Parabolic Trough Power for the California Competitive Market

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Restructuring of California Power Market

• March 31, 1998 – California Deregulates Power Market
• California Independent System Operator (CAISO)
• California Power Exchange Opens (CalPX)
• Investor Owned Utilities
  – IOUs Sell Generation Assets
  – Purchase & sell power through CalPX
  – Renewables (QFs) on must take contracts
• Consumer Retail Rates Frozen
California Market 1998 & 1999

• Good hydro resource
• Low cost natural gas
• Low cost electricity
• Utilities control most generation

⇒ Electricity Prices 2-3¢/kWh
1999 Cal PX Day Ahead Pricing

![Graph showing price vs. CalPX System Load (GWe)]
California Market 2000

- Reduced hydro resource
- Utility generation sold to non-utility generators
- Natural gas supply limitations & increasing prices
- Caps on CalPX pricing
2000 Cal PX Day Ahead Pricing
Resulting Impacts

- Transfer of utility generation assets
  - Commercial decisions used to decide when and where to sell power
- Price Caps
  - Natural gas prices too high for generators to make profit in CalPX market
  - Generators sell power outside CA
  - Generators sell power to CAISO outside of CalPX
- Utilities
  - Utilities forced to pay more for electricity than they can charge
  - Utilities stop paying for QF and CalPX generation
Re-Restructuring of California Power Market

- January 2001 – CalPX Closes
- California Department of Water Resource
  - Purchases power for CAISO
- CAISO Balances load with out of market purchases
# CalPX Market Clearing Prices

<table>
<thead>
<tr>
<th></th>
<th>1999 ( $ /kWh )</th>
<th>1999 % Inc</th>
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<tbody>
<tr>
<td>Average Price</td>
<td>2.83</td>
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<td>Price For Solar</td>
<td>3.32</td>
<td>17%</td>
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<td>8%</td>
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<td>14.31</td>
<td>29%</td>
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</table>
California 2000 Peak Day Resource Summary

Wednesday, August 16, 2000

Data from California ISO
California 1999 Average Hourly System Load

![Graph showing the average hourly system load for California in 1999 for August (Aug), December (Dec), and April (Apr)]
Solar Output for 3 Solar Plant Configurations
Compared to CalPX System Load (July 1, 1999)
Solar Output for 3 Solar Plant Configurations
Compared to CalPX System Load (July 1, 1999)

% Capacity During Hour

Peak Load Hour (Decending)

Solar w/o Storage
Solar w/Storage
2x Solar w/Storage
Wind Generation Duration Curve for 2000
[Peak Hours Only]

Maximum Generating Capacity: 1876 MW

Data from California ISO
### Meeting Peak Hour Demand

<table>
<thead>
<tr>
<th>Source</th>
<th>Capacity Factor</th>
</tr>
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<tbody>
<tr>
<td>Wind</td>
<td>25%</td>
</tr>
<tr>
<td>Solar w/o Storage</td>
<td>36%</td>
</tr>
<tr>
<td>Solar w/ Storage</td>
<td>87%</td>
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<tr>
<td>2x Solar w Storage</td>
<td>102%</td>
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</table>
Wholesale Electric Price for Modern Combined Cycle Plant

CEC Assumptions: Heat rate = 6800 Btu/kWh, Cap = $100/kW/yr, O&M = $2.5/MWh
Wholesale Electric Price
Combined Cycle Verses Trough Solar Plant

100 MWe Trough Plant, Solar Multiple 1.6, 4 Hours Thermal Storage

- $2/MBtu
- $4/MBtu
- $7/MBtu
- $10/MBtu
- $15/MBtu

- Single Plant
- Power Park with Incentives

Power Plant Annual Load Factor

Generation Cost (¢/kWh)