CLIMATE INVESTMENT FUNDS

CTF/TFC.3/7
April 27, 2009

Meeting of the CTF Trust Fund Committee
Washington, D.C.
May 11, 2009

CLEAN TECHNOLOGY FUND: CONCEPT NOTE FOR A CONCENTRATED SOLAR POWER SCALE-UP PROGRAM IN THE MIDDLE EAST AND NORTH AFRICA REGION

Proposed Trust Fund Committee Decision

The Trust Fund Committee welcomes the document CTF/TFC.3/7, *Clean Technology Fund: Concept Note for a Concentrated Solar Power Scale-up Program in the Middle East and North Africa Regions*, and requests the MDBs to work with the countries of the region to complete the preparation of the associated regional investment plan, taking into account the discussion of the Trust Fund Committee.

Introduction

1. The World Bank Group made an informal presentation on Concentrated Solar Power (CSP) scale-up in the Middle East and North Africa (MENA) region during the January 2009 CTF Trust Fund Committee meeting. In their feedback, committee members requested the MDBs to prepare a concept note for a MENA regional investment plan, for discussion at the May meeting of the committee. It should also be noted that previous country-specific CTF investment plans prepared or those under preparation (Egypt and Morocco) have not included CSP as it was considered more appropriate to consider this technology under a regional program.

2. The purpose of this concept note is to seek the Trust Fund Committee's views on:

a) Whether the proposal has the appropriate scope and level of ambition and is of transformational scale

b) The minimum level of country-specific information and analysis that the TFC would expect in a regional investment plan

c) The range of financial instruments to meet the large investment and risk mitigation needs of the proposed program

d) How bilateral development agencies/banks and other donors could contribute to the objectives of the proposed program

Global and Regional Context

3. This concept note is for a regional investment plan to implement a Gigawatt-scale CSP program in the MENA region that will accelerate the global adoption of CSP technology. A confluence of factors provides a unique opportunity for the CTF to provide scaled-up financing for the demonstration, deployment and transfer of a low-carbon technology with significant potential for long-term greenhouse gas emissions savings:

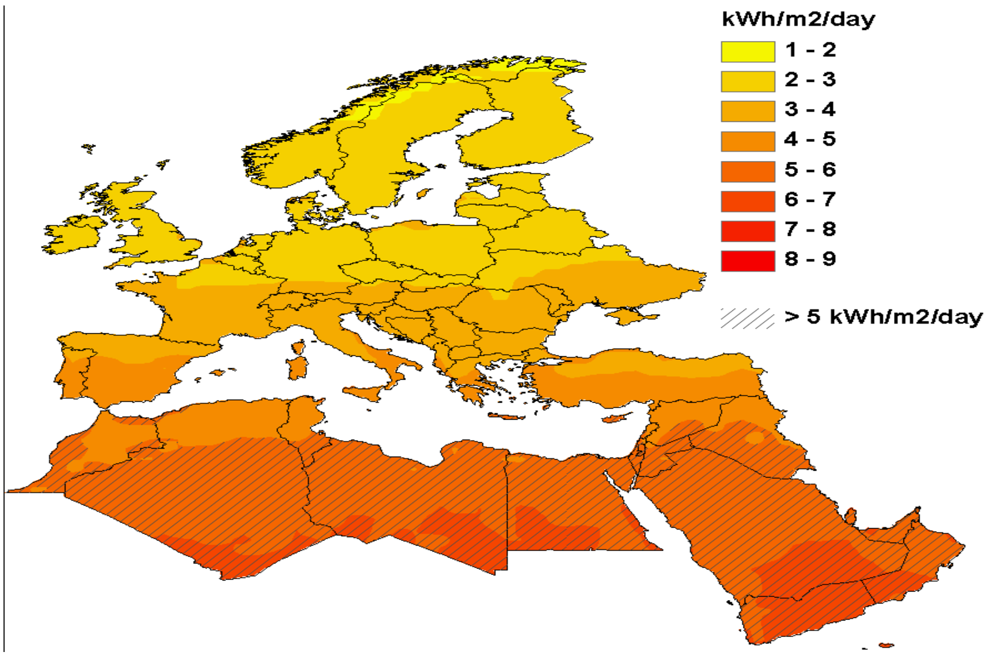
a) *CSP is a technology with unexploited manufacturing scale economies:* In terms of its commercial viability as a power generation option, CSP falls between wind power and photovoltaics (PV) and represents a technology that is ready for scale-up (see Figure 2 for cost comparisons), since it has yet to benefit from cost savings that often come with manufacturing scale.

