A Solar Water&Power Source for Recovery of Gaza

a project for

Gaza, for global climate stability and for regional cooperation for sustainability[1]

Concept developed by TREC and presented to Forum2000 in Prague, 9/10 October 2005:

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Executive summary: The Trans-Mediterranean Renewable Energy Cooperation (TREC) propose to consider to build a Solar Water&Power Source (SW&PS) as core of a Gaza Recovery Program, and as a means of introducing the technology of concentrating solar power (CSP) for low cost and secure power and water production from sunlight and seawater into the region. The SW&PS would have an annual capacity of 9 Tera Watt hours (1 TWh = 1 billion kWh) electricity and 360 Million m³ desalinated water produced in cogeneration, for an expected population of 3 Million. A site of 40 km² is needed for solar collectors. This brings Egypt into a key role as it could host the SW&PS in the nearby Sinai coastal region, produce clean power and fresh water for export to Gaza and eventually to other neighbours, and acquire competence in the SW&PS technology development and construction.

Construction of a **demonstration plant** with about 1% of the final capacity, i.e. with ca. 400x1000 m² collector field in or near the Gaza could begin immediately and become operational within 1 year. The step wise expansion to the above mentioned full capacity could be stretched over a period of 10 – 20 years, following the urgency of demand. These are the benefits of a solar energy based power&water plant:

- In terms of energy and water security the solar solution is superior to fossil fuel plants because of unpredictable fuel costs and also because of uncertainty of supply in the future.
- In terms of economy the input energy for a project of this size will be cheaper from solar collectors than from oil or natural gas, when considered for a plant operation time of 30 to 40 years as expected for the collectors.
- If properly financed the SW&PS would offer low-cost power and water to Gaza and thus give infrastructure for Gaza to attract investments for development.
- This project would contribute to reducing solar energy cost for raising steam by concentrating solar collector (CSP) technology, up to 50%, helping to stop climate change, and for avoiding economic crashes stemming from fossil fuel costs growth and volatility. EU could in about 20 years import low cost and secure clean power.
- The project is replicable to the benefit of many MENA cities with similar power and water needs.
- Construction of solar steam generators could give a boost to industrial development and to transformation to a knowledge based economy of MENA countries.

This project would establish a long-term cooperation between Egypt and Palestine, and also with Jordan, Israel and the EU for the sake of creating new and sustainable water and energy sources.

An international Gaza Recovery Agency (GARAGE) could be formed to handle the political and financial sides of this project. Such an agency could be a step towards a Trans-Mediterranean community for energy and water security, and for peace building in these regions.

Thus the Gaza Solar Water&Power Source project could help to create trans-boundary cooperation for more economical, ecological and political stability.

[1] This proposal has been accepted by Vaclav Havel and Prince El Hassan bin Talal (see Figure 10 in Appendix) for promotion within the so called Prague Process, see http://www.forum2000.cz/index.php.

Introduction

The conflicts for land, water, and "security" in the Middle East cannot be solved by brute force or confrontation. In addition, the rapidly growing population in MENA countries and the frictions of religions are aggravating the situation. A new chapter in the relations between countries and parties involved in and affected by these conflicts is urgently needed. Here we will propose an attempt of turning the mounting water crisis into a turning point from confrontation to cooperation. Energy and water security, and even sustainable prosperity in the Middle East and in North Africa can be achieved by a joint effort for large-scale utilization of solar energy.

Gaza is a hotspot of needs and conflicts. It is running out of drinking water by overextracting the aquifers. This may lead to a critical situation. There is little hope that this crisis will be resolved *from inside*. It is rather certain that it will escalate and send shock waves to the world around it. If things just continue Gaza might quite rapidly become a source of escalating violence with disastrous and costly implications, inside and beyond its borders – may be with a global reach. Here we propose a technical solution for the Gaza water crisis: Instead of fighting for insufficient resources of water and energy the region and its human forces could concentrate on creating new ones.

