Flexible Capacity Needs and Availability Assessment Hours Technical Study for 2020

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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 2020 and advisory flexible capacity requirements for compliance years 2021 and 2022

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 upward ramps
  - Add contingency reserves
  - Calculate monthly Flexible Capacity requirement
- Overview of methodology used for system/local availability assessment hours
  - 2020 availability assessment hours
  - 2021-2022 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

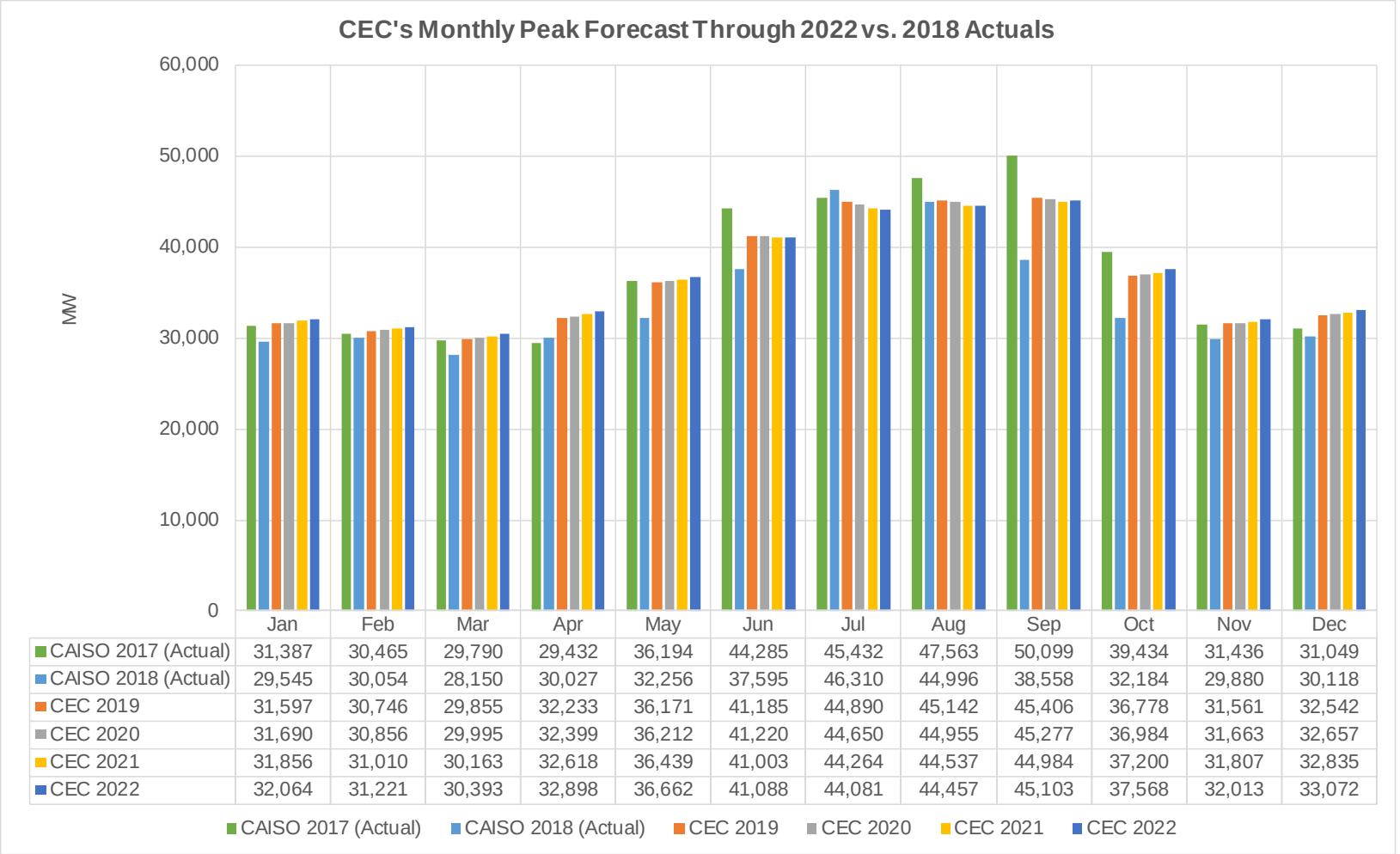
Resource Adequacy (RA)

- 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 3-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

The ISO used the following data to determine the flexible capacity

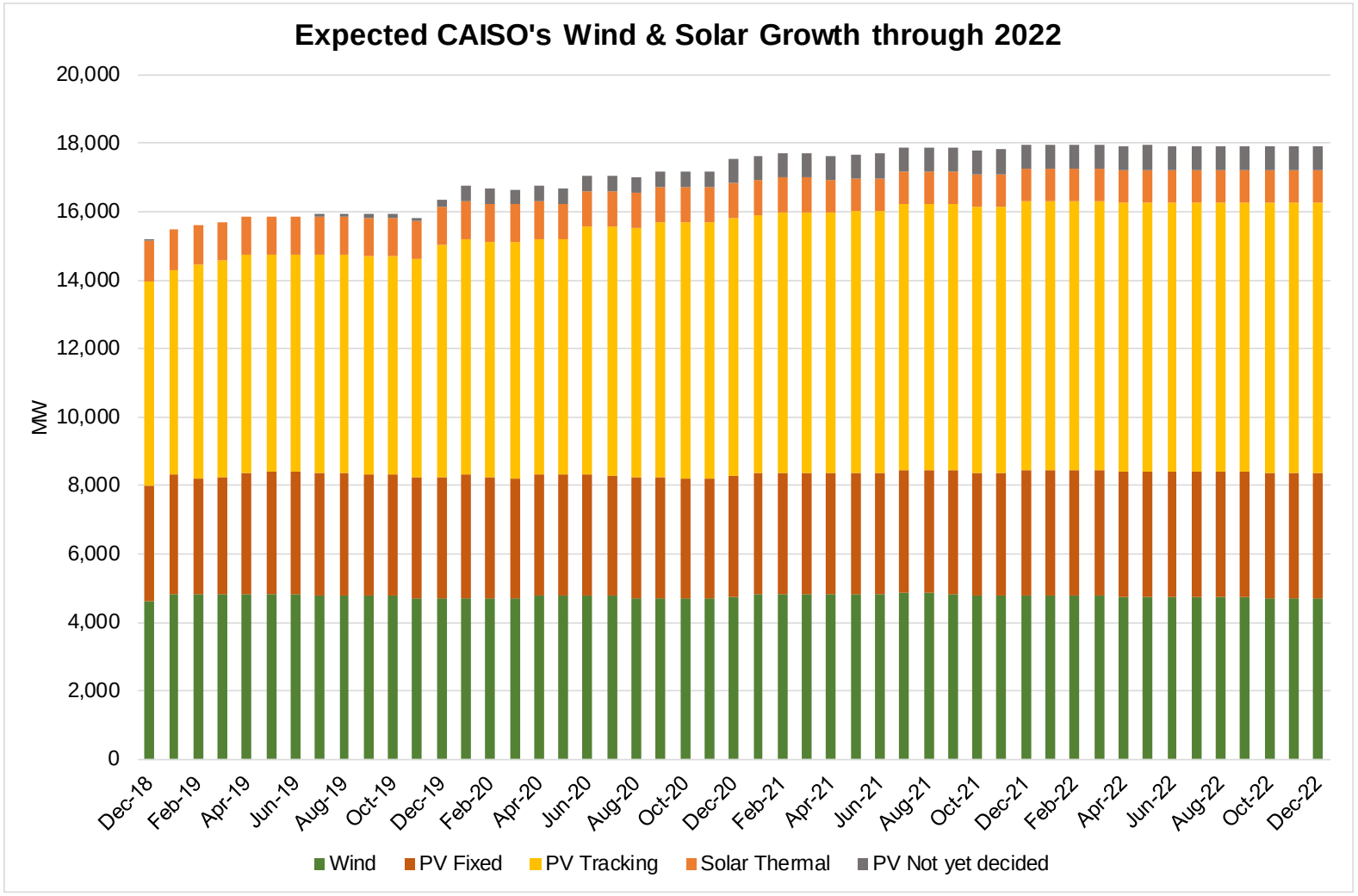
- CEC's "1-in-2" Mid-hourly demand forecast for 2020 through 2022
  - Behind-the-meter hourly solar PV production
  - Hourly AAEE
- LSE SCs updated renewable build-out for 2018 through 2022
- The data included:
  - Installed capacity by technology and expected operating date (e.g. Solar thermal, solar 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

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

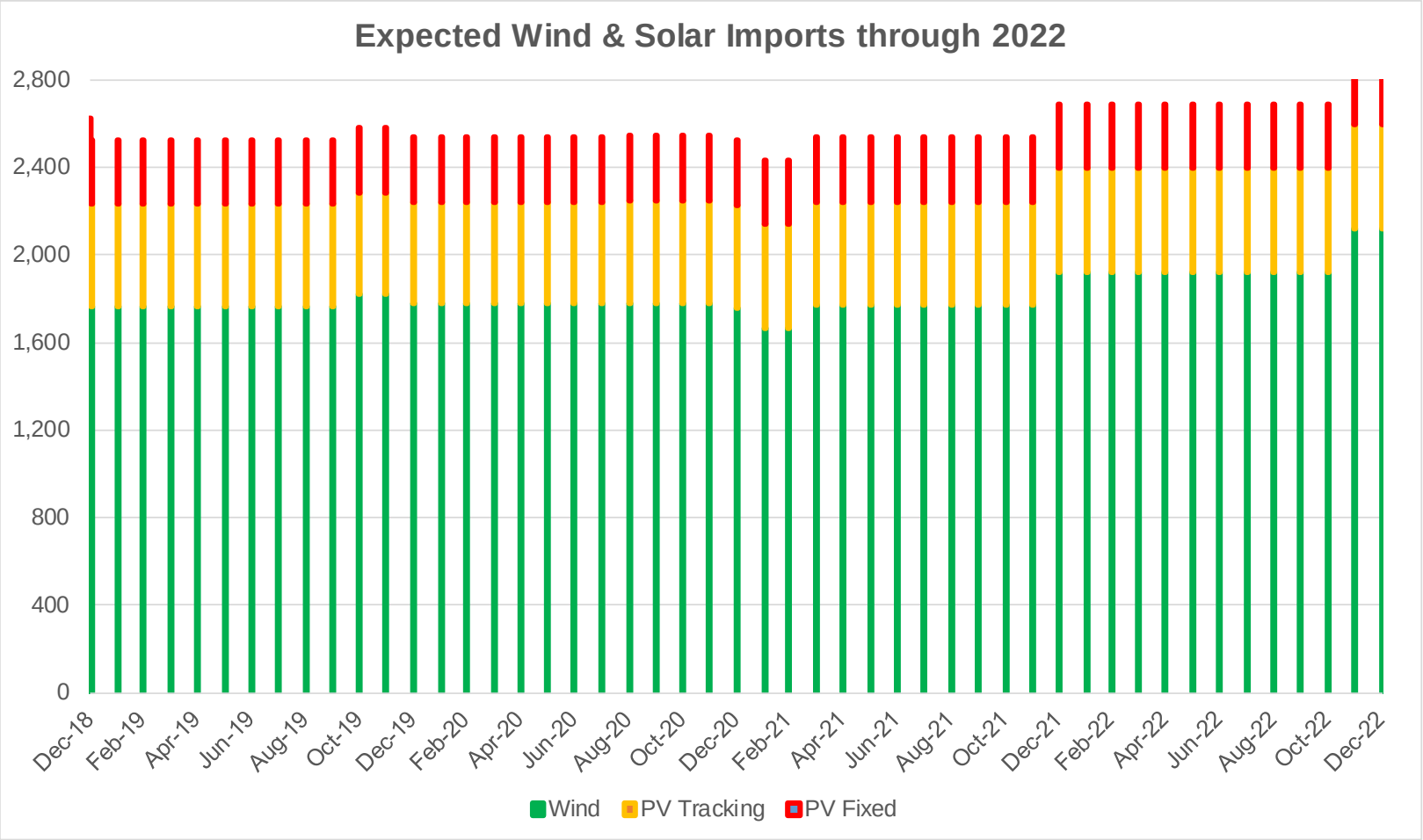


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CAISO 2017 (Actual)	31,387	30,465	29,790	29,432	36,194	44,285	45,432	47,563	50,099	39,434	31,436	31,049
CAISO 2018 (Actual)	29,545	30,054	28,150	30,027	32,256	37,595	46,310	44,996	38,558	32,184	29,880	30,118
CEC 2019	31,597	30,746	29,855	32,233	36,171	41,185	44,890	45,142	45,406	36,778	31,561	32,542
CEC 2020	31,690	30,856	29,995	32,399	36,212	41,220	44,650	44,955	45,277	36,984	31,663	32,657
CEC 2021	31,856	31,010	30,163	32,618	36,439	41,003	44,264	44,537	44,984	37,200	31,807	32,835
CEC 2022	32,064	31,221	30,393	32,898	36,662	41,088	44,081	44,457	45,103	37,568	32,013	33,072

