CSP Technologies, Markets, Challenges

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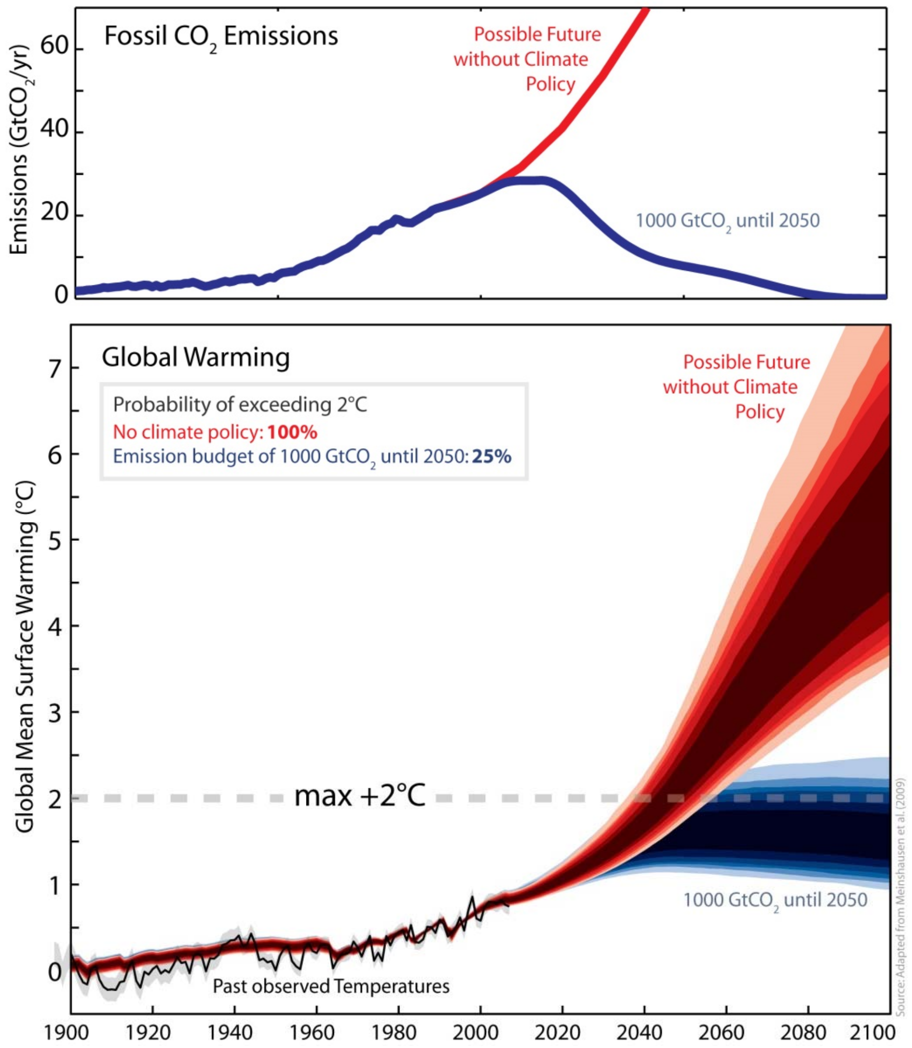
DLR, Institute of Solar Research

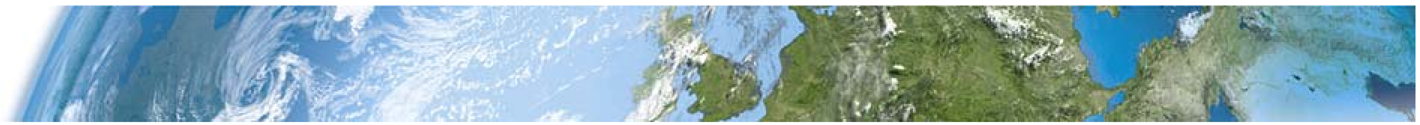
Agenda

- 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

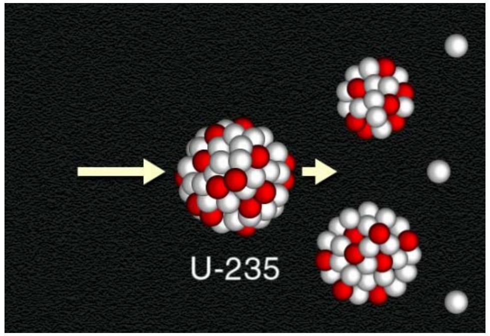
Why renewable energies?
- Scenarios on global warming -



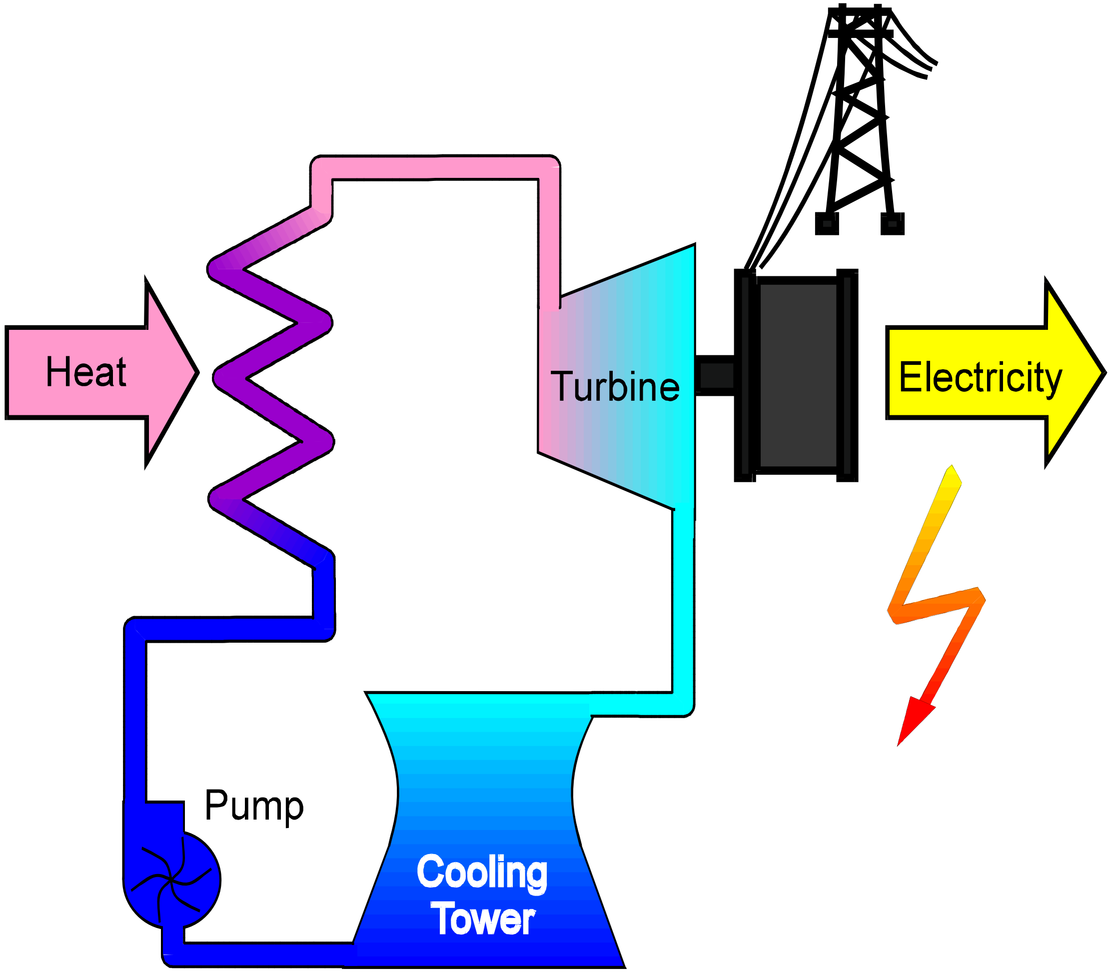
Source: M. Meinshausen et al. (2009)



Why solar thermal power plants ?

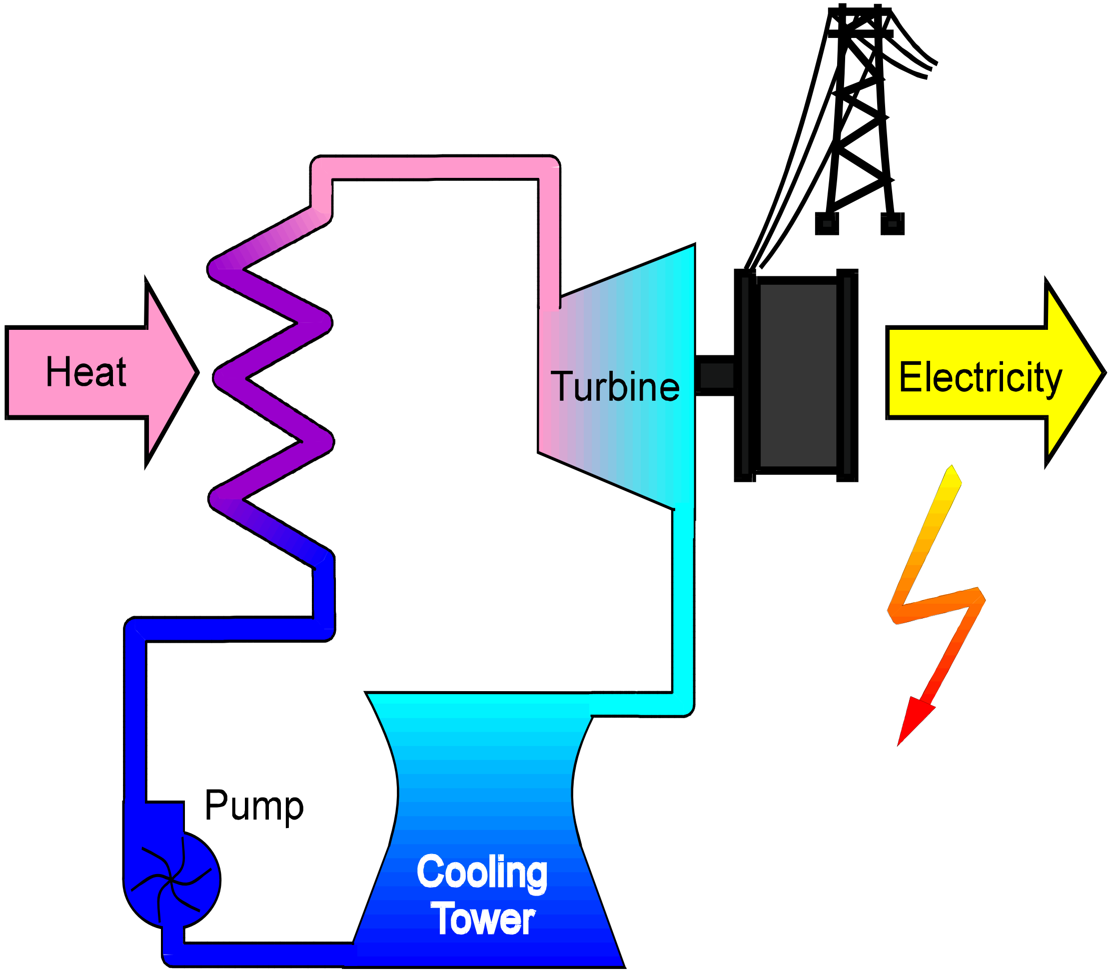


Conventional power plants



Why solar thermal power plants ?

