The Role of CSP in the Future MENA Electricity Mix

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in der Helmholtz-Gemeinschaft

Part 1: The scope of renewable energy in MENA

1. Technology options
2. Resource potentials
3. Sustainability indicators
4. A sustainable electricity supply scenario
5. Seawater Desalination

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

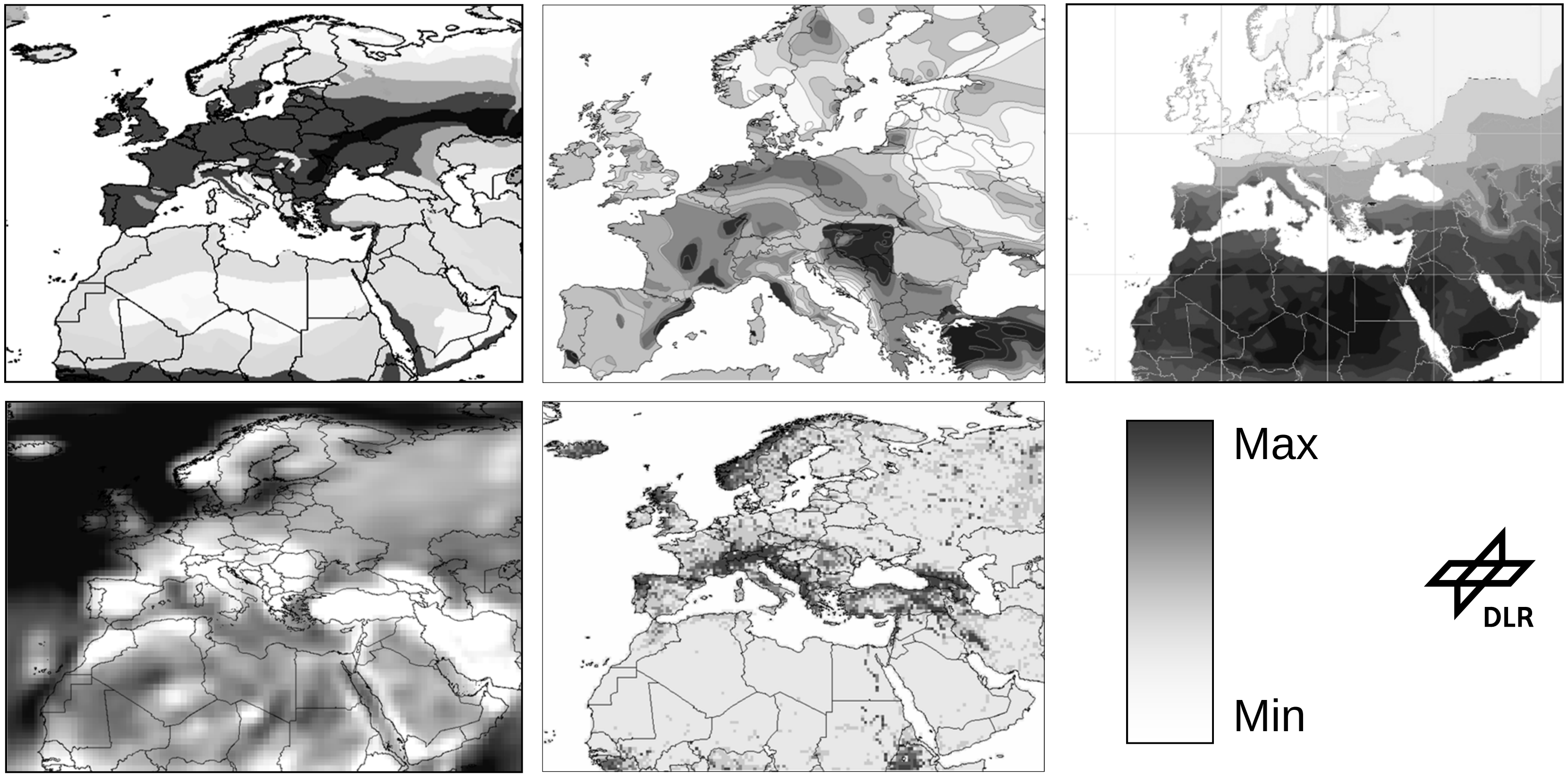
storable primary energy

- ✓ 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)

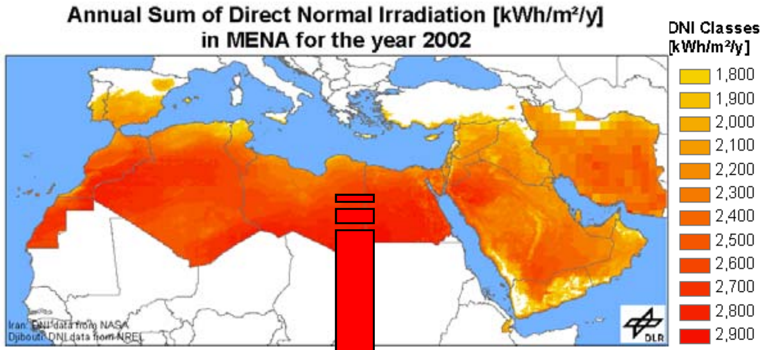


Wind Energy (5-50) | Hydropower (0-50)

