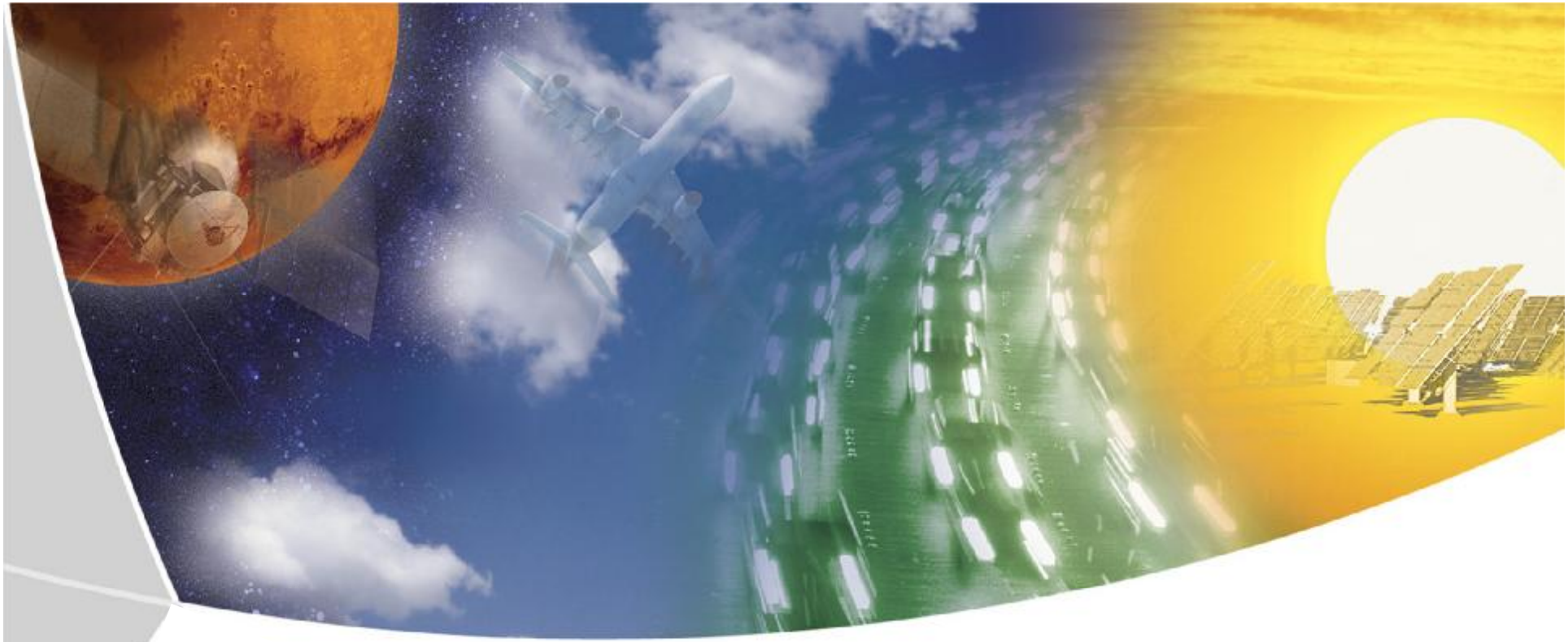


DLR

Germany’s aerospace research center and space agency

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

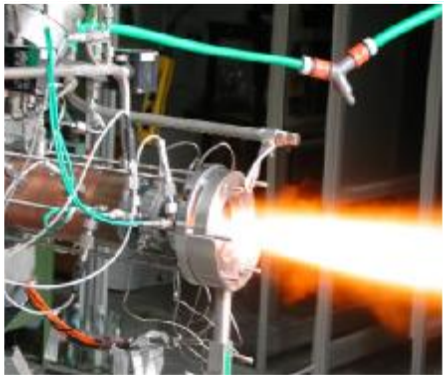
Scientific competence

5,600 employees

2,500 scientists

600 doctoral students and junior scientists

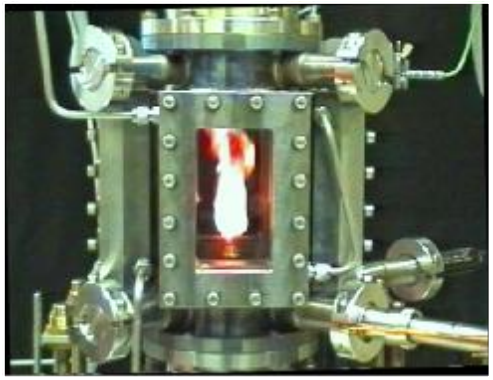
100 visiting scientists



Space Exploration

Aeronautics

Transport



Energy

Renewable Energies in the MENA Region: Potential for Sustainable Energy Provision and Export to Europe

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Institute of Technical Thermodynamics, German Aerospace Center (DLR)

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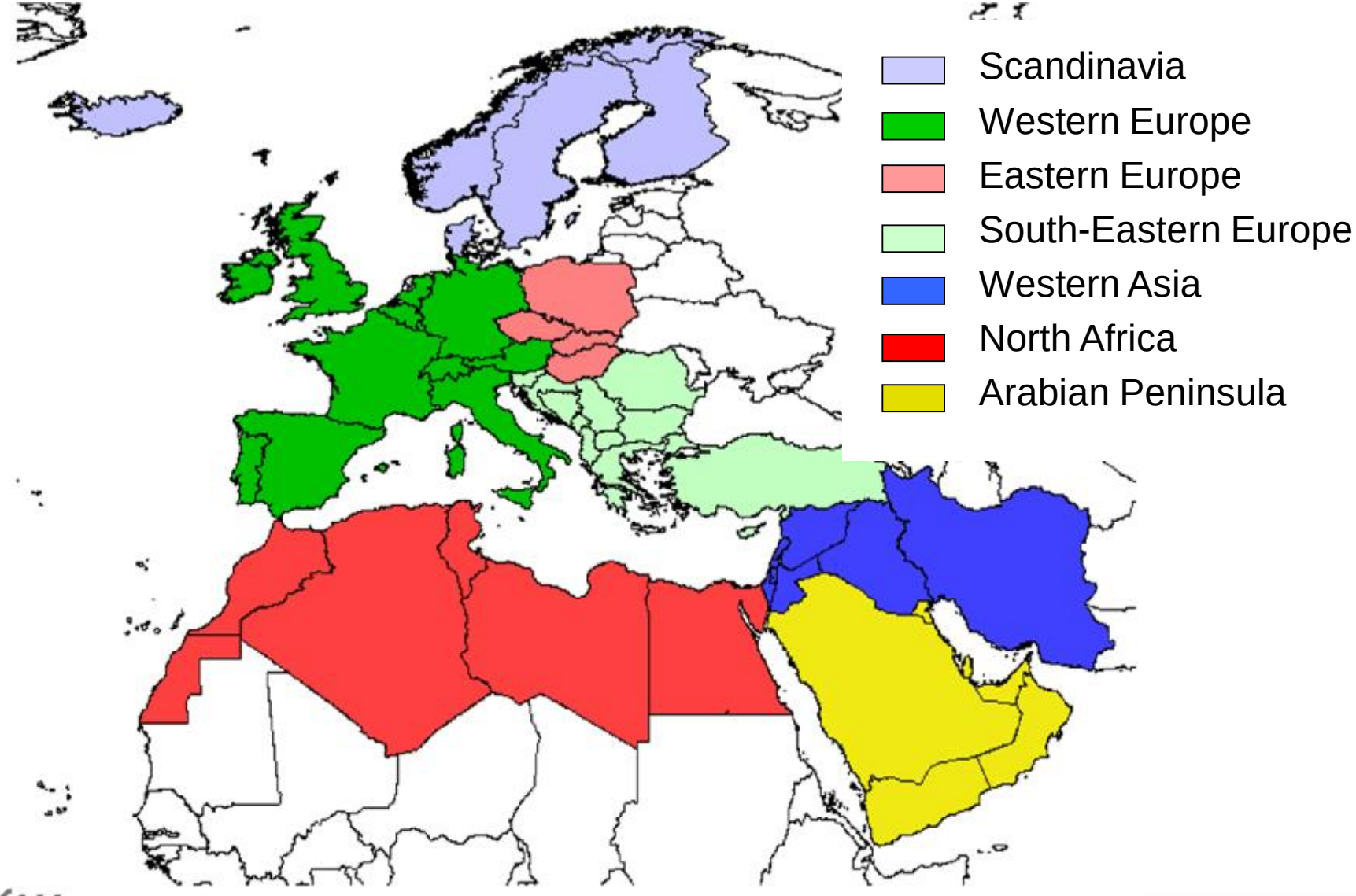
House of Water and Environment (Palestine)
Center for Solar Energy Studies (Libya)
Centre de Developpement des Energies Renouvelables (Morocco)
University of Bremen (Germany)
New Energy Algeria (Algeria)
New and Renewable Energy Authority (Egypt)
Hamburg Institute of International Economics (Germany)
Honorat Satoguina
MASDAR (Abu Dhabi)

