Flexible Capacity Needs and Availability Assessment Hours Technical Study for 2019

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April 16, 2018

What's the purpose of this call?

To discuss the assumptions, methodology, and draft results of the monthly flexible capacity requirement and Availability Assessment Hours Technical Study.

Specifically

Calculating requirements for all LRAs within the ISO footprint for RA compliance year 2019 and advisory flexible capacity requirements for compliance years 2020 and 2021

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
- Overview of methodology used for system/local availability assessment hours
  - 2019 availability assessment hours
  - 2020-2021 draft availability assessment hours

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

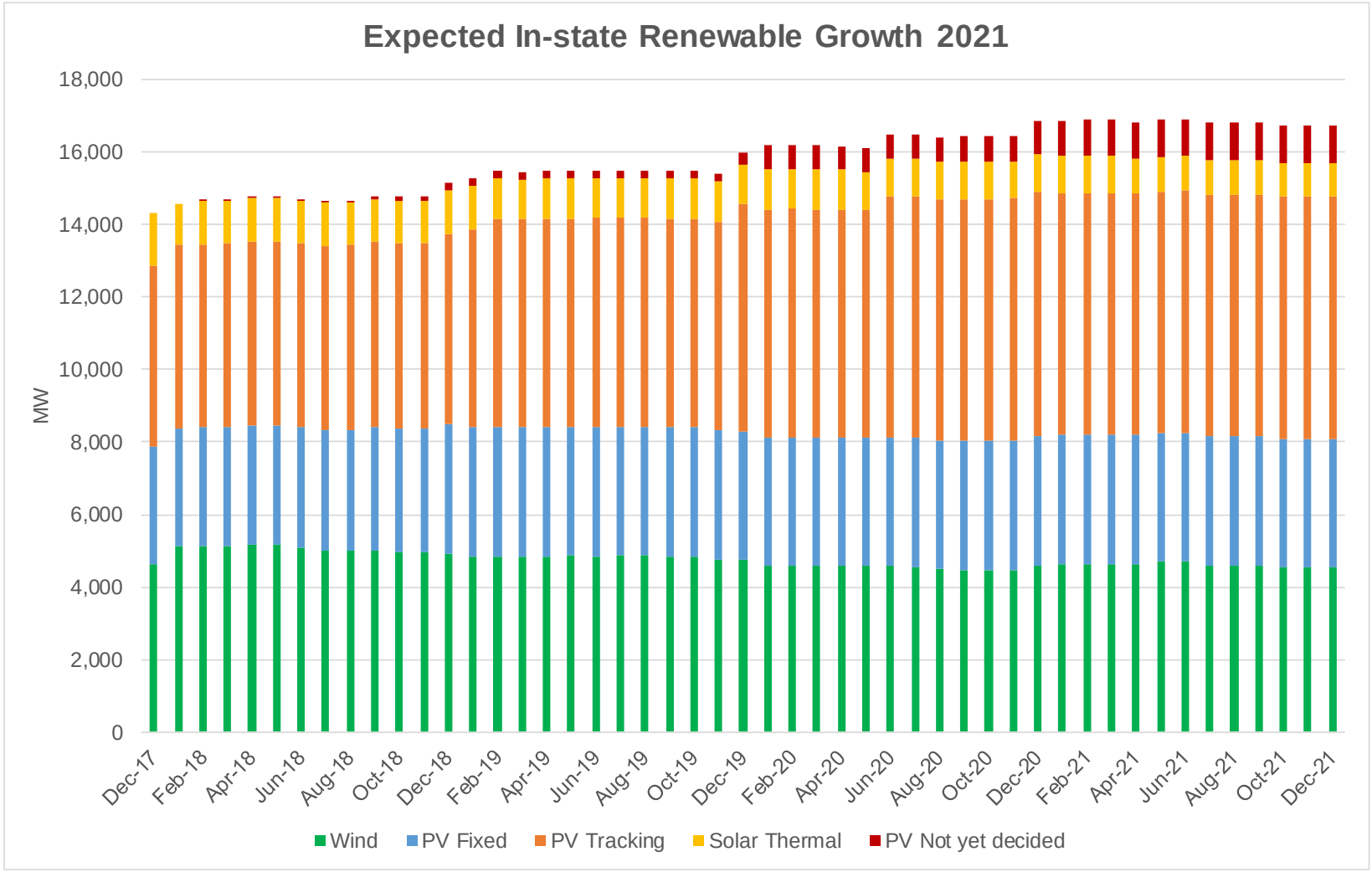
Resource Adequacy (RA)

- 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

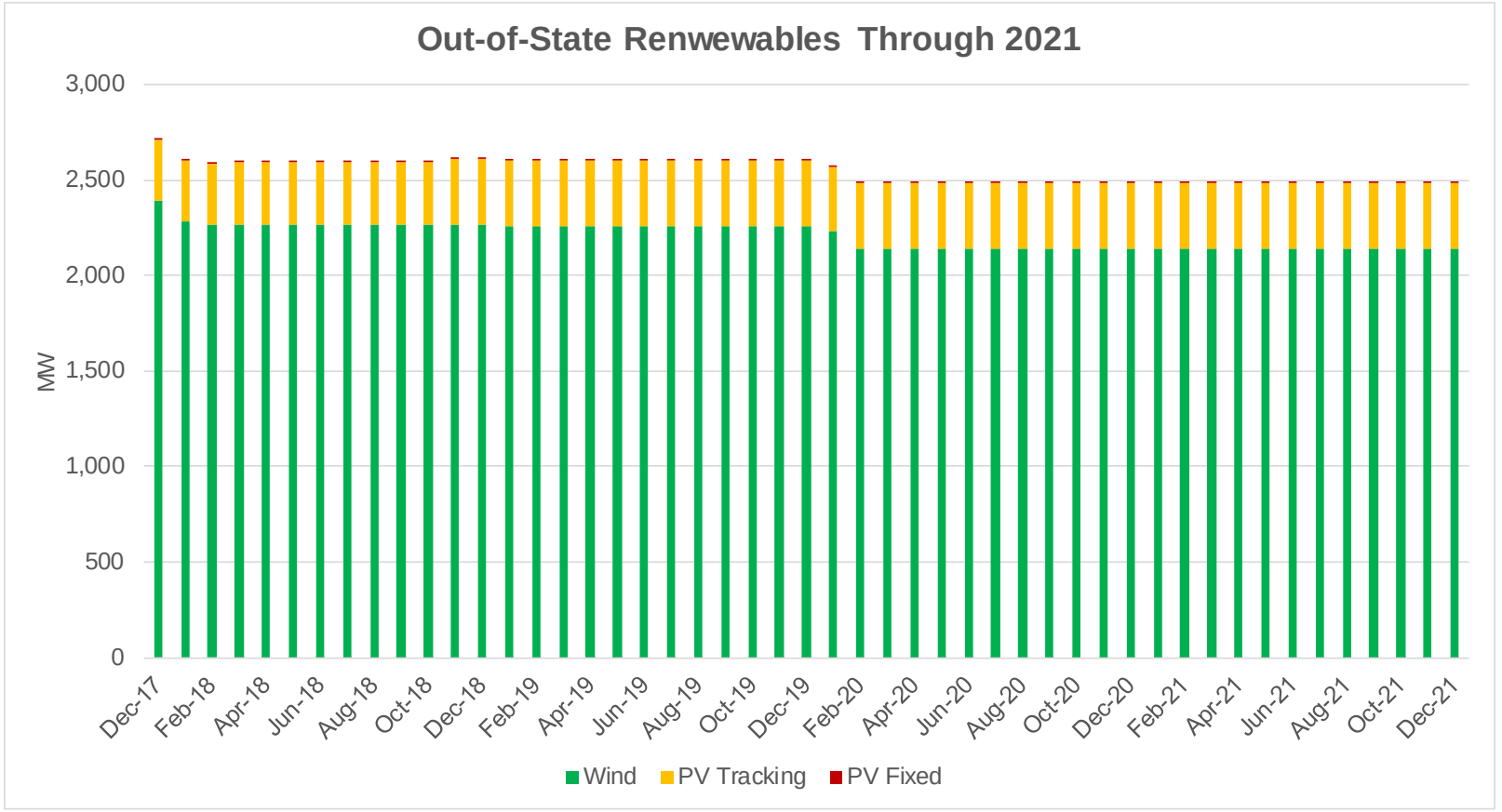
What data did the ISO collect?

- CEC's "1 in 2" Mid monthly demand forecast for 2017 through 2021
  - Behind-the-meter hourly solar PV production
  - Hourly AAEE
- LSE SCs updated renewable build-out for 2017 through 2021
- 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

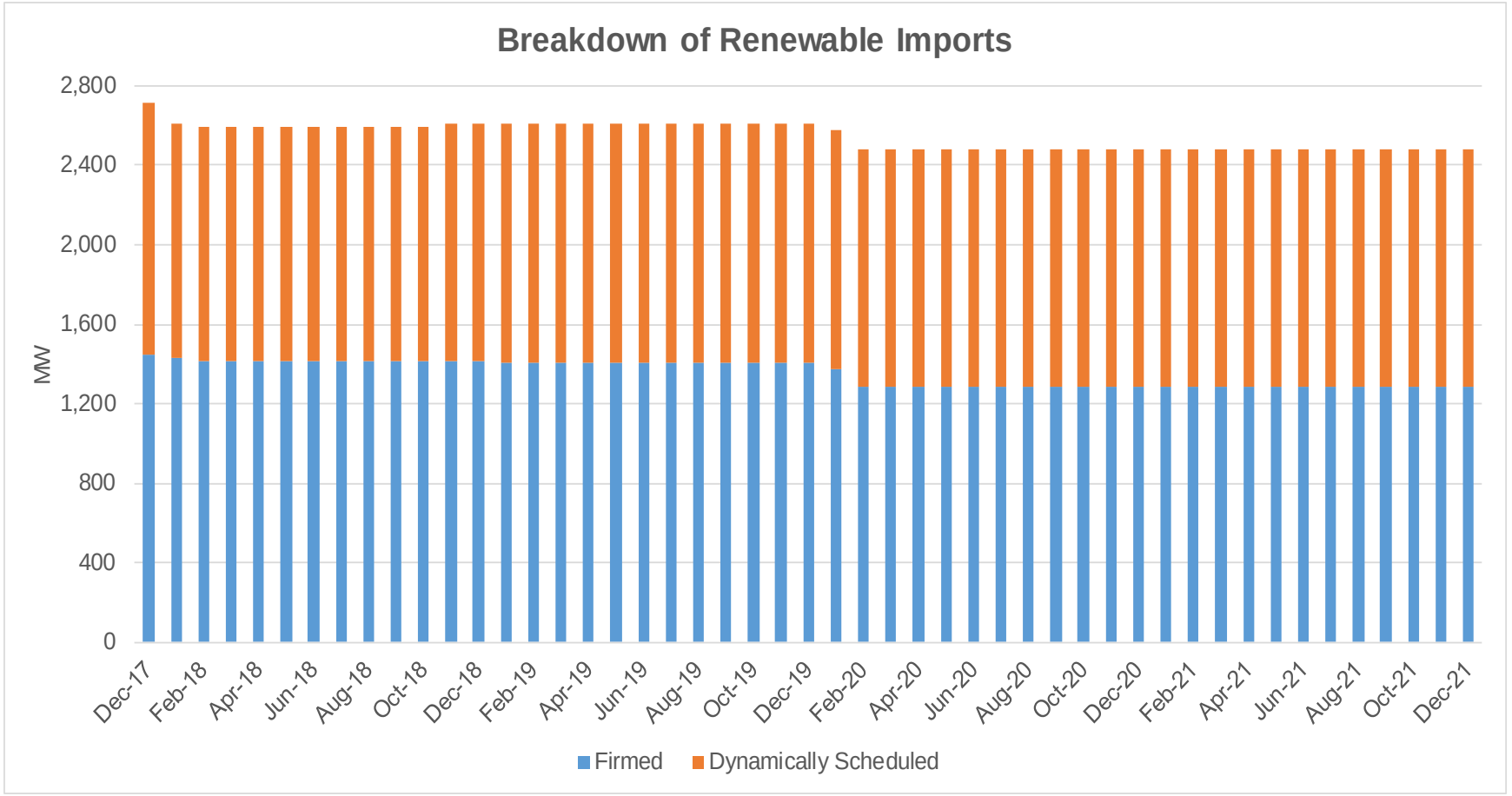
Renewable build-out through December 2021



