REGULATORY AND FINANCIAL INCENTIVES FOR SCALING UP CONCENTRATING SOLAR POWER

REDUCING THE COST OF CSP ELECTRICITY GENERATION IN INDIA

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www.worldbank.org/energy
The WBG mandate is to reduce poverty and promote sustainable economic growth.

Role in climate change:

- Mitigation: assist countries in transition to a low carbon economy
- Adaptation: assist countries to adapt to unavoidable climate change

The World Bank Group is composed of:

- **International Bank for Reconstruction and Development (IBRD) and International Development Agency (IDA)** – **World Bank** – policy development support, institutional capacity building, government-backed project finance and risk mitigation for new entrants

- **International Finance Corporation (IFC)** – private sector arm of WBG: Investment support for private sector project developers and manufacturers in development-focused projects

- **Multilateral Insurance Guarantee Agency (MIGA)** – political, investment and credit guarantees
Conventional financial instruments for energy sector programs

**Loans**
- Sovereign guaranteed LIBOR-based investment loans:
  - Development policy loans;
  - Sector investment (project) loans

**Guarantees**
- Partial Risk Guarantee:
  - Conditional; 100 % on principle;
  - Risks covered - devaluation, regulatory risks, contract breach, technology failure;
- Partial Credit Guarantee:
  - Unconditional; reducing the cost of borrowing;
- Combined Guarantees

**IFC Debt and Equity**
- Support of private sector investments by market-term financing
**Climate mitigation financing sources & instruments**

<table>
<thead>
<tr>
<th>Source</th>
<th>Activities</th>
</tr>
</thead>
</table>
| **Global Environmental Facility (GEF)** | • Grant financing requested by host governments  
• WB is implementing agency  
• Co-financing of policy implementation and pilot & demonstration of new technologies |
| **Clean Technology Fund (CTF)**  | • Co-financing of concessional donor loans requested by host governments  
• Promote scaled-up financing for demonstration, deployment and transfer of low-carbon technologies  
• Risk mitigation for new entrants |
| **Carbon Finance**            | • Enhancing viability of investments  
• WB-managed Kyoto Funds  
• Carbon Partnership Facility |
| **ESMAP – Energy Sector Management Assistance Program** | • Donors’ trust funds to support upstream policy and sector work in energy sector |
Public Sector Investment Example: Egypt Kureimat Integrated Solar Combined Cycle Project

- **Multi-lateral (WBG and/or GEF)**
  - Grant: $49.8m for solar component
  - IBRD project preparation, regulatory and policy support

- **Bilateral**
  - Japanese Bank for International Cooperation
  - Loan or grant

- **Recipient equity (Govt of AR Egypt)**
  - Through public utility or special purpose vehicle
  - Equity and management

For more details, please visit:
www.worldbank.org/energy
http://go.worldbank.org/ERF9QNT660
Financing from WBG (IBRD and IFC), CTF (up to $750 m), development agencies, Clean Development Mechanism, and private sector

Scale-up investment plan – about 1 GW at cost of $6-8 billion ($4 billion for generation, $2-4 for transmission)

Projects in Morocco, Algeria, Tunisia, Egypt, and Jordan presented recently at Tunis Conference on Oct 21 and 22

Cross-border transmission infrastructure included through projects in Jordan and Tunisia
South Africa CSP Program

- Financing a project of about $100 MW capacity to be built by the largest South African State Utility – ESKOM
- WB is assisting with the preparation of bidding documents for an EPC contract for ESKOM
- Financing from WB (about $200 ml), and CTF (up to $100 ml), AfDB (about $100), development agencies, Clean Development Mechanism, and ESKOM
India CSP Program

- Technical assistance through MNRE
  - Study of local capabilities to manufacture and supply components for development of concentrating solar thermal power plants (CST) in India (Phase I and Phase II);
  - Knowledge exchange, and learning international experience and best practices between international industries and Indian institutions and companies
  - Support to C-WET in compiling a solar resource database for the country
  - Assistance on design of technical specifications and tender evaluation criteria for CSP projects in India
Global World Bank CSP Program

ASSESSMENT OF COST REDUCTION STRATEGIES for CSP ELECTRICITY GENERATION IN INDIA
The purpose is to assess cost efficient and cost effective approaches to reduce Levelized Cost of Electricity (LCOE) for CSP plants in India.