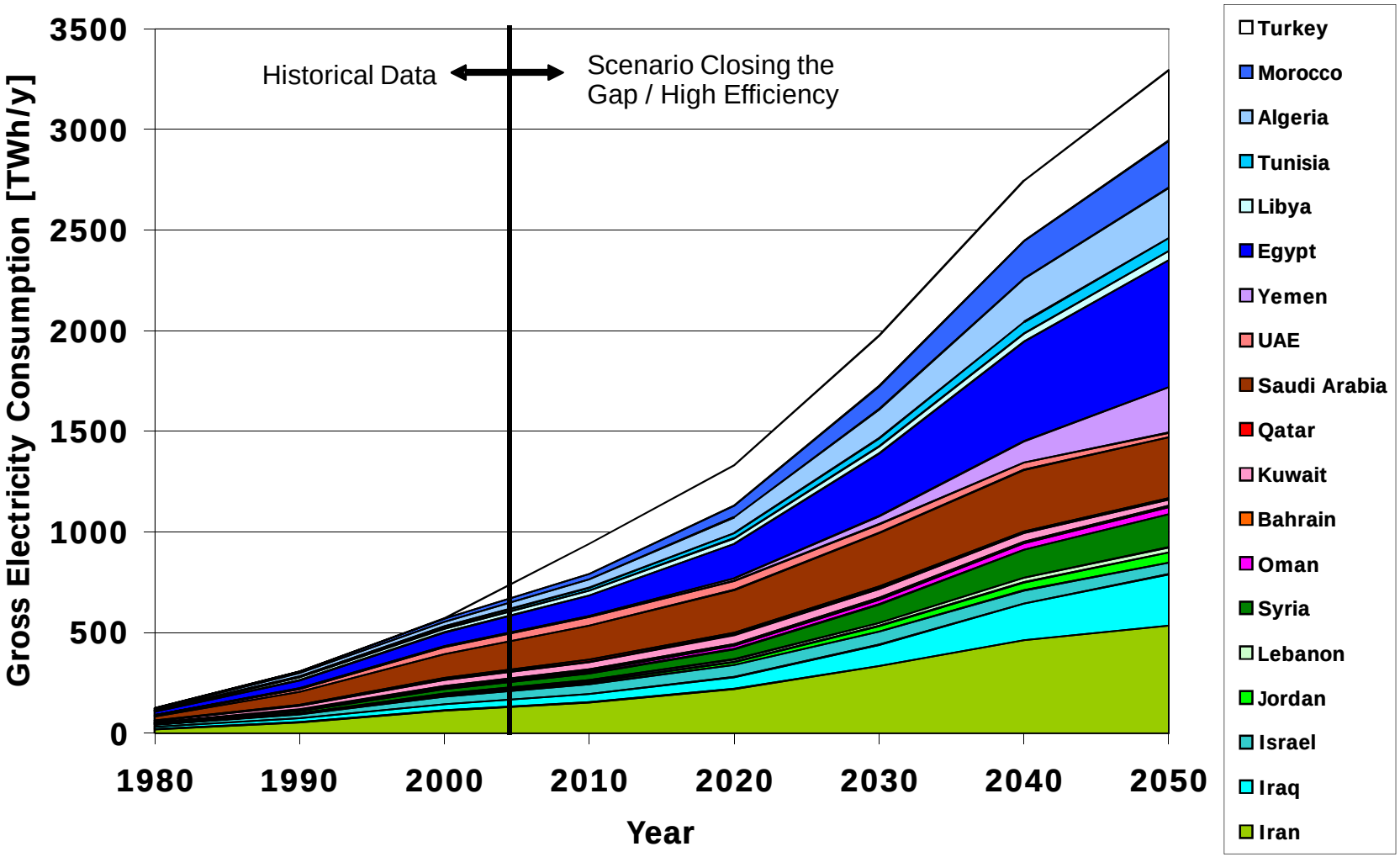
50 countries analysed within the MED-CSP and TRANS-CSP Studies



Parameters considered in the analyses for each country

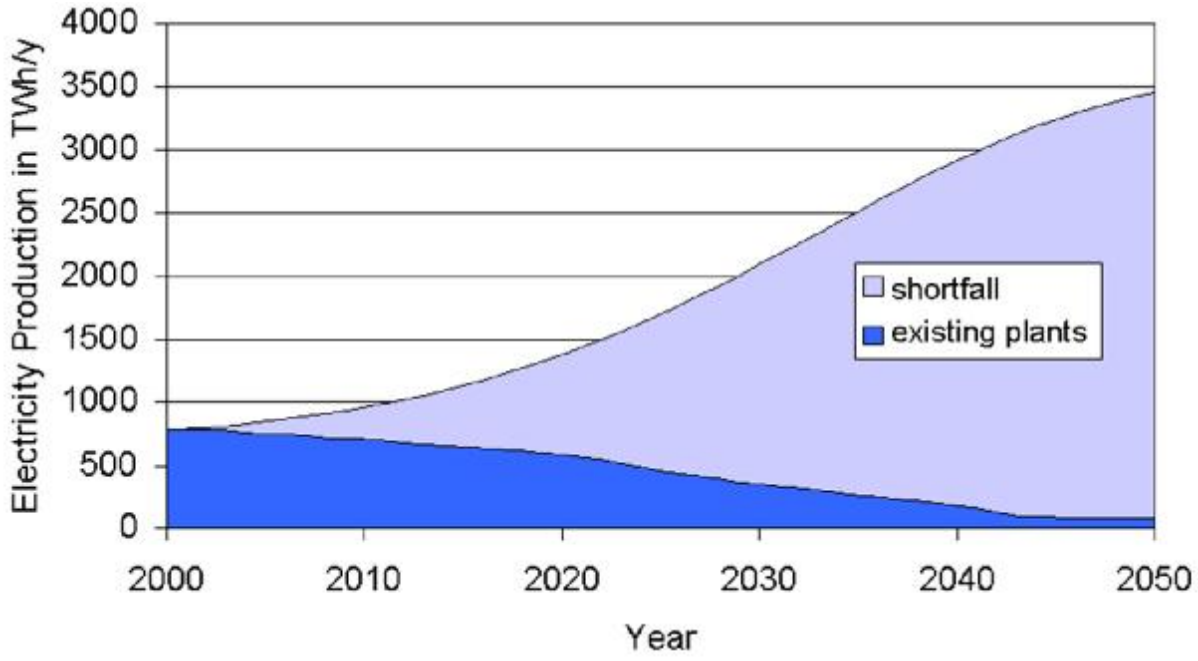
- Annual electricity demand
- Annual load curve
- Available fossile and renewable resources
- Existing power plants in 2000 and their expected lifetime
- Cost of fossil fuels (oriented at IEA Scenario)
- Maximum production growth rates of relevant industries
- Existing grid infrastructure
- 100% power availability
- Peaking power demand and 25 % reserve capacity
- Sustainability criteria
- Opportunities of financing
- Policies and energy economic boundary conditions

