Loss of Load Expectation, Effective Load Carrying Capability, and Planning Reserve Margin Studies for 2024

Resource Adequacy R.21-10-002

March 3, 2022
Energy Resource Modeling Team
Energy Division

California Public Utilities Commission

TODAY'S AGENDA

1:00 – 1:15 pm Introduction. Workshop Logistics, Overview and Purpose of Workshop

- Donald Brooks, Program and Project Supervisor

1:15 – 1:45 pm Inputs and Methods

- Definitions and Background
- Data Assumptions
- ELCC study steps
- Donald Brooks/Kevin Carden, Astrape Consulting

20 min presentation/ 10 min Q/A

1:45 – 2:15 pm Base Portfolio Level Results and PRM Calculation

- Donald Brooks

20 min presentation / 10 min Q/A

2:15 – 2:30 pm Break

2:30 – 3:00 pm Technology Specific ELCC results and Alternate Portfolios

- ELCC results
- Alternate Portfolios and ELCC values
- PRM and ELCC Conclusions
- Donald Brooks, Kevin Carden

20 min presentation / 10 min Q/A

3:00 - 3:45 pm Questions for Stakeholders

- 10 min presentation / 35 min Discussion

3:45 – 4:00 pm Wrap Up/Next Steps

California Public Utilities Commission

Workshop Logistics

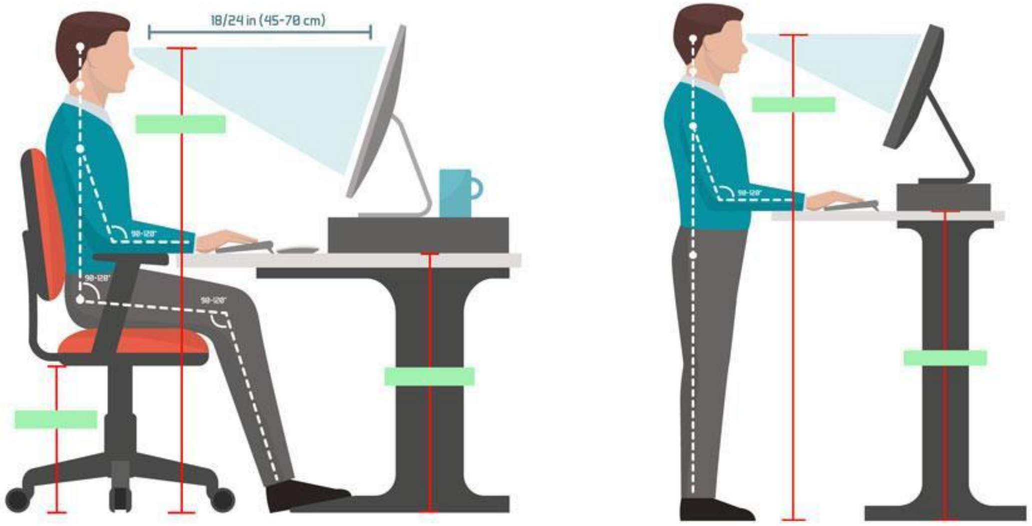
- Online only
- https://cpuc.webex.com/cpuc/j.php?MTID=m155616ed13e063544de83f575656ba3d

Audio through computer or phone

- Toll-free 1-855-282-6330
- Access code: 2490 582 2641
- ***This workshop is being recorded***

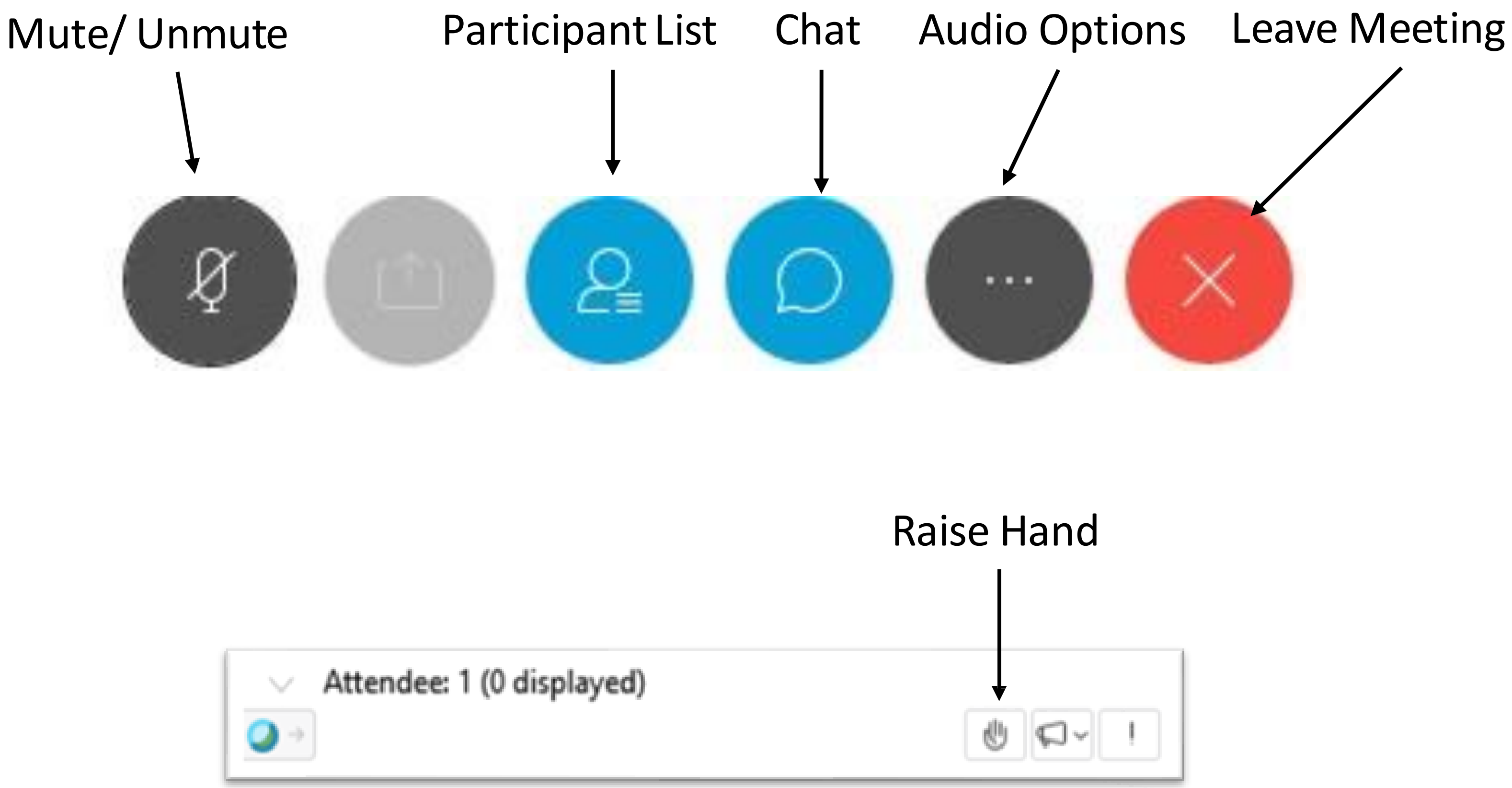
- Hosts:
  - Energy Division Staff:
    - Donald Brooks
    - Patrick Young
    - Jaime Gannon

- Safety
  - Note surroundings and emergency exits
  - Ergonomic Check



Workshop Logistics

- Please submit questions for speakers in the Chat box or raise your hand to be unmuted by staff
- Questions will be read aloud by staff (Reminder: Mute back!)



