Overview CSP Technologies, Markets, Challenges

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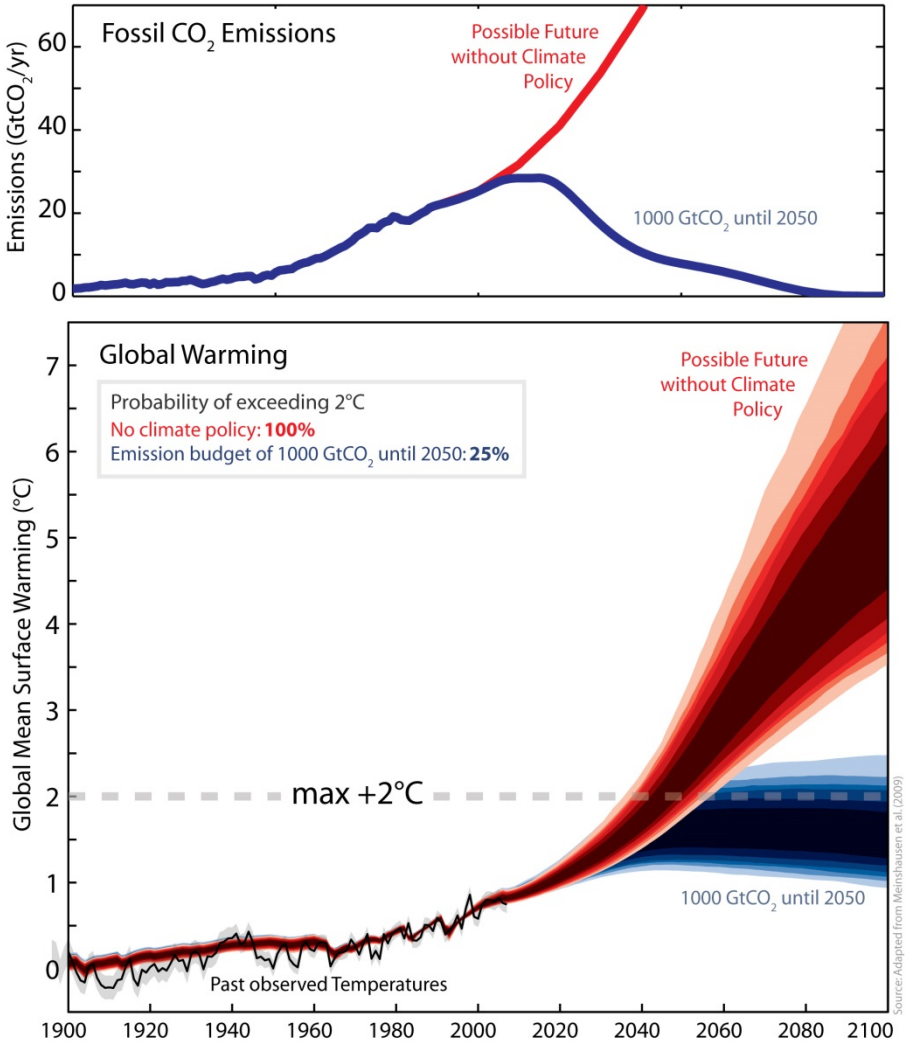
DLR Institute of Solar Research

Solar Qatar Summit,
18.11. 2013

Agenda

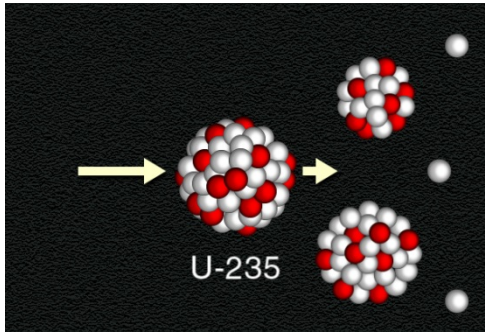
- Why renewable energies?
- Why Concentrated Solar thermal Power (CSP) plants?
- Solar resources
- Value of CSP electricity
- Technologies
  - Trough
  - Tower
  - Fresnel
- CSP vs PV
- Real data of CSP dispatchable solar generation
- Markets
- Trends

Why renewable energies?
- Scenarios on global warming -

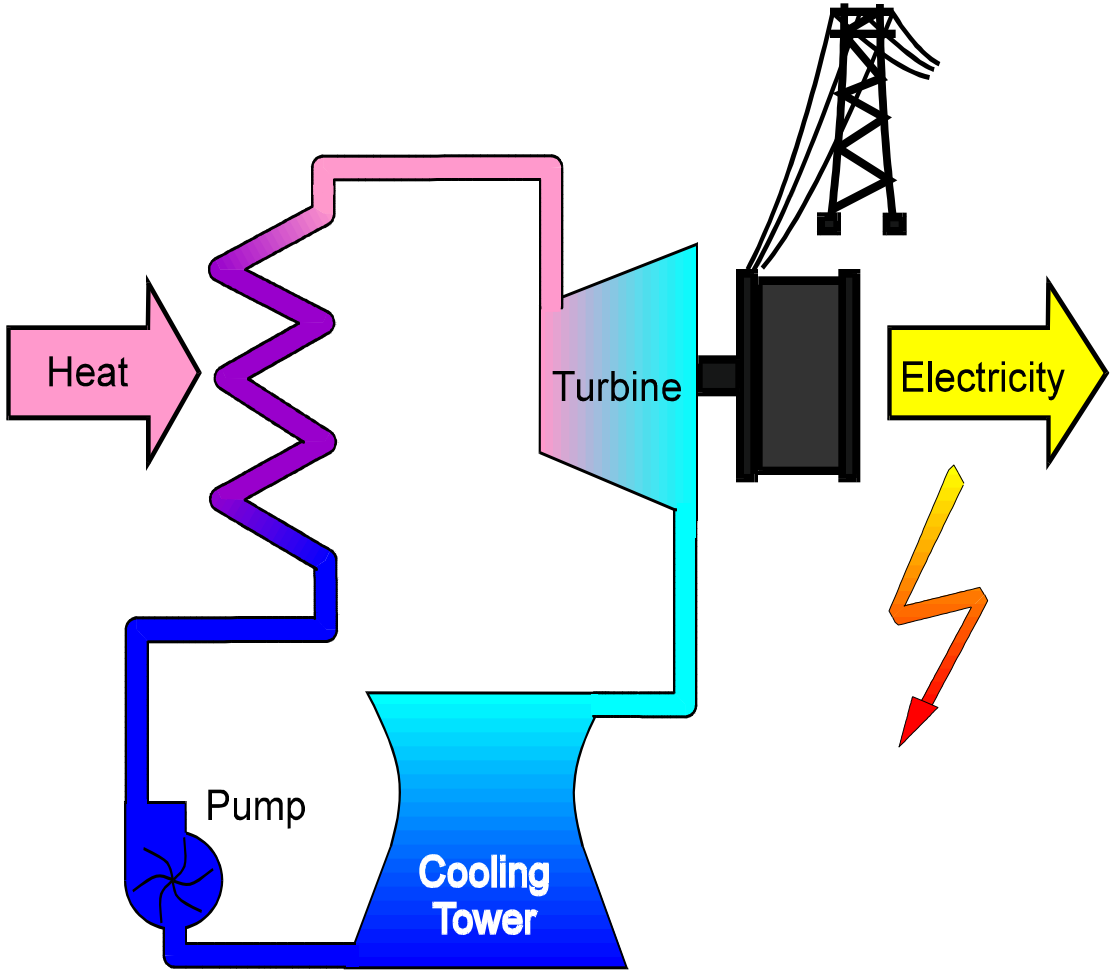


Source: M. Meinshausen et al. (2009)

Why solar thermal power plants ?



Conventional power plants



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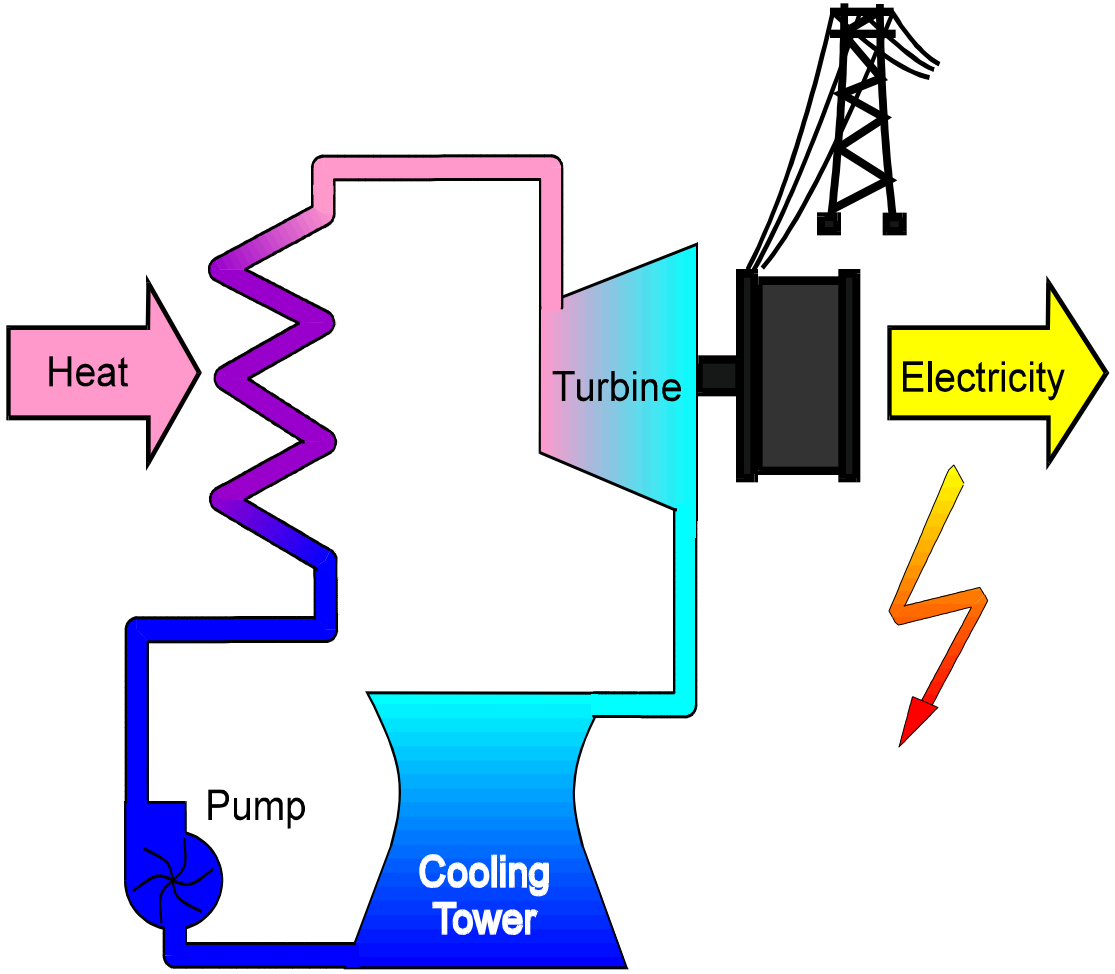
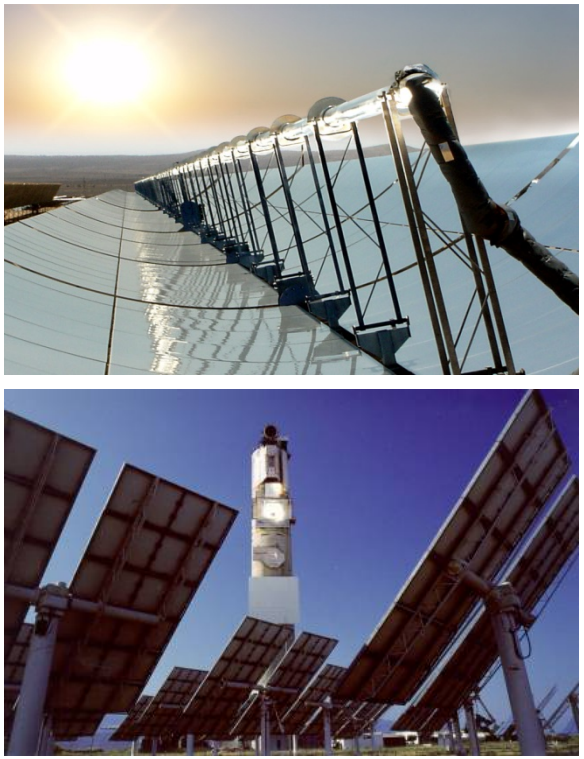
Why solar thermal power plants ?