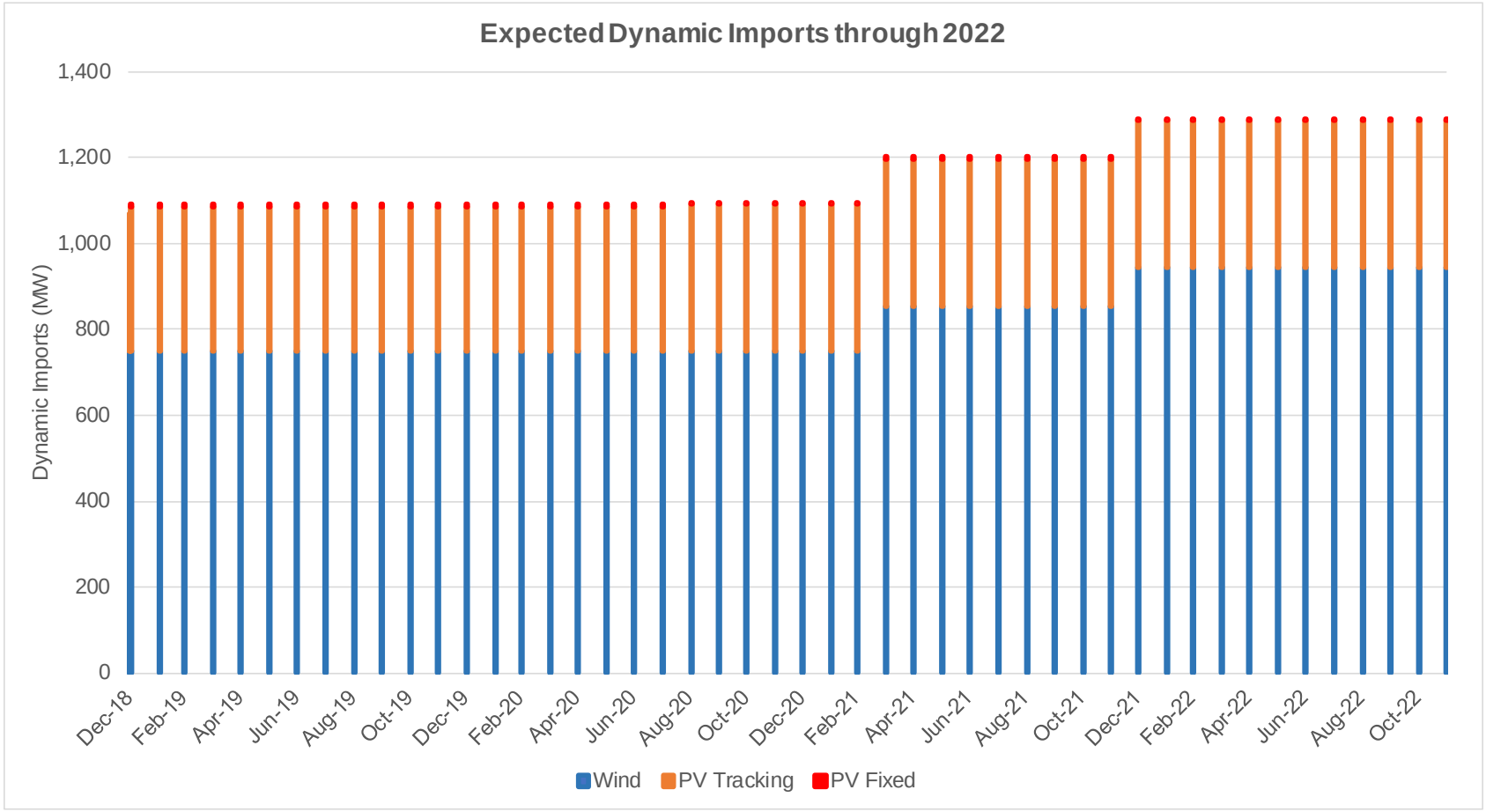
Solar & wind build-out through December 2022



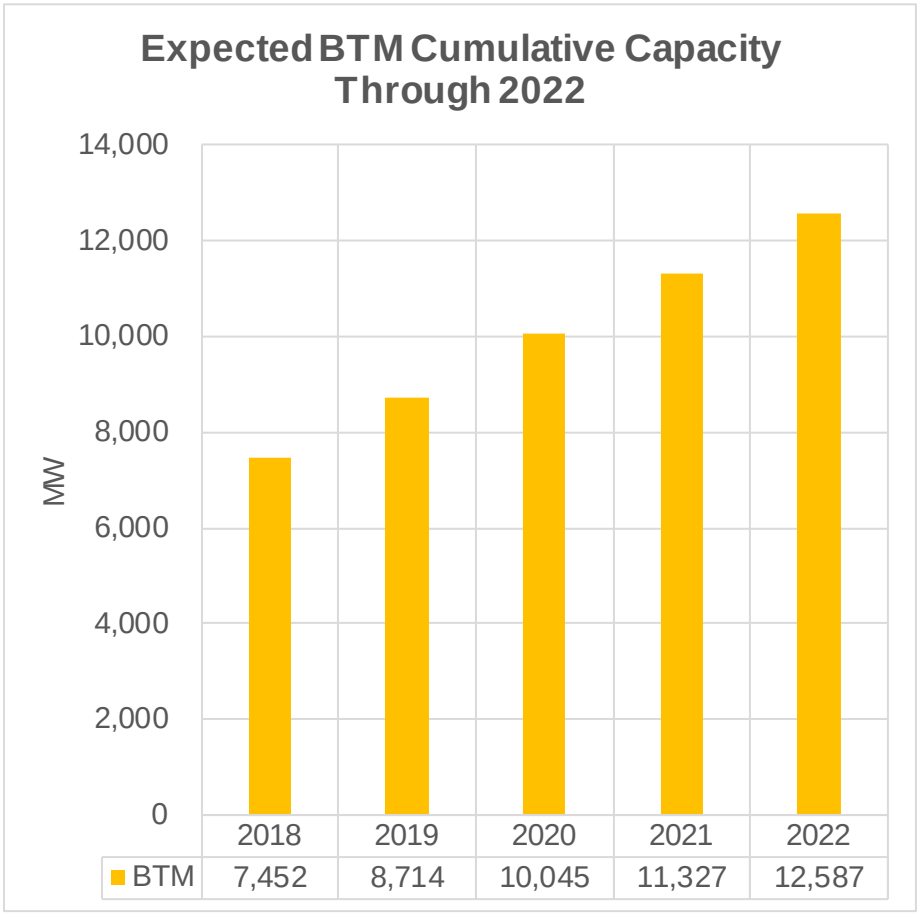
Firmed and non-firmed out of state contracted solar & wind through December 2022

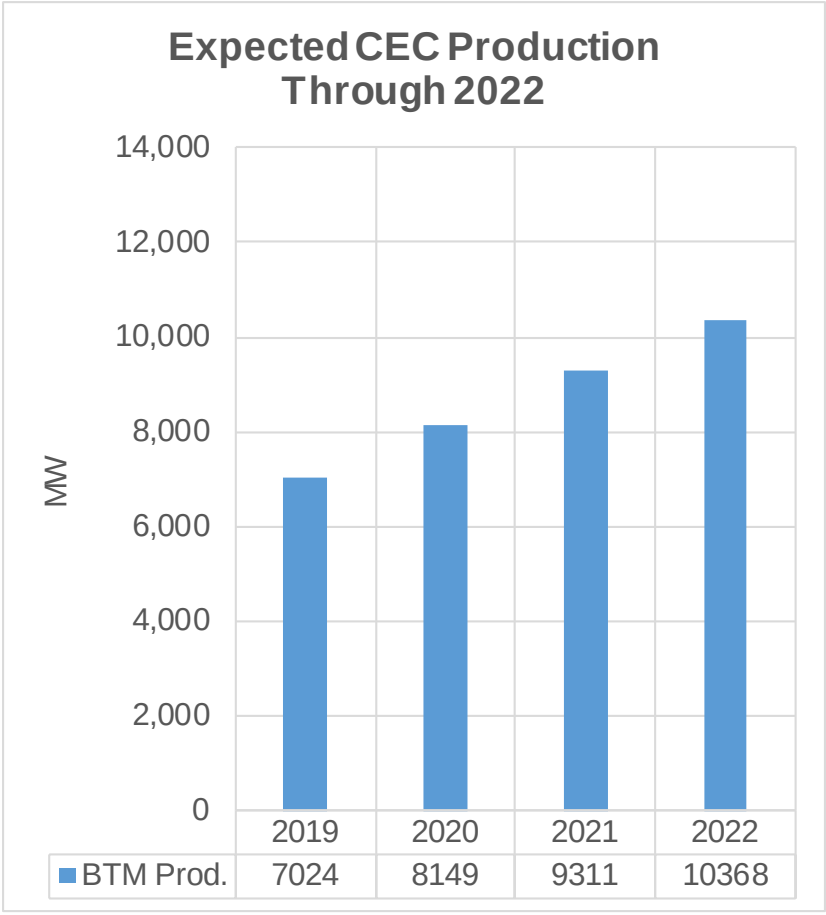


Non-firmed out-of-state contracted renewables through December 2022



LSEs estimate of behind-the-meter solar PV capacity & CEC's estimated production through 2022





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

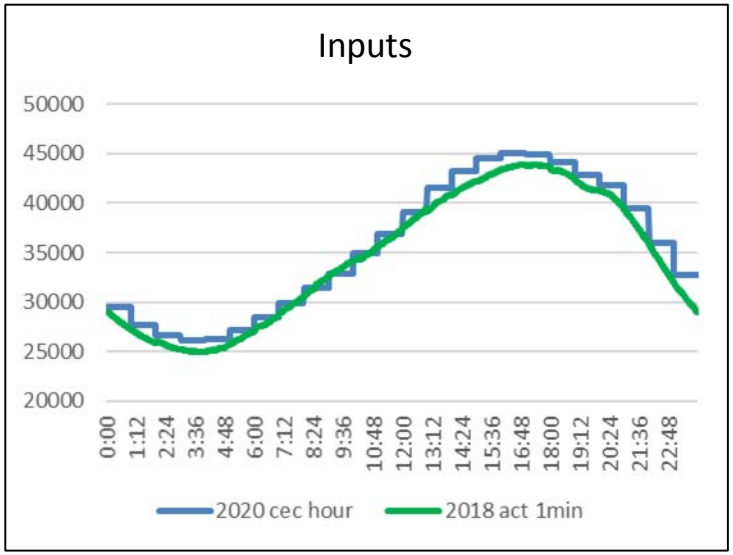
- Used the most current data available for renewable build-out submitted by all LSE SCs
- For new renewable installation scale 2018 actual production data based on installed monthly capacity in subsequent years
- Generated net load profiles for 2020 through 2022 using the simulated:
  - Load profiles for 2020 through 2022
  - Solar profiles for 2020 through 2022
  - Wind profiles for 2020 through 2022

