Flexible Capacity Requirement Methodology for 2023 through 2025

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What’s the purpose of this call?

- Discuss the criteria, methodology, and assumptions used in calculating monthly flexible capacity requirement.
- Calculate requirements for all LRAs within the ISO footprint for RA compliance year 2023 and advisory flexible capacity requirements for compliance years 2024 and 2025
- Discuss the input assumptions and methodology of the annual CAISO’s Availability Assessment Hour (AAH).

Agenda / Overview

- Background
- Process review
  - Expected build out from all LSEs (CPUC jurisdictional and non-Jurisdictional)
  - Actual load, wind and solar 1-minute profiles for 2021 and expected profiles for 2023-2025
  - Calculate 3-hour net-load ramps
  - Expected monthly maximum contingency reserve requirements
  - Calculate monthly Flexible Capacity requirement
  - Allocation Methodology
  - Availability Assessment Hours (AAH)
  - Next steps

Each LSE's SC 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 timeframe: LSEs need to secure a minimum of 90% of the next years monthly needs
- Month ahead timeframe: LSEs need to secure adequate net qualified capacity to serve their monthly 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 for which it is shown

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

- Uses the most current data available for renewable build-out obtained from all LSE SCs
- For new renewable installation scale 2021 actual production data based on the expected installed capacity in subsequent years
- Generate net-load profiles for 2023 through 2025
  - Generate load profiles for 2023 through 2025
  - Generate solar profiles for 2023 through 2025
  - Generate wind profiles for 2023 through 2025
- CAISO will look into impacts of curtailments when running draft requirement values

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

- 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.

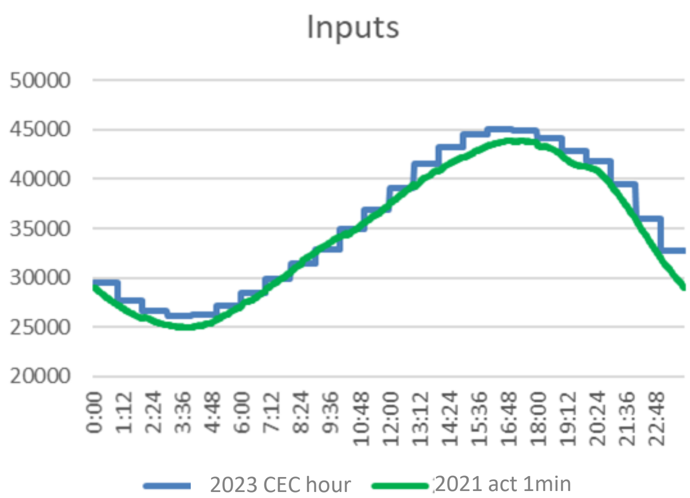
- CEC IEPR Load Forecast
  - https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2021-integrated-energy-policy-report/2021-1

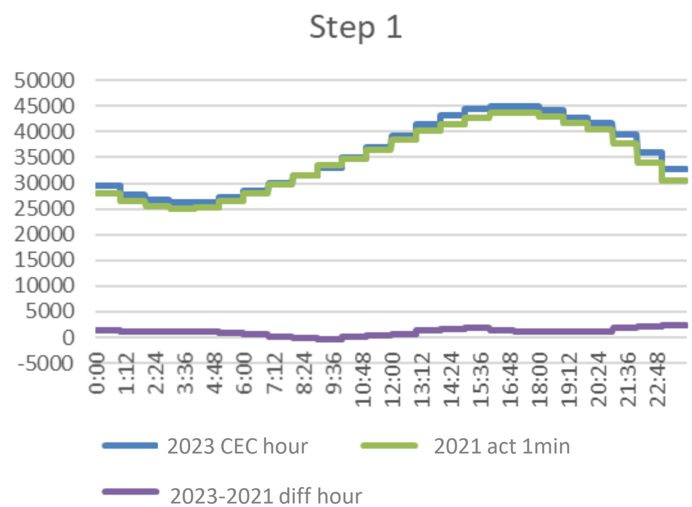
The ISO will use the CEC's 1-in-2 IEPR forecast to develop the monthly flexible capacity

- CEC IEPR Load Forecast
  - https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2021-integrated-energy-policy-report/2021-1
  - Title of File: "CED 2021 Hourly Forecast - CAISO - Mid Baseline- AAEE Scenario 3 – AAFS Scenario 3"
    - CAISO will be using Managed Net Load (column U) within the spreadsheet
      - **Managed Net Load (col U)** = Baseline Net Load (col T)
        + AAEE (Col R) + AAFS (Col S)
      - Baseline Net Load (col T) = Baseline Consumption (col N)
        - BTM PV (col O)
        - BTM Storage Res (col P)
        - BTM Storage NonRes (col Q)
      - Baseline Consumption (col N) = unadjusted consumption (col E)
        + Pump DWR (col F)
        + Pump MWD (col F)
        + climate change (col I)
        + light duty EV (col J)
        + medium heavy EV (col K)
        + TOU impacts (col L)
        + other adjustments (col M)

Building expected 1-minute load profile requires actual 2021 hourly and 1-minute data and CEC's hourly forecast

