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California Energy System

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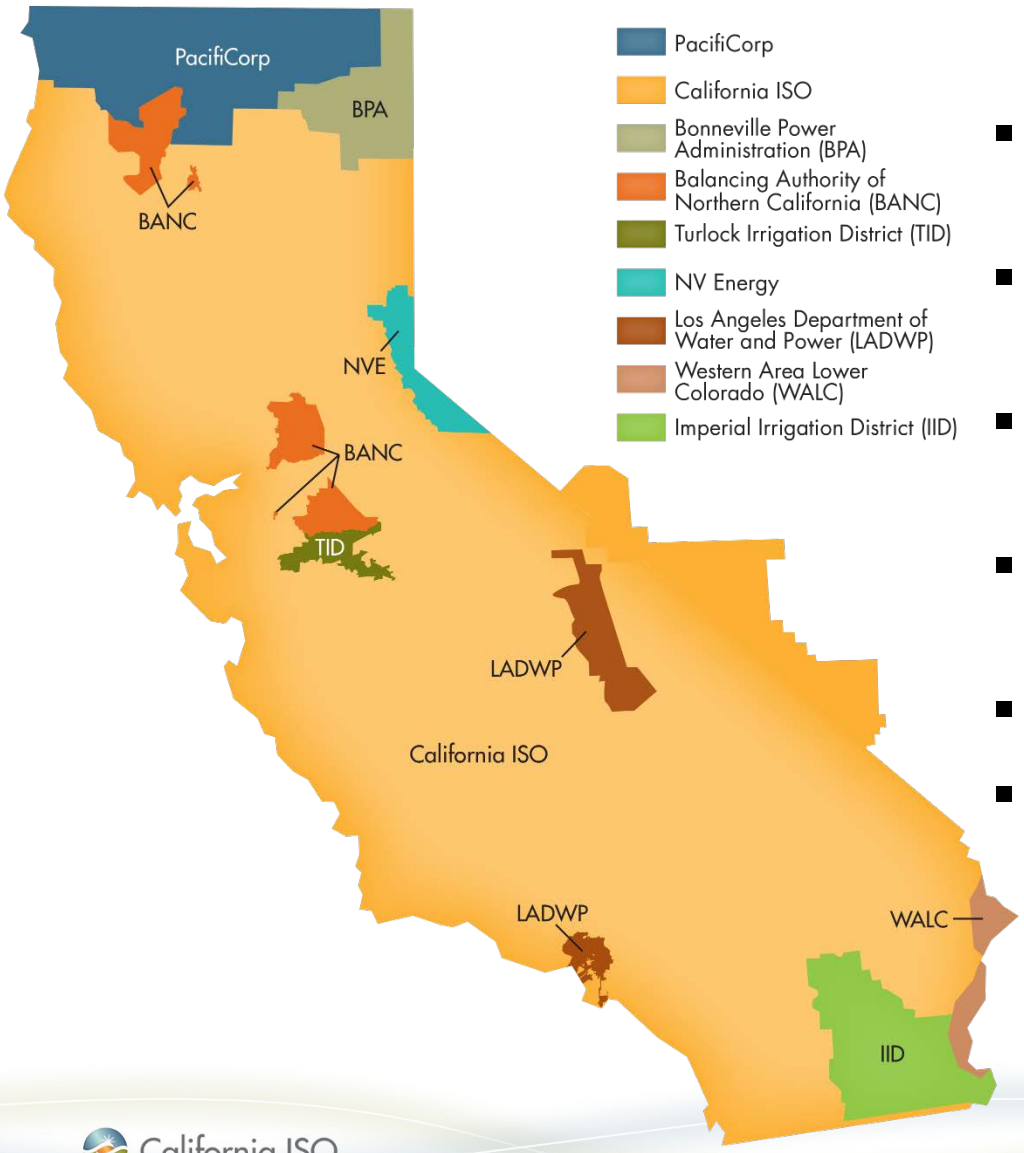
California Energy Commission - Staff Workshop on Offshore Renewable Energy

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

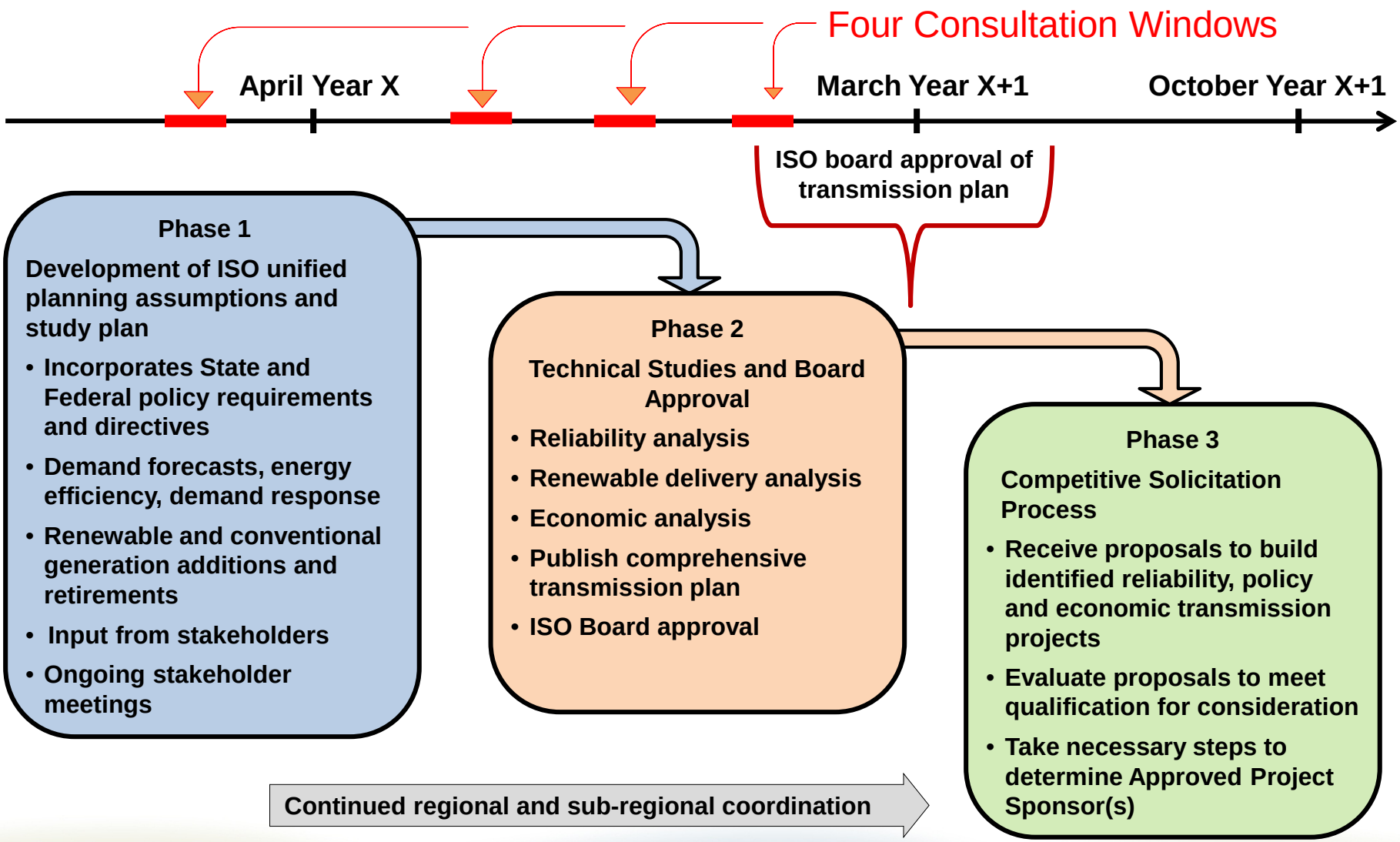
Procurement plan (Reg. Agency)

