The Role of CSP in the Future MENA Electricity Mix

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MENA Regional Water Outlook, The World Bank, January 26, 2012
Part 1: The scope of renewable energy in MENA

1. Technology options
2. Resource potentials
3. Sustainability indicators
4. A sustainable electricity supply scenario
5. Seawater Desalination
Portfolio of Energy Sources for Electricity:

- Coal, Lignite
- Oil, Gas
- Nuclear Fission, Fusion
- Concentrating Solar Power (CSP)
- Geothermal Power (Hot Dry Rock)
- Biomass
- Hydropower
- Wind Power
- Photovoltaic
- Wave / Tidal

- Ideally stored primary energy
- Storable primary energy
- Fluctuating primary energy
## Renewable Electricity Potential in Europe, Middle East & North Africa

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Min</th>
<th>Max</th>
<th>Electricity Yield in GWh/km²/y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass (0-1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geothermal (0-1)</td>
<td></td>
<td></td>
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<tr>
<td>Solar (10-250)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind Energy (5-50)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydropower (0-50)</td>
<td></td>
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<td></td>
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</tbody>
</table>

*Images courtesy of DLR.*
For example: CSP potential in MENA

I. Solar Resource Assessment

II. Land Resource Assessment

III. CSP Potential

IV. Statistical Evaluation
## Renewable Electricity Potential in the Middle East & North Africa

<table>
<thead>
<tr>
<th>Country</th>
<th>Hydro</th>
<th>Geo</th>
<th>Bio</th>
<th>CSP</th>
<th>Wind</th>
<th>PV *</th>
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<td>4.7</td>
<td>12.3</td>
<td>135771</td>
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<td>0.2</td>
<td>16</td>
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<td>0.5</td>
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<td>Djibouti</td>
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<td>0.0</td>
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<td>1.0</td>
<td>50.0</td>
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<td>25.7</td>
<td>14.1</td>
<td>57140</td>
<td>125.0</td>
<td>54.0</td>
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<tr>
<td>Gaza &amp; WB</td>
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<td>1.7</td>
<td>8</td>
<td>0.5</td>
<td>20.0</td>
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<tr>
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<td>1.0</td>
<td>5.0</td>
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<tr>
<td>Libya</td>
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<td>82714</td>
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<tr>
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<td>0</td>
<td>0.2</td>
<td>0.2</td>
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<tr>
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<td>14.3</td>
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<tr>
<td>Oman</td>
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<td>4.1</td>
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<td>Qatar</td>
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<td>Saudi Arabia</td>
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<tr>
<td>Tunisia</td>
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<td>3.2</td>
<td>5673</td>
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<td>3.7</td>
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<tr>
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<tr>
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<td>9.1</td>
<td>8486</td>
<td>3.0</td>
<td>19.3</td>
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<tr>
<td><strong>Total (TWh/a)</strong></td>
<td><strong>182</strong></td>
<td><strong>233</strong></td>
<td><strong>111</strong></td>
<td><strong>462196</strong></td>
<td><strong>304</strong></td>
<td><strong>356</strong></td>
</tr>
</tbody>
</table>

* PV potential includes demand side restrictions, the total potential is similar to CSP
“Sustainable” electricity supply should be:

- **Inexpensive**
  - low electricity cost
  - no long term subsidies

- **Secure**
  - diversified and redundant supply
  - power on demand
  - based on inexhaustible resources
  - available or at least visible technology
  - capacities expandable in time

- **Compatible**
  - low pollution
  - climate protection
  - low risks for health and environment
  - fair access
Installed Capacity in all MENA Countries by Sources

125% firm capacity with respect to peak load

260 GW fluctuating capacity!
Electricity Production of all MENA Countries by Sources

Electricity Production (TWh/y)

Year

Photovoltaics
Wind
Geothermal
Hydropower
Biomass
CSP Plants
Oil
Gas
Coal
Nuclear
CO₂- Emissions from Power Generation by Sources

<table>
<thead>
<tr>
<th>Source</th>
<th>t/GWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>12</td>
</tr>
<tr>
<td>Photovoltaics</td>
<td>70</td>
</tr>
<tr>
<td>Geothermal</td>
<td>80</td>
</tr>
<tr>
<td>Biomass</td>
<td>68</td>
</tr>
<tr>
<td>CSP Plants</td>
<td>17</td>
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<tr>
<td>Hydropower</td>
<td>17</td>
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<tr>
<td>Oil</td>
<td>700</td>
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<tr>
<td>Gas</td>
<td>450</td>
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<tr>
<td>Coal</td>
<td>800</td>
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<tr>
<td>Nuclear</td>
<td>65</td>
</tr>
</tbody>
</table>

MENA Regional Water Outlook, Phase 1
Why CSP for Water in MENA?

