue.
By June 05:	Completion of technical and economical evaluation by CFE
June 2005:	Presentation to the Treasury Ministry
Nov./Dec. 05:	Approval by Treasury ministry
Jan. 06:	PEF approval
Feb. 06:	Invitation for tenders (published)
Sep06 - Jan07:	Start construction
April 09:	Grid-connection of the plant

4.2.3 GEF/WB/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 US$ 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 cum 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 RREC (16 March 2004) stating that the agreed gas price would be INR270.47/MMbtu, including transmission, and escalating at 5 %/yr (note RREC modelling assumes 5 %/yr for first 5 yrs 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 modelling shows 2.82) and suggesting that it would be "desirable that the concerted efforts be made to implement the project at its earliest" (3 Sept, 2004).
2005	MNES informed of new large gas/oil find near Mathania.

Future development according to current planning:

Currently no clearly defined time schedule for the future development.

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 %, 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, who dropped the project on the grounds it was “techno-economically non viable” in 1992 have recently (3rd Sept 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 16th Sept 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 20yr average LEC of INR 2.82/kWh (taking into account: US$ 45 million GEF grant, INR 500 million GoI grant and INR 500 million GoR grant). The total project cost, including IDC, is INR 8226.87 million. This is based on a gas price of INR 270.47/Mmbtu, a water price of INR 20/1000 Cuft, and O&M at 1 % of total project cost for first 2 years, then 2.5 % in year 3 with 4 % escalation following. These costings 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 %. This seems high for an insolation regime of 2240 kWh/m^2/yr DNI, even allowing for the advantages of ISCCS in terms of start-up and transients. However, even if a 20 % 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 desensitises the overall LEC to solar performance (in both directions).

With regard to gas supply, RREC have 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. The contact person in India for this new oil and gas reserve is Mr Bhandari (National Advisor). This is closer than the present 425km, 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 in fact 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 optimised 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 vs. 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 GWhe) 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 bears 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, according to Mr Verma, the revised proposal has a consortium of contractors/participants to address this issue. According to Mr Verma, the Department of Economic Affairs fully support 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, and it is now a different party to that in the State of Rajasthan. 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). Mr Gokhle (secretary of MNES) has personally visited the Mathania site and approved the project in principle. According to Mr Verma, about six weeks ago the Chief Minister of Rajasthan wrote to the Prime Minister to speed up the process but no reply has been received yet. RREC believe formal approval could be gained any day.

Mr Ahmed (Chairman and MD, Rajstahan Vidyut Vitran Nigam) stated that he fully supports the project and will purchase electricity subject to Rajasthan Regulatory Commission setting the price. His personal opinion was that pressure from the World Bank on the Department of Economic Affairs and the Prime Ministers Office would be useful. People such as Mr Muntag Singh and Mr Vasudev should be contacted to speed up this project.

4.2.4 GEF/WB 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 programme in May 1999.
2000	Assistance by Fichtner Solar for the design of bidding documents under an IPP scheme.
?	Feasibility study report under the IPP scheme.
2002	The Moroccan electricity sector started to open to competition in a limited way (smaller consumers remain captive). Process still ongoing in 2005.
2003	Publication of the IPP call in 2003; organisation 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 cum O&M the same year.
2003?	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 before mid 2005.
Currently	"Non-objection" in principle, World Bank agreement to be provided to Fichtner Solar and ONE as the last step before publishing the call for bids.

Future development according to current planning:

2005 June-Dec.	Bidding and evaluation of the bids
2006 January	Contract signature
2006 February	Construction is to begin
2008 June	plant starts operation towards the middle of 2008

5 Long-term CSP development scenarios for the WB/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 GEF/WB portfolio in itself with at best around 120 MW solar thermal power capacity at the end is not able to reduce significantly the costs of CSP technology, and was never intended to do so, although this issue is mentioned as an aim for the GEF/WB portfolio at some places. The institutional learning aspects, which cannot be so easily measured quantitatively as Levelised 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 represents roughly one third of its annual budget for climate change issues in the recent years.

Given this important engagement and the initially stated objective of the GEF/WB portfolio, it is legitimate to consider the long-term contribution of the CSP portfolio and possible evolvement of a long-term strategy by the GEF/WB, independent from the possible short-term aleas of large organisations which might change the focus of interest in time driven by failures, pressure from alternative development routes, or up-coming issues "à la mode". Nevertheless, it is clear also that a complex issue[19] such as the introduction of CSP technology in developing countries needs more time than just the time of the realisation of a portfolio of four projects. ***It is therefore not astonishing that the portfolio encountered the difficulties and delays which have been observed so far.***

The main question for the GEF/WB today is rather whether the effort necessary to continue the support for the joint development of technology and structures is worthwhile to continue in some way or the other, or whether the mixed experience accumulated so far, makes it difficult for the GEF/WB to engage further on the CSP technology despite the short-term aspect of bringing the currently existing portfolio to a successful end.

Given these heterogeneous interests it appears legitimate to discuss the implications of different scenarios for action, both at the short and the long-term before giving recommendations on a market strategy within and beyond the currently existing portfolio in chapter 6.

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19 Not so much complex from the technological side, given the fact that a variety of components for CSP technology are already well-proven, even in larger schemes 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 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 in difference to CSP the development in industrialised 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 a strongly reduced importance for these technologies.

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

This section explores, in the form of different scenarios, the possible consequences and impacts of decisions made at the GEF/WB for the CSP technology on the short or longer term in one or the other direction. **It therefore gives not value judgement on one or the other option** but simply departs from the present situation and explores the impacts of the choices.

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 with short-term aspects and in particular the current GEF/WB 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:
  - *"The First Round" - "Falling Dominos":* This scenario assumes that the GEF/WB portfolio would be cancelled as a whole due to the delays accumulated so far as well as the recognition that GEF/WB 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 paralleling efforts in industrialised countries.
  - *"The First Round" - "Getting to the harbour":* This scenario assumes that the GEF/WB portfolio would be partially or totally realised during the next 2 years.
- **The "Second Round"** assumes a (more or less) successful termination of the "First Round" and considers options for GEF/WB 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.
  - *"The Second Round" - "Wait and See":* This scenario is based on the recognition by GEF/WB 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 likely not to have much impact.
  - *"The Second Round" - "2-Track approach" (CSP in industrialised + developing countries):* This scenario is based on the recognition by GEF/WB that CSP will not develop simply in regions other than industrialised 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".
  - *"The Second Round" - "Specialising":* This scenario is based on one hand on the recognition by GEF/WB that the large scale promotion of CSP might exceed its financial and institutional capacities, and on the other hand of the recognition of the fact that CSP is to play an important role in the power mix of developing countries. This requires specialisation of the GEF/WB 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[20]:

- *Group 1 countries:* Industrialised countries with suitable climatic resources for CSP technology and highly developed economies which have already set up a comprehensive framework to promote renewables or which could potentially do so (Southern Europe, South Western US, 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[21]). Figure 17 clearly illustrates the importance of this issue with the example of the Mediterranean rim. There are a variety of developments going on which make this "ring" more concrete to happen in the future than in previous times. Such aspects concern the opening of electricity markets, although to various degrees of Northern African countries, the establishment of physical links for power exchange among North African countries themselves as well as towards Spain and Italy. CSP can potentially play an important role in this power exchange. However, the implication of such a power ring goes well beyond the mere importance of electricity exchange: it contains elements of political[22] 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, e.g. for CSP technologies. Structures of this type exist with the so-called "maquiladoras", manufacturing companies of small up to large size along the Mexican-US border, cooperating intensively with companies producing in the US[23]. Depending on the success or failure of the "First Round" of CSP development, this group of country

[20] This grouping is derived from a similar classification proposed in the Global Market Initiative (GMI). There was an intensive debate on one of the workshops organised in the course of this project, whether the distinction between the Group 2 and the 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.

[21] Mexico is an OECD country but presents still some aspects of a developing country which is caused by the larger split in wealth within the population.

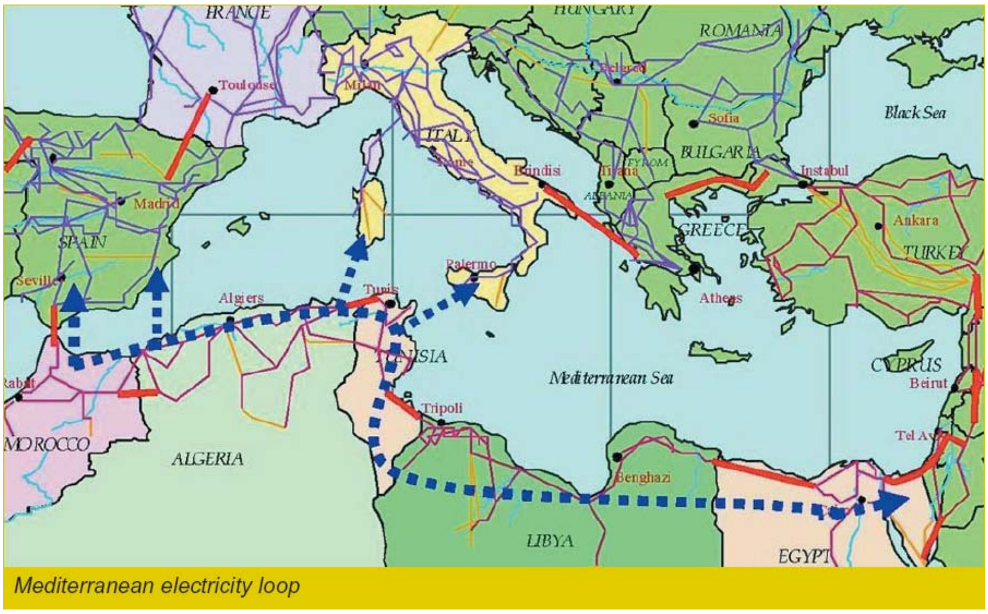
[22] Political relationships among countries in North Africa, for example among Morocco and Algeria, continue to be difficult for a variety of historic reasons. However, there are encouraging efforts and symbols to overcome these divisions. Potentially, on the longer term Northern Africa can parallel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

[23] 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 the national employment, see for example the recent discussion in Europe after the opening of the EU towards 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.

appears as strategic in the future development of CSP. For the moment, given the somewhat more hesitating development of CSP in the South West of the US as compared to the development in Spain, the impression that the North African GEF/WB CSP projects have the highest chance of being realised, the stage of the ISCC project proposed outside the GEF/WB portfolio in Algeria, as well the CSP activities of 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 organisations.

- *Group 3 countries:* This group of developing countries is located not in proximity to the electricity grids of Group 1 countries. This comprises important countries like India, China, Brazil or South-Africa where the driving force is essentially the tremendous need for new electricity generation capacity. The importance of this group of countries appears not as less relevant as for the Group 2, but the motivation to invest in CSP might be different and focussed 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)



Source: Algerian Ministry of Mining and Energy

5.2 "The First Round" - "Falling Dominos"

This scenario, dealing with shorter term aspects, assumes that the GEF/WB portfolio would be cancelled as a whole in a short frame of time due to the delays accumulated so far as well as the recognition that GEF/WB 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 paralleling efforts in industrialised 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, which has a solid policy framework for CSP in place, it appears less likely that there would be an impact of a GEF/WB decision to phase out the portfolio, although at the longer term (Spain has a decision point concerning the continuation of its favourable support frame for CSP once 500 WM are reached), some impact cannot be excluded.

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

Comments:

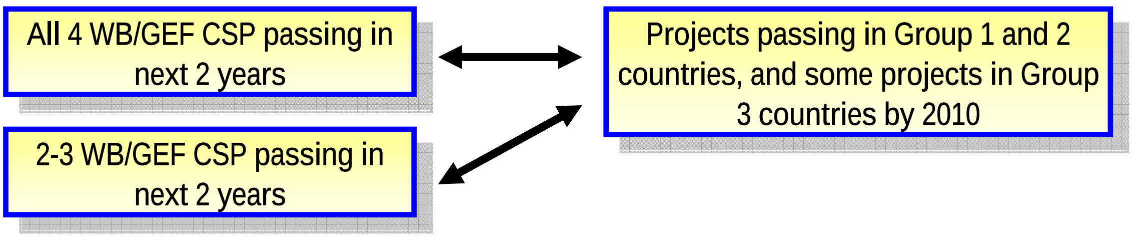
- **Critical moment in time for CSP: a variety of projects are in a phase of consolidation Other projects in a phase of stabilization.**
- **The GEF/WB portfolio represents a relatively small installed solar capacity of around 120 MW; nevertheless important amount of solar technology, given the early stage of the industry and the few plants under construction, yet.**
- **The GEF/WB projects represent with Algeria, the only ISCC 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 looses 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 GEF/WB 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 developing countries. ISCC 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) which propose ISCC technology. This could have negative consequences for the future co-operation 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 harbour"

This scenario, also dealing with shorter term aspects, assumes that the GEF/WB portfolio would be partially or totally realised[24] during the next 2 years. The timeframe of 2 years appears as reasonable in order to provide enough time for the projects to progress. It is difficult to conceive that the GEF/WB portfolio should exceed this time frame up to contract signature given the fact that the catalyser function in a now more favourable 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.



Comments:

- **The frame for CSP technology take-off is currently the most favourable since 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 the face"**
- **Revision/cancellation of 1-2 projects: Question of alternatives? Alternative technology lines to ISCC 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 (ISCC plants). Success aspect more important than environmental expectations.**

Possible Impacts:

- **In total about 1000 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 ISCC technology line in the WB/GEF portfolio and in Algeria), opening up options for future choices**

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[24] The expression "has been realised" 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.

In 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 industrialised countries as well as the imminence of the GEF/WB portfolio and other projects in developing countries being realised.

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 objectively in the last two years: first, the general energy price environment is one of strong tensions on prices and second, 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 realisation 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 realisation of this scenario is that the GEB/WB 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 1-2 projects, and the wish of the GEF/WB to support further this important technology, the following alternative technology lines to the ISCC 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.

5.4 "The Second Round" - "Wait and See"

This scenario, dealing with longer term aspects, is based on the recognition by GEF/WB that as long as the costs for CSP have not come down to levels close to being competitive with fossil power generation[25] and as long as the political frame for renewables and CSP in developing countries is not advanced enough further support to CSP is likely not to have much impact. This means essentially taking a break on the technology for the next 5 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 n particular
- the necessary preparation of the policy frame in developing countries before such a large scale technology can be taken up

No WB/GEF activities in Group 2 or Group 3 countries until costs for CSP are lowered

Group 1 countries going ahead; realisation of projects in Group 2 and 3 countries left to the market and possibly other international funding organisations

Comments:

- **CSP electricity cost reduction continues towards breakeven with fossil generation by 2015-2020**
- **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**
- **ISCC technology line abandoned except for Algeria**
- **By 2015 not more than 2000 MW installed**

[25] 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

5.5 "The Second Round" - "2-Track Approach" (CSP promotion in industrialised + developing countries in parallel)

This scenario, also dealing with longer term aspects, is based on the recognition by GEF/WB that CSP will not develop simply in regions other than industrialised 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 towards 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 learnt 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.

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 „...(ISCC plants may be excluded because of low and unexpendable solar shares (<20 %)"**
- **More critical on environmental performance? (ISCC technology !)**
- **Revision of the bidding procedures (complexity, liability issues: e.g. what is an adequate liability for the solar component in the case of ISCC 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 US where development is still slower or non-existing as compared to Spain.**
- **Concentration on Group 2 countries as a key group at the intermediate stage of development of the CSP technology (previously successful GEF/WB 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. ISCC continues depending on the interest of the host country but more technology options realized in developing countries.**
- **By 2015 more than 2000 MW installed, in case of a very favourable development up to 5000 MW.**

5.6 "The Second Round" - " Specialising "

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

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

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 applications**
- **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)**

Possible Impacts:

- **Longer-term "preparation of grounds" for the faster take-off of the CSP technology thereafter**
- **No large scale CSP projects with GEF/WB involvement. Projects in Group 2 and Group 3 countries mainly market driven or driven form the national level / other international financing sources**
- **ISCC technology line abandoned except for countries with specific interests such as Algeria.**
- **Impact on installed MW comparatively small**
- **By 2015 not more than 2000 MW installed**

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

The present chapter tries to narrow down on 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 realise it but (possibly harmonised) efforts from different actors, including WB/GEF, in both developed and developing countries. This 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

The ***central objective of a long-term vision for solar thermal power*** can be formulated as follows:

Given the concentration of solar resources mainly in developing countries, given the growth of electricity demand in those regions in the next 20 years, CSP must be introduced in developing countries in parallel with the development of CSP in industrialised countries.

