

DESERTEC – an international approach to use solar energies at large scale

TUTORIAL

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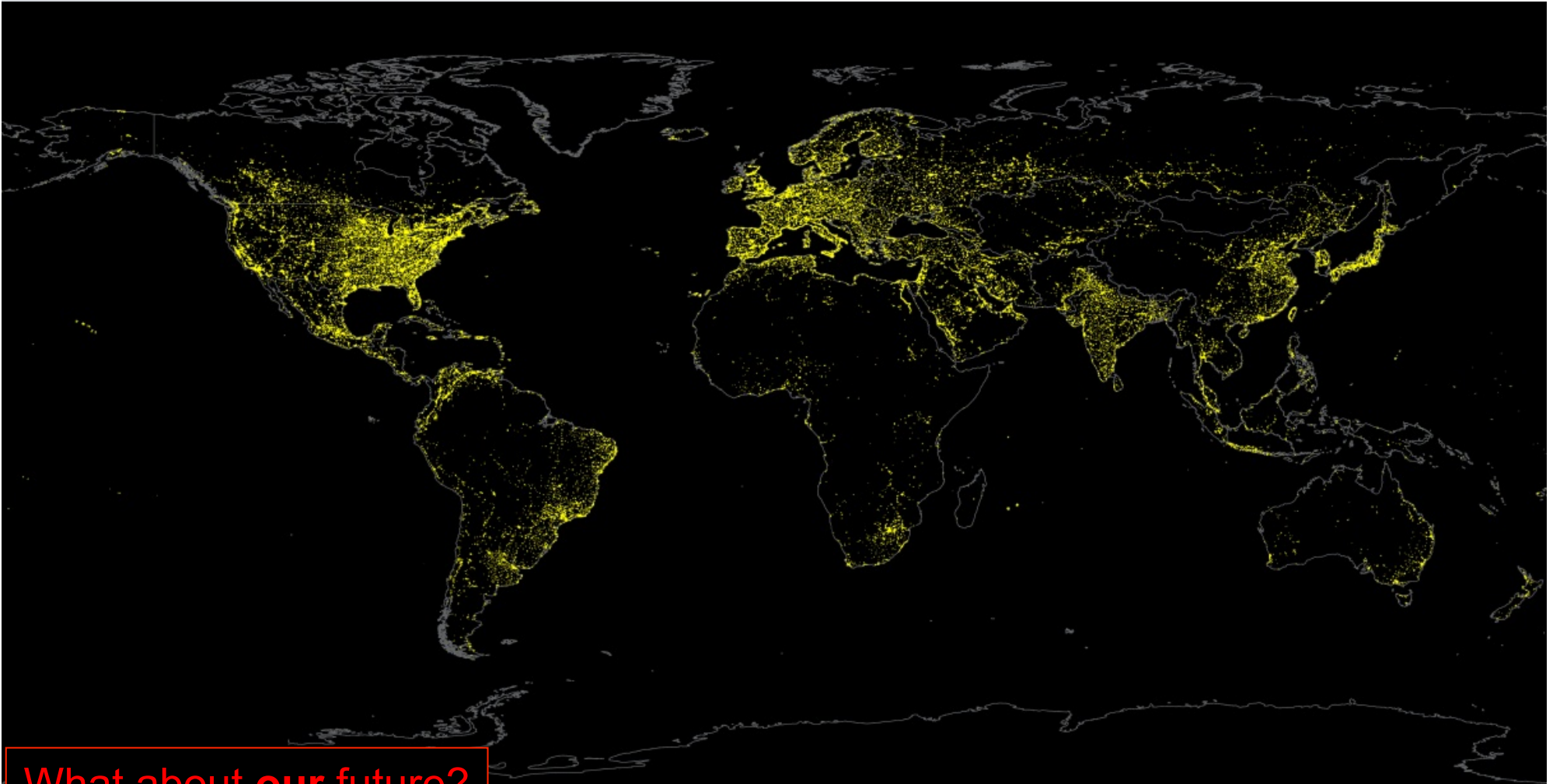
Motivation



- Growing world population
 - Growing energy demand per capita
 - 2010: ~12 000 GW
 - 2060: ~37 000 GW ?
- (1 GW_{el} = 1 nuclear power plant)

Earth at night...

The world of the poor people is dark



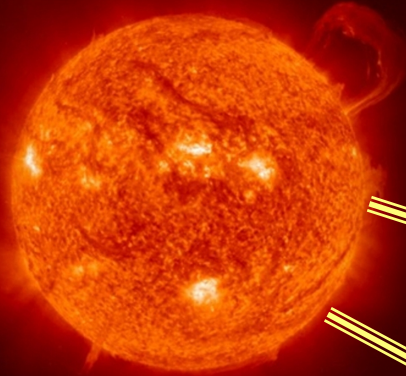
What about **our** future?

Michael Düren, DPG Dresden
13.03.11

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We need to use nuclear fusion energy now!

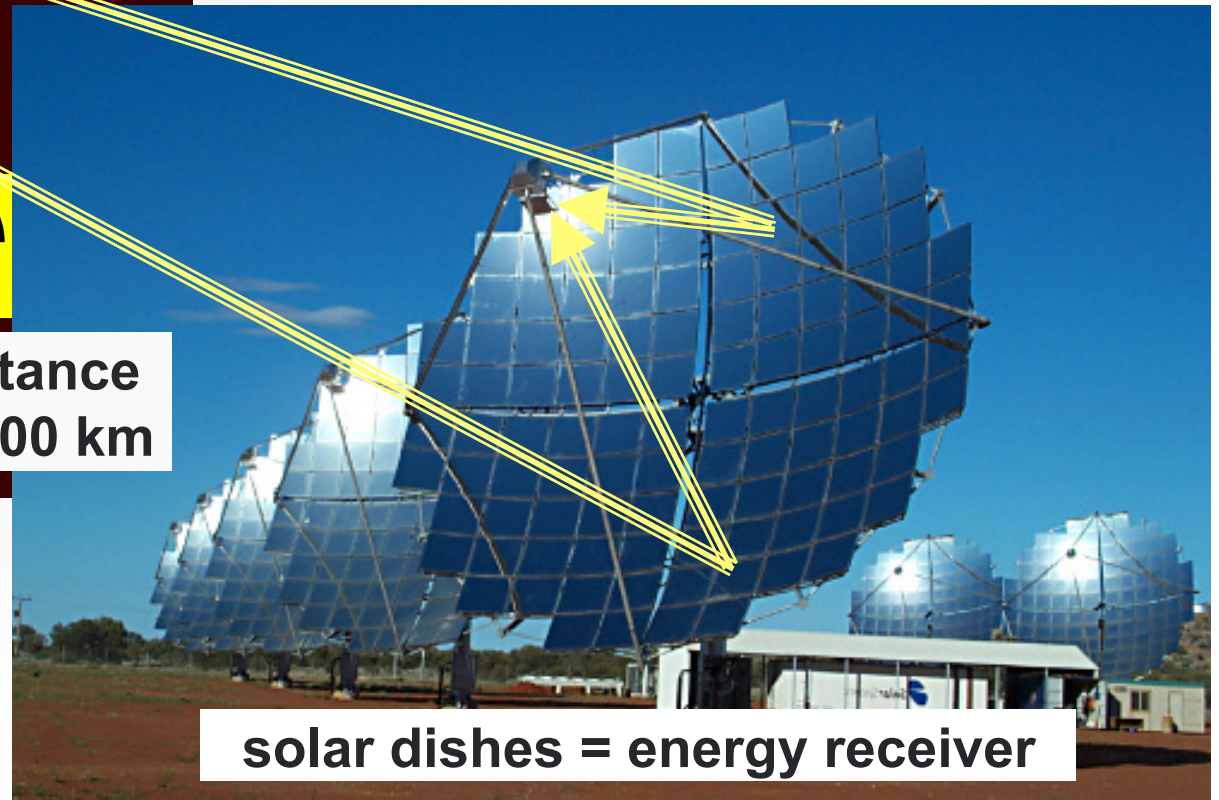
Do not wait for ITER!



