Kimberlina CLFR
Solar Thermal Power Plant
Clean, Reliable Superheated Steam

Silicon Valley Photovoltaic Society
Table of Contents

- AREVA Solar
- AREVA’s solar steam generators
- Kimberlina overview
- Kimberlina performance
Cost-effective. Land-efficient.

AREVA SOLAR
Mission

- Develop and deploy solar energy technology to serve our customers’ global electricity and thermal energy needs in a dependable, market-competitive and environmentally responsible manner

Locations

- Headquarters – Mountain View, CA
- Manufacturing – Las Vegas, NV and Singleton, NSW, Australia
- Operations – Bakersfield, CA and Singleton, NSW, Australia
- Business development – Mountain View, CA; Phoenix, AZ; and Melbourne, Australia
Comprehensive solar solutions

 ► Offer comprehensive and fully integrated CSP solutions:
  ◆ Lowest cost and most land-efficient CSP technology
  ◆ Solar steam generators; offer turnkey solar solutions, including power block and balance of plant
  ◆ High-volume manufacturing and installation; scalable and modular
  ◆ Support services in project development and EPC
  ◆ Life-cycle services for long-term operations and maintenance
  ◆ AREVA brand and financial support, including performance guarantees backed by AREVA

 ► Provide breakthrough innovation to lower our customers’ cost of energy

Lowest cost, most land-efficient CSP technology
CLFR technology

- Compact Linear Fresnel Reflector (CLFR)
- Arrays of optically-shaped reflector mirrors
- Concentrate over 50 “suns” of energy
- Boiler tubes generate high pressure superheated steam
Application and Markets

- Enhanced oil recovery & refining
- Mining
- Chemical processing & refining
- Food processing
- Desalination

Customers
- Utilities
- IPPs

- Solar Steam Augmentation

- Industrial Processing

- Utilities
- IPPs

- Standalone Solar & Solar Hybrid Power Plants

AREVA SOLAR
AREVA Solar has the most mature CLFR design in operation

- Kimberlina Solar Power Station near Bakersfield, CA
- First new solar thermal plant in California in 20 years
- Demonstrated thermal performance with high availability
- Advanced product development facility: SSG4 being constructed to demonstrate 900F/450C steam production
Kogan Creek Power Station

What  Solar addition to existing 750 MW Kogan Creek Power Station under development in Queensland, Australia
Who   CS Energy and AREVA Solar
Capacity 44 MW peak (23 MW average) additional electrical output; this will equate to 40 gigawatt-hours of electricity per year.
Simple. Reliable. Carbon-free.
AREVA’S SOLAR STEAM GENERATORS
Key Product Attributes

- AREVA Solar Steam Generators (SSGs) use Concentrated Solar Power (CSP) to drive steam turbines or provide process steam.
- Each SSG is 1200’ long, 60’ high, 120’ wide.
- Each can produce up to 24,000 #/hour of saturated or superheated steam.
- Only solar boiler with ASME S-Stamp Certificate of Authorization and qualification from National Board of Boiler and Pressure Vessel Inspectors.
- SSG will not overheat, even with coincident failure of offsite power (feedwater and reflector drive) and backup power (reflector drive) at solar noon on the summer solstice.
- Durable designs of standard materials can be erected rapidly and deployed at scale.
- IBC/UBC structural design for Seismic Zone 4 and 90 mph wind.
Engineered for customer needs

<table>
<thead>
<tr>
<th>Solar Steam Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature</strong></td>
</tr>
<tr>
<td>Up to 750°F (400°C)</td>
</tr>
<tr>
<td>Up to 900°F (482°C)</td>
</tr>
<tr>
<td>available in 2011</td>
</tr>
<tr>
<td><strong>Pressure</strong></td>
</tr>
<tr>
<td>Up to 1,535 psia (106 bara)</td>
</tr>
<tr>
<td>Up to 2,400 psia (165 bara)</td>
</tr>
<tr>
<td>available in 2011</td>
</tr>
<tr>
<td><strong>Annual Energy per 5.3 Hectares (13 acres)</strong></td>
</tr>
<tr>
<td>88,500 MMBtu (25,950 MWh)</td>
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</tbody>
</table>

- Performance
- Constructability
- Reliability
- Scalability
- Operability
First and only solar boiler with ASME “S” Stamp

