DESERTEC –
Clean Power from Deserts

Dr. Oliver Steinmetz
Co-Founder & Member of the Supervisory Board
Oliver.Steinmetz@desertec.org

Workshop on “Solar Energy (Concentrated Solar Power)"
Academy of Athens & the European Academies Science Advisory Council (EASAC)
Athens, 9 December 2011
Agenda

- DESERTEC: A global concept
- DESERTEC Initiatives
Challenges of the 21st century

- Energy supply AND climate protection

How can 10 billion people live in a sustainable way on this planet that’s already overburdened by 5 billion people?
Desert Regions with Solar Energy Potential
Energy Consumption: Light
Power Supply (Deserts) vs. Demand Regions

Graphic Concept by DESERTEC Foundation and P3 Group
Based on Data from NASA and German Aerospace Center (DLR)
Solar power generation

Basic idea behind DESERTEC

Within 6 hours deserts receive more energy from the sun than humankind consumes within a year.

Dr. Gerhard Knies
The DESERTEC Concept integrates CSP with other renewables and HVDC

EU–MENA = Europe – Middle East & North Africa • CSP = Concentrated Solar Power • HVDC = High-Voltage Direct Current

The symbols for power sources are only indicators of potential locations.

Sources: Clean Power from Deserts • White Book 4th Edition • DESERTEC Foundation • February 2009 • www.desertec.org • www.dlr.de

O. Steinmetz – DESERTEC – EASAC Athens, 9 December 2011
More than 90% of world population could be served by clean power from deserts.

World electricity consumption 2050: 50,000 TWh/y

50% from deserts worldwide

= 25,000 TWh \rightarrow 10,000 GW capacity from 360 \times 360 \text{ km}^2 (130,000 \text{ km}^2)

= 0.31\% of Earth’s deserts
distributed across “10,000” sites

NB: Deserts grow by 60,000 km$^2$ / year!
Role of DESERTEC Foundation

■ Promote the Vision

■ Networking & Coordination Hub
  – Partnering Strategy
    • Industrial Partners
    • Academic Partners
    • Individual Partners

■ Roadblock Remover
2009: MedGrid
2010: MedGrid
2011: Greece?
2012: Web 2.0:
- Knowledge Platform
- Crowdsourcing

Charitable Foundation
by private citizens
est. 2008 / 09

TREC
Scientific Studies
2004-2006

2007: EU Parliament
2008: Med. Solar Plan
2009: Morocco Solar Plan
2013-15: Dii Reference Project in Morocco
Where DESERTEC Foundation can help

- As an NGO we can open doors
  - Non-profit, citizens’ initiative ➔ credibility

- Connections to partner countries
  - Citizen-to-Citizen communication
  - Consulting for governments
  - Acceptance in the civil societies
  - Own coordinators in the countries
Why a University Network?

- Question from the Desert Countries:
  - “What’s in it for Us?”
- Maximise “local content”
- “Human Capacity Building” is Key!
  - Exchange Best Practices (Curricula etc.)
  - Exchange Researchers & Students
Socio–Economic Consequences

- The wealth, well-being and peace of our partner countries in and near desert regions depends on

  - Access to energy
    - DESERTEC power

  - Access to water
    - DESERTEC desalination
      - Conflicts, e.g. Jordan river: Israel / Palestine / Jordan ...

  - Access to food
    - even in currently arid regions?!

  - Birth rates are inversely proportional to wealth!

20 Shareholders

- ABB
- ABENGOA SOLAR
- ceVital
- Enel Green Power
- Deutsche Bank
- Flagsol
- e.on
- HSH Nordbank
- M+W Group
- RED Electrica de Espana
- Siemens
- Schott Solar
- Terna
- UniCredit

35 Associated Partners

- 3M
- AGC
- Audi
- Bilfinger Berger
- Commerzbank
- Concentrix Solar
- Deloitte
- Evonik Industries
- FCC
- First Solar
- Fraunhofer
- Garrad Hassan
- HSBC
- IBM
- ILF
- Itaigen
- Krefel
- Laemmyer International
- Morgan Stanley
- NREL
- OMV
- Rexroth Bosch Group
- SMA
- Terna Energy
- TUV SUD
- Unilever
- Unipol
- Intesa Sanpaolo

Cooperating with institutions, associations and other initiatives:
MSP, UfM, IRENA, RECREE, ENTSO-E, ESTELA, OME, MEDRING, MEDGRID, etc.