MED-CSP: Gross Electricity Demand in Middle East and North Africa

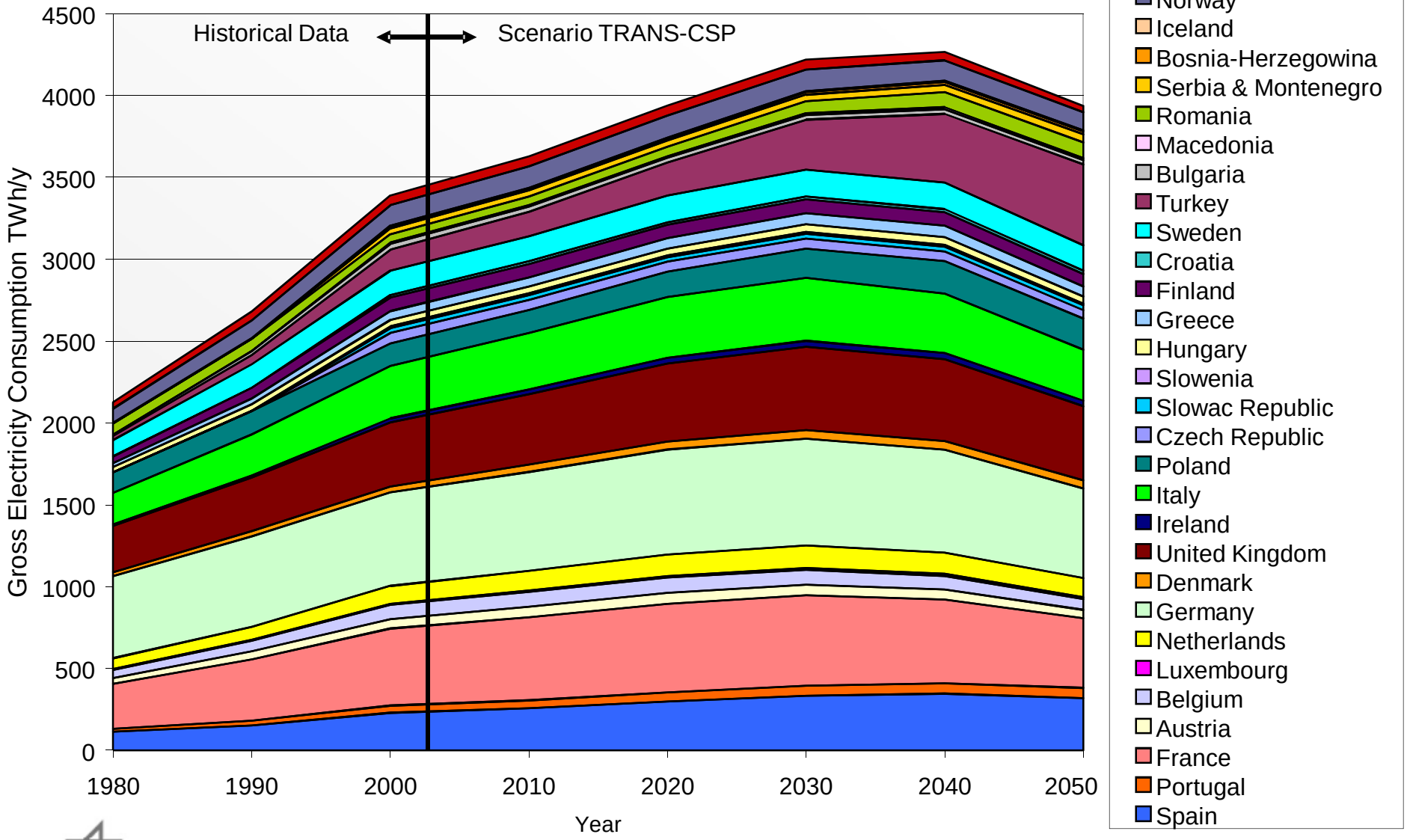


Development of MENA electricity demand, and its coverage by power plants already existing in 2000

- Ø significant increase due to economic and population growth
- Ø significant investments required for new plants
- Ø window of opportunity for sustainable local electricity and water supply
- Ø unique opportunity for closer economic, political and social links with Europe

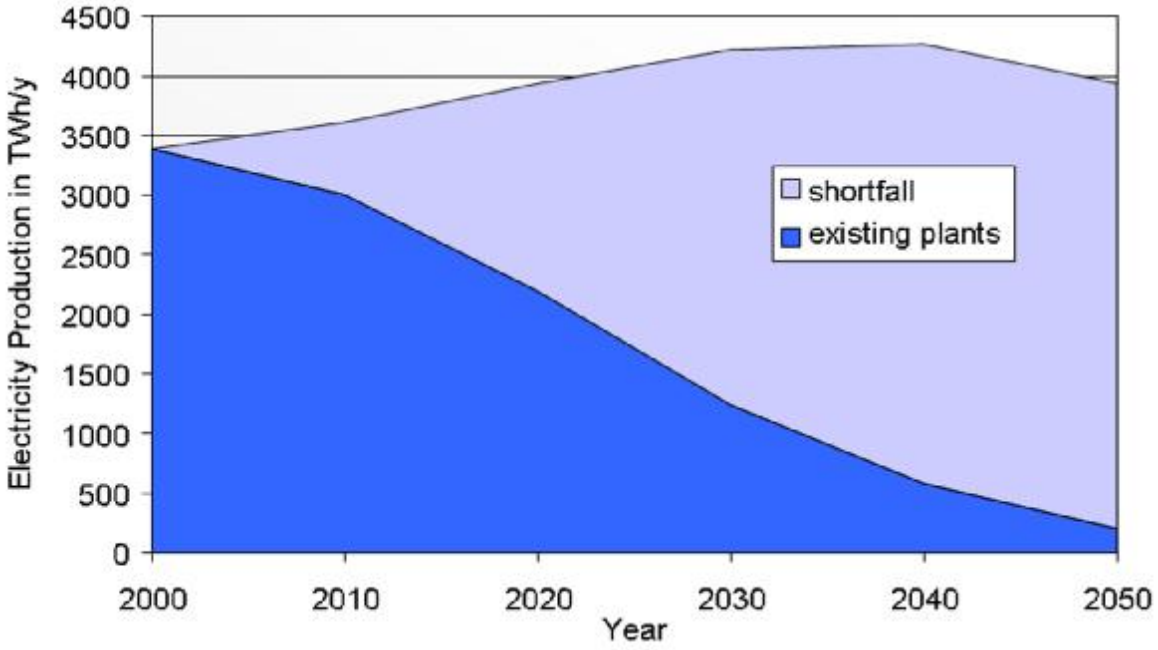


Gross electricity demand in the analysed European countries



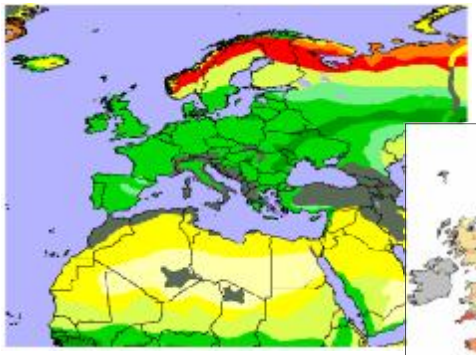
Development of European electricity demand, and its coverage by power plants already existing in 2000

- moderate increase due to efficiency gains and socio-demographic development
- significant investments required to replace “old” plants
- targets for reduced CO_2 emissions and use of renewable resources
- window of opportunity for restructuring of electricity sector
- and to reduce dependency on imported fuels

