Draft Flexible Capacity Needs Assessment for 2018

Clyde Loutan
Principal, Renewable Energy Integration

Karl Meeusen, PhD
Senior Advisor, Infrastructure Policy

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What's the purpose of this call?

To discuss the assumptions, methodology and results of the monthly flexible capacity requirement

Specifically

Calculating requirements for all LRAs within the ISO footprint for RA compliance year 2018 and advisory flexible capacity requirements for compliance years 2019 and 2020

Agenda / Overview

- Background
- Process review
  - Expected build out from all LSEs (CPUC jurisdictional and non-Jurisdictional)
  - Load, wind and solar profiles
  - Calculate 3-hour net-load ramps
  - Add contingency reserves
  - Calculate monthly Flexible Capacity requirement
  - Next steps

Each LSE Scheduling Coordinator shall make a year-ahead and month-ahead showing of flexible capacity for each month of the compliance year

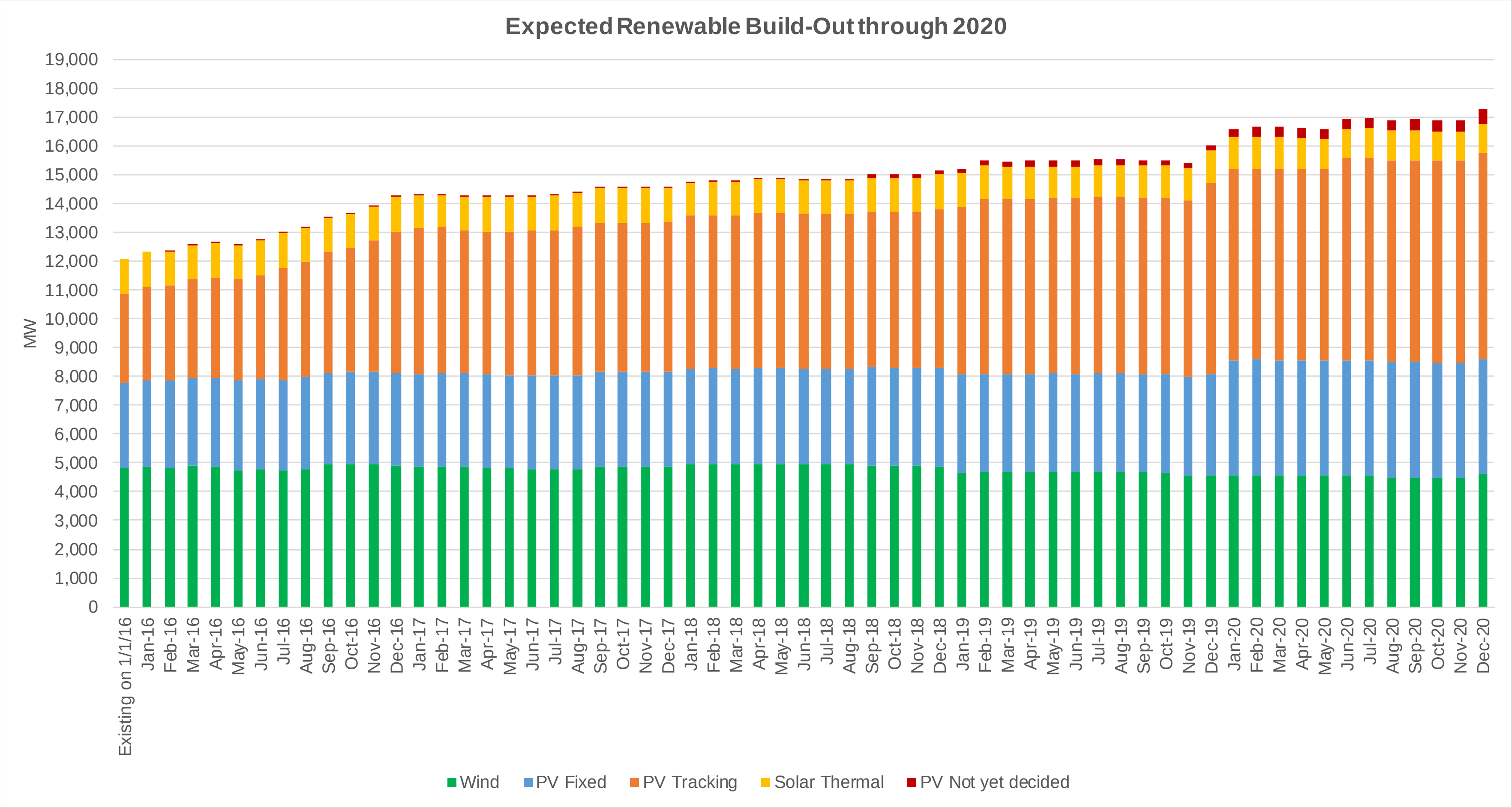
Resource Adequacy (RA)

- Ensure LSEs contract for adequate capacity to meet expected flexible needs
- Year ahead: LSEs need to secure a minimum of 90% of the next years monthly needs
- Month ahead: LSEs need to secure adequate net qualified capacity to serve their peak load including a planning reserve margin and flexible capacity to address largest three hour net load ramps plus contingency reserves
- All resources participating in the ISO markets under an RA contract will have an RA must-offer-obligation
- Required to submit economic bids into the ISO's real-time market consistent with the category of flexible capacity

What data did the ISO collect?

