Part 1: Sustainability in the Electricity Sector

Franz Trieb

MBA Energy Management, Vienna, September 9-10, 2010

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

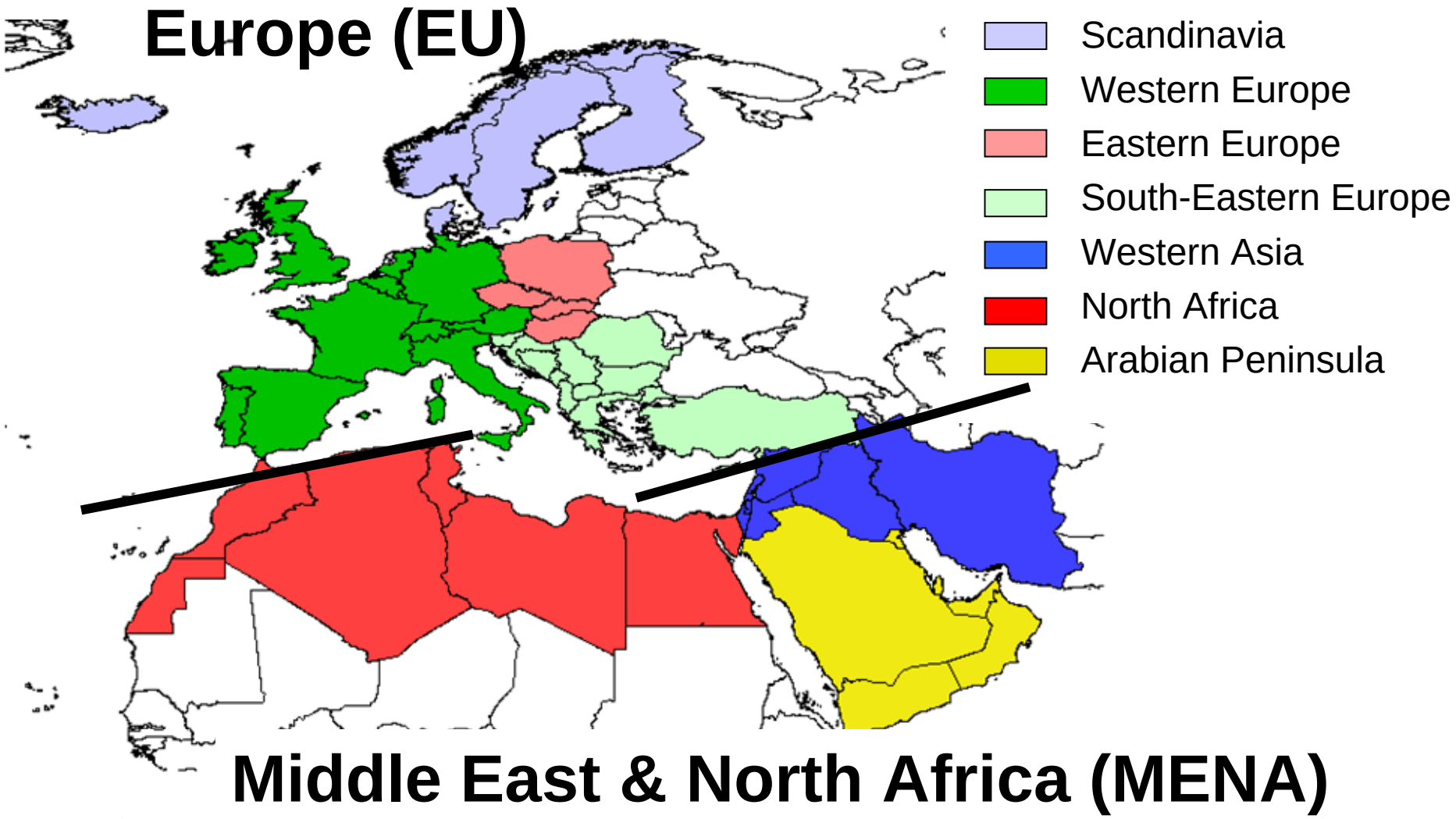
A Scenario for Sustainability

Studies:

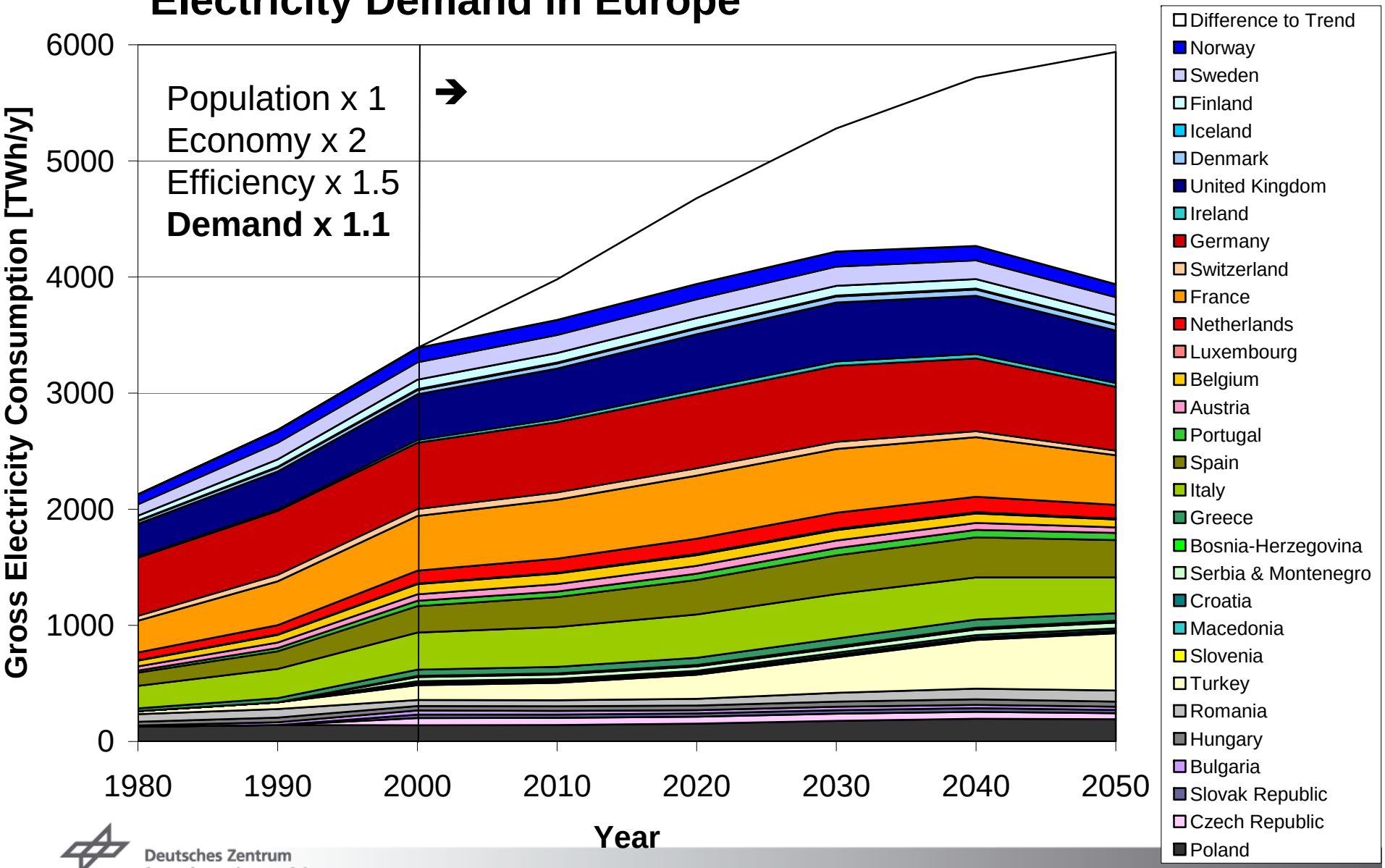
Assessment of the renewable energy potential for the sustainable supply of electricity and water in 50 countries of Europe, the Middle East and North Africa taking into consideration the option of Concentrating Solar Power (CSP).

Bundesministerium
für Umwelt, Naturschutz
und Reaktorsicherheit

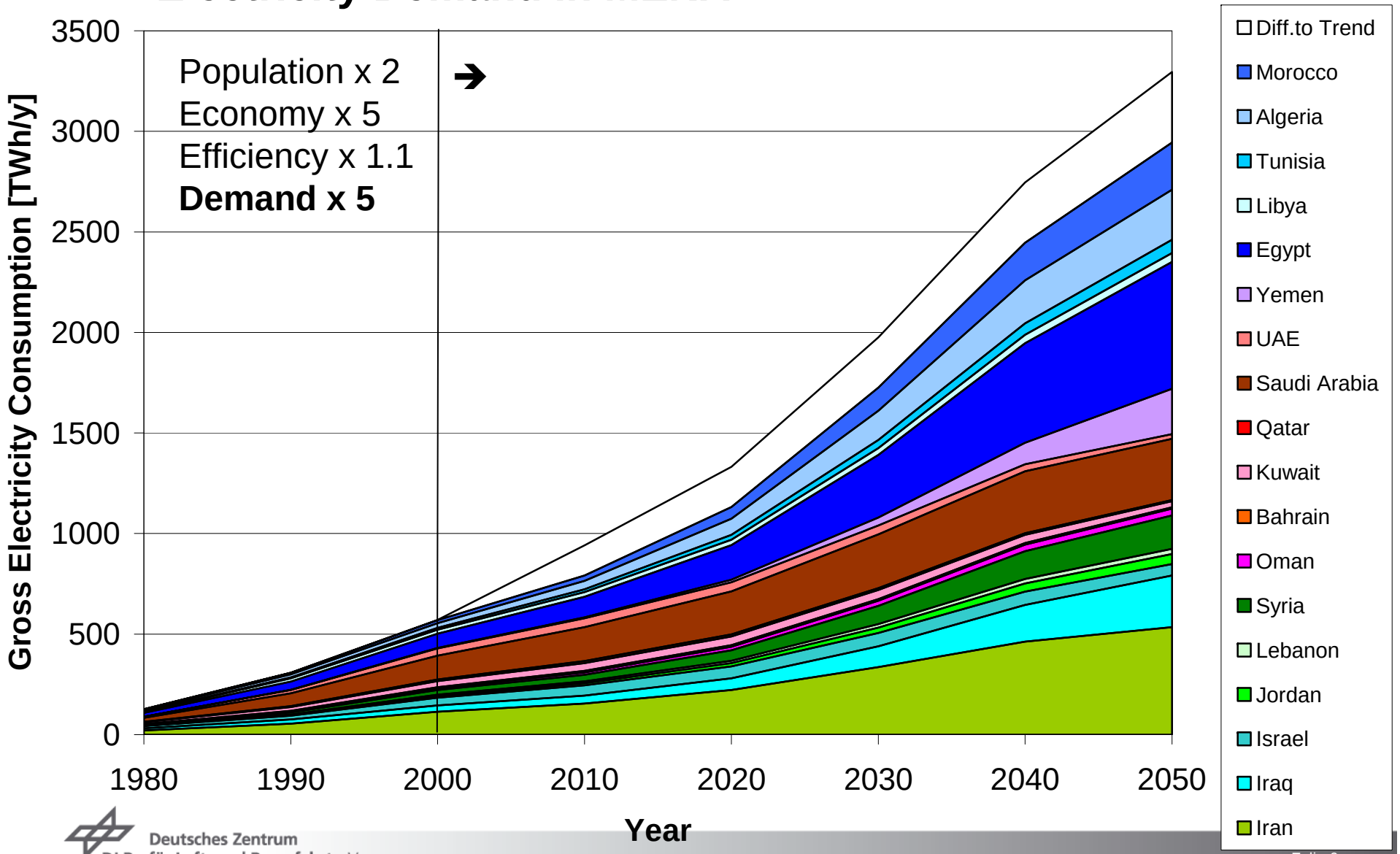
50 Countries in EUMENA analysed



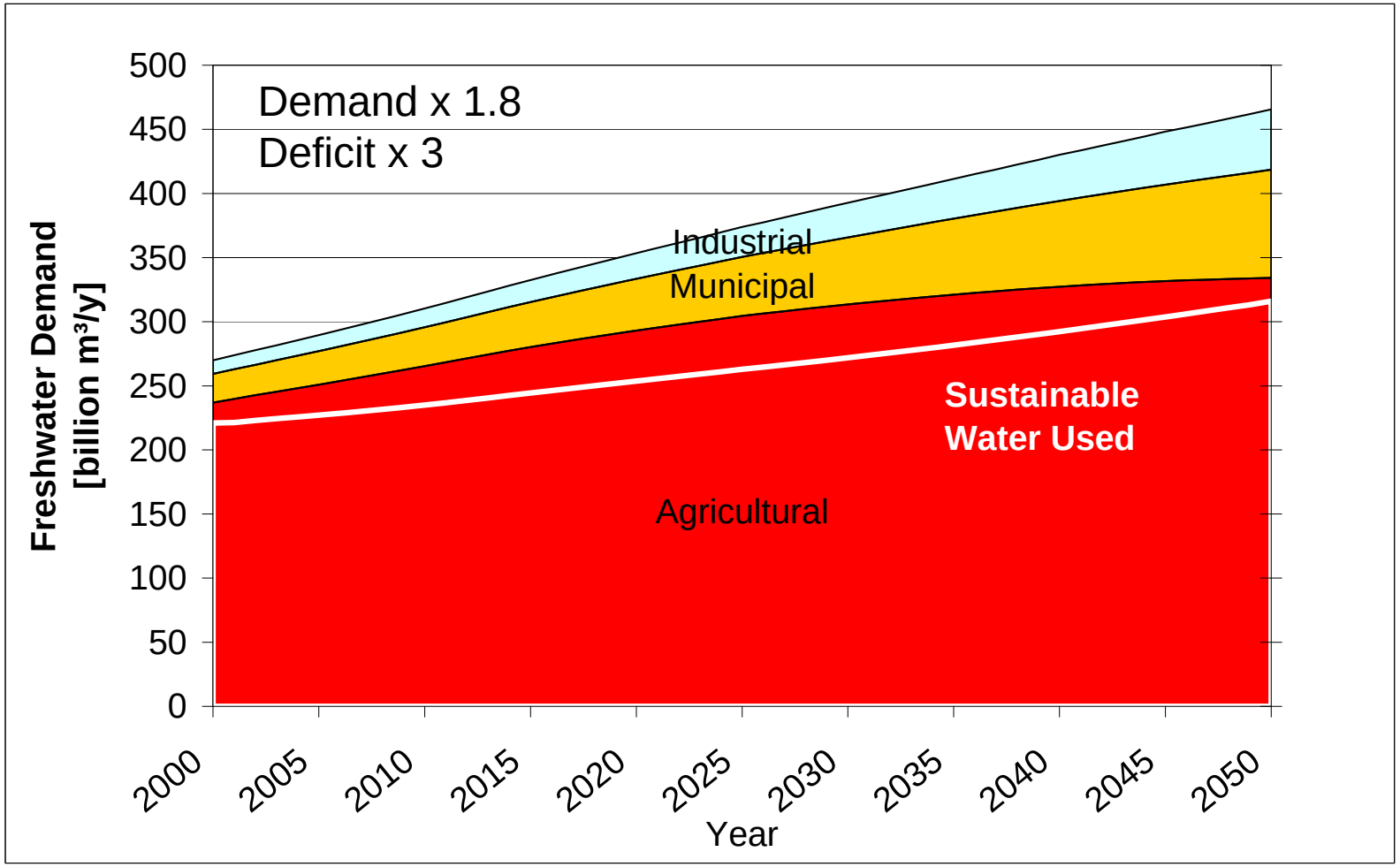
Electricity Demand in Europe



Electricity Demand in MENA



Water Demand in MENA



Criteria for Sustainable Electricity Supply:

