How can 10 billion people live sustainably on Earth?

DESERTEC

a solution model for a

Sustainable World with 10 billion People

thru Clean Power from Deserts

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Brief calendar of DESERTEC mile stones

• 26.04.1986 Tschernobyl Accident
• 21.09.2003: Founding of the Trans-mediterranean Renewable Energy Co-operation TREC in Hamburg, and beginning of DLR CSP studies
• 1.04.2006 creation of the brand name DESERTEC for the TREC plan to put DESERts and TECHnology into service for global energy and climate security.
• 15.01.2008 consultation with French President‘s office for Union of the Mediterranean UfM and Mediterranean Solar Plan MSP
• 13.07.2008 Union for the Mediterranean and the MSP announced
• 1.10.2008 Proposal for DESERTEC Industrial Initiative to MunichRe
• 23.01.2009 Founding of DESERTEC Foundation DF
• 13.07.2009 Announcement of DESERTEC Industrial Initiative Dii
• 30.10.2010 Founding of DESERTEC University Network DUN
DESERTEC – *a solution model* for a Sustainable World with 10 billion People thru Clean Power from Deserts

1. Humankind on the way to 10 billion people,
2. Earth’s carrying capacity is declining from 5 to 3 billion. 

I will describe how by DESERTEC sufficient clean power from deserts can be provided:
what are the required volumes for 10 billion people,
the required pace for the 2° limit,
the needed technologies and financial incentives,
and the needed political approaches to put the DESERTEC Concept in place at a global scale.
**Sustainability** = strategy of survival for a growing mankind on a finite planet

Structural diagrams for 2 different views of sustainability,

**scientists view** $E < M < N$

- **Nature**
  - earth, sun, ...
- **Mankind**
- **Economy**

**economists view:**
- $M$ and $N$=external resources for $E$
- Claim: Maximal market economy $\Rightarrow$ optimal sustainability
  - ("invisible hand“ effect)

\[ E \rightarrow M \rightarrow N \]
„invisible(?) hand“ of current market economy is degrading Earth’s carrying capacity

Ostritz/Zittau, 9.8.2010
The 2 most important events in history of mankind:
(1) – 250,000 years: appearance of homo sapiens sapiens
(2) 1985: No. of homo sapiens exceeds carrying capacity of planet Earth
Visible fist of capital economy: Natural disaster events 1980 – 2009, global

- Hydrological (floods), meteorological (storms) events
- Geo physical events (Earthquakes, etc)

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A sustainable world for 10 bn people?

HUMAN SECURITY Octet:

- POPULATION Limit 10 bn
- reliable EN-supply
- WATER&FOOD reprocessing, desalination, irrigation, fertilizer distribution
- more MATERIALS reprocessing
- more civilization & wealth per cap
- Global and inter-generational justice
- Bio Diversity
- Clean and secure energy/power = key to ecological and social stability of a world with 10 bn people
Organization of players for global sustainability:
“invisible hand of economy“ :  ➞ no alignment for sustainability

Principles of organization:
- National advantage
- Capital economy

main players
- United Nations
- National governments
- Capital & investors
- Sciences, S-community
- Oil, Gas & Coal, big business
- Civilization, Culture
- NGOs
- Techno, Manufacturers
Organization of players for global sustainability:

- a solution model can align for sustainability

Principle of organization:
- strategy of survival for 10 bn people on Earth
How much power for 10 billion people like us?

1. 2050 average power per person and year
   - 5 MWh/y
     - Data 2006
       - World: 3.1
       - OECD: 8.6
       - USA: 12.2
       - India: 0.9
       - Germany: 6.4

2. 2050 electro mobility per person and year
   - 1 MWh/y
     - km/person: 10,000
     - Germany 2007: 13,000
     - person/car: 2
     - Electr./100km: 20kWh

3. World population 2050:
   - 9 - 10 billion people
   - 60 PWh/y
     (+/- 20%)
     - 2009: world: 18 PWh/y
     - GERMANY: 0.5 PWh/y
     - in 2050: 50% as solar power from DESERTS
     - DESERTEC for 30 PWh/y

4. 2500 solar hours per/y:
   - 12,000 solar GigaWatt collectors globally
   - 35 years, 1GW/day
   - Ready for that?

1 GW/day ~1-2 bn €/day ~ 35% of military expenses ~ 1% GNP industrial
Saving the planet will become largest business case of the decades ahead of us
Energy from DESERTS – a world-wide resource

Economic power potential: **3000 PWh/year** (1 PWh = 1000 TWh)

Present global demand (2008): **18 PWh/y**

Source: Trieb et al., DLR, 2009

World 2050:
- Total: 60 PWh/y
- Scen.: **50% from deserts:** 30 PWh/y
- Collectors for: 12,000 GW-elu
  - From 500 x 500 km²
  - = 1% of useful deserts
  - Distributed over “10,000” sites

Solar energy into red square = total world energy consumption (2005)

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Wind – a world wide power resource

Global distribution of annual average onshore wind power potential (W/m²) for 2006 spatial limitations on placement, no limitations on capacity factors.

