THE SECOND MIDDLE EAST AND NORTH AFRICA RENEWABLE ENERGY CONFERENCE
AMMAN, MAY, 9-11, 2005
UNDER THE PATRONAGE OF HRH PRINCE EL HASSAN BIN TALAL

MENAREC 2

المؤتمر الإقليمي الثاني للطاقة المتجددة لدول الشرق الأوسط وشمال أفريقيا
عمان 9-11 أيار 2005
تحت رعاية سمو الأمير الحسن بن طلال رئيس المجلس الأعلى للعلوم والتكنولوجيا

Potential and Economy of Renewable Energies in MENA

Results of the MED-CSP Study Project

commissioned by the

German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

Dr. Franz Trieb

German Aerospace Center (DLR)

The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

MED-CSP

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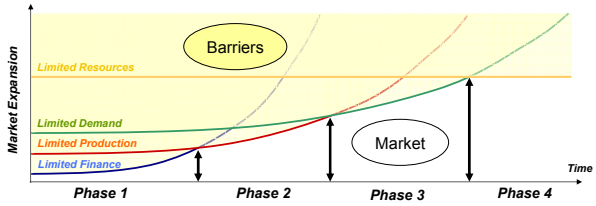
Finding Renewable Energy Scenarios with the Crash-Barrier Principle: Subsequently, different factors limit technology expansion.

Phase 1: Technology cost is high and expansion requires preferential investment

Phase 2: Prices have become competitive but production capacities are limited

Phase 3: Production catches up and the market is defined by demand

Phase 4: As demand grows the availability of resources may become limiting



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Technology Portfolio: Concentrating Solar Thermal Power Technologies

parabolic trough (PSA) *solar tower (SNL)*

linear Fresnel (Solarmundo) *parabolic dish (SBP)*

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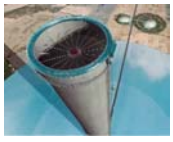
Other Renewable Energies for Power

Wind Power (Enercon)

Hydropower (Tauernkraft)

Solar Chimney (SBP)



Photovoltaic (NREL)

Hot Dry Rock (Stadtwerke Urach)

Biomass Power (NREL)

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Renewable Energy Resource Mapping

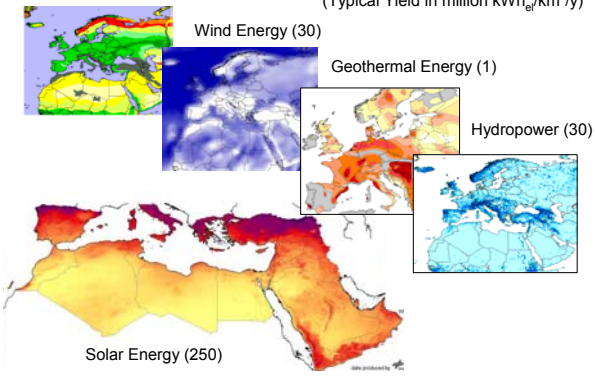
Biomass (1)

(Typical Yield in million $kWh_{el}/km^2/y$)

Wind Energy (30)

Geothermal Energy (1)

Hydropower (30)



Solar Energy (250)

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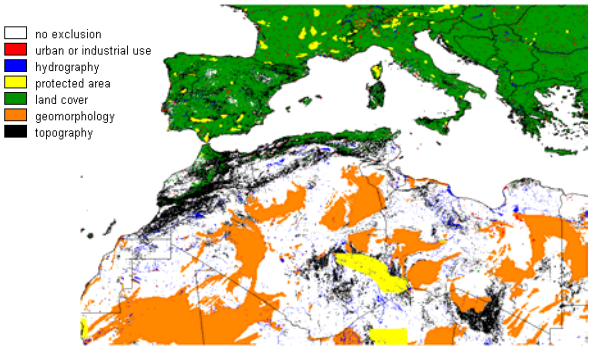
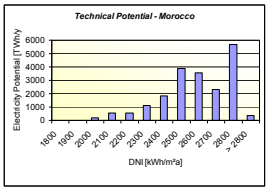
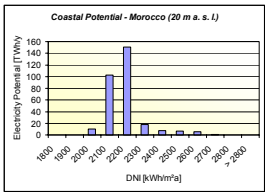
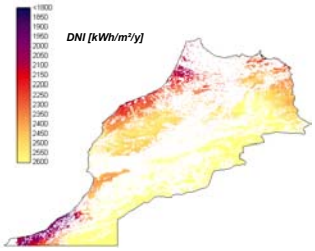
Exclusion Areas for Concentrating Solar Thermal Power Plants in Southern Europe and Maghreb Countries