b) *CSP is of particular interest to utilities*: From the utilities' perspective, CSP is seen as lower cost and more scalable than conventional PV. CSP is also more consistent with the utilities' centralized and dispatchable generation model.

c) *MENA region has physical attributes that make it particularly promising for CSP scale-up:* The region has amongst the world's best production conditions for solar power: abundant sunshine, low precipitation, and plenty of unused flat land close to road networks and transmission grids (see figure 1).

d) *Political economy of the MENA region can provide a strong enabling environment for large-scale investments:* The region's consumption of energy is growing faster than that of any other region in the world and countries are increasingly looking to scale-up energy efficiency and renewable energy as part of their energy development and security strategies. In the Mediterranean Basin as a whole, demand for "green electricity is growing very rapidly and opportunities to trade "green" electricity are quickly opening up.

Figure 1 Global Direct Normal Solar Radiation (kWh/m2/day)



Source: Ummel, Kevin and Wheeler, David, Desert Power: The Economics of Solar Thermal Electricity for Europe, North Africa and the Middle East, Center for Global Development, 2008.

Technology and Market Status

4. Solar thermal power generation using concentrating collectors, commonly referred to as concentrating solar power (CSP), involves the conversion of solar radiation to thermal energy, which is then used to run a power plant. Solar thermal power generation can integrate well with conventional power options and is attractive to utility markets because of scalability and storage potential. Several technological variations for CSP have been considered and tried so far (see Annex 1, where key options are described). These technologies typically take the form of a large power plant and can focus solar energy using mirrors in a line or around a point. There is also the potential for

storing the heat to make the power more dispatchable – a significant advantage in matching resource variability to demand. [1]

5. The first power plants utilizing CSP were built in the U.S. After a period of brisk development during the 1980s, there was a period of stagnation in the 1990s due to reduced government support for the CSP program in the U.S. There is a resurgence of interest in recent times in CSP due the increasing importance of climate change and the heightened energy security concerns caused by volatile fossil fuel prices. Incentive schemes in Europe and the U.S. are beginning to attract renewed attention of investors and utilities. For example, a key CSP policy driver in Spain has been the 27 US cents/kWh feed-in-tariffs. In the U.S, a 30% federal investment tax credit helped propel the CSP industry[2]. Consequently projects totaling more than 9,000 MW are in the pipeline globally, a large majority in the U.S and Spain.

6. In the last decade, several companies have emerged as leaders in the various CSP technologies. With respect to the trough systems, key players include Abengoa Solar (Spain), Acciona (Spain), FPL Energy (USA), Solar Millennium (Germany), Solel (Israel), and SkyFuel (USA). In Tower systems, the market players include Spanish company Abengoa Solar, and the US companies, Bright Source Energy, eSolar, and Solar Reserve. In Linear Fresnel Reflector technology (LFR), the main players are the US companies Ausra and SkyFuel, while the US companies, Stirling Energy Systems and Infinia are leaders in dish technology.

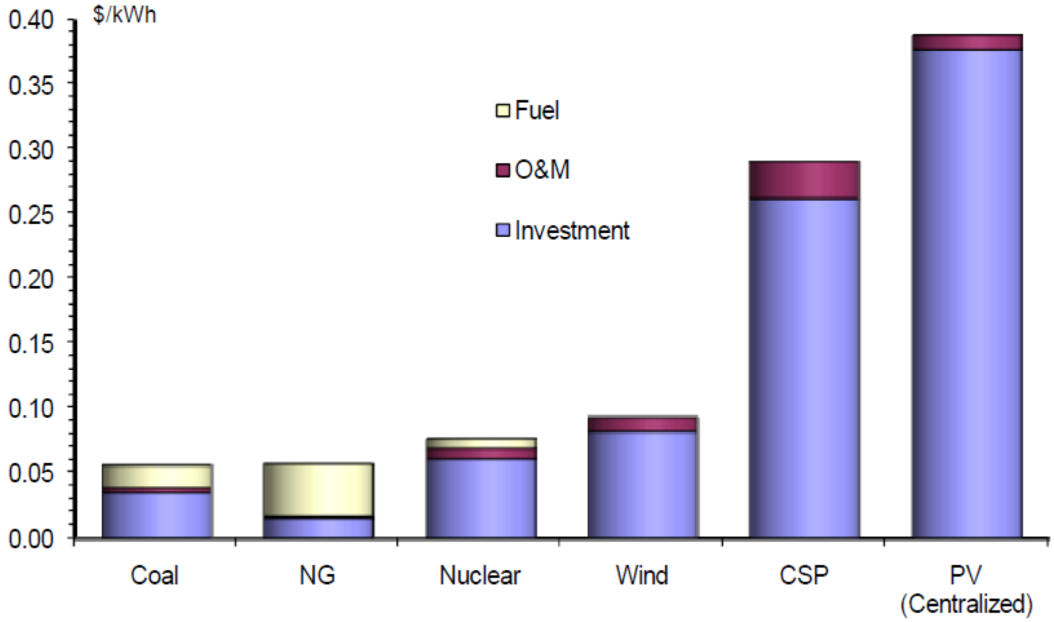
7. In the MENA region, there is an increasing interest in CSP with projects under implementation in Morocco, Egypt and Algeria. These projects used the Integrated Solar Combined Cycle (ISCC) configuration where energy from a solar field is combined with a conventional combined cycle gas turbine plant. Demonstration projects in Egypt and Morocco are receiving Bank/GEF support and have solar field capacities in the range of 20 MW each. These plants are expected to be commissioned in 2010.