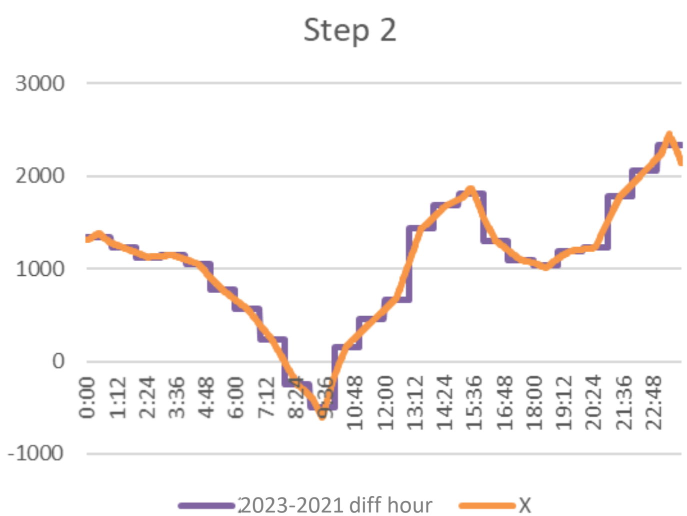
Using the 2023 CEC hourly forecast and the 2021 1-minute actuals, we will create the estimated 2023 1-minute forecast

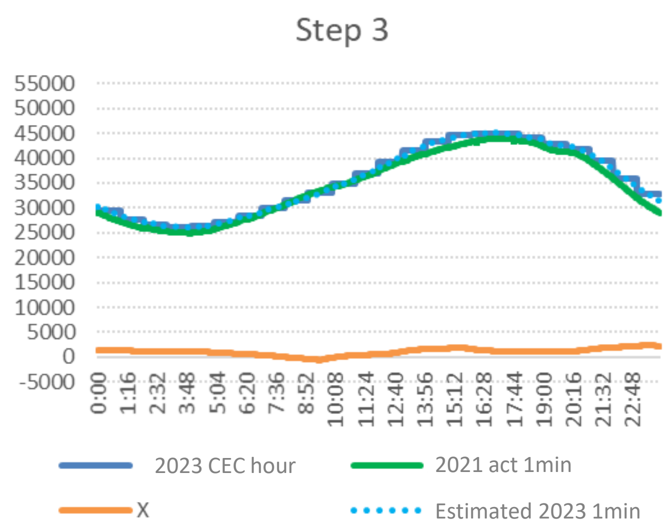




Take the hourly average of the 1-minute data and find the difference between the hourly 2021 actuals and 2023 forecast

Smooth the hourly 2023-2021 difference from Step 1 to a 1-minute granularity





Add the 1-minute data from Step 1 to the 2021 1-minute actuals to get a smoothed 2023 forecast

Hourly load forecast to 1-minute load forecast

- Used 2021 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 2021 1-minute actuals.

2022 Load 1-Minute Forecast

– **2022 $L_{CECfcst\_1\text{-}min}$ = 2021 $L_{Act\_1\text{-}min}$ + X**

  - **Where X = Interpolated 1min profile from the difference**

    (2022 $L_{CECfcst\_hourly}$ - 2021 L_{actual_hourly})

2023 Load 1-Minute Forecast

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  - **Where X = Interpolated 1min profile from the difference**

    (2023 $L_{CECfcst\_hourly}$ - 2021 L_{actual_hourly})

*See slide 8 for more graphs showing steps to calculate **X**

Wind growth assumptions

- Use the actual 1-minute wind production data for the most recent year i.e. for 2022 wind forecast, use actual 1-minute data from 2021 (**$2021_{Act\_1\text{-}min}$**)
  - Wind actual data utilized includes dynamic resources
- Projects installed in 2021 would be modeled in 2022 for the months the projects were not yet in-service (e.g. projects installed in May 2021 would be included in January through April of 2021)
- Scale 1-minute data using expected capacity for the new plants scheduled to be operational in 2022
- Repeat the above steps for 2023

$$2022\ W_{Mth\_Sim\_1\text{-}min} = 2021\ W_{Act\_1\text{-}min} * 2022\ W_{Mth\ Capacity} / 2021\ W_{Mth\ Capacity}$$

$$2023\ W_{Mth\_Sim\_1\text{-}min} = 2021\ W_{Act\_1\text{-}min} * 2023\ W_{Mth\ Capacity} / 2021\ W_{Mth\ Capacity}$$

Note: This approach maintains load/wind, load/solar and wind/solar correlations

Solar growth assumptions

Existing solar

- Use the actual solar 1-minute production data for the most recent year
  - Solar actual data utilized includes dynamic resources
  - i.e. for 2022 forecast, use 2021 actual 1-minute data (**$2021_{Act\_1\text{-}min}$**)

New solar installation

- Develop 1-minute solar production profiles by scaling actual 2021 1-minute data by the expected monthly installed capacity in 2022 divided by the monthly installed capacity in 2021

- Projects installed in 2021 will be modeled in 2022 for the months the projects were not yet in-service in 2021

$$2022\ S_{Mth\_Sim\_1\text{-}min} = 2021\ S_{Act\_1\text{-}min} * 2022\ S_{Mth\ Capacity} / 2021\ S_{Mth\ Capacity}$$

$$2023\ S_{Mth\_Sim\_1\text{-}min} = 2021\ S_{Act\_1\text{-}min} * 2023\ S_{Mth\ Capacity} / 2021\ S_{Mth\ Capacity}$$

$$2024\ S_{Mth\_Sim\_1\text{-}min} = 2021\ S_{Act\_1\text{-}min} * 2024\ S_{Mth\ Capacity} / 2021\ S_{Mth\ Capacity}$$