Discussion Logistics

- Workshop is structured to stimulate an honest dialogue and engage different perspectives
- Keep comments friendly and respectful
- Chat feature is only for Q&A or technical issues. Do not start or respond to sidebar conversations
  - This will be held via WebEx Events, where everyone is muted at the beginning of the webinar.
  - Speakers are asked to state their name and their organization before speaking.
  - To speak during the Q/A times, please send your questions to the moderator via the Chat feature.

Outline

- Overview and Purpose of workshop
- Inputs and methods
- Base Portfolio-level results and PRM calculation
- Technology-specific ELCC results and Alternate Portfolios
- Conclusion and questions for stakeholders

Purpose of Workshop

- Present CPUC staff's assumptions, methods, and results for Loss of Load Expectation (LOLE) studies of 2024 Resource Adequacy (RA) Year to:
  - Calculate monthly Planning Reserve Margins (PRM) consistent with achieving a probabilistic reliability standard of 0.1 LOLE
  - Calculate monthly Effective Load Carrying Capability (ELCC) values for solar, wind, storage, and hybrid technologies across a variety of penetration
- Objective: share results with stakeholders and solicit comments and questions
- Present revised ELCC values and PRM values for debate and comment in the current RA proceeding
- Discuss how the overall LOLE and ELCC framework fits in the RA reform discussions

Inputs and Methods

Input assumption updates

- Started from assumptions used in 2021 Integrated Resource Plan (IRP) Preferred System Plan Proposed Decision (issued December 22, 2021) including:
  - Baseline electric generation resources
  - 2020 IEPR Update Mid-Mid electric demand forecast (with High EV assumption)
  - Include LSE IRP filings planned and in-development resources plus IRP Mid Term Reliability (MTR) Decision procurement
- Wind shapes updated
  - Sourced from higher quality satellite data (MERRA)
  - Improved negative correlation with hot weather
- Hybrids now modeled, some with solar charging restriction or cap on combined capacity as reported from LSE IRP filings

System constraint updates

- Loss-of-load event threshold changed from 4.5% above hourly demand to 6% (i.e., 6% operating reserves requirement)
- 4,000 MW import constraint in HE17-22 imposed on all 12 months (instead of only Jun – Sept as studied in the IRP PRP)
- Storage constraints revised to better reflect market performance
  - Average outage rate 5%
  - Economic discharge cap 90%
  - Price to override reliability-based dispatch set high
- No sharing of operating reserves between intra-CAISO regions

Definitions

- LOLE equals the expected number of loss-of-load days with events, regardless of event length, in a given year. 0.1 LOLE equates to "1 day with an event in 10 years."
- ELCC equals the comparative value of a generator in terms of reducing LOLE compared to Perfect Capacity (PCap) – also termed "effective capacity"
- $ELCC\ \% = \dfrac{PCap\ MW}{Installed\ capacity\ MW\ of\ generator}$
- Average ELCC equals ELCC % of whole portfolio of a technology or multiple technologies across the entire system
- Marginal ELCC equals ELCC % of the next incremental block of a technology added to the system

Resource diversity

- Resource diversity means that a generating fleet is comprised of many technologies in varying amounts and a generator's ELCC is sensitive to this composition – different technologies affect each other's ability to reduce LOLE
- ELCC (in PCap MW) of a portfolio of generators equals the sum of the ELCC MWs of the generators comprising the portfolio – if resource diversity effects properly accounted for and allocated to generators comprising the portfolio

Portfolio PCap MW = Individual Wind PCap MW + Individual Solar PCap MW + Diversity effects

Allocate diversity effects

Portfolio PCap MW = Diversity adjusted Wind PCap MW + Diversity adjusted Solar PCap MW

Modified “Delta Method” for calculating ELCC

- New method to develop technology-specific average ELCCs from within a portfolio of technologies
- For each technology, calculate “first-in” (0% penetration) marginal ELCC and “last-in” (100% penetration) marginal ELCC
- Use marginal ELCCs to calculate portfolio interactive effects and individual technology interactive effects
- Delta Method adjusts for resource diversity by scaling interactive effects proportionally to allocate the total portfolio ELCC to individual technology ELCCs
- For this report, Delta Method was modified to use the ratio of portfolio ELCC to capacity-weighted average technology ELCC to adjust for diversity – driven by staff having limited resources for simulating “last-in” monthly marginal ELCCs

Overall ELCC study steps

1. Calculate portfolio average ELCC
    a. Determine the portfolio of technologies to calculate ELCC
    b. Establish system model calibrated to target LOLE level, by adding/removing generation not part of that portfolio
    c. Remove the portfolio and iteratively add back PCap until LOLE returns to target level

$$Average\ ELCC\%_{Month\ X,\ Total\ Portfolio} = \frac{PCap\ Added_{Month\ X}}{Installed\ Capacity_{Solar,Wind,Storage,Hybrid}}$$

Overall ELCC study steps (Cont'd)

2. Calculate "first-in" marginal ELCC for each technology
    2. Remove whole portfolio from system and recalibrate to target LOLE level with PCap
    3. Add 1,000 MW block of technology to recalibrated system, then iteratively add "perfect load" (negative PCap) until LOLE returns to target level
    4. Marginal ELCC = Perfect Load MW / 1,000 MW
    5. Repeat for each technology group in the portfolio
3. Calculate "last-in" marginal ELCC for each technology
    2. Similar to step 2. but instead start with whole portfolio present in system
4. Apply modified "Delta Method" to calculate technology-specific average ELCCs

Base Portfolio-level results and PRM calculation

PRM calculation

1. Sum effective (ELCC or UCAP capacity) capacity of all units present in system calibrated to target LOLE level
   a. Use current NQC (ICAP) counting for units not part of the ELCC calculation
   b. Use portfolio ELCC to represent effective capacity of units comprising the portfolio
2. Determine level of imports that can be relied on to support reliability
3. Extract median sales peak demand as modeled in SERVM
4. Determine PRM adjustment for planned outages (based on minimum daily MW on outage for each month)
5. $$PRM = \frac{\text{sum of effective capacity of all units not in portfolio} + \text{effective capacity of portfolio} - \text{effective capacity of units on planned outage} + \text{imports}}{\text{median MW sales peak}} - 1$$
6. UCAP PRM is same as step 5. except for all units not in portfolio:

   effective capacity = (installed capacity of unit) x (1 – forced outage rate)

Monthly PRMs and ELCCs

- RA program is monthly – so studies were configured to produce monthly PRMs and monthly ELCCs
- Required targeting a LOLE level in each month individually
- For CAISO system, peak demand generally occurs in June to September period, so LOLE is concentrated in these months and off peak months generally have no LOLE
- To determine monthly PRMs and ELCCs the system needed to be calibrated to surface LOLE in off peak months – meant removing more existing units (that are not in the portfolio to calculate ELCCs) in off peak months