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



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

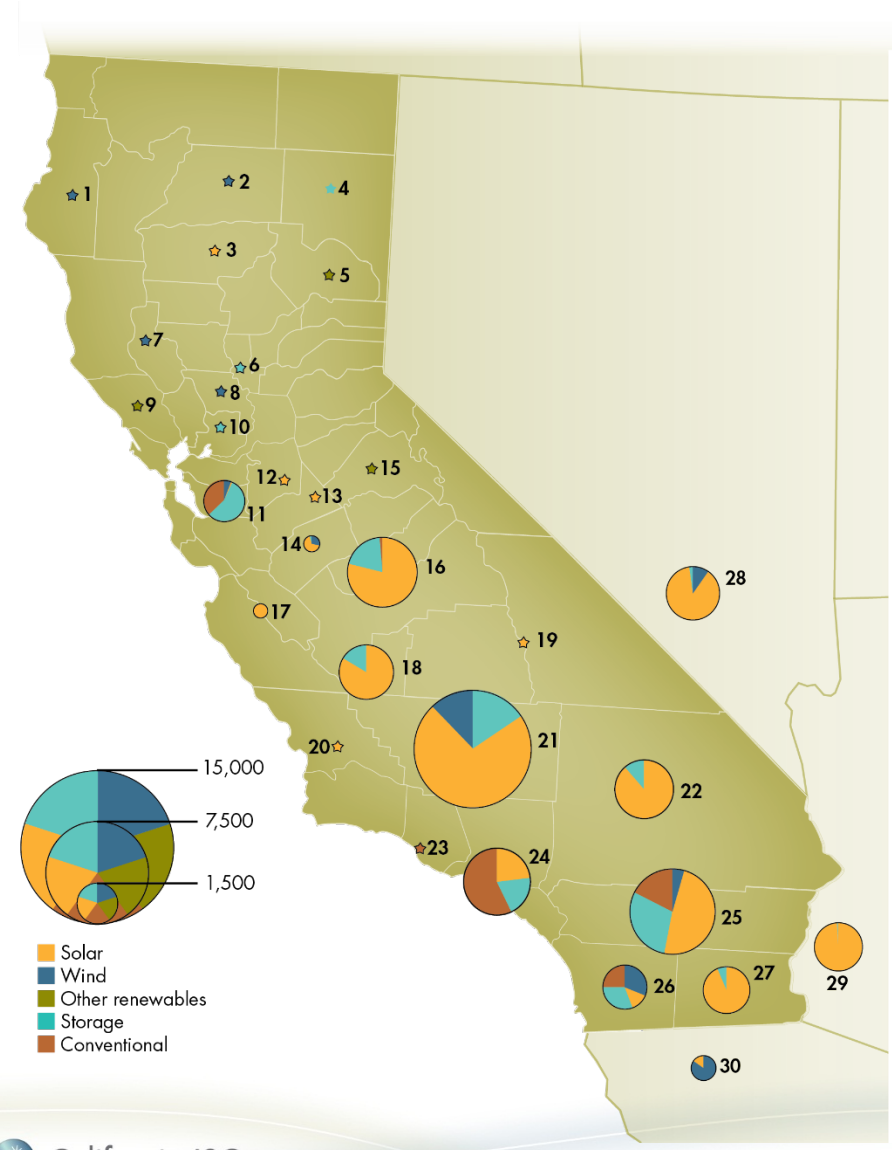
Transmission Planning Studies - Renewables