The proposal

We propose that Palestine and Egypt, and potentially also Jordan, Israel and the EU engage in constructing a solar water and power source (SW&PS) for Gaza as a multi-national effort. This can be done with existing technologies, human labour and ingenuity, available technology and existing financial resources, and with the over-abundant sources of sunlight and seawater. With energy from concentrating solar collectors (Fig. 2 and 3) combined power and desalination plants can transform deserts along shore lines into inexhaustible sources of power and water with unlimited capacity. This will give those countries a new horizon for their development.

Primarily the Gaza SW&PS will produce power, water and optionally also cooling for buildings for the mounting demand coming up in Gaza for a population expected to reach 3 Million within a few decades. The full project may be accomplished within 10 to 15 years.

That's why the Gaza Solar Water&Power Source effectively would give to humanity an efficient tool to end global warming and to avoid global energy scarcity. It is a *global sustainability project*.

Basic parameters of the project

How much water and power is needed in Gaza?
For defining the size of the plant we consider the population expected for 2030 and beyond:

Population in 2005	Expected in 2015	In 2025	In 2035
1.4 Mio	2.0	2.6	3.3
From Palestinian Central Bureau of Statistics		Assuming 3.0% ann. Growth	Assuming 2.0% ann. Growth

Since there are virtually no sustainable resources for power and fresh water within Gaza we propose to consider a power and water source with the capacity 3 million people. We adopt the vision that Gaza will not for ever live at the edge of poverty, but rather become a productive and prospering city, like Milan or Dubai for instance, and assume the following per capita demands:.

Demand	Per capita and year	For 2.5 Million inhabitants
Power	~4000 kWh	~10 TWh (Tera Watt hours)
Water	~300 m³	>0.7 billion m³

Parameters for the solar power and desalination plants:
Assuming 8000 h/y (hours/year) operation for the power and desalination plant, the 10 TWh/y require ca. 1200 MW installed power capacity (1 TWh = 1 billion kWh, 1 Mega Watt = 1000 kW). Such a capacity would not be built as one single big plant, but step by step as a set of many plants with an optimized capacity profile (e.g. 10, 20, 20, 50, 100, 200, 200, 300, 300 MW). After each stage further expansion can be stopped. The waste heat could be used to desalinate 0.36 billion m^3/y of water in cogeneration, or to produce cooling for buildings, or both. Further water may be desalinated by additional reverse Osmosis desalination plants.

Concentrating solar collector technology
The most appropriate solar energy technology to produce steam in sun-belt countries is that of concentrating solar power (CSP, Figure 2 and 3). Here large light concentrating mirror collectors generate heat at high temperature to generate steam for power plants. The collector fields can be made large enough to operate the plant at day time and to produce surplus heat which will be stored for the night. This makes solar operation possible at day and night time. Also supplementary steam generation by oil or gas boilers (hybrid operation) is possible in case of rainy seasons. Thus firm power can be delivered according to demand.

Trans-boundary co-operation for deployment of solar collectors
Since an area of about 5 km² for the collector field is required for the production of 1 TWh/y electricity, an area of 45 km² would be needed for the 9 TWh/y of Gaza itself. Envisaging an export of power and water to the adjacent regions in Israel and Palestine West Bank at a later stage, further power and desalination plants with a capacity of about 1.0 GW may be added. For the additional solar collector fields 40 km² of land should be available for the later extensions. Such an area is not available within the 360 km² of the Gaza strip (Figure 4).

At this point Egypt enters as essential partner. The land use and radiation maps (Fig. 4 and 5) show 3 features:

1. the average annual direct normal irradiation in the Gaza region yields ca. 2300 kWh/m² which is good enough for an economical operation,
2. there are regions adjacent to Gaza in the south (Israel) and west (Egypt) with suitable space for solar collector fields. The Egyptian site has much better access to water from the Mediterranean Sea.

We therefore propose to build the solar power and desalination plants outside the Gaza strip, along the Egyptian Mediterranean coast line between Gaza and El-‘Arish with easy access to sea water. There is ample space for a strip of about 20 km length and about 4 km depth. By choosing this site Egypt not only would own the SW&PS, but would get the largest solar plant of the world on its soil. Pipe lines and HV transmission lines of about 50 km length will bring water and power into the Gaza strip. To this end a long-term contract for trans-boundary co-operation needs to be established.