Solar Thermal Electricity Generating Potentials in Morocco







Technical Potential: 20151 TWh/y (DNI > 1800 kWh/m²/y)
Economic Potential: 20146 TWh/y (DNI > 2000 kWh/m²/y)
Power Demand 2000: 15 TWh/y
Power Demand 2050: 235 TWh/y (Scenario CG/HE)
Tentative CSP 2050: 150 TWh/y (Scenario CG/HE)
Coastal Potential: 300 TWh/y (< 20 m a. s. l.)
Water Demand 2050: 1.2 TWh/y (Power for Desalination)

Renewable Electricity Potentials in TWh/year

	Hydro		Geo		Bio		CSP		Wind		PV		Wa/Ti	
	Tech.	Econ.	Tech.	Econ.	Tech.	Econ.	Tech.	Econ.	Tech.	Econ.	Tech.	Econ.	Tech.	Econ.
Bahrain	5.0	n.a.	n.a.	n.a.	n.a.	0.2	36	33	n.a.	0.1	n.a.	0.3	n.a.	n.a.
Cyprus	24.0	1.0	n.a.	n.a.	n.a.	0.5	23	20	10.0	0.5	n.a.	0.2	n.a.	0.2
Iran	88.0	48.0	n.a.	11.3	n.a.	23.7	>	20000	n.a.	8.0	n.a.	16.0	n.a.	n.a.
Iraq	90.0	67.0	n.a.	n.a.	n.a.	8.6	30806	28647	300.0	10.0	n.a.	6.8	n.a.	n.a.
Israel	44.0	7.0	n.a.	n.a.	n.a.	2.2	318	318	22.0	0.5	n.a.	4.0	n.a.	n.a.
Jordan	n.a.	0.1	n.a.	n.a.	n.a.	1.6	6434	6429	109.0	2.0	n.a.	4.5	n.a.	n.a.
Kuwait	n.a.	n.a.	n.a.	n.a.	n.a.	0.8	1525	1525	n.a.	n.a.	n.a.	2.5	n.a.	n.a.
Lebanon	2.0	1.0	n.a.	n.a.	n.a.	0.8	19	14	9.0	0.2	n.a.	1.5	n.a.	n.a.
Oman	n.a.	n.a.	n.a.	n.a.	n.a.	1.1	20611	19404	44.0	8.0	n.a.	4.1	n.a.	n.a.
Qatar	n.a.	n.a.	n.a.	n.a.	n.a.	0.1	823	792	n.a.	n.a.	n.a.	1.0	n.a.	n.a.
Saudi Arabia	n.a.	n.a.	n.a.	70.9	n.a.	9.9	125260	124560	300.0	20.0	n.a.	13.9	n.a.	n.a.
Syria	7.0	4.0	n.a.	n.a.	n.a.	4.7	10777	10210	98.0	12.0	n.a.	8.5	n.a.	n.a.
UAE	n.a.	n.a.	n.a.	n.a.	n.a.	0.7	2078	1988	n.a.	n.a.	n.a.	3.0	n.a.	n.a.
Yemen	n.a.	n.a.	n.a.	107.0	n.a.	9.1	5143	5100	8.0	3.0	n.a.	25.8	n.a.	n.a.
Algeria	5.0	0.5	n.a.	4.7	n.a.	12.1	169440	168972	7278	35.0	n.a.	13.9	n.a.	n.a.
Egypt	80.0	50.0	n.a.	25.7	n.a.	15.3	73656	73656	7650	90.0	n.a.	36.0	n.a.	n.a.
Libya	n.a.	n.a.	n.a.	n.a.	n.a.	1.7	139600	139477	5363	15.0	n.a.	3.9	n.a.	n.a.
Morocco	5.0	4.0	n.a.	10.0	n.a.	14.3	20151	20146	1188	25.0	n.a.	17.0	n.a.	n.a.
Tunisia	1.0	0.5	n.a.	3.2	n.a.	3.2	9815	9244	50.0	8.0	n.a.	5.0	n.a.	n.a.
Greece	25.0	12.0	n.a.	4.7	n.a.	11.8	44	4	136.0	15.0	n.a.	4.0	n.a.	4.0
Italy	105.0	54.0	n.a.	9.8	n.a.	86.4	88	7	223.0	60.0	n.a.	10.0	n.a.	3.0
Malta	n.a.	n.a.	n.a.	n.a.	n.a.	0.2	2	2	n.a.	0.2	n.a.	0.1	n.a.	0.1
Portugal	33.0	20.0	n.a.	7.0	n.a.	26.6	436	142	63.0	20.0	n.a.	3.0	n.a.	7.0
Spain	70.0	41.0	n.a.	9.4	n.a.	111.1	1646	1278	226.0	60.0	n.a.	5.0	n.a.	13.0
Turkey	216.0	122.0	n.a.	150.0	n.a.	55.0	405	131	200.0	55.0	n.a.	28.6	n.a.	n.a.
Total		432		414		402		632099		447		218		27

