The World Bank

ESMAP
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Middle East and North Africa Region
Assessment of the Local Manufacturing Potential for Concentrated Solar Power (CSP) Projects

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Taking Advantage of Exceptional Natural Conditions

Concentrated Solar Power (CSP) is a renewable energy technology which, after a period of stagnation, has started to penetrate the energy market, particularly in Spain and the United States but also in the Middle East and North Africa Region (MENA) as well as other regions of the world. The MENA region has amongst the world's best conditions for CSP: abundant sunshine, low precipitation, plenty of unused flat land close to road networks and transmission grids. It is also close to Europe, where green electricity is much valued.

Box: What is CSP?

In a nutshell, CSP power plants produce electricity by converting concentrated direct solar irradiation into energy. Unlike photovoltaic (PV) cells or flat plate solar thermal collectors, CSP power plants cannot use the diffuse part of solar irradiation which results from scattering of the direct sunlight by clouds, particles, or molecules in the air, because it cannot be concentrated.

The process of energy conversion consists of two parts:

- The concentration of solar energy and converting it into usable thermal energy;
- The conversion of heat into electricity.

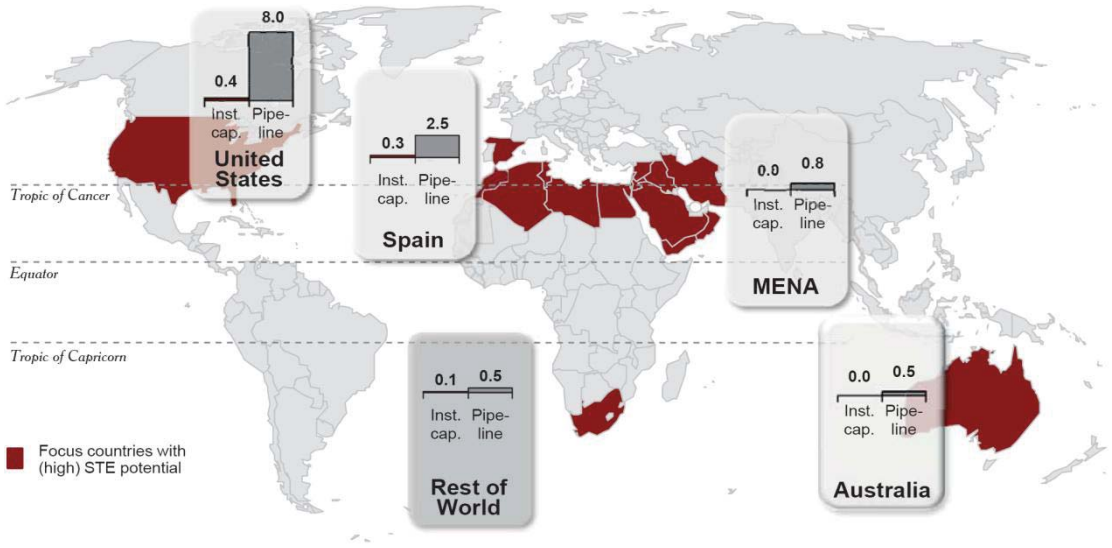
The conversion of heat into electricity is generally realized by a conventional steam turbine (Rankine cycle). Concentrating solar collectors are usually subdivided into two types, with respect to the concentration principle. Both types use mirrors to concentrate sunlight:

- Line-focusing systems, such as the parabolic trough collector (PTC) and linear Fresnel collector. These systems track the sun position in one dimension (one-axis-tracking);
- Point-focusing systems, such as solar towers or solar dishes. These systems realize higher concentration ratios than line-focusing systems. Their mirrors track the sun position in two dimensions (two axis-tracking).

One main advantage of CSP power plants over other renewable power technologies, such as PV and wind energy converters, is the option of energy storage. Unlike the storage of electric energy, thermal energy storage is practically and economically feasible already today, even in large-scale applications. Solar thermal power plants can be equipped with thermal energy storage with a full-load storage capacity in the range of several hours. Usually, the storage is filled during the day, and emptied again after sunset, so that electricity is still produced even after sunset. This allows for plant operation in concordance with load requirements from the grid, because in many countries there is an electricity demand peak after sunset.