This objective is grounded on the following reasons. A more detailed rational 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 otherwise fossil infrastructure in developing countries which 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 towards 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 realise that climate change will threaten their development before they can reach the level of the developed world. Correspondingly many of them take first steps towards 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 sun-belt 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 towards reducing GHG emissions from power generation in the own country. Two regions, the Mediterranean/Near East area and Mexico have – on the longer term - the potential to export additional solar electricity to the Northern industrialised countries (US 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***).

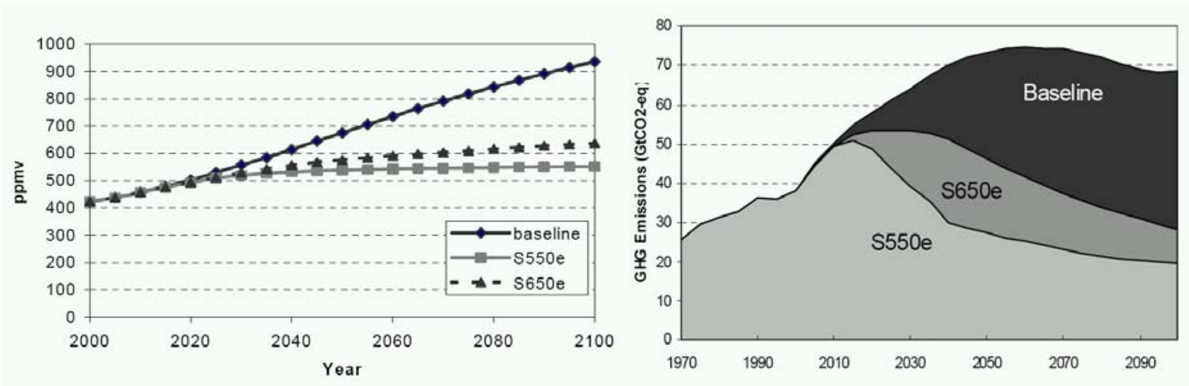
The central objective is underpinned by the following ***accompanying hypotheses***:

- ***Hypothesis 1: Now is the right time slot for CSP to increasingly replace new installations of large centralised fossil power stations***
  Electricity demand is currently growing in many countries of the sun-belt with 6-7 % 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, i. e. until the middle of this century, creating 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 stabilise GHG concentrations in the atmosphere at levels of 550 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 1000 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 build 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***[26]. In this case, ***even the 650 ppmv level is very unlikely to***

[26] see the Policy Recommendations for Renewable Energies of the Bonn International Conference for Renewables (2004): "As developing countries work to expand and modernise their energy systems, and industrialised 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 US$16 trillion. The opportunity is to orient a large and increasing share of these investments towards renewable energy, in order to advance the transition to a global

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 % in 1995 to 45 % in 2025 and 66 % 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 next generation of power plants beyond 2030.

Figure 18: Global GHG concentration stabilisation profiles (left) and emission profiles for stabilising greenhouse gas concentrations at 550 ppmv (S550e) and 650 ppmv (S650e) versus baseline emissions



Source: Criqui *et al.*, 2003

- ***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 on 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 in the late eighties comparable to wind energy. This is one of the reasons why the technology was consid-

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."

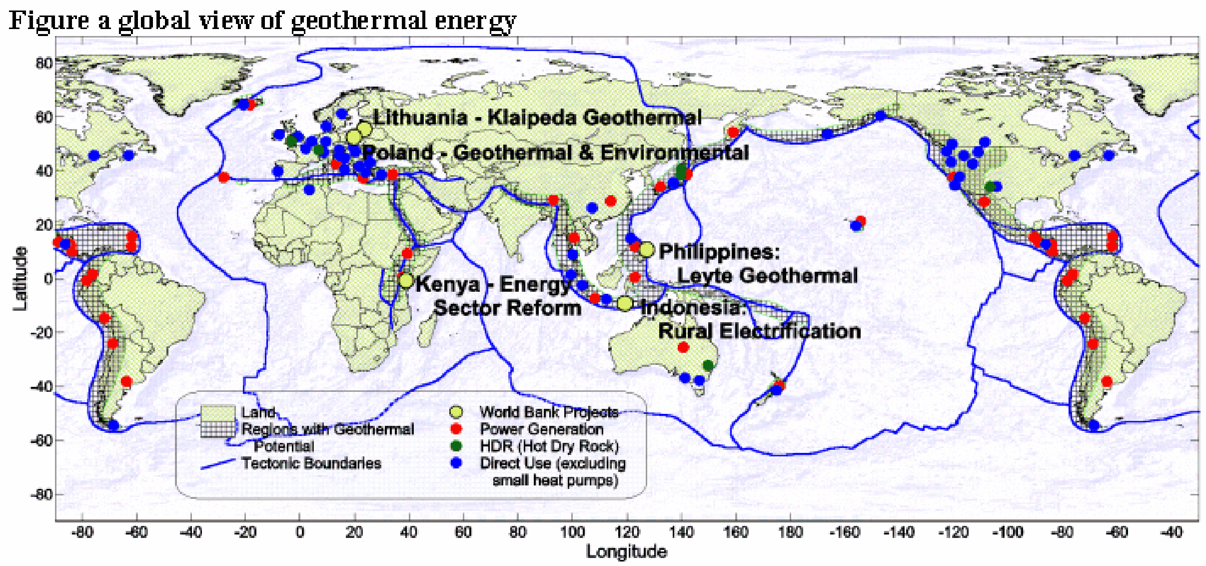
ered interesting for developing countries, as it was expected that costs could be brought down quite soon to competitive levels. The costs of CSP have potentially been brought down in the last decade since the first plants in California by further R&D, but now steady and sustainable implementation is 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 sun-belt: wind energy is in principle a competitor for solar thermal power, due to its advanced maturity among the renewable energy sources together with hydro power, but needs a "stabilising partner" in the power mix in particular as long as countries are not well interconnected. Technical progress [27], 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. Hydro power 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 sun-belt, biomass is not abundant and PV is, on 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 has still 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 respects, on a world-wide level, complementary to CSP although in some countries the technologies could be in competition (in particular for example in Mexico, which has already installed sev-

[27] 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 1600 (18 %) to 2400 hours (27 %) per year. On average, in the European Union, the wind converters produce during 3000 h/year (34 %) as compared to 20 % in 1995, and the newest 5 MW machines approaches 40 %. Wind speeds to be used extend now from 9 to 100-120 km/h as compared to 14-79 km/h a decade ago (Source: Science & Vie, 2005).

eral geothermal power plants). Tidal and wave energy is in a more early stage of development as compared to CSP.

Figure 19: Implementation of geothermal power plants world-wide



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

- ***Hypothesis 5: Developing countries are increasingly favouring 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 between 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 sun-belt which 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***
  Industrialised 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 US and Australia have in principle enough 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 own electricity needs with solar thermal power. Japan has even more limited own solar

thermal power potential. In such cases, importing clean electricity from the sun-belt region can be an important reduction option for industrialised 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 the regional development and co-operation. As long as a country's own needs are not covered by clean electricity, tradable solutions[28] could constitute a suitable approach also. This supposes, however, the installation of an international trading system 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 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 2.3):

- The Global Market Initiative with the objective "to facilitate and expedite the building of 5,000 MW_e 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 %. 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 % in developing countries), for 2020 around 21,500 MW (of which 30 % in developing countries).
- The ATHENE scenarios in the SOKRATES project (DLR, 2004) which envisages 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

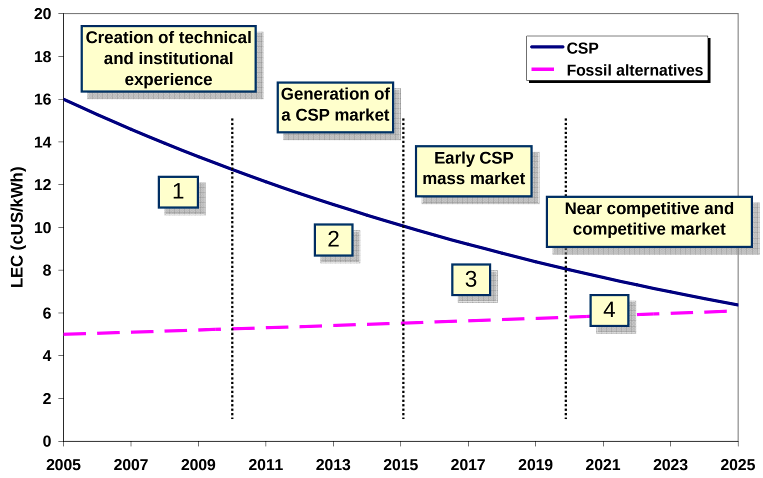
[28] Tradable solutions constitute an alternative to physical export of Green Electricity by unbundling the environmental attributes of a unit of renewable energy from the underlying electricity. Possible trading solutions are in particular Renewable Energy Certificates RECs and Certified Emission Reductions CERs (under the CDM). The development of tradable certificate programmes 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. more risk for the investors. For RECs electronic issuing and tracking systems have been developed in parts of North America, European Union and Australia to support the development of RECs as a compliance and market tool. A pilot project has also been carried out by to develop RECs to finance renewable energy projects in Brazil, China & 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 renewable as they make investments in renewable electricity plants more risky. Therefore, the emergence of additional investments in the renewable may take more time with this system than with other systems that guarantee a fixed premium price for the renewable electricity.

around 50 % already in 2025) due to a lower installed capacity in the US as compared to Greenpeace/ESTIA.

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

Any successful strategy aiming at the realisation 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.

Figure 20: Four stages in the development of CSP



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 seen from today.

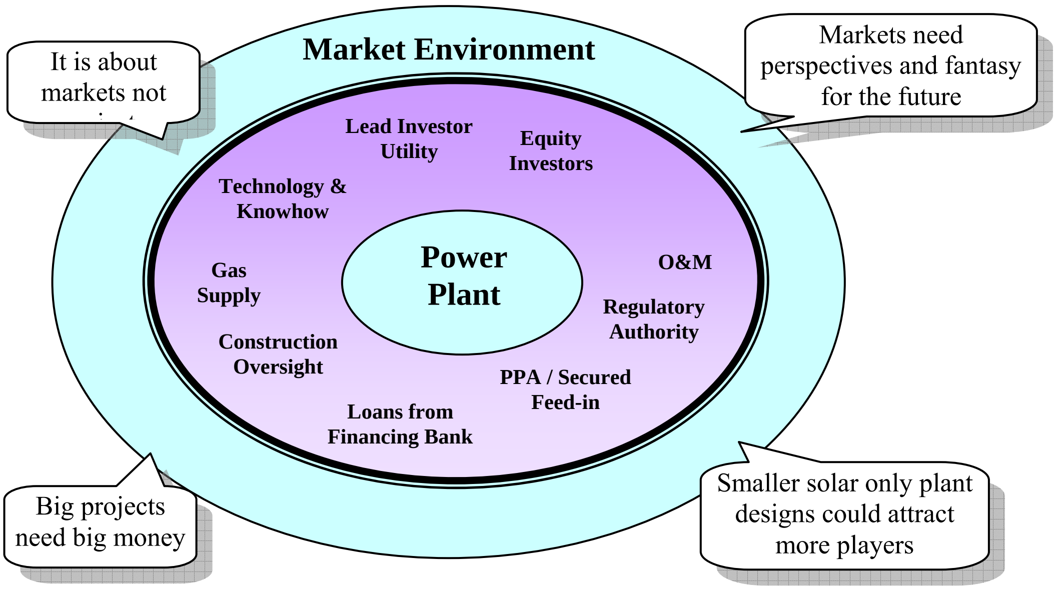
- ***Part 1 of the cost reduction curve: Creation of technical and institutional experience.*** Small number of new units (in addition to the Californian SEGS plants), a few hundred MW. Creation of confidence, lowering of risk factors applied to first plants, first "pilots" in developing countries. Corresponds to the realisation of a few plants in Spain, US 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 500-2000 MW). Diversification in technologies, certain degree of cost reduction but still far away from economic margins. Target of perhaps 15-20 % of capacities installed in developing countries. Financing driven in industrialised 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 2000-7000 MW). Substantial decrease in costs due to scale and volume effects, costs approaching competitive ranges but not yet generally cost effective. Target of perhaps 20-25 % of capacities installed in developing countries. In some applications, however, even without subsidies interesting, 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 30-40 % of capacities installed in developing countries. This is a stage that is currently reached by wind, however, with a still comparatively low share of the developing world (by the end of 2004 around 47 GW of wind were installed world-wide, of which around 8.5 % in the developing world).

A successful strategy must further take into account that the main purpose is not to realise 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).

Figure 21: Market environment for the introduction of CSP technology



Source: Haeussermann (2005)

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

- 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 towards 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 realise 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.

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 at the shorter term and for the acceptance of the whole technology line on the longer term. It also might determine strongly the choice of the technology. Although technologies that promote solar-only technologies might be preferred in principle there are various functions that might favour ISCC as the preferred technology in a country.

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 is the basic aim of the GEF which is to promote technologies directed to non-Annex I countries. The GEF document describing OP7 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:

a) are country driven and in conformity with, and supportive of, national development priori ties;
b) are consistent with and supportive of internationally agreed programs of action for sustain able 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 emphasises "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 $200 million per year, over 5 to 10 years as investment demand and absorptive capacity grow. One analysis of the median amount of resources required to induce cost reductions in just one of the technology-applications listed in the Operational Program (for large scale electricity production using PV cells) is around US$ 3.3 billion[29], 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".

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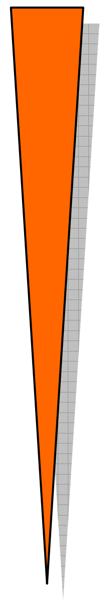
[29] This is in good compliance with the Athene cost reduction forecast (see chapter 2.3.2): 2.5 million € (under the assumptions of an internal project revenue rate of 8% and CO_2-trading)

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	OP7 objective linked to criteria	Criteria relevant for Chapter 5 scenario	Ranking of criteria from an <u>early</u> market perspective
1	Insure increasing participation of developing countries in CSP development	1-3	Main objective	"Two-Tracks"	very important
2	Spur CSP Market Deployment in industrialised 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	Mobilise 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	Mobilise 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	-	"Specialising"	less important

Notes for Table 7:

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 industrialised 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, especially Fresnel collectors because of high local value creation (due to larger share of simple collector components)
Environmental protection	Spain, Italy, US	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, US	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; ISCC 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	ISCC technology
Remote Power Producer	Remote regions with larger electricity demand that cannot	Quality of energy service	Small scale CSP

	be satisfied by PV		
Transmission Stabilizer	Crete	Quality of energy service	Storage technology

Source: Geyer (2005), own additions

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

The following describes shortly two important new market initiative which have in common that they try to integrate the different stakeholders relevant for the development of a technology and take in particular into account the regulatory/institutional framework, meeting thus some of the most important criteria for successful market creation mentioned previously. The first, the Global Market Initiative (GMI) is specifically directed towards CSP, whole the second, EM Power, addresses renewable electricity (RE) more broadly.

6.3.1 Global Market Initiative (GMI)[30]

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 10 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 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 neighbouring 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-

30 Section based on " The Concentrating Solar Power Global Market Initiative"

term power purchase agreements or similar long-term contracts with credit-worthy off-takers, or equity ownership by public organizations will build 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 centres, 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? [31])

An initiative is under development, involving UNEP and KfW (GEF not involved so far), 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 the GEF does a few pilot MSPs, and links them up with investment, scaling up the effects.

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[31] Section based on the Report of the STAP Brainstorming Session on Operational Programme 7 10-11 March 2003 Washington D.C. which took the information from a presentation by Peter Hilliges, GEF Secretariat.

6.4 The possible role of the Clean Development Mechanism in project financing: How to cross the bridge towards 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 the additional financing expected from CDM projects could contribute substantial fractions to the project financing. Currently the contribution would be typically several million US Dollar with a need for additional financing of around 50 million US Dollar, corresponding to the amount of the grants of the current GEF portfolio.