**The sun is our
fusion reactor**



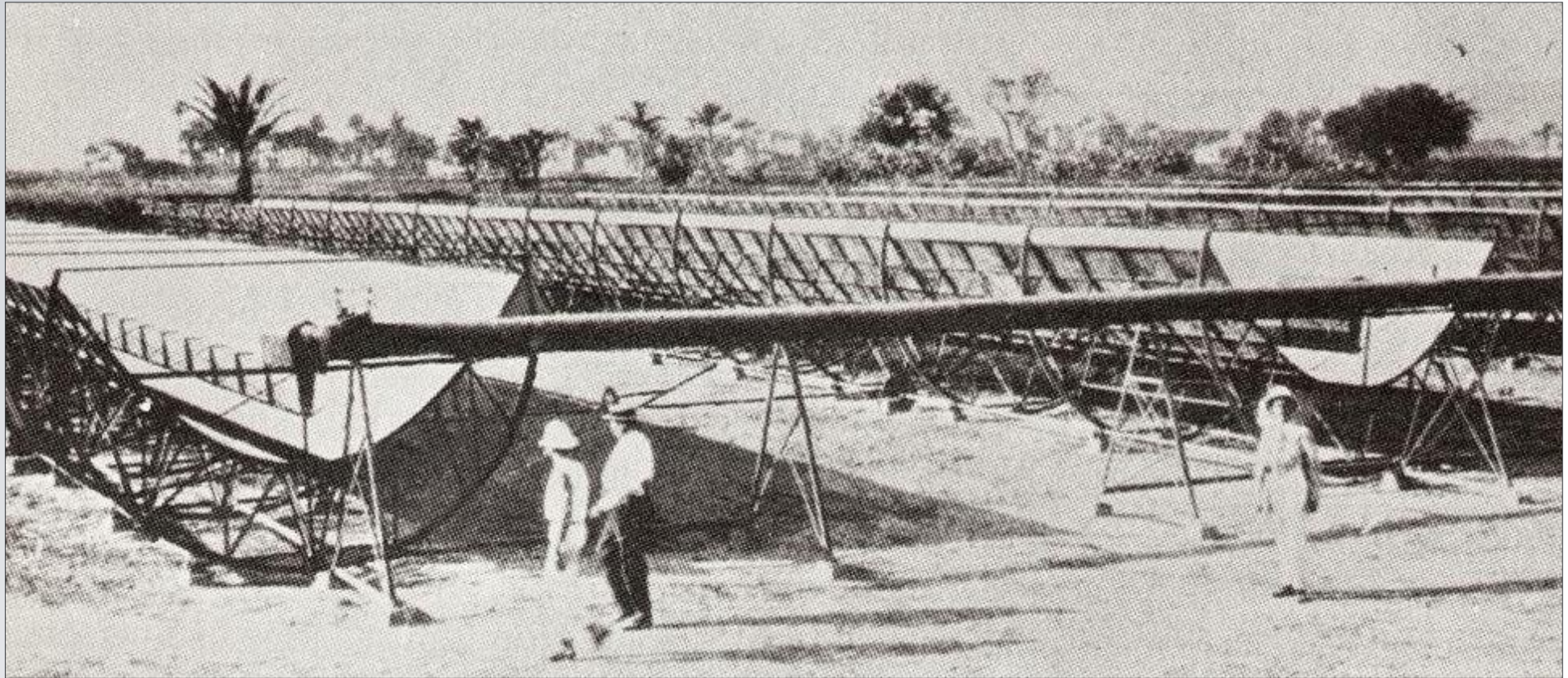
**Safety distance
150 000 000 km**



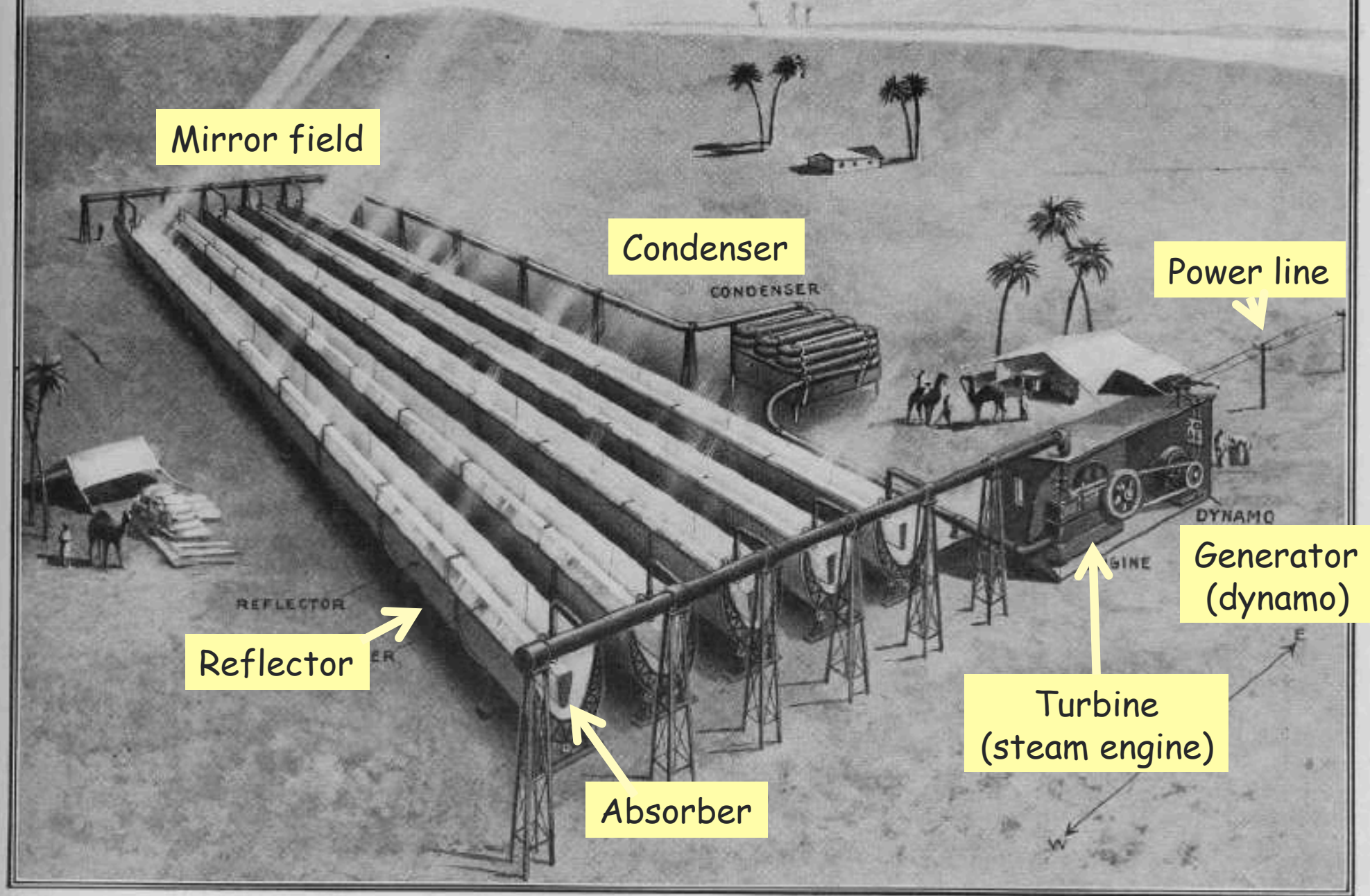
solar dishes = energy receiver

Concentrating Solar Thermal Power (CSP)

100 year old technology (El-Maadi, Egypt, 1913)



Concentrating Solar Thermal Power (CSP)



