Renewable Energy Policy Experts Workshop
26th - 27th MASDAR Institute, Abu Dhabi, UAE

- EU-GCC co-operation potential in the field of Renewables: Technology and Research perspective

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Research Areas

- Aeronautics
- Space Research and Technology
- Transport
- Energy
- Space Administration
- Project Management Agency
Total income 2011 – Research, operations and management tasks (excluding trustee funding from the Space Administration / DLR Project Management Agency): € 796 Mio.

All values in € million

- Space Research and Technology
- Aeronautics
- Transport
- Energy
- Space Administration / DLR Project Management Agency
- Other income / earnings

Participation in the Helmholtz Association

- Success in obtaining program-oriented funding
- Added value from support of the Helmholtz Association
- Helping to shape the organisational development process
Energy Program Themes

- Efficient and environmentally compatible fossil-fuel power stations
  (turbo machines, combustion chambers, heat exchangers)
- Solar thermal power plant technology, solar conversion
- Thermal and chemical energy storage
- High and low temperature fuel cells
- Systems analysis and technology assessment
- Plataforma Solar de Almería (PSA)
EU-GCC Clean Energy Network
RE Policy Expert Workshop - MASDAR

Projects and Milestone

- MED-CSP  www.dlr.de/tt/med-csp  2005
- TRANS-CSP > DESERTEC  www.dlr.de/tt/trans-csp  2006
- MED-CSD  2008-2010
- EU GCC Clean Energy Network  2010-
  - Renewable Energy Policy Experts Workshop  today
- CSP Finance  2011
- World Bank MENA Water Outlook  2011
- IRENA Solar Atlas  2010-2013
- BETTER  2012-
  - Bringing Europe and Third countries closer together through Renewables Energies
- QatDLR  2012-
- DLR-KA.CARE Cooperation on CSP Research  2013-

Overview

- Energy, Renewables and Solar Power
- Transformation of the Energy System towards Sustainability
- Seawater Desalination with Concentrating Solar Power
- Renewable Energy Resource and Site Assessment
- Renewable Energy Expansion and Unit Commitment Model REMix-CEM
- Flexible, High Value Solar Power Exports
- Fields of EU-GCC R&D Activities
Shortage of energy?

- 25 cm crude oil annually on the hole surface of earth
- 2 millions barrels per square kilometer

Energy, Renewables and Solar Power
Transforming the Energy System towards Sustainability

Solar Power Technologies

Market available Technology
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 Potentials in EUMENA

Biomass (0-1)  Geothermal (0-1)  Wind (0-50)  Hydro (0-50)

Solar (10-250)

A CSP plant of the size of Lake Nasser equals the total Middle East oil production.
Renewable Power – Continuous Capacity

Power supplied by 10 MW wind capacity and conventional backup power from the grid needed to provide constant 10 MW base load supply.

Power supplied by 10 MW PV capacity and conventional backup power from the grid needed to provide constant 10 MW base load supply.

Solar power provided by a CSP-plant with 16 hour storage and conventional power from fuel from the same plant for constant 10 MW base load supply.

Criteria for Sustainable Electricity Supply

1. Affordability
   - Low cost
   - Low subsidies
   - Low structural effort

2. Security
   - Diversification of supply
   - Power on demand and redundancy
   - Sustainable energy resources
   - Available technology

3. Environmental compatibility
   - Low pollution, climate protection
   - Low risks for health and nature
   - Low land use and structural impacts

4. Social compatibility
   - Fair access to energy
   - Balance of dependencies and interdependencies
   - Strategic flexibility during transition

➔ One consistent pathway towards sustainable supply under specific limitations
Prospects for RES-E expansion in MENA

MED-CSP Study 2005:
Electricity supply in the Middle East & North Africa

Prospects for RES-E exports from MENA to Europe

TRANS-CSP Study 2006:
Electricity Supply in Europe
Desalination with Renewable Energy: Experience in the MENA region

Global Water Scarcity

- Physical water scarcity
- Economic water scarcity
- DLR area water scarcity
- Not estimated

Note: Indicates countries that will report more than 50% of their consumption in 2025.
Global Potential for CSP Solar Power

Global Potential 3,000,000 TWh/y – Global Demand 18,000 TWh/y

CSP Desalination Markets MENA until 2050

CSP Desalination is the solution to feed the world
Conventional Desalination Plant

- Tunel Intake
- Screening, Filtration
- Desalination Plant
- Heat / Power
- Direct Discharge
- Anti-Scaling
- Anti-Foaming
- Anti-Corrosion
- Desinfection

Advanced CSP-Desalination Plant

- Concentrating Solar Collector & Storage
- Nano-Filtration
- Desalination Plant
- Heat / Power
- Multiport Diffuser Discharge
- Horizontal Drain Intake or Micro- & Ultrafiltration
catalanadeperforaciones.com; cormix.info
Renewable energies for desalination: why CSP?

Desalination plants require continuous operation

- Conflict with the intermittent nature of renewable energies
- CSP offers the option of thermal energy storage
- Hybrid operation is possible in the same power block (no "shadow power plant" required)

Publications

The World Bank

www.dlr.de/tt/menawater
Renewable Energy Expansion and Unit Commitment Model
REMIX-CEM

Methodology for an optimized integration of RES-E technologies into existing power plant portfolios in MENA

- Emphasis on cost-optimized short-term integration of renewable energy systems for electricity generation (RES-E) and on security of supply
- Results for decision support for electricity authorities and power utilities in MENA
Prospects for RES-E expansion in MENA
ReMix cost optimization model for capacity expansion

Example: Case study for Jordan

Jordan’s situation:
- Strongly increasing electricity demand
- High dependency on fossil fuel imports

Business case MENA: Jordan
Strongly required firm and flexible renewable power capacity

- CSP competitive in the peak and upper-mid merit segment in the short-term.
- CSP providing strongly required firm and flexible power capacity.
- Very limited availability of electricity storage and of other flexible and firm RES-E.
- PV and Wind power as cheap “fuel saver”
- In the medium-term CSP competitive in mid-merit and base load segment.
- CSP in long-term as back-bone of electricity supply.

