Global energy and climate security through solar power from deserts

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July 2006

Introduction

The present world energy supply system is facing 3 basic problems: limitation of fossil fuel resources, climate change by carbon dioxide emission, insecurity by nuclear weapon competence and radioactive materials. The strategic goal therefore should be: transition to unlimited resources, zero-emission fuels and no options for abuse.

Renewable energies, in particular solar energy as the most abundant form, are an alternative for a global energy supply:

Solar energy cannot be depleted by using it: it comes to earth at day as light, and leaves to outer space as heat radiation at day and night – whether we "use" it or not. Being non-material solar energy does not create pollution, and the biotope earth is in natural balance with it. So far, no military applications of solar energy are known or planned – otherwise solar energy technologies would have received support since long.

The most efficient places to harvest solar energy in large amounts are the deserts. To be considered as a world-wide substitute for the fossil fuels there are 4 questions to be answered:

1. Is there enough solar energy in the deserts for the demands of a growing world population?
2. Can solar energy supply power as demands occur in time?
3. Can energy be transmitted from deserts to large enough regions of the world?
4. Is solar power from deserts economically viable?

1. How much solar energy is coming to the Earth's deserts?

The solar energy potential of the sun-belt deserts and desert-like regions can be estimated according to UNEP (www.unep.org/geo/gdoutlook/018.asp#fig12) as

desert space = 36 Million km

and from the energy they receive annually from the sun. A reasonable average value for the energy of direct normal solar radiation is

2.2 TeraWatt-hour (TWh) /km /year.

This is as if a layer of oil of 24 cm depth is put onto the deserts, each year again. Slightly other values can be considered, but the conclusions do not change with such choices.

The energy received each year by 1 km of desert is equivalent to the (thermal) energy contained in:

- 300 000 ton hard coal
- 1.5 Million barrel oil

The solar energy arriving annually at the 36 Million km of desert areas is equivalent to

- 80 Million (Mega) TWh (thermal)
- 10,000 Billion (Giga) ton coal
- 50,000 Billion barrel oil
- 300,000 Exajoule

Since we do have the technologies to convert (at least) 11% of solar radiation into electricity, we can generate in deserts typically

0.24 TWh-electric /km /year

2. Comparison to global demands

How the terrestrial fossil reserves, resources and their annual depletion/consumption compare to the annual solar yields is summarized in the table. According to site selection studies by DLR using satellite data the deserts in the MENA region would allow for production of electricity of 630,000 TWh/year, about 40 times the present world electricity demand. Collectors for the German total power consumption would require a square of 45km side length, i.e. the area of Berlin and Hamburg.

Table: Fossil reserves, resources, consumption rates, depletion time (*source: Federal Institute for Geosciences and Natural Resources, Hanover, 2004*), and corresponding energy delivery times by solar radiation in deserts.

Fossil energy source In Giga tonnes coal equivalent 1 Gtce = 29 EJ = 8,140 TWh-thermal = 5 Billion bbl	Proven Reserve (expected additional Resources) Gtce	Annual Production/ consumption Gtce	Static depletion time of reserves In years	Solar energy delivery time in the global deserts, corresponding to	
				Global reserves (Resources) In days	annual fossil consumption In hours
Total	1.279 (6224)	13.1	98	47 (227)	5.7
Oil (conventional)	233 (118)	5.5	42	8.5 (4.3)	2.4
Oil (non-conv.)	96 (361)			3.5 (13.2)	
Natural gas (conv.)	196 (230)	3.0	65	7.2 (8.4)	1.3
Natural gas (non-conv.)	2 (1687)			0.1 (62)	
Coal (hard and lignite)	697 (3541)	4.1	170	25 (129)	1.8
Uranium, Thorium	56 (293)	0.5	101	2.0 (11)	0.2

There are 4 particularly interesting messages:

1. The present global annual demand for primary energy arrives as solar energy in the deserts within 5.7 hours of sun shine.

2. The global annual demand of 55 Gtce expected for 2100 (WBGU) is arriving in 2 days.

3. The energy contained in the total known fossil reserves on Earth arrives in 47 days, and that in the expected total resources in 227 days in the deserts.

4. The total known and expected resources for nuclear energy are delivered as solar energy to the worlds deserts within 13days.

In fact, deserts can be made to sustainable powerhouses for the world.