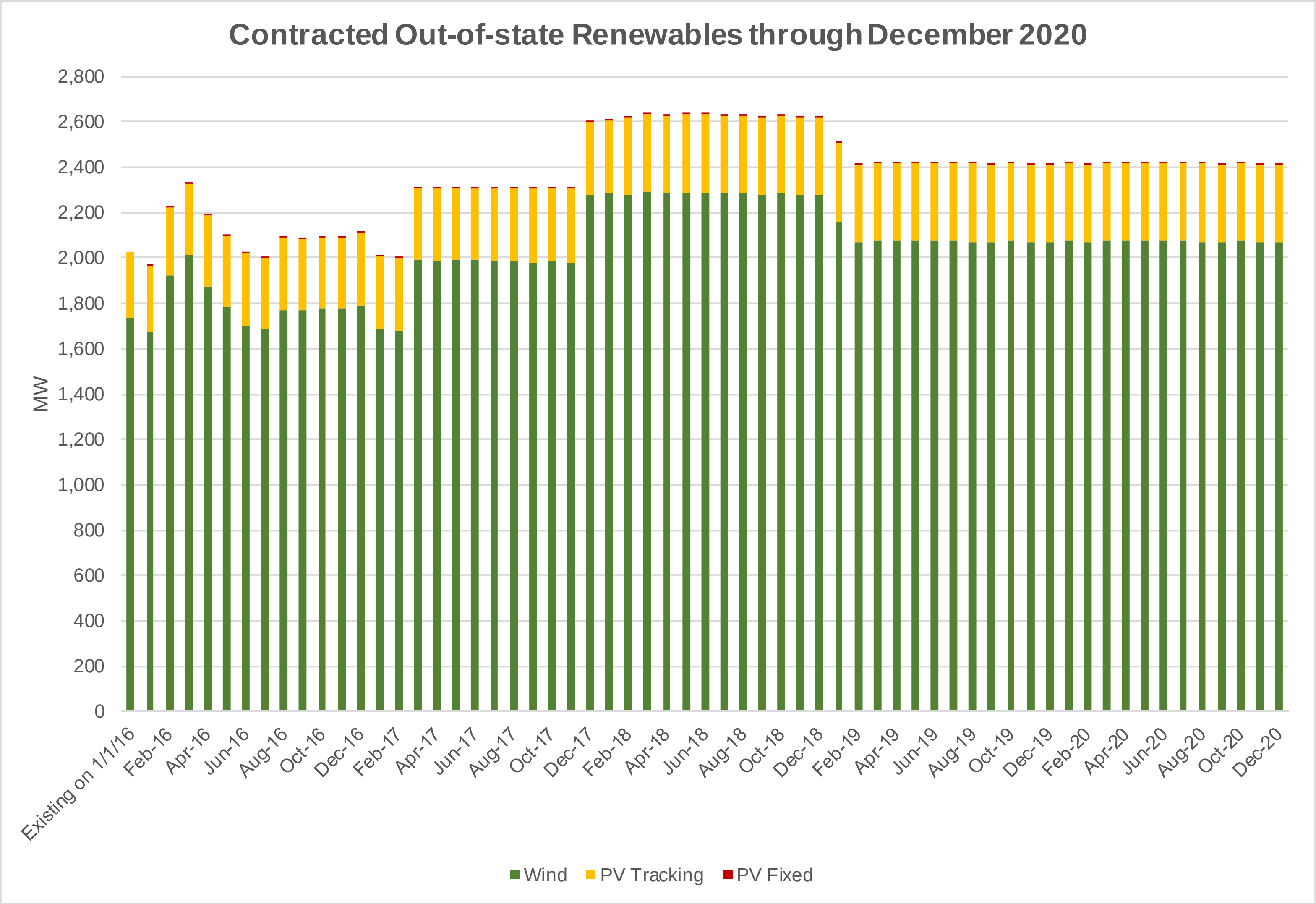
- CEC’s monthly demand forecast (e.g. 2017-20 demand forecast)
- LSE SCs updated renewable build-out for 2016 through 2020
- The data included:
  - Installed capacity by technology and expected operating date (e.g. Solar thermal, solar PV tracking, solar PV non-tracking, estimate of behind-the-meter solar PV etc.) for all variable energy resources under contract
  - Operational date or expected on-line date
  - Location of CREZ latitude and longitude coordinates
  - Resources located outside ISO’s BAA indicated if the resources are firmed or non-firmed