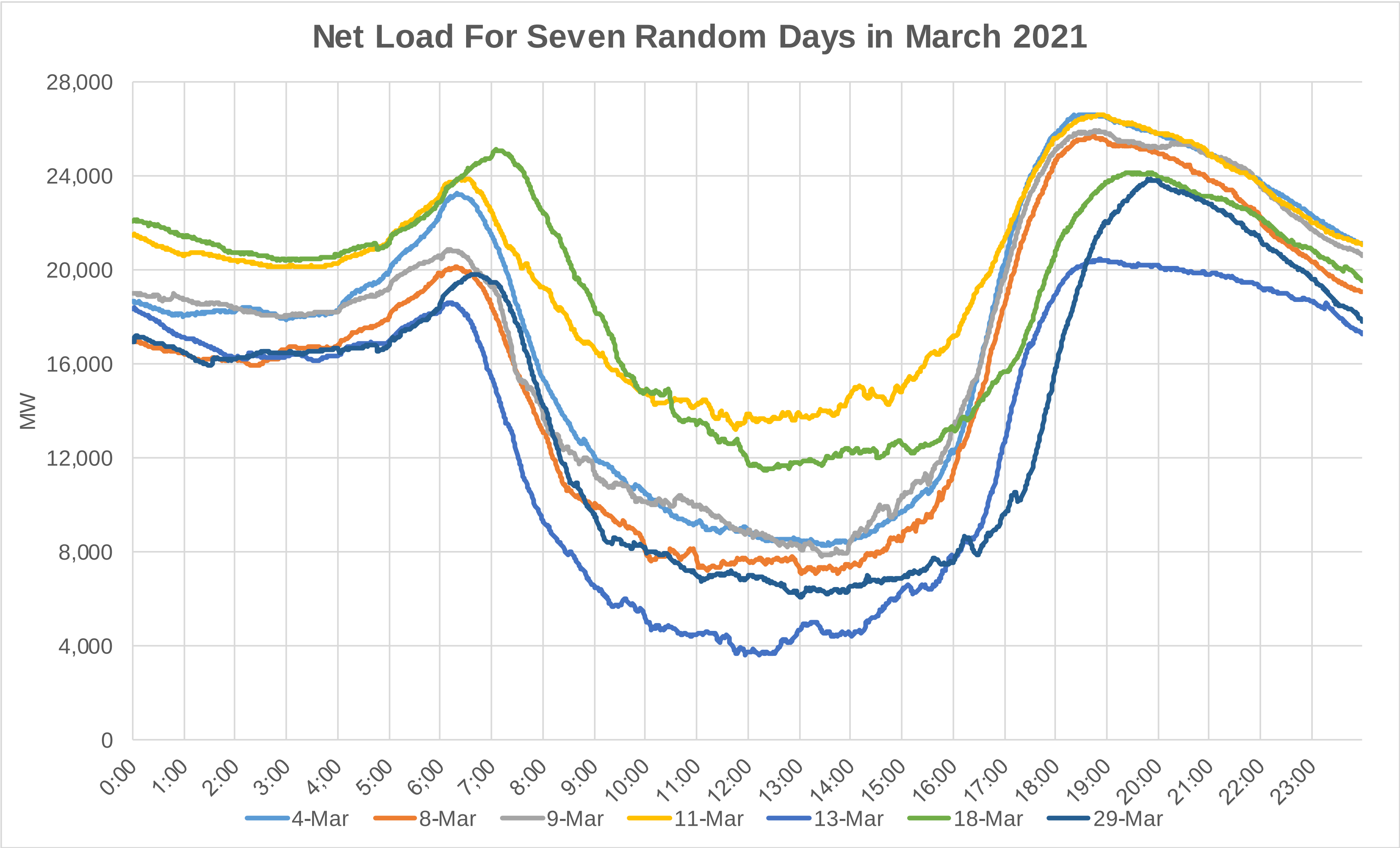
$$2025\ S_{Mth\_Sim\_1\text{-}min} = 2021\ S_{Act\_1\text{-}min} * 2025\ S_{Mth\ Capacity} / 2021\ S_{Mth\ Capacity}$$

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

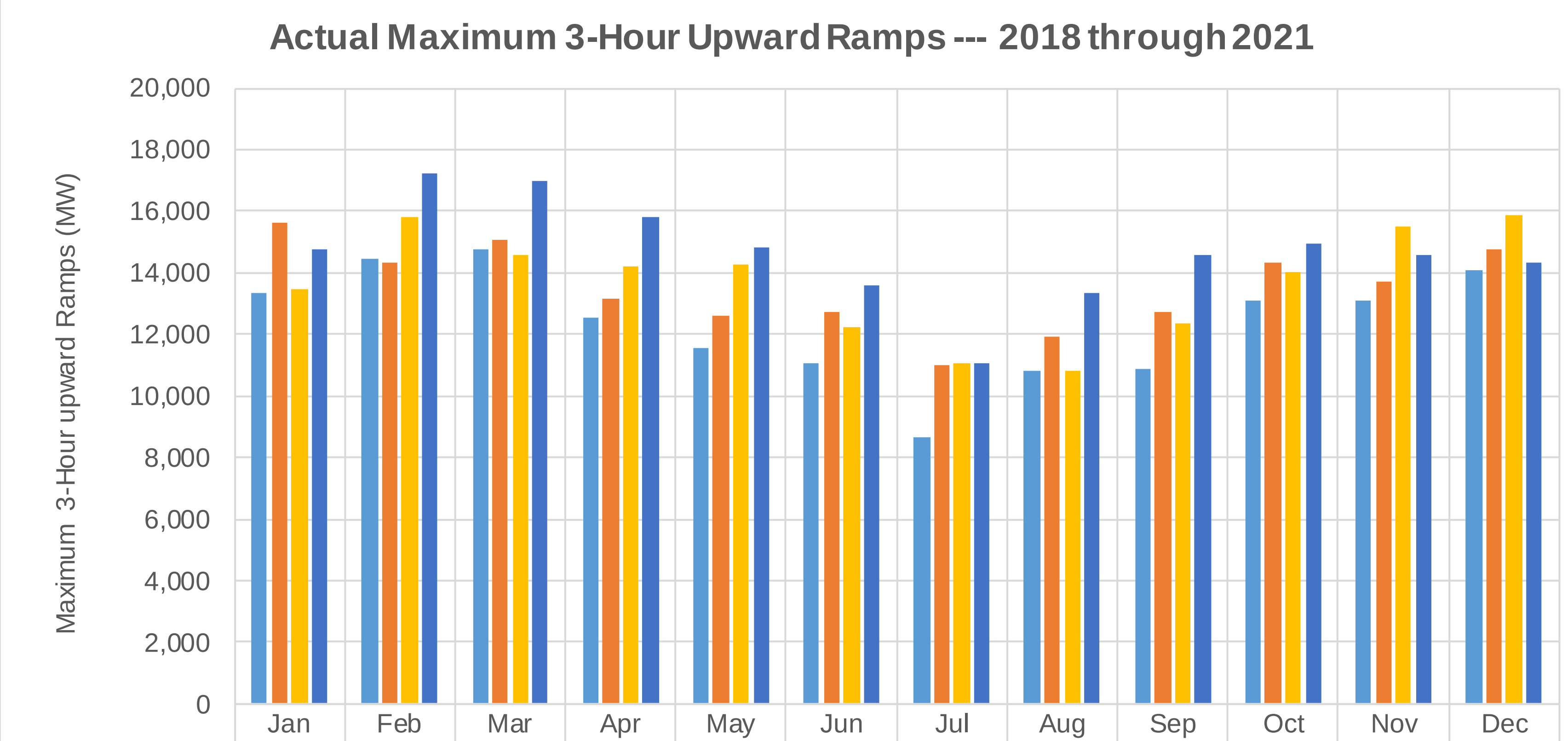
- Net-load is the aggregate of customer demand reduced by variable generation power output
- Net-load is more variable than load itself and it increases as VER production increases
- The monthly three-hour flexible capacity need equates to the largest expected up-ward change in net-load when looking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