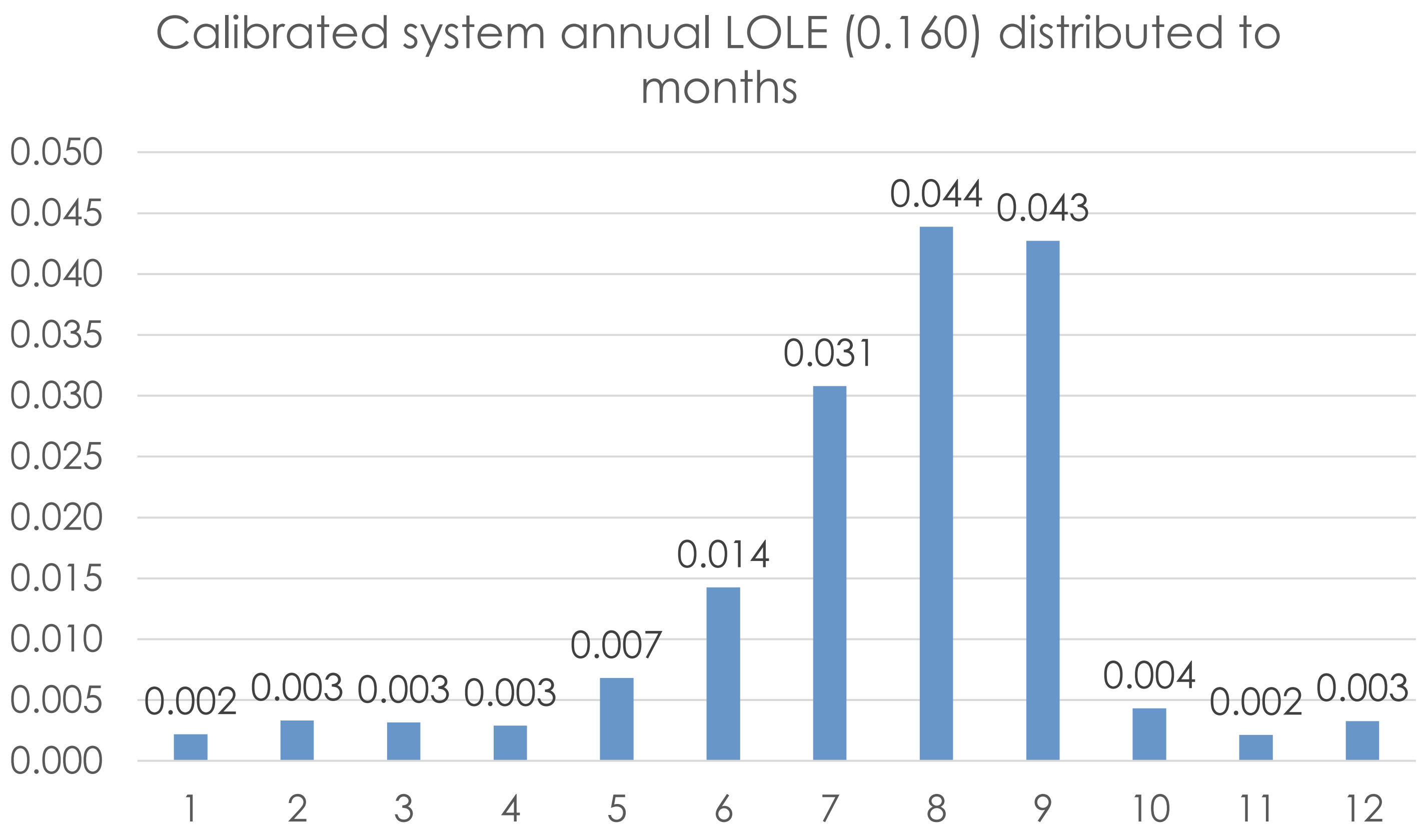
Monthly units removed to calibrate system

Before calibration installed capacity MW		Units removed (negative values) for calibration by month in installed capacity MW											
Unit Category	CAISO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CC	16,135	-4,737	-5,404	-6,836	-9,318	-9,367	-2,986	0	0	-603	-4,029	-5,404	-4,591
Cogen	2,298	-2,298	-2,298	-2,298	-2,298	-2,298	-2,298	-2,298	-2,298	-2,298	-2,298	-2,298	-2,298
CT	8,370	-2,924	-3,039	-3,607	-4,274	-3,413	-2,629	-311	0	-1,295	-2,724	-3,170	-3,050
ICE	255	0	0	0	0	0	-44	0	0	0	-44	0	0
Nuclear	2,935	-1,785	-1,785	-1,785	-1,785	-1,785	-1,785	-1,150	-1,150	-1,150	-1,150	-1,785	-1,785

- Units removed in peak months include Intermountain, the cogeneration fleet, a handful of oldest CTs, and one unit of Diablo Canyon Power Plant

Monthly LOLE of calibrated system

- The CAISO system model was calibrated to a 0.1 LOLE annual target, but to understand monthly reliability sensitivity, we tuned the demand and resource balance to surface LOLE events in each month.
- This tuning resulted in a LOLE of 0.16 LOLE across all 12 months of the year
- 0.13 LOLE concentrated in the peak months of June through September, but we are imposing additional stress or constraints that are not present in reality, so 0.13 is likely to approximate the 0.1 annual LOLE target.



Base Portfolio (in installed capacity MW) to calculate ELCCs for

Portfolio Technology Group	Unit Category	Existing Online	LSE Plans and development resources	Additional capacity selected in RESOLVE	Portfolio Totals
Solar	Solar	12,066	3,762	0	15,829
Wind	Wind	6,971	1,307	0	8,279
Storage	Battery Storage	2,093	3,916	4,077	10,086
	PSH	2,099	0	0	2,099
Hybrid	Hybrid Combined	4,676	2,806	0	7,482
	Hybrid Solar Portion	3,158	2,135	0	5,292
	Hybrid Storage Portion	1,619	953	0	2,571

- BTM PV and BTM battery storage were grouped with all other units in the calibrated system and remote generators (Out-of-state wind and solar) were considered comingled with imports. These groups were not part of the portfolio to calculate ELCCs.

Base Portfolio included large amounts of new construction

- "LSE Plans and development resources" represents projects under development as reported in LSE IRP Plans (filed September 2020) including any portion that can count towards the IRP Mid Term Reliability (MTR) Procurement Decision (D.21-06-035)
- "Additional capacity selected in RESOLVE" represents what the RESOLVE model selected to fill out the remaining MTR procurement need not already counted with "LSE Plans and development resources"
- New construction to meet reliability targets in 2024 includes nearly 9,000 MW installed capacity of new storage (including from hybrid projects)

Base Portfolio monthly ELCC results

Base Portfolio size, effective capacities, and ELCCs from this study

Month	1	2	3	4	5	6	7	8	9	10	11	12
Portfolio Size (installed capacity MW)	Total: 43,774 (Storage: 12,185, Hybrid: 7,482, Solar: 15,828, Wind: 8,279)											
Portfolio Effective Capacity MW	10,396	12,152	11,834	12,597	14,539	16,431	17,926	16,582	15,742	12,613	12,048	10,385
Portfolio ELCC %	23.7%	27.8%	27.0%	28.8%	33.2%	37.5%	41.0%	37.9%	36.0%	28.8%	27.5%	23.7%