✓ **Inexpensive**

low electricity cost
no long term subsidies

✓ **Secure**

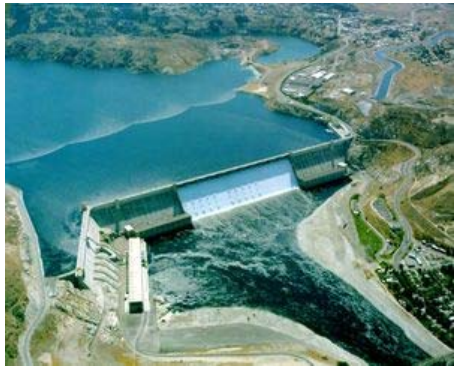
diversified and redundant supply
power on demand
based on inexhaustible resources
available or at least visible technology
capacities expandable in time

✓ **Compatible**

low pollution
climate protection
low risks for health and environment
fair access

Renewable Energy Technologies

Geothermal



Hydropower

Concentrating Solar Power

Biomass

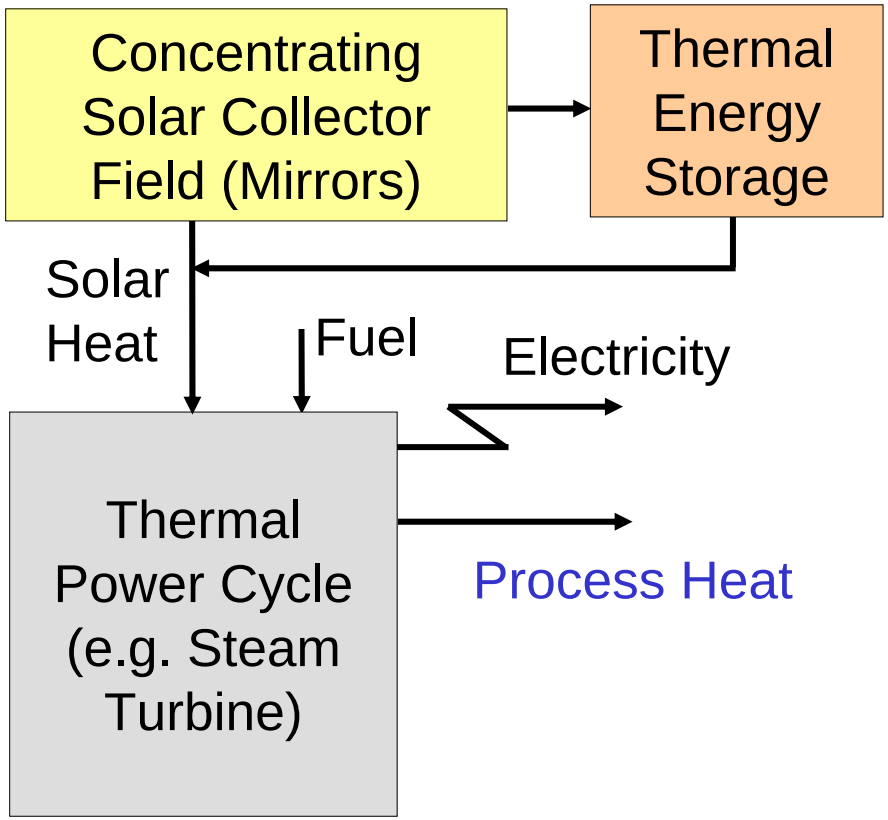
Tides

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

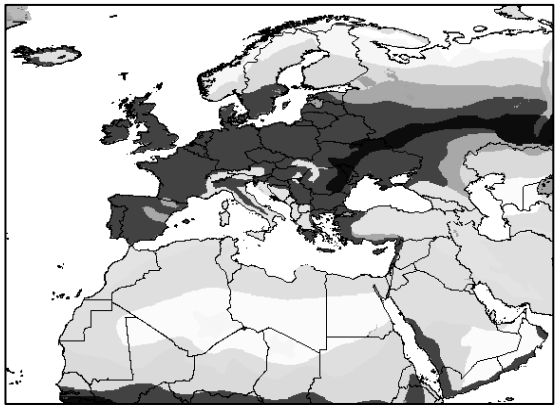
} storable primary energy

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

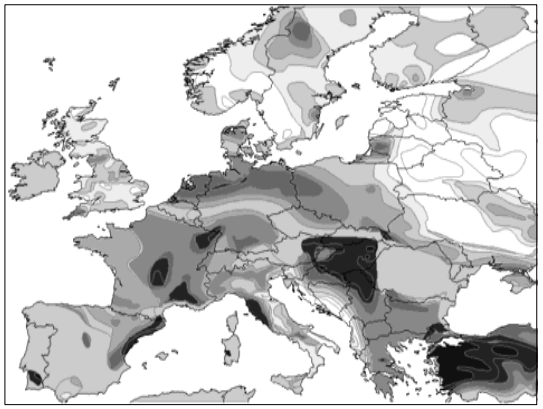
} fluctuating primary energy

Renewable Electricity Potential in Europe, Middle East & North Africa

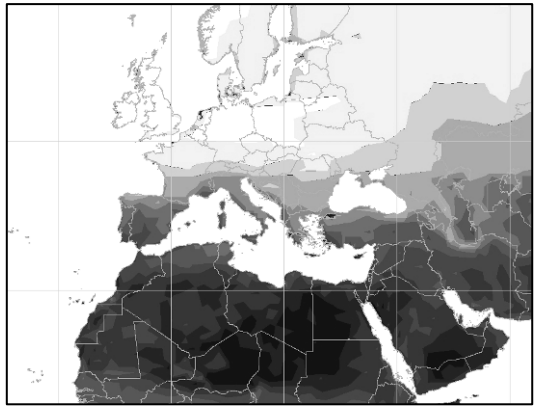
Biomass (0-1)

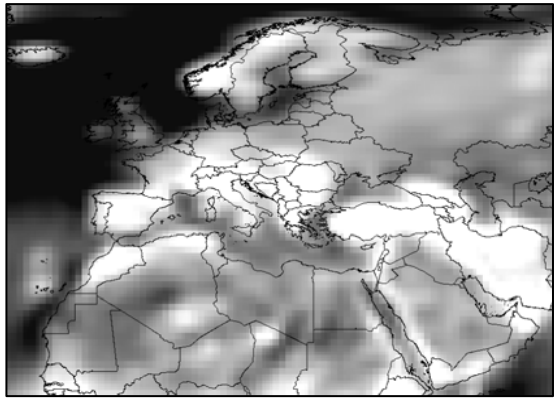


Geothermal (0-1)

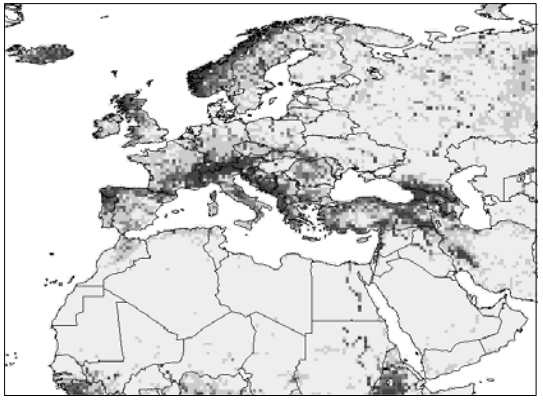


Solar (10-250)





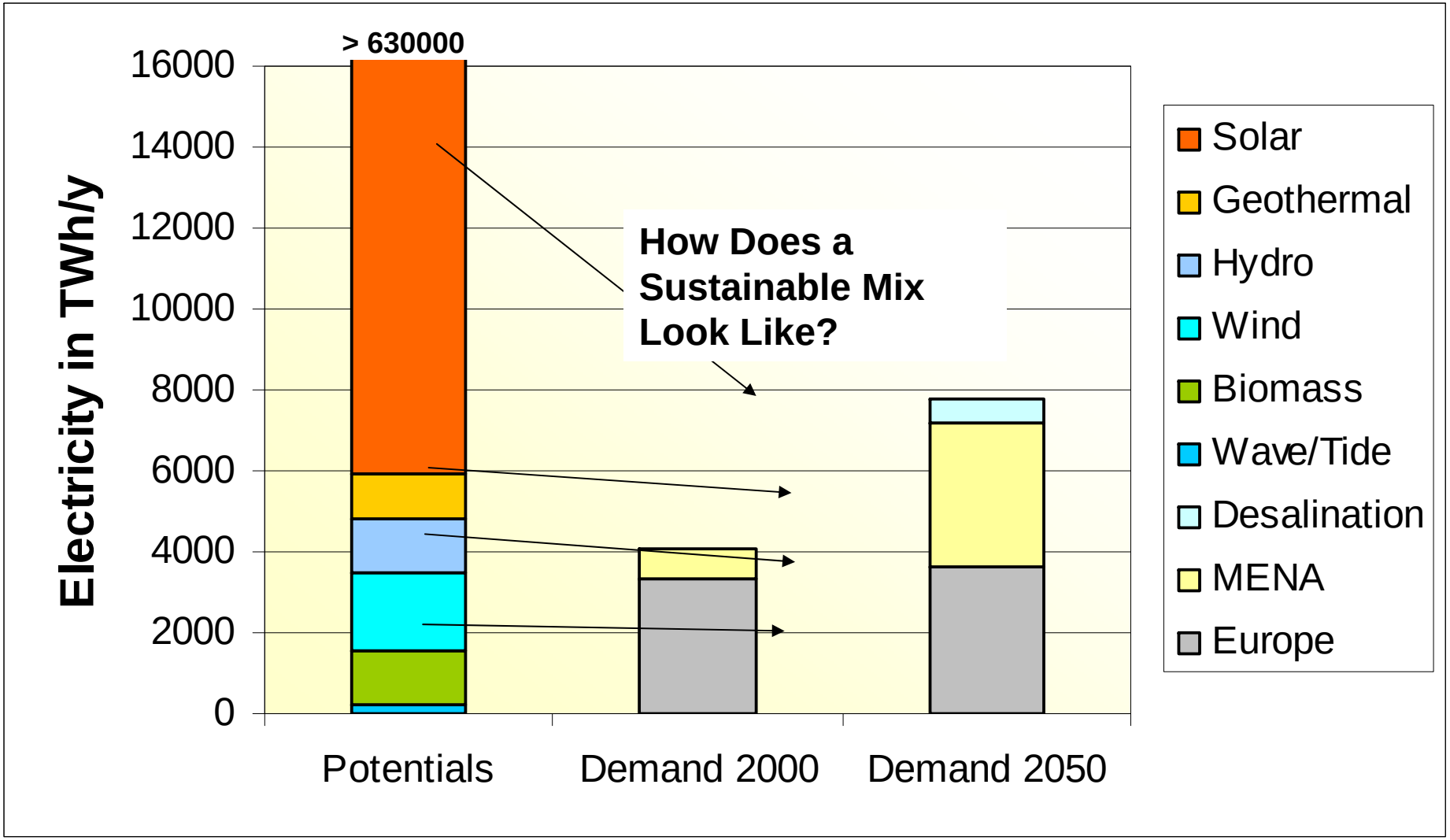
Wind Energy (5-50)



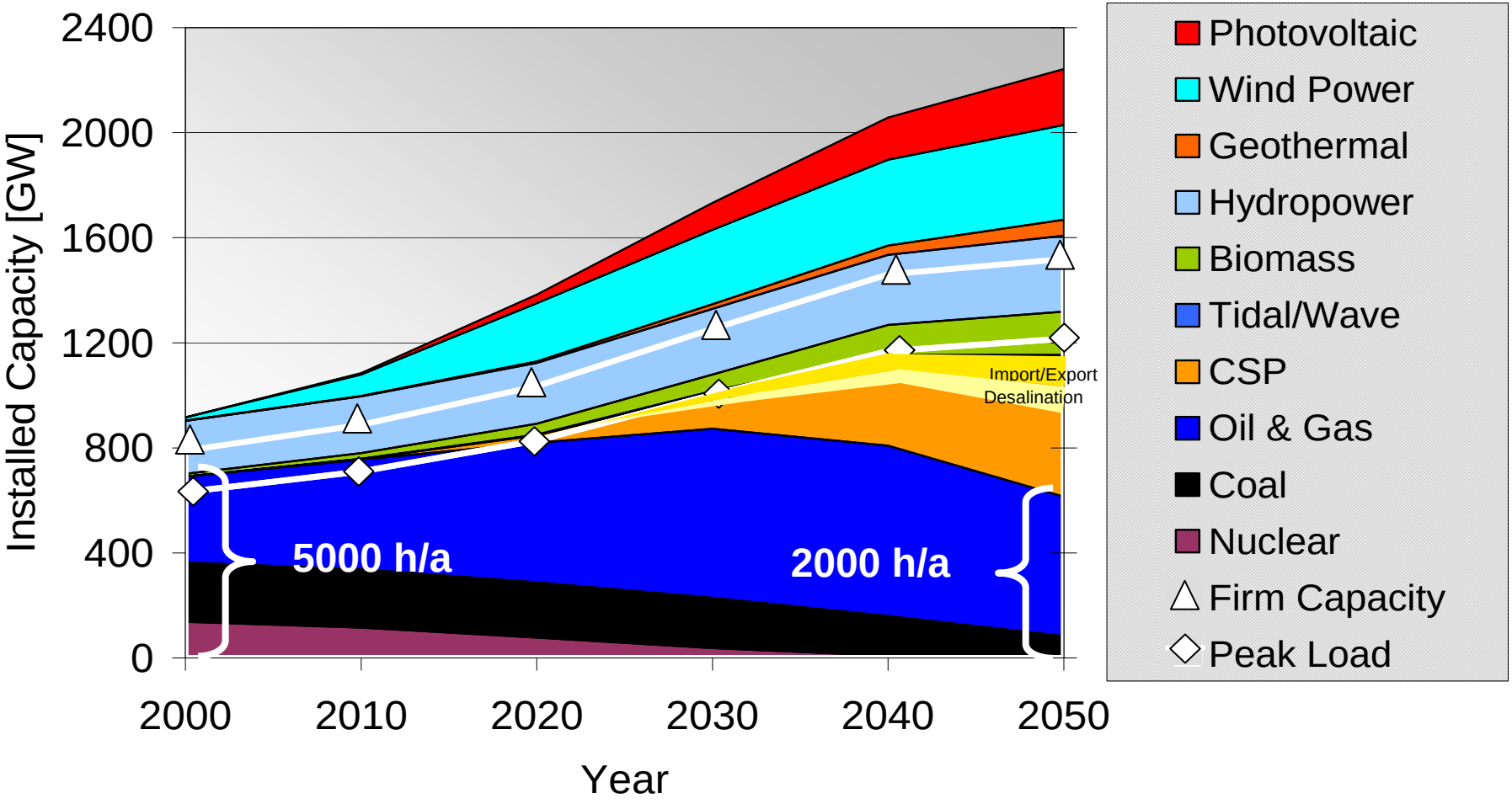
Hydropower (0-50)