A first assessment of costs of the project:

Estimate of Investment

Most components, such as steam turbines, power generators and multi effect distillation (MED) units are standard technology. The most appropriate solar steam generator are concentrating solar collectors (like parabolic trough), a proven technology. Their costs however would undergo substantial reduction in the course of the project, due to a beginning mass production and further due to system improvements. Very preliminary cost figures have been estimated in deployment scenario, developed by TREC and the German Center for Air and Space Technology (DLR). The cost estimate includes learning curves and cost reduction during progressing deployment. This study yields the following preliminary cost estimate for the Gaza proposal:

Components of the Gaza SWPS	**Very preliminary estimate on investment**
Solar Thermal Power Stations, in total with 1200 MW	3 – 5 b$
Multi-Effect Desalination for 360 Mm³/year	1.5 b$
Infrastructure (roads, pipe lines, power transmission, ..)	0.5 b$
Total investment	**6 +/- 1 billion $**
Stage 1: 10 MW power capacity on Gaza site	**50 - 70 million $**

A flexible set of stages

The first stage of 10 MW would cost around 60 million $, and require a collector space of 100,000 m². The following stages of expansion can be chosen to match the actual demands and the financing opportunities. The project expansion can be terminated or interrupted after completion of any stage, with each stage fully functional. This way the installation of the project can be adjusted to real conditions of Gaza.

Estimate of the annual costs

We assume that the total investment of 6 billion $ is to be amortized within a period of 15 years with an interest rate of 7% per year. Using a deployment scenario we can give a first preliminary assessment of the costs and of the economy of the Gaza project. Eventually these numbers need to be examined and adjusted to the exact conditions of Gaza, based on a deployment strategy optimized for Gaza. Here we find the following results (for more details see table in Appendix):

Costs for capital, operation and maintenance, insurance and supplementary fuels amount to 1.3 b$/y during amortization, and to 0.6 b$/y afterwards. The 1.3 billion $/y can be recovered when power is sold for 0.11$/kWh and water for 1.0 $/m³, and when carbon credits of 10$ per ton CO_2 are included. After amortization, during the expected remaining physical life time of 15 to 25 years of the plants, the prices can go down, to 0.05 $/kWh and to 0.5 $/m³ or even lower. We also mention that if the interest rate was 0%, the power and water costs during amortization could go down by 20%, and if the investment would come as a donation by more than 50%.

The cost assessment also shows: when fossil fuel costs will remain constant over the coming 40 years, then oil must be cheaper than 50 $/barrel to be competitive with solar steam produced at day time. If we expect a cost doubling period of 23 years then today's fuel costs need to be below 33$/barrel to be competitive over the full life time. If we consider steam from stored solar heat, then the corresponding numbers would be 72 and 50 $/barrel, respectively. In other words, for day and night time operation

solar energy is already now the least cost solution, even if oil costs will rise much more slowly than in the recent 5 years, and if a total life time of 30 – 40 years is considered.
The equivalent figures for natural gas (NG) can also be inferred. 5.34 MBtu (Million British thermal units) contain the same amount of thermal energy as 1 bbl oil. 5$/MBtu then correspond to 27 $/barrel

The expected solar cost reduction by this project makes the solar solution to an excellent opportunity for large savings in the sunbelt already now.

In summary we can conclude, that with solar conditions as around Gaza (2300 kWh/m²/y), the solar energy solution will be cheaper than the fossil fuel solution from the beginning, and it is by far the least cost solution for the complete proposed Gaza water and power source.

An international cooperation for implementation

Gaza in the poverty trap

The population of Gaza is unlikely to be able to pay normal (i.e. unsubsidized) prices already before Gaza has recovered from extreme poverty to normal conditions. One might speculate that Gaza waits for cost reduction of solar technology to happen somewhere else. This, however, may delay the recovery program of Gaza by several years. On the other hand, the proposed project would accelerate the cost reduction to the benefit of the MENA region, and it would provide an opportunity to bring this technology into the hands of sunbelt countries.

