

TREC

Clean Power from Deserts
Trans-Mediterranean
Renewable Energy Cooperation
An Initiative of The Club of Rome



DESERTEC
a practical program
for energy and climate security
of a world with 10 billion people
based on clean power from deserts
and **GLOBAL JUSTICE**

Climate Change Task Force Meeting
Initiative for Policy Dialogue, Brooks World Poverty Institute
Manchester, 17th June 2009

Dr. Gerhard Knies
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Co-ordinator of TREC
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Mankind is running into a problem until 2050

How can 10 billion People
live **sustainably**
on a planet for <5 ?



21st century security paradigm:
Global Energy & Climate Security
Instead of National Security

Climate change

- faster than expected
 - may get out of control any time, “*run away process, avalanche*”
 - will change the world beyond human capacity of adaptation
- ➔ Either we take massive countermeasures NOW , or we run into a global emergency!

What can be done
in an organized and targeted way
at global scale ?

- ➔ clean power from deserts !
- ➔ This is developmental opportunity
and not economic burden

The task:

Global demands for power

How much power will be in demand by 10 billion people?

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

60,000 TWh/y

(+/- 20%)

2009: 18,000 TWh/y

in 2050: 50% as solar power from DESERTS

**DESERTEC for
30,000 TWh/y**

(+/- 20%)

4.

2500 solar hours per/y:

**12,000
solar GigaWatt
collectors
globally**

12 m² mirror/person
12,000 GW collectors
→ 5,000 GW plant capa.

Potential of deserts

Solar Energy coming to Deserts: like 22 cm of oil, each year
700-fold World Energy Consumption
6 hours sunshine deserts = 1 year world energy consumption

Energy in deserts vs fossil energy reserves

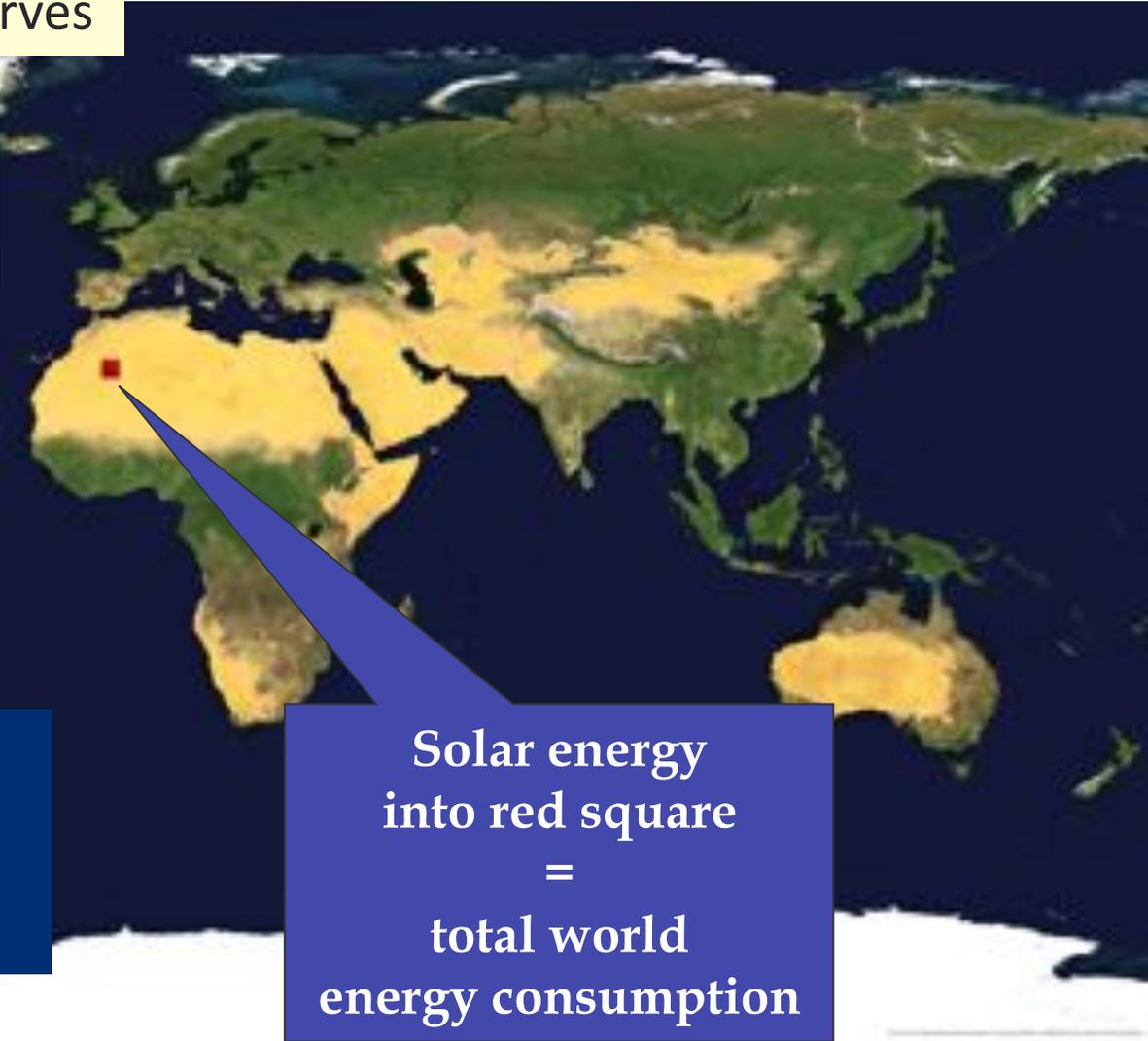
**All known+expected reserves
(BGR 2005 report)
Conv. NatGas 2 weeks sun**

**Conv. Oil 2 weeks
sun**

**Uran. Thorium 2
weeks sun**

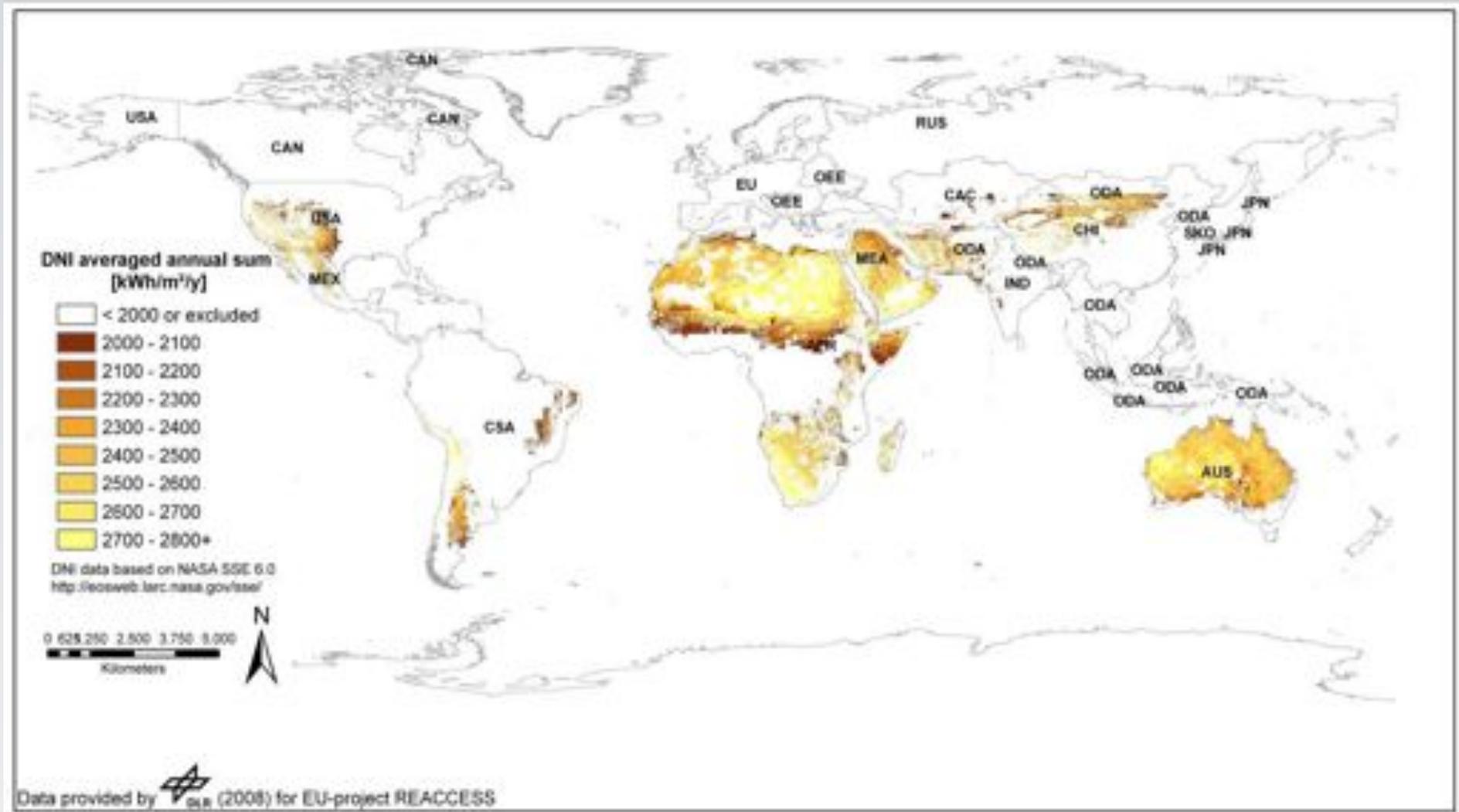
**Coal, hard+lig. 22 weeks
sun**

**All fossil fuel reserves, known
+expected,
Conv. + unconv. 40 weeks
sun**



**Solar energy
into red square
=
total world
energy consumption**

Technically and economically useful desert regions
 for *Concentrated Solar Thermal Power (CSP) technology*
 ~ 27 million km² = ¾ of desert surface
 (from satellite data, DLR, Trieb et al., 2009)



