Market and Operational Challenges of an Evolving Power System

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- **Nonprofit** public benefit corporation
- Part of Western Electricity Coordinating Council
- Energy Imbalance Market covers 10 Western States and British Columbia
- 75,747 MW of power plant capacity
- 50,270 MW record peak demand (July 24, 2006)
- >1,100 power plants
- 26,014 circuit-miles of transmission lines
CAISO Markets

Transmission-Right Markets
- CRR allocation
- CRR auction

Day Ahead Market
- Market Power Mitigation
- Integrated Forward Market
- Reliability Unit Commitment

Real-Time (EIM) Market
- Fifteen Minute Market
- Real-Time Dispatch

Monthly, seasonal and TOU intervals
- Congestion Revenue Rights (Obligations)

Hourly intervals
- Energy
  - a) physical
  - b) virtual
- Mileage
- Capacity
  - a) Reliability
  - b) Ancillary services
    - Spinning
    - Non Spinning
    - Regulation

15- and 5-minute intervals
- Energy
- Flex Ramp
- Mileage
- Capacity
  - Spinning
  - Non Spinning
  - Regulation
Major progress on meeting CA’s renewable goals

• Currently Installed:
  – 21,000 MW of utility-scale renewables
  – ~11,000 MW of consumer rooftop solar

• Additional renewables:
  – 4,000+ MW additional utility-scale renewables by 2026
  – ~16,750 MW of consumer rooftop solar by 2026

• Projected 5000+ MW of storage and hybrid resources
System and markets are evolving towards a non-deterministic environment

- Weather variables, such as temperatures, introduce uncertainty components to multiple variables in the power system, including
  - Load forecast
  - Behind the meter generation
  - Utility-based wind and solar production
  - Regulation requirements
- CAISO still uses a deterministic market clearing process with deterministic inputs
- Different products and procedures are developed to then “factor in” uncertainty
Demand Forecast Movement due to Behind the Meter Solar

Load Forecast Movement due to BTM Solar

BTM Solar Forecast Updates vs. Actual
### Comparing conventional to variable generation

<table>
<thead>
<tr>
<th><strong>Conventional Generation</strong></th>
<th><strong>Variable Generation</strong></th>
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<tbody>
<tr>
<td>- Predictability</td>
<td>- Hard to predict</td>
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<tr>
<td>- No surprises</td>
<td>- Forecast inaccuracy is high</td>
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<tr>
<td>- Dependable energy schedules</td>
<td>- Maximum generation at night when loads are low and there is no place for the energy – 70% of the wind produced during a 24 hour period is at nights and 30% of the Solar produced in a week is on weekends</td>
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<tr>
<td>- Accurate forecasts</td>
<td>- Large ramp demands both up and down</td>
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<td>- Contingency reserves available</td>
<td>- Lack of visibility of anticipated generation production changes</td>
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<tr>
<td>- Generators that follow dispatch commands</td>
<td>- May not follow dispatch commands --- treated as “Must Take” generation</td>
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<tr>
<td>- Excellent tools for visibility of system status</td>
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<tr>
<td>- High quality data</td>
<td></td>
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<tr>
<td>- De-rate information on units is timely and accurate</td>
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The duck turns 10 years old: Actual net-load and 3-hour ramps are approximately four years ahead of the CAISO’s original estimate.

Typical Spring Day

- **Steeper Upward Ramps**
- **Steeper Downward Ramps**
- **Deeper Belly**

Actual 3-hour ramp over 15,000MW

Net load valley in the 5,000MW
Variability poses a great forecasting challenge which results in uncertainty in market and systems operations.
Flexible ramping product implemented in 2016 makes important changes to the real-time market

- Secures ramping capability in the fifteen-minute market and real-time dispatch
- Accounts for upward and downward ramping needs
- Compensates resources who provide ramping and charges those that consume ramping capability
- Procures ramping capability for uncertainty when expected value greater than cost
- Aligns cost allocation with those who benefit from additional ramping capability to meet net load uncertainty
Day-Ahead imbalance in CAISO market will factors in uncertainty in load and renewable resource
Advancements to handle uncertainty in CAISO’s market and system

Operating under Uncertainty

- Real Time Flexible Ramp Requirement Enhancements
- In-house Persistence
- Integration and Forecasting for Hybrid and Co-Located Resources
- Implemented Multiple Renewable Forecast Provider
- BTM Forecast and Actual Provider integrated into Demand Forecasting
- Regulation Requirement Enhancements
- Multi-interval optimization
- Confidence bands for day-ahead forecast
California is seeing an explosive growth of storage resources.
Rapid growth in storage technologies will require new forecasting techniques and market design to support market participation

- **Hybrid Resource Initiative**
  - Phase 2 go-live Fall 2021
  - Phase 1 go-live was Dec 2020
- Expected to have 5,000 MW of renewable + storage by 2024
  - Based on LSE survey
- CAISO will provide wind and solar forecasting services:
  - Optional for hybrid renewables
  - Required for co-located

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**Hybrid vs. Co-located**

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<th>Hybrid</th>
<th>Definition</th>
<th>Forecasting / Dispatch</th>
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<td>Hybrid</td>
<td>A Generating Unit, with a unique Resource ID at a single Point of Interconnection, with components that use different fuel sources or technologies.</td>
<td>• No aggregate forecast for hybrid&lt;br&gt;• Hybrid expected to follow dispatch</td>
</tr>
<tr>
<td>Co-located</td>
<td>A Generating Unit with a unique Resource ID that is part of a Generating Facility with other Generating</td>
<td>• VER component will be forecast&lt;br&gt;• VER dispatched rules&lt;br&gt;• Battery will dispatched and state of charge managed</td>
</tr>
</tbody>
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**Diagram**

- Hybrid Resource Initiative
- CAISO will provide wind and solar forecasting services:
  - Hybrid
  - Co-located