Solar thermal power plants



Why solar thermal power plants ?

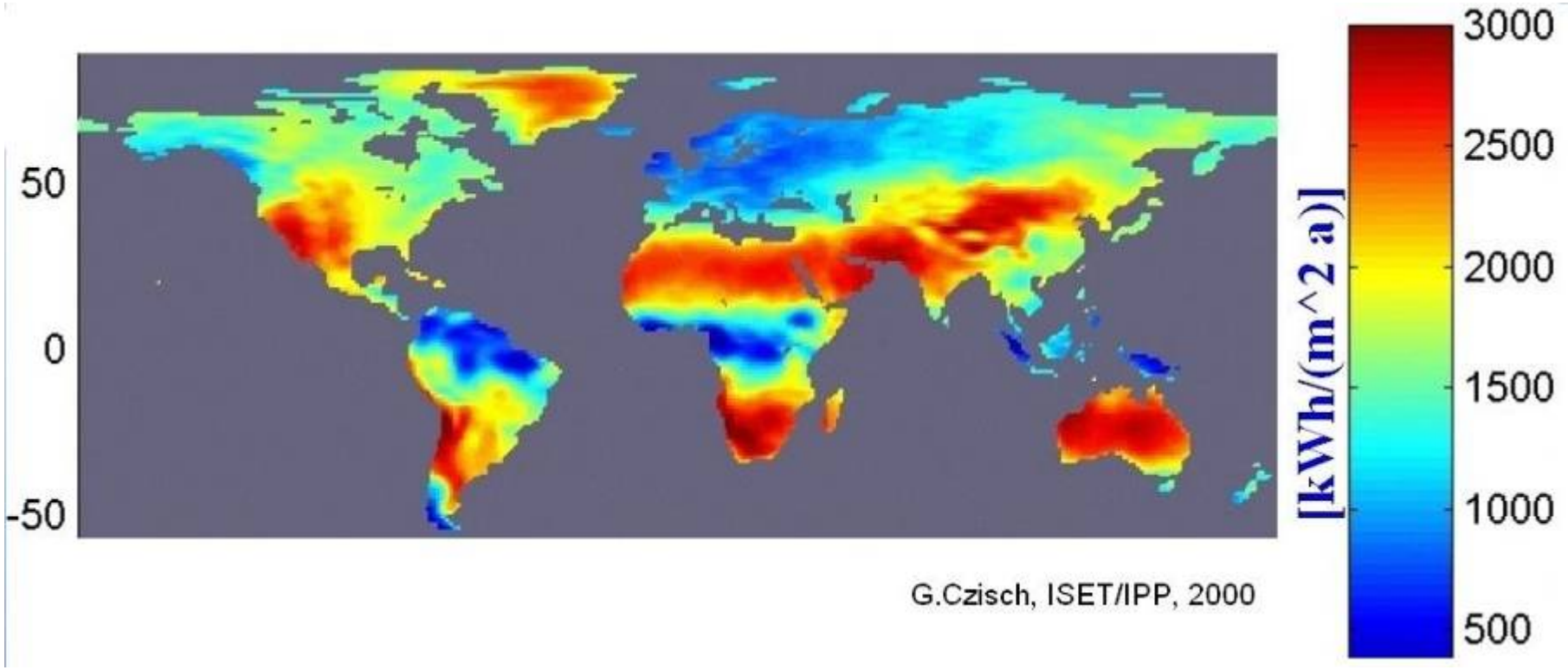


Solar thermal power plants

- 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

World Sun Belt

DNI – Direct Normal Irradiance [W/m²]



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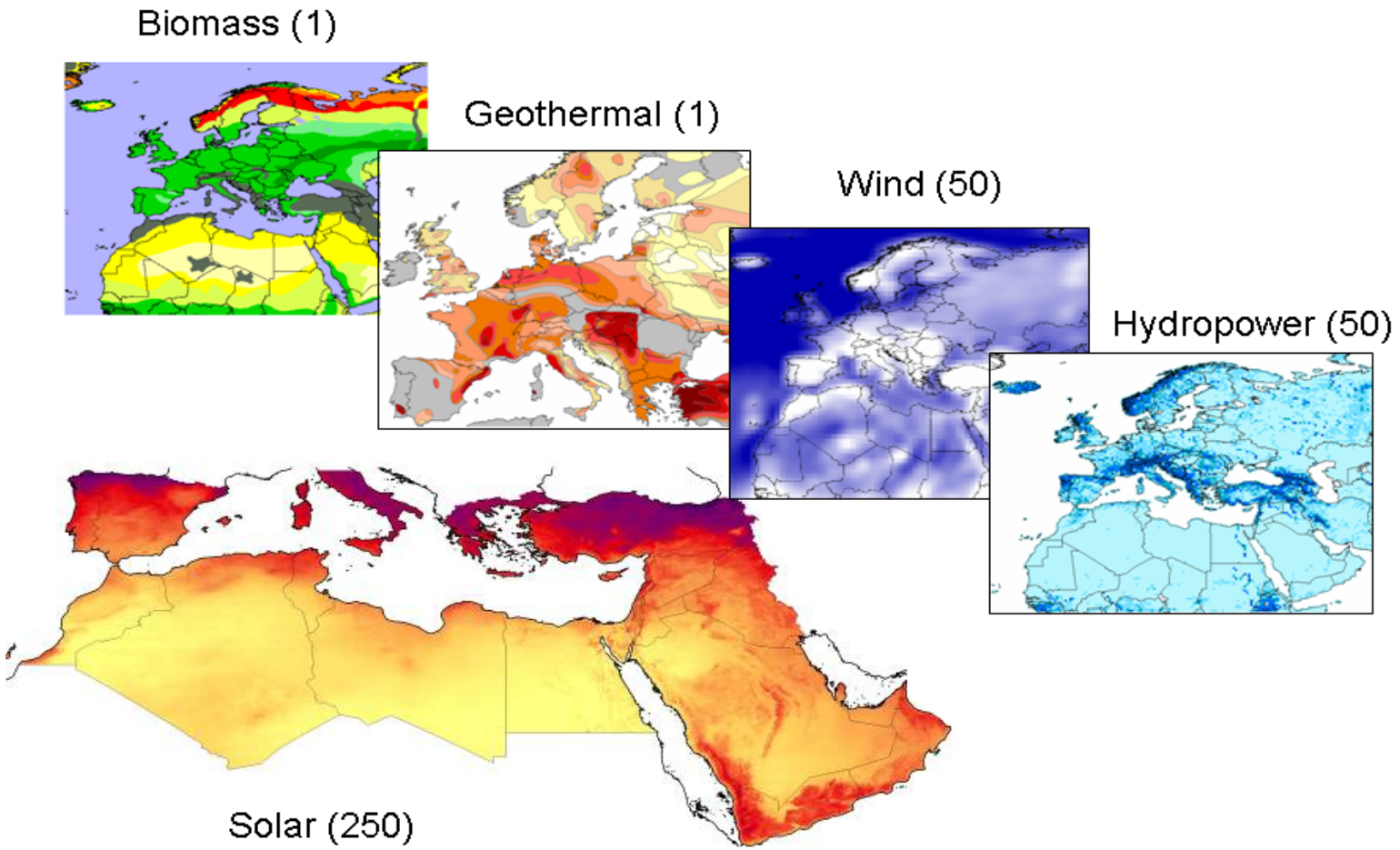
Renewable energy resources in Europe and MENA

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



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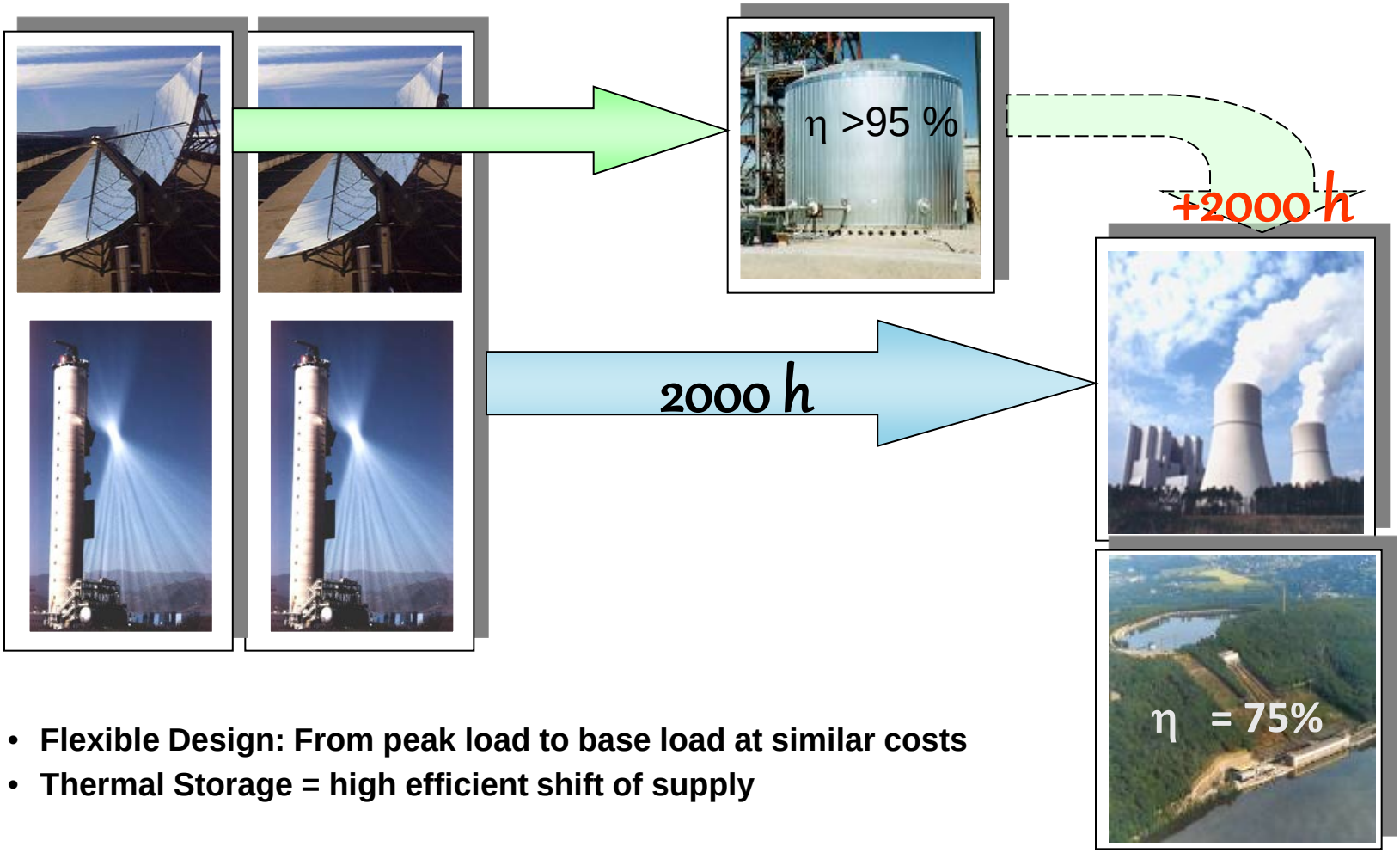
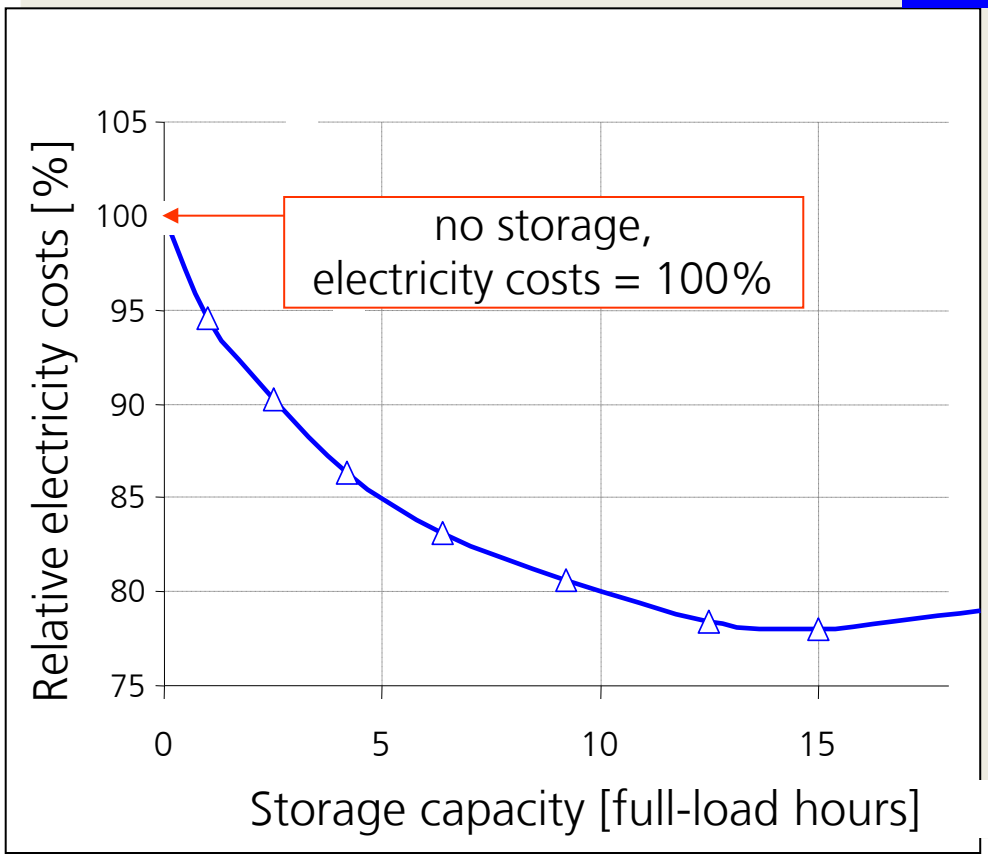
The Value of CSP Electricity