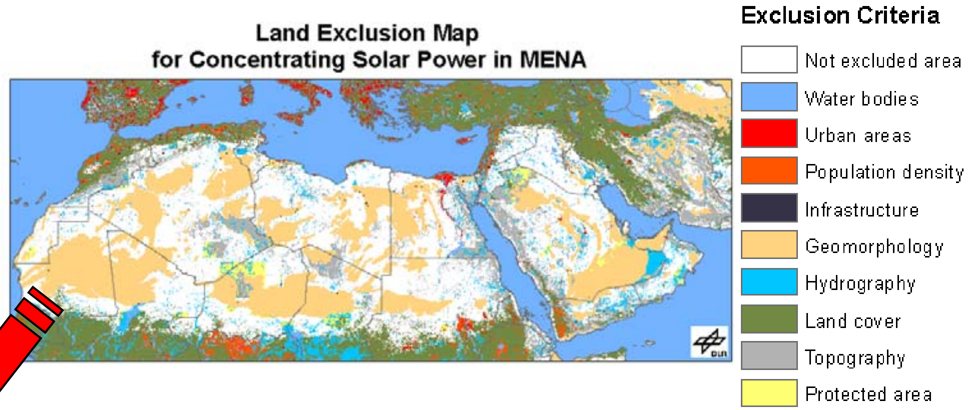
Electricity Yield
in GWh/km²/y

For example: CSP potential in MENA

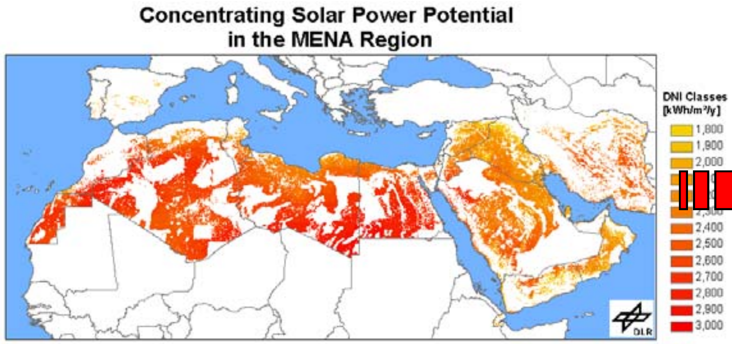
I. Solar Resource Assessment



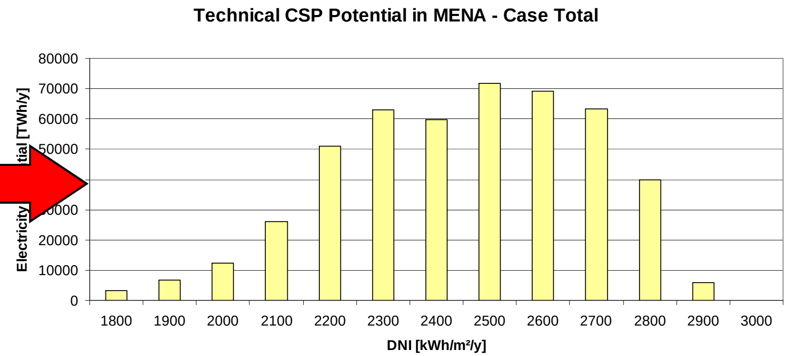
II. Land Resource Assessment



III. CSP Potential



IV. Statistical Evaluation



Renewable Electricity Potential in the Middle East & North Africa

	Hydro	Geo	Bio	CSP	Wind	PV *
Algeria	0.5	4.7	12.3	135771	35.0	20.9
Bahrain	0.0	0.0	0.2	16	0.1	0.5
Djibouti	0.0	0.0	0.0	300	1.0	50.0
Egypt	50.0	25.7	14.1	57140	125.0	54.0
Gaza & WB	0.0	0.0	1.7	8	0.5	20.0
Iran	48.0	11.3	23.7	32134	12.0	54.0
Iraq	67.0	0.0	8.8	24657	20.0	34.6
Israel	7.0	0.0	2.3	151	0.5	6.0
Jordan	0.1	0.0	1.6	5884	5.0	6.7
Kuwait	0.0	0.0	0.8	1372	n.a.	3.8
Lebanon	1.0	0.0	0.9	5	1.0	5.0
Libya	0.0	0.0	1.8	82714	15.0	7.8
Malta	0.0	0.0	0.1	0	0.2	0.2
Morocco	4.0	10.0	14.3	8428	35.0	17.0
Oman	0.0	0.0	1.1	14174	8.0	4.1
Qatar	0.0	0.0	0.2	555	n.a.	1.5
Saudi Arabia	0.0	70.9	10.0	75832	20.0	20.8
Syria	4.0	0.0	4.7	8449	15.0	17.3
Tunisia	0.5	3.2	3.2	5673	8.0	3.7
UAE	0.0	0.0	0.7	447	n.a.	9.0
Yemen	0.0	107.0	9.1	8486	3.0	19.3
Total (TWh/a)	**182**	**233**	**111**	**462196**	**304**	**356**

* PV potential includes demand side restrictions, the total potential is similar to CSP

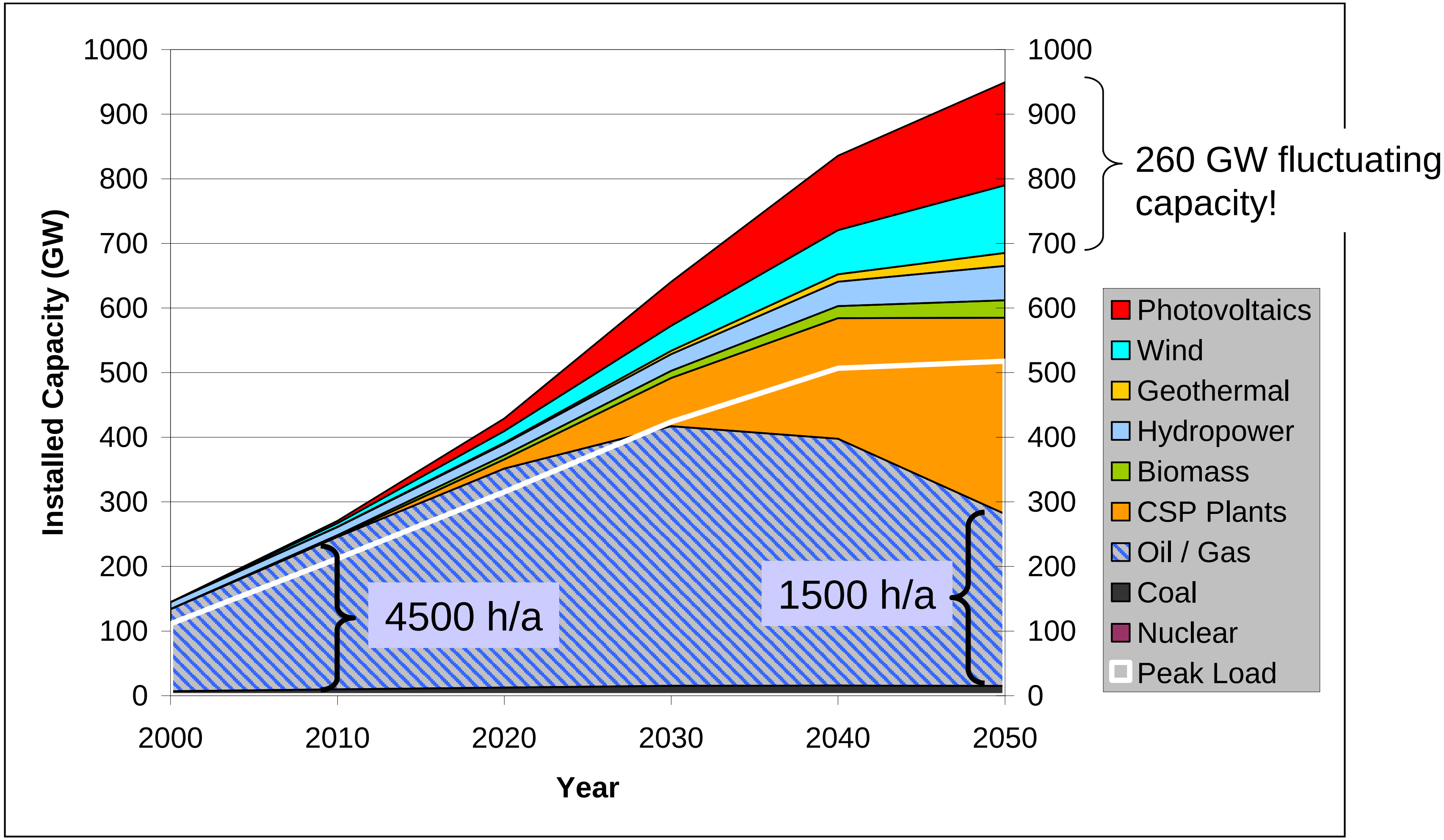
“Sustainable” electricity supply should be:

✓ **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

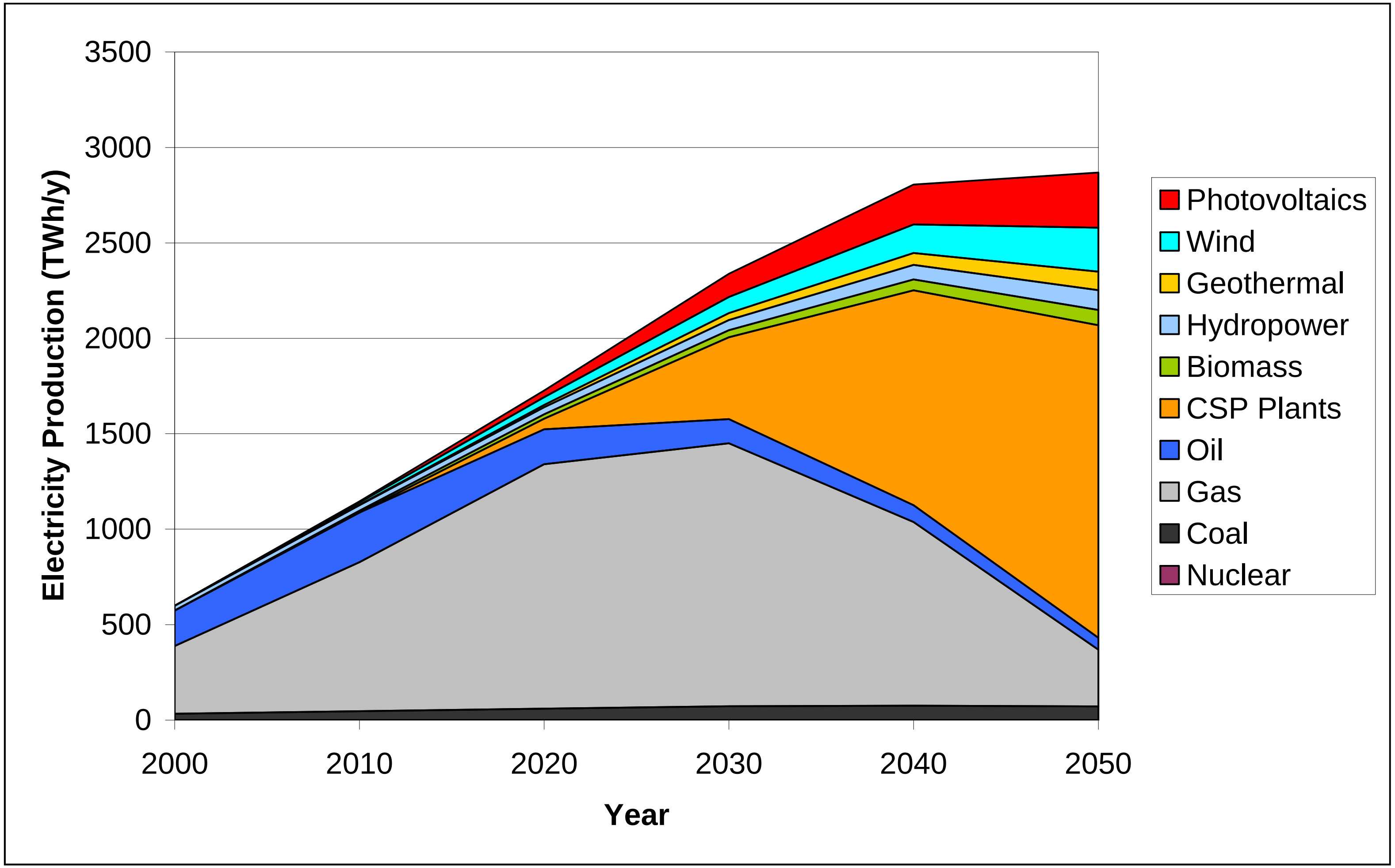
✓ **Compatible**
- low pollution
- climate protection
- low risks for health and environment
- fair access