8. High initial capital costs are still a significant barrier for adoption of this technology. Estimates range the capital costs between $4000 and $6000 per kW for a typical capacity factor of 22-24 %. Comparisons of the Levelized Cost of Energy (LCOE) of different electricity supply options indicate that CSP is at least twice as expensive as wind power (see Figure 2). But it should be noted that the costs are driven by a number factors such as the quality of solar resource, land costs, and technology choice. Annex 2 summarizes the major CSP technology characteristics that drive the technologies' Levelized Cost of Energy (LCOE). In addition, environmental impacts resulting from such a scale-up program also need to be considered – for example it is important to note that there could be an increasing stress on water resources due to the water requirements for cooling. Dry cooling alternatives are available but increase costs due to increased auxillary consumption and decrease the overall efficiency of the steam cycle.

[1] However, it should be noted that storage options would increase the capital costs by at least 30% while reducing the energy generation costs by about 5-6% on a per kWh basis on account of a higher load factor from 22% to 34% (Merrill Lynch, 2008)

[2] American Recovery and Reinvestment Act, 2009 also allows developers to apply for 30% grant in lieu of the Investment Tax Credit from the Treasury Department for projects that start construction in 2009 or 2010.

Figure 2: Comparison of Current Average LCOEs for different technologies ($/kWh)



Source: Byrne et al, 2008. Data Sources(NEA/IEA 2005, Falk et al 2008, LAZARD 2008, ESMAP/World Bank 2008, IEA 2008)

9. Additional barriers increase difficulties of CSP investments in many developing countries. These include uncertain policies related to power purchase arrangements and land access, as well as lack of adequate transmission infrastructure for evacuating power and lack of regional power sharing agreements.

10. Given the uncertainties of future business, the supply industries have operated on the basis of serving one-off customers instead of setting up complete R&D, large-scale manufacturing, and operations and maintenance programs. The result is very high cost, underexploited economies of scale and limited investment in R&D leading to technology development and innovation.

Proposed Transformation

11. It is proposed that the CTF co-finance a one gigawatt (GW) level deployment of CSP in the MENA region over a 6-8 years time frame -- which would represent 8-10 commercial-scale power plants in multiple countries and 10% of the planned capacity additions globally. Such an investment program would provide the critical mass of investments necessary to attract significant private sector interest, benefit from economies of scale to reduce cost, result in organizational learning in diverse and several operating conditions, and manage country and technical risk. An investment program at this scale would firmly establish the region on the transformational path of achieving 5 GW of installed CSP capacity by 2025 and provide the stimulus necessary for replication in other developing countries.

12. Energy use trends in MENA are also driving the need for energy efficiency and diversifying supply options. According to a recent World Bank study on Energy Efficiency in the MENA region, MENA's total final consumption of energy has grown faster than that of any other region since 1980. Today, the region's "energy intensity" is estimated at 0.18 toe per thousand U.S. dollars in 2005 PPP terms (/'000US$2005PPP), 60 percent higher than that of OECD countries (0.11toe/'000US$2005PPP), and 40 percent above the world's average energy intensity of 0.13. The energy intensity of the region's economies is not explained simply by differences in their energy resources. Energy-abundant countries such as Iraq and UAE are among the most energy-intensive. But some energy importing countries (for example, Lebanon and Jordan) are also energy intensive (World Bank, 2009).