Solar thermal power plants

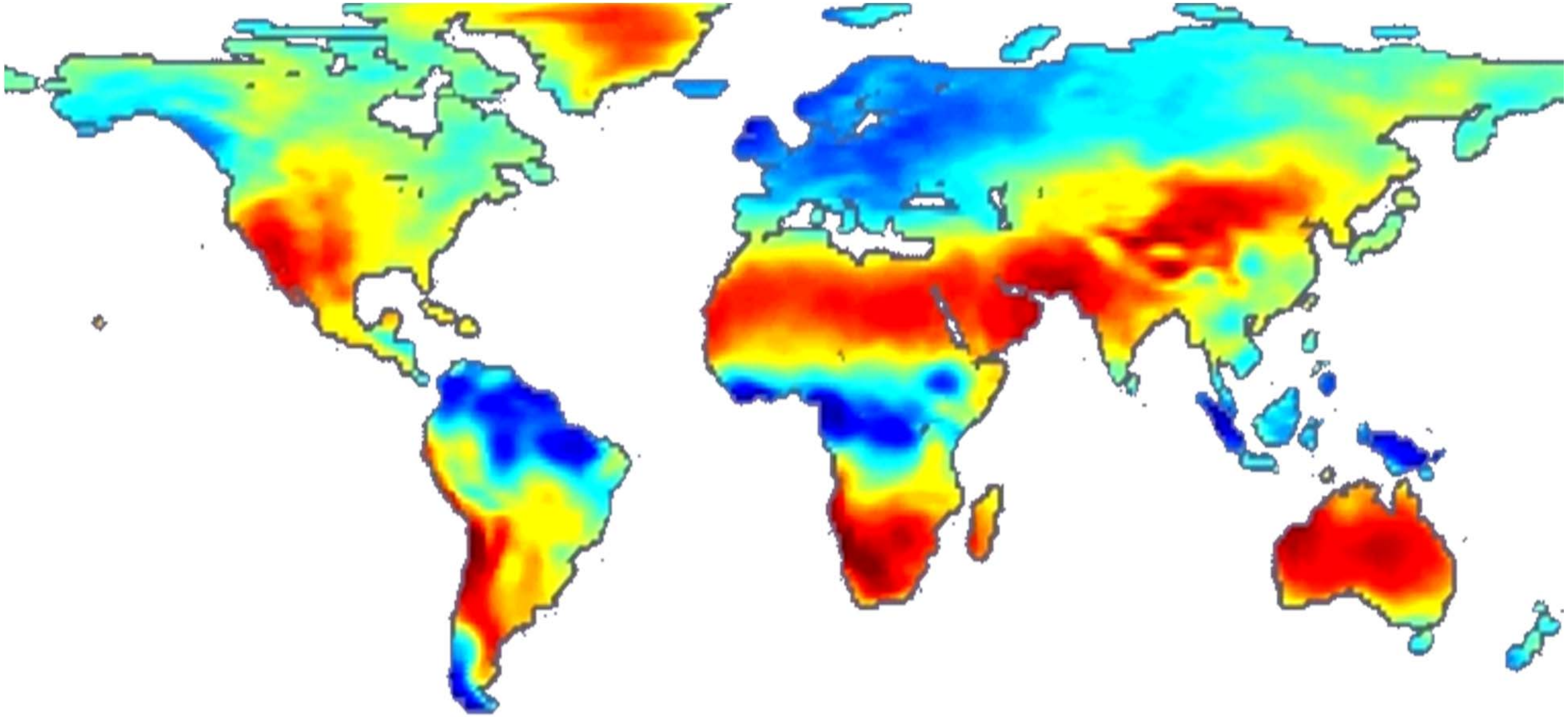


Why solar thermal power plants ?

Solar thermal power plants

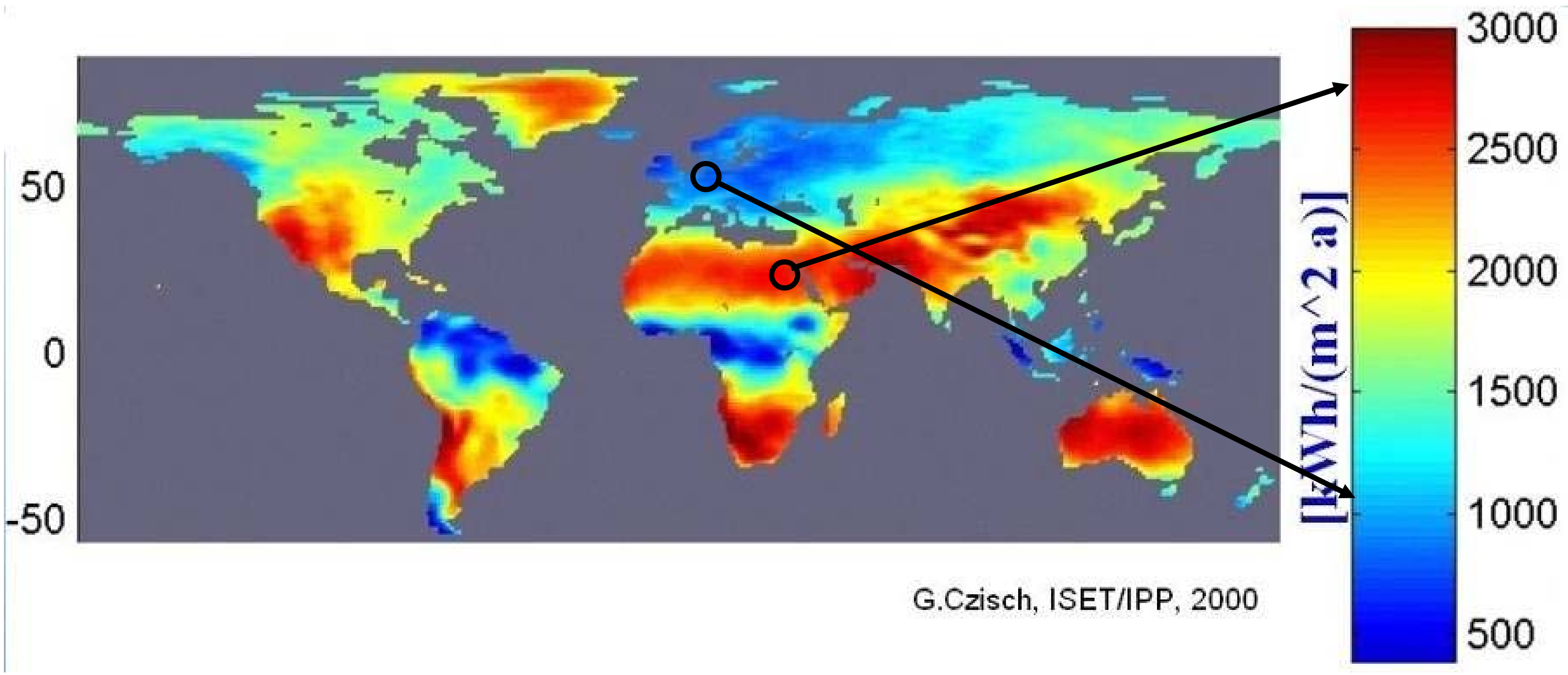
- can be integrated into conventional thermal power plants
- provide firm capacity (thermal storage, fossil backup)
- serve different markets (bulk power, remote power, heat, water)
- have an energy payback time of only 6-12 months

World Sun Belt



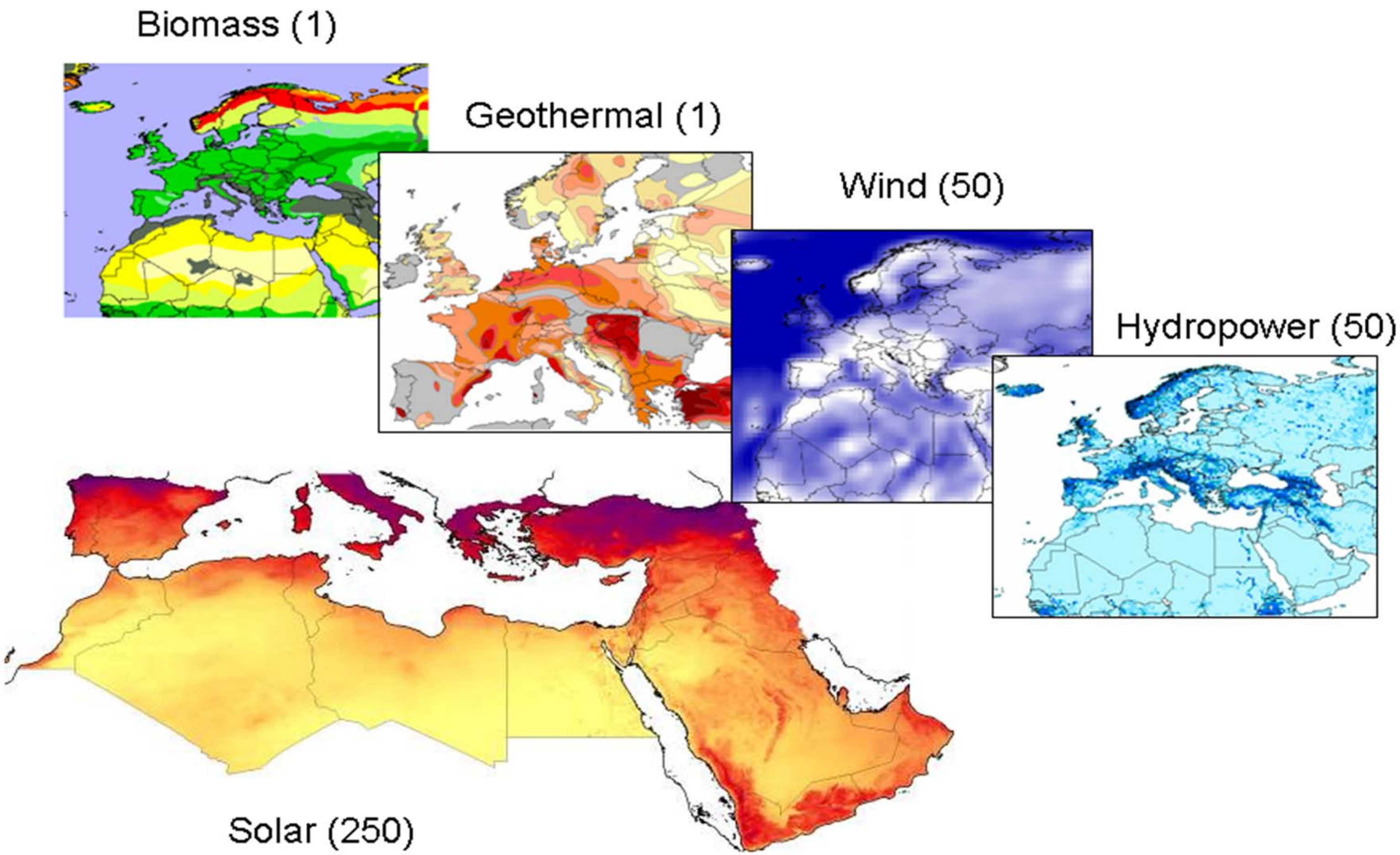
World Sun Belt

DNI – Direct Normal Irradiance [W/m²]



Renewable energy resources in Europe and MENA

in brackets: (max. yield in GWh_{el} / km² /y)



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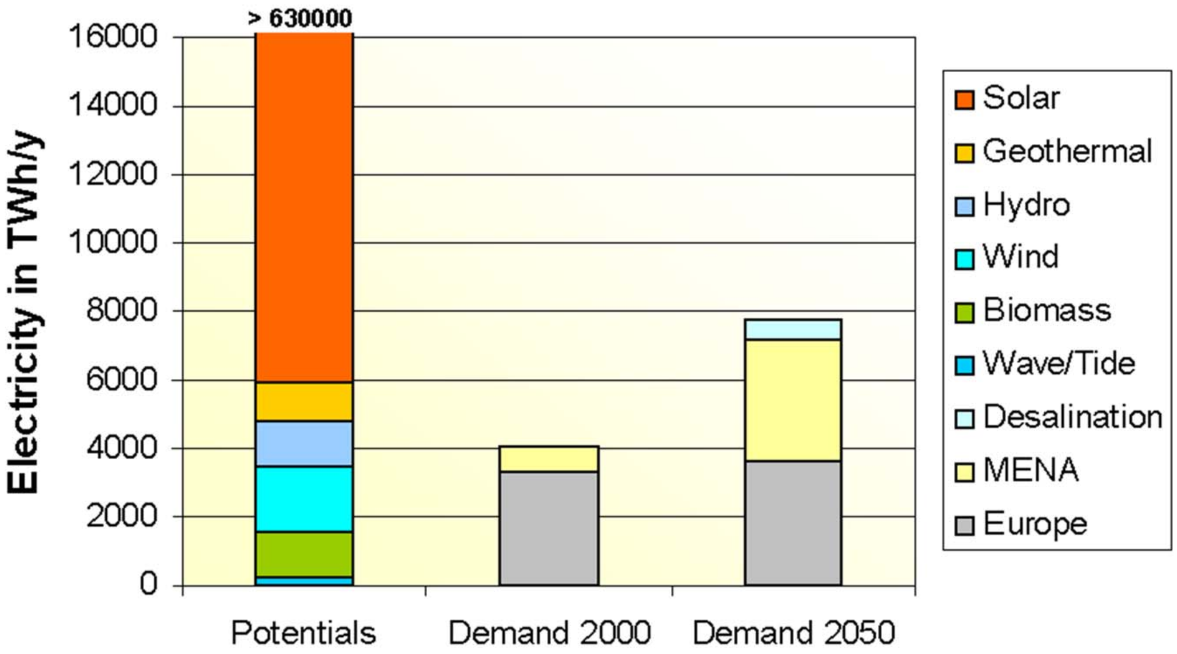
Renewable energy resources in Europe and MENA

- renewable resources greatly exceed the present and future electricity demands
- solar radiation is by far the most abundant source of energy