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

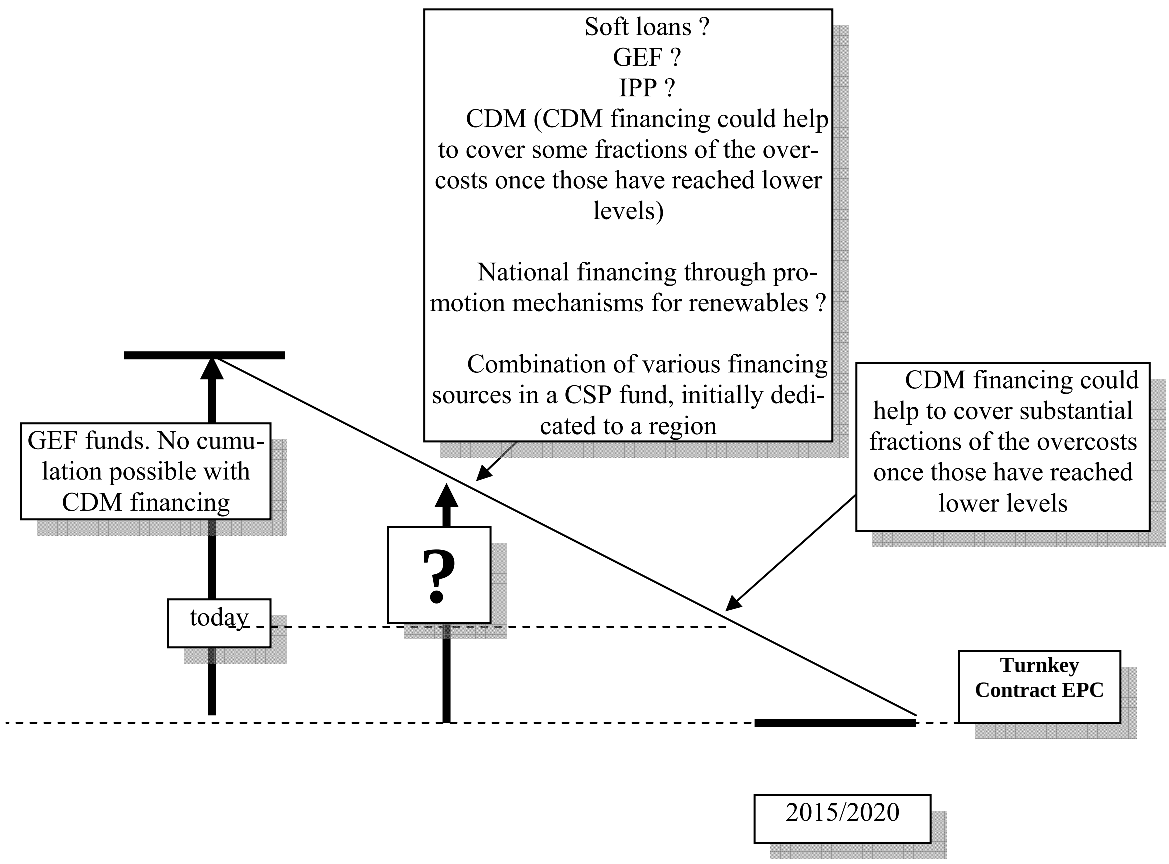


Table 9: Example of CDM financing for CSP

Project		
Investment:	250 Mio USD	
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 Mio US$ / year (over crediting life of 20 years, 10[32] US$ / t CO_2)	
Split up of revenues	Conventional electricity sale 6 cUS$ / kWh	CER sale

Increase in IRR

Source: Sutter (2002)

6.5 Central questions for determining the role of the WB/GEF in the realisation of the CSO vision

In view of the vision formulated previously in Chapter 6.1 and the criteria describing a successful strategy for the realisation of such a vision, as presented in Chapter 6.2, the GEF/WB has to answer a variety of questions addressing its implication in CSP, technology choices etc at different time horizons: short-term or long-term questions (or otherwise formulated, questions addressing the four phases for CSP development discussed previously). The long-term questions concern both strategic questions as well as operational questions.

32 The value of 10 US$ used by this author appears as high. Typical CER prices are on average rather 5 US$ than 10 US$, although it must be emphasised 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 GEF/WB CSP portfolio	
(1)	Can the rational to include CSP in the OP7 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 2 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)	How are the opportunities for successive plants ?
(9)	What are the chances/risks of each of the four GEF/WB projects to reach realisation ?
Questions addressing the long-term development of the GEF/WB CSP portfolio	
Strategic questions	
(10)	Which strategy choice as discussed in Chapters 5.4 to 5.6 ("Wait and See", "2-Track-Approach", Specialisation") 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 GEF/WB strategy concentrate on regions with best chances to create volume markets ?
(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 6.1.
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 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 means?

These questions will be answered in the following chapters.

6.6 Answers to the questions addressing the short-term development of the GEF/WB 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 Chapters 6.1 and 6.2, the current chapter provides answers to the questions addressing the short-term development of the GEF/WB CSP portfolio raised in Chapter 6.5. A third section then addresses in detail the chances/risks of each of the four GEF/WB projects to reach realisation (question (9)).

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

The present section investigates in how far 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 the Chapters 6.1 and 6.2, or whether there are individual characteristics of the current portfolio which are in striking contradiction with the development of a long-term strategy. For this purpose, the current portfolio is evaluated below against the list of criteria set up previously.

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

	Criteria	**Relevance in the current GEF/WB portfolio**	**Strong/ weak/ medium point in portfolio**
1.	Insure 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. However, successful termination of the larger part of the GEF/WB 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 industrialised countries	Not taken into account. Only indirectly accessible to GEF/WB. However can be influenced through a parallel development of the market in developing countries.	Medium
3.	Make sense for the country‘s power market	Given to a certain degree but limited	Medium

(*Table continued*)

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 GEF/WB projects, once realised 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 GEF/WB 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.	Mobilise 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**
	Mobilise 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**
	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 4 ISCC plants might have been determined by the country choice for large capacity increase. Important issue for part 2 of the cost reduction curve	Medium
	Enhance previous country experience with CSP	Not an issue in Part 1 of the cost reduction curve	-
	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 industrialised countries, no local manufacturer has arisen so far	Medium

(*Table continued*)

	Contribute to the sustainable development of a country/region	The contributions to the overall sustainable development of the current portfolio are limited to the direct economic and the environmental impact (see below). Criteria less important in Part 1 of the cost reduction curve.	Medium
	Reduce environmental impact	Is in principle the case but depends on the quality of the plants realised (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
	Assure acceptability of technology in regions to which CSP electricity is exported	So far no export of electricity is foreseen for any of the 4 GEF/WB 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.	-
	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 and the fact that the main CSP development strategy can only occur through the contribution to bulk power generation, although diversification is an important step at a later stage.	-

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 finalisation).
- The weakest point seems to be the fact that currently ***no incentives are given to actually operate the installed solar fields in the ISCC 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 delicate that the solar field will not be operated. Punishments on an kWh_{th}-basis for the solar field might a possibility to mitigate that weak point.
- 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 GEF/WB portfolio countries in difference for example with Algeria where 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-fletched 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 the 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 GEF/WB Portfolio

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

(1) Can the rational to include CSP in the OP7 objectives be confirmed ?

The background to the recommendations given 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 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 OP7*** 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 sits favourably in terms of technology development – no exotic material breakthroughs are required, it comprises thermal processes which 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 are able to be undertaken relatively easily and without too much dependence upon 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 world-wide 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, one because we believe they are crucial to building momentum in the solar thermal industry, and two because 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 to release of 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 the writing of this report the question has been raised whether the present portfolio context is not similar to a few years ago where hopes were high for an immediate realisation of the WB/GEF projects which have not materialised so far. However, there are substantial differences in the context now, as there are: considerably higher energy price context, concrete CSP projects coming up in the developed world, stabilisation of the business model (move from the IPP approach to public EPC).

(3) Are there particular conditions for the continuation of the portfolio ?

However, given the time elapsed for the project portfolio, ***the country itself needs to 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:

4. Release of RfP (i. e. must have passed "non-objection")
5. Assessment of bids and presentation of preferred bidders to WB
6. Signing of contracts

Such timelines need to be discussed and fixed with each of the four countries individually. From the current perspective it appears as realistic that by the end of 2006 the Moroccan pro-

ject 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 would be such as may 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 labour. However we could not see that this would be money well spent given the tenuous chance of immediate subsequent projects in those countries.

There was also the possibility of splitting the grant into 2 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 1-2 projects, and the wish of the GEF/WB to support further this important technology in the given country without looking for alternative sites, the following alternative technology lines to the ISCC 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.

(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 %. 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 % 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 are not likely to be fundamental in nature, but rather to do with optimizing energy flows, particularly under transient solar conditions.

ISCC makes particularly 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 case of 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 ISCC technology is not a frank yes but there are some arguments that point to ISCC as a suitable solution for the current phase of market introduction. Nevertheless, ***the ISCC choice has introduced a variety of additional problems that have delayed project realisation*** (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 technol-***

ogy 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 this stage baulk 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 2 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, and willing to take on the whole project, the single EPC approach appears favoured.

There is no fundamental reason why the 2 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 very well defined in the specifications, requiring a detailed design and optimization study. In the single EPC, the consortium carries out the optimisation 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^{o}C steam temperature, yet the steam turbine requires perhaps 500^{o}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. So that if the superheater area was designed for say 370^{o}C to enable troughs using htf to comply, it would be an excessive area for say a tower that could supply the full 500^{o}C. The end result is that the HRSG ends up being designed to suit a particular solar temperature, and thus 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

($220{,}000m^2 \pm 3$ %) for the troughs. Given that the grant from GEF is also a fixed amount, there is no flexibility should costs come in higher than was 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 off-load some of the solar field cost against the combined cycle power block cost to make the solar field appear more attractive on a $/MWh 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 US$50M[33] 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 (refer 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 of the order of 10-20 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).

33 the exact amount is 194.2 million US$

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 US, to help underwrite significant deployment activity. Nonetheless, at this point in time, there is less than 300 MW 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 in time though, the industry is totally reliant on external financial incentives, and 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 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 RPS's in the US, although we feel that something like the US South-West CSP Initiative needs to be confirmed with strong financial incentives attached for a robust CSP market to develop in the US.

At this point in time the industry still appears fragile. However once construction is well underway 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 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, the economic conditions by then will dominate the decisions.

6.6.3 Specific recommendations on the four GEF/WB projects

(9) What are the chances/risks of each of the four GEF/WB projects to reach realisation ?

Egypt:

It must be recognised that currently Egypt is a net exporter of energy, namely through its reserves of oil and natural gas and provides valuable foreign income. However, the Egyptian Government does recognise that these reserves of oil and gas do have a finite life. The Egyptian Government further recognises that it has good renewable energy resources such as wind and solar insulation that can be exploited. Additionally the Egyptian Government has as one its primary objectives the expansion of its manufacturing industry that includes the manufacture of components for its energy sector. The Egyptian Government recognises 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 Egyptian Government recognises that the GEF grant has provided the catalyst to explore the application of solar thermal technologies.

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

- An issue that needs to be resolved before the first project can progress further are:
  - Agreement being reached between NREA and the World Bank with regard to incremental costs not only covering capital costs but also operation and maintenance 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. Fichtner Solar is currently preparing the two bid documents. Although this approach has many unknowns (see the discussion in section 6.6.2), it is an occasion to learn on a different institutional arrangement for the contract.
- The RfP does allow for a broad range of collector technologies (trough, dish, tower, Fresnel) to be bidded for. This will stimulate the level of interest in the Egyptian project and reduce the probability of no successful bidders being found.
- Flexibility must be allowed to explore JBIC's request for two bid documents, but once any concerns with regards to this approach have been resolved then careful management of timelines to execute the project must be maintained.
- To stimulate Egyptian interest in implementing further solar thermal power projects it is recommended that the World Bank seriously consider a role in facilitating:

   - Egypt establish 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.
   - the 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.

- The World Bank keep the ISCC 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 between the four countries and reduce the communications load off of the WB.

India

The following is recommended for India:

- There are 2 prime outstanding issues for India before the project can progress further
   - a reply from the GoI to the World Bank letter of 2004 stating they are committed to the project proceeding and meeting the requirements stated therein.
   - A resolution of the balance of funding from KfW, which is the subject of a meeting understood to be planned for May 2005.

  Without these issues resolved, it is difficult to see the Indian project proceeding further.
- 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 underway. 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 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 110MW combined cycle was mentioned, but the existing steam turbine would need resizing to accommodate a 30MW solar field, or a smaller solar field. The Mathania solar resource of 2240kWh/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 2-3 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 ground-work 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 CSP market. A Mexican company has already provided structures for the Californian SEGS collectors. In the future, over 50 % of the solar field invest 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.

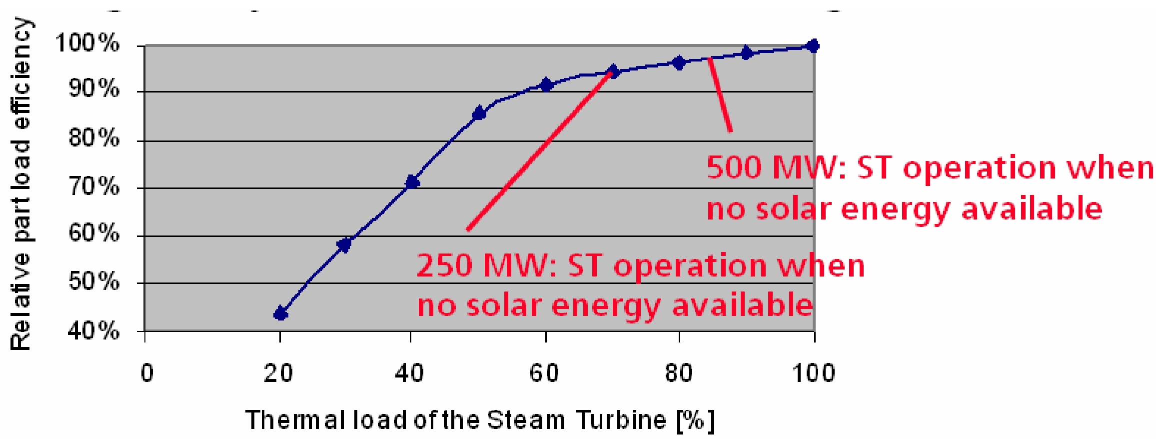
Recommendations on the Mexican project

Given the fact that in the long run, the country will profit from CSP technology and that CFE shows strong interest in the current ISCC project, it is recommended to maintain the GEF/WB 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 % of its original contribution, should not be grounds (from an energetic, ecological or economical 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.

We are unsure if the same methodology has been used to model annual output in both the Sargent & Lundy (2004) feasibility study and the earlier Spencer (2000) study, and for clarification suggest this is reviewed.

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



Diluting the solar share of the plant does not appear as a decisive argument against the 500 MW plant because high solar shares anyway are not among the advantages of the ISCC concept. 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 ISCC 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 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 concepts is strongly recommended.

In any case it is also recommended that CFE, 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 Moroccan project appears from the current perspective the most advanced of the four GEF/WB projects. It is therefore a key project in the portfolio and important for the whole GEF programme 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 a particular attention to the Morocco project so that delays are cut down to a minimum and the deadlines as proposed currently, with contract signature by January 2006 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 (currently, the non-objection of the World Bank to the bidding documents as proposed by Fichtner Solar and ONE is awaiting). 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 ISCC 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 GEF/WB CSP portfolio

This section provides answers to the questions addressing the long-term development of the GEF/WB CSP portfolio raised in Chapter 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 which are important for the future development of the GEF/WB 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 Chapters 5.4 to 5.6 ("Wait and See", "2-Track-Approach", Specialisation") 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 5.4) is incompatible with the success criteria and OP7 main objective: The "Wait and See" strategy described in Chapter 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 entrance of this chapter.

Pursuing the "Specialisation" strategy now will for some decades only lead to a limited contribution to a path towards 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 "Specialisation" 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 towards reduced CO_2 emissions for some decades. However, in the absence of a more ambitious strategy in 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 GEF/WB strategy concentrate on regions with 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 best chances to create volume markets*** (Criteria 4) in the shortest time and should not disperse efforts. OP 7 is at first independent from a particular region on focussing on the technology. How-ever, 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***[34]. 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 GEF/WB portfolio and the ISCC 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), Criteria 12 (if the current GEF/WB portfolio is successful). A successful strategy in this area must enhance the partially fulfilled criteria in other countries and in particular (1) stabilise and increase the participation of the European Mediterranean countries and Israel (2) Replicate the current GEF/WB portfolio in Morocco and Egypt (3) Support the current efforts in Algeria (4) Activate stronger and support the CSP efforts in Jordan and Iran (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 the power sector development. In some or all cases this might be ISCC technology, either because it best fits the needs of the economy (Algeria) or because it insures 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

[34] 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).

such as Spain which have a different weighting of the criteria in the early stage of the cost reduction curve, in particular of 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 combined with the nascent efforts to create an 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[35] could gain interest from a strong uptake of CSP in the South West of the US or from a strong national strategy for CSP. India constitutes similar to China a market in its own, but is hampered by the complexity of the decision levels that has manifested in the current GEF/WB portfolio. A minimum requirement for this market to be considered is a successful implementation of the corresponding current GEF/WB 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 efficient 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 6.1.