13. In the Mediterranean basin, countries broadly share the same goals as their northern neighbors for "green" electricity - energy security considerations and local environmental needs predominate, but climate change mitigation is a rapidly emerging issue in the South.

14. In this context, the MENA CSP scale-up program has strong synergy with the Mediterranean Solar Plan (MSP) whose vision[3] is to take the world-scale solar potential of the South, and the green electricity needs of the entire Mediterranean Basin, and transform it into a massive opportunity - by linking large scale power production from solar (as well other renewable energy resources and suitable energy efficiency and demand side management options) through reinforced transmission grids to demand centers of the Mediterranean region, both in the North and the South.[4] This would provide an opportunity to satisfy regional demands for green electricity, and an opportunity to promote regional integration and energy security in the Mediterranean and beyond. This would also be an opportunity to use clean technology as an investment stimulus at a time of regional economic recession, and to create "green jobs." The success of the MSP depends on the development of an operational framework for sharing of the costs and benefits between partners. To the extent that such a framework is agreeable to the parties, MDBs could play a key role in financing.

15. It is proposed that the regional CSP scale-up investment program would consist of two sub-programs to maintain the institutional and implementation complexities at manageable levels. One program on Maghreb (Algeria, Libya, Morocco, Tunisia) and another focused on Mashreq (Egypt, Jordan, Syria, Lebanon, West Bank and Gaza). For each regional program, an investment plan will be prepared for those countries that are CTF eligible.[5]

[3] The European council approved in principle the Union for Mediterranean (UfM) in 2008, presided over concurrently by France and Egypt. Proposed regional initiatives under the UfM to enhance regional cooperation include de-pollution of the Mediterranean, maritime and land highways, civil protection, Mediterranean solar plan (MSP), higher education and research and the Mediterranean business development initiative.

[4] Demand-side management energy efficiency measures may also be needed to facilitate the grid integration of solar power.

[5] Countries may access CTF funding if they are eligible for Overseas Development Assistance (ODA) and if there is an active MDB lending program. Morocco, Algeria, Tunisia, Egypt, Lebanon and Jordan are currently eligible under these criteria. Syria is ODA eligible but there isn't currently an active MDB lending program. Libya is not ODA eligible, and therefore there is no MDB lending program. However, in both Syria and Libya there is the potential for MDB technical assistance for a solar scale-up program. West

16. The focus of the Maghreb investment plan will be on solar energy scale-up within the region as well as possible export to Europe given that some interconnections already exist. In the case of the Mashreq, there are critical transmission constraints within the countries that need to be overcome to facilitate increased trade of green power within the region before contemplating any significant exports to Europe. Therefore, the Mashreq plan will focus on scale-up of solar power between and within Egypt, Jordan, Syria and Lebanon. In all there would be about 8-10 projects of significant size (~100 MW) in 6-9 countries.

17. There are different ways in which the CTF could support the scale-up of Concentrated Solar Power. The possible instruments could be as follows:

a) Financing or guarantees for private or public sector CSP power projects. Priority would be to develop IPP type private sector projects where CTF support for private sector investments could be channeled through the IFC or the AfDB following a market aggregation model where incentives could be provided on a competitive basis. Risk mitigation instruments such as World Bank, MIGA and CTF Partial Risk Guarantees (PRG) could be utilized in parallel. Public sector projects could be supported by the World Bank or the African Development Bank (AfDB), through investments and partial credit guarantees, on a case by case basis depending on the policy environment for private sector investments within the countries. Other contingent finance schemes for technology risk mitigation will also be assessed during preparation.

b) Overcoming the grid constraints for CSP scale-up within the countries and between countries. Interconnections are likely to be publicly funded, at least in part, and the CTF could accelerate the construction of this dedicated infrastructure by offering concessional financing[6].

c) Project-related preparatory activities such as feasibility and detailed engineering studies, development of bidding and contracting packages and power purchase agreements, support developing the regional power grids needed to evacuate power to the load centers, support for financial structuring of projects etc.

