CSP Technologies, Markets, Challenges

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Energie Forum Aachen
20.03.2014

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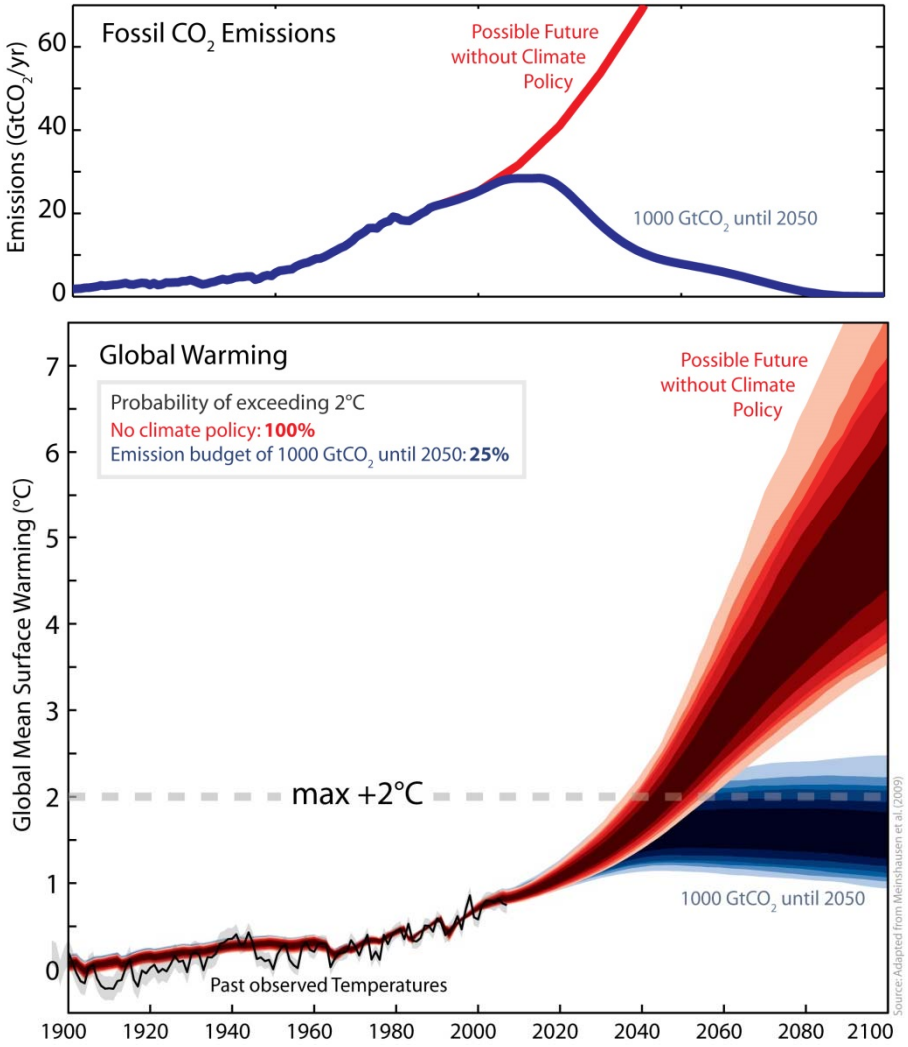
Agenda

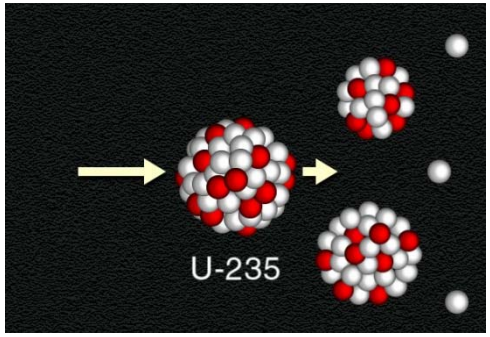
- Why renewable energies?
- Why Concentrated Solar thermal Power (CSP) plants?
- Solar resources
- Value of CSP electricity
- Technologies
  - Trough
  - Tower
  - Fresnel
- CSP vs PV
- Real data of CSP dispatchable solar generation
- Markets
- Trends

Why renewable energies?
- Scenarios on global warming -

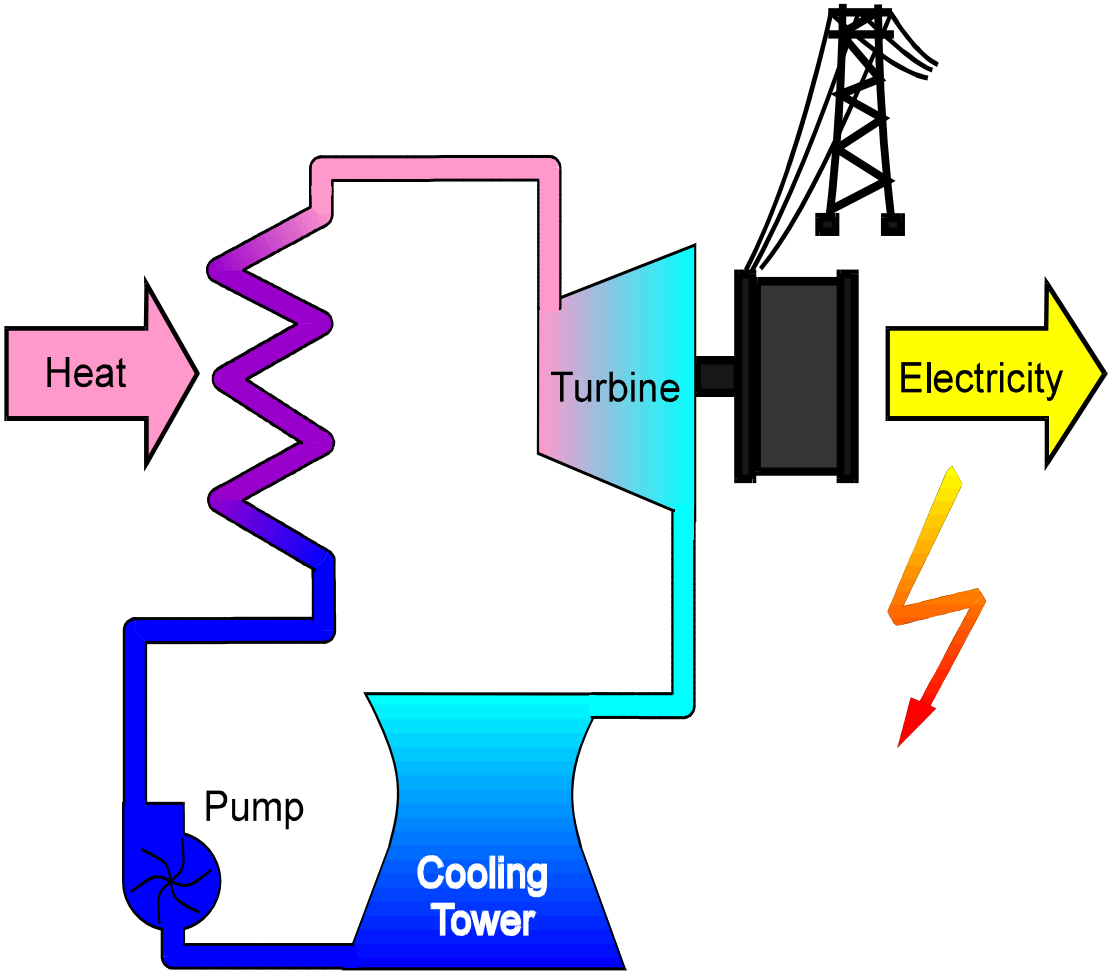


Source: M. Meinshausen et al. (2009)

Why solar thermal power plants ?

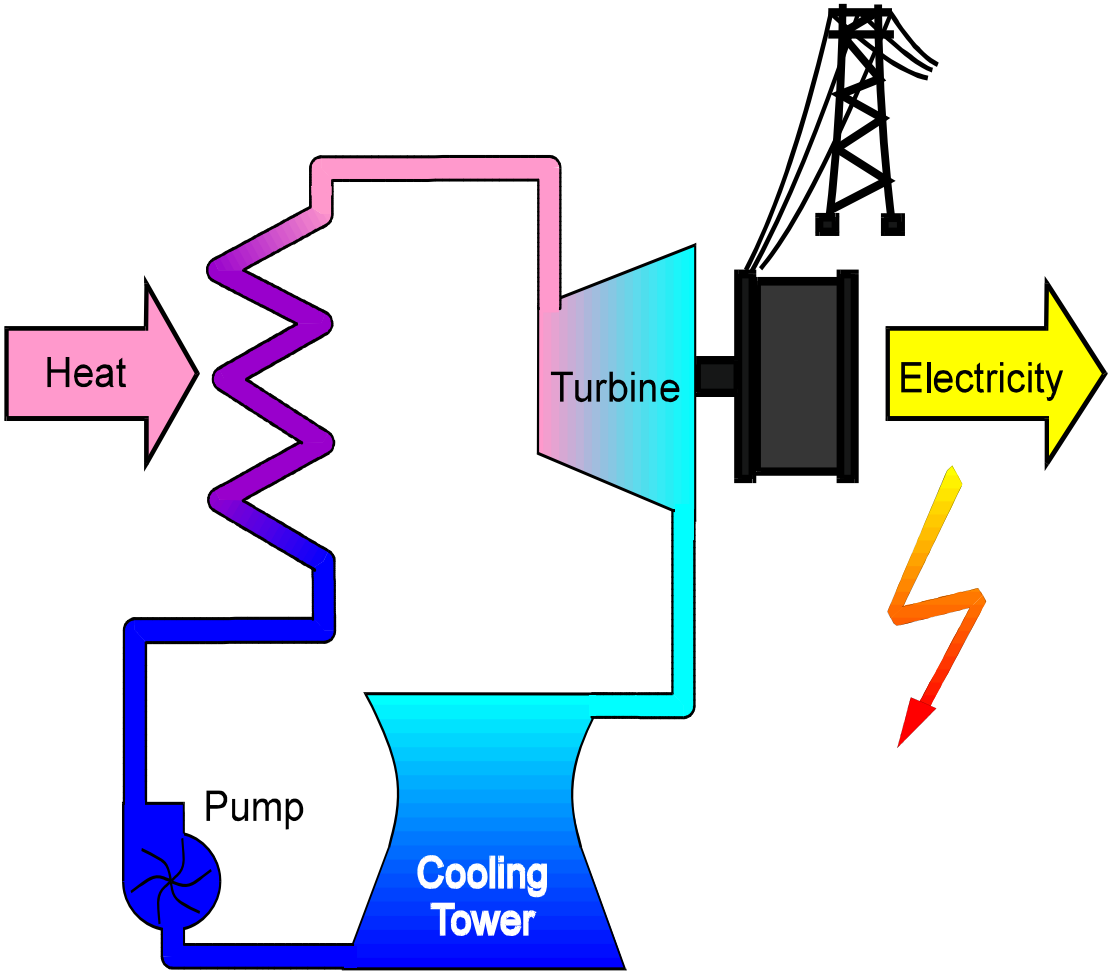


Conventional power plants



Why solar thermal power plants ?