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 said that for the developing countries about 200-300 MW of solar thermal power are to be installed by say 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 the minimum another four projects in the Mediterranean/ Middle East region. Out of these projects, each one in the range of 30-50 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 financing but at small amounts 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

[35] Mexico's long-term-prospects of solar electricity export (to the USA) are less promising compared to North Africa and Middle East (to Europe). Because the USA themselves have huge solar resources (irradiation and land) in contrast to Europe.

phase of the cost reduction curve (developing countries only) might be around 200-300 million Euro.

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 ISCC 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[36] the promoted technology options should be wider (see power cycle integration options in chapter 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 emphasised 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 it should also be discussed to operate future CSP plants under the IPP scheme in sufficiently liberalised markets. The commitment of the plant operator would also be leveraged by the fact that the total plant financing has to provide for. The plant operator would get its electricity remuneration in a strong currency (e.g. US$/MWh), potentially with a GEF implementing agency (e.g. WB) 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:

[36] 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)[37] discribes 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 industrialised 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 programme, 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 of how the 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 be a guidance of how to develop for example a Mediterranean/Middle East centred fund. The aim of the vision developed by DLR (2004) is, as described above, to implement 5000 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 Euro (required with a 15 % 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 significantly be reduced. As a consequence the investors' expected internal rate of return of the projects will be reduced from 15% down to 8 %[38]. Through such a mechanism alone the additional costs of the market introduction are calculated to be lowered to about 12 billion Euro. 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 Euro if the carbon pricing is added with a carbon price increasing from initially 7.5 Euro/t CO_2 to 30

37 GMI (2003) emphasises 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 favourable 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.

38 Given the fact that this not equity interest but project IRR with mixed financing (debt and equity), the used interest rate of 15% 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% (in real terms) appears as a realistic if not conservative assumption.

Euro/t CO_2 in 2050. If every project receiving financing from the fund revolves a unique fee of 21 million Euro to the fund, the market introduction cost is lowered to 1.75 million Euro. Under these conditions by 2015 and with 5000 MW installed power a price can be achieved that can be covered from the electricity sales and carbon financing. Starting 2023 and with an installed power of 20 GW a cost level is reached that covers cost also with conventional project financing and carbon financing. Starting 2030 solar power plants would be according to the calculations also cost competitive without carbon financing. It must be emphasised that the ATHENE approach is a rather conservative approach to estimate cost competitiveness (see also chapter 2.3.2). If the market introduction is realised according to the calculations of the ATHENE model, the 1.75 billion Euro initial market financing flows back to the fund with an Internal Rate of Return of 4 % and will achieve a surplus between 2020 and 2050 of about 8 billion Euro. 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 % 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 organises its CSP funding according to the above-mentioned fund in order to reduce risk and thereby significantly the technology's market introduction costs. On the other hand, the environmental and economical benefit of the funding will significantly be enhanced by motivating the power producers to produce MWh instead of MW.

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

Necessary GEF (and other donor) CSP engagement accounts to US$ 44 million on an annual average up to around 2025e: Under the assumption that 35 % of the CSP installations by 2025 will be installed and operated in developing countries, the cumulated subsidies would account to 875 million €[39], respectively US$ 1.12 billion[40]. If it is further assumed that 30 % of this amount will be borne by countries like Algeria from own national means, an amount of 610 million €, respectively US$ 786 million has to be financed by international funding. If the GEF is supposed to finance this part, on an average US$ 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 accounts to US$ 189 million.

39 Under the assumption of a project IRR of 8% without revolving fee of 21 million €.

40 Exchange rate (May 10, 2005) 1€ = 1.2835 US$

(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, the following two alternatives are being suggested:

- 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 organisations 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[41]
- In the case of significantly reduced financial means for future CSP projects in combination with the wish of the GEF/WB to support further this important technology, the following technology lines (alternative to the ISCC) concept might be considered (see also chapter 2.2):
    - Feed-water preheating in fossil steam plants (approximate invest: US$ 10 million for 10 MW_e): 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.
    - 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).
    - Industrial process heat applications of 200-1000 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) which have to be met by the projects have to be defined by the GEF/WB, for example:
    - Multiplication effect (the project suggestion should make clear that it is a pilot project which will induce several successors of its kind.)
    - Environmental benefit

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41 German Federal Ministry for Economic Cooperation and Development (BMZ) / KfW Entwicklungsbank *Special Facility for Renewable Energies and Energy Efficiency* (budget of € 500 million over 5 years for soft loans for RES projects in Developing countries.)

- Cost-effective use of GEF-funding (possibly based on a criterion like solar MWh per $)
- Social benefit (the project should prove that it will have a positive impact on social and economic aspects)

Based on such criteria, bidders are invited to present their project ideas, without limitations concerning the collector technology nor the heat usage (power, heat, cooling etc.), without limitations concerning countries, possibly even without limitations concerning the budget[42]. Possible technology options are given in chapter 2.2.2, 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 ISCC portfolio might not come to successful implementation.

42 Depending on the available budget more capital intensive power options like SEGS plants are to favoured.

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Annex 1: Characterisation of the Status of Important Ongoing CSP Projects World-wide (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 of 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 was 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 % and the EIB with a profit-sharing loan (QUASI EQUITY). BUILD OWN OPERATE contract or BOO/BOT, "non recourse". Sonatrach has engaged themselves to buy the electric-ity (NEAL: a company set up by SONATRACH, SONELGAZ and SIM to carry out projects that make use of renewable energy. Sonatrach: National company for the production, transport and commercialisation of hydro-carbons. Sonelgaz: Electricity and Gas Company of Algeria. BEA: Banque Extérieure d'Algérie).
Liability provisions	
Status of plant	Ahead of the bidding process
Expected project time schedule	Invitation for expressions of interest launched on 8 June 2004. The publication of the bidding call is still pend-ing. Originally planned for September 2004 with contract award December 2004 and project start by September 2005. Start of bidding procedure expected towards summer
Project developer / Prequalified De-velopers	NEAL is the project developer. Following the invitation for expressions of interest launched on 8 June 2004 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	Agregate investment: 177 million US$ (of which EPC 143.9, intercalary interests 12, preliminary costs 0.5, con-tingency 4.3, customs taxes 5.3). Investments of nearly 140 million dollars will be contributed by the German investment bank KFW in preferential rate loans and the European Investment Bank (EIB). The BEA will syndi-cate with the EIB the portion in dinars.
Final owner of plant	Foreign investor or consortium
Institutional frame for renewables in host country	➢ Algeria has set up a national programme for the promotion of renewable energy sources in the frame of a sustainable development up to 2020 (5-years programme) (Law N° 04-09 of 14 August 2004 relative to the Promotion 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 envis-

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aged 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 % of the total electricity to be produced by 2010, by introducing incentive measures for all the branches of energies used to produce electricity. Premiums for each kWh from renewables 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".
<table>
<tr><th>Type of renewables</th><th>Premiums (expressed as a percentage of the electricity price per kWh defined by the market operator)</th></tr>
<tr><td>Electricity from solar thermal – natural gas hybrid plants</td><td>200 % if the contribution of solar energy represents a minimum of 25 % of the total primary energy, 180 % if the solar share is 20-25 %, 160 % if the solar share is 15-20 %, 140 % if the solar share is 10-15 %,100 % if the solar share is 5-10 %, no premium below 5 %.</td></tr>
<tr><td>Electricity from solar only (PV or solar thermal)</td><td>300 %</td></tr>
<tr><td>Electricity from wastes</td><td>200 %</td></tr>
<tr><td>Hydro power</td><td>100 %</td></tr>
<tr><td>Wind power</td><td>300 %</td></tr>
<tr><td>CHP</td><td>160 % (the production capacities should not exceed 50 MW).</td></tr>
</table>
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 % of the total plant output: This would lead to a production premium of 140 % on the conventional price estimated at 2.2 cUS$/kWh
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<td>Institutional frame in host country for the electricity market</td>
<td>Electricity is currently growing at around 4 % a year. The additional requirements in production capacity are estimated at 6000 MW for the period mentioned. The law 02-01 on electricity and distribution of gas from February 2002 has liberalised the electricity sector by opening production and distribution to competition. This law is in the perspective of an interconnected and liberalised Euro-Maghreb market comprising the neighbours of Algeria and the closest European countries (signature of the Rome agreement in December 2003 by three Maghreb countries and the European Commission in view of a common electricity market starting 2006). This law also</td>
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</table>

	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" constituted 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 1200 MW, ➢ under-sea connection cables with a minimum capacity of 2000 MW linking Algeria to Spain. to reach the European markets. In addition Algeria investigates the possibility of a second project of 500 – 1000 MW destined also to electricity export via an under-sea cable that links Algeria to Italy (Sardinia), see Figure 17.
Key governmental institutions and their interests	The contribution of revenues from oil and natural gas was 55 % of the state budget, 97 % of foreign currency inflow and about 40 % of the GDP. Algeria has therefore on the one hand an interest to export gas but on the other hand also a need to diversify the economy. Algeria is exporting 95 % of it exportations to Europe. One main objective for Algeria, being a producer for gas, is to export this energy carrier, in particular to Europe (Algeria envisages to increase 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 Europ 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, the living standard and its industrialisation. 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 liberalisation.
Near-term strategy for CSP in the country	Algeria has considered, in addition to the presently planned ISCC plant the following two options, but no concrete plans exist for the moment (2) Size 306 MW (combined cycle 258.8 MW net, solar field 54.1 MW net. (3) 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 realisation: ➢ *Project Kahrama at Arzew 321 MW:* combined cycle unit coupled to a sea water desalination unit of 90.000 m^3/day. Total project cost is 400 million US$. Financing is assured to 80 % by the company Black & Veatch and to 20 % by the Algerian Energy Company (AEC), a mixed Algerian company between Sonatrach and Sonelgaz. ➢ *Project Sharikat Kahraba Skikda (SKS) 824 MW:* combined cycle unit Total project cost is 460 million US$. Financing is assured to 20 % by the company SNC Lavallin and to 80 % 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

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<td>venture has been launched:
➢ Project de Hadjerat Nouss – bidding call - 1400 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 % and the remainder from public Algerian companies (SONELGAZ, SONATRACH and AEC).
Project Sharikat Kahraba Berrouaghia 400-500 MW (EPC won by Siemens).</td>
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<tr>
<td>View of the country on a mid-term strategy for CSP with possible future options (5-10 years)</td>
<td>Algeria envisages 500 MW generating power from renewables in 2010 and further strongly increasing power generation both for the local use and for the export from 2010 to 2020. The first electric cables linking Algeria and Europe are currently investigated or in the starting phase.
<table>
<tr><td>Year</td><td colspan="2">Renewable Energy Capacities (MW)</td></tr>
<tr><td></td><td>Local</td><td>Export</td></tr>
<tr><td>2010</td><td>500</td><td>200</td></tr>
<tr><td>2015</td><td>1000</td><td>400</td></tr>
<tr><td>2020</td><td>1500</td><td>6000</td></tr>
</table>
The first 500 MW for local production are supposed to be 400 MW solar thermal capacity (corresponding to 2200 MW hybrid plants, and to 100 MW wind energy and other renewable energy sources. Investment costs will be of the order of 2 billion US$. After 2015, Algeria believes that it will be possible to construct solar-only CSP, as they will be competitive with the combined cycle plants.</td>
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</table>

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 m2 to provide 285°C/70 bar steam to the feedwater cycle of a 500 MW steam turbine. 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
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 where this project is located has a deregulated electricity structure, with generation supply bid competitively into a pool. Generators are separate organisations 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, and certificate prices presently sit 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 NGAC's on top of the REC's worth approximately AU1c/kWh. An Energy White Paper was released by the Australian Government late 2004, which 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 organisations 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 3 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 prices of wind, which are presently around AU7-8c/kWh. There still appears to be a good availability of good wind sites. Good solar sites are abundant, and hybridising 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 2500kWh/m2/yr
Business model (as per 2002 proposal 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 366,240m2. 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 $322M (incl existing GT's $67M) comprising $150M Iranian Ministry of Energy, $50M GEF (note this is not a GEF project), $55M balance from eg soft loans (note $10M 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 towards 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 organise 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/m2/yr DNI. Approximately 9km2 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 $115M

	would result in an additional net electricity generation of 964 GWh/yr and upgrade the plant efficiency from 32.2 % to 50.2 %. The solar field, costing around $138M, would further improve annual average efficiency to 53.1 %.
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	US$250M for 100 MW, expected to yield LEC of 9c/kWh.
Final owner of plant	IPP
Key governmental institutions and their interests	Public Utilities Authority (Electricity) responsible for setting strategic targets such as the national need for CSP to be developed. Israel Electric 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 $250M investment cost. The IEC approved this on the basis that IEA approves e 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/m2
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	Eskom undertook a prefeasibility study on CSP technologies. In the first task fourteen CSP technologies and/or variations were identified to be studied further. Information on the technologies were 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 screen 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 the conducting of 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 optimised to provide the lowest Levelised 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. Eskom 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 thermal 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 Eskom's decision towards the further investigation into central receiver option. Eskom 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 Eskom
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 the 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. Recognising 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 on the Energy Policy: ➢ 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 underpinned by growth in industrial, mining and commercial sectors. The NIRP has estimated that about 2640 MW of **new peaking generation capacity** will be required between 2006 and 2010. These requirements for new capacity are over and above the need to return to service the mothballed coal fired power plants as currently planned by Eskom. 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 Cabinet. The aim of the policy is to create the conditions for the development and commercial implementation of Renewable Energy. This includes: ➢ Ensuring that economically feasible technologies and applications are implemented through the development and implementation of an appropriate programme. ➢ 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 2004-2013. Renewable Energy will be used for power generation to the grid and for water heating. Non-grid applications will be integrated in the Electrification Programme and research and development within the 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; a policy that 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 utilised for power generation and non-electric technologies such as solar water heating and bio-fuels. *This is approximately 4 % (1667 MW) of the projected electricity demand for 2013 (41539 MW).* Some of the main benefits of the Renewable Energy White Paper will be renewable energy for rural communities, 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 utilisation of renewable energy will also reduce the emissions of carbon dioxide, thus contributing to an improved environment both locally and worldwide.

<table>
<tr><td>Key governmental institutions and their interests</td><td>The key institutions that influence the electricity sector, including Eskom in adopting new technologies such `as solar thermal systems are:

The Department of Minerals and Energy. The DME establishes energy policy and legislation as well as provides direction, through planning processes, as to what courses of actions are to be undertaken to meet energy policy objectives.

The Department of Science & Technology. The DST together with DME has formulated an energy research and development strategy for SA. One of the areas identified for R&D is renewable energy.

Department of Public Enterprises. Eskom, as a public enterprise, reports directly to this department.

