NOKRASCHY ENGINEERING
Mechanical Vibrations and Infrasound under Control
Solar Power for Sustainable and Everlasting Energy

Shifting Egypt's Electricity to Renewables for Security of Supply

Presentation at the Management Engineering Society

Cairo, 20 April 2008

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Prof. Amin Mobarak was the chairman of the energy and industry parliamentary group.

He is considered as the father of renewables in Egypt

At present he is professor of mechanical engineering at the faculty of engineering Cairo University

Dr. Hani Nokraschy is resident in Germany of Egyptian origin.

Since several years he is engaged in renewable energy research and specially concentrating solar power for electricity generation on big scale.

He is founder and CEO of Nokraschy Engineering GmbH in Germany and co-founder of SOLAREC-Egypt, the Egyptian Solar research center.

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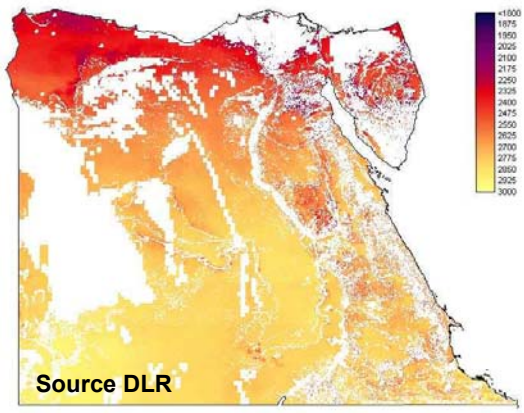
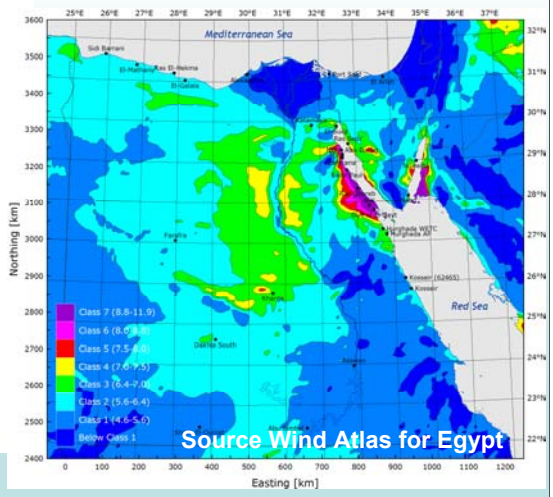
Egypt enjoys excelent Renewable Energy Sources

Electricity Demand 2007 ~100 TWh/y → ~630 TWh/year 2050



Direct Normal Irradiance
up to 3200 kWh/m²/year
Potential 73 656 TWh/year



Wind speed up to 12 m/sec
Potential 90 TWh/Year

This map, offered by the New and Renewable Energy Authority NREA, shows the good wind regime of Egypt.
Beside having high wind speeds, **12 m/sec** compared to northern Germany 8 m/sec, it is steady with very few wind stills.
The **Potential** is estimated to be **90 TWh/Year.**

This map shows the Direct Normal Irradiance DNI, calculated by the German AeroSpace center using satellite data. Exclusions of spaces where solar thermal plants cannot be erected, like cities, farms and moving sands are shown in white. The remaining area is sufficient to cover Egypt's demand about a hundred times.

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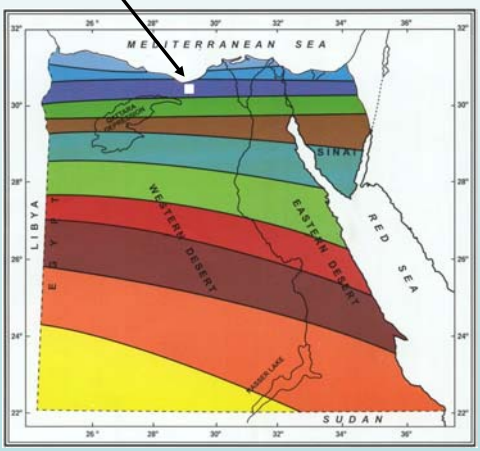
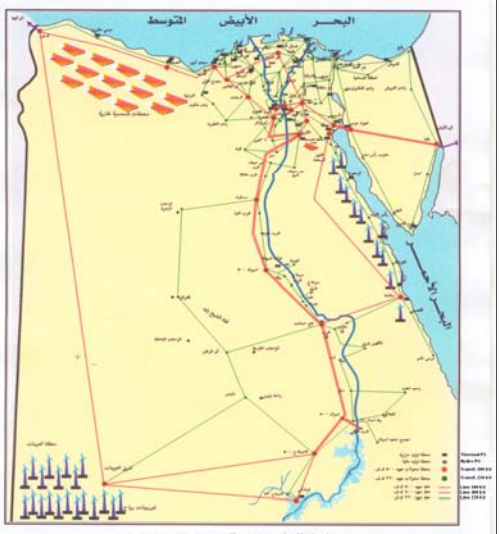
Short term planning and Electricity export possibilities

This Area 32x32 km = 1000 km² gives 50% of Germany's electricity



Source NREA



Source MoEE

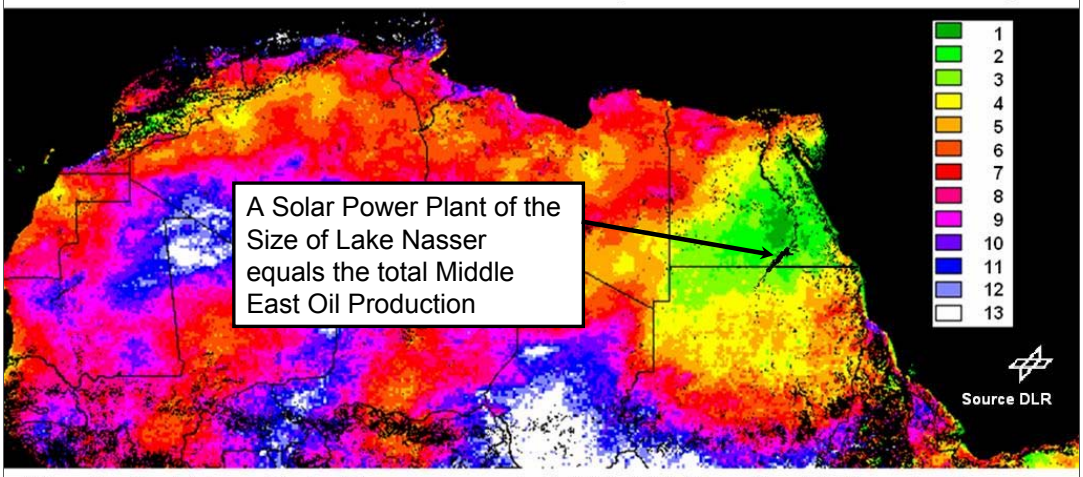
The Ministry of Electricity and Energy MoEE, is aware of these facts and includes them in there planning, for example, wind farms along the shores of the Gulf of Suez and solar thermal power plants in the western desert.