Electricity Yield
in GWh/km²/y

Economic Renewable Electricity Potentials vs. Demand in EUMENA

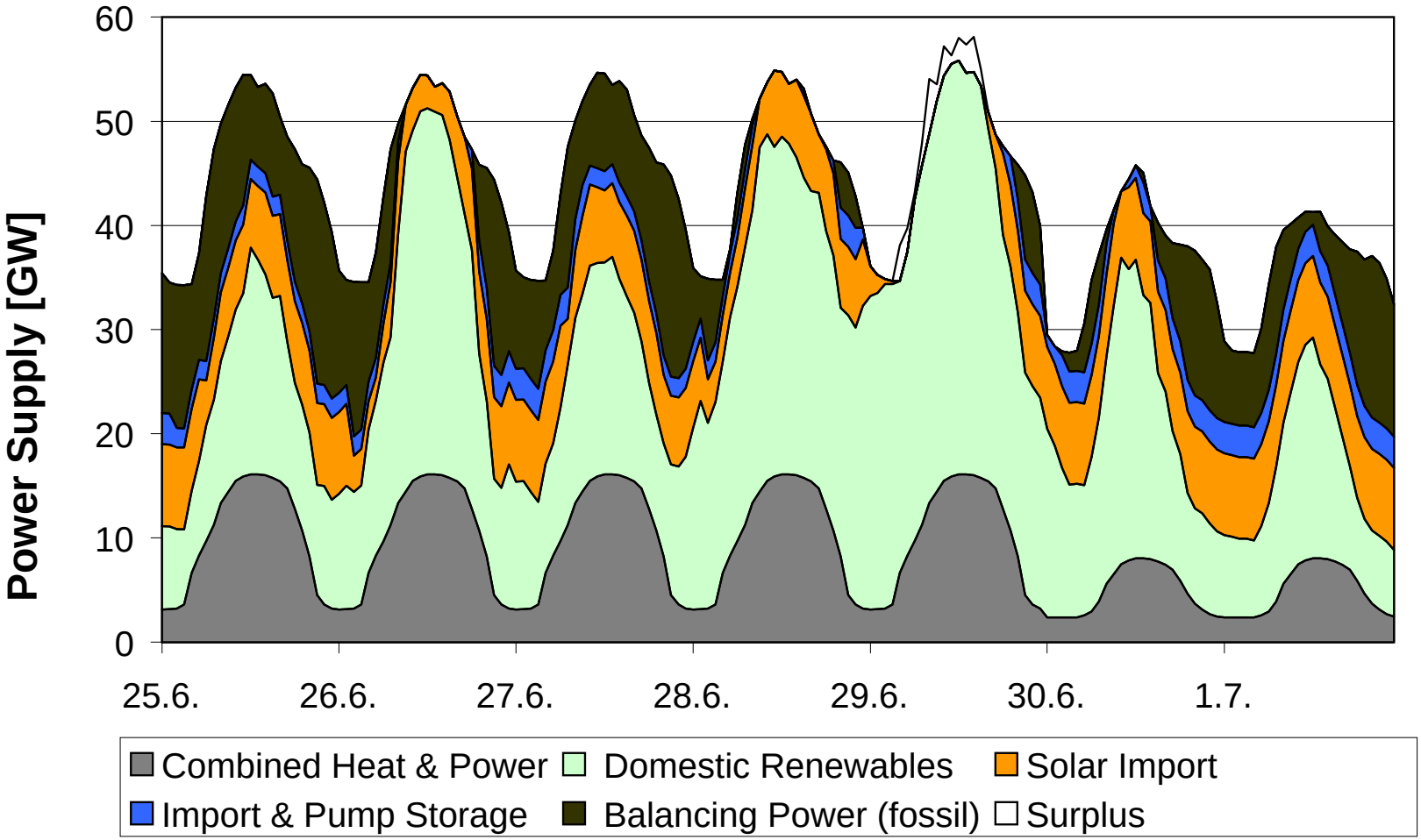


Installed Capacity vs. Peak Load in EUMENA

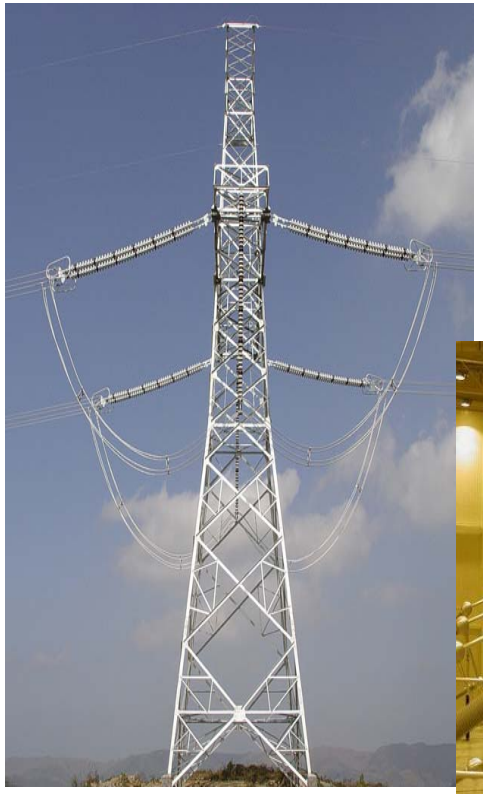


➔ 100 % availability plus 25 % reserve capacity

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



High Voltage Direct Current Transmission

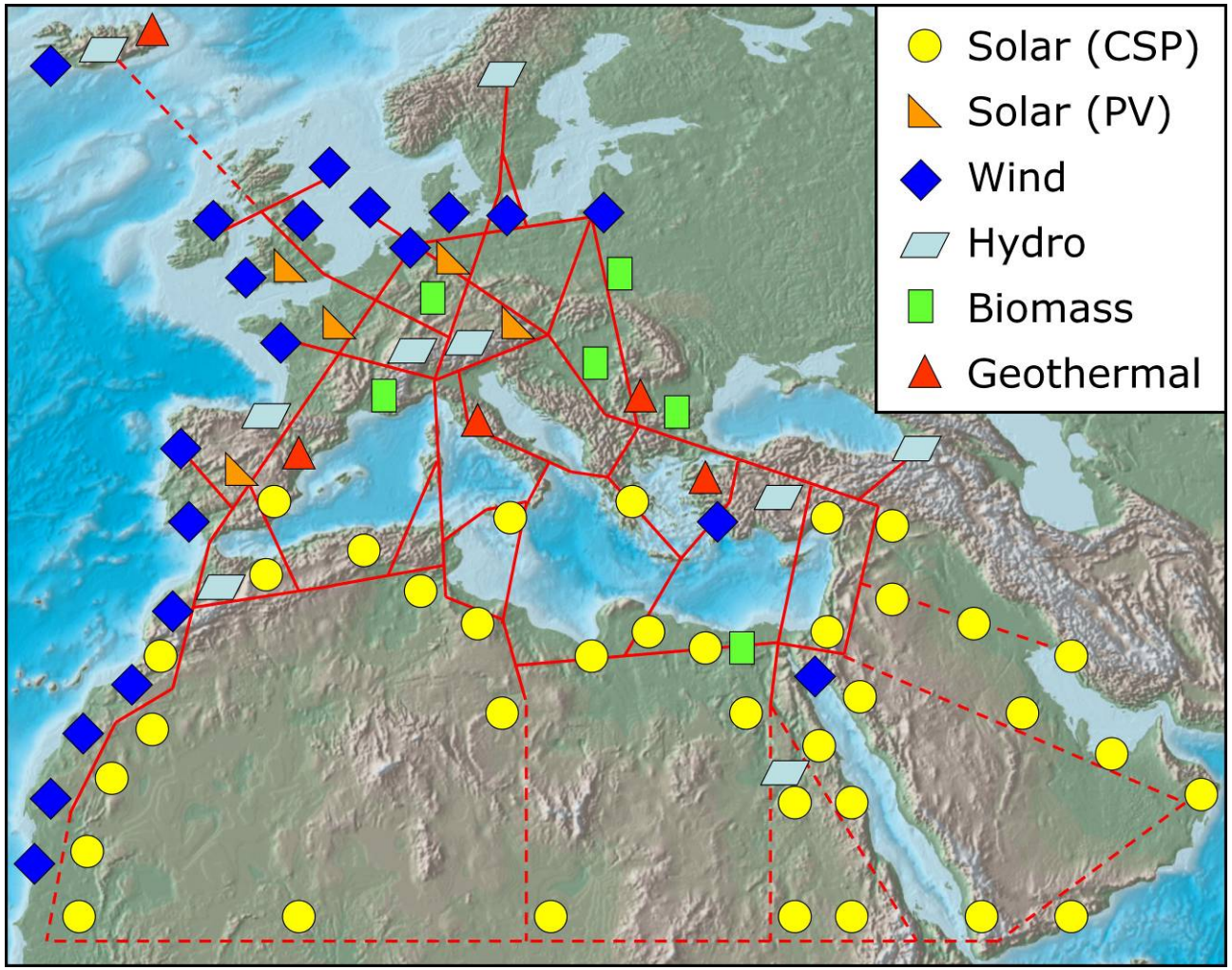


Voltage:	± 800.000 Volt
Power:	6400 Megawatt
Length:	2070 km
Source:	Hydropower
Losses:	7-8%
Construction:	2 years