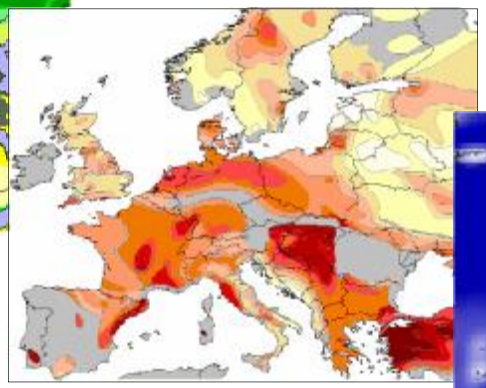


Renewable energy resources in Europe and MENA

Biomass (1)

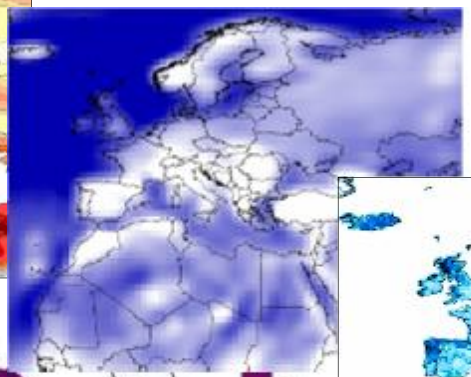


Geothermal (1)

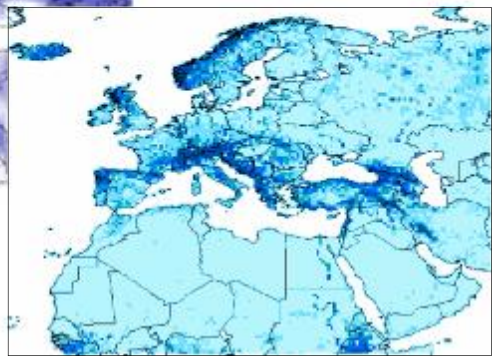


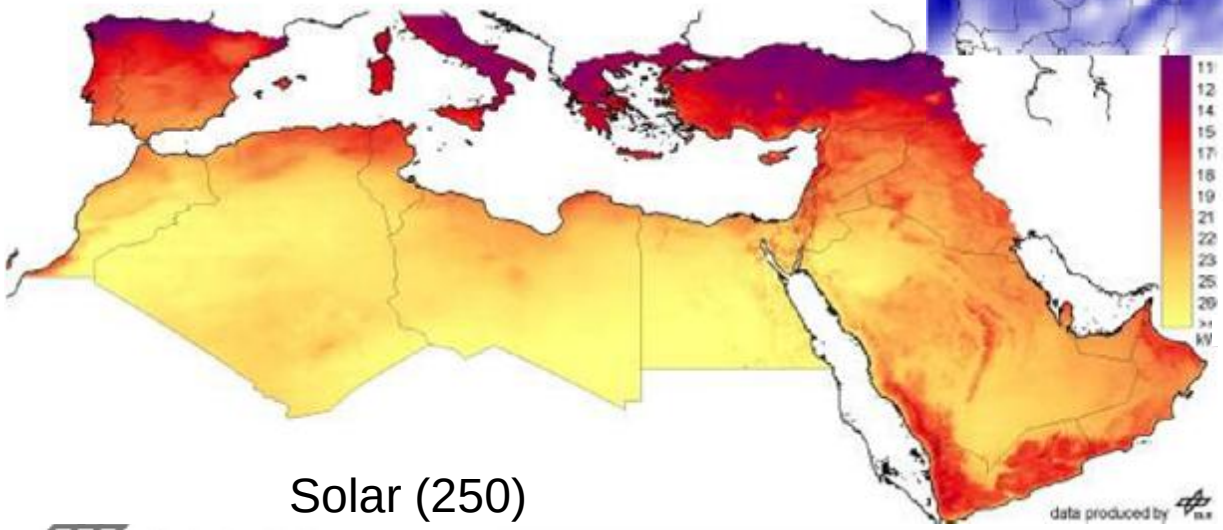
în brackets: (max. yield in GWh_{el} / km^2 /y)

Wind (50)



Hydropower (50)

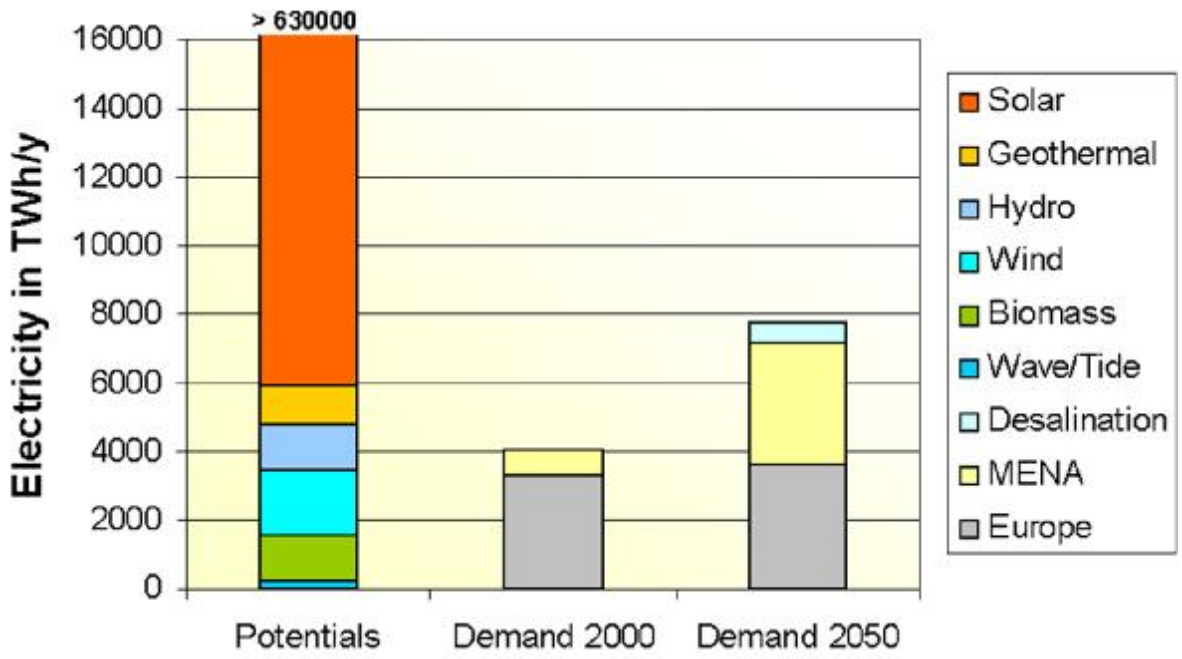




Solar (250)