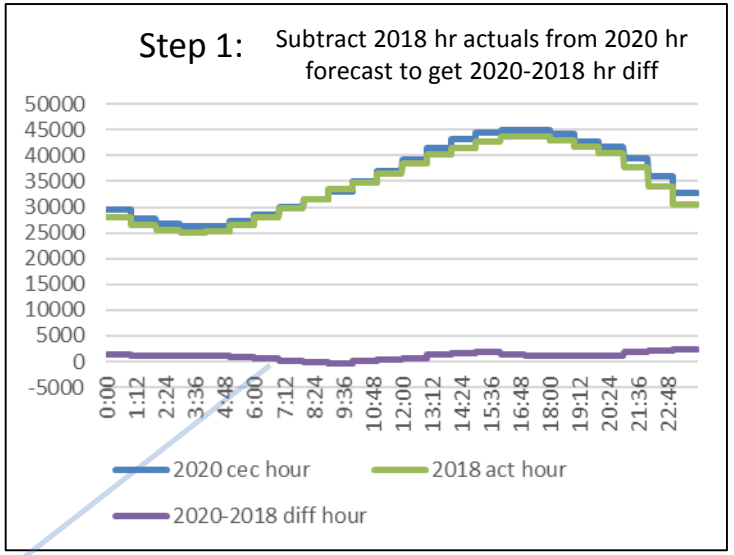
The ISO will use the CEC's 1-in-2 IEPR forecast to develop the load forecast

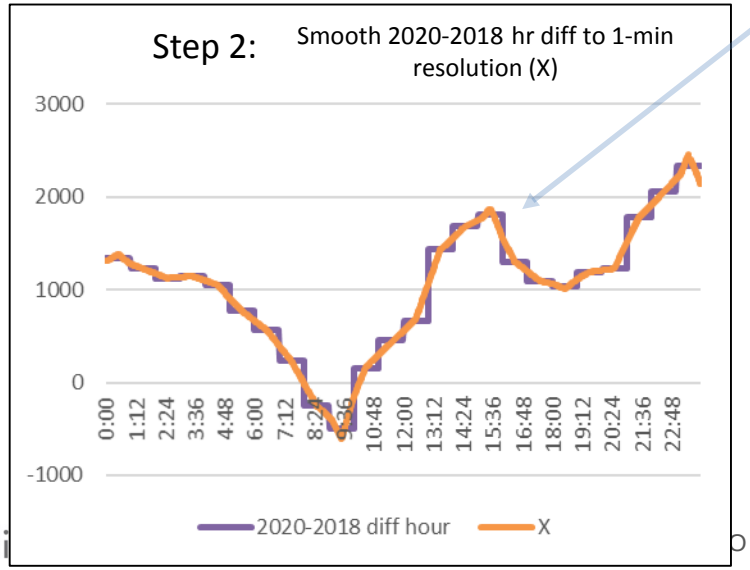
- The ISO uses "1-in-2" IEPR forecast; the IEPR forecast has both an hourly view and a monthly view.
  - The forecast is correlated such that the peak of the month can be seen in the hourly profile.

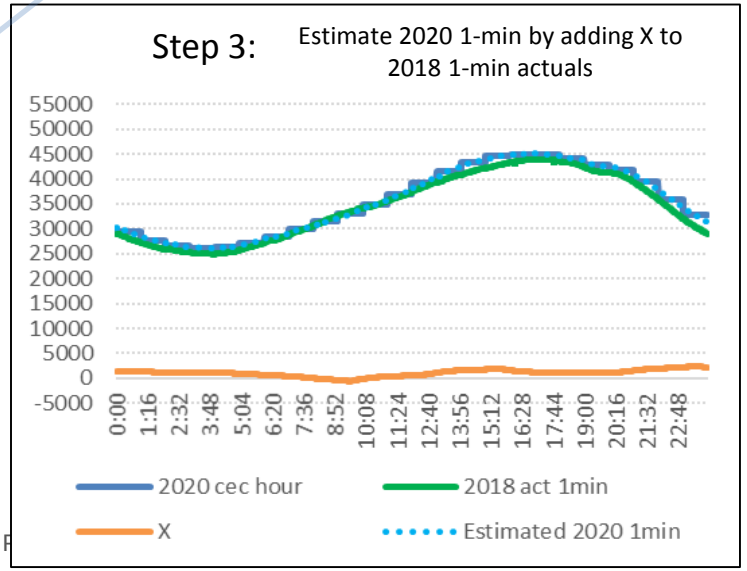
- CEC IEPR Load Forecast
  - https://www.energy.ca.gov/2018_energypolicy/documents/index.html
  - Title of File: "Corrected CAISO Hourly Results CEDU 2018-2022"
    - The ISO will be using column AR (Managed Total Energy for Load) within the spreadsheet.
    - Managed Total Energy for Load =
      + Baseline Consumption Load
      – Committed PV Generation
      – Additional achievable PV generation
      – AAEE
      – POU AAEE

Smoothing 2020 1-minute load profile









Hourly load forecast to 1-minute load forecast

- Used 2018 actual 1-minute load data to build 1-minute load profiles for subsequent years
- Scaled the hourly CEC load forecast value of each hour into 1-minute forecast data using a smoothing equation looking at the differences between the forecasted year and the 2018 1-minute actuals.

2020 Load 1-Minute Forecast

- **2020 $L_{CECfcst\_1\text{-}min}$ = 2018 $L_{Act\_1\text{-}min}$ + X**
  - **Where X = Interpolated 1min profile from the difference**

    (2020 $L_{CECfcst\_hourly}$ - 2018 L_{actual_hourly})

2021 Load 1-Minute Forecast

- **2021 $L_{CECfcst\_1\text{-}min}$ = 2018 $L_{Act\_1\text{-}min}$ + X**
  - **Where X = Interpolated 1min profile from the difference**

    (2021 $L_{CECfcst\_hourly}$ - 2018 L_{actual_hourly})

Solar growth assumptions through 2022

- Used the actual solar 1-minute solar production data for 2018 to develop the 1-minute solar profiles for 2019 through 2022
- Scaled 1-minute solar data using the forecast monthly solar capacity for the new plants scheduled to be operational in 2019
- Repeated the above steps for 2020, 2021 & 2022

$$\text{2019 } S_{\text{Mth\_Sim\_1-min}} = 2018S_{\text{Act\_1-min}} * 2019S_{\text{Mth Capacity}} / 2018S_{\text{Mth Capacity}}$$

$$\text{2020 } S_{\text{Mth\_Sim\_1-min}} = 2018S_{\text{Act\_1-min}} * 2020S_{\text{Mth Capacity}} / 2018S_{\text{Mth Capacity}}$$

$$\text{2021 } S_{\text{Mth\_Sim\_1-min}} = 2018S_{\text{Act\_1-min}} * 2021S_{\text{Mth Capacity}} / 2018S_{\text{Mth Capacity}}$$

$$\text{2022 } S_{\text{Mth\_Sim\_1-min}} = 2018S_{\text{Act\_1-min}} * 2022S_{\text{Mth Capacity}} / 2018S_{\text{Mth Capacity}}$$

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

- Net load is defined as load minus wind and solar power production
- Net load variability increases as more and more wind and solar resources are integrated into the system
- The monthly 3-hour flexible capacity need equates to the largest upward change in net load when looking across a rolling 3-hour evaluation window
- The ISO dispatches flexible resources (including renewable resources with energy bids) to meet net load

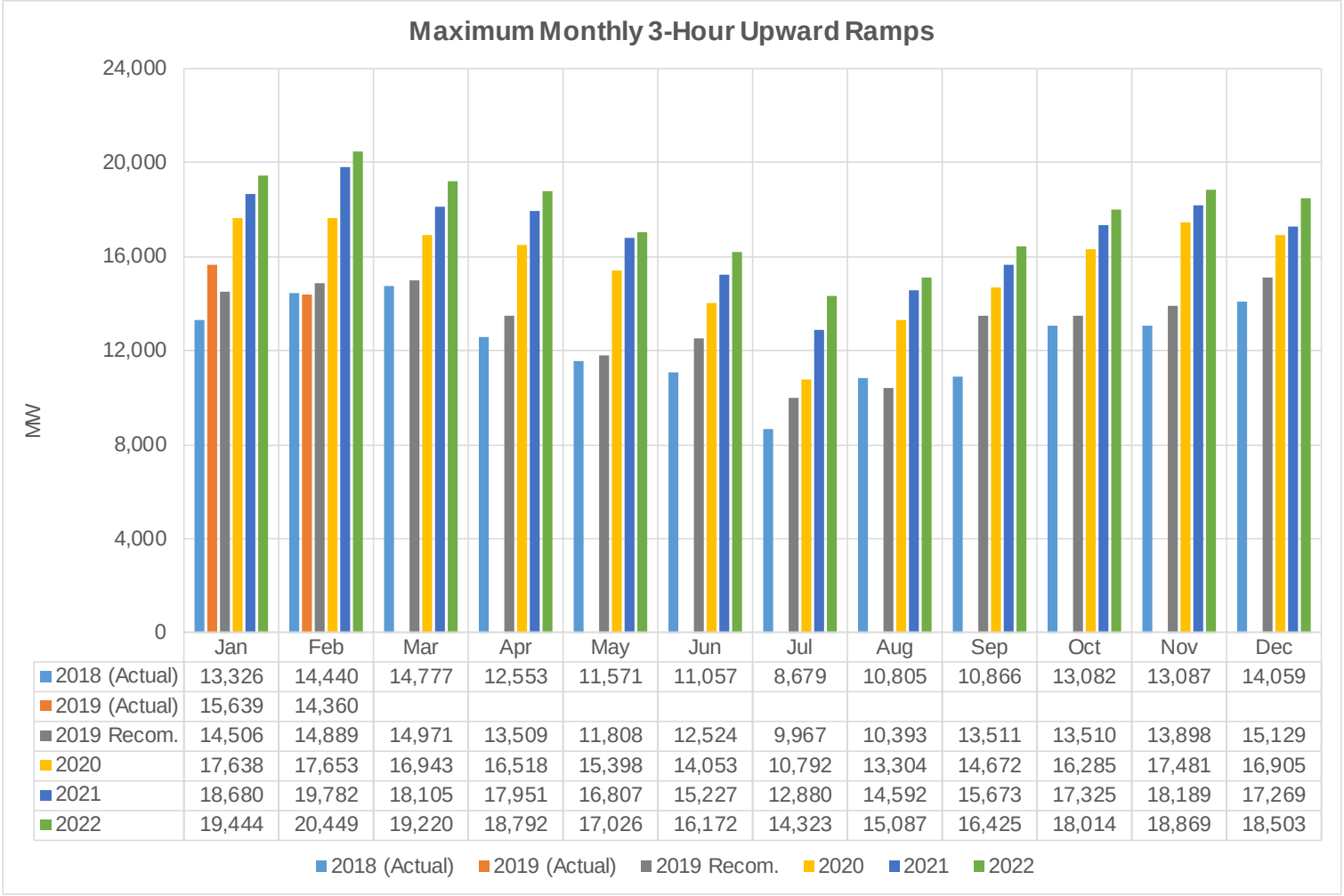
1 NERC Special Report
Flexibility Report Requirements and metrics for Variable Generation: Implications for System Planning Studies, August 2010 . http://www.nerc.com/files/IVGTF_Task_1_4_Final.pdf

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

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

$$\text{Net Load}_{181\ min}\text{-Net Load}_{1},\ \text{Net Load}_{182\ min}\text{-Net Load}_{2},\ \ldots.\ \text{Net Load}_{n+180min}\text{-Net Load}_{n}$$

Maximum monthly 3-hour upward net load ramps for 2018 through 2022



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018 (Actual)	13,326	14,440	14,777	12,553	11,571	11,057	8,679	10,805	10,866	13,082	13,087	14,059
2019 (Actual)	15,639	14,360										
2019 Recom.	14,506	14,889	14,971	13,509	11,808	12,524	9,967	10,393	13,511	13,510	13,898	15,129
2020	17,638	17,653	16,943	16,518	15,398	14,053	10,792	13,304	14,672	16,285	17,481	16,905
2021	18,680	19,782	18,105	17,951	16,807	15,227	12,880	14,592	15,673	17,325	18,189	17,269
2022	19,444	20,449	19,220	18,792	17,026	16,172	14,323	15,087	16,425	18,014	18,869	18,503

