

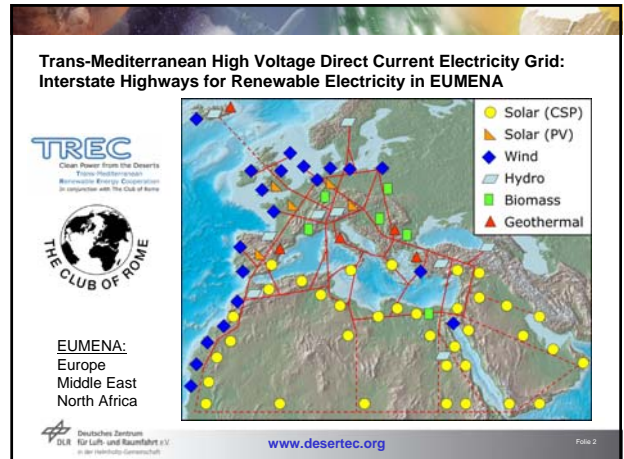
DESERTEC: Solar Power from the Desert

Franz Trieb

EUSJA Press Trip DLR Stuttgart

September 14, 2009

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

TREC
Clean Power from the Desert
France, Mediterranean
Renewable Energy Cooperation
in conjunction with The Club of Rome

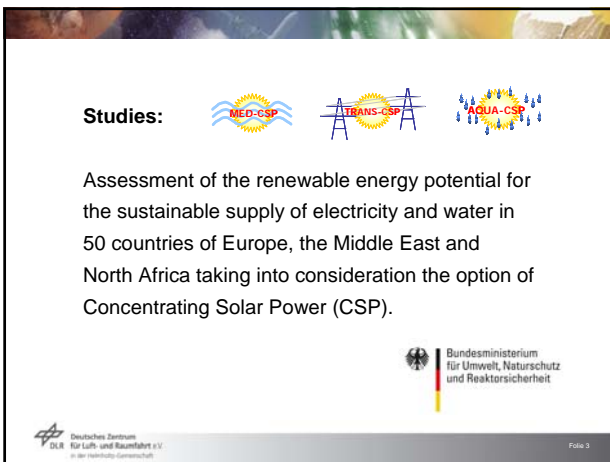
THE CLUB OF ROME

EUMENA:
Europe
Middle East
North Africa

www.desertec.org

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Foto 2



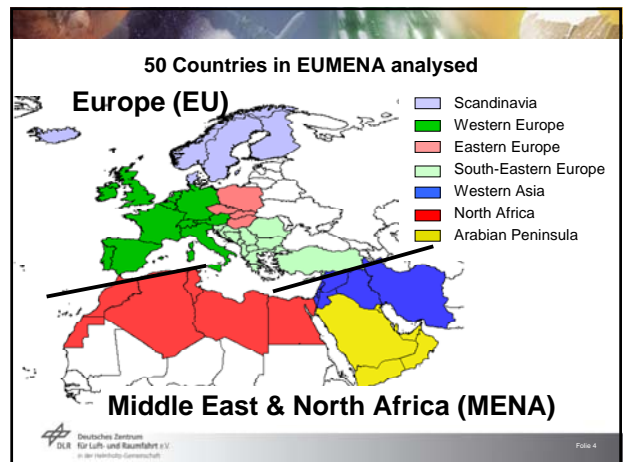
Studies: MED-CSP, TRANS-CSP, AQUA-CSP

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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Foto 3



50 Countries in EUMENA analysed

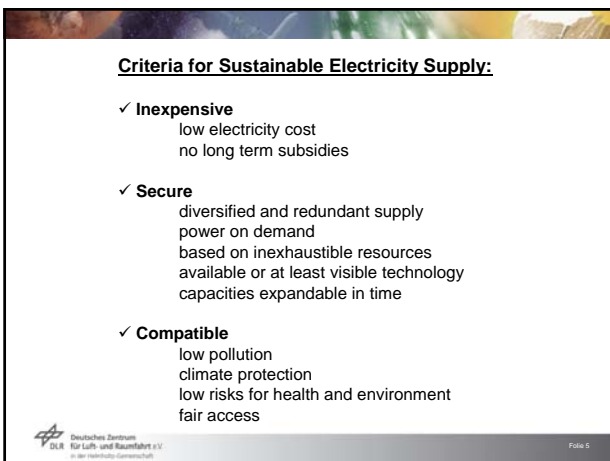
Europe (EU)

