Part 7: Electricity Supply Scenarios – How achieve Sustainability?

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What is Sustainable?

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**

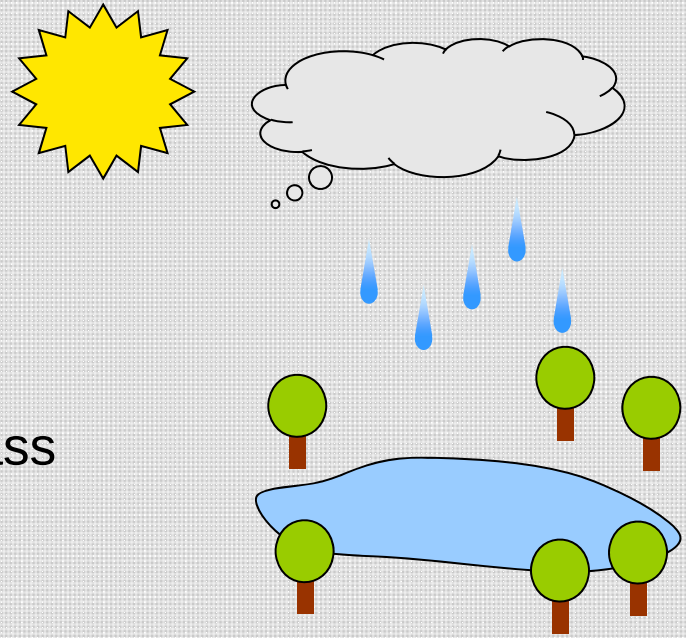
low pollution
climate protection
low risks for health and environment
fair access

What‘s the Big Mistake?

