California ISO
Shaping a Renewed Future

Electric Advisory Committee Meeting

Distribution Resource Integration

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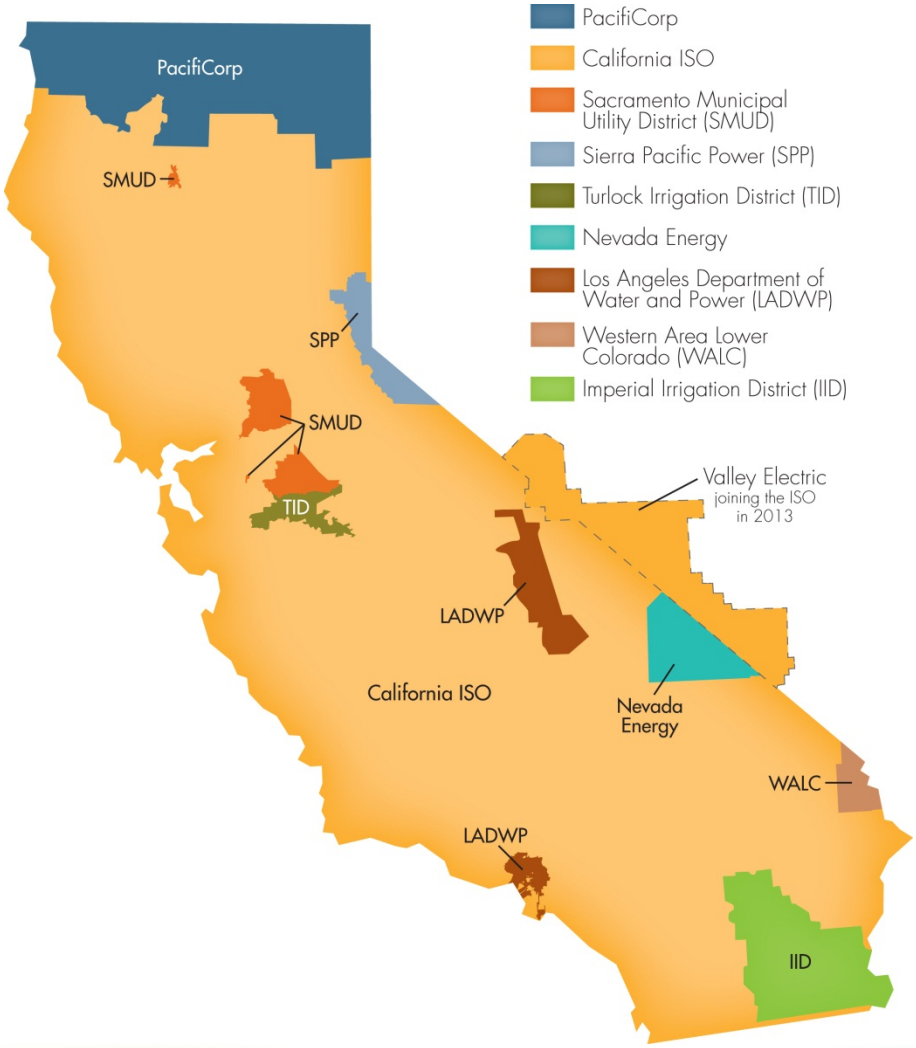
March 12, 2014

Presentation Overview

- California energy and environmental policy drivers
- Current and expected impacts of renewable resources on the CAISO's system
- Need for flexible resources
- Operational challenges on the distribution network
- Operational challenges on the transmission network
- Potential challenges Distributed Energy Resources (DERs) need to overcome
- Meeting operational challenges with high levels of renewable resources connected to the transmission & distribution systems