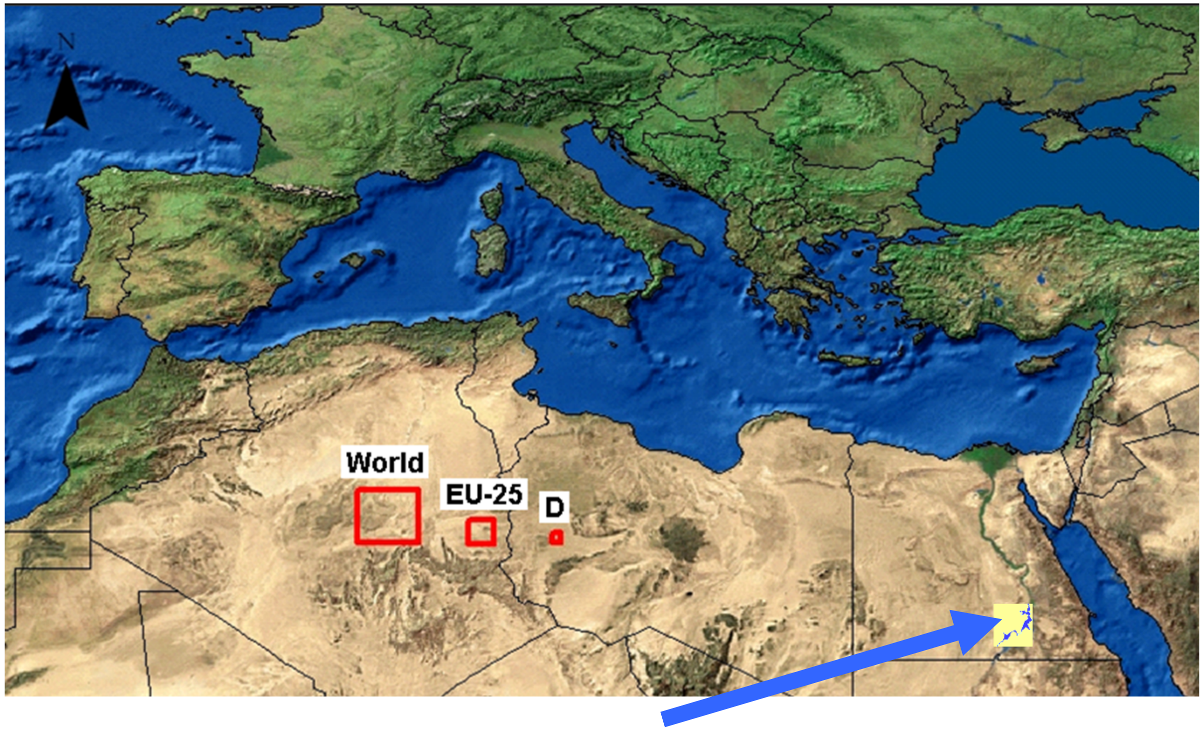
Economic renewable electricity potentials vs. demand in Europe and MENA



Renewable energy resources in Europe and MENA

- renewable resources greatly exceed the present and future electricity demands
- solar radiation is by far the most abundant source of energy
- 1 km² of desert land may generate 50 MW of electricity
- 1 km^2 of desert land may produce 200 - 300 GWh_{el} / year
- 1 km² of desert land avoids 200,000 tons CO_2 / year
- Solar thermal power plants are the most effective technology to harvest this vast ressource

Economic renewable electricity potentials vs. demand in Europe and MENA



The electrical energy produced by a solar power plant with the size of Lake Nasser equals the total Middle East oil production

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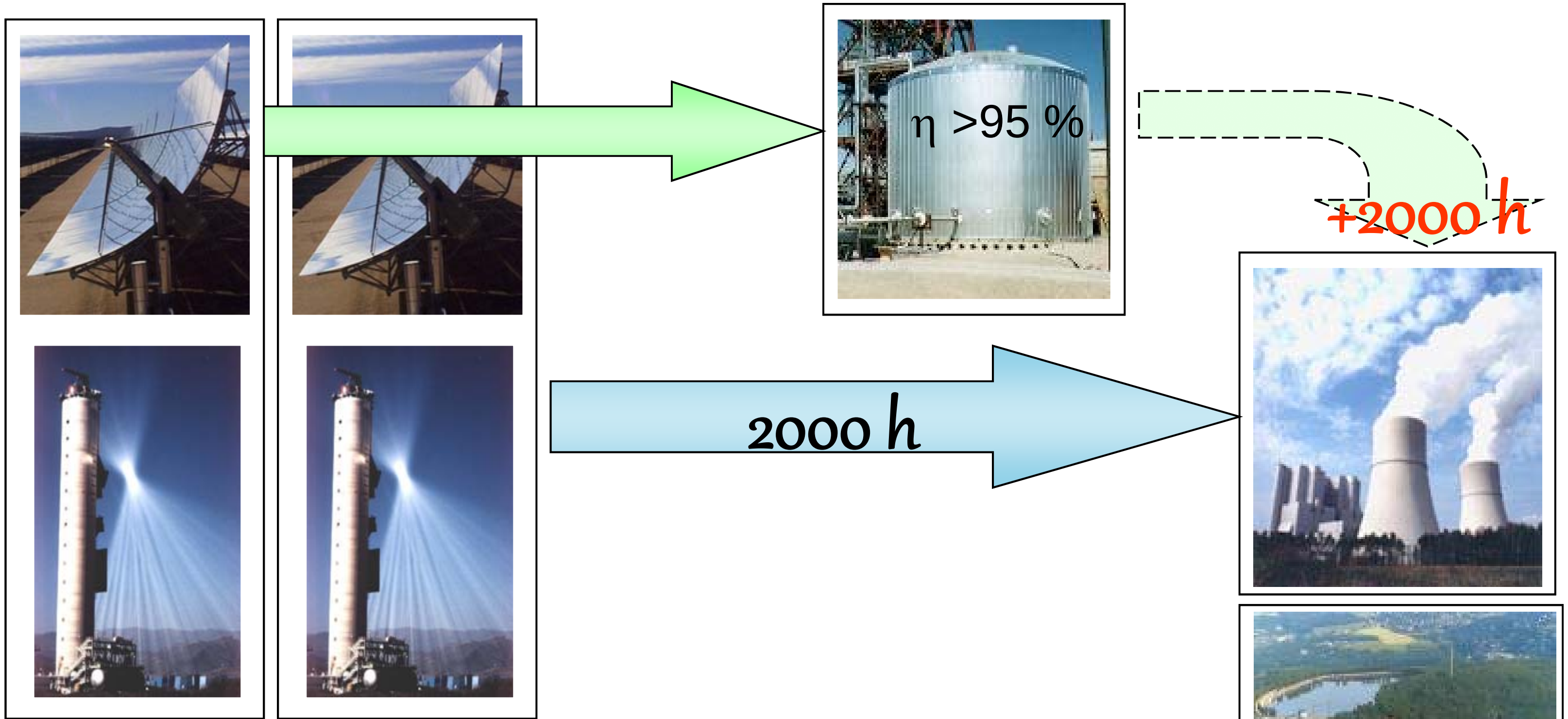
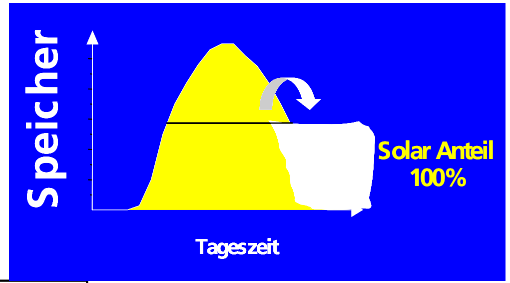
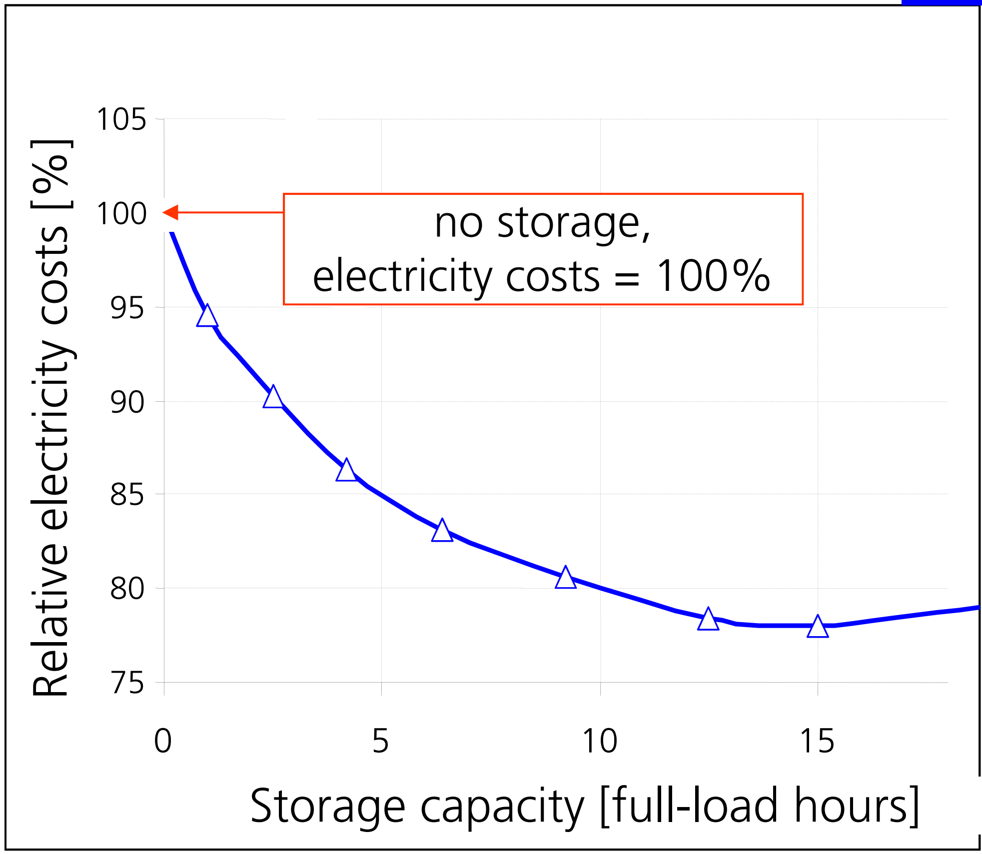
The Value of CSP Electricity



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

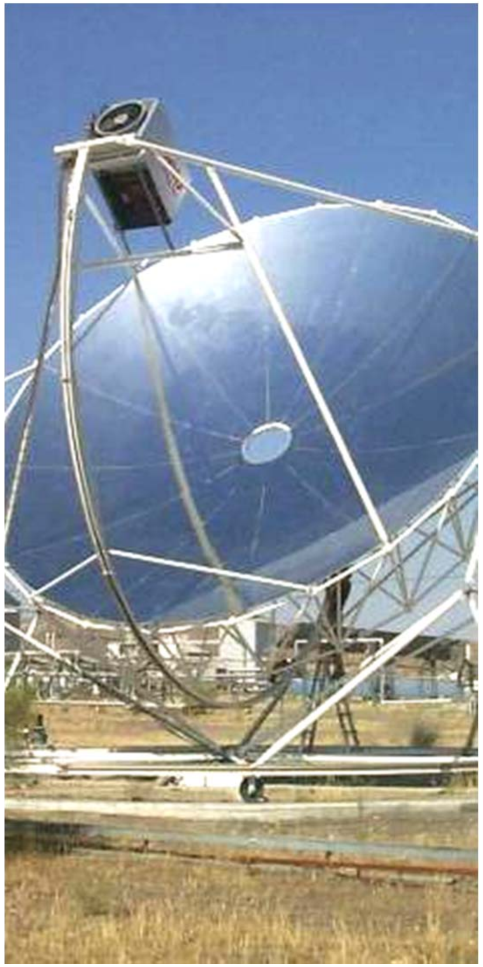
The Value of CSP Electricity





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

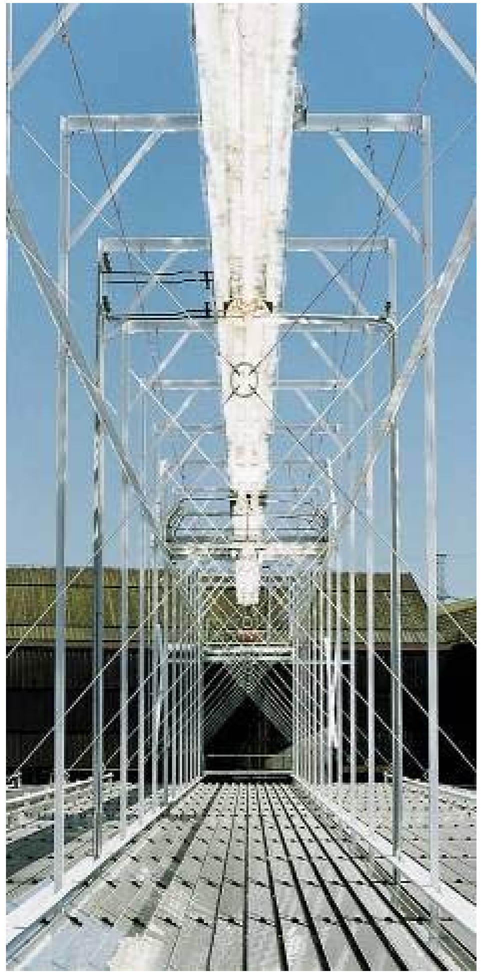
Types of Concentrating Solar Thermal Technologies



