Draft Flexible Capacity Needs Assessment for 2017

Clyde Loutan
Senior Advisor, Renewable energy Integration

Karl Meeusen, PhD
Senior Advisor, Infrastructure Policy

April 18, 2016

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 2017 and advisory flexible capacity requirements for compliance years 2018 and 2019

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)

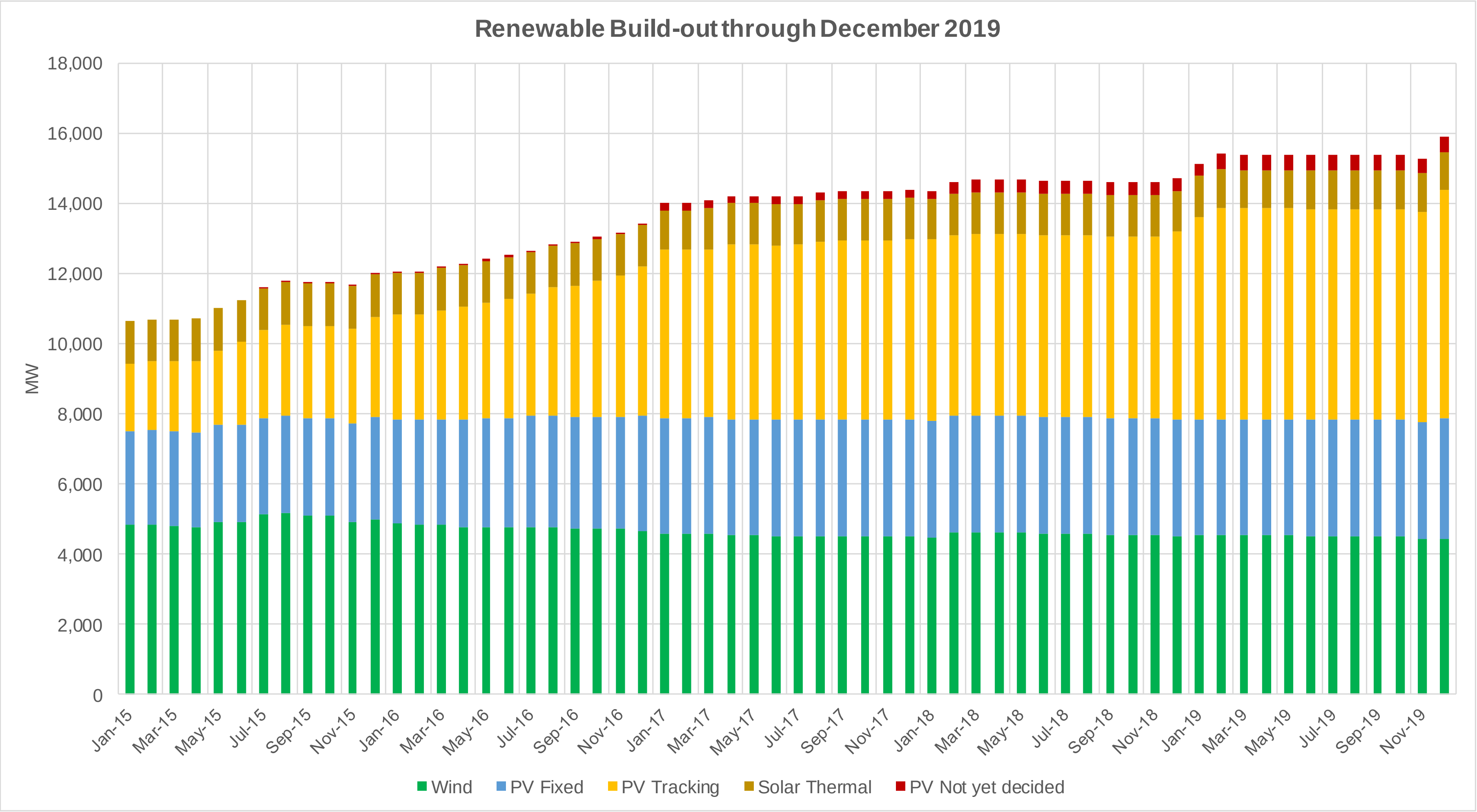
- Ensure LSEs contract for adequate capacity to meet expected flexible needs
- Year ahead: LSEs need to secure a minimum of 90% of the next years monthly needs
- Month ahead: LSEs need to secure adequate net qualified capacity to serve their peak load including a planning reserve margin and flexible 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?

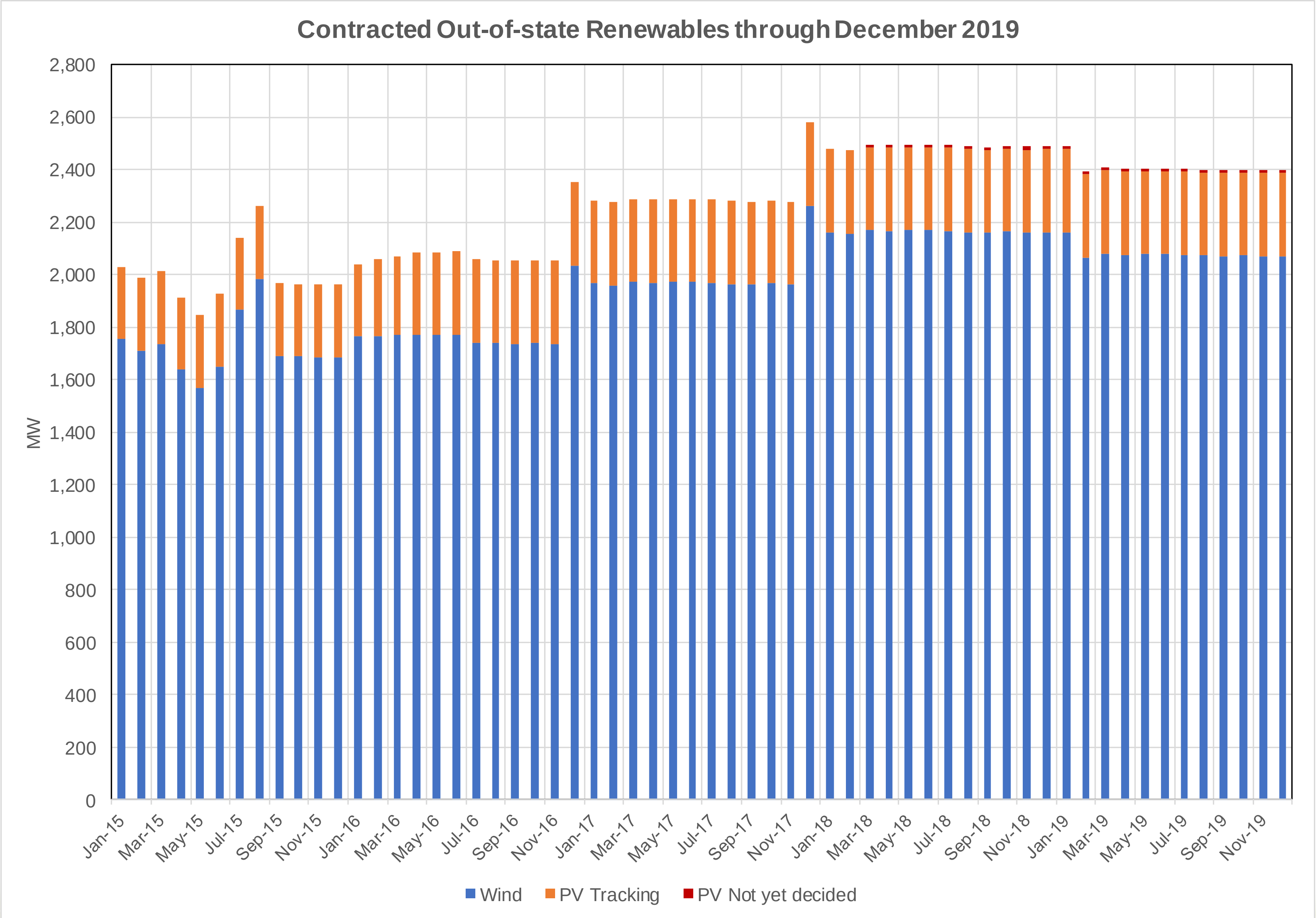
- CEC's monthly demand forecast (e.g. 2016-19 demand forecast)
- CEC provided monthly AAEE for 2016 and hourly AAEE for 2017 through 2019
- LSE SCs updated renewable build-out for 2015 through 2019
- The data included:
  - Installed capacity by technology and expected operating date (e.g. Solar thermal, 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