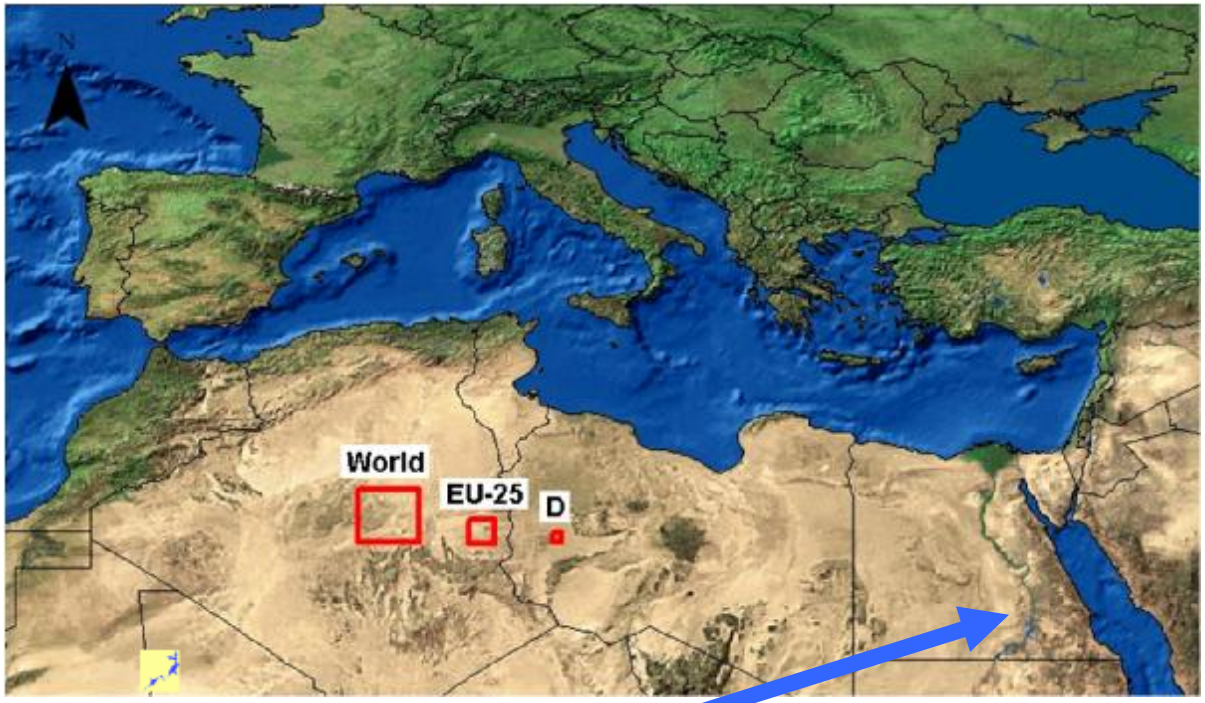
- renewable resources greatly exceed the present and future electricity demands
- solar radiation is by far the most abundant source of energy

Economic renewable electricity potentials vs. demand in Europe and MENA



Economic renewable electricity potentials vs. demand in Europe and MENA

- renewable resources greatly exceed the present and future electricity demands
- solar radiation is by far the most abundant source of energy
- 1 km² of desert land may generate 50 MW of electricity
- 1 km² of desert land may produce 200 - 300 GWh_{el} / year
- 1 km² of desert land avoids 200,000 tons CO_2 / year

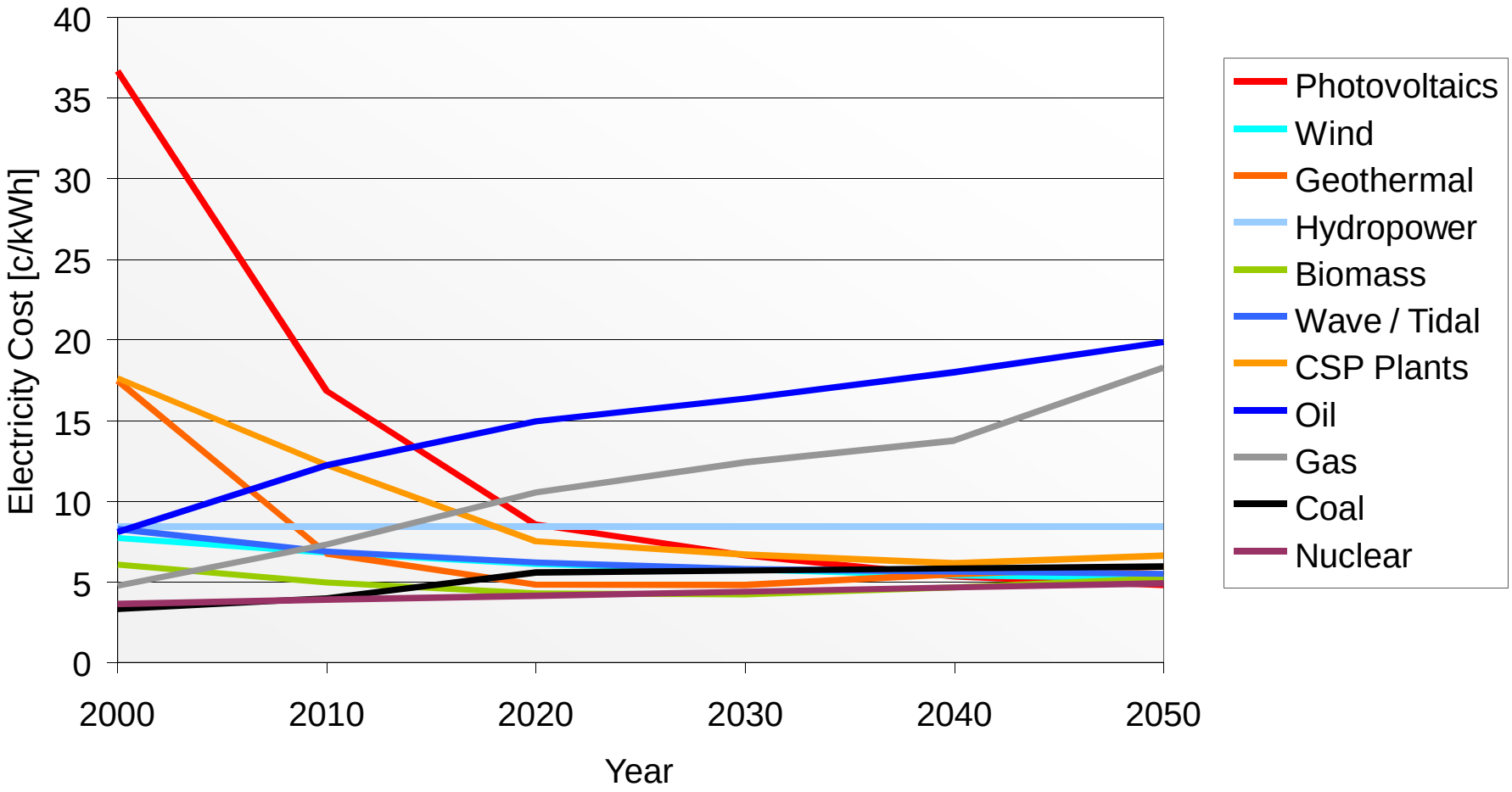


A solar power plant of the size of Lake Nasser equals the total Middle East oil production

Solar thermal power plants are the most effective technology to harvest this vast ressource