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Greece: A Special Case?

- A Marshall Plan for Greece? Solar plants as part of that?

- Mediterranean Climate Initiative (Greece & Turkey & 12 other Eastern Med. States)

- Greece: Relatively small solar thermal potential compared to Spain: (“economic” = all non-excluded areas with DNI > 2000 kWh/m²/y)
  - Greece: 4 TWh/y = 500 MW of plants = 10 ANDASOL-type plants = 2 bn € Investments
  - Italy: 7 TWh/y
  - Spain: 1,278 TWh/y
“Clean Power from Deserts”

“The ultimate test of human intelligence”

www.DESERTEC.org
Oliver.Steinmetz@DESERTEC.org

Charitable Foundation – Volunteers & Donations Welcome

GLS Gemeinschaftsbank eG
IBAN: DE92 4306 0967 1100 1105 00
BIC: GENODEM1GLS
Crisis? What Crisis?

“When written in Chinese, the word ‘crisis’ is composed of two characters. One represents danger – and the other represents opportunity.”

John F. Kennedy
CSP “losing against” PV?

May the best technology win!
And that depends on the application case.

Both PV and CSP are facing a huge market potential

Differences in technology maturity

“It depends”:

• Daytime applications => PV

• Dispatchable, large size => CSP
  Peaks in desert countries: sunset +/- 3 hours => storage inevitable
Who pays the Delta?

CSP still “more expensive” than gas, coal (and wind)

• But rapid cost degression: Watch for the real price offers for Ouarzazate (Morocco) and in the U.S.

The rest depends on “political will” – expressed as budgets!

There are several ways to shave down these costs:

• Concessional loans
• State / EU grants, subsidies, tax breaks, …
• PPA’s (local + from EU via Article 9)
• CO$_2$ emission rights trading (CDM)
• Insurance premium against oil price volatility …

“If you always ask for least cost, you will wind up with a least-cost planet.” (Franz Trieb)
Solar energy has the largest potential

Electricity yield and potential in EU–MENA

- **Biomass**: 0–1 GWh/km²y, 1,350 TWh/y
- **Geothermal**: 0–1 GWh/km²y, 1,100 TWh/y
- **Hydropower**: 0–50 GWh/km²y, 1,350 TWh/y
- **Wind power**: 5–50 GWh/km²y, 1,950 TWh/y (off-shore excluded)
- **Solar power**: 10–250 GWh/km²y, **630,000** TWh/y

EU–MENA = Europe – Middle East & North Africa
Source: DLR · MED–CSP · Concentrating Solar Power for the Mediterranean Region · Stuttgart 2005 · www.dlr.de/tt/med–csp

NB: Electricity demand
EU–25: 3,200 TWh/y
MENA: **600** TWh/y
Data for 2005

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Power demand & supply scenario (TWh/y) in MENA and EU

**MENA:** Transition Mix 2000–2050

including export to Europe and power for water desalination

**EU:** By clean power from deserts EU may gain

10–15 years in the fight against climate change, by importing 17% from MENA

Thanks to energy efficiency and renewable energies, nuclear energy can be phased out completely, and oil, gas and coal largely.
Resulting de-carbonisation in EU–MENA, compatible with climate goal $\Delta < 2^\circ$.