Note: Data was submitted late by five small LSEs and one LSE was missed in the overall flexible capacity needs assessment

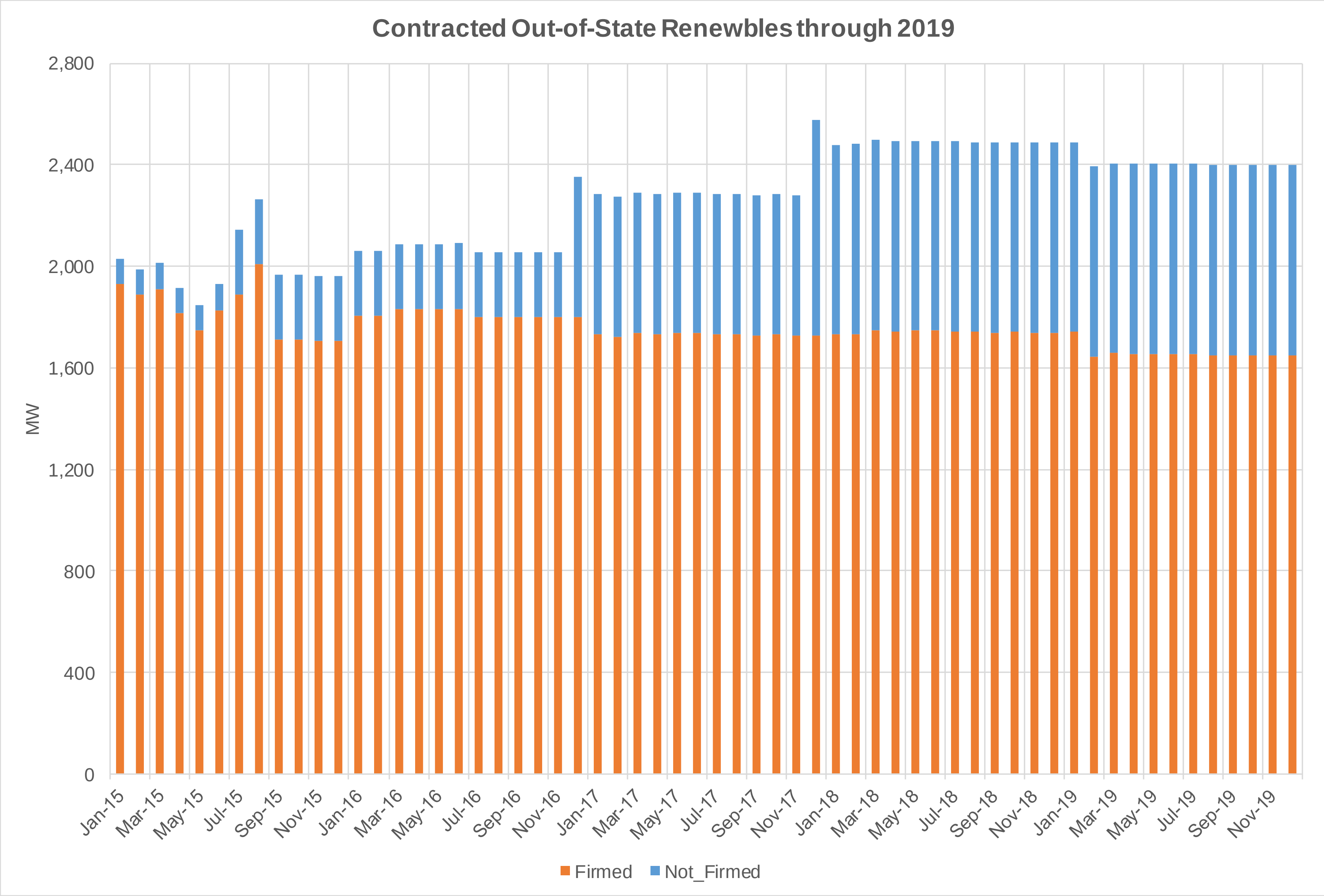
Renewable build-out through December 2019



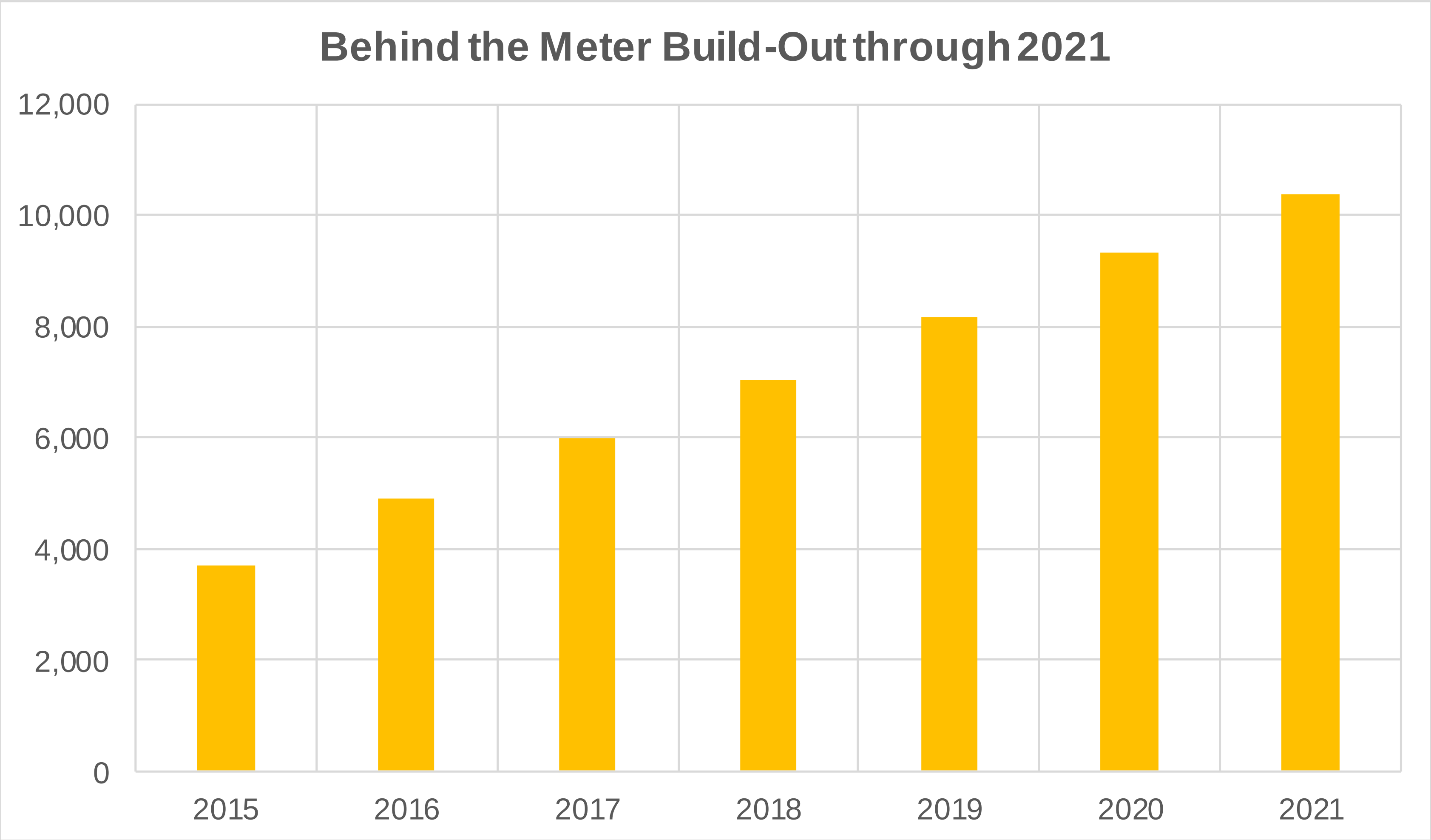
Out of state renewable imports through December 2019