Assumptions are key - used physical data inputs from US DOE database and actual incentives provided by GoI to solar projects.

Assessments are done for 1) parabolic trough & power tower; and b) wet and dry (air) cooling methods.

With scaling up of CSP in India, majority of future plants will be air-cooled – need to be accounted as an input for cost analysis.
Levelized Cost of Electricity

- Represents the cost of generating electricity for a particular plant or system
- Accounts for all accumulated costs of the plant over its lifecycle relative to the total energy produced over its lifecycle:

\[
LCOE = \frac{\text{Total Lifecycle Cost}}{\text{Total Lifecycle Energy Production}}
\]

- The best indicator to compare different technologies, plant sizes, and served markets (base load vs. peaking plants)
Assessment Methodology

Current Scenario – Parabolic Trough and Power Tower

LCOEs under current scenario using NREL’s Solar Advisory Model and DNI data for Jodhpur provided by US DOE

Sensitivity Analysis – Cost Impact on Developers

Impact of variations in DNI and local conditions on LCOE
Impact of different financial and regulatory incentives on LCOE
Impact of different technical eligibility criteria on LCOE

Sensitivity Analysis – Cost Impact for Government

Impact of regulatory/financial incentives and storage eligibility on government cost burden
# Main Financial and Regulatory Assumptions

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Analysis Period</strong></td>
<td>25 years</td>
</tr>
<tr>
<td><strong>Loan Term</strong></td>
<td>12 years</td>
</tr>
<tr>
<td><strong>Inflation Rate</strong></td>
<td>5.5%</td>
</tr>
<tr>
<td><strong>Loan Rate</strong></td>
<td>11.75%</td>
</tr>
<tr>
<td><strong>Real Discount Rate</strong></td>
<td>15%</td>
</tr>
<tr>
<td><strong>Debt Fraction</strong></td>
<td>70%</td>
</tr>
<tr>
<td><strong>Minimum Alternative Tax</strong></td>
<td>18.5%</td>
</tr>
<tr>
<td><strong>ROE</strong></td>
<td>19%</td>
</tr>
<tr>
<td><strong>Property Tax</strong></td>
<td>0%</td>
</tr>
<tr>
<td><strong>Min required IRR</strong></td>
<td>15%</td>
</tr>
<tr>
<td><strong>VAT+ Excise Duties</strong></td>
<td>5% on 100% of Direct Costs</td>
</tr>
<tr>
<td></td>
<td>Min required DSCR</td>
</tr>
<tr>
<td><strong>Depreciation Schedule</strong></td>
<td>7% first 10 years</td>
</tr>
<tr>
<td></td>
<td>EX Rs/US$</td>
</tr>
</tbody>
</table>
Current Scenario

![Bar chart showing comparison between Air-cooled and Wet-Cooled systems for Parabolic Trough and Power Tower technologies. The x-axis represents the technologies, and the y-axis represents the performance metrics. The chart includes the CERC FIT line.]

- Air-cooled: Parabolic Trough - Wet-Cooled: Power Tower

Legend:
- Blue: Parabolic Trough
- Red: Power Tower
DNI Sensitivity Analysis – Cost for Developers

25% decrease in DNI causes LCOE to increase by 25-35%

Current Scenario

- Parabolic Trough (Air-Cooled)

Lower DNI Scenario

- Power Tower (Air-Cooled)
Local Conditions Sensitivity Analysis – Cost for Developers

- Current Scenario
- Lower Labor Cost
- Provision of "Free" Land

- Parabolic Trough (Air-Cooled)
- Power Tower (Air-Cooled)

CERC FIT
Financial & Regulatory Incentives II
Cost Impact – Wet Cooling

- Longer Loan Term 20 years
- Concessional Financing lowers loan rate to 8%
- Higher D/E Ratio 75/25
- Accelerated Depreciation without FIT reduction
- GBIs at 1.0Rs/kWh granted
- All incentives combined

Parabolic Trough (Wet-Cooled)  Power Tower (Wet-Cooled)
Financial & Regulatory Incentives I
Cost Impact – Air Cooling

