Technical Perspective in System Operation: US Perspective

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The California ISO: One of nine grid operators in North America – 2/3 of the U.S. is supported by an ISO

- One of 38 balancing authorities in the western interconnection
- Uses advanced technology to balance supply & demand every 4 seconds
- Operate markets for wholesale electricity & reserves
- Manage new power plant interconnections
- Plan grid expansions
Key functions of an ISO

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Western Energy Imbalance Market (EIM):

• Total savings of $650 million since start in Nov 2014

• 810,116 MWh curtailment avoided, displacing an estimated 346,649 metric tons of CO2
Power industry transformation

**Wind**
- 6,705 MW Installed Capacity
- 5,221 MW Peak – May 8, 2019

**Solar Thermal / Photo Voltaic**
- 11,949 MW Installed Capacity
- 11,363 MW Peak – June 1, 2019

**Roof Top Solar**
- Behind the meter – Residential
- 7,500 MW Estimated Capacity
Comparing conventional to variable generation

**Conventional Generation**
- Predictability
- No surprises
- Dependable energy schedules
- Accurate forecasts
- Contingency reserves available
- Generators that follow dispatch commands
- Excellent tools for visibility of system status
- High quality data
- De-rate information on units is timely and accurate

**Variable Generation**
- Hard to predict
- Forecast inaccuracy is high
- 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
- Large ramp demands both up and down
- Lack of visibility of anticipated generation production changes
- May not follow dispatch commands --- treated as “Must Take” generation
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.
Net load = load – wind – solar

Typical Spring Day

Net load of 5,439 MW on 5/5/19

Actual 3-hour ramp of 15,639 MW on 1/1/19
Distribution of negative prices have shifted from early morning hours to midday hours.
Wind and Solar production can vary significantly between days.

Forecasting wind and solar production in the day-ahead timeframe is a challenge.
July 18, 2015 illustrates variability and forecast challenges
Net load varies significantly day-to-day and minute-to-minute.
Behind the Meter Solar is Growing

Expected BTM Cumulative Capacity Through 2022

<table>
<thead>
<tr>
<th>Year</th>
<th>BTM (MW)</th>
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</thead>
<tbody>
<tr>
<td>2018</td>
<td>7,452</td>
</tr>
<tr>
<td>2019</td>
<td>8,714</td>
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<tr>
<td>2020</td>
<td>10,045</td>
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<tr>
<td>2021</td>
<td>11,327</td>
</tr>
<tr>
<td>2022</td>
<td>12,587</td>
</tr>
</tbody>
</table>
Seasonal Load Shapes

- Load shape varies by:
  - Month

January

July
BTM Impacts

• Behind the meter solar
  – Non-utility scale solar, such as commercial or residential rooftop panels
• Sunny days lead to high BTM penetration and lower mid-day loads
Day-Ahead uncertainty in CAISO market
Flexible ramping product conceptual design

- **FRU(t)** procurement target
- **FNL(t+1)+UU(t+1)**
  - **FNL(t)**
- **FNL(t+1) – DU(t+1)**
  - **FNL(t)**
- **FRD(t)** procurement target

FRU and FRD cover the net load movements from binding interval t to the advisory interval t+1.

Forecasted net load (FNL)

FNL+ upward uncertainty (UU)

FNL – downward uncertainty (DU)

**t** (binding interval) **t+1** (advisory interval) **Time**

Net system demand
Questions

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