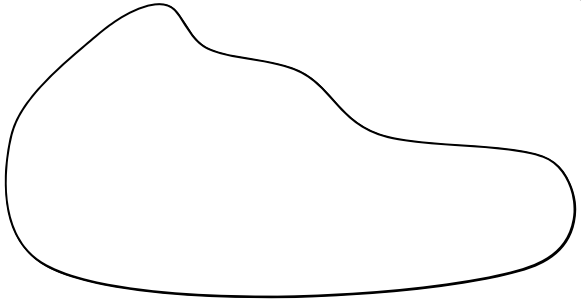
Fossil Energy ~~Sources~~ Storage

Oil
Gas
Lignite
Coal

Renewable Energy Sources



Sun
Wind
Water
Biomass

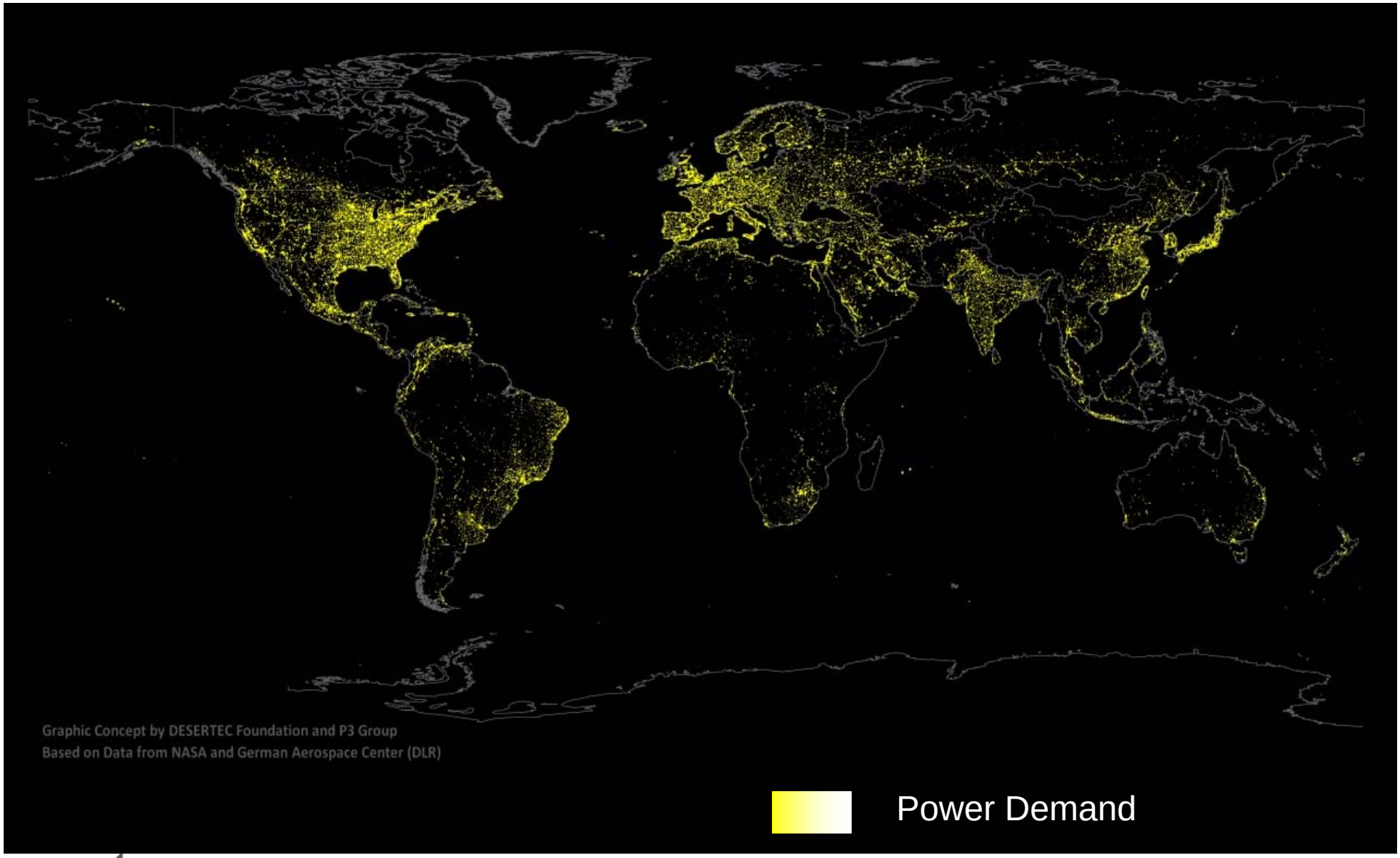


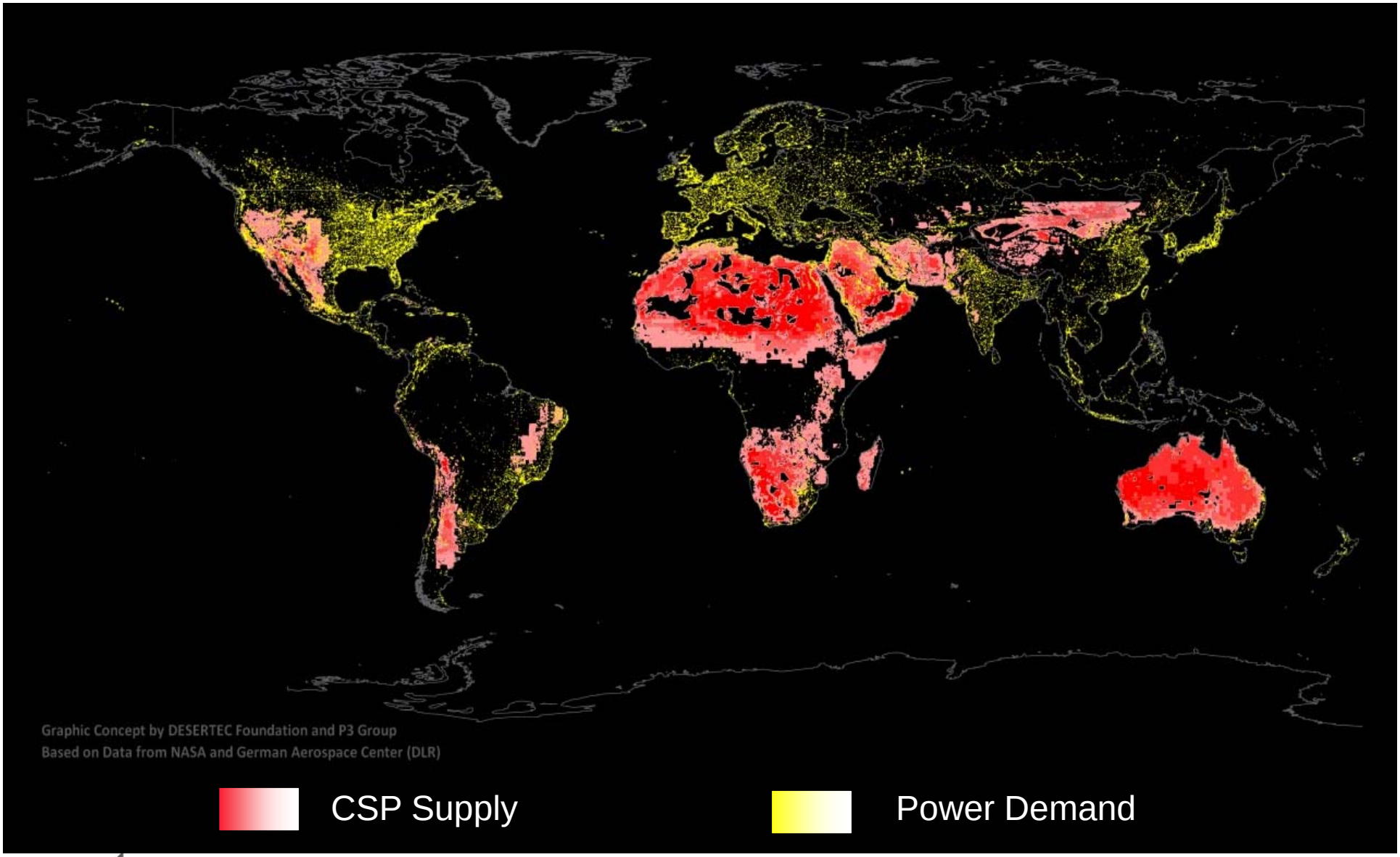
500 years later

Who finds the big mistake?

Homo sapiens sapiens, the wise wise man,
is the only species on earth that abstains from
making use of the world‘s energy sources and
instead empties the global energy storage.