Solar thermal power plants



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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

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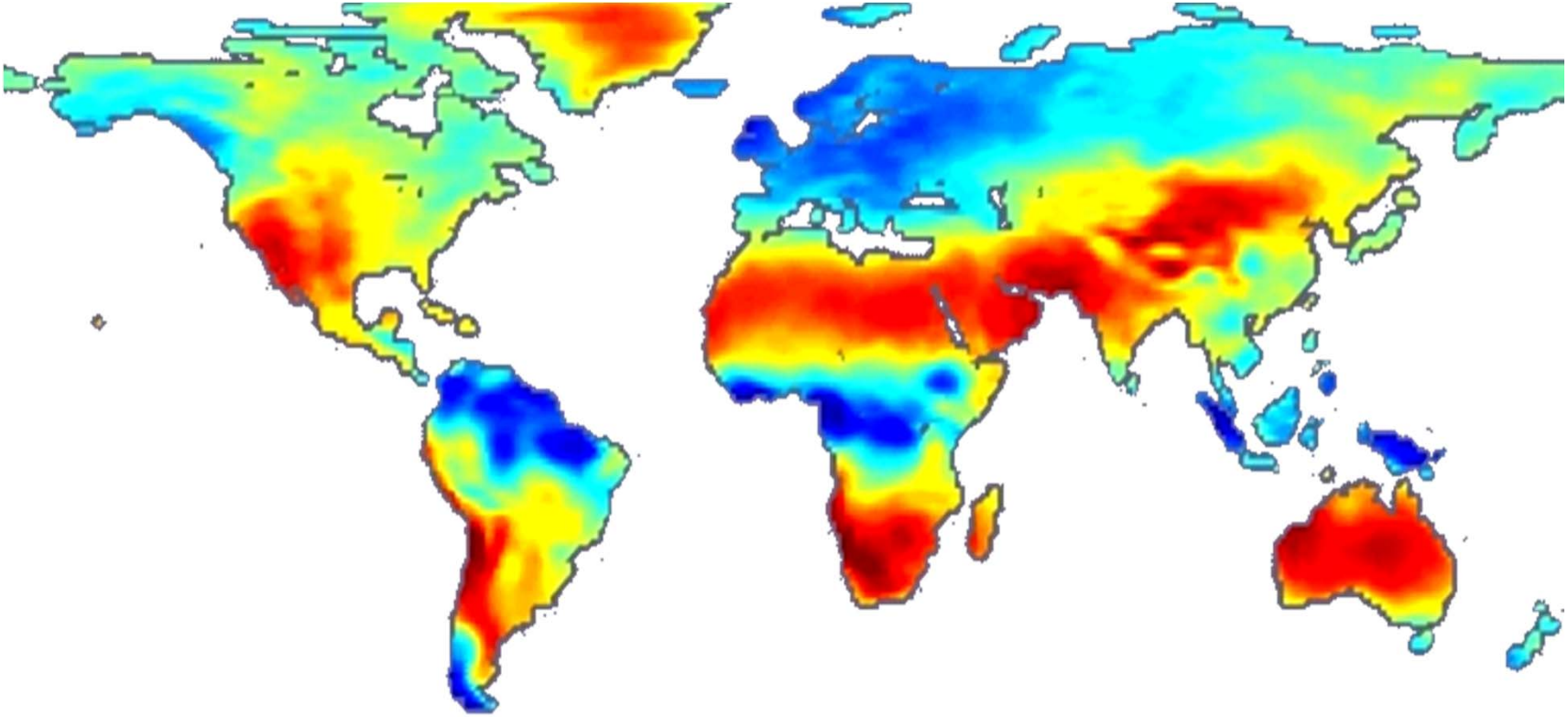
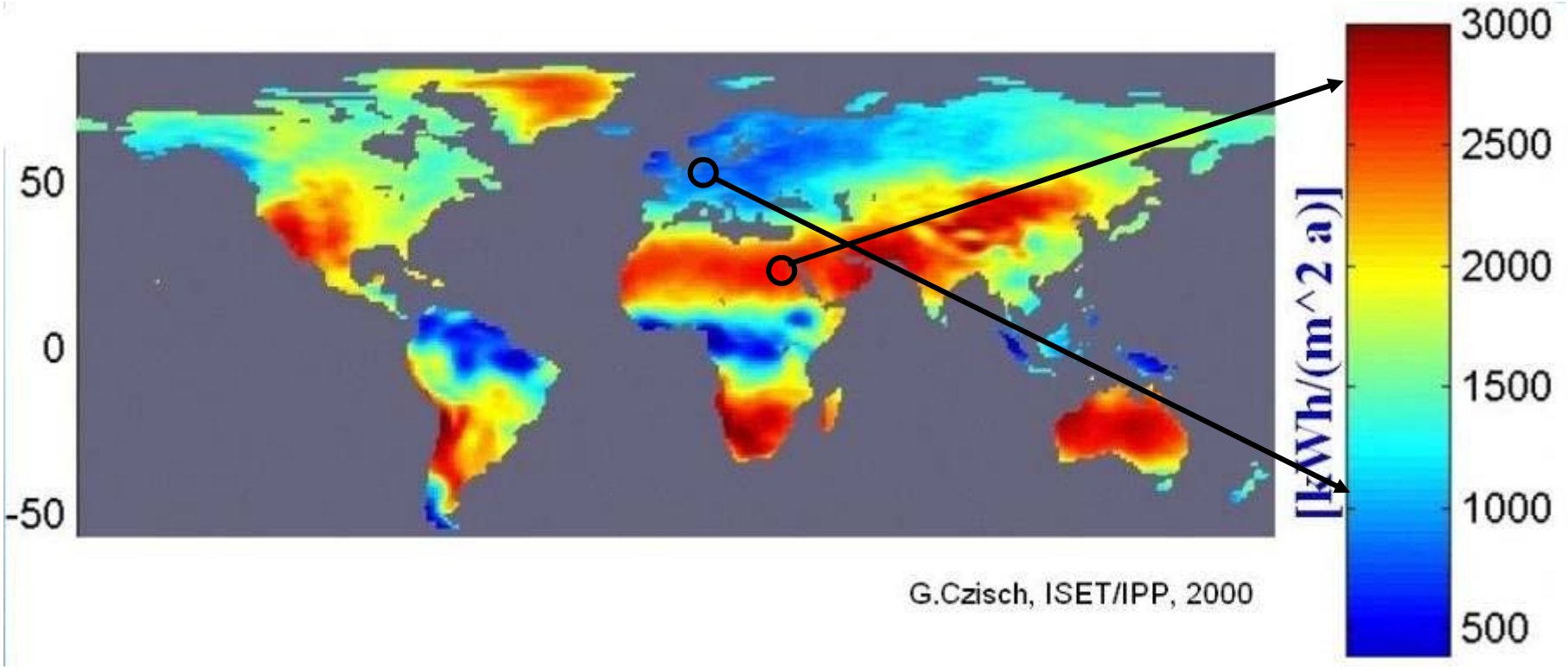
World Sun Belt



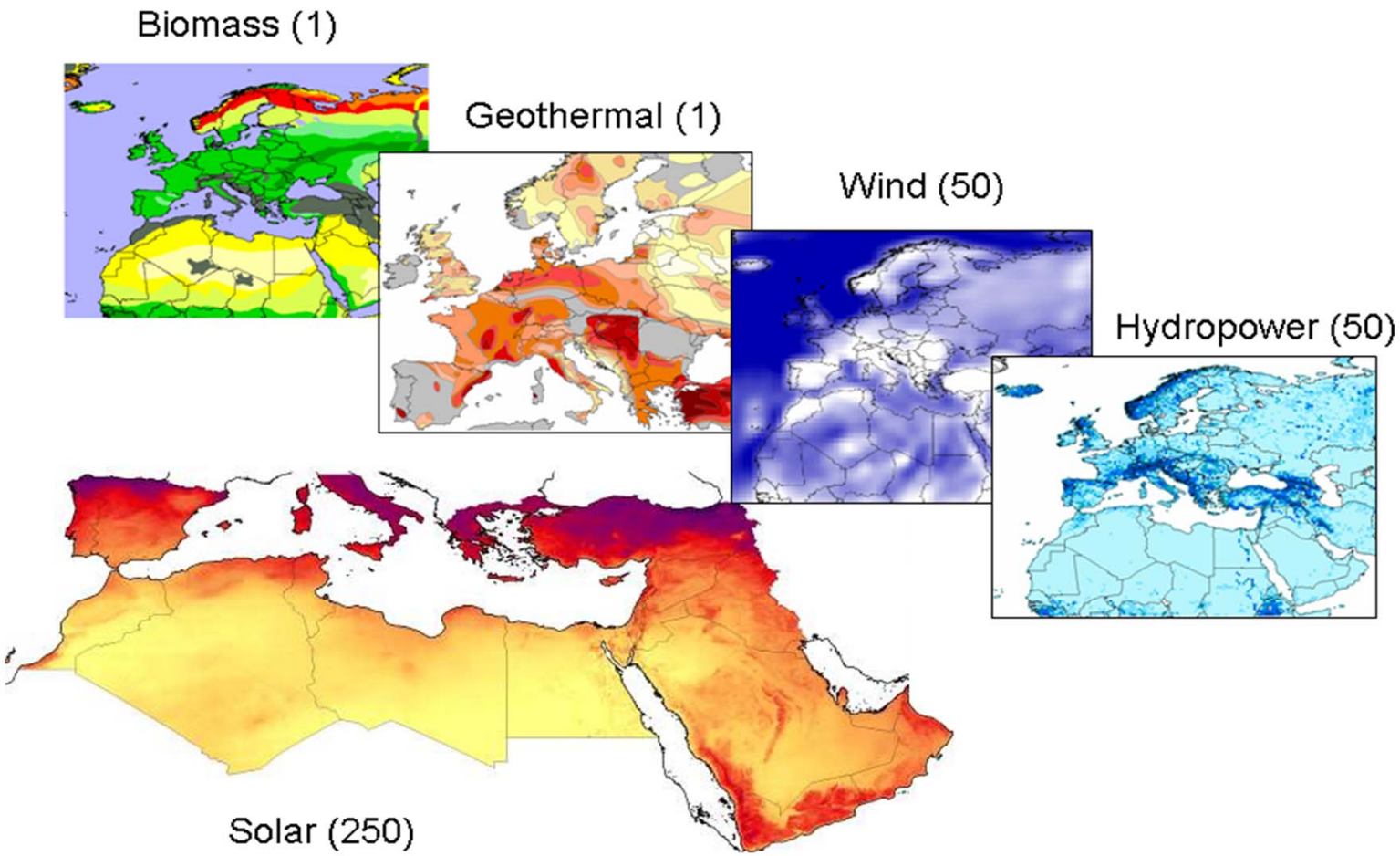
World Sun Belt

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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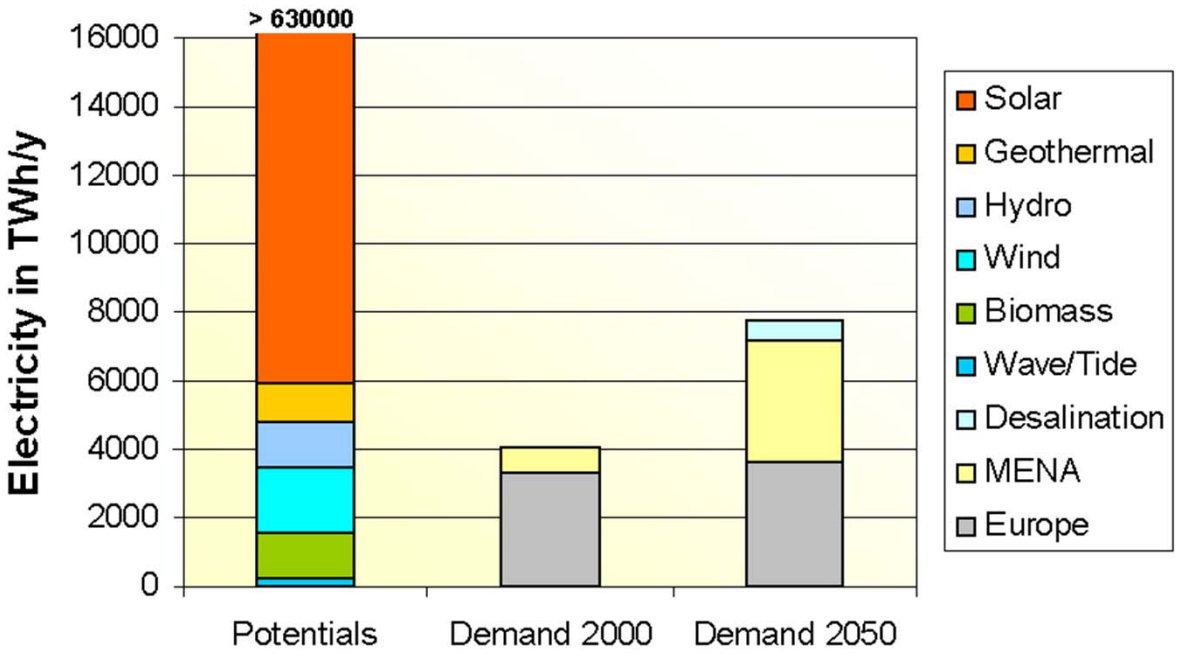
Renewable energy resources in Europe and MENA