Installed Capacity in all MENA Countries by Sources

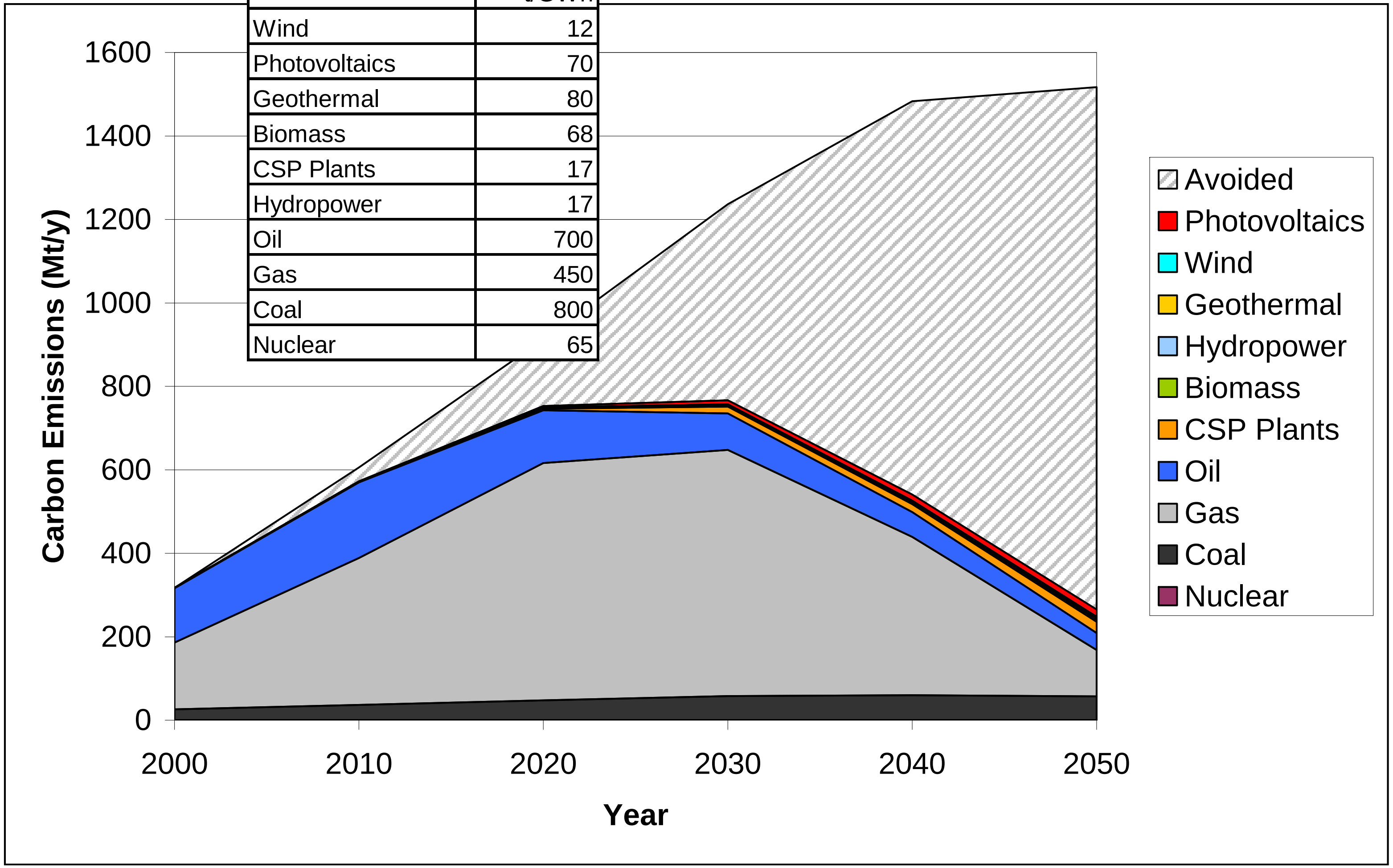


125% firm capacity with respect to peak load

Electricity Production of all MENA Countries by Sources



CO_2- Emissions from Power Generation by Sources

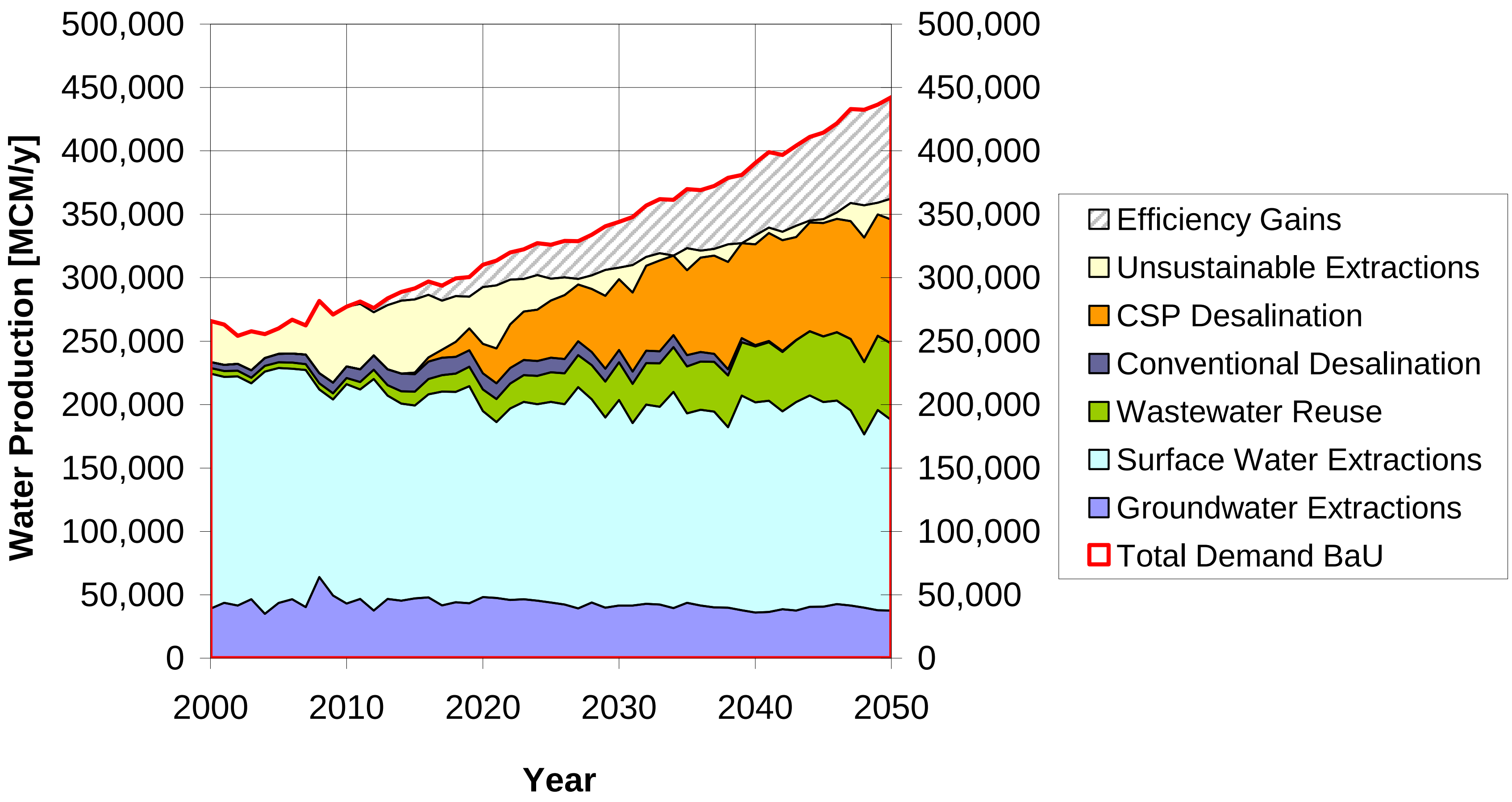


	t/GWh
Wind	12
Photovoltaics	70
Geothermal	80
Biomass	68
CSP Plants	17
Hydropower	17
Oil	700
Gas	450
Coal	800
Nuclear	65

Why CSP for Water in MENA?

1. CSP potential is very large even at coastal sites
2. good seasonal correlation of availability and demand
3. most abundant in regions with highest water scarcity
4. base load for uninterrupted operation of desalination plants
5. solar powered pre-treatment replaces chemicals

Middle East & North Africa (MENA)



Part 2: The associated challenges

1. The flexibility challenge
2. The investment challenge
3. The quality challenge
4. The policy challenge
5. The role of CSP in the future electricity mix