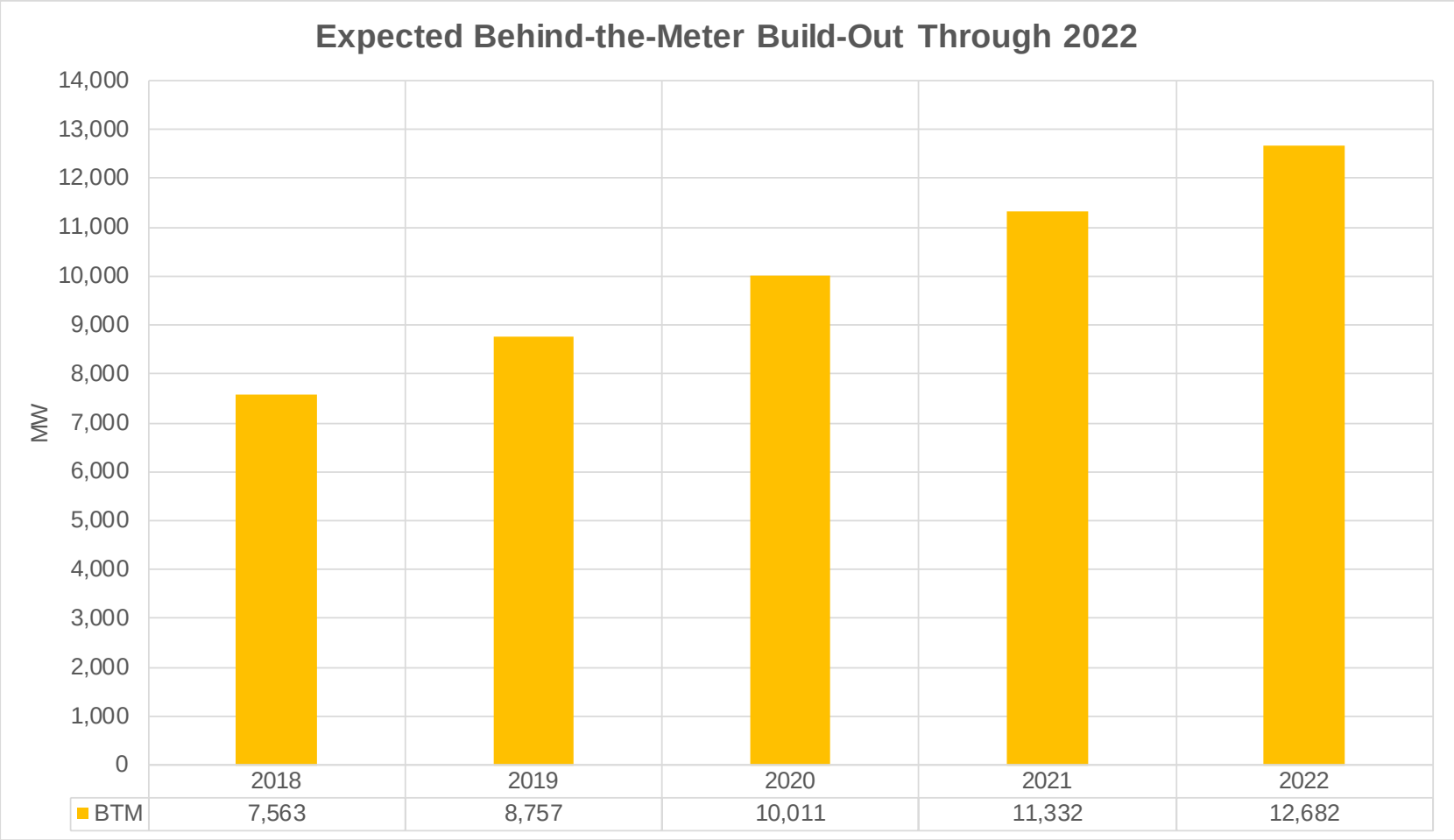
Out of state contracted renewable through December 2021



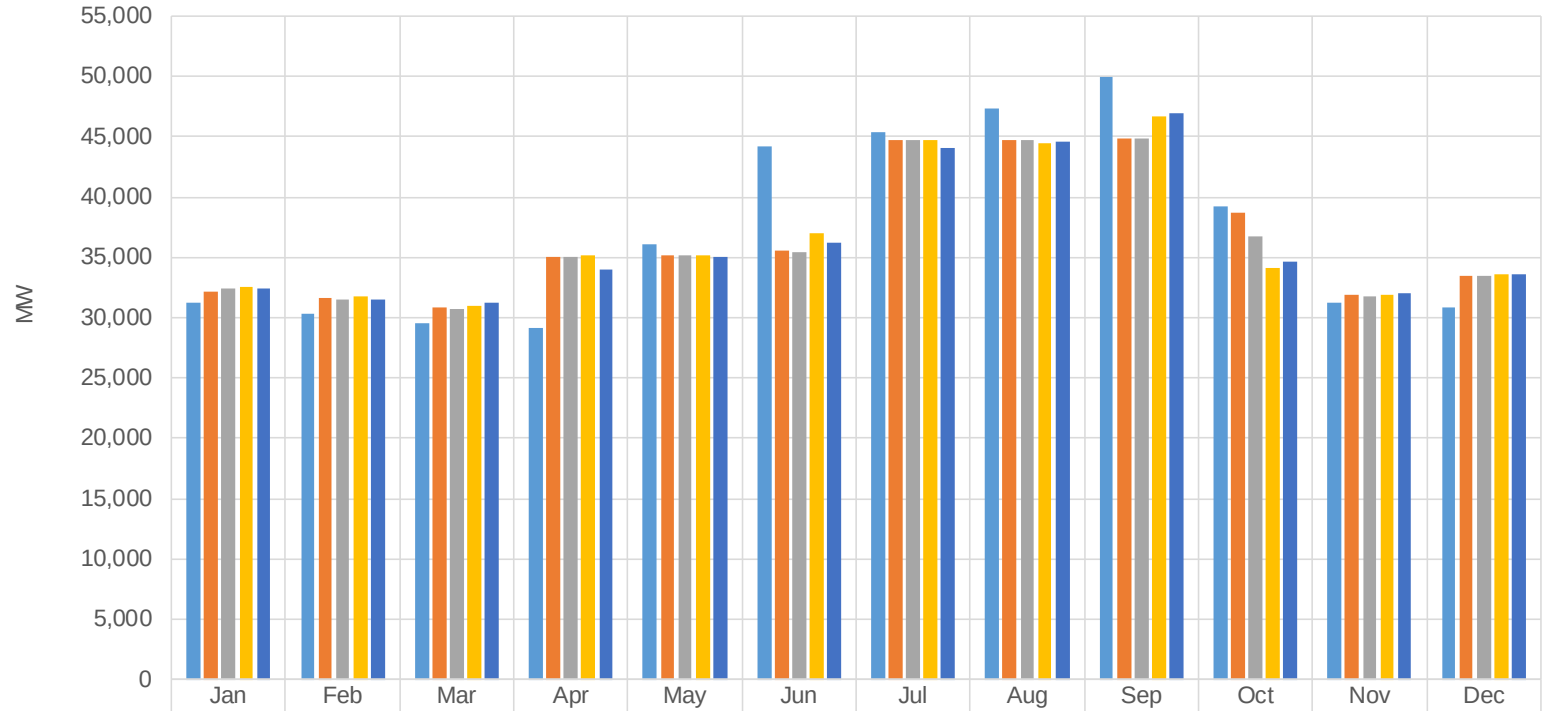
Firmed and non-firmed out of state contracted renewables through December 2021



LSEs estimate of behind the meter solar PV capacity build-out through 2022



CEC (mid baseline, mid AAEE) projected 1 in 2 CAISO coincident peak forecast



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017 (Actual)	31,291	30,348	29,531	29,119	36,040	44,182	45,366	47,345	49,900	39,247	31,308	30,888
2018	32,179	31,597	30,819	35,083	35,201	35,566	44,695	44,720	44,826	38,756	31,904	33,470
2019	32,361	31,568	30,783	35,085	35,146	35,474	44,686	44,719	44,833	36,769	31,820	33,466
2020	32,532	31,705	30,925	35,134	35,232	37,042	44,720	44,486	46,735	34,145	31,938	33,607
2021	32,412	31,523	31,195	33,942	35,038	36,227	44,027	44,550	46,902	34,586	32,031	33,556

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

- Used the most current data available for renewable build-out submitted by all LSE SCs
- For new renewable installation scale 2017 actual production data based on installed monthly capacity in subsequent years
- Used NEXANT production data to develop 1-minute profiles for new behind-the-meter solar PV
- Generated net-load profiles for 2018 through 2021 using the simulated:
  - Load profiles for 2018 through 2021
  - Solar profiles for 2018 through 2021
  - Wind profiles for 2018 through 2021
  - BTM profiles for 2018 through 2021

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

- Used 2017 actual 1-minute load data to build 1-minute load profiles for 2018 through 2021
- Scaled the actual 1-minute 2017 load of each hour using a growth factor of CEC's hourly peak forecast divided by actual 2017 hourly peak for each year

2018 Load Growth Assumptions

- Scale the actual 1-minute load value of each hour of 2017 by the fraction $(Hourly_{2018\_Peak\_Load\_Forecast}/Hourly_{2017\_Actual\_Peak\_Load})$

2019 Load Growth Assumptions

- Scale the actual 1-minute load value of each hour of 2017 by the fraction $(Hourly_{2019\_Peak\_Load\_Forecast}/Hourly_{2017\_Actual\_Peak\_Load})$

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

TRACK I DIRECT TESTIMONY OF MARK ROTHLEDER ON BEHALF OF THE CALIFORNIA INDEPENDENT SYSTEM OPERATOR CORPORATION (CORRECTED)

(Rulemaking 10-05-006)

Located at:

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

Wind growth assumptions through 2021 based on the LSEs expected installations

- Used the actual 1-minute wind production data for 2017 to develop the 1-minute wind profiles for 2018 through 2021
- Wind projects installed in 2017 were modeled in 2018 for the months the projects were not yet in-service in 2017 (e.g. wind projects installed in May 2017 were included in January through April of 2018
- Scaled 1-minute wind data using the forecast monthly wind capacity for the new plants scheduled to be operational each year
- Repeated the above steps for 2019, 2020 & 2021

$$\text{2018 } W_{\text{Mth\_Sim\_1-min}} = \text{2017}W_{\text{Act\_1-min}} * \text{2018}W_{\text{Mth Capacity}} / \text{2017}W_{\text{Mth Capacity}}$$

$$\text{2019 } W_{\text{Mth\_Sim\_1-min}} = \text{2017}W_{\text{Act\_1-min}} * \text{2019}W_{\text{Mth Capacity}} / \text{2017}W_{\text{Mth Capacity}}$$

$$\text{2020 } W_{\text{Mth\_Sim\_1-min}} = \text{2017}W_{\text{Act\_1-min}} * \text{2020}W_{\text{Mth Capacity}} / \text{2017}W_{\text{Mth Capacity}}$$

$$\text{2021 } W_{\text{Mth\_Sim\_1-min}} = \text{2017}W_{\text{Act\_1-min}} * \text{2021}W_{\text{Mth Capacity}} / \text{2017}W_{\text{Mth Capacity}}$$

