Resource Adequacy
Slide of Day Translation Tool and Update to Thermal Derate Model

Energy Division

October 25, 2023

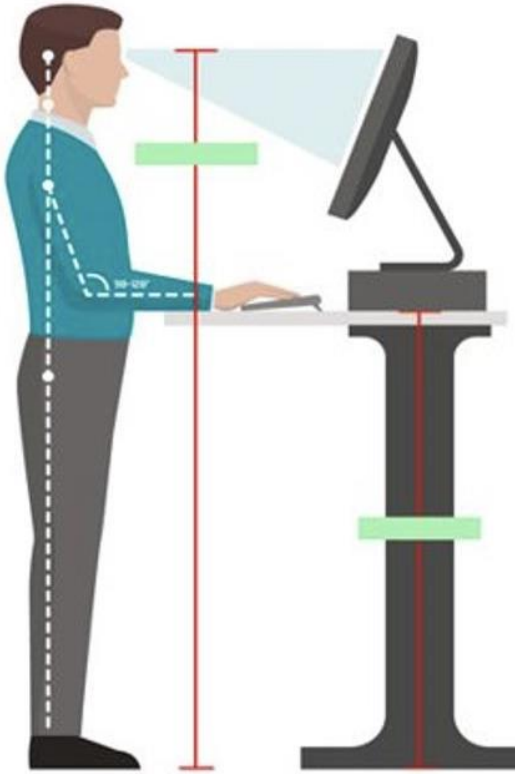
California Public Utilities Commission

Logistics

- Online and will be recorded

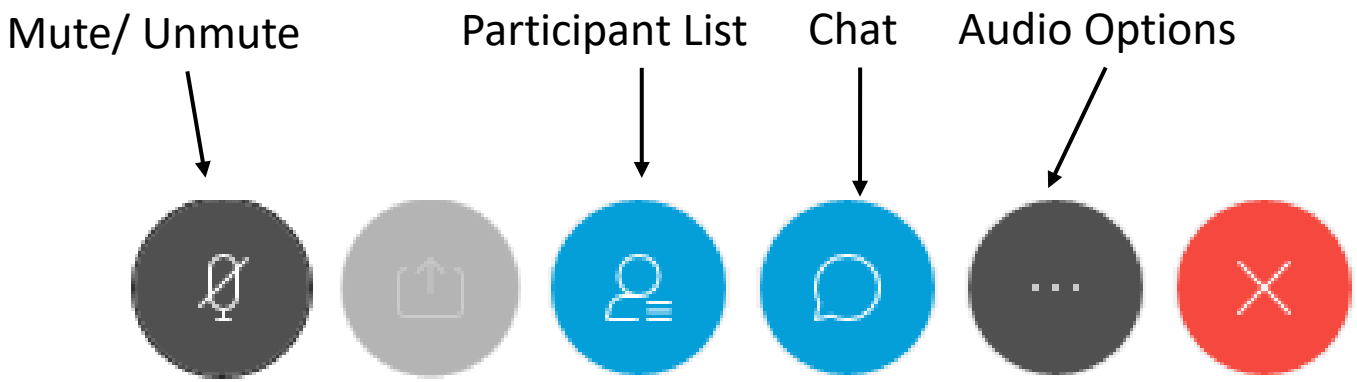
- Today's presentation & recording will be uploaded onto RA history website
  - https://www.cpuc.ca.gov/General.aspx?id=6316

- Safety
  - Note surroundings and emergency exits
  - Ergonomic check

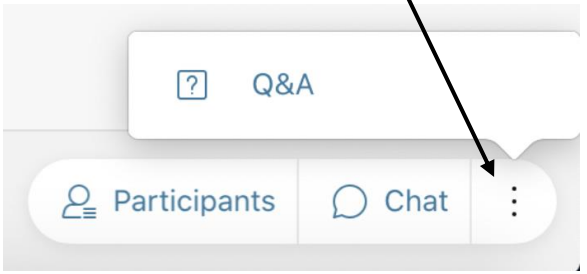


Logistics

- All attendees have been muted
- To ask questions, please use the "Q&A" function (send "To All Panelists") or raise your hand
- Questions will be read aloud by staff; attendees may be unmuted to respond to the answer. (Reminder: Mute back!)



"Q&A": on the bottom right of screen, click "3 dots"



RA Reform Background

- D.21-07-014: **Adopted "slice-of-day" (SOD) concept and six principles.** Established a process and timeline for developing a final restructuring proposal based on PG&E's "slice-of-day" proposal.
- D.22-06-050: **Adopted SCE's 24-hour approach to the "slice of day" framework.** Directed additional working groups and submittal of a working group report to address remaining implementation details.
- D.23-04-010: **Adopted implementation details** including compliance tools, resource counting rules, test year details and coordination with CAISO processes.

Next Steps – *Test Year Implementation*

- **LSE Compliance Templates** – Used for SOD RA showings.
- **Master Resource Database (MRD)** – CPUC will maintain an official database of resources eligible to sell RA that includes their key attributes, as listed below. Resources must be fully represented in the MRD to be eligible for use in the 24-hour slice RA showing.
- **Planning Reserve Margin (PRM) Calibration** – A SOD calibration tool is adopted that will convert the results of a LOLE study to the SOD framework.
- **LSE Filings for 2024 Test Year** – LSEs are required to make year-ahead SOD filing by November 30, 2023, and month-ahead compliance showings for March, June and September by the first day of the showing month.
  - SOD showings also used if LSE showing storage in MCC bucket 4.
- **Assessment Report** – CPUC staff to solicit public feedback after key milestones during the 2024 test year, and to prepare a report summarizing the feedback after the year-ahead test showings (due by February 1, 2024). Stakeholders will have an opportunity to provide formal comment on the staff report.

Agenda

- **Resource Adequacy Slice-of-Day Translation Tool Demo and Results** – Mounir Fellahi, Energy Resource Modeling, Energy Division
- **Update - Derating Thermal Power plants based on Ambient Temperatures**– Robert Hansen, Energy Resource Modeling, Energy Division

Resource Adequacy Slice-of-Day Translation Tool Demo and Results

October 25, 2023

Mounir Fellahi

Resource Modeling Team

California Public Utilities Commission

Today's Presentation

Objective: Present revised and updated SOD translation tool, demonstrate its usage, and present results using inputs from February 2023 LOLE study and recent October 2023 LOLE study

Outline of presentation:

- Background – Use of SOD framework and SOD translation tool
- Updating SOD tool and inputs – Feb 2023 versus Oct 2023 study
- SOD LOLE Translation Steps and Process
- SOD LOLE translation results (Feb 2023 vs Oct 2023)
- Next steps to implement and update tool

Background – Use of SOD framework and SOD translation tool

RA Proceeding (R.21-10-002) Background

- D.23-04-010
  - "As determined in D.22-06-050, for initial implementation of the SOD framework, a single PRM shall apply to all hours of the year"
  - "To provide flexibility in developing the calibration tools for the initial implementation of the SOD framework, we find it reasonable to authorize Energy Division to integrate both NRDC's and SCE's calibration tools, to the extent possible . Once Energy Division has modified the calibration tool, Energy Division is directed to publish the draft calibration tool on the Commission's website and solicit informal party comments"
- D.23-06-029
  - Given the realities of available RA supply and persistent delays in development projects, it is prudent to retain the status quo 17 percent PRM for the 2024 and 2025 RA years. Increasing the PRM without greater certainty about installed RA resources for 2024 and 2025 is not appropriate at this time.

Summary of LOLE Studies and SOD translations in 2023

Overall Goal of SOD translation tool:

The SOD translation tool is created to translate results of a Loss of Load Expectation (LOLE) study to a portfolio and energy sufficiency analysis to back up the SOD framework in the RA proceeding

Key background:

- SOD is not just a capacity counting requirement; it is also an energy sufficiency requirement
- SOD requirements mandate firm capacity contracting, not just economic energy or resource availability
- SOD determines RA margin based on 1 in 2 managed peak, meaning managed peak is the base of the requirement, not GROSS peak. Thus margin is dependent on demand modifiers and weather effects, thus required margin is variable from year to year
- SOD requirements are not stochastic or attempting to meet expected events; instead, it is intentionally creating scenarios that are worst case
    - One worst day over 24 hours using low recurrence expected resource performance

Summary of LOLE Studies and SOD translations in 2023 Cont'd

Staff performed two LOLE studies in 2023

Staff performed a LOLE study released in February 2023 (Feb 2023 LOLE study) and translated the results of that study into a draft SOD RA Requirement.