- 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

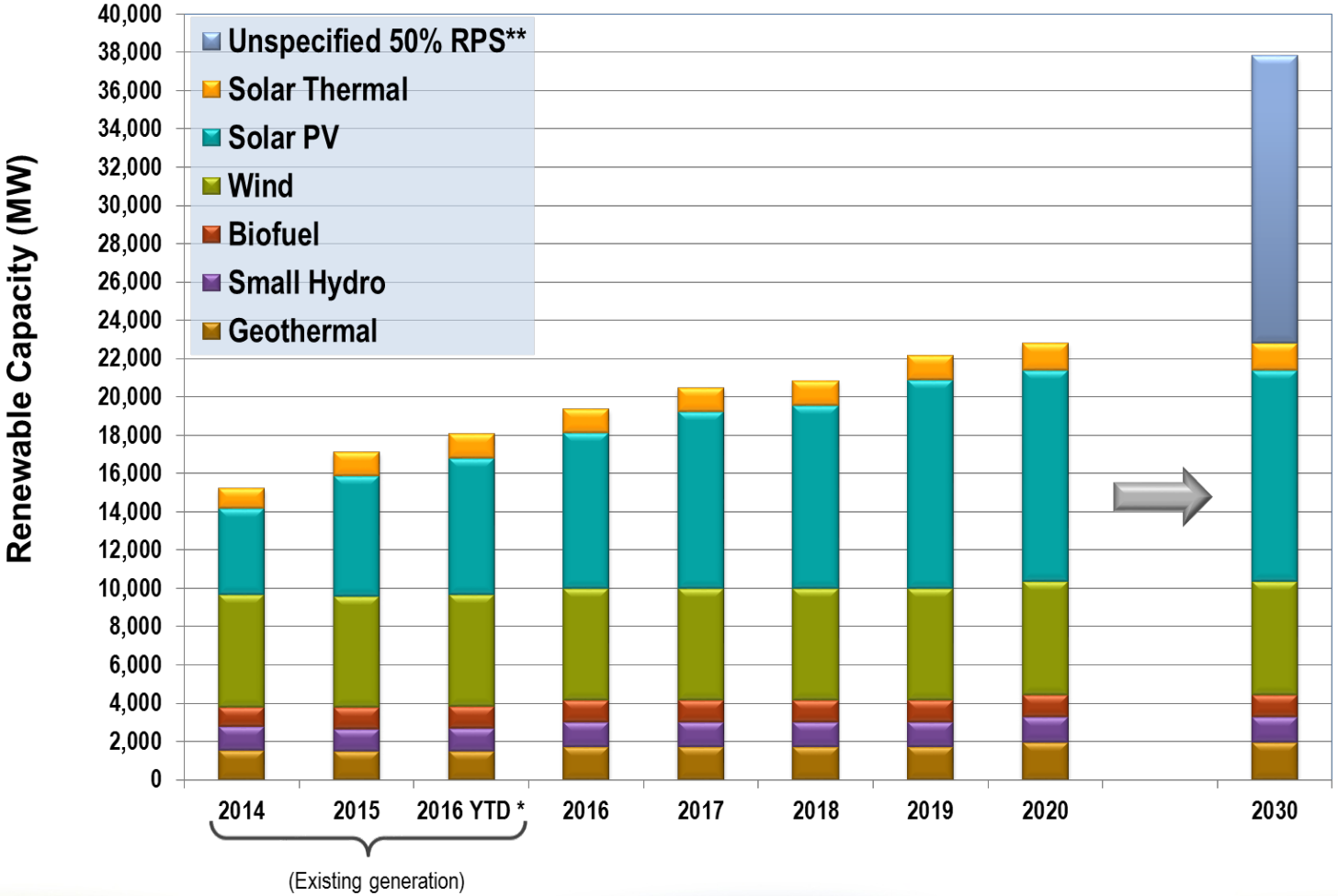


Interconnection queue by county

			Megawatts			
	County	# of Projects	Renewables	Storage	Conventional	Total
1	Humboldt	2	106	28		134
2	Shasta	1	200			200
3	Tehama	3	259			259
4	Lassen	2	21	27		48
5	Plumas	1	35			35
6	Sutter	1		64		64
7	Lake	2	145	13		158
8	Yolo	2	170			170
9	Sonoma	1	35			35
10	Solano	1		314		314
11	Alameda, Contra Costa, Santa Clara	11	139	1,087	723	1,949
12	San Joaquin	6	171	55	24	250
13	Stanislaus	3	451			451
14	Merced	6	591	28		619
15	Toulumne	2	11	10		21
16	Fresno, Madera	45	3,887	972	60	4,919
17	San Benito, Monterey	2	520			520
18	Kings	21	2,388	468		2,856
19	Tulare, Inyo	6	305	23		328
20	San Luis Obispo	1	40			40
21	Kern	60	8,696	1,187		9,883
22	San Bernardino	21	2,924	369		3,293
23	Ventura	2		26	300	326
24	Los Angeles, Orange	10	1,082	912	2,644	4,638
25	Riverside	24	3,571	1,989	1,170	6,730
26	San Diego	20	811	560	457	1,828
27	Imperial	7	1,880	125		2,005
	In-state Totals	263	28,438	8,257	5,378	42,073
28	Nevada	14	3,078	64		3,142
29	Arizona	14	3,493	20		3,513
30	Mexico	4	1,321			1,321
	Out-of-state Totals	32	7,892	84		7,976
	TOTAL ALL PROJECTS	**295**	**36,330**	**8,341**	**5,378**	**50,049**