The solar energy is so dense that an area of just 32 x 32 km = 1000 km² is sufficient to cover 50% of Germany's demand

Economic Site Ranking

Calculation of the economic site ranking
from the electricity yield and the project costs

North Africa – Solarthermal Electricity Generation Cost Ranking

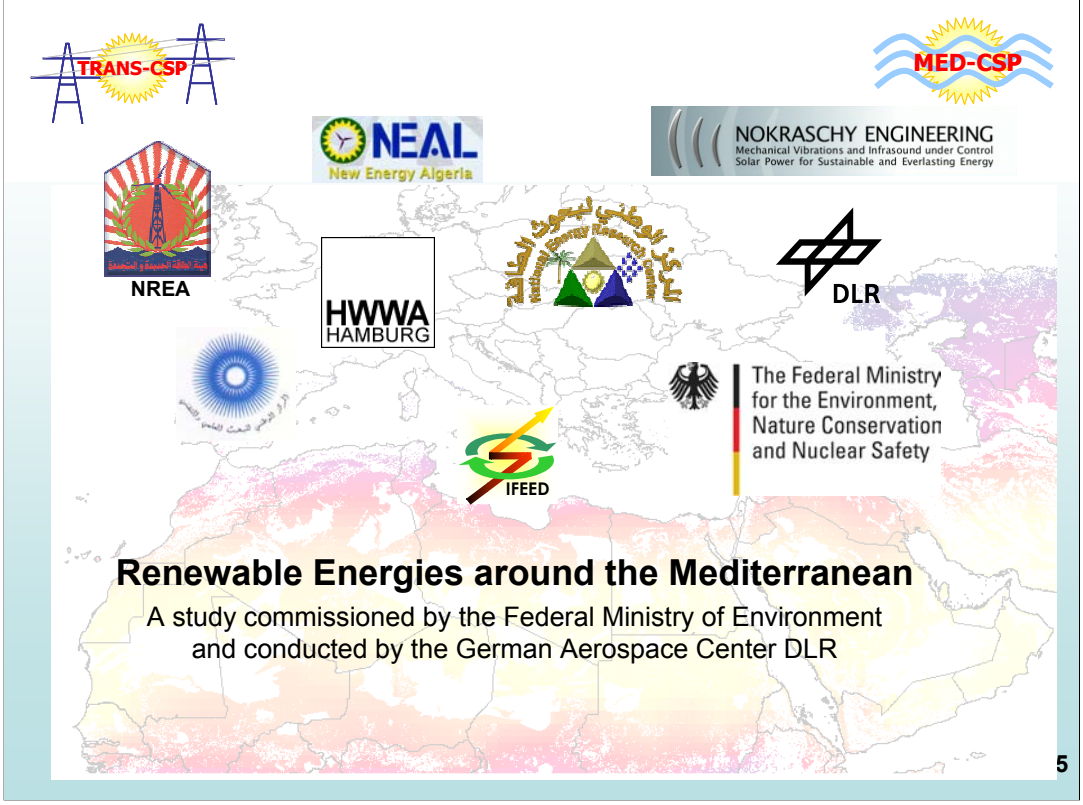


The North African Solar Energy equals 1 000 000 Barrels of Oil per km² yearly

Compared to other North African countries, Egypt obtained the best ranking in terms of electricity generation costs from solar thermal power plants.

Parameters that influence the costs are beside solar irradiance, plane area, distance to demand centers, availability of skilled personnel, a.s.o.

To demonstrate the richness of solar power, a SCP plant with the size of Lake Nasser would give energy that equals the total oil production of the Middle East.



The German Federal Ministry of Environment commissioned 3 studies that were conducted by the German AeroSpace Center DLR.
MED-CSP , TRANS-CSP , AQUA-CSP

Members of the study Team from Germany and MENA are:

NREA, New and Renewable Energy Authority, Egypt

NEAL, New Energy Algeria

Nokraschy Engineering, Germany/Egypt

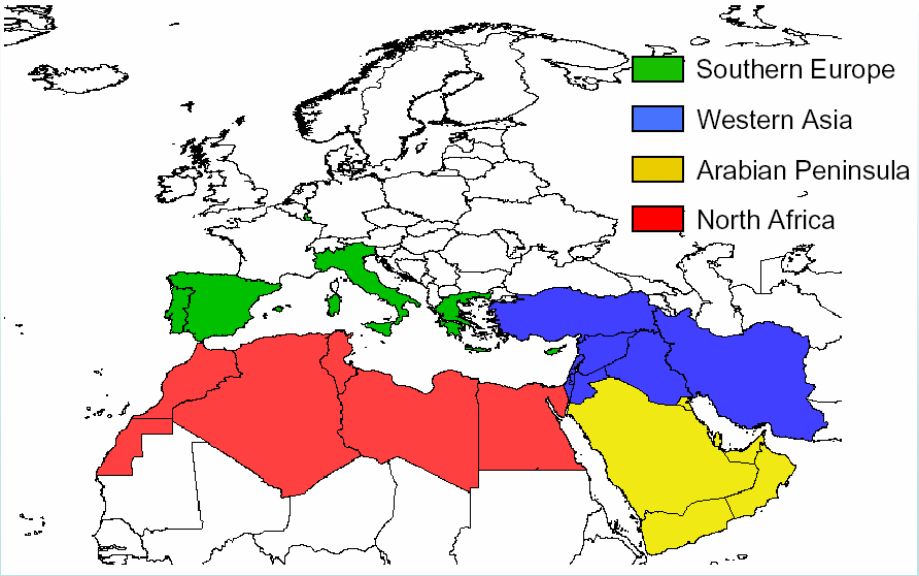
National Center of Research and Technology, Morocco