After twenty years of operation of the first large scale CSP plants in California, the world-wide market growth of renewable energies has given CSP technology a new prospective in countries with high direct radiation. Starting in Spain and the US electricity, many projects are now under development and under construction:

Figure 1 - Global CSP capacity - Existing and through 2015



Source: Estela, 2010

However, high initial capital costs remain a significant issue for adoption of CSP technology. To make CSP projects in MENA cost effective in the short to medium term, a combination of factors is necessary, including local incentives (like long-term power purchase agreements [PPA], feed-in tariffs or tax rebates), climate related and other concessional finance options, as well as export of green electricity to Europe.

In the longer term, to make concessional finance less critical, generation costs will need to be dramatically lower. This implies that investment costs, and therefore manufacturing costs of the main components and systems, need to decrease. It will be made possible by a combination of technical innovation, economies of scale, and learning curve effect. The potential for such cost decrease is considerable, as CSP is a nascent industry, with a limited number of large players. MENA, like other emerging regions of the world, has technical and industrial capabilities which are likely to form a good basis on which to build CSP-related activities, as shown for example by the strong auto parts industry in several countries of the region. It could become home to a new, high value added industry, serving the local markets, as well as existing markets in Southern Europe, in the US and elsewhere. The region could benefit from significant job and wealth creation, while the global benefit would be from increased competition and lower costs in CSP equipment manufacturing.

To assess the local manufacturing potential for CSP components in the MENA region, a study was commissioned by the World Bank with donor support from the Energy Sector Management Assistance Program (ESMAP). It was carried out during the year 2010 by Ernst & Young (France) and the Fraunhofer Institute (Germany). A stakeholder workshop was conducted on September 30th, 2010, in Cairo, and feedback was received from the client countries, industry participants and donors. The AfDB and World Bank teams actively participated in the review and finalization of the study.

The MENA CSP Scale-up Investment Plan

The MENA CSP scale-up Investment Plan (MENA CSP IP), supported by the World Bank Group and the African Development Bank (AfDB), is intended to strategically utilize concessional financing from the Clean

Technology Fund (CTF) to accelerate global adoption of the technology in the region. It was endorsed by the CTF Trust Fund Committee on December 2, 2009.

This plan is a landmark climate change mitigation program aimed at co-financing nine commercial-scale power plants (totaling around 1.2 GW) and two strategic transmission projects in five countries of the MENA region (Algeria, Egypt, Jordan, Morocco and Tunisia, called the “MENA CTF” countries in the rest of this note). The vision is for the Mediterranean MENA countries ultimately to become major suppliers and consumers of CSP-generated electricity. The MENA CSP IP is conceived as a transformational program, leading to the installation of at least 5 GW of CSP capacity in MENA by 2020, based on the 1.2 GW triggered by the MENA CSP IP. The first projects are expected to start commercial operations by 2014, and initially to supply domestic markets in MENA countries.

Regional Transformation for a Global Impact

The transformational opportunity from local manufacturing of CSP in MENA countries could benefit from the following interrelated factors:

- MENA CSP is well placed to benefit from the massive scale-up of concessional climate financing envisaged under the United Nations Framework Convention on Climate Change (UNFCCC), and recently reaffirmed at the Copenhagen and Cancun conferences. The CTF allocation for the MENA CSP IP could be the seed money for financing a more ambitious scale-up. CSP in MENA and other regions could benefit from the recent Cancun agreements in 2010 which have opened the way for a much larger funding framework. The climate conference of Cancun agreed on a Green Climate Fund of US$100bn a year of climate funding from 2020 onwards that will be generated from a "wide variety of sources, public and private, bilateral and multilateral, including alternative sources." This could include a range of mechanisms such as auctioning carbon credits and levies on international aviation and shipping.
- Within such a framework, the Mediterranean Solar Plan is one of the key programs under the Union for the Mediterranean (UfM) and provides political momentum for initiatives such as Desertec at a bilateral level. MENA CSP could make solar energy trade a fundamental pillar of MENA-EU (European Union) economic integration, and it therefore presents a major opportunity for MENA to earn export revenue. MENA CSP could be key to realizing the EU's GHG emissions reduction and energy security objectives. The April 2009 EU Renewable Energy Directive, with its provisions for the import of renewable energy to achieve the mandatory renewable energy targets of EU member states, is a first step in that process, as are the Desertec Industry Initiative and the Transgreen/Medgrid Initiative.
- MENA's oil-producing countries are embarking on CSP investment programs to free-up oil and gas from the power sector for higher value-added uses and exports, and in the longer term for CSP energy export.