Global Potential of Concentrating Solar Power

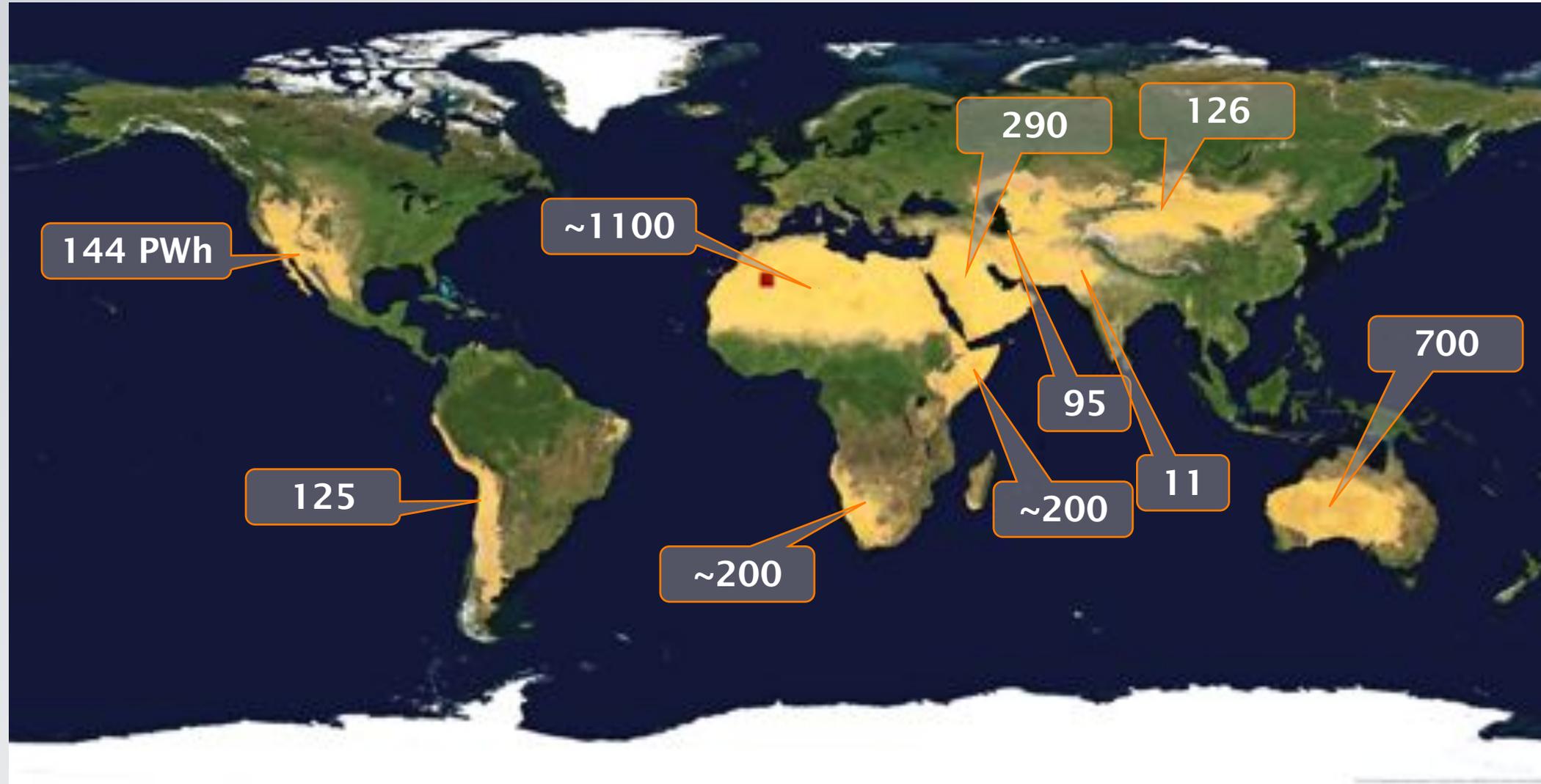
Annual economic potential, in PWh (= 1000 TWh)



Source: Trieb et.al., DLR, 2009

Global demand: 18 PWh/y

Desert Potential: 3000 PWh/y



DESERTEC-WORLD

12,000 solar GigaWatt from Deserts

via HVDC super grid to a World with 10 billion People



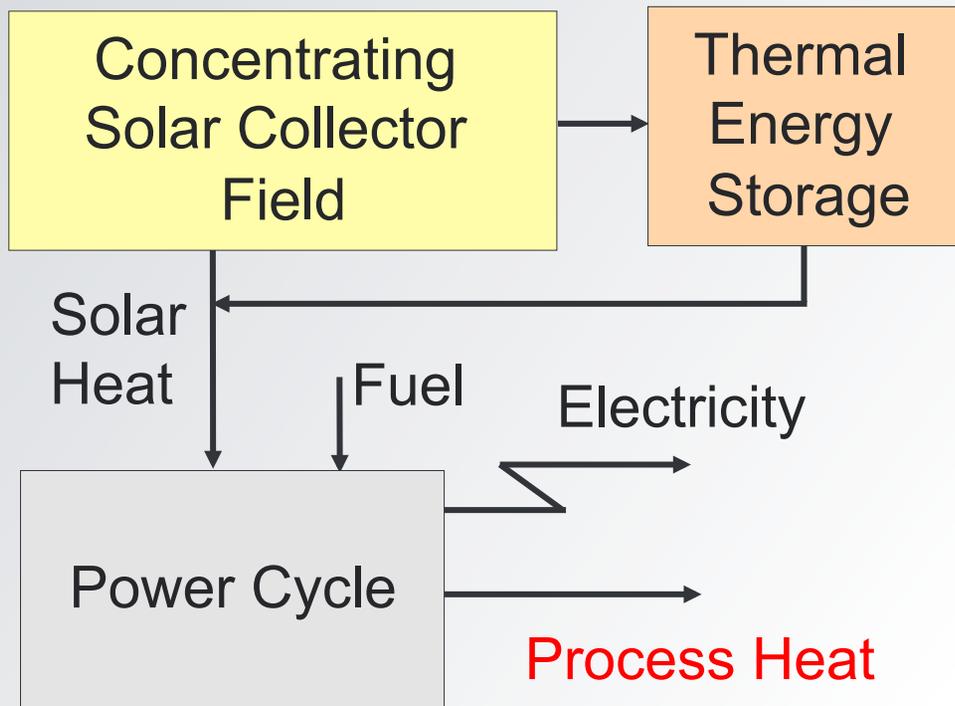
World total demand 2050:
60,000 TWh/y
Scenario: 50% from deserts:
30,000 TWh/y
→ collectors for
12,000 GW-el
from 500 x 500 km²
= 0.68% of all deserts
= 1% of useful deserts
distributed over "10,000" sites

Within 3000 km from deserts:
To more than 90% of world pop
clean power from deserts available.

Technologies for deserts

Thermal power plant

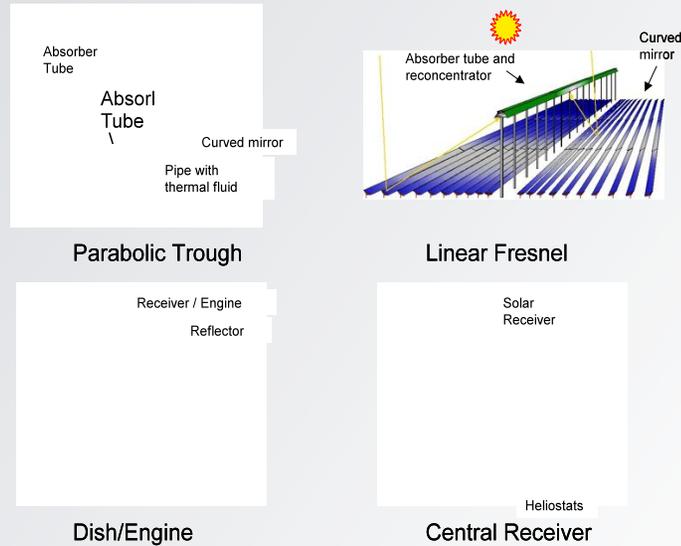
Principle of a Concentrating Solar Thermal Power Plant



- concentrated light → heat,
- solar heat replaces fuel
- solar heat can be stored

- firm capacity, power on demand via storage or hybrid operation
- additional process heat for cooling, drying, seawater desalination, etc.