External beneficiaries

For many reasons the best strategy for Gaza and for the whole MENA region would be to implement the Gaza SW&PS as fast as possible. Low cost power and water and just the existence of such a program could attract further investments to Gaza. A number of urban regions in MENA, for instance the Yemenite cities Taizz and Sana'a, could then take advantage of an accelerated cost reduction process. All MENA countries could profit from reduced power costs sooner. According to the development scenario in the MED-CSP study by DLR (www.dlr.de/tt/med-csp), 2500 TWh electricity may be produced by CSP plants in MENA in the year 2050. A cost reduction by 1 ct/kWh would then translate into a saving of 25 billion $/year. Also Europe could benefit, since solar power at reduced costs could then be transmitted to Europe.

Since there are a number of economical beneficiaries of the Gaza project outside of Gaza, we propose that the outside world makes a contribution to this project. To this end we propose to organize an international effort.

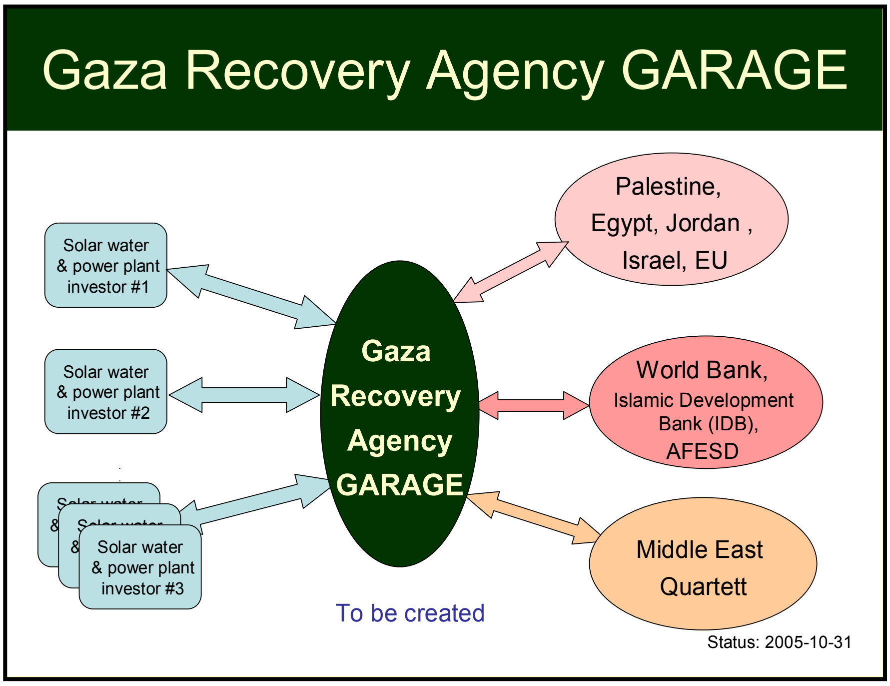
An International Gaza Recovery Agency

There are many ways of handling international support for development, some being more and others less successful. A proven financing method for bringing renewable energy technologies into the market is a feed-in regulation which guarantees take-in, here of power and water, at guaranteed prices over a guaranteed period of years. Prices for power and water have to be set such that they attract investors.

This task could be accomplished by an international agency for the recovery of Gaza, which is to be formed and financed by countries and institutions with a positive interest in the Gaza recovery and with a benefit from access to low-cost, secure and clean energy. By an international contract they establish the legal body Gaza Recovery Agency (GARAGE). It should include regional bodies like the Islamic Development Bank (IDB) and Arab Fund for Economic and Social Development (AFESD).

GARAGE acts as the contractor for long term purchase agreements with investors for water and power from plants erected for the Gaza SW&PS. GARAGE buys water and power for agreed prices from the plants in Egypt and sells these products to the city or citizens of Gaza for a (lower) price, which meets the buying power of Gaza citizens.

The plants on Egyptian soil will be erected in compliance with regulations set by Egyptian authorities.



The proposed Gaza Recovery Agency and its functions are in analogy to the German feed in regulation, a proven tool for successful advancement of renewable energies. The role of the national German feed-in law is here taken by the Gaza Recovery Agency. The financial volumes GARAGE will need for making the project go are to be determined in a targeted study.

Summary of general benefits of the project.