The Role of Wind, PV and CSP

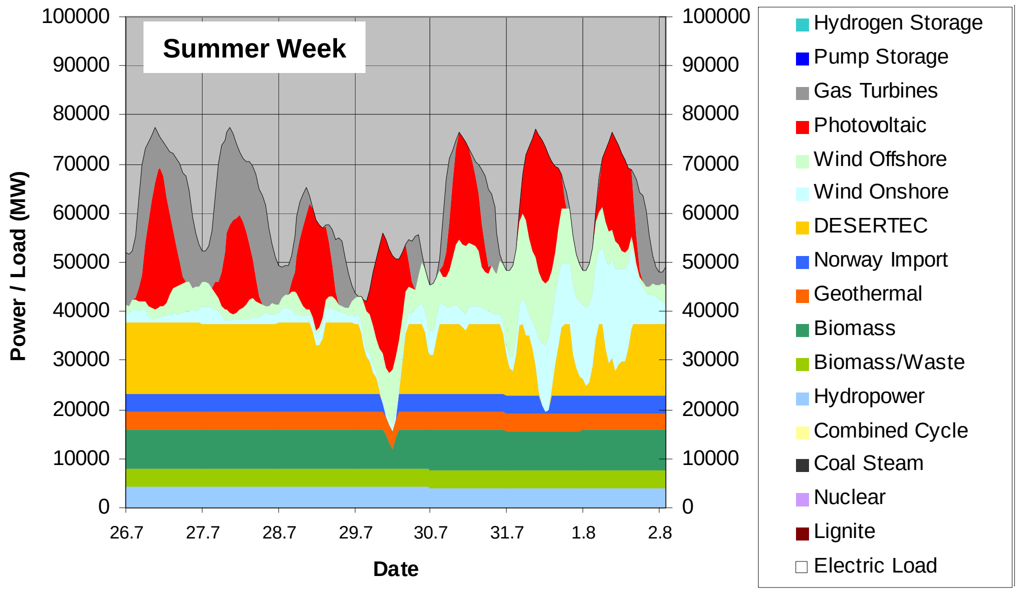
- PV and Wind do not deliver firm capacity.
- Strong, well developed power markets in industrial countries can easily integrate large amounts of PV and wind power, as the existing capacity can balance fluctuations.
- Growing power markets in developing countries need addition of firm capacity, preferrably by CSP, biomass or hydropower.

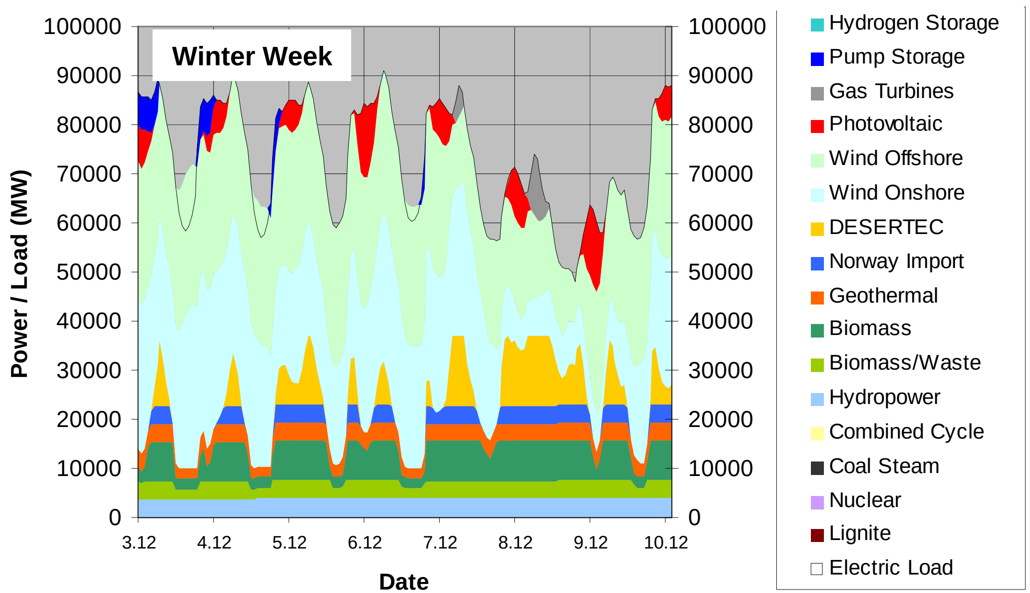
Case study Germany 2050

The role of variable and flexible renewable power sources in a 90% renewable electricity scenerio for the year 2050 for Germany.

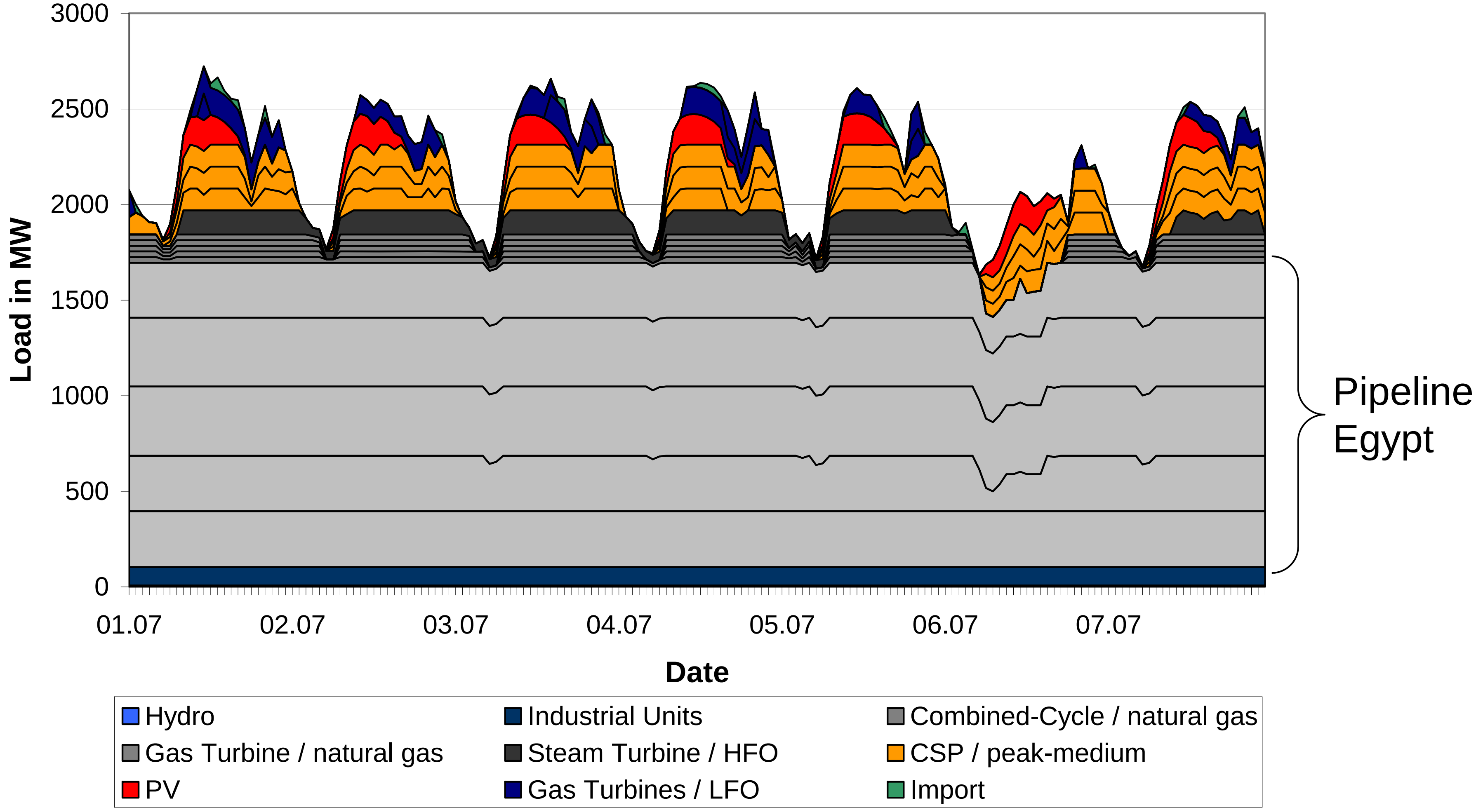
Installed Capacities:

Photovoltaics:	55 GW	var. RE
Wind Onshore:	40 GW	
Wind Offshore:	30 GW	
DESERTEC:	16 GW	flex. RE
Import Norway	4 GW	
Geothermal:	4 GW	
Biomass:	9 GW	
Biomass Waste:	4 GW	
Hydropower:	6 GW	
Natural Gas:	63 GW	flex. Fuel

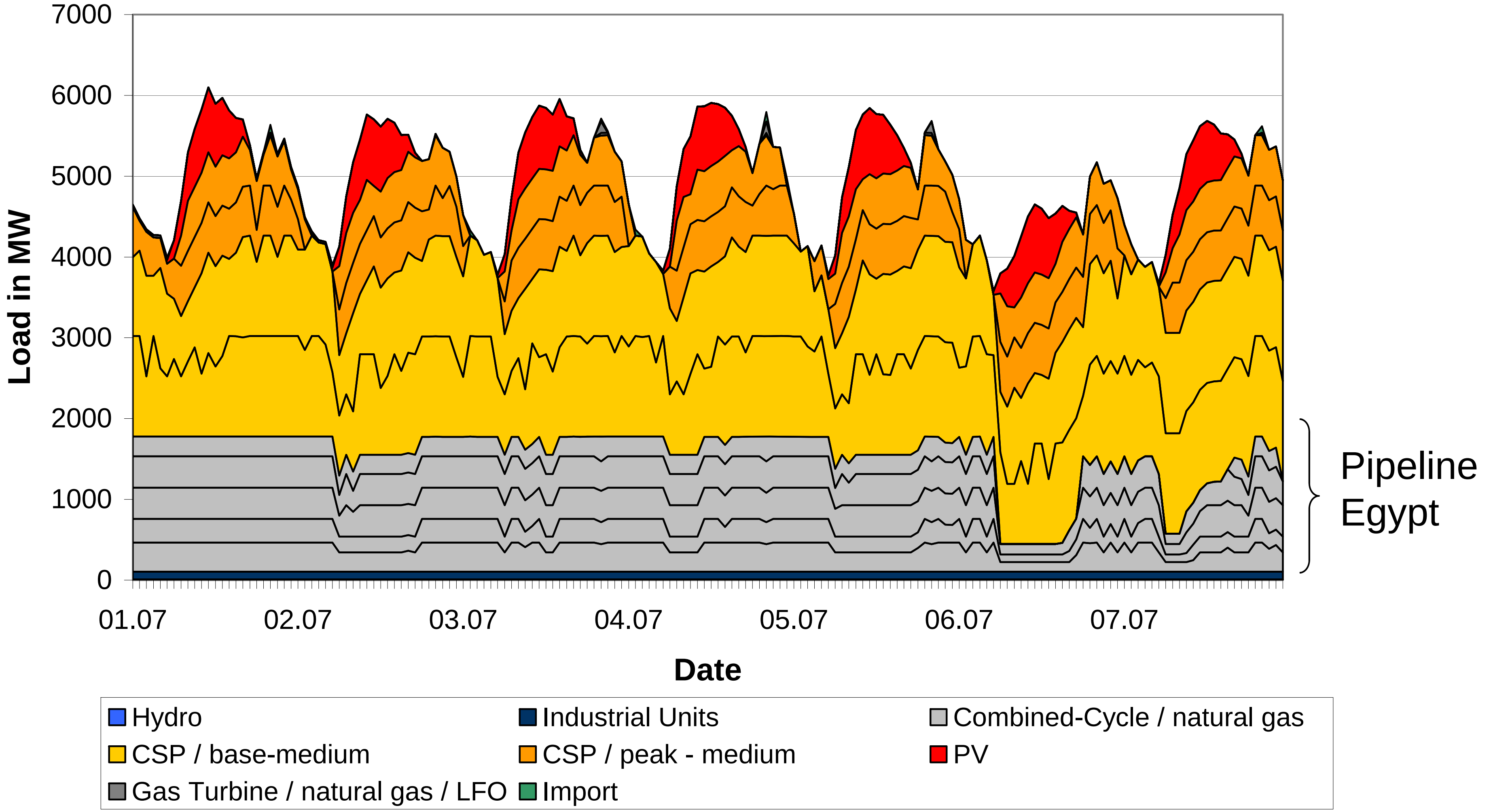




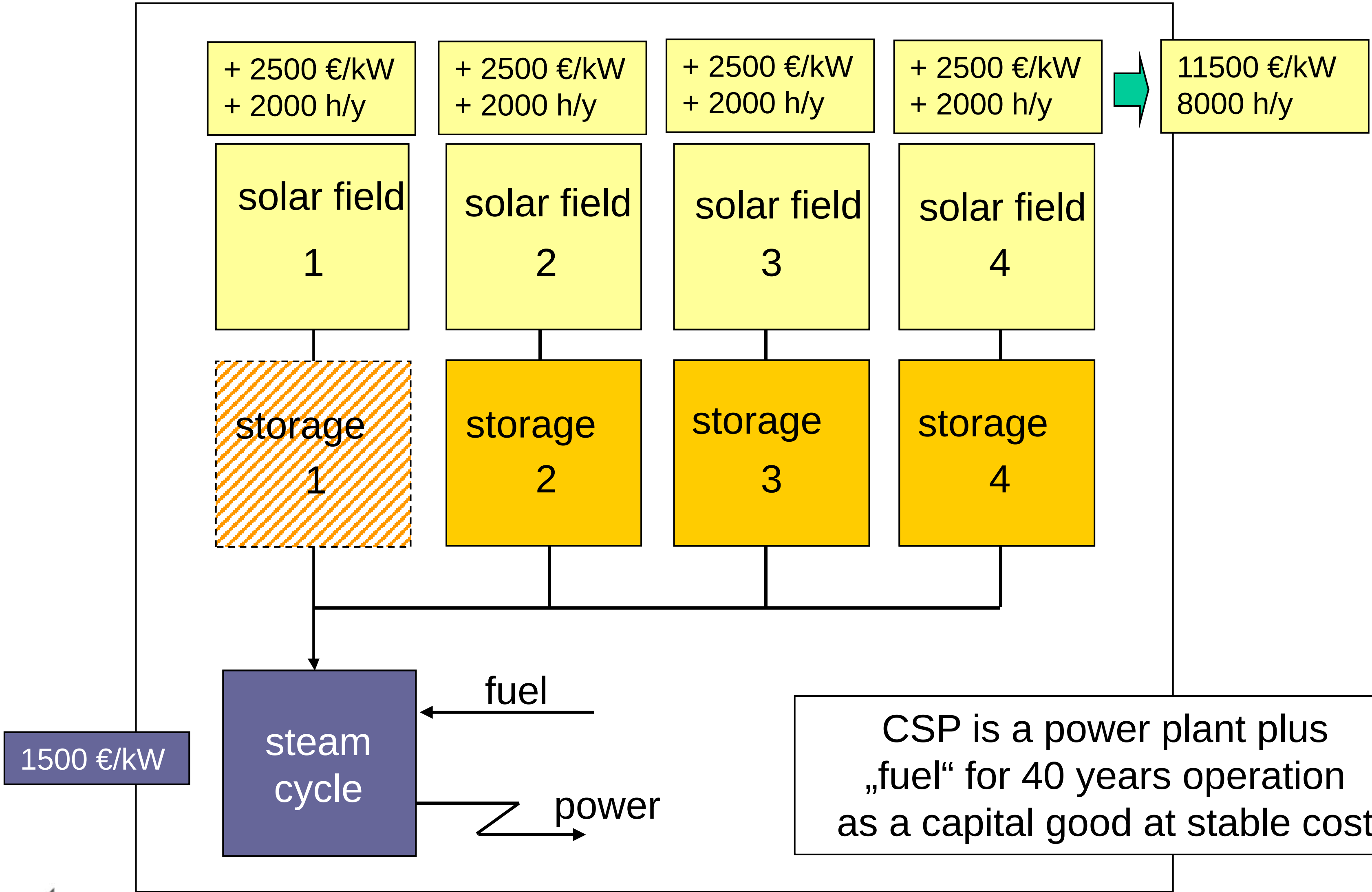
Case study Jordan 2015: role of CSP and PV



Case study Jordan 2030: role of CSP and PV



The CSP Investment Challenge



CSP is a power plant plus „fuel“ for 40 years operation as a capital good at stable cost

High capital cost of CSP is prohibitive for developing countries