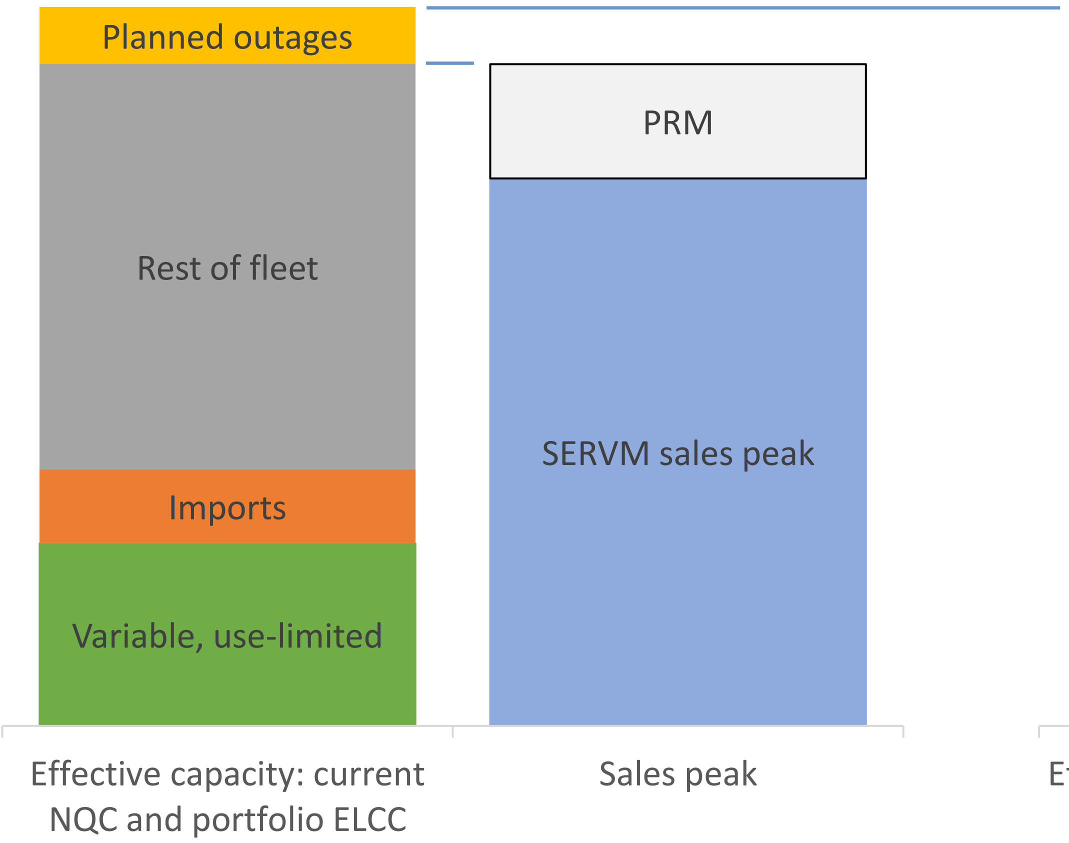
Compared to February 2019 Energy Division study portfolio size, effective capacities, and ELCCs

Month	1	2	3	4	5	6	7	8	9	10	11	12
Portfolio Size (installed capacity MW)	Total: 25,495 (Storage: 1,187, Solar: 13,785, Wind: 10,522)											
Portfolio Effective Capacity MW	3,257	2,839	6,684	6,000	6,128	8,936	8,794	7,200	4,600	2,300	2,700	2,600
Portfolio ELCC %	12.8%	11.1%	26.2%	23.5%	24.0%	35.1%	34.5%	28.2%	18.0%	9.0%	10.6%	10.2%

February 2019 studies included ~2.2 GW remote wind and did not include ~2 GW PSH

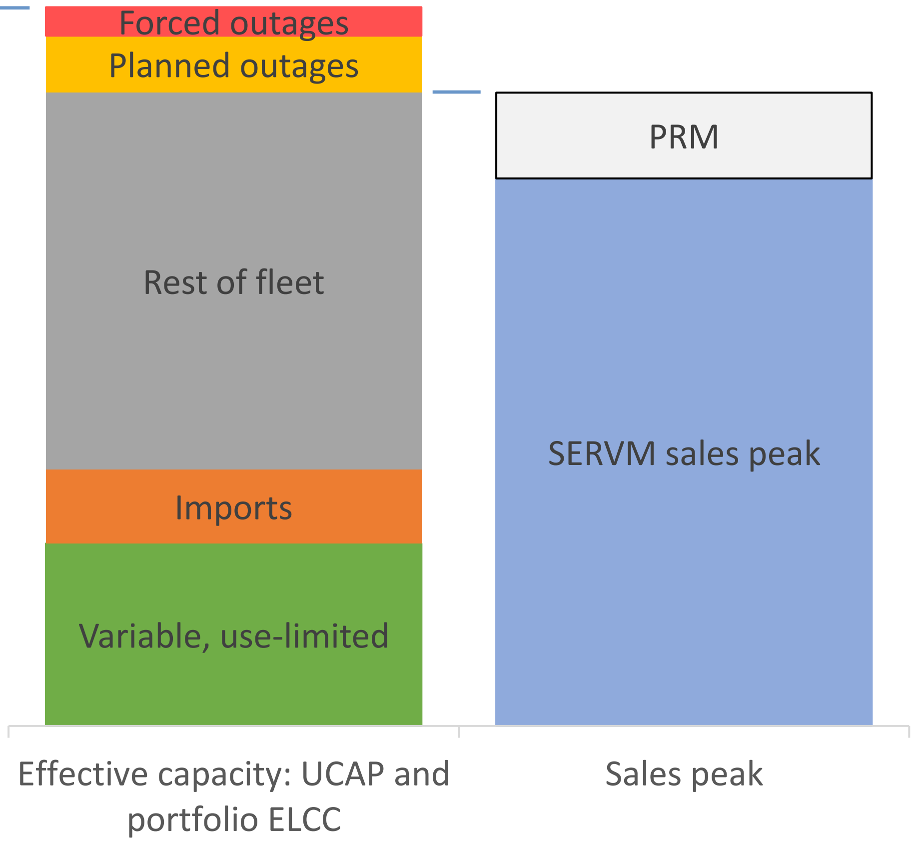
Base Portfolio PRM calculation

Method 1: Counting effective capacity requirement with current NQC and new portfolio ELCC



Planned outages on monthly peak deducted from effective capacity requirement since they don't contribute to reliability

Method 2: Counting effective capacity requirement with UCAP and new portfolio ELCC

