Local Manufacturing Potential for CSP Projects in MENA

Context of the study and CSP value chain: components, market structure and trends

Dr. Wolfgang Eichhammer, Dr. Gabriel Morin
Motivation: The Need for a CSP Home Basis in MENA

- High potential for application of the technology exists in MENA itself
- In difference to other renewable energy technologies, such as photovoltaic or wind energy, the CSP potential is more limited in many of the major developed countries
- A CSP industry in MENA could serve not only the regional market but also existing markets in Southern Europe, the USA and elsewhere
- Examples of emerging wind industries in India and China demonstrate the positive effects that manufacturing of innovative renewable energy technologies can have on the respective economies

➢ MENA could become home to a new, high potential industry in a region with large solar energy resources and benefit from the associated job- and wealth creation
Countries in focus of the study:
Algeria, Egypt, Morocco, Tunisia, Jordan
➢ Realized or submitted CSP-projects to CTF

Main objectives of the study:

1. Provide an overview of manufacturing processes, costs and cost reduction potential for key CSP components
2. Assess the potential for a CSP manufacturing industry in the MENA region
3. Establish roadmaps and an action plan for the development of local CSP manufacturing in MENA
4. Analyze potential economic benefits of a CSP component manufacturing industry in MENA
CSP Technologies

Left: Parabolic Trough collector: 64 MW\textsubscript{el} power plant \textit{Nevada Solar One}; dimensions: collector aperture width 5 m (Morin, 2010)

Linear Fresnel Collector: 1.4 MW\textsubscript{el} plant \textit{PE1} in Murcia, Spain; dimensions: receiver height above mirror field: 7 m (Novatec, 2010)

Solar Tower plant PS10, 11 MW\textsubscript{el} in Seville, Spain (Abgengoa, 2010)

Dish Stirling prototype plants of 10 kW\textsubscript{el} each in Almería, Spain; diameter 8.5m (DLR, 2010)
CSP Market Shares and Development

<table>
<thead>
<tr>
<th>CSP Technology</th>
<th>Operational (MW)</th>
<th>Construction (MW)</th>
<th>Planning Phase (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tower</td>
<td>44</td>
<td>17</td>
<td>1603</td>
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<tr>
<td>Parabolic</td>
<td>778</td>
<td>1400</td>
<td>8144</td>
</tr>
<tr>
<td>Fresnel</td>
<td>9</td>
<td>30</td>
<td>134</td>
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<tr>
<td>Dish &amp; Stirling</td>
<td>2</td>
<td>1</td>
<td>2247</td>
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</tbody>
</table>

- Parabolic Trough today over 90% market share, today
- Other CSP Technologies gaining market shares
- 20 GW installed CSP capacity by 2020 is feasible
- BUT: Reliable financial and political framework needed!

(Συν Ωινδ Ενεργη, 2010)
The CSP Value-chain – Opportunities for Local Industries

Analysis of the CSP value-chain:
- Identification of current market players
- Review of production processes
- Cost analysis / cost reduction potential
- Complexity assessment for components

Core value chain:
- Project Development
- Materials
- Components
- Plant Engineering & Construction
- Operation
- Distribution

Elements of the core value chain:
- Concept Engineering
- Geographical Determination
- Determination of general requirements
- Concrete
- Steel
- Sand
- Glass
- Silver
- Copper
- Salt
- Other chemicals
- Mirrors
- Mounting Structure
- Receiver
- HTF
- Connection piping
- Steam generator / heat exchanger
- Pumps
- Storage System
- Power Block
- Grid connect.

EPC-Contractor:
- Detailed Engineering
- Procurement
- Construction

Essential partners:
- Finance & Ownership
- Research & Development
- Political Institutions

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Components of Parabolic Trough Power Plants

Parabolic Trough Power Plant

Solar Field
- Receiver
- Mirror
- Support Structure
- Tracking
- Piping
- HTF (Oil)
- HTF Pumps
- Heat Exchanger

Thermal Storage
- Molten Salt
- Hot Tank
- Cold Tank
- Heat Exchangers
- Pumps

Power Block
- Turbine
- Generator
- Condenser
- Pumps
- Heat Exchangers
- Fossil Boiler (optional)
- Balance of Plant
## Collector: Metal Support (Examples)

