Perspectives of Wind and Solar Energy Sources at Global and European Level

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Spring of Research, EDF, October 8, 2009

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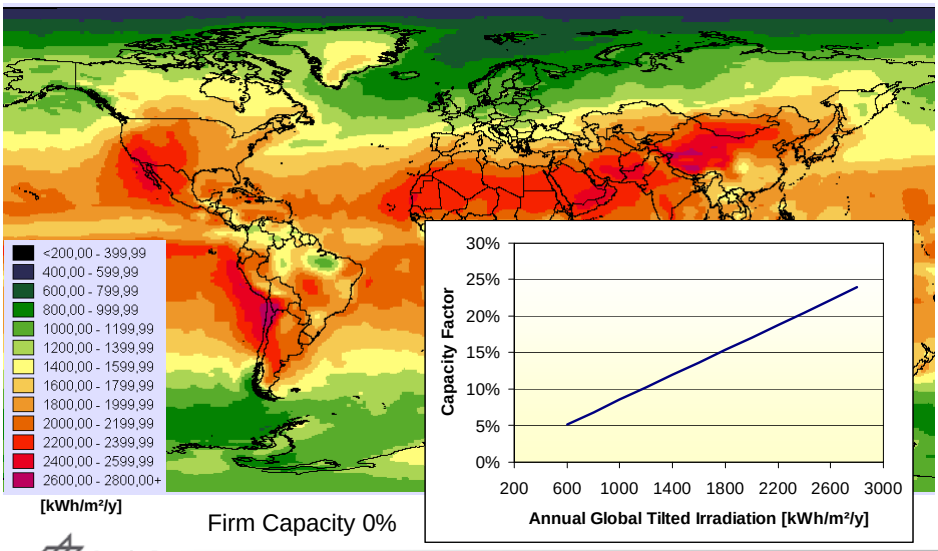
Annual Global Irradiance for PV Systems



Firm Capacity 0%

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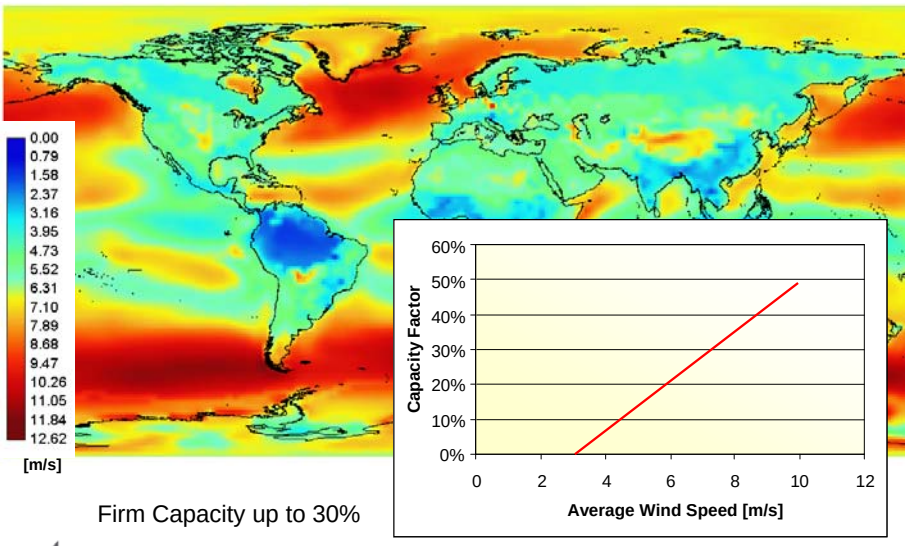
Source: ECMWF