Solar growth assumptions through 2021 based on the LSEs expected installations

- Used the actual solar 1-minute solar production data for 2017 to develop the 1-minute solar profiles for 2018 through 2021
- Solar projects installed in 2017 were modeled in 2018 for the months the projects were not yet in-service in 2017 (e.g. solar projects installed in May 2017 was included in January through April of 2018
- Scaled 1-minute solar data using the forecast monthly solar capacity for the new plants scheduled to be operational in 2018
- Repeated the above steps for 2019, 2020 & 2021

$$\mathbf{2018\ S_{Mth\_Sim\_1\text{-}min} = 2017S_{Act\_1\text{-}min} * 2018S_{Mth\ Capacity} / 2017S_{Mth\ Capacity}}$$

$$\mathbf{2019\ S_{Mth\_Sim\_1\text{-}min} = 2017S_{Act\_1\text{-}min} * 2019S_{Mth\ Capacity} / 2017S_{Mth\ Capacity}}$$

$$\mathbf{2020\ S_{Mth\_Sim\_1\text{-}min} = 2017S_{Act\_1\text{-}min} * 2020S_{Mth\ Capacity} / 2017S_{Mth\ Capacity}}$$

$$\mathbf{2021\ S_{Mth\_Sim\_1\text{-}min} = 2017S_{Act\_1\text{-}min} * 2021S_{Mth\ Capacity} / 2017S_{Mth\ Capacity}}$$

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

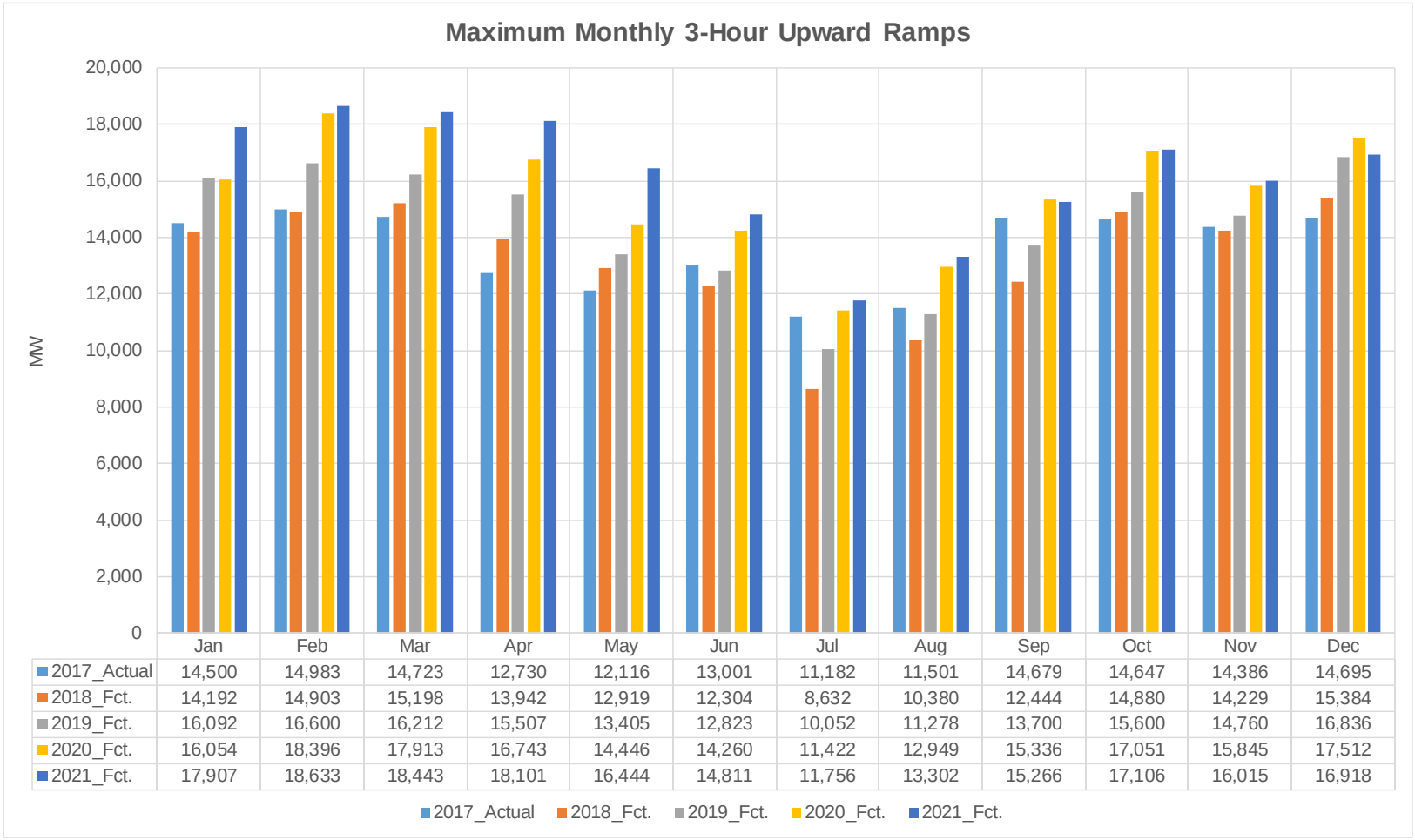
1 NERC Special Report
Flexibility Report Requirements and metrics for Variable Generation: Implications for System Planning Studies, August 2010 . http://www.nerc.com/files/IVGTF_Task_1_4_Final.pdf

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:

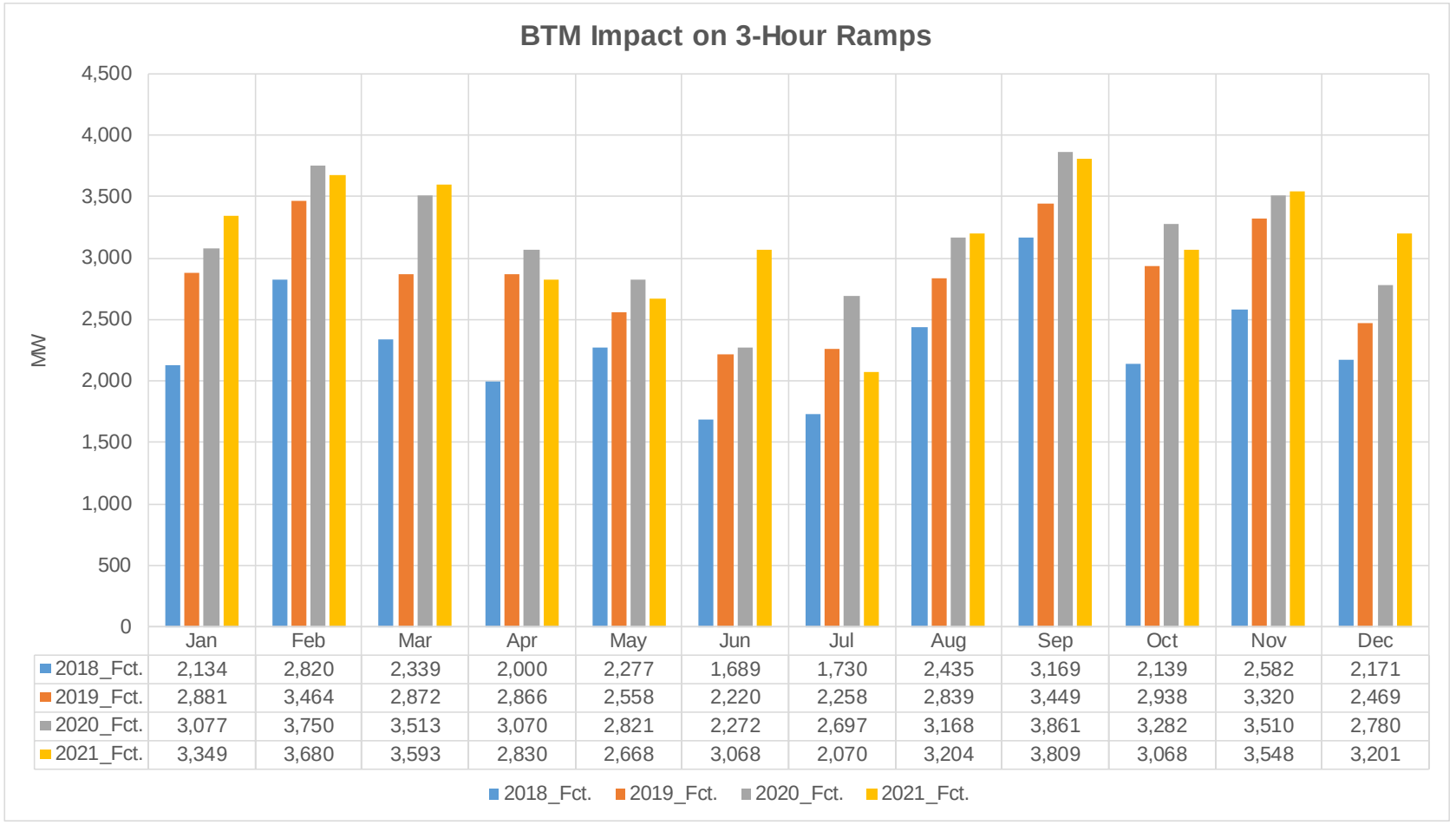
  Net Load_{181}-Net Load_{1}, Net Load_{182}-Net Load_{2}, …. Net Load_{n+180}-Net Load_{n}