Remarks:

well documented resource taken from literature

from 5000 m temperature map considering areas with T>180°C as economic

from agricultural (bagasse) and municipal waste and renewable solid biomass potentials

from DNI and CSP site mapping taking sites with DNI > 2000 kWh/m²/y as economic

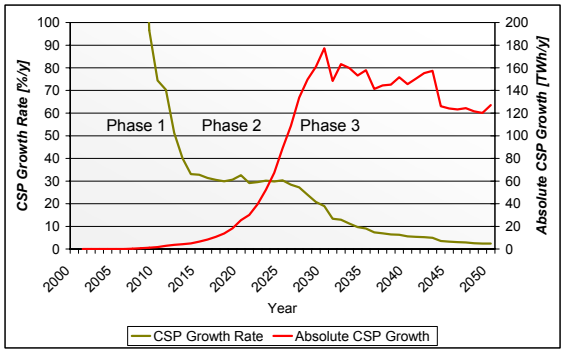
from wind speed and site mapping taking sites with a yield > 14 GWh/y and from literature (EU)

No information except for EU. General PV growth rates used for calculation

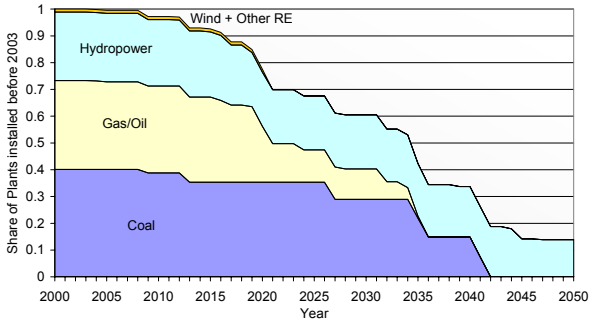
No information except for EU mid term economic potentials

for Iran, the CSP potentials are still rough estimates

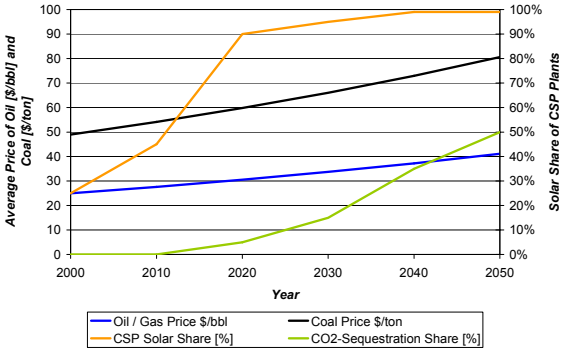
Industrial Plant Production Capacity of CSP