Dish-Stirling

Solar Power Tower

Parabolic Trough



Linear Fresnel

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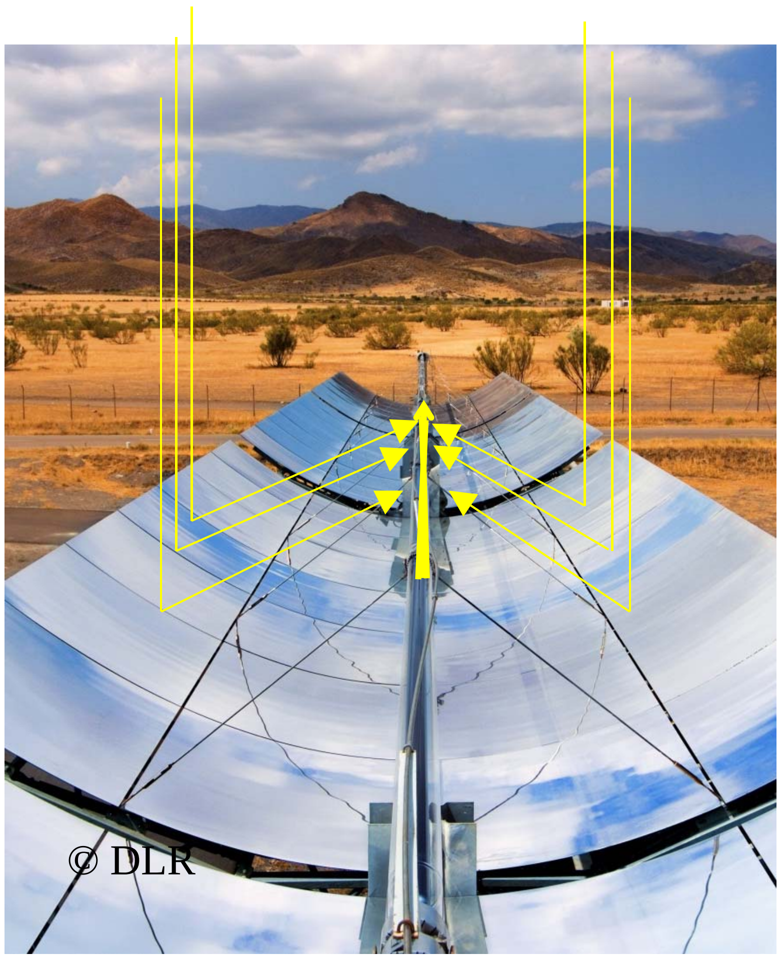
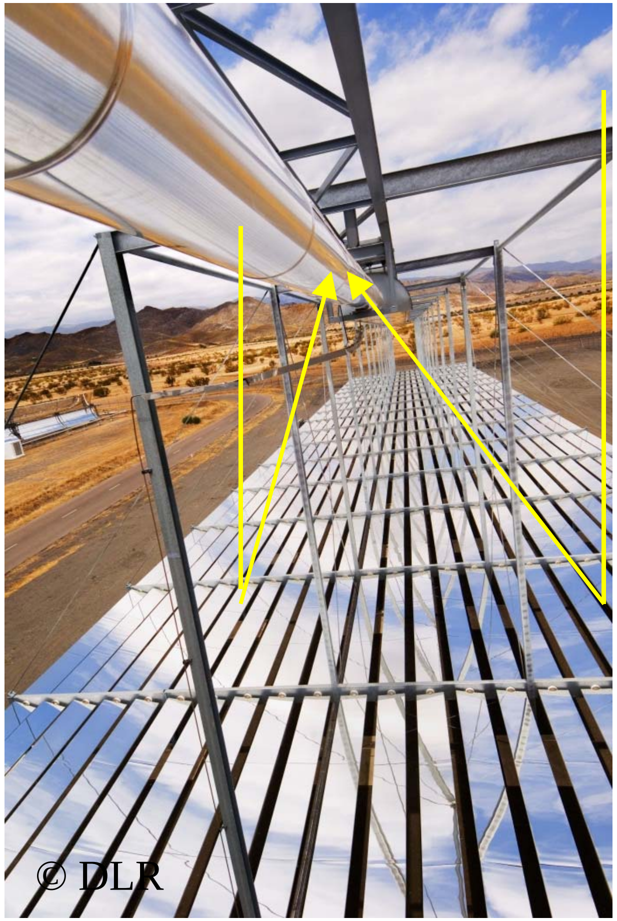
Parabolic Trough Collector

- 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

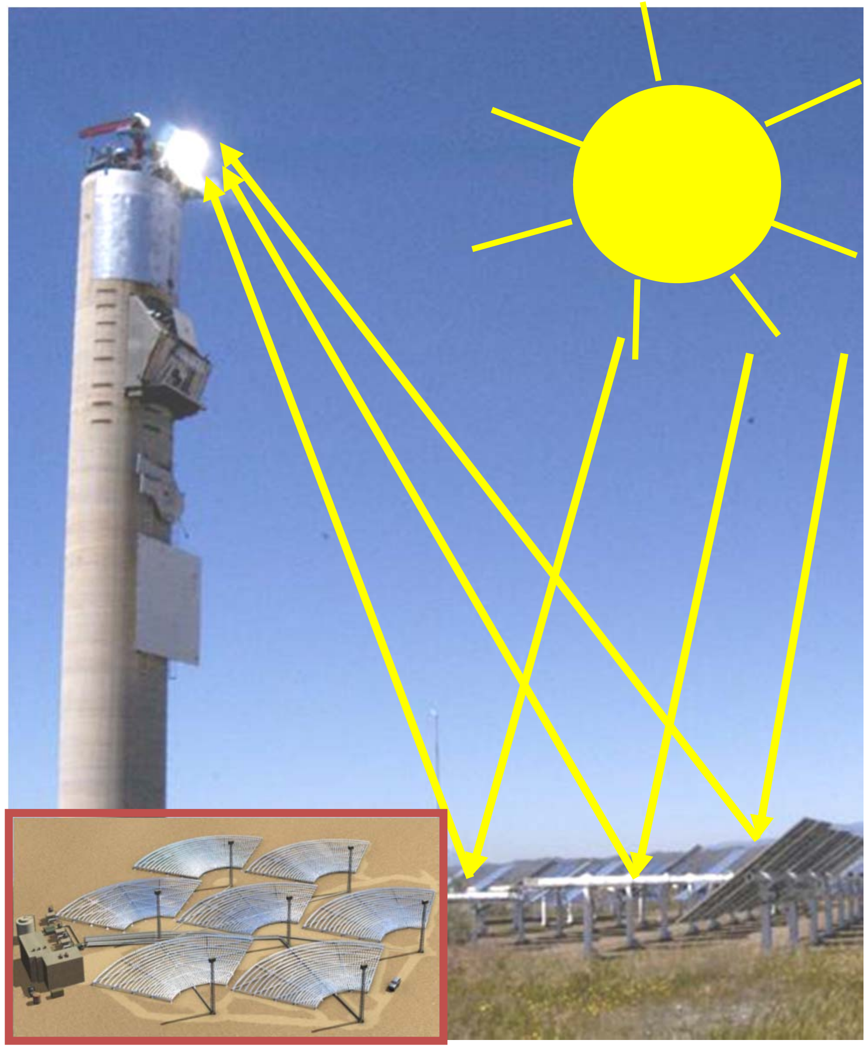
- Advantages:
  - Simple construction
  - High land use
  - Possible integration into buildings
- Disadvantages:
  - Low efficiency
  - State of the art without storage



