Dispatchable Solar Power: Perenjori Study

ASTRI Symposium, Brisbane
February 2015
Abengoa Solar

Perenjori Dispatchable Solar Thermal Project

Key Findings and Recommendations
## Abengoa Solar CSP plants in commercial operation

<table>
<thead>
<tr>
<th>Location</th>
<th>Plant</th>
<th>MW</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spain</td>
<td>Solnova 1,3,4</td>
<td>3x50</td>
<td>Trough</td>
</tr>
<tr>
<td></td>
<td>PS10</td>
<td>11</td>
<td>Tower</td>
</tr>
<tr>
<td></td>
<td>PS20</td>
<td>20</td>
<td>Tower</td>
</tr>
<tr>
<td></td>
<td>Ecija Solar Complex</td>
<td>100</td>
<td>Trough</td>
</tr>
<tr>
<td></td>
<td>Carpio Solar Complex</td>
<td>100</td>
<td>Trough</td>
</tr>
<tr>
<td></td>
<td>Extremadura Solar Complex</td>
<td>200</td>
<td>Trough</td>
</tr>
<tr>
<td></td>
<td>Castilla-La Mancha Solar Complex</td>
<td>100</td>
<td>Trough</td>
</tr>
<tr>
<td>Algeria</td>
<td>ISCC Hassi R'mel, Algeria</td>
<td>150</td>
<td>ISCC</td>
</tr>
<tr>
<td>Abu Dhabi</td>
<td>Shams-1</td>
<td>100</td>
<td>ISCC</td>
</tr>
<tr>
<td>USA</td>
<td>Solana, Arizona</td>
<td>280</td>
<td>Trough</td>
</tr>
<tr>
<td></td>
<td>Mojave, California</td>
<td>280</td>
<td>Trough</td>
</tr>
</tbody>
</table>

**Total CSP in operation** 1,491

## PV Plants in operation

<table>
<thead>
<tr>
<th>Location</th>
<th>Plant</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spain</td>
<td>Sevilla PV</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>Casaquemada PV</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td>Las Cabezas PV</td>
<td>5.7</td>
</tr>
<tr>
<td></td>
<td>Copero PV</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Linares PV</td>
<td>1.9</td>
</tr>
</tbody>
</table>

**Total PV in operation** 11.7
## Abengoa Solar CSP Plants in construction & pre-construction

### Abengoa Solar CSP Plants in construction

<table>
<thead>
<tr>
<th>Country</th>
<th>Plant Description</th>
<th>MW</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>Khi Solar One</td>
<td>50</td>
<td>Tower</td>
</tr>
<tr>
<td></td>
<td>Kaxu Solar One</td>
<td>100</td>
<td>Trough</td>
</tr>
<tr>
<td>Chile</td>
<td>Project in Atacama Desert</td>
<td>110</td>
<td>Tower</td>
</tr>
</tbody>
</table>

**Total in construction**: 260

### Abengoa Solar CSP Plants in pre-construction

<table>
<thead>
<tr>
<th>Country</th>
<th>Plant Description</th>
<th>MW</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>Xina Solar One</td>
<td>100</td>
<td>Trough</td>
</tr>
<tr>
<td>Israel</td>
<td>Project in Ashalim of Negev Desert</td>
<td>110</td>
<td>Trough</td>
</tr>
</tbody>
</table>

**Total in pre-construction**: 210
Technology as a competitive advantage for Abengoa

- +150 in-house researchers
- R&D center in Denver, CO
- R&D center in Seville, Spain
- Abengoa Research
- Collaboration with key research institutions and companies worldwide
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Perenjori Dispatchable Solar Thermal Project

Key Findings and Recommendations
Perenjori Dispatchable Solar Thermal Power Plant

- 20 MW net capacity
- 7 hours molten salt storage
- ca. 230,000 m² heliostat field
- ca. 92 GWh production per yr
- 24 - 30 month construction period
- 25 year operation period
The Challenge

- **Replicability**
  Potential for the widest possible replicability and relevant learnings for future CSP project applications.

- **Plant Capacity**
  Logical minimum capacity for a CSP plant to minimize requirement for Government support whilst maintaining relevance for future development.

- **Dispatchability**
  The Project should include a thermal energy storage (TES) system which will allow the CSP plant to generate electricity when needed, and to provide the benefits of firm capacity to the local transmission network.

- **Pathway to Cost Reduction**
  Select state-of-the-art technology which offers the highest potential for cost reduction of the three compared technologies: parabolic trough, linear fresnel and tower.
**Perenjori Dispatchable Solar Thermal Power Plant**

- **ARENA**
  - Funding support for Perenjori project preparation activities / feasibility study

- **The Project Partners**
  - Abengoa Solar Power Australia
  - Abengoa Solar, SA
  - CSIRO
  - WestGen / National Power
  - Institute for Sustainable Futures (UTS)
The Technology

Molten salt tower overview

- Provides dispatchable renewable energy.
- Offers unique flexibility since the energy collection and energy delivery processes are decoupled.
- Energy is collected when the sun is shining, but only converted into electricity when it is demanded.
- No round-trip losses associated with storing the energy for later use.
- Higher temperature increases efficiency and reduces storage costs.
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Perenjori Dispatchable Solar Thermal Project

Key Findings and Recommendations
Rationale for Site Selection

- Ideal site for the proposed plant, including world class direct solar irradiation;
- Fringe of grid connection will provide significant network benefits;
- Proposed off-take arrangements include a combination of electricity retailers and a large iron ore mining operation;
- WA Government and local community are supportive of such activity;
- Strong demand for peak and especially shoulder generation;
- Excellent prospects for further roll-out of solar thermal power generation with storage in end of grid and off-grid applications, with an emphasis on powering the mining sector.
Perenjori Dispatchable Solar Thermal Power Plant

What did the feasibility study test?

- Solar radiation resource
- CSIRO heliostat design compared with Abengoa
- Optimum storage capacity
- Socio-economic, environmental and network benefits
- Cost to install a CSP plant in a remote area of Australia
- Pathway to cost reduction
- Feasibility of implementing the project
What were our findings?

- World class DNI
- Abengoa heliostat design has commercial maturity, CSIRO design has optical benefits
- Storage capacity increased from 3 to 6 and finally 7 full load hours
- Lack of awareness by grid operator of characteristics / benefits of CSP with storage
- Cost to install a CSP plant in a remote area of Australia
- Pathway to cost reduction – project learnings, pipeline, supply chain, and increased capacity lead to competitive LCOE
- Potential to be a feasible project
What are our recommendations to reduce costs?

- Create a baseline - build the first project
- Encourage market demand (through combination of RET, and ARENA/Government programmes)
- Facilitate a pipeline of projects to create a local supply chain; local technical, project and financial expertise; leading to lower costs
- Increase plant scale from 20MW to 100MW+
- Focus on value creation as well as reduced cost
Thank You!

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