Firmed and non-firmed out of state imports through December 2019



Behind the meter solar PV build-out through 2021



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

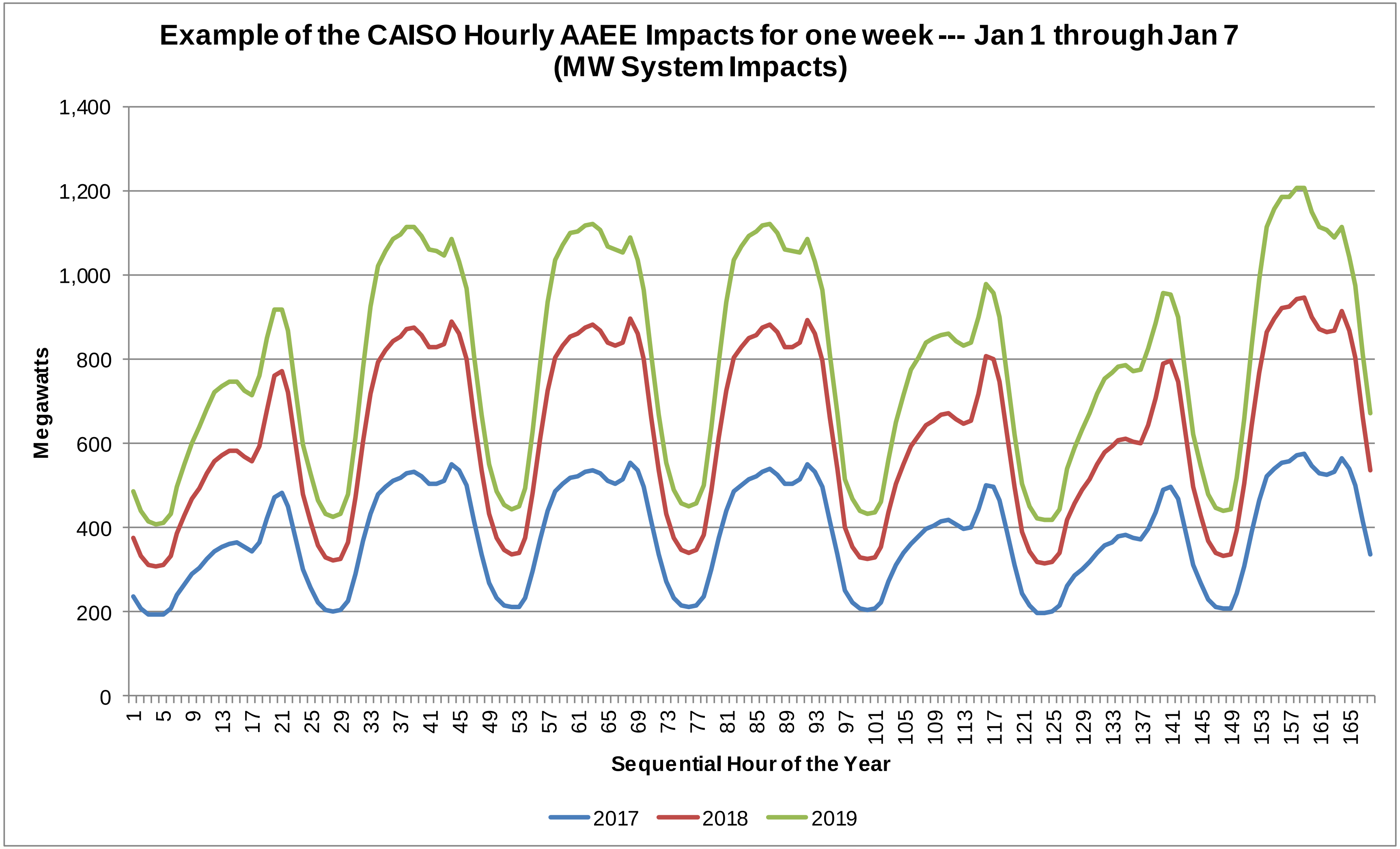
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	32,555	31,704	31,195	33,375	37,271	42,142	45,586	46,302	45,826	37,667	32,581	33,930
2017	32,532	31,668	31,158	33,338	37,250	42,156	45,593	46,288	45,823	37,618	32,543	33,930
2018	32,277	31,403	30,895	33,060	36,971	41,889	45,302	45,963	45,511	37,299	32,267	33,696
2019	32,046	31,163	30,660	32,806	36,687	41,593	44,975	45,612	45,171	36,995	32,015	33,477

New Energy Efficiency (MW-future only)-- coincident with CAISO totals, CEC Planning Forecast (Mid Baseline, Mid AAEE) [Includes Behavior/Conservation Programs)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	302	308	295	330	375	405	468	495	459	425	316	275
2017	597	608	592	645	707	742	840	895	844	789	625	557
2018	976	994	974	1,050	1,128	1,170	1,306	1,397	1,331	1,251	1,025	921
2019	1,232	1,259	1,233	1,331	1,441	1,499	1,669	1,785	1,707	1,585	1,303	1,166

Note: The load profile for 2016 was developed using 2016 AAEE monthly values while the load profiles for 2017 through 2019 were developed using hourly AAEE values

CEC provided hourly AAEE impacts for each hour of 2017 through 2019



California ISO

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 2015 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 2016 through 2019
  - Generate load profiles for 2016 through 2019
  - Generate solar profiles for 2016 through 2019
  - Generate wind profiles for 2016 through 2019

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

- Used 2015 actual 1-minute load data to build 1-minute load profiles for 2016 through 2019
- Scaled the actual 1-minute load value of each month of 2015 using a load growth factor of monthly peak forecast divided by actual 2015 monthly peak

2016 Load Growth Assumptions

- Scale the actual 1-minute load value of each month of 2015 by the fraction $(Monthly_{2016\_Peak\_Load\_Forecast}/Monthly_{2015\_Actual\_Peak\_Load})$

2017 Load Growth Assumptions

- Scale each 1-minute load data point of 2017 by the fraction $(Monthly_{2017\_Peak\_Load\_Forecast}/Monthly_{2015\_Peak\_Load})$

2018 Load Growth Assumptions

- Scale each 1-minute load data point of 2018 by the fraction $(Monthly_{2018\_Peak\_Load\_Forecast}/Monthly_{2015\_Peak\_Load})$
- Apply hourly AAEE to load growth for 2017 through 2019