Renewable build-out through December 2020

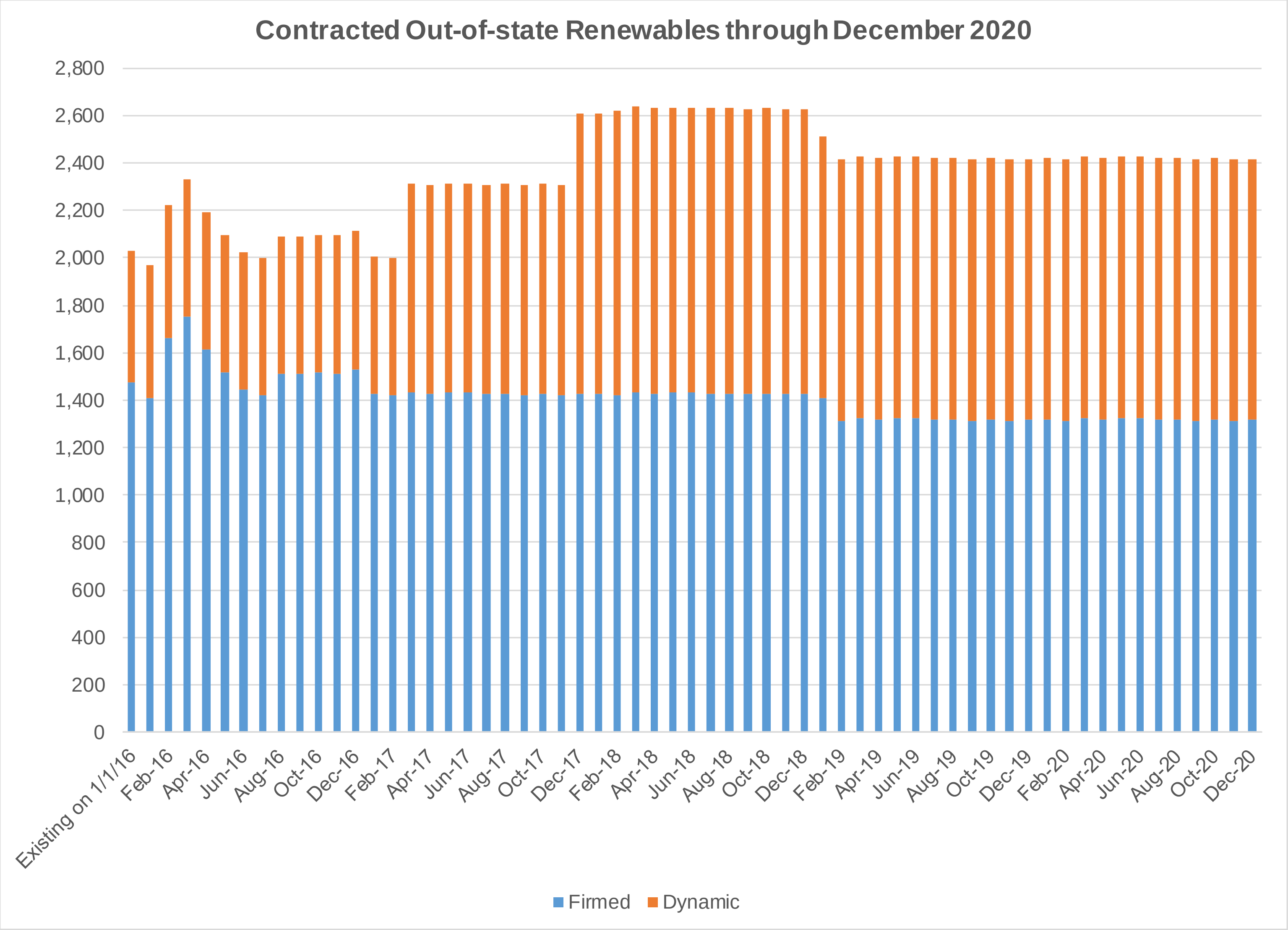


California ISO

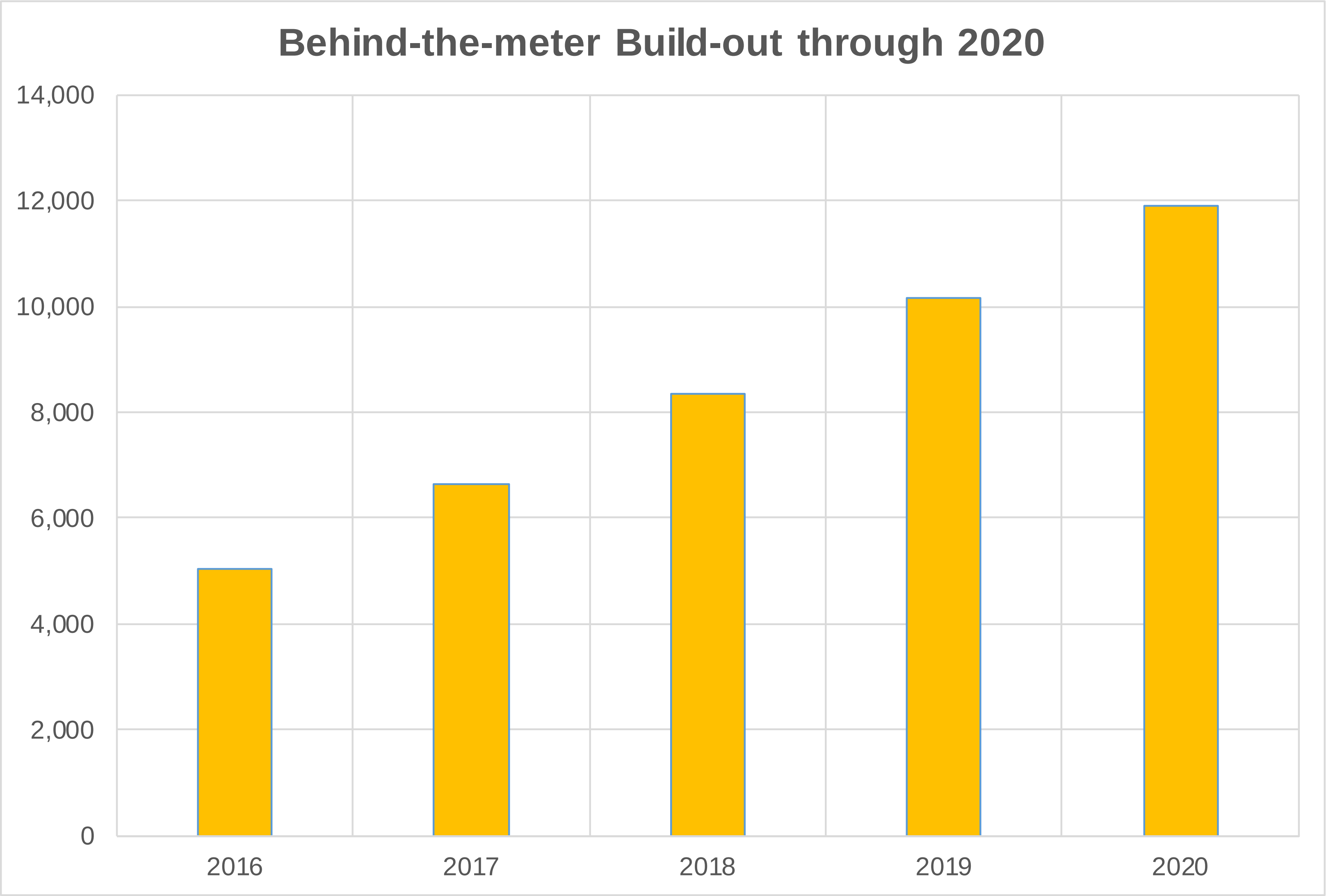
Out of state renewable imports through December 2020