Maximum monthly three-hour upward net-load ramps for 2017 through 2021



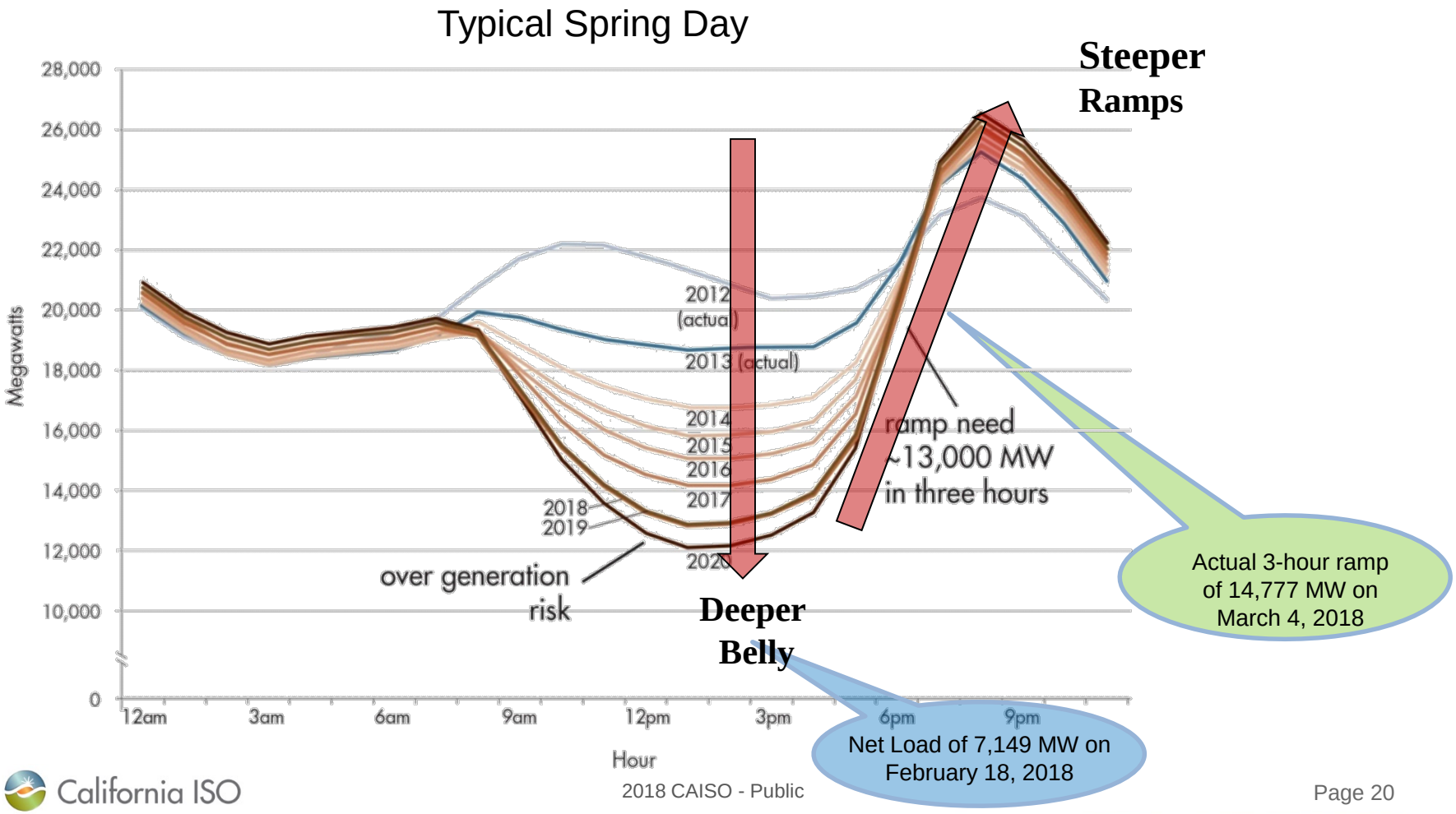
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017_Actual	14,500	14,983	14,723	12,730	12,116	13,001	11,182	11,501	14,679	14,647	14,386	14,695
2018_Fct.	14,192	14,903	15,198	13,942	12,919	12,304	8,632	10,380	12,444	14,880	14,229	15,384
2019_Fct.	16,092	16,600	16,212	15,507	13,405	12,823	10,052	11,278	13,700	15,600	14,760	16,836
2020_Fct.	16,054	18,396	17,913	16,743	14,446	14,260	11,422	12,949	15,336	17,051	15,845	17,512
2021_Fct.	17,907	18,633	18,443	18,101	16,444	14,811	11,756	13,302	15,266	17,106	16,015	16,918

Expected contribution of behind-the-meter solar PV on the 3-hour upward ramps through 2021

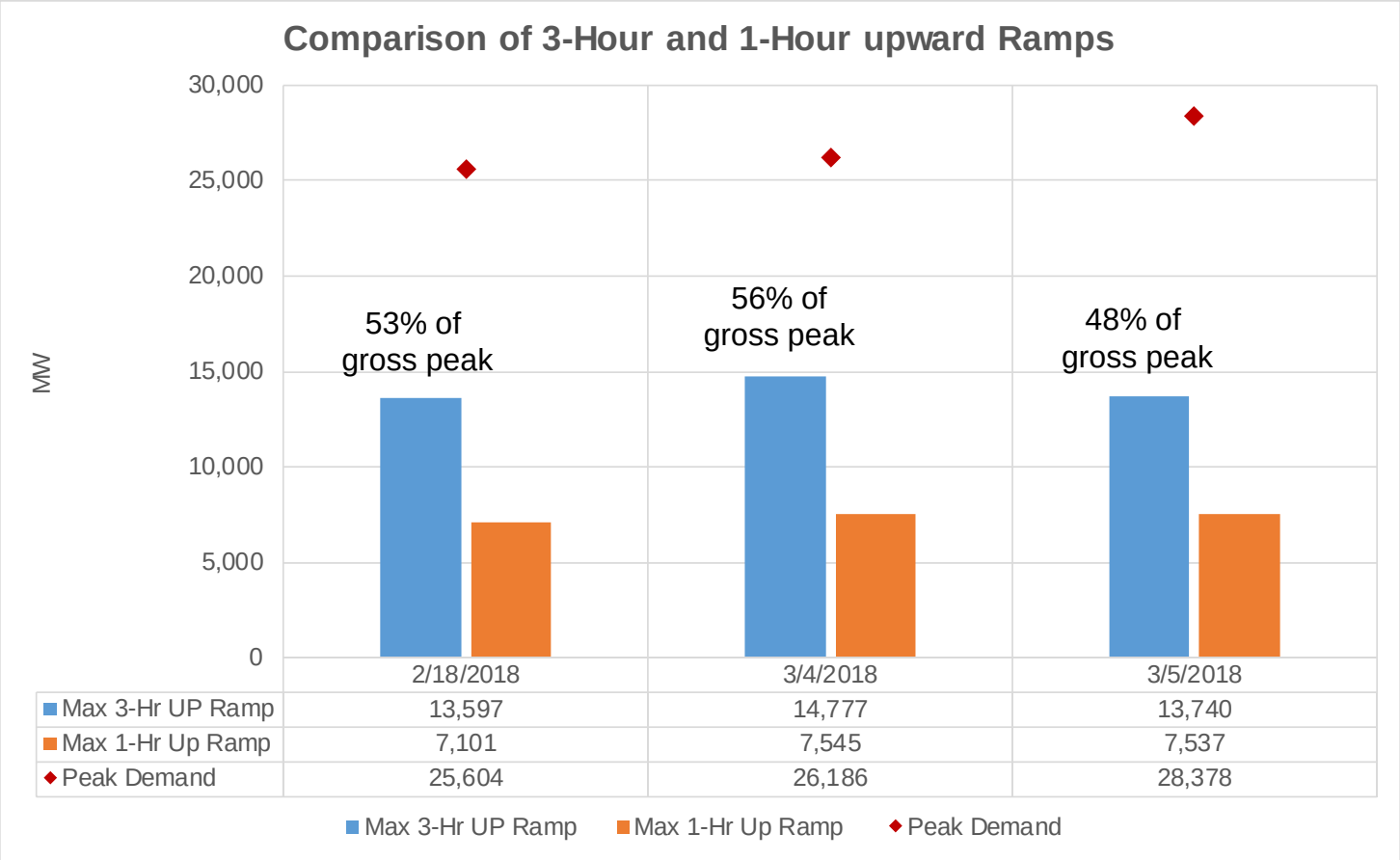


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018_Fct.	2,134	2,820	2,339	2,000	2,277	1,689	1,730	2,435	3,169	2,139	2,582	2,171
2019_Fct.	2,881	3,464	2,872	2,866	2,558	2,220	2,258	2,839	3,449	2,938	3,320	2,469
2020_Fct.	3,077	3,750	3,513	3,070	2,821	2,272	2,697	3,168	3,861	3,282	3,510	2,780
2021_Fct.	3,349	3,680	3,593	2,830	2,668	3,068	2,070	3,204	3,809	3,068	3,548	3,201

Actual net-load and 3-hour ramps are about four years ahead of the CAISO's original estimate primarily due to under forecasting roof-top solar PV installation



The 3-Hour upward ramps are more than 50% of the daily peak demand, which indicates the need for faster ramping resources



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

California ISO

Preliminary Results

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

- Current Methodology

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

Where:

$\text{Max}[(3RR_{HRx})_{MTHy}]$ = 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

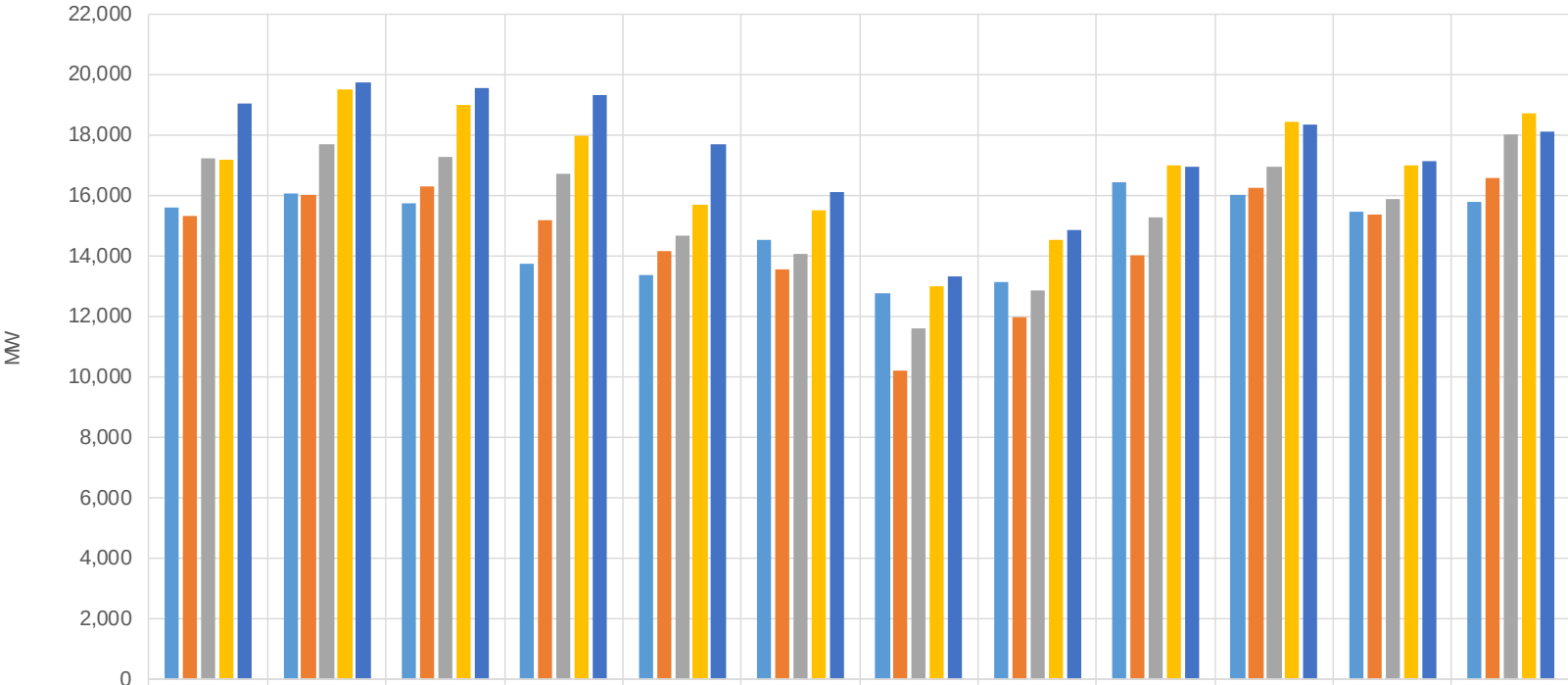
  Three hour net load ramp =

  Δ Load – Δ Wind – Δ Solar – Δ BTM

  Maximum of the Most Severe Single Contingency or 3.5 percent of forecasted coincident peak