Middle East & North Africa (MENA)

- Scandinavia
- Western Europe
- Eastern Europe
- South-Eastern Europe
- Western Asia
- North Africa
- Arabian Peninsula

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Foto 4

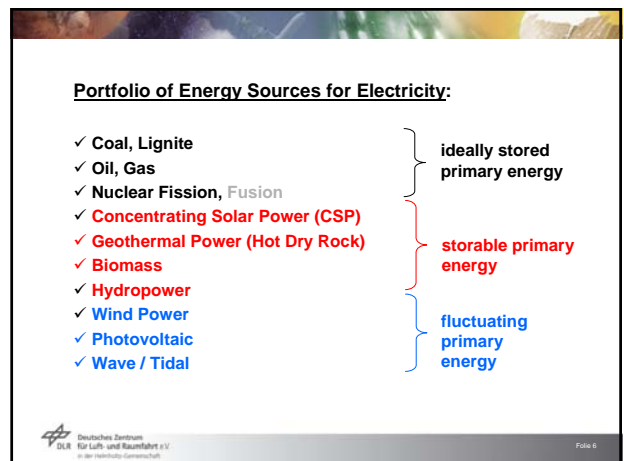


Criteria for Sustainable Electricity Supply:

- ✓ **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

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Foto 5



Portfolio of Energy Sources for Electricity:

- ✓ Coal, Lignite
- ✓ Oil, Gas
- ✓ Nuclear Fission, Fusion
- ✓ Concentrating Solar Power (CSP)
- ✓ Geothermal Power (Hot Dry Rock)
- ✓ Biomass
- ✓ Hydropower
- ✓ Wind Power
- ✓ Photovoltaic
- ✓ Wave / Tidal

ideally stored primary energy

storable primary energy

fluctuating primary energy

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Foto 6

Renewable Energy Technologies

Hydropower

Concentrating Solar Power

Biomass

Geothermal

Tides

Waves

Photovoltaic

Wind Power

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<http://www.erneuerbare-energien.de/inhalt/36983/35338/>

Folie 7

Concentrating Solar Power

Parabolic Trough (PSA)

Solar Tower (SNL)

Up to 550 °C

over 1000 °C

Steam Turbines

Gas Turbines, Engines

Linear Fresnel (MAW/SPG)

Dish-Stirling (SBP)

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Folie 8

Principle of a Concentrating Solar Thermal Power Plant

Concentrating Solar Collector Field (Mirrors)

Thermal Energy Storage

Solar Heat

Fuel

Electricity

Thermal Power Cycle (e.g. Steam Turbine)

Process Heat

- 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.

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Folie 9

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

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www.solarmillennium.de

Folie 10

High Voltage Direct Current Transmission

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

Mongolia

China

Xiangjiaba

Shanghai

Philippines

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

Folie 11

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)