Firmed and non-firmed out of state imports through December 2020

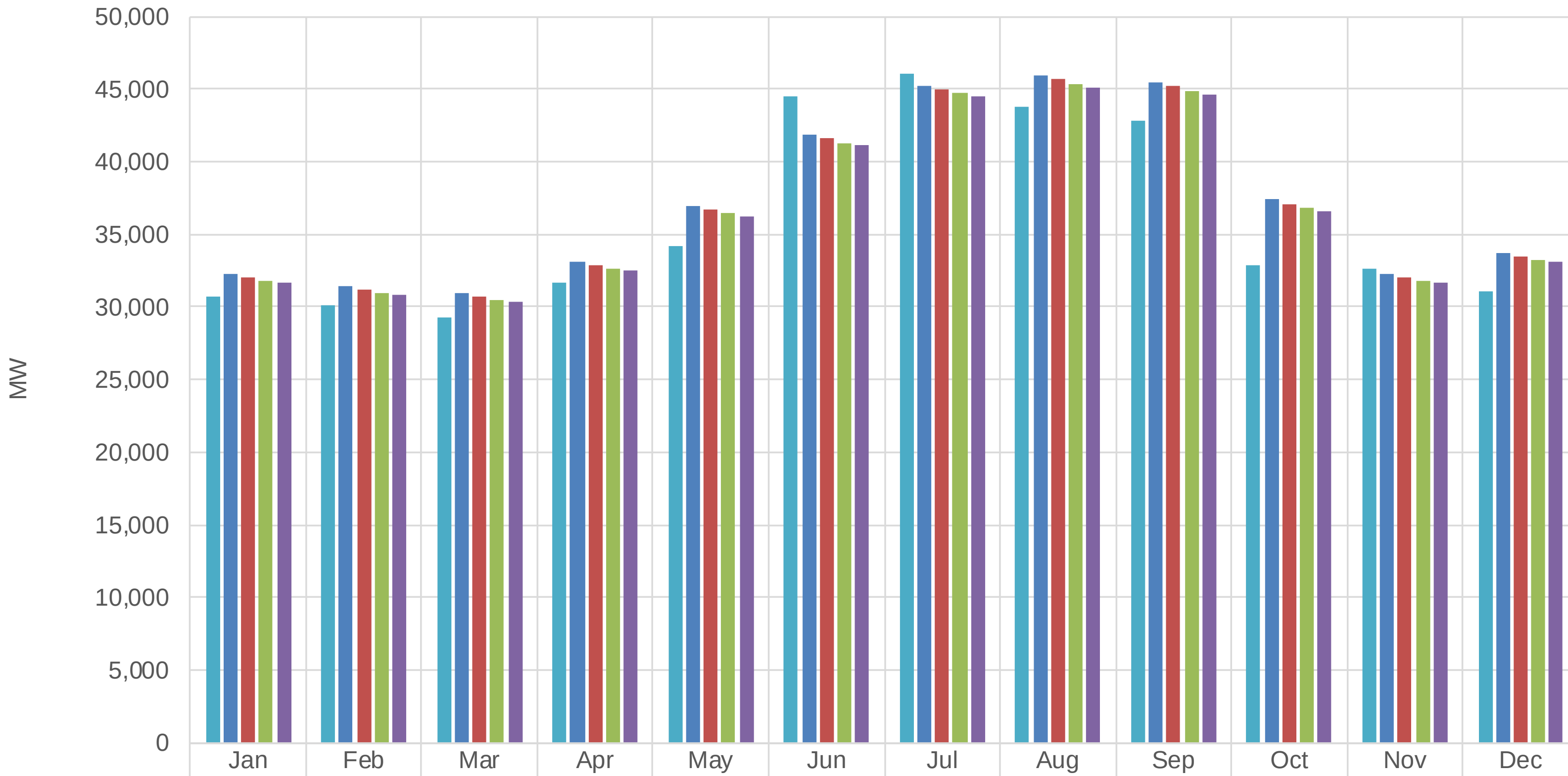


Behind the meter solar PV build-out through 2020



Projected 1 in 2 CAISO coincident peak, CEC Planning Forecast (Mid Baseline, Mid AAEE)

CEC Planning Monthly Forecast for 2017 through 2020 vs. 2016 Actuals



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016 (Actual)	30,669	30,096	29,294	31,619	34,250	44,452	46,008	43,798	42,837	32,823	32,664	31,039
2017	32,299	31,453	30,944	33,113	36,989	41,834	45,259	45,967	45,489	37,384	32,322	33,661
2018	32,052	31,195	30,688	32,843	36,719	41,577	44,978	45,652	45,188	37,074	32,054	33,434
2019	31,845	30,979	30,477	32,613	36,463	41,312	44,685	45,336	44,882	36,799	31,826	33,241
2020	31,709	30,832	30,335	32,455	36,288	41,137	44,487	45,115	44,671	36,606	31,667	33,121

2016 (Actual) 2017 2018 2019 2020

The ISO flexibility capacity assessment is based on current LSE's RPS build-out data

- Uses most current data available for renewable build-out obtained from all LSE SCs
- For new renewable installation scale 2016 actual production data based on installed capacity in subsequent years
- For new BTM use NEXANT production data located in close geographic proximity
- Generate net-load profiles for 2017 through 2020
  - Generate load profiles for 2017 through 2020
  - Generate solar profiles for 2017 through 2020
  - Generate wind profiles for 2017 through 2020

The ISO used the CEC's 1-in-2 monthly peak load forecast to develop the load forecast

- Used 2016 actual 1-minute load data to build 1-minute load profiles for 2017 through 2020
- Scaled the actual 1-minute load value of each month of 2016 using a load growth factor of monthly peak forecast divided by actual 2016 monthly peak

2017 Load Growth Assumptions

- Scale the actual 1-minute load value of each month of 2016 by the fraction $(\text{Monthly}_{2017\_Peak\_Load\_Forecast}/\text{Monthly}_{2016\_Actual\_Peak\_Load})$

2018 Load Growth Assumptions

- Scale each 1-minute load data point of 2017 by the fraction $(\text{Monthly}_{2018\_Peak\_Load\_Forecast}/\text{Monthly}_{2016\_Peak\_Load})$

2019 Load Growth Assumptions

- Scale each 1-minute load data point of 2018 by the fraction $(\text{Monthly}_{2019\_Peak\_Load\_Forecast}/\text{Monthly}_{2016\_Peak\_Load})$

1-minute behind the meter solar PV data was developed using the methodology outlined below

TRACK I DIRECT TESTIMONY OF MARK ROTHLEDER ON BEHALF OF THE CALIFORNIA INDEPENDENT SYSTEM OPERATOR CORPORATION (Rulemaking 10-05-006)

Located at:

https://www.caiso.com/Documents/2011-08-10_ErrataLTPPTestimony_R10-05-006.pdf

Wind growth assumptions

- Use actual 1-minute wind production data for the most recent year e.g. 2017 wind forecast uses actual production data from 2016
- Projects installed in 2016 were modeled in 2017 for the months the projects were not yet in-service in 2016 (e.g. projects installed in May 2016 was included in January through April of 2017
- Scale 1-minute data using expected capacity for the new plants scheduled to be operational in 2017
- Repeat the above steps for 2018, 2019 & 2020

$$2017\ W_{Mth\_Sim\_1\text{-}min} = 2016W_{Act\_1\text{-}min} * 2017W_{Mth\ Capacity} / 2016W_{Mth\ Capacity}$$

$$2018\ W_{Mth\_Sim\_1\text{-}min} = 2016W_{Act\_1\text{-}min} * 2018W_{Mth\ Capacity} / 2016W_{Mth\ Capacity}$$

$$2019\ W_{Mth\_Sim\_1\text{-}min} = 2016W_{Act\_1\text{-}min} * 2019W_{Mth\ Capacity} / 2016W_{Mth\ Capacity}$$

$$2020\ W_{Mth\_Sim\_1\text{-}min} = 2016W_{Act\_1\text{-}min} * 2020W_{Mth\ Capacity} / 2016W_{Mth\ Capacity}$$

Solar growth assumptions

Existing solar

- Use the actual solar 1-minute production data for the most recent year

  e.g. 2017 forecast uses 2016 actual 1-minute data (**$2016_{Act\_1\text{-}min}$**)

New solar installation

- Develop 1-minute solar production profiles by scaling actual 2016 1-minute data by the monthly installed capacity in 2017 divided by the monthly installed capacity in 2016
- Projects installed in 2016 were modeled in 2017 for the months the projects were not yet in-service

Total solar $2017_{1\text{-}min} = 2016_{Act\_1\text{-}min} * 2017_{Monthly\_1\text{-}min} / 2016_{Installed\_Capacity}$