<table>
<thead>
<tr>
<th>Sample Collectors</th>
<th>Flagsol Skal-ET 150 (e.g. Andasol I-III)</th>
<th>Solargenix SGX-2 (e.g. Nevada Solar One)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure</td>
<td>Torque box design-galvanized steel</td>
<td>Recycled aluminum or steel struts and geo hubs</td>
</tr>
<tr>
<td>kg/m² per aperture area</td>
<td>~ 18.5 kg/m² steel</td>
<td>~ 11-12 kg/m² aluminum</td>
</tr>
<tr>
<td>Material quality</td>
<td>85% S235JR G2</td>
<td>6061 T6 aluminum</td>
</tr>
<tr>
<td></td>
<td>14% S355JR G2</td>
<td>(70-80% recycled content)</td>
</tr>
<tr>
<td></td>
<td>1% X5CrNi 19-10</td>
<td></td>
</tr>
<tr>
<td>Materials used</td>
<td>Equal angles (60%), Plates (10%), Square Tubes (15%), Rods, mills, profiles and fasteners (15%)</td>
<td>Similar parts</td>
</tr>
</tbody>
</table>
## Value Chain in CSP – Part 1

### Components

<table>
<thead>
<tr>
<th>Project Develop.</th>
<th>EPC</th>
<th>Materials (Raw &amp; Semi-finished)</th>
<th>Mirrors</th>
<th>Mounting Structure</th>
<th>Receiver</th>
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<tr>
<td>Concept Engineering</td>
<td>EPC</td>
<td>Pilkington</td>
<td>Flabeg Gmbh</td>
<td>Abengoa</td>
<td>Schott Solar AG</td>
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<tr>
<td>Companies</td>
<td></td>
<td>Solar Millennium</td>
<td>Abengoa Solar</td>
<td>Abengoa</td>
<td>(Solel Solar Sys)</td>
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<td>Solar Millennium</td>
<td>Abengoa Solar</td>
<td>Abengoa Solar</td>
<td>Flabeg Gmbh</td>
<td>Abengoa</td>
<td></td>
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<td>Abengoa Solar</td>
<td>Flabeg Gmbh</td>
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<td>Abengoa</td>
<td>Flagisol</td>
<td></td>
</tr>
<tr>
<td>Aries</td>
<td>Guardian Ind.</td>
<td>Guardian Ind.</td>
<td>Adacona</td>
<td>Acciona</td>
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<tr>
<td>Iberolica</td>
<td>Rieglass Solar</td>
<td>Rieglass Solar</td>
<td>Grupo Sener</td>
<td>Siemens</td>
<td></td>
</tr>
<tr>
<td>Torresol/Masdar</td>
<td>Heidelberg Cement</td>
<td>Heidelberg Cement</td>
<td>Siemens</td>
<td>Siemens</td>
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<tr>
<td>Novatec</td>
<td>Hydro</td>
<td>Hydro</td>
<td>Sky Fuel</td>
<td>Sky Fuel</td>
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<tr>
<td>Abengoa</td>
<td>Bertram Heatec</td>
<td>Bertram Heatec</td>
<td>Alcoa</td>
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<tr>
<td>Epuron</td>
<td>Haifa Chemicals</td>
<td>Haifa Chemicals</td>
<td>Areva (Auszra)</td>
<td>Areva (Auszra)</td>
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</tr>
<tr>
<td>Fichtner</td>
<td>SQM</td>
<td>SQM</td>
<td>Albas Solar</td>
<td>Abengoa</td>
<td></td>
</tr>
<tr>
<td>Brightsource</td>
<td>BASF</td>
<td>BASF</td>
<td>Abener</td>
<td>Abener</td>
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<tr>
<td>eSolar</td>
<td>Linde</td>
<td>Linde</td>
<td>Orascom</td>
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<td></td>
</tr>
<tr>
<td>M+W Zander</td>
<td>ACS Cobra</td>
<td>ACS Cobra</td>
<td>Ferrostaal</td>
<td>Ferrostaal</td>
<td></td>
</tr>
</tbody>
</table>
Value Chain in CSP – Part 2

Components

Value chain
- HTF
- Connecting Piping
- Steam Generator/Heat Exchanger
- Storage System
- Power Block & pumps
- Grid Connection