Example of actual net-load variability for seven random days in March 2021



Actual 3-hour ramps with curtailments --- 2018 through 2021

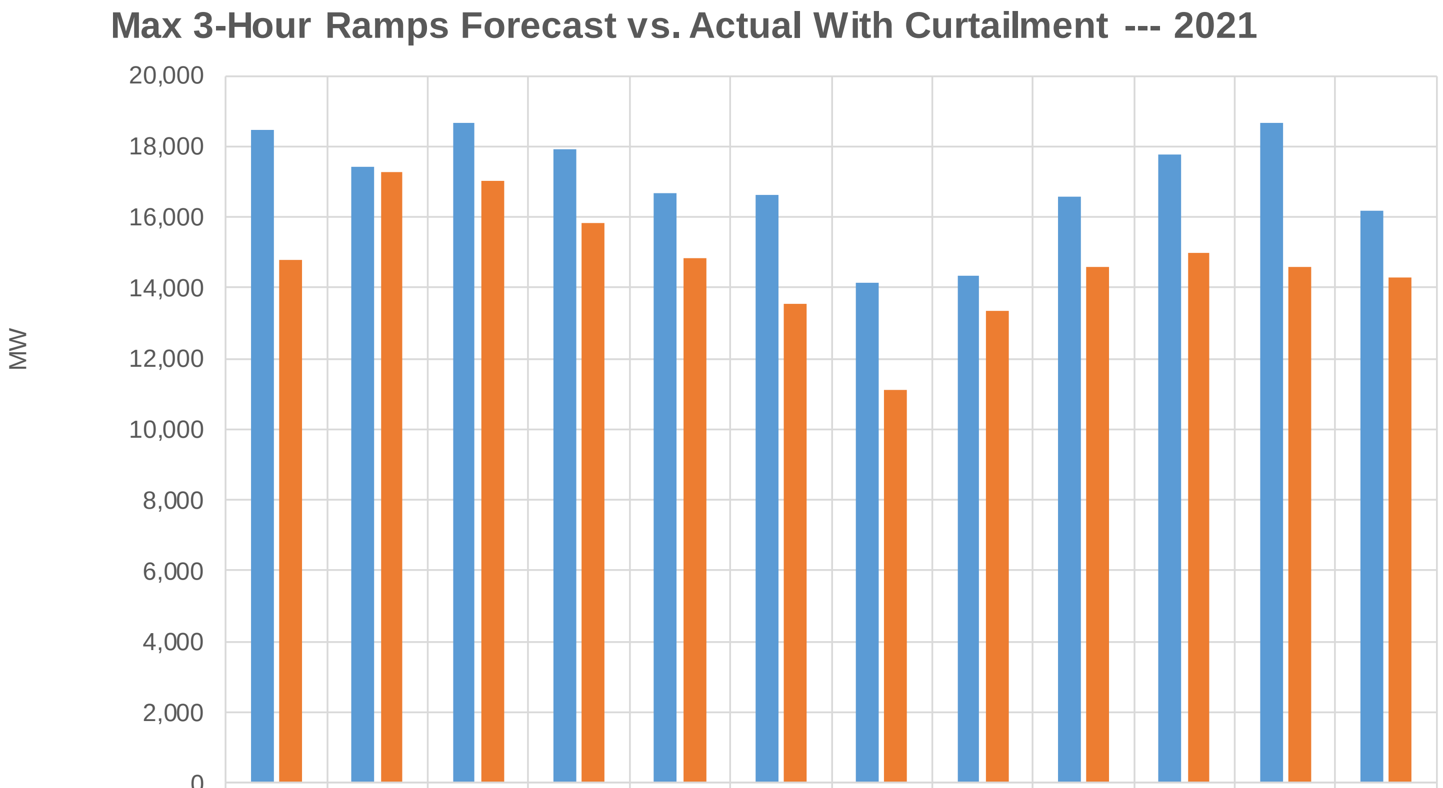


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018 (Actual)	13,326	14,440	14,777	12,553	11,571	11,057	8,679	10,805	10,866	13,082	13,087	14,059
2019 (Actual)	15,639	14,360	15,070	13,177	12,611	12,744	10,981	11,914	12,757	14,333	13,704	14,782
2020 (Actual)	13,441	15,840	14,562	14,241	14,274	12,212	11,070	10,848	12,351	14,005	15,512	15,859
2021 (Actual)	14,795	17,259	17,012	15,825	14,831	13,573	11,091	13,374	14,596	14,969	14,590	14,317