Annual Average Wind Speed at 50 m Height



Firm Capacity up to 30%

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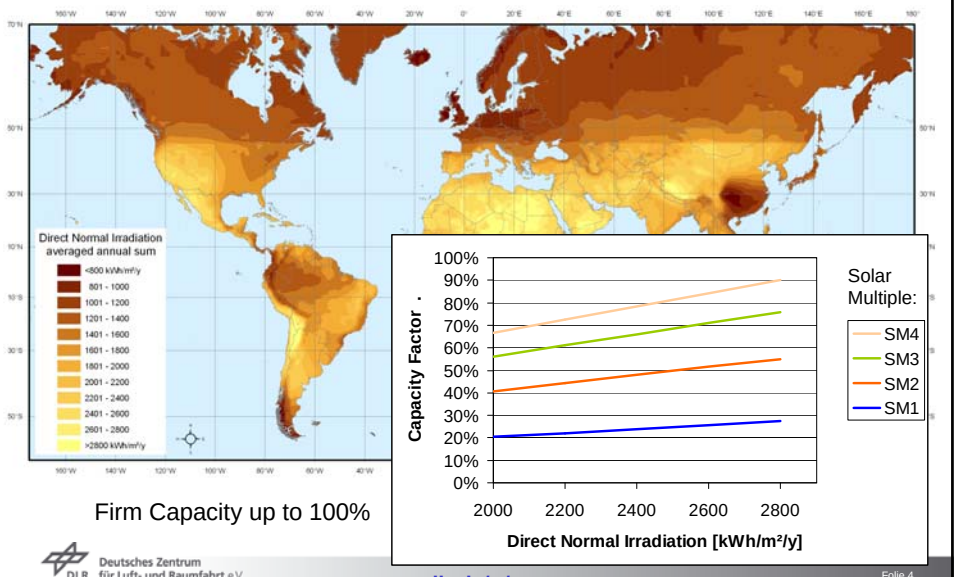
http://eosweb.larc.nasa.gov/sse/

Folie 3

Annual DNI for Concentrating Solar Thermal Power Plants



Firm Capacity up to 100%

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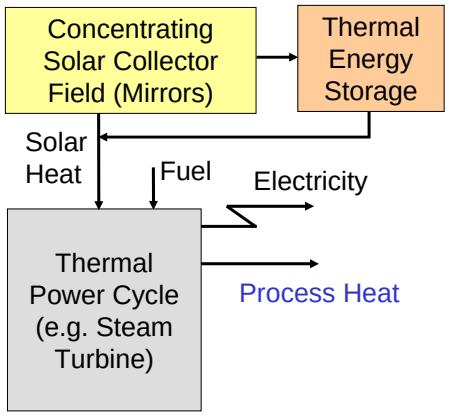
www.dlr.de/tt/csp-resources