Companies
- Dow Chemicals
- Solutia
- Linde
- BASF

- Abengoa
- Bharat Heavy Electrical Ltd.
- Acciona
- ACS Cobra
- Bilfinger Berger
- Käfer
- Siemens
- MAN Turbo
- GE Power
- Sener
- MAN Turbo
- Kraftanlagen München
- Siemens
- GE Power
- Alstom
- ABB
- MAN Ferrostaal
- Siemens
- Abengoa Solar
- ABB
Value Chain in CSP – Part 3

Value chain

- Operation
- Distribution

Operation & Maintenance
- Nevada Solar
- Iberdrola
- Acciona
- ACS Cobra
- Abengoa
- FlagSol
- MAN
- Ferrostaal
- FPL Energy

Utility / Transport Distribution
- APS
- Endesa

Finance & Ownership
- Local banks
- International banks
- World Bank
- African Development Bank
- Investors
- Public institutions

Research & Development
- Plataforma Solar de Almeria
- DLR
- Fraunhofer
- CIEMAT
- NREL
- Sandia National Laboratory

Political Institutions
- Local governments

Essential partners

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Cost Structure of 50 MW PTC plant with 7.5 h storage

<table>
<thead>
<tr>
<th>Component</th>
<th>Relative Value of plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor Cost Site and Solar Field</td>
<td>17.14%</td>
</tr>
<tr>
<td>Solar Field</td>
<td>3.11%</td>
</tr>
<tr>
<td>Site Preparation and Infrastructure</td>
<td>5.82%</td>
</tr>
<tr>
<td>Steel Construction</td>
<td>2.50%</td>
</tr>
<tr>
<td>Piping</td>
<td>1.75%</td>
</tr>
<tr>
<td>Electric installations and others</td>
<td>3.96%</td>
</tr>
<tr>
<td>Equipment Solar Field and HTF System</td>
<td>38.54%</td>
</tr>
<tr>
<td>Mirrors</td>
<td>6.36%</td>
</tr>
<tr>
<td>Receivers</td>
<td>7.11%</td>
</tr>
<tr>
<td>Steel construction</td>
<td>10.71%</td>
</tr>
<tr>
<td>Pylons</td>
<td>1.07%</td>
</tr>
<tr>
<td>Foundations</td>
<td>2.14%</td>
</tr>
<tr>
<td>Trackers (Hydraulics and Electrical Motors)</td>
<td>0.43%</td>
</tr>
<tr>
<td>Swivel joints</td>
<td>0.71%</td>
</tr>
<tr>
<td>HTF System (Piping, Insulation, Heat Exchangers, Pumps)</td>
<td>5.36%</td>
</tr>
<tr>
<td>Heat Transfer Fluid</td>
<td>2.14%</td>
</tr>
<tr>
<td>Electronics, Controls, Electrical and Solar Equipment</td>
<td>2.50%</td>
</tr>
</tbody>
</table>
Complexity versus Investment-Intensity

Investment

Complexity

- Float Process
- Wet-Chemical Mirror Coating
- Sputter Process
- Sag Bending
- Galvanize Process
- Sol-Gel Process
- Jig-Assembly
Conclusion: CSP Components Production in MENA

Near-term: Low-Investment and Low-Complexity Activities in MENA:
- Collector Assembly
- Collector Installations
- Civil: Groundworks, Collector Foundations, Buildings, Infrastructure

⇒ MENA manufacturing of approximately 17% of plant invest
(+ optional EPC, Proj. Management)

If sustainable MENA-CSP-Markets are given:
- More investment-intensive and more complex CSP-Activities in MENA:
  - Mirror Production
  - Receiver Production
  - Other specialized components and processes

⇒ Local Value Creation: up to 80% of plant invest
Thank you for your Attention!