- 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



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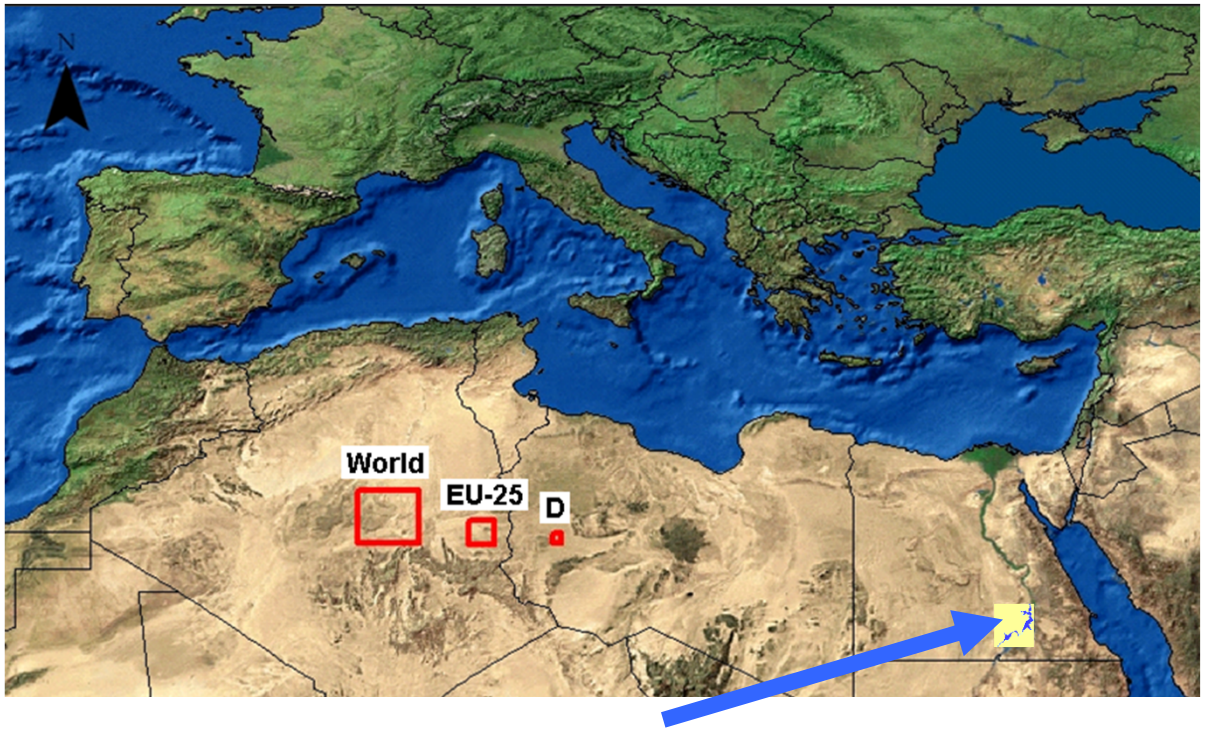
Renewable energy resources in Europe and MENA

- renewable resources greatly exceed the present and future electricity demands
- solar radiation is by far the most abundant source of energy
- 1 km² of desert land may generate 50 MW of electricity
- 1 km² 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 resource

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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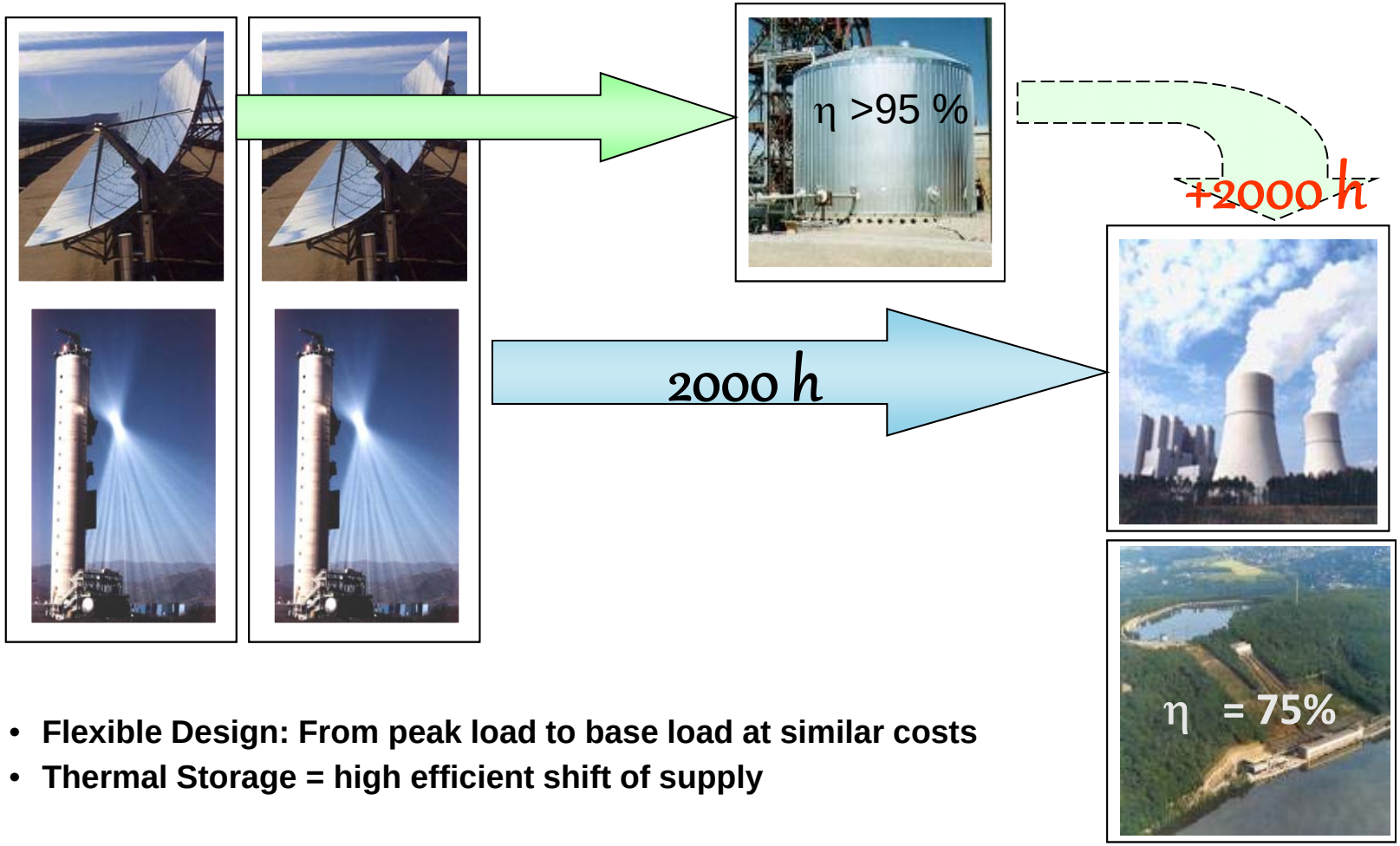
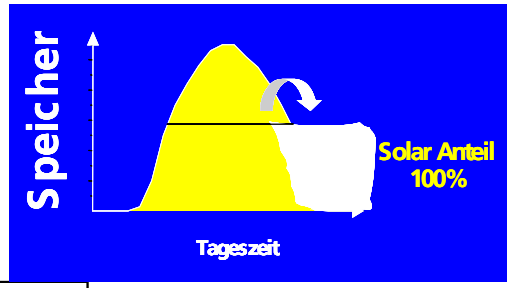
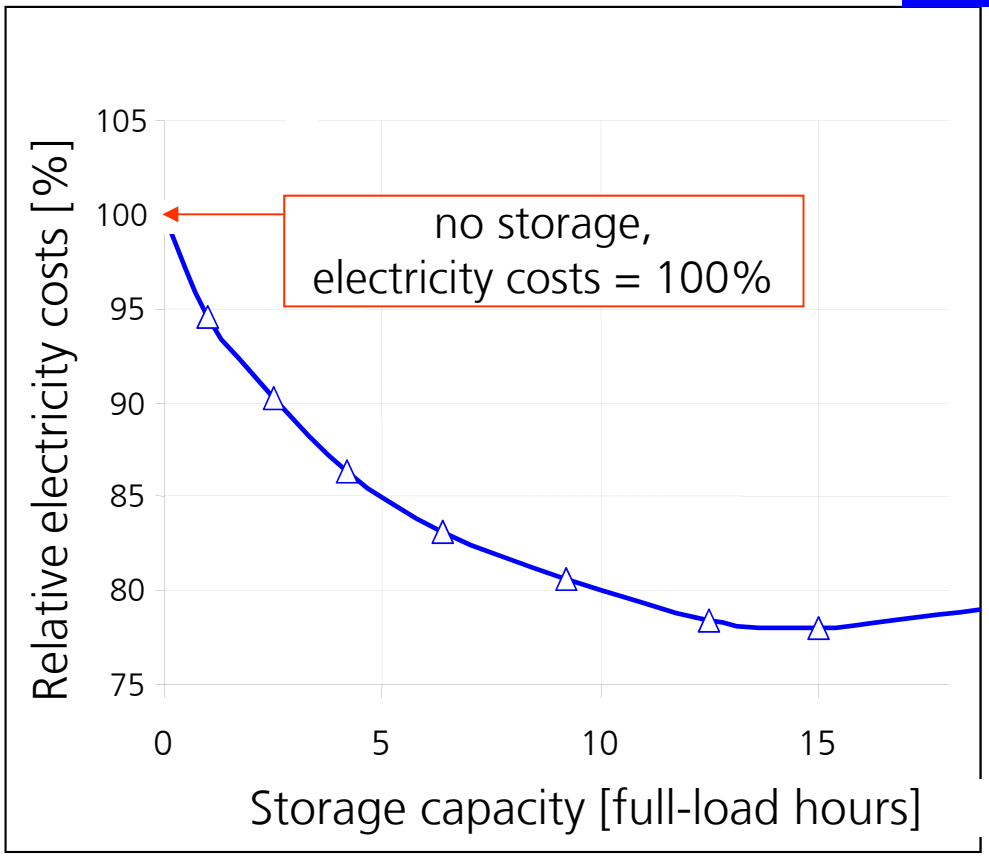
The Value of CSP Electricity



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

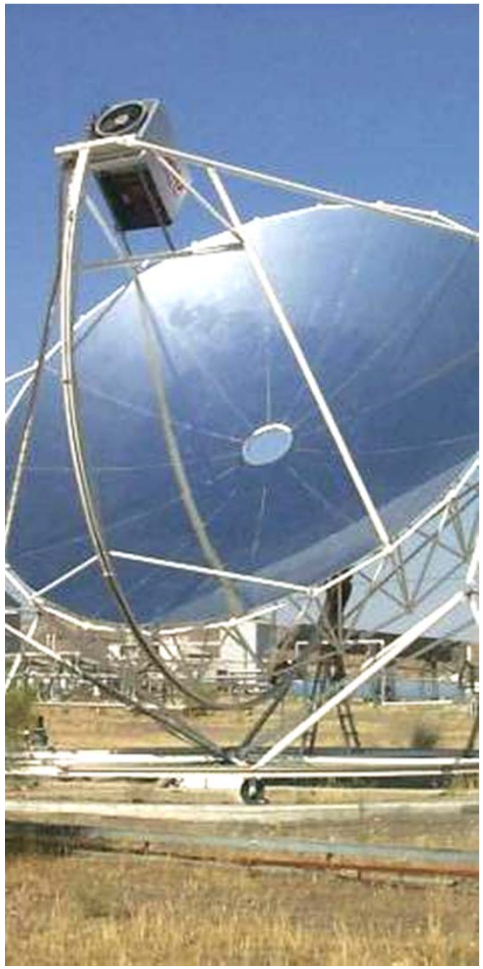
The Value of CSP Electricity





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

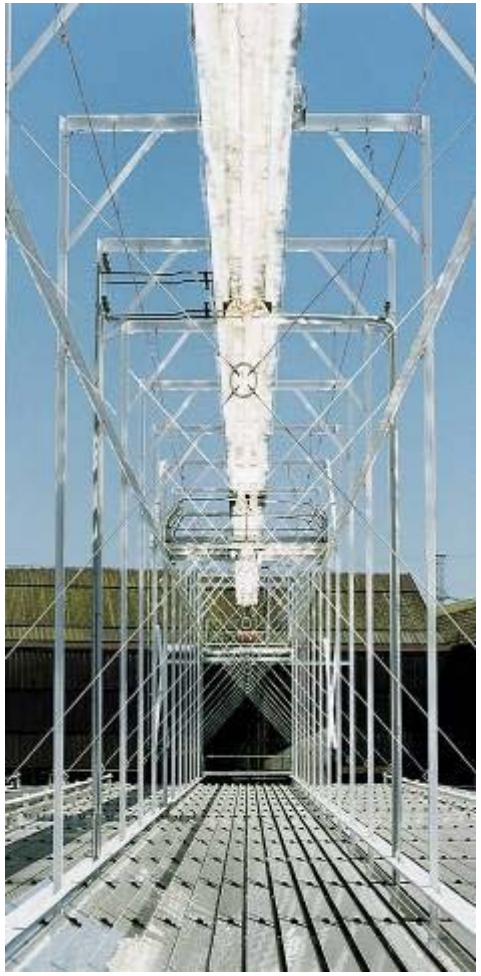
Types of Concentrating Solar Thermal Technologies