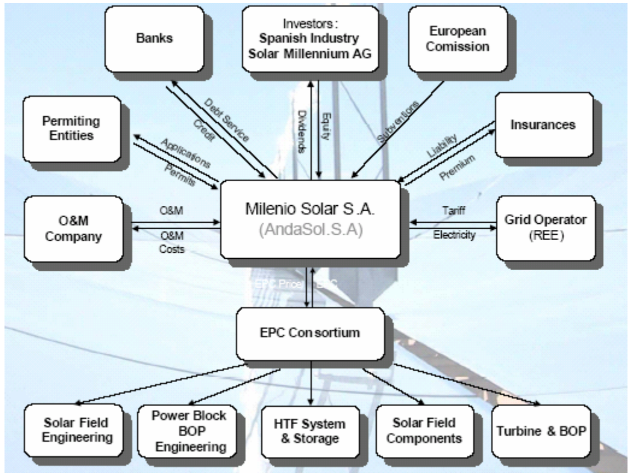
The National Electricity Regulator (NER). The NER sets tariff prices as well as granting licences for electricity production. Any new electricity generation facility will need to ensure that it complies with regulations as managed by the NER.</td></tr>
<tr><td>Expected LEC (in SA Rands)</td><td>In the prefeasability study full component costs & maintenance cost figures were determined for the base case plants. These figures were used to calculate the cost of productions over the plants lifetimes. A comparison was done for the trough and tower technologies

<table>
<tr><th>Parameter</th><th>Trough</th><th>Tower</th></tr>
<tr><td>Capacity, MWe</td><td>100</td><td>100</td></tr>
<tr><td>Annual capacity factor</td><td>0.4</td><td>0.51</td></tr>
<tr><td>Winter Peak Capacity Factor</td><td>0.87</td><td>0.98</td></tr>
<tr><td>Summer peak capacity factor</td><td>0.86</td><td>0.86</td></tr>
<tr><td>Capital cost (1000 Rand/kW)</td><td>22.5</td><td>22.2</td></tr>
<tr><td>Annual O&M costs (Millions Rands)</td><td>24.2</td><td>19.0</td></tr>
<tr><td>LEC (R/kWh)</td><td>0.5</td><td>0.39</td></tr>
</table>
</td></tr>
<tr><td>Near-term strategy for the country</td><td>CSP will cost more that Eskom’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.</td></tr>
<tr><td>Mid-term strategy for the country with possible future options (maybe 10 years)</td><td>See above</td></tr>
<tr><td>Suggested approach to improve chances of CSP success in South Africa</td><td>Coal Resource/Reserve
South Africa's current coal resource/reserve information (of 55 billion tonnes of reserves and 115 billion</td></tr>
</table>

	tonnes 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 in 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 deemed paramount 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 re-evaluate the amount of coal available in the national coal resource/reserve base, but also the amount of coal that 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 undertake the investigation. Coal is the second largest earner of foreign exchange in South Africa today and coal energy is used by different sectors of the South African economy. Coal composition is a complex structure of organic and inorganic components, which determine its specific characteristics. The efficient utilisation of coal reserves demands the production of different but very specific saleable products to satisfy the market requirements. The outcome of this study is very likely to influence decisions on how the remainder of SA's coal reserves will be utilised. **Coal Discards** The result of the beneficiation of South African coals are the generation of approximately 60 million tonnes per annum of discard coal, which is estimated to have already accumulated to more than 1 billion tonnes. These large amounts of carbonaceous material impact negatively on the environment while it simultaneously contains significant amounts of usable coal. Discard coal is therefore a major concern to the Department of Minerals and Energy regarding the potential future environmnental impact. It poses the challenge of being a major resource that provides an economic opportunity through its utilisation. In 2001, the Department of Minerals and Energy commissioned a survey to establish an inventory of the discard 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 ➢ Eskom (SA electricity utility) The primary objective of SA Government is to alleviate poverty by creating an enabling environment for socio-economic development to take place. This is primarily planned 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 & awareness of the technology in the "host" country. Here a "critical mass" of knowledge & expertise is required. Key issues to be considered in developing local knowledge & expertise are: Knowledge transfer precedes technology transfer Knowledge enables wider choices to be made and increases the probability of new technologies being accepted by all stakeholders Complete technology transfer is sensitive to the sociological dimension - ensures complete "ownership" Human pride & dignity taken into account With regards to barriers for solar thermal technologies in developing countries technology transfer is made up of 2 legs, technology push and market-pull. As far as technology push is concerned, this is well established, understood, well resourced and well organised as this issue has been heavily influenced by stakeholders which are mostly if not all from the developed world. 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 that has to be formulated with stakeholders from the developing world. Without active participation and 'championing' 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 towards meeting the objectives of the Millennium Development goals ➢ Implemented SA's energy policy taking into account that SA's coal reserves do have a limited life ➢ Implementation of the energy efficiency policy with encouragement on the utilisation of clean coal technologies ➢ Within the context of the renewable energy & energy efficiency policy encourage the exploitation of SA's renewable energy resource to meet the targets that have been established by Government

	➢ Develop local expertise, know-how and intellectual capital ➢ Establish local manufacturing enterprises to position themselves 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 GWhe (gross)/yr; 15 MWh sat steam thermal storage (25min @ full load)
Business model	EPC Consortium	EPC
Status of plants	SKAL-ET loop tested in SEGS V; all permitting applications 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 received 5M Euro for preparatory work. Construction underway
Expected project time schedule	Commence construction mid to late 2005, commence operation approx 24 months later	
Project developer & owner	Milenio Solar S.A., AndaSol-2 S.A. (now held 70 % by ACS Cobra, 30 % 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 Euro  Solar 2004, Paul Nava, Flagsol	Total capital investment cost 33M Euro
Country	Spain/ Solar Tres	Spain/ EuroSEGS

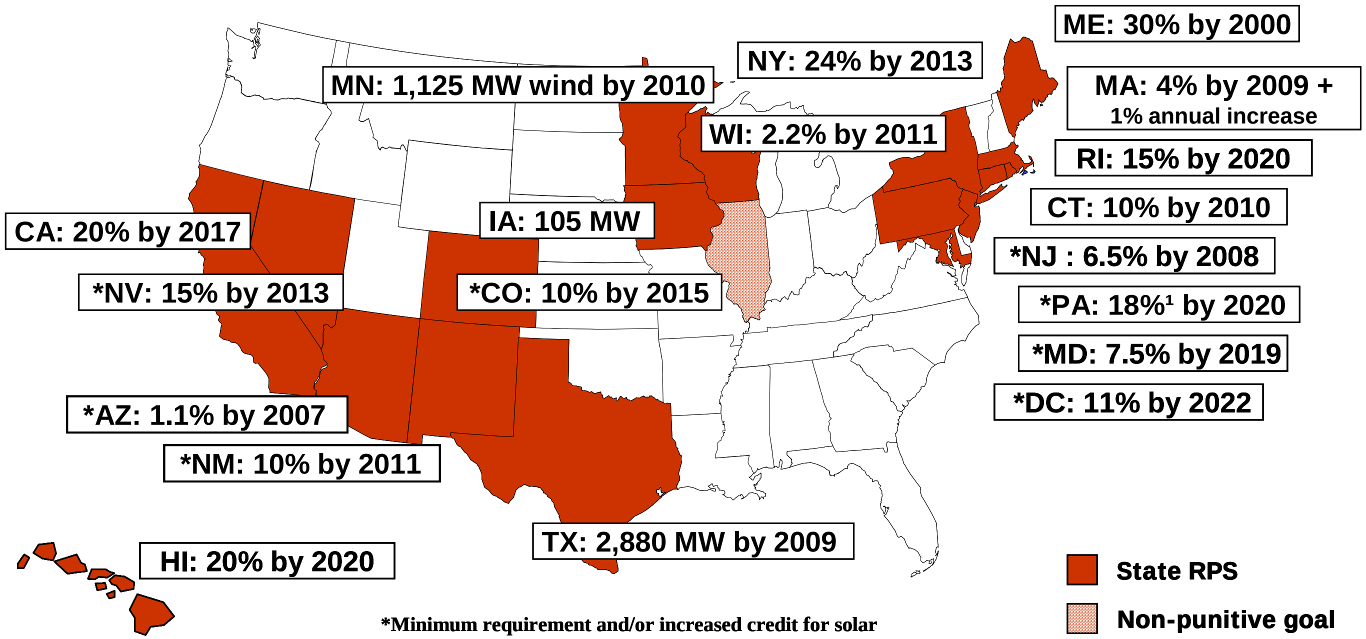
Type of technology	Tower with molten salt	Trough (oil htf)
Technical parameters	15 MWe, approx 240,000 m^2 (heliostats) considering 16hrs full load thermal storage, 78.8 GWhe/yr	15 MWe, 95,880m2, originally proposed to use two different types of solar collector, solar radiation at this site poor compared to other Spain sites
Business model	IPP	IPP
Status of plants	Activity in this project has recommenced with the announcement of the new tariffs in Spain.	Prefeasibility study, site assessment, pre-engineering of power block and soalr field all completed
Expected project time schedule	Operation in 2006	Not known
Project developer & owner	Ghersa, assisted in technical design by Boeing and Nexant (these 3 companies have formed Solar Tres)	EHN
Financing and project structure	2002 estimate $72M	2002 estimate $45M
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 0.21Euro/kWh, allows 12-15 % gas backup for purposes of dispatchability and firm capacity, is secure for 25yrs (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 downwards 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 18Eurocents/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 future 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 instalment 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	50 MWe (net)	1 MWe, 2000 MWh annual generation, O&M US$0.0291/kWh, 95 % plant availability, 10,346m^2 aperture,
Business model	EPC	
Status of plant	Successful EPC expected to be awarded this month; Financial close within a couple of months;	Construction commenced March 2004, Expected start-up 2005
Project developer / Prequalified Developers	Solargenix is project developer; 4 large companies 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 US map below). In Arizona, the standard goes further to specify that 60 % of the RPS must be solar electric.	
Tariff structure in country	The retailing of electricity in the US 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 US will be influenced largely by statutory requirements based on regulation or legislation. The major policy driver at present for CSP in the US is the "1000 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 US West. A comprehensive study of CSP options for New Mexico ahs just been completed. The South West of the USA is a rapidly growing area with a corresponding need for increased power. As this is also the sunbelt of the USA, 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 US 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 programmes. The next stage for CSP in the US 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 technolo-	

	gies. Under the present RPS of the 4 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 generation required in these four states over the net 3-5 years of which 87.6 % is natural gas. There is an estimated 7,858,560 MW of solar capacity potential from these 4 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 SW USA.

DSIRE: www.dsireusa.org **March 2005**

Renewables Portfolio Standards

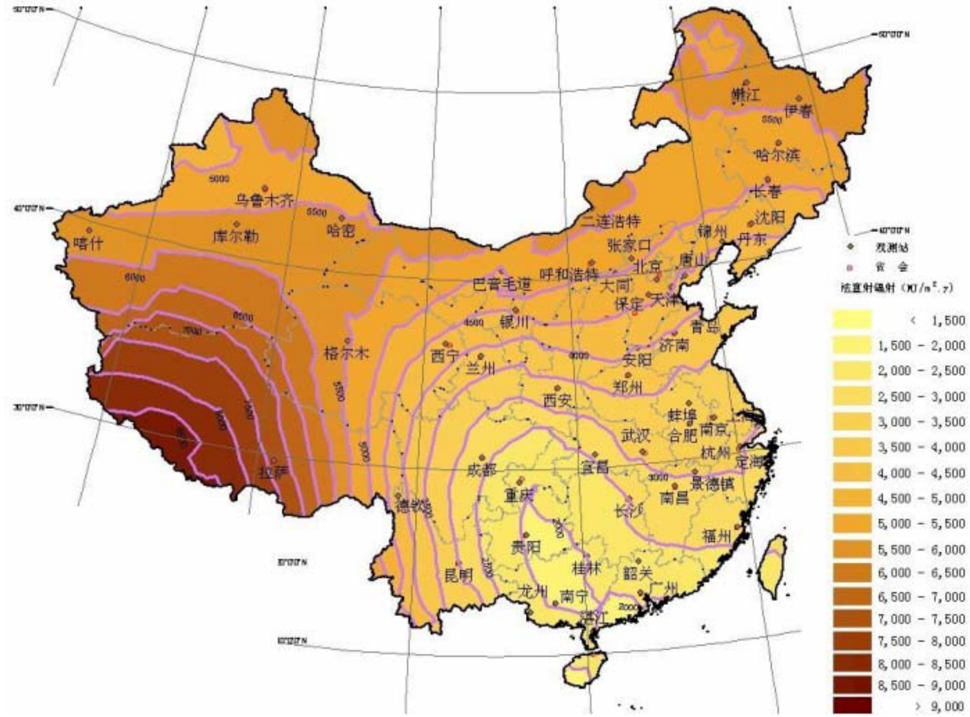


*Minimum requirement and/or increased credit for solar
[1] PA: 8% Tier I, 10% Tier II (includes non-renewable sources)

Annex 2: The Frame 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 % 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 Energies in the scale of: 60 GWe by 2010 RES 121 GWe by 2020 RES RES for heat supply and biofuels China’s RES goals are also implemented in national frameworks on a 5 and 15 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 (5) and create a social atmosphere conducive to renewable energy. This law is considered as a strategic investment not only into clean energy but also into 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.

<table>
<tr>
<td>Near- and long-term strategy for CSP in the country</td>
<td>
Solar Resources in China (DNI-map, Source):



Especially in the South West of the country, solar conditions are favourable to CSP.

The Chinese Academy of Science is developing different types of solar collectors for the 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 favourable RES-conditions, a pilot project could induce a significant multiplication-effect for CSP market development. On the long-term, CSP being a dispatchable power source, can (to some extent) be a safe and clean alternative to nuclear energy.
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</table>

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 to 12 ct/kWh. The plants have proven a maximum efficiency of 21 % 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 the 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 1200 °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 pressurised solar receiver with a solar window. Combined cycle power plants using this method will require 30 % less collector area than equivalent steam cycles.

Parabolic Dish

Parabolic dish concentrators are 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, respectively. 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 decentralised power supply and remote, stand-alone power systems.

Annex 4: Characterisation of the GEF 4-Country Portfolio (Description of each of the 4 projects according to a set of criteria)

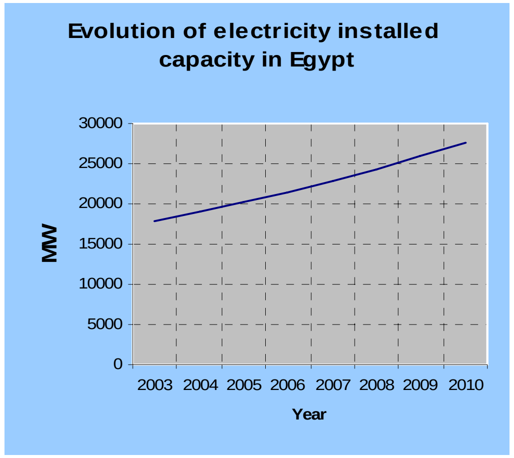
Egypt

Country/Location	**Egypt/Kuraymat**
Type of technology	conventional combined cycle plant with solar thermal power collector (not trough-specified)
Technical parameters (installed MW etc.)	About 90 km South of Cairo. The project site has been selected due to: An uninhabited flat desert landscape, high intensity direct solar radiation that reaches 2400 kWh/m^2/annum, an extended unified power grid and extended natural gas pipeline, near to 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 MW$_e$, 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 ➢ Tow 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$_e$. ➢ 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 of parallel rows of Solar Collector Arrays (SCAs), sets of typical mirrors – that 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 000m^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 400^{0}C. 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.

<table>
<tr><td></td><td>Summary of Technical Parameters of Baseline Design
<table>
<tr><td>Capacity of Solar portion (MW_e)</td><td>30</td></tr>
<tr><td>Capacity of gas turbine (MW_e)</td><td>2 X 41.5</td></tr>
<tr><td>Capacity of steam turbine (MW_e)</td><td>68</td></tr>
<tr><td>Net electricity generated (GWh_e/annum)</td><td>985</td></tr>
<tr><td>Exegetic solar generation (GWh_e/a)</td><td>65</td></tr>
<tr><td>Solar share</td><td>6.6 %</td></tr>
<tr><td>Fuel saving due to solar portion (toe/annum)</td><td>14000</td></tr>
<tr><td>CO_2 reduction (Tonnes/annum)</td><td>38000</td></tr>
</table>
</td></tr>
<tr><td>Business model (EPC, separate EPC for solar and fossil, IPP)</td><td>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 cum 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 ISCC plant.
Business models that will be applied will depend on a large extent on future investment policies as presented by the Egyptian government.
Furthermore international investment organisations such as the World Bank, JBOC, KfW should also facilitate investments into the Egyptian manufacturing industry
Egypt derives much of its foreign exchange through exporting crude oil and natural gas.
Solar thermal projects, as well as other Renewable Energy projects has the potential to save Egyptian natural gas, which could then be exported at a premium price, with a small margin (profit), possibly 2 Piasters/kWh, going into a Renewable Energy fund</td></tr>
<tr><td>Liability provisions
(in particular for hybrid)</td><td>NREA will be the owner of the project and the recipient to the GEF's grant. The private sector can participate in the O&M through contracts of limited time frame that will not exceed 5 years.
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 as bidding documents will be designed to be very specific as to how to manage these two island approach.</td></tr>
<tr><td>Status of project</td><td>NREA is waiting for the Japan Bank for international Cooperation (JBIC) final approval for financing the rest of the foreign investment project cost around (97 mil US $) in addition to the GEF grant. NREA will then invite the EPC con-</td></tr>
</table>

	tractors to submit their bids for two packages, one for Combined Cycle island financed by JBIC and the other for Solar island covered by GEF's grant.
Expected project time schedule	(see schedule below)
Financing structure	The current plan is for JBIC to finance the CC island with the GEF grant to cover the incremental cost of the solar power plant.