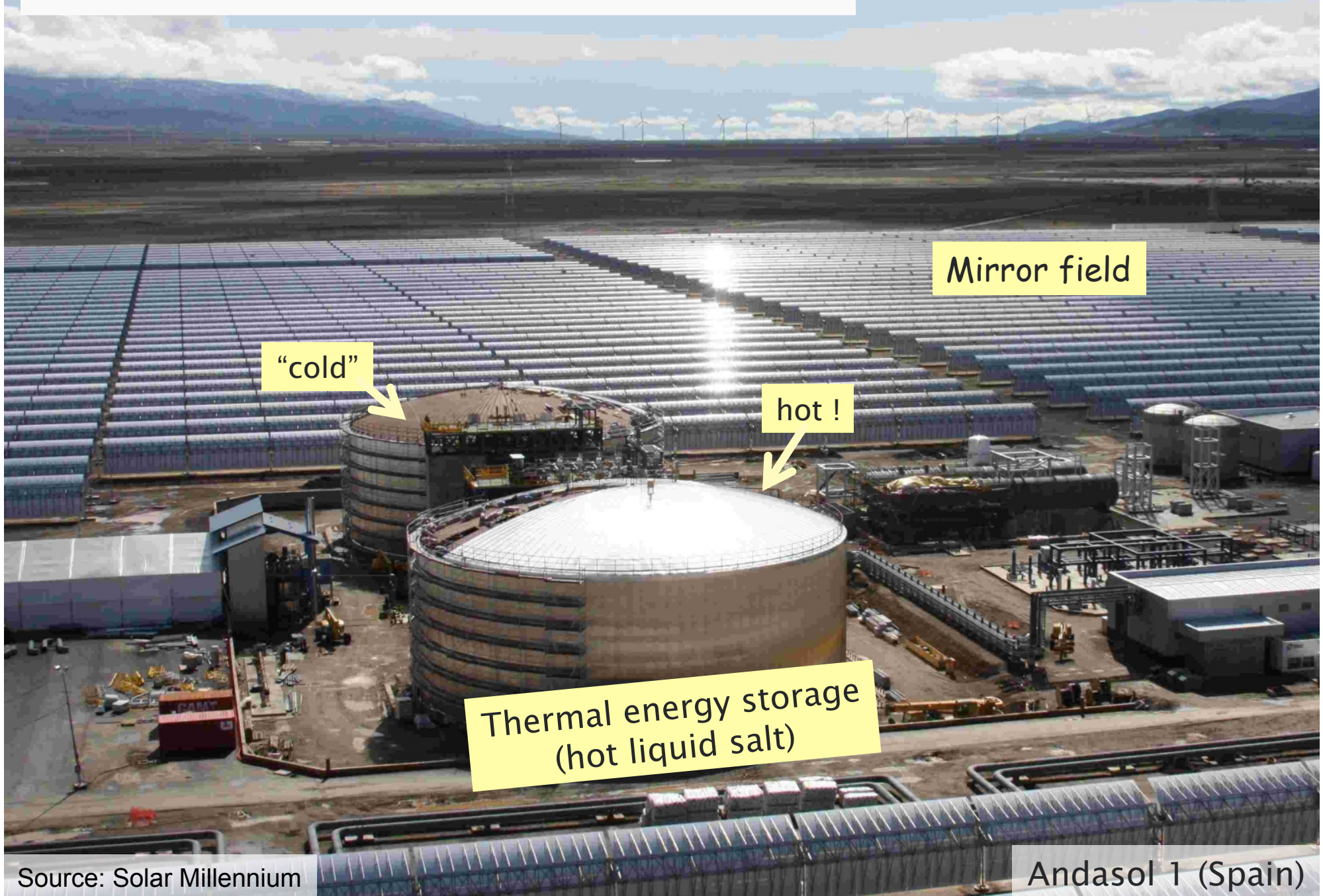
A Successful 100 H.P. Sun Power Plant Located at Meadi, on the Nile, Egypt.

Concentrating Solar Thermal Power (CSP): In commercial use for more than 20 years

Kramer Junction (USA), operating since 1990



Solar power day and night (2009)



Mirror field

"cold"

hot !