18. In addition, parallel technical assistance resources would be mobilized to support country dialogue, establishment of the regulatory frameworks, prepare international cooperation agreements, and undertake technical and economical analyses for including CSP projects in the countries' generation expansion plans. Projects implemented in developing countries could also be eligible for CDM/CDM successor credits for the

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Bank and Gaza are both ODA eligible and in receipt of an active MDB lending program, but CTF design did not envisage the inclusion of countries which are not MDB shareholders. Similarly, the proposed Scaling-up Renewable Energy Program (SREP) for low income countries under the Strategic Climate Fund has not envisaged the inclusion of non-shareholders such as West Bank and Gaza. However, in the MSP, Palestine plays an important role. Bilateral development agencies/banks will be encouraged to supplement CTF financing to CTF-eligible countries with bilateral support to those countries that are not eligible. Such investments by bilateral donors would be considered for inclusion in the CTF annual report as being in conformity with and supporting the objectives of the CTF.

[6] The electricity industry group from around the Mediterranean (MEDELEC) is looking into the specific nature of in-country and inter-country transmission requirements for increased trade of green electricity. See www. medelec.org for more details.

energy consumed within the countries. Assistance would be provided for developing and applying the already approved programmatic CDM approach.

Rationale for CTF Financing

19. CSP is poised for market take-off, driven primarily to-date by strong potential growth in Spain and the U.S. The proposed CTF co-financed program seeks to develop a similar expansion pathway in developing countries. In the absence of significant concessional financing such as from the CTF, large scale deployment outside of the U.S. and Spain is unlikely to occur for another 5-10 years. With CTF support, the cost reduction curve would be steeper and the adoption rate would be substantially accelerated.

Potential for GHG emissions savings

20. It is estimated that a 1 GW-scale of CSP deployment would result in carbon emissions avoidance of **2.6 million tons** per year in the MENA region based on current conditions and assumptions from previous work. This represents about 1.5 % of the current energy sector emissions in the Southern Mediterranean countries. This estimate would be further reviewed and improved during the preparation of the regional programs.

Cost Effectiveness

21. Several studies have examined the future cost reduction potential, some of the key studies are Enermodal (1999), DLR (2004), Sargent and Lundy (2003), DLR and others (2005), and World Bank (2006). The cost reduction factors have mainly involved improved efficiencies, learning effects due to volume production, and economies of scale due to larger units.

22. One of the recent studies assumes a four part cost reduction strategy; Part 1 (0-0.5 GW by 2010) that is the creation of technical and institutional expertise is represented by ongoing pilot projects including the Egypt and Morocco GEF projects; Part 2 (0.5 – 2 GW by 2015) that generates the market and is driven by feed-in tariffs in industrialized countries and a mixture of grants, national financing and preferential loans in developing countries that would bring down levelized costs to about 11 US cents/kWh by 2015; Part 3 (2-7 GW by 2020) that represents early phase of mass market development would reduce costs to about 9 US cents/kWh by 2020 and finally, Part 4 (7-25 GW 2025) that represents near competitive market (World Bank, 2006).

Replicability

23. The proposed program is regional in nature, but will have a far-reaching impact globally. Together with the planned capacity additions in the U.S and Europe, cost reductions and institutional learning that will be achieved through this program will facilitate faster and greater diffusion of this technology in other countries in Asia and Africa that have significant potential for CSP. Estimates for realizable CSP potential vary from 20-42 GW by 2025 (DLR 2004). The total planned capacity additions are in the range of 10 GW and include projects in Algeria, China, Iran, Israel, Portugal, South Africa, Spain, and the U.S.

Development Impact

24. A key development impact from this program is the contribution to fulfilling the growing energy needs in the region. This particularly useful as many of the MENA countries such as Egypt, Jordan and Morocco are increasingly looking to diversify their energy supply sources for meeting domestic energy needs. Scaling-up of CSP can also provide a catalyst for increase in manufacturing in the MENA region. For the current plants under implementation, roughly 30% of the hardware is locally manufactured. If there is an assured demand for a large capacity additions in the GW scale, manufacturing of precision components like the receiver tubes and mirrors may also become viable in the region.

25. According to a survey[7] among European companies, for Solar Thermo-Electric Power Plants, every 100 MW installed will provide 400 full-time equivalent manufacturing jobs, 600 contracting and installation jobs and 30 annual jobs in Operations and Management. Economic development can also benefit a community indirectly, such as an increase demand in local service commodities. It is widely accepted that for each construction job, four service jobs are created to support it and once construction is completed, operations and management jobs will require local services as well.