Dish-Stirling

Solar Power Tower

Parabolic Trough



Linear Fresnel

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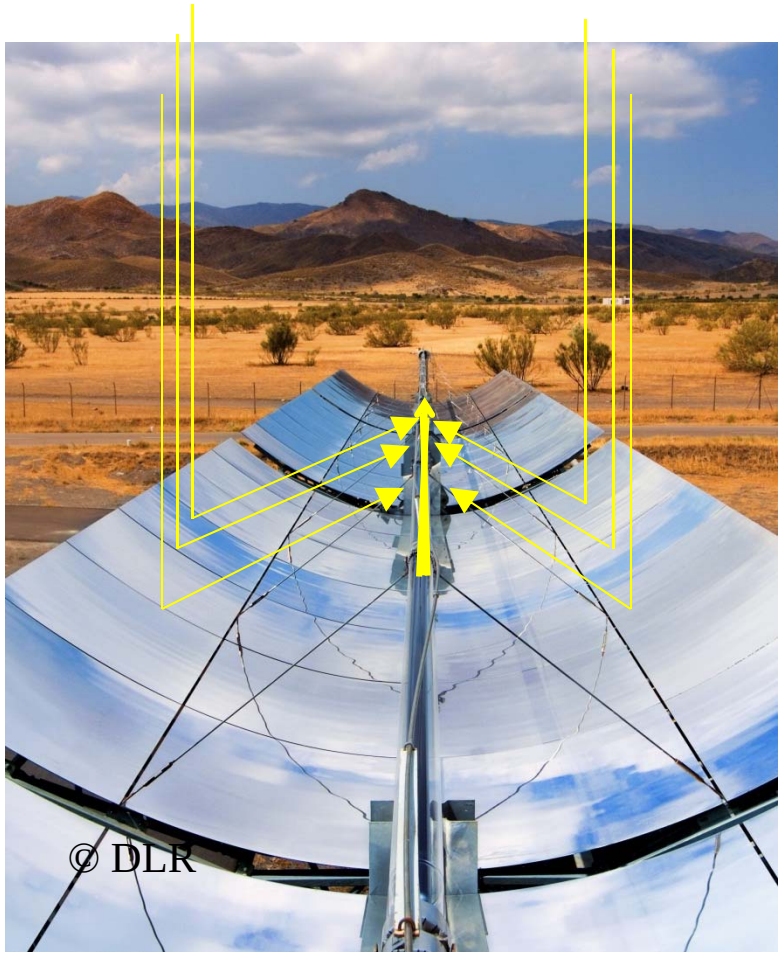
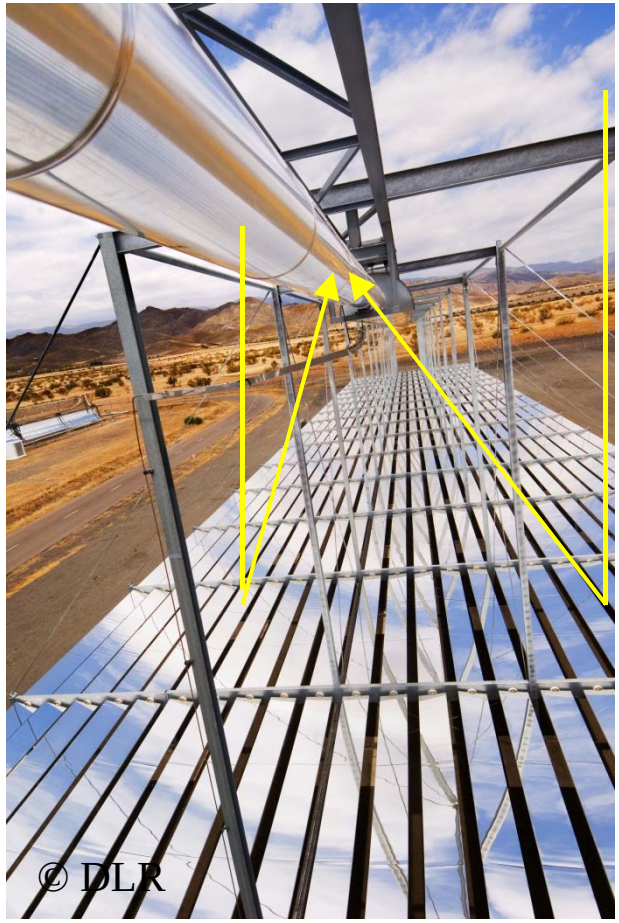
Parabolic Trough Collector

- 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

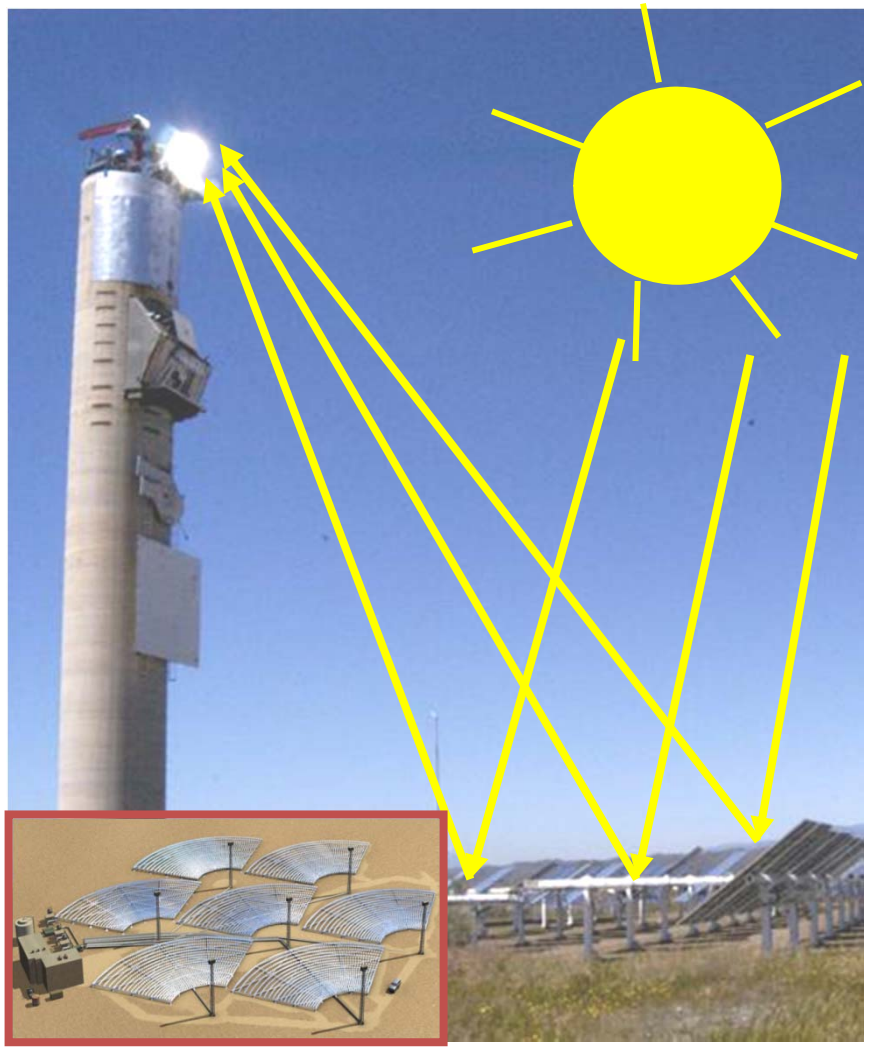
- Advantages:
  - Simple construction
  - High land use
  - Possible integration into buildings
- Disadvantages:
  - Low efficiency
  - State of the art without storage



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



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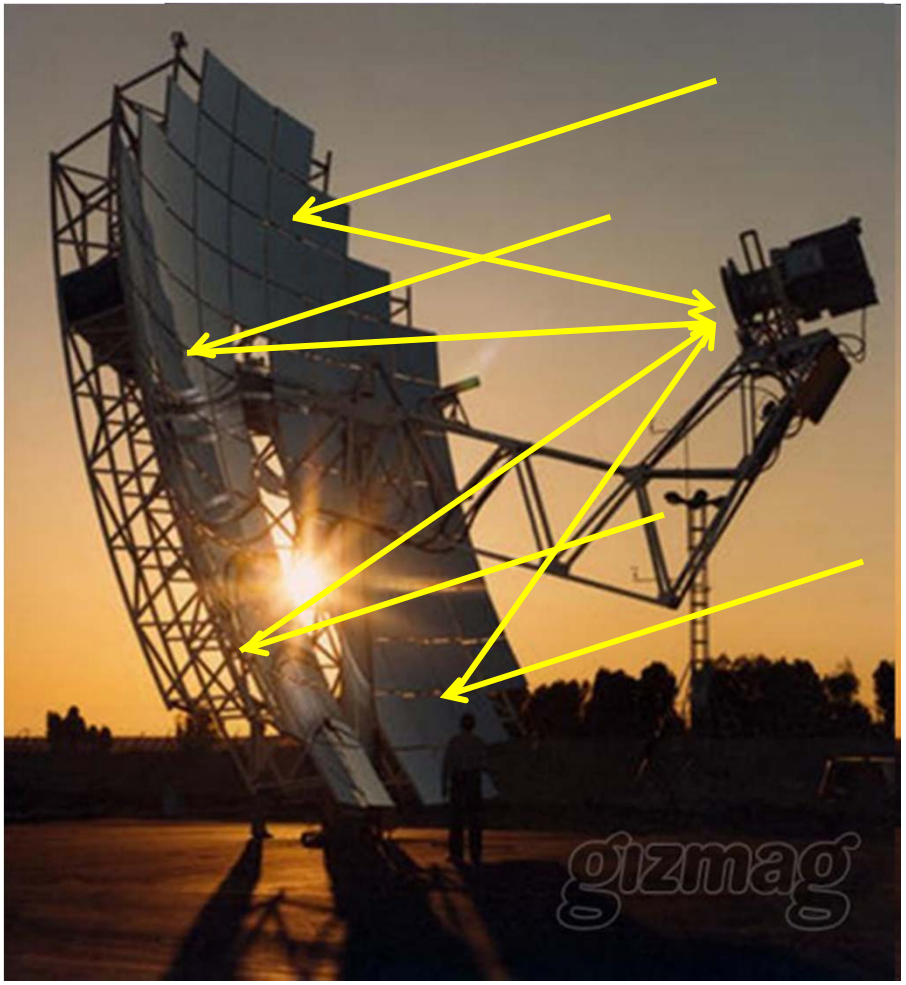
Dish-Stirling

