Yakout Mansour
President & CEO
California ISO

September 18, 2009
Who is the California ISO?

- Began operations in 1998 - Not for Profit
- Controls 80% of the State grid
- Federally Regulated
- Responsibilities:
  - Reliability
  - Market Development
  - Market Operations
  - Market Monitoring
  - Grid Planning
- Resources:
  - 55,000 MW In-state Generation
  - 10,000 MW Imports
- Peak Demand of the ISO Footprint:
  - 51,000 MW (2006)
  - Total State peak is about 60,000 MW
Reliability Management – EMS

- Load Forecasting
- Network Model
  - 6,000 buses
  - 1,800 generators
  - 3,200 load points
  - 8,000 circuits
  - 35,000 switching devices
  - 1,200 shunt compensators
- State Estimator
  - Every minute based on 17,000 measurements
Reliability Management – EMS (con’t)

- Real Time Contingency Analysis
  - 700 potential scenarios
- Security Assessment
- Wide-Area Phasor Measurements
- Visualization – Google Earth
Market Operation

- 15,000 Market Transactions every hour
  - 100 participating entities
- Day-Ahead Market – Integrated Forward Market
- Hour-Ahead Market
- Market Power Mitigation & Reliability Requirement
- Residual Unit Commitment
- Real Time Unit Commitment
Market Operation – (con’t)

- Real Time Economic Dispatch
- Real Time Contingency Dispatch
- Real Time Manual Dispatch
- Congestion Revenue Rights
- Long Start Unit
33% of Energy Supply from Renewable Resources by 2020

20% of Energy Supply Renewable By 2010

CO2 Emission Level Rolled Back to 1990 Level by 2020

One Million Roof-Top Photo-Voltaic

Ban Once-through Cooling Technology on all Coastal Plants by 20xx

Storage

Accommodating the Climate Change Initiatives
What is necessary to integrate 20% renewable generation?

- We have published engineering studies on how to integrate renewable generation to meet the 20% RPS.

- Intermittency and timing of renewable resources create operational challenges.
  - Morning and evening ramp will increase 20-30%.
  - Potential wind forecast errors will drive the need for increased regulation capacity (as much as 500 MW) and a much deeper supplemental energy stack.
  - Over-generation will occur during certain hours but can be mitigated by minimal curtailment.

- Needed integration services can be provided by:
  - Hydro, IF there is enough water.
  - New thermal, IF it has the right characteristics.
  - Existing thermal, IF it is kept operating at certain levels (but could defeat the purpose).
What is necessary to integrate 20% renewable generation? (Con’t)

- Other mitigation measures are also necessary:
  - Advanced demand response
  - Curtailment mechanisms
  - Improved technology
  - Better forecasting tools
  - Storage

- Maintaining existing generation is essential (although replacement or re-powering can work).
What does it take to integrate a higher RPS in California?

“Out of the Box” on all fronts!

<table>
<thead>
<tr>
<th>Case</th>
<th>GWh</th>
<th>Avg. Mw</th>
<th>Nameplate Mw</th>
</tr>
</thead>
<tbody>
<tr>
<td>20% RPS (2010)</td>
<td>55,657</td>
<td>6,353</td>
<td>13,614</td>
</tr>
<tr>
<td>33% RPS (2020)</td>
<td>102,000</td>
<td>11,600</td>
<td>29,000</td>
</tr>
</tbody>
</table>

- Achieving 33% requires us to meet two times load growth with renewables between now and 2020.
- The increase in need for capacity, ramping, and regulation to achieve 33% RPS is not linear – it is much greater.
- 5-7 major transmission projects.
- Regional diversification is important technically and economically.
- Key questions are:
  - How much “in the box” thinking is still viable?
  - Can we retain and invest in more non base-load facilities?
  - Does retirement or replacement make sense?
Wind Production on Peak Heat Days

You have to go a very long distance to get diversity!

CAISO Wind Generation
Hot Day

Total Wind Generation Installed Capacity = 2,648 MW

Wind Generation at Peak

MW

07/16/06 07/17/06 07/18/06 07/19/06 07/20/06 07/21/06 07/22/06 07/23/06 07/24/06 07/25/06 07/26/06

0 200 400 600 800 1,000 1,200

Wind Generation
Wind Generation at Peak
Towards RPS – Green Energy

The capacity element and the crown prince (storage)!

<table>
<thead>
<tr>
<th>Capacity Element</th>
<th>Wind</th>
<th>Solar PV (non-DG)</th>
<th>Solar Thermal</th>
<th>Geothermal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capacity Value</strong></td>
<td>15-30% prior CPUC</td>
<td>Approx. 3-8% new CPUC</td>
<td>65%</td>
<td>71-80%</td>
</tr>
<tr>
<td><strong>Capacity Factors</strong></td>
<td>18-20% historical</td>
<td>&lt;30% new turbines</td>
<td>18-24%</td>
<td>20-28%</td>
</tr>
</tbody>
</table>
Tehachapi Wind Generation with 100 MW Storage
The Future – The Grid

- The Smarter Grid
  - IT
  - Telecom
  - Power Equipment
  - Demand Side

- The Greener Grid
Achieving Statewide 1990 Level Emissions by 2020 (CA Assembly Bill 32)

Target

Enabler

Source: CARB Emissions Inventory, updated Nov. 2007
Into the Future

Electricity Sector Emission Reductions Potential Compared to Historic Electricity Sector Emissions

- Total CO2e (MMT)
- 33% renewable energy
- 3,000 MW rooftop solar PV
- "High goals" energy efficiency
- "High case" combined heat and power
- Natural gas only build-out
- 1990 emissions level

- Gas Build-out
- Reference Case
- Accelerated Policy Case

Source: Energy & Environment Economics, Inc. (E3)
Into the Future - The Demand

- Smart Homes
- Smart Appliances
- Electrification of the Transportation
- Electrification of Industrial Processes
- Conservation
- Distributed Generation
Into the Future - The Education

- The largest vital single element
- We are all students before becoming teachers
- Inspiring the new and older generations
- The ISO Academy
- The ISO Sabbatical