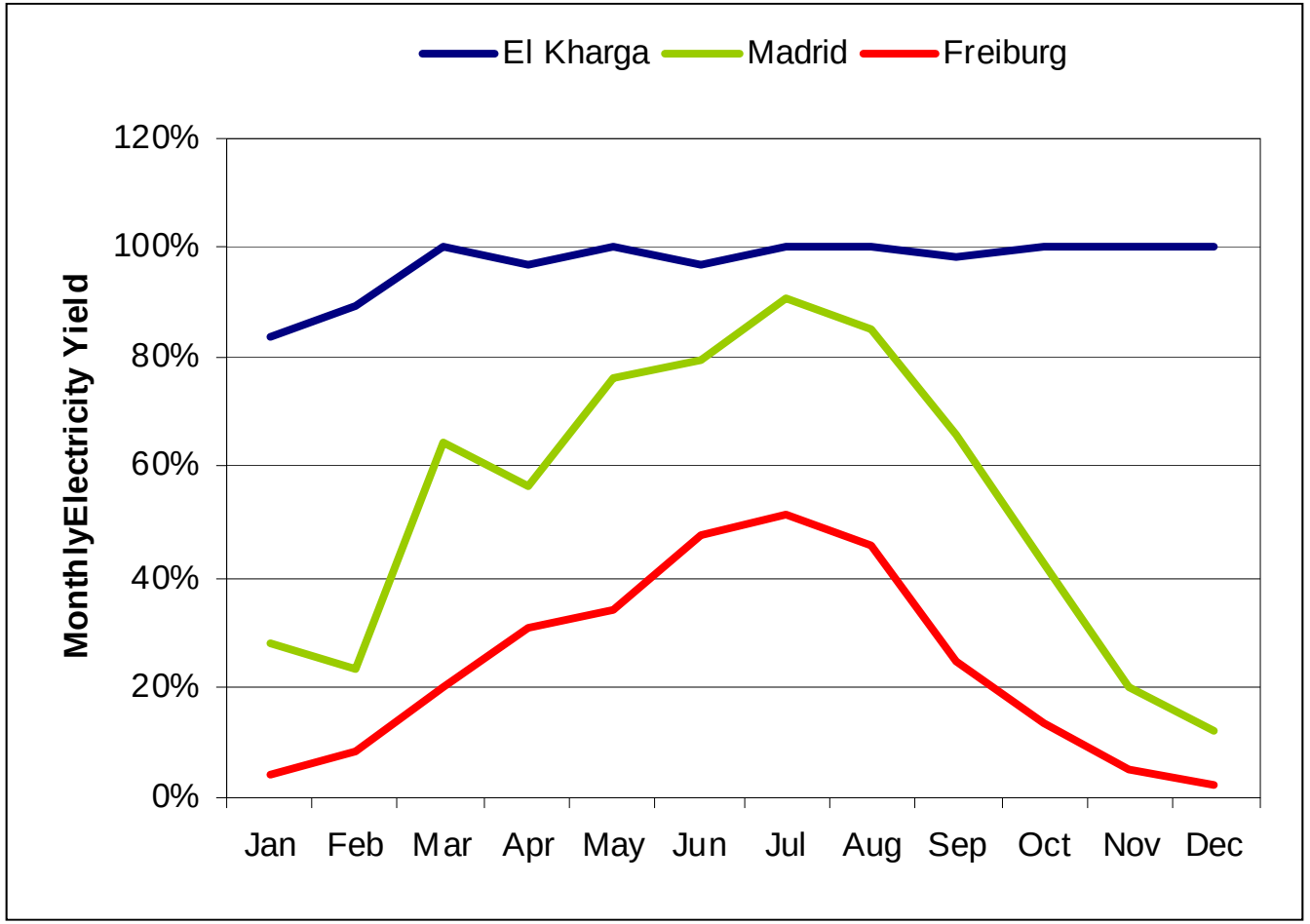
Why HVDC-Interconnections?


Graphic Concept by DESERTEC Foundation and P3 Group
Based on Data from NASA and German Aerospace Center (DLR)
Power Demand