HHWA, Hamburger World Economy Institute, Germany

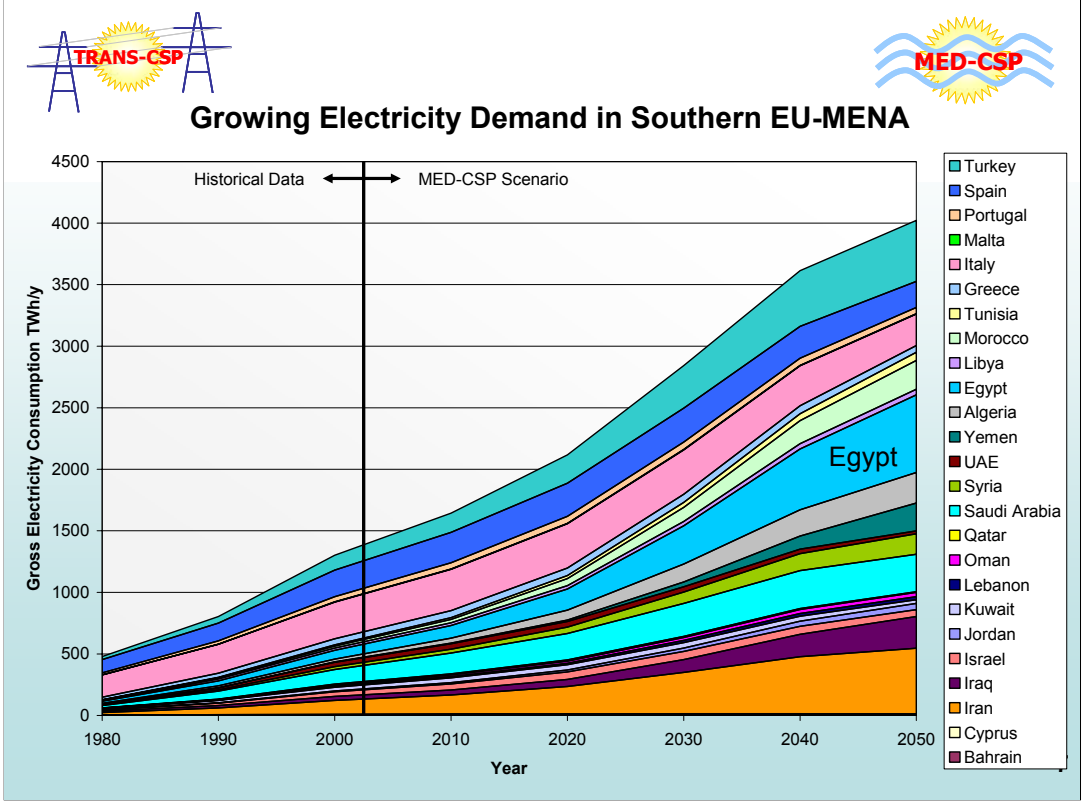
NERC, National Energy Research Center, Jordan

IFEED, International Research Center for Renewable Energy, Germany/Iraq

Countries analysed within the MED-CSP and TRANS-CSP Studies



This map shows the countries analyzed within the study MED-CSP. They mainly countries around the Mediterranean.



Based on historical data available till 2004, a scenario was predicted till 2050.

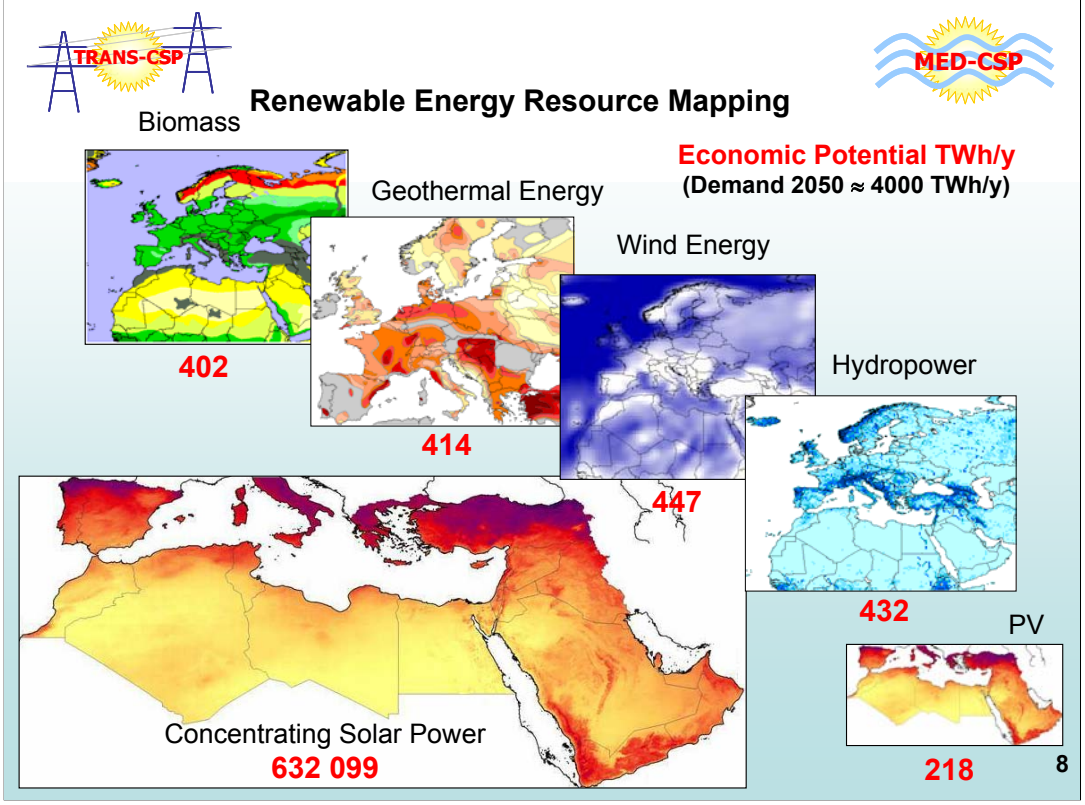
Under the estimation that all these countries aim to reach the GDP of Europe in 2050. Since Europe's GDP increases 1.2% yearly, then each of these countries will have to increase its GDP at a higher rate to catch up with Europe in 2050.

2050 was chosen as a time limit for the study, as it gives a horizon that can be well overviewed. Also it is expected that the main fossil energies: Oil, Gas and Uranium are still available at higher prices.

As in the time frame of 2050 to 2100 these three main fossil fuels will be completely depleted, it is nearly impossible to calculate how the GDP will evolve.

These scenarios are based on the prediction of population growth with a simultaneous growth in economy, both cause an increase on demand for electricity. For example Egypt's demand will be equal to that of Italy and Spain together. This rapid increase on demand flattens down when energy conservation measures are effective.

It is remarkable that the total energy needed in 2050 nearly equals the demand of western Europe, 4000 TWh/Year.



The second step of the MED-CSP study was to determine the available economic potential of renewable energies in the countries subject to the study.

The map shows to total available economic potential for each sort or RE

It is obvious that the sum of all of them except CSP will cover just half of the demand expected 2050.

But CSP alone covers the demand 160 times.