![Graph showing CO2 emissions from various sources with a significant reduction over time, indicating a decrease of 81% by 2050. Source: DLR studies.](image)
DESERTEC – from Concept to Organisation

2003–2007 Development of the DESERTEC Concept:

- 3 DLR Studies on feasibility of a „Trans-Mediterranean Renewable Energy Cooperation“ (TREC) → Worldwide informal network of scientists & other specialists under patronage of HRH Prince Hassan bin Talal of Jordan, President of the CLUB OF ROME

2008 Mediterranean Solar Plan of the Union for the Med.

2009 Charitable DESERTEC Foundation established by private citizens from the TREC network + Club of Rome

2009 Industrial Initiative Dii GmbH established – to accelerate the implementation of DESERTEC in EU–MENA

2010 Start of the DESERTEC University Network in EU–MENA
Start of MedGrid – for the EU–MENA Supergrids
### Rough estimate for DESERTEC

**Power for 10 billion people in 2050**

<table>
<thead>
<tr>
<th>Demand</th>
<th>6 MWh/y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply</td>
<td>60,000 TWh/y</td>
</tr>
<tr>
<td>Power</td>
<td>20,000 GW</td>
</tr>
<tr>
<td>Construction</td>
<td>~1.4 GW/Day</td>
</tr>
</tbody>
</table>

- **Demand**: Average power per person in 2050: ~6 MWh/y
- **Supply**: Power for 10 billion people in 2050: 60,000 TWh/y
- **Power**: 3,000 hours per year from sun, wind etc.
- **Construction**: 40 Years ≈ 14,600 Days

<table>
<thead>
<tr>
<th>Region</th>
<th>2006 MWh/y</th>
<th>2007 TWh/y</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>3.1</td>
<td>18,000</td>
</tr>
<tr>
<td>OECD</td>
<td>8.6</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>12.2</td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>6.4</td>
<td></td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>World 2007</th>
<th>18,000 TWh/y</th>
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<td>Germany</td>
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</tr>
</tbody>
</table>


Comparison with China:
- 174 coal fired plants of ~500 MW new in 2006
- 2009: ~0.21 GW/Day
- 2011: ~0.24 GW/Day

\[
\frac{0.24}{1.2} = \frac{1.4}{7} \quad \checkmark
\]
Why Nuclear Energy? We can use Fusion Today!

... and no need to wait for ITER ...

The sun is our fusion reactor!

Safety distance 150 000 000 km

solar dishes = energy receivers
“Favourite Misunderstandings” about DESERTEC

- “Colonialists!” “Imperialists!”
  - The energy should first feed the region, only the (vast) surplus should be exported
  - Partnerships with “sunny” countries – growing number of “candidates”!

- “CSP fanatics!”
  - We’re open for all renewables: May the best technologies win!

- “Oligopolists!” “Big business!”
  - The overall capacity can be provided through many installations, big and small
  - E.g. why not combine off-grid micro-CSP or PV with microfinance in Africa?

- “We can produce enough renewable energy within Europe!”
  - We cannot reach the CO₂ goals if we do not implement all possible means quickly
  - We need to complement EU–internal sources with – diversified! – external sources

- “Germans!”
  - Climate change is global, so DESERTEC is global
  - International network, only started in Germany
Oliver Morton, The Economist

- Emphasise links between Climate Change and Development (J. Sachs would agree!)
- New thinking needed: Make clean, renewable energy cheaper! Foster R&D, preferential loans etc.
- A greater emphasis on the smaller but more attainable remedies
The potential offered by solar power was recognized at an early point in time

El–Maadi • Egypt • 1913

“Using solar power you would only need (...) about one tenth of the area of Sweden in the Sahara in order to supply the whole world with energy.”