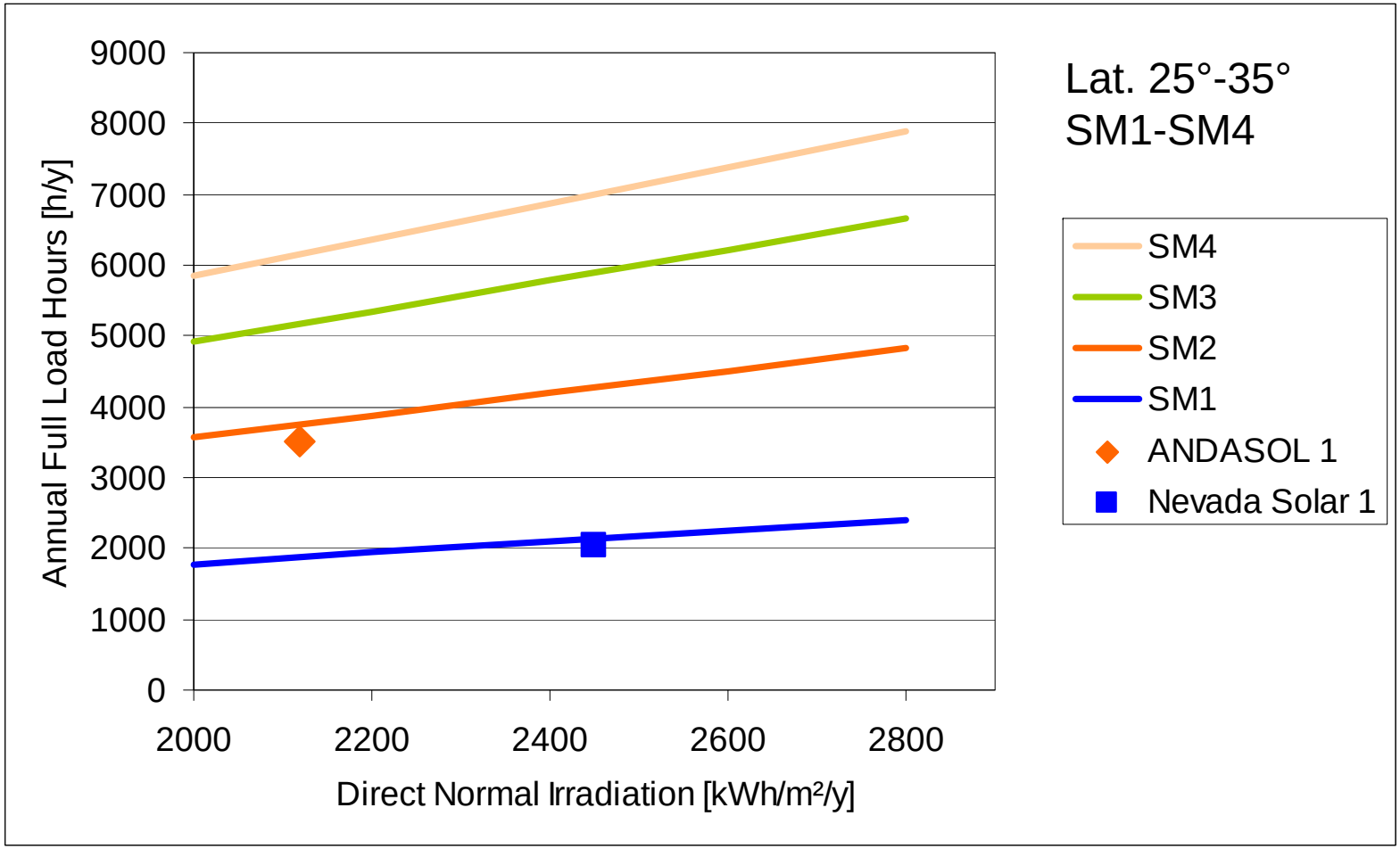

Graphic Concept by DESERTEC Foundation and P3 Group
Based on Data from NASA and German Aerospace Center (DLR)
CSP Supply
Power Demand

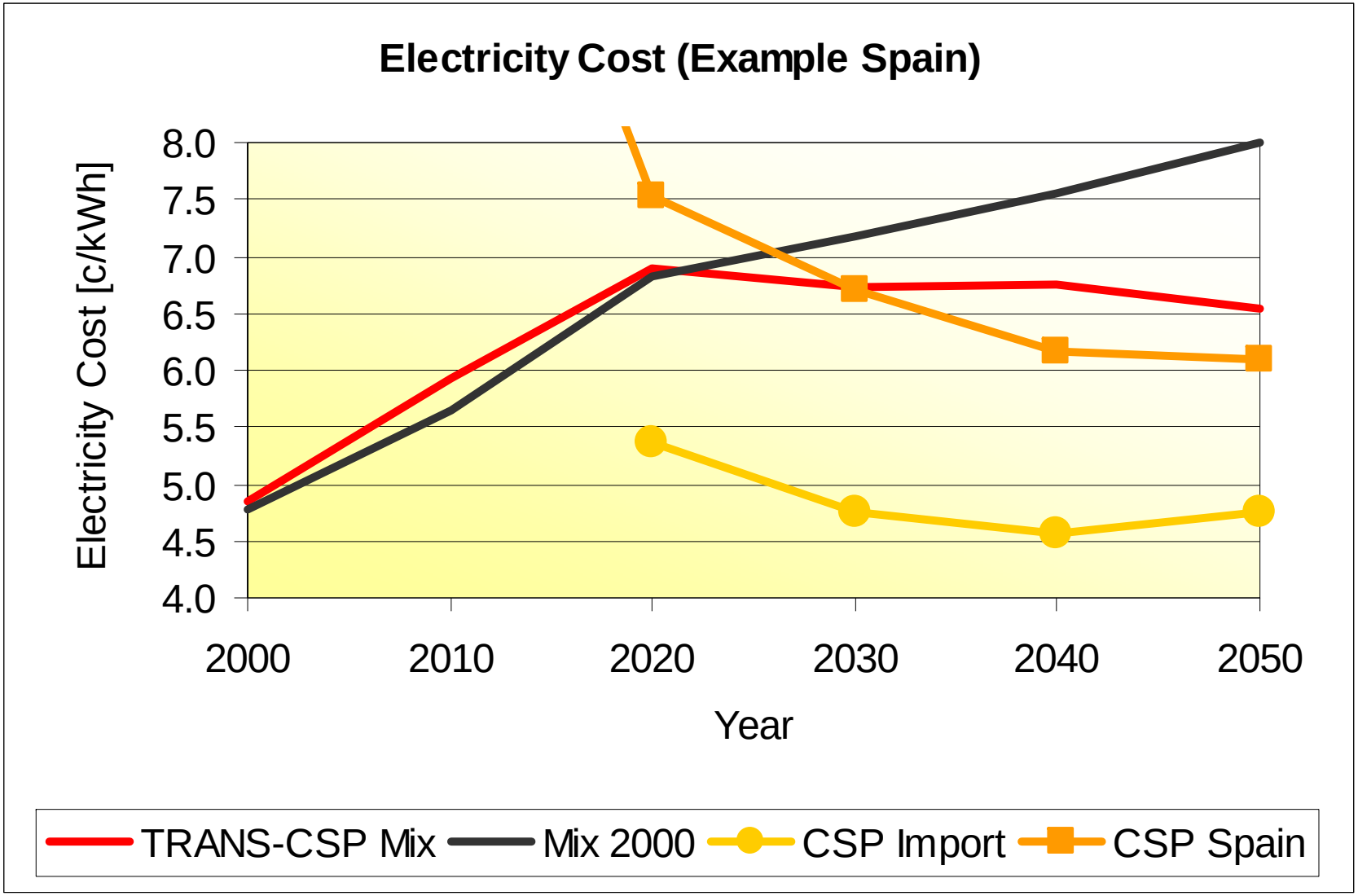
Effect of Site Conditions on the Availability of CSP