- **Flexible Design: From peak load to base load at similar costs**
- **Thermal Storage = high efficient shift of supply**

The Value of CSP Electricity



* assuming specific investment costs for the storage of 10 Euro/kWh

Types of Concentrating Solar Thermal Technologies

Dish-Stirling

Solar Power Tower

Parabolic Trough

Linear Fresnel

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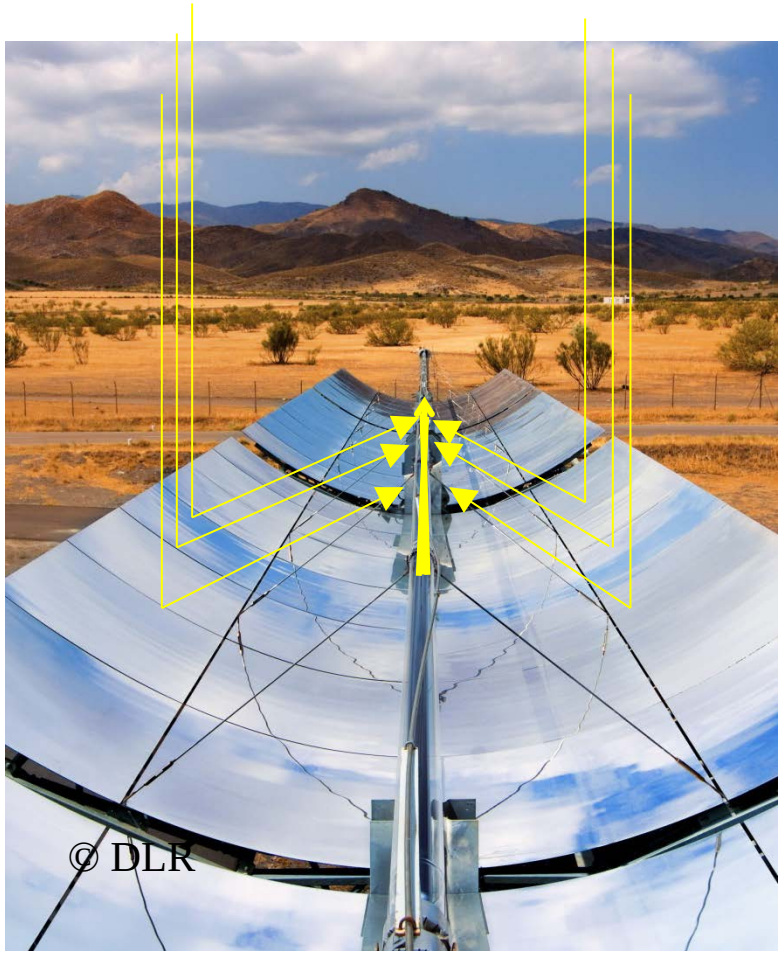
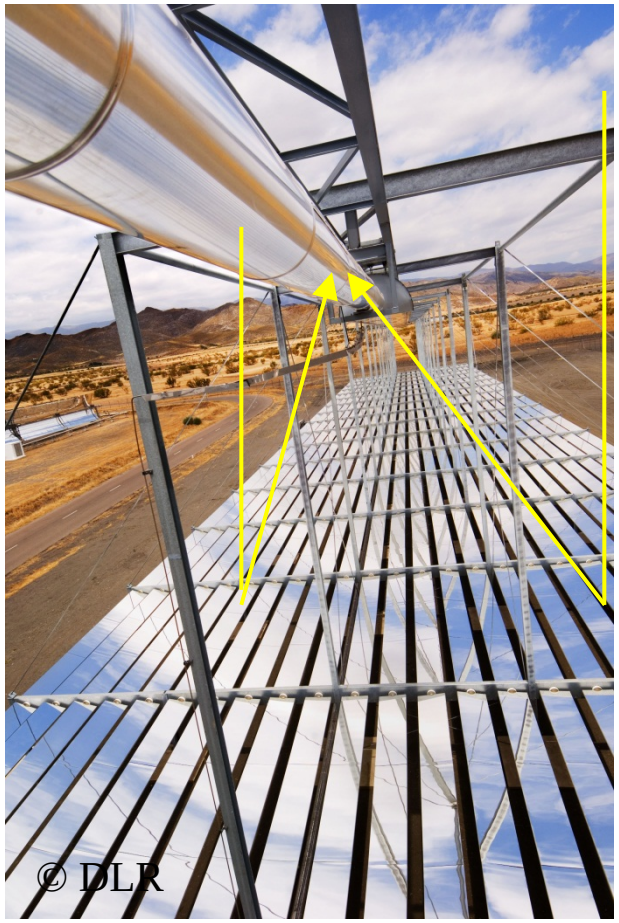
Parabolic Trough Collector

- Advantages:
  - Large scale proven technology
  - Bankable
- Disadvantages:
  - Up to now max. temperature of HTF limits the efficiency
  - Nearly flat side topography needed



Linear Fresnel Collector

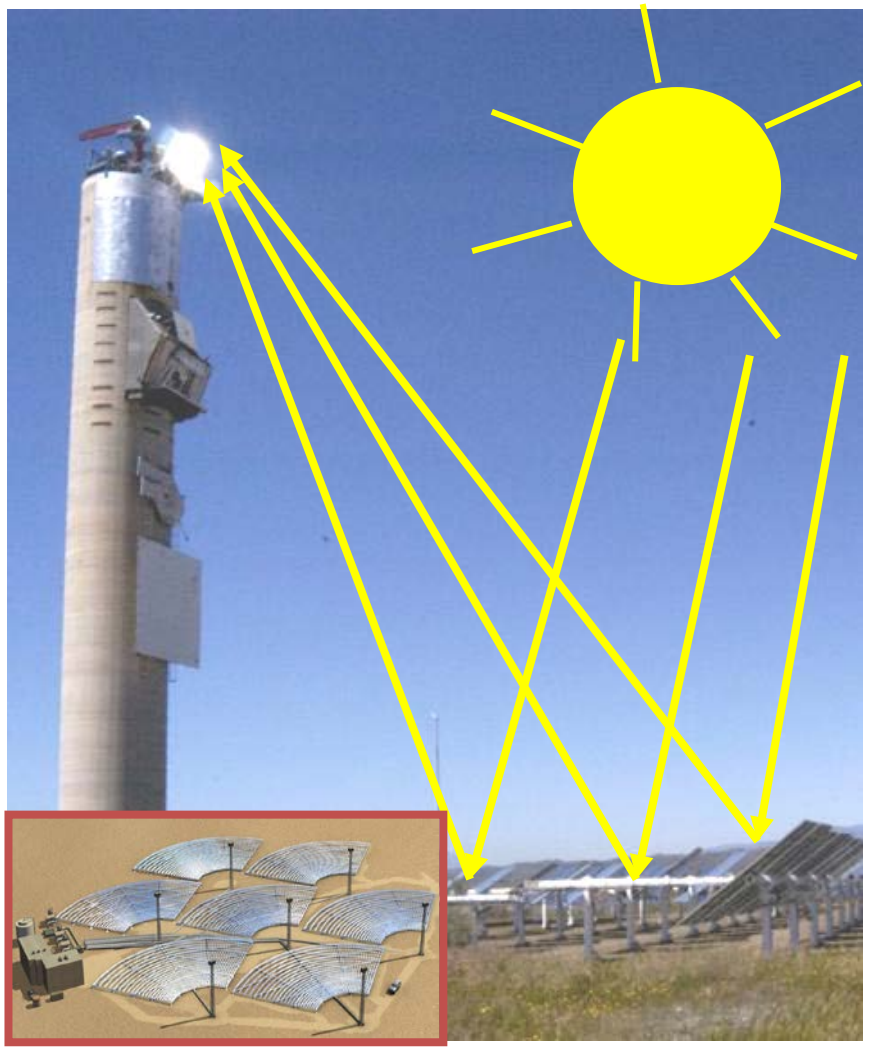
- Advantages:
  - Simple construction
  - High land use
  - Possible integration into buildings
- Disadvantages:
  - Low efficiency
  - State of the art without storage



