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Topic: Agua Prieta II. Integrated Solar Combined Cycle
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- What is an ISCC plant?
- Advantages of an ISCC plant
- Agua Prieta II, ISCC project (solar field details)
- Experience of Abengoa in thermosolar power plants
Agua Prieta II. Case study

- Owner: Comisión Federal de Electricidad (CFE)
- Financial scheme: Financed Public Work (OPF) + GEF* subvention
- Equipment arrangement: 2 - 2 - 1 + 26 loops thermosolar field = 14 MWe
- Project stages:
  1. Gas turbines → supplied by CFE
  2. Combined Cycle integration → Sener/Elecnor
  3. Solar field supply/construction → Abengoa

*GEF: Global Environmental Facility
Thermosolar technologies for ISCC integration

Tower technology

Parabolic trough
What is an ISCC plant?

Conventional Combine Cycle (CC)

Solar field

Agua Prieta is a hybrid plant (solar + gas)
Advantages of an ISCC plant

1. Heat Rate (HR) improvement

High radiation time during the day can decrease Heat Rate.
Advantages of an ISCC plant

2. No reduction of capacity at sun peak hours

Solar field during the day minimize effect of high temperatures in Capacity
Advantages of an ISCC plant

3. Greenhouse effect reduction
   • Due to extra capacity obtained with no extra fuel burning.

4. Proven technology
   • Parabolic trough is applied commercially since early ‘80.
   • Agua Prieta project, as the first thermosolar plant in Mexico, will allow to implement more projects in the country, due to the fact Mexican northern border is located precisely in the sun belt area.
Agua Prieta II, ISCC project – Solar Field details

- **Technology**: ISCC (Integrated Solar Combined Cycle)
- **Capacity**: 14 MWe (12 MWe according to requirements + 2 MWe extra)
- **Solar field technology**: Parabolic trough
- **HTF System**: Thermal oil, volume of 277 tm
- **Area**:
  - Solar field area: 60 ha
  - Reflective aperture area: 85,000 m²
- **Loops**:
  - Total number of loops: 26
  - Number of collectors per loop: 4
  - Collector length: 150 m
- **Steam production**: 86 t/h saturated
  @ 130 bar, 330 ºC
- **An additional natural gas duct–burner is included in CC to allow a similar production of 14 MWe (SF capacity) when solar field is not in operation.**
- **Extreme design environmental conditions**:
  - Wind speed 175 km/h
  - Minimum design temperature -20º C
Agua Prieta II, ISCC project - Critical dates

- Gas turbines
  - Purchase awarding: January 6th, 2010
  - Delivery: April (1st gas turbine) - May (2nd gas turbine), 2012
- Combined Cycle
  - Contract starting date: August 26th, 2010
  - Commercial Operation Date: April 1st, 2013
- Solar field
  - Contract starting date: July 28th, 2011
  - Commercial Operation Date: April 6th, 2013

Less than 22 months for Agua Prieta solar field construction period
Agua Prieta II, ISCC project - GEF subventions

• 200 MM USD to four countries:
  – Morocco ($50 MM) → In commercial operation
  – Mexico ($50 MM) → Under construction
  – Egypt ($50 MM) → CC and solar field completed.
  – India ($50 MM) → No gas available. In standby

• GEF conditions: to be invested in proven CSP hybrid technology. This is ISCC

Agua Prieta solar field is included into GEF’s subvention program
Agua Prieta II, ISCC project

Main disturbances between solar field and CC when are designed – constructed by different EPC constructors

- Operation modes and integration between solar field and CC
- Battery limits interconnection into CC: Piping and cable routing integration avoiding interferences between solar field - HTF and CC
- Material specifications and design conditions can be different in battery limits between solar field - HTF and CC
- Where to send steam produced in solar field during start-up period till getting nominal conditions with CC in operation
- Where to send steam produced in solar field during shutdown periods
- High risk with changes in critical load electrical list to preserve reserve feeding in electrical cabins, UPS and emergency diesel from CC.
- Definition and supplying consumptions of compressed air and fire water from CC and solar field.
- If both parts are completely independent in terms of consumptions feeding, etc., installation is not optimized and is more expensive
Agua Prieta II, ISCC project

Recommendation for owners in ISCC approach

Unique EPC integrating both parts, CC and HTF-solar field, avoiding division in two EPC contracts