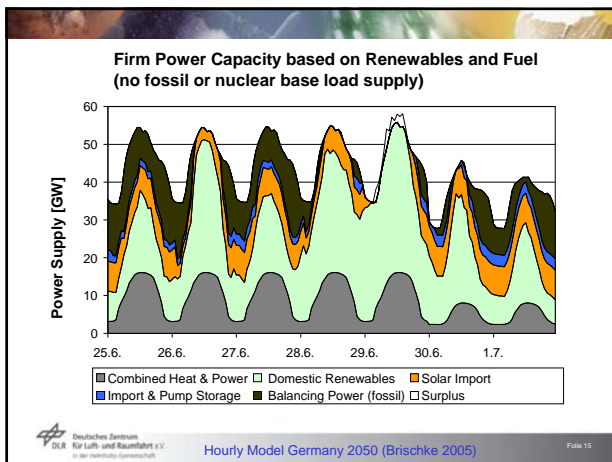
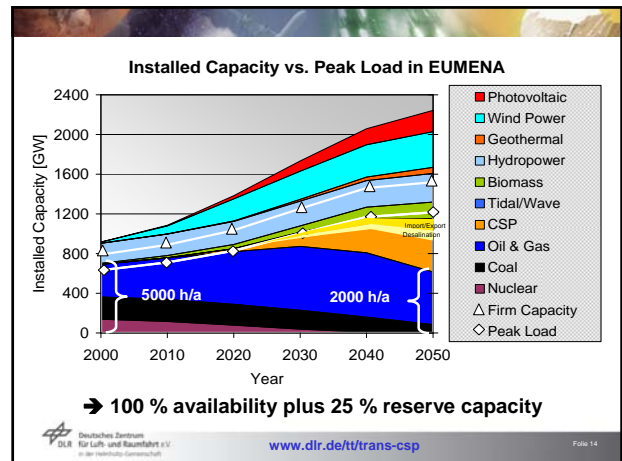
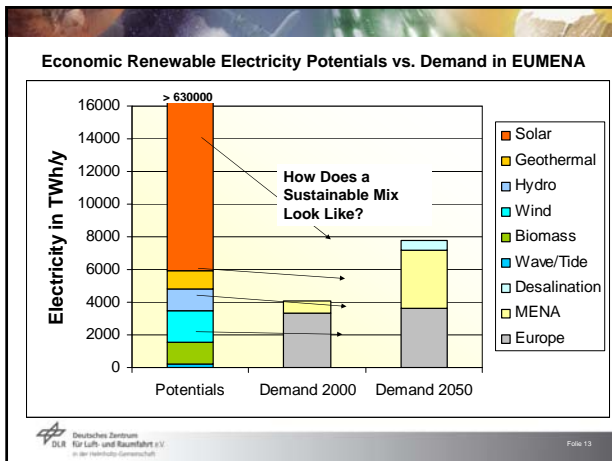
Max

