California’s Evolving Energy Market

Harvard Electricity Policy Group – Seventy-First Plenary Session
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Vice President Market & Infrastructure Development
California ISO
California Market - Today

CAISO Market – FERC Jurisdictional
- Day-Ahead and Real-time Spot Market
- Energy & Ancillary Services

Bilateral Procurement – State Regulatory Authority
- Year-Ahead Resource Adequacy
- LSE Forward Hedging
- Long-term Procurement – New Build
Significant Generation Investment over Past Decade

[Graph showing capacity additions/retirements (MW) for years 2003 to 2013.]

[Bar chart showing ISO Operating Reserve Margin based on Normal Scenario for years 2005 to 2013.]

3% Firm Load Shedding
CAISO Market Revenues – Missing Money or Right Signal?

Estimated CAISO Market Revenues for Hypothetical Combined Cycle Unit

CAISO Department of Market Monitoring
California Energy and Environmental Policy Drivers

- Greenhouse gas reductions to 1990 levels by 2020
- 33% of load served by renewable generation by 2020
- 12,000 MW of distributed generation by 2020
- Ban on use of once-through cooling in coastal power plants
- Limits on availability of air emission credits for replacement generation
Roughly 11,000 MW of Gas-Fired Generation Subject to Meeting Compliance under OTC Regulations

### Generating Units Compliance with California Statewide Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling

<table>
<thead>
<tr>
<th>Plant (Unit)</th>
<th>Owner</th>
<th>Final Compliance Date</th>
<th>Capacity (MW)</th>
<th>PTO Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compliance Plan Yet to be Implemented (Natural Gas Fired)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>El Segundo Units 3 and 4</td>
<td>Dyneg</td>
<td>12/31/2015</td>
<td>335</td>
<td>SCE</td>
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<tr>
<td>Morro Bay Units 3 and 4</td>
<td>Dyneg</td>
<td>12/31/2015</td>
<td>640</td>
<td>PG&amp;E</td>
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<tr>
<td>Encina Power Station Units 1-5</td>
<td>Dyneg</td>
<td>12/31/2017</td>
<td>946</td>
<td>SDGE</td>
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<tr>
<td>Pittsburg Units 3 and 4</td>
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<td>12/31/2017</td>
<td>250</td>
<td>PG&amp;E</td>
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<tr>
<td>Moss Landing Units 1 and 2</td>
<td>AES</td>
<td>12/31/2017</td>
<td>750</td>
<td>SCE</td>
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<tr>
<td>Moss Landing Units 6 and 7</td>
<td>AES</td>
<td>12/31/2017</td>
<td>1,520</td>
<td>SCE</td>
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<tr>
<td>Huntington Beach Units 1-2</td>
<td>AES</td>
<td>12/31/2020</td>
<td>452</td>
<td>SCE</td>
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<tr>
<td>Redondo Beach Units 5-8</td>
<td>AES</td>
<td>12/31/2020</td>
<td>1,343</td>
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<tr>
<td>Alamosa Units 1-6</td>
<td>AES</td>
<td>12/31/2020</td>
<td>2,011</td>
<td>SCE</td>
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<tr>
<td>Mandalay Units 1 and 2</td>
<td>NRG</td>
<td>12/31/2020</td>
<td>430</td>
<td>SCE</td>
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<tr>
<td>Ormond Beach Units 1 and 2</td>
<td>NRG</td>
<td>12/31/2020</td>
<td>1,516</td>
<td>SCE</td>
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<tr>
<td><strong>Total MW</strong></td>
<td></td>
<td></td>
<td><strong>18,032</strong></td>
<td></td>
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</table>

### In Compliance

<table>
<thead>
<tr>
<th>Plant (Unit)</th>
<th>Owner</th>
<th>Final Compliance Date</th>
<th>Capacity (MW)</th>
<th>PTO Area</th>
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<tbody>
<tr>
<td>Humboldt</td>
<td>PG&amp;E</td>
<td>Sept. 2010</td>
<td>105</td>
<td>PG&amp;E</td>
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<tr>
<td>Petrowa Unit 3</td>
<td>GenOn</td>
<td>7/28/2011</td>
<td>206</td>
<td>PG&amp;E</td>
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<tr>
<td>South Bay</td>
<td>Dyneg</td>
<td>1/1/2011</td>
<td>702</td>
<td>SDGE</td>
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<tr>
<td>Huntington Beach Units 3-4</td>
<td>AES</td>
<td>12/7/2012</td>
<td>452</td>
<td>SCE</td>
</tr>
<tr>
<td><strong>Total MW</strong></td>
<td></td>
<td></td>
<td><strong>1,465</strong></td>
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</tr>
</tbody>
</table>