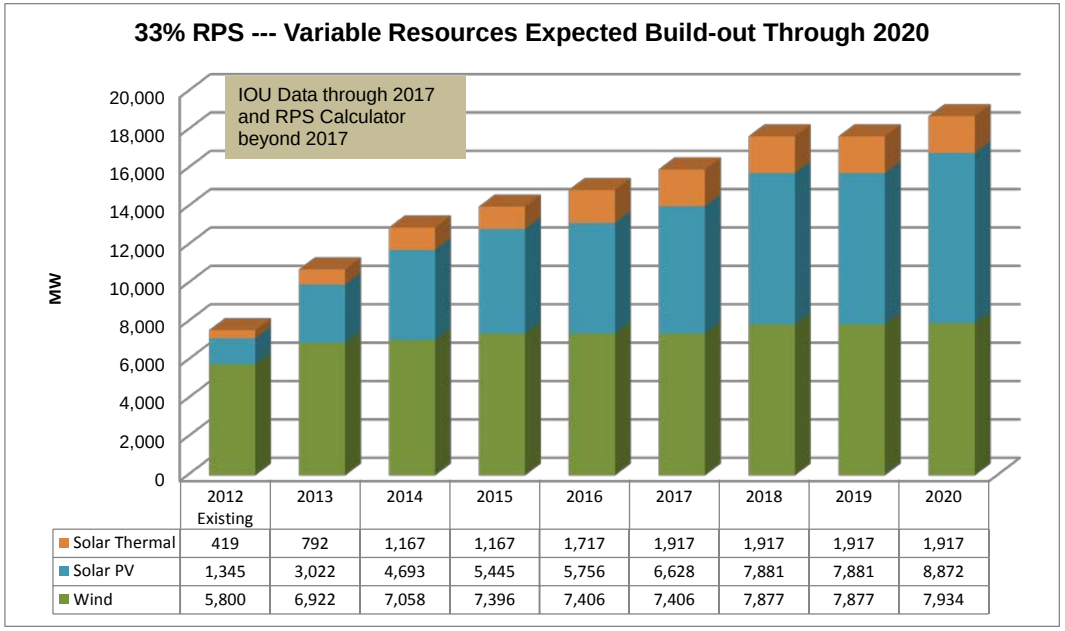
California ISO by the numbers



- **60,703 MW** of power plant capacity
- **50,270** MW record peak demand (July 24, 2006)
- **27,589** market transactions per day
- **26,024** circuit-miles of transmission lines
- **30 million** consumers served
- **246 million** megawatts of electricity delivered annually

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
- Possibly 12,000 MW of distributed generation by 2020



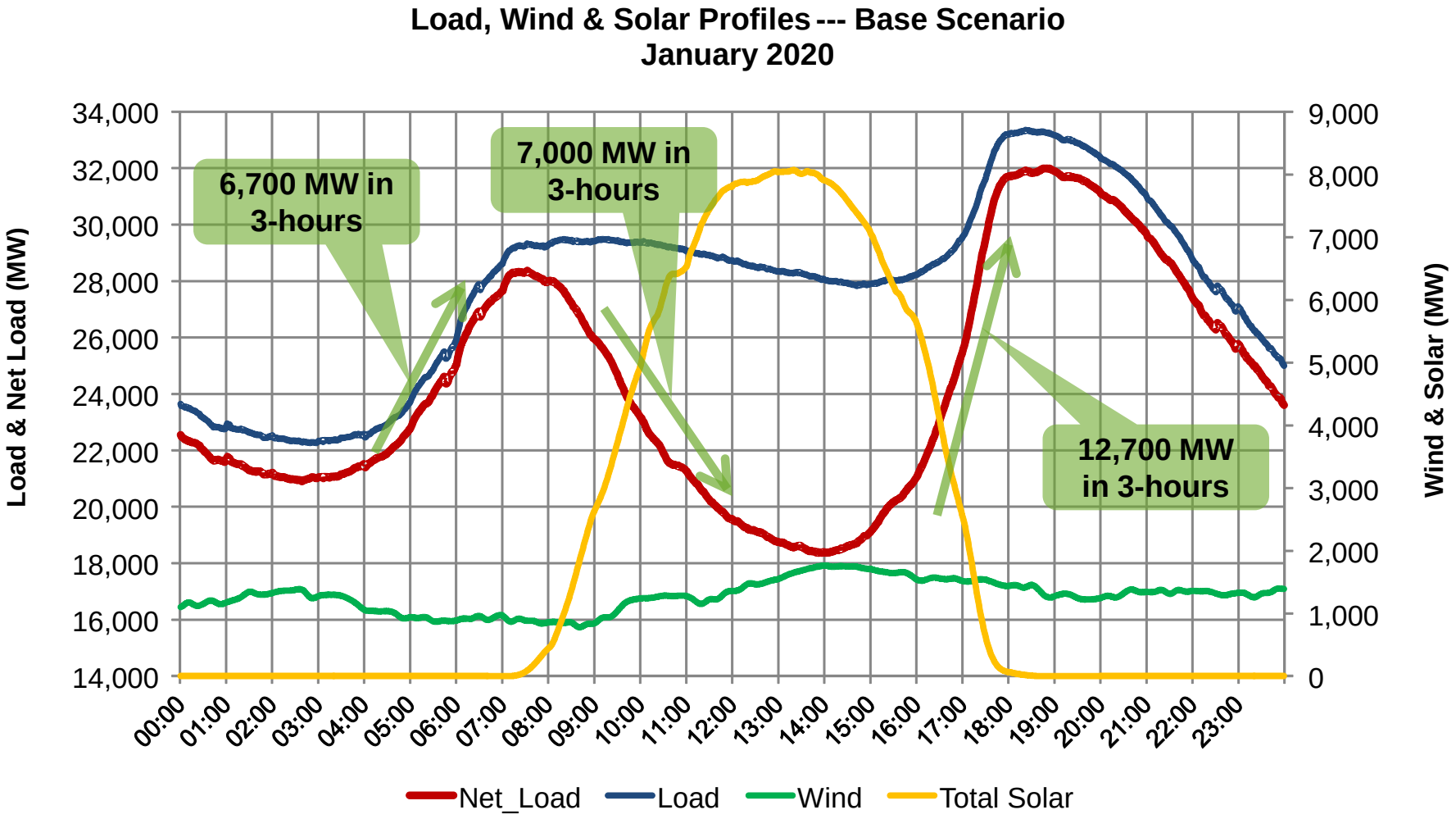
	2012 Existing	2013	2014	2015	2016	2017	2018	2019	2020
Solar Thermal	419	792	1,167	1,167	1,717	1,917	1,917	1,917	1,917
Solar PV	1,345	3,022	4,693	5,445	5,756	6,628	7,881	7,881	8,872
Wind	5,800	6,922	7,058	7,396	7,406	7,406	7,877	7,877	7,934