SM = 4



CSP for Peak, Medium and Base Load





constant $€_{2000}$, fuel cost IEA 2005, CCS after 2020, 5% discount rate

Solar Power & Desalination Plants

Energy,
Water,
Food,
Labor and
Income

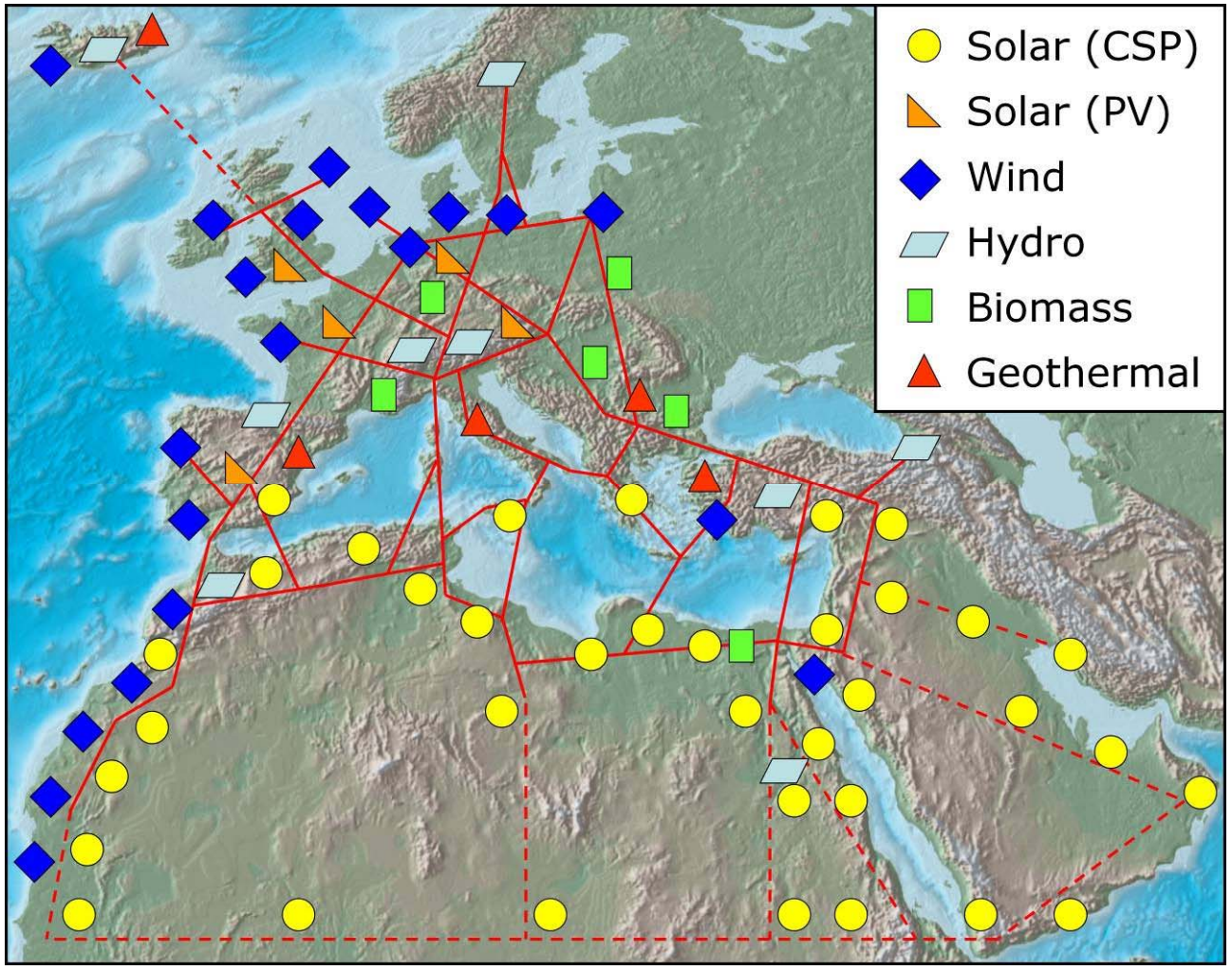
for further
300 Million
People
in MENA ?

(artist view created with
Google Earth)

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

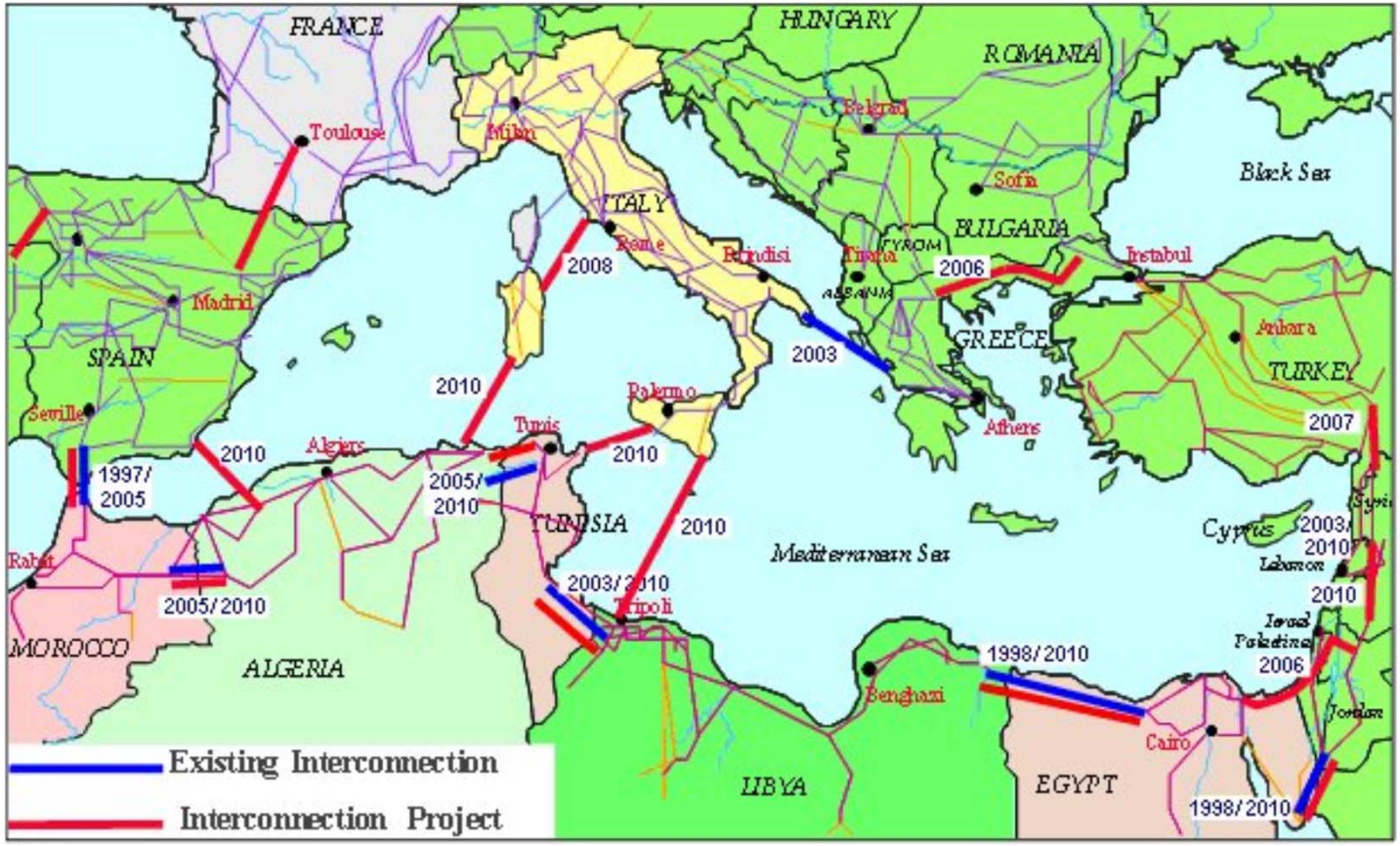
TREC
Clean Power from the Deserts
Trans-Mediterranean
Renewable Energy Cooperation
In conjunction with The Club of Rome