Thermal energy storage
(hot liquid salt)

Solar power plants II:

Fresnel technology:

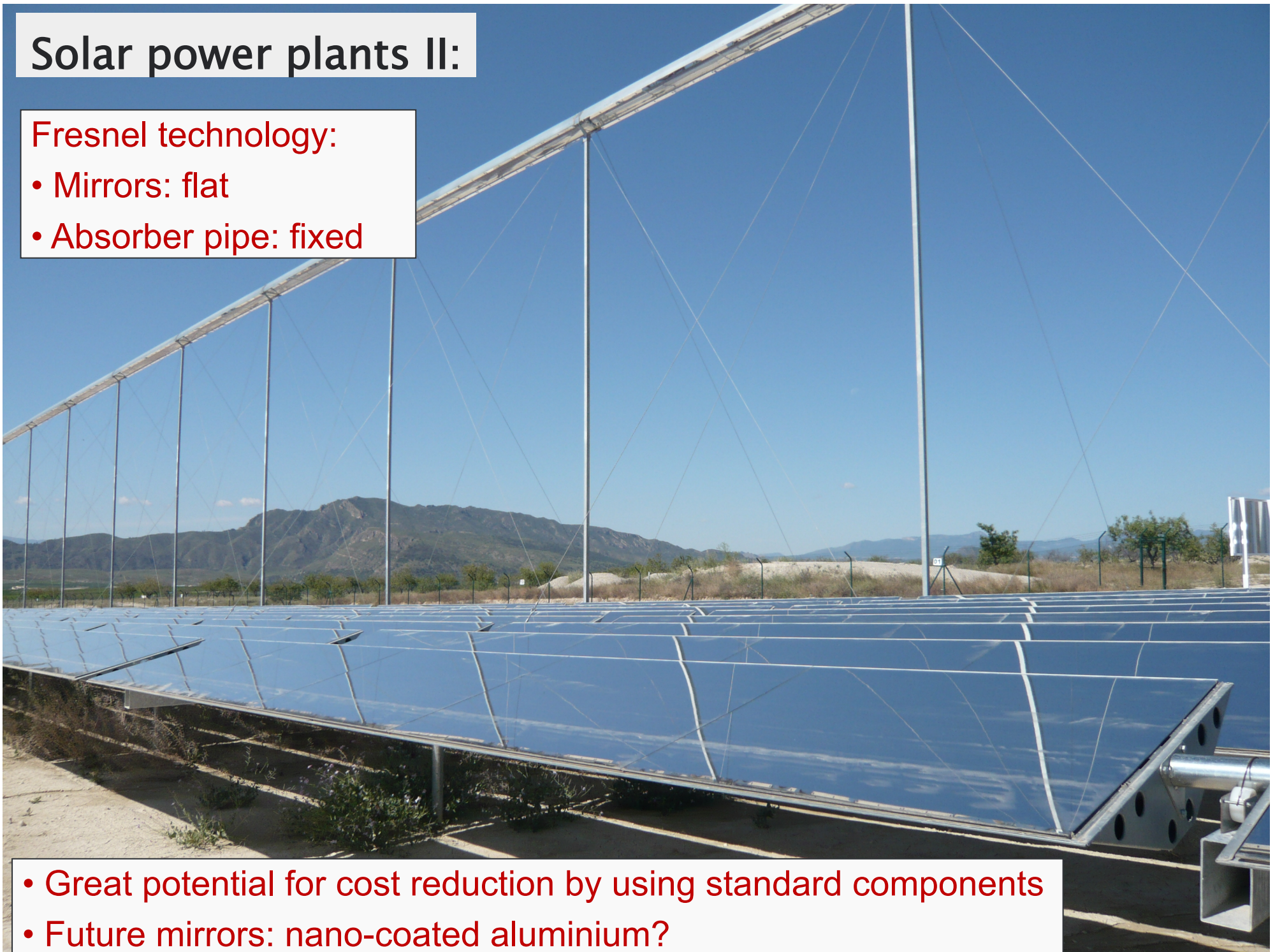
- Mirrors: flat
- Absorber pipe: fixed



Solar power plants II:

Fresnel technology:


- Mirrors: flat
- Absorber pipe: fixed



- Great potential for cost reduction by using standard components
- Future mirrors: nano-coated aluminium?

No water usage:

- Air cooled condenser
- Mirror cleaning without water usage



The first linear Fresnel solar power plant from NOVATEC-BioSol (Germany), 1.5 MW, in Spain

Solar power plants III:

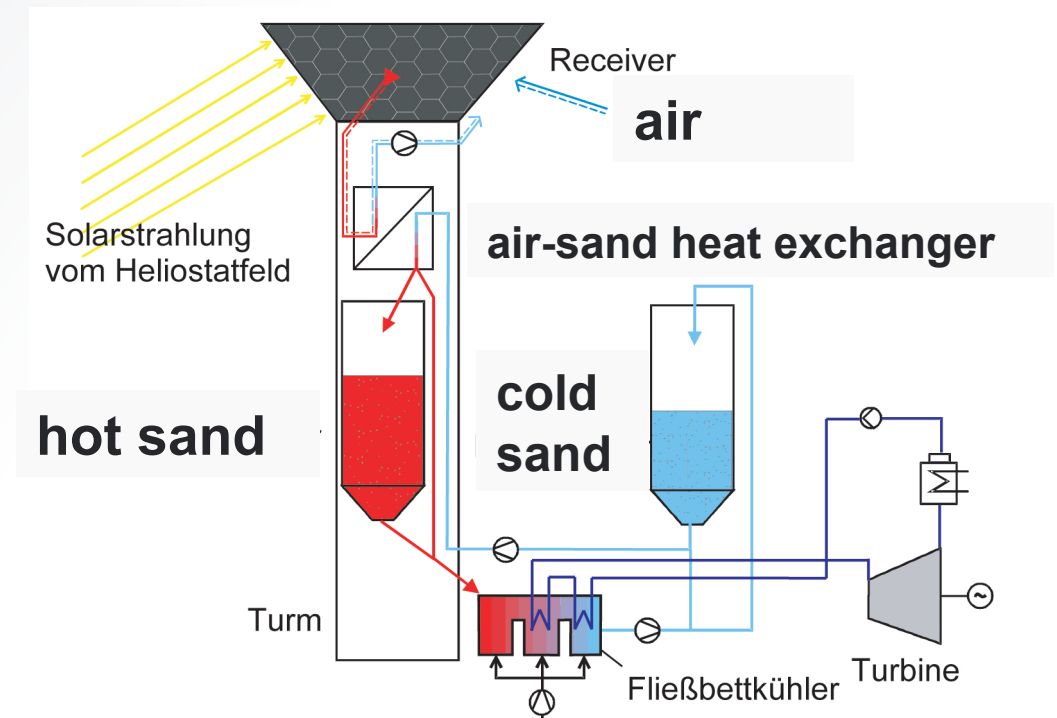
Solar towers:

- work in hilly area
- highest temperatures ($>800\text{ }^{\circ}\text{C}$)
- high efficiencies ($>20\%$)