Quelle: MSM

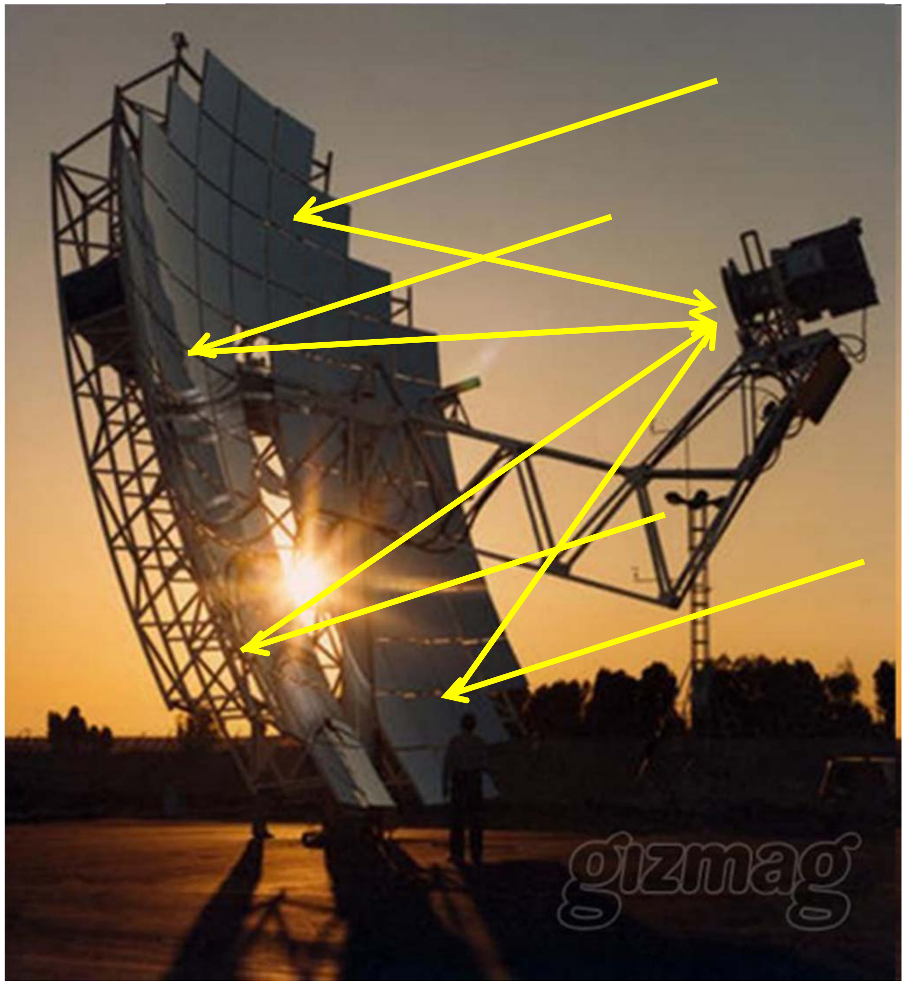
Solar Power Tower

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

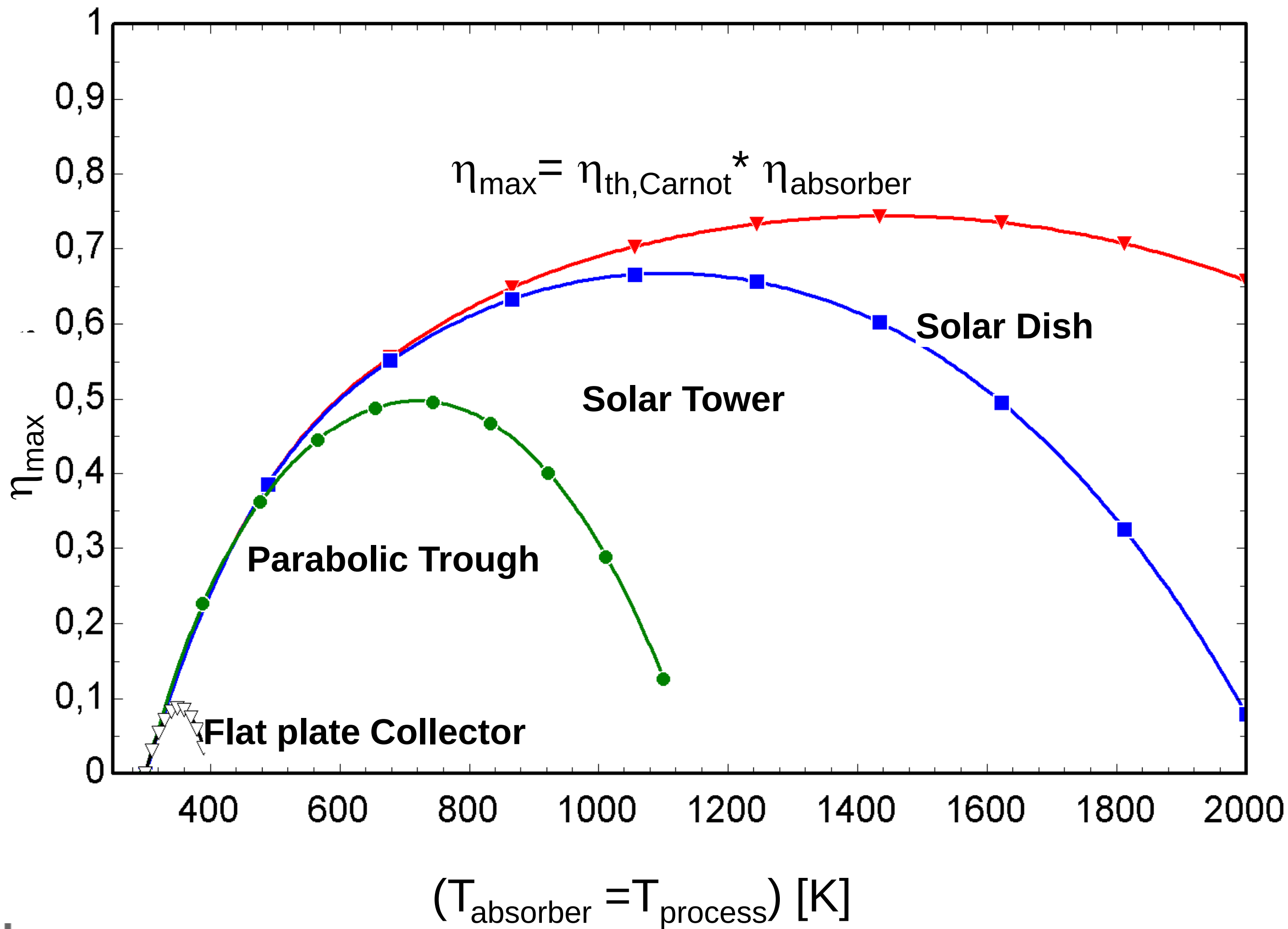


Dish-Stirling

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



Theoretical efficiency potential



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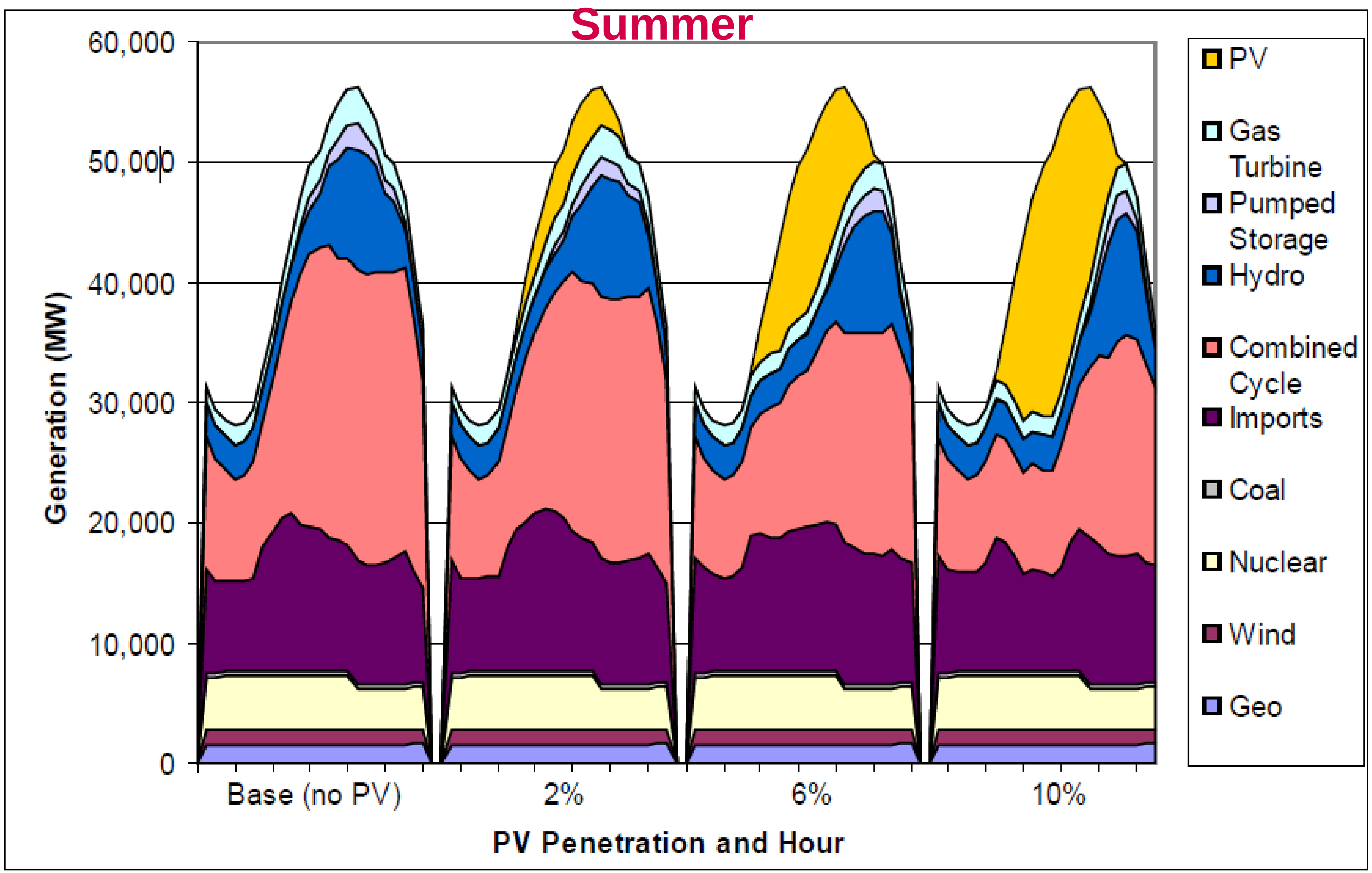
CSP vs PV

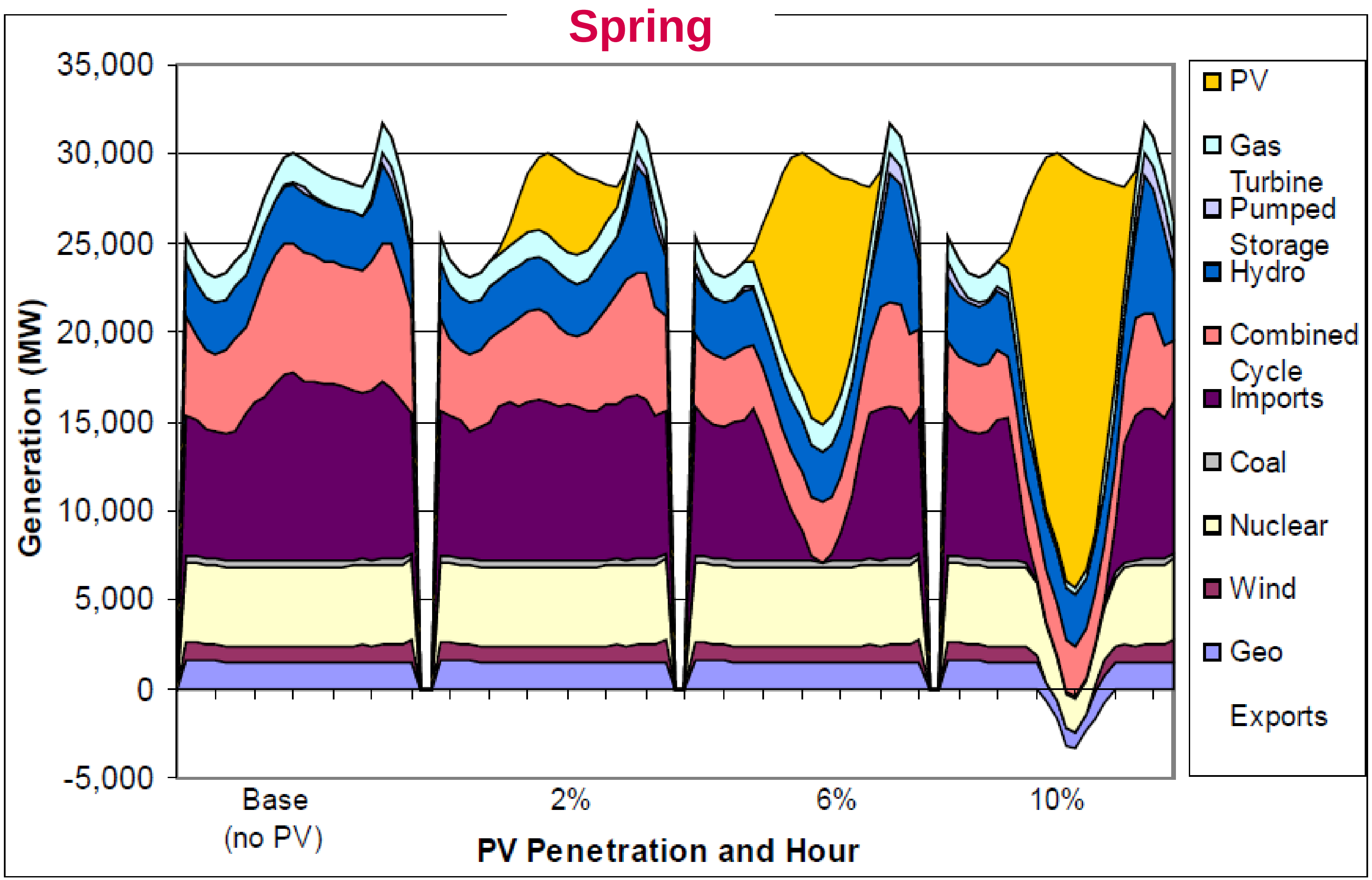
Simulation of supply and demand with increasing PV share



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

CSP vs PV

Simulation of supply and demand with increasing PV share



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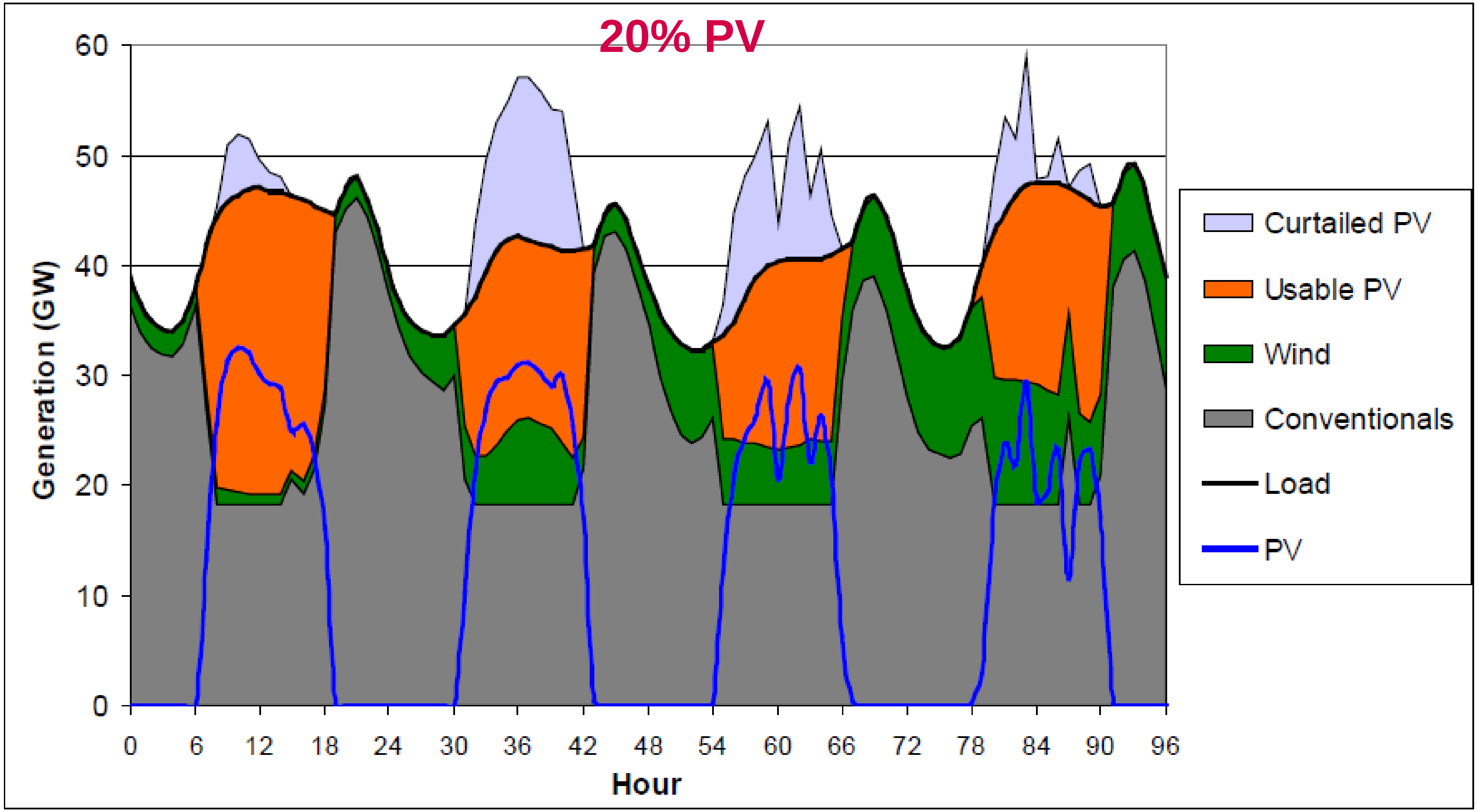
CSP vs PV

