Renewable Energies in the MENA Region: Potential for Sustainable Energy Provision and Export to Europe

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50 countries analysed within the MED-CSP and TRANS-CSP Studies
Parameters considered in the analyses

- Annual electricity demand
- Annual load curve
- Available fossil and renewable resources
- Existing power plants in 2000 and their expected lifetime
- Cost of fossil fuels (oriented at IEA Scenario)
- Maximum production growth rates of RE industries
- Existing grid infrastructure
- 100% power availability
- Peaking power demand and 25% reserve capacity
- Sustainability criteria
- Opportunities of financing
- Policies and energy economic boundary conditions
Gross electricity demand in the analysed MENA countries

First Slowdown: Efficiency Gains & Liberalisation

Second Slowdown: Demand Stabilisation

Historical Data

Scenario Closing the Gap / High Efficiency

Year

Gross Electricity Consumption TWh/a

Turkey
Spain
Portugal
Malta
Italy
Greece
Tunisia
Morocco
Libya
Egypt
Algeria
Yemen
Saudi Arabia
Qatar
Oman
Lebanon
Kuwait
Jordan
Israel
Iraq
Iran
Cyprus
Bahrain
Gross electricity demand in the analysed European countries

- Switzerland
- Norway
- Iceland
- Bosnia-Herzegovina
- Serbia & Montenegro
- Romania
- Bulgaria
- Turkey
- Sweden
- Croatia
- Finland
- Greece
- Hungary
- Slovenia
- Slovak Republic
- Czech Republic
- Poland
- Italy
- Ireland
- United Kingdom
- Denmark
- Germany
- Netherlands
- Luxembourg
- Belgium
- Austria
- France
- Portugal
- Spain

Renewable Energies in the MENA Region
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Electricity production of power plants already existing in 2000 and deficit to be covered by new plants until 2050, in the European countries analysed within TRANS-CSP
Renewable energy resources in Europe and MENA

In brackets: (max. yield in GWhel / km² / y)

Biomass (1)

Geothermal (1)

Wind (50)

Hydropower (50)

Solar (250)

A solar power plant of the size of Lake Nasser equals the total Middle East oil production.
Area Required to Provide the Electricity Demand of the World, EU-25 and Germany
Renewable Energies in the MENA Region

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Solar Thermal Power Plants

SEGS 350 MW, California

Planta Solar 10 MW, Seville

Novatec Lorca

MAN/SPG Almeria

Nevada Solar I, 64 MW

Andasol 2 x 50 MW, Guadix
Solar Electricity Cost of Concentrating Solar Power Plants

Source: EU-IP NEEDS (New Energy Externalities Developments for Sustainability)
Economic renewable electricity potentials vs. demand in Europe and MENA
## Options for solar electricity transfer over 3000 km distance

<table>
<thead>
<tr>
<th>Solar Power Transfer by:</th>
<th>Hydrogen</th>
<th>AC / HVAC</th>
<th>HVDC Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Losses</td>
<td>75 %</td>
<td>45 % / 25 %</td>
<td>10 %</td>
</tr>
<tr>
<td>Cost</td>
<td>very high</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>Adaptation to Consumers (Transformer)</td>
<td>has to be transformed to AC first</td>
<td>directly transformable</td>
<td>has to be transformed to AC first</td>
</tr>
<tr>
<td>Over Sea Transport</td>
<td>by tankers or pipelines</td>
<td>not over 30 km</td>
<td>standard solution</td>
</tr>
<tr>
<td>Visibility Impact</td>
<td>very low</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>Materials and Emissions</td>
<td>moderate</td>
<td>moderate</td>
<td>low</td>
</tr>
<tr>
<td>Preferred Application</td>
<td>eventually fuel for transport</td>
<td>regional and local power</td>
<td>long distance power transfer</td>
</tr>
</tbody>
</table>
Concept of a EU-MENA Renewable Energy Link Using HVDC Power Transmission Technology
Analysed Examples for EU-MENA HVDC Interconnection

3 x 5 GW x 7000 h/y = 105 TWh/y
Scenario for total EU-MENA HVDC interconnection 2020 – 2050 *

<table>
<thead>
<tr>
<th>Year</th>
<th>2020</th>
<th>2030</th>
<th>2040</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity GW</td>
<td>2 x 5</td>
<td>8 x 5</td>
<td>14 x 5</td>
<td>20 x 5</td>
</tr>
<tr>
<td>Transfer TWh/y</td>
<td>60</td>
<td>230</td>
<td>470</td>
<td>700</td>
</tr>
<tr>
<td>Capacity Factor</td>
<td>0.60</td>
<td>0.67</td>
<td>0.75</td>
<td>0.80</td>
</tr>
<tr>
<td>Land Area km x km</td>
<td>CSP 15 x 15 3100 x 0.1</td>
<td>HVDC 30 x 30 3600 x 0.4</td>
<td>40 x 40 3600 x 0.7</td>
<td>50 x 50 3600 x 1.0</td>
</tr>
<tr>
<td>Investment Billion €</td>
<td>CSP 42 5</td>
<td>HVDC 134 16</td>
<td>245 31</td>
<td>350 45</td>
</tr>
</tbody>
</table>

* All countries analysed in TRANS-CSP
Concentrating Solar Thermal Power for Seawater Desalination (Options)

Heat Only

Solar Field → Storage

Solar heat → MED → Water

Power Only

Solar Field → Storage

Solar heat → fuel → RO → Water

Combined Heat & Power

Solar Field → Storage

Solar heat → fuel → MED → Power Plant → Water

MED: Multi-Effect-Distillation; RO: Reverse Osmosis Membrane Desalination
Projected cost of water (CoW) from reverse osmosis plants using conventionally generated power or solar electricity
Concentrating Solar Thermal Power Plants combined with Sea Water Desalination in Coastal Desert Areas

Energy + Water + Income = Sustainable economic development in arid regions
Renewable Energies in the MENA Region

Electricity and fresh water provision in MENA
Conclusions

- Within 15 years, a well balanced electricity mix may lead to less expensive electricity than business as usual. Domestic sources reduce the import of fuels.

- Solar electricity from concentrating solar power stations in MENA can provide firm capacity for base load, intermediate and peaking power.

- The most efficient and economic way to transfer electricity from MENA to Europe is via high voltage direct current transmission lines, adding about 1.5-2 cents/kWh to the local generating cost.

- By 2050, 700 TWh/y solar electricity could be imported from 20 locations in MENA at a cost of 5 c/kWh, providing about 15% of European electricity demand.

- To establish and maintain such a trans-national HVDC electricity grid, strong political support will be required.
for more information look at

www.dlr.de/tt/med-csp
www.dlr.de/tt/trans-csp
www.dlr.de/tt/aqua-csp