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. 2016 wind forecast uses actual production data from 2015
- Projects installed in 2015 were modeled in 2016 for the months the projects were not yet in-service in 2015 (e.g. projects installed in May 2015 was included in January through April of 2016
- Scale 1-minute data using expected capacity for the new plants scheduled to be operational in 2016
- Repeat the above steps for 2016

$$2016\ W_{Mth\_Sim\_1\text{-}min} = 2015W_{Act\_1\text{-}min} * 2016W_{Mth\ Capacity} / 2015W_{Mth\ Capacity}$$

$$2017\ W_{Mth\_Sim\_1\text{-}min} = 2015W_{Act\_1\text{-}min} * 2017W_{Mth\ Capacity} / 2015W_{Mth\ Capacity}$$

$$2018\ W_{Mth\_Sim\_1\text{-}min} = 2015W_{Act\_1\text{-}min} * 2018W_{Mth\ Capacity} / 2015W_{Mth\ Capacity}$$

$$2019\ W_{Mth\_Sim\_1\text{-}min} = 2015W_{Act\_1\text{-}min} * 2019W_{Mth\ Capacity} / 2015W_{Mth\ Capacity}$$

Solar growth assumptions

Existing solar

- Use the actual solar 1-minute production data for the most recent year
  e.g. 2016 forecast uses 2015 actual 1-minute data (**$2015_{Act\_1\text{-}min}$**)

New solar installation

- Develop 1-minute solar production profiles by scaling actual 2015 1-minute data by the monthly installed capacity in 2016 divided by the monthly installed capacity in 2015
- Projects installed in 2015 were modeled in 2016 for the months the projects were not yet in-service

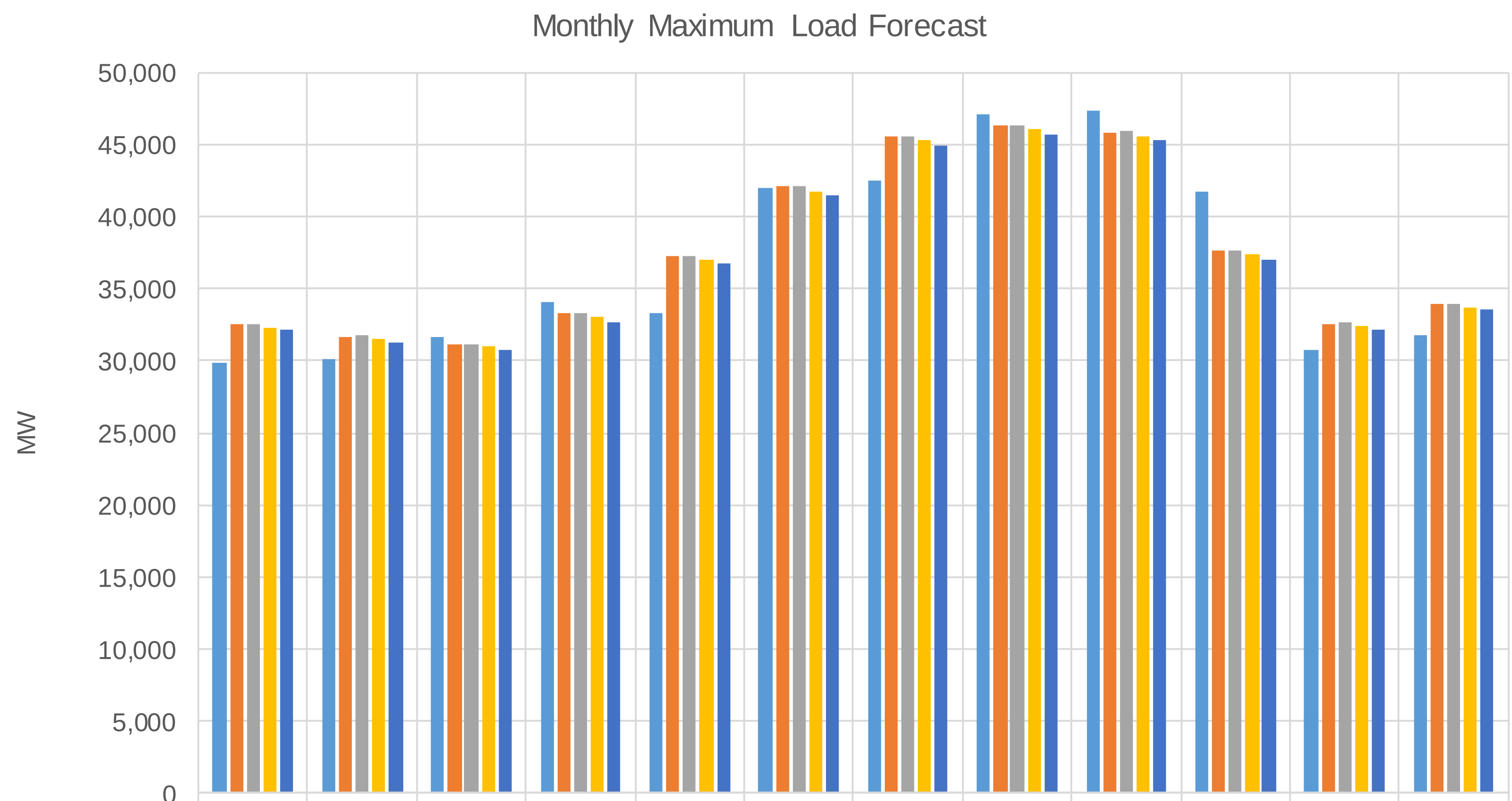
Total solar $2016_{1\text{-}min} = 2015_{Act\_1\text{-}min} * 2016_{Monthly\_1\text{-}min} / 2015_{Installed\_Capacity}$

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

Maximum monthly load forecast for 2016 through 2019



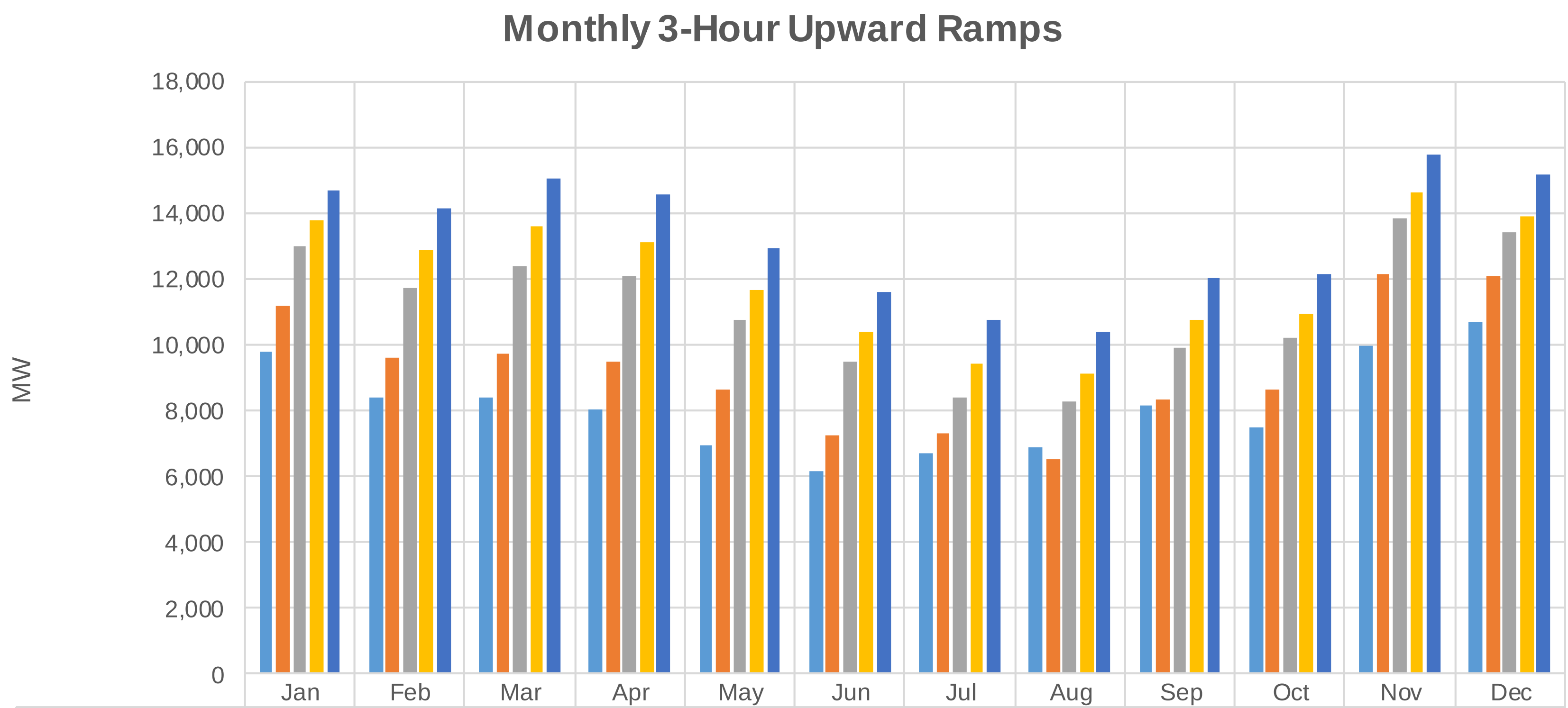
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015_Actual	29,823	30,184	31,611	34,152	33,302	42,058	42,493	47,183	47,353	41,729	30,738	31,782
2016_Max	32,555	31,704	31,195	33,375	37,271	42,142	45,586	46,302	45,826	37,667	32,581	33,930
2017_Max	32,589	31,738	31,196	33,300	37,319	42,123	45,623	46,370	45,909	37,669	32,620	33,958
2018_Max	32,362	31,516	30,967	33,017	37,051	41,814	45,329	46,048	45,619	37,366	32,388	33,753
2019_Max	32,144	31,318	30,795	32,737	36,768	41,483	44,994	45,700	45,293	37,063	32,165	33,560