as of January 9, 2017

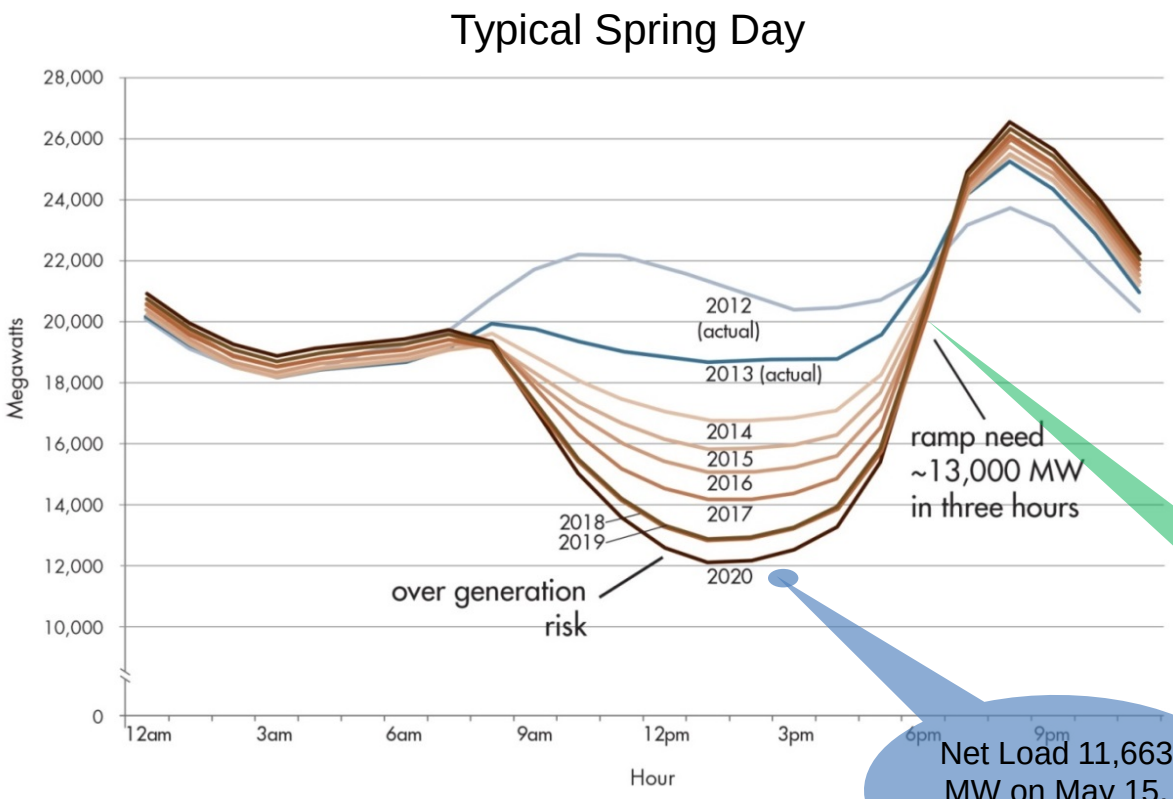
5,000 MW of additional transmission-connected renewables by 2020 and up to additional 15,000 MW by 2030 (predominately Solar PV)



*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

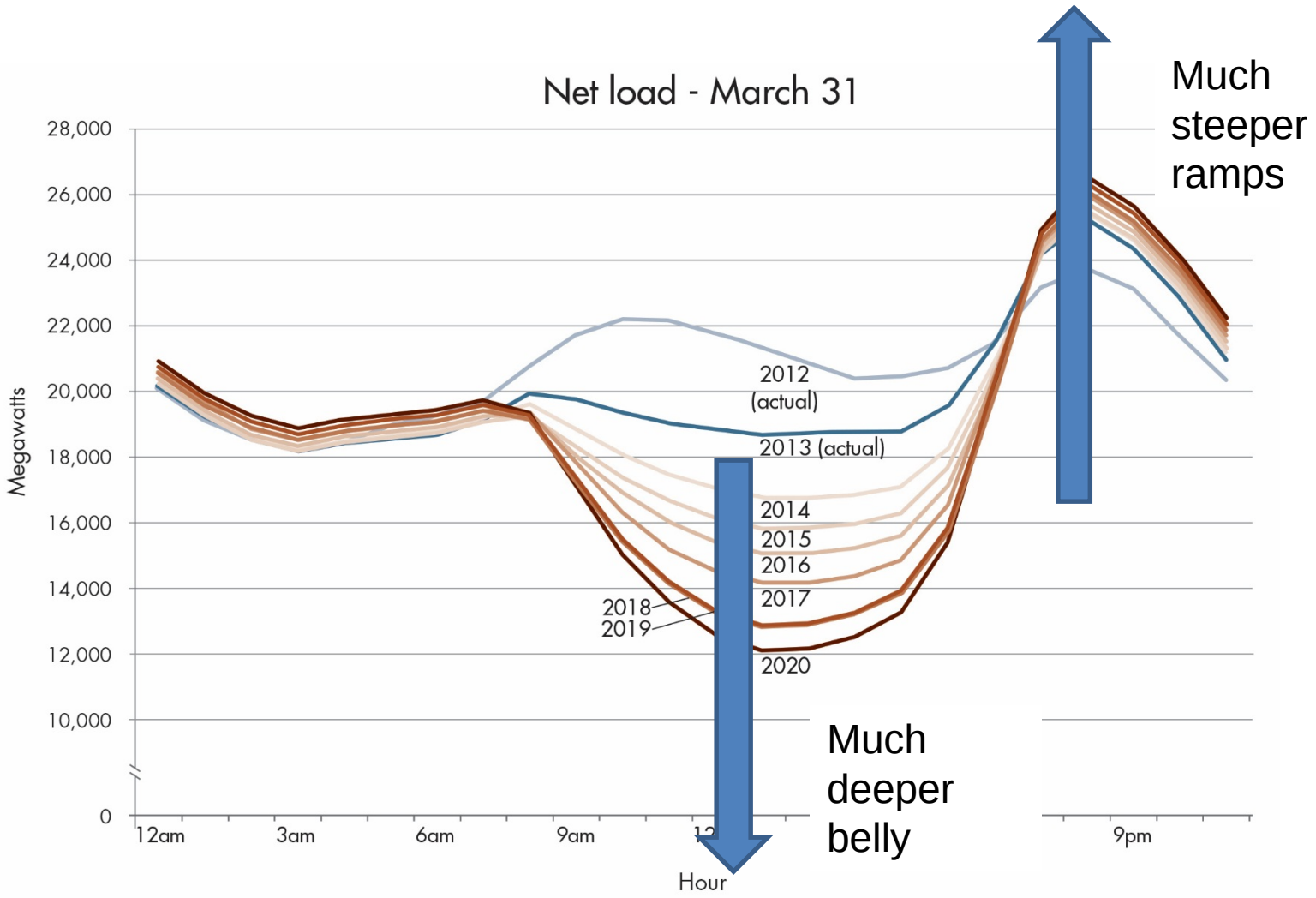


- ISO has already seen the need to curtail generation
- Oversupply may lead to curtailment because of dispatch limitations on some resources, such as
  - geothermal
  - nuclear
  - small hydro
  - combined heat and power
- Operational requirements include
  - minimum gas necessary to provide ramping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