1. The water stress could be taken away from the Palestine-Israel region.
2. It could pave the way for the Sana'a Solar Water project and for water&power projects at many other (actually: most) urban areas of the MENA region, which are about to outgrow their natural water resources.
3. A technology can be advanced which can become world-wide a powerful tool for secure power supply (see Fig. 6) and for stopping global warming.
4. It furthers international cooperation for water and energy, and for environmental and international security:
    a. Egypt may become a preferred producer of components and materials (glass and iron) for the collectors. Egypt might develop to a center for solar technology in and for the MENA region.
    b. Jordan and Israel might contribute know-how on solar collector technology and on project management.
    c. EU could contribute technology and funds, and experience in project realization.
    d. Other international donors, in particular Arab financial institutions or oil-rich countries could participate in investments.
5. It could facilitate constructive co-operation for peace and for a sustainable future among peoples from 3 world religions.
6. Gaza could become a producer of solar collector components for a world market, and thus get a long term perspective for its economy, for the employment situation, and opportunities for young people.
7. The augmentation of energy and water sources could enhance the perspectives for peace and for sustainable prosperity in this conflict ridden region and in many parts of the world.

Such benefits may justify a classification of this project as a "World Sustainability Project".

Next steps

1. Design and build a small SP&WS (10 MW) demonstration plant near Gaza.
2. Form a Gaza SW&PS team to develop the full concept and to promote the proposal
3. Collect political assessments of the proposal by appropriate political bodies or persons.
4. Perform a feasibility study addressing technical, environmental, economic and developmental issues, and the impact on local employment.
5. Compile an assessment of industrial and economic impact to Gaza
6. Compile an assessment of potential benefits for other urban centers in MENA.
7. Find funding for the tasks 1-6.

Appendix: Figures and Tables

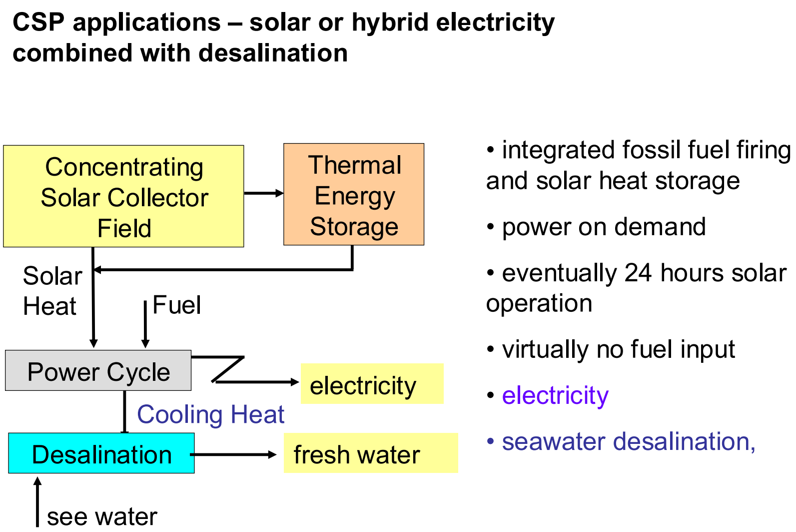


Figure 1: scheme of a co-generating plant for solar power and seawater desalination

Figure 2: Photograph of the "parabolic trough" solar electricity generating systems (SEGS) in California, constructed in 1990. The parabolic trough collectors are traced to follow the sun from sunrise to sunset. The steam power plant is in the middle of the collector field. In the Gaza Solar Water&Power Source there would be desalination plants instead of cooling towers.

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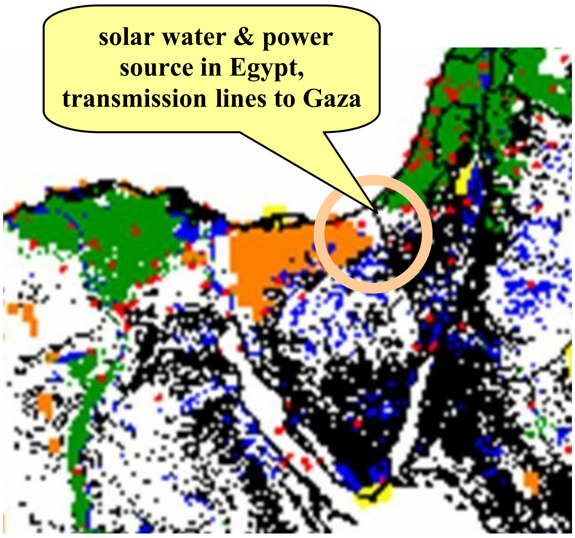
Figure 3: solar steam generators by concentrated solar power (CSP)
a: line concentrator Fresnel collector (compuer animation)
b: line concentrator parabolic trough (Cramer junction)
c: point concentrator: tower with heliostat field