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:

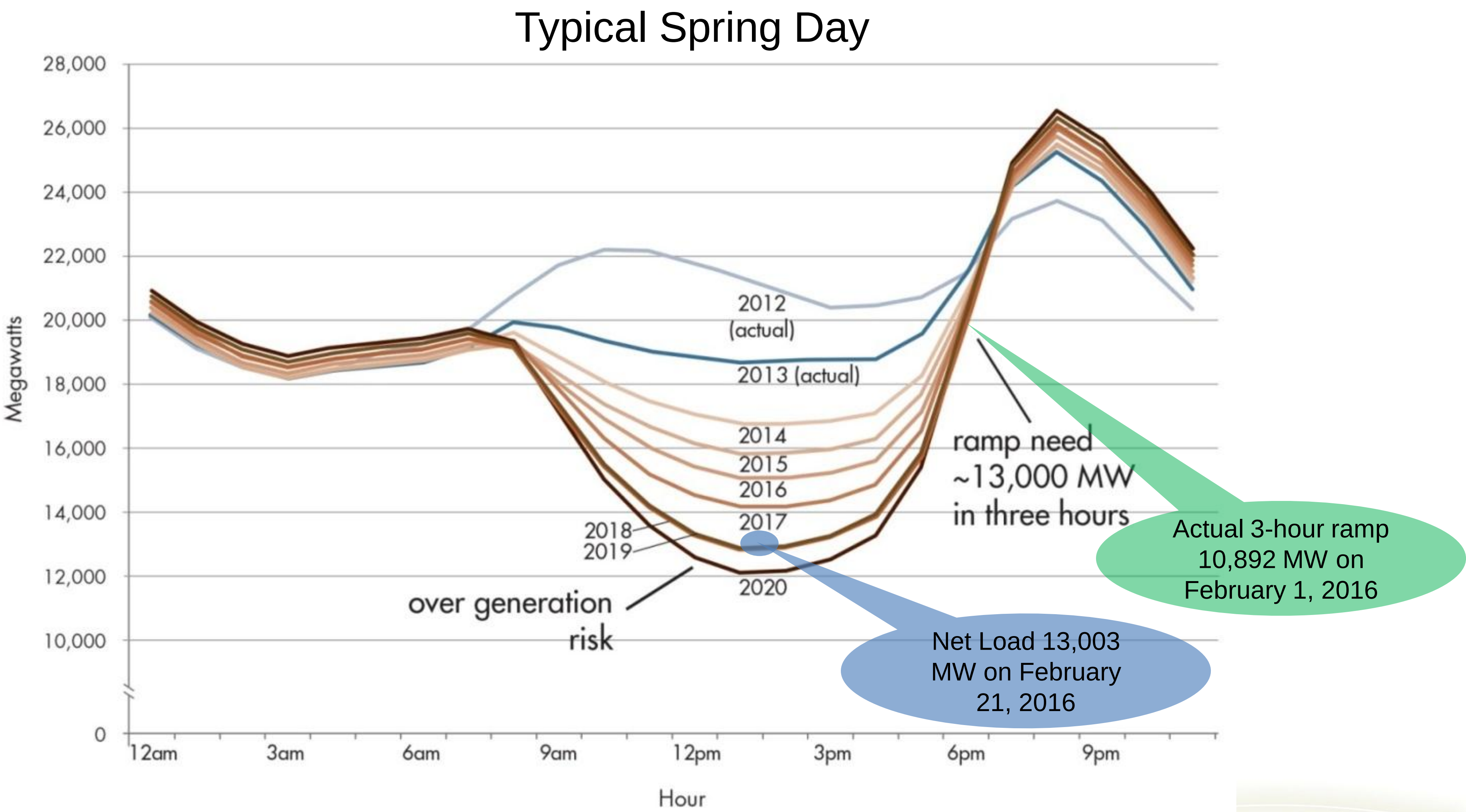
  Net Load_{181}-Net Load_{1}, Net Load_{182}-Net Load_{2}, …. Net Load_{n+180}-Net Load_{n}

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



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015_Actual_Rmp	9,775	8,366	8,367	8,001	6,962	6,153	6,672	6,882	8,158	7,469	9,987	10,684
2016_3HR_Rmp	11,191	9,578	9,700	9,484	8,629	7,262	7,335	6,540	8,353	8,640	12,155	12,096
2017_3HR_Rmp	12,970	11,729	12,364	12,054	10,737	9,464	8,397	8,295	9,918	10,196	13,835	13,399
2018_3HR_Rmp	13,758	12,846	13,596	13,117	11,672	10,383	9,402	9,123	10,728	10,939	14,636	13,896
2019_3HR_Rmp	14,691	14,114	15,067	14,543	12,904	11,571	10,750	10,407	12,003	12,121	15,781	15,186