Conclusion: it is advisable to start immediately to exploit the most abundant RE in the region which is CSP

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Concentrating Solar Power

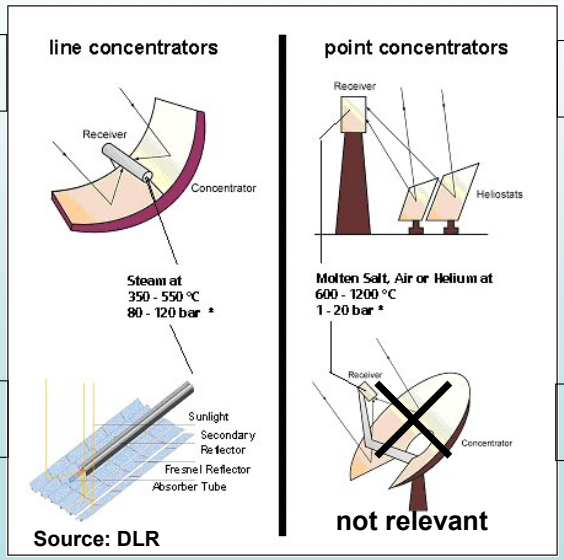
relevant for Power Stations are 5 MW to 1000 MW

Parabolic Trough 5-600 MW

Solar Tower 5-100 MW

Linear Fresnel 5-600 MW

Parabolic Dish 0,5-50 kW



The task of CSP is to collect sunrays and concentrate them in such a way that a temperature of several hundred degrees is achieved. The heat is used for a further process like evaporating water to drive a steam turbine or to effect a chemical process.

The CSP technologies can be categorized as:

A) Point concentrators and

B) Line concentrators.

The first ones are the parabolic dish with Stirling motor and the solar tower with heliostats.

The dish tracts the sun and concentrates the sunrays on its focus where a stirli98ng motor is driven. As the dish is limited in its power by its diameter, it does not exceed 50 kW, thus it is not relevant for electricity production on large scale.

The heliostats of the solar tower are tracking the sun to concentrate the sunrays on a receiver at the top of the tower. The power yield is limited in by the largest distance to the heliostats. This shall not be too big to have the sunrays well aimed on the top of the tower.

The second ones are the parabolic trough and the linear Fresnel collectors_

The parabolic trough tracks the sun from east to west and concentrates on its focus which is a pipe in which a heat transfer fluid (HTF) is passing.

The linear Fresnel is similar to the trough, but the mirrors are flat and the pipe with the HTF is fixed. The single mirrors are tracking the sun from east to west.

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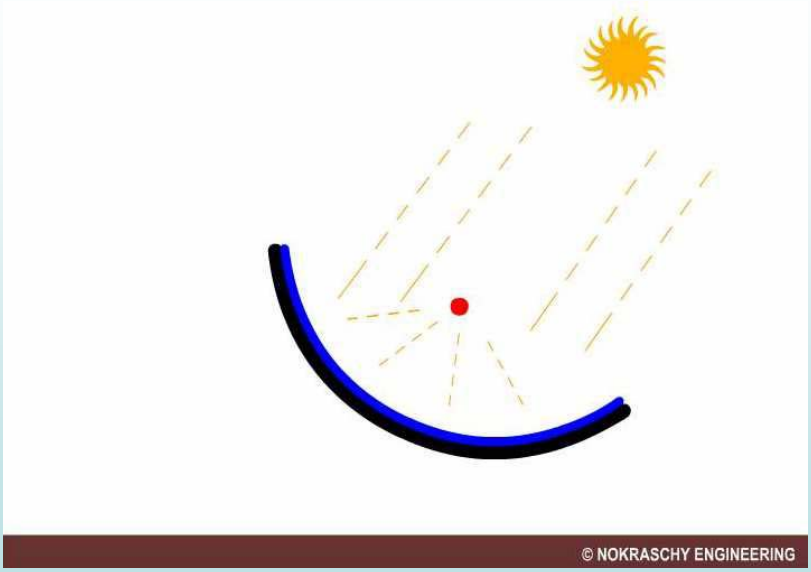
Parabolic trough Technology



Proven Technology of the past century

The parabolic trough technology is working in California producing 354 MW electricity since about 20 years.

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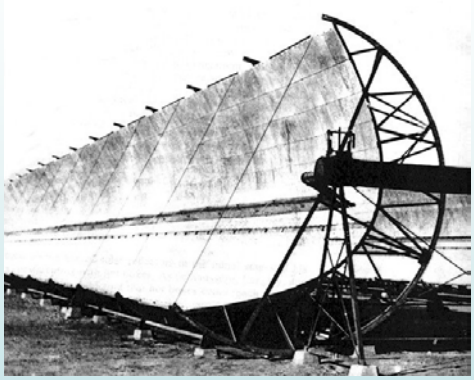
Following a German Patent from 1906



Frank Shuman
built in Maady 1912
the first CSP facility

He wrote: “One thing I am sure of; the human race should either utilize solar energy directly or go back to pre-civilization”.

The first application was in Egypt as the American Frank Shuman installed it in Maady, Egypt. The power generated was 55 kW and it was used to drive an irrigation pump.

CSP-Plant in California

The plant in California is working satisfactorily since 1985

The first picture shows a part of the plant. The width of the troughs is about 6 meter and the spacing between the rows is 11 meter to prevent shadowing.

The second picture shows a a trough segment of 100 meters length tested in Spain. It shows the receiver pipe and its flexible connections that allow for swiveling of the trough.

The third picture shows the cleaning of the mirrors from dust.

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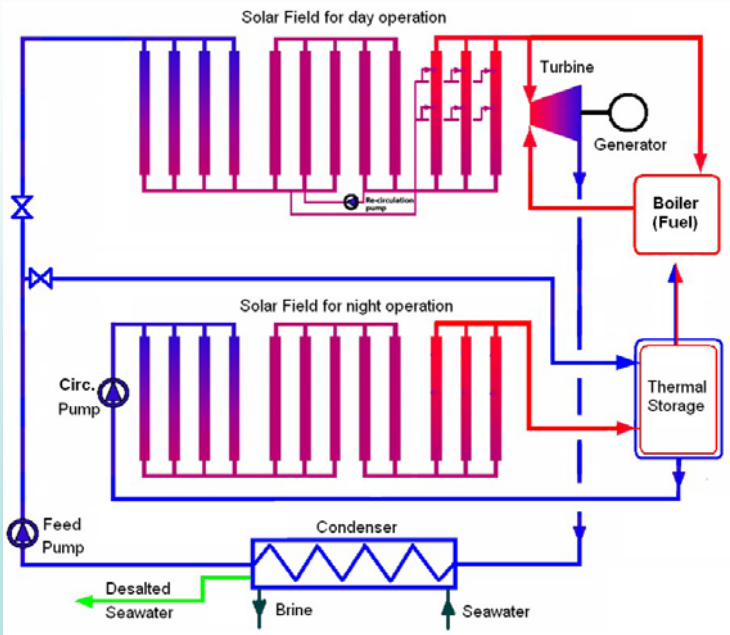
Solar Hybrid Power Station with Desalination



Desalination (MED) with Waste Heat

Step 1:
Solar field in Hybrid operation for day and night service.