Quelle: MSM

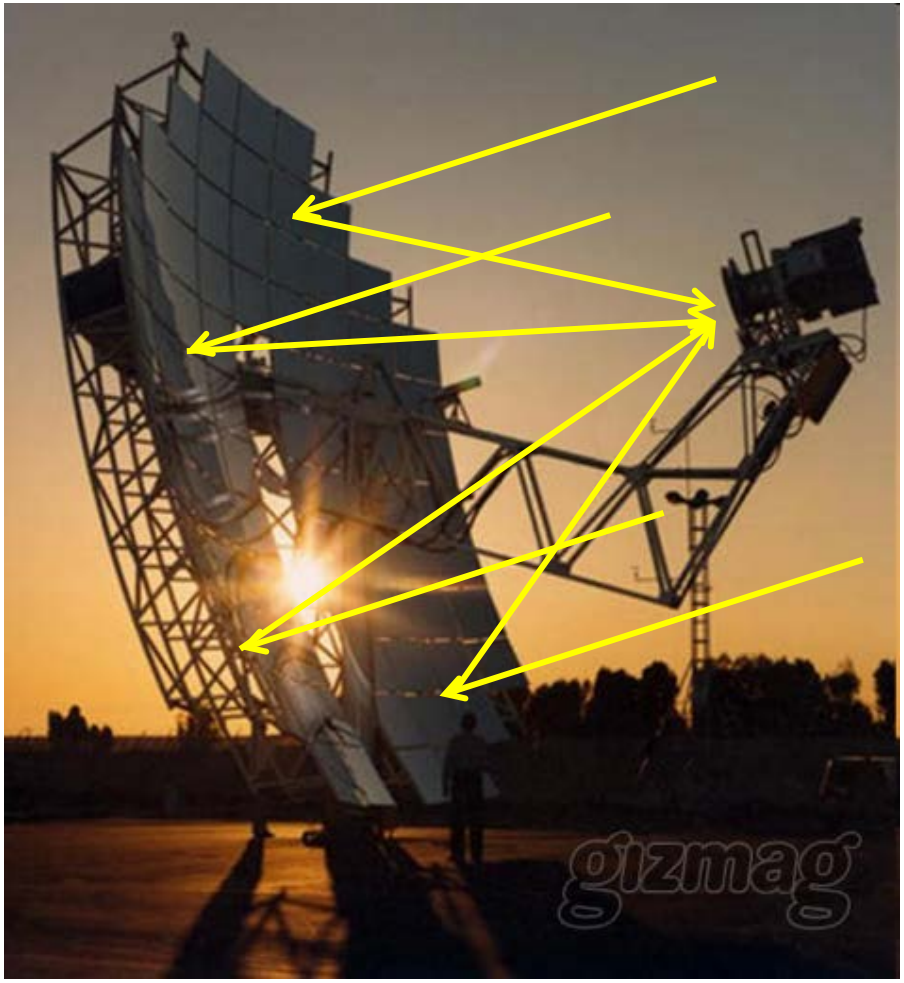
Solar Power Tower

- Advantages:
  - High efficiency potential
  - High cost reduction potential
  - Usable in hilly area
- Disadvantages:
  - Less commercial experience
  - Radiation attenuation by dust in the atmosphere

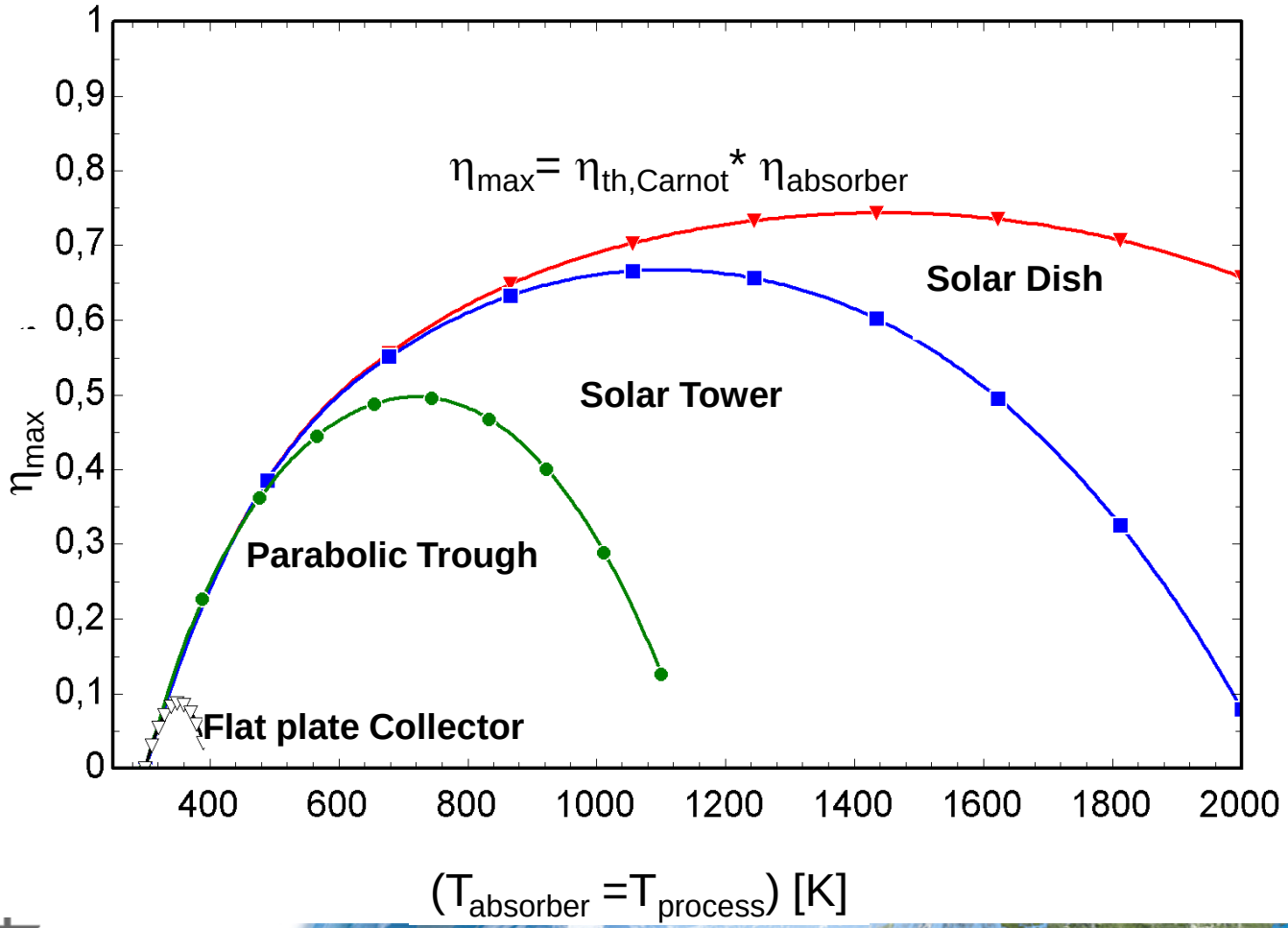


Dish-Stirling

- Advantages:
  - Very high efficiency
  - Small units
  - Decentralized application
- Disadvantages:
  - Expensive
  - No storage