Min

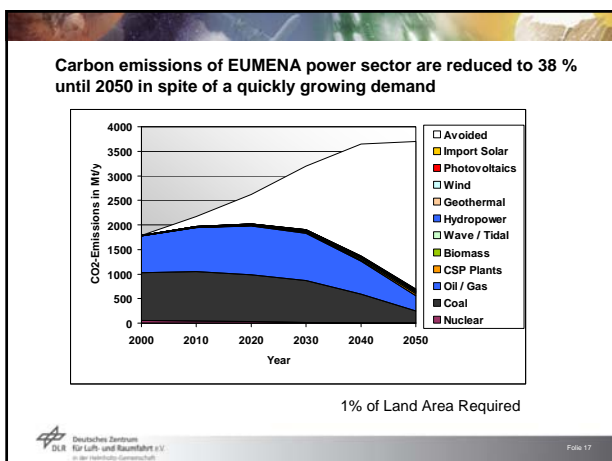
Electricity Yield in GWh/km²/y

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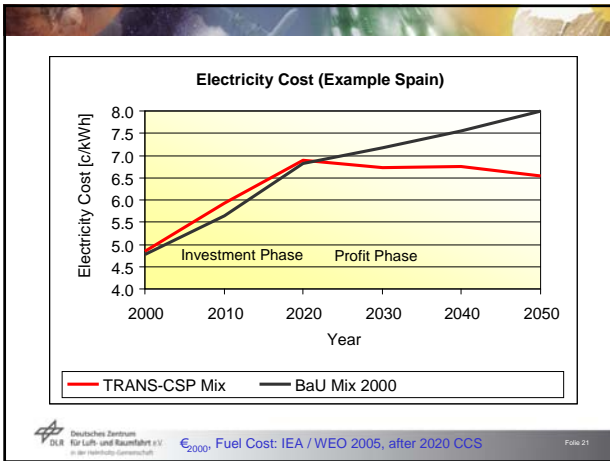
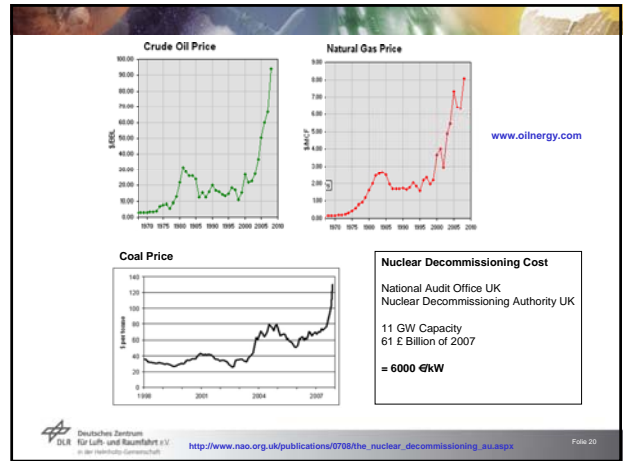
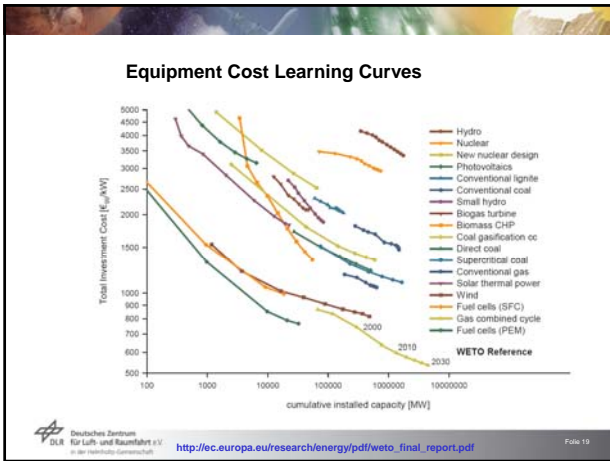
Folie 12



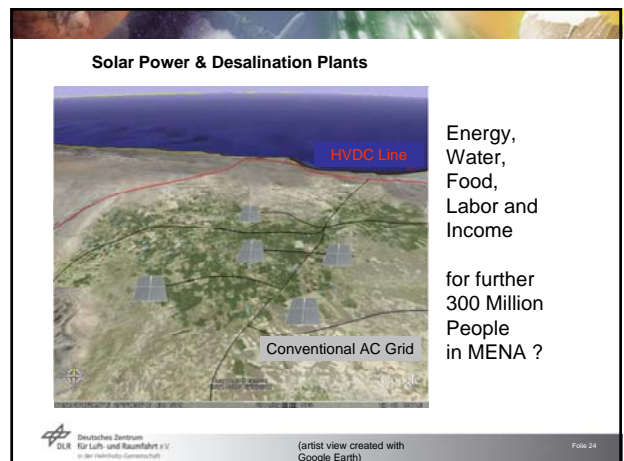
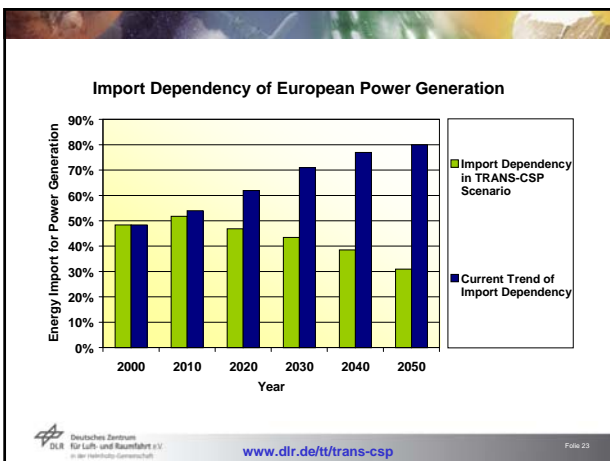
- ### Availability and Redundancy
- Power on Demand by a Mix of Fluctuating and Balancing Sources
 - Increased Number of Non-Correlated Energy Sources
 - Increased Number and Reduced Average Size of Power Plants
 - Increased Number of Supply Regions
 - Additional HVDC Grid Infrastructure for Long-Distance Transfer
 - Domestic Sources Dominate the Electricity Mix
 - Non-depletable Sources Dominate the Electricity Mix
 - Strategy is Based on Proven Technologies
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- ### 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
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- ### 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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 Foto 22



