Integrating CSP w/ TES into a Utility System

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General Manager
Resource Management

April 25, 2013
Outline

- Background on APS
- History of Solana
- Value of CSP
- Challenges and Resource Outlook
Largest utility in Arizona
- 1.1 million customer accounts
- 34,646 square miles

Scope of Energy Delivery
- 28,000 distribution miles
- 5,300 transmission miles
- 410 substations

Resources
- 8,600 MW total capacity
- Peak demand – 7,300 MW
- Over 1,000 MWs of renewables owned or in development
Regulatory Commitments

Arizona’s Renewable Energy Standard (RES)
- 15% of retail sales by 2025
  - 4.0% in 2013, increasing one half-percent annually to 5% in 2015
  - DE Requirement is 30% (of total)

2009 APS Rate Case Settlement Agreement
- Requires an additional 1.7 GWHs above 2008 contracts
- Represents approximately 3.4 GWHs by 2015
- Projected to be >10% of retail sales by 2015

APS is on-track to meet these targets
Projected 2013 Energy Mix

- Coal: 38.4%
- Nuclear: 29.3%
- Natural Gas: 21.7%
- Renewable: 5.7%
- Energy Efficiency: 5.0%
Five Major Categories of Resources

**Nuclear**
- Palo Verde

- Reliable source of carbon-free around-the-clock power
- Lowest operating cost

**Coal**
- Four Corners
- Cholla
- Navajo

- Affordable source of around-the-clock power
- Relatively expensive and time consuming to start/stop

**Natural Gas Intermediate Units**
- Redhawk, Gila, Arlington
- West Phoenix Units 1-5
- Saguaro and Ocotillo Steamers

- Large, high efficiency units
- Long start-up, required minimum up and down times
- Reliable and flexible to system demands

**Natural Gas Peaking Units**
- Sundance
- Yucca
- West Phoenix, Saguaro, and Ocotillo GTs

- Small, less efficient units
- Short start-up, can be online in 10-30 minutes
- Very flexible

**Renewables**
- Wind
- Solar
- Geothermal/Biomass

- Clean source of energy
- Most sources are non-dispatchable (must take energy as it is produced)

- 1,146 MWs
- 1,753 MWs
- 3,371 MWs
- 1,017 MWs
- 475 MWs
APS Renewable Generation

### Generating Facility Capacity COD
1. CE Turbo  
   Capacity: 12  
   COD: 01/27/06
2. Aragonne  
   Capacity: 90  
   COD: 12/29/06
3. Snowflake  
   Capacity: 14  
   COD: 06/10/08
4. High Lonesome  
   Capacity: 100  
   COD: 07/16/09
5. Glendale Energy  
   Capacity: 2.86  
   COD: 01/13/10
6. Ajo  
   Capacity: 4.5  
   COD: 09/26/11
7. Prescott  
   Capacity: 10  
   COD: 11/29/11
8. Bagdad  
   Capacity: 15  
   COD: 12/30/11
9. Perrin Ranch  
   Capacity: 99  
   COD: 06/24/12
10. Waste Management  
    Capacity: 3.2  
    COD: 08/31/12
11. Saddle Mtn 1 Solar  
    Capacity: 15  
    COD: 12/20/12
12. Solana  
    Capacity: 250  
    Status: UC  
    Anticipated COD: 07/23/13
13. Paloma  
    Capacity: 17  
    COD: 09/12/11
14. Cotton Center  
    Capacity: 17  
    COD: 10/24/11
15. Hyder  
    Capacity: 16  
    COD: 10/31/11
16. Chino Valley  
    Capacity: 19  
    COD: 11/25/12

### Operating Plants

#### Generating Facility Capacity Status Anticipated COD
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    Capacity: 19  
    Status: UC  
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## Renewable Resource Summary

### Renewable Resources by Type (by end of 2014):

<table>
<thead>
<tr>
<th>Resource Type</th>
<th>MWs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>289</td>
</tr>
<tr>
<td>Geo./Biomass/LFG</td>
<td>32</td>
</tr>
<tr>
<td>Solar PV</td>
<td>225</td>
</tr>
<tr>
<td>Solar CSP/TES</td>
<td>250</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>796</strong></td>
</tr>
</tbody>
</table>

Note – does not include Distributed Energy (DE) which is currently over 200 MWs
History of Solana

- APS Selected Solana via a competitive solicitation process
  - 2007 Renewable Resource RFP
  - Solana was not the lowest LCOE resource
  - Selected because it provided a favorable overall value proposition for our customers
  - APS entered into a 30 year PPA to purchase all of Solana’s energy production
Solana (Solar Trough with Storage)