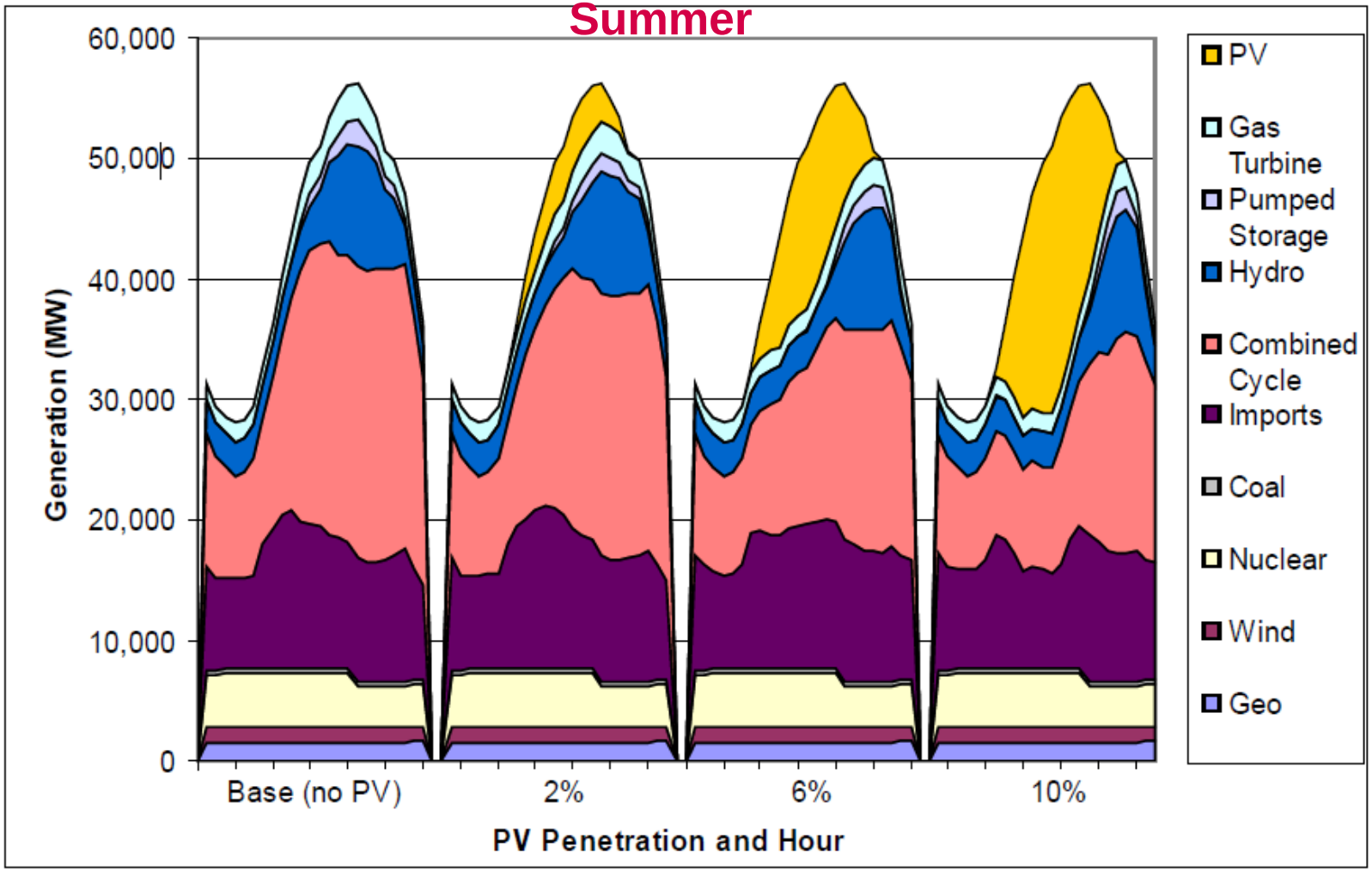


Theoretical efficiency potential



CSP vs PV

Simulation of supply and demand with increasing PV share



Source: NREL/TP-6A20-52978, Nov. 2011

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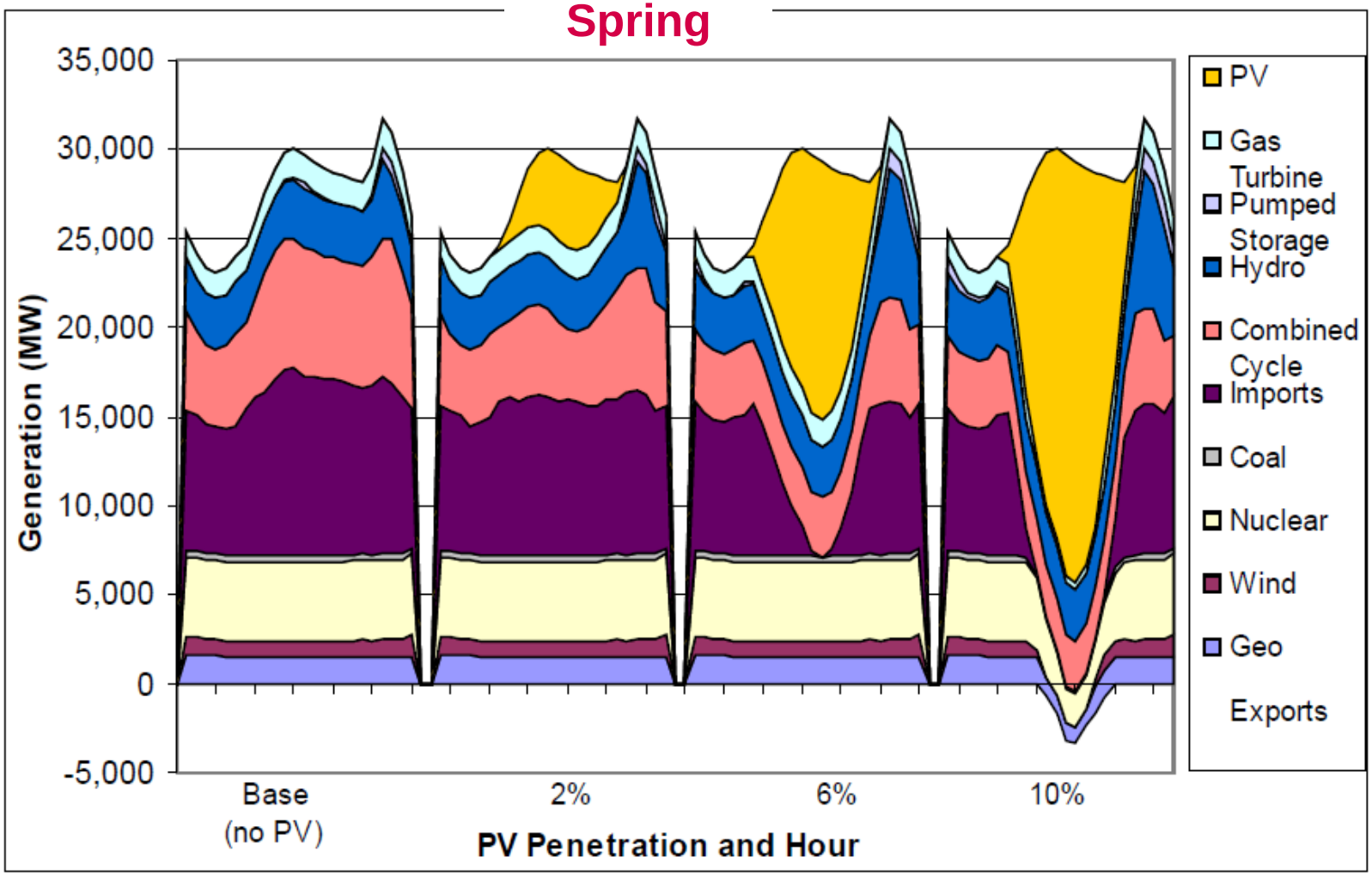
CSP vs PV

Simulation of supply and demand with increasing PV share



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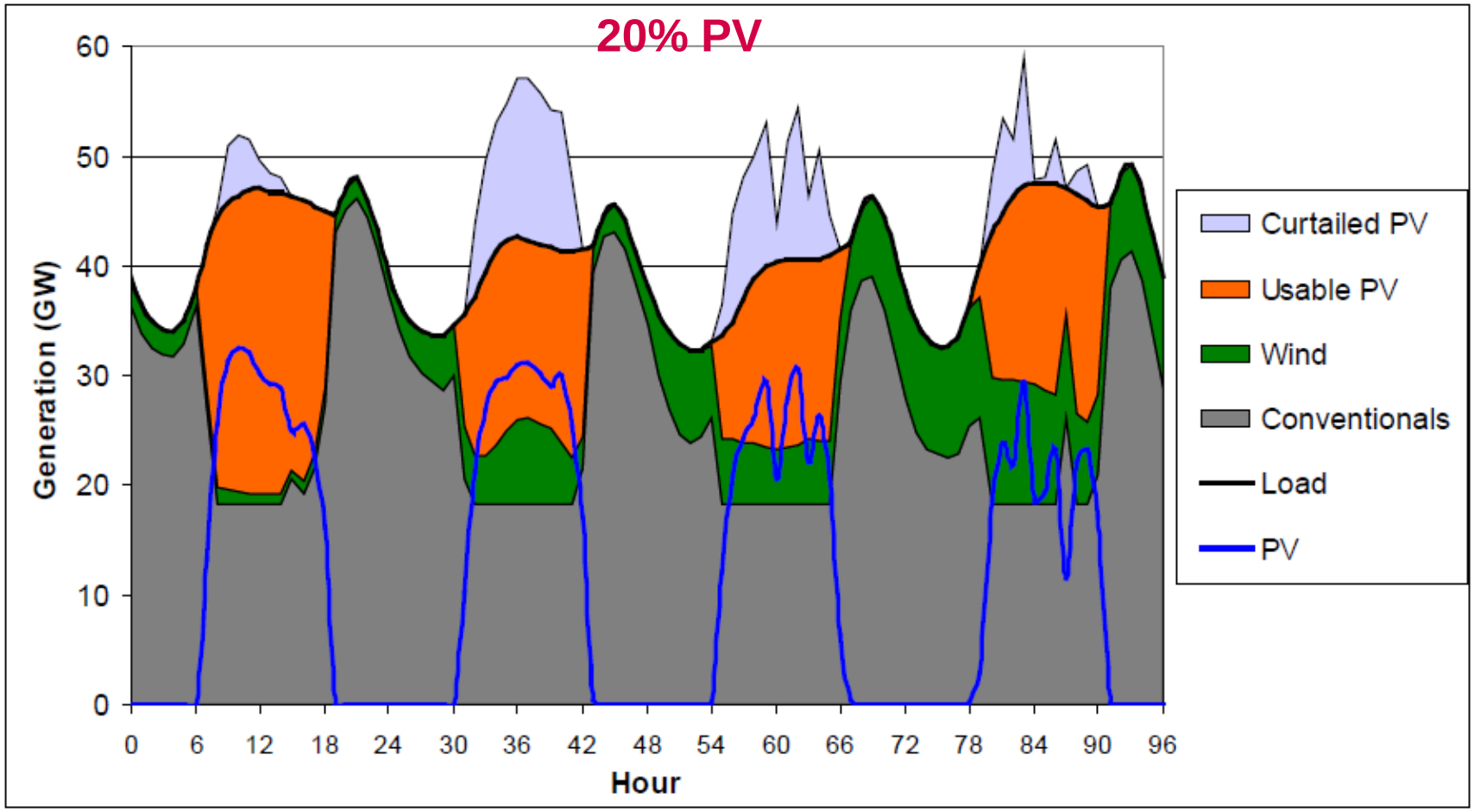

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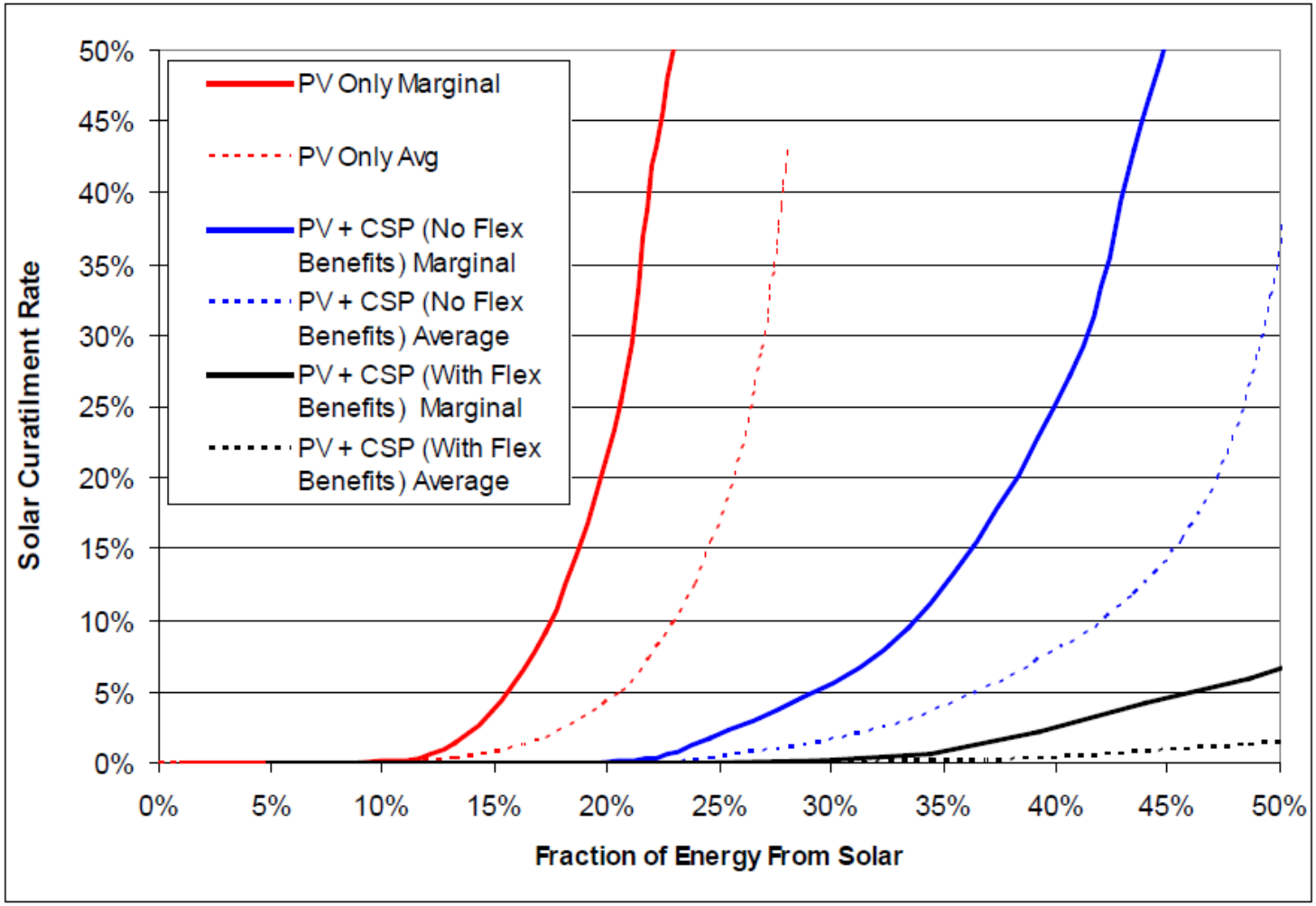

Source: NREL/TP-6A20-52978, Nov. 2011

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Real data of CSP dispatchable generation (Andasol III data)

Andasol 3: Facts & Figures

- Owner: Marquesado Solar S.L.
- Location: Aldeire/La Calahorra (Granada, Spain)
- Technology: Parabolic trough incl. 7.5h molten salt storage
- Capacity: 50 MW_{el}
- Size of the collector area: ~ 500,000 m²
- Forecasted electricity production: ~200 GWh/a
- Annual CO_2 savings: 150,000 tonnes
- Commissioning in autumn 2011
- Investors:

SWM Stadtwerke München, RWE The energy to lead, RheinEnergie, Solar Millennium, Ferrostaal