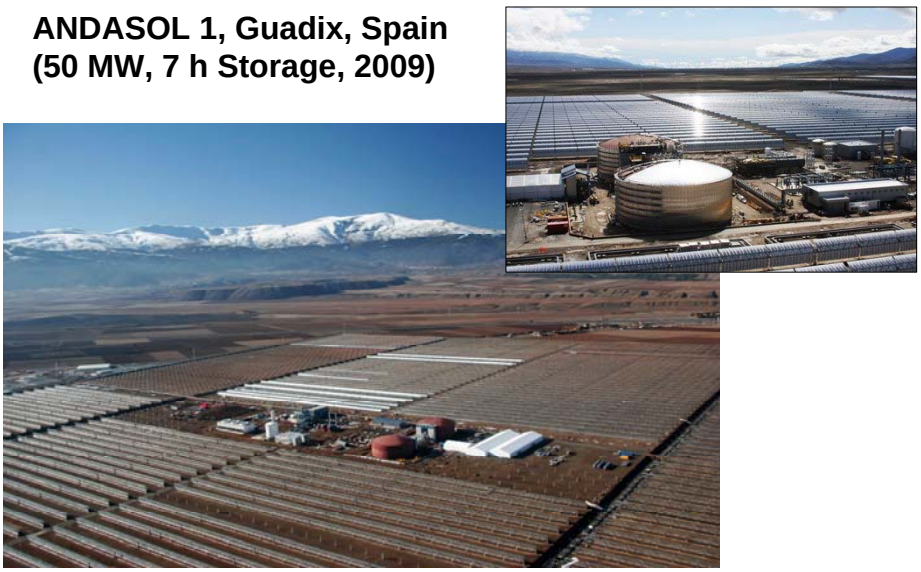
Folie 4

Principle of a Concentrating Solar Thermal Power Plant

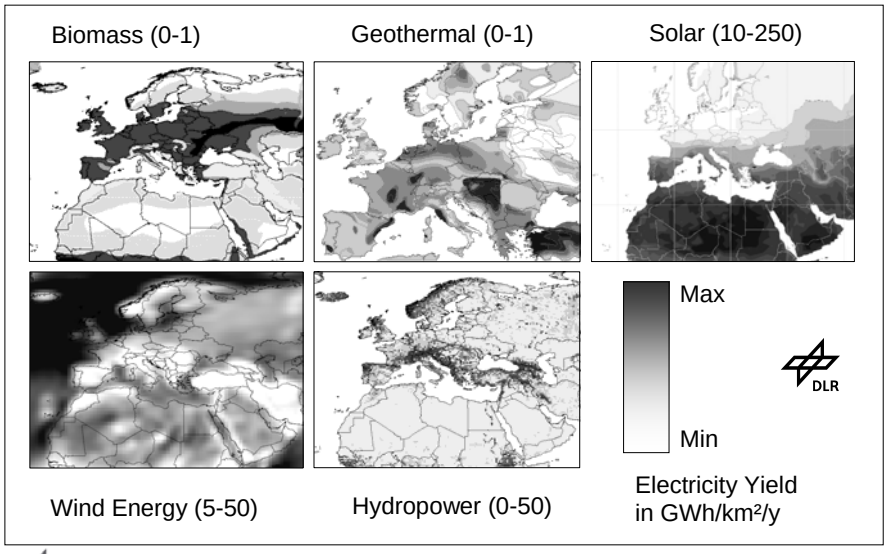


- concentrated, easily storable solar thermal energy as fuel saver
- spinning reserve
- firm capacity, power on demand
- combined generation of process heat for cooling, industry, desalination, etc.

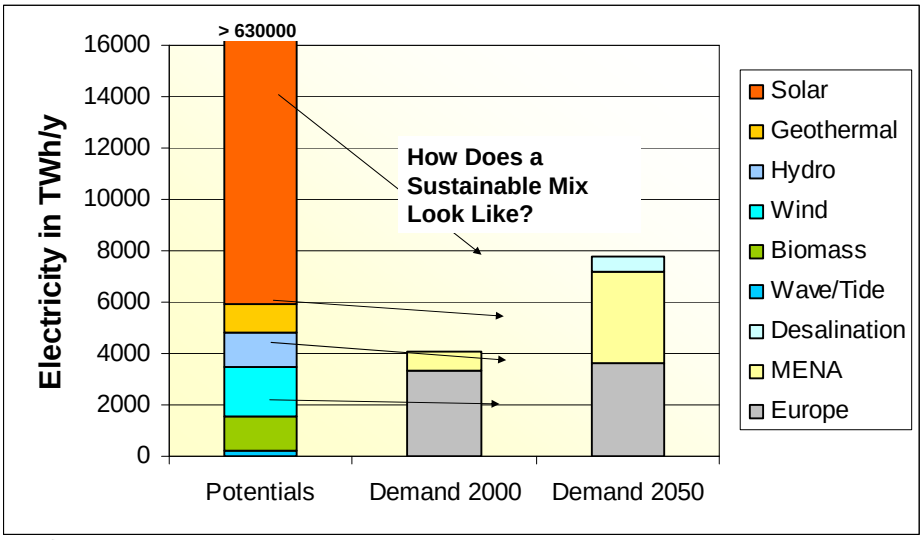
ANDASOL 1, Guadix, Spain (50 MW, 7 h Storage, 2009)



Renewable Electricity Potential in Europe, Middle East & North Africa



Economic Renewable Electricity Potentials vs. Demand in EUMENA



Criteria for Sustainable Electricity Supply:

✓ **Inexpensive**
- low electricity cost
- no long term subsidies

✓ **Secure**
- diversified and redundant supply
- power on demand
- based on inexhaustible resources
- available or at least visible technology
- capacities expandable in time

✓ **Compatible**
- low pollution
- climate protection
- low risks for health and environment
- fair access

Portfolio of Energy Sources for Electricity:

- ✓ **Coal, Lignite**
- ✓ **Oil, Gas**
- ✓ **Nuclear Fission, Fusion**

} **ideally stored primary energy**

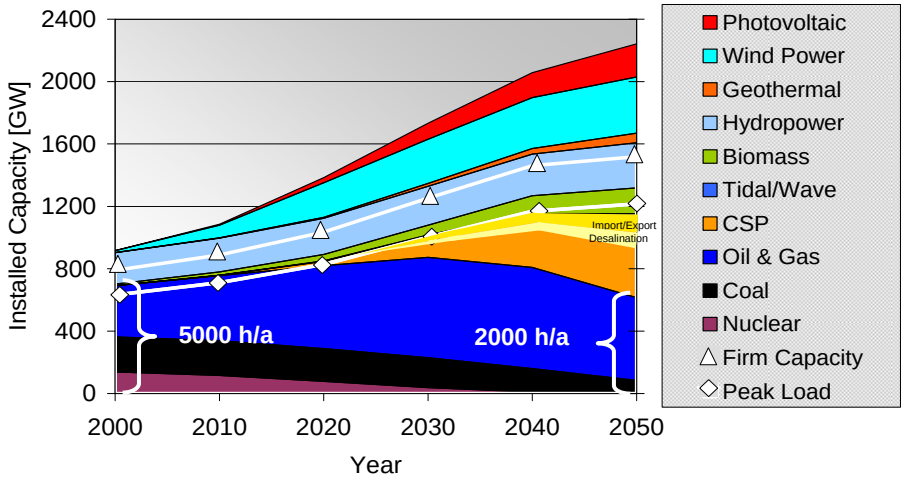
- ✓ **Concentrating Solar Power (CSP)**
- ✓ **Geothermal Power (Hot Dry Rock)**
- ✓ **Biomass**
- ✓ **Hydropower**

} **storable primary energy**

- ✓ **Wind Power**
- ✓ **Photovoltaic**
- ✓ **Wave / Tidal**

} **fluctuating primary energy**

Installed Capacity vs. Peak Load in EUMENA

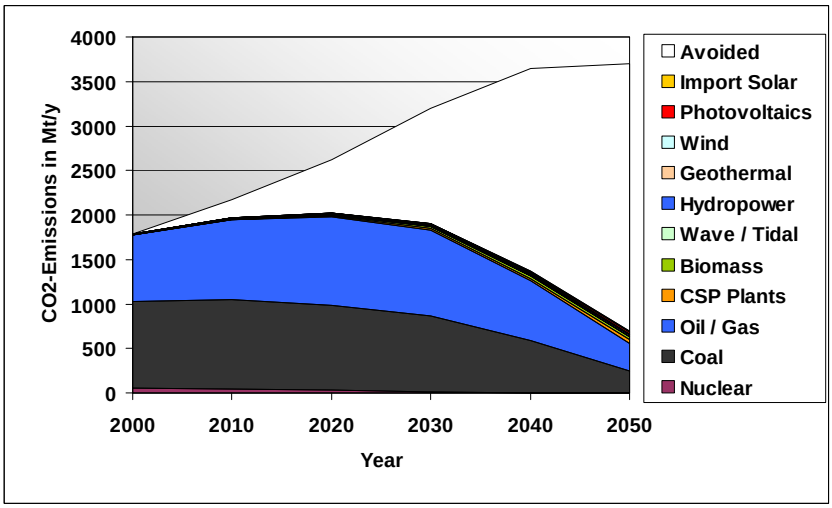


➔ **100 % availability plus 25 % reserve capacity**

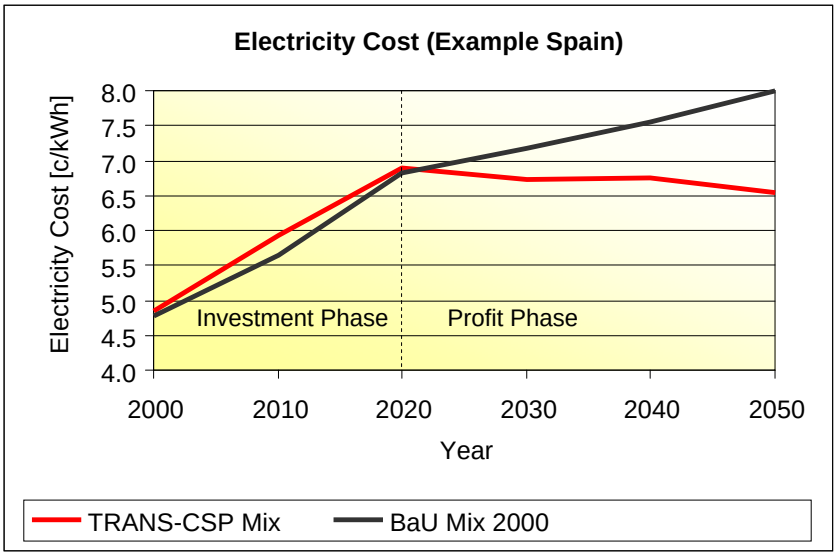
High Voltage Direct Current Transmission in China

Voltage:	± 800.000 Volt
Power:	6400 Megawatt
Length:	2070 km
Source:	Hydropower

Carbon emissions of EUMENA power sector are reduced to 38 % (0.5 t/cap/y) until 2050 in spite of a quickly growing demand

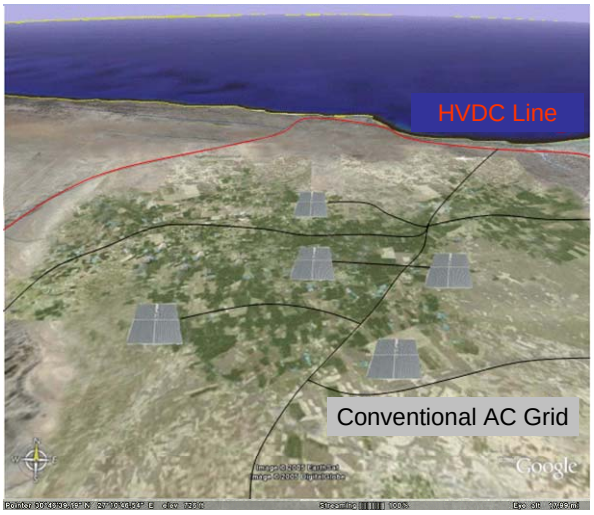


Electricity Cost (Example Spain)



$€_{2000}$, Fuel Cost: IEA / WEO 2005, after 2020 CCS

Solar Power & Desalination Plants



Energy,
Water,
Food,
Labor and
Income

for further
300 Million
People
in MENA ?

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(artist view created with Google Earth)

Folie 15

Thank You!

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Folie 16

Some Background Information

Availability and Redundancy

- **Power on Demand by a Mix of Fluctuating and Balancing Sources**
- **Increased Number of Non-Correlated Energy Sources**
- **Increased Number and Reduced Average Size of Power Plants**
- **Increased Number of Supply Regions**
- **Additional HVDC Infrastructure for Long-Distance Transfer**
- **Domestic Sources Dominate the Electricity Mix**
- **Renewable Sources Dominate the Electricity Mix**
- **Strategy Based on Proven Technologies**

Environmental Security

- **Reduced Greenhouse Gas Emissions from Power Generation**
- **Reduced Risks of Nuclear Pollution and Proliferation**
- **Reduced Pollution by Combustion Products**
- **Optimal Land Use (1%) through Diversified Mix**
- **Technology based on Recyclable Materials**

Economic Security

- **Economic Risk Hedged by Increased Portfolio**
- **Intrinsic Trend to Lower Cost and Lower Price Volatility**
- **Energy Cost Stabilization through Investment in New Sources**
- **Prevention of Cost Escalation due to Environmental Constraints**
- **Prevention of Cost Escalation due to Scarcity**
- **Reduction of Energy Subsidies in Europe and MENA**

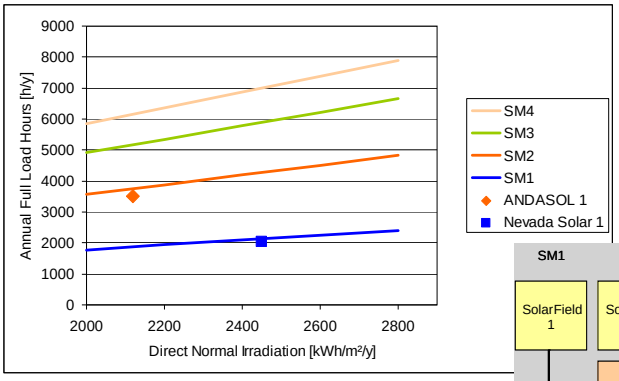
Political Security

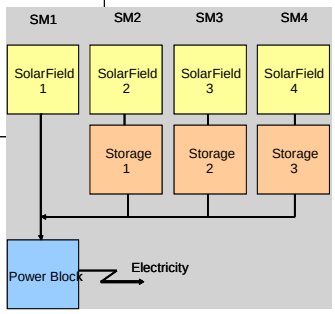
- Conflict Prevention between EU and MENA Reducing Pressure on Fuels
- Conflict Prevention in MENA Solving Energy and Water Scarcity
- Conflict Prevention in Europe Increasing Energy Diversity
- Reduction of European Energy Import Dependency
- Addition of Energy Corridors for European Supply
- Initiating EU-MENA (Energy) Partnership

Challenges

- Requires New Structures and New Thinking (Changes of Paradigm)
- Long-Term Infrastructure Requires Long-Term Financing
- Strategy Based on International Cooperation and Interdependencies
- Higher Complexity than Using Ideally Stored Fossil Energy Sources
- More Stakeholders Involved due to Decentralized Generation
- Cultural and Political Differences in EUMENA
- Lobby Groups Acting Against Each Other
- Speed of Environmental Change and Conflict Potentials

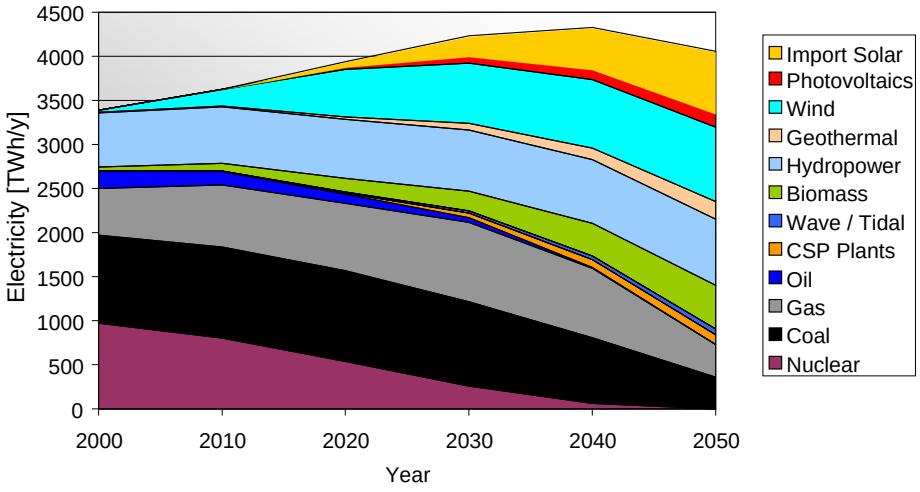
Effect of Thermal Energy Storage on the Availability of CSP



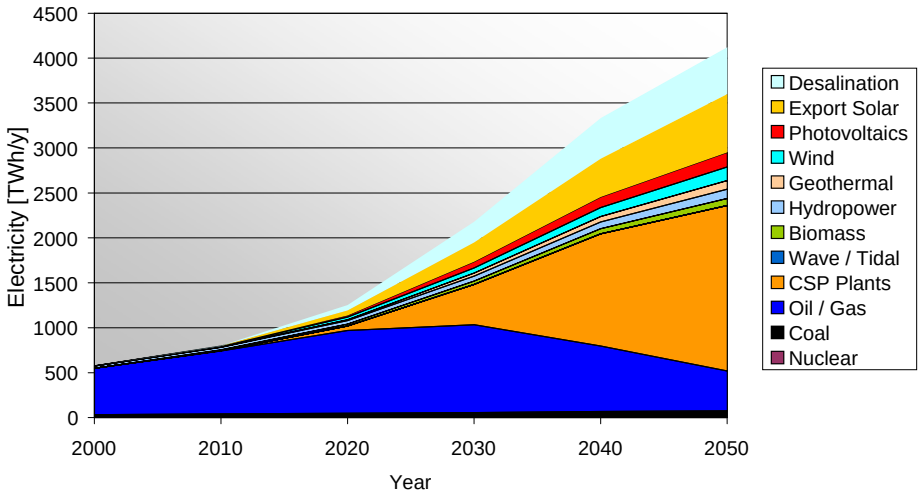


SM = Solar Multiple
1 Solar Field = 6000 m²/MW
1 Storage = 6 hours (full load)

Electricity Supply in Europe (TRANS-CSP Scenario)



Electricity Supply in the Middle East & North Africa



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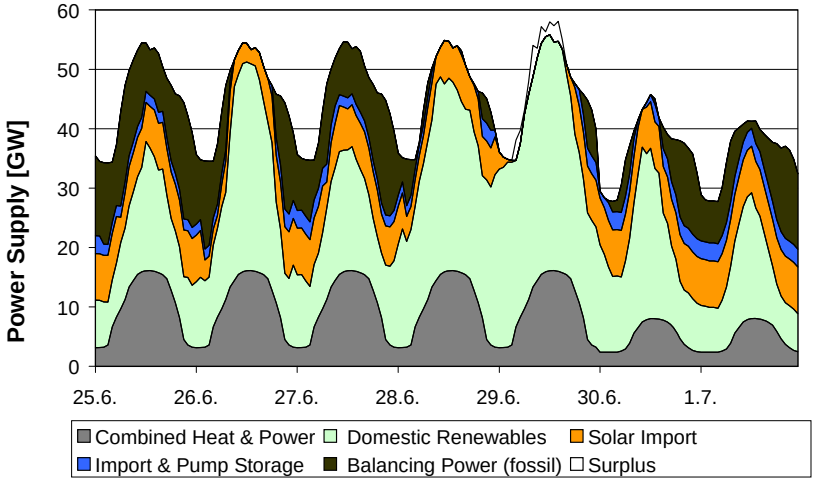
Folie 25

Firm Power Capacity based on Renewables and Fuels (no fossil or nuclear base load supply)



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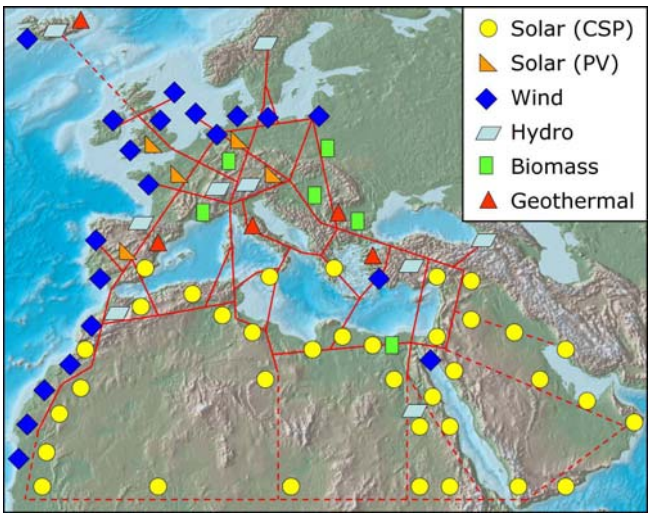
Hourly Model Germany 2050 (TRANS-CSP)

Folie 26

Trans-Mediterranean High Voltage Direct Current Electricity Grid: Interstate Highways for Renewable Electricity in EUMENA

TREC
Clean Power from the Deserts
Trans-Mediterranean Renewable Energy Cooperation
In conjunction with The Club of Rome

THE CLUB OF ROME



EUMENA:
Europe
Middle East
North Africa

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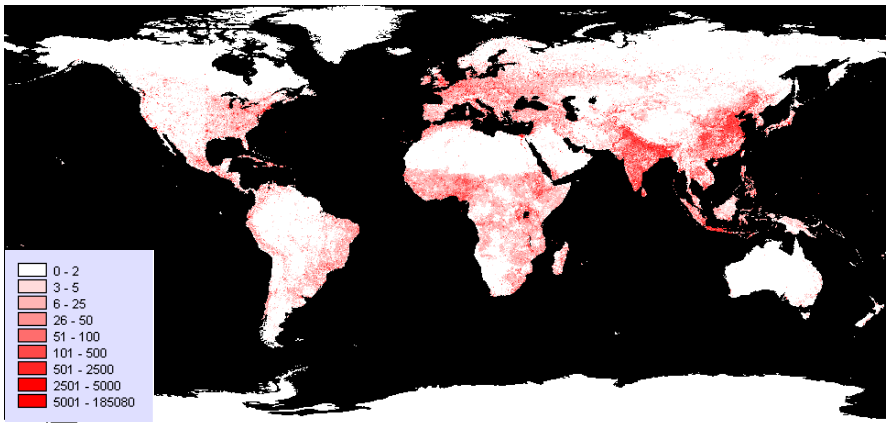
www.desertec.org

Folie 27

Population Density per km² in 2006



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Source: land scan 2006

Folie 28