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



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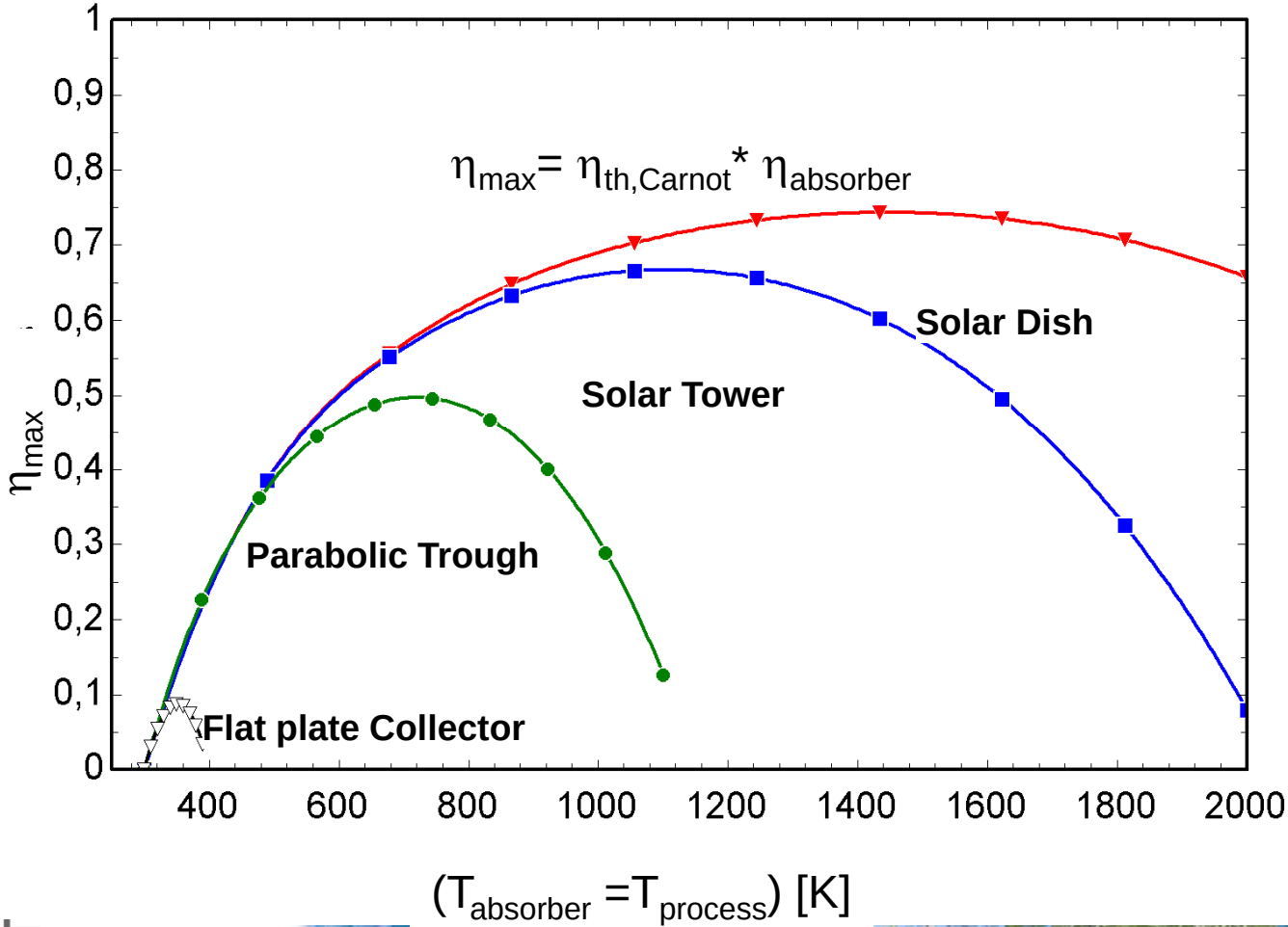
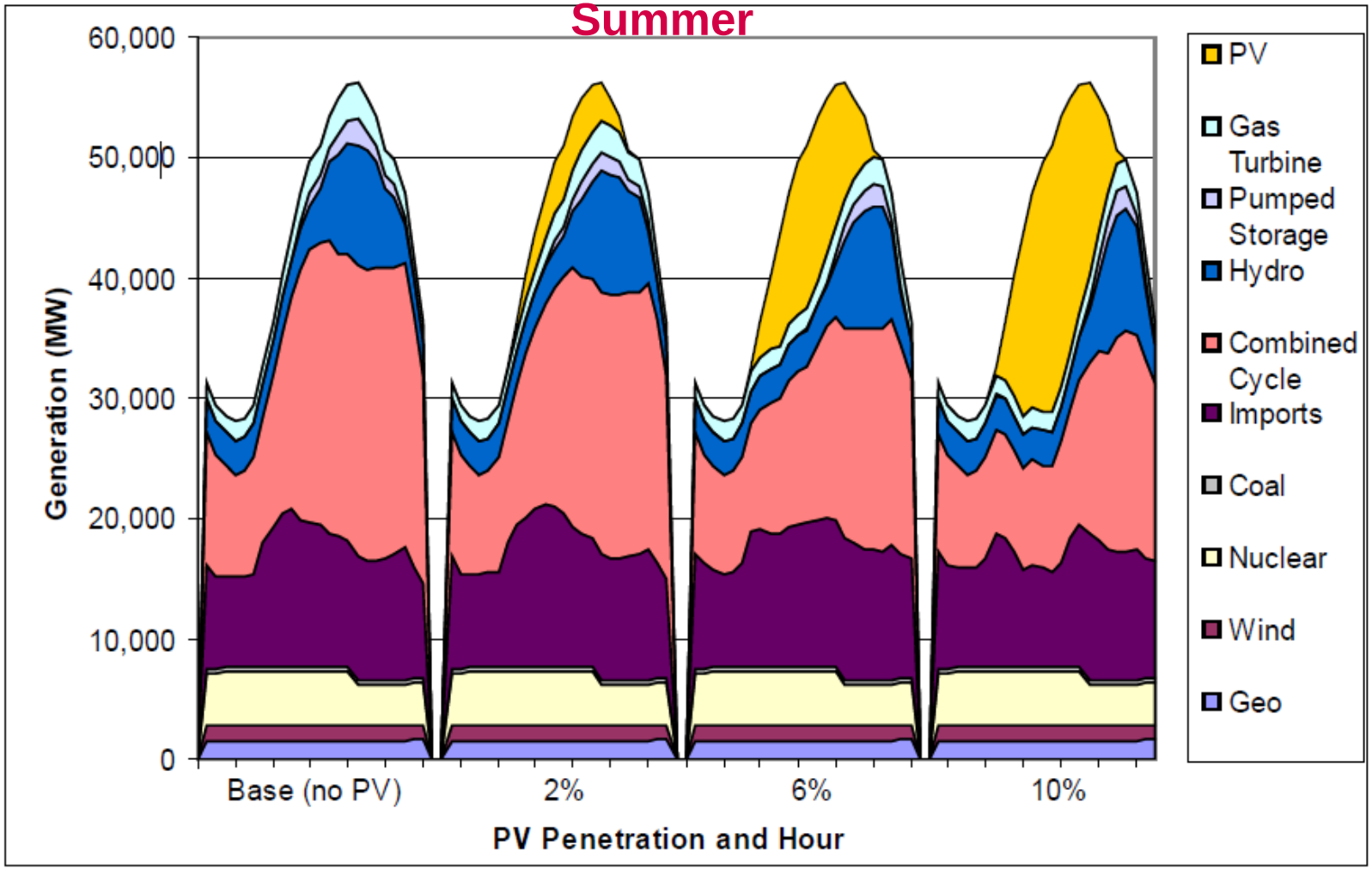
Theoretical efficiency potential



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

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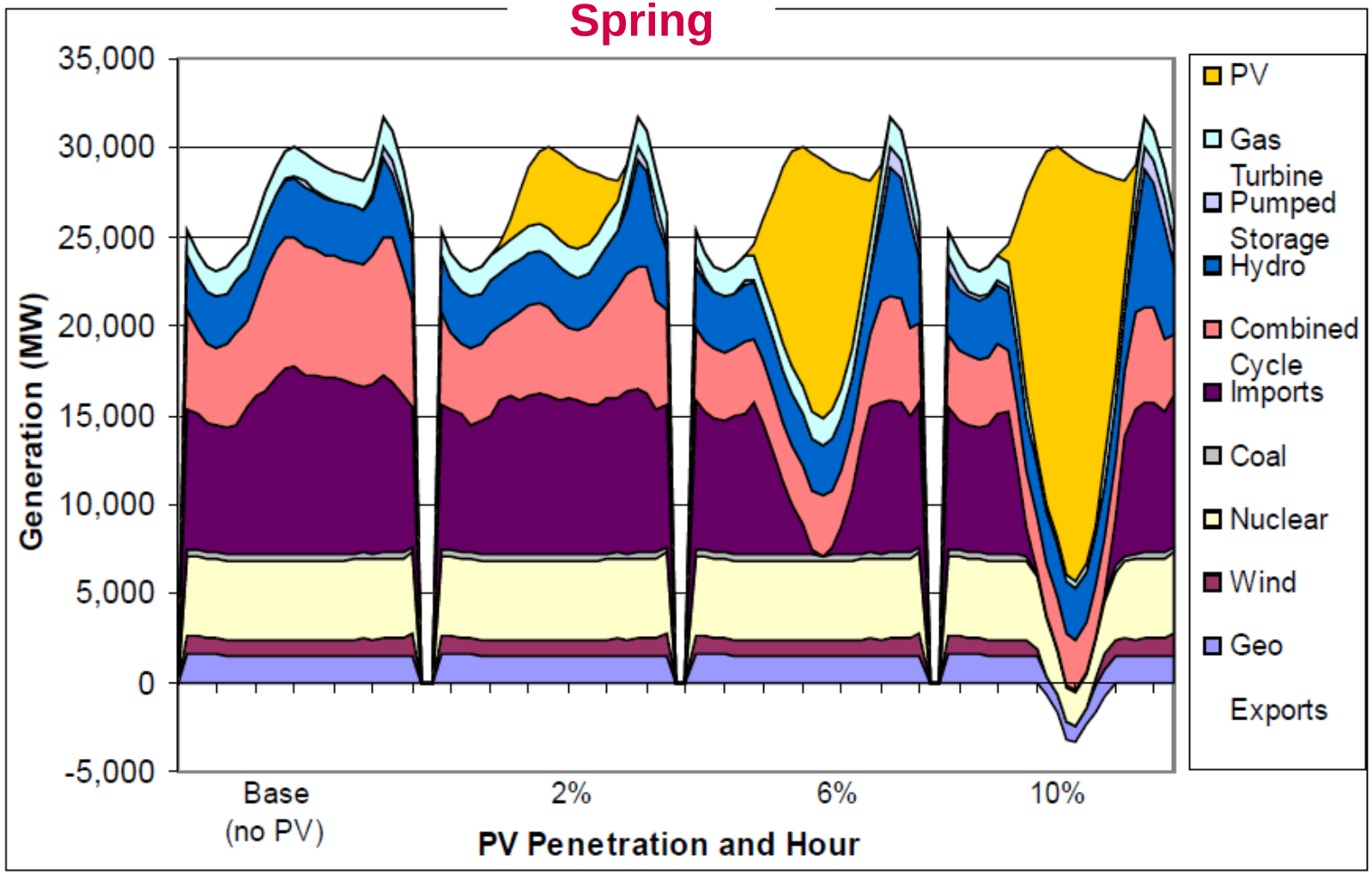