Simulation of supply and demand with increasing PV share



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CSP vs PV

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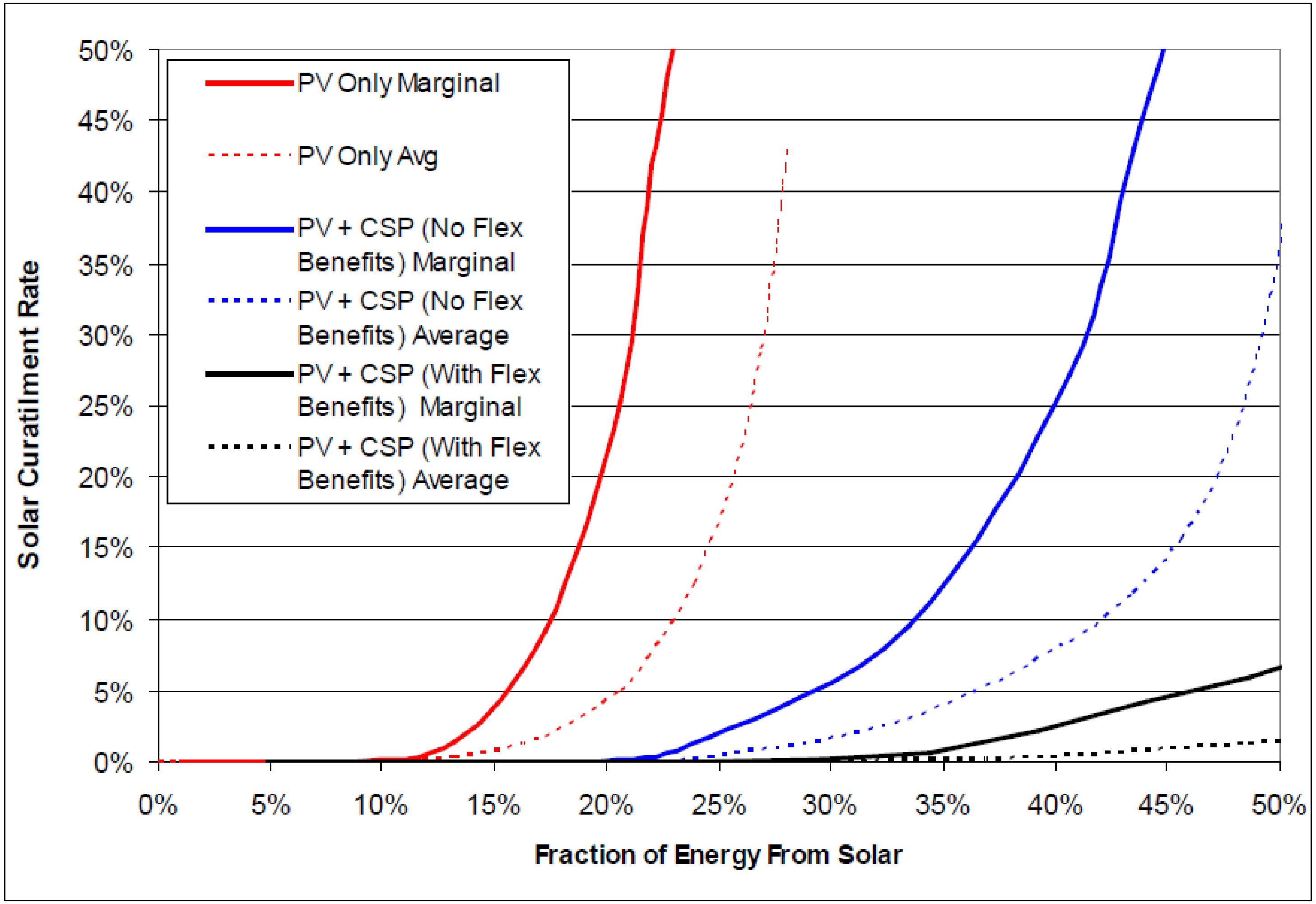


Source: NREL/TP-6A20-52978, Nov. 2011

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:

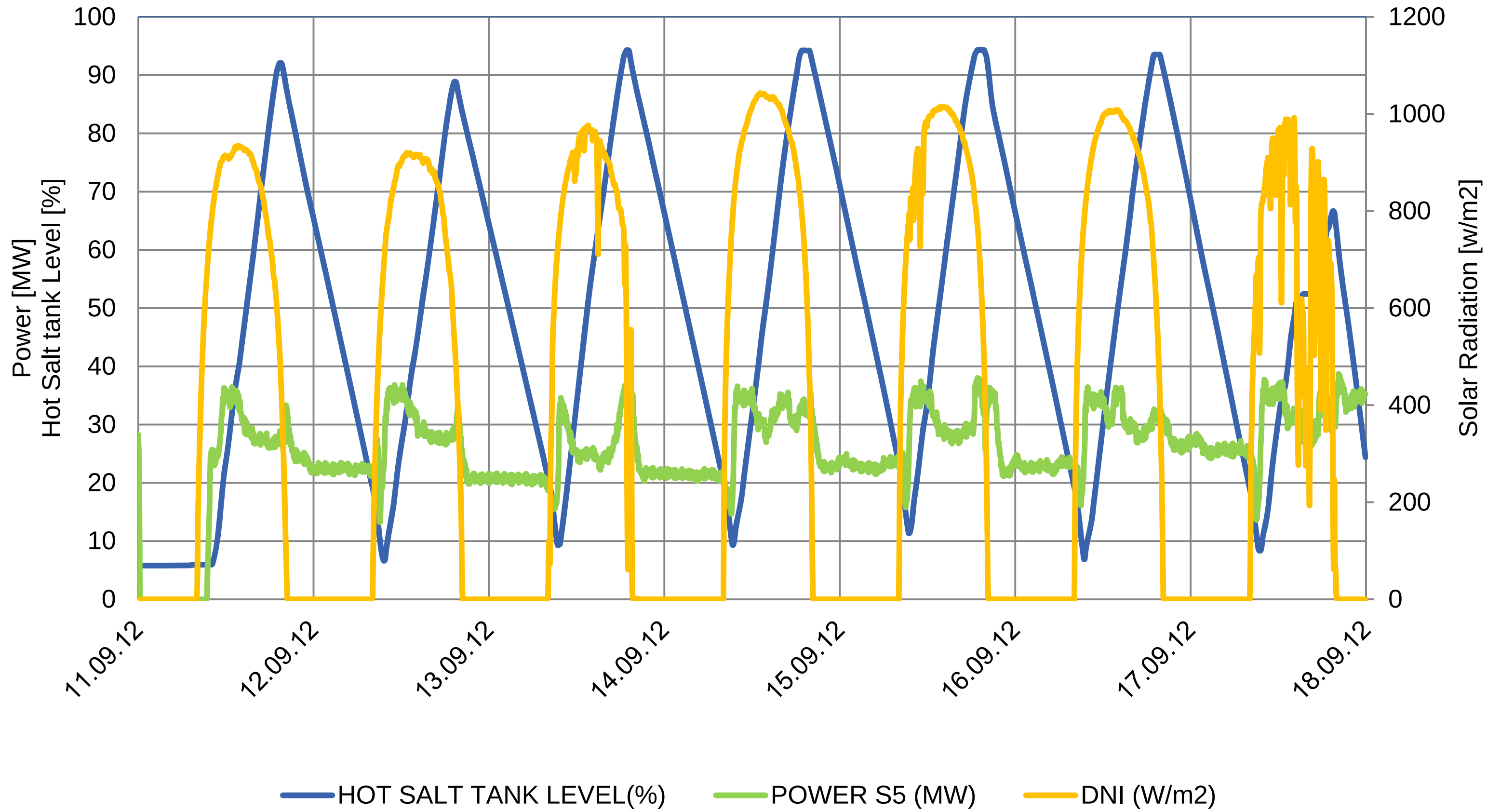
  SWM Stadtwerke München, RWE The energy to lead, RheinEnergie, Solar Millennium, Ferrostaal
- EPC contractor: UTE