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



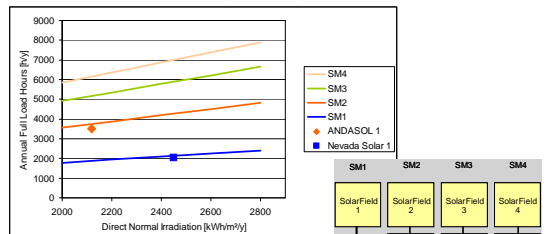
Some Background Information

Total EU-MENA HVDC Interconnection 2020 – 2050 *

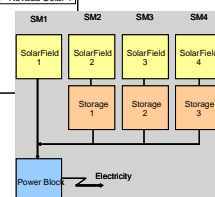
Year		2020	2030	2040	2050
Lines x Capacity GW		4 x 2.5	16 x 2.5	28 x 2.5	40 x 2.5
Transfer TWh/y		60	230	470	700
Capacity Factor		0.60	0.67	0.75	0.80
Turnover Billion €/y		3.8	12.5	24	35
Land Area km x km	CSP	15 x 15	30 x 30	40 x 40	50 x 50
	HVDC	3100 x 0.1	3600 x 0.4	3600 x 0.7	3600 x 1.0
Cum. Investment Billion €	CSP	42	134	245	350
	HVDC	5	16	31	45
Elec. Cost €/kWh	CSP	0.050	0.045	0.040	0.040
	HVDC	0.014	0.010	0.010	0.010