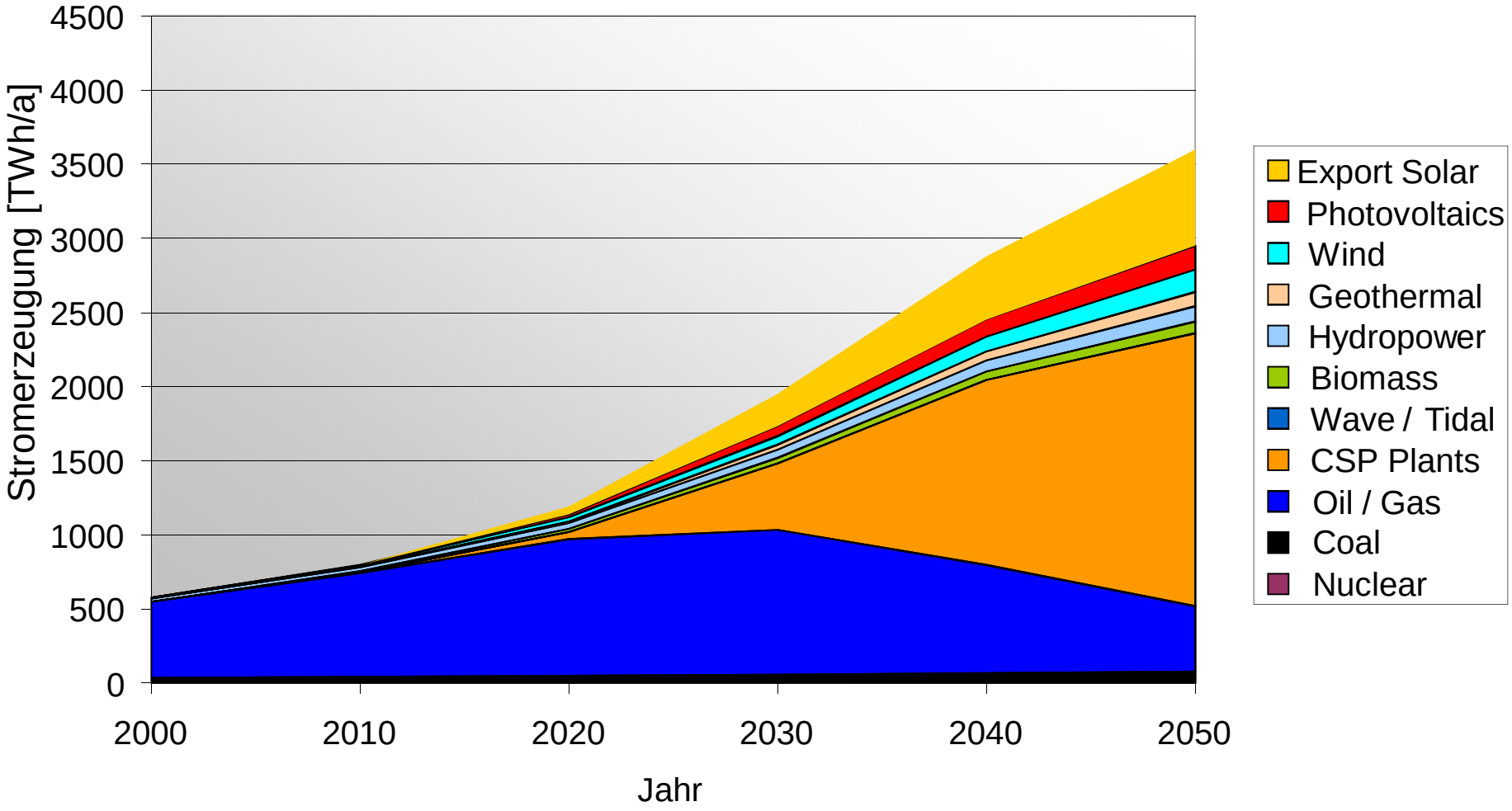
- can be integrated into conventional thermal power plants
- provide firm capacity (thermal storage, fossil backup)
- serve different markets (bulk power, remote power, heat, water)
- have an energy payback time of only 6-12 months
- have the lowest costs for solar electricity

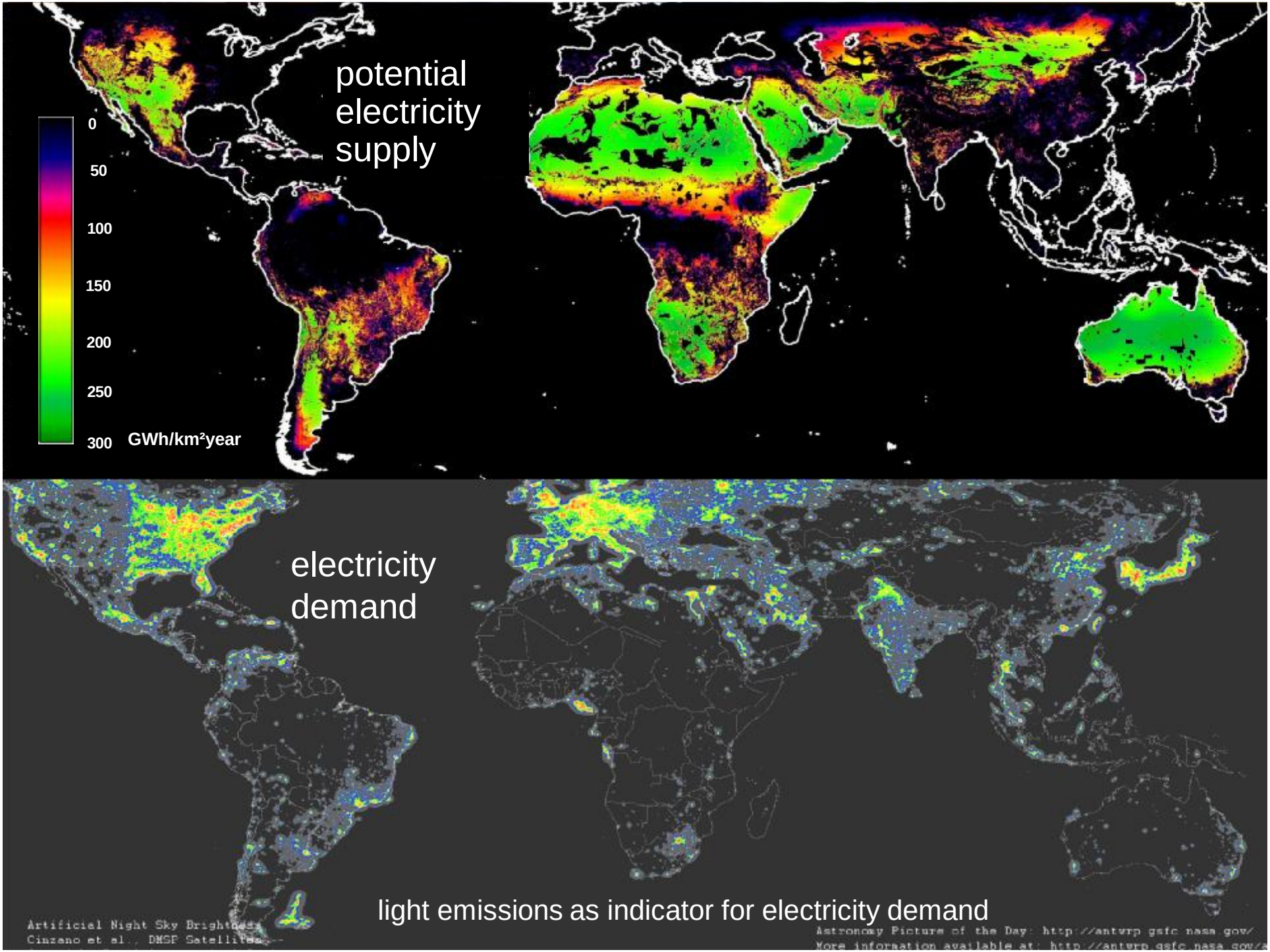
Electricity generation cost of various technologies



CO_2 Capture and Sequestration (CCS) included in fossil fueled generation costs after 2020
CSP in solar only operation