- Feb LOLE study was translated into the NRDC SOD tool and used a Nov 2022 Baseline of resources. The LOLE study resulted in 0.1 LOLE, which needed only minor calibration

Staff also performed a LOLE study in September and October 2023 (October 2023 LOLE study) in support of the IRP Preferred System Plan. Results are posted to the CPUC website HERE

Since the previous SOD translation in February 2023, staff have extensively upgraded the SOD tool (combining SCE and NRDC tools) and made several improvements.

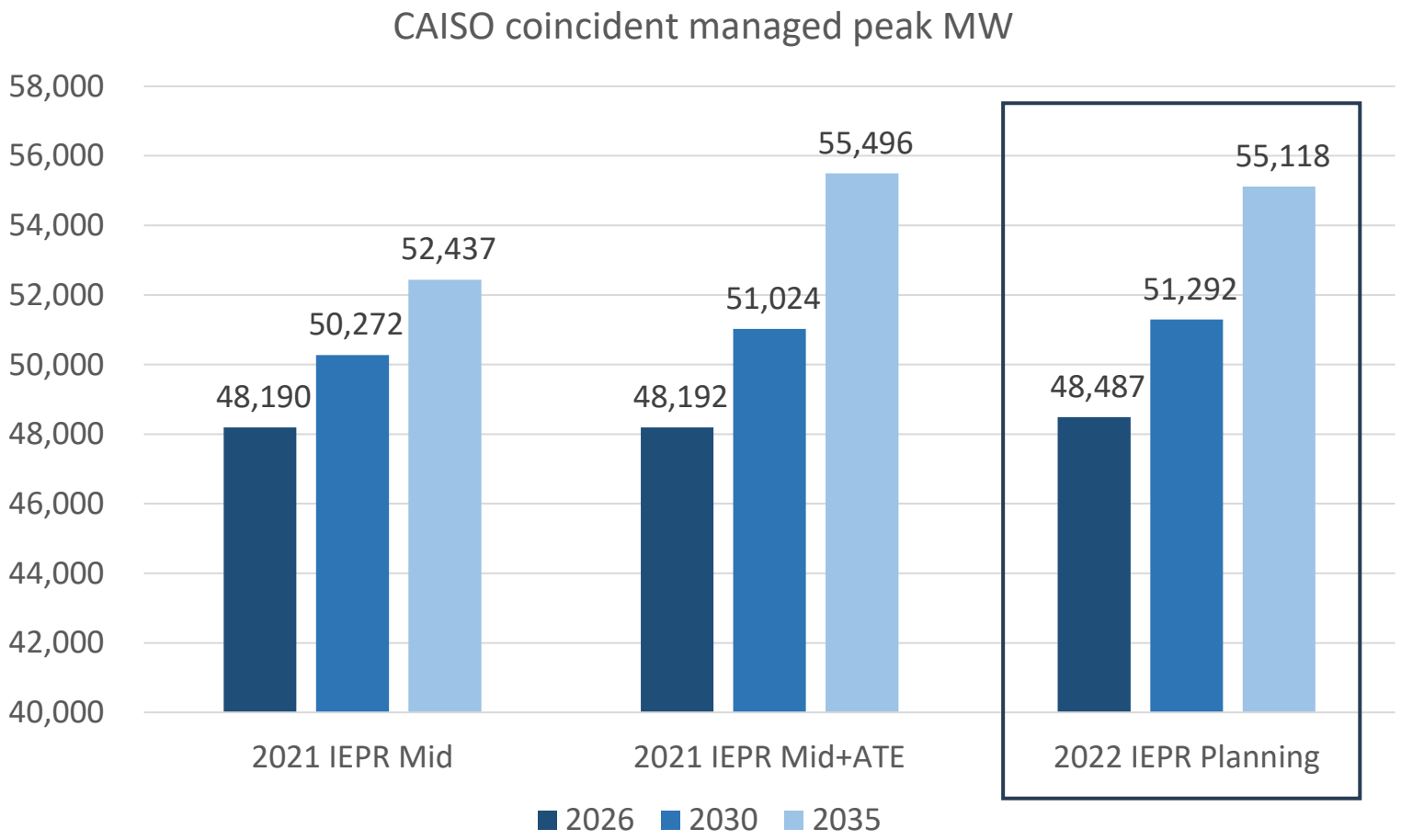
- Staff updated the February 2023 SOD translation by using the new tool on the previous 2021 IEPR demand forecast and 0.1 LOLE calibrated portfolio of resources. Staff also translated the October LOLE study in the new updated SOD tool . Both studies are summarized in this presentation

Updating SOD tool and inputs Feb 2023 versus Oct 2023 study

Summary of LOLE studies and SOD translation

- The previous SOD tool used in February 2023 was based on the NRDC tool and resulted in a RA SOD PRM of 8% energy needed over managed peak net demand.
  - Key assumptions – 2021 IEPR Mid-High ATE
  - Used older NRDC translation tool. Included portfolio of resources from the 2022 Modeling Baseline (published November 2022)
  - Initial results were very close to 0.1 LOLE; minor calibration was performed by adjusting the peak day import constraint (the 4,000 MW constraint applied in HE 17-22). LOLE was calibrated with adjustments of about 500 MW to the import constraint
- The updated October 2023 LOLE study is also shown in the updated SOD translation tool
  - This analysis is based on the 2022 IEPR Planning Scenario and adds some additional capacity that reached COD between LSE plans submitted in August 2022 and January 2023.
  - Results showed that the Baseline alone was not reliable, requiring resource additions in 2024.
  - **Calibration to 0.1 LOLE was accomplished by addition of 2,200 MW of Perfect Capacity**
  - Staff also updated the SOD tool considerably

Comparison 2021 IEPR vs. 2022 IEPR Managed Peak Forecast



- February 2023 SOD translation results based on 2021 IEPR Mid-ATE
- PSP modeling is based on 2022 IEPR Planning, which is very similar in 2024, and within 380 MW in 2035. Very similar peak demand between both SOD translations

Marginal ELCC values – PCAP translation

Staff translated 2,200 MW of PCAP to actual RA capacity (Batteries and solar) on a 1 to 1 basis, 1 MW of storage to 1 MW of batteries until total ELCC added totaled 2,200 MW.

Marginal Battery ELCC (%)

Battery marginal ELCC increases for a given battery penetration as solar is added →

Solar Nameplate Capacity (GW)

4-Hour Battery Nameplate Capacity (GW)	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	90%	92%	92%	92%	92%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
5	90%	92%	92%	92%	92%	92%	92%	95%	95%	95%	95%	95%	95%	95%	95%
10	90%	90%	92%	92%	92%	92%	92%	92%	92%	95%	95%	95%	95%	95%	95%
15	70%	79%	79%	87%	90%	90%	91%	92%	92%	92%	92%	95%	95%	95%	95%
20	33%	33%	33%	65%	70%	75%	81%	84%	84%	84%	90%	90%	92%	92%	95%
25	33%	33%	33%	33%	37%	44%	45%	52%	52%	52%	52%	52%	52%	52%	52%
30	27%	27%	27%	27%	27%	27%	28%	30%	32%	36%	36%	36%	36%	36%	36%
35	17%	17%	17%	17%	17%	17%	17%	17%	28%	32%	36%	36%	36%	36%	36%
40	9%	9%	9%	9%	9%	9%	9%	11%	11%	12%	12%	32%	36%	36%	36%
45	9%	9%	9%	9%	9%	9%	9%	9%	11%	11%	11%	11%	12%	36%	36%
50	9%	9%	9%	9%	9%	9%	9%	9%	9%	11%	11%	11%	11%	11%	12%

Battery margind ELCC saturates without supporting solar capacity

Marginal Solar ELCC (%)

Solar marginal ELCC increases for a given solar penetration as batteries are added ↓

Solar Nameplate Capacity (GW)