1. limited national budgets cannot cope with high investments

2. low national credit ratings translate to low project credit ratings

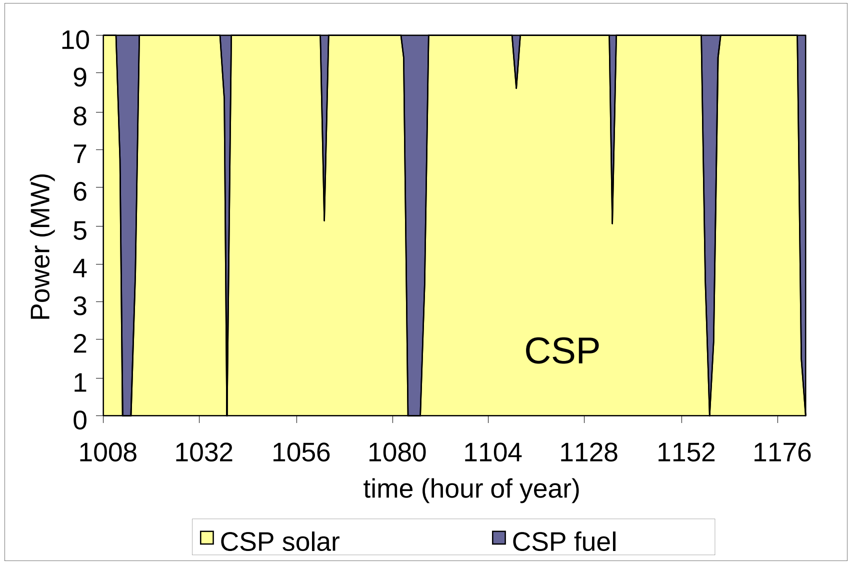
➔ cost of capital (interest rates) higher than for industrial countries

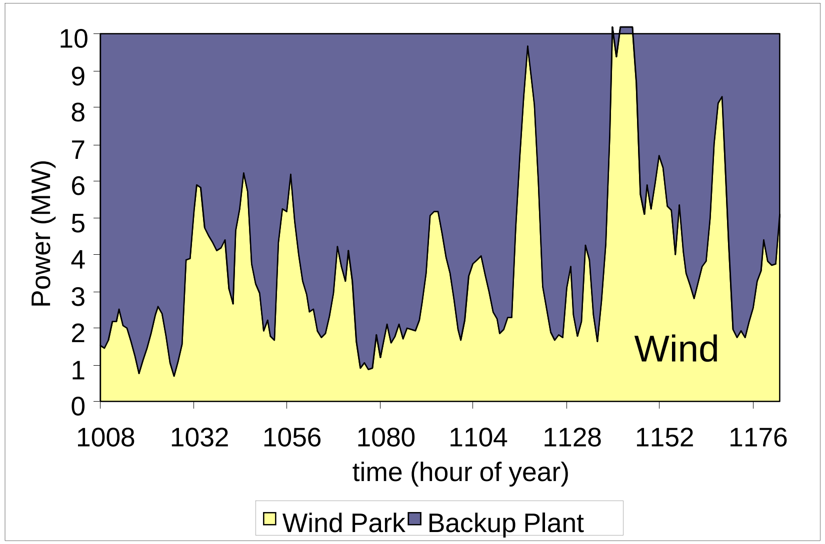
➔ CSP can be introduced in a series of subsidized projects but markets will not develop

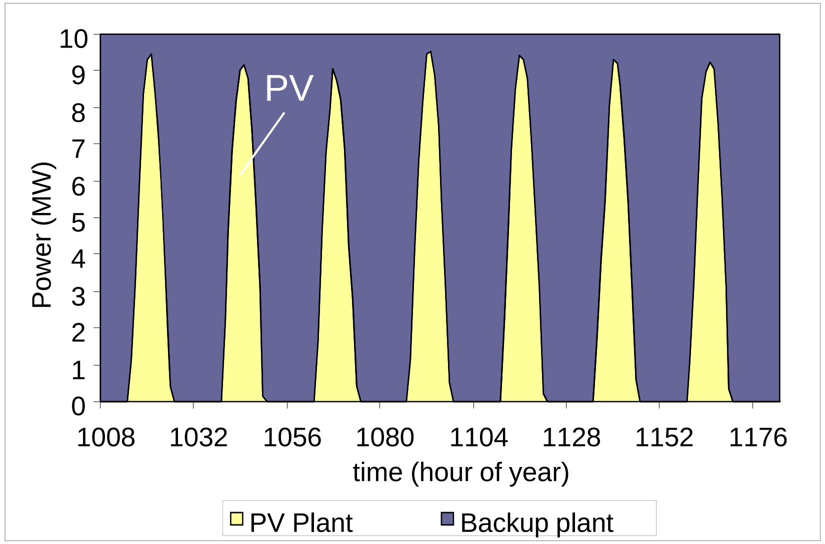
➔ real markets can only be initiated by increasing the ratings of CSP projects in developing countries towards AAA standard

The quality challenge:
How to cover a defined load with RE?