- Less predictable load patterns – rooftop solar, electric vehicles, and smart grid
- Ban on use of once-through cooling in coastal power plants affects approximately 12,000 MW of generating capacity

Summary of grid operations to manage a more complex grid

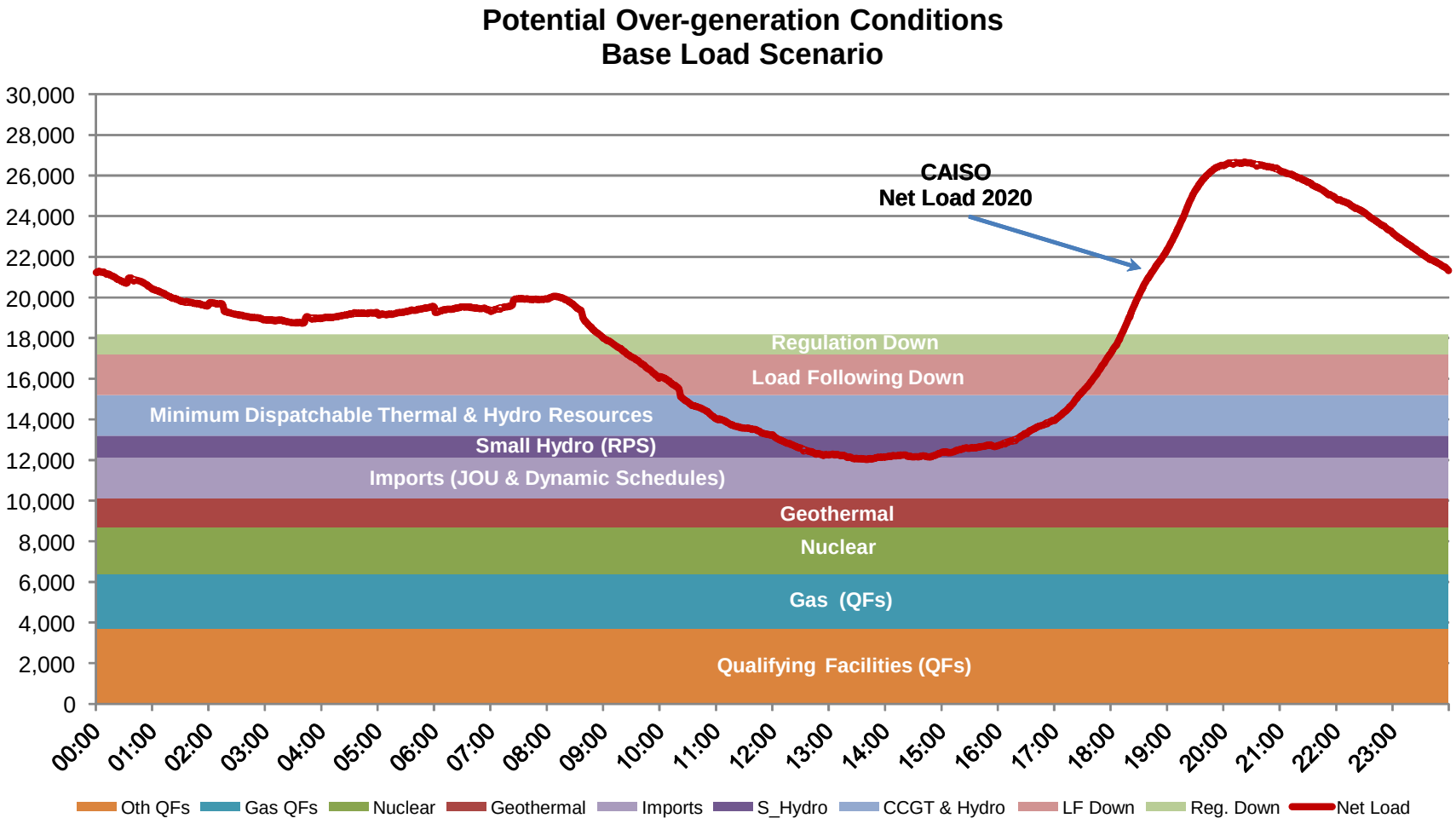
- Increased requirements for regulation up and down
- Need to manage increased intra-hour flexibility and daily ramps
  - Need to manage approximately 3,000 MW of intra-hour load-following
  - Need to manage approximately 13,000 MW of continuous up-ramp within a 3-hour time period (almost double current up-ramps)
- Non-dispatchable resources serving load varies is greater than 10,000 MW based on maximum capability of resources
- Increased frequency 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 transmission grid is still not fully understood