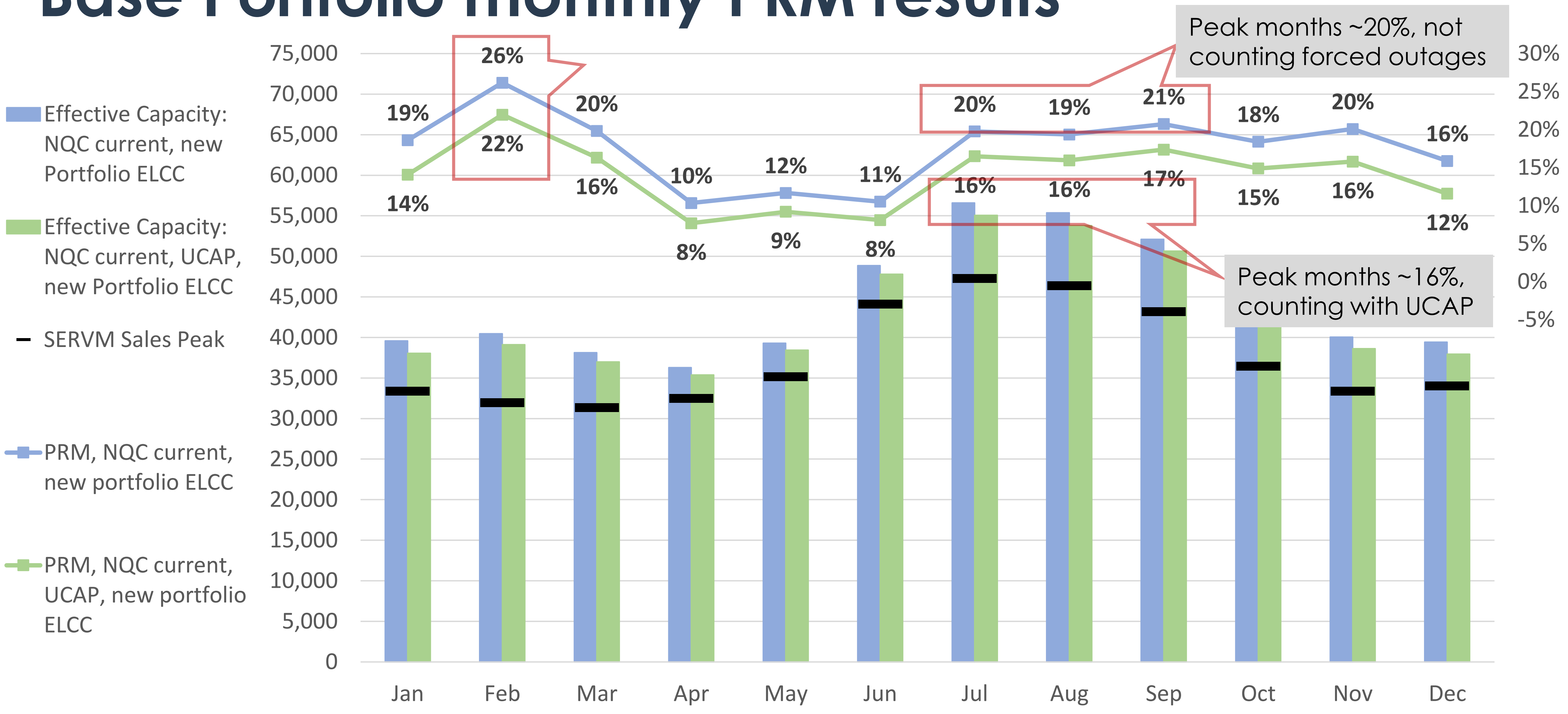


Units with forced outages (EFORd) attribute have their effective capacity derated under UCAP counting, reducing the total effective capacity requirement and thus, PRM

Implications from using SERVM monthly peaks

- SERVM demand forecast inputs are determined by the 2020 IEPR annual peak and energy forecast, however SERVM's 20 weather year monthly distribution of demand differs from the IEPR's annual forecast allocation to months
  - To remain internally consistent, staff used the median monthly peaks from SERVM to determine PRMs since that was the monthly peak distribution determining the effective capacity requirement modeled in SERVM
- SERVM median annual peak is higher than any of the median monthly peaks – weather variability causes peaks to occur across the summer, not in the same month
  - To conform to annual constructs used in both IRP and IEPR, staff "annualized" the median monthly peaks in SERVM by scaling the median monthly peaks by the ratio of the median annual peak to the highest median monthly peak. This ensures the median annual peak matches the highest median monthly peak.

Base Portfolio monthly PRM results



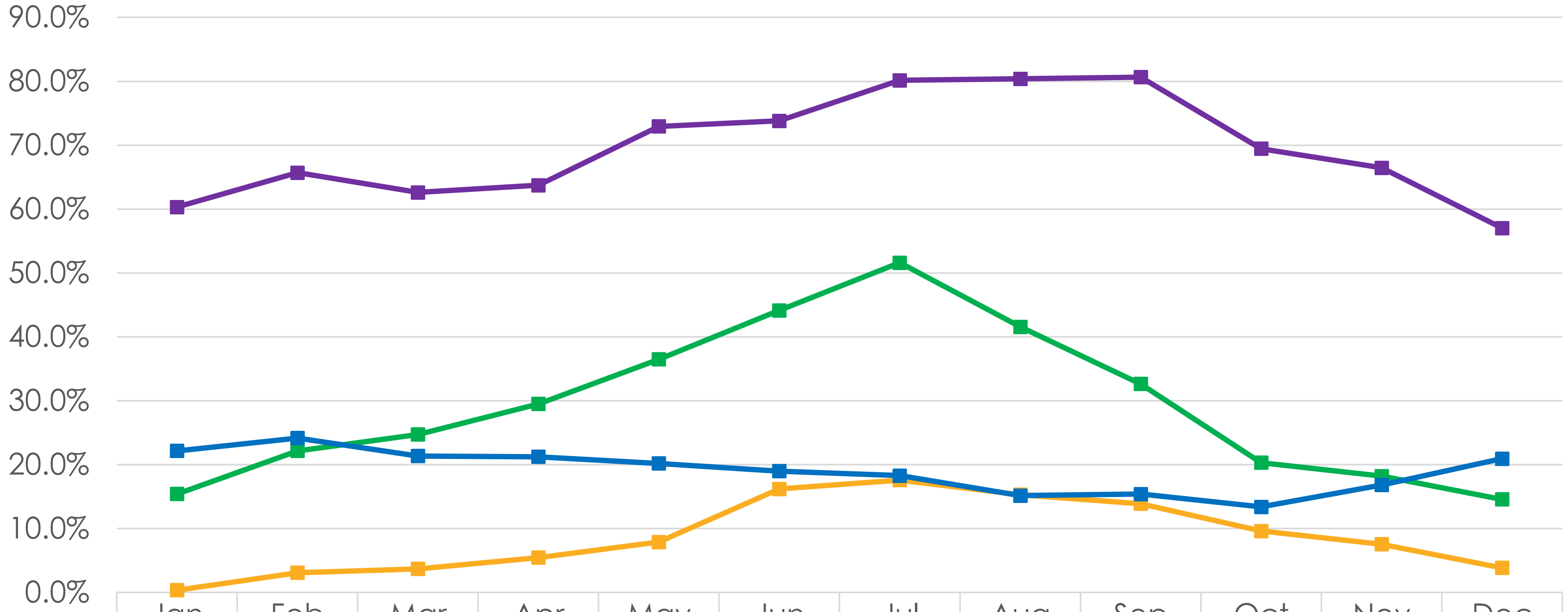
Higher PRM in February driven by 1) difference in optimal annual maintenance scheduling and optimal monthly maintenance scheduling and 2) high EUE during import constrained hours leading to more need for internal generation. We are confident that 20% PRM will suffice in real market operations

Technology-specific ELCC results and Alternate Portfolios

Base Portfolio monthly effective capacity results

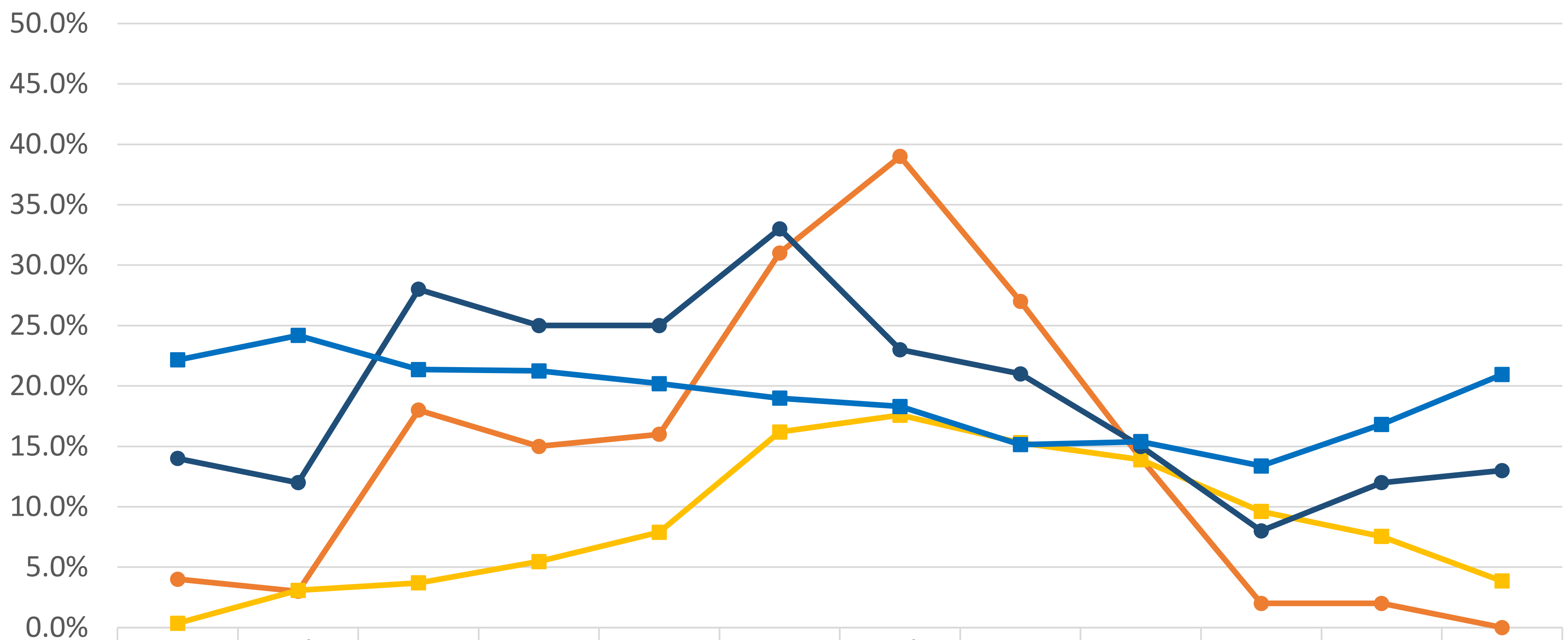
Installed Capacity Total	12,185	15,828	7,482	8,279	43,774
	Individual Technology Effective Capacity				Portfolio Effective Capacity
	Storage	Solar	Hybrid	Wind	
January	7,351	58	1,153	1,834	10,396
February	8,004	488	1,658	2,002	12,152
March	7,629	586	1,851	1,768	11,834
April	7,765	865	2,208	1,759	12,597
May	8,887	1,249	2,731	1,672	14,539
June	8,994	2,563	3,302	1,572	16,431
July	9,766	2,783	3,862	1,515	17,926
August	9,795	2,422	3,111	1,254	16,582
September	9,827	2,199	2,442	1,274	15,742
October	8,464	1,522	1,519	1,108	12,613
November	8,099	1,194	1,362	1,392	12,048
December	6,950	611	1,090	1,734	10,385