2018 (Actual) 2019 (Actual) 2020 (Actual) 2021 (Actual)

Actual data shown is draft

2021 forecast ramps vs. actual 3-hour ramps with curtailments

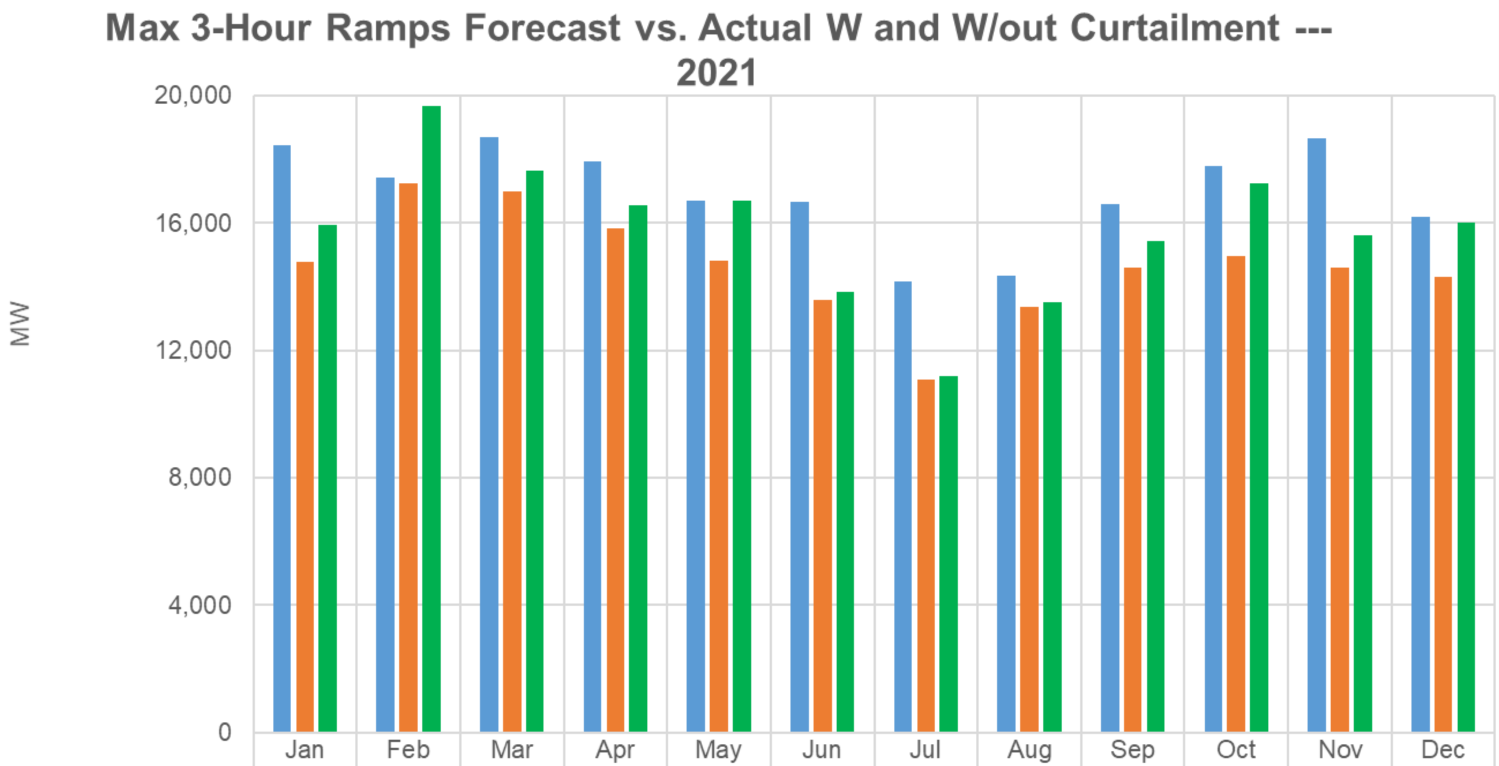


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3-Hr_Ramp (Forecast)	18,446	17,424	18,682	17,936	16,695	16,652	14,156	14,335	16,589	17,779	18,666	16,207
3-Hr_Ramp (Actual)	14,795	17,259	17,012	15,825	14,831	13,573	11,091	13,374	14,596	14,969	14,590	14,317

Forecast 2021 3-Hour ramps were derived from the 2020 flex-analysis study using 2019 actual 1-minute data