Conceptual Design Report	3/11/2003
Prequalification Document issued for Solar & CC	12 June 2005
WB non objection of evaluation of PQD	30 Sept 2005
Financing secured (letter of intent from JBIC)	Oct 2005
Issue Bid Documents (two packages)	End Oct 2005
Bidding (first stage)	4 months End Feb 2006
Evaluation by Consultant	45 days Middle April 2006
Review by NREA	15 days End April 2006
Clarification with bidders	1 month End June 2006
Bidding (second stage)	End Aug 2006
I Evaluation by Consultant	45 days Middle Oct 2006
Review by NREA	15 days End Oct 2006
WB non objection	15 days Middle Nov 2006
Negotiation with winning bidder	45 days End DEC2006
Bank appraisal/negotiation of project	2 weeks Middle January 2006
Draft contract prepared	1 month Middle Feb 2007
GEF endorsement	Middle March 2007
WB board approval of grant	Middle April 2007
WB/NREA sign grant agreement	End April 2007
WB non objection on draft contract	2 weeks Middle May 2007
Egyptian Authority approval & ratification (incl financing)	Middle April 2007
Consulting contract for project management in place	End May 2007
Contract signature	End May 2007
Contract effectiveness	Middle June 2007
Completion of EPC works	30 months Middle Dec 2009

	However, NREA and WB/GEF are currently in negotiation with regards to the incremental costs to not only cover capital costs but also the O&M costs. The discount rate is assumed to be 6 %.
Final owner of plant	NREA
Institutional frame in host country for electricity generation	The Egyptian energy policy depends on three main pillars, namely: Diversifying energy resources; Improving energy efficiency and enhancing energy conservation programs; Maximizing the share of renewable energy (RE) in the energy mix. Fossil fuels (oil, Natural Gas, limited deposits of coal), contribute 85.3 % to the energy mix. Hydro (Nile River), contributes13.7 % to the energy mix. Renewable Energy (RE), mainly from wind, contributes nearly 1 % to the energy mix. Currently, the growing demand rate for electric energy to satisfy Egypt's socio/economic plans ranges between 6.5 - 7.5 % annually during this decade till 2010. The target is to increase the installed capacity from 18600 MW in 2004 to about 27000 MW by 2010. Consequently, Egypt is required to add about 2000 MW/year, as an average, to secure the needed energy supplies. Such expansion plan gives a room enough for a considerable share of electricity generation from RE sources. Securing energy demand on a continuous basis is a vital element for sustained development plans, In view of the 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 

Institutional framework in host country for renewable energy	In 1982, a Renewable Energy strategy was formulated as an integral part of the national energy planning in Egypt. Currently, the strategy targets to cover 3 % of Egypt's electric energy demand by Renewable Energy resources, mainly from solar, wind and Biomass applications by the year 2010, with additional contributions of other Renewable Energy applications. The growing demand of electric energy to satisfy economic and social development plans reaches to about 6 % annually up to 2010. Such expansion plans give a room enough 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. ➢ Education, Training and Information dissemination programs. Taking advantage of renewable energy environmental benefits allowing financial support of it's projects implementation through various mechanisms such as Clean Development Mechanism (CDM), financing RE incremental cost, soft loans, mixed credits etc.
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 15 Piasters/kWh (approx 2.63 cUS/kWh as of April 2005). It has been calculated that for the ISCC the cost of generation will be 4.9 cUS/kWh It should be noted that Egypt's installed generation capacity at 2003/2004 was 18119 MW and with the planned ISCC 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 (USc$/kWh)	The LEC for kWh price of the ISCC plant still uncompetitive compared to other schemes of power generation. (See previous note).
Overall energy situation of Egypt	**Energy policies** Egypt 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 reach the country's 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 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.

Primary Energy Resources

Egypt's main energy resources are oil, natural gas, hydropower, and coal, in addition to good potential of renewable energy resources. Oil and gas accounts for 93.5 % of total commercial energy consumption.

The current level of oil reserves is 3.68 billion Barrels, most of which are 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 % of that production and the balance is exported.

The second major energy resource is natural gas with a current reserves level of about 57 trillion cubic feet (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 investments 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 investments in oil and gas exploration. With an annual production level of 796.4 TCF in 2000/01, it is envisioned that natural gas would play an important role in the country's future energy scene. A gas substitution policy has been adopted and being implemented to promote the use of natural gas in electricity generation, industrial, transport, and residential and commercial utilizations.

Hydropower is the third major energy resource in Egypt; nearly most of the Nile's hydro potential has already been ex-

<table>
<tr><td></td><td>ploited 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 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 and the only commercial mining is in "Maghara", Sinai to produce about 600,000 tons per year. However, the current production is 58,000 tons per year. About 1.8 million tons of coal is being imported now as feedstock for the steel industry.</td></tr>
<tr><td>Near-term strategy for CSP for the Egypt</td><td>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 it is planned that 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.
➢ Consulting services for Project Management and support to NREA's PIU.

An additional activity that NREA is planning on having done is: Survey local equipment suppliers/contractors to establish what components may be provided locally and to inform such suppliers and contractors of the opportunity future projects</td></tr>
<tr><td>Mid-term strategy for the country with possible future options (maybe 10 years)</td><td>NREA developed an ambitious program for large scale electricity generation using Integrated Solar Combined Cycle Power 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 the 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 year 2017 producing 7 TWh/year of electricity for local consumption and export through the interconnected electricity grid to Europe among countries in the region. Such a plan envisages a fuel saving of 64000 TOE at year 2017. In addition it will create valuable chances for technology transfer and job creation opportunities in Egypt and the region

<table>
<tr><td rowspan="2">5 year development plans</td><td rowspan="2">Annual Energy Generation at the end of the period GWh/year</td><td colspan="3">Installed plant rate</td><td rowspan="2">Cumulative Capacity</td><td rowspan="2">Accessible Potentials</td></tr>
<tr><td>No. of plants</td><td>Power Capacity (MW)</td><td>Total Capacity(MW)</td></tr>
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<table>
<tr><td>1997-2002</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2002-2007</td><td>0.95</td><td>1</td><td>150</td><td>150</td><td>150</td><td>70</td></tr>
<tr><td>2007-2012</td><td>3.98</td><td>1</td><td>300</td><td>300</td><td>450</td><td>74</td></tr>
<tr><td>2012-2017</td><td>7</td><td>1</td><td>300</td><td>300</td><td>750</td><td>80</td></tr>
</table>
Accessible potentials and installation plants for solar thermal Electricity Generation
1- Accessible potential: Total capacity that can be installed on 50 % 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", technologies
A possible interconnection system for the Mediterranean basin could be one based on the Figure 17.
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<tr>
<td>Suggested approach to improve chances of CSP success in Egypt</td>
<td>
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 the 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 agreement 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 influencing (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 those countries which 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 mid-1970s. Starting 1976, Egypt has been able not only to meet its own needs of energy, but also to export some oil surplus. 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
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	negligible effort of energy conservation, domestic energy consumption went hand in hand with domestic oil and gas production since 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 has been wasted over a long period of time. Now, with increased awareness of the limitation of oil and gas reserves, and 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 behavioural 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 by new and more efficient ones. Therefore, energy conservation should not be considered as one-time process, but rather as an on-going 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 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 payment. A policy recommendations, 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 2 piasters/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 and to this end is known that wealth is created through the expansion of the manufacturing sector. A manufacturing sector that could be expanded to support an Egyptian solar thermal industry. As indicated by NREA one of the first sets activities to be undertaken in this regard is to: ➢ survey local suppliers/contractors to establish what components can be sourced locally ➢ Training of NREA/EEHC and regulatory staff in solar thermal plant operations, in particular in dispatching and integration into the power system ➢ Monitoring, evaluation & dissemination of performance results both locally & internationally with a view to support future replicability

	Critical success factors for Egypt in the field of solar thermal energy ➢ Implemented Egypt's energy policy taking into account that Egypt's oil & gas reserves do have a limited life ➢ Implementation of energy efficiency policy with encouragement of the retention of oil & gas reserves for local consumption ➢ Within the context of the energy efficiency policy encourage the exploitation of Egypt's renewable energy re-source ➢ Develop the Renewable Energy Fund, financed through a levy on exported oil & gas ➢ Develop local expertise, know-how and intellectual capital ➢ Develop local manufacturing enterprises to take advantage of solar thermal projects.

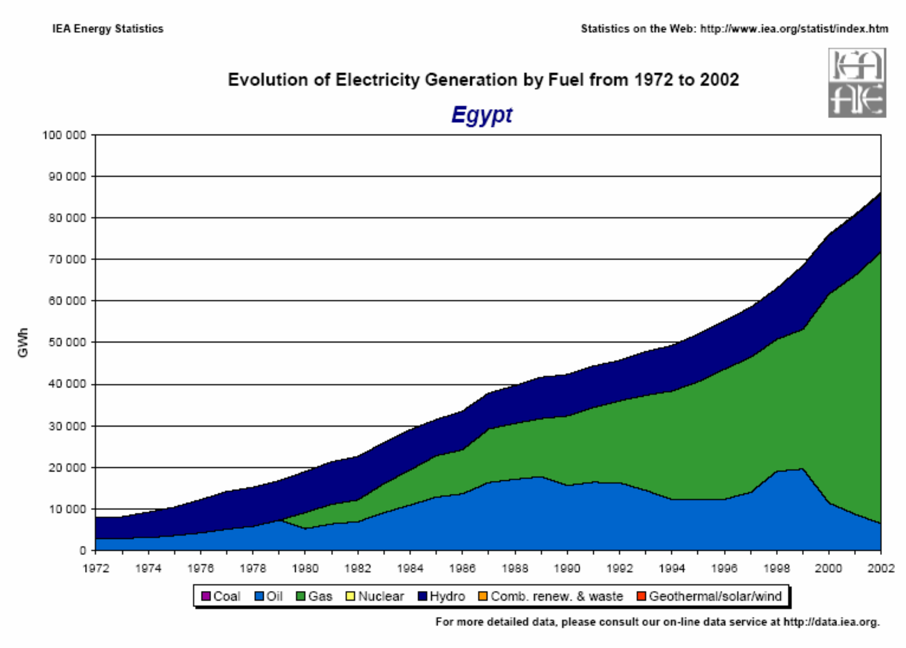
Additional Information for Egypt

An overview of the Egyptian energy situation is outlined in the following paper:
ENERGY SITUATION IN EGYPT, EFFICIENCY PERSPECTIVES
Ibrahim Abdel Gelil
Chairman, Organization for Energy Planning (OEP)
P.O. Box 4604 Cairo 11717, Egypt
Presented to Egypt Energy Day
Executive Assembly, WEC
24 Oct. 2002

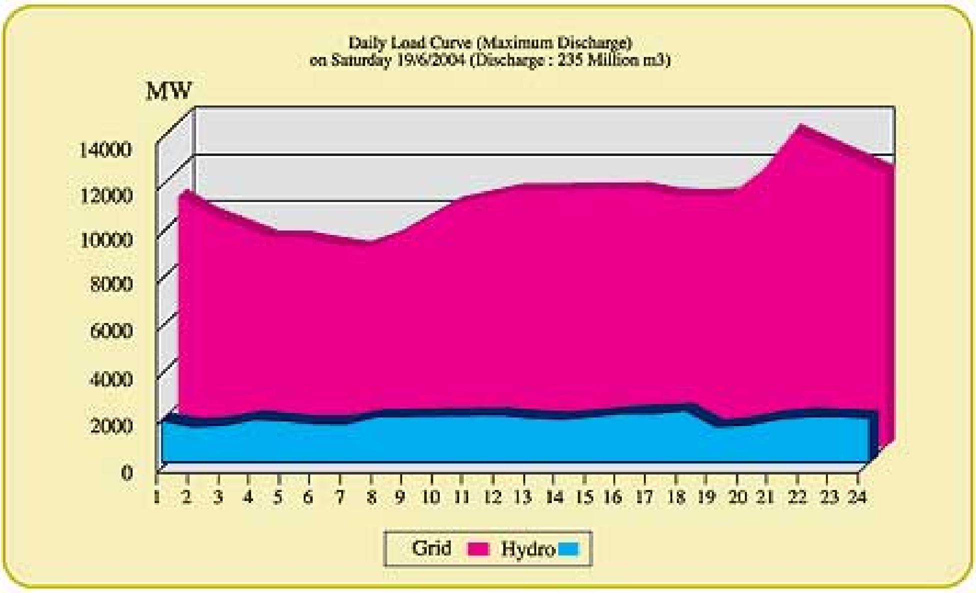
The following pages provide a description and an overview of the characteristics of Egypt's electricity sector:

Description		2003/2004	2002/2003	Variance (%)
Peak Load	*MW*	14735	14401	2.3
Total power generated	*GWh*	94913	88951	6.7
Hydro	*GWh*	13019	12859	1.2
Thermal	*GWh*	67948	68204	(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*	13501	7607	77.5
Net exported power	*GWh*	918	827	11
Sent energy from connected power plants	*GWh*	78029	78065	(0.5)
Generated energy from isolated plants	*GWh*	269.7	239	12.8
Total fuel consumption	*ktoe*	15261	15267	-
H.F.O	*ktoe*	1213	1642	(26.1)
N.G	*ktoe*	14006	13579	3.1
L.F.O	*ktoe*	42	46	(8.7)
Fuel consumption (private sector BOOT)	*ktoe*	2735	1400	95.4
Fuel consumption rate	*gm/kWh gen.*	224.6	223.5	(0.5)
Fuel consumption rate	*kcal/kWh*	2201	2190	(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*	18119	17671	2.5
Hydro		2745	2745	-
Thermal		13186.5	13498	2.3
Wind		140	63	122.2
Private sector		2047.5	1365	50
Transmission lines	*km*			
500 kV		2263	2263	-
400 kV		33	33	-
220 kV		13711	13711	-
132 kV		2466	2466	-
66 kV		15731	14855	5.9
33 kV		2749	2526	8.8
Transformer Capacities	*MVA*			
500 kV		10155	10155	-
220 kV		29208	24605	18.7
132 kV		3641	3591	1.4
66 kV		29362	27917	5.2
33 kV		1851	1801	-

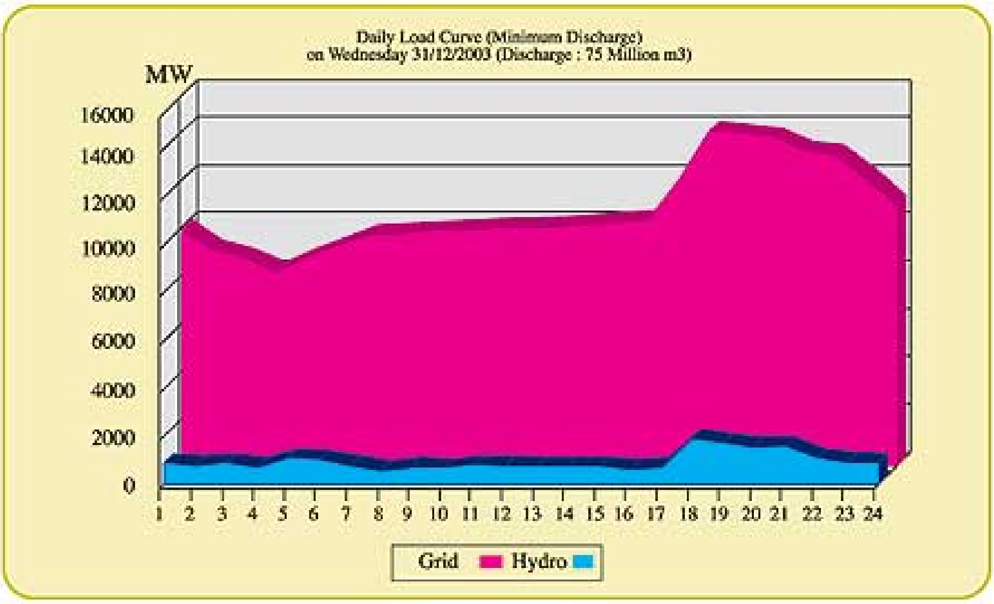
From the International Energy Agency the evolution of the Egyptian electricity sector from 1972 to 2002 is presented



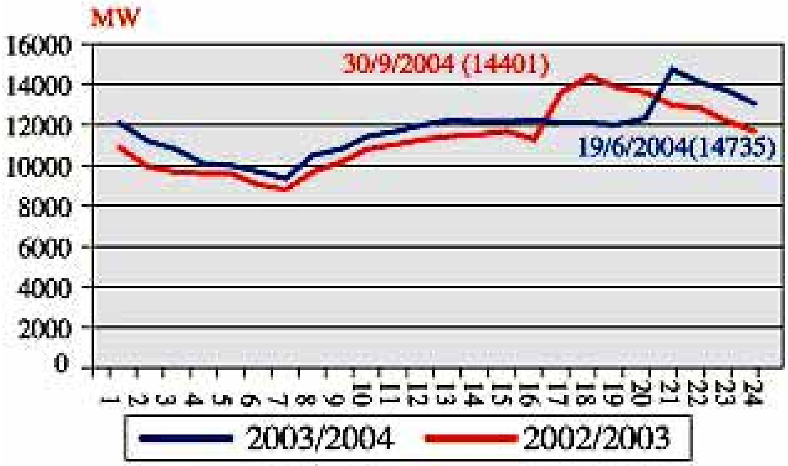
Below is the daily load curve for Saturday 19 June 2004 and provides a perspective of the daily load curve in the middle of the Egyptian summer. Prominent is the maximum demand at about 10:00 pm in the evening.