Concentrating solar collector technologies: basic layout schemes



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

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



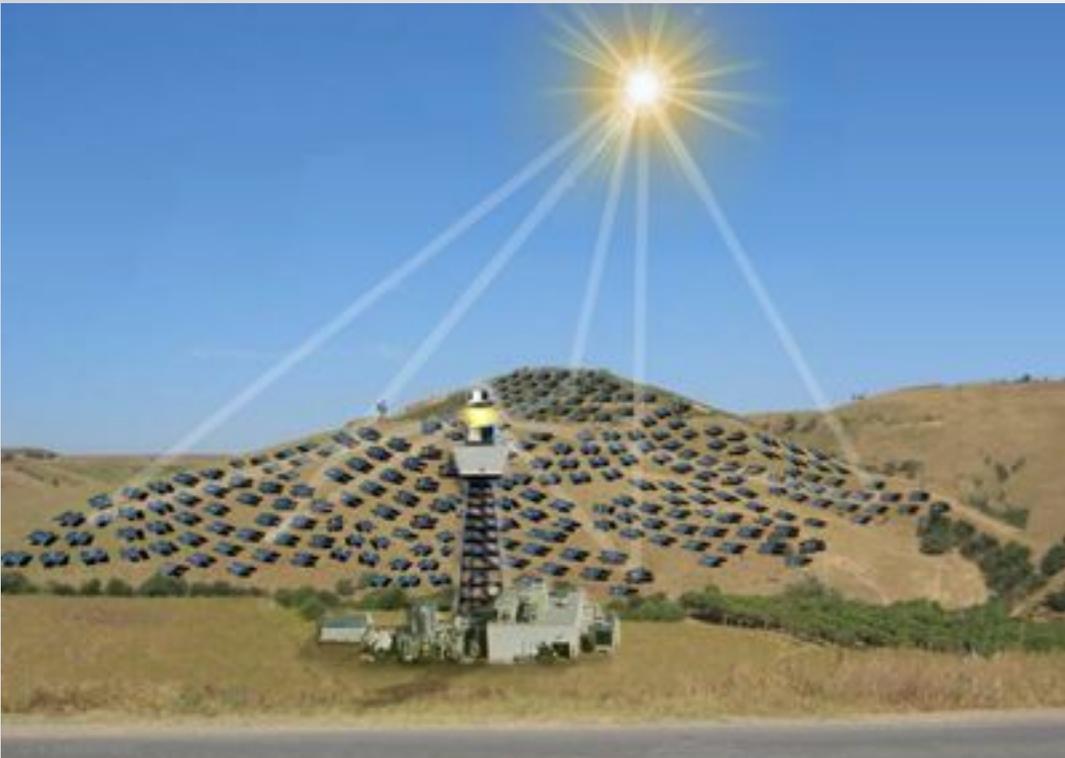
SPAIN: 11 MW PS10

Project Site Sanlucar: 2100kWh/m²a DNI



- 75.700m² Heliostat Field, 30 Minutes Storage
- 12-15% fossil fuel
- 23GWh annual production
- EPC Cost 42Mio Euro
- 5Mio EU Grant and 1.2 Mio Andalusian Grant
- STARTUP APRIL 2007
- PS20 Construction started

Point and line concentrating mirrors



Andasol 50 MW plant, power block + heat storage liquid salt tanks: → solar power at night !



Present design:
7h full capacity
14h 50% capacity

The first Linear Fresnel Solar Steam Generator By NOVATEC-BioSol, 1.5 MW, in Spain



NOVATEC-BioSol claims: solar steam competitive with steam by oil, for oil cost of 40 US\$/barrel

**No water
Consumption**

- Dry cooling
- Dry cleaning



**Air cooled
condenser**

Plants in the collector shade – „collector oasis“



Results of DLR studies for DESERTEC-EUMENA

DESERTEC Scenario for EU-MENA

1 / 7 of world: 12,000 → 1,600 GW solar collector capacity
 (desert zone + sun) & (moderate zone + technology)



Studies by DLR for
 EUMENA region

MED-CSP TRANS-CSP for
 German gov't

CLUB OF ROME
 White Paper 2009
www.desertec.org

DESERTEC Concept for EU-MENA

1 / 7 of world: 10,000 → 1,000,000 jobs

TREC/DESERTEC

White Paper 2007

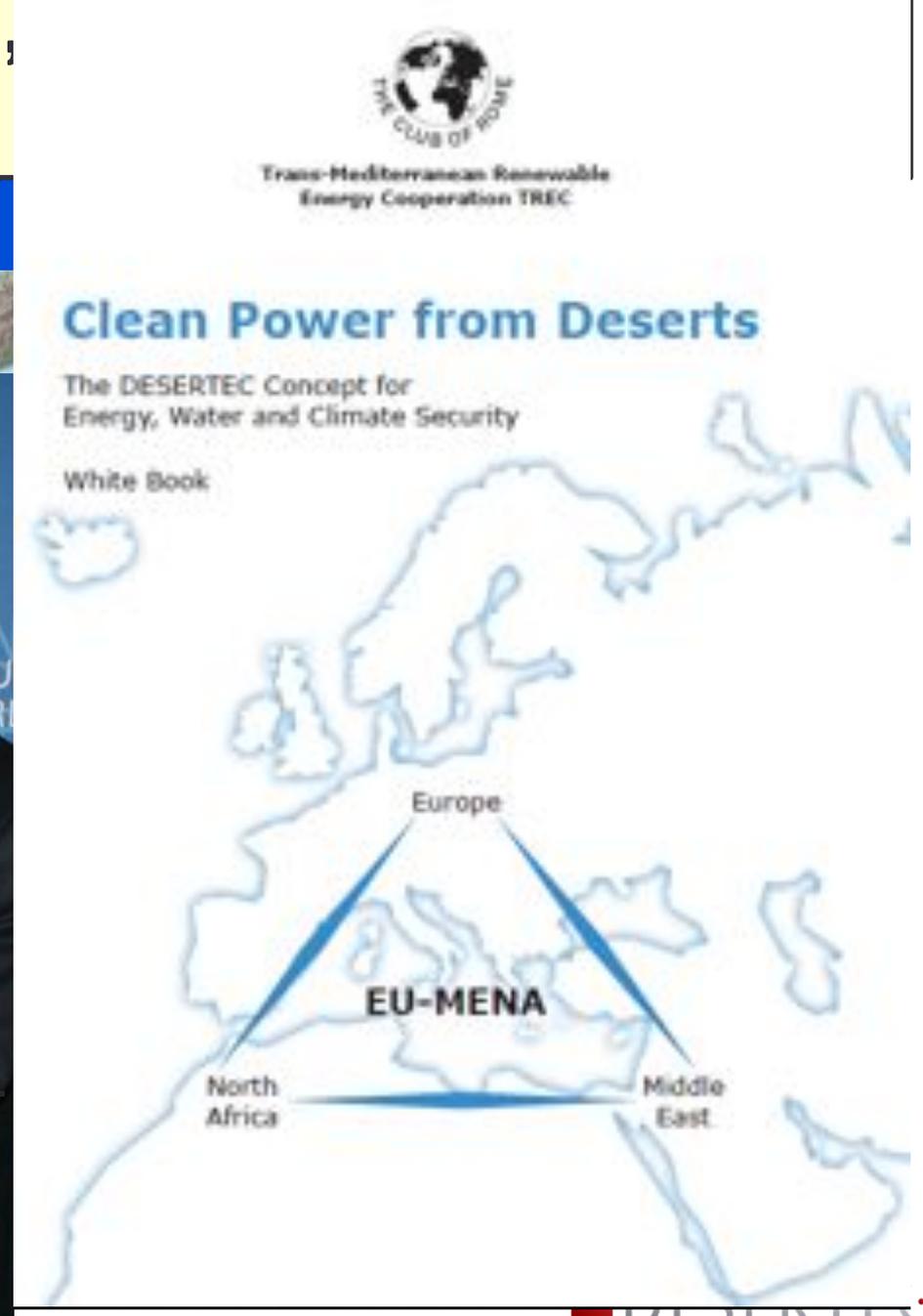
Club of Rome

(www.desertec.org)

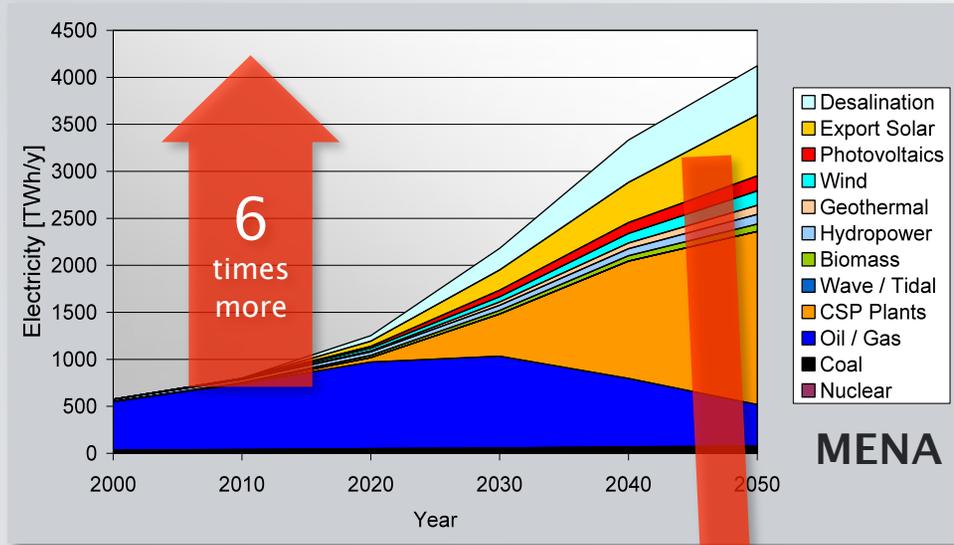
28-November 2007

C.