Source: Fichter (DLR) 2012, ReMix-MENA optimization tool
Flexible, High Value Solar Power for Export

Solar Electricity Imports from MENA to EU (DLR Concept)

- Flexible solar power with firm capacity from CSP plants is transferred directly via point-to-point HVDC links from production sites in NA to European demand centers.
- CSP imports complement European sources from wind and PV and fill the remaining gaps.
- Export is not linked to or required for domestic demand in NA.
- Import capacity will always be lower than reserve capacity.
- About 40 HVDC links will provide 700 TWh/a (15% of demand) with 100 GW (7% of total) capacity.
- Point-to-point-links can be bundled and eventually interconnected to form a HVDC grid in the long term.
- CSP-HVDC links will reduce need for grid, storage and backup capacity.

doi:10.1016/j.enpol.2011.11.091
First model of CSP-HVDC link for Morocco and Germany

- Length: 2300-2600 km
- Capacity: 1500 MW
- Transfer: 9.3 TWh/yr
- Investment: 14-16 bn €
- Cost: 12 6cent/kWh
- Voltage: ±600 kV
- Technology: Trough/VSC
- Land use CSP: 150 km²
- Land use HVDC: 150 km²
- Commissioning: > 2025
- Cooling: dry
- Water supply: desalination
- Project structure: cooperative
- Finance: IIPPA
- Economic Life: 40 yr

Role of CSP imports in Europe (without CSP imports)

A 90% RES-E scenario for Germany without CSP imports:
- 375 GW + 40 GW NTC + 40 GW Storage

- Solar power plants: 375 GW
- Wind onshore: 200 GW
- Wind offshore: 35 GW
- Biomass: 20 GW
- Nuclear: 25 GW
- Hydro storage: 10 GW
- Solar PV: 10 GW
- Storage and net capacity: 20 GW
Role of CSP imports in Europe (with CSP import)

A 90% RES-E scenario for Germany with CSP imports:
225 GW + 8 GW NTC + 20 GW HVDC + 8 GW Storage

<table>
<thead>
<tr>
<th>Energy source</th>
<th>Installed Capacity (GW)</th>
<th>Annual electricity grid (TWh)</th>
<th>average utilization (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Collector</td>
<td>150</td>
<td>224</td>
<td>328</td>
</tr>
<tr>
<td>Wind Onshore</td>
<td>69.5</td>
<td>10.1</td>
<td>346</td>
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<td>346</td>
</tr>
<tr>
<td>Raw Gas</td>
<td>101.5</td>
<td>10.1</td>
<td>346</td>
</tr>
<tr>
<td>Total</td>
<td>480.5</td>
<td>25.2</td>
<td>346</td>
</tr>
</tbody>
</table>

CSP imports from NA to Germany via HVDC links will lead to:
- 150 GW less power plants for the German “Energiewende”
- 5 times less grid capacity (no significant expansion)
- 5 times less power storage (no significant expansion)
- 90% RES-E can be achieved much faster and with much less effort
- Allows every European country to follow a similar strategy without creating external costs by RES-E surplus and gaps to be balanced by neighbors

Alternative:
Surplus (?) from Moroccan wind power and PV (?) exported to Europe through the AC grid of Andalucia (?)

Role of RES-E imports in Europe

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Why CSP imports from North Africa and Middle East?

- more sunny days
- better incidence angle
- lower seasonal variation of electricity yield
- better availability of firm and flexible power

Relative monthly electricity yield of a CSP plant with large solar field and storage (SM 4)

Solar Power & Desalination Plants

- Energy,
- Water,
- Food,
- Labor and Income

for further 300 Million people in MENA
EU-GCC Clean Energy Network
RE Policy Expert Workshop - MASDAR

EU-GCC co-operation potential in the field of Renewables: Technology and Research perspective

Fields of Activities

Fields of Activities for R&D in RE in EU-GCC
- Transformation of the Energy System towards Sustainability
- Seawater Desalination with Concentrating Solar Power
- Renewable Energy Resource and Site Assessment
- Renewable Energy Expansion and Unit Commitment Model REMix-CEM
- Technologie Development of Solar Thermal Power Plants
- Storage Technologies
- Flexible, High Value Solar Power Export
- Future Fuels: Hydrogen and synKWS
Selected publications

- MED-CSP [www.dlr.de/tt/med-csp](http://www.dlr.de/tt/med-csp)
- TRANS-CSP [www.dlr.de/tt/trans-csp](http://www.dlr.de/tt/trans-csp)
- AQUA-CSP [www.dlr.de/tt/aqua-csp](http://www.dlr.de/tt/aqua-csp)
- MED-CSD [www.med-csd-ec.eu/eng](http://www.med-csd-ec.eu/eng)
- MENA Regional Water Outlook [www.dlr.de/tt/menawater](http://www.dlr.de/tt/menawater)
- Solar electricity imports from Middle East and North Africa to Europe Energy Policy 42 (2012) 341-353 [http://dx.doi.org/10.1016/j.enpol.2011.11.091](http://dx.doi.org/10.1016/j.enpol.2011.11.091)

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