Possible future technology: power tower & sand storage

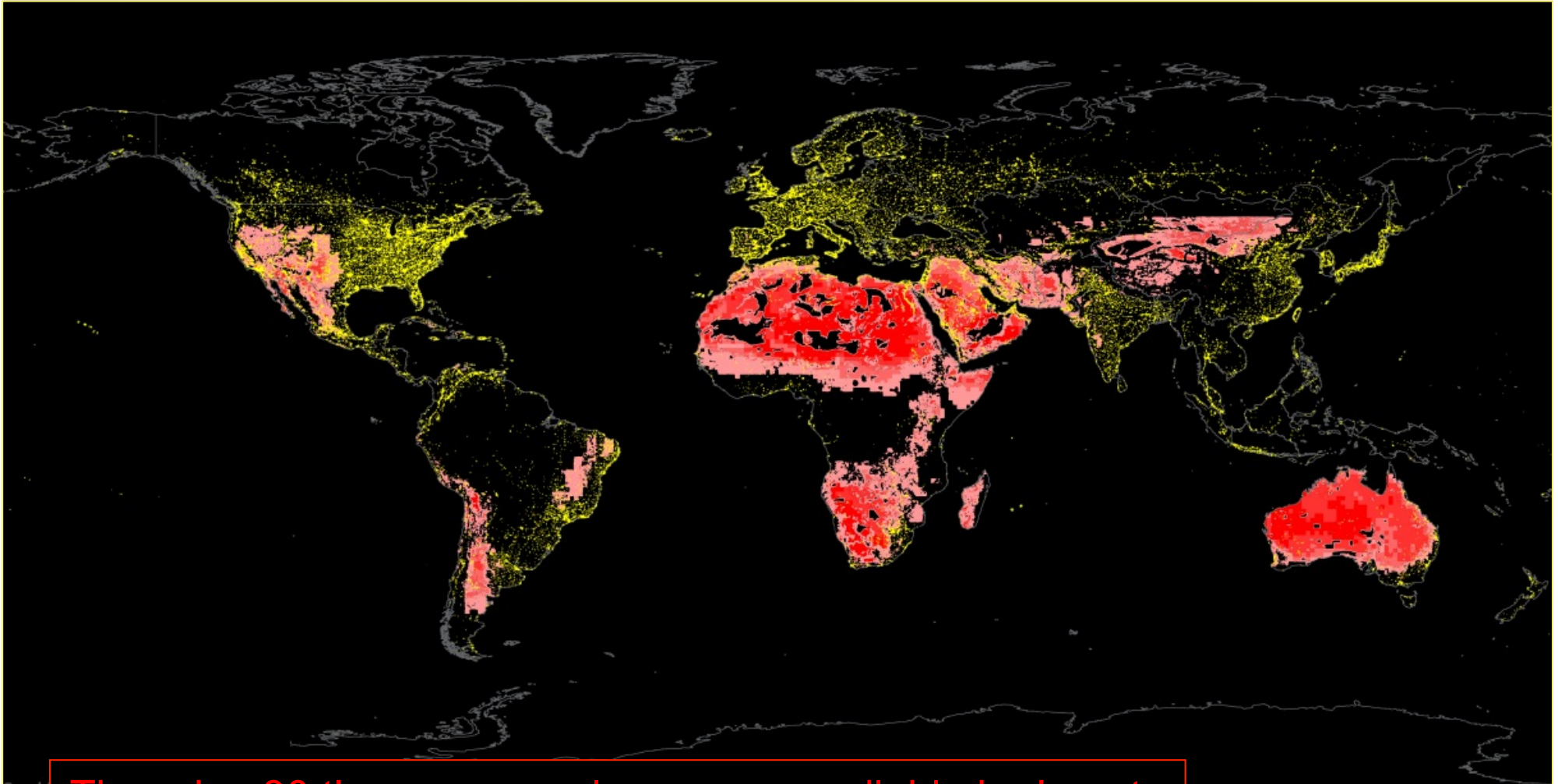
- Air as heat carrier: 800 °C with high efficiency
- Hot air heats up sand: cheap storage material
- Power on demand: hot sand operates steam turbine



There is abundant solar irradiation in deserts

Solar energy potential: $\sim 340\,000\text{ GW}_{el}$

(all year average; day & night average, current technology, 4.5% land use factor)



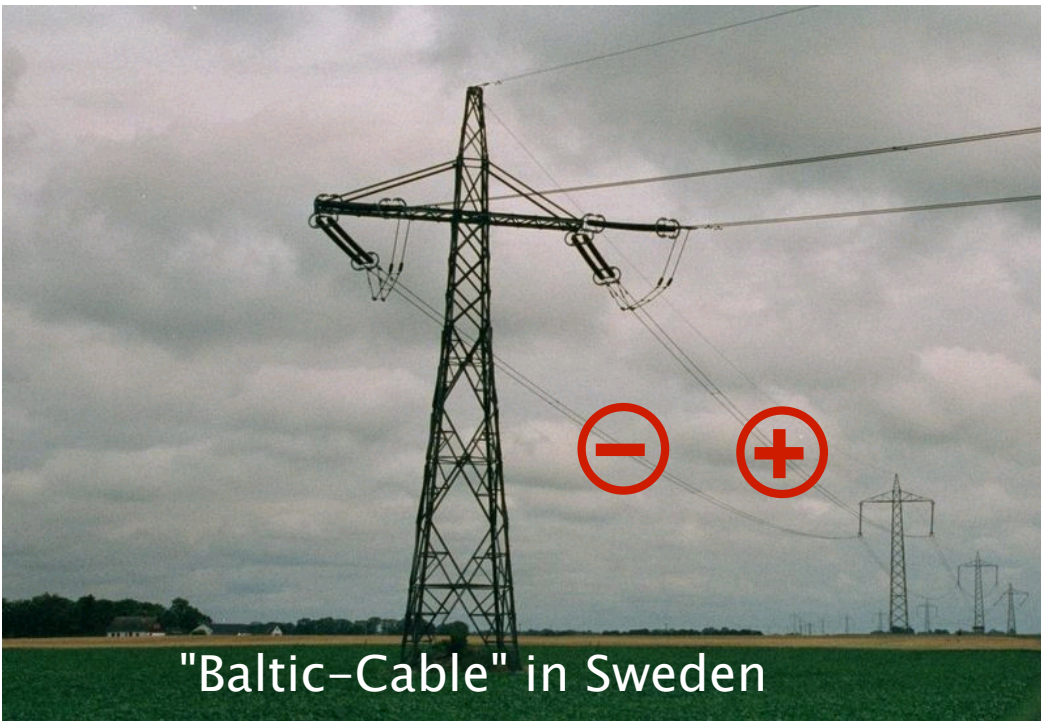
Graph
Based

There is ~ 30 times more solar energy available in deserts than needed to solve all energy problems on earth

How to bring the power to the people?