Net-load is a NERC accepted metric[1] for evaluating additional flexibility needs to accommodate VERs

- Net load is the aggregate of customer demand reduced by variable generation power output
- Net-load is more variable than load itself and it increases as VER production increases
- The monthly three-hour flexible capacity need equates to the largest up-ward change in net-load when looking across a rolling three-hour evaluation window
- The ISO dispatches flexible resources to meet net-load

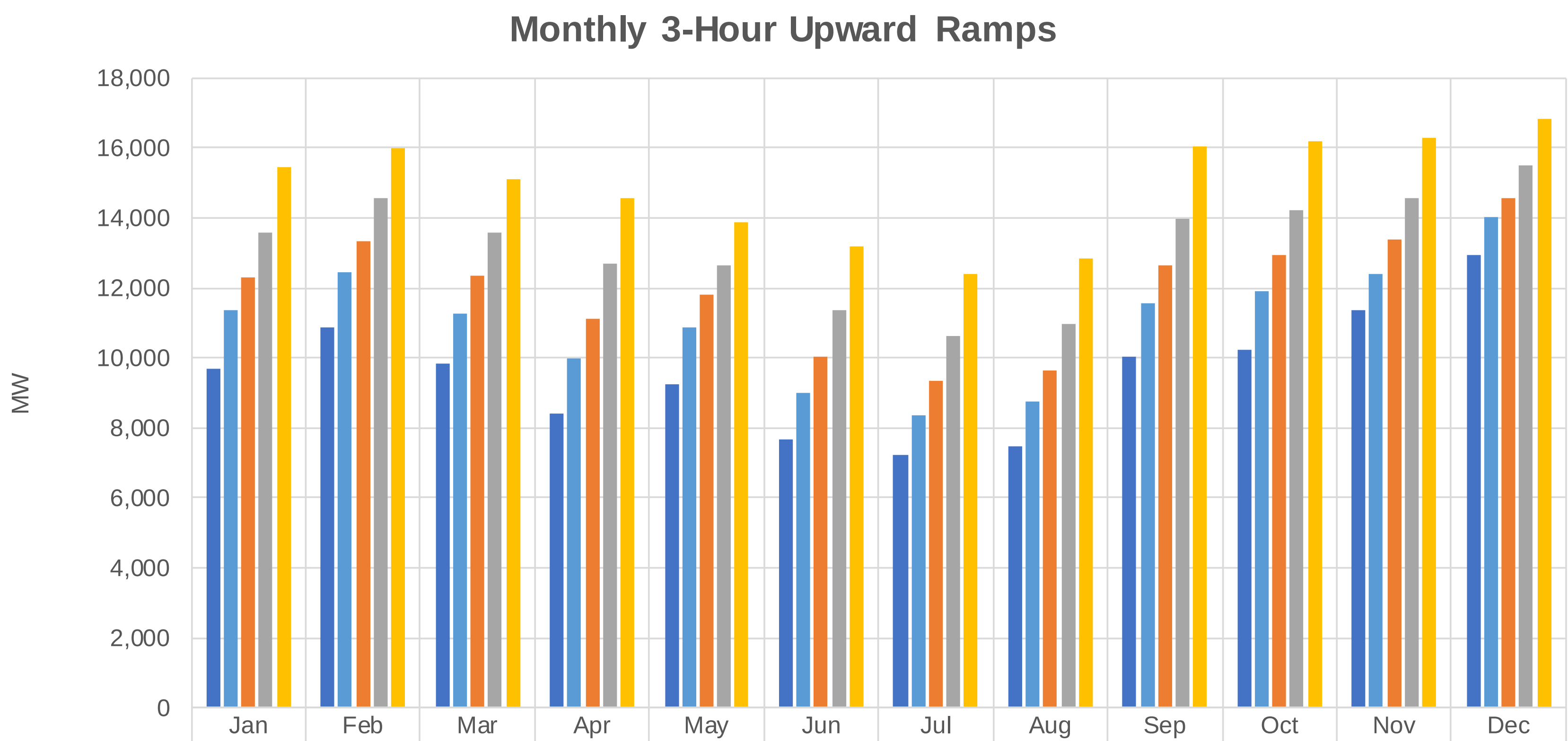
1 NERC Special Report
Flexibility Report Requirements and metrics for Variable Generation: Implications for System Planning Studies, August 2010 . http://www.nerc.com/files/IVGTF_Task_1_4_Final.pdf

The monthly 3-hour upward ramping need is calculated using the largest ramp in each 180 minute period

- The maximum monthly three-hour net load ramp within a three-hour period is the highest MW value reached within any three-hour moving window
- The maximum net-load change in three-hours can occur in less than three hours
- The maximum 3-hour upward ramp was calculated as:

  Net Load_{181}-Net Load_{1}, Net Load_{182}-Net Load_{2}, …. Net Load_{n+180}-Net Load_{n}