Power Plant Inventory (Morocco)



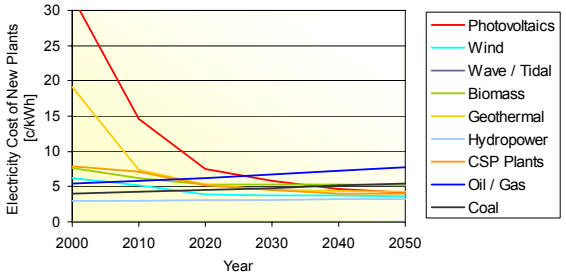
Development of Fuel Prices, Solar Share of CSP Plants and CO_2-Sequestration Share of Fossil Power Generation in Europe within the MED-CSP Scenario



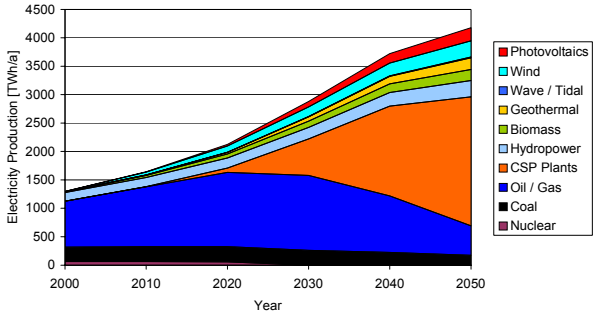
Electricity Cost of Power Technologies (Example)

Discount Rate 5 %
2000-$

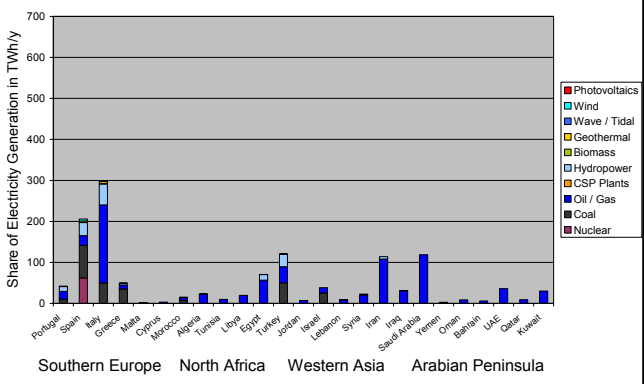
LEC New Plants c/kWh	2000	2010	2020	2030	2040	2050
Wind	6.2	5.2	3.8	3.7	3.7	3.6
Photovoltaics	31.9	14.7	7.4	5.8	4.6	4.2
Geothermal	19.1	7.4	5.3	4.5	4.4	4.3
Biomass	7.6	6.2	5.4	5.3	5.2	5.2
CSP Plants	7.9	7.1	5.2	4.5	4.1	4.0
Wave / Tidal	0.0	0.0	0.0	0.0	0.0	0.0
Hydropower	2.9	3.0	3.1	3.1	3.2	3.3
Oil / Gas	5.4	5.8	6.2	6.7	7.2	7.8
Coal	4.0	4.2	4.5	4.8	5.1	5.5



