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Midterm Reliability Modeling

September 23, 2021

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Workshop Purpose

Provide additional information on the Midterm Reliability Analysis modeling and provide stakeholders the opportunity to ask questions on the method and results.

Note: The discussion today and any comments submitted **will not** impact or inform the Mid-Term Reliability Analysis Report on the agenda for the September 30, 2021 Business Meeting. Comments and inputs will be considered for future improvements to the CEC's modeling work.

Agenda

- Purpose
- Assumptions
- Scenarios
- Results
- Takeaways

We will pause for questions after each section.

Purpose

Primary: Determine if additional capacity beyond current procurement orders needed to meet the standard LOLE of 1 day with unserved energy every 10 years, or 0.1days/year?

Secondary: Does new gas capacity improve reliability compared to a portfolio of new preferred resources with equivalent NQC values?

Additional: What are the potential reliability impacts of supply chain delays for energy storage.

This Study

Is Designed to:

- Provide more insight into reliability from the RA program than a deterministic supply stack.
- Incorporate some chronological impacts on system operation (energy storage).
- Focus on May – October.

Is not Designed to:

- Evaluate capital cost of operational costs.
- Model actual dispatch of the system.
- Analyze actual system reliability from all available power plants.
- Consider energy demands outside of the CAISO.
- Incorporate RPS, GHG, or other policy and environmental impacts or limits on system operations.
- Study November – April.
- Incorporate recently observed extreme weather events.
- Qualitative concerns related to resource deployment.

Important Note

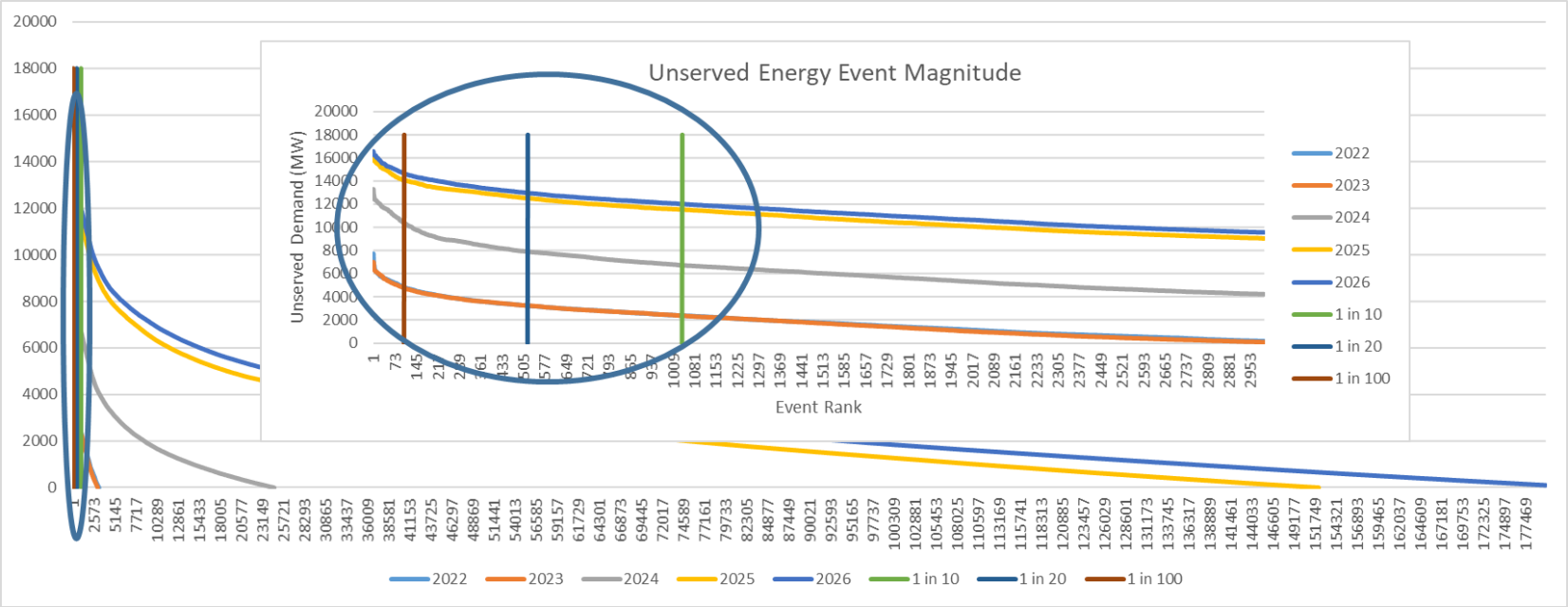
All models are at best an approximation of the system they represent, not exact replicas.