Developer - Abengoa

Location – 10 miles west of Gila Bend, AZ

Total Generation – 250 MW ~ about 900,000 MWHs energy production per year (approximately 3% of APS overall energy requirements)

Size – 3 square miles

Construction – Scheduled completion date of Summer, 2013

Thermal Energy Storage – Includes 6 hours of thermal energy storage
Environmental Benefits

- Zero Emissions
  - 475,000 tons annually of carbon dioxide
  - 520 tons annually of sulfur dioxide
  - 1,065 tons annually of nitrogen oxides
- Equivalent to taking half the cars off US 60 every day
- 75% Less water than current agricultural use
Value of CSP

Diversification in Several Dimensions
- Technology (PV, CSP w/storage, wind, biomass, geothermal)
- Balanced resource portfolio mix
- Ownership vs. PPA
- Capability to integrate smaller scale projects
- Geographic diversity

What Provides the Best Value for our Customers?
- Cost
- Energy production pattern
- Capacity value (contribution to meeting peak load)
- Impact on system regulation
- Solar PV and diminishing returns
Value of Solar PV Declines as Deployment Levels Increase

Expected Penetration in 2025
APS Solar Production on Peak Day 2012

Illustration of declining capacity value

Actual solar production and load data

Six operating solar plants
  • Five plants SAT
  • One plant fixed position, south facing

Peak day, August 8, 2012

<table>
<thead>
<tr>
<th>Facility</th>
<th>Peak</th>
<th>Coincident</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Prescott</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>2) Bagdad</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>3) Ajo</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>AZ Sun</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) Cotton Center</td>
<td>18</td>
<td>14</td>
</tr>
<tr>
<td>5) Paloma</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td>6) Hyder I</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>78</td>
<td>60</td>
</tr>
</tbody>
</table>
Solar Output on APS System Peak Day
(August 8, 2012)
APS System Load Profile With 78 MW Solar PV

- Solar Output
- APS System Load

APS System Load Profile with 78 MW Solar PV showing load and solar output over 24 hours.
APS System Load Profile With 200 MW Solar PV

- Solar Output
- APS System Load
- Solar System Load with 200 MW Solar

Graph shows the APS System Load with and without 200 MW Solar PV output.
APS System Load Profile With 500 MW Solar PV
APS System Load Profile With 1,500 MW Solar PV

- Solar Output
- APS System Load
- APS System Load with 1500 MW Solar
- at 78 MW Solar
- at 200 MW Solar
- at 500 MW Solar
- at 800 MW Solar
- 550 MW
Solar PV Deployment Impacts System Ops

- Higher penetration of solar creates two daily peaks for gas units
  - Multiple gas unit starts per day
- Natural gas units will need to quickly ramp up and down to respond to peaks
Challenges for APS

 Integrating Solana into our System Operations

- Solana is a unique resource
- APS has not had energy storage
- Adds complexity to our optimization decisions
- Operators will need to become familiar with all aspects of Solana to optimize the dispatch
  - Technical aspects of Solana operations
  - Impact of weather variations
  - Contractual terms
- Good communications are critical

 Integration of Variable Energy Resources (VERs)

- Good diversity of resource type so far (mix of wind, solar PV, solar CSP, etc.)
- Has been manageable
- Investigating additional tools like EIM, intra-hour markets, ACE diversity
- Need to improve solar forecasting (utility-scale and behind-the-meter)
APS Resource Outlook

- **Renewable resource needs**
  - Have/will satisfy near-term targets
  - Will not require additional renewable resources (to meet state standard) for several years

- **Major uncertainties in our resource outlook**
  - Coal units may require significant upgrades for environmental compliance
  - Customer contingent resources dependent upon customer willingness to participate
    - EE standard of 20% by 2020
    - DE is 30% of our renewable requirement
Benefits of Solar CSP with TES

- **Solana – Meeting our Customer’s Energy Needs**
  - Full capacity contribution during peak load times
    - Note – no natural gas co-firing
  - Dispatchability to help meet dual-peaks in winter months
  - A stable and dependable source of utility electric generation

- **Solar CSP Deployment – Keys to Success**
  - Stakeholders must appreciate the value proposition of CSP
  - CSP (and competing renewable technologies) must be valued correctly in terms of:
    - Capacity contribution
    - Flexibility
    - Intermittency
  - Lowest LCOE does not necessarily lead to lowest overall cost to customers
Thank You