- By cable!
- High voltage (~ 900 kV)
- Direct current (+/-)
- Power loss $\sim 10\%$ over 3000 km



"Baltic-Cable" in Sweden



Offshore AC-DC converter

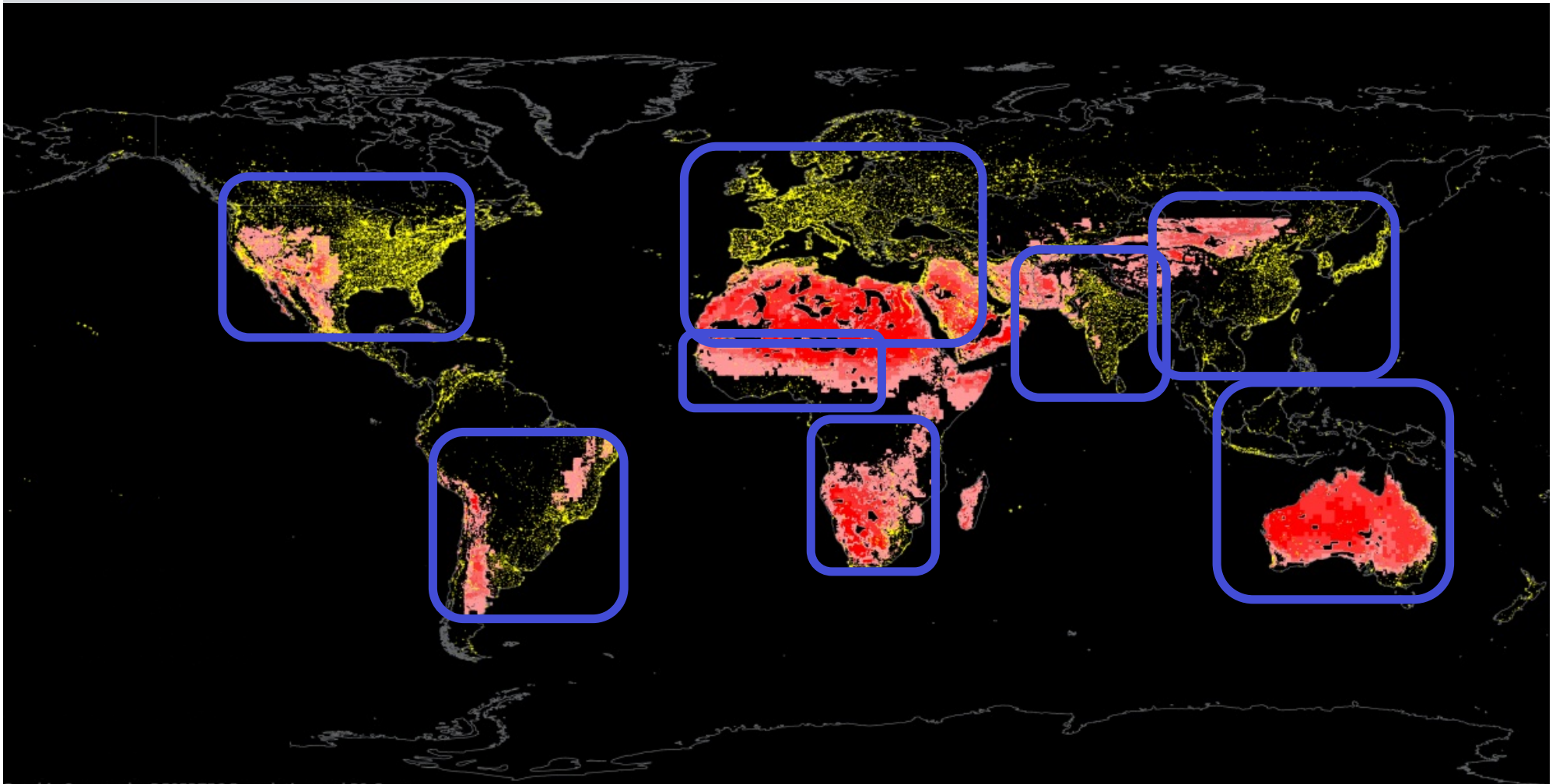


← Ground cables
are more expensive but
building permits are
faster and more easy

The DESERTEC concept: world wide solutions

90% of the world population lives within 3000 km from deserts

Special regions of interest:



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

Michael Düren, DPG Dresden
13.03.11

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Why CSP?

What about photovoltaic and wind power?

- Wind power is cheaper than PV, but it fluctuates.
- PV is (currently) cheaper than CSP, but there is no PV-power at night.
- Only CSP can provide solar power day and night (@GigaWatt scale). That is the reason why CSP is of special importance in a global DESERTEC concept.
- Nevertheless, we need a mix of all renewable energy sources



Centralized or decentralised energy supply? Local power supply or smart super grids?

Case A: Rural area in Namibia.

1 inhabitant per km²

- Forget about long power lines!
- Use PV panels or dish sterling engines in small villages (or wind, biomass etc.)



Centralized or decentralised energy supply? Local power supply or smart super grids?

Case B: Big city in Europe

- Forget about **100% local** renewable energy supply!
- A grid is cheaper and less polluting than any local electricity storage to compensate fluctuations of demand and of supply by solar or wind power



Centralized or decentralised energy supply? Local power supply or smart super grids?



Use your grid in an optimal way:

- to average out fluctuations of renewable energies (on a scale of 3000 km!)
- to adjust the power consumption to the actual power production (today it is done usually in the opposite way only)
e.g. by tariffs that allow to switch off certain consumers at peak times

DESERTEC: Producing clean electricity where it is economically most viable



What about the future of Europe?

- Europe seeks good neighbourship with surrounding countries
- The steep north-south decline of wealth has to be reduced
- Europe and Africa need a strong peace-keeping economical cooperation



Spain, 2008

DESERTEC as a holistic approach: Advantages for North Africa

- Secure energy supply independent from oil and gas
- Drinking water supply (seawater desalination)
- Socio-economic development (local industry creation; huge number of new jobs)
- Export opportunities
- Promotion of peace through international cooperation
- CO₂ reduction

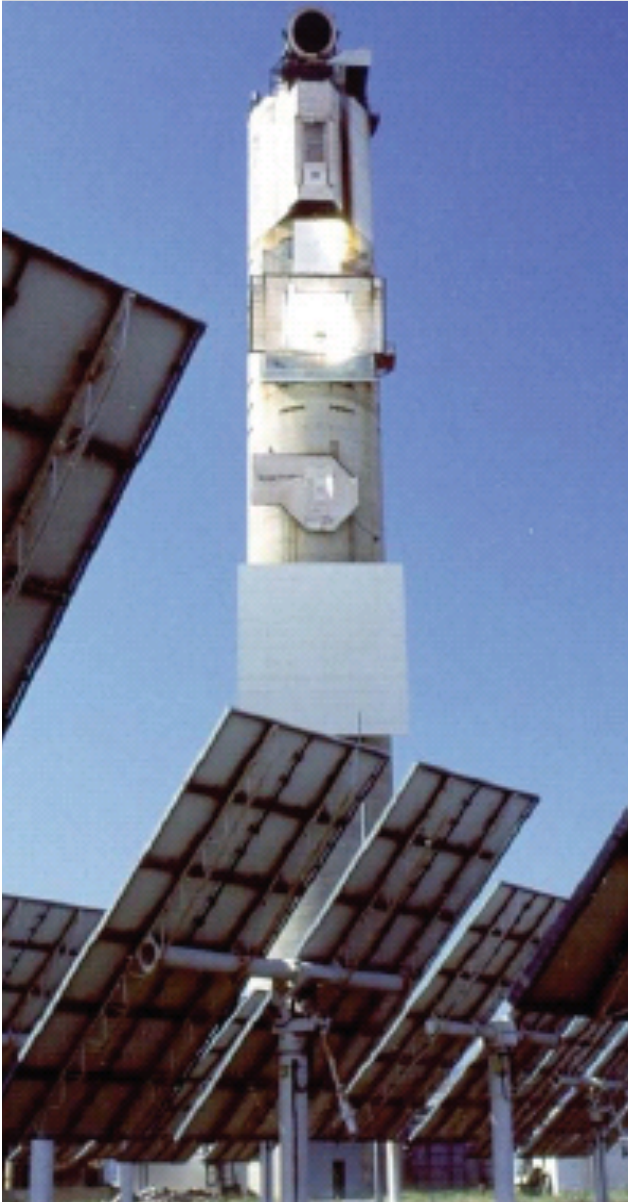
DESERTEC as a holistic approach: Advantages for Europe