Lu X et al. PNAS 2009;106:10933-10938

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Transmission: from deserts to the people

5,000 solar GigaWatt transmission capac. from deserts

⇒ HVDC super grid to a world with 10 billion people

Within 3000 km from deserts:

more than 90% of world pop
7. How to organize the transition? – tipping points!!

- how much more CO2 compatible with $\Delta T<2^\circ$? (WBGU):
  with 67% probability in 2050, equal emission rights per person, population as in 2010

<table>
<thead>
<tr>
<th>Country</th>
<th>Emissions Remaining Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>24</td>
</tr>
<tr>
<td>Japan</td>
<td>10</td>
</tr>
<tr>
<td>EU</td>
<td>11</td>
</tr>
<tr>
<td>USA</td>
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<tr>
<td>India</td>
<td>87</td>
</tr>
<tr>
<td>Indonesia</td>
<td>66</td>
</tr>
<tr>
<td>China</td>
<td>23</td>
</tr>
</tbody>
</table>

World-wide: 720 Gt CO2
with emissions as in 2008

- 24 year global CO2 exit trial & error? – NO!
  strategy required tough but feasible!

- “game over” for national solutions

- For industrial economies: remaining time too short.
  Never 50% reduction by 2020:
  - climate crash or economic crash!

- late countries: remaining time ok but victims of “industrial“ emissions

- ecological & economic security simultaneously only by north-south co-operation:

- new world order for sustainability: clever North-South Climate Alliances
DESERTEC – alliances
pillars of the global solution model
for energy and climate security
Low-loss long-distance transmission by HVDC

\[ \text{Loss} = \delta W/W \sim 1/U^2 \]

HVAC versus HVDC transmission on OH - lines

Required number of lines in parallel to transmit 7000 MW

- 400 kV ac
- 800 kV ac
- 500 kV dc
- 800 kV dc

Cables, (under ground, submarine)
High capacity, AC impossible

**Losses over distance**

100% loss over ~100 km

**Power in MW**

**Distance in km**

- Three 400 kV ac cables
- Two 320 kV dc cables

In favor of DC over AC:
1. un-limited reach (cables, no rad.)
2. lower losses/km (always Vmax)
3. lower power line costs/GW
4. lower space demand/GW
Renewable Energy for Power Generation

Wind Power (Enercon)

Hydropower (Tauernkraft)

Solar Chimney (SBP)

Photovoltaic (NREL)

Hot Dry Rock (Stadtwerke Urach)

Biomass Power (NREL)
Concentrating solar collector technologies: basic layout schemes

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

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

Parabolic Trough
Linear Fresnel
Dish/Engine
Central Receiver

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Solar Power also at Night! Andasol 1: Andalusia, Spain, molten salt heat storage tank day+night operation

CSP:
Clean power on demand
Solar thermal power without water!
Here: Linear Fresnel Solar Steam Power Plant
1.5 MW, in Spain, March 2009

NOVATEC-BioSol claims: solar steam competitive with steam by oil, for oil cost of 60 US$/barrel
CSP Applications – Solar or Hybrid Electricity and Combined Heat & Power

- solar electricity
- integrated fossil fuel backup capacity, power on demand
- increased solar operating hours, reduced fuel input
- additional process heat for cooling, drying, seawater desalination, etc.
Map of CSP Worldwide plant locations

Operating
- Jülich, Jülich, Germany

Planning
- Upington, Upington, South Africa
- Hassi-Rmel II, Hassi-Rmel, Algeria
- Meghri, Algeria
- Neâme, Algeria
- Hassi-Rmel ISCC, Hassi-Rmel, Algeria
- Quarzazate Project, Tamazgha, Ghiatene, Morocco
- Tan Tan CSP-Desal Project, Tan Tan, Morocco
- Ain-Ben-Mathar ISSC 2, Ain-Ben-Mathar, Morocco
- Thézénas, Thézénas, France
- Ashkelon, Ashkelon, Israel
- Negev Desert, Negev Desert, Israel
- Elmed CSP, Tunisia
- IPP CSP Project, Tunisia
- Koura Ombo Project, North of Asswan, Nile, Egypt
- Marsa Alam, Hurghada, Red Sea, Egypt
- Shams 1, UAE
- Joan1, Ma’an, Jordan, Jordan
- Yagir ISCC, Luth Desert, Iran
- Bap Project, Bap, Jodpur, India
- Gujarat, India
- Rajasthan, India
- Uttar Pradesh, India
- Guangdong, China
- Ordos, Inner Mongolia, China
- Inner Mongolia, Xinjiang, Tibet, China

