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<th>17-MISC-01</th>
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<td>California Offshore Renewable Energy</td>
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<td><strong>Document Title:</strong></td>
<td>Presentation - California Energy System</td>
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<tr>
<td><strong>Description:</strong></td>
<td>By Jeff Billinton, CAISO at the Energy Commission staff workshop on offshore renewable energy</td>
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<td><strong>Filer:</strong></td>
<td>Eli Harland</td>
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California Energy System

J.E.(Jeff) Billinton
Manager, Regional Transmission - North

California Energy Commission - Staff Workshop on Offshore Renewable Energy
March 3, 2017
California ISO by the numbers

- **73,306 MW of power plant capacity** (installed capacity)
- **50,270 MW record peak demand** (July 24, 2006)
- **27,488 market transactions per day** (2015)
- **25,685 circuit-miles of transmission lines**
- **30 million people served**
- **240 million megawatt-hours of electricity delivered annually** (2015)
Transmission System

- 500 kV
- 230 kV
- 115 kV
- 60 / 70 kV
California energy and environmental policies drive renewable integration and transmission needs

- Greenhouse gas reductions to 1990 levels by 2020
- 33% of load served by renewable generation by 2020
- Ban on use of once-through cooling in coastal power plants
- Less predictable load patterns – rooftop solar, electric vehicles, and smart grid
- Over 1,300 MW of electricity storage resources deployed by 2024
- 1.5 million electric vehicles on the road by 2025
- **Governor Brown’s 2030 goals**
  - 50% of the load served from renewables
  - 50% reduction in petroleum use – cars & trucks
  - 12,000 MW of distributed generation
  - Double energy efficiency of existing buildings
  - Greenhouse gas reductions to at least 40% below 1990 levels
The state agencies and the ISO have defined responsibilities to produce results:

- **Demand forecast & resource needs (State & ISO)**
  - Projects peak-hour & annual energy demand 20 years forward
  - Adjusted for energy efficiency, rooftop solar and demand response
  - Reflects RPS mandates, system adequacy, local area reliability and flexible capacity needs

- **Transmission plan (ISO)**
  - Identifies
    - new transmission lines
    - upgrades to existing lines
    - non-transmission alternatives
  - Infrastructure needed to support the resource needs and demand forecast, and to address policy or economic needs

- **Procurement plan (Reg. Agency)**
  - Authorizes Utility to procure to meet the demand forecast & resource needs
  - Includes:
    - renewable resources
    - conventional resources
    - demand response
    - energy efficiency
    - distributed resources
The ISO’s transmission planning process

**Phase 1**
Development of ISO unified planning assumptions and study plan
- Incorporates State and Federal policy requirements and directives
- Demand forecasts, energy efficiency, demand response
- Renewable and conventional generation additions and retirements
- Input from stakeholders
- Ongoing stakeholder meetings

**Phase 2**
Technical Studies and Board Approval
- Reliability analysis
- Renewable delivery analysis
- Economic analysis
- Publish comprehensive transmission plan
- ISO Board approval

**Phase 3**
Competitive Solicitation Process
- Receive proposals to build identified reliability, policy and economic transmission projects
- Evaluate proposals to meet qualification for consideration
- Take necessary steps to determine Approved Project Sponsor(s)

**Four Consultation Windows**
- April Year X
- March Year X+1
- October Year X+1

**ISO board approval of transmission plan**

**Continued regional and sub-regional coordination**
Coordination of Assumptions

• **CEC IEPR Energy Demand Forecast**
  - **Input for Demand side assumptions**
    • Includes the consumption load and the load modifiers (behind the meter distributed generation, demand response, electric vehicles, committed energy efficiency and the additional achievable energy efficiency, are included in the forecasts as a baseline assumption)

• **CPUC Assumptions and Scenarios**
  - **Input of Supply side assumptions**
    • Includes assumptions of renewable portfolios, conventional generation, storage and demand response
Transmission Planning Studies - Renewables

• ISO Transmission Planning Process
  – Utilize the CPUC Portfolios
  – Transmission is planned to integrate the generation of the portfolio

• ISO coordinated with the CPUC to perform a special study in 2016-2017 Transmission Planning Process:
  – information purposes only - will not be used to support a need for policy-driven transmission in the 2016-2017 planning cycle;

• Incremental generation in ISO control area to go from 33% to 50% Renewable Goal in the 12,000 MW range
ISO generation interconnection queue