26. To sum up, the scaling-up of CSP can spur local production and create new jobs, while meeting long term energy security and diversification goals of countries in the region.

Implementation Potential

27. The proposed technology already has a track record in the region with pilot projects under implementation in Egypt, Algeria and Morocco. Implementation of these projects has increased the level of familiarity of the CSP technology in the region.

28. A key barrier to implementation is the subsidized fossil fuel prices in the region found in many countries. It is evident that such a scale up will be only achievable by overcoming systemic barriers, such as energy subsidies and introduction of favorable policies that will encourage commercial utility operations in general and promote CSP in particular. Governments have begun to take steps for considering pricing reform and continued progress in this area would be important for integrating renewable energy. The further development of public policies and institutions to support deployment, diffusion and transfer of renewable energy in general (and CSP in particular) is likely to be one of the main issues for dialogue with countries during the CTF investment plan preparation.

29. Countries have already started taking steps to encourage renewable energy development. For example:

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[7] Estela Solar (2008), "Solar Thermal Electricity: contributing to achieve the 20% of RES in the energy mix by 2020" European Solar Thermal Electricity Association, Belgium. Available online at: http://www.estelasolar.eu/fileadmin/ESTELAdocs/documents/2008.05.28_ESTELA_DisseminationDocFull.pdf

a) In Egypt, the Govt. has plans for large scale development of Egypt's renewable resources with the goal of having 20% of its installed generation capacity in the form of renewable by 2020. The main features of the generation expansion plans is large scale deployment of wind resources (estimated to reach 10% by 2027), complementing the addition of thermal generation plants and nuclear technology.

b) In April 2009, the Moroccan Council of Government adopted a new renewable energy law. The new legislation acknowledges the need to promote the underexploited potential of the country's renewable energy sources to: i) reduce its dependence on imported fossil fuels, ii) protect the environment, and iii) contribute to sustainable development. The new law sets the legislative framework for adapting the renewable energy sector to future technological developments and to encourage private sector investments.

c) The Government of Tunisia has formulated a 4 year energy management program (2008-11), which was adopted by the Council of Ministers on January 15, 2008 and presented to the public in a National Conference on Energy Management (NCEM) on February 12, 2008. The objective is to reduce the energy intensity of the Tunisian economy by 3% p.a. over the period and to increase the contribution of renewables to 4% of primary energy demand.

30. On December 17, 2008, the EU adopted a landmark piece of legislation that will drive the expansion of renewable energies in its member countries. Each of the 27 EU member states will be obliged to increase its share of energy from renewable sources in gross final consumption of energy[8] from 8.5% today to 20% by 2020. This Directive on renewable energies underpins the development of CSP projects in MENA countries because it explicitly mentions that green electricity from "third countries" can be counted for achieving the member states' national targets (see Box 2). But there remains the key issue of whether EU countries will give benefit of feed-in tariffs at suitable levels for green power from "third countries."

Box 1. New EU legislation paves the way for MENA exports of green electricity

a. EU countries are free to decide their preferred mix of renewables in order to take account of their different potentials, but must present national action plan by June 30th 2010.
b. To reach the individual targets, EU member states can "inter alia apply" support schemes and measures of cooperation "with third countries"
c. The electricity imported from a third country must be produced by a "newly constructed installation that became operational" or by the increased capacity of an installation that "was refurbished" after January 2009.
d. Under certain conditions, electricity from renewable sources produced and consumed in a third country can be counted towards the EU member states' targets in the context of the "construction of an inter-connector with a very long lead-time", e.g. between Italy and Tunisia.

[8] The gross final consumption of energy is the sum of: gross final consumption of electricity from renewable energy sources, gross final consumption of energy from renewable sources for heating and cooling, and final energy from renewable sources consumed in transport.

Financing Plan

31. Initial estimates suggest that total financing in the range of US$ 6-8 billion[9] will be needed to achieve a GW order scale-up. It is proposed that CTF co-financing constitute about 10% of the total resources required. Therefore, a regional CTF investment plan in the range of US$ 750 million in CTF co-financing could be prepared. Other sources of financing would include public and private debt and equity; EU neighborhood funds; bilateral financing from within the MENA region and from external donors; CDM and green electricity sales revenues; MDB financing; fiscal incentives offered by national governments (including feed-in tariffs).

32. A more detailed analysis of the capital cost buy-down needed and appropriate financing products to leverage private capital will be included in the regional investment plan. The World Bank Group will work with the African Development Bank, Arab and Islamic Funds, European Investment Bank, AFD, KfW, and other donors to mobilize public and private sector financing on the scale required to achieve the program's transformational objectives.