3. Can solar energy be supplied as demands occur in time?

Fossil fuels are available as materials that can be stored, and be employed when demand occurs. Solar energy is delivered when the sun is shining. Sun shine itself cannot be stored, but it can readily be converted into high temperature heat which can be stored in thermal storage devices for hours and even for days, with insignificant losses.

This brings the technology of solar thermal power plants into a particularly attractive position: Equipped with simple and cheap thermal storage tanks they can produce solar power by demand, also at night. Large scale thermal energy storage is technically solved and commercially available.

Longer periods without direct sunshine can be coped with by a supplementary fossil fuel heater. The solar power plant contains its own reserve capacity. Solar thermal power plants provide secured capacity.

4. Can solar energy from deserts be transmitted to the high demand regions of the world?

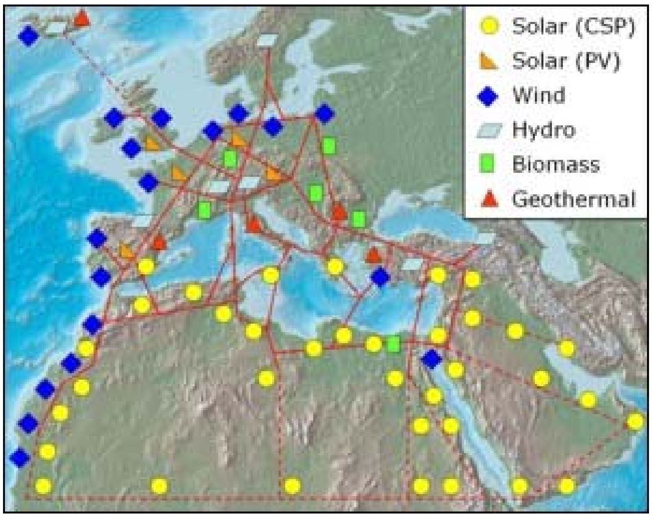
Once solar energy has been converted into electricity, it can be transmitted as direct current at very high voltage (500 kV and higher) over thousands of kilometres with low losses of about 3% per 1000 kilometre. The HVDC (High Voltage Direct Current) transmission is a well established technology. Since large deserts are available in North-and South America, North and South Africa, Western Asia, India, China and Australia, clean power from the deserts can be delivered to more than 90% of world population.

5. Is solar power from deserts economically viable?

In a first step, concentrating solar collectors convert concentrated solar radiation into heat of about 300° Celsius and higher, up to about 1000°C. Steam from solar collectors for thermal power plants, as from 1 barrel of oil, costs between 50 and 70 $. This cost value can be brought down to below 30$ within 10 to 15 years by mass production of such collectors.

These costs vary with the available annual solar radiation and with capital costs. The bulk materials for solar steam generating collectors are glass and iron for which there will be no shortages. According to studies by DLR one can be achieve (www.trec-eumena.org)within 2 to 3 decades:

power production costs of 4-6 c$/kWh
power transmission costs of 1-2 c$/kWh.
Coal and nuclear power plants can be phased out simultaneously.



With an EU-MENA grid as infrastructure for energy and climate security, solar power from deserts can become the least cost option for Europe.

6. Seawater desalination in cogeneration

In solar thermal power plants only 35% of the collected solar energy is converted into electricity. If combined with sea water another 50% of the collected energy, normally released as cooling heat, can be used for thermal desalination. This way up to 85% of the collected solar energy can be used, and with each TWh of power 40 Million m water can be desalinated in cogeneration.

Summary

1. The solar energy available in deserts is more than 700 times the present global primary energy consumption. This is far more than needed to replace fossil fuels.

2. Solar thermal power plants can store solar heat and generate solar power according to demand, also at night (secured capacity).

3. Technologies for power production and long-distance transmission to over 90% of world population are at hand.

4. In a solar energy co-operation technology-belt and sun-belt can achieve energy, water and climate security, and stable power production costs of 4 – 8 c$/kWh.

5. Investments into mining technologies for fossil fuels will accelerate their depletion and boost climate change, while better solar technology will be beneficial for all future.

6. An Apollo-like program for bringing deserts into service for energy, water and climate security, as proposed by Prince El Hassan from Jordan at the Hanover Industrial Fair 2006, could be organized immediately.

7. TREC and The Club of Rome are calling for a conference DESERTEC to bring technology- and sun-belt countries to action.

8. **Solar energy from deserts can give energy security to the world, and it can stop the ongoing devastation of the Earth by fossil fuels.**