Actual data shown is draft

ISO continues to consider how we account for curtailments in Flex RA Study



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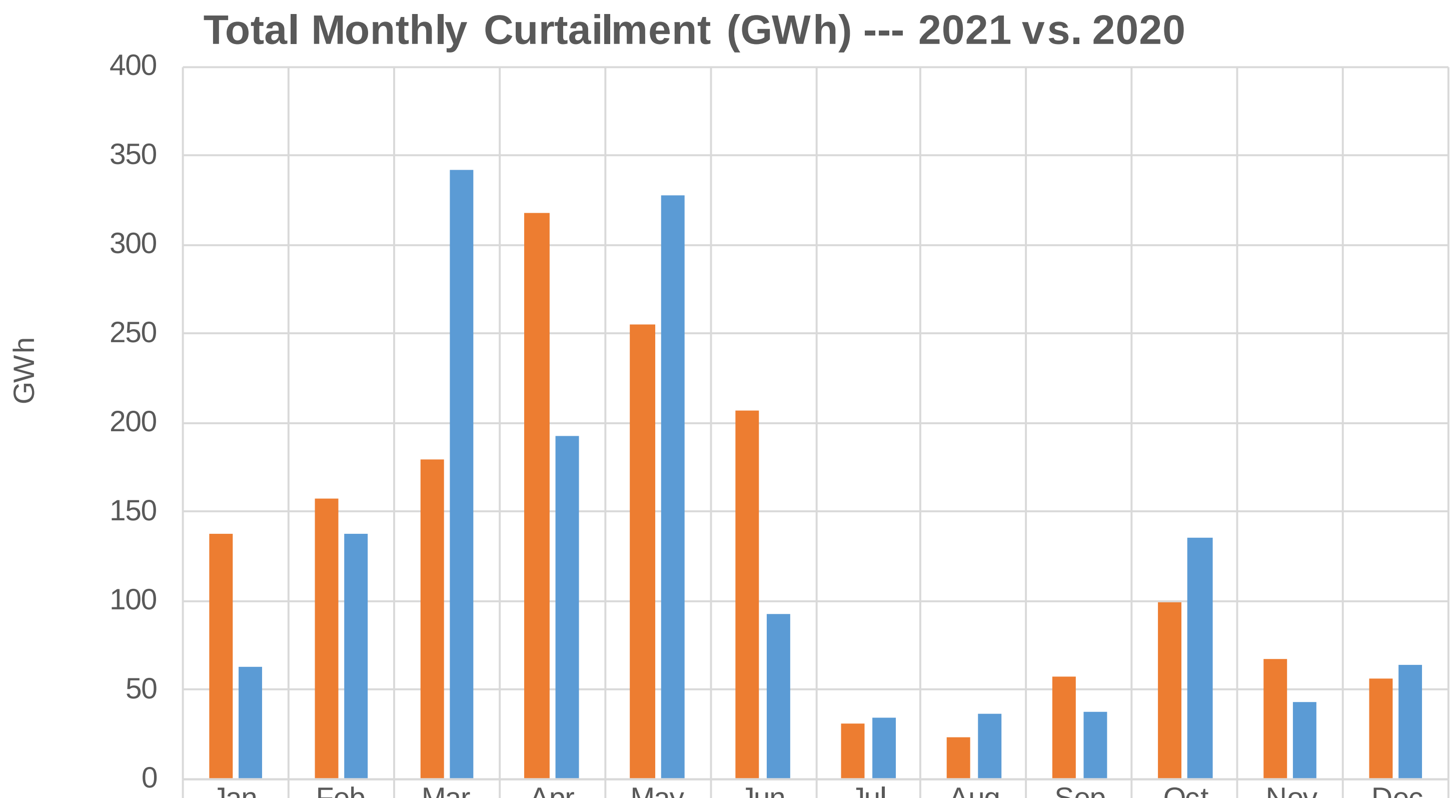
3-Hr_Ramp (Curt_added)	15,949	19,669	17,665	16,558	16,722	13,856	11,187	13,531	15,440	17,254	15,611	16,001

3-Hr_Ramp (Forecast) 3-Hr_Ramp (Actual) 3-Hr_Ramp (Curt_added)