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

Source: RWE Innogy, F. Dinter

Continuous generation 24 h/d

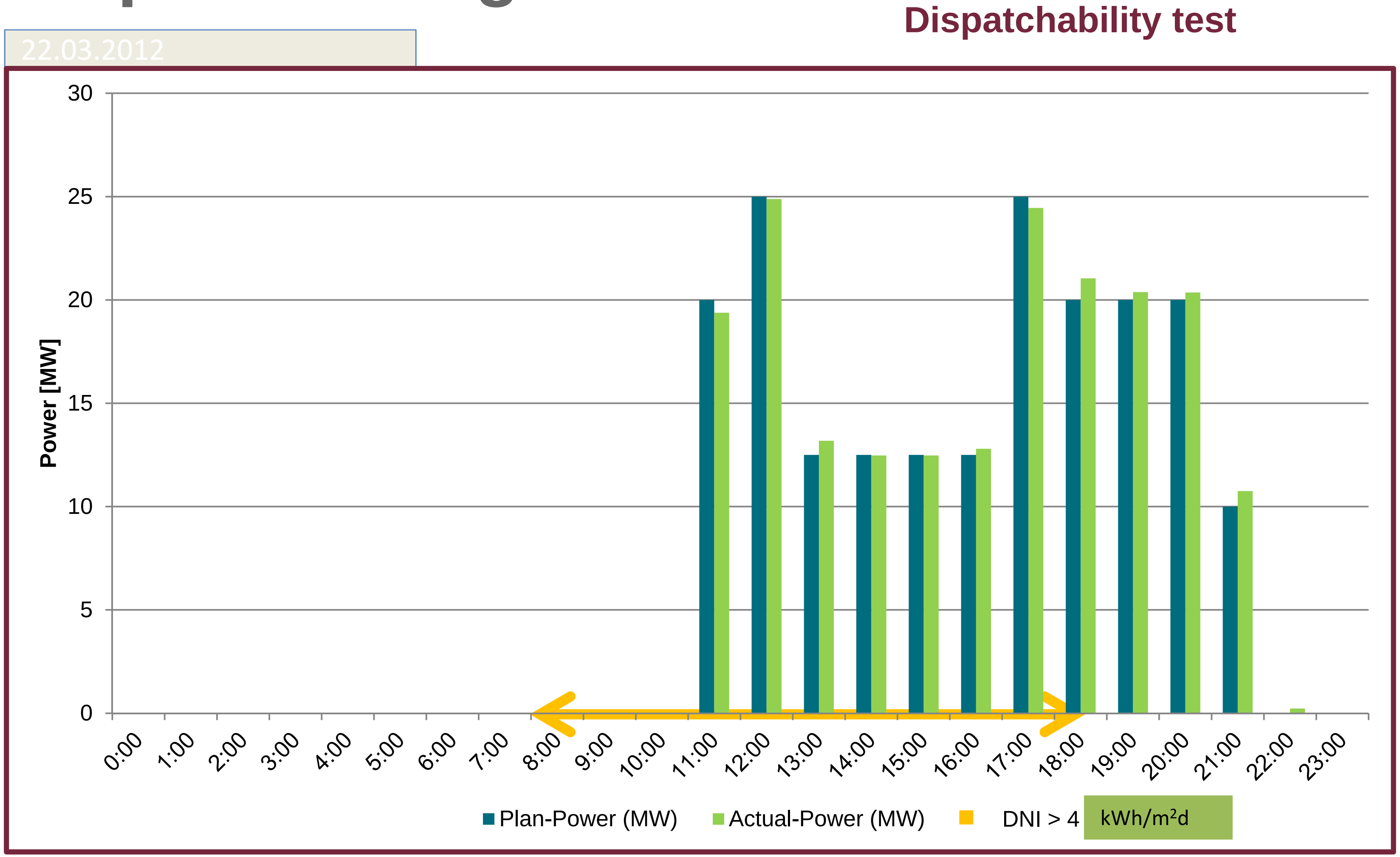
11.09.2012 – 18.09.2012



Source: RWE Innogy, F. Dinter

Dispatchable generation

22.03.2012

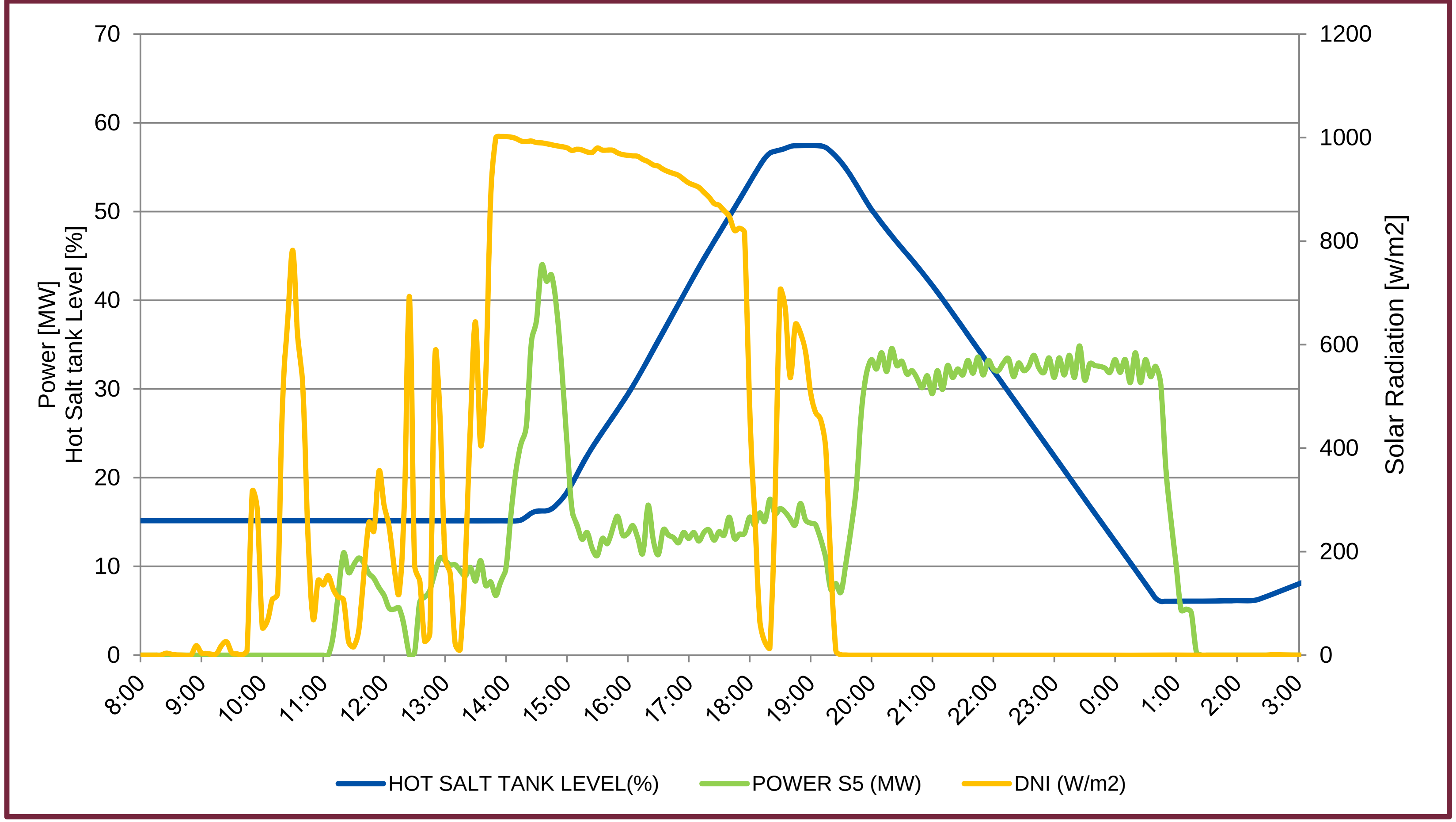


Source: RWE Innogy, F. Dinter

Dispatchable generation

14.10.2012

CECOGE: Tech minimum request 14.10.2012



Source: RWE Innogy, F. Dinter

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Market

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

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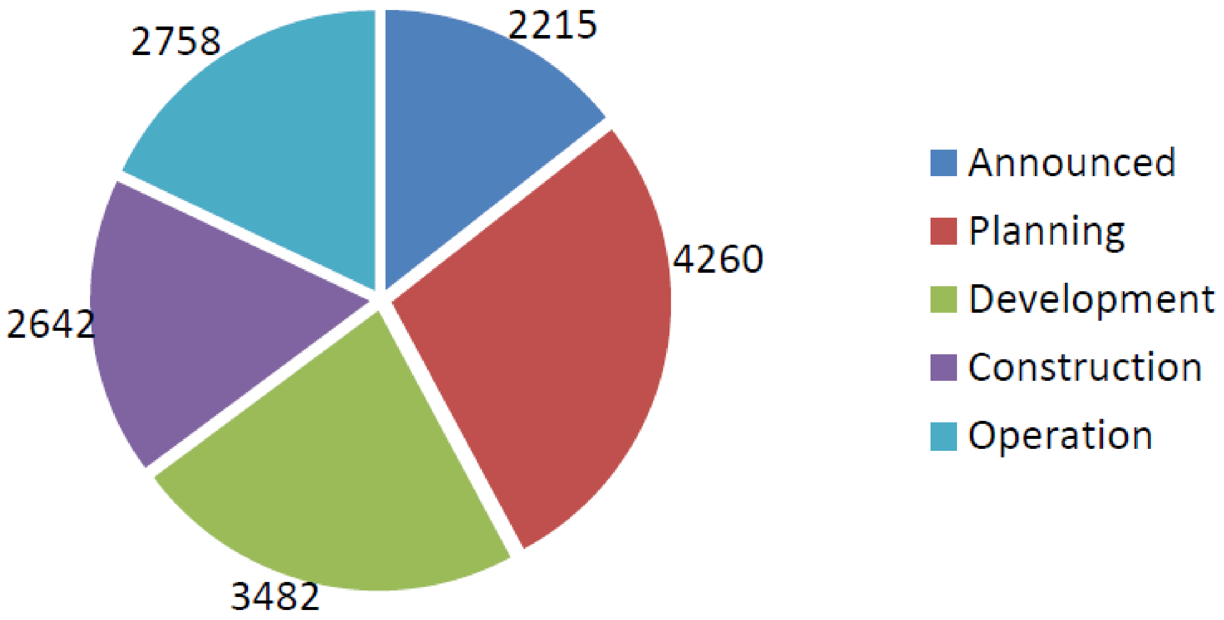
Market

World CSP projects by status (MW)

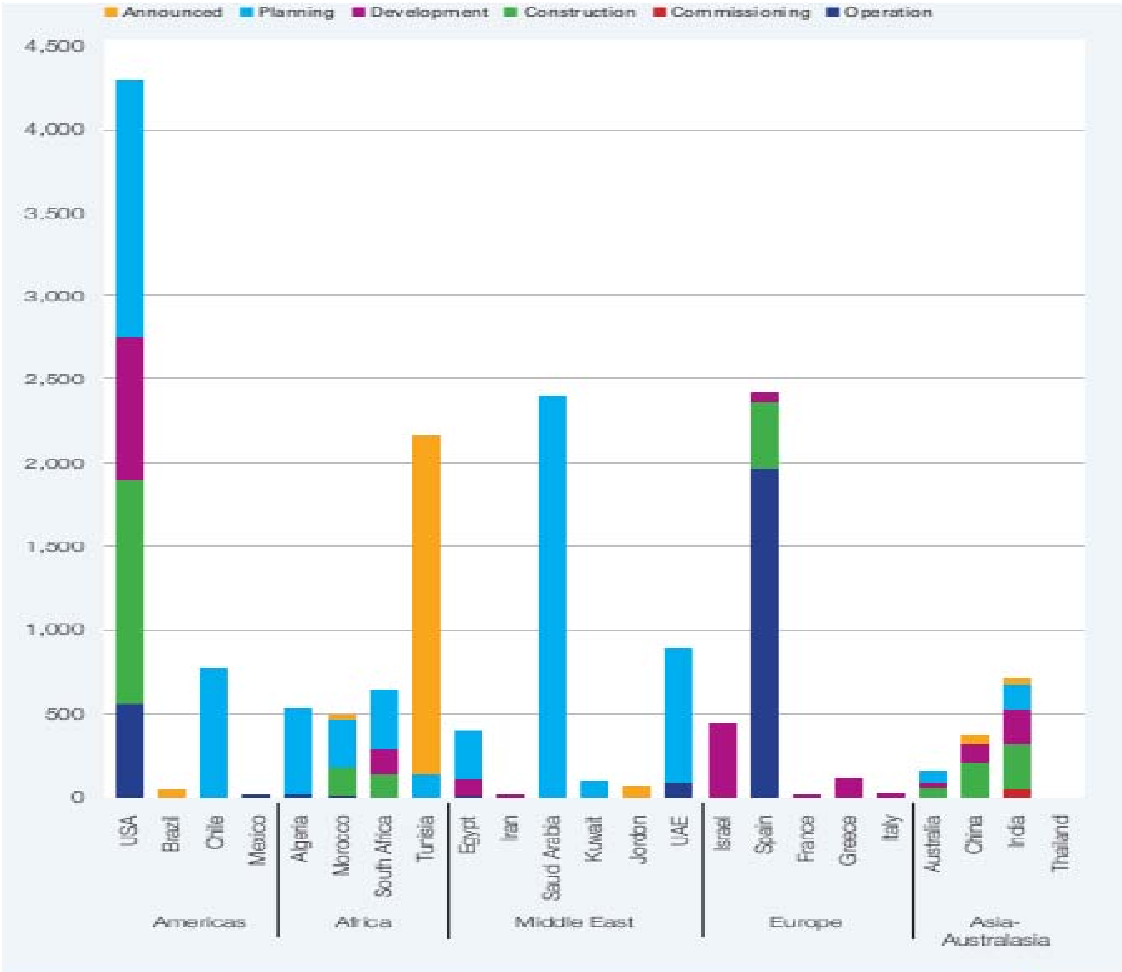


Source: CSP Today Global Tracker www.csptoday.com/tracker

Market

Global CSP Pipeline by Status

(June 2013)



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

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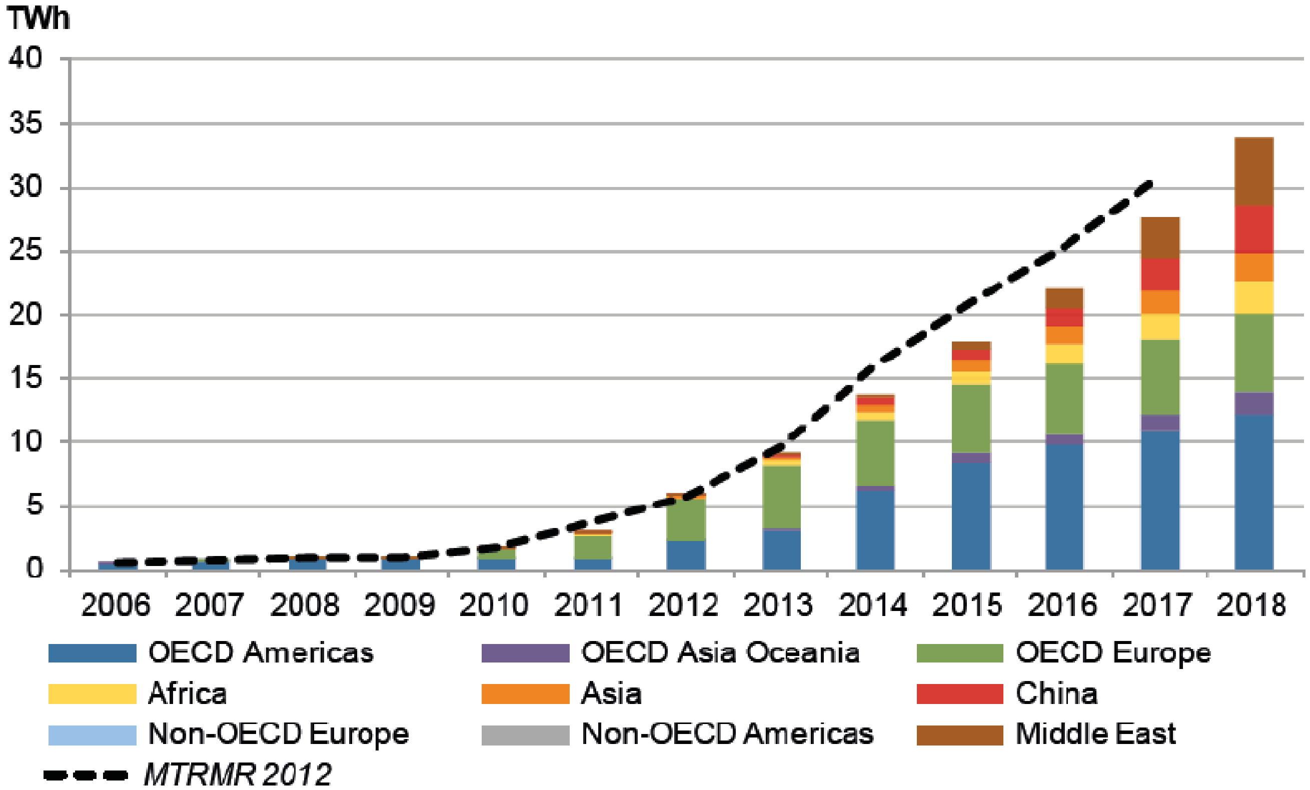
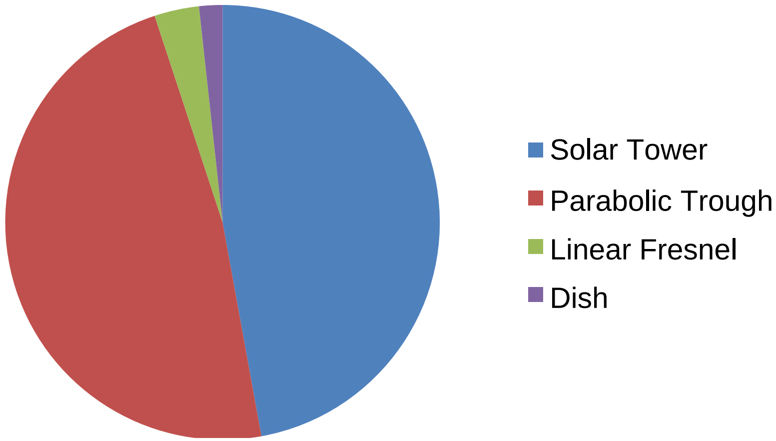
Market: Medium term generation to 2018