10 MW CSP (10% Gas)
10 MW PV + 10 MW backup from grid (75% gas)
10 MW Wind + 10 MW backup from grid (60% gas)







Comparing Wind, PV and CSP

- In most cost comparisons, PV and wind are assumed to have access to a cost-free, loss-free and unlimited storage device: the electricity grid. This seems wonderful, but is a rather expensive illusion!

- In contrast to that, CSP has a real, limited storage with cost and losses. Therefore CSP will always loose when compared to PV and wind in a way that does not compare equal quality of supply.

- There are 1 GW CSP, 40 GW PV and 200 GW wind power installed today. This means that the remaining potential for cost reduction of CSP is much higher than that for wind and PV including storage and backup. This cost reduction potential must be tapped by decidedly developing CSP world wide (just like PV and wind has been developed in the past)

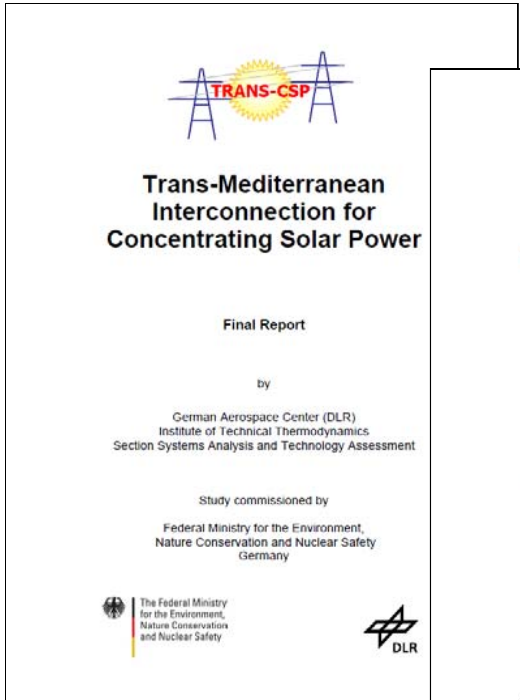
Setting an appropriate policy framework

- recognize the need for large RE investment
(RE investment replaces fuel consumption for decades)
- reduce capital cost by increasing RE project ratings towards AAA
(re-insured PPA, guaranteed renewable electricity tariff)
- recompense the quality of flexible renewable power
(re-insured PPA, guaranteed renewable firm-capacity tariff)
- provide transparent, long-term stable regulatory and policy framework for real RE markets

The role of CSP in the future electricity mix

- Base load and flexible power on demand (storage, hybrid mode)
- By far the largest renewable energy resource from the deserts
- Only alternative for flexible power in MENA except fossil fuels
- Adds to limited flexible alternatives (hydro, biomass, geothermal) in Europe
- Learning curve still ahead (1 GW CSP, 40 GW PV, 200 GW wind in 2010)
- In the long run, the cost of firm and cost-stable capacity is lowest from CSP
- CSP is the only sustainable source for base load supply of desalination plants
- Only alternative for flexible and base load renewable electricity exports
- CSP can selectively substitute the most expensive elements of power supply
- CSP has among others the lowest life cycle carbon emissions and land use
- Renewable base load source for synthetic liquid hydrocarbon production

If we always ask for least-cost solutions,
we may end up with a least-cost planet.


TRANS-CSP

Trans-Mediterranean Interconnection for Concentrating Solar Power

Final Report

by

German Aerospace Center (DLR)
Institute of Technical Thermodynamics
Section Systems Analysis and Technology Assessment

Study commissioned by

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Germany

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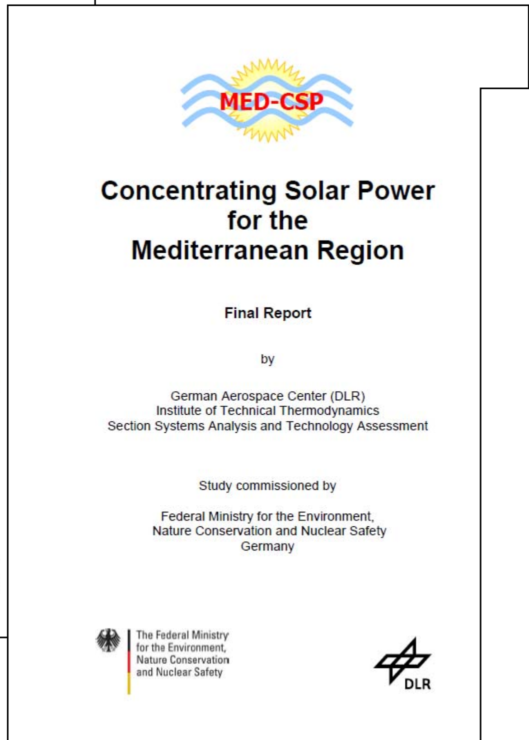
DLR


MED-CSP

Concentrating Solar Power for the Mediterranean Region

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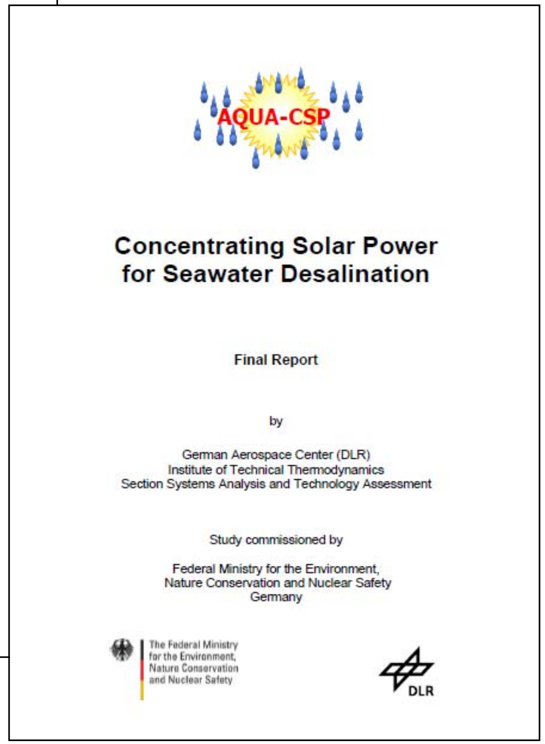
Thank You


AQUA-CSP

Concentrating Solar Power for Seawater Desalination

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