Interconnection queue by county

<table>
<thead>
<tr>
<th>County</th>
<th># of Projects</th>
<th>Renewables</th>
<th>Storage</th>
<th>Conventional</th>
<th>Total</th>
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<tr>
<td>1 Humboldt</td>
<td>2</td>
<td>106</td>
<td>28</td>
<td>134</td>
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<tr>
<td>2 Shasta</td>
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<td>3 Tehama</td>
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<td>4 Lassen</td>
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<td>27</td>
<td>48</td>
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<tr>
<td>5 Plumas</td>
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<td>35</td>
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<tr>
<td>6 Sutter</td>
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<td>7 Lake</td>
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<td>11 Alameda, Contra Costa, Santa Clara</td>
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<tr>
<td>14 Merced</td>
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<td>619</td>
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<td><strong>In-state Totals</strong></td>
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<td>8,257</td>
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<td><strong>Out-of-state Totals</strong></td>
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<td>84</td>
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<td><strong>TOTAL ALL PROJECTS</strong></td>
<td>295</td>
<td>36,330</td>
<td>9,341</td>
<td>5,378</td>
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as of January 9, 2017
5,000 MW of additional transmission-connected renewables by 2020 and up to additional 15,000 MW by 2030 (predominately Solar PV)

(Existing generation)

*All online resources that are not in test mode are included in the 2016 YTD amounts, including those yet to achieve full commercial operation.

**Approximate

(IOU data through 2017 and RPS Calculator data 2018 – 2020)
Oversupply and ramping: A new challenge as more renewables are integrated into the grid

- ISO has already seen the need to curtail generation
- Oversupply may lead to curtailment because of dispatch limitations on some resources, such as
  - geothermal
  - nuclear
  - small hydro
  - combined heat and power
- Operational requirements include
  - minimum gas necessary to provide ramping
  - necessary ancillary services
  - load following

Typical Spring Day

Net Load 11,663 MW on May 15, 2016

Actual 3-hour ramp 12,960 MW on December 18, 2016
ISO working on a 50% duck curve

Net load - March 31

Much steeper ramps

Much deeper belly
Behind the meter solar PV build-out through 2021

Estimated Behind the Meter Solar PV Build-out Through 2021

<table>
<thead>
<tr>
<th>Year</th>
<th>BTM Solar PV (MW)</th>
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<tbody>
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<td>2015</td>
<td>3,695</td>
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<td>2016</td>
<td>4,903</td>
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<td>2020</td>
<td>9,309</td>
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<td>2021</td>
<td>10,385</td>
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NOT the Duck: ISO gross load curve is changing

Dip is attributable to rooftop solar
Solar production varies from one day to the next --- first week of March 2014
Wind production varies from one day to the next --- first week of March 2014
Negative energy prices indicating over-generation risk start to appear in the middle of the day.

Increasing real-time negative energy price frequency indicates over-generation risk in the middle of the day.
Summary of future grid operations to manage a more complex grid

- Increased requirements for regulation up and down
- Need to manage increased intra-hour flexibility and multiple hour daily ramps
  - Approx. 4,000 to 6,000 MW of intra-hour load-following
  - Approx. 13,000 MW of continuous up-ramp within a 3 hour time period (almost double current up-ramps)
- Non-dispatchable resources serving load varies between 8,000 MW to 10,000 MW based on maximum capability of resources
- Increased instances of over-generation conditions
- Need to comply with a frequency response obligation following a disturbance (Compliance with BAL-003-1)
- Impact of DER resources on the BES is still not fully understood
Can variable energy resources provide essential reliability services to reliably operate the grid?

- NERC identified three essential reliability services to reliably integrate higher levels of renewable resources
  - Ramping capability or flexible capacity
  - Voltage control
  - Frequency control

- Advancement in smart inverter technology allows VERs to provide services similar to conventional resources

- VERs with the right operating characteristics are necessary to decarbonize the grid
Meeting the operational challenges beyond 33% RPS with generation, storage and demand response from internal and external (EIM) resources

- **Generation**
  - Dispatchable Wind/Solar
  - Wider Operating Range (lower Pmin)
  - Dispatchable Quick Start

- **Demand Response**
  - Peak Load Reduction

- **Storage**
  - Voltage Support
  - Regulation
  - Fast Ramping Frequency Response
  - Over Generation Mitigation
  - Load Shift

- **Dispatchable Wind/Solar**
  - Fast Ramping
  - Regulation
  - Frequency Response

- **Wider Operating Range (lower Pmin)**

- **Dispatchable Quick Start**

- **Peak Load Reduction**

- **Over Generation Mitigation**

- **Load Shift**

- **Voltage Support**

- **Regulation**

- **Fast Ramping Frequency Response**
Questions!