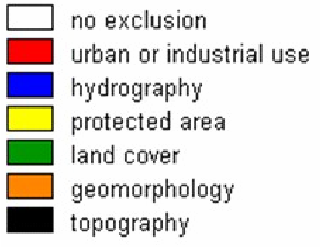


Figure 4: Land use Egypt, Palestine, Israel and Jordan.
Solar energy maps from satellite measurements by DLR.
White areas are suitable for mounting concentrating solar collectors. There is a useful coastal area extending from Gaza to El-'Arish, over a length of about 40 km. (Source: DLR, 2005)

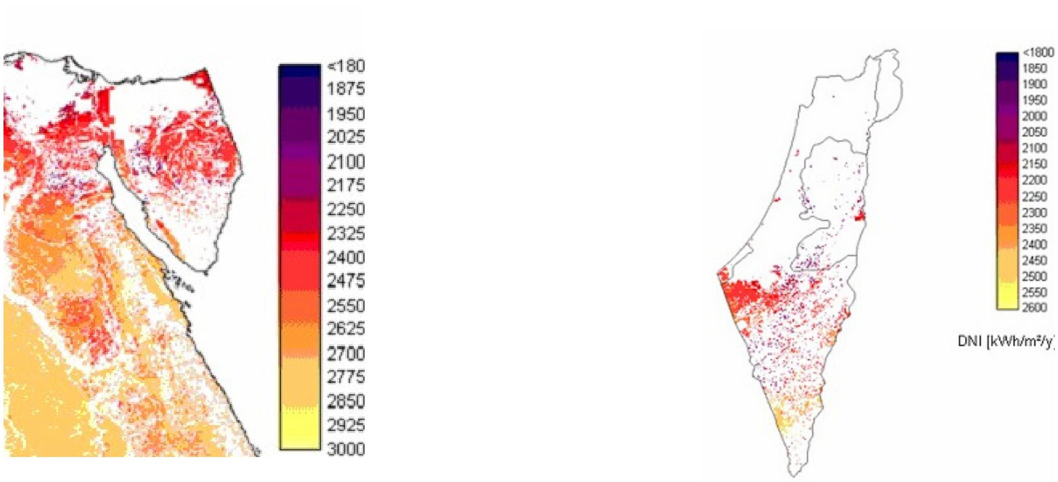


Figure 5: annual yields if direct normal radiation, in kWh/m², according to the color code. White areas are excluded by land use. (Source: DLR, 2005)