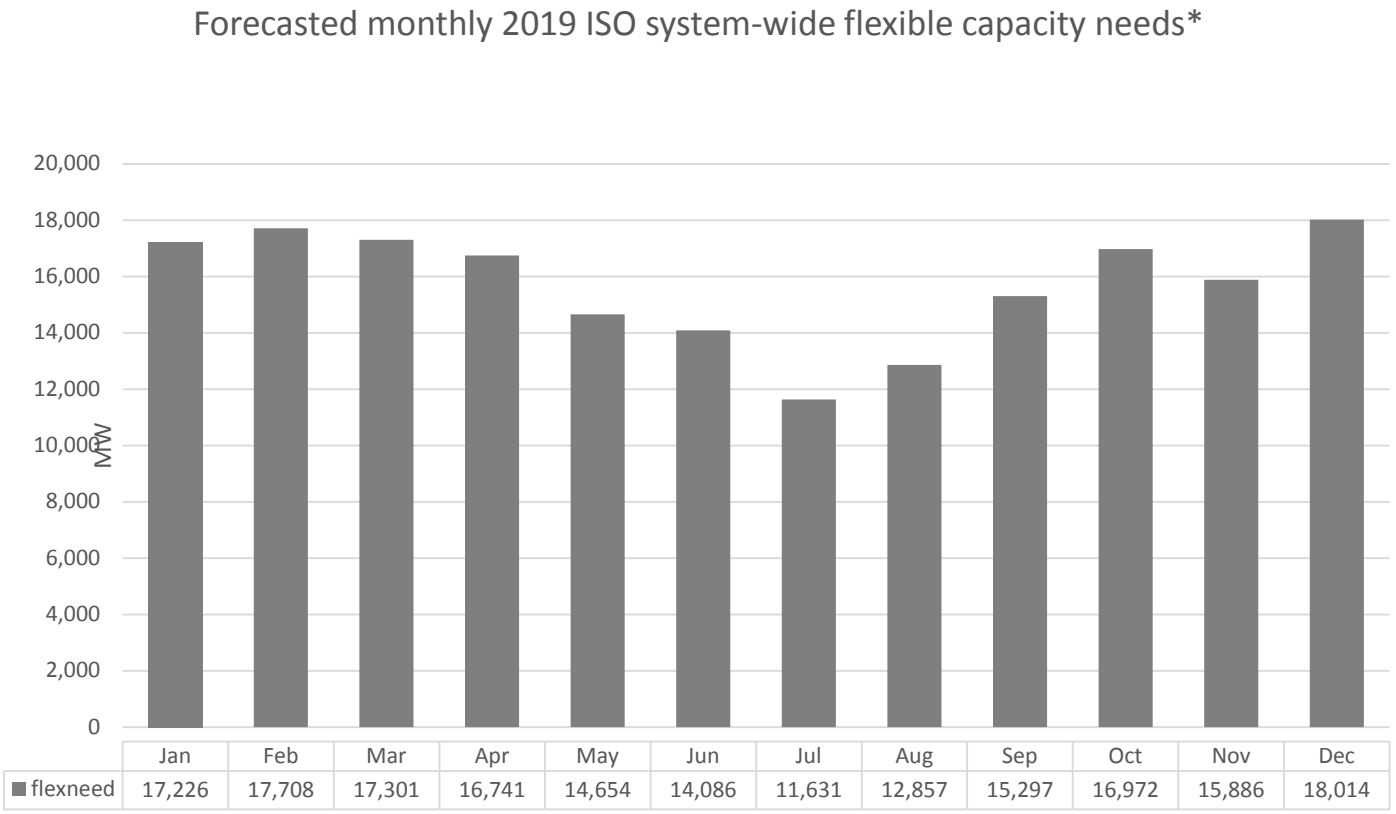
  – Allocated to LRA based on peak-load ratio share

Maximum monthly three-hour upward flexible capacity needs for 2017 through 2021



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017_Actual	15,599	16,049	15,766	13,760	13,383	14,551	12,772	13,166	16,433	16,027	15,486	15,782
2018_Fct.	15,320	16,012	16,288	15,176	14,170	13,569	10,212	11,959	14,040	16,254	15,357	16,562
2019_Fct.	17,226	17,708	17,301	16,741	14,654	14,086	11,631	12,857	15,297	16,972	15,886	18,014
2020_Fct.	17,195	19,509	19,008	17,993	15,701	15,522	13,025	14,532	16,999	18,433	16,982	18,698
2021_Fct.	19,059	19,740	19,548	19,303	17,687	16,099	13,323	14,869	16,937	18,366	17,147	18,099

Forecasted monthly 2019 ISO system-wide flexible capacity needs*



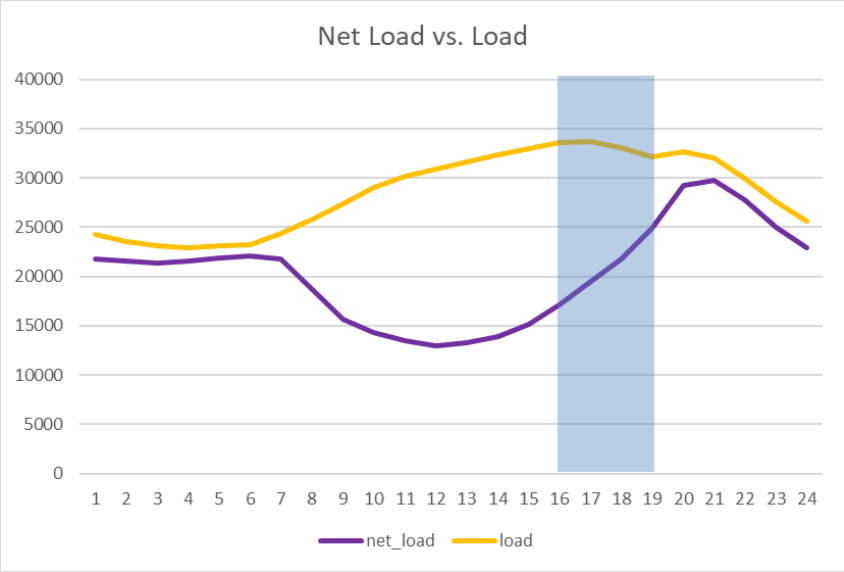
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
flexneed	17,226	17,708	17,301	16,741	14,654	14,086	11,631	12,857	15,297	16,972	15,886	18,014

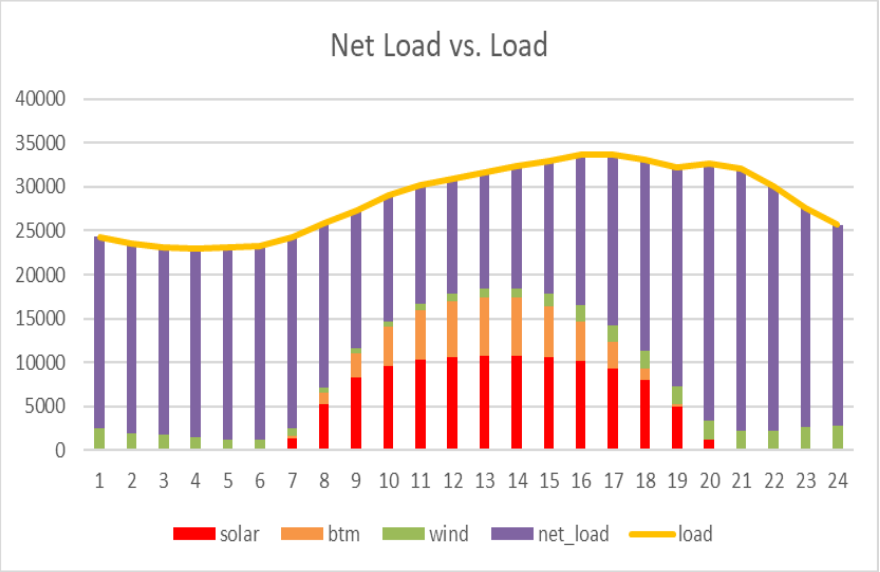
*Flexibility Requirement$_{MTHy}$= Max[(3RR$_{HRx}$)$_{MTHy}$] + Max(MSSC, 3.5%*E(PL$_{MTHy}$)) + ε

Components of the flexible capacity needs based on the 3 hour change in load, wind, solar, and BTM

Month	Average of Load contribution 2019	Average of solar contribution 2019	Average of BTM contribution 2019	Average of Wind contribution 2019	Total percent 2019
January	29.13%	-52.69%	-18.94%	0.76%	100%
February	26.97%	-50.90%	-21.08%	-1.05%	100%
March	25.33%	-61.51%	-19.91%	6.75%	100%
April	21.91%	-56.04%	-23.99%	1.94%	100%
May	17.35%	-66.41%	-19.67%	3.44%	100%
June	13.45%	-68.53%	-21.25%	3.22%	100%
July	-7.31%	-80.63%	-30.30%	3.61%	100%
August	-2.49%	-79.51%	-25.90%	2.91%	100%
September	0.05%	-71.23%	-25.72%	-2.99%	100%
October	15.72%	-59.80%	-18.84%	-5.64%	100%
November	14.63%	-55.13%	-24.43%	-5.80%	100%
December	31.48%	-48.17%	-14.67%	-5.68%	100%

Understanding Negative Contributions of Load to the three hour net load ramp

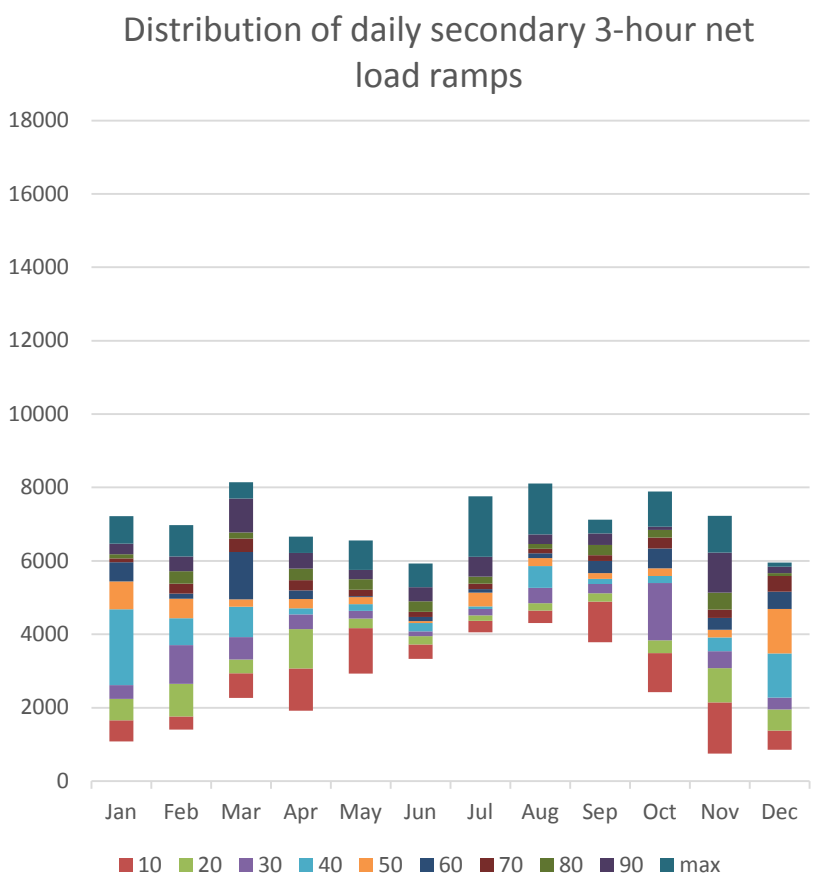


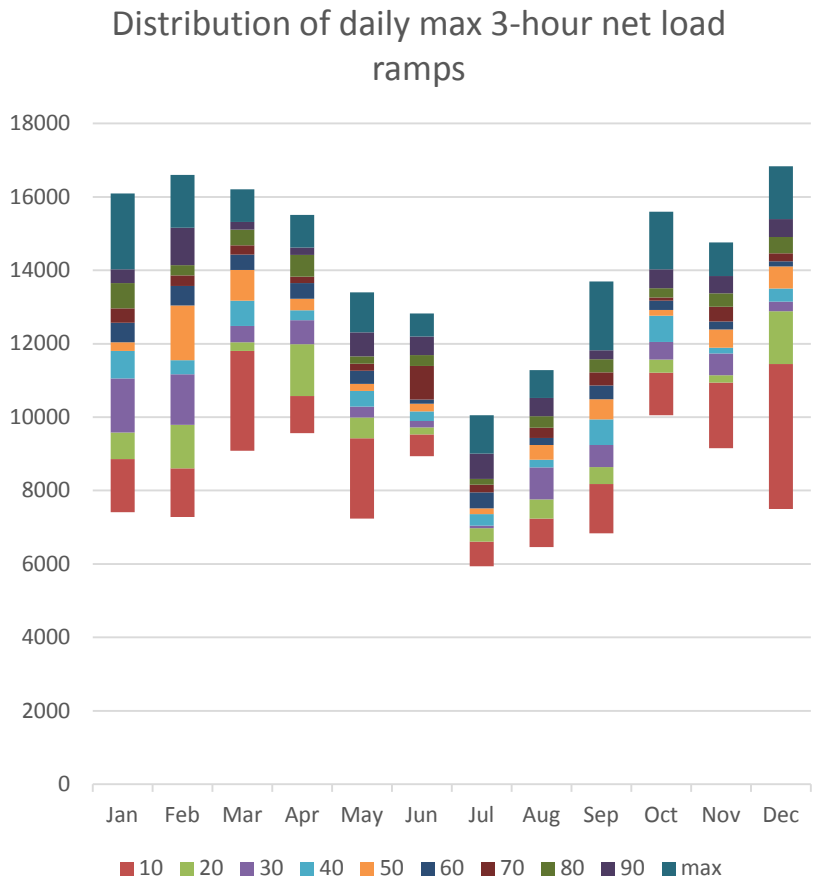


Flexible capacity categories allow a wide variety of resources to provide flexible capacity