security

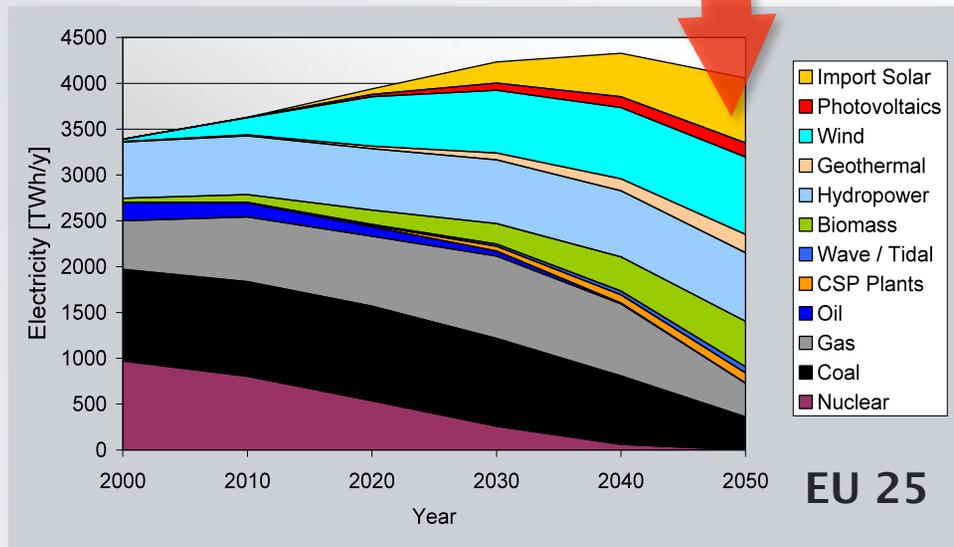


Power demand, and supply scenario (TWh/y) in MENA and EU



Transition Mix 2000–2050

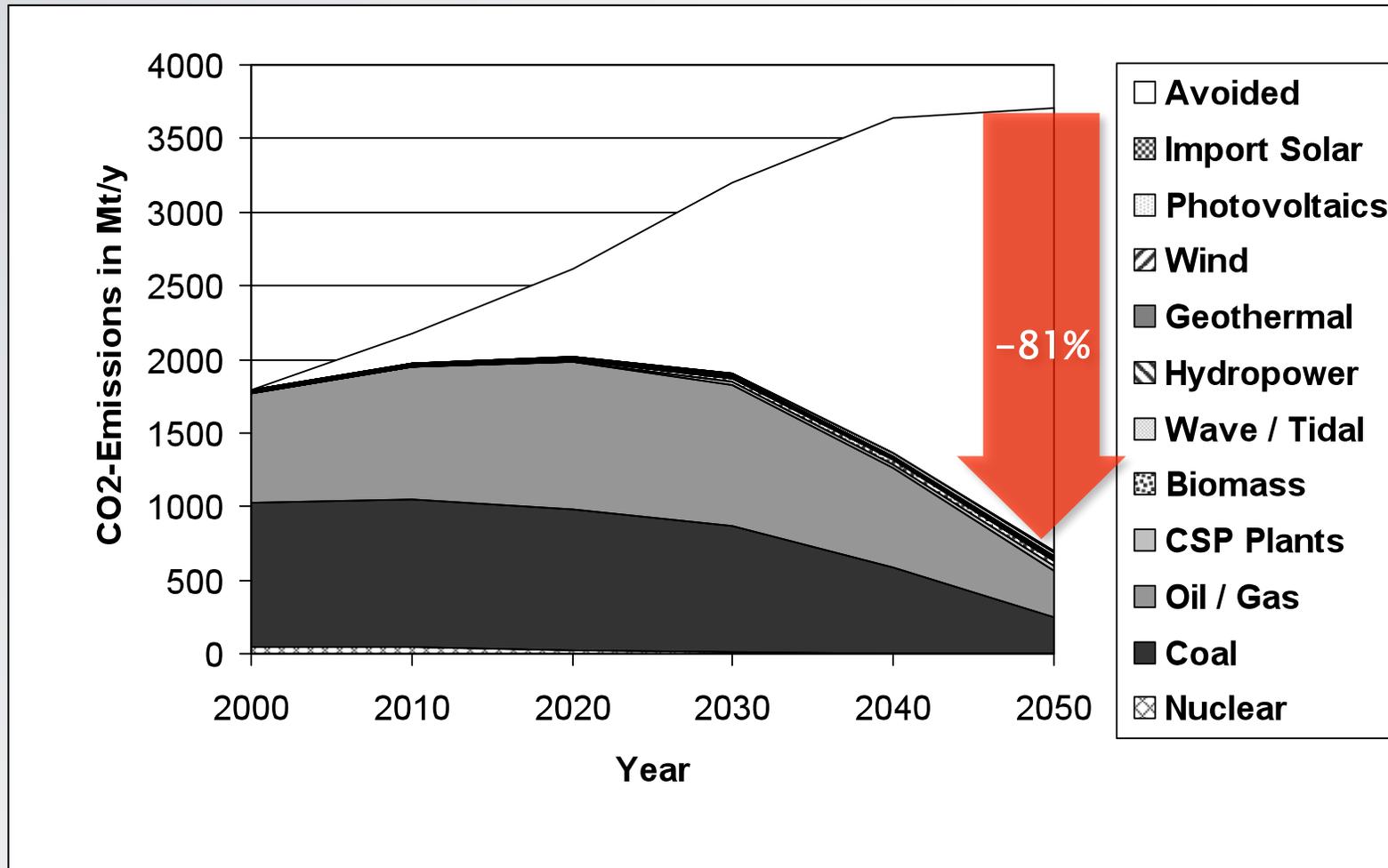
in MENA, including export to Europe and power for desalination: 80% CSP



in EU-25, with 17 % import from MENA

By clean power from deserts EU may win 10–15 years in the fight against climate change.

Resulting decarbonization in EUMENA, compatible with climate goal $\Delta T < 2^\circ$



Where is the energy/climate problem ?

- Energy resource DESERT : over-abundant
 - Solar technology (CSP): working
 - Heat storage technology: working
 - Wind technology: working
 - HVDC transmission techn.: working
 - Capital: existing
 - For EUMENA: 1 400 solar GW (in 2050):
collector prod. from 0.25 GW/y → 100 GW/y by 2050: +16%/y
2035: +26%/y
- Fast CSP collector prod. and deployment is the challenge
- **EUMENA: 1-2 GW/week,** world wide: 1-2 GW/day

A global DESERTEC program

OVERALL TARGET: >90% clean power by 2050

DESERTEC: ~ 50% clean power from deserts

Parameters of global DESERTEC program 2050

by 2050: (assumptions, → implications)

- 30,000 TWh/y, 12000 GW CSP collector, 5000 GW plant capacity
- 20 years constant deployment: → 600 GW-collector/year
- 20 years constant deployment: → 250 GW-plant/year
- Jobs: 1 GW_pl = 4000 man years “on site” installation → 1,000,000 jobs
- Investment: 1 GW_pl ~ 4 bn €: → 1,000 bn €/y
- Sun belt average income/p/y ~ 5 k€ → Living for 200 Mio people !
~ 2% of world population

Phases for global DESERTEC program

DESERTEC CSP DEPLOYMENT PLAN

A rough implementation scheme:

Phase 1 6 years HIGH SPEED MARKET INTRODUCTION

2010 –2015 policy driven

external financial support :GECS funds and Feed in Tariff

Phase 2 20 years COLLECTOR PRODUCTION SCALE UP

2016– 2035, market driven

0.6 →600 GW/year: +30% p.a., duplication in 2.5 years

Phase 3 20 years HIGH SPEED DEPLOYMENT

2031 – 2050, market driven

average 1.5 GW-coll/day, investment ca. 3 bn €/day

Fast completion of phase 1 = key to success !

→ Main task for DESERTEC Foundation

Barrier of Phase 1: CSP market introduction cost

a coarse assessment

- Main uncertainty: development of fossil fuel cost.
- CSP capacity for Market introduction : → 10 GW collectors
- Operating time: 2500h/y → 25 TWh/y
- Feed in Tariff time 20 years: → 500 TWh
- FiT surcharge 0.1 €/kWh → 50 bn €
- CSP market intro cost/y, 20 years long: → ~2.5 bn €/y
- Cost of saving the climate: → 50 bn €

Who should pay 50bn €, and why ?

A proposal along the lines of

GLOBAL JUSTICE

Inspired by “2009 Berlin Speech“ by

Federal President of Germany Horst Köhler

Message from German President Horst Köhler Berliner Rede 2009:



...

**We, all of humanity, are in the same boat.
And people in the same boat
must help each other.**

**In the 21st century,
self-interest has come to mean
that we must take care of one another. . .**

**As the main sources of the factors
causing climate change,
the industrialized nations are responsible
for the people in developing countries
having been hit hardest. . . .**

**We should stop
fooling ourselves into
thinking that this is just.**

Historic emissions: 2 heritages:

1. Global climate change = burden for ALL
("burden sharing")

2. Industrialization = benefits for a FEW:
→ A split world:

→ Late DR cannot get same prosperity as Early DR
thru fossil fuels without killing global climate!

→ Developmental disparity + climate injustice

Historic Contributions to Global Warming: Carbon Dioxide Emissions from Fossil Fuel Combustion, 1900-1999

Historic CO2
emissions:

EDR = 79%

LDR = 21%

Per cap.
Emissions

24 :1

Light at night

Imagine we had developmental parity ...

... then ALL world would be bright at night

then

- “historic” emissions = 440% of real emissions
- climate catastrophe already now!

➔ Thanks-giving from Early to the Late: thank you for late developing!

Developmental disparity: the 15:1 income advantage

34 vs 2.2 k\$/cap GNP advantage of early versus late developing regions

Source: Wikipedia, 2008-11-06) http://de.wikipedia.org/wiki/Internationaleinkommen#Internationaler_Vergleich

Nr.	State	GNP tr US_\$	GNP in %	GNP /cap 1000 (US_\$)	popula on o.	GNP excess relative to late devel- oping world average (tr US_\$)	GNP/cap excess relative to the late D'ing-World av'ge (1000 US_\$)
1	USA+Canda	14.1	31%	42.2	334	13.4	40
2	Japan	5.0	11%	39.1	128	4.7	37
3	EU	13.5	30%	27.5	492	12.4	25
4	Early DR	32.6	71%	34.2	954	30.5	32
5	World	45	100%	6.8	6,618		4.6
6	Late DR	12.4	29%	2.2	5,664	0	0
7	India	0.8	1.8%	0.7	1,130	-6.9	-1.5
8	China	2.2	5%	1.7	1,323	-6.7	-0.5

DESERTEC COST: CSP market intro cost (Phase 1)

→ 50 bn €

“Cost” of saving the climate =

- ***Saving 1 bank***
- ***0.2% of 1 year income advantage of EDR***
= 1 day income benefit from historic GHG
- ***5% of 1 year world weapon expenses of EDR***
= 19 days of world weapons expenses

We do need a defence against global climate change

Globalization :

Security of global commons instead of nation states

- Nation state security has become a phantom
- Securitization of nation state against others (militarization) provokes destabilization of global community
- A 10 billion people world requires protection of global commons: a
COMMON-WEALTH for global commons instead of efforts for national security as top security task.
- Parallel transitions
 - inherently destructive fossil fuels => renewable energies
 - nation state border security => global common security
- North-South polarization is counterproductive, future of ALL humankind at stake
- Instead of arms race for fossil energy sources – construction program for new RE sources!
- Human security in a world of 10 billion: everywhere or nowhere deserves more efforts than security for nation states

How to organize saving the climate ?