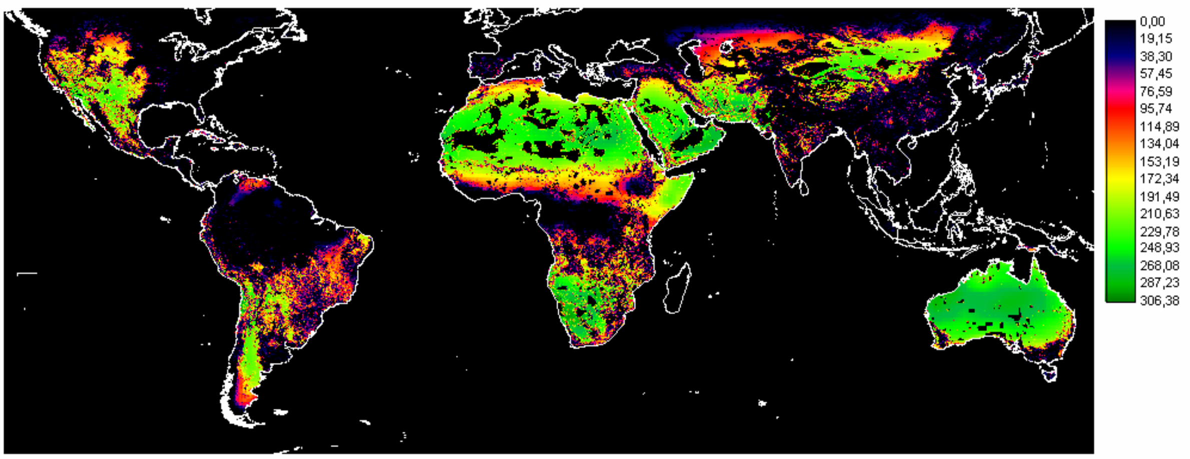


Figure 6: Solar energy fields around the globe. Colour code shows the power yields achievable with CSP collectors, in units of GWh/km²/year. (Source: DLR, 2004)

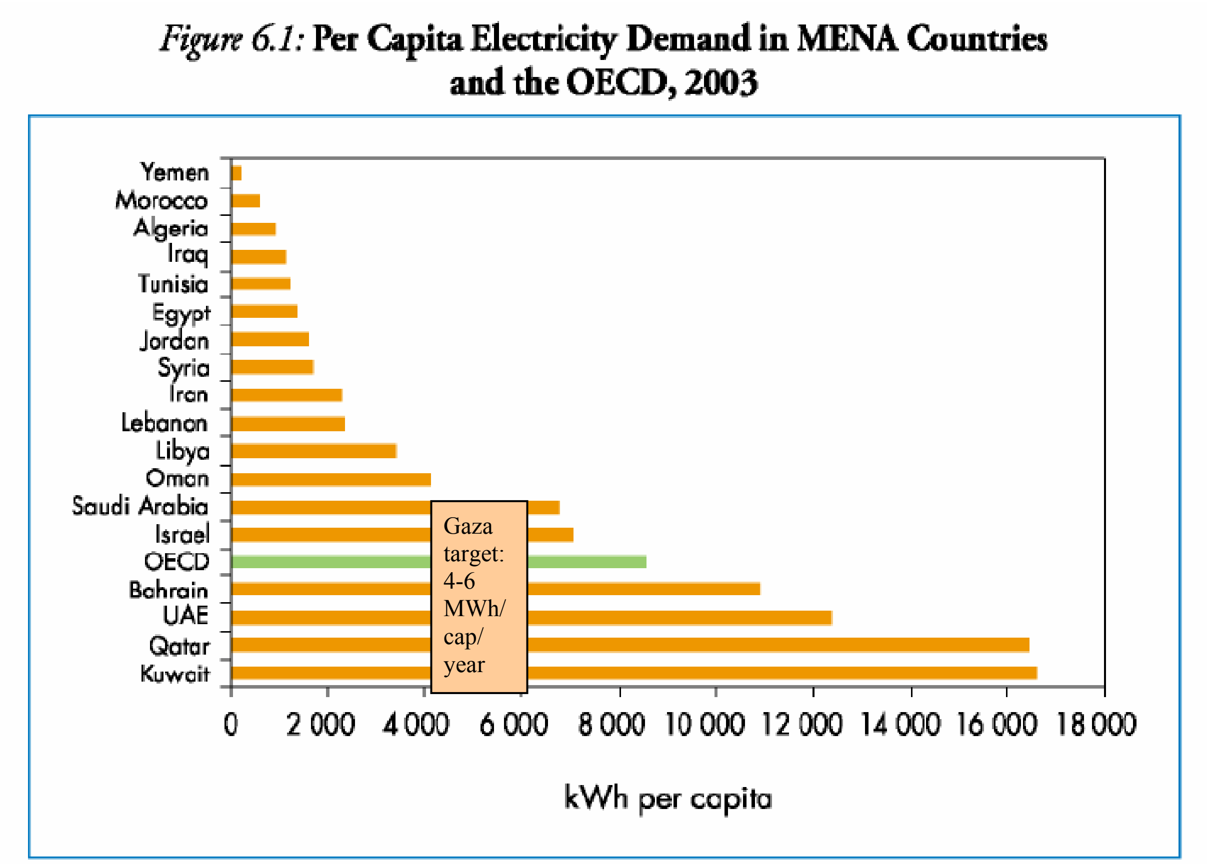


Figure 7: Survey on power consumption in selected MENA countries. Source: World Energy Outlook 2005, IEA.