- 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

The 2019 forecasted distribution range of daily maximum and secondary 3-hour net load ramps

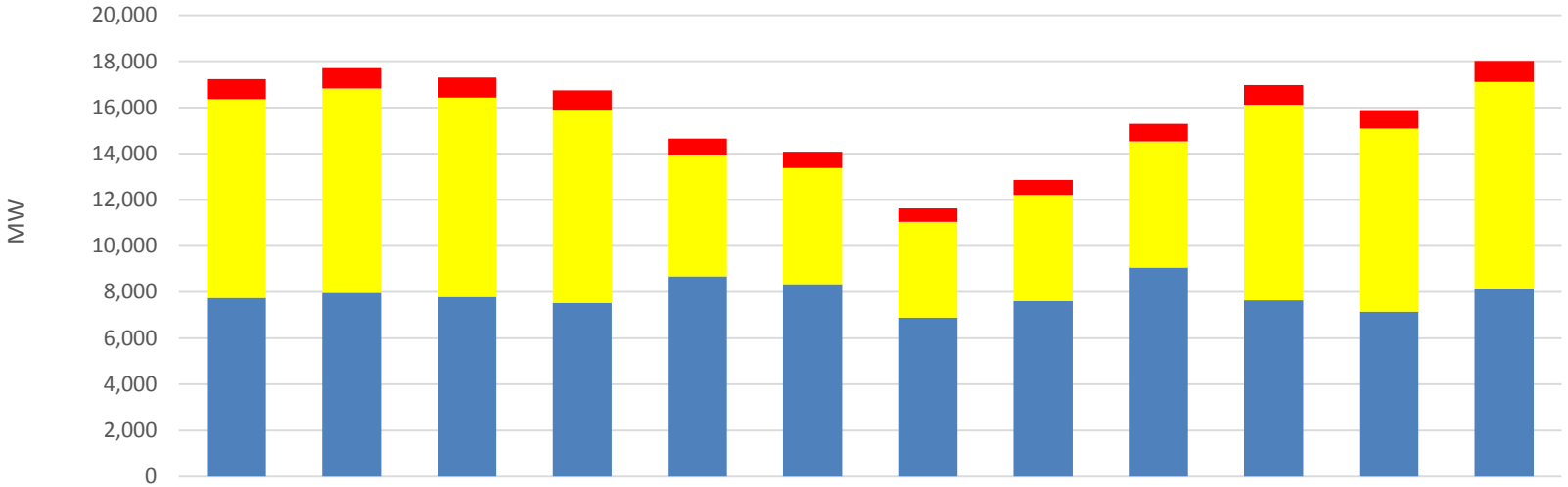




Seasonal breakout of flexible capacity needs

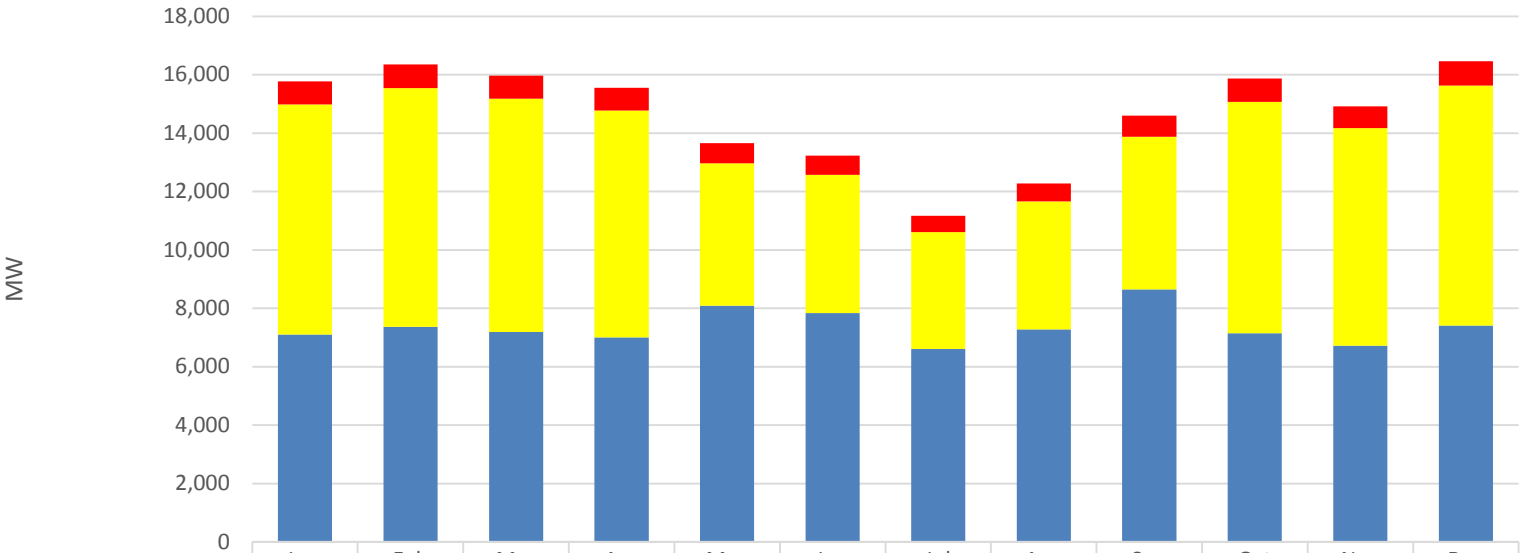
Month	Actual Contributions			Seasonal Contribution		
	Base Flexibility	Peak Flexibility	Super-Peak Flexibility	Base Flexibility	Peak Flexibility	Super-Peak Flexibility
January	45%	50%	5%	45%	50%	5%
February	42%	53%	5%	45%	50%	5%
March	50%	45%	5%	45%	50%	5%
April	43%	52%	5%	45%	50%	5%
May	49%	46%	5%	59%	36%	5%
June	46%	49%	5%	59%	36%	5%
July	77%	18%	5%	59%	36%	5%
August	72%	23%	5%	59%	36%	5%
September	52%	43%	5%	59%	36%	5%
October	51%	44%	5%	45%	50%	5%
November	49%	46%	5%	45%	50%	5%
December	35%	60%	5%	45%	50%	5%

Total flexible capacity needed in each category – seasonally adjusted



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	861	885	865	837	733	704	582	643	765	849	794	901
Peak Flexibility	8,612	8,852	8,649	8,369	5,239	5,035	4,158	4,596	5,468	8,485	7,942	9,005
Base Flexibility	7,753	7,970	7,787	7,535	8,683	8,346	6,892	7,618	9,064	7,639	7,150	8,108

CPUC Jurisdictional Flexible Capacity Allocation - By Flexible Capacity Category



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	788	818	799	778	683	662	558	614	730	793	746	823
Peak Flexibility	7,883	8,177	7,985	7,776	4,881	4,730	3,991	4,390	5,220	7,932	7,457	8,227
Base Flexiblity	7,097	7,362	7,189	7,001	8,090	7,839	6,614	7,276	8,651	7,142	6,713	7,407

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

	Frequency of All Three Hour Net Load Ramp Start Hour (In HE)						
Month	11:00	12:00	13:00	14:00	15:00	16:00	17:00
January				28	3		
February				12	16		
March				2	28	1	
April					17	13	
May				1		30	
June						27	3
July		1				30	
August		1	2			28	
September	2	1	3	3	21		
October				13	18		
November		1	2	27			
December			1	29	1		

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

- Recommended must-offer obligation hours in Hour Ending.
  - HE 14 - HE 19 (2:00 PM to 7:00 PM) January through April and October through December
  - HE 15 - HE 20 (3:00 PM to 8:00 PM) May through September

Summary 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
- Growth of behind-the-meter solar PV and utility scale PV contributes to the larger flexible capacity requirements
- Compared to last year's forecast:
  - Flexible capacity needs and 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
- The Peak and Super-Peak MOO hours have not changed from the 2018 study (information below is in Hour Ending)
  - January through April and October through December: HE 13 - HE 18 (1:00 p.m. to 6:00 p.m.)
  - May through September: HE 14 – HE 19 (2:00 p.m. to 7:00 p.m.)

AVAILABILITY ASSESSMENT HOURS

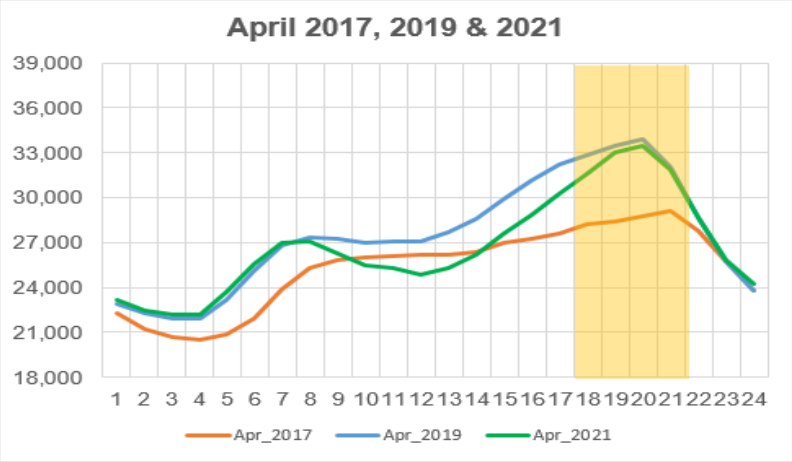
Availability Assessment Hours- Background and Purpose