1. Accepted legal principles:

Causation Principle

Precaution principle

2. Important practical necessities:

Fastest global emission reduction

Create source of clean power for LDR

U+C

EU

JA

3 regions with highest **wealth advantage** (GNP above world average by 30,000 bn \$/year)) stemming from their early development and historic GHG emissions

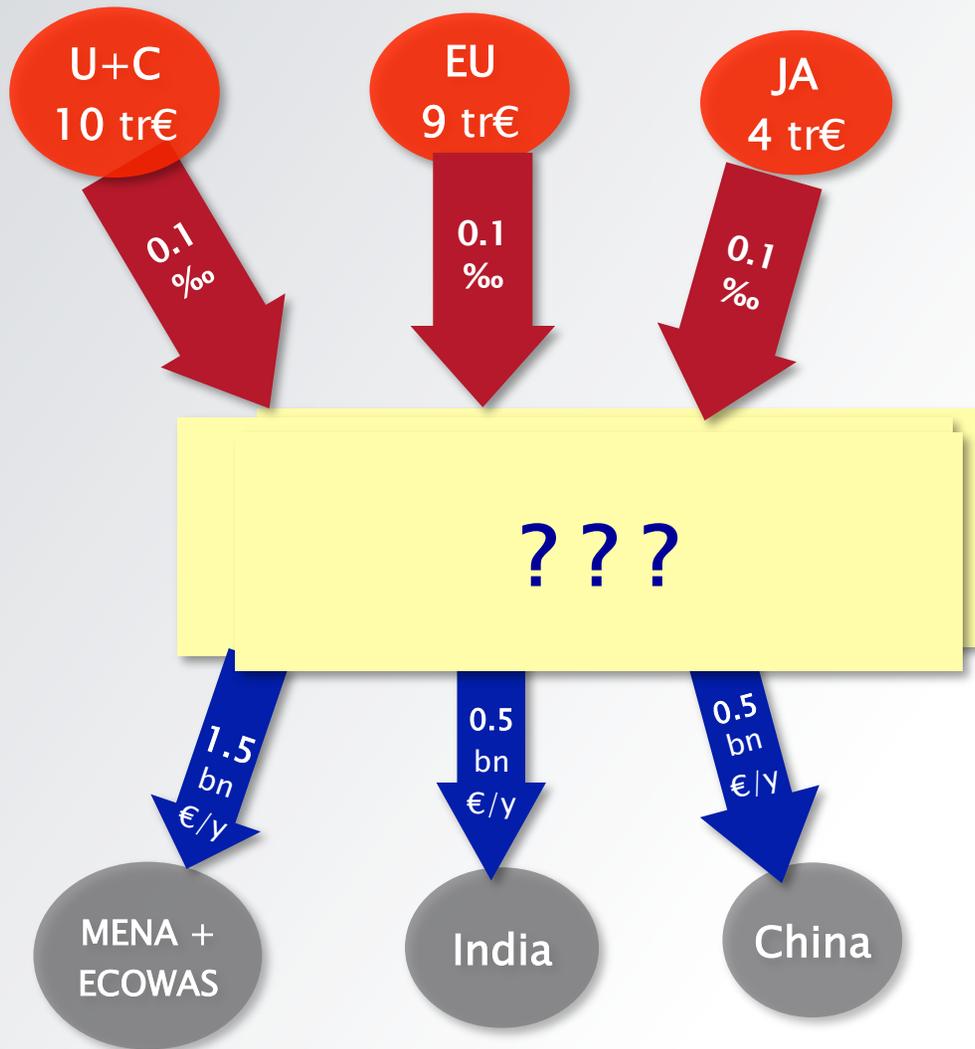
invest 0.2% of 1 year inherited income advantage (from 24 tr €/y) 5% military spending into clean power from desert projects in

regions with very fast growing power demand and proximity to deserts



for solving world energy and climate problems by clean power from deserts

via facilitator for Global Energy and Climate Security: **GECS Facilitator**,
and for equal development opportunity



3 developed regions
24 tr€/year GNP “over”
remaining world av.
from their
early development and
historic GHG emissions

0.2% of
“over” GNP,
or 5% of
national
security
spending

3 regions with very fast
growing power demand
and proximity to deserts

DESERTEC global energy and climate security plan:

With

- 1% of deserts
- 1% of military expenses (coming 5 to 10 years)
- Global climate and energy security for 10 billion people can be achieved til 2050
- 50% clean power from deserts
- 50% from other RE sources

Why don't we do that ???

Thank you for attention – gerhard.knies@DESERTEC.org

DESERTEC + causation principle → stop CC & energy scarcity

stopping CC and energy scarcity: → global justice & equal development opportunity

What can EMPA do ?

1. Set up EUMENA DESERTEC Fund/bank/facility for fast csp market introduction
2. Collect ~0.1 ‰ from “above income” of industrialized EU
= 3€/person/year over 20 years
3. Enable financial support for solar technology industrialization in LDR
4. Select the most effective MENA locations.
5. Support equal development opportunity for all its members.
6. Launch the Gaza Solar Water&Power Project as humanitarian first aid !

Gaza Solar Power&Water project: Plants in Egypt + Pipe and Power Lines to Gaza



DESERTEC ACTION PLAN

1. Transition strategy *Coal* → *CSP* in EUMENA
Replace old coal plants in Northern Mediterranean by HVDC outlets from Africa
2. Financing scheme for CSP market intro
Take 1% from “EU above average GNP” to finance solar industrialization MENA
3. *Socio-economy* of DESERTEC–EXPRESS Jobs, local industry
4. *MENA water plan* Where are expected hotspots of scarcity and how can they be served by desalination?
5. *Global DESERTEC strategy* How can global demands and resources be joined for fastest transition to clean power from deserts ? → human security
6. *Climate protection instead of adaptation:* global
security and prosperity instead of conflicts and burden sharing

What can EMPA do ?

1. Set up DESERTEC Fund/bank/facility
 1. for fast market introduction
 2. for equal development opportunity for its late developing members.
2. Enable financial support North → South for MENA solar industrialization Collect ~0.1 ‰ from “above income” of industrialized EU = 3€/person/year over 20 y
3. Offer the most effective MENA locations for “bankable making”
4. Support initiation of EU–MENA HVDC transmission grid
5. Launch the Gaza Solar Water&Power Project as a humanitarian first aid !

Thank you -

Gerhard.Knies@DESERTEC.org

Mediterranean union launches \$1.3bn infrastructure fund

- The Union for the Mediterranean launched a new regional infrastructure development fund at its meeting in Alexandria on 30 April.
- The union aims to raise more than €1bn (\$1.3bn) in equity capital for its Inframed Fund. The fund is led by France's Caisse de Depots, Italy's Cassa depositi e prestiti, Morocco's Caisse de Depot et de Gestion, and Cairo-based investment bank EFG-Hermes. The four institutions have already committed €400m.
- The fund is also likely to co-operate with other partners from the Gulf.



- The new structure represents a regional framework for public–private–partnerships which would aid the development of infrastructure across the region.
- It will participate in financing energy efficiency, transportation, environmental and urban development projects.
- The sponsors of the fund are also considering setting up a debt financing vehicle.
- Institutions such as Agence Francaise de Developpement, Germany's KFW Bankengruppe, the European Investment Bank and the Forum of Mediterranean Banks expressed their interest in such a vehicle.
- A roadshow covering European and Arab countries will begin this year.
- Meanwhile the World Bank announced at the meeting that it would allocate \$750m from its Clean Technology Development Fund to finance solar projects in the region.
- The Global Environment Facility said it could commit \$50m to international water management schemes.

From Berlin Speech by Federal President Horst Köhler, 2009-03-24

... We, all of humanity, are in the same boat. And people in the same boat must help each other. In the 21st century, self-interest has come to mean that we must take care of one another.

In particular, we in the North must learn to rethink. Currently, about 6.5 billion people live on our earth. A mere 15% of them live in the same circumstances we do. (and they have 70% of global GNP). More than two billion people live on two dollars a day, and one billion people must do with one dollar a day. We should stop fooling ourselves into thinking that this is just.

Security, prosperity and peace – they will be assured for the industrialized nations only if we achieve greater equity throughout the entire world.

We need to have a development policy for the whole planet.

This means that the industrialized nations – including Germany – must find out what changes they need to make, in order to ensure there will be a good future for the world. ...

Let us understand the battle against poverty and climate change as a strategic task to be solved by us all.

As the main sources of the factors causing climate change, the industrialized nations are responsible for the people in developing countries having been hit hardest.

The fight against poverty and climate change must be one.

Let us prove that the North will not fail the South. ...

Clean power from deserts for an earth with 10 billion people ?

YES

by rapid commercialization & massive deployment of CSP
→ DESERTEC CLIMATE EMERGENCY PLAN 2050 (2040 ?)

Energy&Climate Security=
systemic necessity for mankind =
public duty => GECS-Facility
(requires <5 € for each person in 2050)

12,000 solar GW ~ 20,000 bn € total investment
A gigantic world-wide industrial program for sustainability.

How industry can make big business with the public task

“Clean power from deserts for a world with 10 billion people“ ?

1. Rapid CSP market introduction
for global energy, climate and developmental security/
justice (**global security/justice initiative**)
2. Generate thousands of „CSP engineers“, in MENA
countries, India, and China
(**local competence initiative**)
3. Learn from arms industry: create wish for security:
Arms/CSP for prevention of **war/ ecological disasters**
1% of global military expenses would do it!
(**safe ecology initiative**)

How industry can make big business with the public task



“Clean power from deserts for a world with 10 billion people“ ?

4. Learn from financial sector disaster:
rescuing **banks**/**climate** much cheaper than
suffering **financial**/**ecological** collapse
(**system security initiative**)
5. Promote „comprehensive human security“ as security paradigm
for a world with 10 billion people.
+ Offer a solution: CSP and DESERTEC, and demand its
immediate implementation for the global benefit.
6. We can build the energy world of tomorrow: clean and save
 - Not beggars, but attorney of coming generations
 - DESERTEC Foundation and Club of Rome offer you assistance.
 - contact us: www.desertec.org – thank you.