Base Portfolio monthly ELCC% results



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Storage	60.3%	65.7%	62.6%	63.7%	72.9%	73.8%	80.2%	80.4%	80.6%	69.5%	66.5%	57.0%
Solar	0.4%	3.1%	3.7%	5.5%	7.9%	16.2%	17.6%	15.3%	13.9%	9.6%	7.5%	3.9%
Hybrid	15.4%	22.2%	24.7%	29.5%	36.5%	44.1%	51.6%	41.6%	32.6%	20.3%	18.2%	14.6%
Wind	22.2%	24.2%	21.4%	21.2%	20.2%	19.0%	18.3%	15.1%	15.4%	13.4%	16.8%	20.9%

Base Portfolio monthly ELCC% results compared to current



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Current Solar	4.0%	3.0%	18.0%	15.0%	16.0%	31.0%	39.0%	27.0%	14.0%	2.0%	2.0%	0.0%
New Base Solar	0.4%	3.1%	3.7%	5.5%	7.9%	16.2%	17.6%	15.3%	13.9%	9.6%	7.5%	3.9%
Current Wind	14.0%	12.0%	28.0%	25.0%	25.0%	33.0%	23.0%	21.0%	15.0%	8.0%	12.0%	13.0%
New Base Wind	22.2%	24.2%	21.4%	21.2%	20.2%	19.0%	18.3%	15.1%	15.4%	13.4%	16.8%	20.9%

Recall current solar and wind ELCCs were determined in the February 2019 Energy Division studies with a different, smaller portfolio

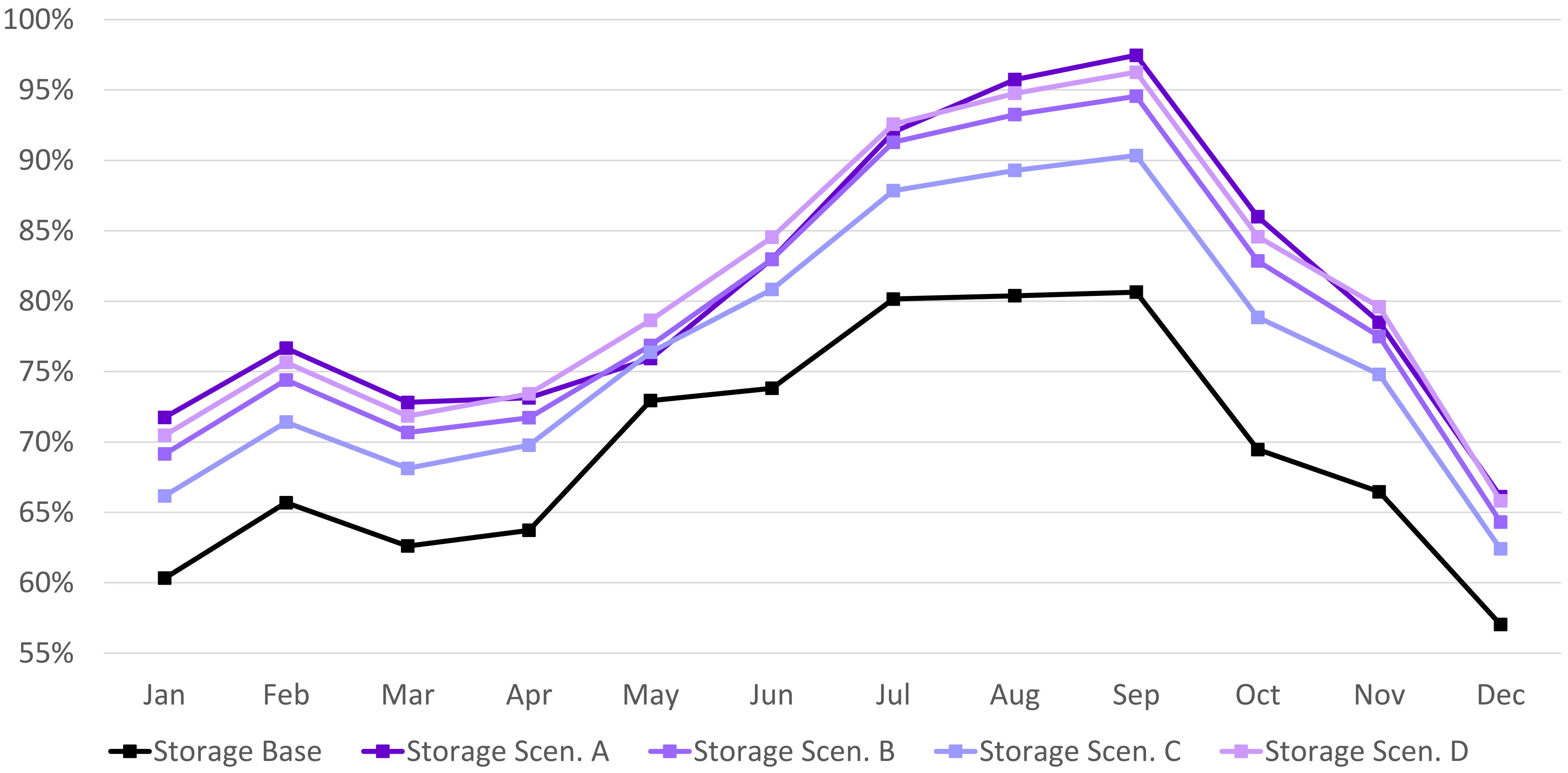
Alternative portfolios (installed capacity MW)

	Assumption #	1	2	3	4	5
Portfolio Technology Group	Unit Category	Existing	50% of LSE IRP Plans in-development resources	100% of LSE IRP Plans in-development resources	Additional Capacity selected in RESOLVE	Potential 2023 Portfolio
Solar	Solar	12,066	1,881	3,762	0	14,805
Wind	Wind	6,971	654	1,307	0	7,946
Storage	Battery Storage	2,093	1,958	3,916	4,077	4,161
	PSH	2,099	0	0	0	2,099
Hybrid	Hybrid Combined	4,676	1,403	2,806	0	6,687
	Hybrid Solar Portion	3,158	1,068	2,135	0	4,540
	Hybrid Storage Portion	1,619	477	953	0	2,108
	Total	27,905	5,896	11,791	4,077	35,698