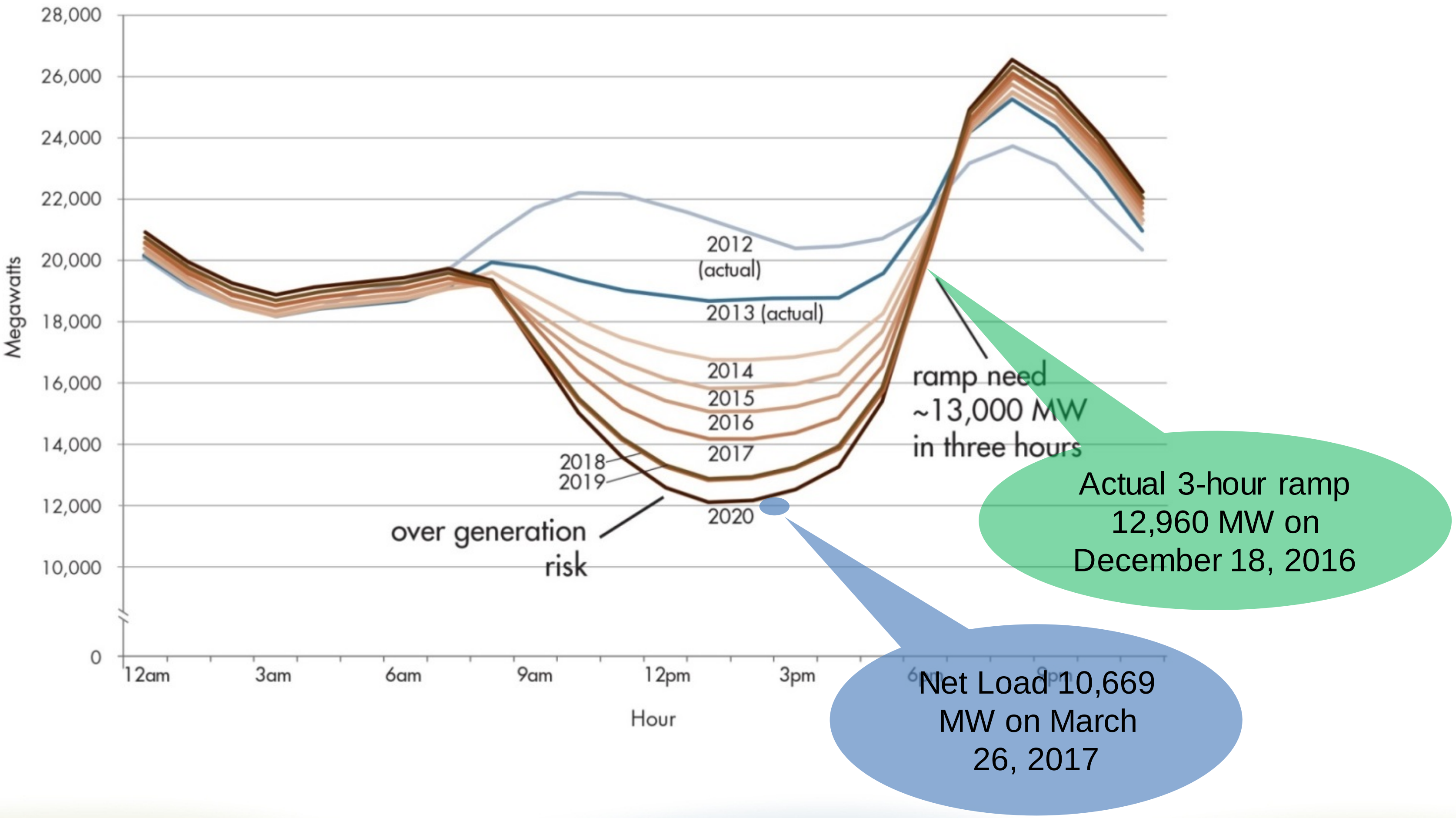
Maximum monthly three-hour upward net-load ramps for 2016 through 2019



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016 (Actual)	9,687	10,891	9,828	8,397	9,263	7,669	7,214	7,463	10,030	10,228	11,375	12,960
2017	11,342	12,465	11,253	9,973	10,878	8,996	8,379	8,768	11,575	11,900	12,391	14,004
2018	12,282	13,313	12,352	11,111	11,803	10,039	9,326	9,617	12,660	12,954	13,376	14,567
2019	13,595	14,543	13,574	12,672	12,631	11,350	10,616	10,982	13,981	14,199	14,553	15,495
2020	15,439	15,984	15,089	14,572	13,859	13,181	12,391	12,821	16,061	16,169	16,293	16,817

Actual net-load and 3-hour ramps are approximately 4 years ahead of the original estimate

Typical Spring Day



Contingency reserves is a NERC/WECC requirement BAs must have available in real-time

- Each Balancing Authority and each Reserve Sharing Group shall maintain a minimum amount of Contingency Reserve, except within the first sixty minutes following an event requiring the activation of Contingency Reserve
- To meet WECC and NERC reliability criteria, the ISO must have contingency reserves equal to the greater of:

    1) the most severe single contingency (“MSSC”)

    2) the sum of 3% of hourly integrated load plus 3% percent of hourly integrated generation

- 50% of the contingency reserve must be spinning reserve
- Contingencies can occur during ramps and the ISO must be prepared to dispatch contingency reserve to recover its Area Control Error (ACE) within 15-minutes following a disturbance
- Contingency reserves are held for contingency events and cannot be dispatched to meet day-to-day net-load ramps

For more information please refer to: WECC Standard BAL-002-WECC-2---Contingency Reserve

Preliminary Results

Karl Meeusen, Ph.D.
Senior Advisor – Infrastructure Policy

The proposed interim flexible capacity methodology designed to provide the ISO with sufficient flexible capacity

- Methodology

Flexibility $Requirement_{MTHy} = Max[(3RR_{HRx})_{MTHy}] + Max(MSSC, 3.5\%*E(PL_{MTHy})) + \varepsilon$

Where:

$Max[(3RR_{HRx})_{MTHy}]$ = Largest three hour contiguous ramp starting in hour x for month y

E(PL) = Expected peak load

MTHy = Month y

MSSC = Most Severe Single Contingency

ε = Annually adjustable error term to account for load forecast errors and variability

Flexible capacity requirement is split into its two component parts to determine the allocation

- The largest 3-hour net-load ramp is decomposed into four components to determine the LRA's allocation

  Three hour net load ramp =

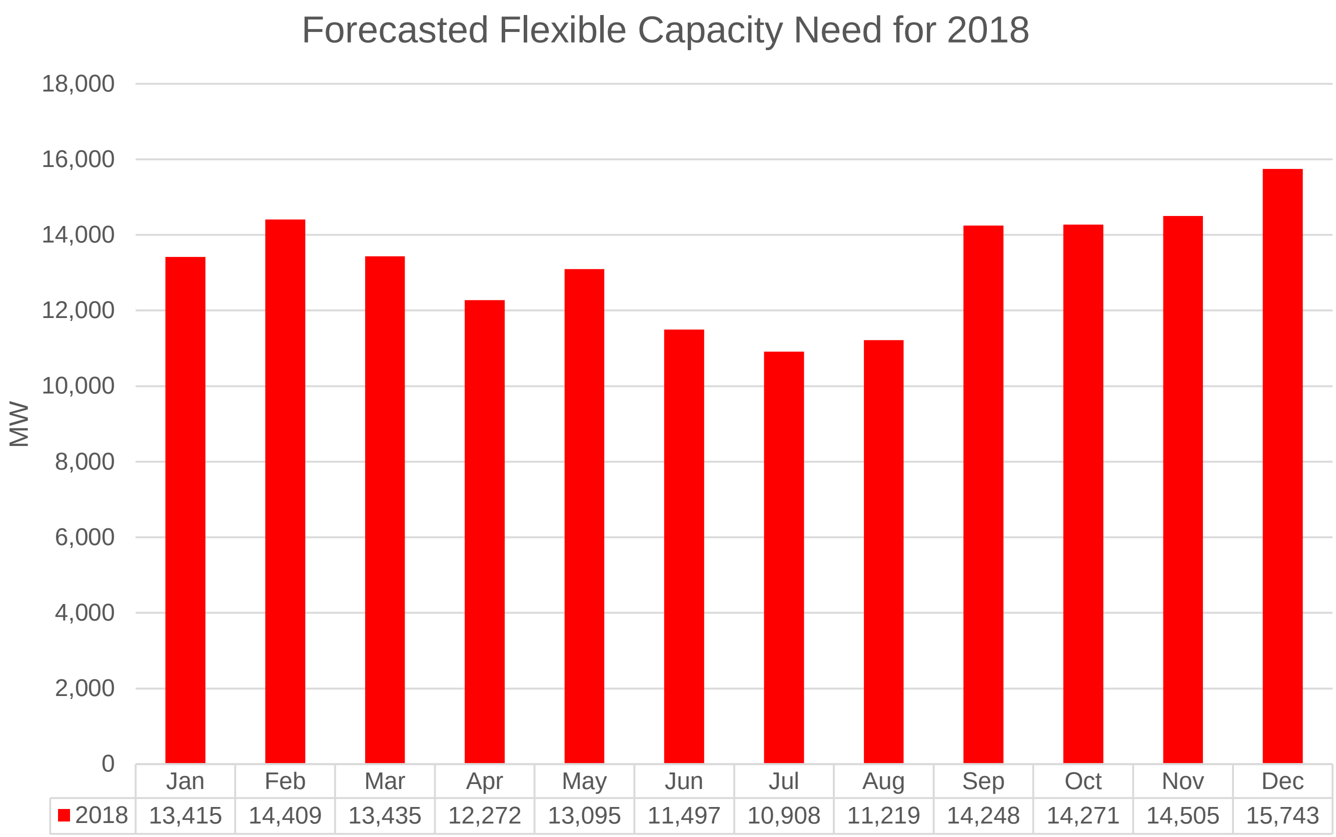
  Δ Load – Δ Wind Output – Δ Solar PV – Δ BTM Solar