- Renewable energy supply independent from oil, gas and nuclear energy on the long term
- Large number of new jobs
- Technology export (solar, HVDC, ...)
- Promotion of peace with African and Arabian countries through international interdependence
- CO₂ reduction

The right project at the right time for Africa and Europe



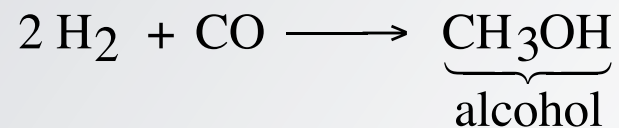
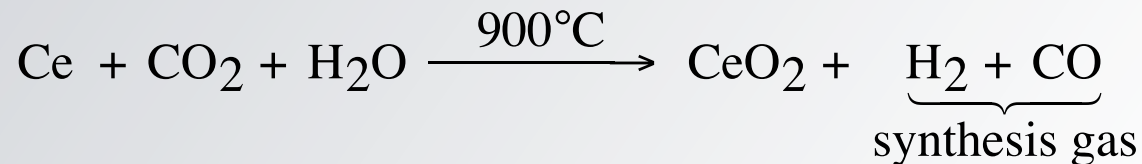
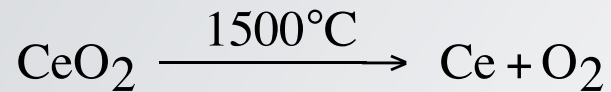
Future vision



- 100% Renewables
- Synthetic fuels from CSP (catalytic reactions at high temperature):
 - liquid hydrogen from water
 - alcohol from CO₂
- Large thermal and pump storage

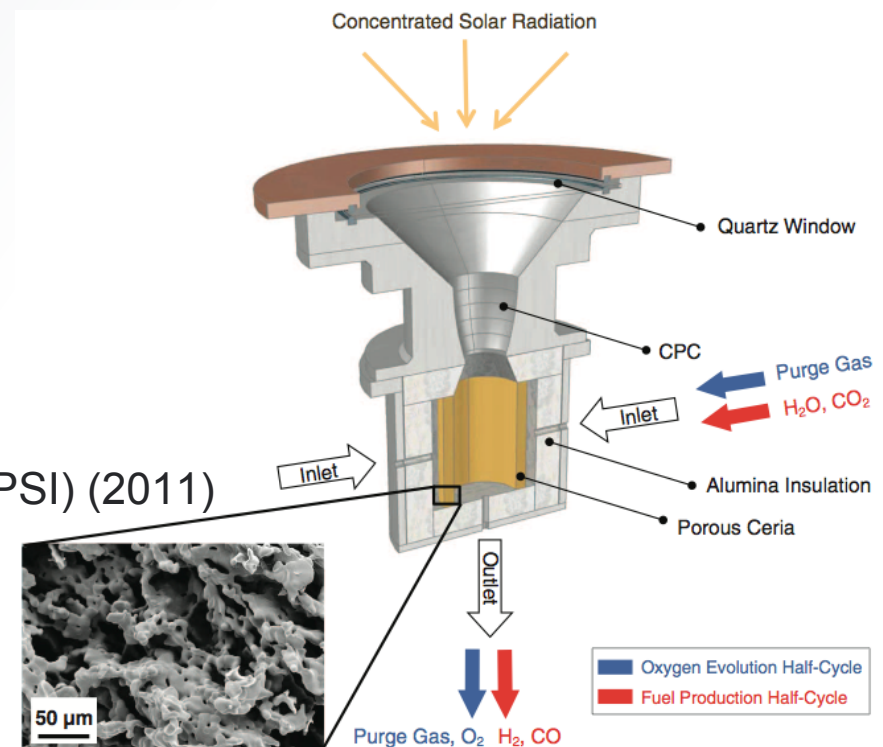
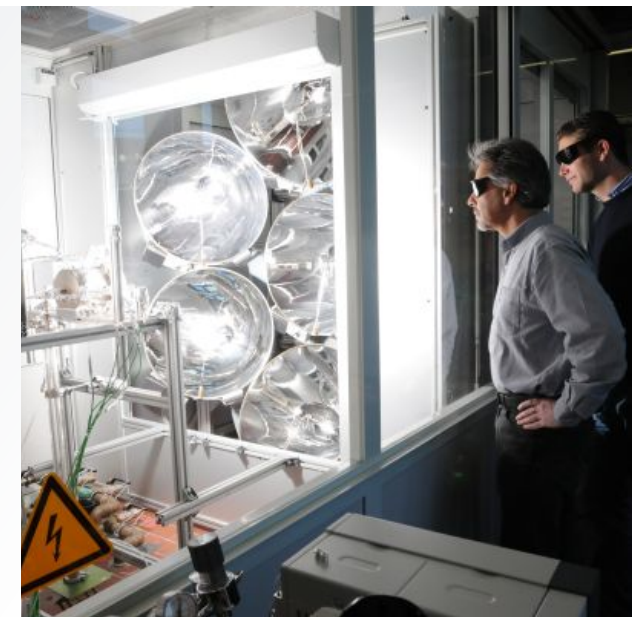
Technological break-through: Sun + H₂O + CO₂ = liquid fuel + O₂