- EPC contractor: UTE

Ferrostaal, duro felguera, s.a. energía, Solar Millennium, FLAGSOL

Source: RWE Innogy, F. Dinter

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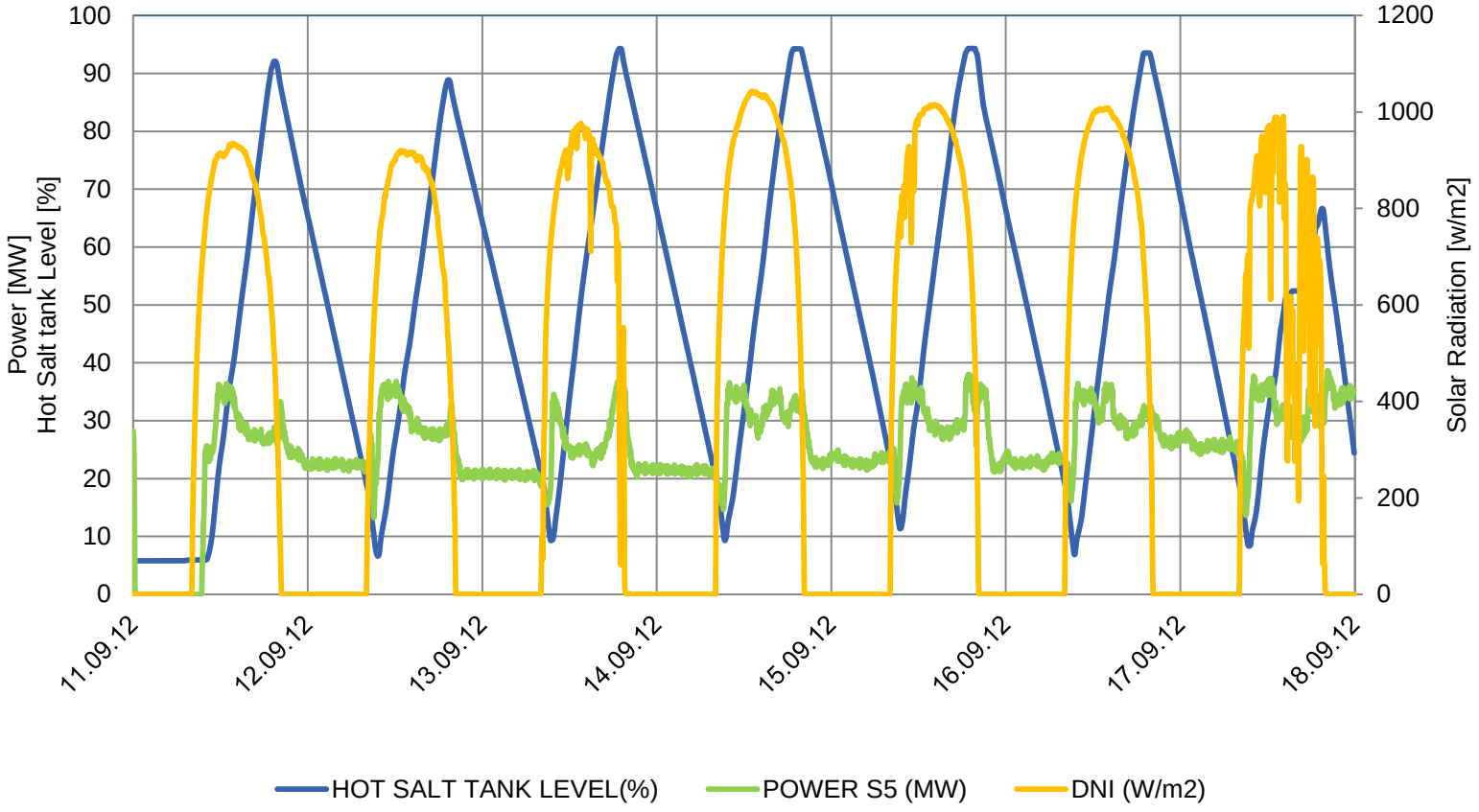
Continuous generation 24 h/d