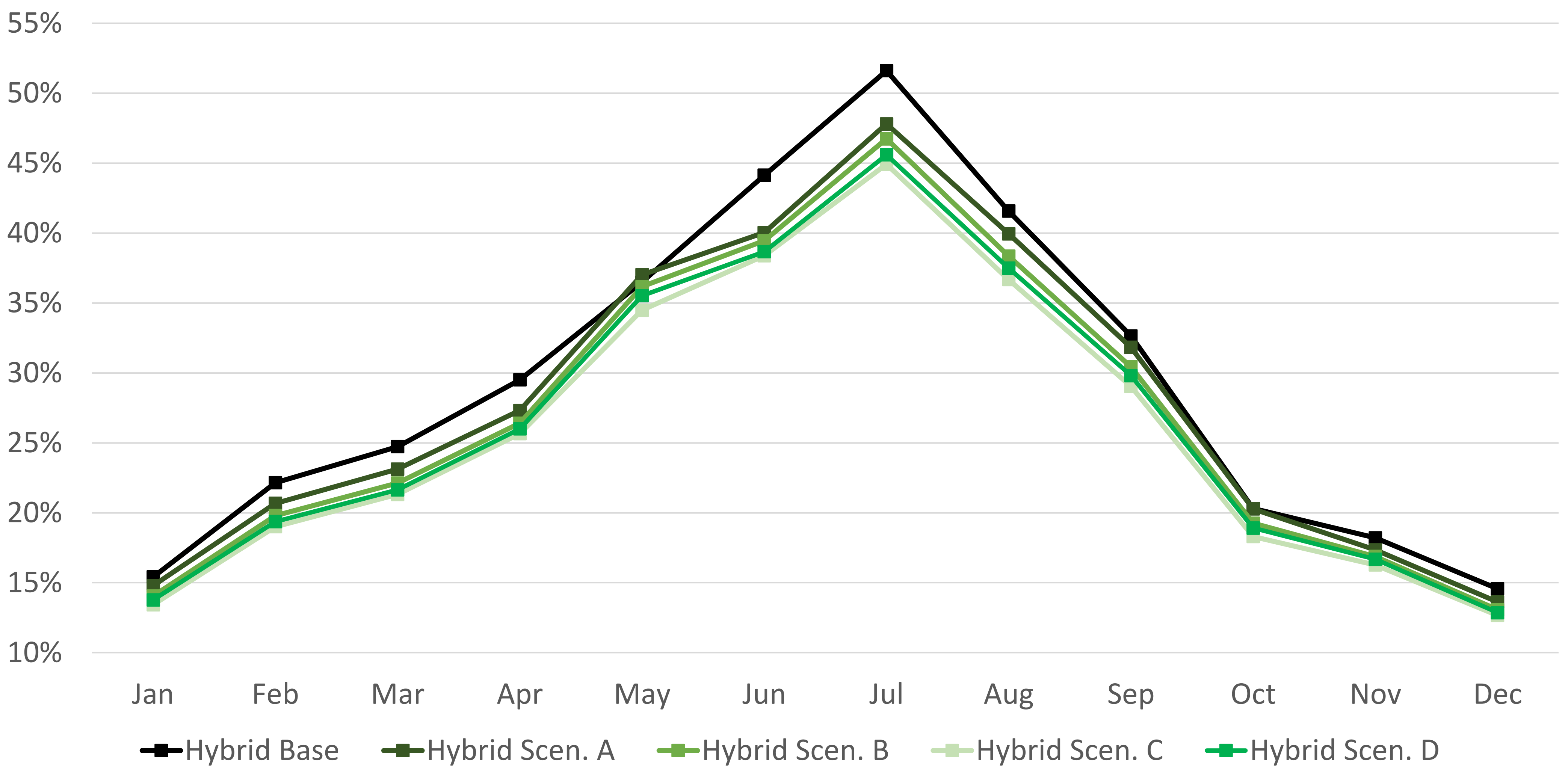
- Given large amounts of new construction included in Base Portfolio and significantly higher resource penetrations and corresponding interactive effects, staff estimated ELCCs for several smaller, alternative portfolios to understand the trajectory of ELCCs from current values to new values reflecting the high penetrations of variable and use-limited resources expected for 2023 and beyond.

Scenarios	Assumption #'s	Portfolio MW
Base	1+3+4	43,773
Scenario A	1	27,905
Scenario B	1+2	33,801
Scenario C	1+3	39,696
Scenario D	5	35,698