Electricity Generation All Countries

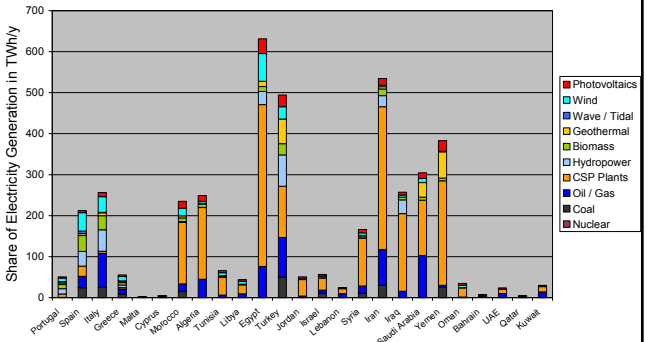


Electricity Mix 2000



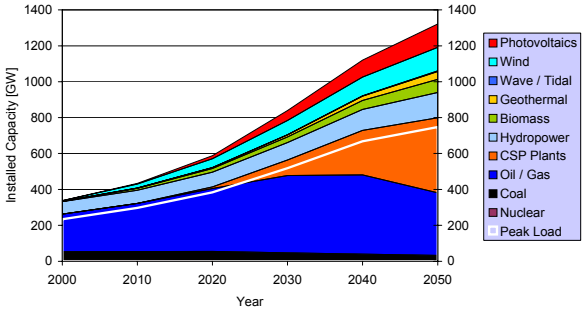
Southern Europe North Africa Western Asia Arabian Peninsula

Electricity Mix 2050



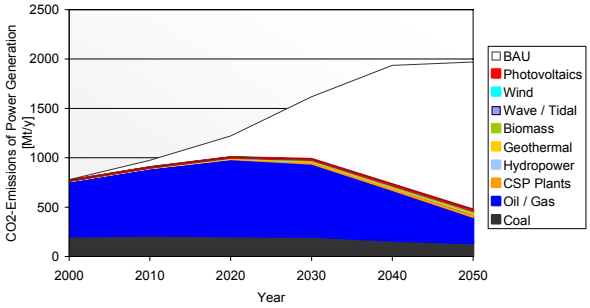
Southern Europe North Africa Western Asia Arabian Peninsula

Installed Capacity All Countries



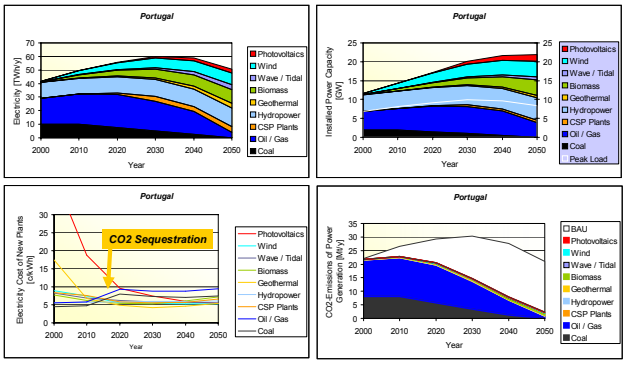
At any time, the electricity supply system must cover the power demand with 25 % reserve (firm capacity)

Total CO2-Emissions of the Power Sector

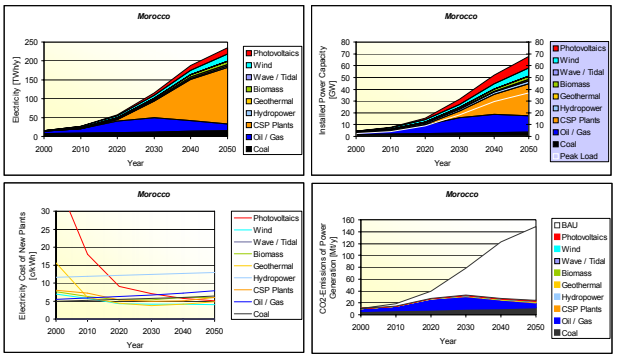


Total avoided emissions until 2050: 28 billion tons
Per Capita Emission in 2050: 0.58 tons/cap/year