### Expected to be in Compliance by end of 2013

<table>
<thead>
<tr>
<th>Plant (Unit)</th>
<th>Owner</th>
<th>Final Compliance Date</th>
<th>Capacity (MW)</th>
<th>PTO Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>El Segundo Units 3</td>
<td>NRG</td>
<td>12/31/2015</td>
<td>335</td>
<td>SCE</td>
</tr>
<tr>
<td>Contra Costa Units 6 and 7</td>
<td>NRG</td>
<td>12/31/2017</td>
<td>674</td>
<td>PG&amp;E</td>
</tr>
<tr>
<td><strong>Total MW</strong></td>
<td></td>
<td></td>
<td><strong>1,099</strong></td>
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</table>

Compliance pending study by Water Board Review Committees for Nuclear Plants

<table>
<thead>
<tr>
<th>Plant (Unit)</th>
<th>Owner</th>
<th>Final Compliance Date</th>
<th>Capacity (MW)</th>
<th>PTO Area</th>
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</thead>
<tbody>
<tr>
<td>San Onofre</td>
<td>SCE</td>
<td>12/31/2024</td>
<td>2,546</td>
<td>SCE</td>
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<tr>
<td>Diablo Canyon</td>
<td>PG&amp;E</td>
<td>12/31/2024</td>
<td>2,240</td>
<td>PG&amp;E</td>
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<tr>
<td><strong>Total MW</strong></td>
<td></td>
<td></td>
<td><strong>4,886</strong></td>
<td></td>
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</tbody>
</table>

Total of all OTC Units **17,992**

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*Huntington Beach generating units 3-4 are retired and are being converted to synchronous condensers. A portion (i.e., about 25%) of the plant cooling system is required only when synchronous condensers are operating. When synchronous condensers are not operating, no excess water cooling is required.*
System flexibility will be significantly reduced as OTC resources retire.

<table>
<thead>
<tr>
<th></th>
<th>Spring</th>
<th>Summer</th>
<th>Fall</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined Cycle OTC</td>
<td>100</td>
<td>540</td>
<td>177</td>
<td>100</td>
</tr>
<tr>
<td>Steam Turbine OTC</td>
<td>6,763</td>
<td>9,544</td>
<td>9,063</td>
<td>8,393</td>
</tr>
<tr>
<td>Combined Cycle Non-OTC</td>
<td>5,812</td>
<td>8,578</td>
<td>7,431</td>
<td>6,676</td>
</tr>
<tr>
<td>Gas Turbine Non-OTC</td>
<td>3,296</td>
<td>3,405</td>
<td>3,292</td>
<td>3,175</td>
</tr>
<tr>
<td>Hydro Non-OTC</td>
<td>3,538</td>
<td>4,743</td>
<td>3,176</td>
<td>2,826</td>
</tr>
<tr>
<td>Pump Storage Non-OTC</td>
<td>344</td>
<td>1,020</td>
<td>1,365</td>
<td>760</td>
</tr>
<tr>
<td>Steam Turbine Non-OTC</td>
<td>530</td>
<td>786</td>
<td>782</td>
<td>757</td>
</tr>
</tbody>
</table>
Resource Mix Changing Dramatically

Changes in the fleet capacity results in potential need of 4,600 MW of flexible capacity by 2020 which represents about 38% of the OTC retired capacity.
Interaction of Wind & Solar on Net-Load Profile (1)

Sample winter day in 2020

Peak demand 44,000 MW
Interaction of Wind & Solar on Net-Load Profile (2)

Sample winter day in 2020

Peak demand
44,000 MW

Net load
minus wind & solar

8,000 MW in 2 hours

6,300 MW in 2 hours

13,500 MW in 2 hours

Total solar capacity = 10,814 MW
(including behind the meter)
Total wind capacity = 5,450 MW
Growing need for flexibility starting in 2015
Our Challenge

• System needs (ramping, load following, etc) changing dramatically over this decade.