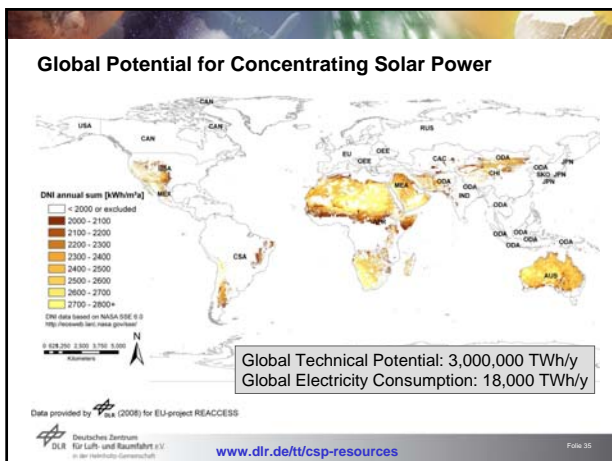
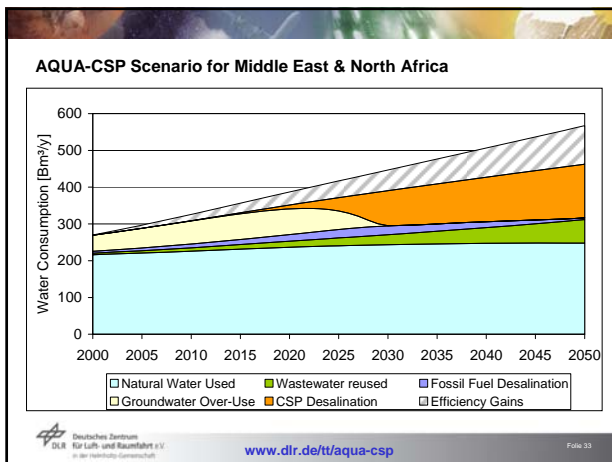
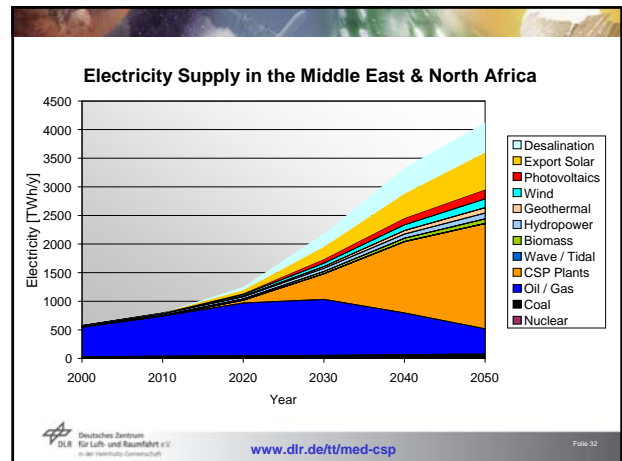
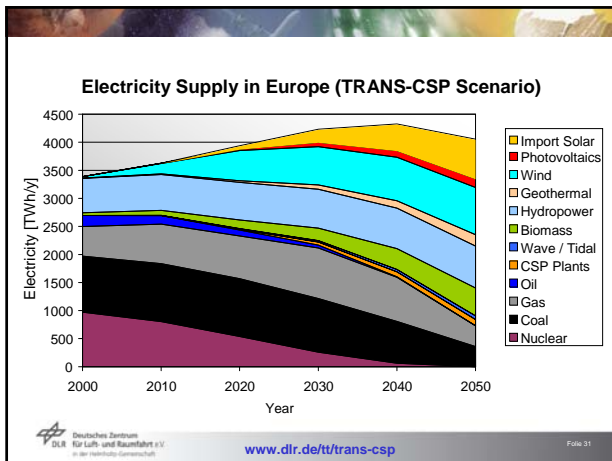
* All countries analysed in TRANS-CSP

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)





DNI Class	Africa	Australia	Central Asia, Caucasus	Canada	China	Central South America	India	Japan
2000-2099	102,254	6,631	14,280	0	8,332	31,572	7,893	0
2100-2199	138,194	18,587	3,000	0	18,276	20,585	1,140	0
2200-2299	139,834	36,762	372	0	43,027	24,082	550	0
2300-2399	141,066	87,751	177	0	28,415	20,711	774	0
2400-2499	209,571	148,001	64	0	11,157	6,417	426	0
2500-2599	203,963	207,753	0	0	11,330	3,678	13	0
2600-2699	178,480	142,490	0	0	2,180	5,120	119	0
2700-2800+	346,009	49,625	0	0	3,079	11,827	15	0
Total	1,459,370	697,600	15,193	0	125,835	123,992	10,928	0

DNI Class	Middle East	Mexico	Other Developing Asia	Other East Europe	Russia	South Korea	EU27+	USA
2000-2099	3,432	1,606	4,491	6	0	0	866	14,096
2100-2199	12,443	3,378	5,174	13	0	0	497	17,114
2200-2299	39,191	3,650	10,947	2	0	0	660	21,748
2300-2399	60,188	5,807	30,778	0	0	0	162	16,402
2400-2499	71,324	15,689	19,355	0	0	0	90	23,903
2500-2599	34,954	7,134	4,429	0	0	0	68	8,116
2600-2699	32,263	1,534	253	0	0	0	31	2,328
2700-2800+	36,843	1,878	136	0	0	0	34	0
Total	290,639	40,675	75,561	21	0	0	2,409	103,704

CSP potentials in TWh/y available in the REACCESS world regions for different DNI Classes

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www.dlr.de/tt/csp-resources