- Maximum of the Most Severe Single Contingency or 3.5 percent of forecasted coincident peak
  - Allocated to LRA based on peak-load ratio share

Contributions to the three hour net load ramp: Load, wind, grid scale solar, incremental behind the meter solar

	3-hour net load ramp 2018	3.5% expected peak load 2018	Flexible Capacity Requirement 2018	Average of Load contribution 2018	Average of solar PV contribution 2018	Average of BTM Solar contribution 2018	Average of Wind contribution 2018	Total percent 2018
January	12,282	1,133	13,415	40%	-56%	-5%	1%	100%
February	13,313	1,096	14,409	39%	-54%	-5%	-3%	100%
March	12,352	1,082	13,435	32%	-60%	-8%	-1%	100%
April	11,111	1,161	12,272	21%	-71%	-9%	1%	100%
May	11,803	1,292	13,095	15%	-72%	-7%	-6%	100%
June	10,039	1,458	11,497	9%	-80%	-10%	-1%	100%
July	9,326	1,582	10,908	6%	-83%	-12%	1%	100%
August	9,617	1,602	11,219	11%	-87%	-12%	10%	100%
September	12,660	1,588	14,248	16%	-73%	-10%	0%	100%
October	12,954	1,317	14,271	21%	-65%	-10%	-4%	100%
November	13,376	1,129	14,505	28%	-60%	-10%	-2%	100%
December	14,567	1,176	15,743	42%	-48%	-6%	-3%	100%

Forecasted monthly 2018 ISO system-wide flexible capacity needs*



*Flexibility Requirement$_{MTHy}$= Max[(3RR$_{HRx}$)$_{MTHy}$] + Max(MSSC, 3.5%*E(PL$_{MTHy}$)) + ε
ε = 0

Flexible capacity categories allow a wide variety of resources to provide flexible capacity

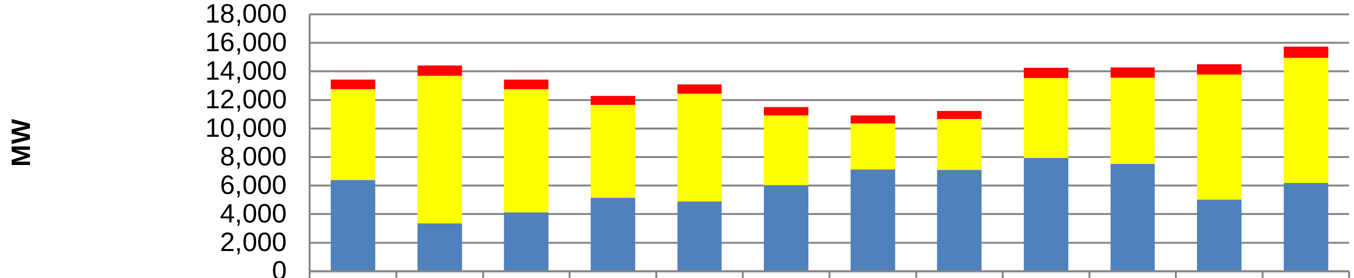
- <u>Category 1 (Base Flexibility)</u>: Operational needs determined by the magnitude of the largest 3-hour secondary net-load ramp
- <u>Category 2 (Peak Flexibility)</u>: Operational need determined by the difference between 95 percent of the maximum 3-hour net-load ramp and the largest 3-hour secondary net-load ramp
- <u>Category 3 (Super-Peak Flexibility)</u>: Operational need determined by five percent of the maximum 3-hour net-load ramp of the month

Seasonal breakout of flexible capacity needs

	Actual Contributions			Seasonal Contribution		
Month	Base Flexibility	Peak Flexibility	Super-Peak Flexibility	Base Flexibility	Peak Flexibility	Super-Peak Flexibility
January	48%	47%	5%	39%	56%	5%
February	23%	72%	5%	39%	56%	5%
March	31%	64%	5%	39%	56%	5%
April	42%	53%	5%	39%	56%	5%
May	37%	58%	5%	55%	40%	5%
June	52%	43%	5%	55%	40%	5%
July	65%	30%	5%	55%	40%	5%
August	63%	32%	5%	55%	40%	5%
September	56%	39%	5%	55%	40%	5%
October	53%	42%	5%	39%	56%	5%
November	35%	60%	5%	39%	56%	5%
December	39%	56%	5%	39%	56%	5%