1. CSP potential is very large even at coastal sites
2. good seasonal correlation of availability and demand
3. most abundant in regions with highest water scarcity
4. base load for uninterrupted operation of desalination plants
5. solar powered pre-treatment replaces chemicals
Middle East & North Africa (MENA)

Water Production [MCM/y]

- Efficiency Gains
- Unsustainable Extractions
- CSP Desalination
- Conventional Desalination
- Wastewater Reuse
- Surface Water Extractions
- Groundwater Extractions
- Total Demand BaU

Year

MENA Regional Water Outlook, Phase 1
Part 2: The associated challenges

1. The flexibility challenge
2. The investment challenge
3. The quality challenge
4. The policy challenge
5. The role of CSP in the future electricity mix
The Role of Wind, PV and CSP

- PV and Wind do not deliver firm capacity.

- Strong, well developed power markets in industrial countries can easily integrate large amounts of PV and wind power, as the existing capacity can balance fluctuations.

- Growing power markets in developing countries need addition of firm capacity, preferably by CSP, biomass or hydropower.
Case study Germany 2050

The role of variable and flexible renewable power sources in a 90% renewable electricity scenario for the year 2050 for Germany.

Installed Capacities:

- Photovoltaics: 55 GW
- Wind Onshore: 40 GW
- Wind Offshore: 30 GW
- DESERTEC: 16 GW
- Import Norway: 4 GW
- Geothermal: 4 GW
- Biomass: 9 GW
- Biomass Waste: 4 GW
- Hydropower: 6 GW
- Natural Gas: 63 GW

The German Case Study, DLR 2011
Case study Jordan 2015: role of CSP and PV

Load in MW

Date

01.07 02.07 03.07 04.07 05.07 06.07 07.07

Pipeline Egypt

Hydro
Gas Turbine / natural gas
PV
Industrial Units
Steam Turbine / HFO
Gas Turbines / LFO
Combined-Cycle / natural gas
CSP / peak-medium
Import

Jordan Case Study, DLR 2012
Case study Jordan 2030: role of CSP and PV

Load in MW

Date

- Hydro
- CSP / base-medium
- CSP / peak - medium
- Gas Turbine / natural gas / LFO
- Pipeline Egypt
- Industrial Units
- Combined-Cycle / natural gas
- PV
- Import
The CSP Investment Challenge

CSP is a power plant plus „fuel“ for 40 years operation as a capital good at stable cost

- **steam cycle**
  - + 2500 €/kW + 2000 h/y
- **solar field 1**
  - + 2500 €/kW + 2000 h/y
- **solar field 2**
  - + 2500 €/kW + 2000 h/y
- **solar field 3**
  - + 2500 €/kW + 2000 h/y
- **solar field 4**
  - + 2500 €/kW + 2000 h/y
- **storage 1**
- **storage 2**
- **storage 3**
- **storage 4**

1500 €/kW

11500 €/kW 8000 h/y
High capital cost of CSP is prohibitive for developing countries

1. limited national budgets cannot cope with high investments
2. low national credit ratings translate to low project credit ratings

⇒ cost of capital (interest rates) higher than for industrial countries

⇒ CSP can be introduced in a series of subsidized projects but markets will not develop

⇒ real markets can only be initiated by increasing the ratings of CSP projects in developing countries towards AAA standard
The quality challenge: How to cover a defined load with RE?

10 MW CSP (10% Gas)
10 MW PV + 10 MW backup from grid (75% gas)
10 MW Wind + 10 MW backup from grid (60% gas)
Comparing Wind, PV and CSP

- In most cost comparisons, PV and wind are assumed to have access to a cost-free, loss-free and unlimited storage device: the electricity grid. This seems wonderful, but is a rather expensive illusion!

- In contrast to that, CSP has a real, limited storage with cost and losses. Therefore CSP will always loose when compared to PV and wind in a way that does not compare equal quality of supply.

- There are 1 GW CSP, 40 GW PV and 200 GW wind power installed today. This means that the remaining potential for cost reduction of CSP is much higher than that for wind and PV including storage and backup. This cost reduction potential must be tapped by decidedly developing CSP world wide (just like PV and wind has been developed in the past)
Setting an appropriate policy framework

- recognize the need for large RE investment
  (RE investment replaces fuel consumption for decades)
- reduce capital cost by increasing RE project ratings towards AAA
  (re-insured PPA, guaranteed renewable electricity tariff)
- recompense the quality of flexible renewable power
  (re-insured PPA, guaranteed renewable firm-capacity tariff)
- provide transparent, long-term stable regulatory and policy framework for
  real RE markets
The role of CSP in the future electricity mix

- Base load and flexible power on demand (storage, hybrid mode)
- By far the largest renewable energy resource from the deserts
- Only alternative for flexible power in MENA except fossil fuels
- Adds to limited flexible alternatives (hydro, biomass, geothermal) in Europe
- Learning curve still ahead (1 GW CSP, 40 GW PV, 200 GW wind in 2010)
- In the long run, the cost of firm and cost-stable capacity is lowest from CSP
- CSP is the only sustainable source for base load supply of desalination plants
- Only alternative for flexible and base load renewable electricity exports
- CSP can selectively substitute the most expensive elements of power supply
- CSP has among others the lowest life cycle carbon emissions and land use
- Renewable base load source for synthetic liquid hydrocarbon production
If we always ask for least-cost solutions, we may end up with a least-cost planet.