Step 2:
Solar field with Heat Storage for Night operation + fossil boiler as reserve.

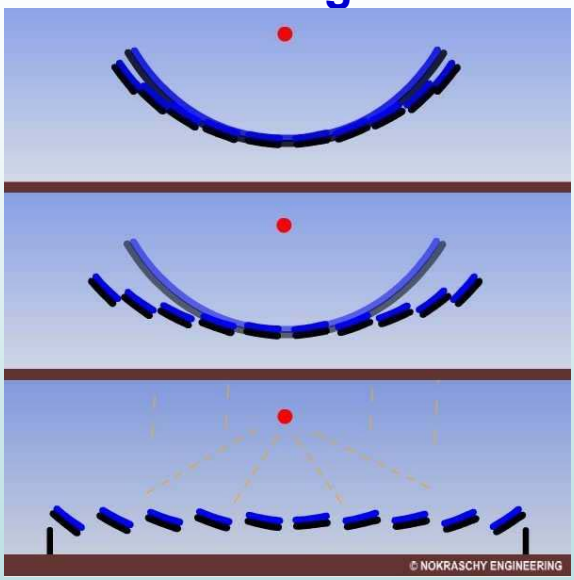
To start introduction of CSP it is advisable to add a solar field to an existing steam power station. The solar field size may start with a small size, 5% of the power, and increased gradually to the full power of the power station.

During day time it works as a fuel saver. During night the fossil fuel boiler delivers the required heat for the steam process. The power station operates completely normal as a conventional steam power station.

After supplying 100% of the heat needed from the solar boiler, a second solar field for night operation shall be erected. Its heat is stored in molten salt or special concrete to be used in the night.

If the power station is erected near sea shore, then it is advisable to use the waste heat of the condenser for seawater desalination, thus getting two products from the power station.

Advanced Design: Flat Mirrors



Best collection of the Sunrays. Simple, cost effective and usage of area underneath mirrors is possible

The flat mirrors cover nearly all the area, thus give an optimal sunray collection factor.

The design is simple and the mirror costs are much less than the shaped mirrors to form the parabolic contour.

The pipe with the hot HTF is fixed, thus costs and maintenance of the flexible joints are eliminated.

The area underneath the mirrors is usable for planting, stores or parking.

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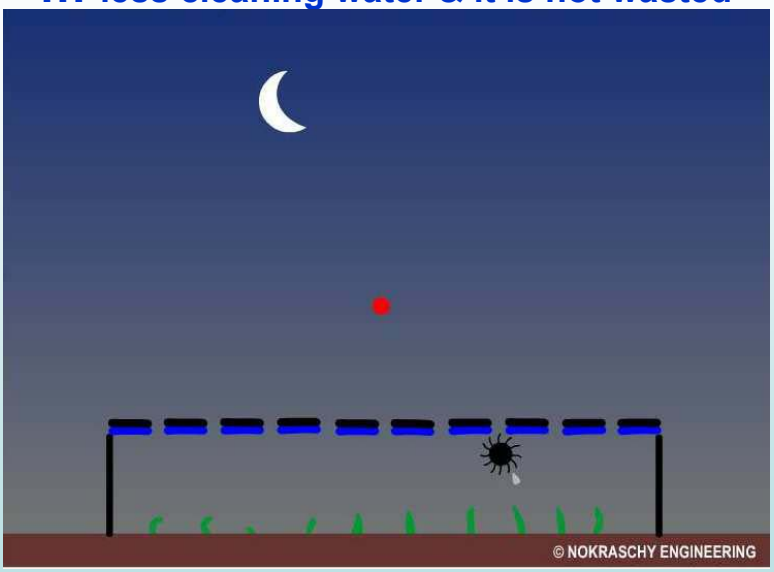
Automated Cleaning …

… less cleaning water & it is not wasted



In the shadow plants need less irrigation water

The plants grow in the shadow better than in the glazing sun, because they have enough light and do not need excessive water for evaporation cooling. It is also a credit for water saving.

The cleaning is automated and allows dry cleaning or with a little amount of water, which is not wasted as it goes to the plants.

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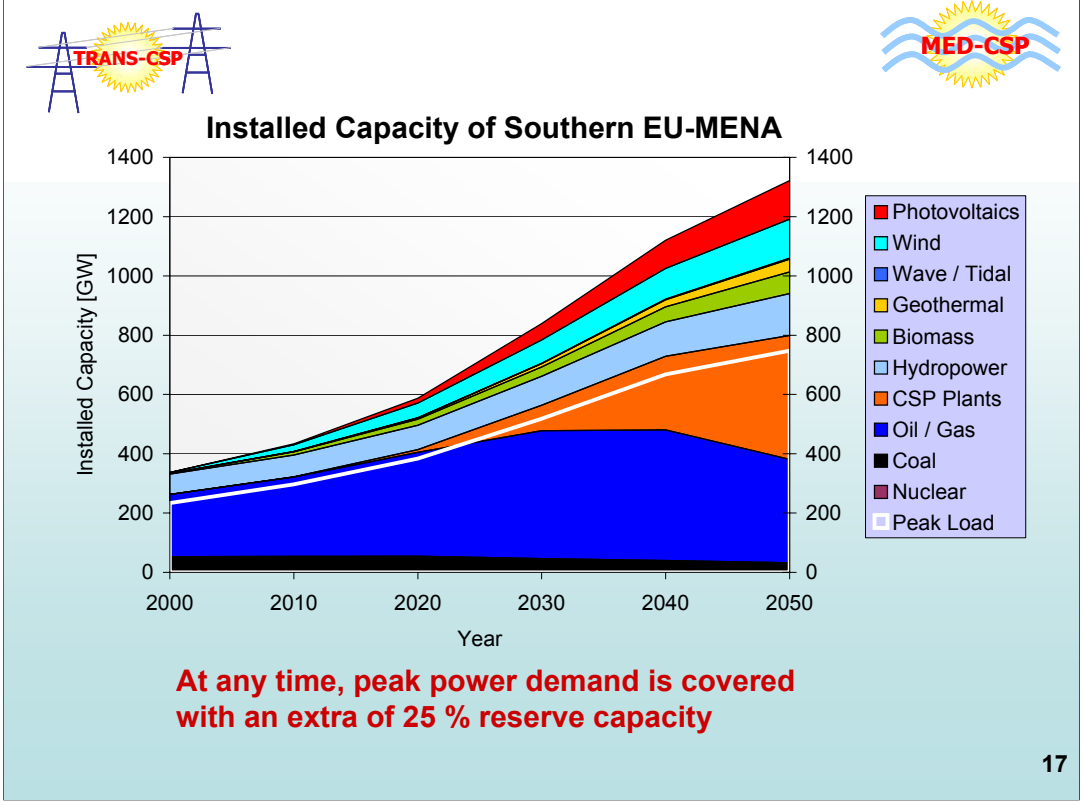
CSP in action

A large prototype 100 m long and 24 m wide proved its feasibility.