- Longer Loan Term 20 years
- Concessional Financing lowers loan rate to 8%
- Higher D/E Ratio 75/25
- Accelerated Depreciation without FIT reduction
- GBIs at 1.0Rs/kWh granted
- All incentives combined

- Parabolic Trough (Air-Cooled)
- Power Tower (Air-Cooled)
Technical Eligibility Sensitivity Analysis – Storage Cost Impact

Current Scenario: 3 hours of Thermal Storage
Parabolic Trough (Air-Cooled) 69.2% 16.9%
Power Tower (Air-Cooled) 35.2% -29.3%

Comparison:
- CERC FIT
  - 3 hours of Thermal Storage: -16.9%
  - 6 hours of Thermal Storage: -29.3%

Legend:
- Parabolic Trough (Air-Cooled)
- Power Tower (Air-Cooled)
Financial & Regulatory Incentives and Storage Eligibility – combined

Current Scenario w/ Financial & Regulatory Incentives and 6 hours of storage

Parabolic Trough (Air-Cooled) Power Tower (Air-Cooled)
### Sensitivity Analysis Parabolic Trough - Cost Impact for Government

<table>
<thead>
<tr>
<th>Incentive granted</th>
<th>Reduction in LCOE</th>
<th>Cost Effect</th>
<th>Cost Impact for 500 MW</th>
<th>US$ per -1% LCOE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current scenario + Concessional Financing</td>
<td>-9.5%</td>
<td>Cost of guarantees</td>
<td>Not quantifiable but likely to be very low</td>
<td>Not quantifiable but likely to be very low</td>
</tr>
<tr>
<td>Current scenario + Accelerated Depreciation</td>
<td>-6.5%</td>
<td>Lower tax revenues</td>
<td>$184 m</td>
<td>$28 m</td>
</tr>
<tr>
<td>Current scenario + GBIs at 1.0 Rs/kWh</td>
<td>-4.3%</td>
<td>Additional Expenditures</td>
<td>$464 m</td>
<td>$108 m</td>
</tr>
<tr>
<td>All three of the above</td>
<td>-20.3%</td>
<td>Lower tax revenues + cost of guarantees + expenditures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 hrs of Thermal Storage</td>
<td>-13.8%</td>
<td>Additional expenditures</td>
<td>$2,480 m</td>
<td>$180 m</td>
</tr>
</tbody>
</table>
## Sensitivity Analysis Power Tower - Cost Impact for Government

<table>
<thead>
<tr>
<th>Incentive granted</th>
<th>Reduction in LCOE</th>
<th>Cost Effect</th>
<th>Cost Impact for 500 MW</th>
<th>US$ per -1% LCOE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current scenario + Concessional Financing</td>
<td>-9.4%</td>
<td>Cost of guarantees</td>
<td>Not quantifiable but likely to be very low</td>
<td>Not quantifiable but likely to be very low</td>
</tr>
<tr>
<td>Current scenario + Accelerated Depreciation</td>
<td>-6.4%</td>
<td>Lower tax revenues</td>
<td>$ 148 m</td>
<td>$ 23 m</td>
</tr>
<tr>
<td>Current scenario + GBIs at 1.0 Rs/kWh</td>
<td>-5.1%</td>
<td>Additional Expenditures</td>
<td>$ 457 m</td>
<td>$ 90 m</td>
</tr>
<tr>
<td>All three of the above</td>
<td>-21.0%</td>
<td>Lower tax revenues + cost of guarantees + expenditures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 hrs of Thermal Storage</td>
<td>-29.3%</td>
<td>Additional expenditures</td>
<td>$ 3,151 m</td>
<td>$ 108 m</td>
</tr>
</tbody>
</table>
Conclusions

- DNI accuracy matters – LCOE is very sensitive to DNI changes
- LCOE much less sensitive to cost of labor and land
- Current LCOEs are too high to allow for cost recovery and meeting financing constraints
- Financial and regulatory incentives combined with payment for electricity generated through storage can lower LCOEs
- Allowing for storage is most effective but least cost-efficient way
- Concessional finance is still effective and likely to be cost-efficient
Thank You!

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