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

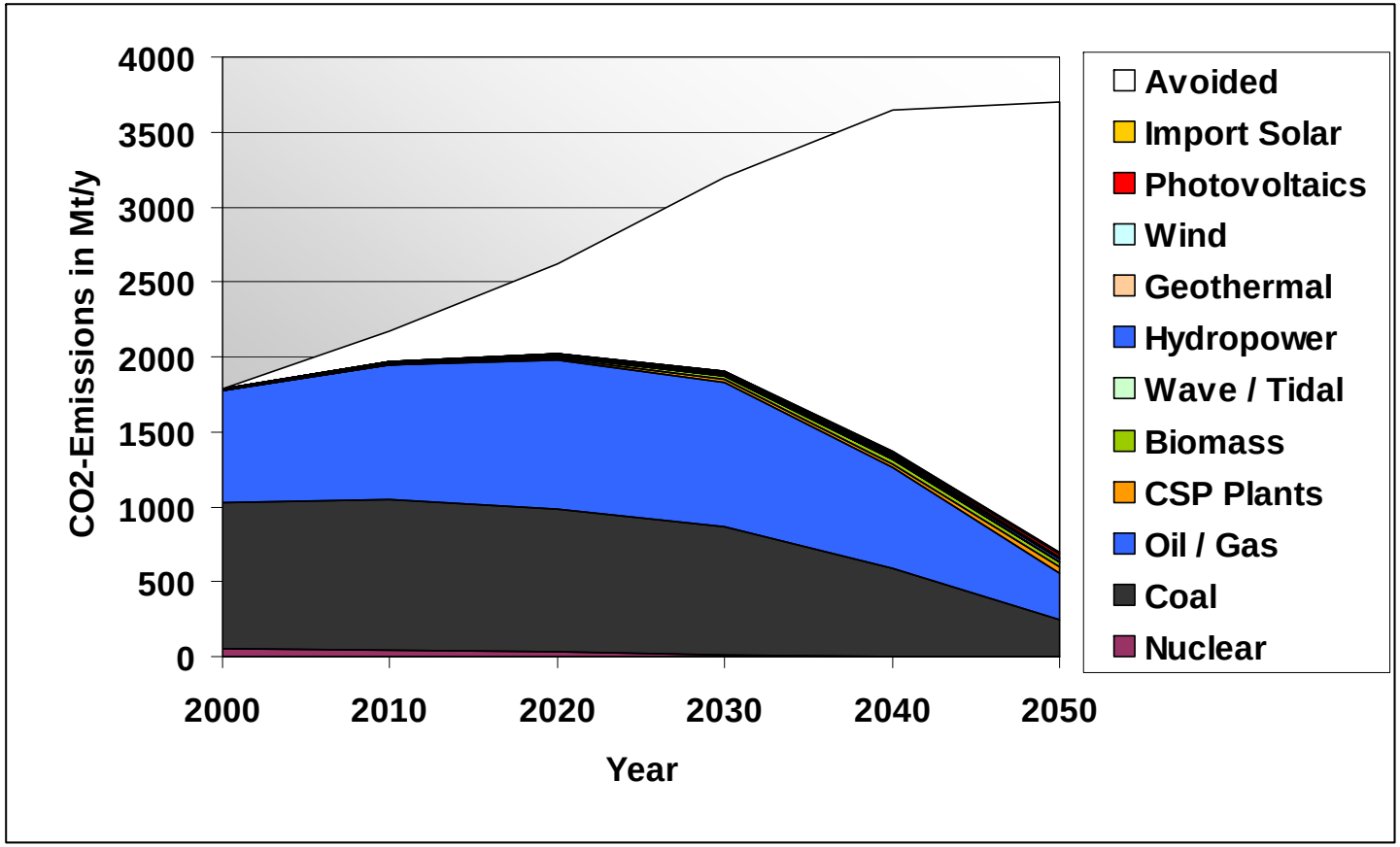


EUMENA:
Europe
Middle East
North Africa

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

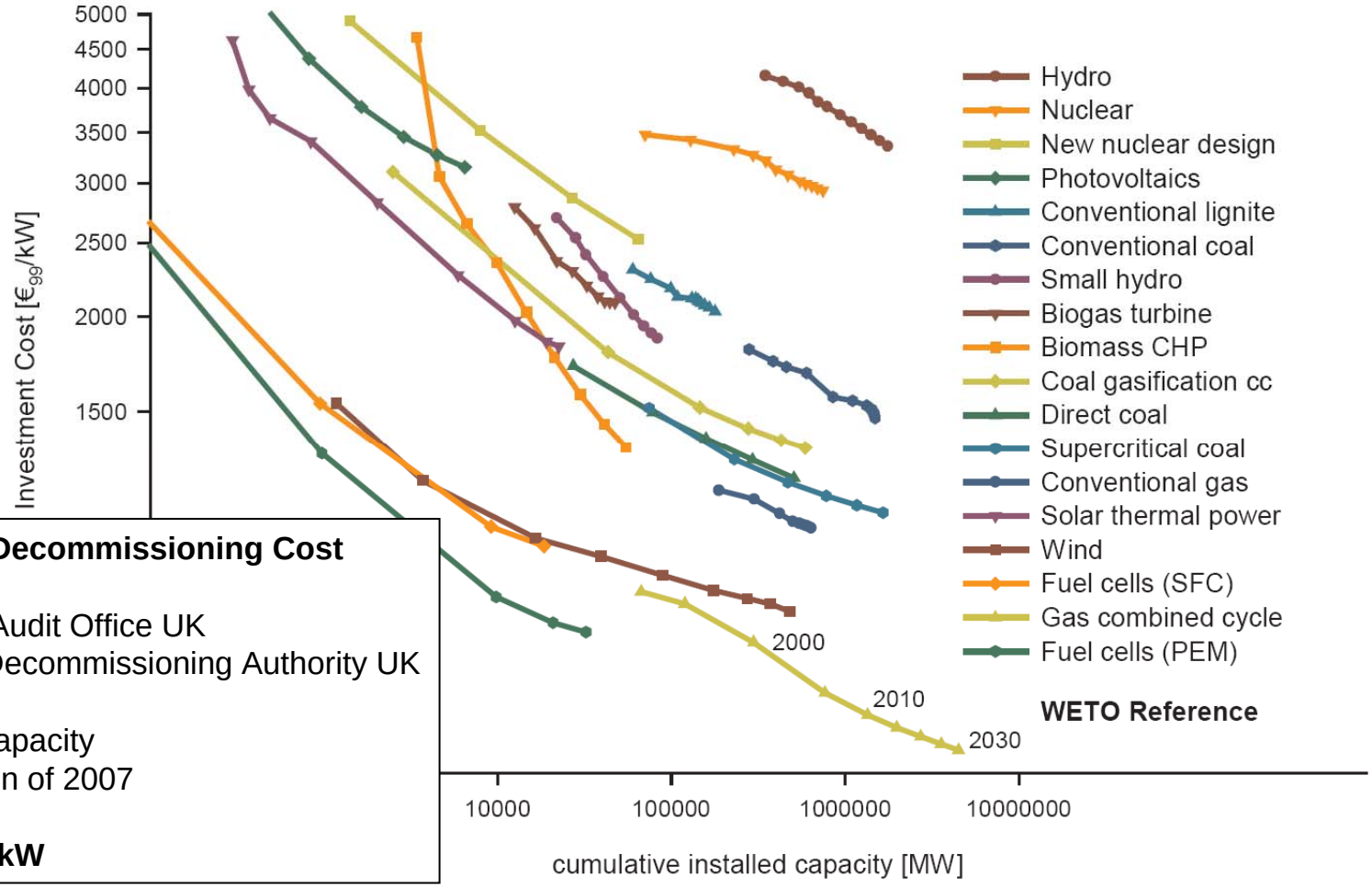


1% of Land Area Required

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

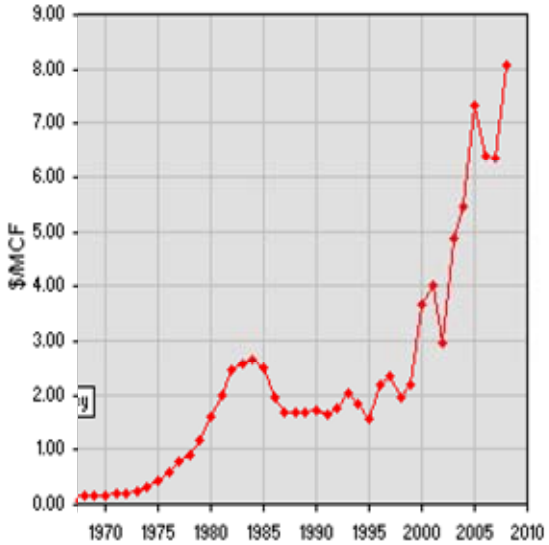
11 GW Capacity
61 £ Billion of 2007

= 6000 €/kW

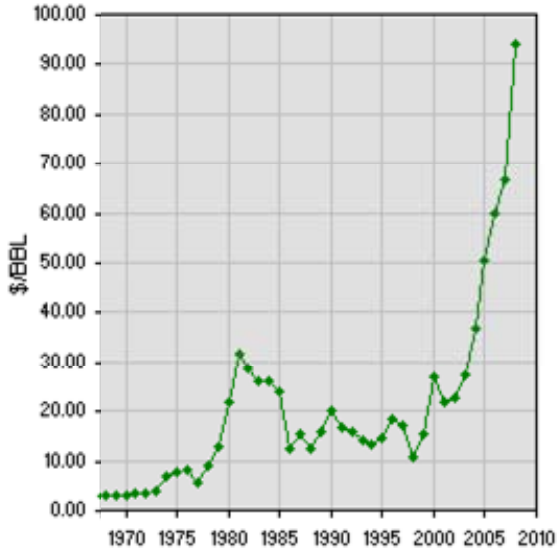
Fuel Cost Perspectives?

Coal Price

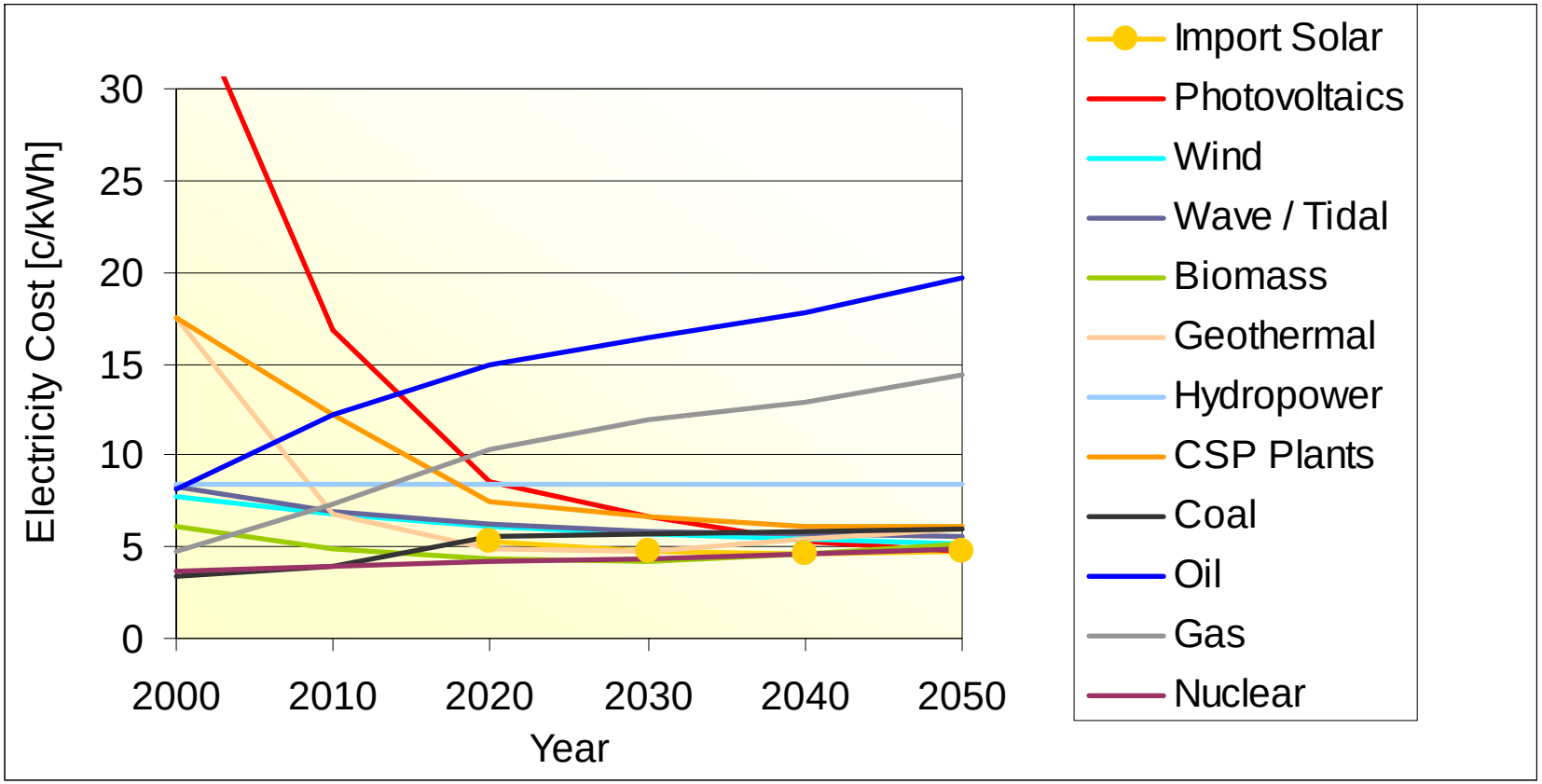
Natural Gas Price

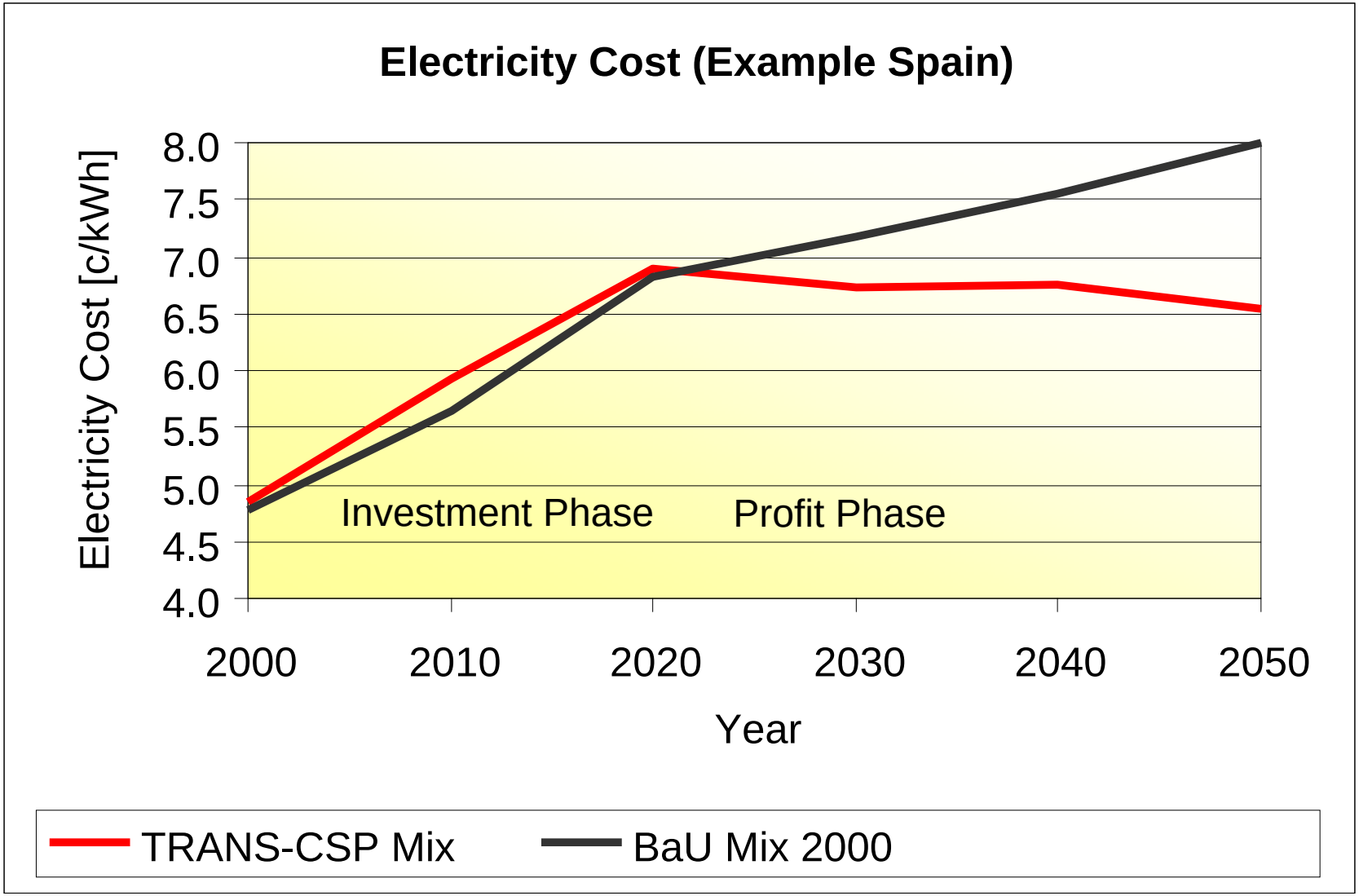


Crude Oil Price



Electricity Cost Learning Curves (example Spain)