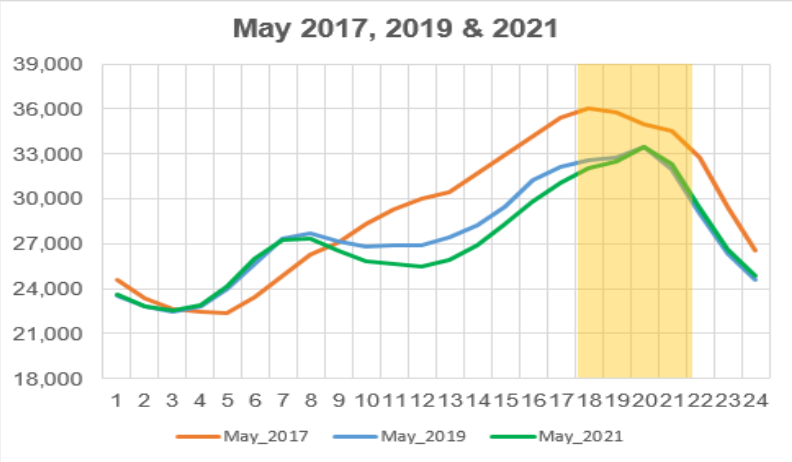
- Concept originally developed as part of the ISO standard capacity product (SCP)
  - Maintained as part of Reliability Service Initiative – Phase 1 (i.e. RA Availability Incentive Mechanism, or RAAIM)
- Determine the hours of greatest need to maximize the effectiveness of the availability incentive structure
  - Resources are rewarded for availability during hours of greatest need
  - Hours determined annually by ISO and published in the BPM
    - See section 40.9 of the ISO tariff

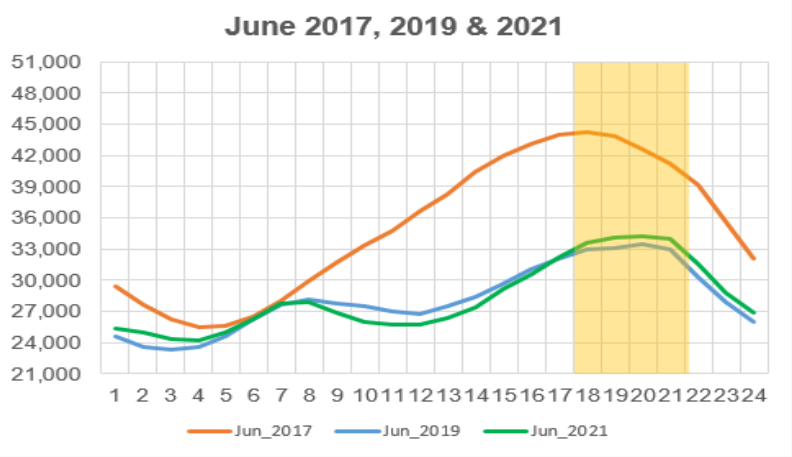
Methodology Overview of System/Local Availability Assessment Hours

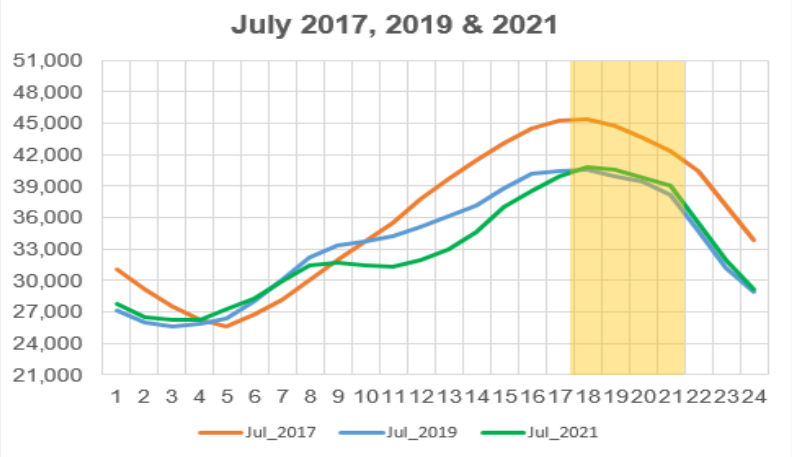
- Used data described in previous slides to obtain:
  - Hourly Average Load
    - By Hour
    - By Month
    - Years 2017-2021
- Calculated:
  - Top 5% of Load Hours within each month using an hourly load distribution
  - Years 2017 through 2021

Expected Load Shape Evolution: Summer Season:

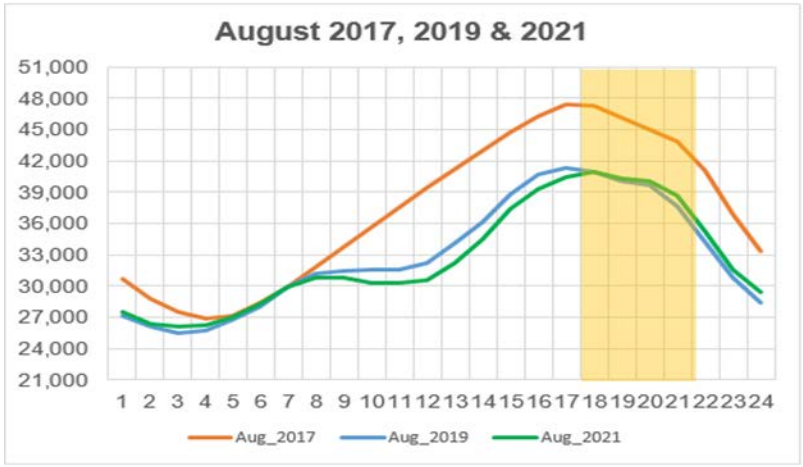


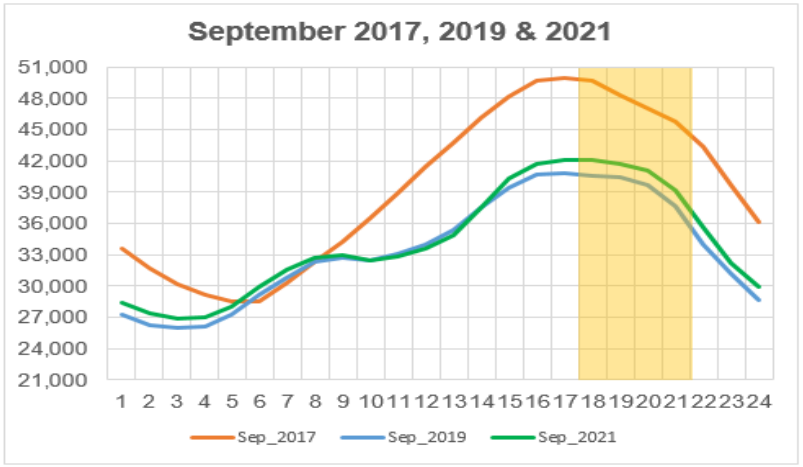


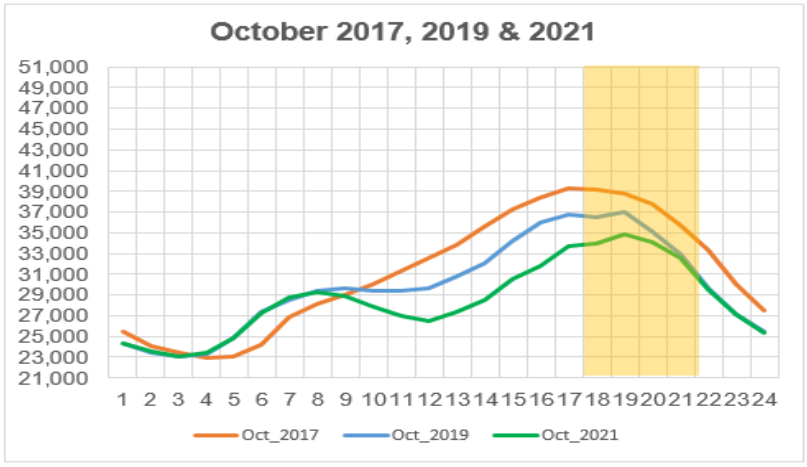




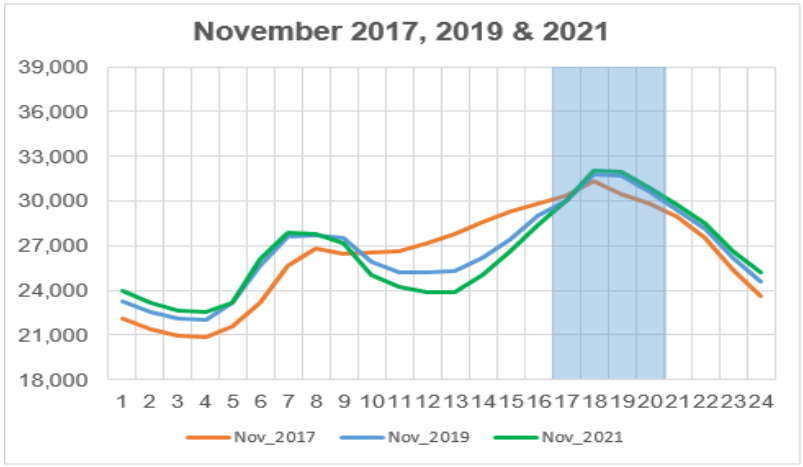
Expected Load Shape Evolution: Summer Season

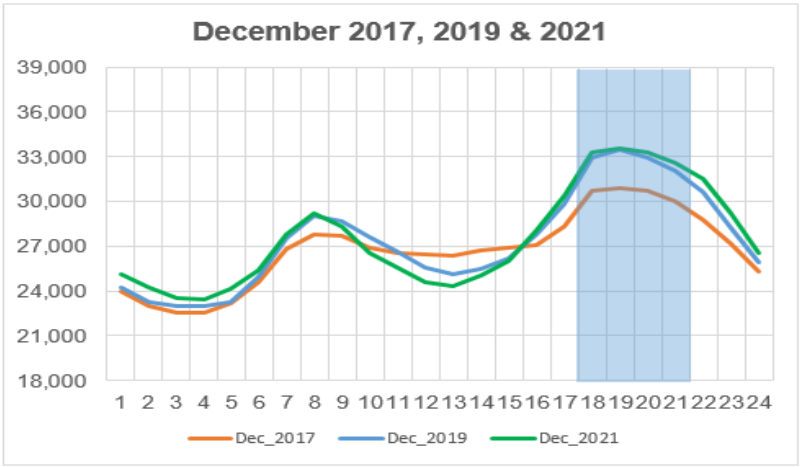




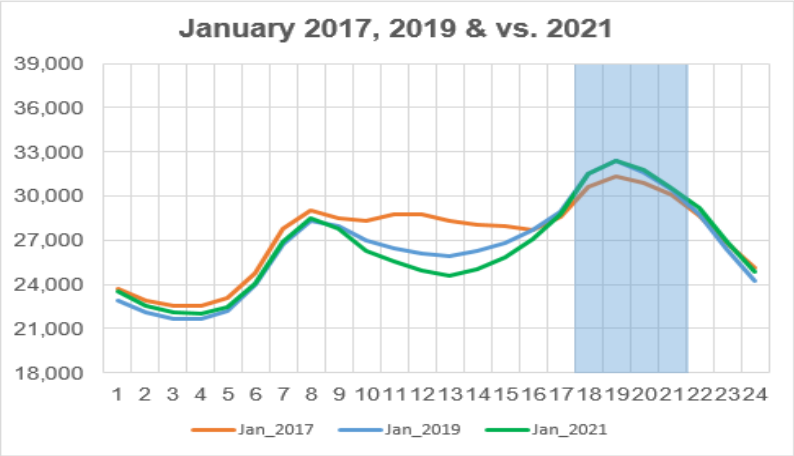


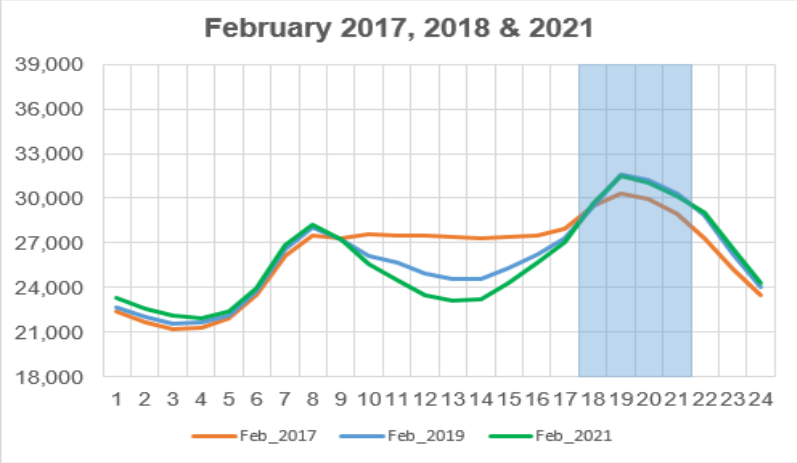
Expected Load Shape Evolution: Winter Season