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



The diagram below presents the daily load curve for two days, 19 June 2004 and 30 September 2004. The peak demands are very similar but with differing times of occurrences.



India

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 155 MW_e, of which 30 MW solar (original was 35 MW using 220,000±3 % 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 % 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 % 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 cum O&M contract to build the plant on a turnkey basis and operate it for a period of 5 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 % below Performance Model), net heat rate (if 2 % above Performance Model), and the solar field (if 5 % below Performance Model). Penalties for performance deficiencies apply to a number of parameters. In relation to the solar field, a penalty of 100,000 INR's is payable per kW_{th} of deficiency (2002 RfP). A second acceptance test applies at the end of the 5year O&M period whereby penalties amounting to 80 % of the first acceptance test penalties apply. An agreed level of degradation is permitted.
Status of project	The Indian GEF project has had the longest gestation period of all the GEF projects. When pre-qualification of contractors was carried out in 2001, there was little interest in bidding for an ISSCS. An 18-month period of negotiation with potential bidders was concluded in September 2003, with no formal bids received. It was then decided to reopen the bidding process, as international interest had arisen in the meantime from the other GEF projects and from a general promotion of CSP. This bidding arrangement was to be more flexible, allowing bidders to choose between a full ISCCS EPC package, or separate EPC contracts for the solar field and the combined cycle power block. This new RfP appar-

	ently could have been released by mid 2004, however the World Bank requested that the Indian Government restate their commitment to the project prior to the new RfP being released. According to the World Bank, this commitment is outstanding at this time. An analysis by the World Bank (2004)[43] concluded that the LEC of the plant, including the GEF grant, is of the order of INR 3.49/kWh, which they note is considerably higher than the competitive price in the region. A more recent study by RREC (Sep 2004) calculates an LEC of INR 2.82/kWh, which is more than the pool price in the region of around INR2.2/kWh, but less than the imported price INR 4-5/kWh (it is noted that more electricity is imported than the ISCCS plant could provide). The new Wind Policy for Rajasthan allows for PPA's with RVPN of INR3.3/kWh. State authorities (RVPN and RREC) have both stated their strong interest in having the project proceed. CEA have asked Government of Rajasthan to expedite the project. Waiting on MNES to provide final approval to proceed.
Expected project time schedule	At this time, a letter from the Indian Government, confirming commitment, is awaited by the World Bank. It is understood the decision by Bank management to present the project to the Board would be taken if the concerned parties submit additional information that modifies the basis for the Bank's appraisal. KfW and the Indian authorities have planned a meeting for around May 2005 to attempt to come to an agreement about the next steps. A maximum time for completion (from commencement date to start of commercial operation) of 36 months is included in the RfP.
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 Euro (this figure is from the RREC 2004 financial spreadsheet, however KfW advise their loan at present is 125.7 million Euro). ➢ Grant from GEF US$ 45 million ➢ Grant from GoI US$ 10.86 million ➢ Grant from GoR US$10.86 million ➢ Total INR 8226 million Capital cost break-down (including IDC) is solar block (INR 3557.2) and CC block (INR 4669.6).
Owner of plant	RREC
Institutional framework in host country for electricity genera-	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 distri-

[43] Solar Thermal Portfolio – A Status Report, Global Environment Facility (prepared by the World Bank), p2, May 2004

tion

bution of power has been privatised.

India requires significant power generation installation over the coming years. It's tremendous growth rates makes 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 shortage has 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 utilisation). The national average energy shortage in FY99 was 5.9 %, and the peak deficit was high as 14 %. 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 US$100bn 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 28-02-2005

SL. NO.	REGION	HYDRO	THERMAL				WIND	NUCLEAR	TOTAL
			COAL	GAS	DSL	TOTAL			
1	**Northern**	10596.6	16914.5	3213.2	15.0	20142.7	178.5	1180.0	**32097.8**
2	**Western**	5702.1	20791.5	5035.7	17.5	25844.7	632.5	760.0	**32939.3**
3	**Southern**	10437.8	13892.5	2720.4	939.3	17552.2	1671.7	780.0	**30441.7**
4	**Eastern**	2459.5	15737.4	190	17.2	15944.6	5.2	0.0	**18409.3**
5	**N. Eastern**	1133.9	330.0	750.5	142.7	1223.2	0.3	0.0	**2357.5**
6	**Island**	5.3	0.0	0.0	70.0	70.0	0.0	0.0	**75.3**
7	**All India**	30335.2	67665.9	11909.8	1201.8	80777.5	2488.1	2720.0	**116320.8**

Year	Electricity Consumption (GWh)	Annual compounded growth rate (%)
1950	4157	-
1960-61	13841	11.6
1970-71	43724	12.2
1980-81	82367	6.5
1990-91	190357	8.7
2000-01	316600	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 (see table below) (Source: 16th EPS Report)

Sector	Hydro	Thermal	Nuclear	Total
Central	15828	11740	4940	32508
State	4328	12523	0	16851
Private	2264	9273	0	11537
Total	**22420**	**33536**	**4940**	**60896**

(Source: 16th EPS Report)

Source: TERI, 2000.

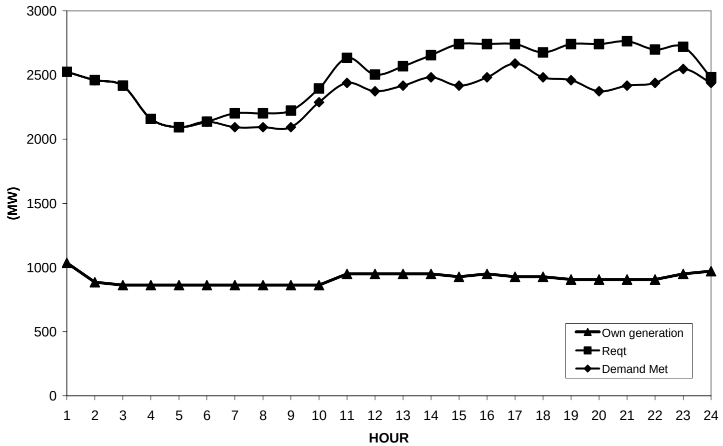
Institutional frame in host country for renewables	India is keen to promote and develop its renewable energy resources. There is apparently a goal (administered by the MNES) to have 10 % of new power come from renewables by 2012. The technologies pursued are mainly solar PV’s, solar thermal, wind, many 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 renewable energy sector, which include direct taxes (100 % 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.[44] We heard of a 10 % target for renewables but can't confirm its status at this time.
Key governmental institutions and their interests	The key institutions in respect of Renewables in India are the Government of India itself, The Ministry of Non-Conventional Energy Sources (MNES), the Renewable Energy Development Agency (IREDA). In the State of Rajasthan, the State Government formed a new company – Rajasthan Renewable Energy Corporation (RREC) – on 9th August 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 Photo-Voltaic (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 ➢ Development of Mini-hydro Power Projects ➢ Designated agency under Energy Conservation Act. The State government has 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 @ 2 % ➢ Wheeling charges fixed at 10 % ➢ Provision for third party sale/captive consumption. ➢ Exemption of Electricity Duty for 5 years

44 http://www.mnes.nic.in

	➢ Allotment of sites at concessional rate 200 MW commissioned/Application for 500-600 MW registered with RREC.
Electricity data for the State of Rajasthan	(see table below)
Near-term strategy for CSP in India	India, being the first ISSCS 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

PARAMETER	JODHPUR DISCOM	RAJASTHAN
GENERAL		
Population	15317007	53523388
Area(Sq.km)	182509	242239
Population Density (Persons/sq.km)	84	156
District.	10	32
Employees	9249	40223
ELECTRICAL		
Total connected load(MW)	2614	9902
33KV lines (kms)	10000	25718
33/11KV S/S (Nos./Capacity in MVA)	581/2140 MVA	1650/6490 MVA
Domestic Connected Load(MW)	725	2181
Agriculture Connected Load	793	3110
Ind.Connected Load(MW)	714	3382
Domestic Electrification	47 %	42 %
Villages/Towns Electrified	83 %	92 %
T&D Losses (%)	39 %	38 %
Revenue from sale of electricity (Rs.Crores)	785	2948
Energy Sold (MU)	3463	12716
Average Tariff (Rs./unit)	2.11	2.18
CONSUMER		
Total Consumers	1520871	5082743
Domestic Consumers	1174897	3703259
Agricultural Consumers	104813	577443
Industrial Consumers	35172	134084
HT Consumers	600	2505
Domestic Consumers as % of total consumers	77 %	73 %

	could now stand to benefit from the renewed interest shown in CSP and ISSCS. 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 % of the Raj desert could provide up to 6000 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 hrs 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.  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.
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 % and energy shortage of 7.5 %. The 10th Plan (2002-2007) recommended an additional 46,000 MW to be installed by 2007, and the 11th Plan is likely to suggest a further 60,896 MW required by 2012. The modelled break-up by fuel type is shown below. For the longer term, a further 69,500 MW is expected to be

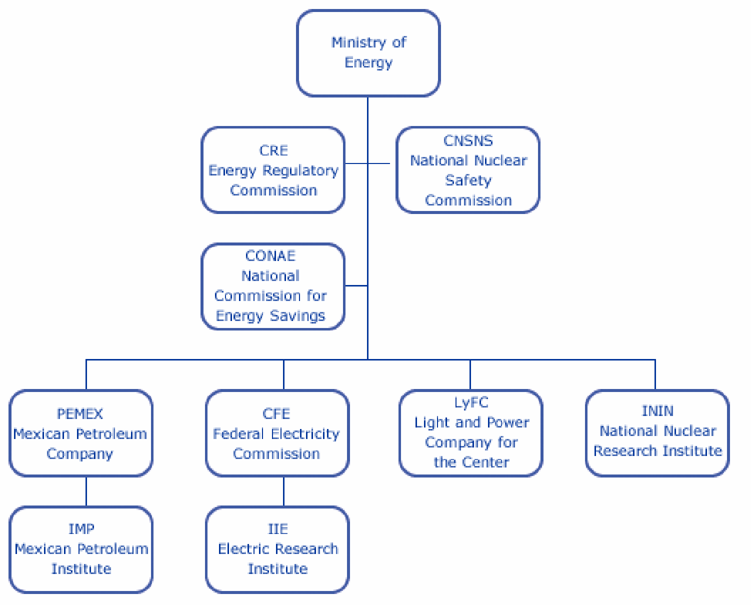
	required during the 12th Plan (2012-2017). The 12th Plan continues with the same expected trend of hydro, thermal and nuclear. The Plans also consider various scenarios. In particular, gas is a limited resource in the country, and it is likely that gas will have to be sourced outside of India. Hydro 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 ⅓ 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 35-40 MW of solar have been circulated, however 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 optimised 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 vs 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 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 OP7 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's 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 underway for a 5 MW linear Fresnel plant in India, and strong interest in a dish-based solar steam plant.

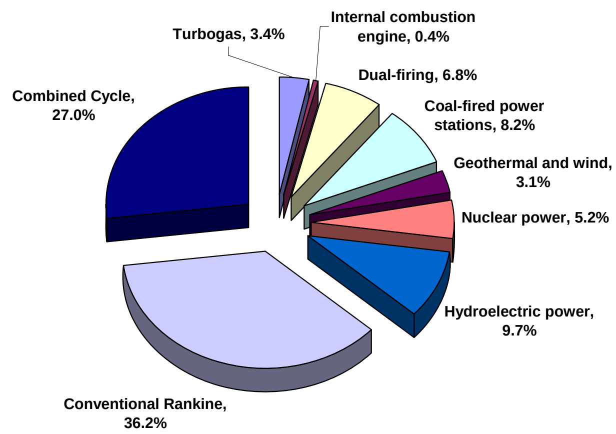
Mexico

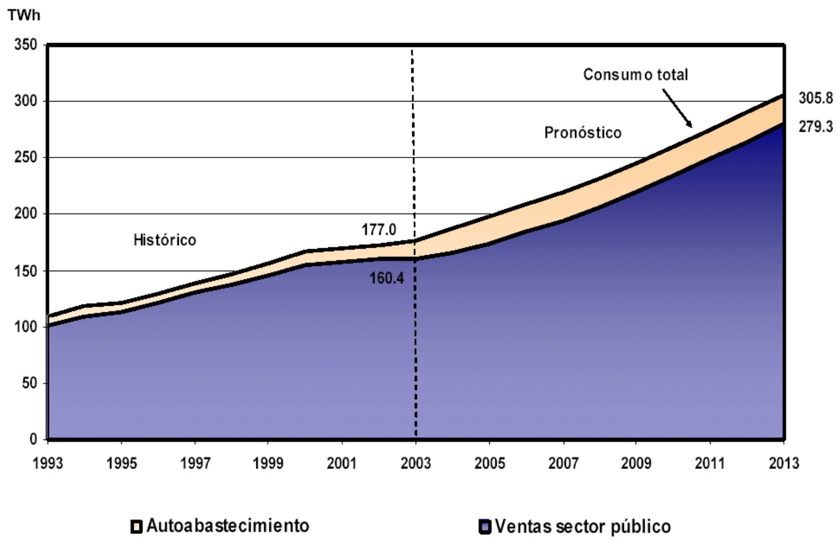
Country/Location	**Mexico / Sonora State there are currently 3Aqua Prieta**
Type of technology	Parabolic trough integrated with a combined cycle plant
Technical parameters	For the former site Cerro Prieto near Mexicali in Baja California Norte (source: SMA study, June 2000): 285 MWe plant with a 39.6 MWe parabolic trough solar field, 14 % of plant capacity is solar corresponding to 4 % of annual electricity yield (site has an average DNI of 2.600 kWh/(m^2a)). Plant site was changed to Sonora state in November 2004, irradiation data there even seems to have slightly higher values (Irradiation data provided in the S&L study from November04 are however very questionable due to wrong physical units and calculations instead of measurements are used). Latest inquiry from CFE to the WB: increase the ISCC total plant size from 250 MW to 500 MW. The solar field capacity is not yet determined (in between 25 MWe and 40 MWe).
Business model	"Obra Pública Financiada OPF" corresponds to an EPC contract (Engineering, Procurement & Construction = Turnkey contract). The operation will be done 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 GEF / World Bank could/would not commit to its funding before the winning 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 formerly 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	One 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	Two sites near Agua Prieta are in discussion. However, before CFE will further promote project development, CFE is waiting for a response from GEF/WB to the question whether GEF/WB are still willing to grant the 50 million US$ for a 500 MW instead of a 250 MW hybrid CC-Solar Power plant. CFE needs a firm commitment from the WB and GEF in order to complete the technical and economical evaluation that needs to be presented to the Treasury Ministry for approval in the month of June 2005. If GEF/WB will not agree, Mexico will have to cancel the project because of contradiction to least-cost-requirement.
Expected project time schedule	As soon as possible: Get Feedback from GEF/WB on 500 MW issue. June 2005: presentation to the Treasury Ministry

	Nov./Dec. 05: Approval by Treasury ministry Jan. 06: PEF approval Feb. 06: invitation for tenders (published) Sep06-Jan07: start construction April 09: Grid-connection
Project developer / Prequalified Developers	In the IPP bidding procedure in 2002 several companies were putting 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.
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 invest 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 who has to approve the investment in agreement with the 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 (subsidised tariffs for the residential and agricultural sector, the subsidies are planned to be reduced (POISE – Programa de Obras e Inversiones del Sector Eléctrico 2004-2013)). CFE has a legally fixed least-cost expansion plan (law: LSPEE). I.e. investments have to be justified in compliance with the objective to provide the least-cost electricity. The Mexican power sector is opened 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 and owns it.
Institutional frame in host country for renewables	Currently no green tariffs exist in Mexico but 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 renewables plants. Mexico has a capacity payment for generation capacities (subsidy for availability). E.g. 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** are cost-effective ➢ **Wind energy** According to CFE calculations wind energy (LEC 4-7 $ct/kWh) cannot compete with CC technology, however 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 strict 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 % 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:

	 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 ➢ Achieve a competitive pricing policy.
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 subsidised 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 8th in natural gas production Despite these promising numbers Mexico is a net importer of natural gas, app. 30-40 % 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).  Accordingly the use of fossil energy sources accounts to 82 % of the annual energy production. 9.4 % of the national electricity production are self-producing (autonomous) units. The past and future (forecasted) electricity consumption are given in the following graph:



For the years 2004-2013 (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 it’s production in Mexico is decreasing. Nuclear energy is not considered to be practicable (Mexico already has one nuclear power plant), the utilisation 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 which 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 Belice, the cumulated importations accounted 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 2004-2013.
View of the country on a mid-term strategy for CSP with possible future options (5-10 years)	Once successful experiences will have been made with a first solar thermal power plant (i.e. the ISCC 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.