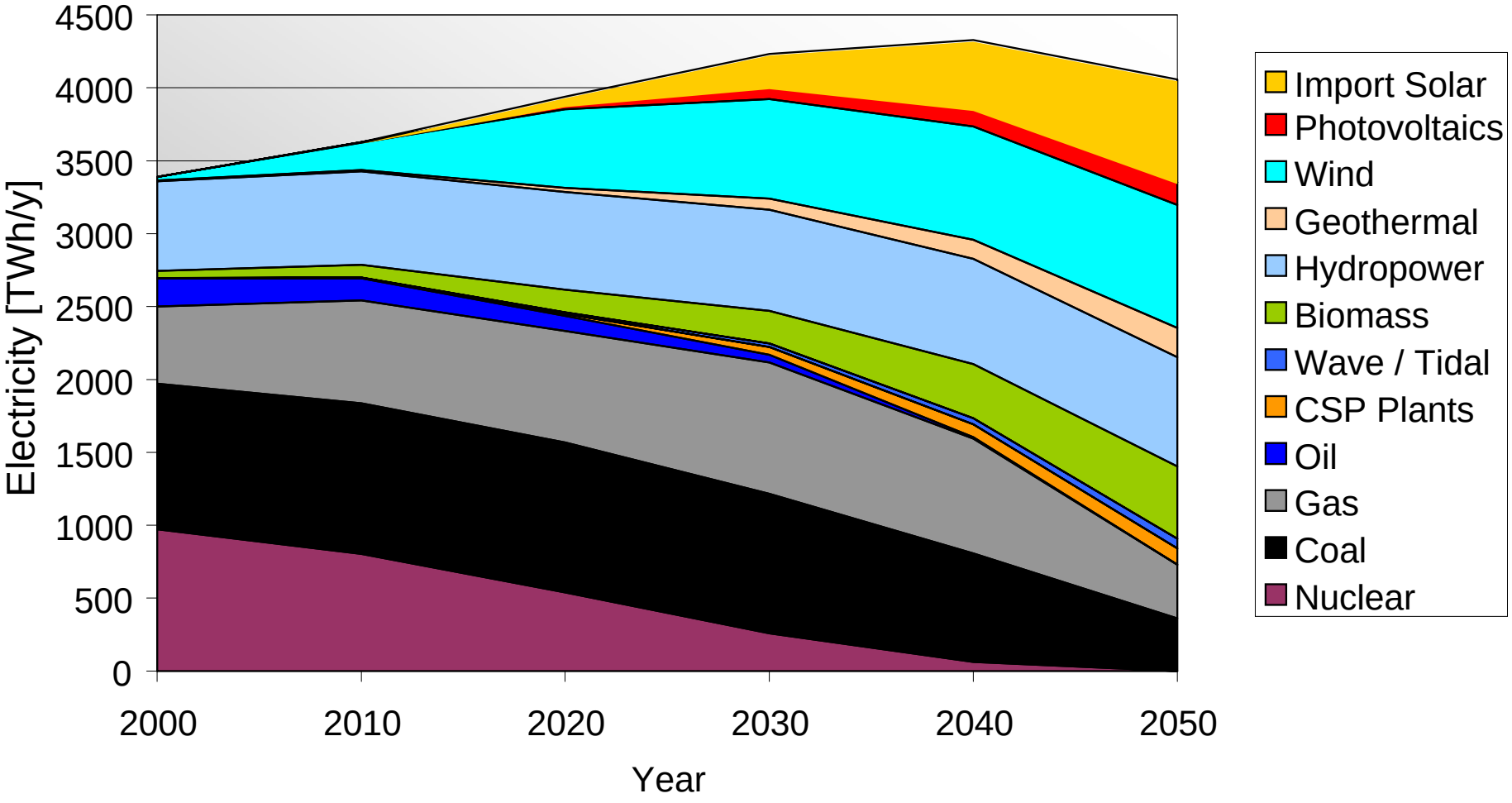


$€_{2000}$, Fuel Cost: IEA / WEO 2005, after 2020 CCS

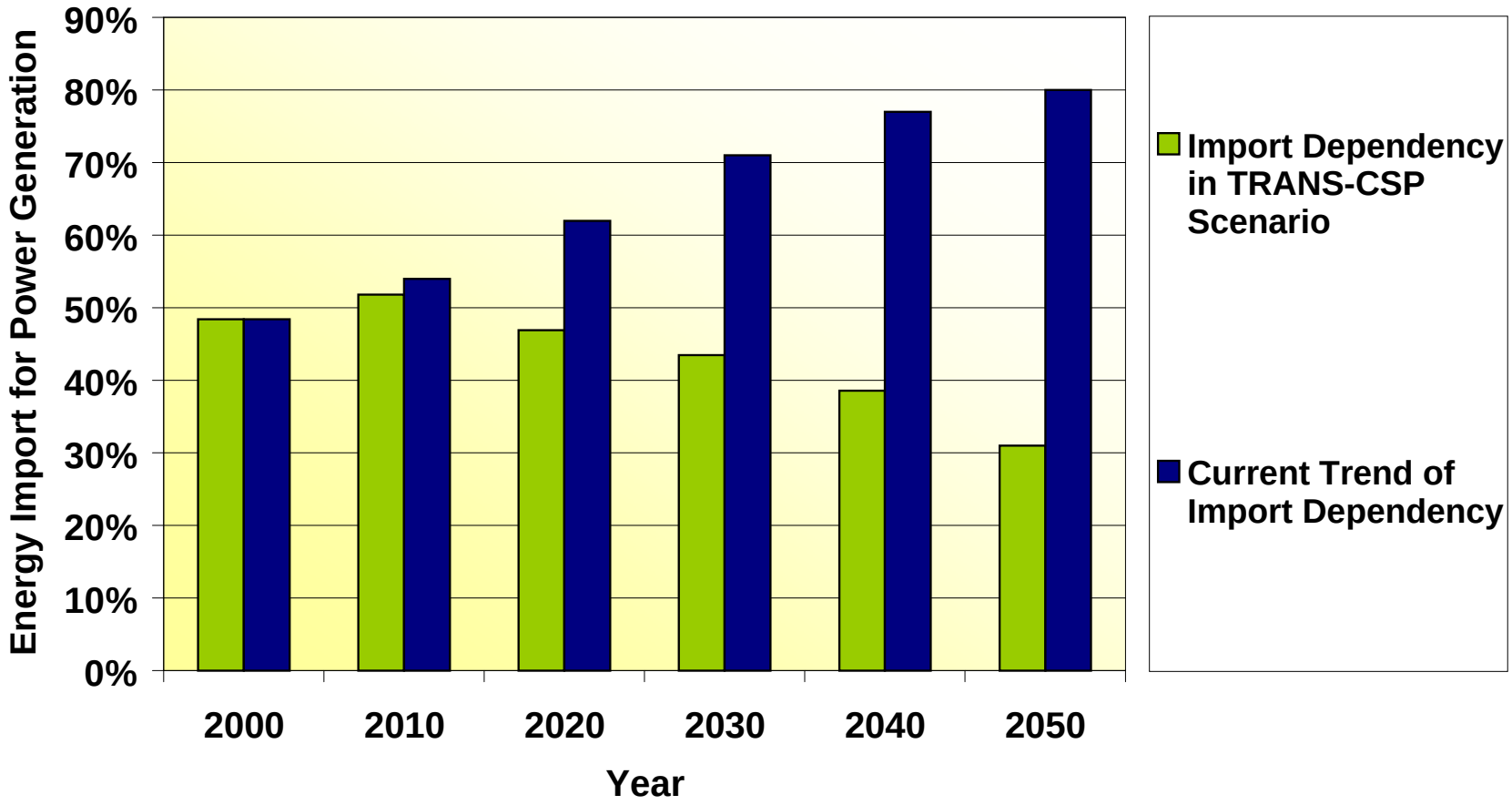
Economic Security

- 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

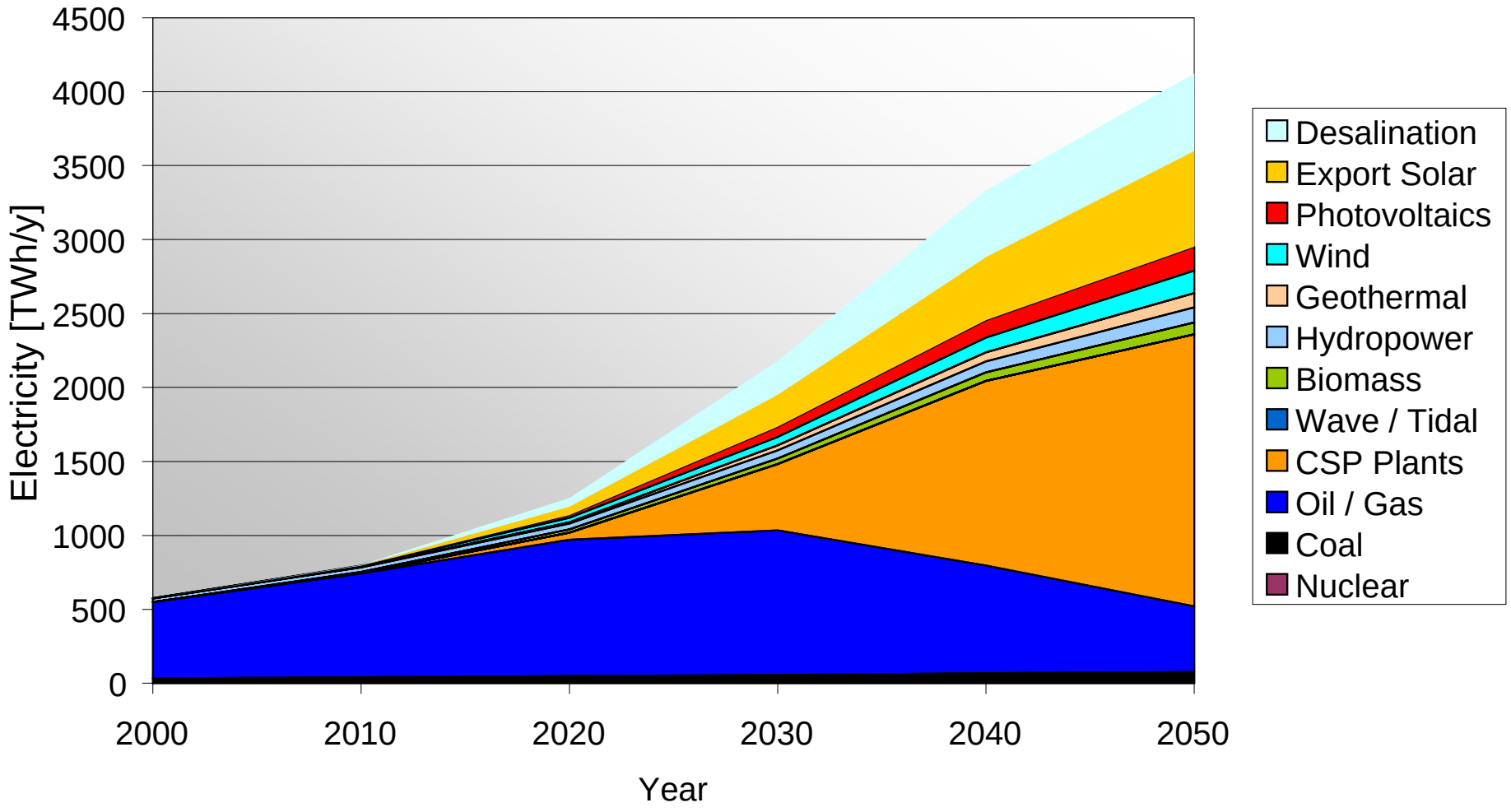
Electricity Supply in Europe (TRANS-CSP Scenario)



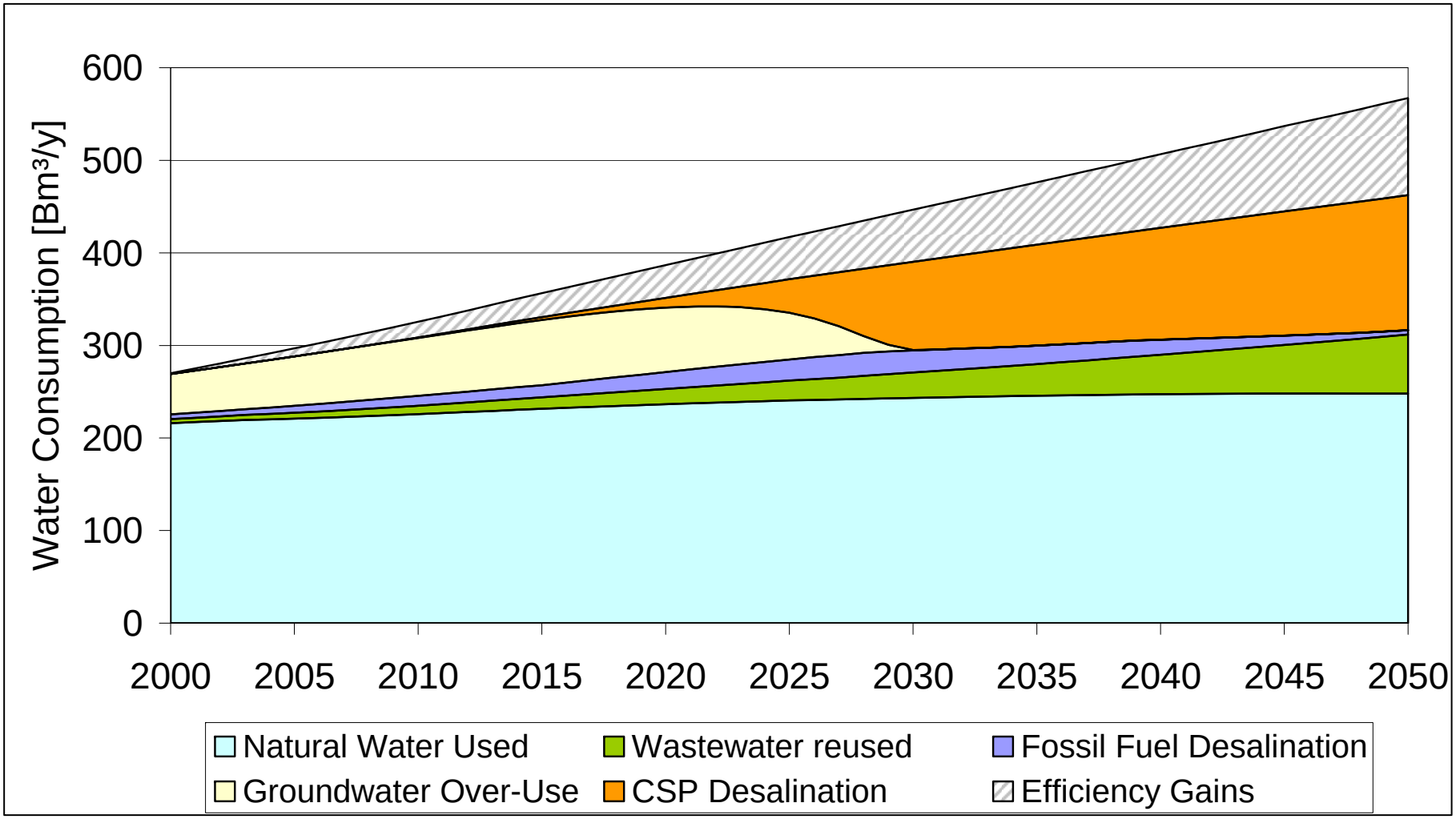
Import Dependency of European Power Generation