It is seen how the pipe is bright from the concentrated sun heat.



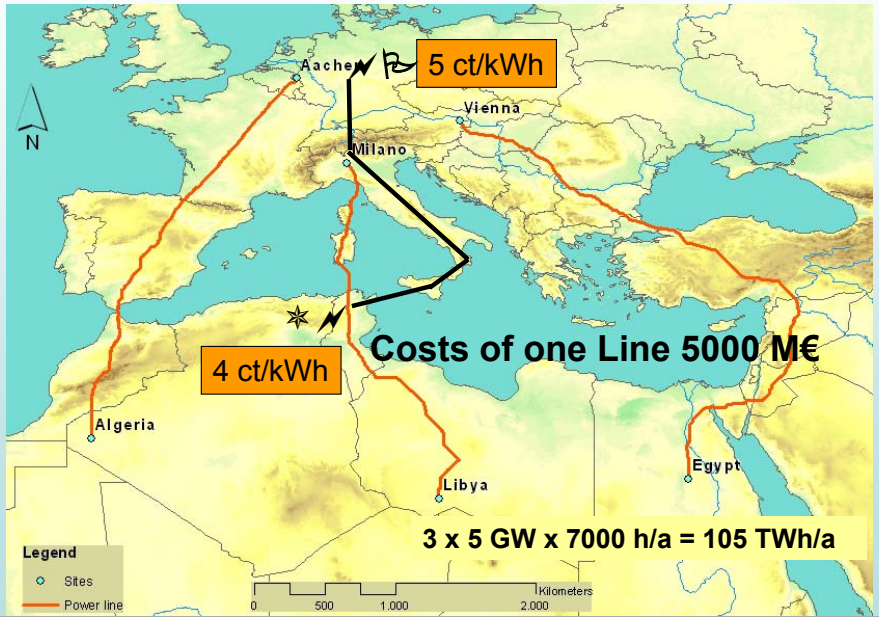
The DLR study suggests a scenario for shifting to renewables.

Till 2030 usage of oil and gas will increase. Thes starts gradually to decrease.

In the same time all sorts of renewables are increasing, however, CSP has the largest rate of increase.

This is because CSP is storable and thus can replace steam power stations in their service as base load PS or as peel load service that can deliver power on demand.

3 Samples for EU-MENA HVDC Interconnection



The second study of DLR, TRANS-CSP investigated the possibility of exporting electricity to Europe over a distance of 3000 to 4000 km.

- Transforming the electricity to Hydrogen, transport it to Europe and retransform it to electricity will result in a loss of 75%
- Transmission via the available High Voltage AC lines at 400 kV will result in losses of 30 to 40%
- Using High Voltage Direct Current (HVDC) lines will result in losses of 10 to 15% which is reasonable and can be afforded within the transportation costs.

In 2050 it will be possible to produce CSP electricity in North Africa at a Levelized Electricity Cost LEC) of 4 ct/kWh and the transportation costs will be 1 ct/kWh

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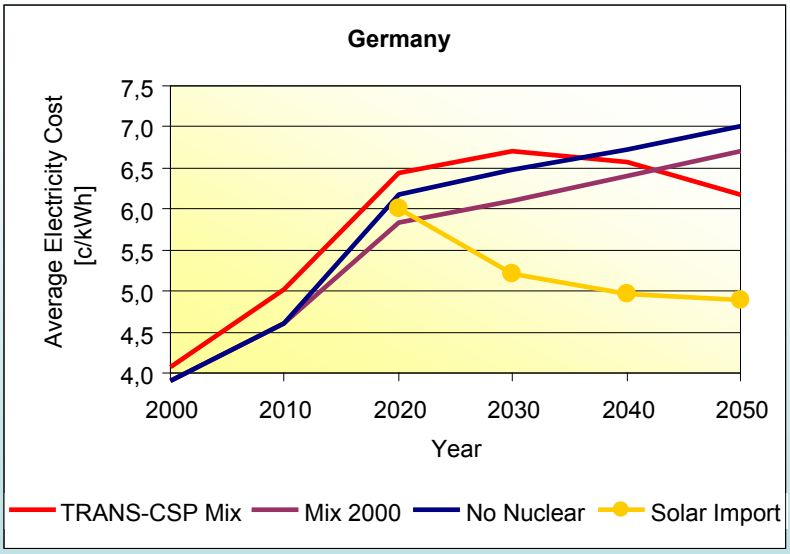
Cost of Electricity… 2050 about 7 ct/kWh in Germany

RUE
Rational Use of Energy

RES
Renewable Energy Systems

CCS
Carbon Capture & Sequestration



TRANS-CSP Mix: Energy Mix as described here incl. RUE, RES and CCS
Mix 2000: Maintaining exactly the Power Mix like in the Year 2000 with CCS
No Nuclear: Mix like in the Year 2000, but substituting Nuclear by Coal & CCS

In German the electricity production costs are increasing:

Starting from 2010 Carbon Capture and Sequestration will cause a significant increase in electricity costs.

Even if the nuclear power stations continue production instead of shutting them down as planned, the electricity production costs will decrease by about 5% only.

If the shift to renewables as recommended by TRANS-CSP is adopted, then the electricity costs will be about 5-10% higher till 2030, then start to decrease.

Injecting a share of 10-20% of solar electricity in the German electricity mix will result in stabilizing the electricity production costs. Then push the costs down again.