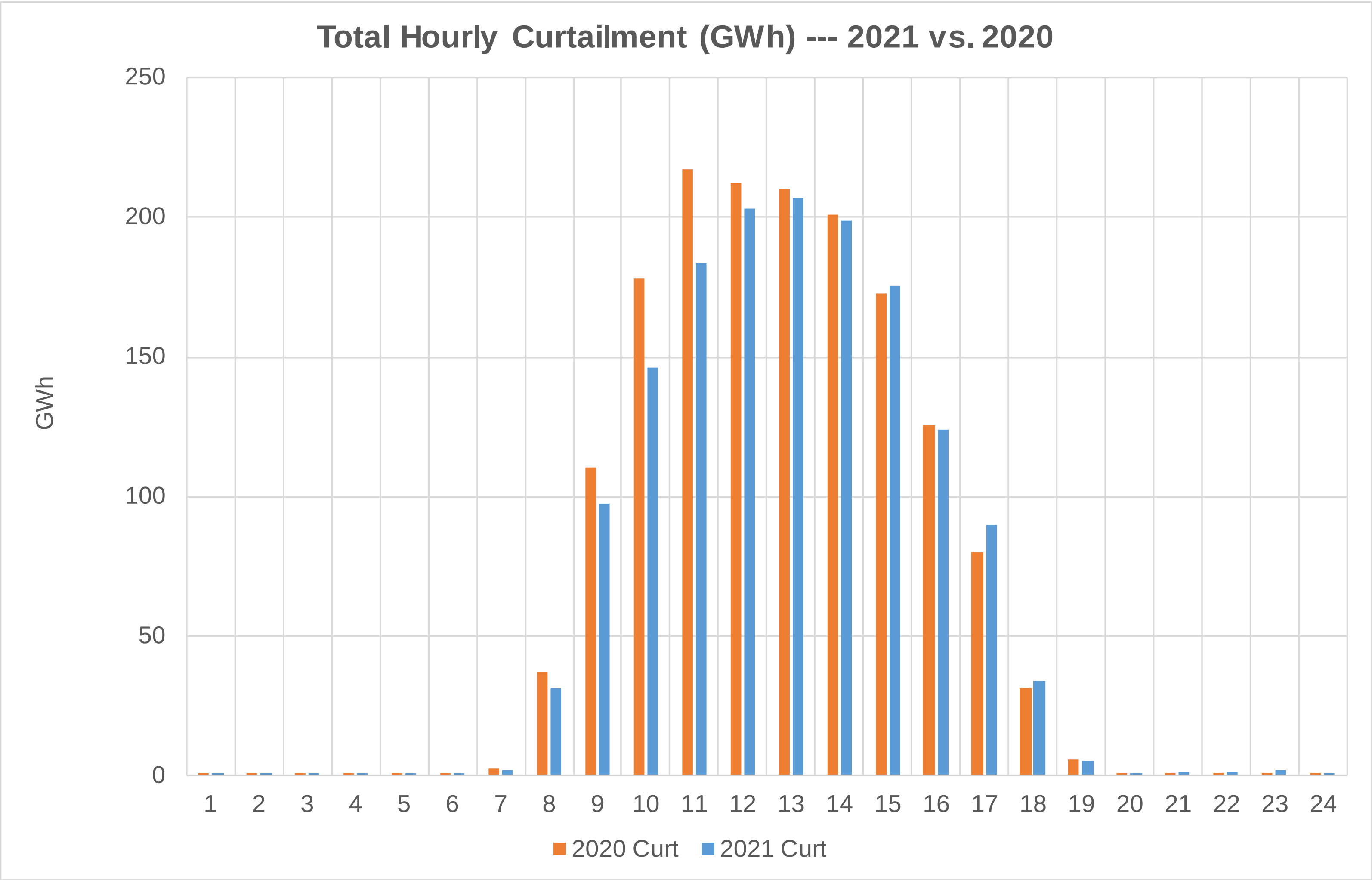
Actual data shown is draft

2021 vs. 2020: Higher levels of curtailments typically occur during the spring months between sunrise and sunset (GWh)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2020 Curt	138	157	179	318	255	206	31	23	57	99	67	56
2021 Curt	62	138	342	193	328	92	34	37	37	136	43	63

2021 vs. 2020: Higher levels of curtailments typically occur between sunrise and sunset (GWh)



Contingency reserves is a NERC/WECC requirement all BAs must comply with 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.
- Contingencies can occur during the three hour 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.

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

Methodology

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

Where:

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

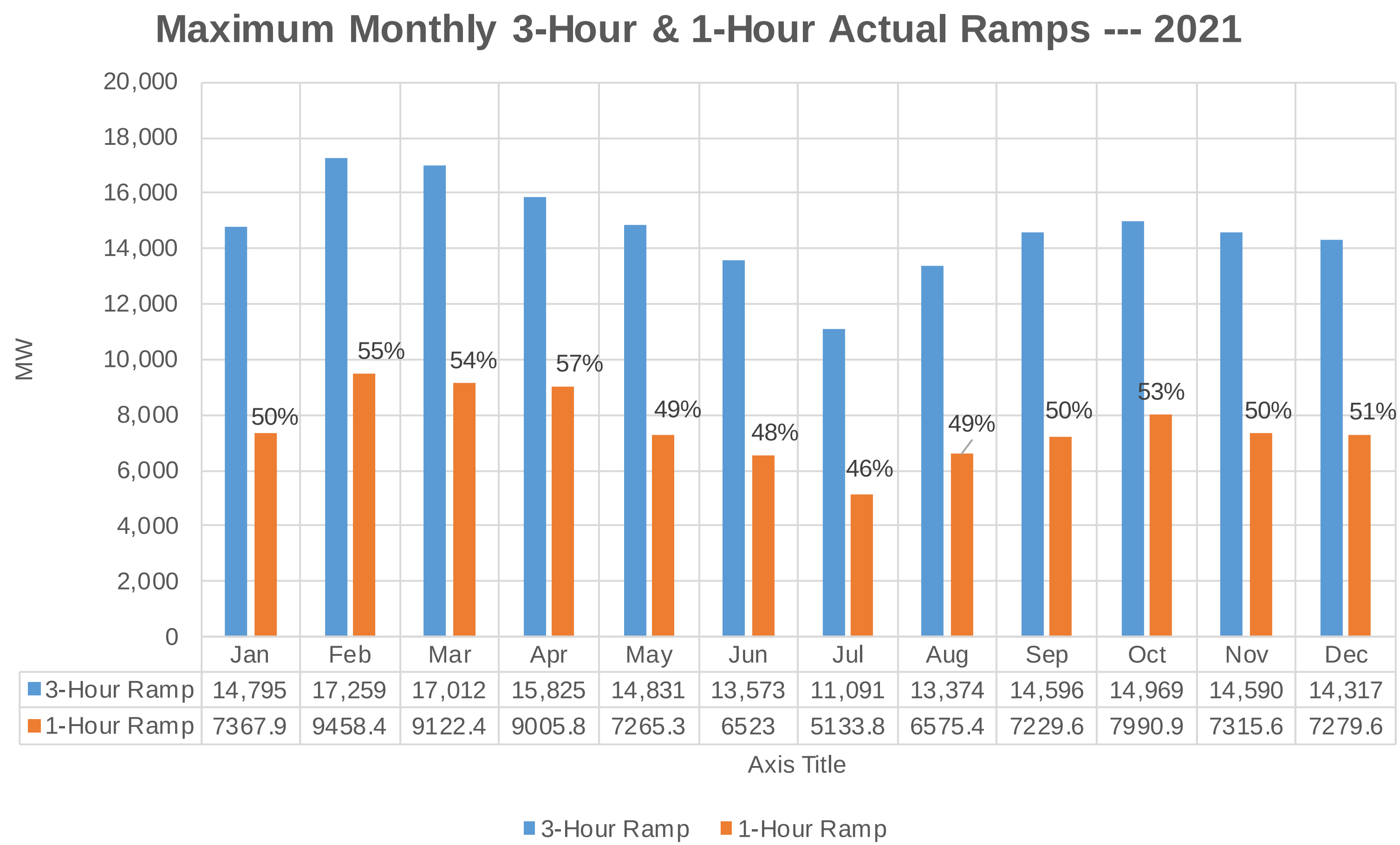
E(PL) = Expected peak load

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

Maximum 3-Hour upward ramps are not evenly distributed each hour which demonstrates the need for faster ramping capability



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3-Hour Ramp	14,795	17,259	17,012	15,825	14,831	13,573	11,091	13,374	14,596	14,969	14,590	14,317
1-Hour Ramp	7367.9	9458.4	9122.4	9005.8	7265.3	6523	5133.8	6575.4	7229.6	7990.9	7315.6	7279.6

What data does the ISO need?