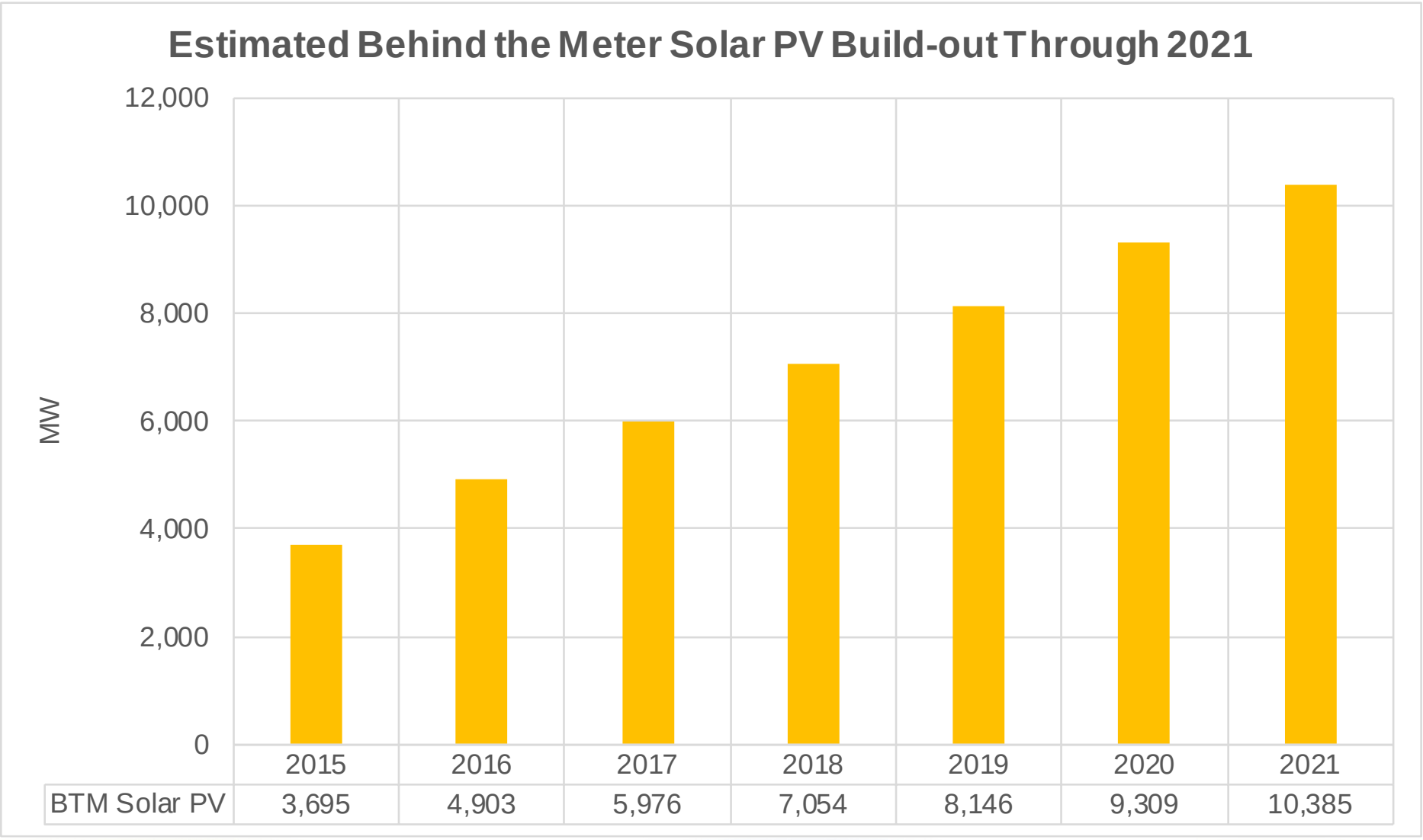
Net Load 11,663 MW on May 15, 2016

Actual 3-hour ramp 12,960 MW on December 18, 2016

ISO working on a 50% duck curve

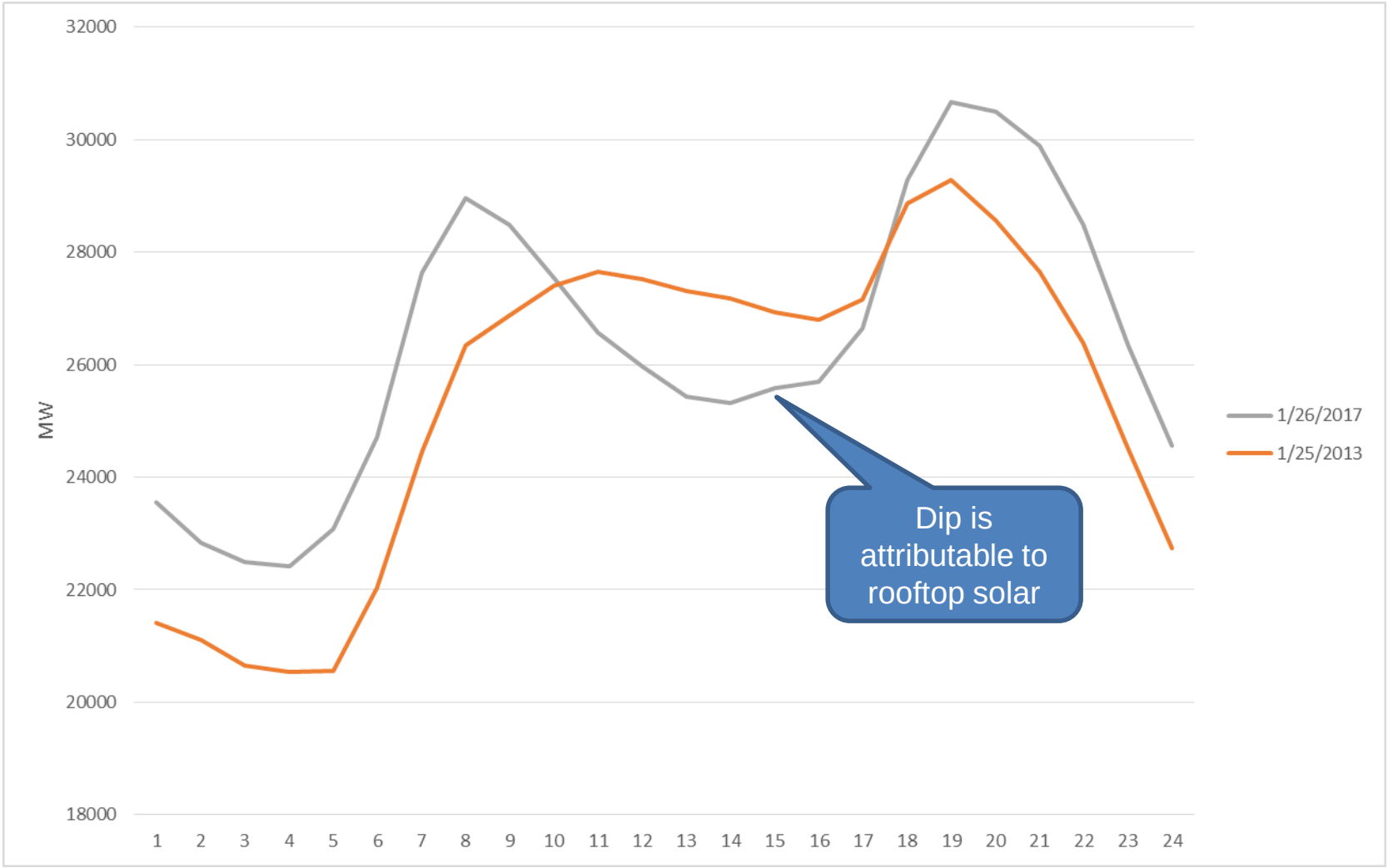