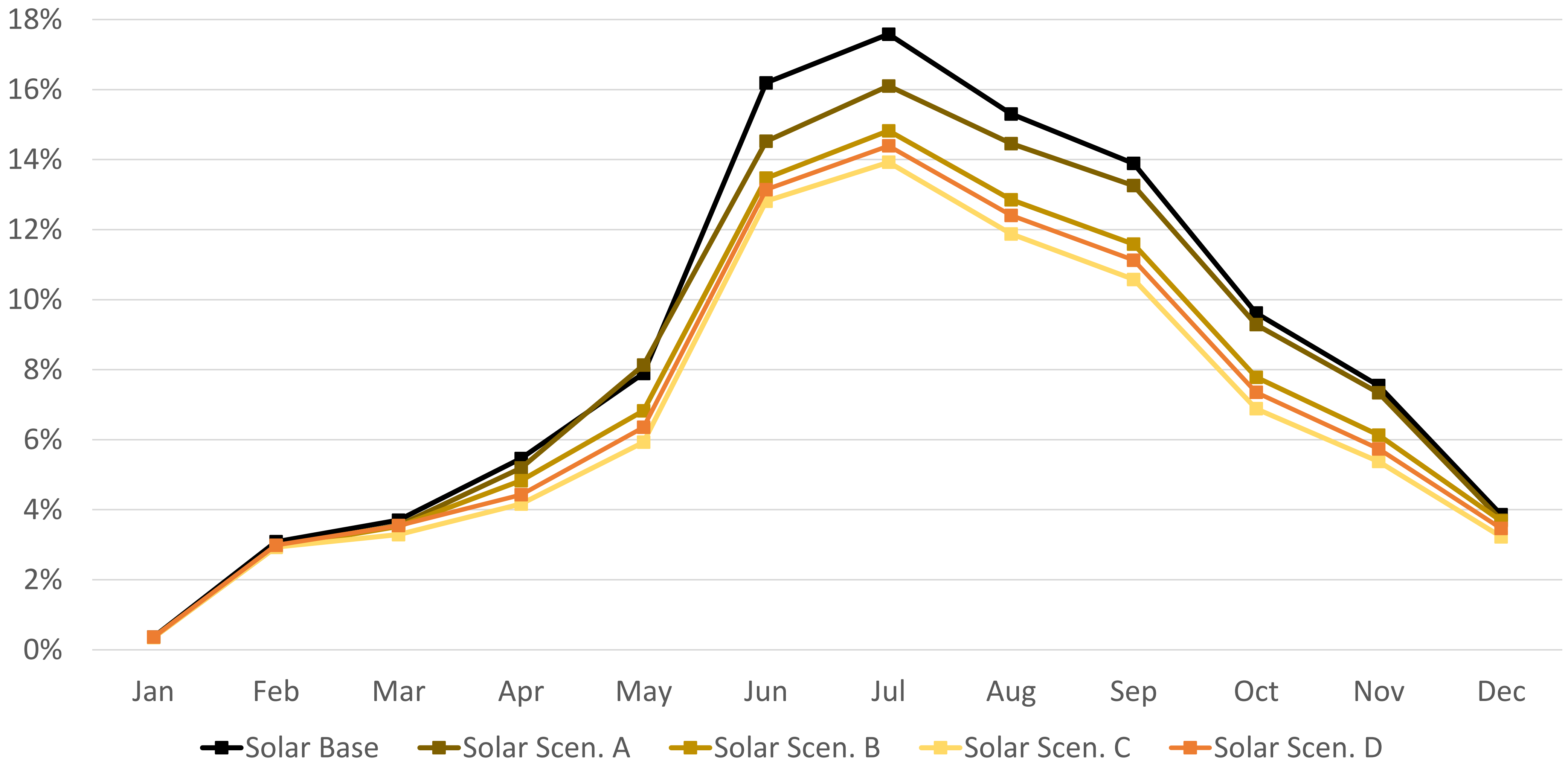
Storage ELCC% across Scenarios



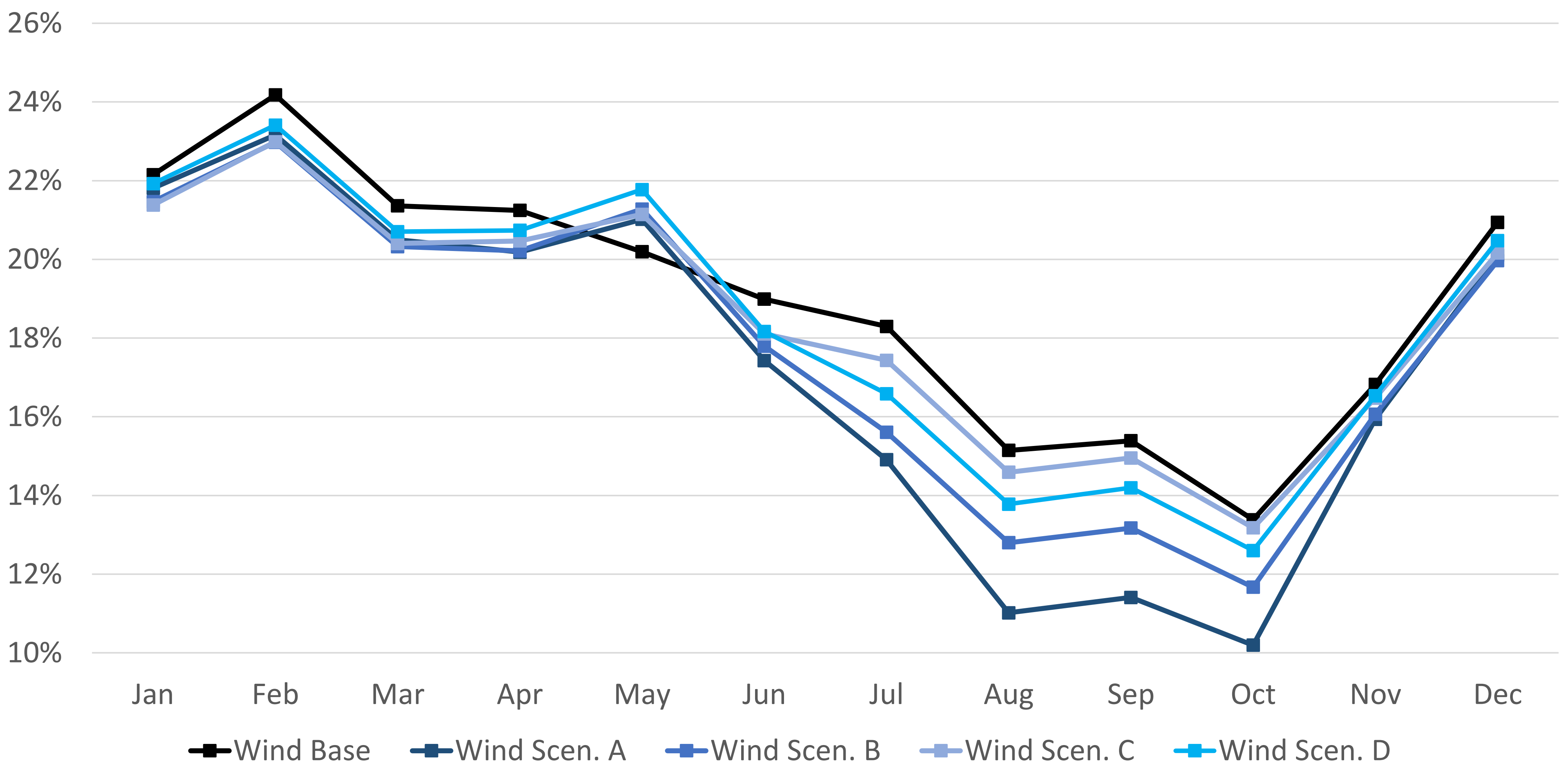
Hybrid ELCC% across Scenarios



Solar ELCC% across Scenarios



Wind ELCC% across Scenarios



Conclusion

- Using current NQC counting (without forced outages) and the new ELCCs from this study, a PRM requirement of 20-21% can be applied to all months and be consistent with achieving a 0.1 LOLE reliability level
- Using UCAP counting and the new ELCCs, the PRM requirement can be 16-17% across all months
- Significantly larger and different mix of variable and use-limited in this study yield different ELCCs by technology than 2019 ELCC results
    - Large amounts of new storage and modeling of storage constraints reduce ELCC
    - Interactive and saturation effects across all technologies
- Alternative smaller portfolios show sensitivity of technology-specific ELCCs to portfolio size and mix

Questions for stakeholders

Questions for Discussion (1 of 2)

1. Which portfolio scenario (Base, A, B, C or D) best represents the likely portfolio in 2024? Which set of technology ELCC values should be assumed in selecting the short term average ELCC values?
2. What, if any changes should be made to the assumptions used to perform the LOLE study?
3. Is a LOLE study appropriate to calculate RA obligations for: 1.) a peak RA capacity framework, 2.) a slice of day reliability construct?
4. How should planned outages be treated in calculating an RA PRM using a LOLE study?
5. Would removing deliverability restrictions in the NQC calculation be an accurate translation of the way that resources provide reliability value to CAISO in most instances, outside of particularly constrained times? Would it be possible that certain resources would avoid making transmission upgrades because they have less of an incentive? Do parties have any other arguments pro or con about deliverability restrictions in the QC calculation?
6. How often should staff perform LOLE studies for RA obligations and ELCC values? Are there problems with performing RA studies and ELCC studies together simultaneously as is done in this proposal?

Questions for Discussion (2 of 2)

7. Do parties have comments on the revised ELCC methodology which assign diversity benefits via a series of marginal ELCC studies at different portfolio penetration points? Or do parties prefer the older method of calculating a capacity weighted average method of assigning diversity benefit?
8. Should storage and hybrid resources be valued using an ELCC methodology? Should we include the 5% forced outage rate and discharging target inputs in storage modeling like we did in IRP?
9. Should the PRM be static across the year or vary monthly (or seasonally)? How should PRM and ELCC values be allocated across months? Via month specific studies or via some allocation method (from annual studies)?
10. Should forced outage rates on thermal resources be included in setting their QC value? In other words, should the PRM be set using a UCAP or ICAP framework? If an UCAP framework is used should the forced outage rates also include ambient derates?
11. Should the load forecast used to set RA requirements be based on the monthly load forecast produced by SERVM or the IEPR (as done today)? Should the PRM calculation be based on the IEPR monthly forecast as opposed to the SERVM monthly load forecast? Why or why not?