222

Table 6.9: **Water Demand and Desalination Capacity in Selected MENA Countries, 2003**

	Water demand (mcm)	Water demand per capita (litres/day/capita)	Water supply from desalination (%)	Reverse osmosis capacity (mcm)	Reverse osmosis capacity (%)	Distillation capacity (mcm)	Distillation capacity (%)	Total capacity (mcm)
Saudi Arabia	22 484	2 734	8	780	35	1 427	65	2 207
UAE	2 694	1 843	42	75	5	1 390	95	1 465
Kuwait	679	775	64	62	11	519	89	582
Libya	4 867	2 401	2	71	26	201	74	272
Qatar	375	1 408	38	5	3	201	97	206
Algeria	6 244	537	2	67	54	58	46	125
Iran	92 000	3 798	0.2	58	32	124	68	182
Egypt	73 533	2 975	0.1	92	86	15	14	107
Iraq	43 208	4 768	0.2	82	95	4	5	86

Note: Due to the lack of accurate data by sector and by country, water consumption for 2003 is estimated for some countries, on the basis of previous years.

Gaza target: 750 litres/day = 300 CM/cap/year

World Energy Outlook 2005

Figure 8: Survey on water consumption in selected MENA countries.

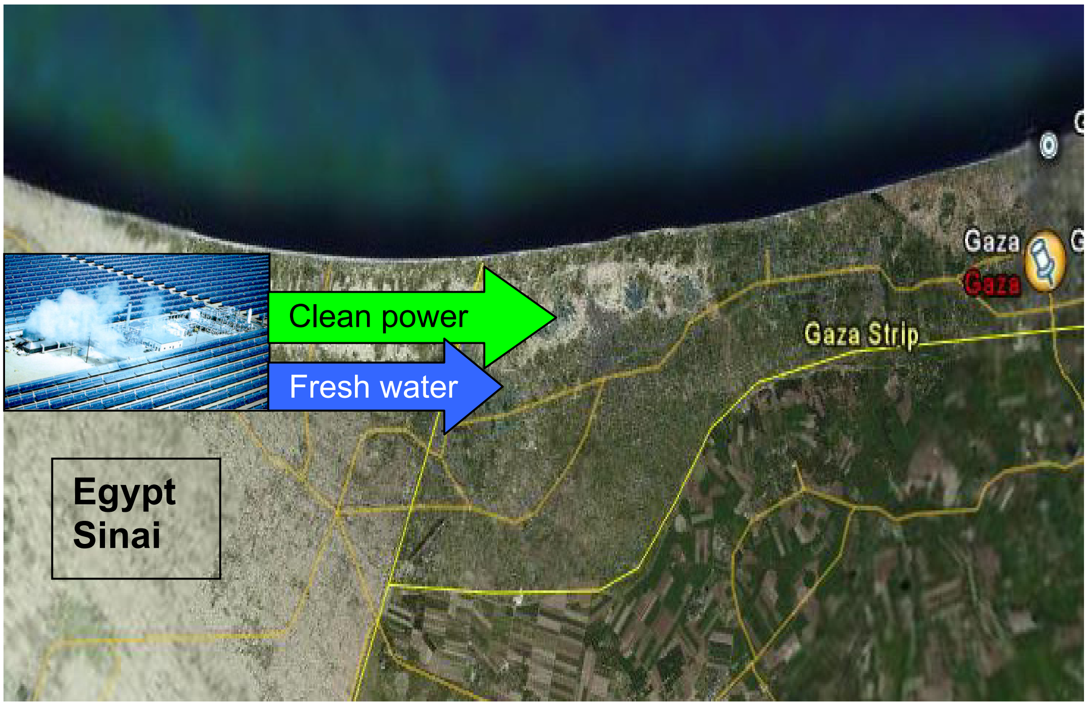


Fig.9: Space view by Google Earth onto Gaza and Egypt, showing free and suitable sites for solar collector fields on the Egyptian part of the Sinai along the Mediterranean shore line.