CSE Solar Thermal Conference

4th Feb 2016
Outline

Topics

• Indian DNI Characteristics
• Performance of CSP Technologies in India
• Addressing the Challenges for CSP in India
• CSP in India - Addressing the challenges
• CST in India - Controlling carbon emissions
CSP challenge in India
Indian DNI Characteristics

Solar Resource for CSP in India

Low Yearly Average DNI: 4.5 kWh/m²/day (vs. 7)

Typical DNI values: 400 to 700 W/m²

Effect of Monsoon: 2 very cloudy months

Few Location with good DNI
CSP challenge in India
Performance of CSP Technologies in India

CSP Performance in Indian conditions

Parabolic Trough and Central Tower
Modular technology proven against simulation models
Addressing the Challenges in India for CSP - 1

Cost / Value Challenge

*Cost Competitiveness*
- CSP - radically lower prices via hybridization
- Power Block cost are shared
- Make in India

*Create extra value*
- Thermal storage and dispatchablity
- Benefits of hybridization
### Potential for Hybridization of CSP with Coal - A

#### Solar Steam without Thermal Storage

<table>
<thead>
<tr>
<th>Re.</th>
<th>Injection Point</th>
<th>Energy of total steam (%)</th>
<th>Solar Steam %</th>
<th>Solar without thermal storage CUF%</th>
<th>Carbon Saving Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Steam Inlet of LP Feed Water Heaters and de-aerator</td>
<td>15%</td>
<td>100%</td>
<td>25%</td>
<td>3.75%</td>
</tr>
<tr>
<td>2</td>
<td>Steam Inlet of LP Steam Reheater</td>
<td>55%</td>
<td>70%</td>
<td>25%</td>
<td>9.6%</td>
</tr>
<tr>
<td>3</td>
<td>Steam Inlet of HP Superheater</td>
<td>70%</td>
<td>70%</td>
<td>25%</td>
<td>12.2%</td>
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</tbody>
</table>
# Potential for Hybridization of CSP with Coal - B

## Solar Steam with Thermal Storage

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<td>15%</td>
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<tr>
<td>2</td>
<td>Steam Inlet of LP Steam Reheater</td>
<td>55%</td>
<td>70%</td>
<td>60%</td>
<td>23%</td>
</tr>
<tr>
<td>3</td>
<td>Steam Inlet of HP Superheater</td>
<td>70%</td>
<td>70%</td>
<td>60%</td>
<td>29.4%</td>
</tr>
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</table>
Addressing the Challenges in India for CSP - 2

Performance in Low DNI environment

*Low DNI due to aerosols*
Use median DNI value for field design

*Higher Soiling*
Shorter cleaning cycle and efficient cleaning systems

*Cloud intermittent events*
High Inertia systems, storage
Hybridized, low inertial systems
CST for India – the challenges

Low prices of carbonaceous fuels - Coal

(Source: www.tradingeconomics.com / ICE)
CST for India – the challenges

Low prices of carbonaceous fuels - FO
CST for India – the way forward

Carbon offsets the only way

Harsh Reality – Coal and Oil prices are low and likely to go lower

Furnace Oil today is cheaper than bottled water

Carbon offset only way to promote CST / CSP (2 year payback possible with FO@Rs. 50)

Cogeneration of power and heat
Thank you