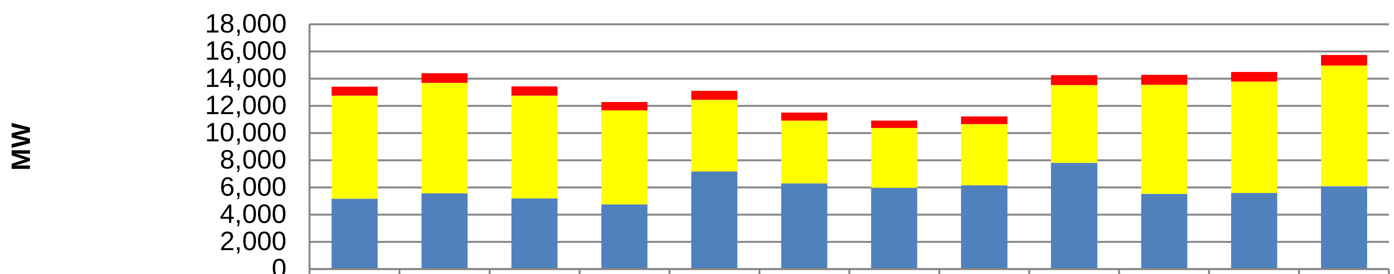
Flexible capacity needs by category

Total Unadjusted Flexible Capacity MW Need by Category



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	671	720	672	614	655	575	545	561	712	714	725	787
Peak Flexibility	6,351	10,321	8,630	6,511	7,564	4,889	3,235	3,549	5,607	6,020	8,750	8,778
Base Flexibility	6,393	3,367	4,133	5,147	4,876	6,033	7,128	7,109	7,928	7,537	5,030	6,178

Total Seasonally AdjustedFlexible Capacity Needed in Each Category



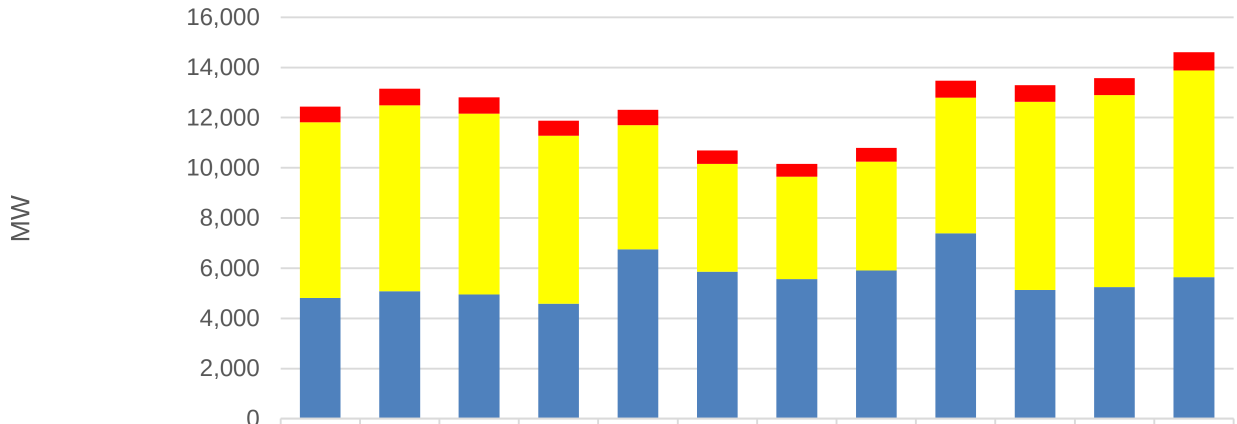
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	671	720	672	614	655	575	545	561	712	714	725	787
Peak Flexibility	7,561	8,121	7,572	6,917	5,262	4,620	4,384	4,509	5,726	8,043	8,175	8,873
Base Flexibility	5,183	5,567	5,191	4,742	7,178	6,302	5,979	6,150	7,810	5,514	5,604	6,083

Flexible capacity needs are largely attributable to change in output from solar resources

Month	Average of Load contribution 2018	Average of solar PV contribution 2018	Average of BTM Solar contribution 2018	Average of Wind contribution 2018
January	93.34%	92.01%	99.01%	87.43%
February	89.64%	92.06%	99.01%	87.31%
March	101.99%	92.07%	99.01%	87.32%
April	114.01%	92.12%	99.01%	87.23%
May	105.85%	92.12%	99.01%	87.16%
June	98.70%	92.12%	99.01%	87.11%
July	102.03%	92.12%	99.01%	87.01%
August	124.09%	92.12%	99.01%	87.02%
September	104.70%	92.28%	99.01%	87.08%
October	95.07%	92.28%	99.01%	87.22%
November	95.58%	92.28%	99.01%	87.23%
December	93.28%	92.39%	99.01%	87.15%

Three categories of flexibility allow a variety of resource types to help address flexible capacity need

Draft CPUC Flexible Capacity Allocation by Catagory



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	622	658	640	594	615	534	508	539	673	665	678	731
Peak Flexibility	7,010	7,413	7,215	6,694	4,946	4,295	4,081	4,336	5,413	7,491	7,648	8,236
Base Flexiblity	4,806	5,081	4,946	4,589	6,746	5,858	5,567	5,914	7,383	5,135	5,243	5,646

Seasonal must offer obligations for peak and super-peak flexible capacity

	Frequency of All Three Hour Net Load Ramp Start Hour ramp Start						
Month	11:00	12:00	13:00	14:00	15:00	16:00	17:00
January				28	3		
February				15	14		
March					12	19	
April					2	16	12
May			1		2	13	15
June			1		1	22	6
July	1	2			5	23	
August			1	1	21	7	
September	1		1	4	17	7	
October				6	23	2	
November				25	5		
December			1	29	1		

- Must-offer obligation hours
  - 3:00 p.m. to 8:00 p.m. for May through September
  - 2:00 p.m. to 7:00 p.m. for January through April and October through December

Review of preliminary assessment results

- Flexible Capacity need is largest in the off-peak months
  - Flexible capacity makes up a greater percentage of resource adequacy needs during the off-peak months
  - Increase almost exclusively caused by 3-hour ramp, not increase in peak load
- Inclusion of incremental behind-the-meter solar PV contributes to the larger flexible capacity requirements
- Compared to last year’s forecast flexible capacity needs are high in many months,
- Using the ISO flexible capacity contribution calculation majority of three-hour net-load ramps are attributable to CPUC jurisdictional LSEs
- The Peak and Super-Peak MOO hours have changed from the 2017 study
  - January through April and October through December: 2:00 p.m. to 7:00 p.m.
  - May through September: 3:00 p.m. to 8:00 p.m.

Next steps

- Published Draft Flexible Capacity Needs Assessment for 2017 – April 12, 2016
  - Stakeholder call April 6, 2017
  - Comments due April 16, 2016
    - Please submit comments on the assumptions to

      initiativecomments@caiso.com

- Publish Final Flexible Capacity Needs Assessment for 2018 – May 1, 2017