11.09.2012 – 18.09.2012

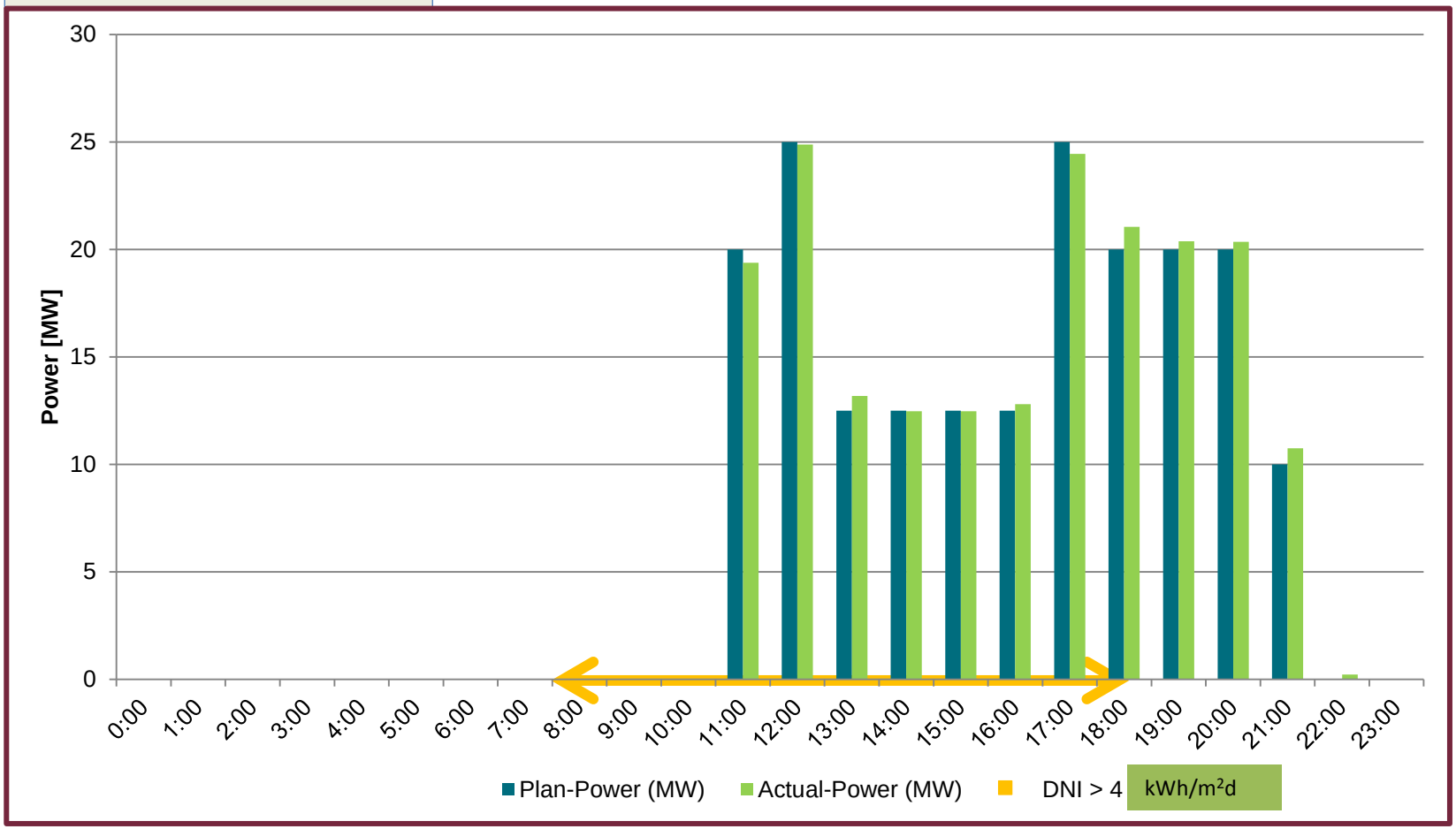


Source: RWE Innogy, F. Dinter

Dispatchable generation

Dispatchability test

22.03.2012

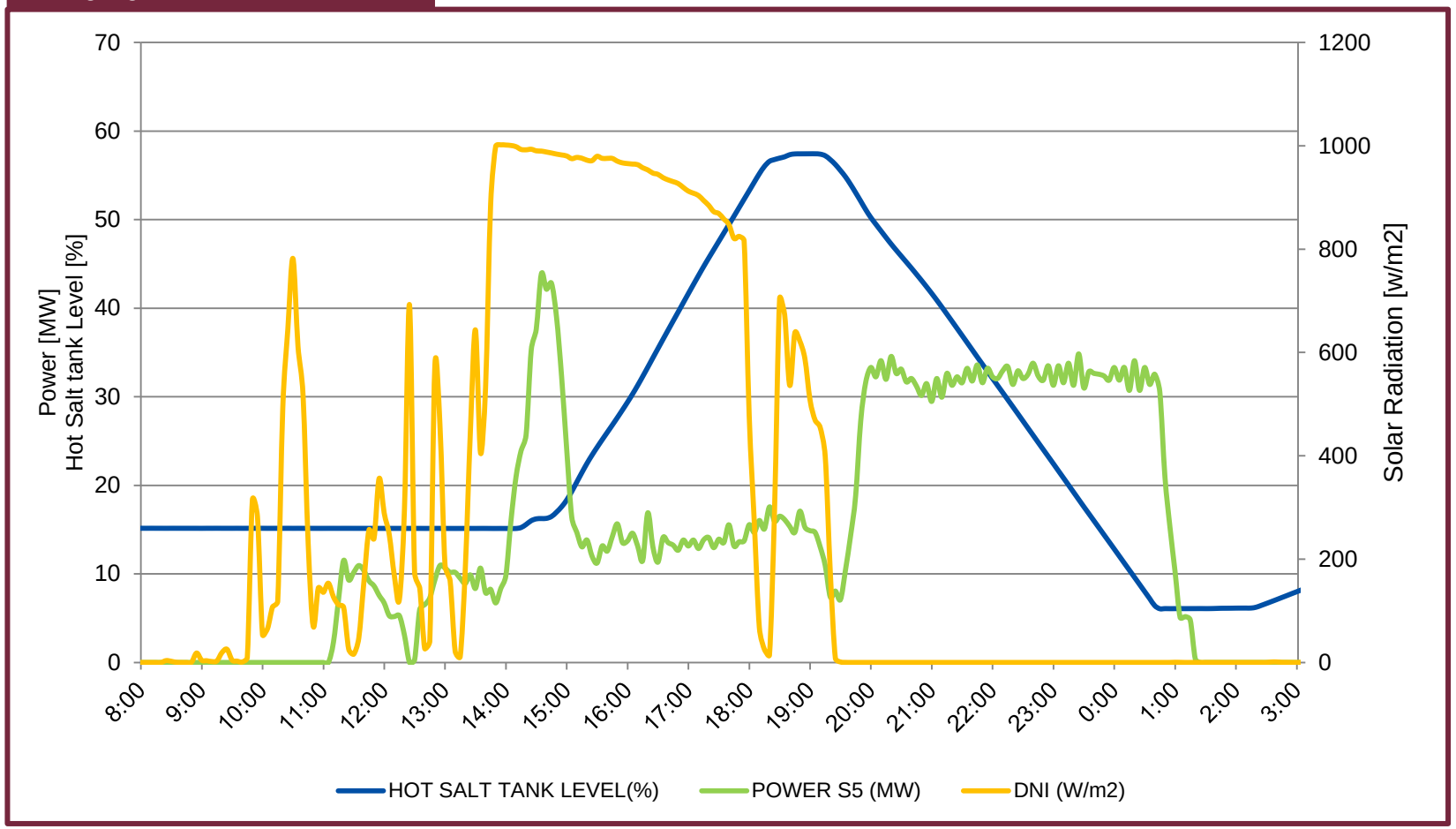


Source: RWE Innogy, F. Dinter

Dispatchable generation

14.10.2012

CECOGE: Tech minimum request 14.10.2012



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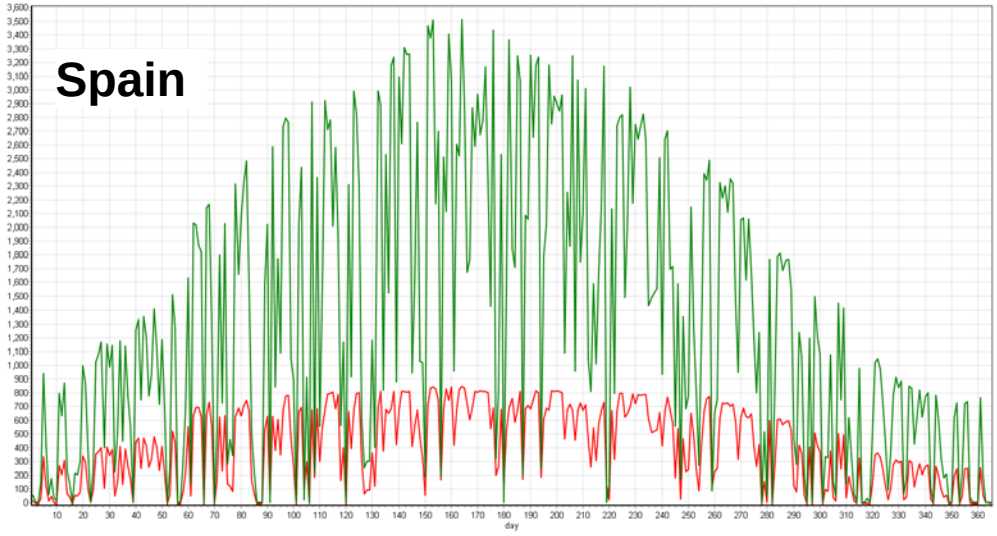
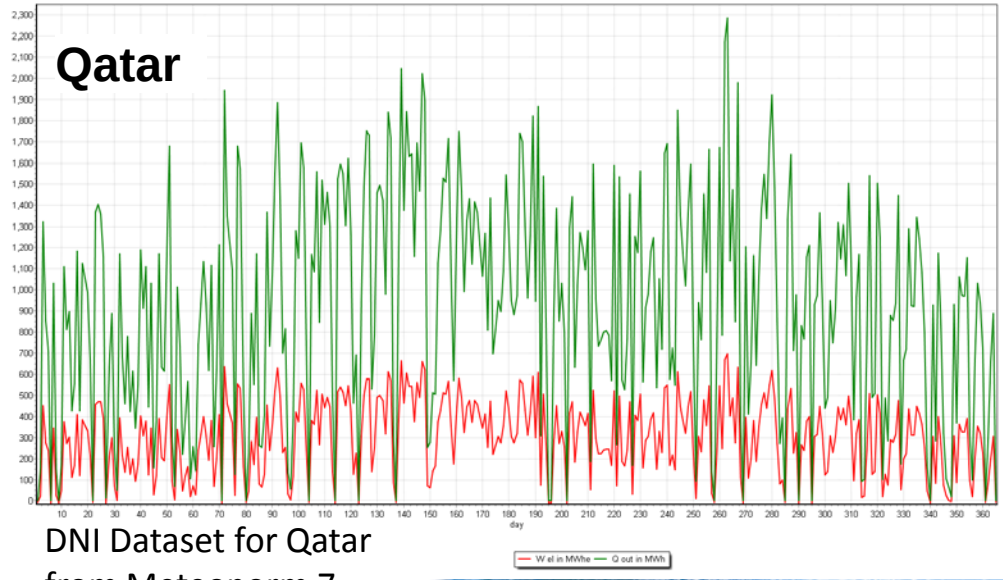
Dispatchable generation





DNI Dataset for Qatar from Meteonorm 7

Site	Spain	Qatar	Unit	relative
Annual DNI	2164	1582	kWh/m²	0,73
Solar field aperture	510120	693240	m²	0,74
Storage capacity	940	940	MWh	
Net electricity output from solar	146,9	146,7	GWh/a	
LCOE	0,189	0,235	€/kWh	0,80

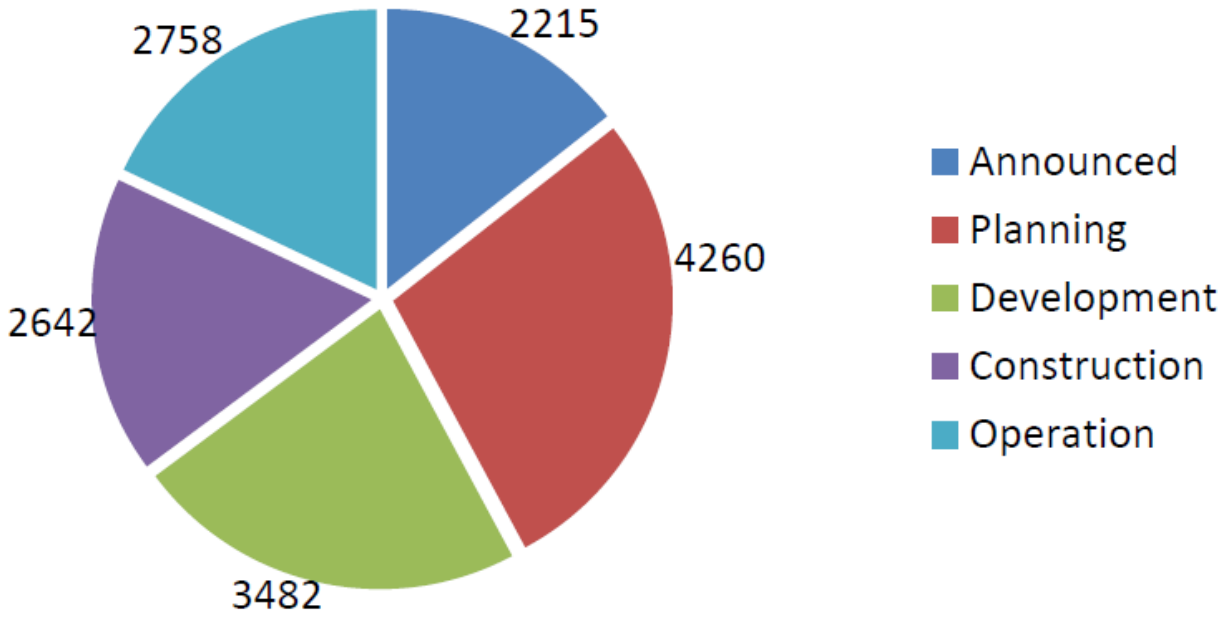
Source: DLR

Market

Source: CSP Today Global Tracker www.csptoday.com/tracker

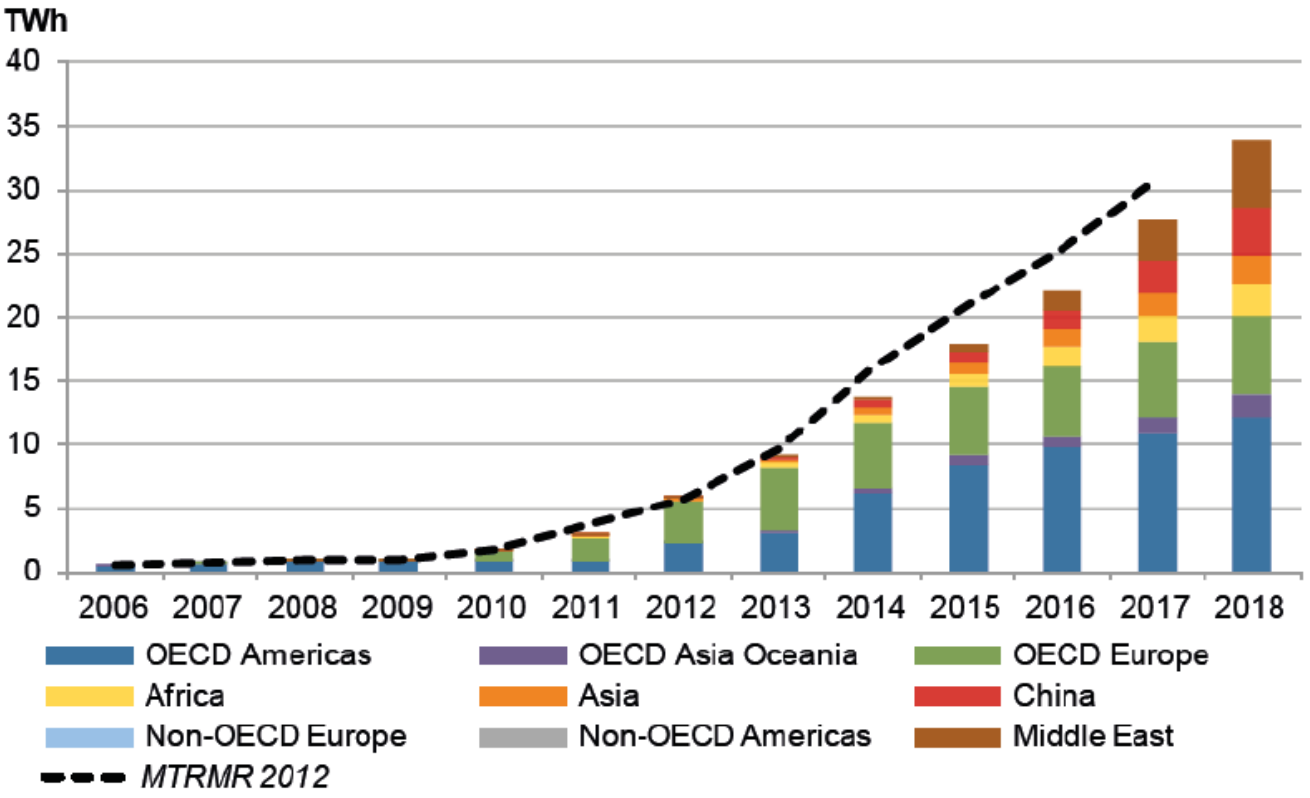
Market

World CSP projects by status (MW)

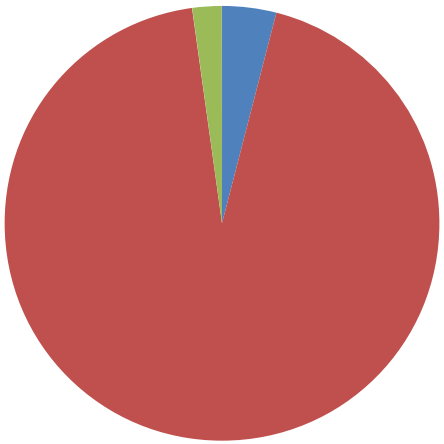


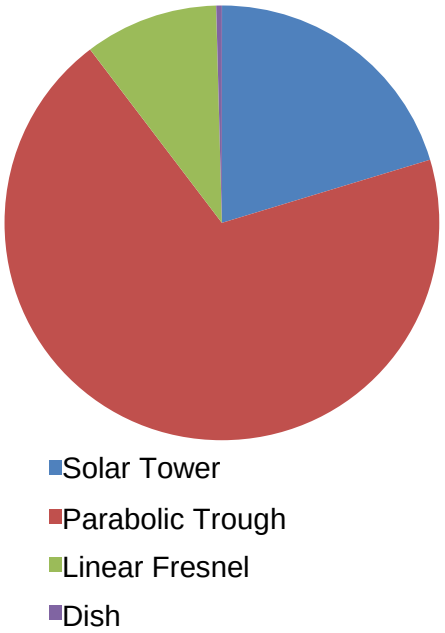
Source: CSP Today Global Tracker www.csptoday.com/tracker