Behind the meter solar PV build-out through 2021

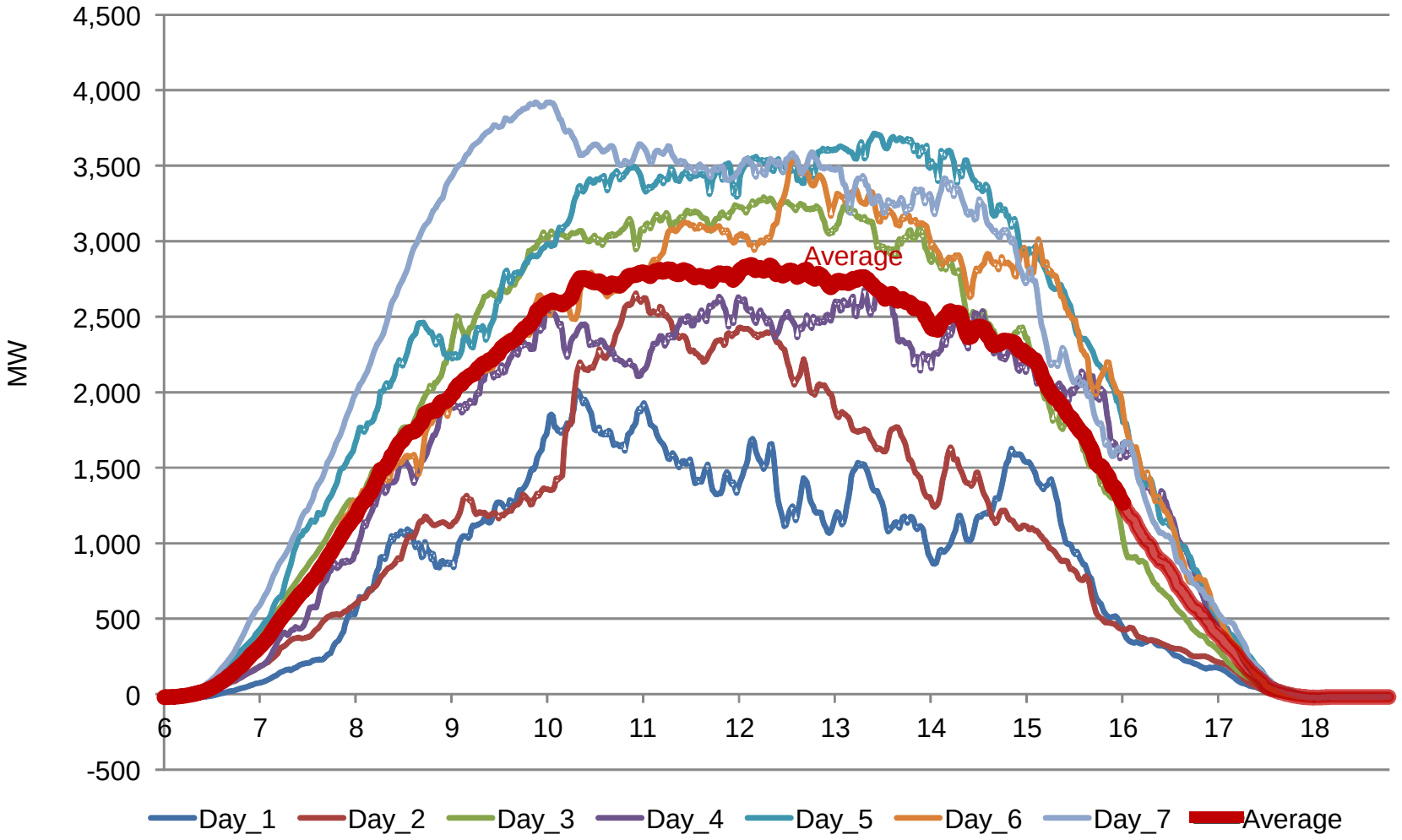


	2015	2016	2017	2018	2019	2020	2021
BTM Solar PV	3,695	4,903	5,976	7,054	8,146	9,309	10,385