Original estimate of net-load as more renewables are integrated into the grid

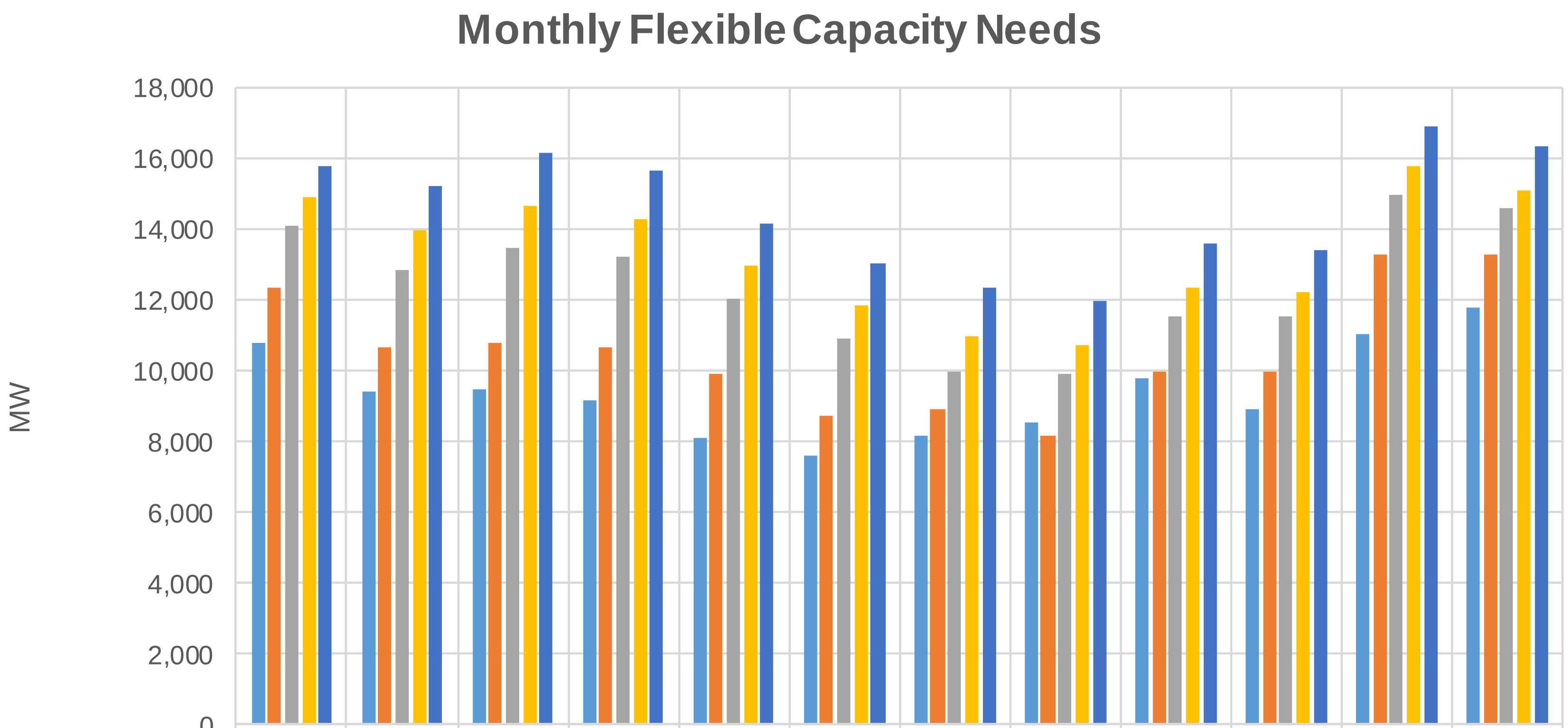


Contingency reserves is a NERC/WECC requirement BAs must have available in real-time

- 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

Monthly 2017 flexible capacity procurement target for CPUC's jurisdictional LSEs



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015_Act_Flex	10,818	9,422	9,473	9,196	8,128	7,625	8,159	8,533	9,815	8,929	11,062	11,796
2016_Flex_Cap	12,330	10,687	10,792	10,652	9,933	8,737	8,930	8,161	9,957	9,959	13,295	13,283
2017_Flex_Cap	14,110	12,840	13,456	13,220	12,044	10,939	9,994	9,918	11,525	11,514	14,977	14,588
2018_Flex_Cap	14,890	13,949	14,680	14,273	12,968	11,846	10,989	10,735	12,325	12,247	15,770	15,077
2019_Flex_Cap	15,816	15,211	16,145	15,688	14,191	13,023	12,324	12,007	13,588	13,418	16,907	16,361

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

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

  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

- Methodology for 2017 and beyond needs to be developed as needs change

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

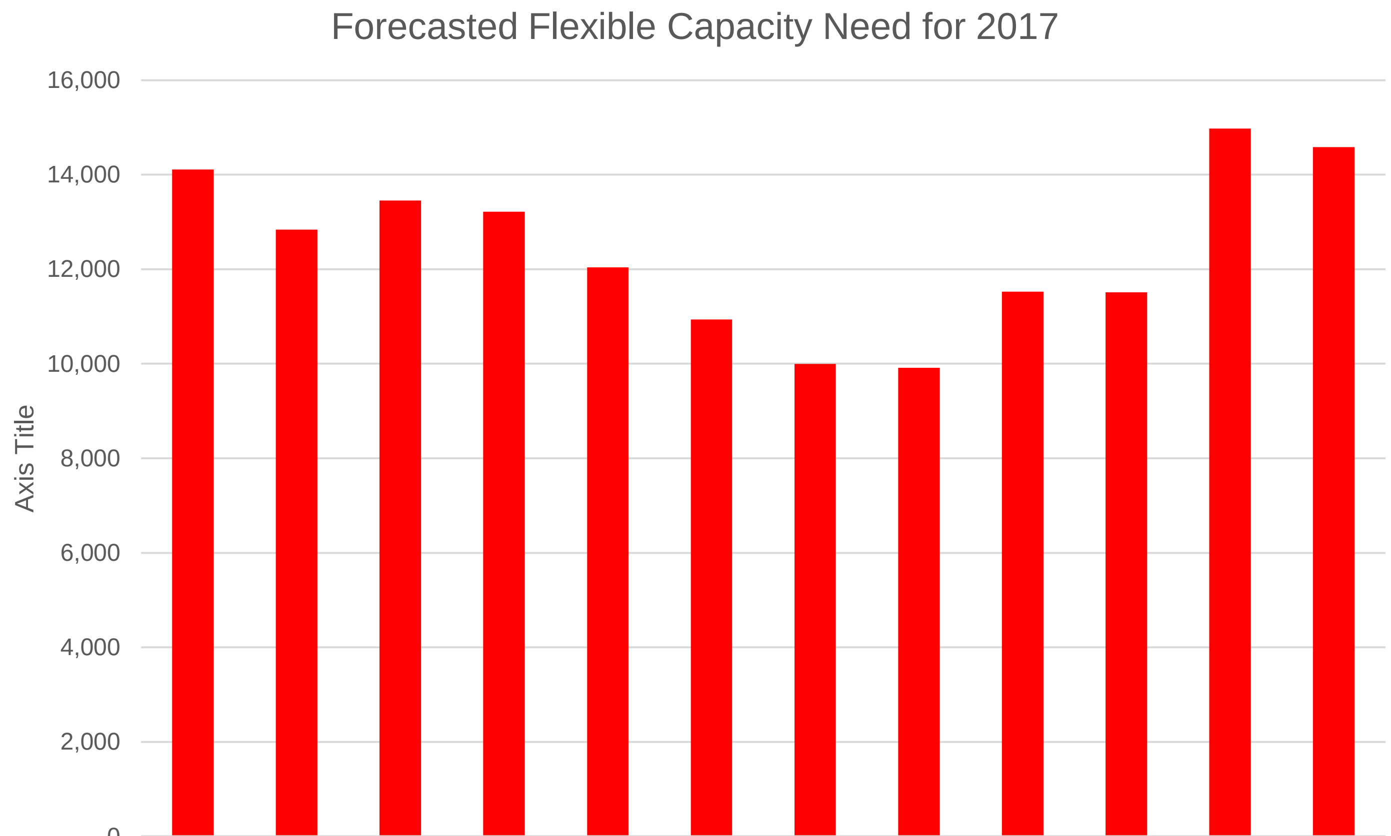
Contributions to the three hour net load ramp: Load wind, grid scale solar, incremental behind the meter solar, out-of-state wind