4-Hour Battery Nameplate Capacity (GW)	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0	5%	3%	3%	3%	3%	2%	2%	2%	2%	2%	2%	2%			
5	6%	3%	3%	3%	3%	3%	3%	2%	2%	2%	2%	2%			
10	6%	5%	3%	3%	3%	3%	3%	3%	3%	2%	2%	2%			
15	13%	8%	8%	4%	3%	3%	3%	3%	3%	3%	3%	2%	2%	2%	2%
20	25%	25%	21%	9%	6%	4%	4%	4%	4%	4%	3%	3%	3%	3%	2%
25	25%	21%	21%	21%	16%	9%	8%	4%	4%	4%	4%	4%	1%	1%	1%
30	25%	21%	21%	21%	19%	19%	10%	9%	4%	1%	1%	1%	1%	1%	1%
35	25%	21%	21%	21%	19%	19%	17%	14%	10%	4%	1%	1%	1%	1%	1%
40	25%	21%	21%	21%	19%	19%	17%	14%	14%	14%	14%	4%	1%	1%	1%
45	25%	21%	21%	21%	19%	19%	17%	17%	14%	14%	14%	14%	14%	1%	1%
50	25%	21%	21%	21%	19%	19%	17%	17%	17%	14%	14%	14%	14%	14%	14%

Solar marginal ELCCs saturate without supporting storage capacity

Batteries support solar margind ELCC by shifting solar generation to hours when it is needed most

Source – I/A ELCC inputs slide deck from June, 2023. Total Batteries about 15,000 MW and total solar about 30,000 MW translating to marginal battery ELCC of 70% and marginal solar ELCC of 13%

Updates and Improvements to the Previous SOD tool

During workshops in February 2023, staff previewed analysis translating LOLE studies into a SOD framework using the NRDC tool. The new revised SOD translation tool is a combination of the SCE tool into the NRDC tool. There are several specific updates made, which are summarized below

- Unit Specific (Oct 2023 updated tool) versus aggregated class (Feb 2023 tool) treatment of Batteries and Pumped Storage Hydro (PSH)
  - Evaluating cycle efficiency and duration parameters for batteries and PSH
- Revised exceedance profiles for wind and solar and qualified at exceedance from Master Resource Database (MRD) instead of ELCC
  - Utilizing exceedance profiles to assess the performance of wind and solar resources in the new SOD approach instead of ELCC
  - The shift from ELCC to Exceedance harmonizes with RA compliance and the MRD.
- Operational Characteristics of resource classes as reflected in SERVM, including:
  - Updating availability of Demand Response (DR) resources
- Hourly generation data Instead of monthly
- Revised Optimization Algorithm

SOD LOLE translation steps and process

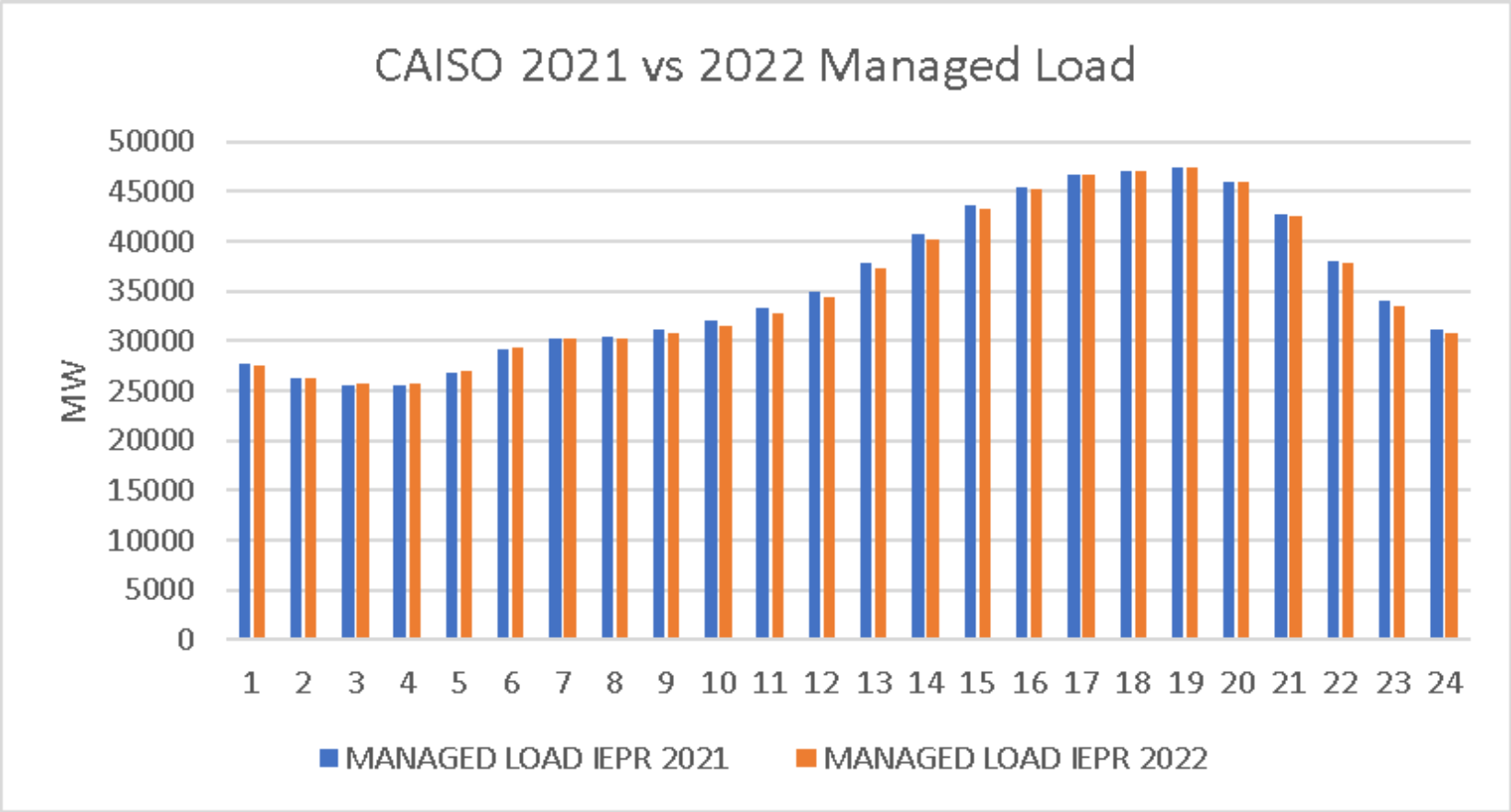
Sequence of steps and Process

- Staff performed LOLE studies and calibrated resource portfolio to a 0.1 calibrated LOLE portfolio
  - Add Perfect Capacity to meet 0.1 LOLE target
  - Convert Perfect Capacity (generic) into real world RA capacity (by realistic mix of preferred resources, i.e., 1 to 1 mix of solar and storage)
- Input CEC 1-2 annual managed peak day forecast – choosing CAISO "worst day" from September. These forecasts cover 24 hours of the managed peak day for the modeled year (i.e., 2024)
- Input Resource Portfolio from LOLE study
  - All resources (including renewables) to count at their expected hourly generation using NQC (exceedance), not their nameplate, following RA program resource counting rules and logic
  - No UCAP framework yet, but possibly in future
- Resource portfolio from LOLE (Loss of Load Expectation) study. Transfer the characteristics of the 24-hourly slices (daily) and hourly availability of the resource portfolio to the SOD translation tool

Sequence of steps and Process Cont'd

- Special treatment for batteries, import, and demand response:
  - Batteries and PSH:
    - Make them available from hour 16-17 to 21 (Batteries discharging over 5 or 6 hours, not just 4)
    - Batteries and PSH must demonstrate there is sufficient excess deliverable (not energy only) energy to charge from in other hours to enable their dispatch (plus losses)
    - Imports are to be firm contracts, not just non-specific economic energy
    - PSH is available for 12 hours, covering the peak hours from HE 12 to HE 24
  - Import Levels: Set import at 4000 MW during all 24 hours
  - Demand Response: Use LIP values and use during DR availability hours