- American Society of Mechanical Engineers (ASME) Boiler & Pressure Vessel Code is internationally renowned for setting standards of excellence in safety and reliability
- AREVA Solar is the first and only ASME-certified solar boiler manufacturer
- An ASME “S” Stamp is considered the industry hallmark of acceptance and certification
- Recognized in more than 100 countries, including U.S. and Canada, as a means of meeting government safety regulations
- Also received the National Board Certificate of Authorization "NB" to register its solar boilers
CLFR advantages

- Most land-efficient solar technology; lowest cost CSP technology
- Lower land and grading costs and ongoing O&M costs; less time-intensive permitting
- Easier access to contiguous, flat land; can be built on sloping sites (<3% grade)
- Reduced environmental impact (no oil containments), lower view shed impact
- Simple erection, operation and maintenance; less time-intensive permitting
- Scalable by adding solar steam generators; greater ability to site at existing power plants and industrial sites
Modular, scalable deployment

► SSG is the building block
► Each SSG contains one receiver with boiler tubes
► Receiver heated by reflector rows in segments
► Segments comprised of factory assembled reflectors and drives
Field assembly from factory components

- Height ~ 60 ft
- Width ~ 120 ft
- 13 Reflectors
- Downward facing receiver cavity supports boiler tubes
- 25 towers support 1200 ft long receiver
- Install on <3% grade in both E-W and N-S directions
Rapid field erection

- Minimal grading required (3% grade acceptable)
- Simple pier foundations (100 per SSG)
- Structural Steel placement and tower lift
- Receiver (boiler tube and housing) assembled at grade, hoisted, hydrostatically tested and stamped
- Assemble reflectors on beams and connect drive
Code compliant design

- ASME Boiler & Pressure Vessel Code

- ASME B31.1 Power Piping Code

- Structural Codes
  - Uniform building code
  - International building code

- Authorized inspector
  - Hartford Steam Boiler Insurance Co.
Boiler Safety

- Boiler Trips rotate reflected light away from receiver
  - High exit pressure
  - High exit temperature
- UPS back-up for reflector drive power
- Passive thermal protection protects against concurrent loss of
  - Feedwater
  - AC mains
  - UPS backup

Worst Case:
- Summer Solstice Solar Noon
- Boiler is completely hot and dry
Kimberlina Facts

- Operates as standalone power plant with 5MWe STG connected to grid
- Flexible development facility to advance technology
- Three solar steam generators (SSGs) operate in parallel
  - SSG 1 and 2 saturated
  - SSG3 saturated or superheated
- 4th SSG dedicated to superheat under construction
- Critical components made at AREVA Solar Las Vegas, NV plant
  - Reflector assemblies
  - Coated boiler tubes
- Outstanding operating record with high availability
# Kimberlina SSG Design Evolution

<table>
<thead>
<tr>
<th>SSG</th>
<th>1, 2, 3</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam Generation</td>
<td>Recirc 3:1</td>
<td>Once Thru</td>
<td>Once Thru</td>
</tr>
<tr>
<td>Maximum Allowable Working Pressure (psia)</td>
<td>1335</td>
<td>1010</td>
<td>1535</td>
</tr>
<tr>
<td>Max Mean Wall Temperature (deg F)</td>
<td>562</td>
<td>750</td>
<td>900</td>
</tr>
<tr>
<td>Heating Surface (ft(^2))</td>
<td>2,540</td>
<td>2540</td>
<td>2260</td>
</tr>
<tr>
<td>Reflector Surface (ft(^2))</td>
<td>93,243</td>
<td>93,243</td>
<td>121,216</td>
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<tr>
<td>Maximum Heat Input (MMBtu/hr)</td>
<td>19.2</td>
<td>19.2</td>
<td>25.0</td>
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2009 Kimberlina operating experience

► Confirmed optical and heat loss models Spring 2009
► 100% availability; June – October; no forced outages
► Conducted superheat operations to demonstrate controllability

High fidelity thermal input model

Conservative heat loss model

March 30, 2009
Stable superheat delivered through clouds

Demonstration trials conducted 29 October 2009
Simple, reliable, robust
Superheated steam at pressure and temperatures that customers want
High-volume manufacturing and installation; scalable and modular
ASME Section I design
AREVA’s commitment to customers world-wide

Lowest cost, most land-efficient CSP technology
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