Fossil heritage: the developmental disparity and dilemma

1. The fossil fuels burnt up to now have gone – BUT they leave 4 heritages:
 1. **Early developed economies**, mainly in the north with 1 bn people, with a wealth advantage of 27,000 \$/cap over world average of 6,600 \$/cap, as a result of historic use of cheap fossil fuels.
 2. A demolished global common: atmosphere and climate, with a severe global risk potential, including a global climate disaster
 3. Largely depleted fossil fuel stocks (“PEAK OIL”), and rising energy costs
 4. A desire in the rest of world (5.5 bn people, 2,200 \$/cap, a wealth disadvantage of = 4,600 \$/cap under world average) for similar wealth as the 1.0 bn early developed rich.
2. But the **delayed developing countries**
 1. have no way to achieve similar wealth with the remaining fossil fuels, without producing a global climate disaster.
 2. are more vulnerable and less adaptable to weather extremes + long term climate change processes: higher temp., different precipitation, different agriculture, new diseases etc
 3. do not have the economic strength to cope with rising fuel costs: developmental barrier
 4. Many will be pushed to the edge of survival or to below

Historic Contributions to Global Warming:

Carbon Dioxide Emissions from Fossil Fuel Combustion, 1900–1999

Historic CO2
emissions:
EDR = 79%
LDR = 21%

U+C
10 tr €

EU
9 tr €

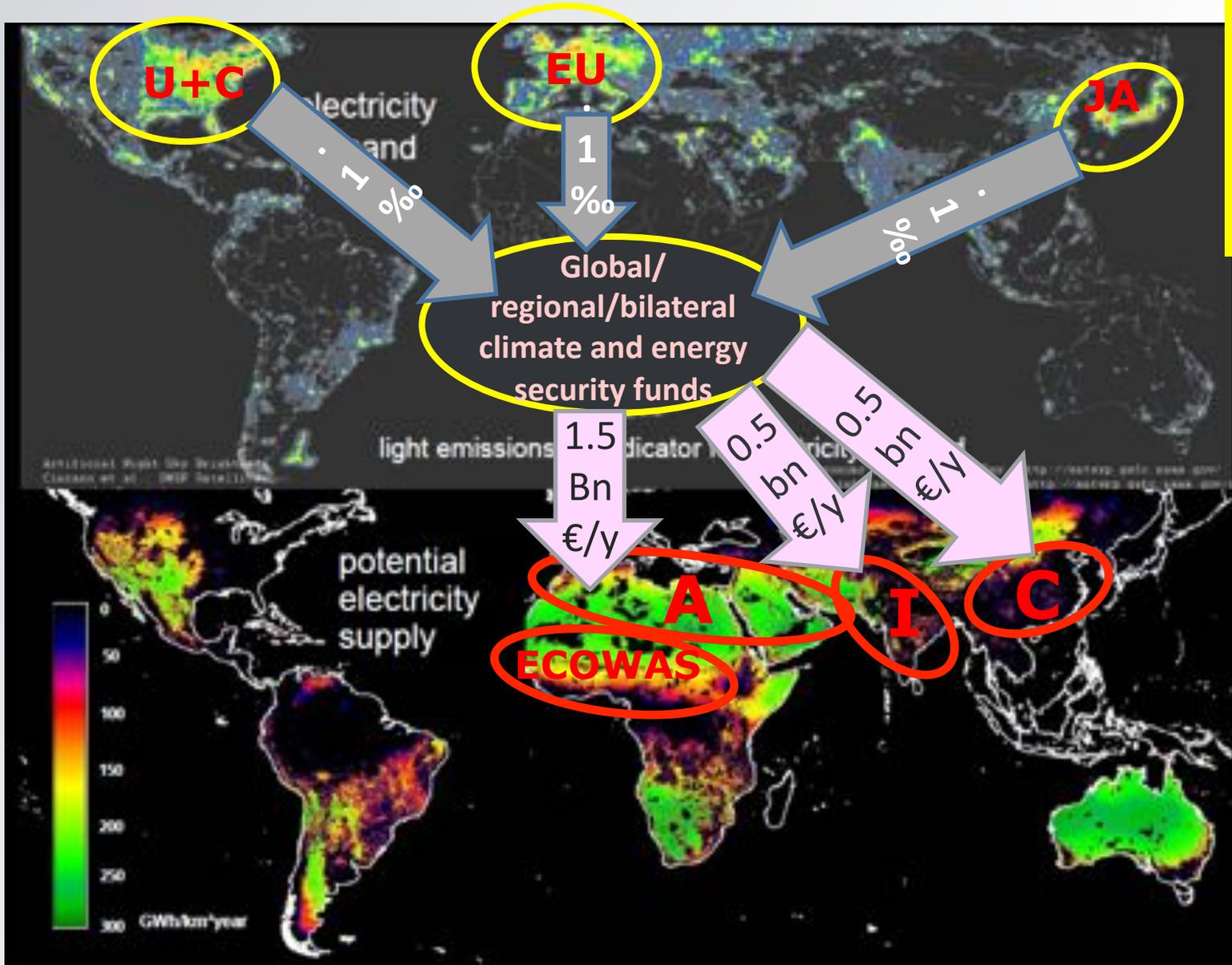
JP
4 tr €

EDR GNP in
excess over
LDR level

1-WORLD strategy along causation principle and fastest progress path

for energy and climate security, and equal development opportunity

3 regions with highest **wealth advantage**
(GNP above world average by 30,000 bn \$/year))
stemming from their early development and historic GHG emissions

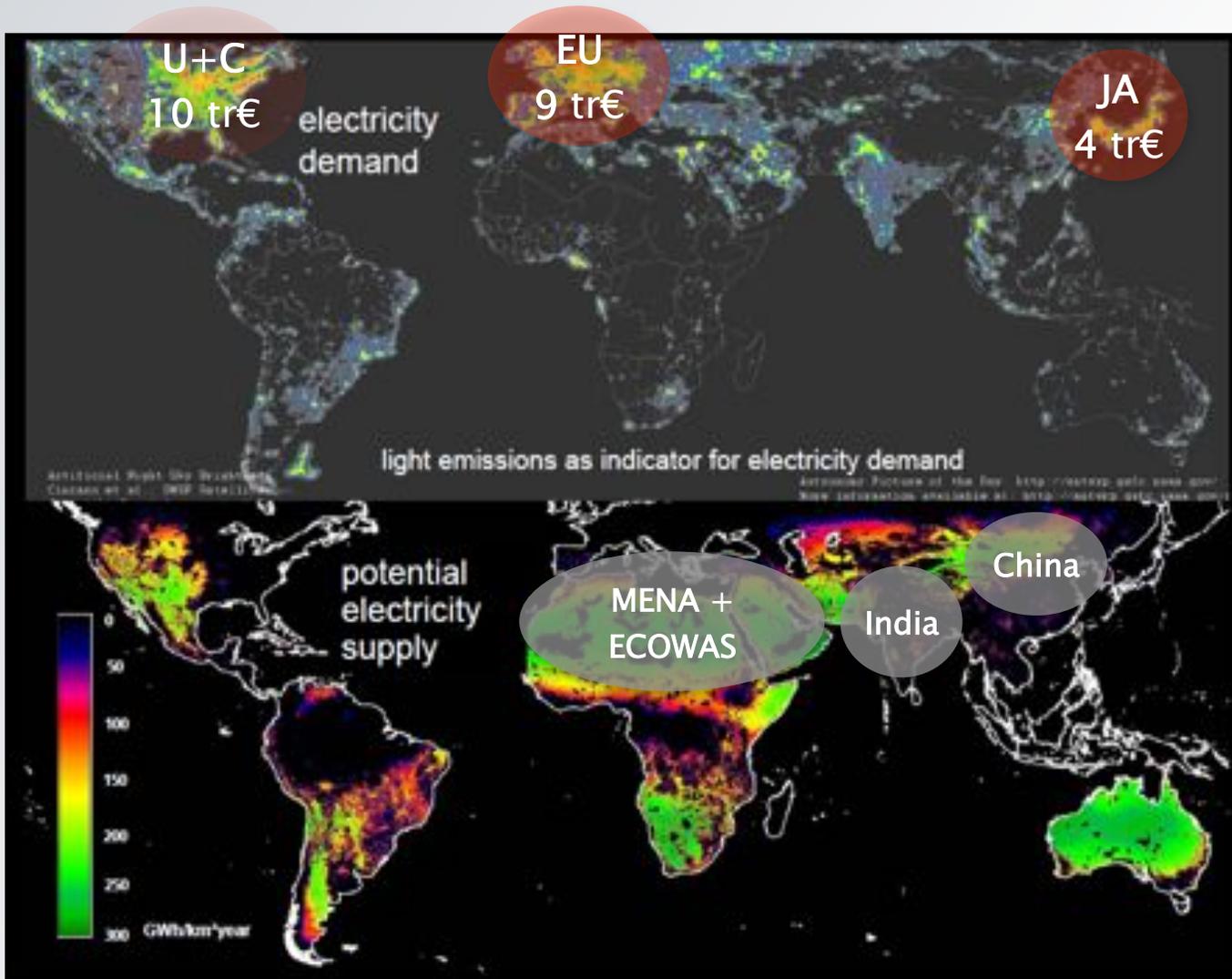


invest 0.1% of inherited wealth advantage (from 30 tr \$/y) into clean power from desert projects in

regions with very fast growing power demand and proximity to deserts

DESERTEC ONE-WORLD strategy, as requested by Köhler for energy and climate justice

e.g. via funds for Global Energy and Climate Security: **GECS Funds**, and equal development opportunity



3 developed regions
24 tr€/year GNP
above remaining world av.
from their
early development and
historic GHG emissions