Next Steps and Time Schedule

33. The MDBs propose the following preparation schedule for the regional investment plan:

a) In-country stakeholder consultations done through a regional workshop in June 2009 to get input on program design, preparation and implementation approach
b) Preparation of Draft Investment Plan (one document comprising two sub-regional sub-programs) and identification of other resources for concessional financing July- October 2009
c) Wider consultations with industry/civil society on the draft investment plan. September 2009
d) Investment Plan submission to the Trust Fund Committee: October 2009

[9] This is a preliminary estimate for an approximate 1 GW addition based on an average of US$ 4000/kW, plus transmission infrastructure costs. These will be revisited during the preparation of the investment plan.

Annex 1

CSP Technologies

1. **Trough** – Trough systems consist of a solar field in the shape of a parabolic trough that concentrates the sun's heat on to a medium like salt or oil, which then is run through a heat engine to convert the heat into electricity. Trough configuration is currently the most widely used across the world, with the most currently operating and under construction plants. The largest plant made with this configuration is of 80MW, with a total of around 400MW under operation. Another 500MW of capacity is under construction across the world. This technology has been commercialized since 1985 and is the most mature.

2. **Tower** – Tower systems have a large central tower on which sun's energy is concentrated from an encircling solar heliostat field. It can provide the highest efficiency in conversion, since very high temperatures can be reached. This technology has been demonstrated several times, including recently in Spain, but remains less mature than trough plants. As a result this industry has not converged to a widely accepted best solution, and many configurations and technologies are still being explored.

3. **Linear Fresnel Reflector (LFR)** – LFR configuration uses a lens solar field to concentrate the energy and then uses a heat engine, much like trough systems. LFR solar fields have been developed as a potentially lower cost alternative to parabolic trough, but they are still in a prototype stage.

4. **Dish-Engine -** The dish engine configuration combines large parabolic dishes for the solar field with heat engines to produce power. These are mostly built in modular sizes of around 15-50kW and a plant can be scaled up easily by just adding more dishes. This configuration is still in a nascent pre-commercial stage, though it provides promise for small power installations.

Annex 2
CSP Cost Drivers

These main drivers and their significance are explained below.

1. Land footprint refers to the land area required by each technology per MW of installed capacity. Tower configurations need the most land (between 12-14 acres/MW), while dish engines need between 8-10 acres/MW, and trough configurations and Linear Fresnel Reflector (LFR) needs the least, between 4-8 acres/MW.

2. Heat generated refers to the temperature range that each system can achieve. According to Carnot efficiency, the CSP system achieves conversion efficiencies with higher temperatures. Tower configurations can achieve the highest temperatures (from 250 to 1,200 °C), followed by dish engines (from 600 to 750 °C) and through configurations and LFR (from 250 to 400 °C).

3. Tracking required states the type of tracking that is required by each technology. Concentrators that focus light on a line such as throughs and LFRs require 1-axis tracking, while concentrators that focus light onto a point require 2-axis tracking.

4. Concentration ratio refers to the ratio of the aperture of the concentrator to the area of the receiver. Systems with higher concentration ratios are capable of achieving higher temperatures and hence higher efficiencies, but also higher manufacturing costs. Tower and dish engine configurations have the highest concentration ration (between 500 and 1,500), whereas through and LFR configurations have between 80 to 100.

5. Modularity refers to the technology's capability to be scaled up or down easily by adding or removing modules of fixes capacity. Through and LFR plants are the least scalable plants as they are built as complete plants, while tower plants are slightly more scalable and dish engine are the most scalable.

6. Time of implementation refers to the lead time to build and make a plant operational. Due to the nature of differences in construction, tower plants take much longer to execute than trough or dish plants, though there are not enough large projects to make a projection. Longer implementation times increase the finance charges and hence the levelized cost of energy (LCOE).

Table 1. CSP technology characteristics

Technology Type	Foot print (acres/MW)	Heat (°C)	Tracking required	Concentration ratio	Modularity	Time of Implementation
Through	4-8	250-400	1-Axis	80-100	Low	Low
LFR	4-8	250-400	1-Axis	80-100	Low	Low
Tower	12-14	250-1200	2-Axis	500-1500	Medium	High
Dish-Engine	8-10	600-750	2-Axis	500-1500	High	Low

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