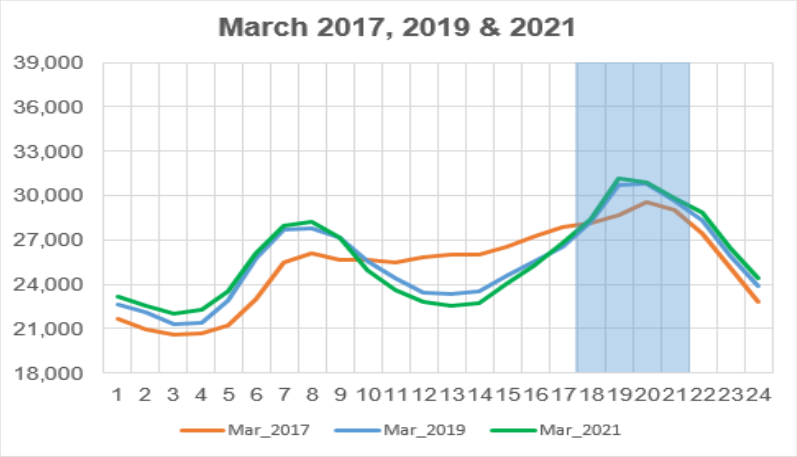




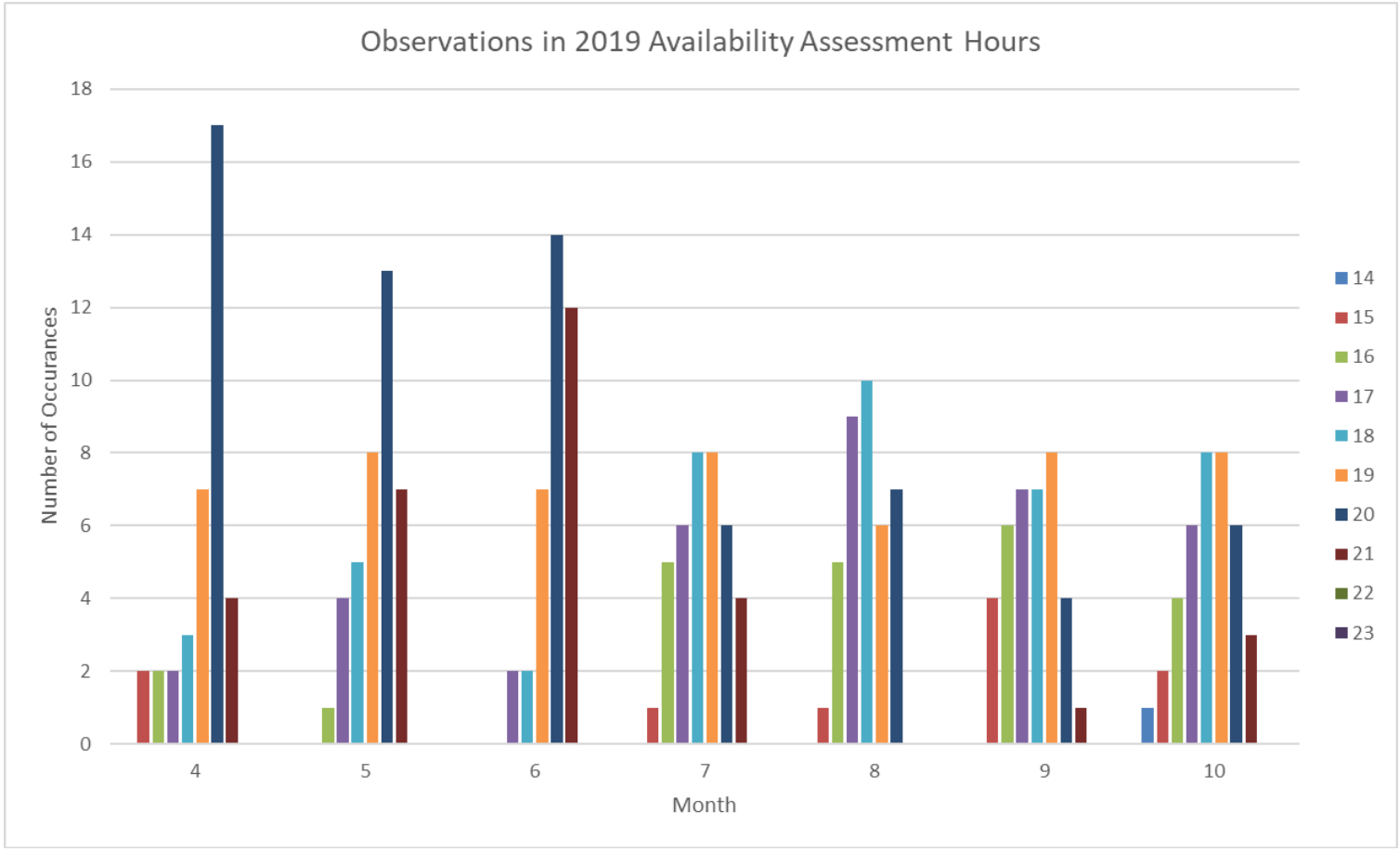
Expected Load Shape Evolution: Winter Season



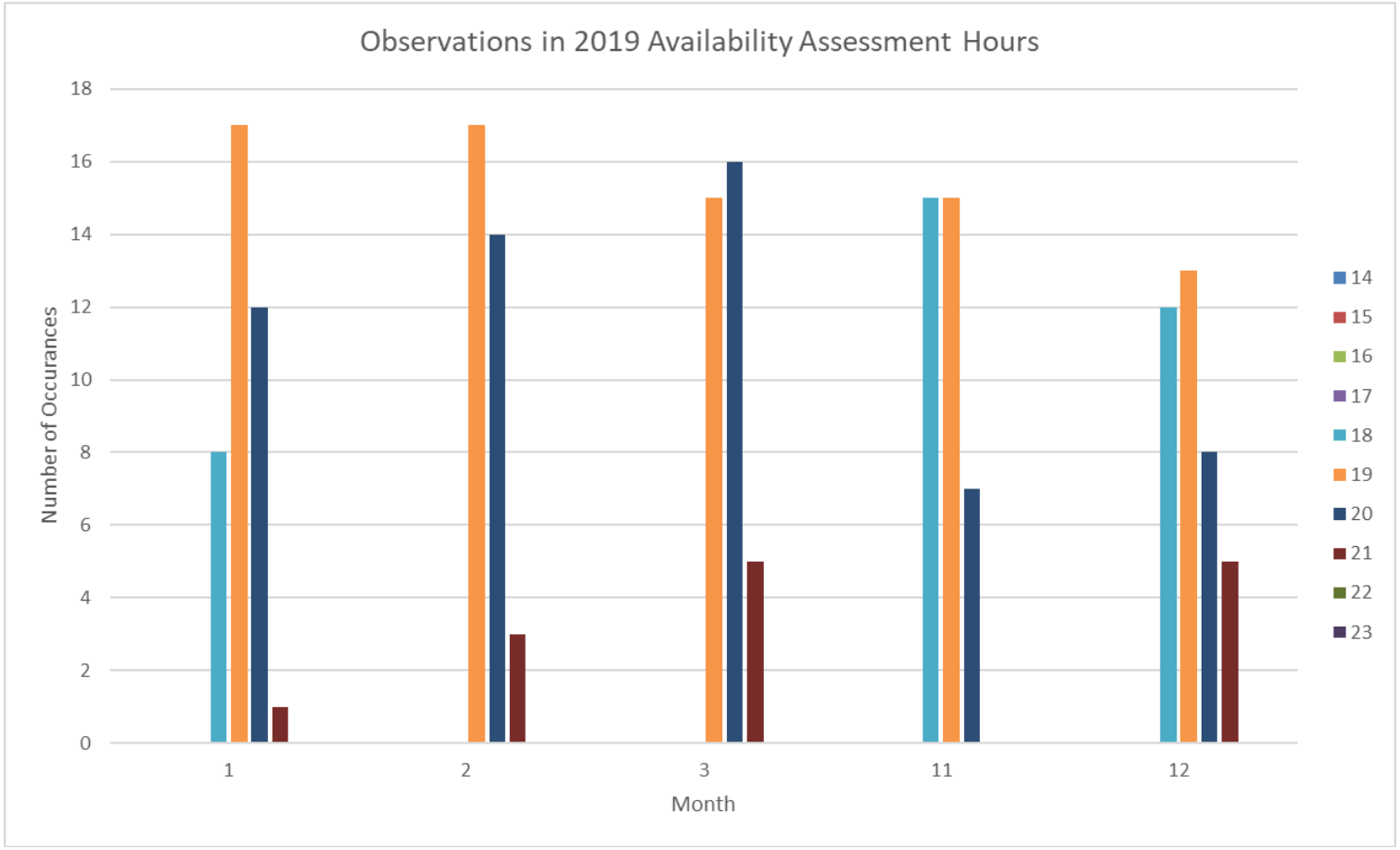




Summer Season



Winter Season



Availability Assessment Hours Draft Recommendation

Winter Season Draft Recommendation

Year	Start	End
2017 (Final)	HE 17	HE 21
2018 (Final)	HE 17	HE 21
2019 (Draft)	HE 17	HE 21
2020 (Estimate)	HE 17	HE 21
2021 (Estimate)	HE 17	HE 21

Summer Season Draft Recommendation

Year	Start	End
2017 (Final)	HE 14	HE 18
2018 (Final)	HE 17	HE 21
2019 (Draft)	HE 17	HE 21
2020 (Estimate)	HE 17	HE 21
2021 (Estimate)	HE 17	HE 21

Reliability Requirements; Section 7 – No BPM Updates Needed

2019 System and Local Resource Adequacy Availability Assessment Hours

Analysis employed: Top 5% of load hours using average hourly load

Summer – April 1 through October 31

Availability Assessment Hours: 4pm – 9pm (HE17 – HE21)

Winter – November 1 through March 31

Availability Assessment Hours: 4pm – 9pm (HE17 – HE21)

2019 Flexible Resource Adequacy Availability Assessment Hours and must offer obligation hours

Flexible RA Capacity Type	Category Designation	Required Bidding Hours (All Hour Ending Times)	Required Bidding Days
January – April October – December			
Base Ramping	Category 1	05:00am to 10:00pm (HE6-HE22)	All days
Peak Ramping	Category 2	2:00pm to 7:00pm (HE14-HE19)	All days
Super-Peak Ramping	Category 3	2:00pm to 7:00pm (HE14-HE19)	Non-Holiday Weekdays*
May – September			
Base Ramping	Category 1	05:00am to 10:00pm (HE6-HE22)	All days
Peak Ramping	Category 2	3:00pm to 8:00pm (HE15-HE20)	All days
Super-Peak Ramping	Category 3	3:00pm to 8:00pm (HE15-HE20)	Non-Holiday Weekdays*

Next steps

- Published Draft Flexible Capacity Needs Assessment for 2019 – April 13, 2018
  - ~~– Stakeholder call April 16, 2018~~
  - – Comments due April 23, 2018
    - Please submit comments on the assumptions to initiativecomments@caiso.com

- Publish Final Flexible Capacity Needs Assessment for 2019 – May 15th, 2018

Questions

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