Electricity Supply in the Middle East & North Africa



AQUA-CSP Scenario for Middle East & North Africa



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

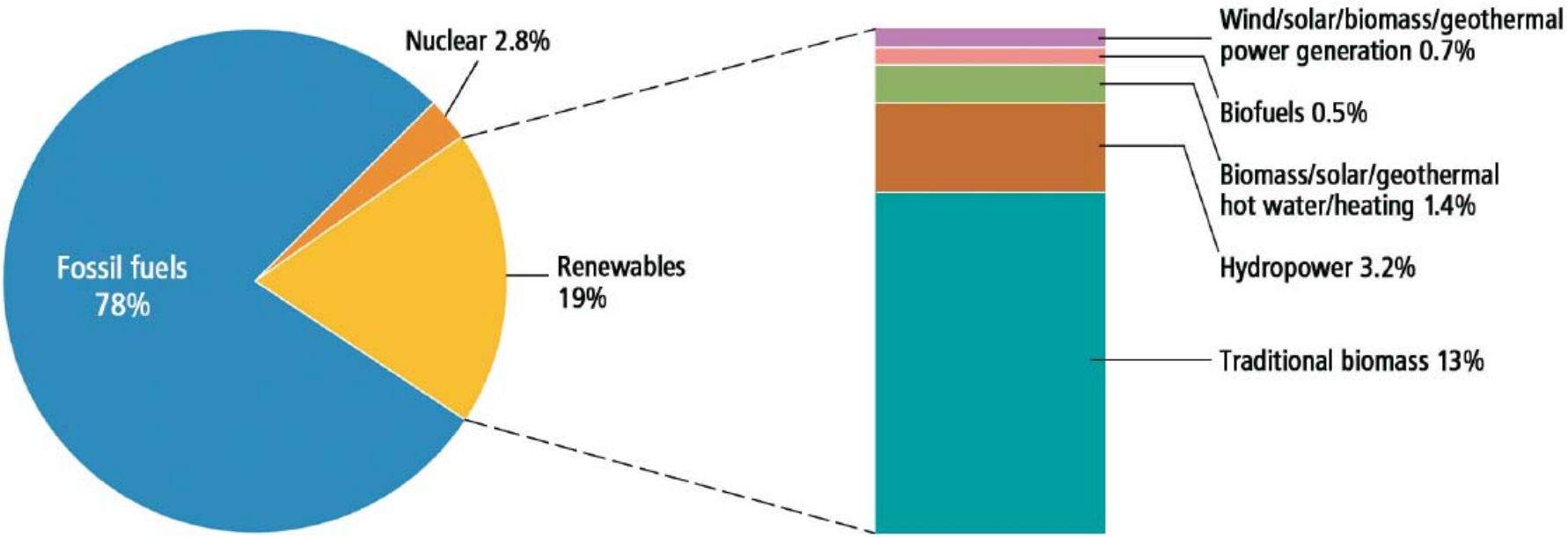
- Conflict Prevention between EU and MENA Reducing Pressure on Fuels
- Conflict Prevention in MENA Solving Energy and Water Scarcity
- Conflict Prevention in Europe Increasing Energy Diversity
- Reduction of European Energy Import Dependency
- Addition of Energy Corridors for European Supply
- Initiating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

Challenges

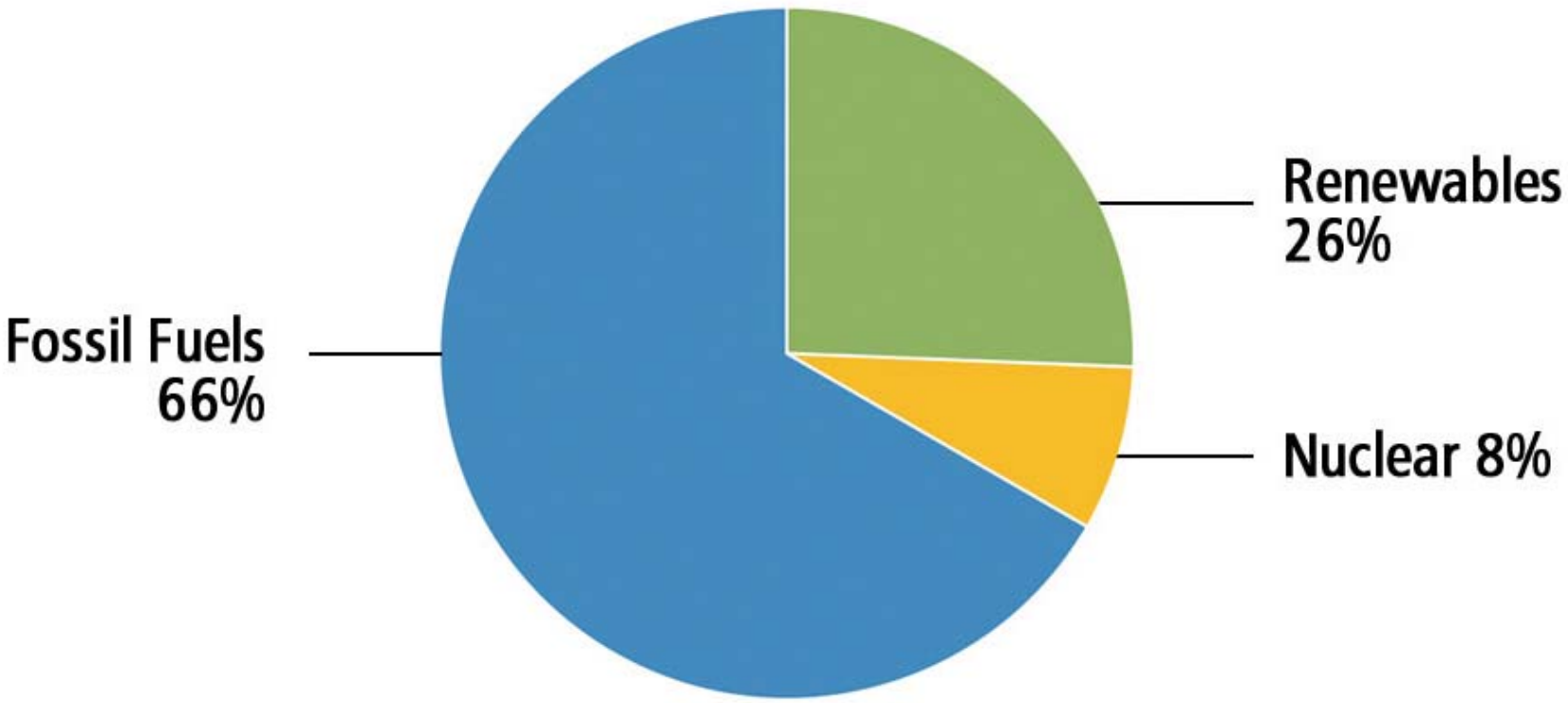
- Requires New Structures and New Thinking (Change of Paradigm)
- Requires Long-Term Financing Schemes due to Long-Term Investments
- Based on International Cooperation and Interdependencies
- Higher Complexity than Using Ideally Stored Fossil Energy Sources
- More Stakeholders Involved due to Decentralized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

Global Achievements

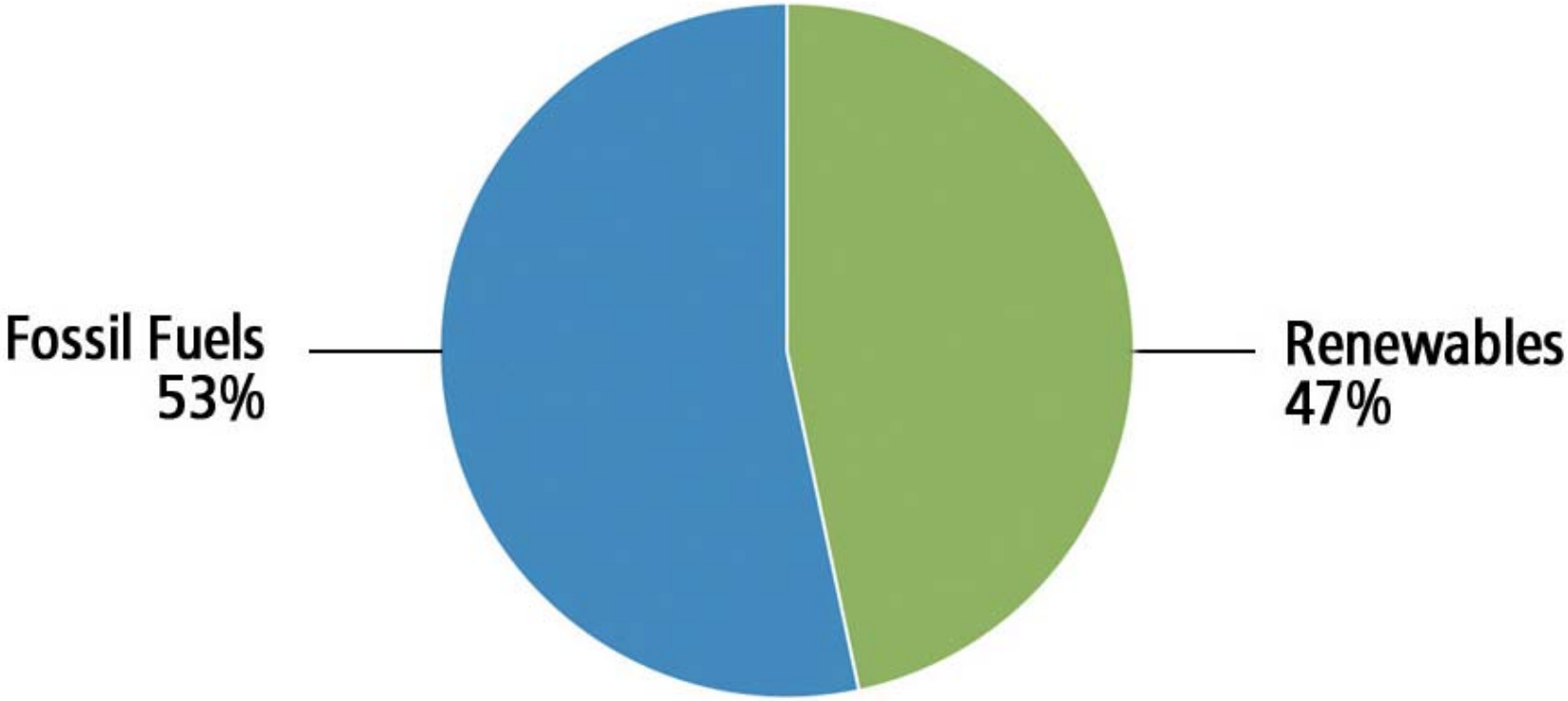
Renewable Share of Global Final Energy Consumption in 2008



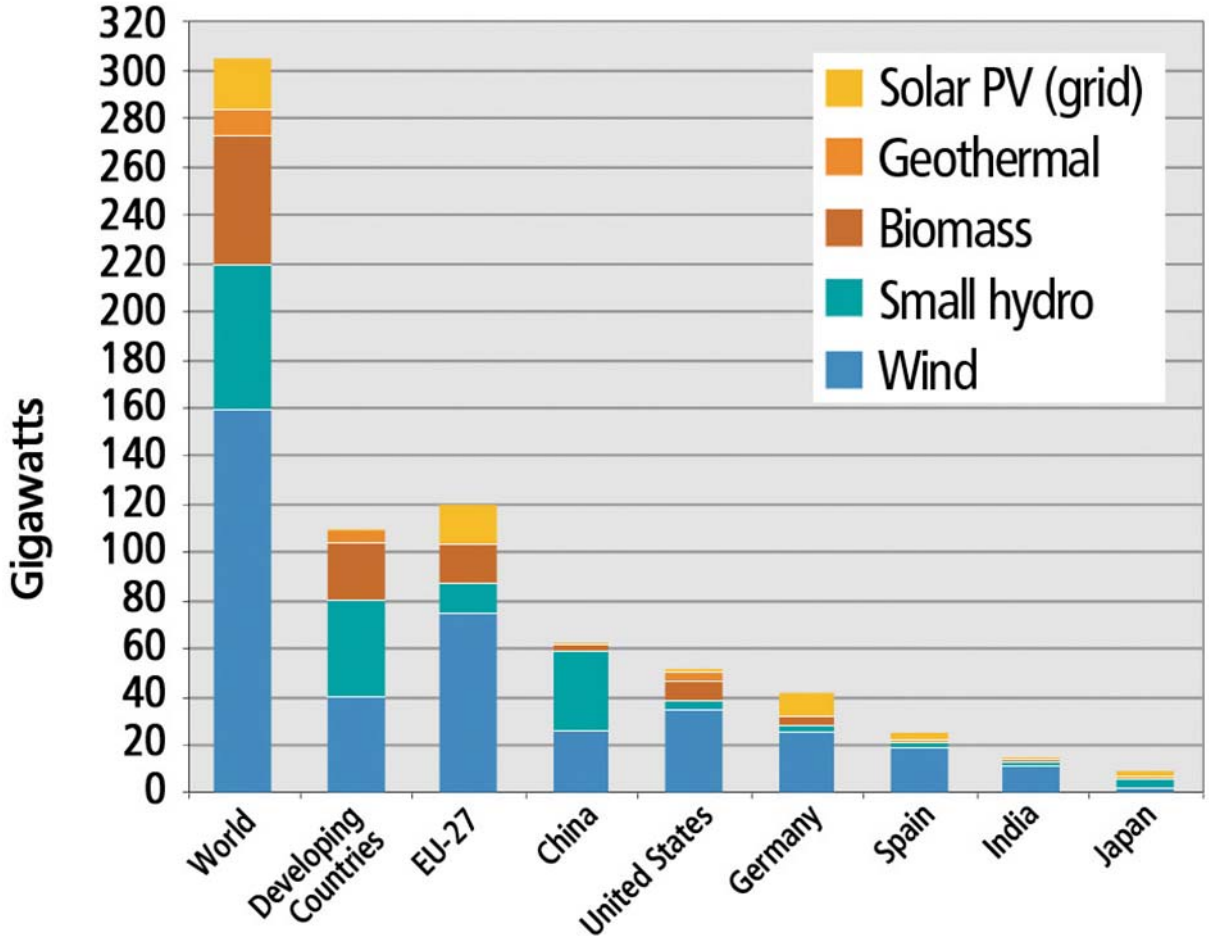
World Power Generating Capacity in 2009 by Source