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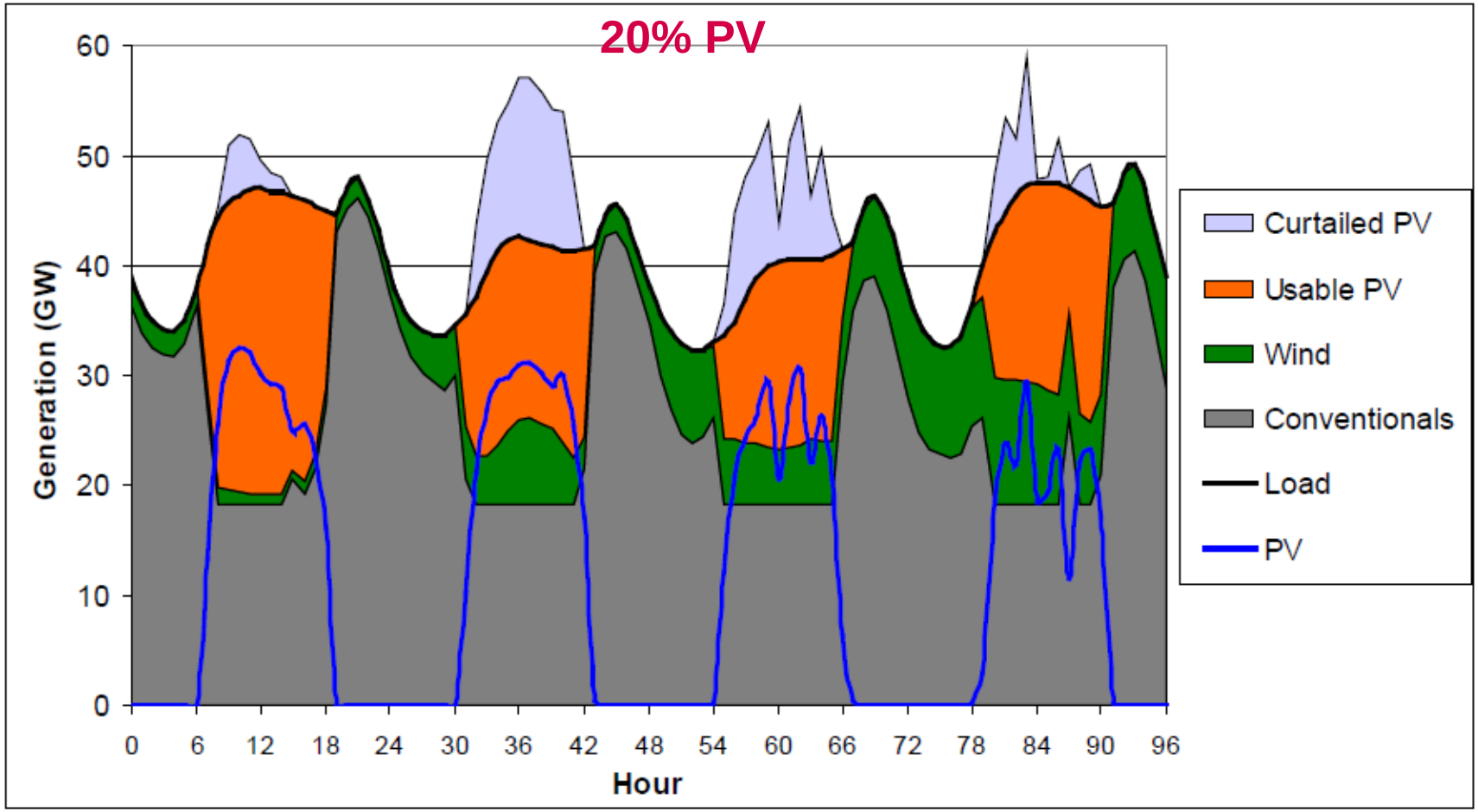

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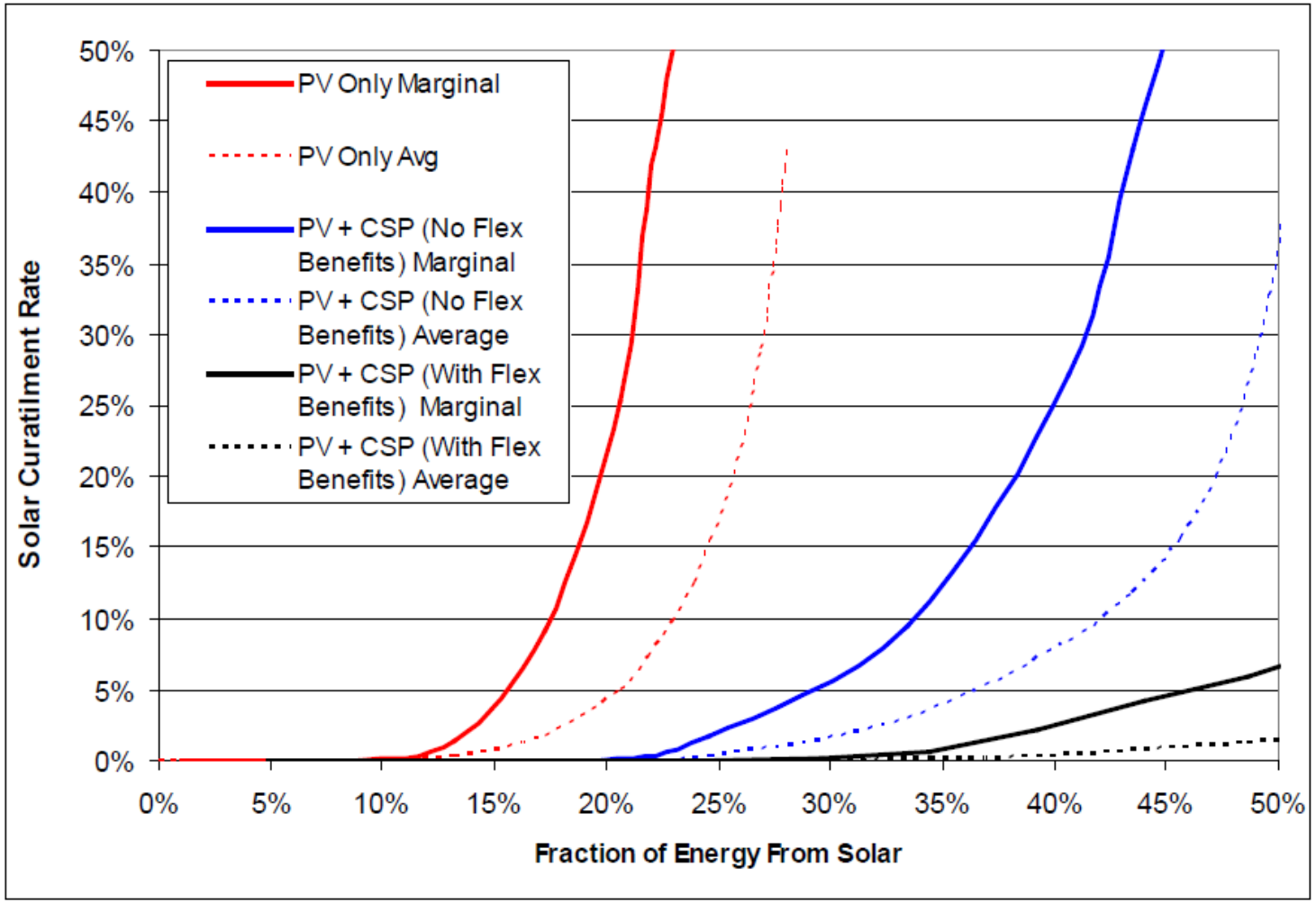

Source: NREL/TP-6A20-52978, Nov. 2011

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Real data of CSP dispatchable generation (Andasol III data)