*Please note Actuals in this graph may have solar/wind curtailments present

The flexible capacity methodology should provide the ISO with sufficient flexible capacity

Methodology

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

Where:

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

E(PL) = Expected peak load

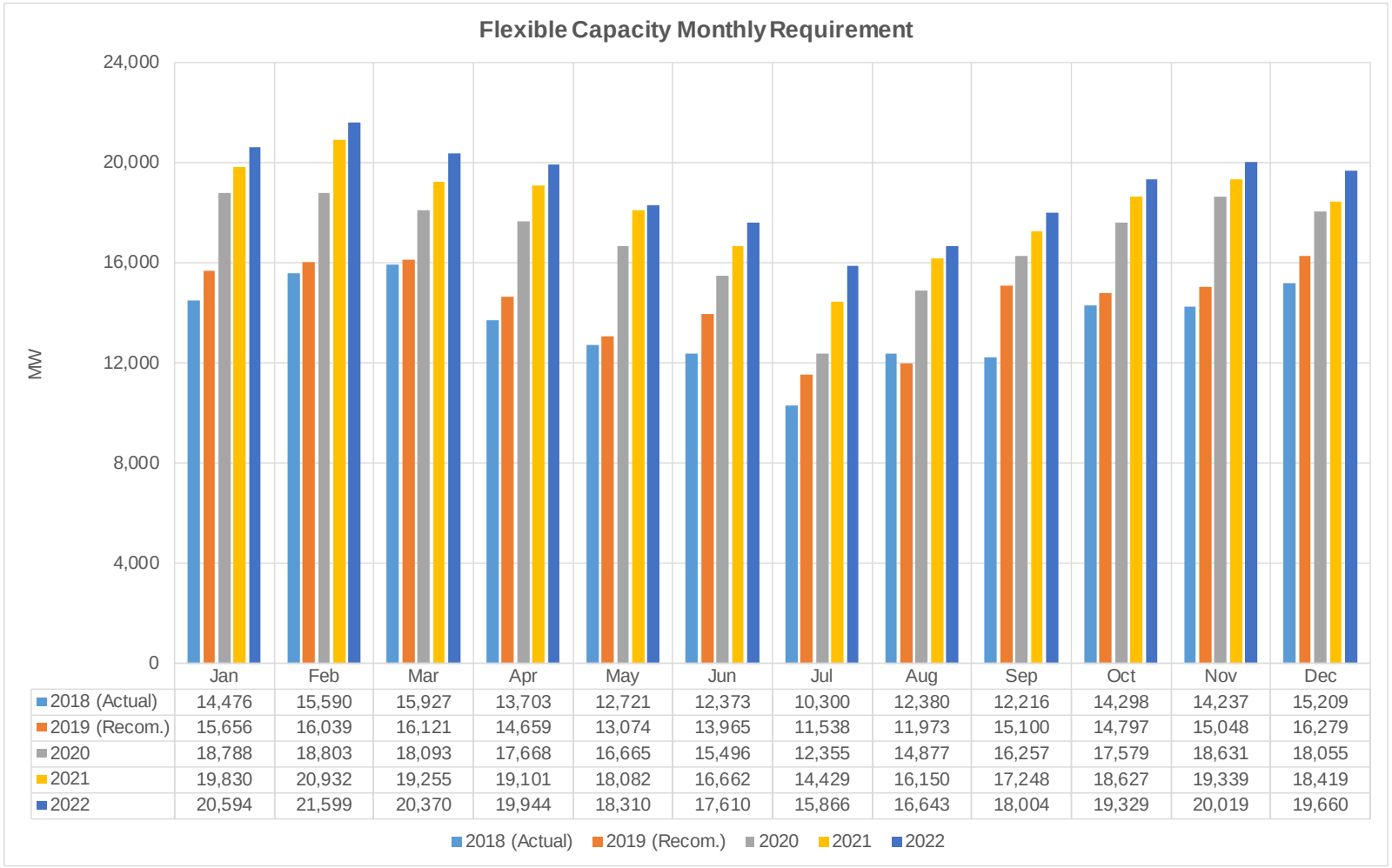
MTH_y = Month $_y$

MSSC = Most Severe Single Contingency

ε = Annually adjustable error term to account for load forecast errors and variability. ε is currently set at zero

For next year the ISO will work towards changing the Flex RA standard to be reflective of the current WECC/NERC reliability requirements.

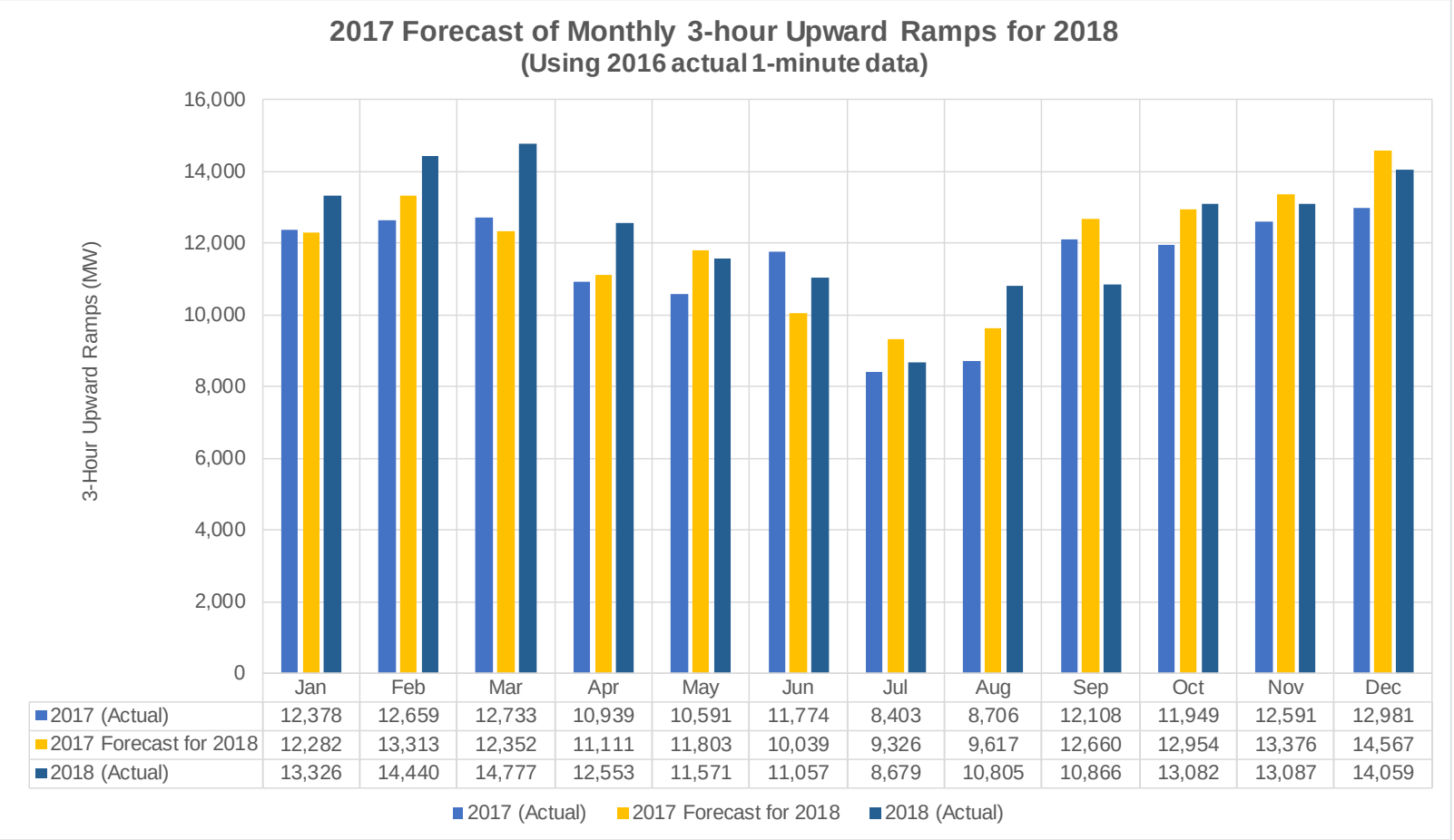
Maximum monthly 3-hour upward flexible capacity needs for 2020 through



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018 (Actual)	14,476	15,590	15,927	13,703	12,721	12,373	10,300	12,380	12,216	14,298	14,237	15,209
2019 (Recom.)	15,656	16,039	16,121	14,659	13,074	13,965	11,538	11,973	15,100	14,797	15,048	16,279
2020	18,788	18,803	18,093	17,668	16,665	15,496	12,355	14,877	16,257	17,579	18,631	18,055
2021	19,830	20,932	19,255	19,101	18,082	16,662	14,429	16,150	17,248	18,627	19,339	18,419
2022	20,594	21,599	20,370	19,944	18,310	17,610	15,866	16,643	18,004	19,329	20,019	19,660

*Please note Actuals in this graph may have solar/wind curtailments present

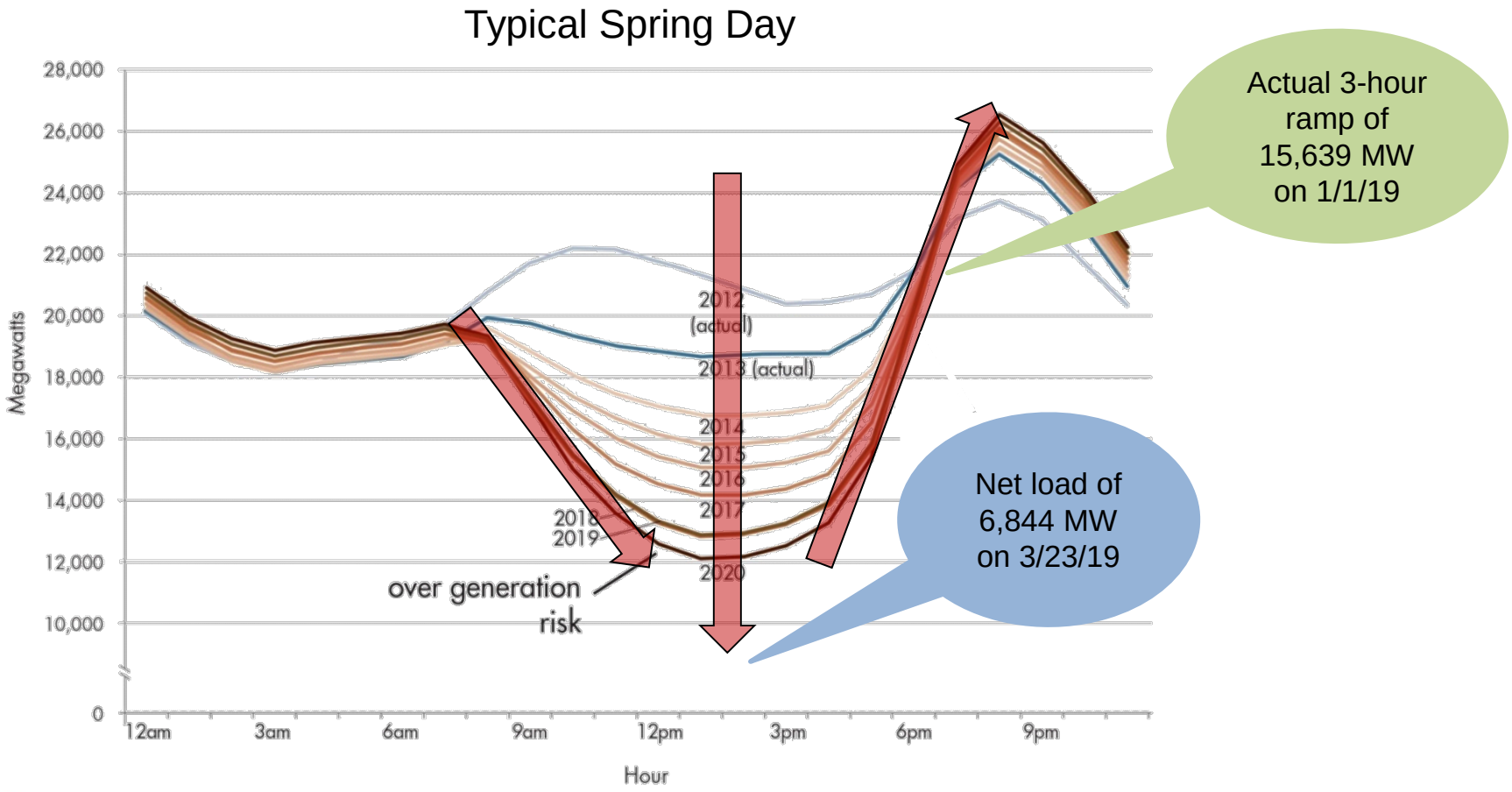
Example of the recommended monthly 2018 upward 3-hour ramps using 2016 actual 1-minute data