The combination of these factors could uniquely advantage MENA as a global location of choice for CSP production and, while creating demand for installed capacity, could strongly drive local manufacturing.

Three Scenarios

The analysis provided in the report is based on the assumption that the volume of the installed CSP capacity within the MENA region is a main precondition for the emergence of local manufacturing. The opportunity for local manufacturing of different components in the value chain depends on scenarios that represent critical levels of market development. The market volume is described for the five MENA CTF countries investigated in detail in the study in the form of three scenarios (figure 2). For the MENA region

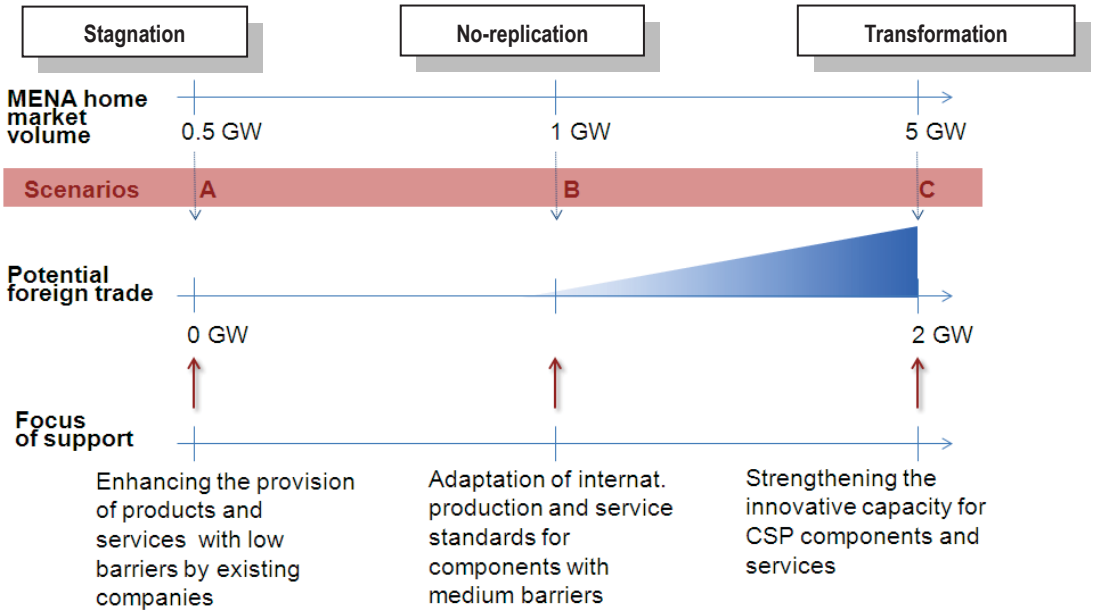
as a whole it can be assumed that the market volume could be twice as large as in the MENA CTF countries alone.

Scenario A—Stagnation: The domestic market volume of the five MENA CTF countries amounts to 0.5 GW only. Strong obstacles to local manufacturing of CSP components remain in MENA countries and most components, particularly those whose production requires high investment costs, are imported from more advanced markets. This scenario implies an incomplete realization of the MENA CSP IP.

Scenario B—No-replication: The domestic market volume of the five MENA CTF countries amounts to 1 GW in 2020, which is strictly the MENA CSP IP target without any significant replication effect. In this scenario, the market offers some opportunities for the development of local manufacturing of CSP components and provision of CSP services.

Scenario C—Transformation: This scenario implies the full success of the MENA CSP IP, and the development of a strong local manufacturing industry, with 5 GW of CSP by 2020 in the MENA CTF countries, as well as 2 GW worth of exported components. Such a scenario may materialize under favorable conditions only. A more conservative level of installed power may be found somewhere between the "no-replication" scenario and the "transformation" scenario; the approach here was to estimate a range rather than to come up with a precise figure for how many GW out of the 5+2 underlying this scenario will be realized by 2020.