• Resource mix changing dramatically
  – Increasing levels of wind & solar
  – Decreasing levels of flexible/dispatchable resources due to:
    • OTC Retirements
    • Potential retirements due to current market conditions

Challenges –

How to ensure we identify and secure the resource capabilities needed in future years.

How to ensure we optimally utilize and price resource capabilities in the ISO markets.
Should the CAISO pursue a Multi-year Ahead Capabilities Market?

Bilateral Procurement – State Regulatory Authority

Year-Ahead Resource Adequacy

LSE Forward Hedging

CAISO Spot Market

CAISO Multi-year Ahead Capabilities Market?
  - Flexibility (Ramping, Load Following, Regulation)
  - Local
  - System

Long-term Procurement – New Build
Should we instead focus on evolving the state regulatory procurement framework?

Bilateral Procurement – State Regulatory Authority

- CPUC Multi-year Ahead RA Requirement
  - Flexibility, Local, System

CAISO Spot Market

CAISO Backstop Procurement

Long-term Procurement – New Build
CAISO market design is evolving to meet changing needs of the system.

- **LMP Market Design (April 2009)**
  - Security constrained unit commitment and economic dispatch
  - Day-ahead and Real-time
  - Co-optimize energy and ancillary services (Regulation, Spin, Non-Spin)

- **Key Enhancements (2011 - 2013)**
  - Flexible Ramping Constraint
  - Regulation Energy Management
  - Multi-Stage Generation Modeling

- **Proposed Enhancements (2014)**
  - FERC Order 764 (15-minute inter-tie scheduling, 15-minute market)
  - Flexible Ramping Product
  - Energy Imbalance Market – CAISO/PacifiCorp Agreement
Flexible Ramping Constraint

- Implemented December 2011
- Secure additional upward ramping capability based on projected variability in real-time imbalance forecast.
- Compensation based on an administrative price capped between $0 and $800/MWh.
- Flexible ramping payments totaled $20M in 2012, compared to $35M for spinning reserve.

Flexible Ramping **Product** under consideration
- Bid-based capacity product – similar to ancillary services
- Upward and downward flexibility requirements
Improvements to Regulation Market

• Regulation Energy Management
  – Implemented Spring 2012
  – Allows resources that can produce energy for only short durations (less than 60-min) to provide hourly regulation service.

• Pay for Performance Regulation (FERC Order 755)
  – Implemented June 1, 2013
  – Two-Part Payment for regulation service
    • Capacity Payment
    • Payment for response to regulation signal (mileage & accuracy)
      – Mileage – Resource movement between 4 sec intervals
      – Accuracy – Regulation signal to actual telemetry
FERC Order 764

- FERC Order 764 requires:
  - Transmission providers to offer an option to schedule energy in 15-minute increments, and
  - Variable energy resources to provide meteorological and forced outage data

- Compliance created opportunity to revamp ISO real-time market design.
  - Proposing a full three settlement market
    - Day-Ahead, 15-Minute Market, 5-minute market
    - Real-time fixed hourly-intertie transactions settled as price takers
    - Convergence bids settled between Day-Ahead and 15-minute market.
    - Improved forecasting and market settlements for VERs.

- Implementation planned for Spring 2014
CAISO Energy Imbalance Market (EIM)

- CAISO developing EIM to optimize real-time balancing across multiple balancing areas.
- PacifiCorp and ISO have entered into an EIM implementation agreement.
- Implementation planned for Fall 2014.
- Stakeholder process on design is underway. Some key issues:
  - Day-ahead scheduling and system modeling.
  - Allocation of uplift costs.
  - GHG emissions and CA Cap & Trade
California’s Evolving Energy Market

CAISO Spot Market Design
• Increasingly sophisticated
• Defining & pricing needed resource capabilities
• Removing barriers to broader participation
  – Regionally & Clean/smart technologies

Multi-Year Procurement Framework
• State regulated
• Procurement requirements evolving
  – Local, System, Flexibility
• Promoting clean technologies

Optimally utilize and price resource capabilities in the ISO markets

Identify and secure the resource capabilities needed in future years.

Where do we go from here?

ISO Capabilities
Market?

Regulated procurement?

Hybrid?