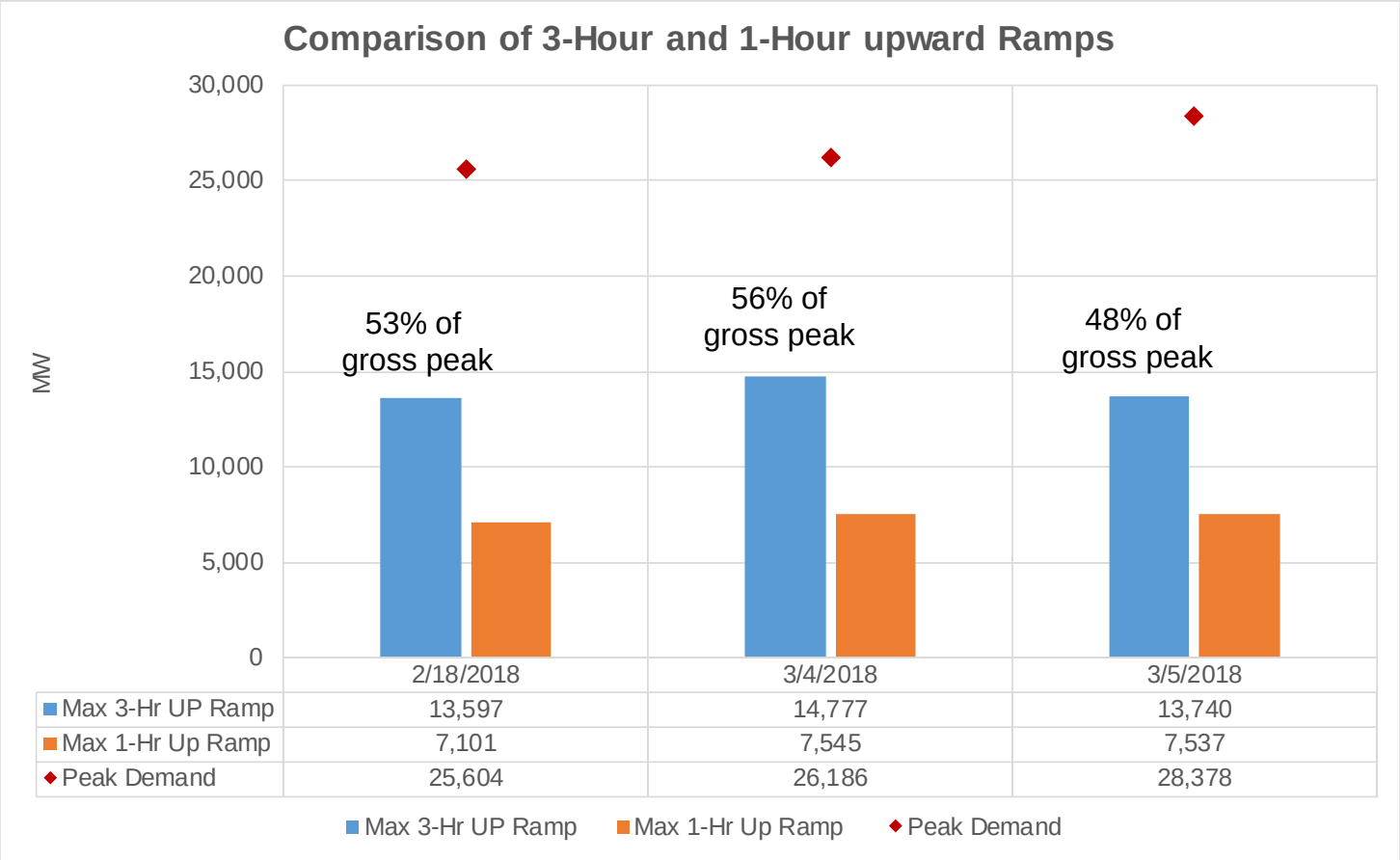
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017 (Actual)	12,378	12,659	12,733	10,939	10,591	11,774	8,403	8,706	12,108	11,949	12,591	12,981
2017 Forecast for 2018	12,282	13,313	12,352	11,111	11,803	10,039	9,326	9,617	12,660	12,954	13,376	14,567
2018 (Actual)	13,326	14,440	14,777	12,553	11,571	11,057	8,679	10,805	10,866	13,082	13,087	14,059

*Please note Actuals in this graph may have solar/wind curtailments present

The actual net load and 3-hour ramps are about four years ahead of the ISO's original estimate primarily due to under forecasting rooftop 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



Preliminary Results

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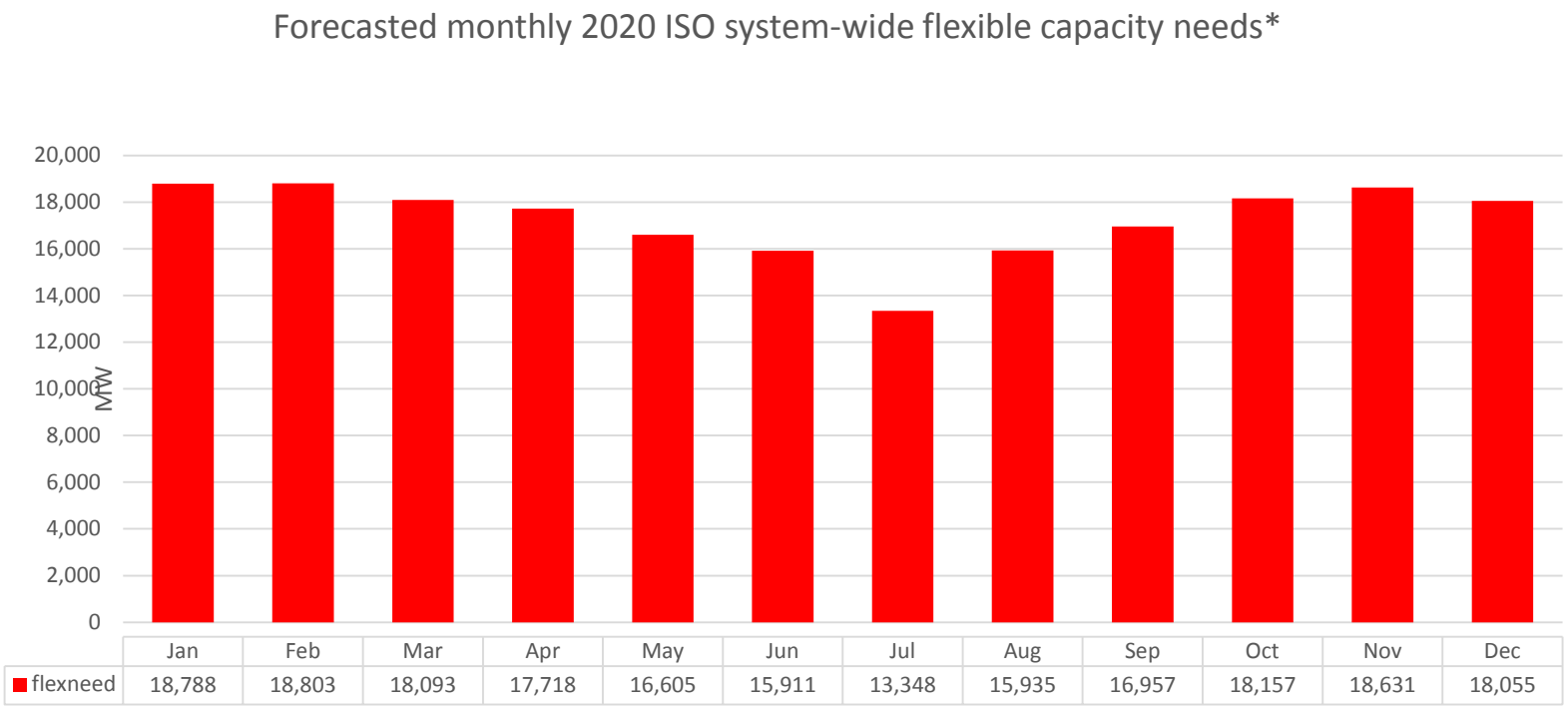
Manager, Short Term Forecasting

Forecasted monthly 2020 ISO system-wide flexible capacity needs*



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
flexneed	18,788	18,803	18,093	17,718	16,605	15,911	13,348	15,935	16,957	18,157	18,631	18,055

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

Components of the flexible capacity needs

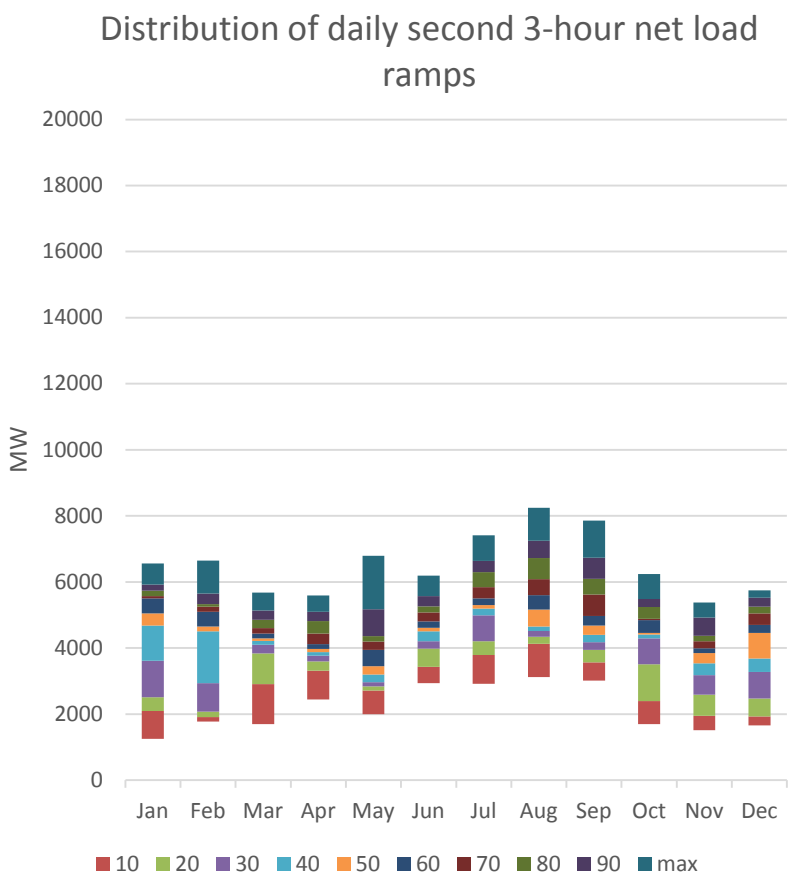
Month	Average of Load contribution 2020	Average of Wind contribution 2020	Average of Solar contribution 2020	Total percent 2020
January	43.11%	-1.61%	-55.28%	100%
February	39.86%	4.63%	-64.76%	100%
March	30.70%	-4.79%	-64.51%	100%
April	32.26%	-0.46%	-67.28%	100%
May	31.36%	-2.56%	-66.08%	100%
June	26.46%	-4.83%	-68.71%	100%
July	15.30%	2.43%	-87.13%	100%
August	24.06%	-1.89%	-74.05%	100%
September	27.26%	-1.36%	-71.39%	100%
October	34.39%	-1.57%	-64.04%	100%
November	38.87%	-5.43%	-55.69%	100%
December	44.27%	-0.94%	-54.80%	100%