The Requirements in Egypt are different than those of Europe…

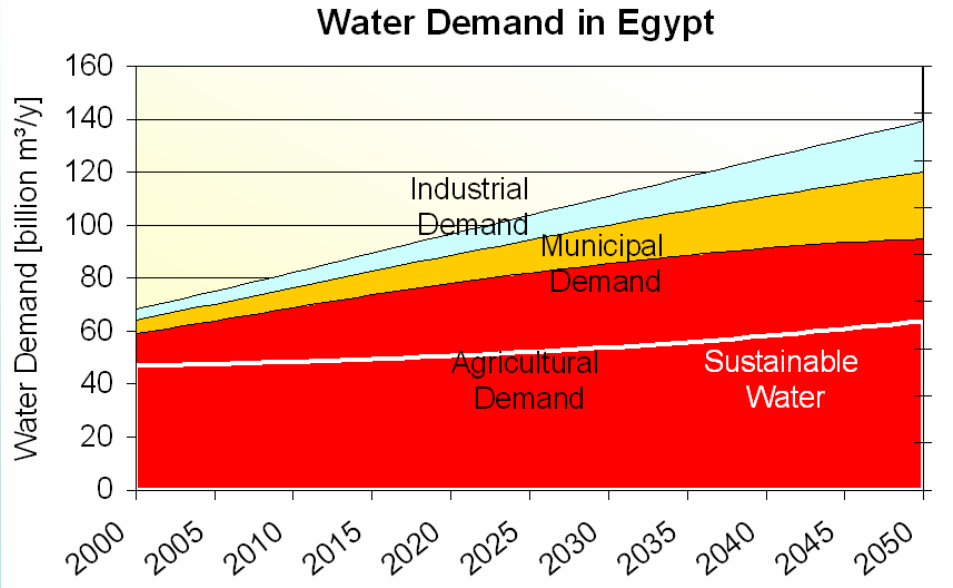
- Not only Electricity is needed …

  … 6-8% increase yearly

- Water is also needed …

  … One more Nile by 2050

The big problem facing Egypt is water scarcity in spite of the blessing Nile.



Already now Egypt is using water more than the sustainability measures allow.

In 2050 it is expected that the water demand will be 140 Bm³, which means more than one Nile extra.

The only possible way to obtain water is seawater desalination because ground water is already depleted.

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AQUA-CSP

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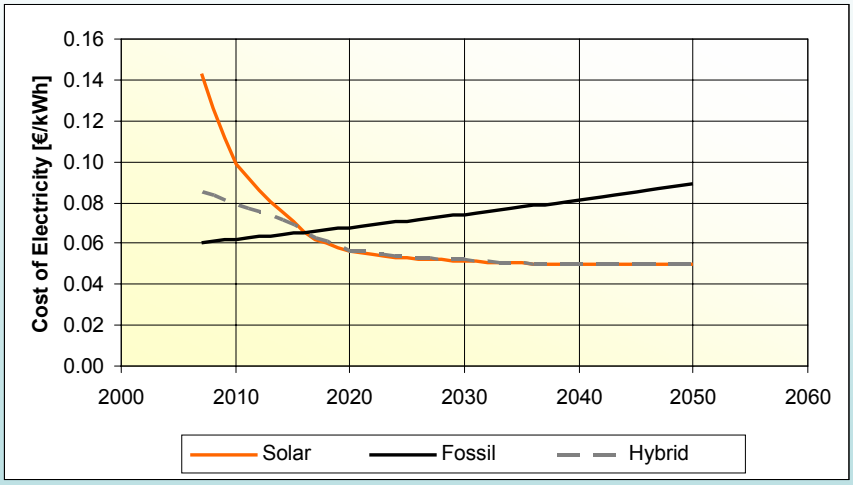
Unsubsidised cost of electricity of CSP versus natural gas CC



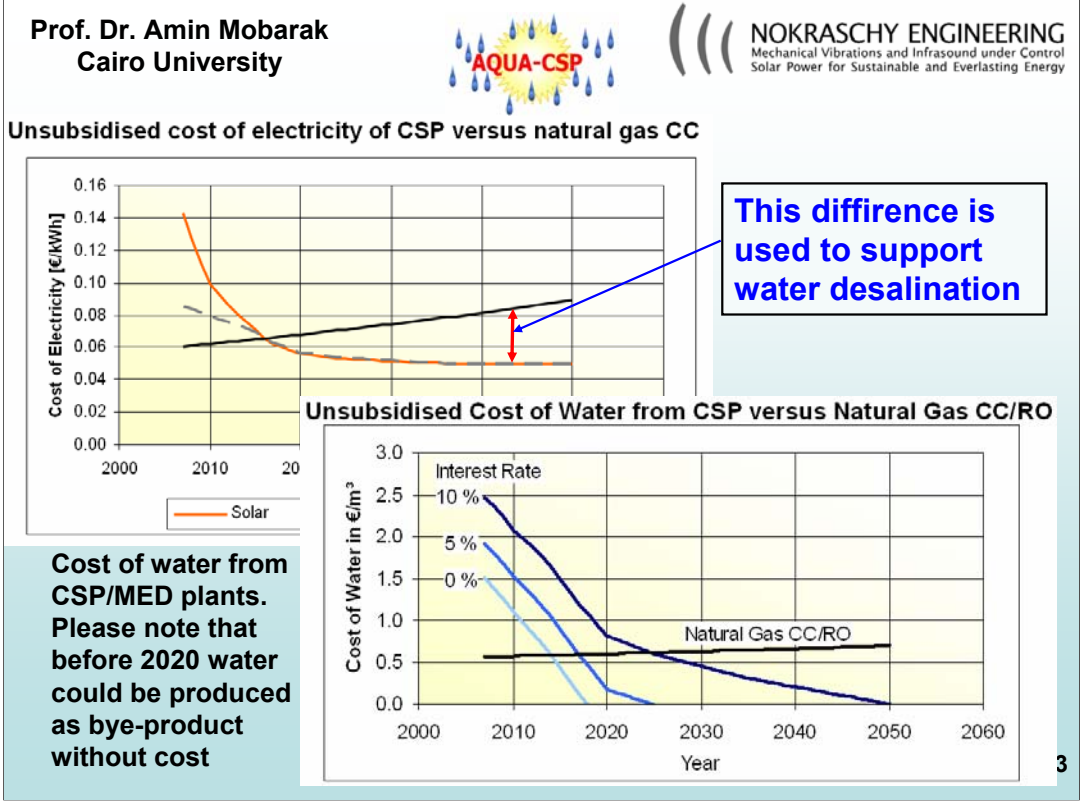
Discount rate 5%, economic life 25 years, fuel cost 25 €/MWh, fuel cost escalation 1 %/y, irradiance 2400 kWh/m²/y, real €2007, €/$=1

Seawater desalination needs mu8ch energy, thus energy price is an important factor in calculating water costs.

Continuing business as usual: to produce electricity from gas by combined cycle (CC), which is the most efficient way for electricity production, 55%, will result in an increase in electricity production costs just because gas price is getting higher.

In the mean time, producing electricity by CSP will reduce the LEC because of scale effects and mass production of components.