Electricity Supply in the Middle East & North Africa

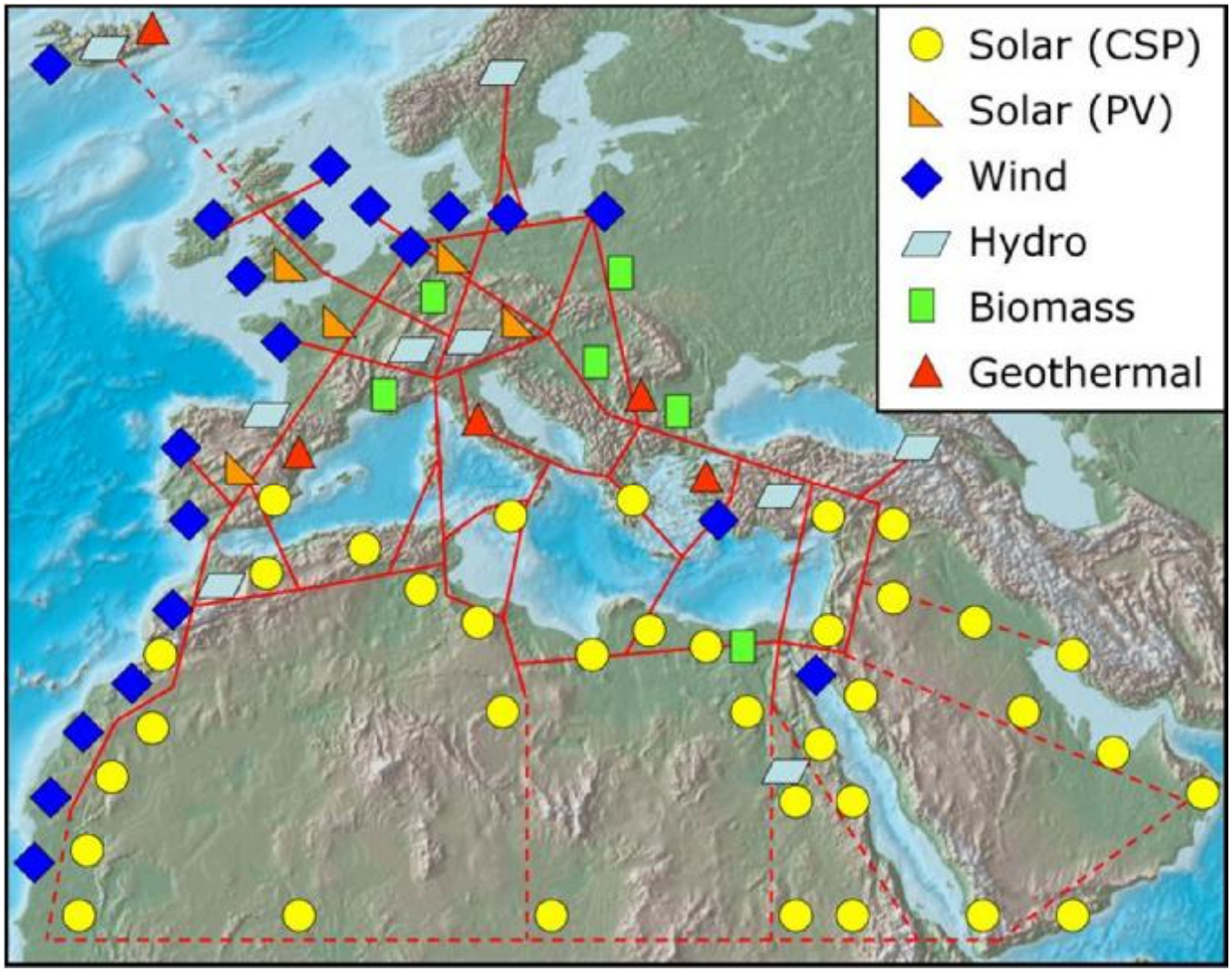



potential
electricity
supply
0
50
100
150
200
250
300
GWh/km²year
electricity
demand
light emissions as indicator for electricity demand
Artificial Night Sky Brightness
Cinzano et al., DMSP Satellites
Astronomy Picture of the Day: http://antwrp.gsfc.nasa.gov/
More information available at: http://antwrp.gsfc.nasa.gov/a

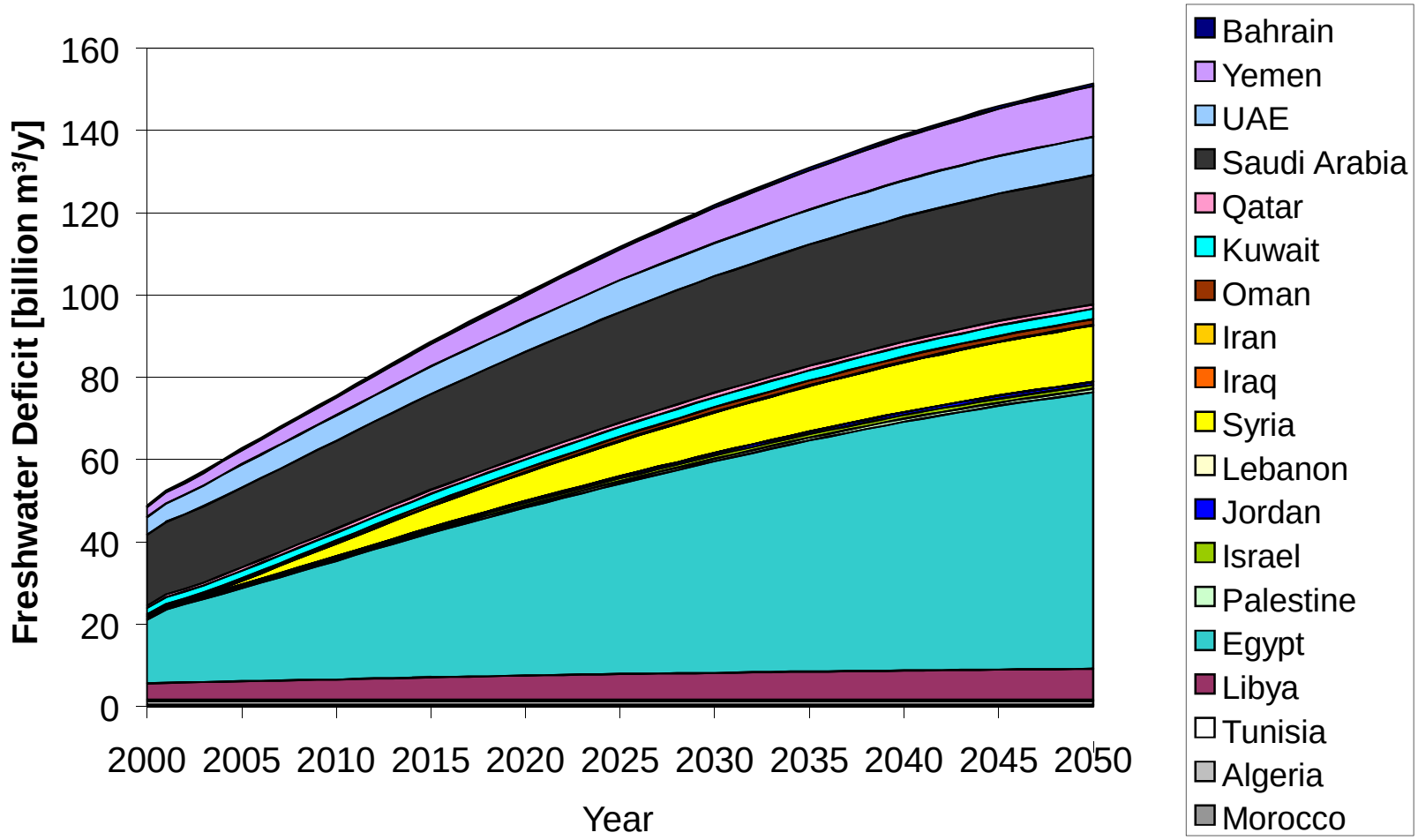
Options for solar electricity transfer over 3000 km distance

Solar Power Transfer by:	**Hydrogen**
Losses	75 %
Cost	very high
Adaptation to Consumers (Transformer)	has to be transformed to AC first
Over Sea Transport	by tankers or pipelines
Visibility Impact	very low
Materials and Emissions	moderate
Preferred Application	eventually fuel for transport