- Make easy integration in process level (key for ISCC)
- Remove interferences and coordination problems
- Avoid misunderstandings with different design conditions in battery limits for same systems
- Concentrate design, construction and guarantees responsibility in only one EPC
## Agua Prieta II, ISCC project

Technology cost comparison

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Project</th>
<th>MM USD / MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 MW</td>
<td>Agua Prieta Solar Field</td>
<td>3.3</td>
</tr>
<tr>
<td>400 MW</td>
<td>Agua Prieta II Combined Cycle</td>
<td>1.01</td>
</tr>
<tr>
<td>400 MW</td>
<td>Salamanca Cogeneration</td>
<td>0.75</td>
</tr>
<tr>
<td>300 MW</td>
<td>Nuevo Pemex Cogeneration</td>
<td>1.53</td>
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<tr>
<td>42 MW</td>
<td>Baja California Sur IV. Internal combustion engine</td>
<td>2.2</td>
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</tbody>
</table>

No feed-in tariff is available in Mexico
Experience of Abengoa in ISCC

- Abengoa has developed the two first ISCC power plants worldwide and both are already in commercial operation

Ain Beni Mathar (470 MW)
- The world’s first commercial ISCC power plant
- 450 MW (CC) + 25 MW (solar field)
- Parabolic trough solar field of 45 acres
- Ain Beni Mathar (Morocco)
- In operation since 2010

Hassi R’Mel (150 MW)
- 130 MW (CC) + 25 MW (solar field)
- Parabolic trough solar field of 45 acres
- Hassi R’Mel (Algeria)
- In operation since 2011
### Experience of Abengoa in thermosolar power plants

<table>
<thead>
<tr>
<th>País</th>
<th>Proyecto</th>
<th>Tecnología</th>
<th>Potencia</th>
</tr>
</thead>
<tbody>
<tr>
<td>España</td>
<td>Solaben 1 &amp; 6</td>
<td>CCP</td>
<td>100 MW (50 MW x 2)</td>
</tr>
<tr>
<td>México</td>
<td>Agua Prieta II</td>
<td>ISCC</td>
<td>14 MW (campo solar) + 464 MW (CC)</td>
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<tr>
<td>Emiratos Árabes</td>
<td>Shams - 1</td>
<td>CCP</td>
<td>100 MW</td>
</tr>
<tr>
<td>EEUU</td>
<td>Solana</td>
<td>CCP + almacenamiento sales</td>
<td>280 MW</td>
</tr>
<tr>
<td></td>
<td>Mojave</td>
<td>CCP</td>
<td>280 MW</td>
</tr>
<tr>
<td>Sudáfrica</td>
<td>Khi Solar One</td>
<td>Torre</td>
<td>50 MW</td>
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<tr>
<td></td>
<td>KaXu Solar One</td>
<td>CCP + almacenamiento</td>
<td>100 MW</td>
</tr>
<tr>
<td>España</td>
<td>PS10</td>
<td>Torre</td>
<td>11 MW</td>
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<tr>
<td></td>
<td>PS20</td>
<td>Torre</td>
<td>20 MW</td>
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<tr>
<td></td>
<td>Solnova 1, 3 &amp; 4</td>
<td>CCP</td>
<td>150 MW (50 MW x 3)</td>
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<tr>
<td></td>
<td>Helioenergy 1 &amp; 2</td>
<td>CCP</td>
<td>100 MW (50 MW x 2)</td>
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<td>Solacor 1 &amp; 2</td>
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<td>Helios 1 &amp; 2</td>
<td>CCP</td>
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<td></td>
<td>Solaben 3 y 2</td>
<td>CCP</td>
<td>100 MW (50 MW x 2)</td>
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<td>Marruecos</td>
<td>Ain Beni Mathar</td>
<td>ISCC</td>
<td>20 MW (campo solar) + 450 MW (CC)</td>
</tr>
<tr>
<td>Argelia</td>
<td>Hassi R’Mel</td>
<td>ISCC</td>
<td>20 MW (campo solar) + 130 MW (CC)</td>
</tr>
<tr>
<td>India</td>
<td>IITB</td>
<td>CCP</td>
<td>1 MW</td>
</tr>
</tbody>
</table>

**Total:** 1,546 MW

**En construcción:** 924 MW

**En operación:** 622 MW
Thank you

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