Comparison 2021 IEPR ATE vs. 2022 Planning IEPR Managed Peak Forecast



Comparison Feb 2023 vs Oct 2023 Portfolio

Unit Category	Feb 2023 NQC	Oct 2023 NQC	Delta
Biogas	287.65	204.51	83.14
Biomass/Wood	508.41	451.78	56.64
CC	16,588.37	16,385.53	202.84
Coal	480.00	480.00	0.00
Cogen	2,291.61	1,837.48	454.13
CT	8,270.98	7,927.84	343.14
DR	1,942.01	2,113.69	-171.68
ICE	254.70	254.70	0.00
Geothermal	1,478.64	1,082.10	396.54
Hydro	6,265.19	5,373.70	891.49
Interchange	4,000.00	4,000.00	0.00
Nuclear	2,935.00	2,915.00	20.00
PSH	1,683.20	895.32	787.88
Storage	2,537.62	6,028.51	-3,490.89
Solar Fixed_Norcal	1,967.81	1,932.14	35.67
Solar Fixed_Socal	2,936.19	2,882.97	53.22
Solar Thermal_Norcal	00	00	0.00
Solar Thermal_Socal	997.00	997.00	0.00
Solar Tracking_Norcal	2,487.01	3,670.04	-1,183.03
Solar Tracking_Socal	6,836.17	10,088.04	-3,251.87
Wind_Norcal	1,961.40	1,950.31	11.09
Wind_Socal	4,692.17	4,665.65	26.52
Total	76,320.67	76,136.31	184.35

Feb 2023 study had 76,320.67MW November 2022 Baseline including some in development resources

Oct 2023 study had 76,136.31MW January Baseline including some resources that came online between previous Baseline and January 2023

Delta partially explained by translation of PCAP needed in Oct 2023 PSP study

In particular, some PSH resources were recharacterized as DR between studies explaining the decrease in PSH and increase in DR

Solving for the PRM – SOD solver function

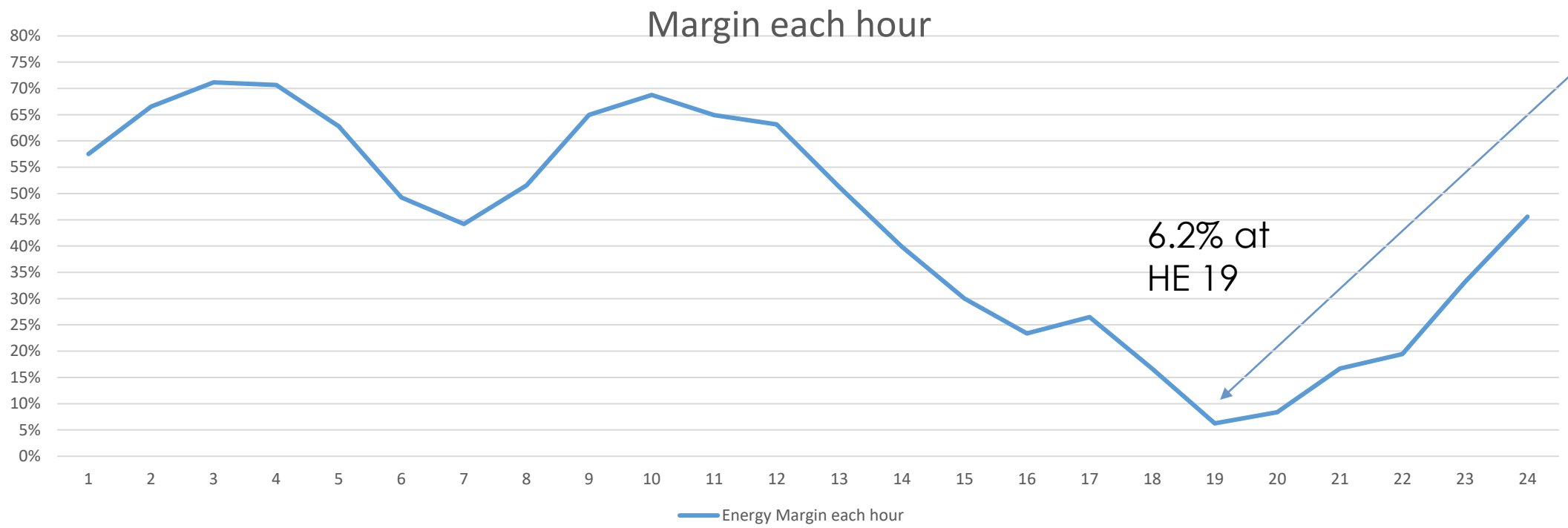
- Utilize solver functionality to determine the maximum PRM that the LOLE resource portfolio can satisfy under slice of day rules while respecting the optimization constraints:
  - RA requirement capacity is enough to cover System RA requirement in each slice.
  - Requirement to show sufficient excess capacity to meet energy storage charging and pump storage.
  - Requirement for portfolio to meet load plus PRM in all hour (i.e., sufficient capacity in every hour)
- The "worst" hour within the worst day within the worst month (September in this case) will set the PRM requirement

Solving for the PRM – SOD solver function Cont'd

- Energy Margin at a certain hour of the day may be low relative to overall PRM
- The Dashboard in the SOD tool will show a result equal to the minimum amount of energy margin (energy MWh divided by demand in MWh) in any single hour of the day
- The SOD tool also enforced other constraints that are necessary to preserve reliability
- Batteries discharge in critical hour, batteries need energy to charge. Since critical hours are later in day (HE19) there are resources needed to meet demand when sun has set
- The "worst" hour within the day within worst month will set the Required Energy Margin
    - In this case Hour Ending 19

SOD LOLE translation results

PRM Calibration on Worst Day – February 2023 results (Worst day is in September)



6.2% at HE 19

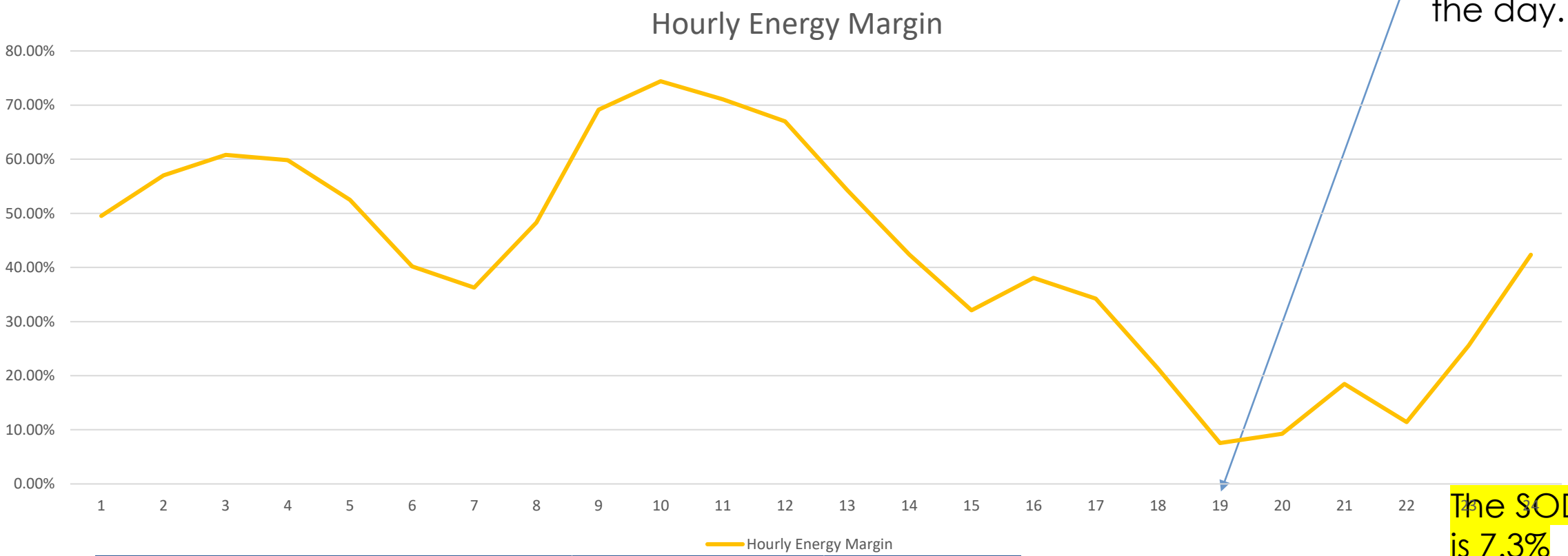
The most constrained hour (HE 19) in the day.

Sufficient excess capacity to meet energy storage	Max Short (Long)	SOD PRM
274,410.18	(16.85)	6.2%

The SOD PRM is 6.2%

2022 IEPR and PSP Baseline Only Portfolio (Oct 23)

The most constrained Hour (HE 19) in the day.