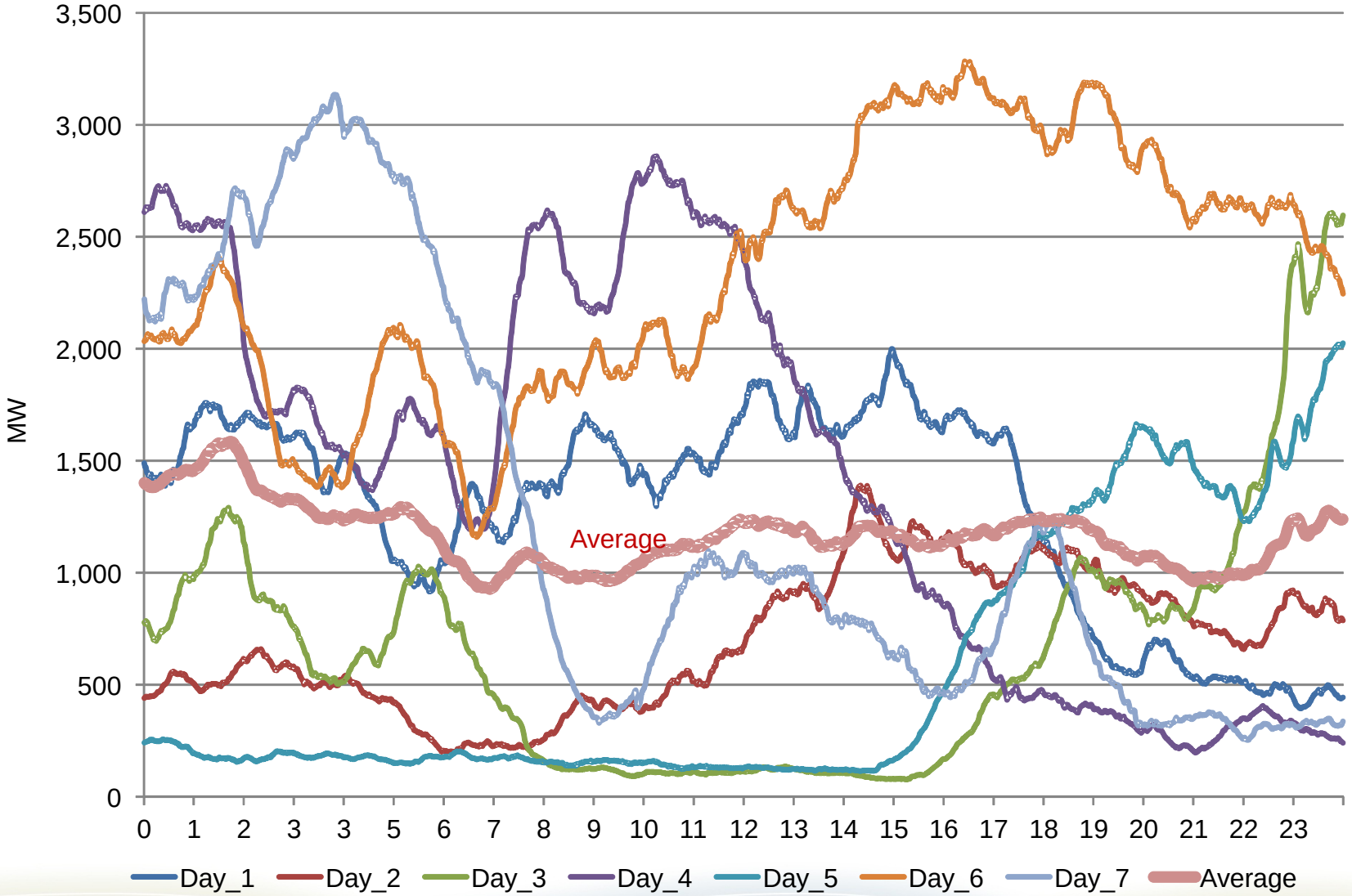
NOT the Duck: ISO gross load curve is changing