Month	Average of Load contribution 2017	Average of solar PV contribution 2017	Average of BTM Solar contribution 2017	Average of Wind contribution 2017	Average of OOS Wind contribution 2017	Total percent 2017
January	49.09%	-47.68%	-2.66%	-0.52%	-0.05%	100%
February	31.99%	-63.00%	-3.77%	-0.77%	-0.47%	100%
March	27.28%	-63.69%	-8.15%	-1.28%	0.40%	100%
April	23.01%	-68.11%	-9.61%	0.71%	0.02%	100%
May	23.87%	-64.15%	-9.83%	-1.65%	-0.50%	100%
June	8.76%	-79.58%	-11.52%	-0.55%	0.41%	100%
July	11.66%	-78.87%	-11.11%	1.47%	0.17%	100%
August	-0.72%	-94.04%	-12.81%	5.93%	0.21%	100%
September	6.27%	-82.42%	-10.82%	-0.28%	-0.21%	100%
October	18.23%	-72.80%	-11.45%	1.61%	0.86%	100%
November	34.75%	-55.91%	-8.69%	-0.51%	-0.15%	100%
December	42.28%	-48.62%	-6.05%	-2.02%	-1.04%	100%

Components of the flexible capacity needs

Month	3-hour net load ramp 2017	3.5% expected peak load 2017	Flex_Req_2017
January	12970	1141	14,110
February	11729	1111	12,840
March	12364	1092	13,456
April	12054	1166	13,220
May	10737	1306	12,044
June	9464	1474	10,939
July	8397	1597	9,994
August	8295	1623	9,918
September	9918	1607	11,525
October	10196	1318	11,514
November	13835	1142	14,977
December	13399	1189	14,588

Forecasted monthly 2017 ISO system-wide flexible capacity needs*

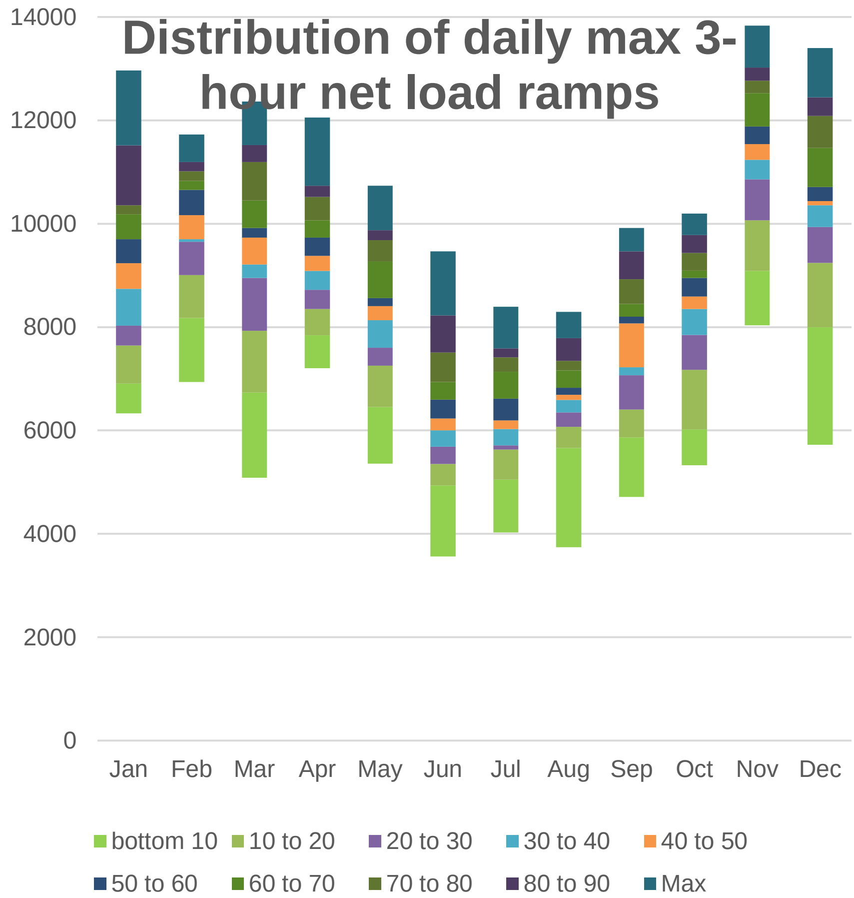


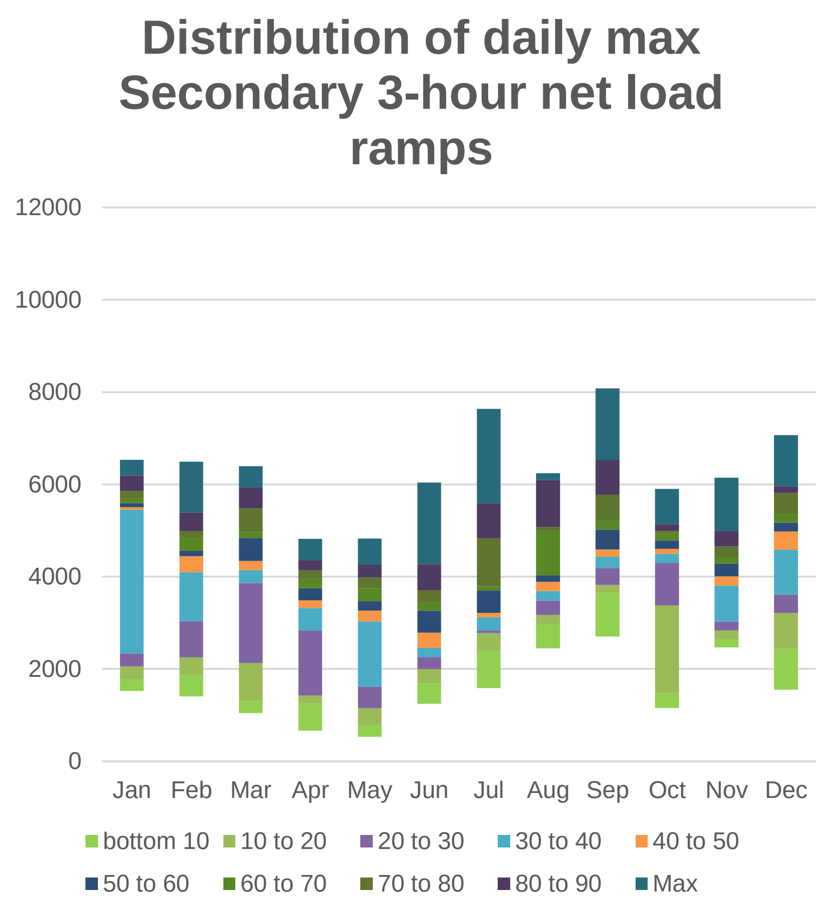
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	14,110	12,840	13,456	13,220	12,044	10,939	9,994	9,918	11,525	11,514	14,977	14,588

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

$\varepsilon = 0$

The 2016 forecasted distribution range of daily maximum and secondary 3-hour net load ramps