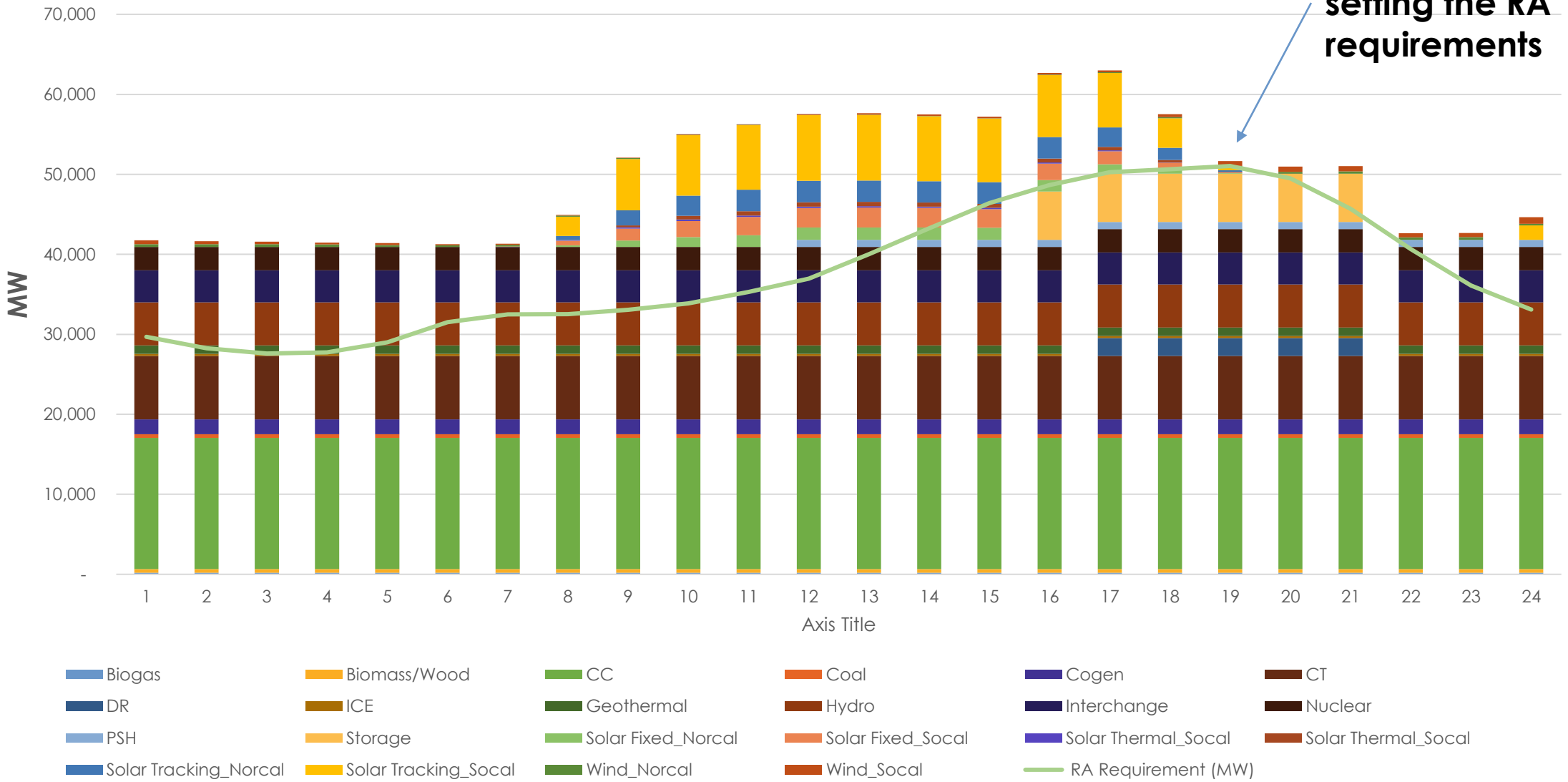


The SOD PRM is 7.3%

Sufficient excess capacity to meet energy storage	Max Short (Long)	SOD PRM
233,237.04	(24.33)	7.3%

CAISO Portfolio for 2024 LOLE Study Using 2022 IEPR

Hour Ending 19 is setting the RA requirements



Next steps to implement and update tool

Next Steps

1. Reissue allocations for RA using the 6.2% PRM and test implementation over this test compliance year
2. Post this slide deck and SOD tool in two versions, with the Feb 2023 LOLE portfolio/2021 IEPR and the October 2023 LOLE study portfolio/2022 IEPR
3. Take informal comments from parties
4. Present final SOD tool for parties to evaluate Q1 2024
5. Update parties with lessons learned during initial test year implementation
    1. **Report in February 2024** to review implementation and experience so far
6. Further Refinement of SOD Methodology as Needed via RA proposal in Q1 2024
    1. Possible addition of UCAP requirements

Questions?

Update - Derating Thermal Powerplants based on Ambient Temperatures

Expected results based on climate-informed weather forecasts

August 8, 2023

Presented by Robert Hansen

Senior Utilities Engineer

Resource Modeling Team

California Public Utilities Commission

Presentation Outline

- Explanation of Revised Methodology
- Explanation of Preliminary Results
- Visualized Results

Updated Methodology

Changes to the originally proposed derating

History of this proposal and objective of this presentation

- Staff presented a methodology for derating thermal powerplants each hour based on hourly temperature in March 2023
- Stakeholders submitted comments and questions, which resulted in very helpful dialogue and led to an improved methodology.

This presentation is meant to describe and share results from the revised methodology:

- Zero curtailment (i.e., full capacity) is now assumed for unreported hours
- Use multilinear regression rather than single regression in two-steps
  - Apply binary variables to categorical values
  - Each weather station becomes a variable for regression which can both be either 0 or 1
  - Allows more data to be included in analysis
  - Each unit type is analyzed separately, yielding different best-fit curves

Updated Methodology

For each unit type, we find the least-squares optimal regression parameters to fit the model:

$$D_i = \beta_1 T_i^* + \beta_{3.1} W_1 + \beta_{3.2} W_2 + \cdots + \beta_{3.n} W_n + \beta_4$$

D_i is the reported or imputed derate percentage for observation i

T_i^* is the recorded temperature of the nearest weather station at the time of observation i normalized for resource

W_j is the j^{th} Boolean variable indicating the weather station closest to the resource associated with observation i, with exactly one of n

β_k is a linear regression parameter applied to the k^{th} of the $2 + n$ variables

Updated Methodology

The regression parameter for temperature is then applied to piecewise-linear model for each class, consisting of a weather station and a unit type

$$\widehat{D}_i = \begin{cases} 100\% & \left| T_i \leq T_0 \right. \\ 100\% - \beta_1 (T_i - T_0) & \left| T_i > T_0 \right. \end{cases}$$

This aspect of the model is unchanged from the previous version.

Explanation of Preliminary Results

Changes to the originally proposed derating

Explanation of Preliminary Results

- The following charts were generated using the results of the multilinear regression analyses for Combustion Turbine and Combined Cycle resources
- The regression parameters (slopes/cut-off temperatures) were used to calculate derates for a variety of weather scenarios:
  - Historic weather (labelled 0°C / 100th percentile)
  - Climate-informed weather forecasts:
    - 1.5°C / 25th, 50th, 75th percentiles
    - 2.0°C / 25th, 50th, 75th percentiles
    - 3.0°C / 25th, 50th, 75th percentiles
  - Scenario percentiles are percentiles of ensemble of climate models