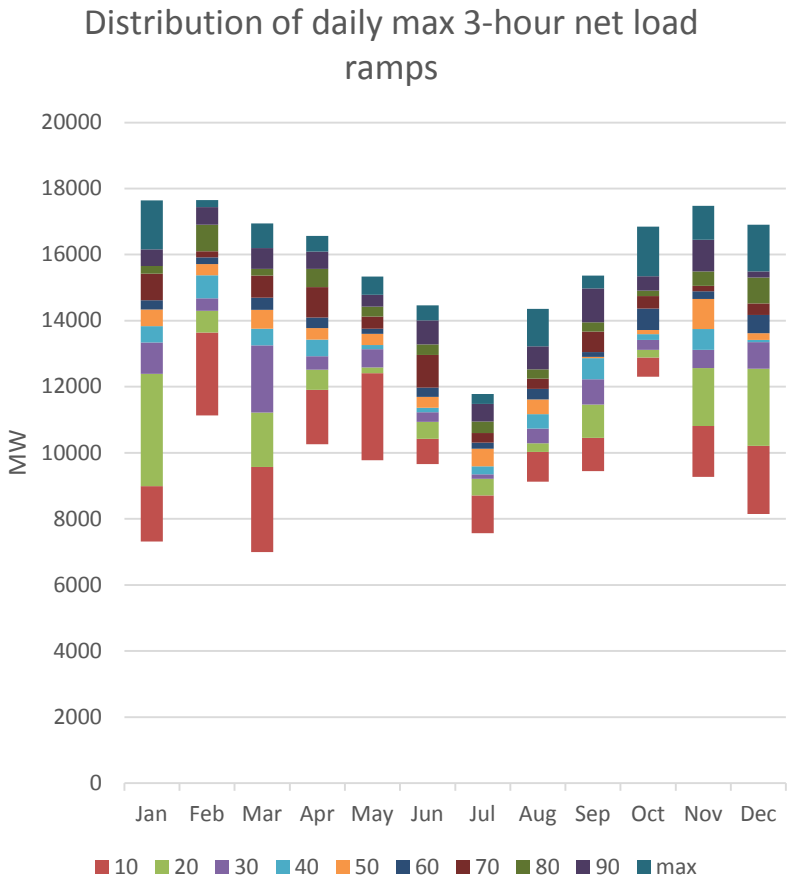
Δ Load – Δ Wind – Δ Solar = 100

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 2020 forecasted distribution range of daily maximum and secondary 3-hour net load ramps

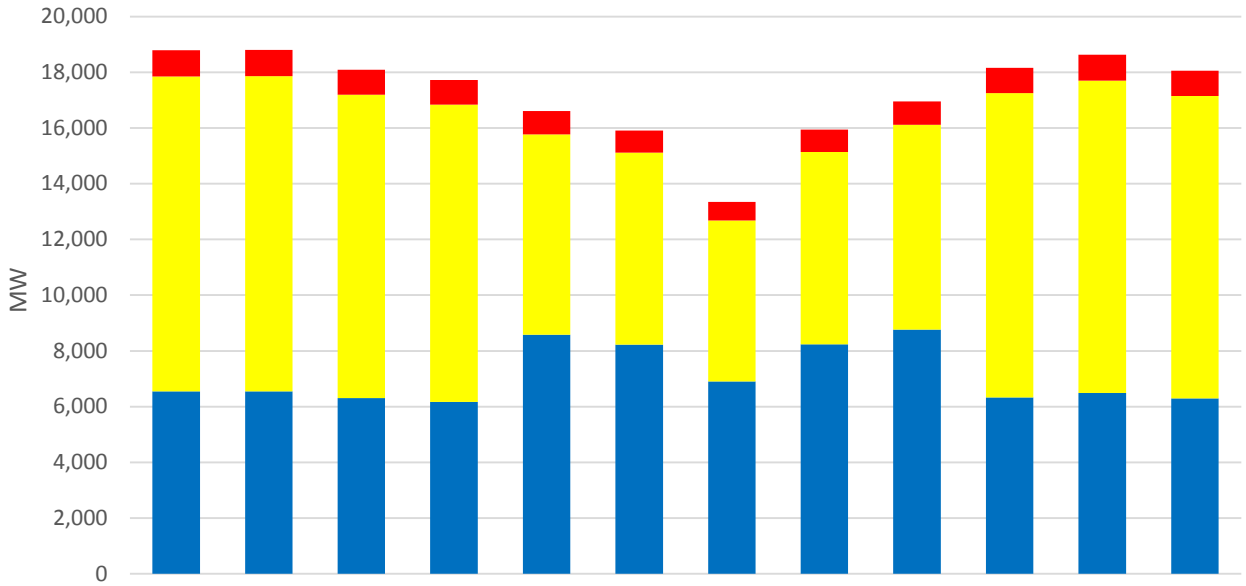




Seasonal breakout of flexible capacity needs

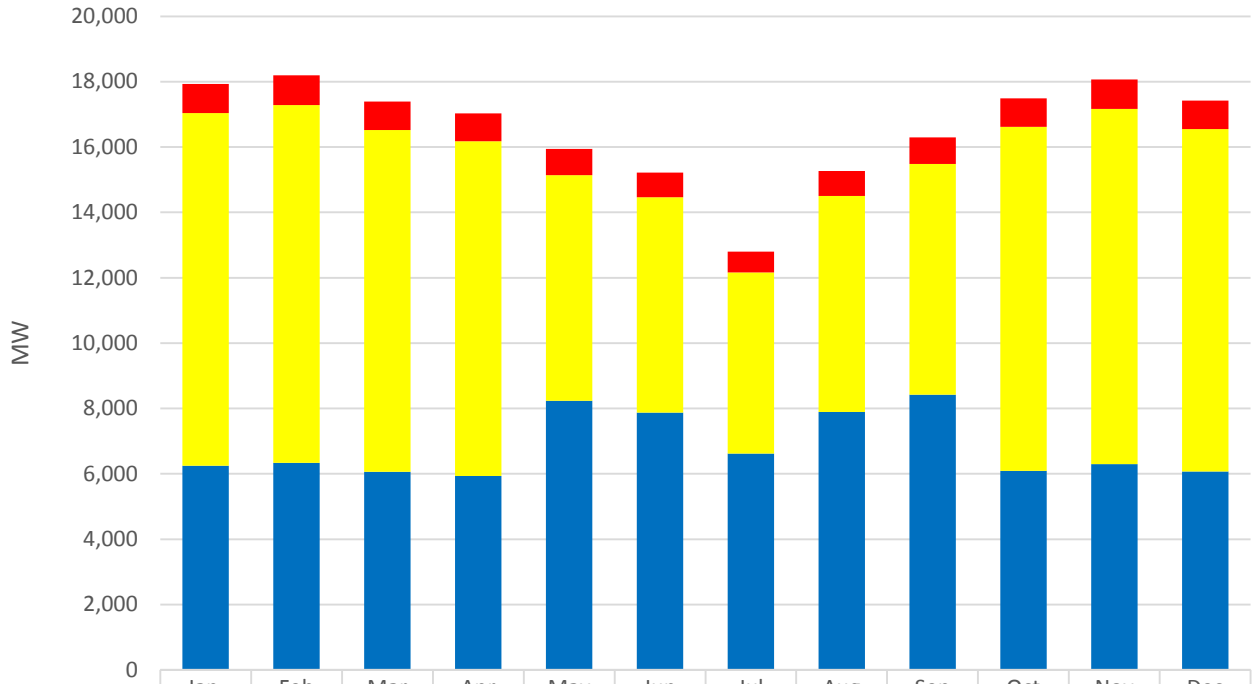
	Unadjusted			Adjusted		
Month	Base Flexibility	Peak Flexibility	Super-Peak Flexibility	Base Flexibility	Peak Flexibility	Super-Peak Flexibility
January	37%	58%	5%	35%	60%	5%
February	38%	57%	5%	35%	60%	5%
March	34%	61%	5%	35%	60%	5%
April	34%	61%	5%	35%	60%	5%
May	44%	51%	5%	52%	43%	5%
June	43%	52%	5%	52%	43%	5%
July	63%	32%	5%	52%	43%	5%
August	57%	38%	5%	52%	43%	5%
September	51%	44%	5%	52%	43%	5%
October	37%	58%	5%	35%	60%	5%
November	31%	64%	5%	35%	60%	5%
December	34%	61%	5%	35%	60%	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	939	940	905	886	830	796	667	797	848	908	932	903
Peak Flexibility	11,303	11,312	10,885	10,659	7,190	6,890	5,780	6,900	7,342	10,924	11,209	10,862
Base Flexibility	6,545	6,551	6,303	6,173	8,584	8,226	6,901	8,238	8,766	6,326	6,491	6,290

CPUC jurisdictional flexible capacity allocation - by flexible capacity category



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	897	910	869	851	797	761	640	763	815	874	903	871
Peak Flexibility	10,790	10,946	10,461	10,245	6,902	6,591	5,542	6,609	7,056	10,522	10,869	10,481
Base Flexiblity	6,248	6,339	6,058	5,933	8,240	7,869	6,617	7,890	8,424	6,093	6,294	6,069

Start time of 3-Hour net load ramp to evaluate seasonal must offer obligations

	3-Hour Net Load Ramp Start Hour (Hour Ending)			
Month	15:00	16:00	17:00	18:00
January	31			
February	18	10		
March	4	10	17	
April		3	26	1
May		3	21	7
June			27	3
July	1	3	27	
August		19	12	
September	2	28		
October	3	28		
November	30			
December	31			

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

- Recommended Must-offer obligation hours in Hour Ending.
  - HE 16- HE 20 (3:00 PM to 8:00 PM) January through April and October through December
  - HE 16– HE 20 (3:00 PM to 8:00 PM) May through September

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
- Growth of behind-the-meter solar PV and utility scale PV contributes to the larger flexible capacity requirements
- Using the ISO flexible capacity contribution calculation majority of 3-hour net load ramps are attributable to CPUC jurisdictional LSEs
- The Peak and Super-Peak MOO hours have not changed from the 2019 study (information below is in Hour Ending)
  - January through April and October through December: HE 16- HE 20 (3:00 p.m. to 8:00 p.m.)
  - May through September: HE 16 – HE 20 (3:00 p.m. to 8:00 p.m.)