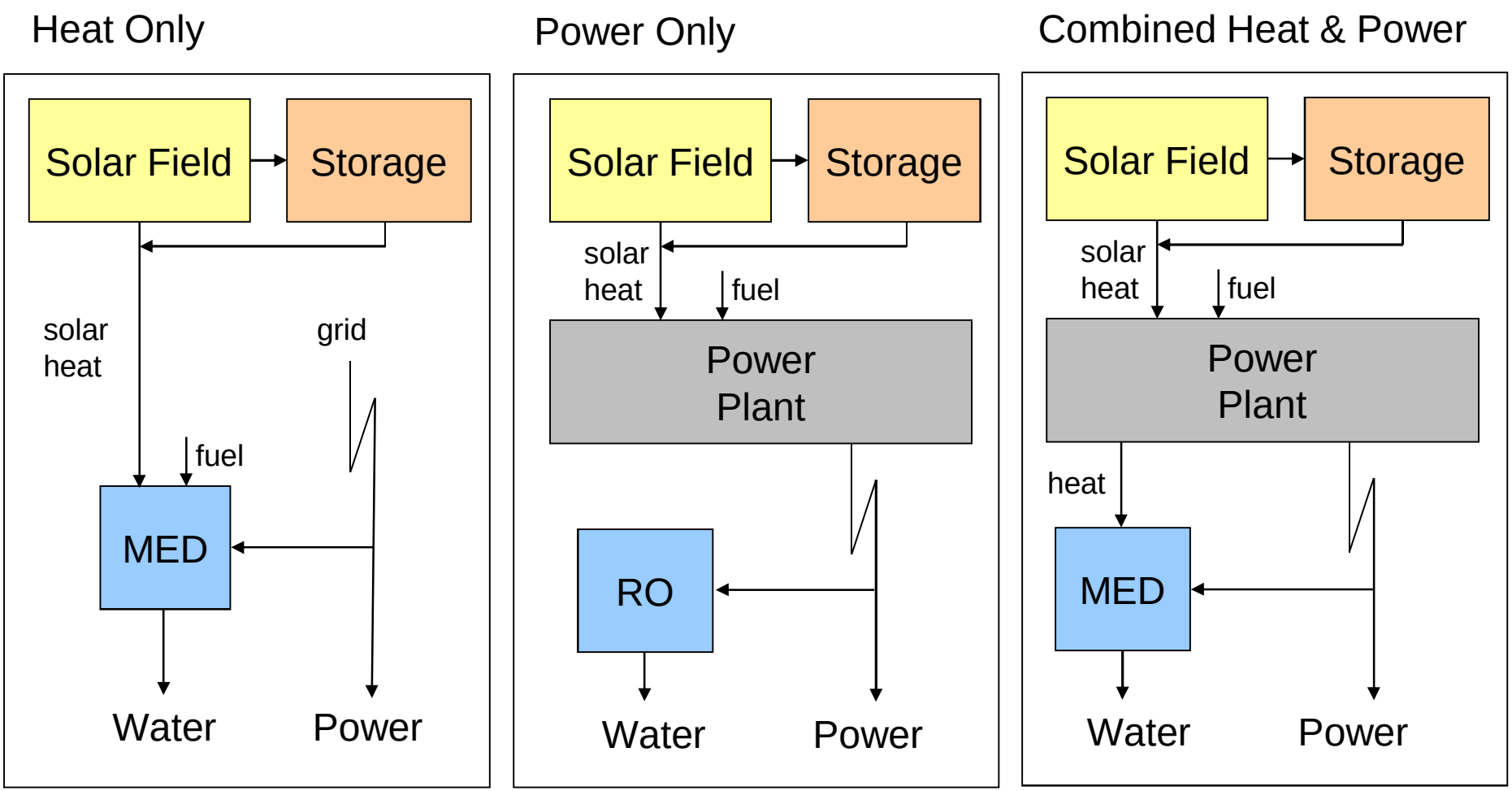
Concept of a EU-MENA Renewable Energy Link Using HVDC Power Transmission Technology



Expected Water Deficits by Country

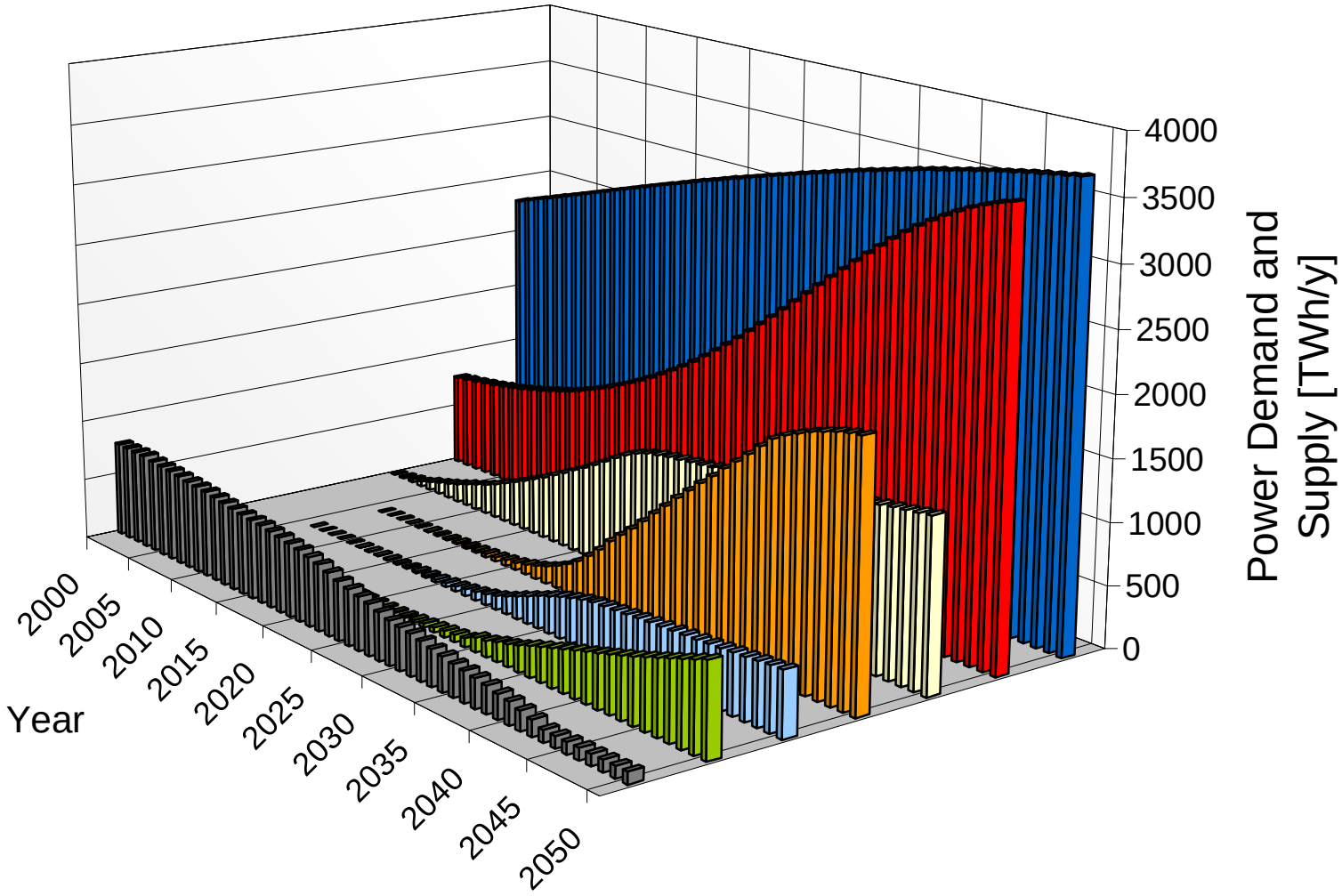


Concentrating Solar Thermal Power for Seawater Desalination (Options)



MED: Multi-Effect-Distillation; RO: Reverse Osmosis Membrane Desalination

Electricity and fresh water provision in MENA



Conclusions

- The potential for electrical power generation from renewable energies available in EU-MENA by far exceeds present and future electricity demands. Solar energy is by far the most abundant source of energy.
- Solar electricity from concentrating solar power stations in MENA can provide firm capacity for base load, intermediate and peaking power.
- With this technology, MENA countries will be able to secure their own electricity demands, produce the required fresh water by desalination, and generate income by exporting electricity to Europe.
- The most efficient and economic way to transfer electricity from MENA to Europe is via high voltage direct current transmission lines, adding about 1.5-2 cents/kWh to the local generating cost.
- By 2050, 700 TWh/y solar electricity could be imported from 20 locations in MENA, providing about 15 % of European electricity demand.
- To establish and maintain such a trans-national HVDC electricity grid, strong political support will be required.

for more information look at

www.dlr.de/tt/med-csp

www.dlr.de/tt/trans-csp

www.dlr.de/tt/aqua-csp