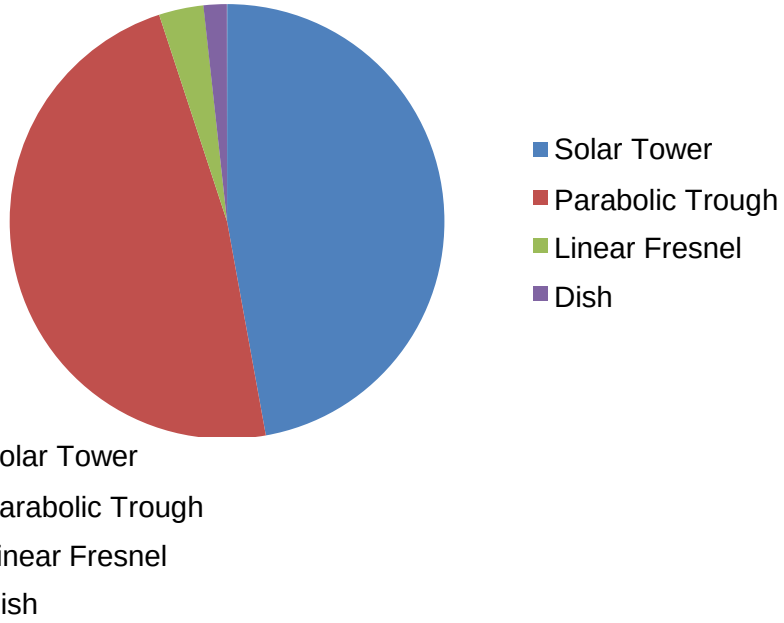
Market: Medium term generation to 2018



Trends / Challenges



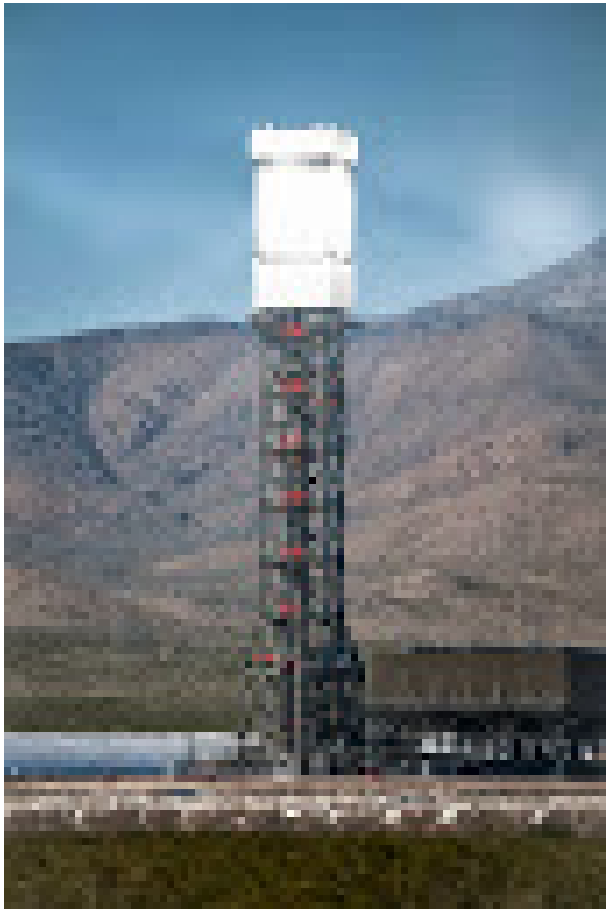


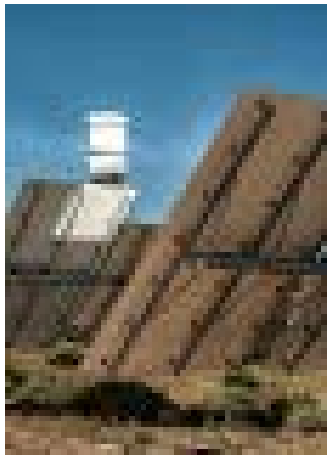


Reasons for the Trend

1. Higher potential in cost reduction
2. More balanced yearly yield

Ivanpah (392 Mwel, 347000 Heliostats, DSG)





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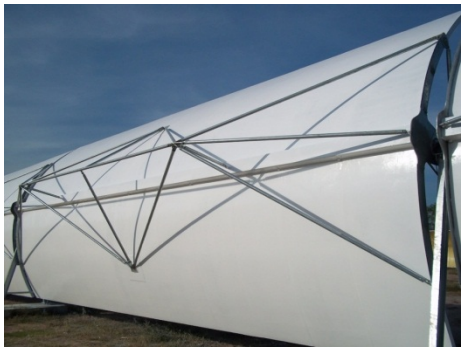
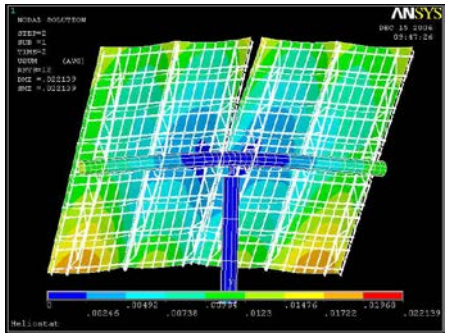
Crescent dunes (110 MW, 17500 Heliostats, Molten Salt)

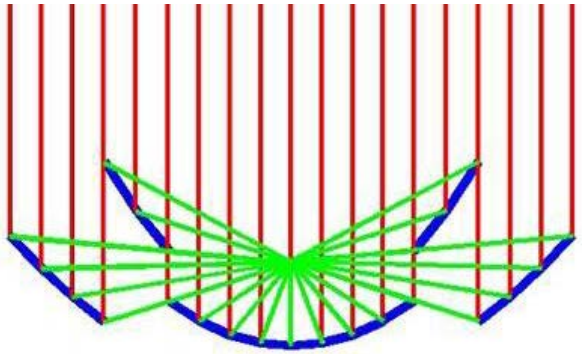
Challenges: Collectors

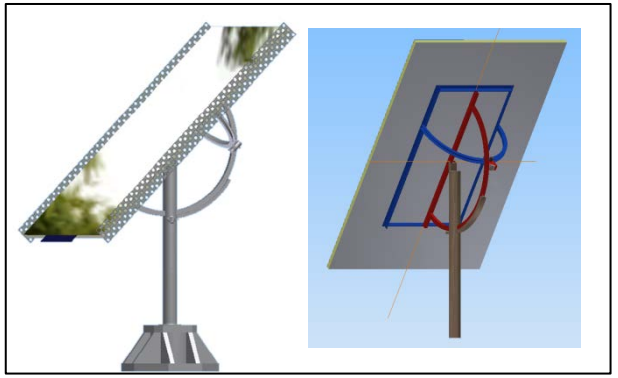




- Lightweight construction

- New designs





- Entire collector performance measurement
- and STANDARDs

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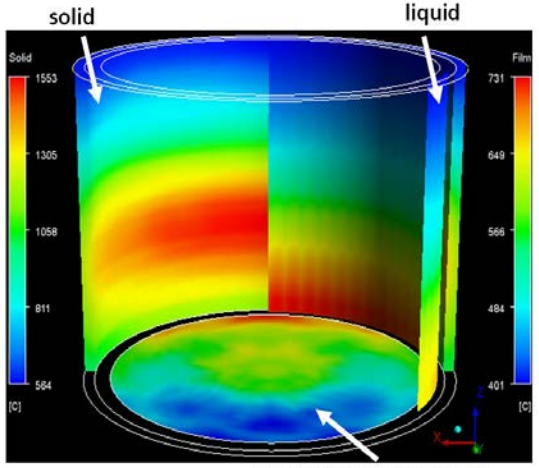
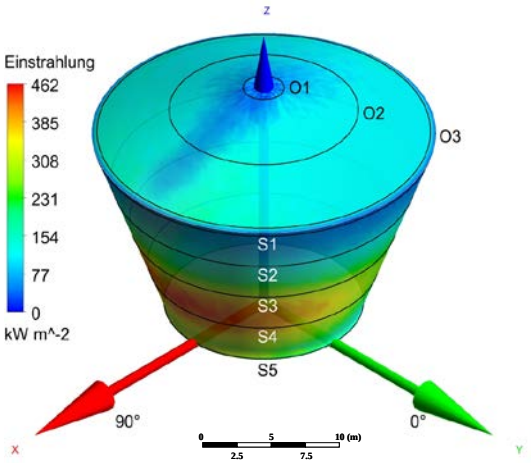
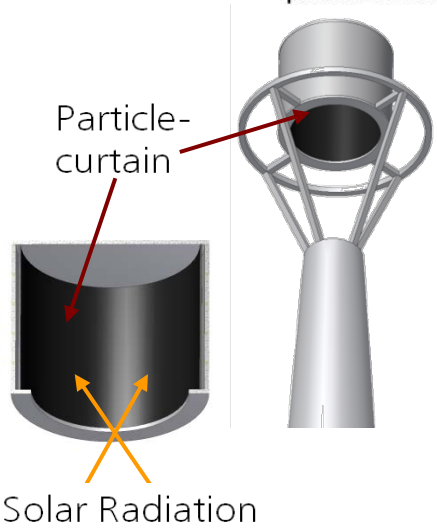
Challenges: Heat Transfer Fluids for Higher Temperature

- Liquid salt
- Liquid metal
- Particles

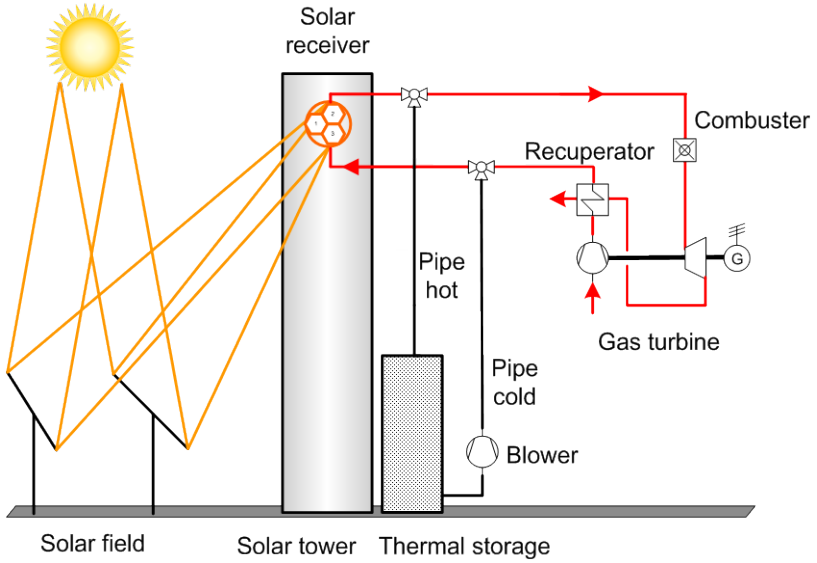




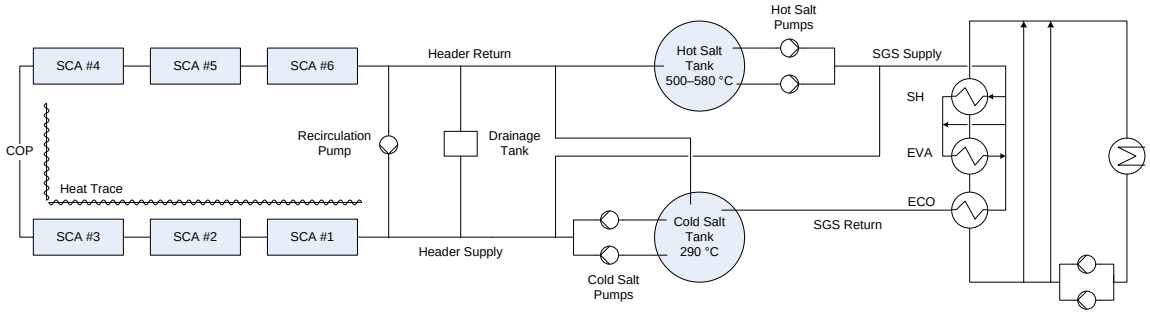


Challenges: Advanced Solar Power Cycles (Solarized Design)

- Top-cycles with pressurized air, liquid salt, liquid metal or particles



- Molten salt in parabolic troughs



Conclusion

- The increasing **global warming** makes **CO2 free systems necessary**
- CSP is **one of the possible CO2 free systems** for electricity production
- CSP systems can be **equipped with a high efficient storage** system, enabling them **to deliver dispatchable electric** power
- CSP enables a **higher feeding of PV and wind** power to the grid
- The demand for cost reduction of CSP systems lead to
  - **Higher temperatures** of the heat transfer fluid
  - **Higher steam parameters**
  - **New heat transfer fluids** like molten salt, liquid metal and particle

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Thank you for your attention