3 regions with very fast
growing power demand
and proximity to deserts

Deficits in World developmental justice: 34 vs 2.2 k\$/cap

Economic disparities between early and late developing regions:



Source: Wikipedia, 2008-11-06)

http://de.wikipedia.org/wiki/Bruttonationaleinkommen#Internationaler_Vergleich

Nr.	State	GNP 1000bn US_-\$	in %	GNP /cap 1000 (US_-\$)	Popula tion Mio.	GNP excess relative to late Developing world average (1000bn US_-\$)	GNP/cap excess relative to the late D'ing-World av'ge (1000 US_-\$)
1	USA+Canda	14.1	31%	42.2	334	13.4	40
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5	India	0.8	1.8%	0.7	1,130	-6.9	-1.5
6	World	45	100%	6.8	6,618		4.6
7	Late d'ping	12.4	29%	2.2	5664	0	0
8	Early d'ped	32.6	71%	34.2	954	30.5	32

Reminder of Global Climate Situation

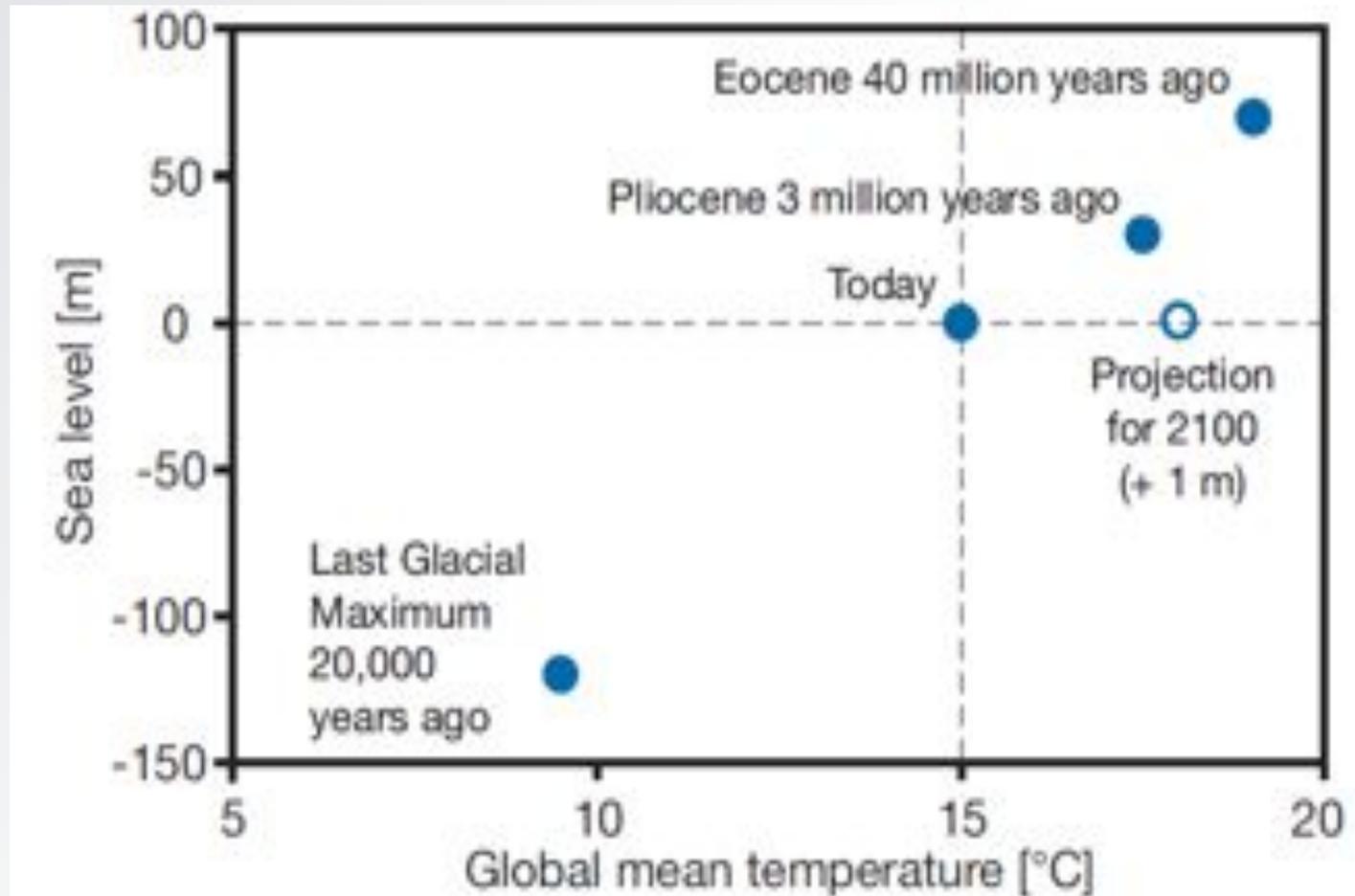
Historic data: sea-level vs earth temperature

‘sea-level equivalent’ of the ice mass of

- **Greenland ice** 7m
- **West Antarctic ice** 6m
- **East Antarctic ice** 50m
- **All arctic ice** 70m

(Zachos et al., 2001; Barrett, 2001)

global temperature
land borne ice
sea level
are closely connected



Source: after Archer, 2006

Sea level: past and projections up to 2100, based on mean temperature projections of the IPCC TAR.



Sea level rises faster than expected!

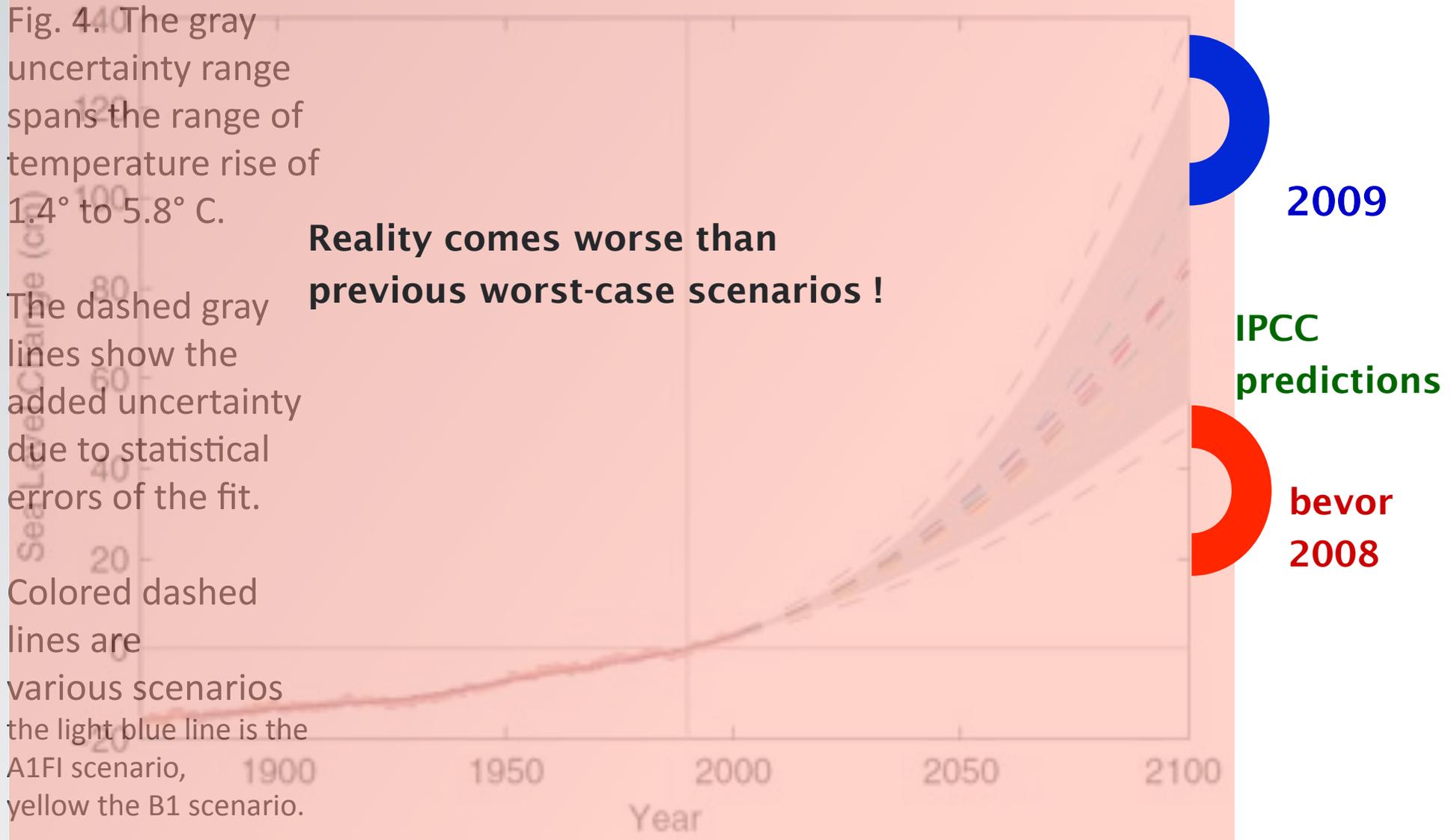
Now: at least 1 meter by 2100, before 2009: 18 –56 cm.

Fig. 44 The gray uncertainty range spans the range of temperature rise of 1.4° to 5.8° C.

The dashed gray lines show the added uncertainty due to statistical errors of the fit.

Colored dashed lines are various scenarios the light blue line is the A1FI scenario, yellow the B1 scenario.