THE CLUB OF ROME



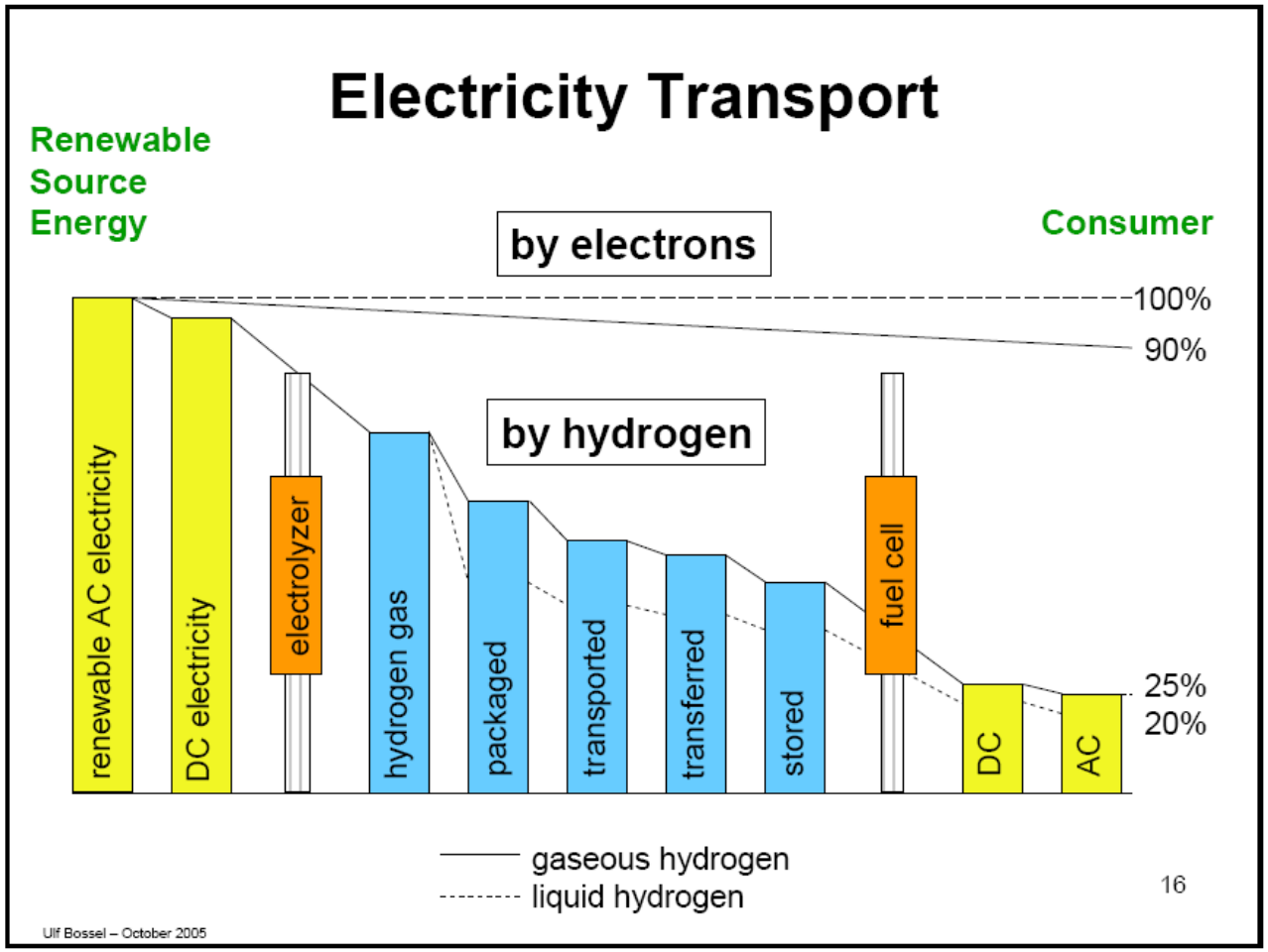
EUMENA:
Europe
Middle East
North Africa

After closing the Mediterranean Ring in 2010, about 0.5 % of European electricity demand could be imported through the conventional AC grid. If upgraded to European standards, 3 %. However, 45 % of the solar electricity would be lost over 3000 km.