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

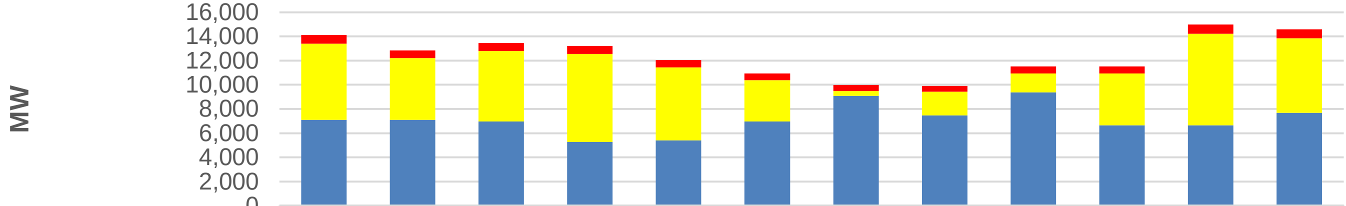
- Category 1 (Base Flexibility): Operational needs determined by the magnitude of the largest 3-hour secondary net-load ramp
- Category 2 (Peak Flexibility): Operational need determined by the difference between 95 percent of the maximum 3-hour net-load ramp and the largest 3-hour secondary net-load ramp
- Category 3 (Super-Peak Flexibility): 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	50%	45%	5%	50%	45%	5%
February	55%	40%	5%	50%	45%	5%
March	52%	43%	5%	50%	45%	5%
April	40%	55%	5%	50%	45%	5%
May	45%	50%	5%	71%	24%	5%
June	64%	31%	5%	71%	24%	5%
July	91%	4%	5%	71%	24%	5%
August	75%	20%	5%	71%	24%	5%
September	81%	14%	5%	71%	24%	5%
October	58%	37%	5%	50%	45%	5%
November	44%	51%	5%	50%	45%	5%
December	53%	42%	5%	50%	45%	5%

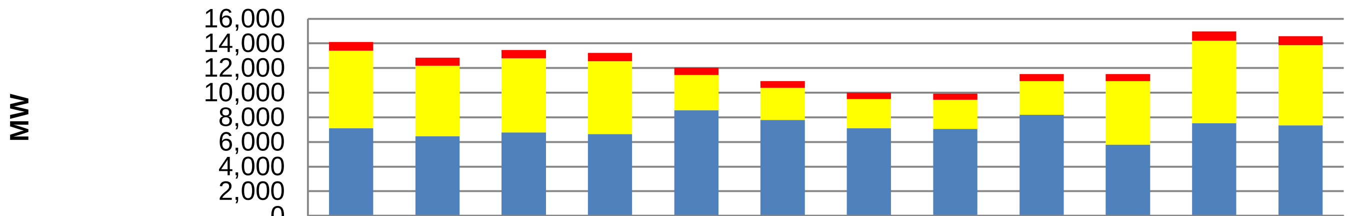
Flexible capacity needs by category

Total Flexible Capacity Needed in Each Category – Unadjusted



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	706	642	673	661	602	547	500	496	576	576	749	729
Peak Flexibility	6,301	5,088	5,821	7,274	6,029	3,412	404	1,957	1,561	4,276	7,578	6,164
Base Flexibility	7,104	7,110	6,962	5,285	5,412	6,980	9,091	7,465	9,388	6,662	6,650	7,694

Total Flexible Capacity Needed in Each Category – Seasonal Adjustment

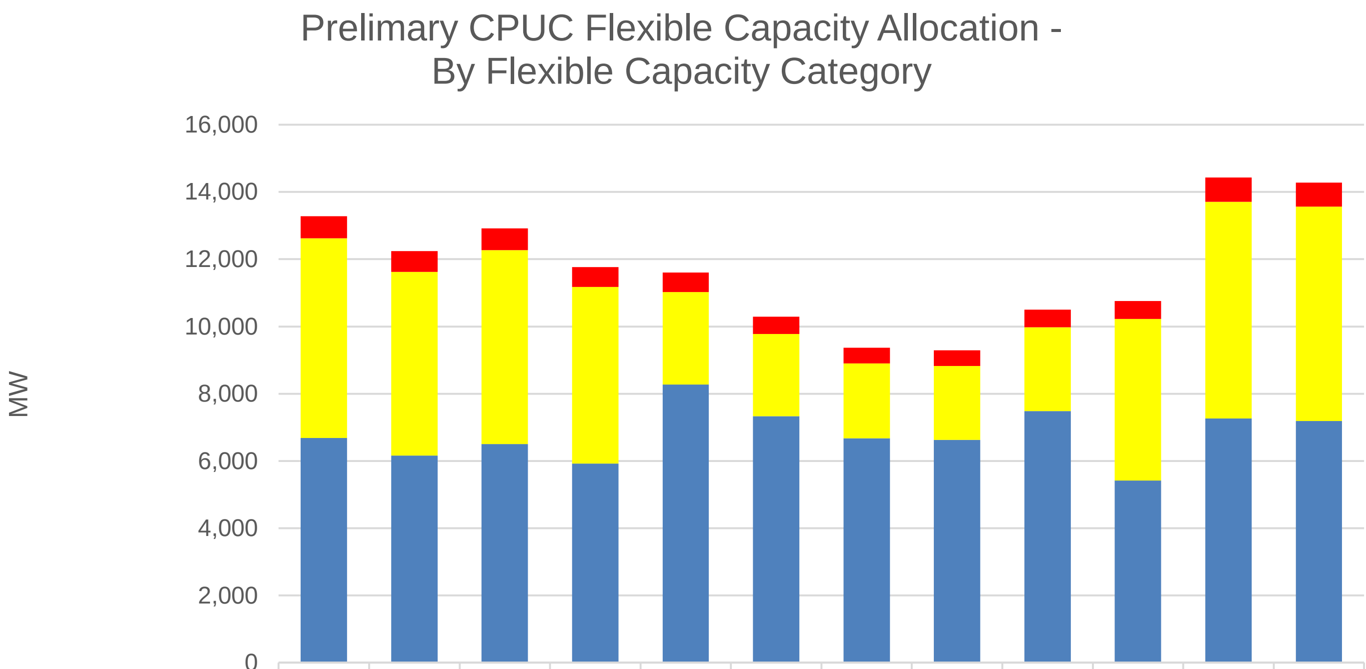


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	706	642	673	661	602	547	500	496	576	576	749	729
Peak Flexibility	6,300	5,733	6,008	5,903	2,856	2,594	2,370	2,352	2,733	5,141	6,687	6,514
Base Flexibility	7,104	6,465	6,775	6,656	8,585	7,798	7,124	7,070	8,216	5,797	7,541	7,345

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

Month	Average of Load contribution 2017	Average of solar PV contribution 2017	Average of BTM Solar contribution 2017	Average of Wind contribution 2017	Average of OOS Wind contribution 2017
January	95%	93%	99%	97%	100%
February	100%	93%	99%	97%	100%
March	103%	93%	99%	97%	100%
April	70%	94%	99%	97%	100%
May	105%	94%	99%	97%	100%
June	97%	94%	99%	97%	100%
July	94%	94%	99%	97%	100%
August	95%	94%	99%	97%	100%
September	43%	94%	99%	97%	100%
October	91%	94%	99%	97%	100%
November	101%	94%	99%	97%	100%
December	104%	94%	99%	97%	100%

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



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	664	612	646	588	580	515	468	465	525	538	721	714
Peak Flexibility	5,930	5,464	5,768	5,253	2,751	2,440	2,221	2,204	2,490	4,805	6,441	6,374
Base Flexiblity	6,687	6,162	6,504	5,923	8,269	7,335	6,677	6,624	7,486	5,418	7,263	7,188

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,
  - Distribution of daily maximum three-hour net-load ramps are comparable
- Using the ISO flexible capacity contribution calculation majority of three-hour net-load ramps are attributable to CPUC jurisdictional LSEs
- Flexible capacity categories demonstrate that there is ample opportunity for participation from various resource types

Next steps

- Published Draft Flexible Capacity Needs Assessment for 2017 – April 12, 2016
  - Stakeholder call April 18, 2016
  - Comments due April 26, 2016
    - Please submit comments on the assumptions to

      initiativecomments@caiso.com

- Publish Final Flexible Capacity Needs Assessment for 2017 – April 29, 2016