- CEC's IEPR demand forecast (e.g. 2022 – 2025 demand forecast)
- LSE SCs to update renewable build-out for 2022 through 2025 by CREZ by January 15, 2022 (Beyond 2025 if data is available)
- The data should include:
  - 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, hybrid, co-located, etc.) for all variable energy resources under contract
  - Operational date or expected on-line date
  - Interconnecting substation, closes substation or switching station
  - Resources located outside ISO's BAA must indicate if the resources are dynamically scheduled or not
- All required LSE SCs have already provided this data
  - LSE SCs must submit data for all LSE for which they are the SC
  - ISO is in the process of reviewing the submitted data

Allocation: Notation

Symbol or Equation	Meaning
L, W, S, NL	Load, wind, solar, net load = load – wind – solar
Δ	Ramp
Δ NL = Δ L – ΔW – ΔS	Net load ramp = load ramp – wind ramp – solar ramp
ΔNL_{2023}	Net Load Ramp Requirement for 2023
$\Delta NL_{sc,2023}$	Net Load Ramp Requirement of SC Allocation for 2023
R	Reserve = max(MSSC, 3.5* peak load)
pl_r_{sc}	CEC peak load ratio
Σ	Summation of all SCs

- 2023 load (L) forecast is from the CEC IEPR forecast
- Wind (W) and solar (S) are from survey results
- 2021 L is 5-minute observed data

Allocation: Formula

- Flex Requirement $= \Delta NL_{2023} \ + R_{2023}$

  $= \Delta NL_{2023} \ + \Sigma pl\_r_{sc} * R_{2023}$

- $\Delta NL_{2023} = \Delta L_{2023} - \Delta W_{2023} - \Delta S_{2023}$

  $= \Delta L_{2023} - \frac{\Sigma W_{sc,2023}}{W_{2023}} * \Delta W_{2023} - \frac{\Sigma S_{sc,2023}}{S_{2023}} * \Delta S_{2023}$

Allocation: Load Proportion

- $\Delta L_{2023} = \Delta L_{2021} + (\Delta L_{2023} - \Delta L_{2021})$

$$= \Sigma \Delta L_{sc,2021} + \frac{\Sigma L^{M}_{sc,2021}}{L^{M}_{2021}} * (\Delta L_{2023} - \Delta L_{2021})$$

ΔL_{2021} is the average load portion of top 5 maximum 2021 3h ramps while matching 2023 maximum 3h ramp on month and time, and L^{M}_{2021} is the average load at the middle point of those top 5 ramps.

- Therefore, each SC will receive:

$$\Delta L_{sc,2021} + \frac{L^{M}_{sc,2021}}{L^{M}_{2021}} * (\Delta L_{2023} - \Delta L_{2021})$$

The ISO accounts for renewables on the grid to determine flexibility needs

- The ISO uses the maximum ramping needs across a 3-hour period to set requirements for flexible capacity
- Renewable resources contribute to this requirement and the ISO incorporates forecasts to estimate these needs
- Resources Included:
  - EIR Wind and Solar Resources
  - Co-located EIRs (2021)
  - Hybrid Renewable Components (proposed 2022)
- Renewable components of hybrid resource must be considered in flexible need assessment because all renewable resources contributes 3-hour net load ramp
- The ISO allows the storage component for co-located and hybrid resources to count for flexible capacity

Co-located and Hybrid in Flex RA study

- Tariff: The Effective Flexible Capacity value of a Hybrid Resource is the sum of what the Effective Flexible Capacity values of the constituent components of the Hybrid Resource would be if those components were each a distinct Generating Unit

- EFC formula $EFC = \min(NQC, Pmax) - Pmin$ is applicable for
  - Battery
  - Battery component in co-located
  - Battery component in hybrid, since
    - Battery component have its own Pmax and Pmin Phase 2B
    - NQC for Battery component is available in the ISO's deliverability study

ANNUAL REVIEW OF AVAILABILITY ASSESSMENT HOURS

Methodology Overview of System/Local Availability Assessment Hours

- Used CEC IEPR data described in previous slides to obtain:
  - Hourly Average Load
    - By Hour
    - By Month
    - Years 2021-2025
- Calculated:
  - Top 5% of Load Hours within each month using an hourly load distribution
  - Years 2023 - 2025

Key information already requested and obtained

- ISO published a market notice for survey data in December 2021 and January 2022
- LSE Survey Data was due on January 15, 2022
- CEC Hourly IEPR Forecast is anticipated to be finalized and published on January 28, 2022

Next Steps

Item	Date
February 2, 2022	ISO Flex RA methodology and criteria stakeholder call
February 16, 2022	Stakeholder comments on Flex RA methodology, criteria and data used for 2023 flexible requirements due
April 6, 2022*	Stakeholder call on preliminary Flexible Capacity and Availability Assessment Hours (AAH) requirements for 2022, 2023, and 2024
April 2022	Publish preliminary Flexible Capacity and AAH requirements for 2023, 2024 & 2025
April 2022*	Stakeholder comments on preliminary requirements due
May 2022	Issue final Flexible Capacity and AAH requirements for 2023 and projected requirements for 2024 & 2025

*We are evaluating our Flex RA schedule based on delay of CEC IEPR forecast publication. At this time, we are expecting a two week delay. The above information is subject to change accordingly.

Questions?

Please submit comments on the assumptions to

initiativecomments@caiso.com

by February 16th, 2022

Thank you for your participation.