Morocco

Country/Location	**Morocco / Ain Beni Mathar**
Type of technology	Parabolic Trough integrated with a combined cycle plant
Technical parameters	240 MW_{el}, of which 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 % of the annual production representing 55 GWh per year. Solar radiation: 5 $kWh/m^2/day$?? Link to the gas pipeline Maghreb-Europe (Algeria to Portugal) (12 km connection). Morocco uses 7-8 % from this pipeline.
Business model	EPC (Engineering, Procurement & Construction = Turnkey contract) cum 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 years O&M guarantee. It shall ensure appropriate incentives for the operation of the plant, including to the full capacity of the solar field. After 5 years renewal possible on O&M contract.
Liability provisions	(in particular for hybrid)
Status of plant	Ahead of the bidding process
Expected project time schedule	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". As soon as the "Non-Objection" will be received, the Bid Document can be issued to the prequalified Bidders. Financial proposal is expected for September/October 2005. Allowing for normal time span for bidding, bid evaluation, and contract negotiations, it is expected that the EPC cum O&M contract for the project can be signed by the end of 2005. Expected start of operation of the plant is mid-2008 (realisation time 30 months) or 2009 (Source: journaldumaghreb.com, 5 March 2005)
Project developer / Prequalified Developers	The prequalification of potential Contractors had been completed 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 213 million Euro (Source: journaldumaghreb.com, 5 March 2005). This includes transmission connection, connection to gas pipeline for the fossil part, land acquisition and substation.

	GEF grant (20 %): 43 million Euro (incremental cost due to solar thermal component) About 34 million Euro from ONE (16 %), Remaining from African Development Bank as a soft loan (The Board of the ADB has already approved the co-financing for this project in March 2005): 136.45 millions Euros
Final owner of plant	Office National de l'Electricité ONE
Institutional frame in host country for the electricity market	The Moroccan electricity market has 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. Interconnection with the Iberian and possibly the Algerian market. Restructuring of ONE. ONE will continue to be solely responsible for distribution and transmission. The programme by ONE for the development of the transmission lines (3 billion dirhams, 270 million Euros) has the objective to enforce the fiability 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 notely: (1) the doubling of the interconnection with Spain, foreseen for 2006 ; (2) the enforcement of the interconnection with Algeria; (3) the development of the 400 kV grid towards the centre (Mediouna) and the East (Oujda) with the realisation of 3 400 kV/ 225 kV stations; (4) The extension of the 225 kV grid; (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 % in 2003 to 10 % in 2011 and close to 20 % in 2020. Since June 2004 Morocco has a national plan for the development of renewables and for the improvement of energy efficiency (EE) which marks the political will to integrate renewables into the national energetic landscape with precise objectives and a large scale deployment, assuring thus a permanent demand for those technologies. 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 the sustainable development. It foresees : the production of electric power at the amount of 600 MW from wind parks, thermo-solar hybrid plants, the valorisation of biomass and cogeneration. Programme for the creation of 1,000 micro enterprises for energetic services close to the user, decentral electrification at the profit of 150,000 rural households already programmed by the PERG. Improvement of the profile of energy consumption: development of solar thermal collectors; installation of 400,000 m^2 thermal collectors; energy efficiency programme in the tertiary and industrial sector; programme for the utilisation of efficient wood energy.

Key governmental institutions and their interests	ONE: Morocco has a strong need for new capacity: peak Power in July was 3190 MW, which is only 12 % 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 Johannesburg 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: 7-8cUS$/kWh. Tariffs are high due to the taxes (tariffs have been lowered by 36 %). Pressure to lower the costs. Costs of hybrid solar plant, including the grant are 3.7-3.8 cUS$/kWh. Average cost of conventional electricity 3-4 cUS$/kWh. Wind energy, which is also taking off, has generation costs of 4.5 to 5 cUS$/kWh.
Description of the electric power system	As of September 2004, the power plants owned by ONE are 26 hydro power plants (total installed power 1265 MW), 5 thermal power plants based on steam generation (2574 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 4508 MW). 40 % 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. 60 % of the hydro power is concentrated in the 5 largest hydro plants: Bine el Ouidane in Azilal (capacity 1.38 billion m3), Idriss 1er on the Oued Sebou (1.186 billion m3), Al Massira at Settat (2.76 billion m3), al Wahda (3.8 billion m3) and Ahmed el Hansali in Zaouiyat Echeikh (0.74 billion m3). The year 2004 has registered a strong increase in the demand of electricity of 7 % and this for the second year in a row, and reached now 17 946 GWh. This demand was satisfied to 56.4 % by concessional production, to 35 % by the power plants exploited directly by ONE and 8.6 % by imports through the interconnection with Spain. Hydro electricity production reached 1591 GWh (increase of 10.4 % compared to 2003 and represents 8.9 % of the electricity demand.
Near-term strategy for CSP in the country	Power projects near finalisation: ➢ First gas-fired combined cycle plant of Tahaddart: Power 385 MW, Owner: E.E.T (Energie Electrique de Tahaddart, created for this purpose. 48 % of the capital is owned by ONE, 32 % by Endesa Europa and 20 % by Siemens Project Ventures), Operator: Siemens O&M, Cost 285 Millions Euros, Start: April 2005. 20 years Power Purchasing Agreement E.E.T – ONE. Financing: 25 % 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 1700 Millions Dirhams (about 155 Million Euro), 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 Euro), Financing: Loan 50 million Euro 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 1800 Million Dirham (about 165 Million Euro), Financing: Loan 80 million Euro from the European Investment Bank, 50 million Euro from KfW, Agence Française de Développement, ONE. Start of operation: beginning 2007
- Hydro power plant Tanafnit-El Borj, Power 2 x 9 MW MW, mean annual production 100 GWh, Owner and operator ONE, Cost 61 Million Euro, Financing: Loan 61 million Euro from KfW. Start of operation: second half of 2007

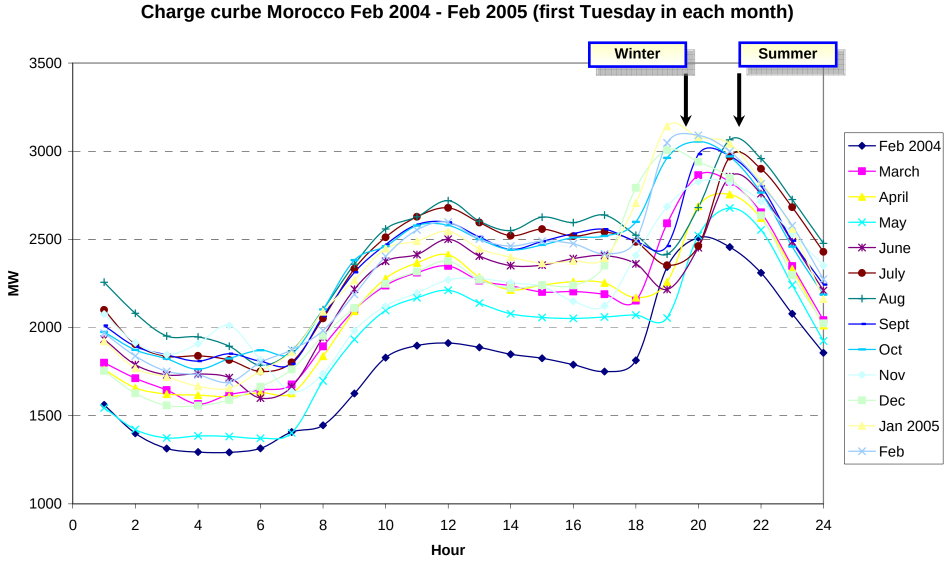
Short term projects	**Installed Power MW**	**Start**
Combined cycle plant Tahaddart	385	2005
Pumping station Afourer	463	2005
Transfer of 3 gas turbines from Tan Tan to Laâyoune	100	2005
Wind Park Essaouira	60	2006
Wind Park Tanger	140	2007
Solar thermal plant Ain Beni Mathar	200 - 250 MW	2008/9
Hydroelectric complex Tanafnit El Borj	2x9 MW et 2x13 MW	2007
Performance boost for the thermal power plant of Mohammedia	600	2007

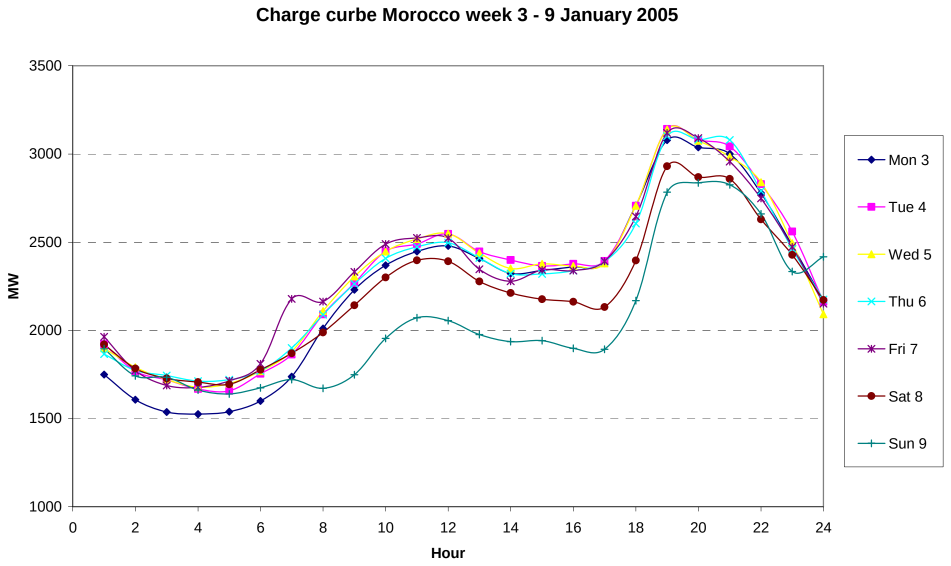
Rural electrification: The PERG, global programme for rural electrification, was approved in the Government Council in August 1995 and put into practice starting 1996. ONE, who is responsible for carry-

	ing out the programme of rural electrification, has accelerated the rhythm since 2002 to generalise the access to electricity by 2007 rather than 2010 originally foreseen. At the end of 2007, the PERG will have contributed to electrify 34,400 villages of which more than 28,000 linked to the national grid, providing thus access to electricity for 12 million people for a global budget of around 20 billion dirham (close to 2 billion Euro). This objective will be realised to 91 % by linking the consumers to the grid and by 7 % through decentralised electricity generation with PV installations. At the end of 2003, a budget of about 12.3 billion dirham (more than a billion Euro) was engaged by ONE to electrify 13.235 villages (989,946 homes, 6,434,000 rural inhabitants). The rural electrification level, which was 18 % in 1995, reached 62 % at the end of 2003, and 72 % 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 millions Euros, 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 Euros). 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 realisation of the first plan at Ain Beni Mathar.**

Additional information for Morocco:

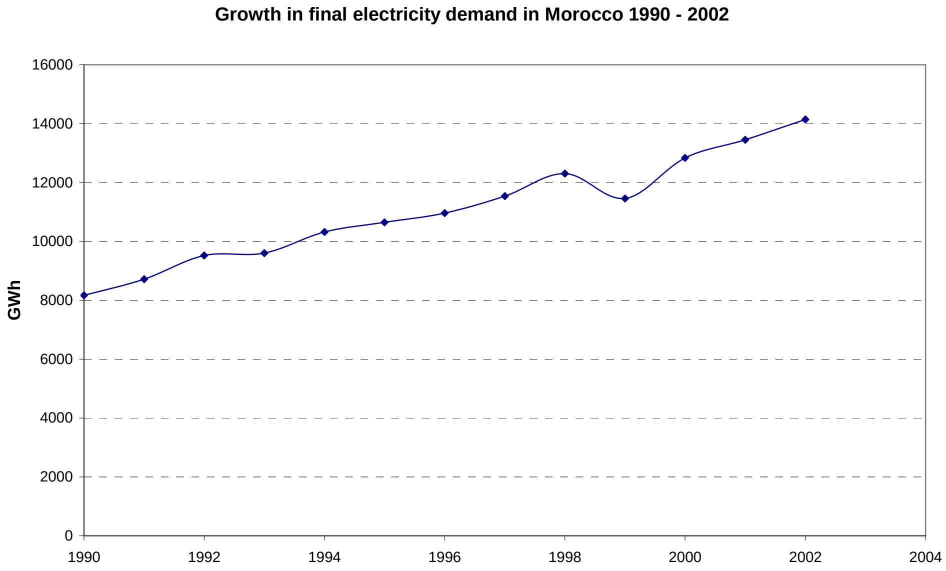
Figure 24: Daily load curve of the Moroccan electricity system (over the year and over the week)





Source: ONE

Figure 25: Growth in electricity demand



Source: Odyssee Database

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

The production parc of ONE end of December 2004 was composed as follows:

	Installed Power in MW
26 hydro power stations	**1 265**
Pumping station and turbines of Afourer	233
5 thermal power stations (steam)	**2 385**
Coal-fired	1785
Oil-fired	720
6 Gas turbines	**615**
Diesel	69
Total thermal plants	**3 189**
Wind (of which 50 MW from the CED*)	**53,9**
Total ONE	**4 621**

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

The total electricity called in 2004 was 17 945 GWh (7 % increase compared to 2003) and is distributed as follows:

	(GWh)	**Part (%)**
Thermal ONE	**4 648**	**25.9**
Hydro	**1 600**	**8.9**
Wind	**13**	**0.1**
Concession	**10 122**	**56.4**
JLEC	9 936	55.4
CED(Wind)	186	1.0
Contributions from third	**76**	**0.4**
Balance of exchange	**1 535**	**8.6**
Morocco-Spain	1 554	8.7
Morocco -Algeria	- 19	- 0.1
Auxiliary consumption and compensators	- 40	- 0.2
STEP (Energy absorbed by the pumping)	- 10	- 0.1
Total electricity called	**17 945**	**100**

(*) CED : Compagnie Eolienne de Détroit

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

Table 15: Hydro power production in Morocco (2004)

	Installed Power * n (MW)	**Net production**	
		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

(**) in relation to the total hydro production

Annex 5: List of interviewed organisations/persons

List of interviewed organisations/persons

- African Development Bank: Nono J.S. Matondo-Fundani
- Ajmer Vidyut Vitran Nigam Limited: Mr Agarwal (Managing Director)
- BMU – German Ministry of Environment: Joachim Nick-Leptin, Ralf Christmann
- CFE (Mexico):
- DLR (German Aerospace Center): Robert Pitz-Paal, Jürgen Dersch, Franz Trieb
- Fichtner Solar GmbH: Georg Brakmann
- FlagSol GmbH: Paul Nava, Michael Geyer
- 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 (Solar Thermal Department): Eng. Salah El Desouky (Project Manager), Eng Ayman M Fayek (Senior Engineer), Eng Khaled M Fekry (Engineer)
- NREL: Henry Price, Mark Mehos, Tom Williams
- ONE: Omar Benlamlih, Abdallah Mdarhri, Mr. Houachmi (Directeur Production), Mr. Azzedine Khatami
- RREC: Mr Verma (Managing Director) and Mr Surana (General Manager)
- Rajstahan Vidyut Vitran Nigam: Mr Ahmed (Chaiman and MD)
- 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 DoE: Thomas Rueckert
- VDI/VDE: Ludger Lorych
- World Bank: Gabriela Azuela, Anne Bjerde, Chandrasekar Govindarajalu, Charles Feinstein, Rohit Khanna, Todd Johnson, Rene Mendonca, Pedro Sanchez