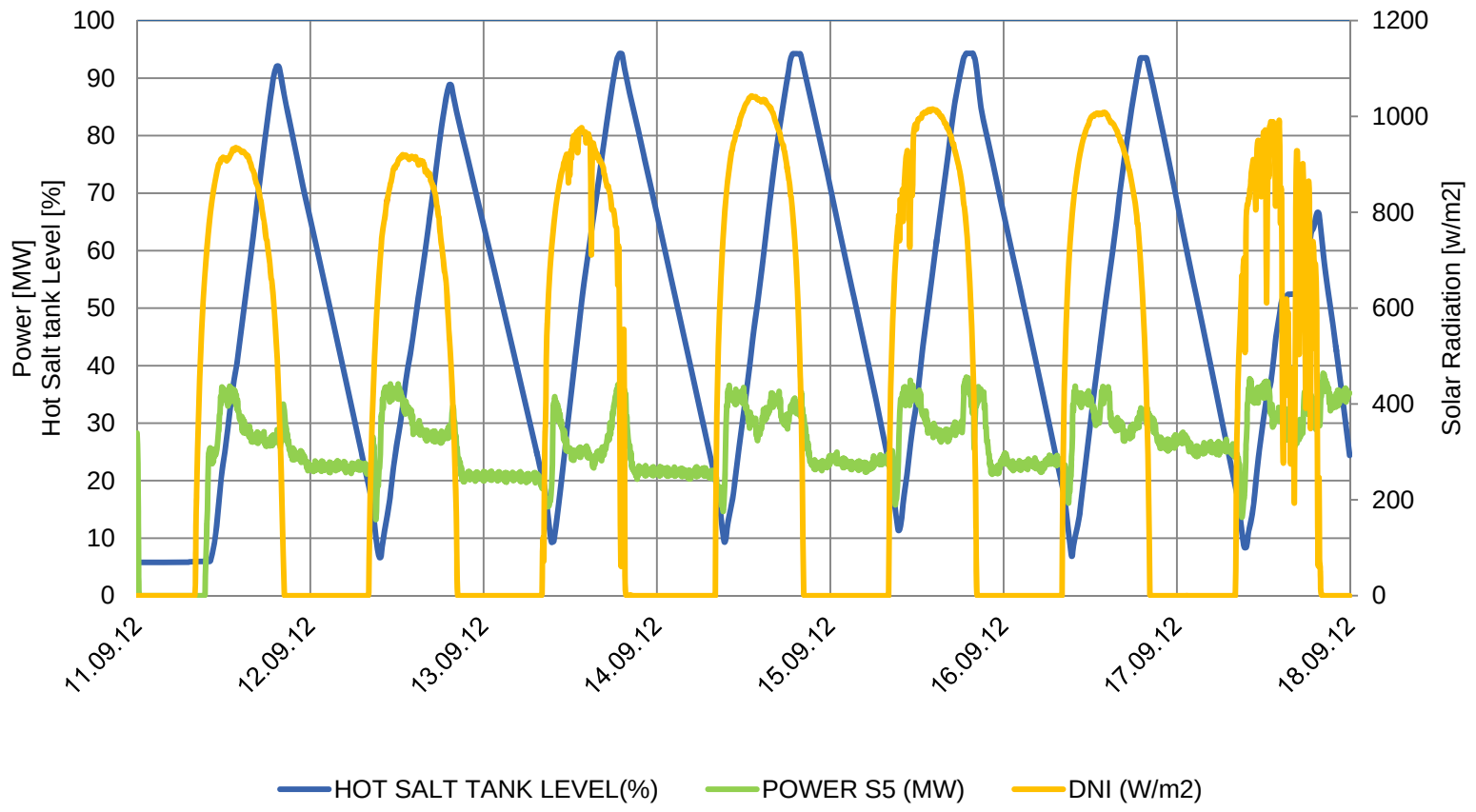
Andasol 3: Facts & Figures

- 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:
- EPC contractor: UTE

Source: RWE Innogy, F. Dinter

Continuous generation 24 h/d

11.09.2012 – 18.09.2012



Source: RWE Innogy, F. Dinter

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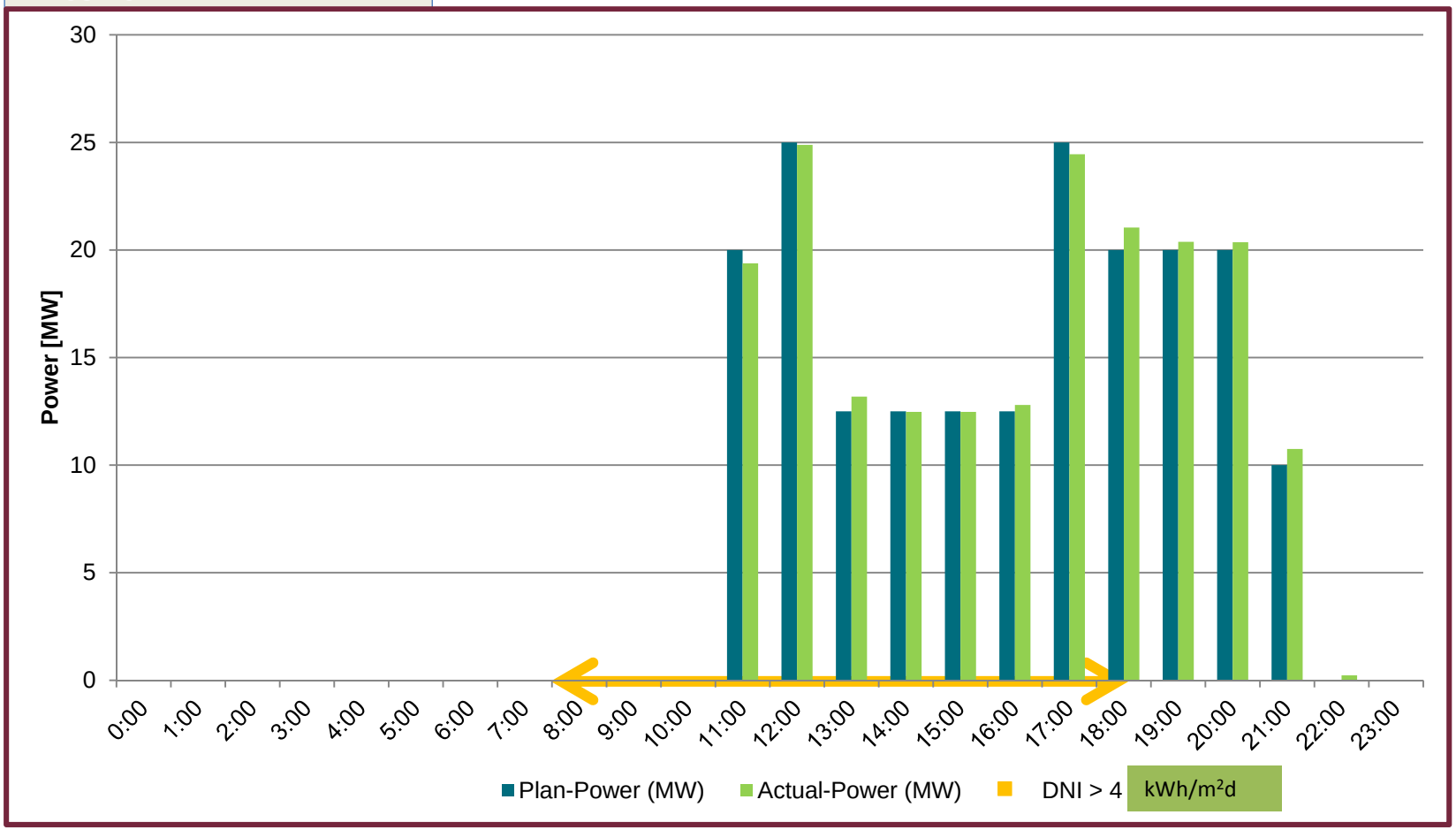
Dispatchable generation

Dispatchability test

22.03.2012



Source: RWE Innogy, F. Dinter

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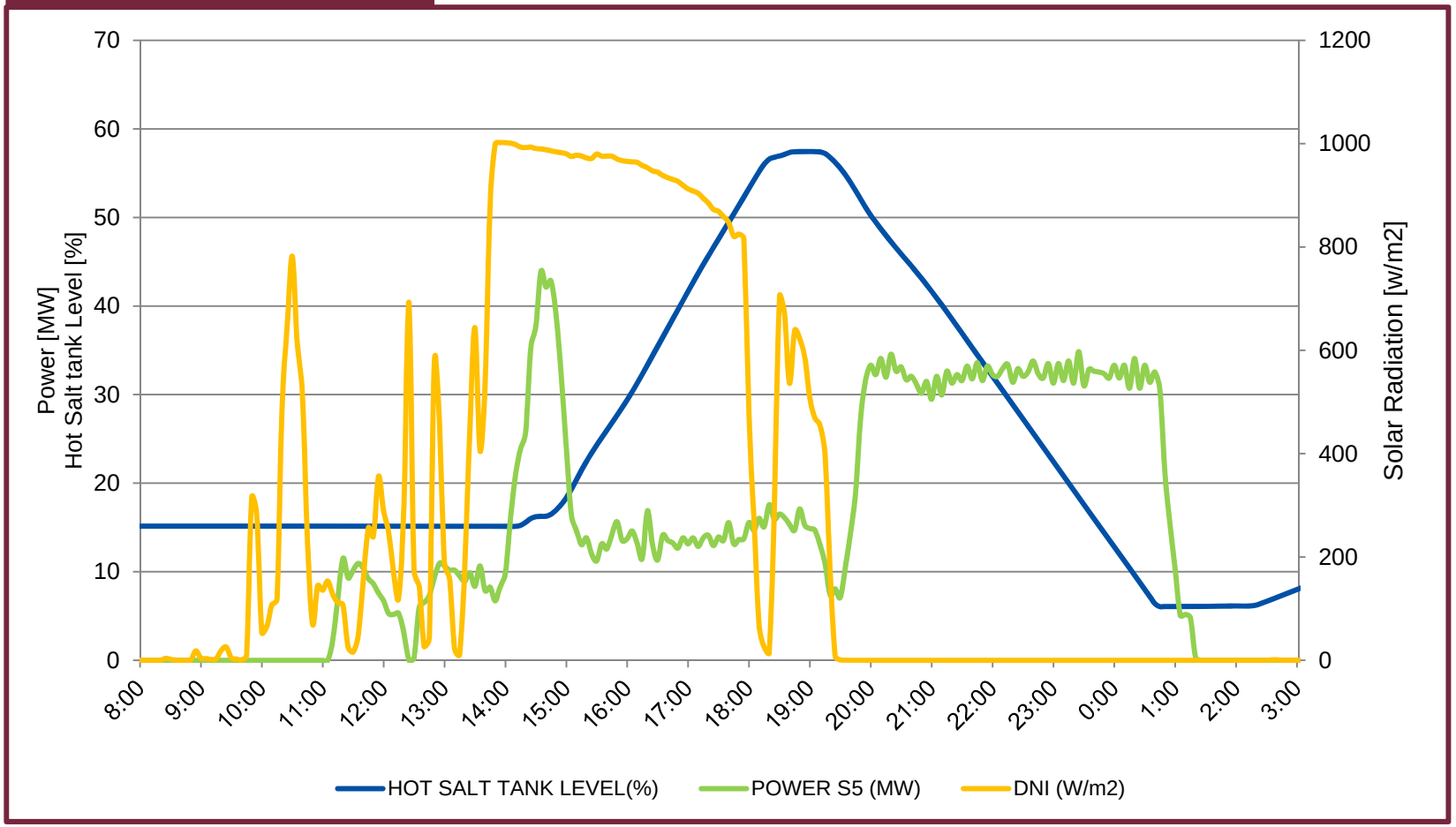
Dispatchable generation

14.10.2012

CECOGE: Tech minimum request 14.10.2012



Source: RWE Innogy, F. Dinter

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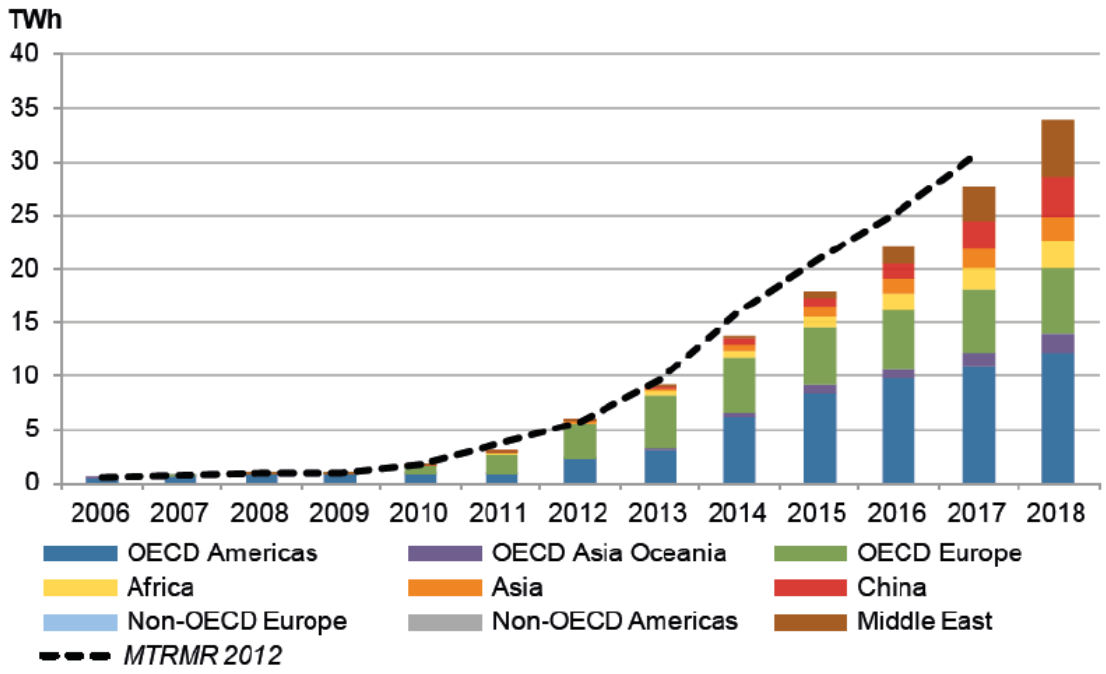
Market: Medium term generation to 2018



Spain	2206
United States	1973
South Africa	700
Morocco	480
China	318
India	378
Chile	340
Israel	231
United Arab Emirates	101
Saudi Arabia	100
Others	310
Total	**7138**

Source: IEA, MTRMR 2013

Source: Bloomberg New Energy Finance

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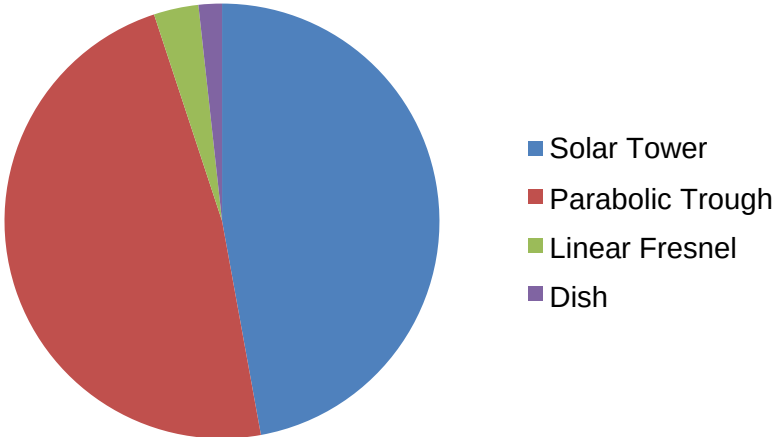
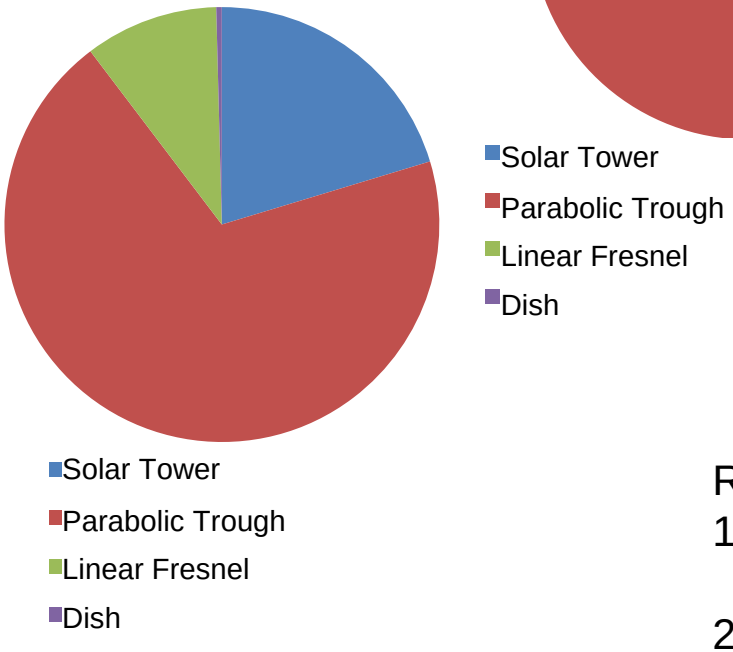
Trends / Challenges

