Overview CSP Technologies, Markets, Challenges

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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?
Why solar thermal power plants?
Why 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

Solar thermal power plants
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)

- Biomass (1)
- Geothermal (1)
- Wind (50)
- Hydropower (50)
- Solar (250)
The Value of CSP Electricity

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

$\eta > 95\%$

$\eta = 75\%$

$+2000\,h$

$2000\,h$
The Value of CSP Electricity

- no storage, electricity costs = 100%
- 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
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
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

η_{\text{max}} = \eta_{\text{th,Carnot}} \times \eta_{\text{absorber}}

\begin{align*}
\text{Flat plate Collector} \\
\text{Parabolic Trough} \\
\text{Solar Tower} \\
\text{Solar Dish}
\end{align*}

\( T_{\text{absorber}} = T_{\text{process}} \) [K]
CSP vs PV
Simulation of supply and demand with increasing PV share

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 CO₂ savings: 150,000 tonnes
- Commissioning in autumn 2011

Investors:
- EPC contractor: UTE

Source: RWE Innogy, F. Dinter
Continuous generation 24 h/d


Source: RWE Innogy, F. Dinter
Dispatchable generation

22.03.2012

Dispatchability test

Source: RWE Innogy, F. Dinter
Dispatchable generation

14.10.2012

CECOGE: Tech minimum request 14.10.2012

Source: RWE Innogy, F. Dinter
Dispatchable generation

### Spain

- Site: Spain
- Annual DNI: 2164 kWh/m²
- Solar field aperture: 510120 m²
- Storage capacity: 940 MWh
- Net electricity output from solar: 146.9 GWh/a
- LCOE: 0.189 €/kWh

### Qatar

- Site: Qatar
- Annual DNI: 1582 kWh/m²
- Solar field aperture: 693240 m²
- Storage capacity: 940 MWh
- Net electricity output from solar: 146.7 GWh/a
- LCOE: 0.235 €/kWh

<table>
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<th>Spain</th>
<th>Qatar</th>
<th>Unit</th>
<th>relative</th>
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<td>1582</td>
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<td>Solar field aperture</td>
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<td>GWh/a</td>
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<td>LCOE</td>
<td>0.189</td>
<td>0.235</td>
<td>€/kWh</td>
<td>0.80</td>
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</tbody>
</table>

Source: DLR
Market

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

World CSP projects by status (MW)

- Announced: 4260 MW
- Planning: 2215 MW
- Development: 3482 MW
- Construction: 2642 MW
- Operation: 2758 MW

Source: CSP Today Global Tracker  www.csptoday.com/tracker
Market: Medium term generation to 2018

- OECD Americas
- Africa
- Non-OECD Europe
- OECD Asia Oceania
- OECD Europe
- Asia
- China
- Non-OECD Americas
- Middle East

MTRMR 2012
Trends / Challenges

Reasons for the Trend
1. Higher potential in cost reduction
2. More balanced yearly yield
Ivanpah (392 Mw, 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 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
Thank you for your attention