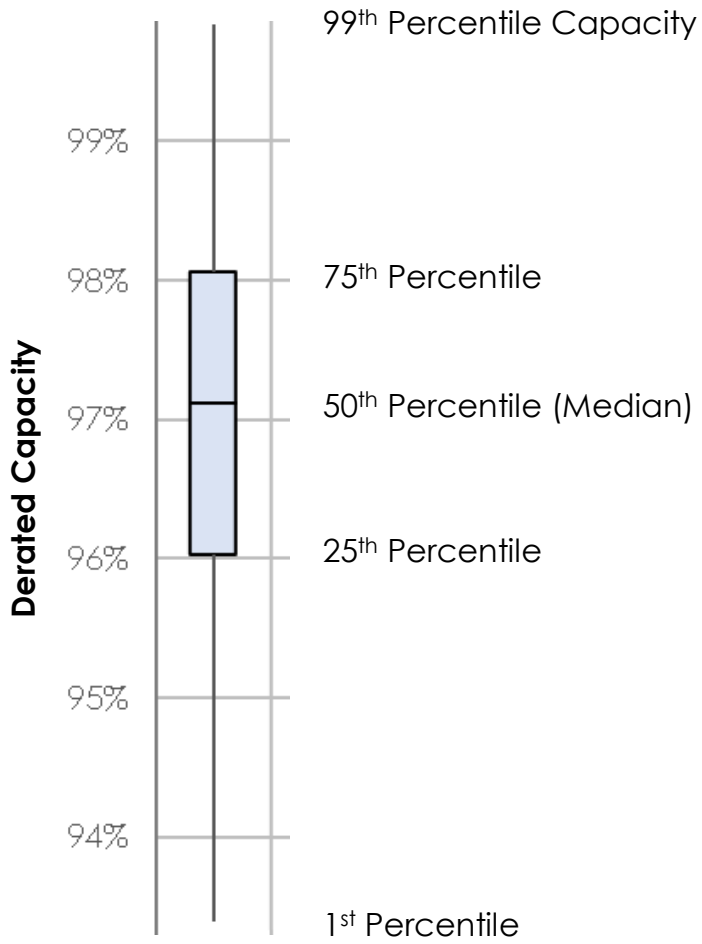
Explanation of Preliminary Results

- Revised Slopes by Unit Type:
  - Combustion Turbine: $\beta_1 = \frac{0.138\%}{^\circ C}$
  - Combined Cycle: $\beta_1 = \frac{0.097\%}{^\circ C}$
  - Revised intercepts vary by Unit Type and Weather Station
- Median derated capacities in current climate across all years and weather stations:

	Original	Revised
Combustion Turbine	95.77%	98.15%
Combined Cycle	96.18%	98.70%

Explanation of Preliminary Results

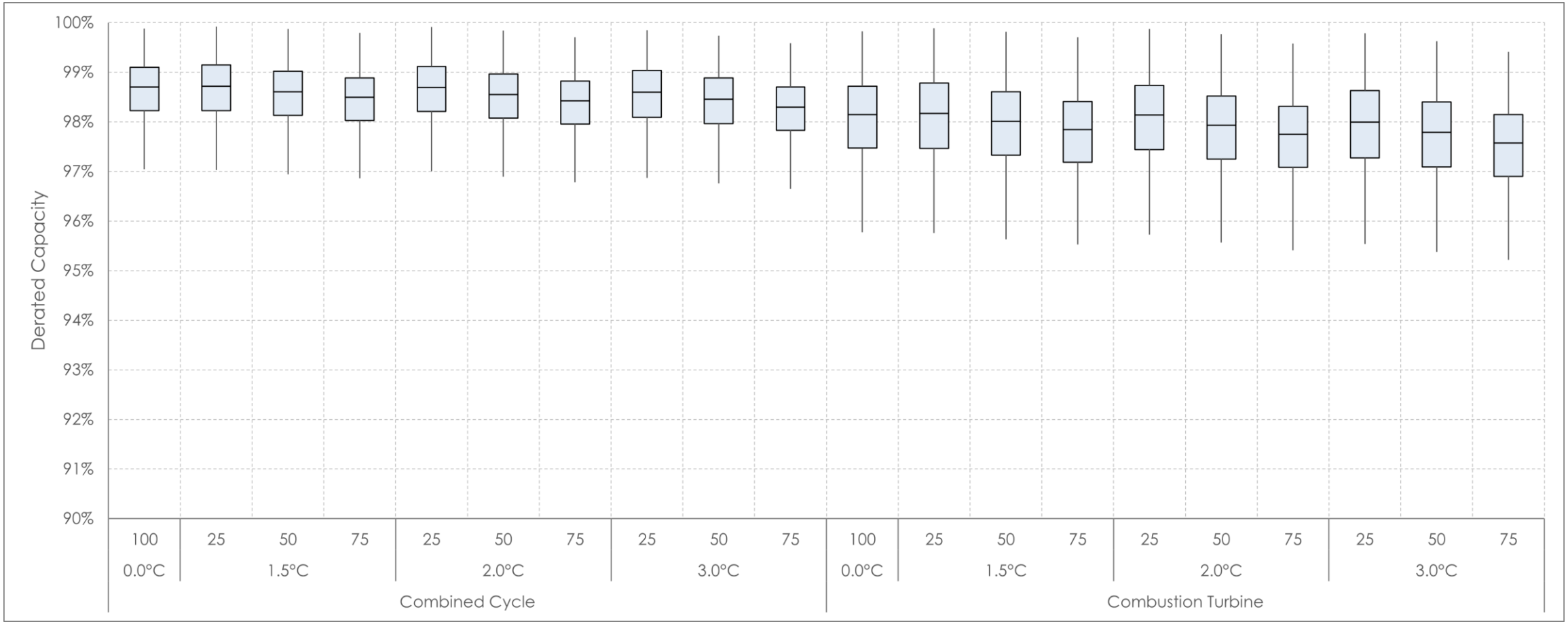
- The error bars indicate the likelihood a matching resource would provide the shown capacity during a randomly selected hour throughout the year under the given climate scenario
- These are preliminary results, as SERVM results are not yet available