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Backup
Potential of the CSP Technology

Potential for solar thermal power generation worldwide

Suitability for solar thermal power plants:
- Excellent
- Good
- Suitable
- Unsuitable

Schott AG: Memorandum zur solarthermischen Kraftwerkstechnologie, 2006
Current CSP Project Development

Existing and planned solar thermal electricity capacity through 2015

Focus countries with (high) STE potential

AT Kearney: Solar Thermal Electricity 2025, Report June 2010
CSP Project Development

Current CSP projects classified by applied technology [in MW capacity]

- **Tower**: 440 MW in operation, 20 MW in planning
- **Parabolic**: 778 MW in operation, 1400 MW in planning
- **Fresnel**: 9 MW in operation, 30 MW in planning
- **Dish & Stirling**: 2247 MW in operation

CSP projects by country (operating, under construction and in planning phase)

- **Morocco**: 20 MW in operation, 20 MW in planning
- **Algeria**: 20 MW in operation, 110 MW in planning
- **Egypt**: 0 MW in operation, 100 MW in planning
- **Jordan**: 0 MW in operation, 50 MW in planning
- **Tunisia**: 5 MW in operation, 0 MW in planning
- **Israel**: 80 MW in operation
- **Abu Dhabi**: 0 MW in operation
- **Iran**: 0.5 MW in operation, 0 MW in planning

Sun & Wind Energy 6/2010
Working Principle of Parabolic Trough Power Plant
(Andasol Example)
Value Chain in CSP - Overview

Value chain

Components

Project Develop. EPC Materials Components

- Concept Engineering
- EPC
- Raw & Semi-finished
- Mirrors
- Mounting Structure
- Receiver

Components

Value chain

HTF Connecting Piping Steam Generator/Heat Exchanger Storage System Power Block & pumps Grid Connection

Operation Distribution

Value chain

Operation & Maintenance Utility / Transport Distribution

Finance & Ownership Research & Development Political Institutions

Essential partners
2. Assessment of Industry Capabilities for CSP Components and Services

- Industry surveys in CSP relevant sectors (MENA and globally)
  - Steel production/transformation
  - Float glass/mirror production
  - Electronic industry
  - Service providers (EPC)

- Surveys at public and private institutions & organizations relevant for CSP development

- Collection of complementary data: patent/foreign trade analyses in CSP relevant industrial sectors

Industrial capability

Assessment of potential for MENA industries to provide CSP components

Identification of potential players

Identification of technical & economic barriers for a CSP industry in MENA

Status of institutional framework

Sectoral competitiveness
3. Development of Roadmaps & Action Plan for CSP Local Manufacturing in MENA

- Based on previous status quo analysis:
  - Value chain assessment
  - Industry surveys

- Presentation of potential development paths for most relevant CSP manufacturing industries:
  - Future goals
  - Intermediate milestones

- Suggestions for actions on different levels to reach the milestones with regard to three market-growth scenarios:
  - Optimistic (5GW until 2020)
  - Medium (1GW until 2020)
  - Pessimistic (0.5 GW until 2020)
Based on market growth scenarios and regarding a reference CSP plant modeling of:

- Impact on GDP
- Labor impact
- Impact on foreign trade

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2012</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>Local share by 2025</th>
<th>Cost reduction by 2025</th>
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</thead>
<tbody>
<tr>
<td>Scenario A</td>
<td>20</td>
<td>233</td>
<td>196</td>
<td>1,496</td>
<td>25.1%</td>
<td>17%</td>
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<tr>
<td>Direct</td>
<td>20</td>
<td>125</td>
<td>571</td>
<td>346</td>
<td>~ 16%</td>
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<tr>
<td>Indirect</td>
<td>12</td>
<td>88</td>
<td>344</td>
<td>311</td>
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<tr>
<td>Scenario B</td>
<td>61</td>
<td>485</td>
<td>2,163</td>
<td>3,495</td>
<td>30.6%</td>
<td>~ 16%</td>
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<tr>
<td>Direct</td>
<td>39</td>
<td>251</td>
<td>1,167</td>
<td>1,959</td>
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</tr>
<tr>
<td>Indirect</td>
<td>22</td>
<td>213</td>
<td>996</td>
<td>1,535</td>
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<tr>
<td>Scenario C</td>
<td>368</td>
<td>2,803</td>
<td>14,277</td>
<td>45,226</td>
<td>56.6%</td>
<td>~ 40%</td>
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<tr>
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<td>1,403</td>
<td>6,999</td>
<td>21,675</td>
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<tr>
<td>Indirect</td>
<td>162</td>
<td>1,401</td>
<td>7,278</td>
<td>23,551</td>
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