Under Construction
- Agua Prieta II Project, Sonora State, Mexico
- Ain-Ben-Mathar ISCC, Ain-Ben-Mathar, Morocco
- Archimedes Prototype Project, ENEL Power Station of Priolo, Siracusa, Sicilia, Italy
- PEGASE, Thézénas, France
- Kuraymat ISCC, Kuraymat, Egypt
- Aceo Rajasthan Solar Power, Jodhpur, Rajasthan, India
- Rajasthan Solar One, Rajasthan, India

2010-10-01
CSP Spain plant locations

2010-10-01
Step 1: DESERTEC – EU–MENA

case study for 1/7 of world pop: 12,000 → 1,600 GW solar collector capacity
EU–MENA Mix: Firm Power on Demand

Hourly time series modelling of power supply in the TRANS-CSP scenario
The 15% CSP power import from Sahara deliver the necessary firm capacity for grid stability. „balancing power“.

transmission MENA-Europe
Decarbonization in EUMENA, compatible with climate goal $\Delta T < 2^\circ$

![Graph showing CO2 emissions reduction](image)
Step 2: DESERTEC–Global

DESERTEC–EUMENA ➔ DESERTEC–GLOBAL

Mediterranean ➔ Global Solar Plan
DESERTEC develops Global Solar Plan

10 Important demand regions for DESERTEC

urban population expected for year 2025
DESERTEC proposes: Global Solar Plan

10 Important demand regions for DESERTEC

urban population expected for year 2025
How to achieve 24 year exit strategy?
Phases of a clever global DESERTEC program

DESERTEC GLOBAL DEPLOYMENT PLAN
A rough implementation scheme:

Phase 1 6 years HIGH SPEED MARKET INTRODUCTION ~20 GW
2010–2015 policy driven; external financial support (DELTA financing).
DELTA (DESERTEC-Δ) ~ 10 – 80 bn $

Phase 2 20 years COLLECTOR PRODUCTION SCALE UP
2016–2035, market driven
3⇒500 GW/year: +30% p.a., duplication in 2.5 years

Phase 3 30 years HIGH SPEED DEPLOYMENT
2020–2050, market driven
average 1.3 GW–coll/day, investment ca. 3 bn €/day

Financing of phase 1 = key to success!
⇒ ?? How much and who should pay DESERTEC-Δ??
How to finance CSP market introduction cost $\Delta$

a coarse assessment

- Main uncertainty: development of fossil fuel cost.
- CSP capacity necessary for market introduction:
  - $\Rightarrow 20$ GW collectors, ($<5$ €/W)
  - $\Rightarrow < 100$ bn €
- Total incentive $\Delta$: $< 50\%$ of investment
  - $\Rightarrow < 50$ bn €
- Cost of saving the climate:
  - $\Rightarrow < 50$ bn €

Cost of saving a bank?

Who should pay?
1. climate change = costs for all
2. industrialization = prosperity for few

3 early developed regions (EDR)
GNP per person
EDR: 34,200 $/y
LDR: 2,200 $/y

per person
Hist. emissions 24 : 1
Present income 17 : 1
DESERTEC–Incentive(Δ) Fund for Human Security

3 industrialised regions
0.9 bn people:
total income advantage
31,000 bn $/y
mil. defence expenses
1,100 bn $/y

Desertec-Δ 10-80 bn $

support for financing
of
clean power
from deserts
projects
in

regions with rapidly
growing power demand
and good conditions
for DESERTEC projects
A DESERTEC-Global Incentive Fund
for climate stability, energy security and more equitable development

The DESERTEC Proposal:

With Δ-money of < 80bn$, as much(little) as

- 1 week global military spending, or
- ½ day GNP of industrialized world,
+ with 1% of global deserts

DESERTEC can ensure the availability of sufficient energy for

1. developed countries to continue
2. later developing countries to catch up (“Brot für die Welt”)
3. stable climate for a world with 10 billion people.

In addition to climate conferences,

an emergency program for clean power implementation

with 10-80 bn $, and DESERTEC-Global Concept
Summary on DESERTEC
solution model for global climate and energy security

1. Clean Energy: commercial commodity AND basis of human security
2. The solar and wind energy resources for global energy and climate security are available, mainly in deserts
3. The necessary technologies (CSP, PV, HVDC) are developed and ready for large scale deployment
4. Powerful industry is getting involved (Dii GmbH)
5. The political goal of 2° limitation is now internationally accepted, but needs implementable enforcement plan
6. DESERTEC + D-Alliances are a feasible solution model for the 2° goal
7. Time for national solutions is over
8. Clean energy for a sustainable world with 10 billion people is feasible

Thank you – gerhard.knies@desertec.org