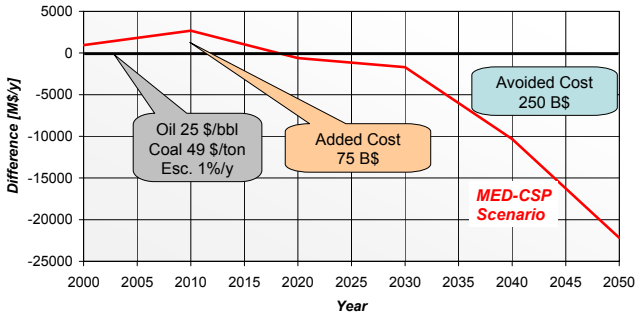
EU Country (Portugal)



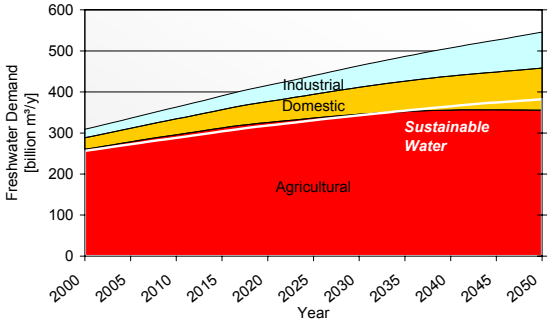
MENA Country (Morocco)



Cost Difference between the MED-CSP Scenario and a Business as Usual Policy Scenario

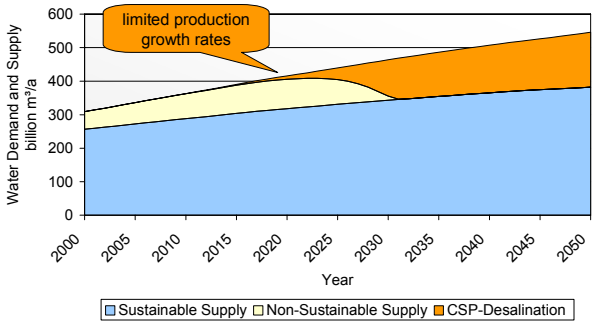


Water Demand in MENA

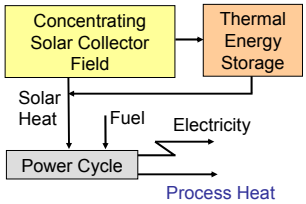


Sustainable Water Deficit: ***today: 60 billion m³/y***
2050: 160 billion m³/y

Water Supply in MENA

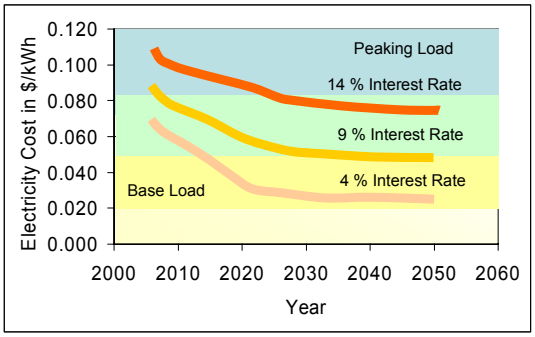


Solar / Hybrid Electricity and Combined Heat & Power

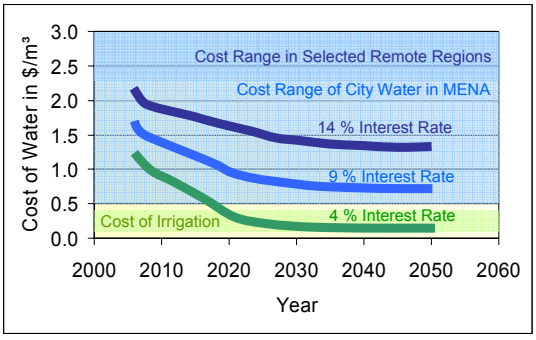


- solar electricity
- integrated fossil fuel backup capacity, power on demand
- increased solar operating hours, reduced fuel input
- additional process heat for cooling, drying, seawater desalination, etc.