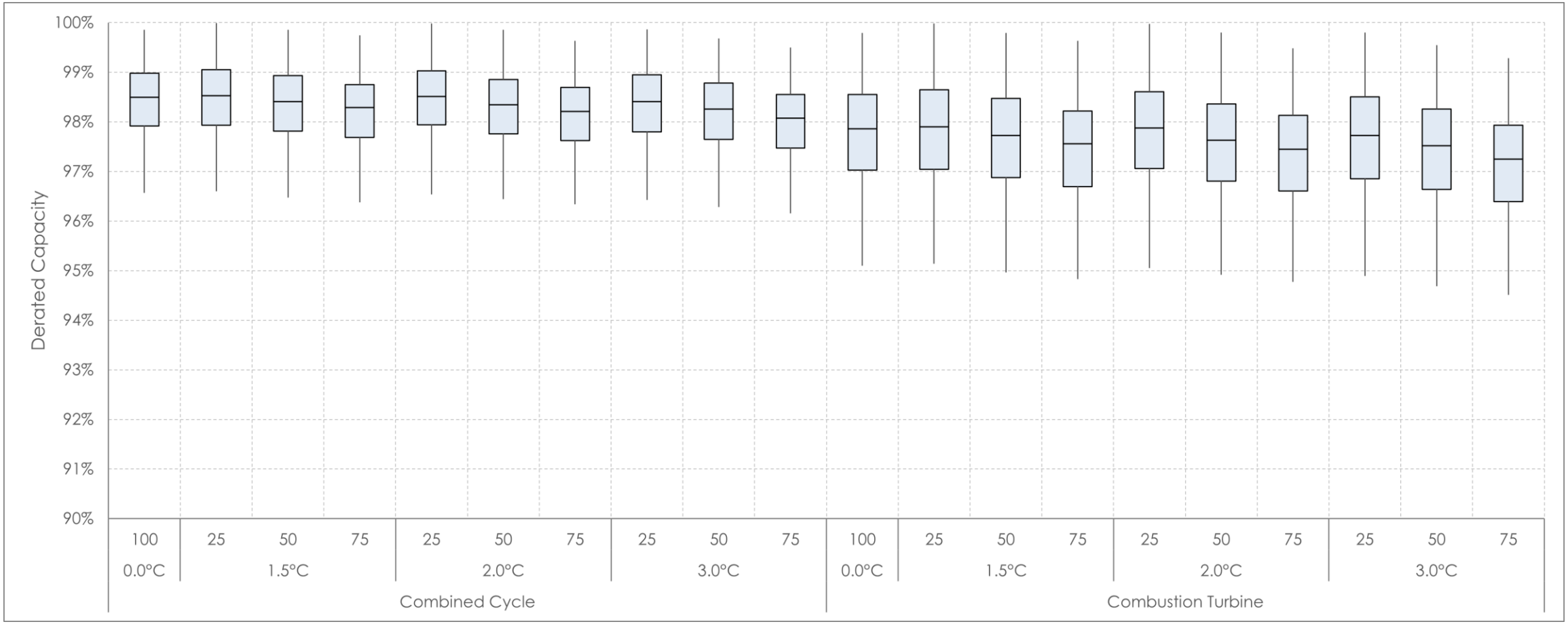
Visualized Results

Overall scenarios with selected years and weather stations

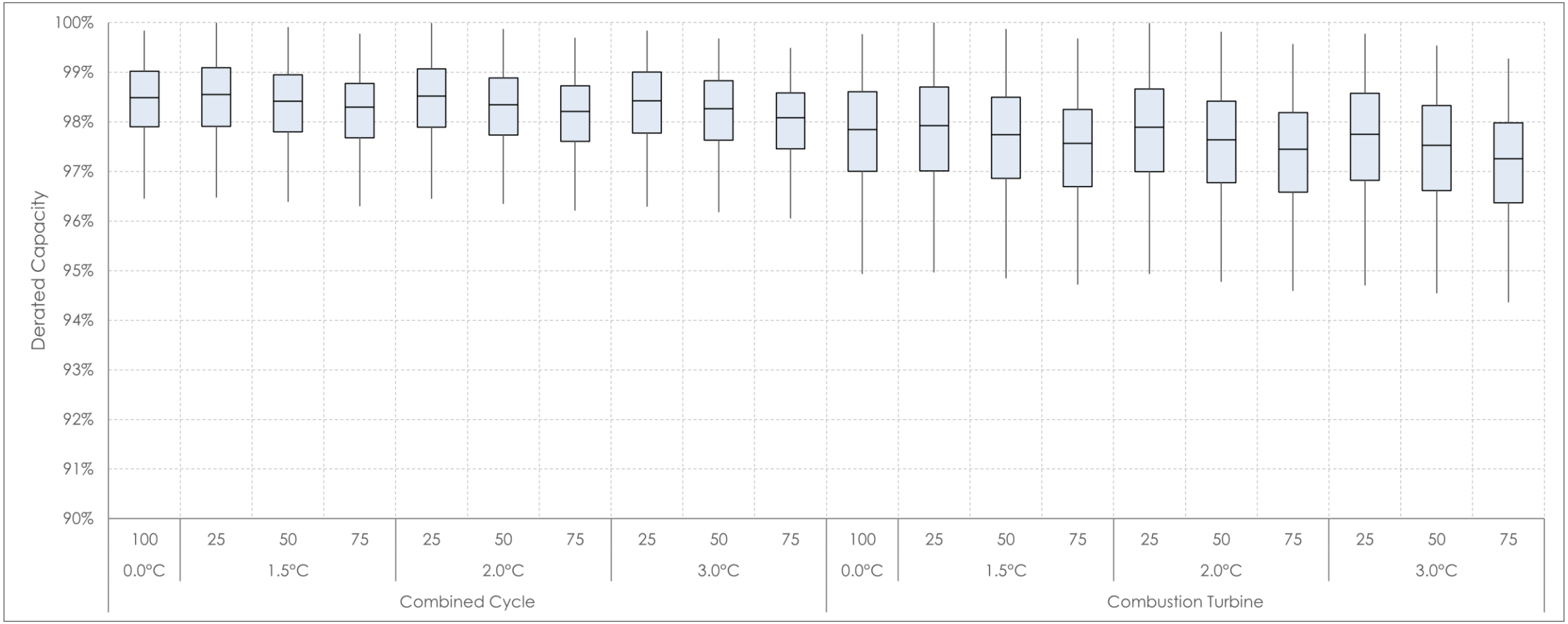
All Years, All Weather Stations



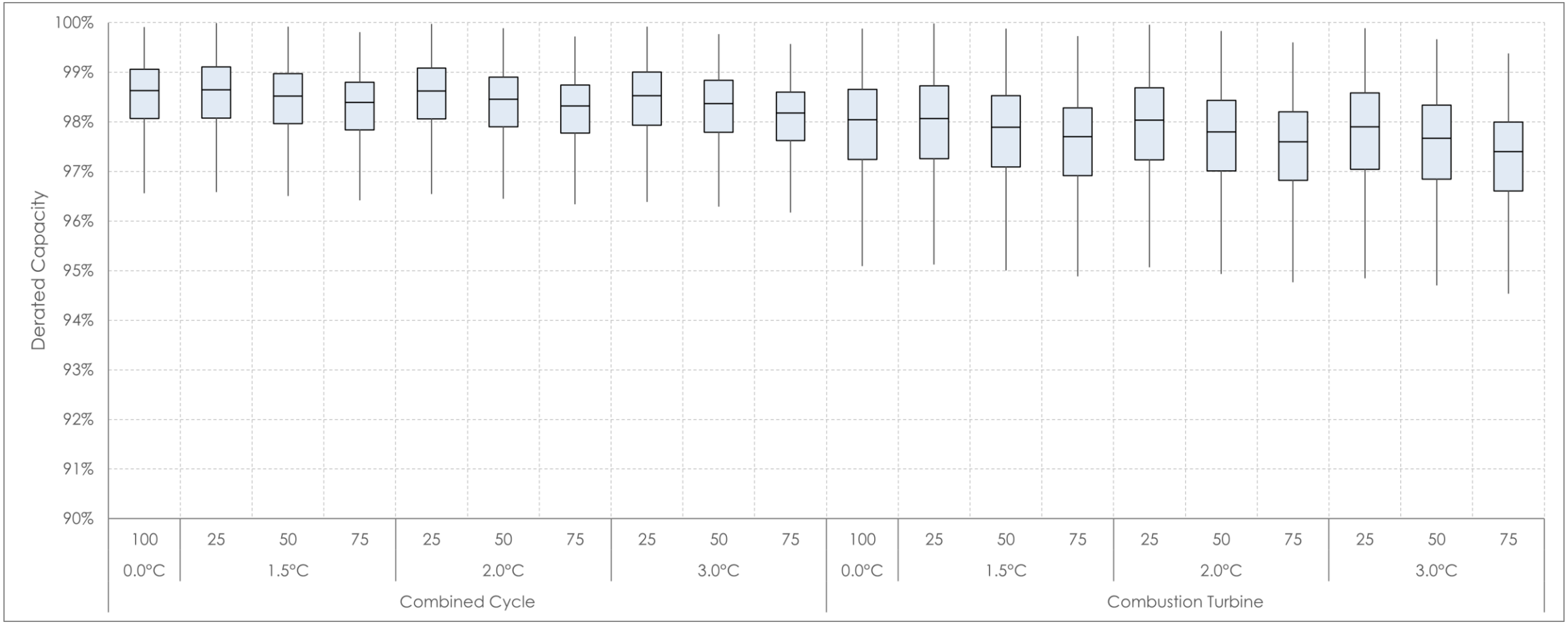
Weather Year 1997, Weather Station KSAC



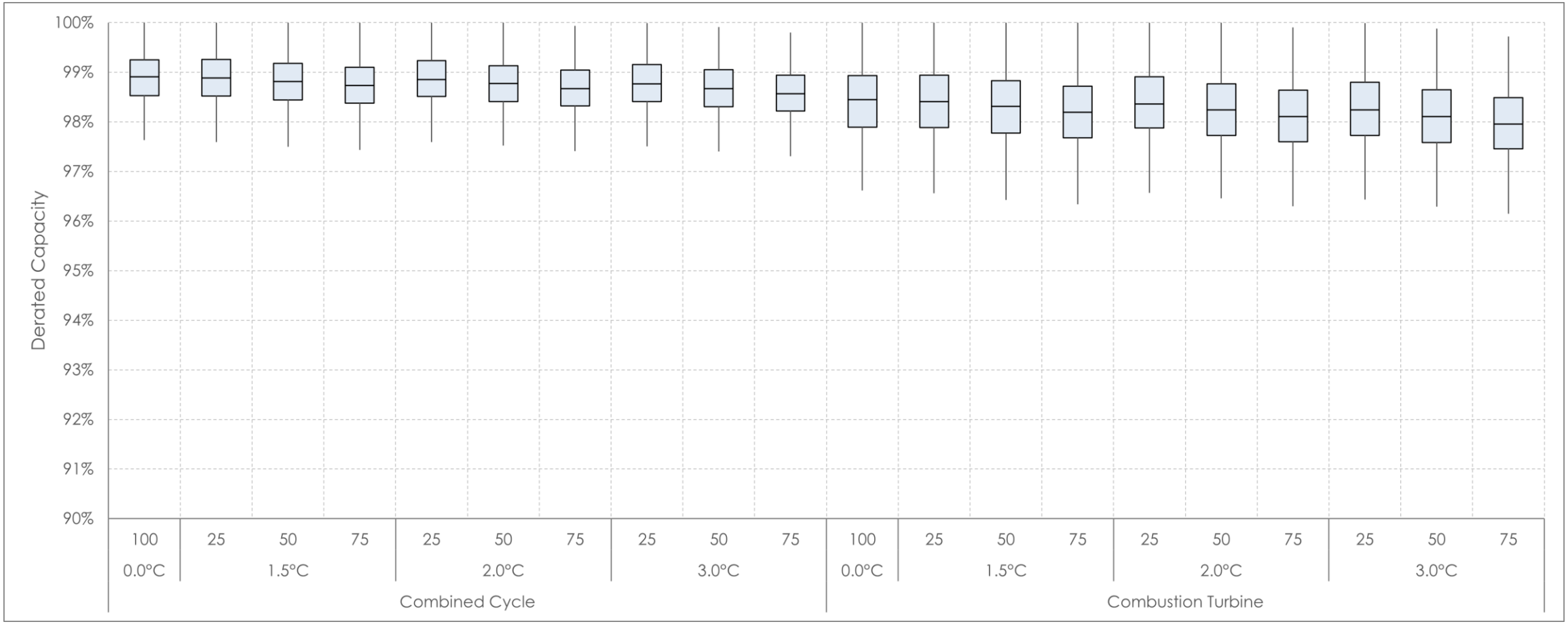
Weather Year 2020, Weather Station KSAC



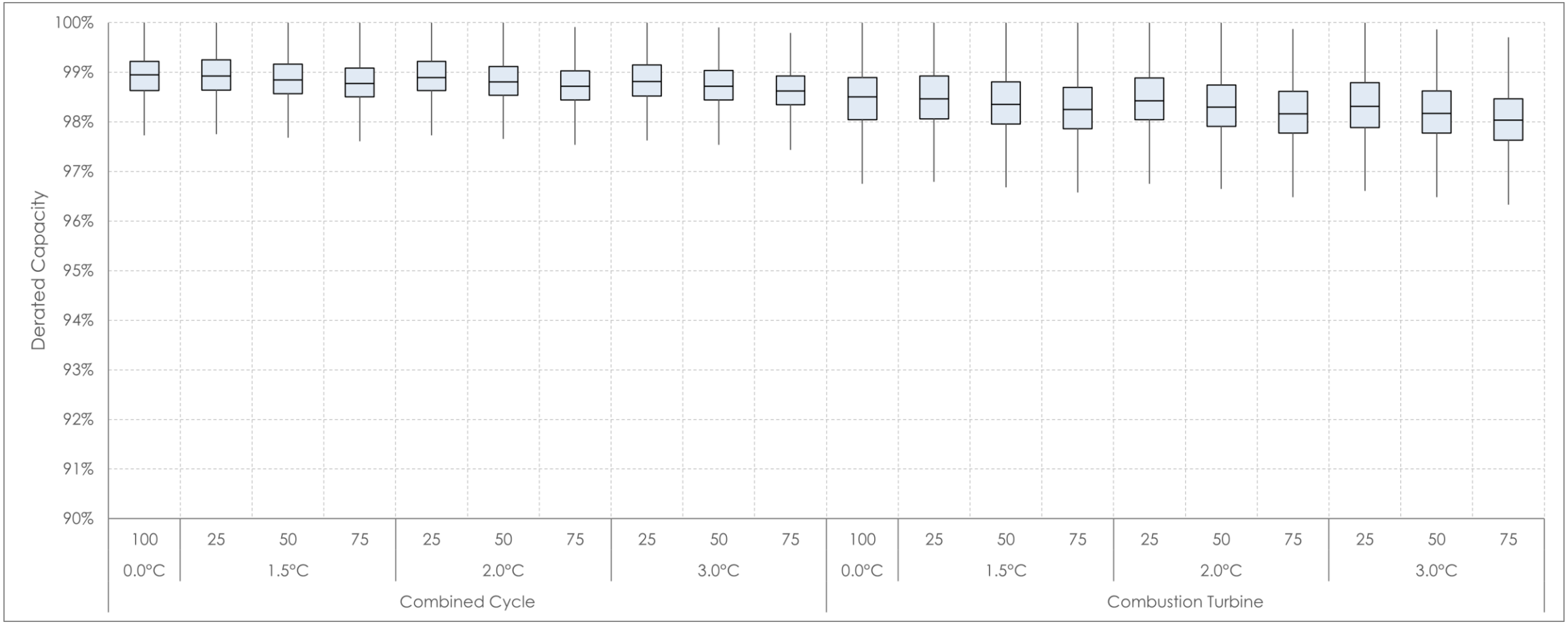
All Weather Years, Weather Station KSAC



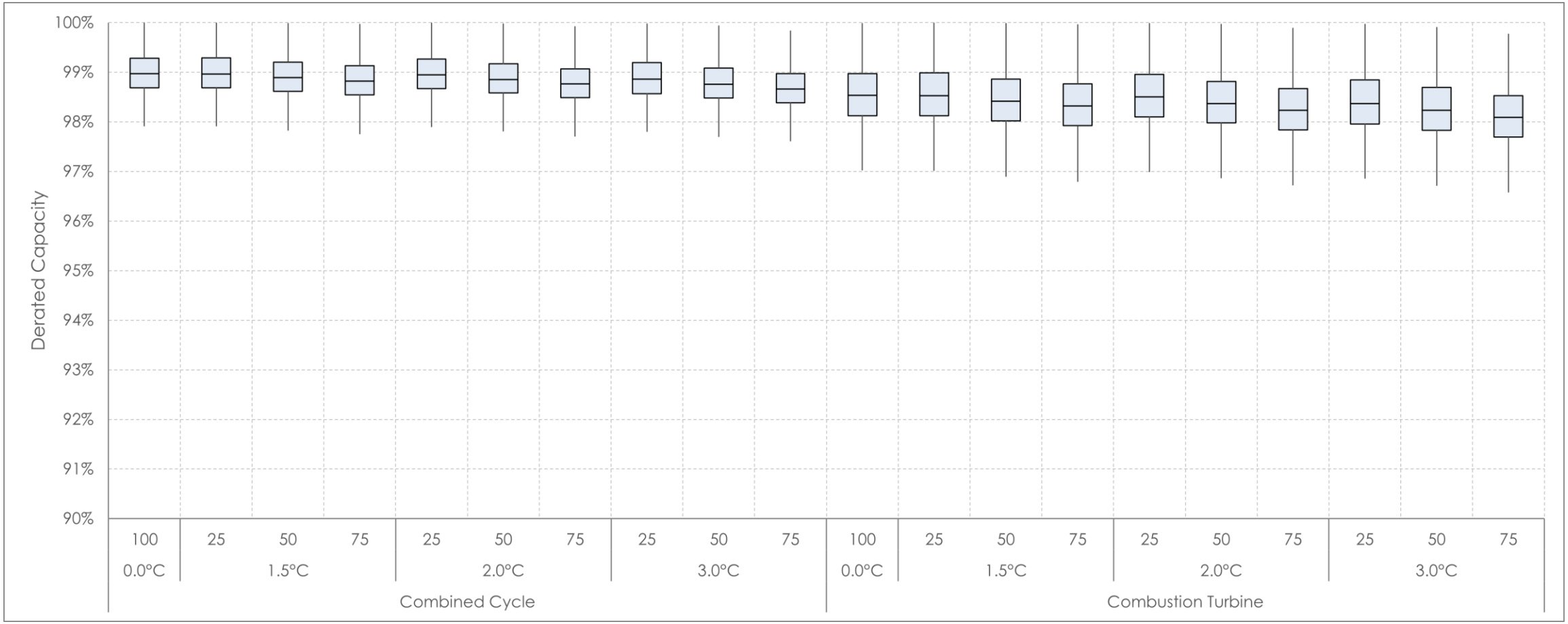
Weather Year 1997, Weather Station KSBA



Weather Year 2020, Weather Station KSBA



All Weather Years, Weather Station KSBA



Results Summary

- New methodology shows reduced derating effects, i.e., resources show more capacity most of the time
  - Original methodology – overall median around 96% capacity, 92% minimum
  - New methodology – overall median around 98% capacity, 94% minimum
- These results focus on weather stations and percent capacities
- SERVM results will show physical resources and MW capacities

Application

Next Steps using the Revised Methodology

Application

- Use results from revised methodology to generate Slice-of-Day values
- Possible Slice-of-Day approaches include:
  - Use X-percentile hour from each month's forecast, or
  - Use each hour from X-percentile day within each month
- Use entire distribution in Loss-of-Load Study
- Incorporate into UCAP framework

For more information:

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Questions?