Frank Shuman • 1914

Sources: The installation “Sun of 1913” • Christina Hemauer and Roman Keller • The Art Biennial • Cairo 2009 • Scientific American

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HVDC is suitable for long-distance transmission of electricity

High-voltage DC power transmission

- ~ 3% losses per 1,000 km
- ~ 10...15% losses from North Africa to central Europe
- More efficient than hydrogen with generation, transport and utilization

Number of transmission lines for 7,000 MW

- 400 kV AC
- 800 kV AC
- 500 kV HVDC
- 800 kV HVDC

Graphic: ABB

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Many HVDC links already exist

HVDC in Europe

existing
under construction
under consideration

Source:
HVDC = High-Voltage Direct Current
Spain–Morocco: 400 kV AC designed for 450 kV DC

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Feasibility studies on HVDC links

North Africa – Europe transmission lines

Source: Eicke Weber · Fraunhofer Forum · Munich · March 15, 2010 · www.energie.fraunhofer.de

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The largest HVDC link is in China

Yunnan–Guangdong

- ±800 kV HVDC (world record)
- Length: 1,400 km
- Power transmission: 5,000 MW
- Power generation in 2 hydropower plants
- Start: 2007
- 2nd pole: Comm. 2010/11

HVDC = High-Voltage Direct Current

Source: Siemens
Summation for numerous individual units with concentrated solar power

**Collector areas for solar power plants**

<table>
<thead>
<tr>
<th>Electricity demand</th>
<th>Collector area</th>
</tr>
</thead>
<tbody>
<tr>
<td>World: 17,000 TWh/y</td>
<td>300 x 300 km²</td>
</tr>
<tr>
<td>EU-25: 3,200 TWh/y</td>
<td>125 x 125 km²</td>
</tr>
<tr>
<td>MENA: 600 TWh/y</td>
<td>55 x 55 km²</td>
</tr>
</tbody>
</table>

Data for 2005 theoretical values

EU-25 = 25 European Countries • MENA = Middle East & North Africa • CSP = Concentrated Solar Power

Source: Clean Power from Deserts • White Book 4th Edition • DESERTEC Foundation • February 2009 • www.desertec.org

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Mission

- Für eine schnelle weltweite Umsetzung des DESERTEC-Konzepts

- Sauberer Strom aus Wüsten für eine Welt mit 10 Milliarden Menschen

- Ein globales Lösungsmodell für Energiesicherheit und Klimaschutz
Lese-Empfehlungen

- www.iea.org – CSP & PV Roadmaps
- WWF & Böll-Stiftung: Studie www.panda.org/heliosthana
- Bellona Foundation – www.bellona.org/subjects/sahara-forest-project
- IIASA & Potsdamer Klima-Institut: “Expanding Solar Energy in North Africa to Achieve Climate Targets” – link
- Solar-Aufwind-Turm – link
- “Cost of Planet”: “Externe” Kosten offenlegen (← WWF Footprint)
Concentrating Solar Collector Technologies

Linear Concentration
conc: 100,
T: ~ 500°C

Parabolic Trough

Point Concentration
conc: 1000+,
T: ~ 1000°C

Dish/Engine

Central Receiver

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Example: CSP Plant with Thermal (Salt) Storage ➔ solar power day & night

<table>
<thead>
<tr>
<th>Surface Area:</th>
<th>1.3 x 1.5 km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar field:</td>
<td>510,120 m²</td>
</tr>
<tr>
<td>No. of mirrors:</td>
<td>~ 210,000</td>
</tr>
<tr>
<td>Construction costs:</td>
<td>~ 300 Mio. €</td>
</tr>
<tr>
<td>Subsidy:</td>
<td>~ 0.27 €/kWh</td>
</tr>
<tr>
<td>CO₂ saved / year</td>
<td>~149,000 t</td>
</tr>
</tbody>
</table>

**Andasol 1** • Andalusia • Spain • 50 MW • 2009

Andasol 2: 50 MW in trial operation • Andasol 3: 50 MW under construction

Subsidy 2008 acc. to Orden ITC/3860/2007 as of 28 Dec. 2007 • CO₂ savings compared to a modern coal-fired power plant

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Example: Linear Fresnel design

CSP with almost no Water Consumption

Puerto Errado 1 · Murcia · Spain · 1,4 MW · 2009
Solar Field: 2 x 980 m x 16 m · Water–Steam: 60°C…270 °C, 55 bar

Sources: Novatec Biosol · www.novatec-biosol.com · National Renewable Energy Laboratory, USA · Nokraschy Engineering

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