- Ceriumoxid is catalyser in CSP application

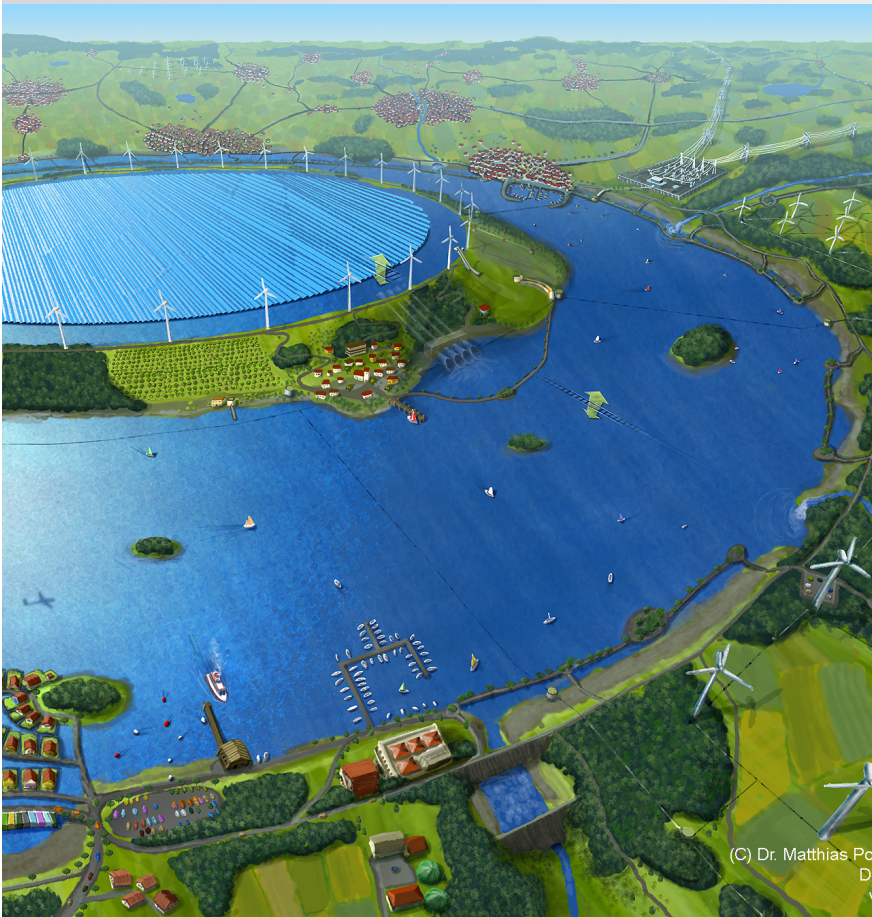


- 0.8% efficiency achieved
- 16-20% or more may be possible

Aldo Steinfeld ETH Zürich and Paul Scherrer Institut (PSI) (2011)



Possible future technology:



- **Sand heat storage:**

a sand cube of 30 m size at 900°C has the same energy as a 1 GW power station operated over 10 h.

- **Water pump storage:**

A Fjord with an area of 400 km² that is pumped up to a level of 25 m has the same energy as a 1 GW power station operated over 340 h.

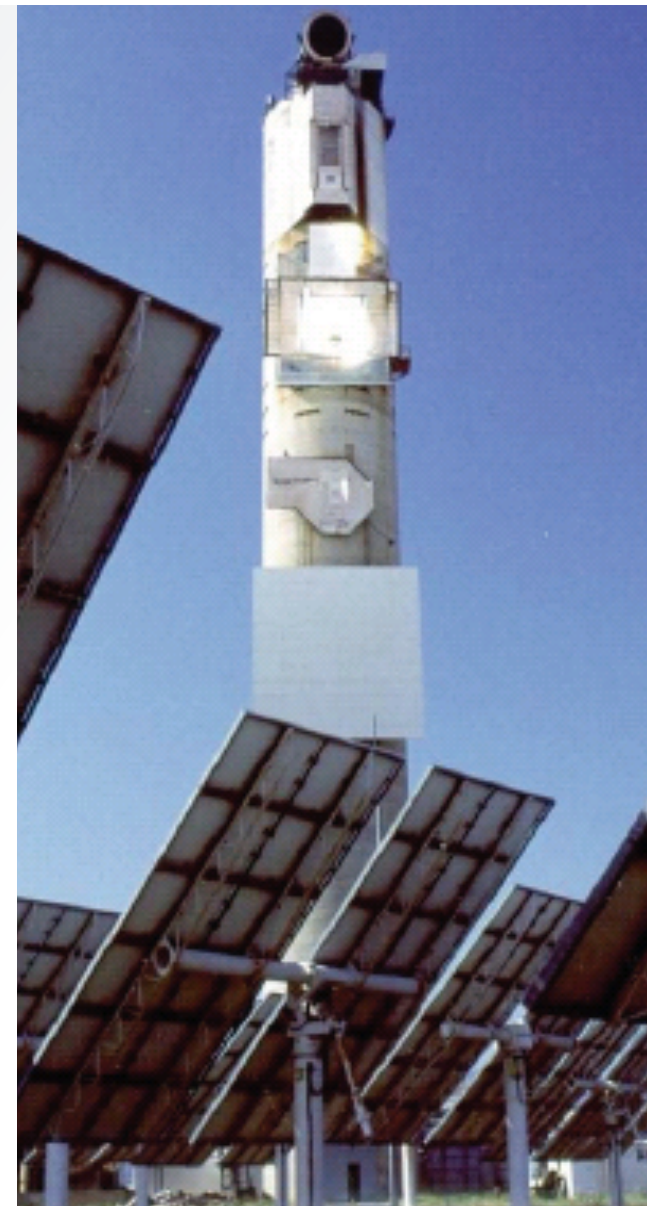
Research and development

Urgent answers needed concerning

... funding, legislation, implementation, political acceptance, socio-economic transitions

How to convert our society in a stable and timely manner?

An international research centre *à la CERN* is needed that operates internationally and beyond commercial interest



References & acknowledgements

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- DESERTEC, DUN, Dii,
- AKE, SEPA, DESY, ...
- G. Knies, G. Luther, M. Miled, K. Richter, F. Trieb, O. Steinmetz, ...
- Google, Wikipedia, ...

– parts of the presentation are subject to copyright –

**There will be more talks about energy at this conference
by the AKE on Monday and Wednesday**

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The right project at the right time for Africa and Europe

... and for Japan and China

... and the rest of the world

Sonntag, 17:55 – 18:30; 30+5 min, Tutorial

Tutorial

AKE 1.4 Sun 17:55 HSZ 03

DESERTEC - an international approach to use renewable energies at large scale — ●MICHAEL DÜREN — II. Physikalisches Institut, Justus-Liebig-Universität Gießen, Gießen, Germany

The DESERTEC concept combines solar power, wind power and other sources of renewable energy in a large and efficient electrical super grid that spans distances of several thousand kilometres. Fluctuations of the individual sources and loads are averaged out to a large extent. A special emphasis in this concept is given to a large network of solar thermal power stations that are located in deserts of the sun belt of the earth to maximize the yearly solar energy yield at a minimum of costs. The solar thermal power plants are equipped with large thermal storage capacity so that they can provide solar power day and night in accordance with the actual demand. The lecture will give an introduction into the basics of the physical and technological concepts and of the political and socio-economic implications of DESERTEC.