Allocation to SC

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Manager, Short Term Forecasting

Notation

- Notation :
  - L (load), W (wind), S (solar), and NL(net load)
  - R (reserve) = max(MSCC, 3.5*peak_load)
  - NL = L – W – S
  - Δ Ramp, Δ NL = Δ L – ΔW – ΔS
  - ΔNL_{2020} Net Load Ramp Req in 2020
  - $\Delta NL_{sc,2020}$ Net Load Ramp Req SC Allocation in 2020
  - Σ summation of all SC
  - 2020 forecast (L) and survey results (W and S);
  - 2018 Load observed
  - pl_r_{sc} CEC peak load ratio
- The history of load allocation formula evolution is detailed in the draft paper

Allocation Formula

$$Flax\ Requirement = \Delta NL_{2020} + R_{2020}$$
$$= \Delta NL_{2020} + \Sigma pl\_r_{sc} * R_{2020}$$

$$\Delta NL_{2020} = \Delta L_{2020} - \Delta W_{2020} - \Delta S_{2020}$$

$$= \Delta L_{2020} - \frac{\Sigma W_{sc,2020}}{W_{2020}} * \Delta W_{2020} - \frac{\Sigma S_{sc,2020}}{S_{2020}} * \Delta S_{2020}$$

Now, Focusing on allocating ΔL_{2020}

Allocation load proportion to SC

- $\Delta L_{2020} = \Delta L_{2018} + (\Delta L_{2020} - \Delta L_{2018})$

$$= \Sigma \Delta L_{sc,2018} + \frac{\Sigma L^{M}_{sc,2018}}{L^{M}_{2018}} * (\Delta L_{2020} - \Delta L_{2018})$$

- ΔL_{2018} is the average load portion of top 5 maximum 2018 3h ramps while matching 2020 maximum 3h ramp on month and time, and L^{M}_{2018} is the average load at beginning and the end of points during those top 5 ramps.
- The subscript SC is for LSC, Δ and Σ is the mathematic notation for difference and summation, Δ is denoted for the ramp here.
- Therefore, each SC will receive:

$$\Delta L_{sc,2018} + \frac{L^{M}_{sc,2018}}{L^{M}_{2018}} * (\Delta L_{2020} - \Delta L_{2018})$$

AVAILABILITY ASSESSMENT HOURS

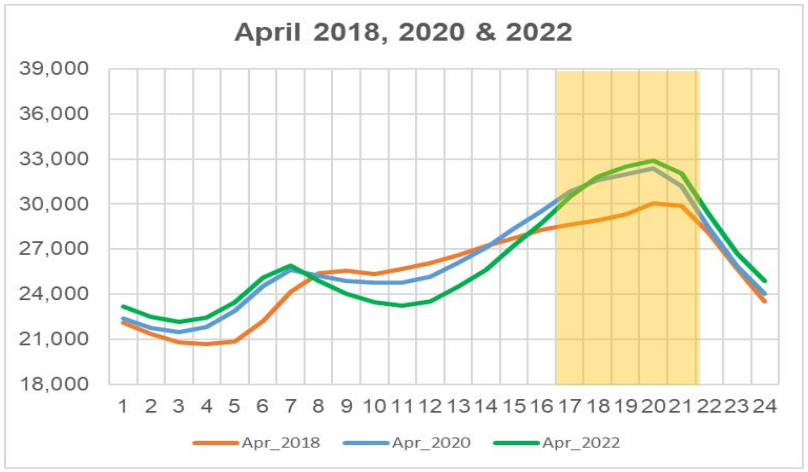
Availability assessment hours: Background and purpose

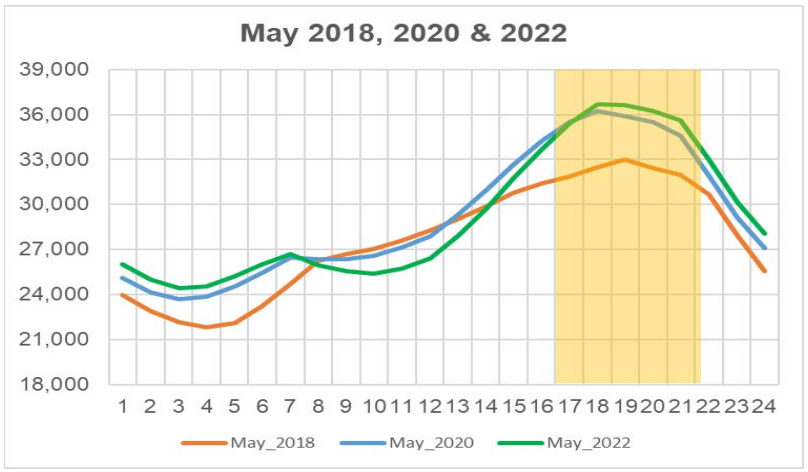
- Concept originally developed as part of the ISO standard capacity product (SCP)
  - Maintained as part of Reliability Service Initiative – Phase 1 (i.e. RA Availability Incentive Mechanism, or RAAIM)
- Determine the hours of greatest need to maximize the effectiveness of the availability incentive 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

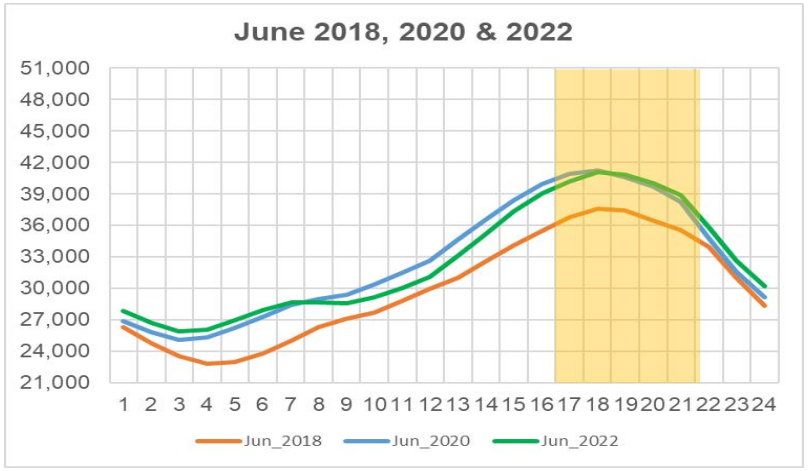
Methodology overview of system/local availability assessment hours

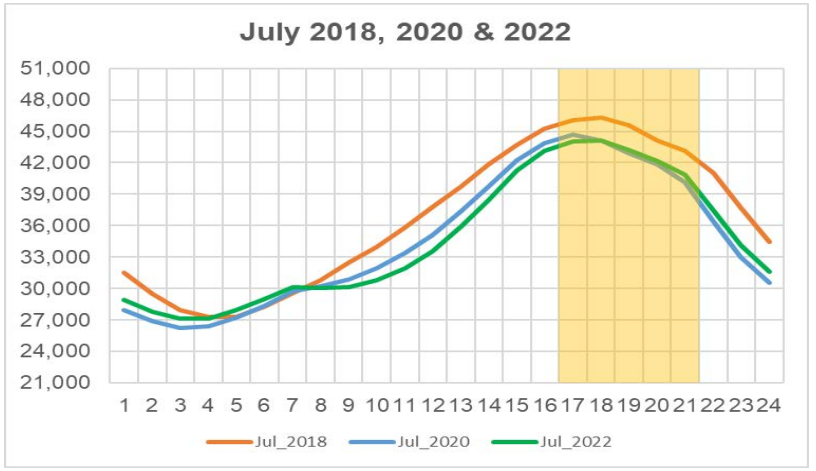
- Used data described in previous slides to obtain:
  - Hourly Average Load
    - By Hour
    - By Month
    - Years 2020-2022
- Calculated:
  - Top 5% of Load Hours within each month using an hourly load distribution
  - Years 2020 through 2022