Figure 2 - Market scenario context for the analysis of local manufacturing opportunities



Source: Authors

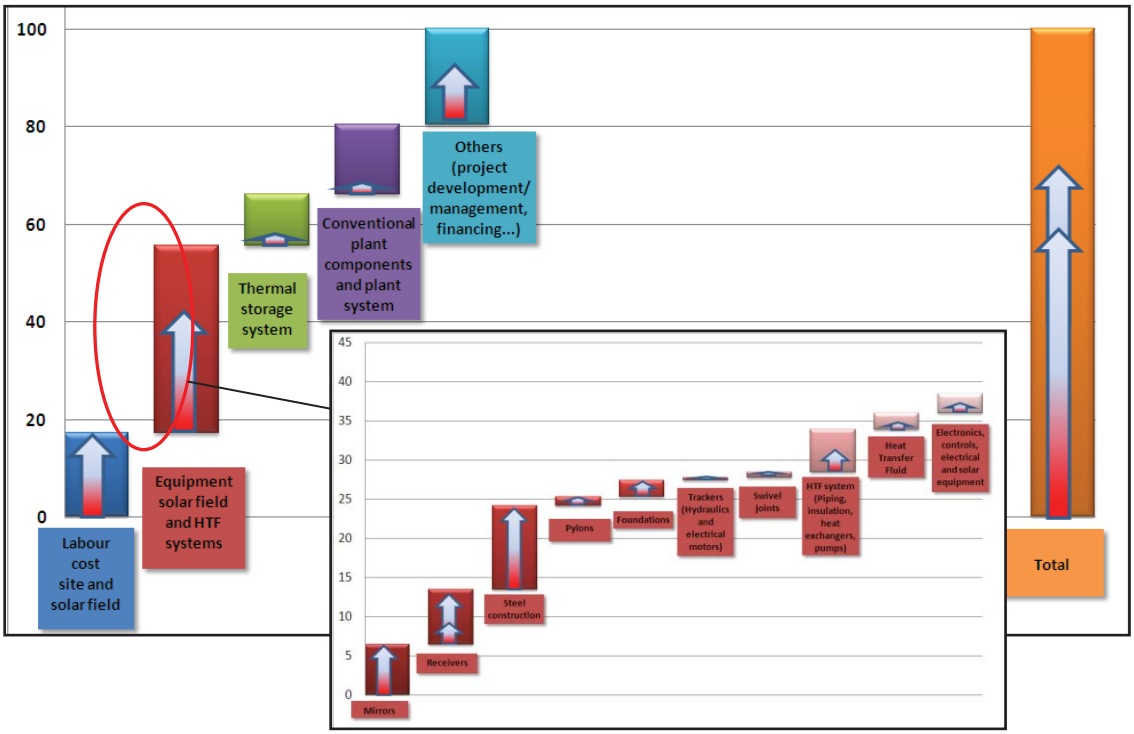
In the framework of these scenarios, the report provides answers to four main questions:

1. **Which parts of the value chain of CSP technologies are suitable for local manufacturing and how do international companies that are active along the value chain perceive such an opportunity?** The main CSP technology manufacturers are already involved in three ongoing CSP projects in the region (Morocco, Algeria, and Egypt). Given their strategies and interests, it is likely that these manufacturers will also participate in future MENA CSP markets. Depending on the

market size in MENA countries, these companies show substantial interest in building up manufacturing capacities in the region. This report analyzes the complexity and required technological knowledge for manufacturing the main CSP components in light of their production and manufacturing processes. Key components and services, as well as secondary components, were identified for local manufacturing under favorable conditions (figure 3).

In addition to construction and civil works, most components could be manufactured locally, starting with mounting structures and non-CSP-specific elements such as piping, then adding mirrors and possibly float glass; local production of receivers will take more time to develop. In conjunction with an evaluation of costs, this analysis provided the background for further assessment on local manufacturing.

Figure 3 - Local manufacturing shares by component (total plant and solar field) achievable by MENA countries within a decade



Source: Authors

Note: represents percent of total investment of a typical CSP plant of 50 MW; the arrows indicate estimations of the attainable local shares per component

2. **Are industries already located in MENA suitable for local manufacturing of CSP components and the provision of CSP-related services?** To answer this question, all relevant industries were analyzed. Regardless of the obstacles identified to participation of local MENA industries, expert interviews with MENA companies and with the existing CSP industry showed an increasing potential for local manufacturing of components for CSP, if the CSP market grows continuously in MENA.