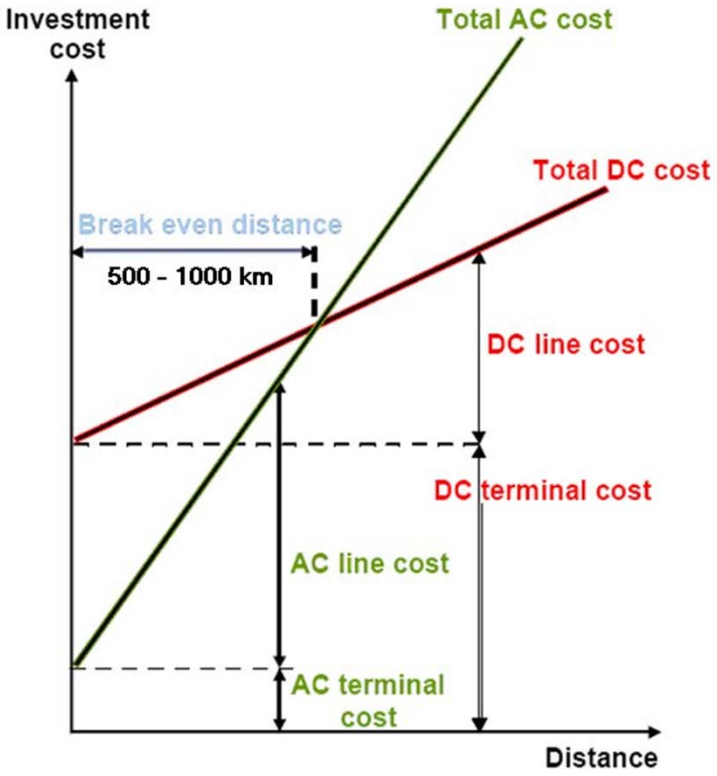


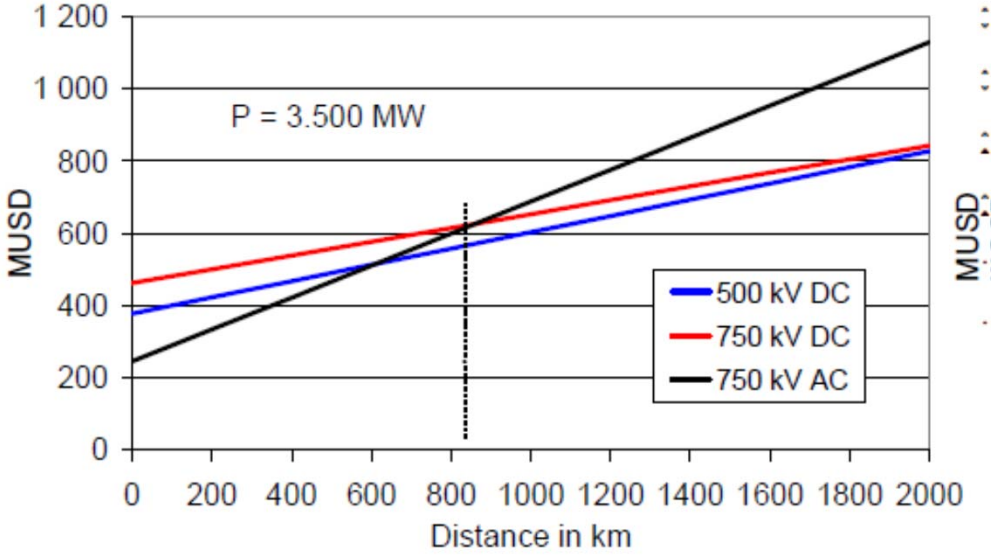
Source: OME

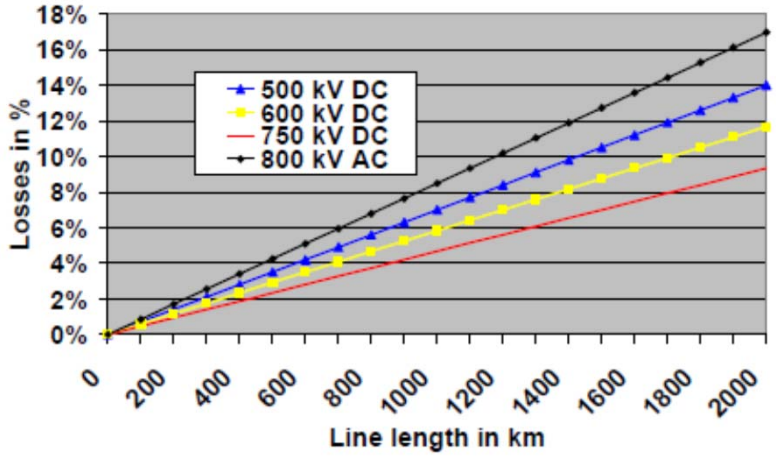
Power transmission via Hydrogen is possible, but 75 % of the solar electricity would be lost.