New Power Capacity added Worldwide in 2008-2009 by Source

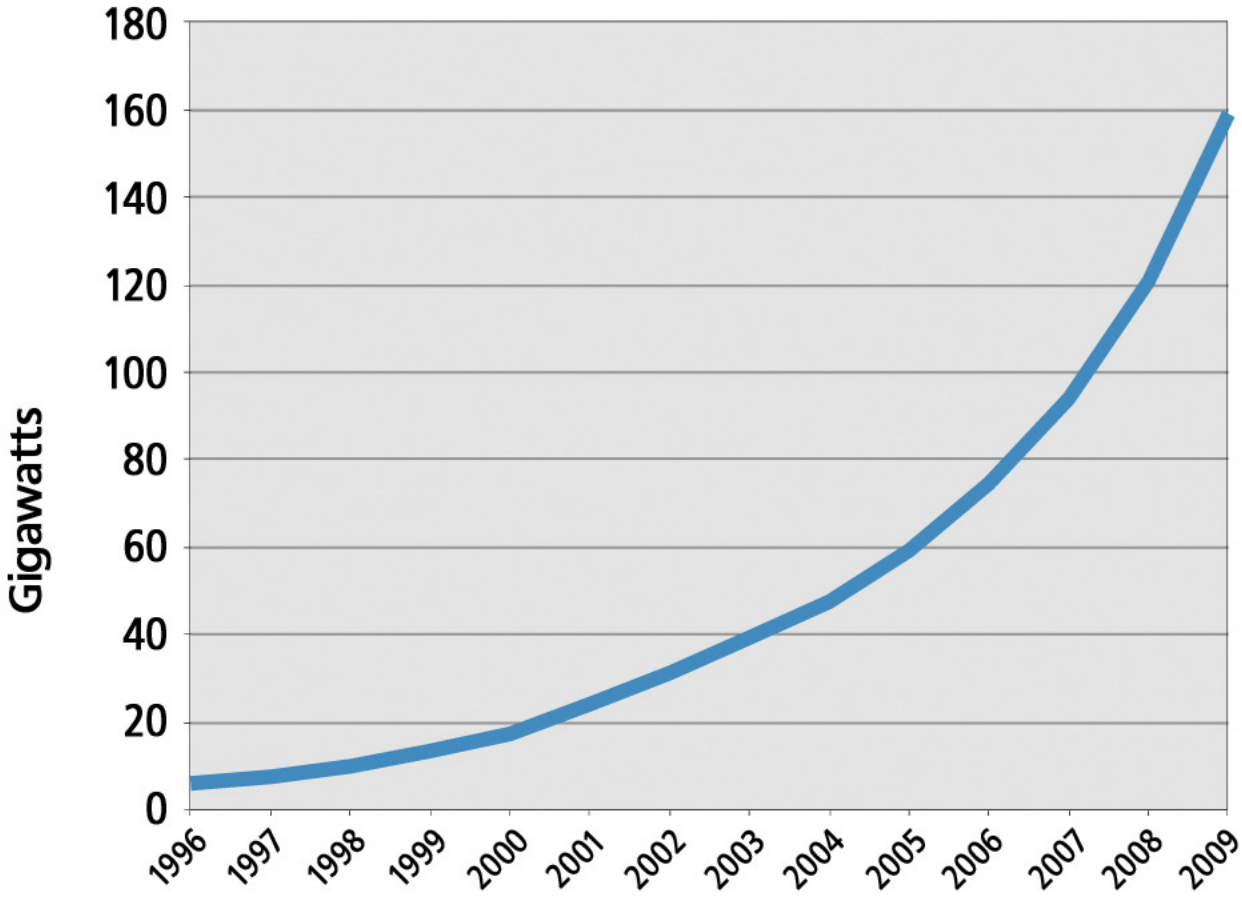


Renewable Power Capacities in 2009

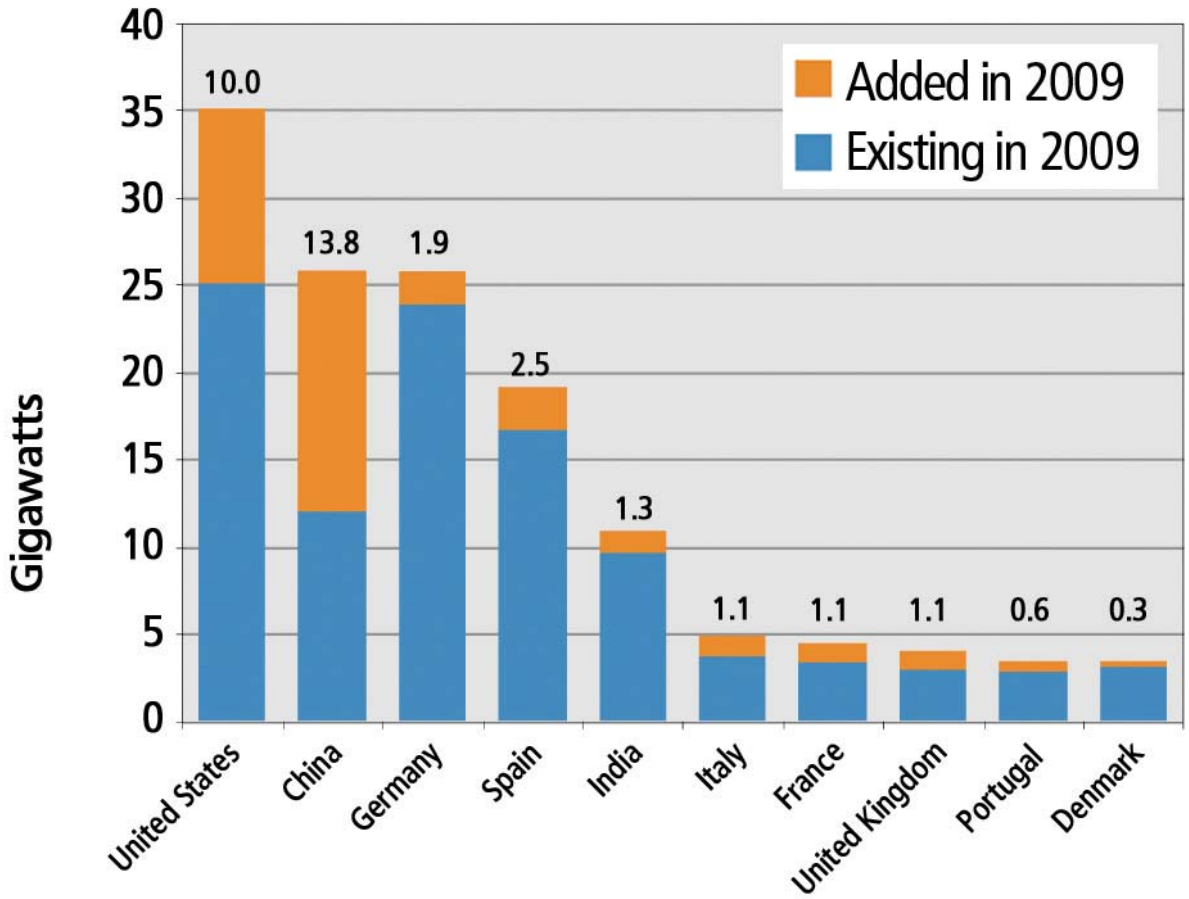


Note: Only includes small hydropower < 10 MW

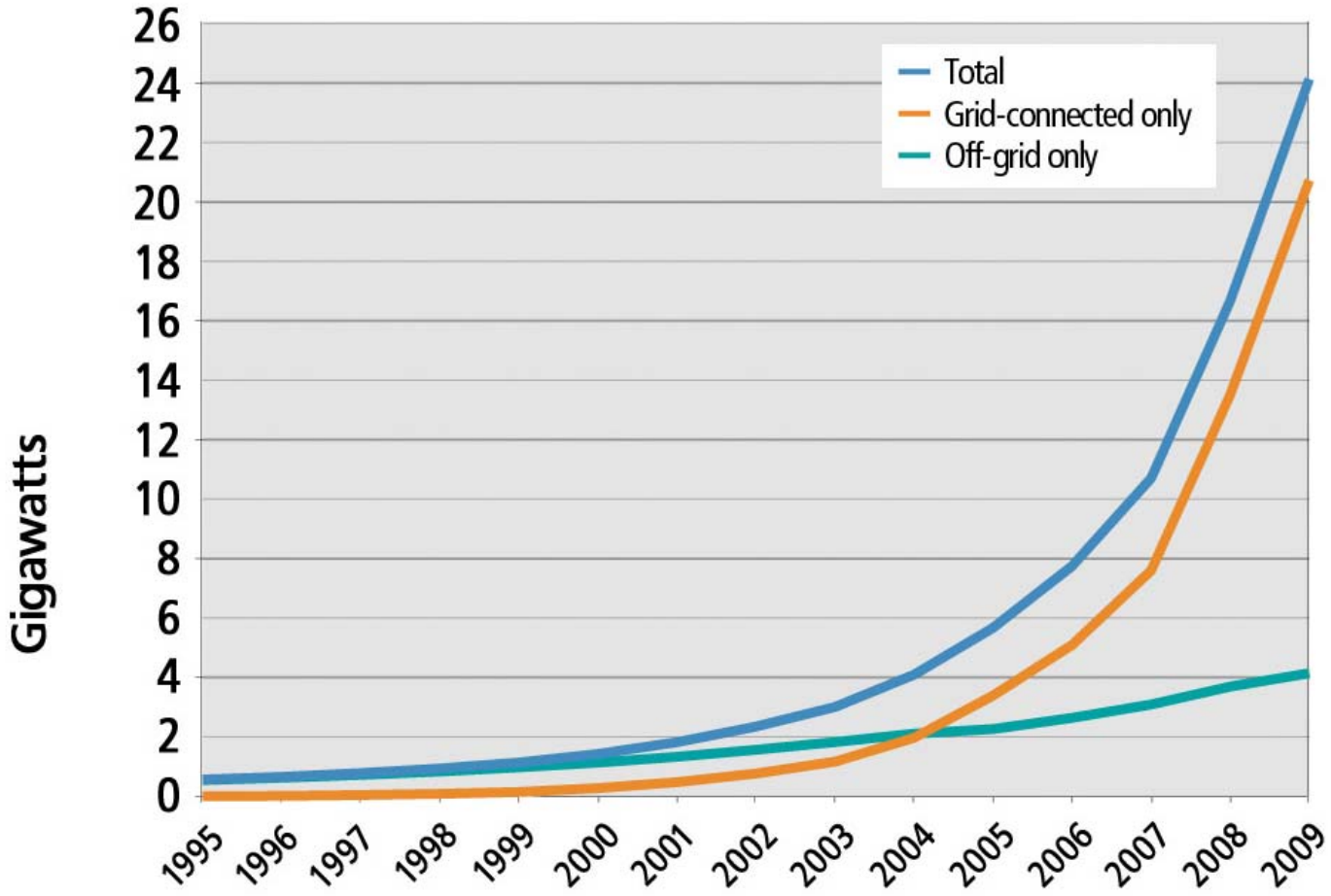
Global Wind Power Capacity Expansion up to 2009



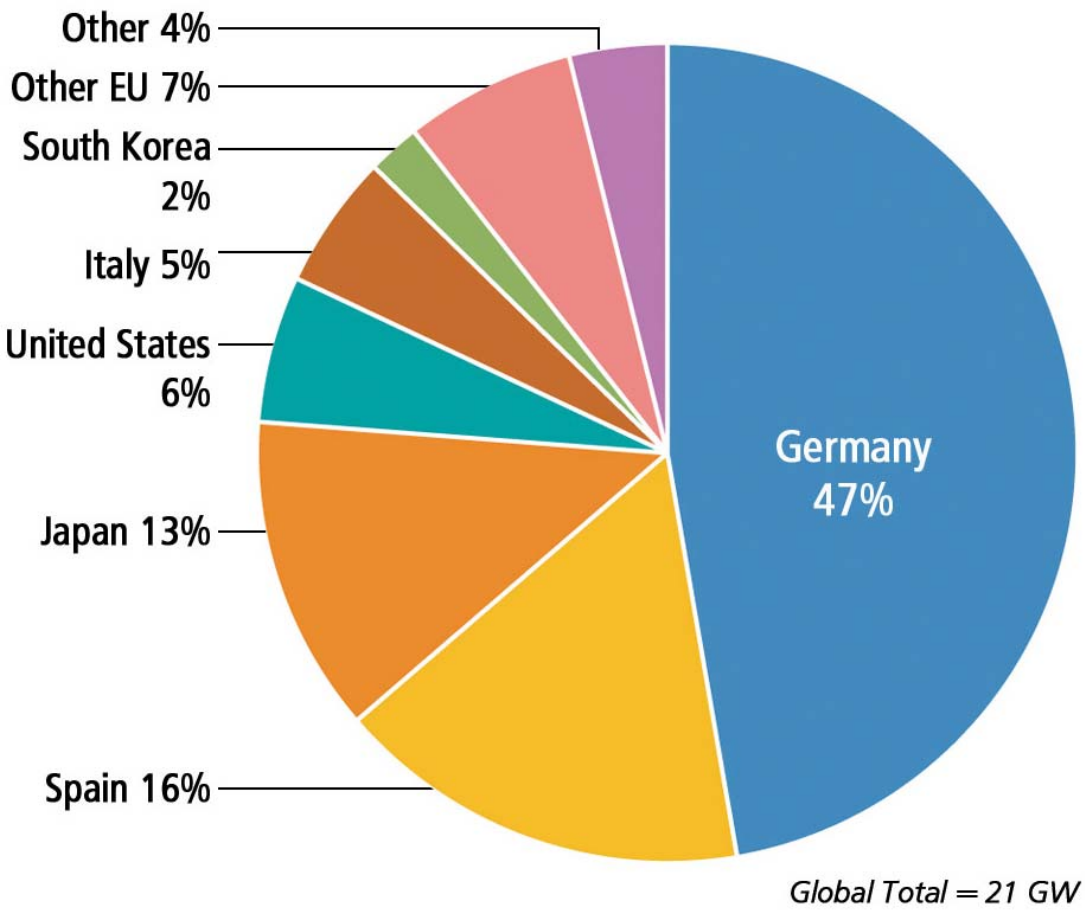
Wind Power Existing and Added in 2009 in Top 10 Countries