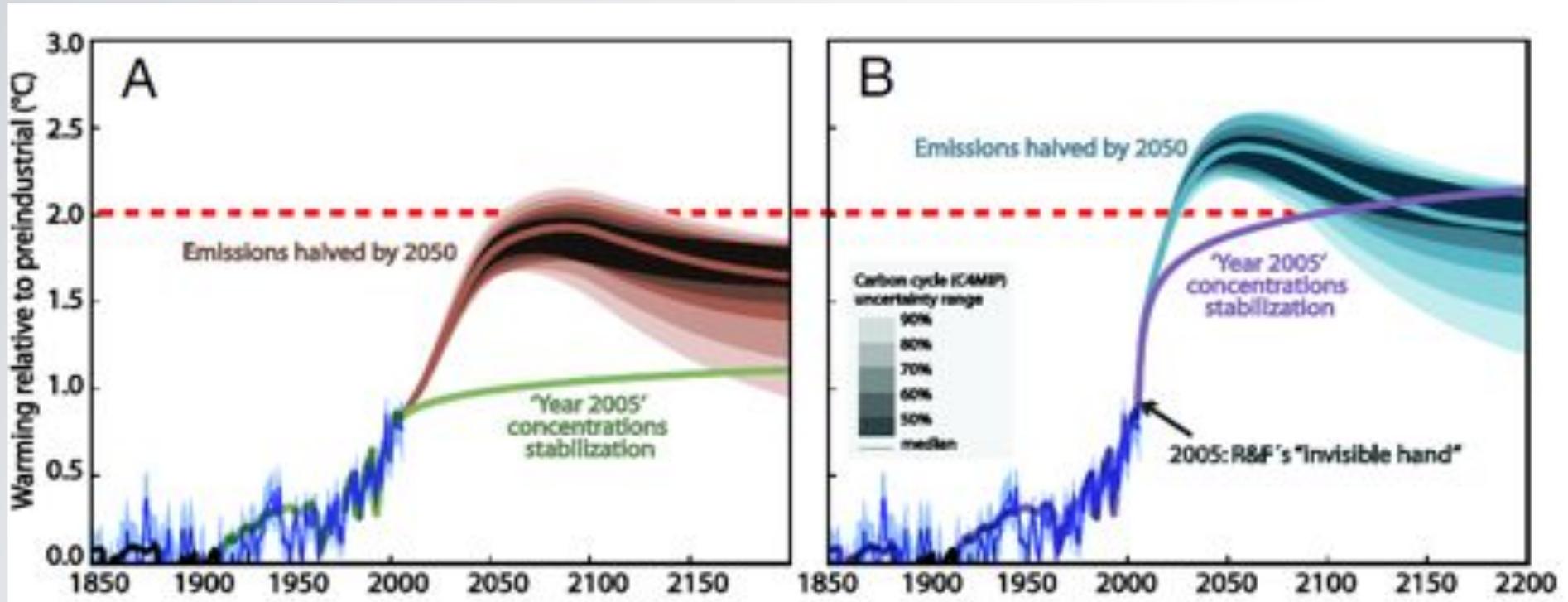
Reality comes worse than previous worst-case scenarios !



Global warming: Stop worrying, start panicking?

Hans Joachim Schellnhuber* † ‡

*Potsdam Institute for Climate Impact Research, P.O. Box 60 12 03, 14412 Potsdam, Germany; and †Environmental Change Institute and Tyndall Centre, Oxford University, Oxford OX1 3QY, United Kingdom



Time left to start massive efforts: < 10 Jahre

Areas less than 2 m above sea level

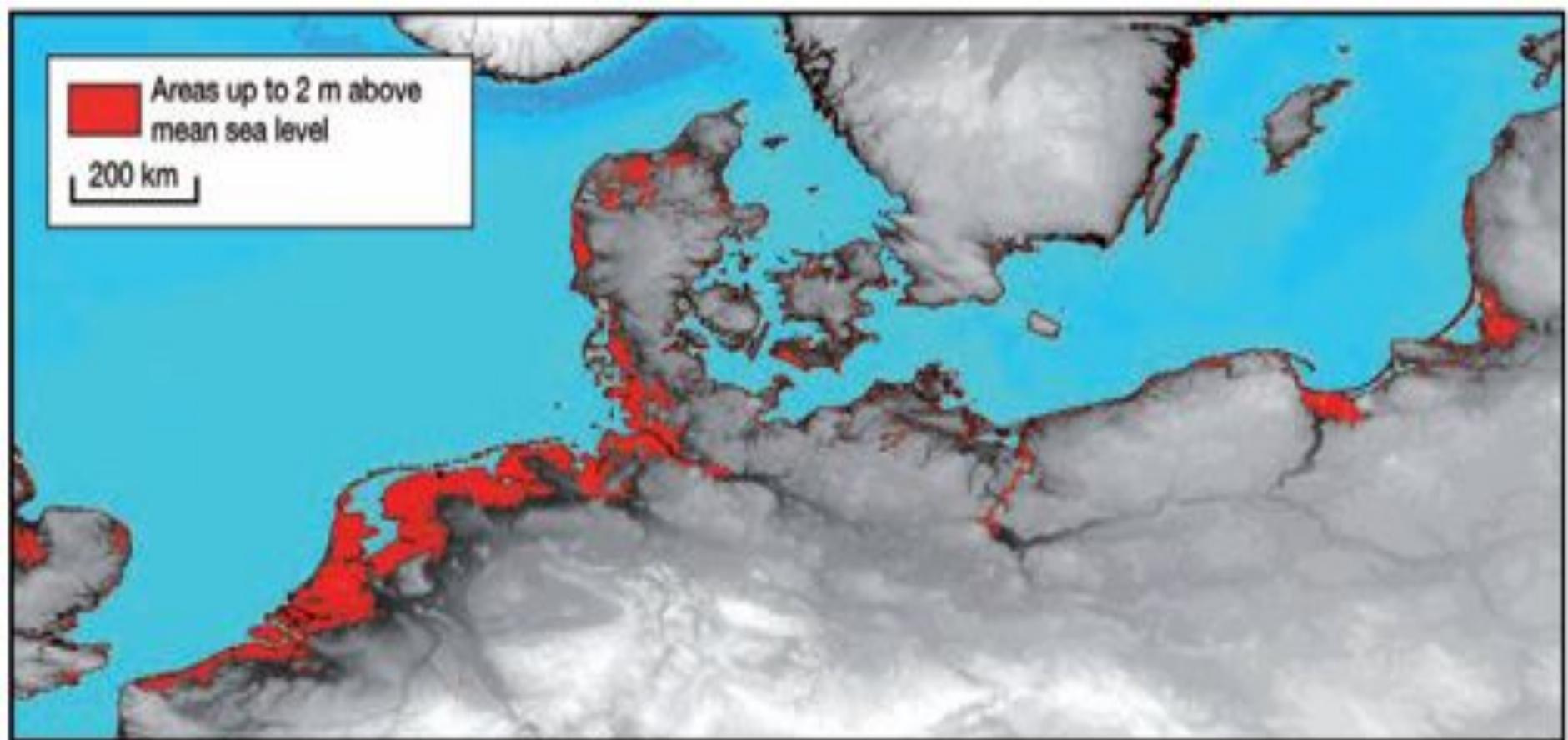


Figure 3.2-3

Coastal areas along the North Sea. Areas below 2m elevation above the present mean sea level are coloured red (not taking future coastal defence measures into account).

Source: Brooks et al., 2006

Cost of solar steam:

1. Depends on location i.e. annual radiation, and on collector technology
2. NOVATEC–BioSol claims: solar steam competitive with steam by oil for oil cost of 40 US\$/barrel

Phases of global DESERTEC program

DESERTEC CSP DEPLOYMENT Program

A rough implementation scheme:

Phase 1 6 years HIGH SPEED MARKET INTRODUCTION

2010 –2015 policy driven

external financial support: GECS funds and Feed in Tariff

Phase 2 20 years COLLECTOR PRODUCTION SCALE UP

2016– 2035, market driven

0.6 →600 GW/year: +30% p.a., duplication in 2.5 years

Phase 3 20 years HIGH SPEED DEPLOYMENT

2031 – 2050, market driven

average 1.5 GW-coll/day, investment ca. 3 bn €/day

Fast completion of phase 1 = key to success !

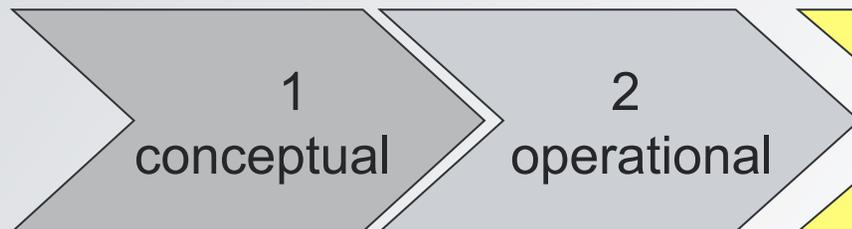
→ Main task for DESERTEC Foundation

Phase 1: Market introduction of CSP technology

Steps of technology introduction :

Phase 0

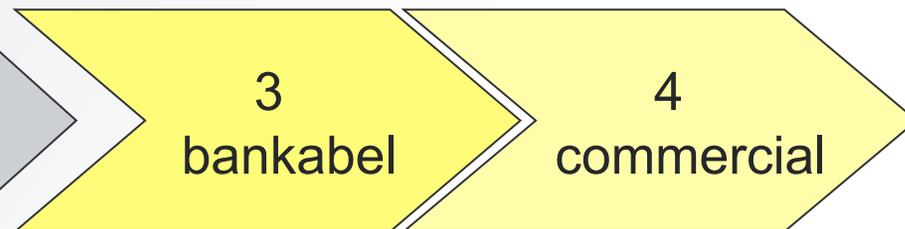
Technology innovation



1. Invention, basic idea
2. Demo of functionality
3. Demo of reliability
4. Cost reduction for competition

Phase 1

Market introduction



- 1&2 technologyinnovation (R&D), Phase 0
 - 3&4 market introduction or pre-commercial phase: Phase 1
- Push for 3&4 by DESERTEC Foundation

Phase2: Capacity expansion for collector production

Tasks and bottlenecks: tbd by DESERTEC Foundation

Phase3:

Mass deployment of solar thermal power plants

Logistic and grid connection: tbd by DESERTEC Foundation