Cost of HVDC versus HVAC Links







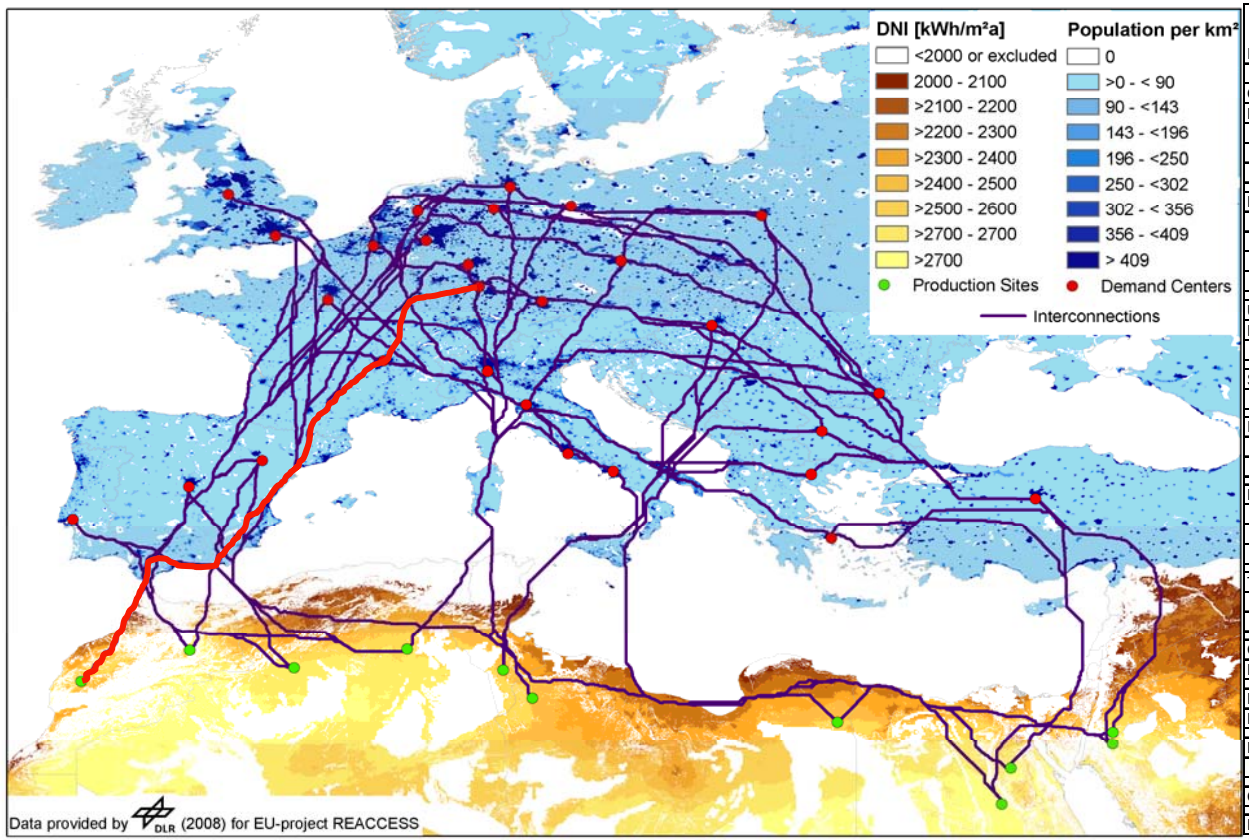
HVDC High Voltage Direct Current
HVAC High Voltage Alternating Current

Options for Solar Electricity Transfer over 2000 km Distance

Solar Power Transfer by:	**Hydrogen**	**AC / HVAC**	**HVDC Line**
Losses	75 %	30 % / 18 %	8 -14 %
Cost	very high	high	low
Adaptation to Consumers (Transformer)	has to be transformed to AC first	directly transformable	has to be transformed to AC first
Over Sea Transport	by tankers or pipelines	not over 30 km	standard solution
Visibility Impact	very low	high	low
Materials and Emissions	moderate	moderate	low
Preferred Application	eventually fuel for transport	regional and local power	long distance power transfer

Business case EU-NA Interconnection

The TRANS-CSP / DESERTEC Concept – flexible solar power plus 33 additional energy corridors with firm capacity for Europe in 2050



Import Country	Start Point	End Point	Net Import Electricity	Total Length
			TWh/a	km
Germany /	Morocco #1	Karlsruhe, Germany	23,0	2.917
Denmark	Morocco #2	Jülich, Germany	24,5	2.455
	Tunisia #1	Mainz, Germany	23,6	2.160
	Algeria #1	Hannover, Germany	24,1	2.851
	Algeria #2	Munich, Germany	24,9	1.998
France	Morocco #1	Paris, France	18,7	2.306
	Morocco #2	Paris, France	19,8	1.939
	Tunisia #1	Paris, France	21,3	2.195
	Algeria #1	Lion, France	25,3	1.847
	Algeria #2	Lion, France	24,6	2.208
United	Morocco #1	London, UK	18,5	2.643
Kingdom	Morocco #2	London, UK	22,4	2.304
	Algeria #1	Newcastle, UK	24,3	2.748
Spain	Morocco #2	Madrid, Spain	20,7	964
	Algeria #1	Zaragoza, Spain	24,2	1.178
Italy	Algeria #2	Milano, Italy	20,1	1.587
	Tunisia #1	Firence, Italy	19,3	1.432
	Libya #1	Roma, Italy	20,6	1.761
Poland	Egypt #1	Warszaw	18,9	3.525
	Jordan #1	Warszaw	18,1	3.500
	Egypt #2	Warszaw	22,1	3.817
	Saudi Arabia #1	Warszaw	23,8	3.586
Turkey	Jordan #1	Ankara, Turkey	19,3	2.255
	Saudi Arabia #1	Ankara, Turkey	20,0	2.310
	Saudi Arabia #1	Ankara, Turkey	20,6	2.310
Czech	Algeria #2	Prague, Czech Republic	19,5	2.230
Republic	Libya #1	Prague, Czech Republic	19,0	2.154
Belgium	Morocco #1	Brussels, Belgium	19,0	2.612
Netherlands	Morocco #2	Appledorn, Netherlands	22,1	2.462
Romania	Jordan #1	Bukarest, Romania	15,8	2.502
	Algeria #2	Bukarest, Romania	18,8	2.918
Greece / Bulgaria	Egypt #2	Sophia, Bulgaria	21,5	2.849
Hungary / Slowakia	Libya #1	Budapest, Hungary	24,7	2.254

Flexible solar power import to Germany starting 2022 with 12 ct/kWh (5% WACC, 40 a)

Source: Trieb et al., Energy Policy 42 (2012) 341-353

Time for Discussion …