Flexible resources would be dispatched to the net (red) load demand curve



Net Load = Load - Wind - Solar

Non-flexible supply creates dispatch issues and potential over-generation conditions



Potential impacts of DERs on the distribution network

- Voltage fluctuation due to upward/downward ramps
- High voltage issues on distribution circuits
- Voltage/power factor regulation control issues
  - Greater number of operations and increase maintenance on voltage control devices
  - Current distribution interconnection codes (IEEE 1547) does not allow for active voltage regulation and/or control
- Maintaining current balance on each phase
- Reverse power flow during times of low demand
- Limited monitoring and control of DER resources

Operational challenges from the grid perspective with large scale DERs and loads

- Lack of visibility of the distribution system
- Uncontrollable nature of DER output
- Large concentration of PV can affect the frequency response and voltage profile of the system
- Forecast assumptions of “net load” seen by operators
- Variability of “combined heat and power” production due to load, natural gas prices, real-time energy prices etc.
- Predicting price responsive loads behavior to real-time prices
- Demand response variability and forecast uncertainty
- Uncertainty/assumptions associated with commercial, Industrial and residential storage

NERC has identified the following factors on bulk system reliability associated with DERs

- Need for establishing requirements to regulate voltage at the point of interconnection to the transmission grid
- Potential over-generation during minimum load periods
- Need for developing standards for DERs wishing to participate in ancillary service markets
- Need to modify DER interconnection standards to address reduced fault current, low-voltage ride-through, frequency control etc.
- Potential system protection coordination due to current flow reversal
- Disconnecting DER during under-frequency load shedding can further reduce frequency
- Need to coordinate transmission and distribution connected resources during system restoration following an outage

DER can contribute to meeting operational challenges

- Energy storage can help mitigate over-generation
- Load shifting may help mitigate the need for new conventional resources
- DERs may also benefit the system by reducing peak demand and thereby avoiding the need for transmission upgrades
- Controlled load dropping can provide spinning reserve and frequency control
- Demand response can reduce the need for conventional resources
- Electric Vehicles can provide regulation service or balancing needs
- Micro grids allows participation in ancillary services markets

Potential challenges DER need to overcome

- Controllability/Sustainability & Visibility of DERs
- Security against cyber-attacks
- Response to faults, low voltage ride through, frequency ride through (coordination with IEEE 1547)
- Uniform standards for DER wishing to participate in AS markets
- Time delay between dispatch instructions and actual response
- Coordination of Transmission/Distribution voltage control devices
- Coordination between distribution and transmission connected resources during system restoration
- Impact of DER on system load forecast
- Market design and pricing policy of DERs are not fully understood

Meeting the operational challenges with high levels of renewable resources