Cost of Electricity by CSP in Cogeneration with MED for 4, 9 and 14% Rate of Return, Water Cost 0.50 $/m³



Cost of Water desalted by CSP in Cogeneration with MED for 4, 9 and 14% Rate of Return, Electricity Cost 4 ct/kWh



Alternatives for Sustainable Energy and Water in EU-MENA

- ***Oil/Gas:*** High Cost Escalation
  Growing Domestic Needs will compete with Exports
  2050 ***15 %***
  Climate vs. Cost (CO_2-Sequestration adds 2 - 3 ct/kWh)
- ***Coal:*** Less Cost Escalation than Oil & Gas
  MENA would shift from Energy Exporter to Energy Importer
  5 %
  New Source will require Infrastructure and Investment
  Climate vs. Cost (CO_2-Sequestration adds 2 - 3 ct/kWh)
- ***Nuclear:*** Cost Escalation & Depletion like Oil
  MENA would shift from Energy Exporter to Energy Importer
  0 %
  New Source will require Infrastructure and Investment
  Security vs. Cost (Nuclear Waste Disposal, Proliferation)
- ***Solar:*** Cost De-Escalation and High Growth Rates
  MENA will export Oil/Gas + Solar Power
  80 %
  New Source will require Infrastructure and Investment
  Climate + Security + Low Cost

What about fusion in EU-MENA ?

	Nuclear Fusion	***Renewable Energy Mix***
1st plant scheduled in year	***2050***	***2006***
Capacity share 2050	***0.7 %***	***70 %***
Additional Cost until 2050	***75 billion $***	***75 billion $ ****
Electricity Cost 2050	***12 cent/kWh***	***5 cent/kWh***
Avoided Cost until 2050	***0***	***250 billion $ ****
Avoided CO_2 until 2050	***0***	***28 billion tons***
Unit size	***5000 MW***	***0 - 5000 MW***
Range of Application	***flat base load***	***base - peak load***
Who will own it ?	***OECD***	***EU-MENA***
Source	***MPI***	***MED-CSP***

* using the reference parameters of MED-CSP scenario CG/HE

Main Results of the MED-CSP Study

- The present energy system is not sustainable and will lead to a critical situation in terms of economical, social and environmental stability.
- The demand for energy will grow by three times until 2050 in EU-MENA, water demand will almost double in the MENA region
- Fossil and nuclear energy sources have triggered economic development in the North Western Hemisphere, but cannot be expected to do the same for the rest of the world
- A well balanced mix of renewable energy technologies is the least cost option for energy and water security in EU-MENA
- The deployment of renewable energies must be accelerated by adequate policy instruments

Policies for Sustainability in the Energy Sector

- International Agreement on RES Deployment Strategy
- Create Instruments adapted to each Country
  - Feed in Tariffs
  - Kyoto Instruments (CT, CDM, JI)
  - Subsidies (Soft Loans, Grants)
  - Bidding System and Quotas
  - Tax Credits
- Grid Enhancement
- Base Decisions on world market prices

➔ ***Mobilisation Fund ?***

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The MED-CSP Team Thanks for Your Attention !

German Aerospace Center (DLR)
Dr. Franz Trieb, Dr. Christoph Schillings, Stefan Kronshage, Dr. Uwe Klann, Dr. Peter Viebahn, Nadine May, Regina Wilde, Christian Paul, Stuttgart, Germany

National Energy Research Center (NERC)
Eng. Malek Kabariti, Amman, Jordan

Centre National pour la Recherche Scientifique et Technique (CNRST)
Prof. Dr. Abdelaziz Bennouna, Rabat, Morocco

Nokraschy Engineering GmbH (NE)
Dr. Ing. Hani El Nokraschy, Holm, Germany

New and Renewable Energy Authority (NREA)
Samir Hassan (Director), Laila Georgy Yussef, Cairo, Egypt

New Energy Algeria (NEAL)
Tewfik Hasni, Alger, Algeria

Internationales Forschungszentrum für Erneuerbare Energien e.V. (IFEED)
Dr. Nasir El Bassam, Braunschweig, Germany

Hamburg Institute of International Economics (HWWA)
Honorat Satoguina, Hamburg, Germany

The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety