Part 1: Sustainability in the Electricity Sector

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MBA Energy Management, Abu Dhabi, November 30, 2009

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DLR für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Studies: MED-CSP TRANS-CSP AQUA-CSP

Assessment of the renewable energy potential for the sustainable supply of electricity and water in 50 countries of Europe, the Middle East and North Africa taking into consideration the option of Concentrating Solar Power (CSP).

Bundesministerium
für Umwelt, Naturschutz
und Reaktorsicherheit

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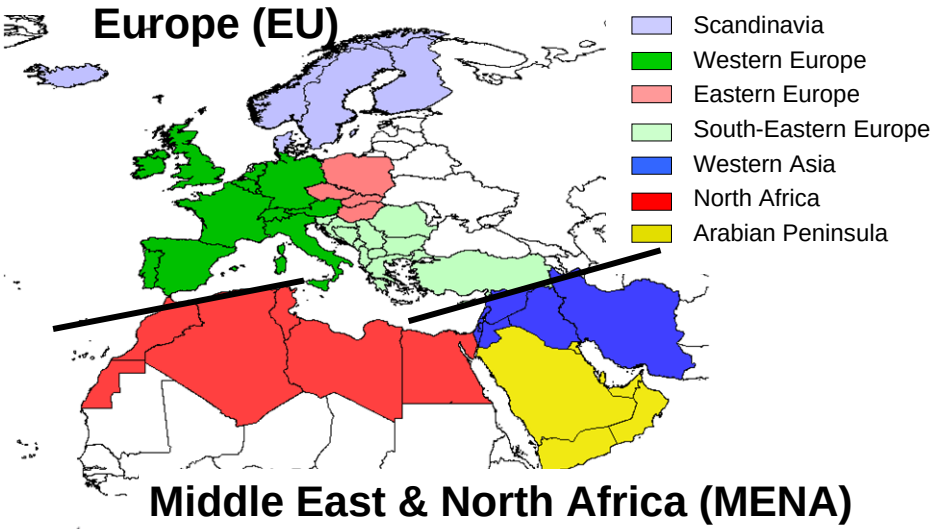
50 Countries in EUMENA analysed



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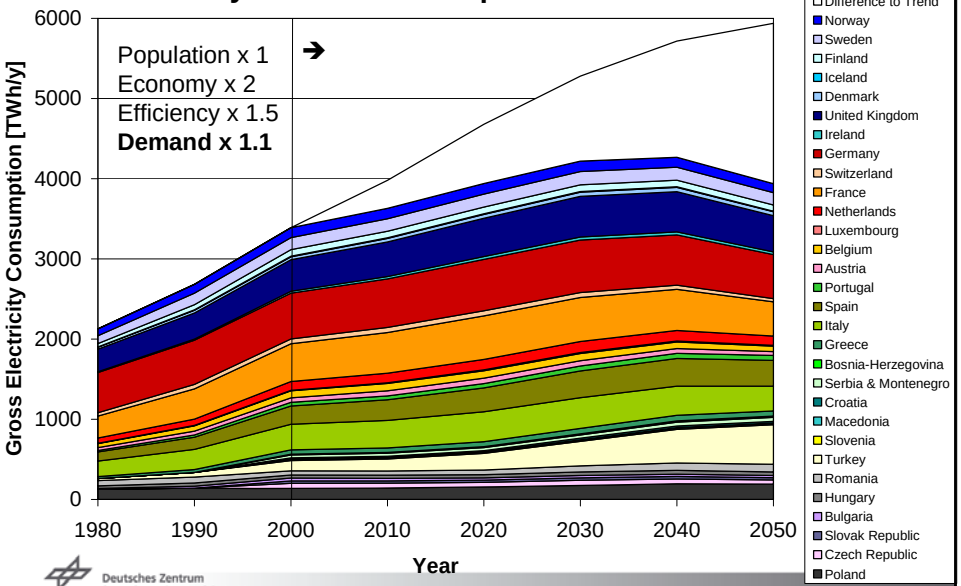
Folie 3

Electricity Demand in Europe



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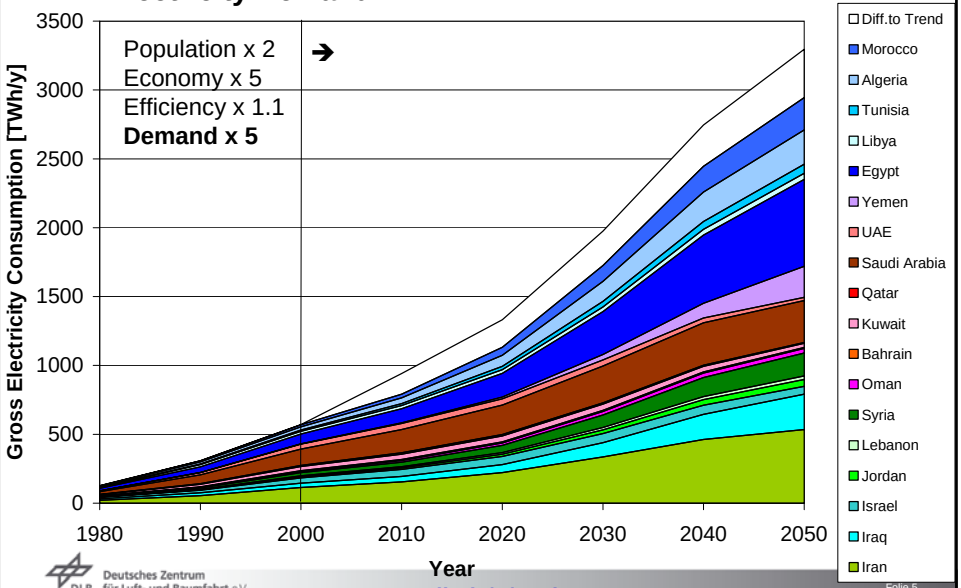
Folie 4

Electricity Demand in MENA



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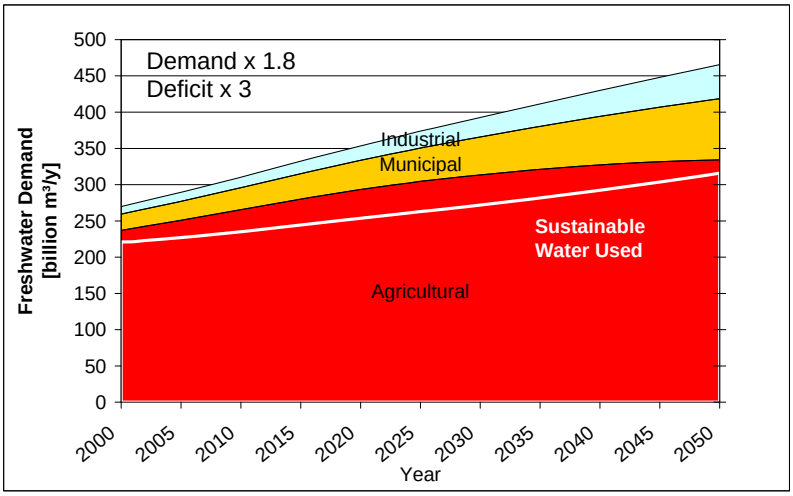
Folie 5

Water Demand in MENA



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Folie 6

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

Renewable Energy Technologies


Hydropower


Concentrating Solar Power


Biomass

Geothermal

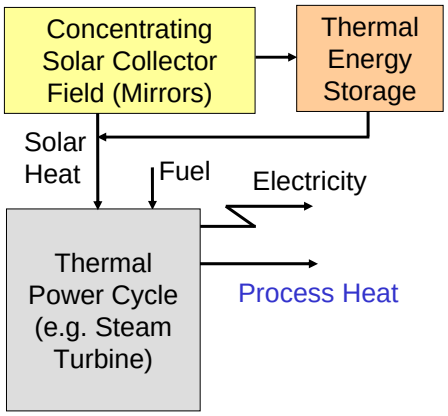

Tides


Waves


Photovoltaic


Wind Power

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.

Portfolio of Energy Sources for Electricity:

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

ideally stored primary energy

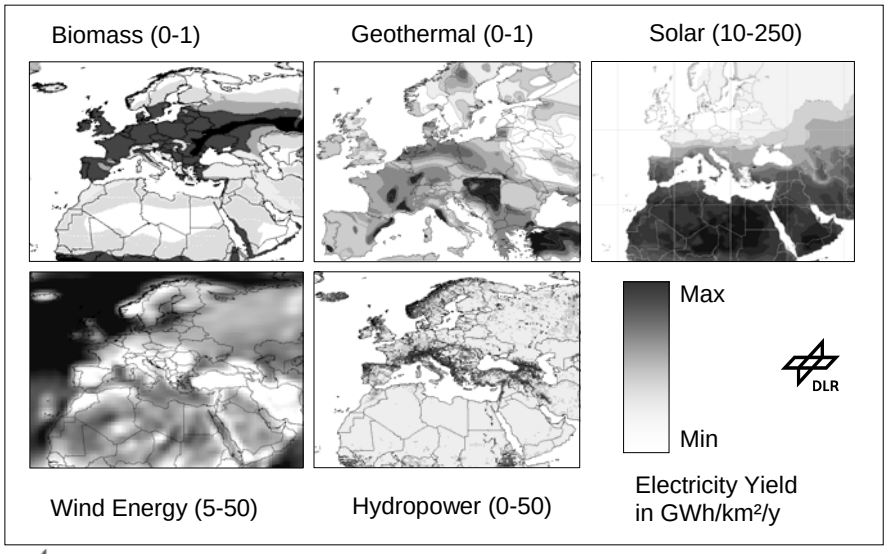
- ✓ **Concentrating Solar Power (CSP)**
- ✓ **Geothermal Power (Hot Dry Rock)**
- ✓ **Biomass**
- ✓ **Hydropower**

storable primary energy

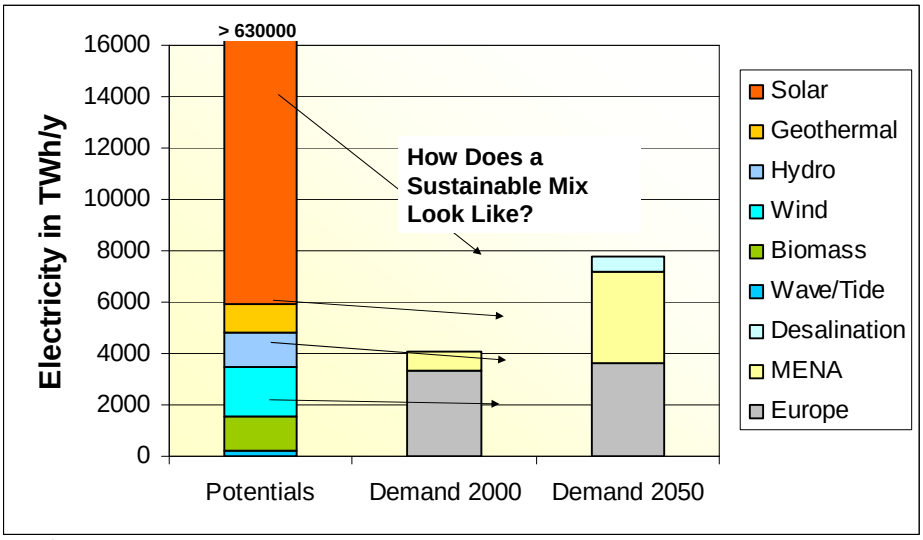
- ✓ **Wind Power**
- ✓ **Photovoltaic**
- ✓ **Wave / Tidal**

fluctuating primary energy

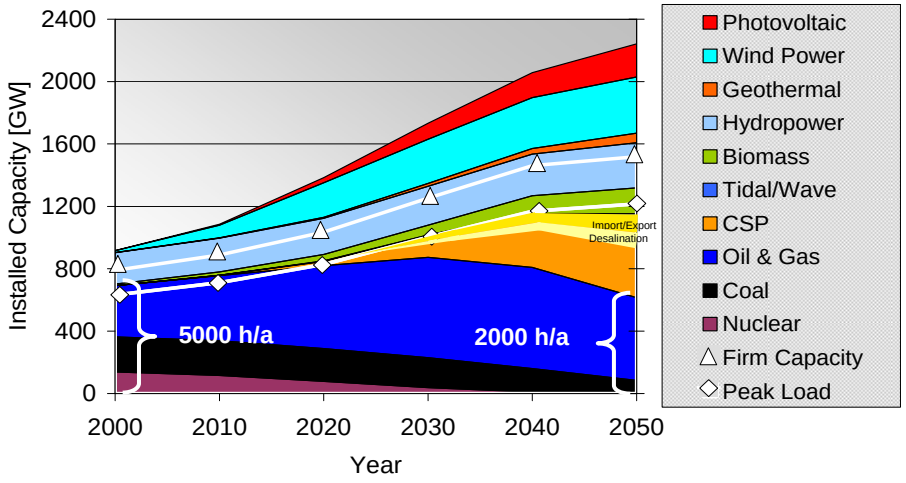
Renewable Electricity Potential in Europe, Middle East & North Africa



Economic Renewable Electricity Potentials vs. Demand in EUMENA

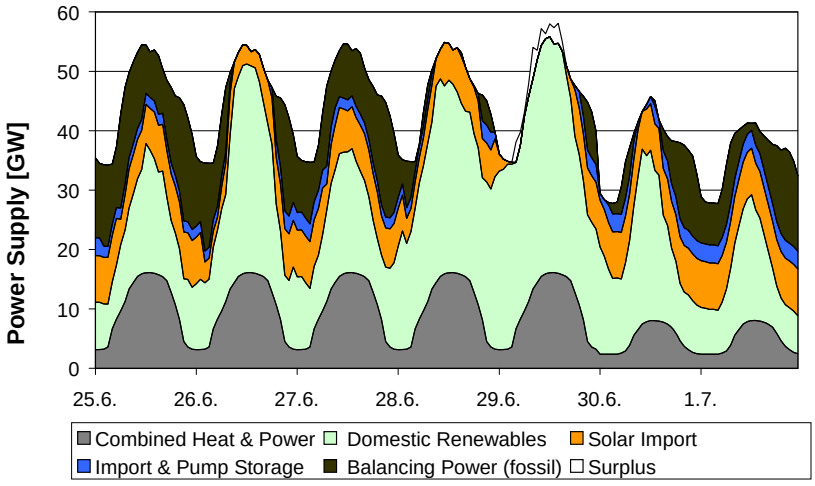


Installed Capacity vs. Peak Load in EUMENA



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

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



High Voltage Direct Current Transmission

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

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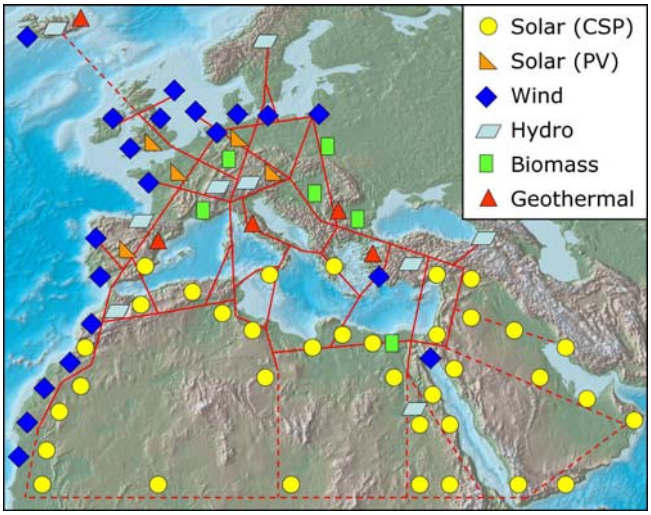
http://www.abb.com
http://www.siemens.com

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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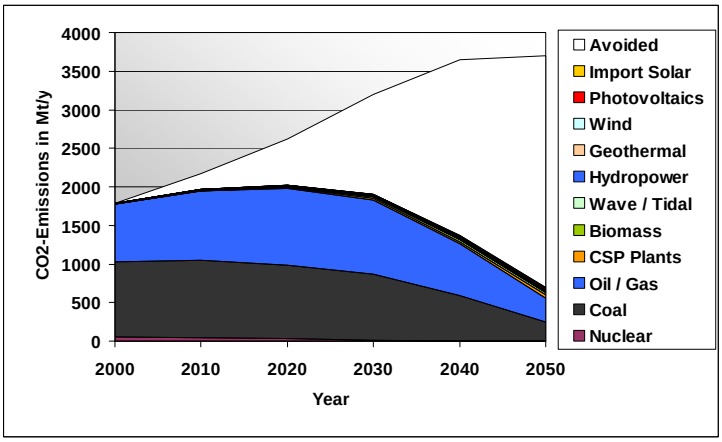
www.desertec.org

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 Grid Infrastructure for Long-Distance Transfer
- Domestic Sources Dominate the Electricity Mix
- Non-depletable Sources Dominate the Electricity Mix
- Strategy is Based on Proven Technologies

Carbon emissions of EUMENA power sector are reduced to 38 % until 2050 in spite of a quickly growing demand

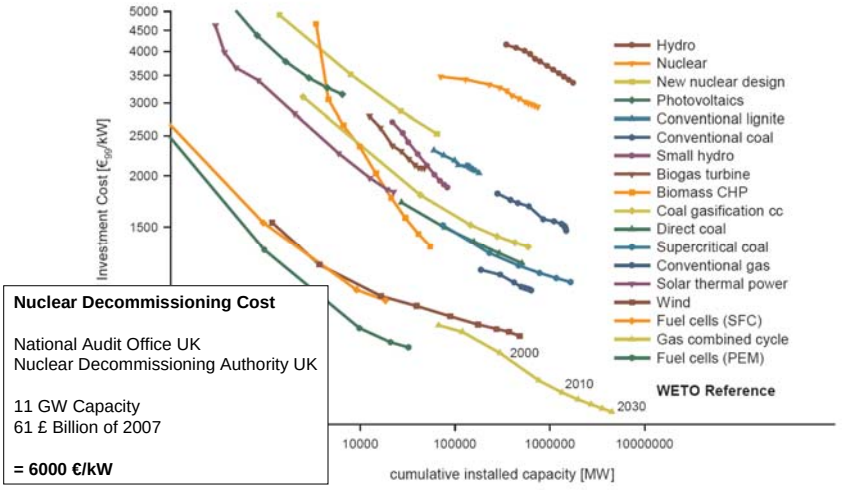


1% of Land Area Required

Environmental Security

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

Equipment Cost Learning Curves



Nuclear Decommissioning Cost

National Audit Office UK
Nuclear Decommissioning Authority UK

11 GW Capacity
61 £ Billion of 2007

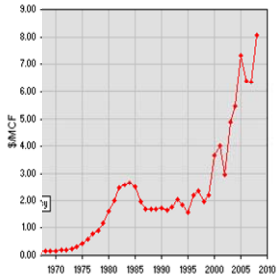
= 6000 €/kW

WETO 2003, NAO 2008

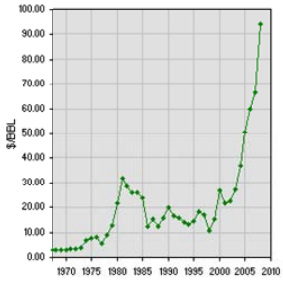
Fuel Cost Perspectives?

Coal Price

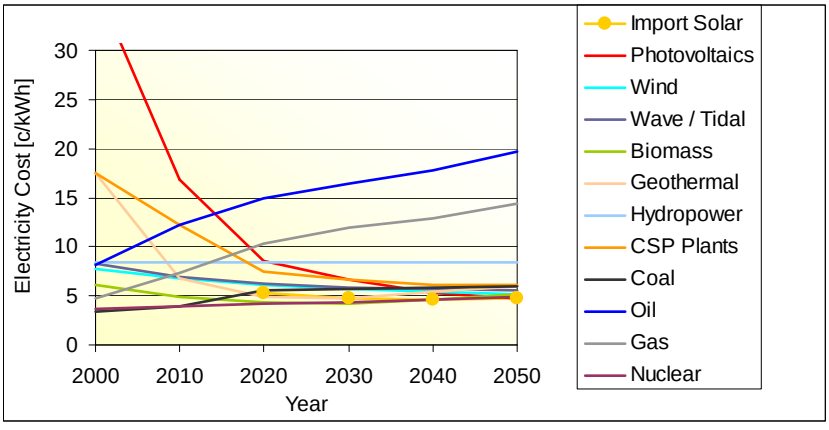
Natural Gas Price

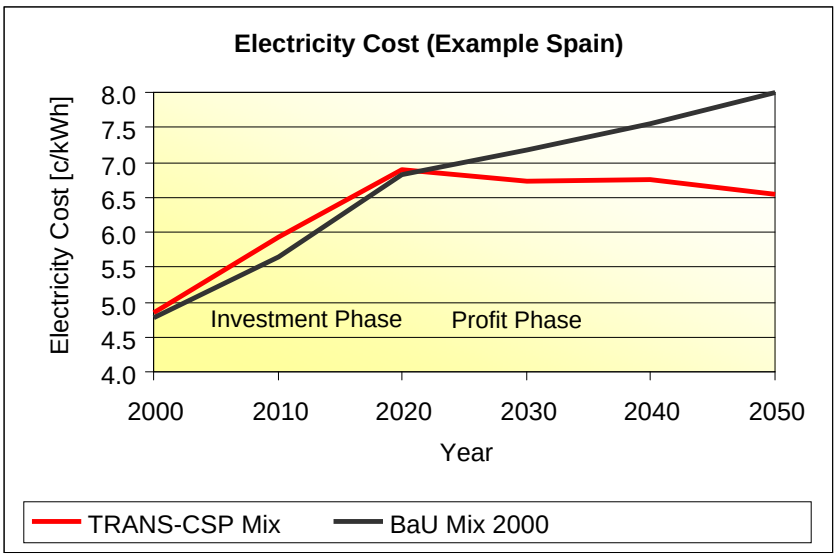


Crude Oil Price



Electricity Cost Learning Curves (example Spain)





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

Folie 23

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**

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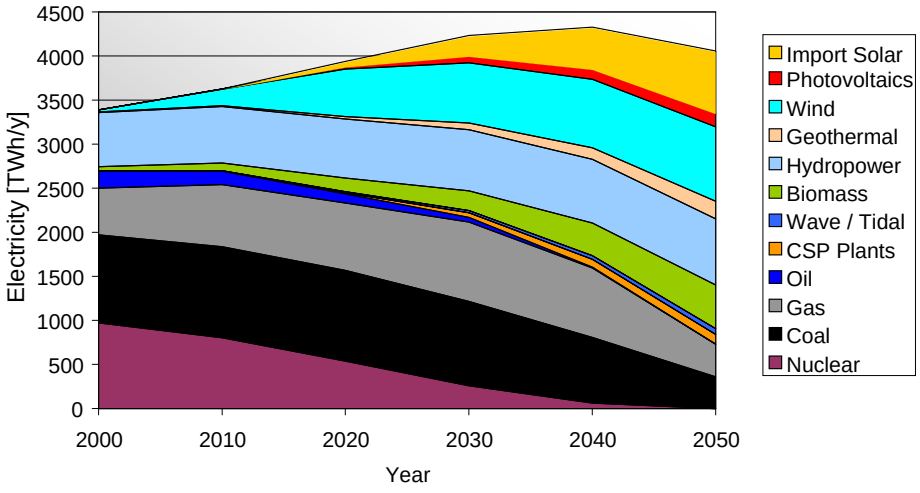
Folie 24

Electricity Supply in Europe (TRANS-CSP Scenario)



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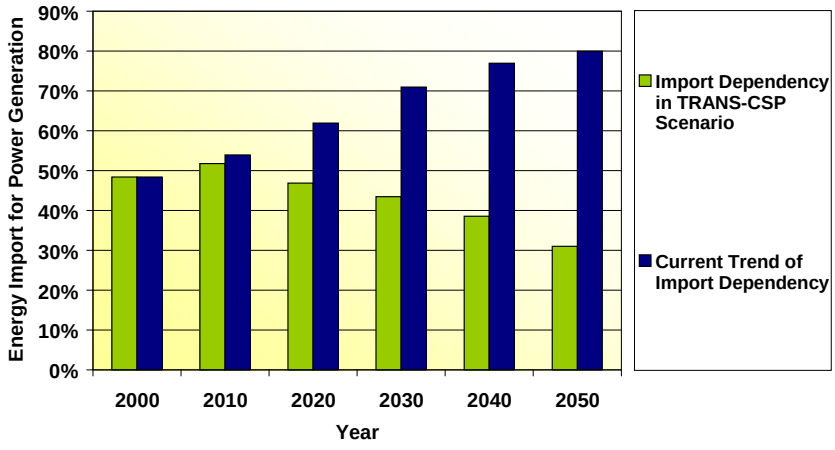
Folie 25

Import Dependency of European Power Generation



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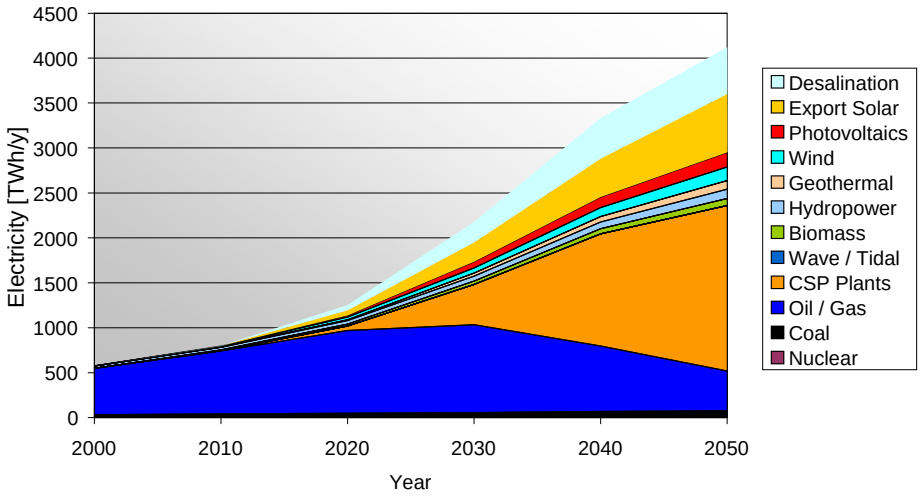
Folie 26

Electricity Supply in the Middle East & North Africa



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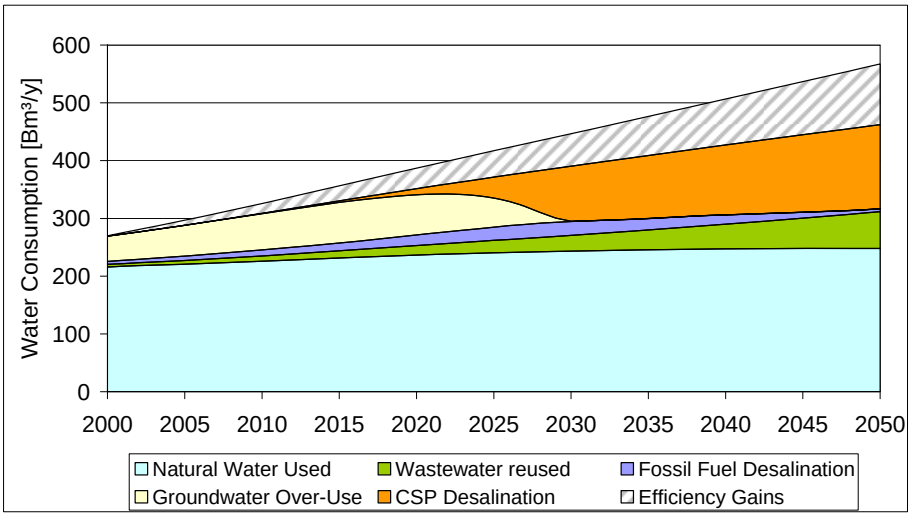
Folie 27

AQUA-CSP Scenario for Middle East & North Africa



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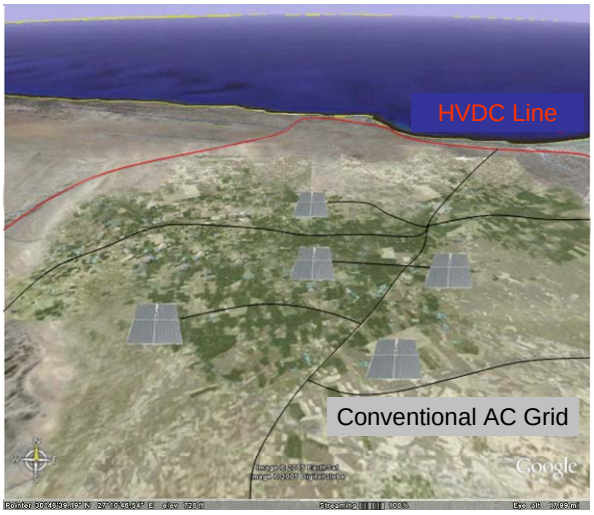
Folie 28

Solar Power & Desalination Plants



Energy,
Water,
Food,
Labor and
Income

for further
300 Million
People
in MENA ?

(artist view created with Google Earth)

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 (Change of Paradigm)
- Requires Long-Term Financing Schemes due to Long-Term Investments
- 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