   The participation of local firms in the provision of construction and engineering services for new CSP plants in the MENA region has been identified as an activity with promising

prospects in the future. Several industrial sectors that have the potential to integrate the CSP value chain in the MENA region are dynamic and competitive at a regional, and sometimes at an international, level. The success of these industries is facilitated by the development of joint ventures between large international companies and local firms, but also by the local implementation of subsidiaries of international players. In the past, the development of MENA CTF industries was driven by the low cost of labor and energy, and also by the geographic proximity to Europe. The landscape is already changing; pure subcontracting is now shifting toward more local R&D and the production of high-tech components. The shift toward higher technology content will require increased international cooperation. **MENA CTF countries are aiming to be "centers of excellence" and transition from offering only labor advantages to attract the private sector.**

3. **How can the potential of industries for local manufacturing of CSP components be encouraged by stimulation measures?** To answer this question, the report presents roadmaps and action plans for the key components and services of the CSP value chain. The success of the MENA CSP IP will be very important to realizing this potential. Unless this initiative reaches its goal of at least 1 GW CSP in the region by 2020, local manufacturing is unlikely to proceed at a rapid pace. However, the initiative alone will not be sufficient. Technological, entrepreneurial, policy, and market developments, which are crucial for the establishment of local manufacturing in MENA, must be driven by national strategies.

   National strategies for industrial development and energy policy should be well coordinated and involve, in addition to clear targets for the market diffusion of CSP, substantial R&D efforts, the creation of strategic funds for industrial development of CSP industry sectors, and stronger regional integration of policies. To enhance the innovative capacity of the industrial sectors, more technology parks/clusters and regional innovation platforms should be created. This would particularly help small and medium-sized firms to overcome innovation barriers and to gain access to the latest technological advances.

   Business models should build on the comparative advantages of certain industrial sectors in MENA countries and also involve international cooperation agreements, e.g. in the form of joint ventures and licensing. In the case of receivers, subsidiaries of foreign companies will most likely be a relevant business model at the beginning. The investment in new production lines based on highly automated processes for the mounting structure and in white glass production as well as an adaption of techniques for coating and bending mirrors will be the crucial first step.

   In order to invest in such developments, market actors will need good access to CSP-related information and certainty about the market development. Technical feasibility studies regarding production line upgrades could be an important element to assist enterprises. Furthermore, the creation of a regional CSP or renewable energy association dealing with issues such as the CSP market development, manufacturing options and the latest technological advances might be an essential element in this respect. Facilitation for local manufacturing will need to involve comprehensive education and training programs for the industrial workforce in relevant sectors. Universities should be encouraged to teach CSP-technology-based courses to educate potential workforces, particularly engineers and other technical graduates related to the CSP branch.

4. **What are the potential benefits to the MENA CTF countries of local manufacturing of CSP components and the provision of CSP-related services?** To assess the potential benefits of a

steady growth of the CSP market in MENA, a dynamic economic modeling approach was used to determine the impact on economic value creation, foreign trade, and job creation. The model considers a continuous local market, based on the three different growth scenarios described above. In the different market scenarios, the share of local manufacturing was dynamically modeled with respect to the required market size and the continuous growth of local technical know-how. **It is shown that MENA countries would obtain large economic and social benefits from a steady CSP market growth.**

The technical know-how in renewable energy technologies would increase with a growth in the CSP market, which would induce further positive effects including significant job creation. In the transformation scenario, the total potential of the local manufactured added value of CSP plants could reach almost 60 percent of the value chain by 2020, and a total local economic impact of US$14.3bn was identified (additional industrial value added). In scenario C in 2025 the number of permanent local jobs could rise to between 64,000 and 79,000 (45,000 to 60,000 jobs in the construction and manufacturing sector plus 19,000 jobs in operation and maintenance). Looking only to the time horizon of the CTF projects (2020), in total 34,000 employees might be working in the CSP industry permanently. In contrast, in scenario B a permanent workforce of 4,500 to 6,000 local employees is in place by 2020. This shows that jobs created in the construction and maintenance of CSP plants and local manufacturing of components are interlinked. **Large economic benefits for MENA countries could also be created by growing export opportunities for components related to a developing CSP market (over US$3bn by 2020 for exported components equivalent to 2 GW).**

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