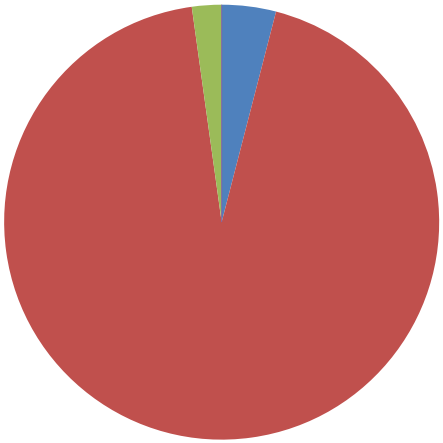
Planning



Under construction



In operation



Reasons for the Trend

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

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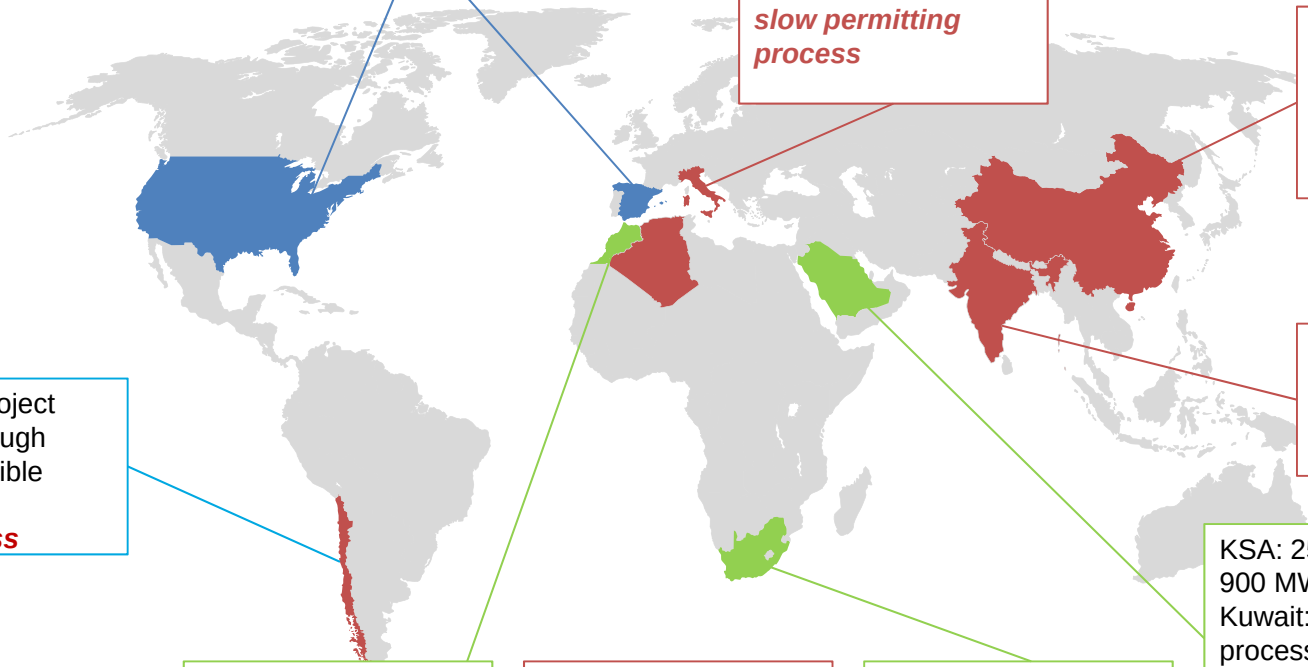
Market



No new projects

250 MW by 2016

slow permitting process

1 GW by 2015
3 GW by 2020

no progress

2,7 GW by 2017
only 3 projects built

no progress

One tower project awarded, Trough projects possible

little progress

KSA: 25 GW by 2032
900 MW by end of 2016
Kuwait: Projects in tender process
serious but slow approach

1 GW until 2020

on track, 500 MW confirmed already

7,2 GW by 2030

no progress

100-200 MW per year, target 1.2GW (3.3 GW)
on track, 400 MW confirmed already

Source: DCSP

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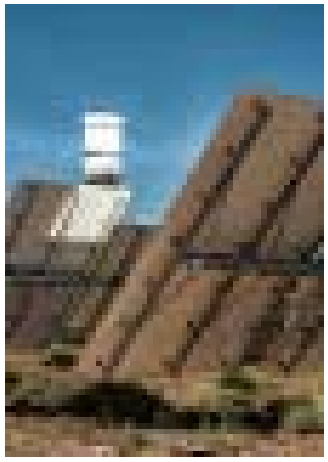
Ivanpah (392 Mwel, 347000 Heliostats, DSG



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

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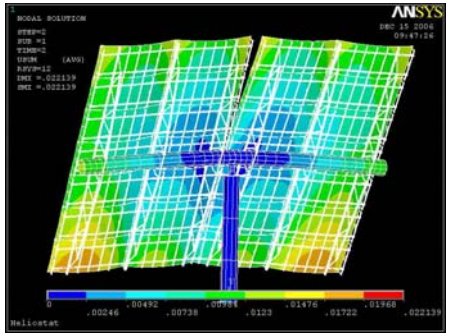
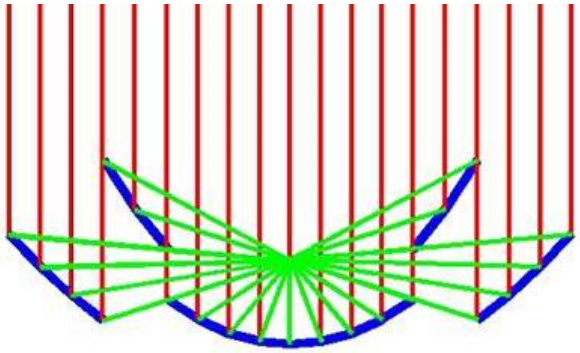
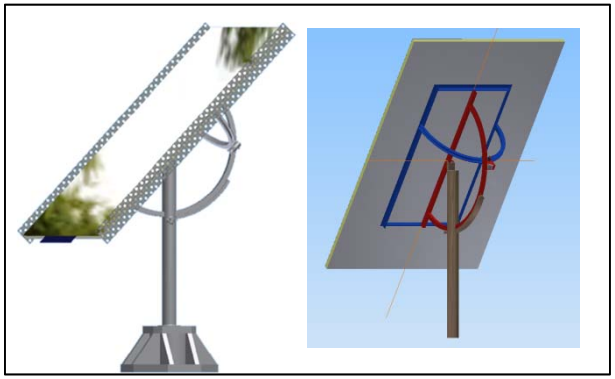
Challenges: Collectors



- Lightweight construction





- New designs

- Entire collector performance measurement
- and STANDARDs

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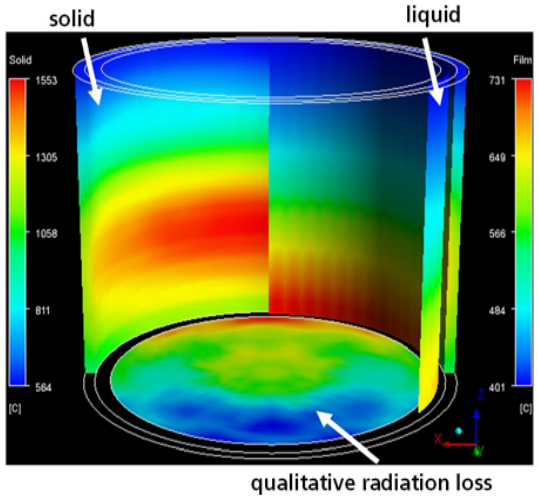
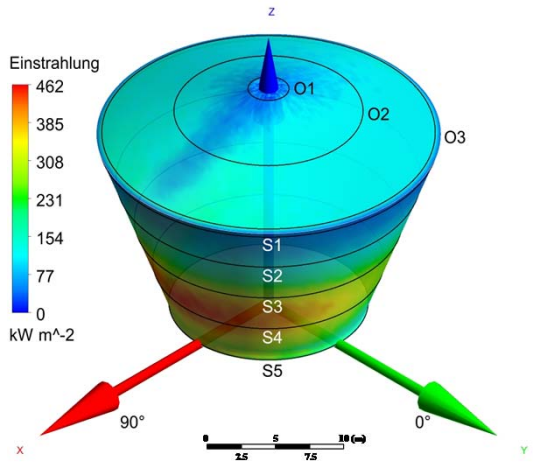
Challenges: Heat Transfer Fluids for Higher Temperature

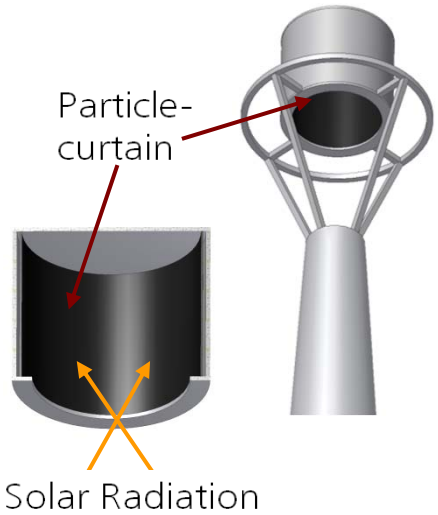
- Liquid salt



- Liquid metal

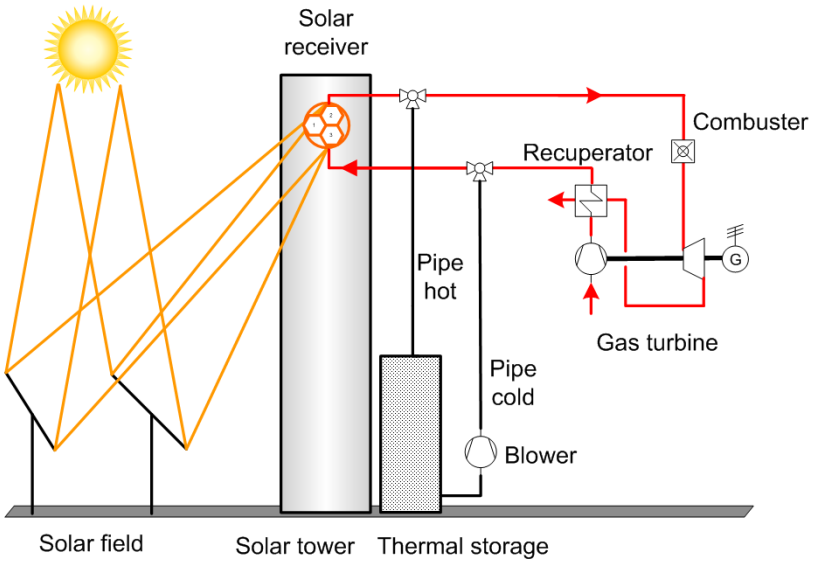


- Particles

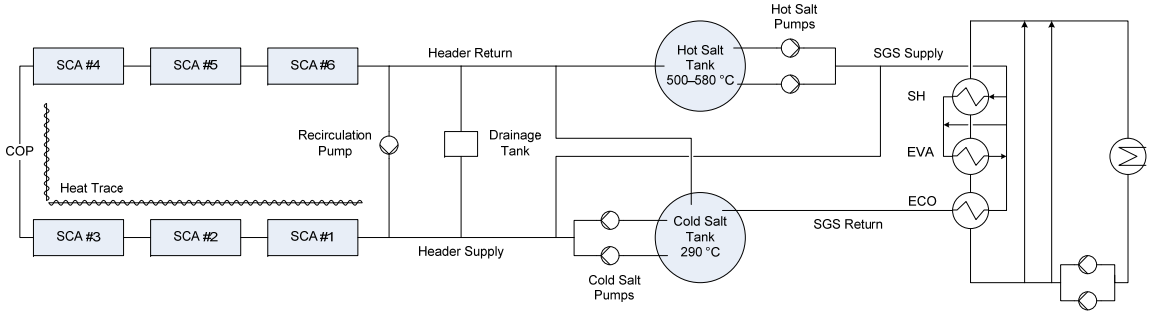


Challenges: Advanced Solar Power Cycles (Solarized Design)

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



- Molten salt in parabolic troughs



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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