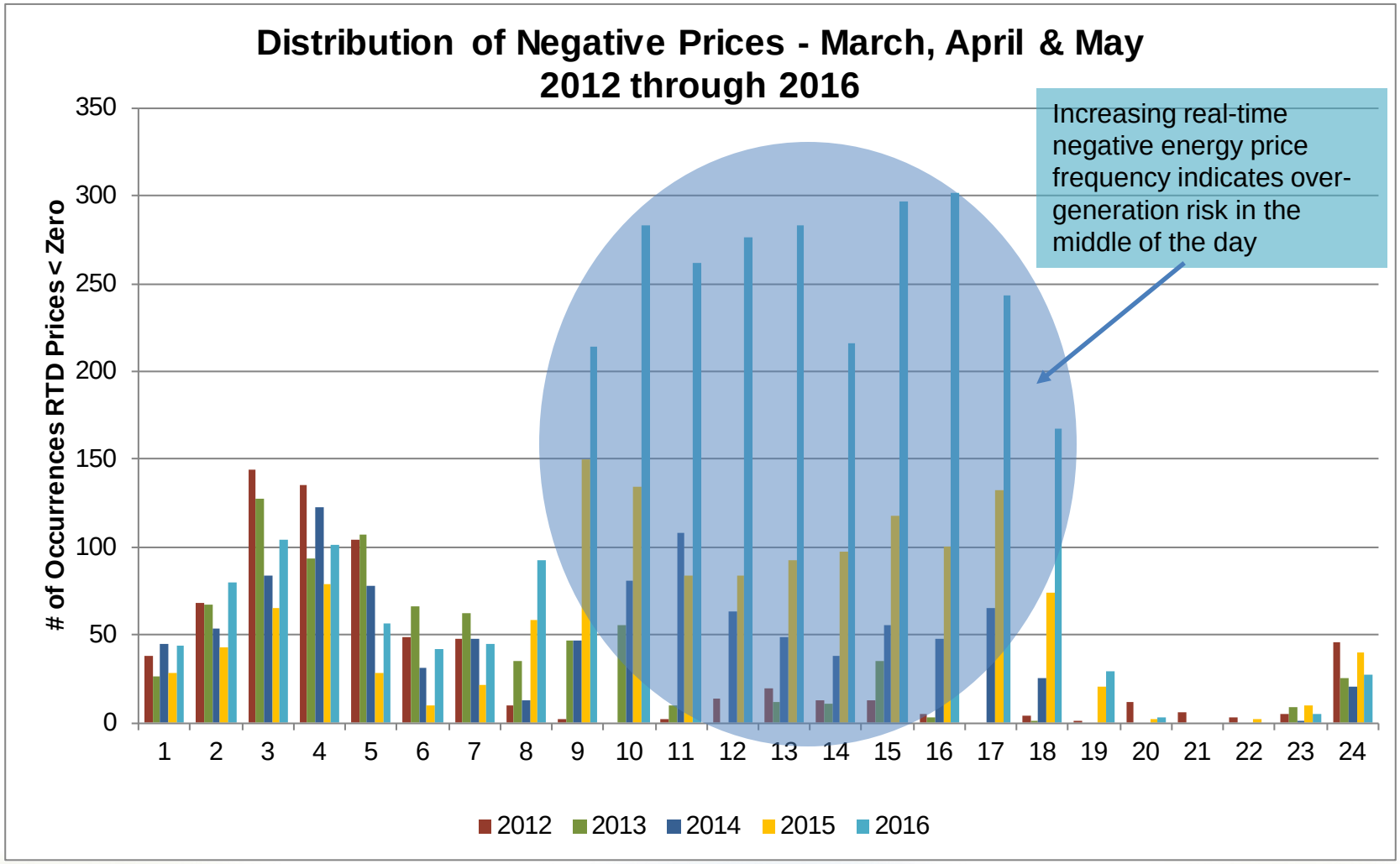
Solar production varies from one day to the next --- first week of March 2014



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



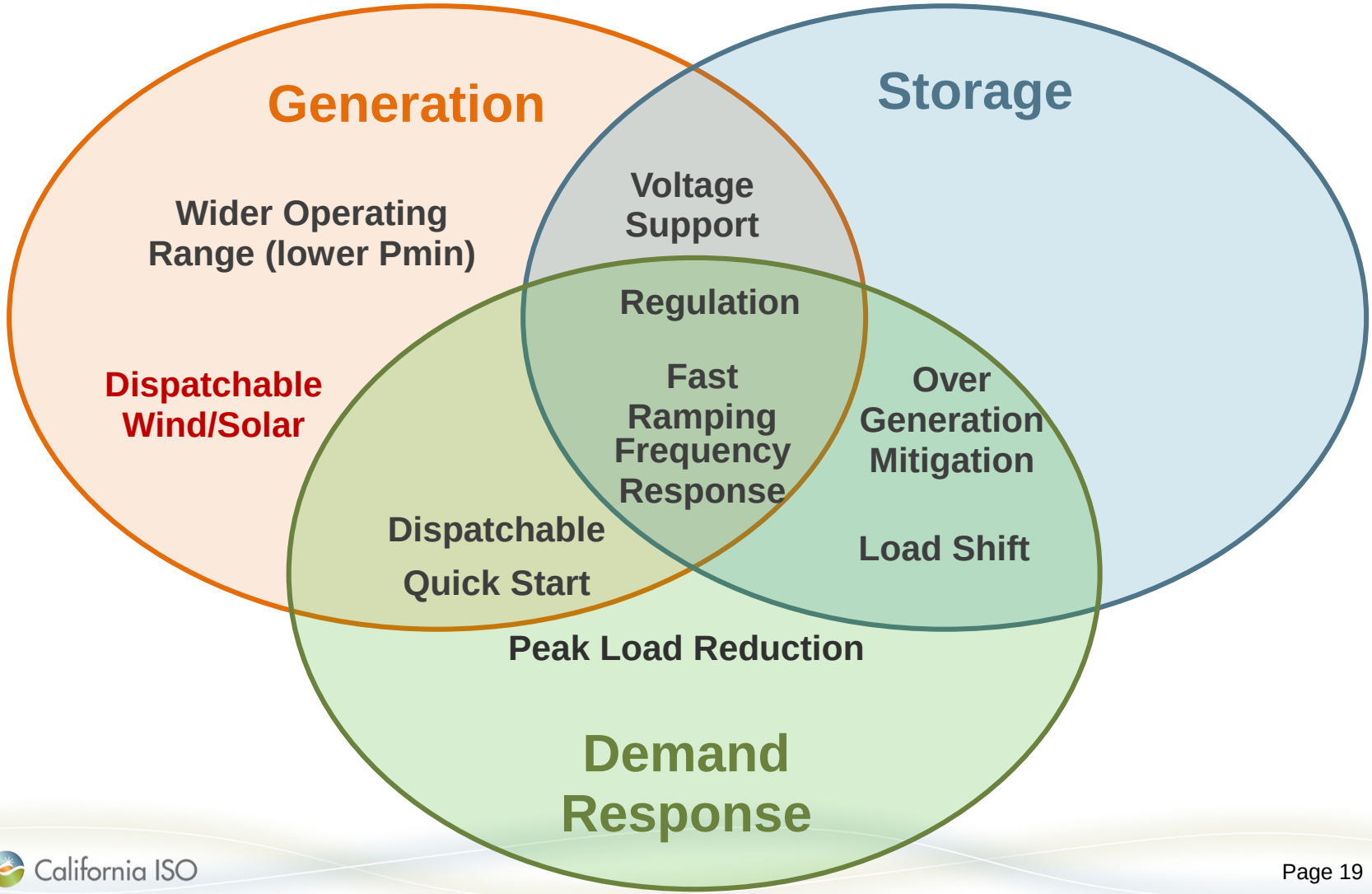
Summary of future grid operations to manage a more complex grid

- 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



Questions!