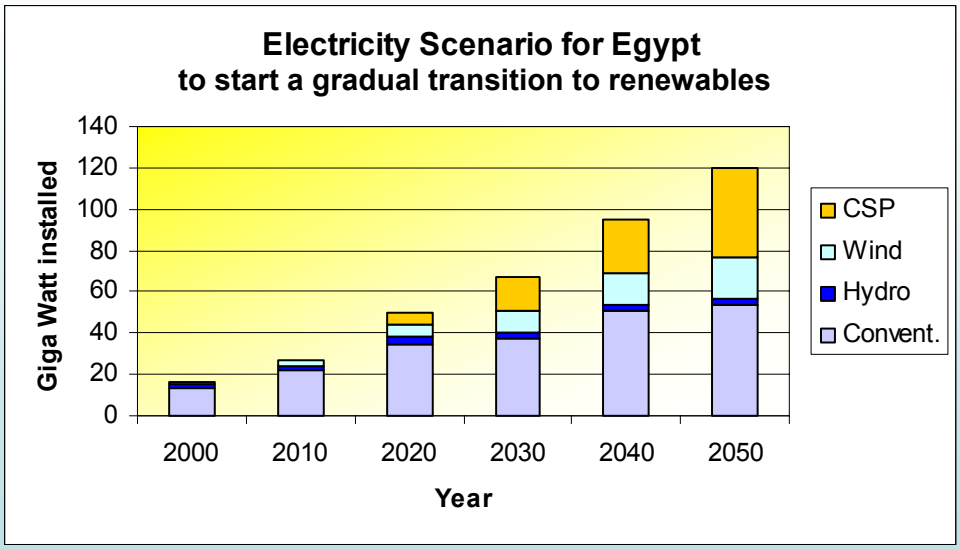
Starting from 2015-2016 CSP electricity will be increasingly cheaper than electricity from the best CC gas production.



In a power station with combined seawater desalination from waste heat, the price difference between CSP electricity and the market price which is governed by the CC gas produced electricity may be used to support water production.

Accordingly water can be produced for free even earlier than 2020.

This gives the Opportunity for a Trans-Mediterranean Partnership



This scenario considers a goal for RE to reach 55% of Egypt's electricity till 2050.

In the first decade hydro power shall be used to its full availability as it is already planned, in the first and second decades wind power shall be built up to reach about 15-20% of the installed capacity in the Egyptian grid.

In the following decades Concentrating Solar Power (CSP) plants shall be built on a large scale to replace thermal power stations that are getting out of service and to cover the domestic demand especially the growing demand for desalination and also to have a surplus for export to Europe starting a large scale "Mediterranean Renewable Energy Partnership".

The concern that a high percentage of wind energy may destabilise the grid is considered by limiting its share to 15-20% and installing compensating capacity of conventional power stations and CSP with thermal storage enabling night operation and supply on demand.

After 2050 the share of conventional power stations shall be reduced by replacing them successively with CSP power station which will produce the electricity by that time at considerably lower costs comparable with its generation from oil and gas.

For more information about CSP please visit www.menarec.org

This presentation in PDF format will be available at www.solarec-egypt.com

A Political and Financial

Framework shall give security to the participants

For Example:

- Taking advantage of CDM certificates to compensate power generation from coal in Europe.
- A European company establishes together with a company from MENA a Low Cost Solar Power Station in a MENA country.
- Solar-Hybrid concept is preferred to ensure supply on demand.
- The solar electricity share of at least 20% will be transmitted to Europe (Transmission costs 1 ct/kWh with HVDC lines) while the conventional share will be consumed in the MENA country.
- Beside electricity, desalted water will be produced from the waste heat of the power station, thus boosting the economies.
- Electricity may be used to produce clean Hydrogen

General Ideas for the Framework

- Renewable energy shall be produced where it is most economical. For example in MENA countries
  - Wind 10 m/s (gulf of Suez and Atlas mountains)
  - Sun 3000 kWh/m²/y (nearly all over the Sahara)
- Agreements between country groups or bilateral agreements are suitable to reach the goal.
- Mutual benefit is aimed in this co-operation.
- At the start phase strong support from the European country to the MENA country will accelerate the development.
- Clean electricity and Hydrogen from MENA shall cover about 15% of Europe´s demand.

What can the MENA-country do?

- Offer free land and infrastructure.
- Buy the conventional electricity share (for example at 2.5 ct/kWh depend. on fuel price)
- Buy the desalted water produced from waste heat (for example at 50 ct/m³)
- Guarantee by law capital security.
- Free from taxes for the first 10 years.

It is also advisable for the MENA countries to change their policies of subisidizing oil products.

For example to transfere the subsidies granted to oil products to the electricity supplpied to the users. With special support for electricity from a clean origin.

What can the European country do?

1. Set a quota for clean electricity, which is increased each year by 1% points over the actual value for each electricity producer. This is compatible with the target of 20% in 2020.
2. Extend support to clean electricity and clean Hydrogen for supplies from outside the country.
3. Set incentive prices for clean electricity import:
   - for example 12 ct/kWh for solar electricity
   - for example 8 ct/kWh for wind electricity

   To cover the initial costs of production and transmission.
4. The incentive price is valid only for the clean share of a hybrid system.
5. The incentive price is guaranteed for 10 years.
6. After 10 years it is reduced by 10% points each year.

The incentive price is the amount granted OVER the mean value for producing electricity conventionally from coal, gas or nuclear. This shall be reduced to ZERO within a reasonable range of time.

What are the „Win-Win-objectives“?

- **Europe wins:**
  - Clean and cheaper electricity and Hydrogen.
  - Employment due to machinery export.
  - Diversification of energy sources.
- **MENA wins:**
  - Water.
  - Sells electricity and Hydrogen for a reasonable price.
  - Social and economic development.
- **Environment wins:**
  - Less CO_2 emission.
  - This system encourages developing low cost equipment and extending solar share to 100% using heat storage.

It seen from this listing that the win objectives are fairly distributed between the partners EU and MENA. Thus there is a mutual dependancy fron each partner on the other increasing the security of supply and reinforcing the partnership.

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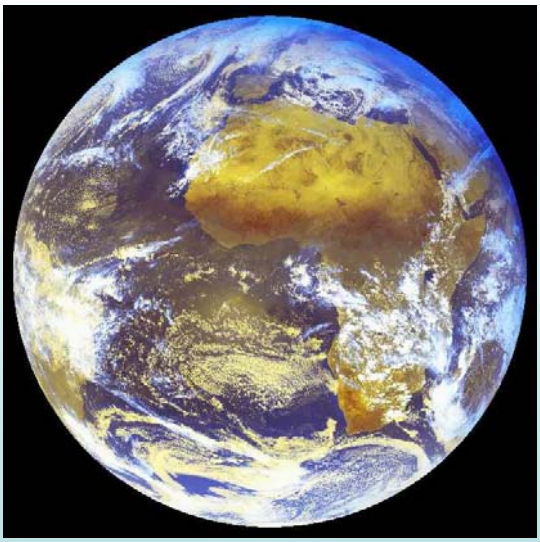
Thanking you for your attention



Source:
MeteoSat
EUMETSAT

To download the DLR studies www.menarec.org

This satelite picture shows how sunny MENA is.