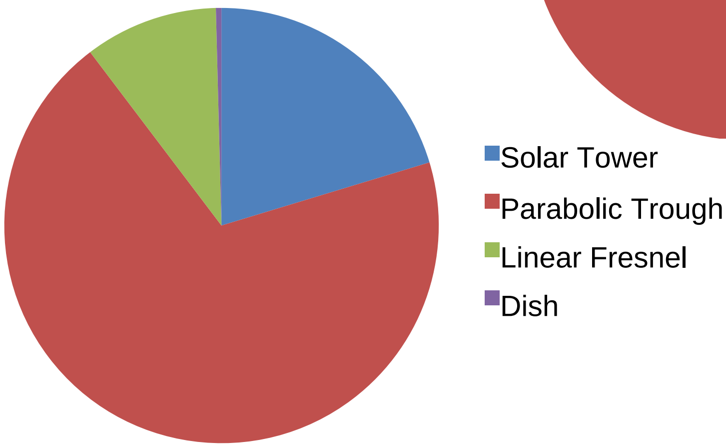


Trends / Challenges

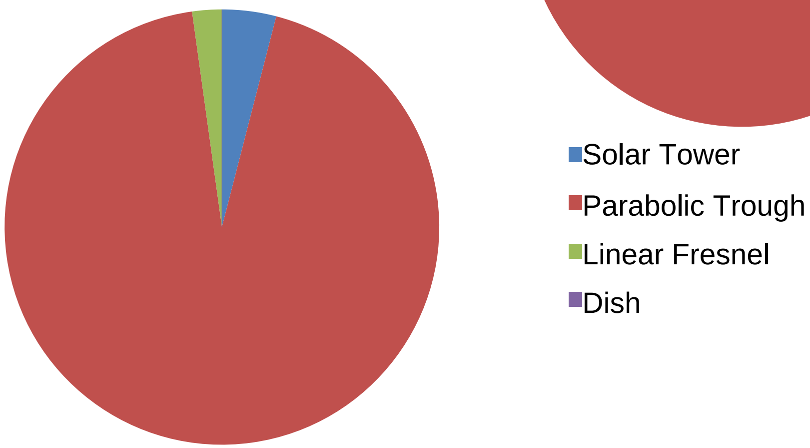
Planning



Under construction



In operation



Reasons for the Trend

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

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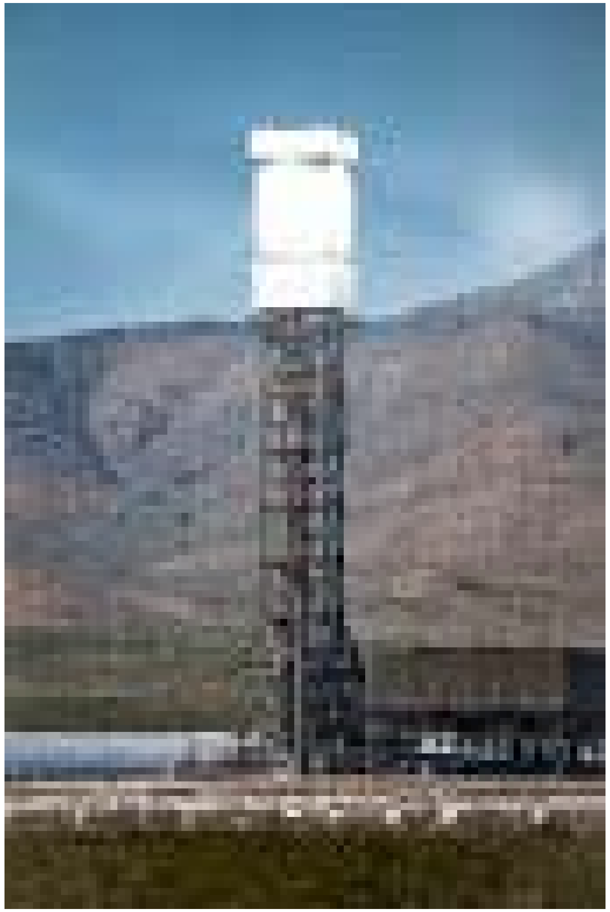
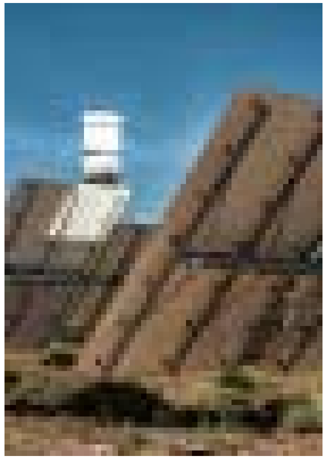
Ivanpah (392 Mwel, 347000 Heliostats, DSG

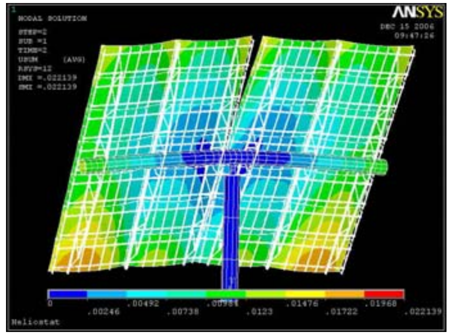




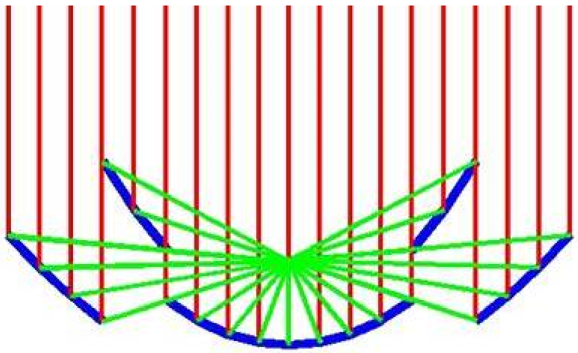
Crescent dunes (110 MW, 17500 Heliostats, Molten Salt

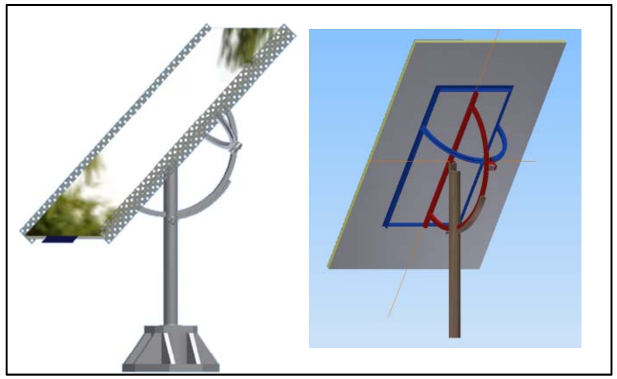
Challenges: Collectors

- Lightweight construction



- New designs

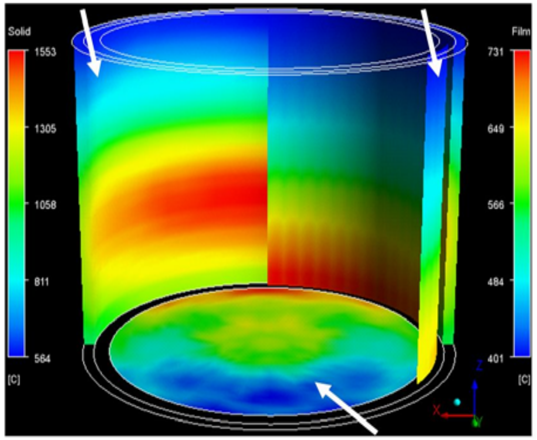




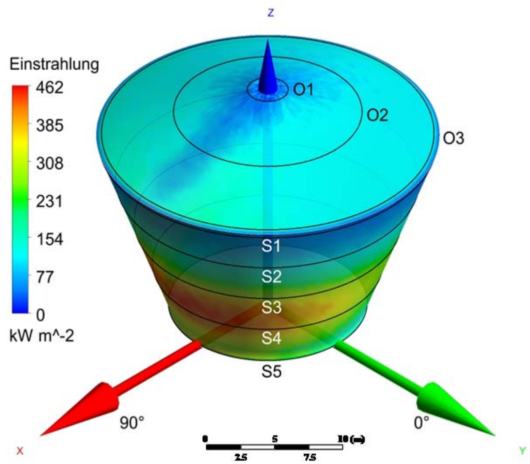
- Entire collector performance measurement
- and STANDARDs

Challenges: Heat Transfer Fluids for Higher Temperature

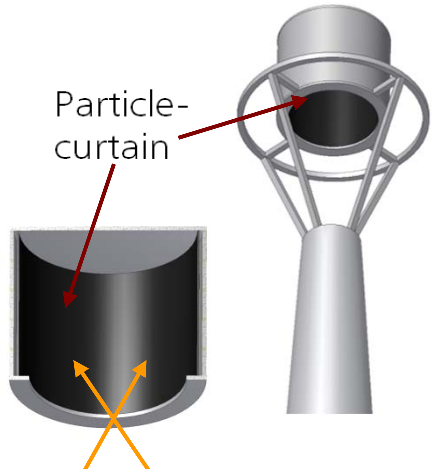
- Liquid salt



- Liquid metal

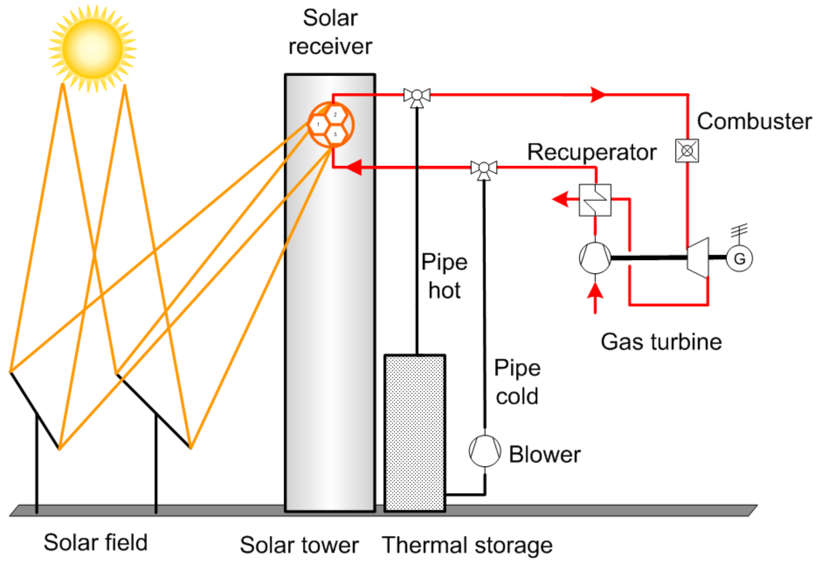


- Particles

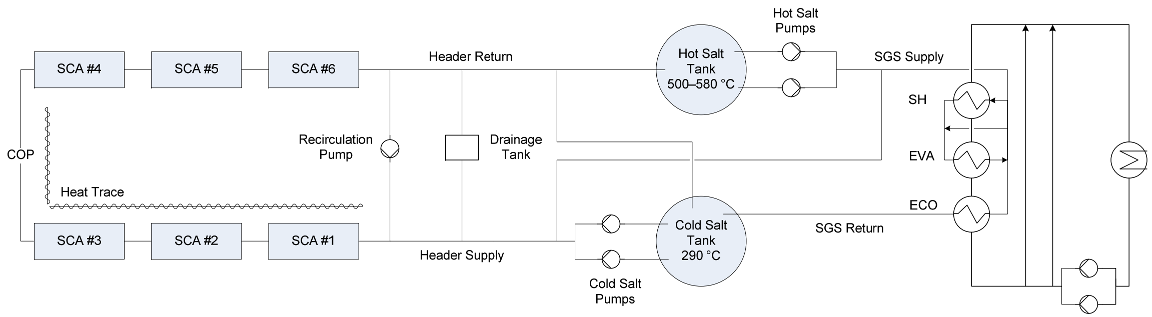


Challenges: Advanced Solar Power Cycles (Solarized Design)

- 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 of 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


Thank you for your attention