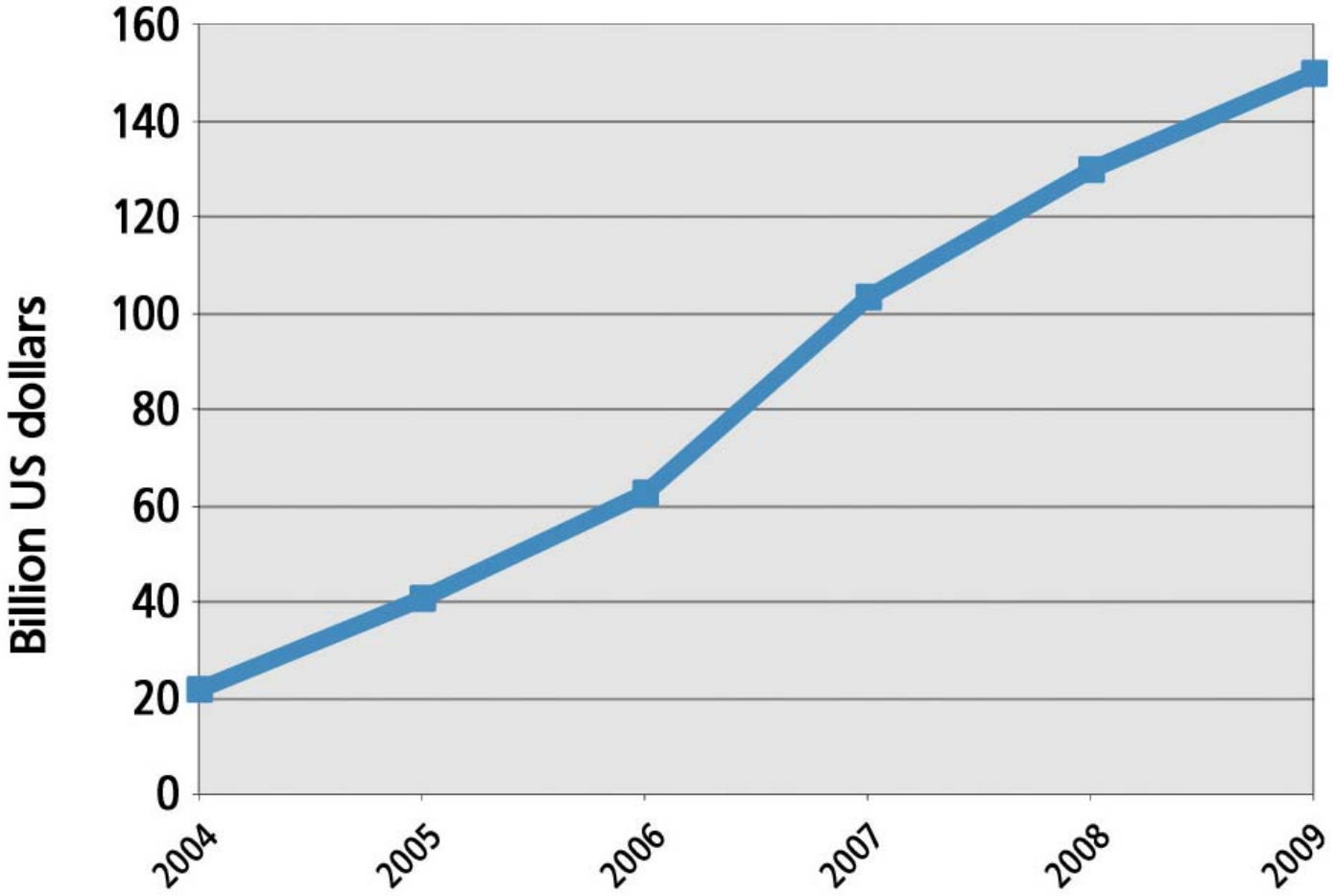
Global Photovoltaic Power Capacity Expansion up to 2009



Existing Photovoltaic Capacity in Top 6 Countries



Annual Investment into Renewable Energy Capacity



LOCALIZACIÓN DE CENTRALES TERMOSOLARES EN ESPAÑA

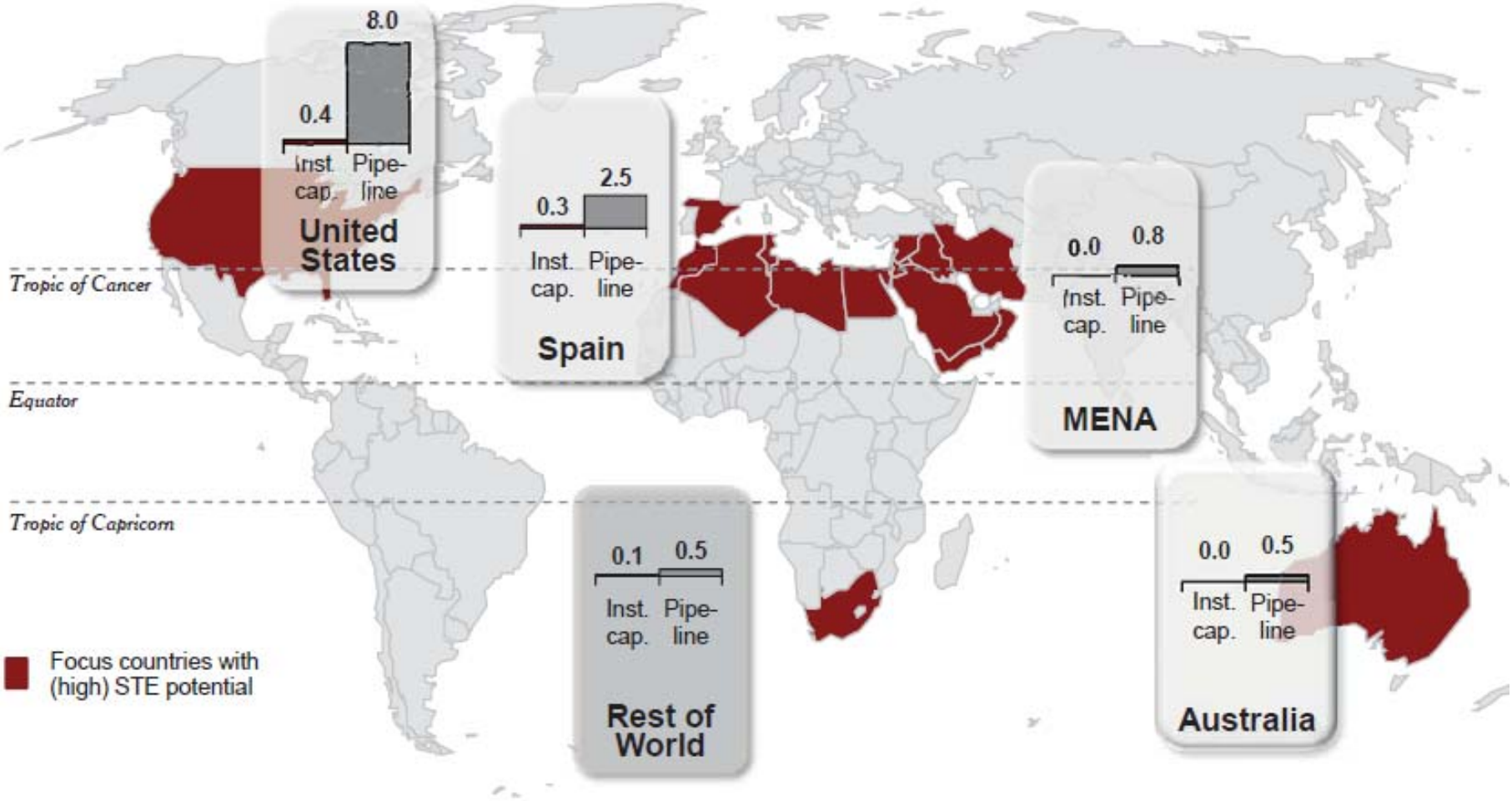
PROTERMO SOLAR

	Nombre	Localidad	Potencia MW	Fase
OPERATIVAS	PS10	San Lúcar la Mayor	11	Fase
	ANDASOL 1	Aldeire	50	Fase
	PS20	San Lúcar la Mayor	20	Fase
	PUERTOLLANO IBERSOL	Puertollano	50	Fase 1
	PUERTO ERRADO 1	Calasparra	1,4	Fase 1
	LA RISCA	Alvarado	50	Fase 1
	ANDASOL 2	Aldeire	50	Fase 1
	EXTRESOL 1	Torre de San Miguel Sesmero	50	Fase 1
	SOLNOVA 1	San Lúcar la Mayor	50	Fase 1
	SOLNOVA 3	San Lúcar la Mayor	50	Fase 1
CONSTRUCCIÓN AVANZADA	ANDASOL - 3	Aldeire	50	Fase 1
	PL. TERMOELÉCTRICA DE MAJADAS	Majadas	50	Fase 1
	PL. TERMOELÉCTRICA DE PALMA DEL RÍO II	Palma del Rio	50	Fase 1
	PL. TERMOELÉCTRICA DE PALMA DEL RÍO I	Palma del Rio	50	Fase 1
	CENTRAL SOLAR TERMOELÉCTRICA LA FLORIDA	Alvarado	50	Fase 1
	CENTRAL SOLAR TERMOELÉCTRICA LA DEHESA	La Garrovilla	50	Fase 1
	MANCHASOL-1	Alcázar de San Juan	50	Fase 2
	PLANTA TERMOSOLAR EXTRESOL-2	Torre de San Miguel Sesmero	50	Fase 2
	CTS SOLAR TRES	Fuentes de Andalucía	17	Fase 2
	SOLNOVA 4	San Lúcar la Mayor	50	Fase 2
	HELIOENERGY 1	Ecija	50	Fase 2
	HELIOENERGY 2	Ecija	50	Fase 2
	LEBRIJA 1	Lebrija	50	Fase 2
	PL. TERMOSOLAR CASAS DE LOS PINOS	Badajoz	50	Fase 3
	TERMESOL-50	San José del Valle	50	Fase 3
	ARCOSOL-50	San José del Valle	50	Fase 3
	PL. TERMOSOLAR 990KW CASAS DE LOS PINOS	Villarobledo	1	Fase 3
PREASIGNADAS	PL. SOLAR TERMOELÉCTRICA	Espejo	50	Fase 1
	C. TERMOSOLAR "LA AFRICANA"	Fuente Palmera	50	Fase 1
	PL. TERMOELÉCTRICA DE CONSOL ORELLANA	Orellana	50	Fase 1
	PUERTO ERRADO 2	Puerto Errado	30	Fase 1
	HELIOS I	Puerto Lápice	50	Fase 1
	HELIOS II	Puerto Lápice	50	Fase 1
	C. SOLAR TERMOELÉCTRICA "ASTE-1A"	Alcázar de San Juan	50	Fase 2
	C. SOLAR TERMOELÉCTRICA "ASTE-1B"	Alcázar de San Juan	50	Fase 2
	SOLACOR I	El Carpio	50	Fase 2
	SOLACOR 2	El Carpio	50	Fase 2
	PL. TERMOSOLAR DE MORÓN	Morón de la Frontera	50	Fase 2
	MANCHASOL-2	Alcázar	50	Fase 3
	PL. TERMOSOLAR DE OLIVENZA 1	Olivenza	50	Fase 3
	PL. TERMOSOLAR EXTRESOL - 3	Torre de San Miguel Sesmero	50	Fase 3
	C. SOLAR TERMOELÉCTRICA "ASTEXOL -2"	Badajoz	50	Fase 3
	SOLABEN 1	Logrosán	50	Fase 3
	SOLABEN 2	Logrosán	50	Fase 3
	SOLABEN 3	Logrosán	50	Fase 3
	TERMOSOL 1	Navalvillar de Pela	50	Fase 4
	TERMOSOL 2	Navalvillar de Pela	50	Fase 4
	TERMOSOLAR BORGES, S.L.	Aigües Blanques	22	Fase 4
	EXTREMASOL 1	Villanueva de la Serena	50	Fase 4
	SOLABEN 6	Logrosán	50	Fase 4
	C. SOLAR TERMOELÉCTRICA CÁCERES	Galisteo	50	Fase 4
	CASABLANCA	Talarubias	50	Fase 4
	C. SOLAR TERMOELÉCTRICA ENERSTAR VILLENA	Alicante	50	Fase 4
	PL. TERMOSOLAR 8MW PUERTOLLANO	Puertollano	8	Fase 4
	PL. TERMOSOLAR 10MW PUERTOLLANO	Puertollano	10	Fase 4
	PL. TERMOSOLAR 10MW PUERTOLLANO	Puertollano	10	Fase 4
	PL. TERMOSOLAR 10MW PUERTOLLANO	Puertollano	10	Fase 4
	PL. TERMOSOLAR 10MW PUERTOLLANO	Puertollano	10	Fase 4
	PL. TERMOSOLAR 10MW PUERTOLLANO	Puertollano	10	Fase 4
	PL. TERMOSOLAR 14 MW PUERTOLLANO	Puertollano	12	Fase 4
	ARENALES	Morón de la Frontera	50	Fase 4

Total de Plantas 61

● Operativas ● Construcción avanzada ● Preasignadas

Existing CSP Capacity in 2009 and Planned Additions until 2015



Existing and Added Renewable Energy Capacity in 2009

	Added during 2009	Existing at end of 2009
Power generation (GW)		
Wind power	38	159
Small hydropower <10 MW	2–4	60
Biomass power	2–4	54
Solar PV, grid-connected	7	21
Geothermal power	0.4	11
Concentrating solar thermal power (CSP)	0.2	0.6
Ocean power	~0	0.3
Hydropower (all sizes)	31	980
Hot water/heating (GWth)		
Biomass heating	n/a	~270
Solar collectors for hot water/space heating	35	180
Geothermal heating	n/a	~60
Transport fuels (billion liters/year)		
Ethanol production	9	76
Biodiesel production	5	17

Jobs in Renewable Energy Industry in 2009

Industry	Estimated jobs worldwide	Selected national estimates
Biofuels	> 1,500,000	Brazil 730,000 for sugar cane and ethanol production
Wind power	> 500,000	Germany 100,000; United States 85,000; Spain 42,000; Denmark 22,000; India 10,000
Solar hot water	~ 300,000	China 250,000
Solar PV	~ 300,000	Germany 70,000; Spain 26,000; United States 7,000
Biomass power	—	Germany 110,000; United States 66,000; Spain 5,000
Hydropower	—	Europe 20,000; United States 8,000; Spain 7,000
Geothermal	—	Germany 9,000; United States 9,000
Solar thermal power	~ 2,000	Spain 1,000; United States 1,000
Total	> 3,000,000	