Expected load shape evolution: Summer season

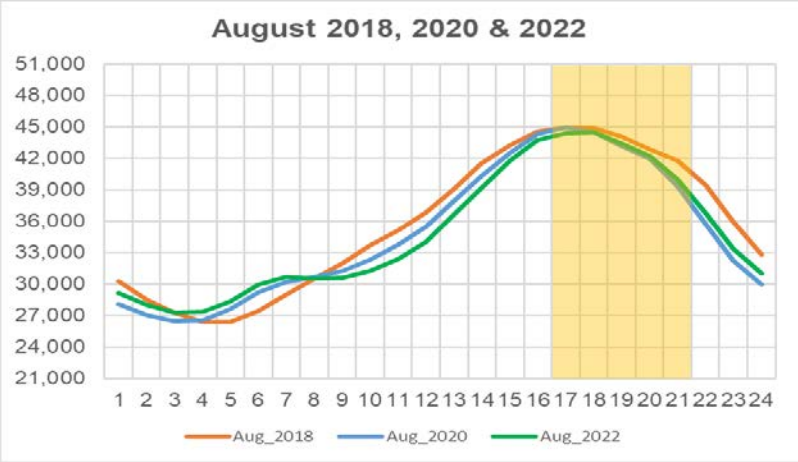


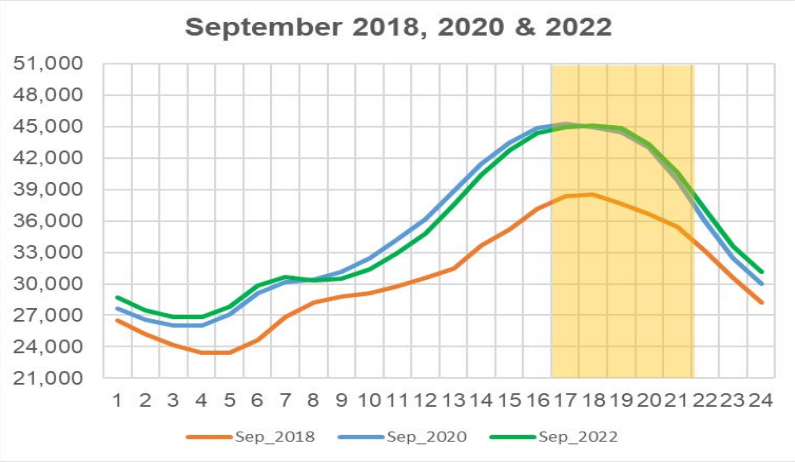




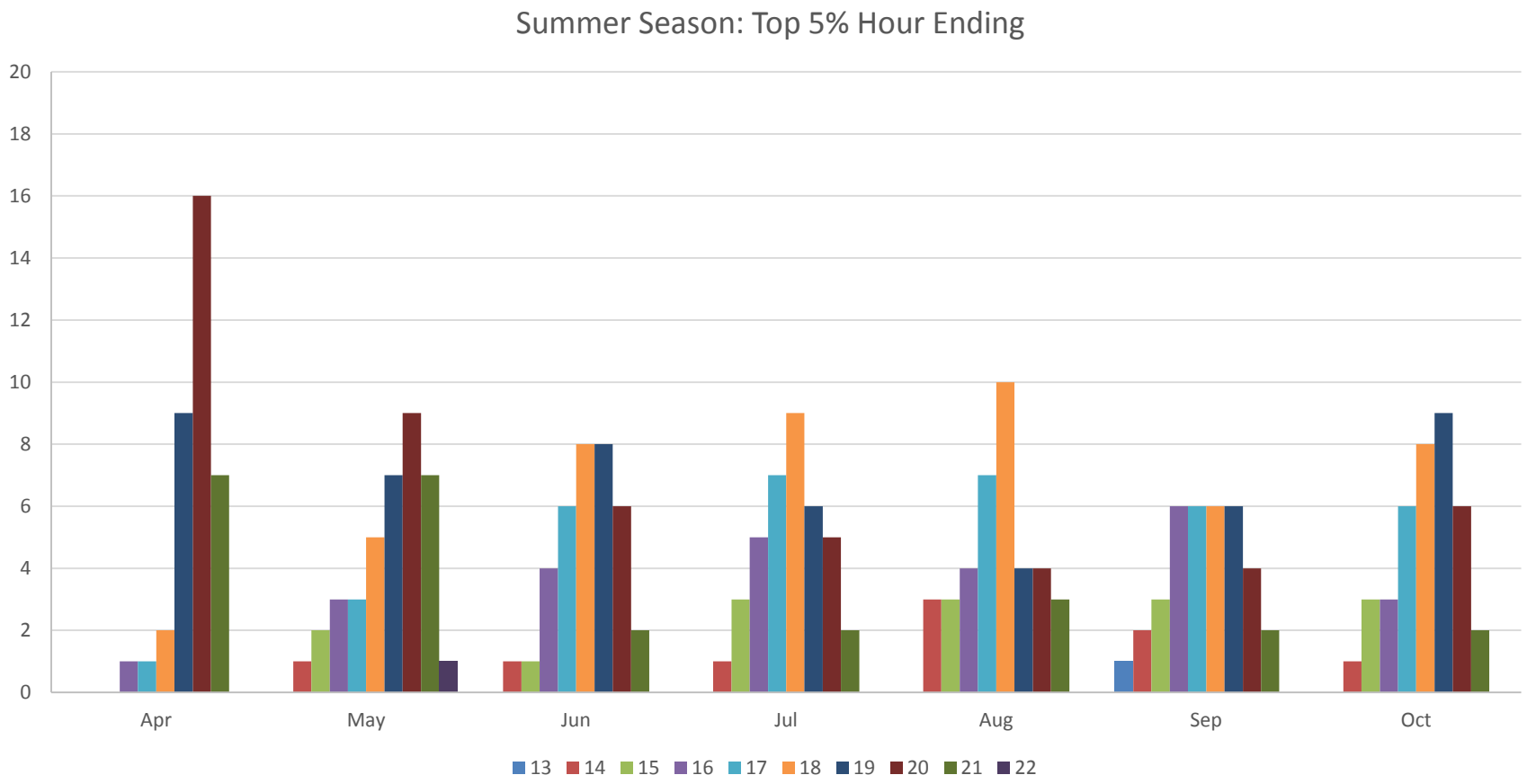


Expected load shape evolution: Summer season

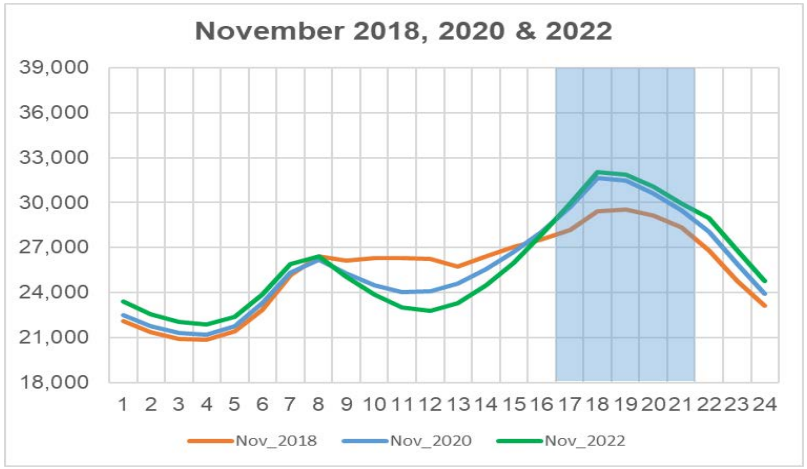


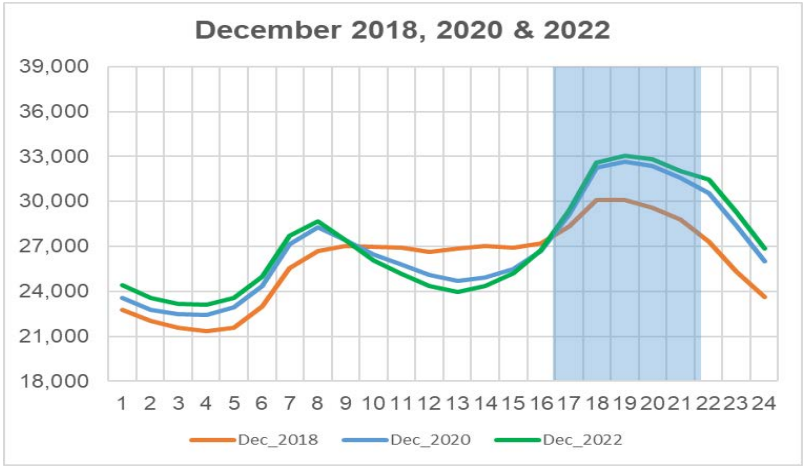


Summer Season
2020 top 5% of load hours (in HE)

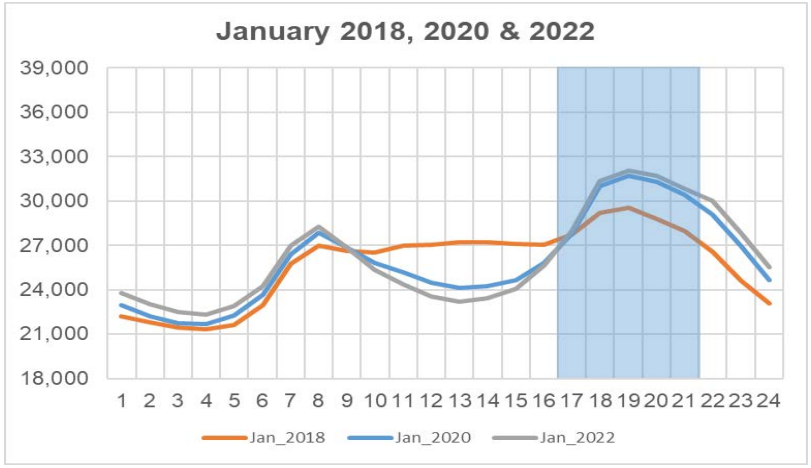


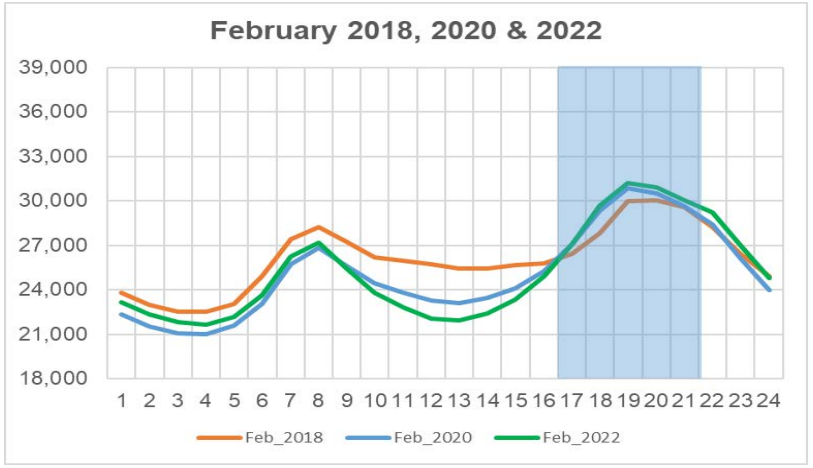
Expected load shape evolution: Winter season

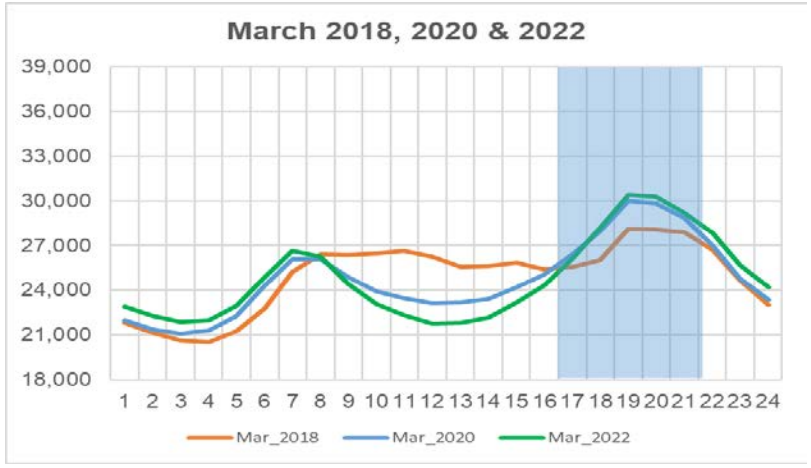




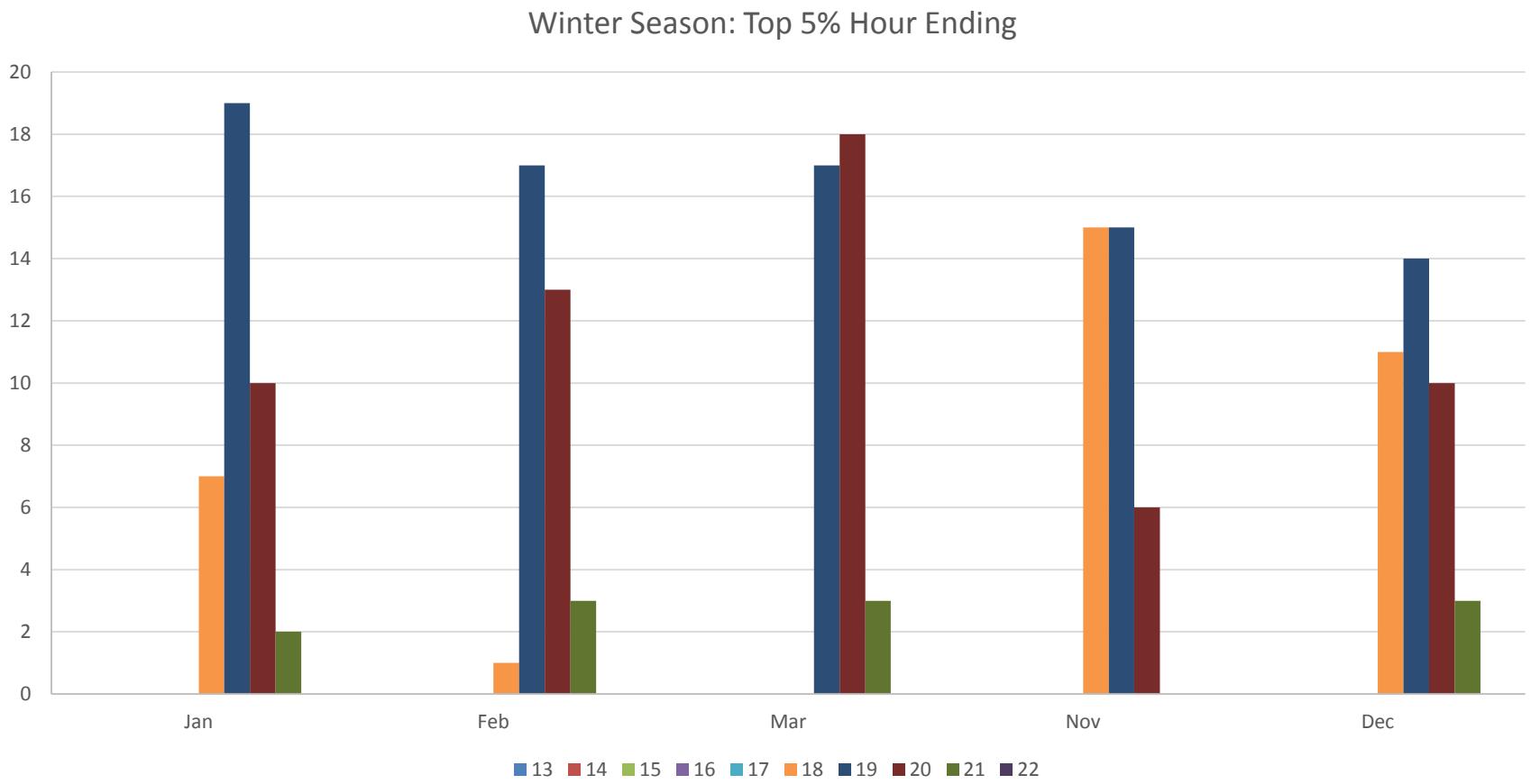
Expected load shape evolution: Winter season







Winter Season
2020 top 5% of load hours (HE)



Availability assessment hours draft recommendation

Winter Season Draft Recommendation

Year	Start	End
2019 (Final)	HE 17	HE 21
2020 (Draft)	HE 17	HE 21
2021 (Estimate)	HE 17	HE 21
2022 (Estimate)	HE 17	HE 21

Summer Season Draft Recommendation

Year	Start	End
2019 (Final)	HE 17	HE 21
2020 (Draft)	HE 17	HE 21
2021 (Estimate)	HE 17	HE 21
2022 (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	3:00pm to 8:00pm (HE16-HE20)	All days
Super-Peak Ramping	Category 3	3:00pm to 8:00pm (HE16-HE20)	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 (HE16-HE20)	All days
Super-Peak Ramping	Category 3	3:00pm to 8:00pm (HE16-HE20)	Non-Holiday Weekdays*

Next steps

- Published Draft Flexible Capacity Needs Assessment for 2019 – April 4, 2019
  - ~~– Stakeholder call April 4, 2019~~
  - – Comments due April 19, 2019
    - Please submit comments on the assumptions to

      initiativecomments@caiso.com

- Publish Final Flexible Capacity Needs Assessment for 2019 –

  May 15th, 2019

Questions