The model used in this analysis is intentionally selecting simplified assumptions to increase the number of samples evaluated of an increased number of scenarios, in a short time period. Thus, outputs of the model are dependent on the inputs and assumptions used in the model.

Results of this study should be viewed as information that can help determine appropriate courses of action, and not a prediction of the future.

A Note on the Presentation Of Results

Unserved Energy Event Duration Curves

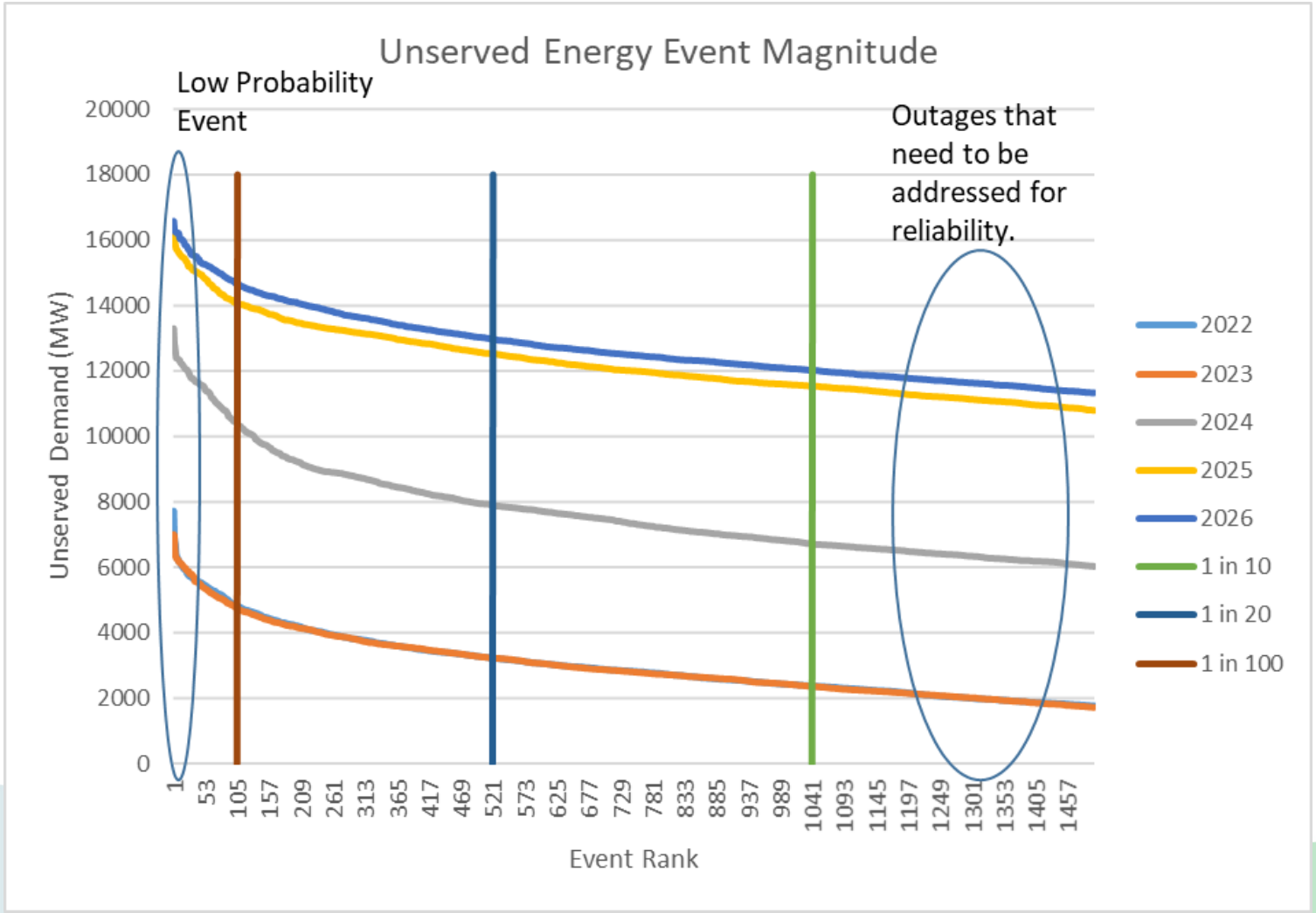


- Each unserved energy event is ranked from greatest to least
- Graphics focus in on rankings up to the 1 in 10 shortfall capacity

- For 10,400 samples (years modeled) 1 shortfall event in:
  - 10 years is the 1,041st highest event
  - 20 years is the 521st highest event
  - 100 years is the 105th highest event

Continuing with the Curves

- Events to the right of the 1 in 10 vertical line must be addressed to meet reliability accounting
- Events near rank 1 are low probability events



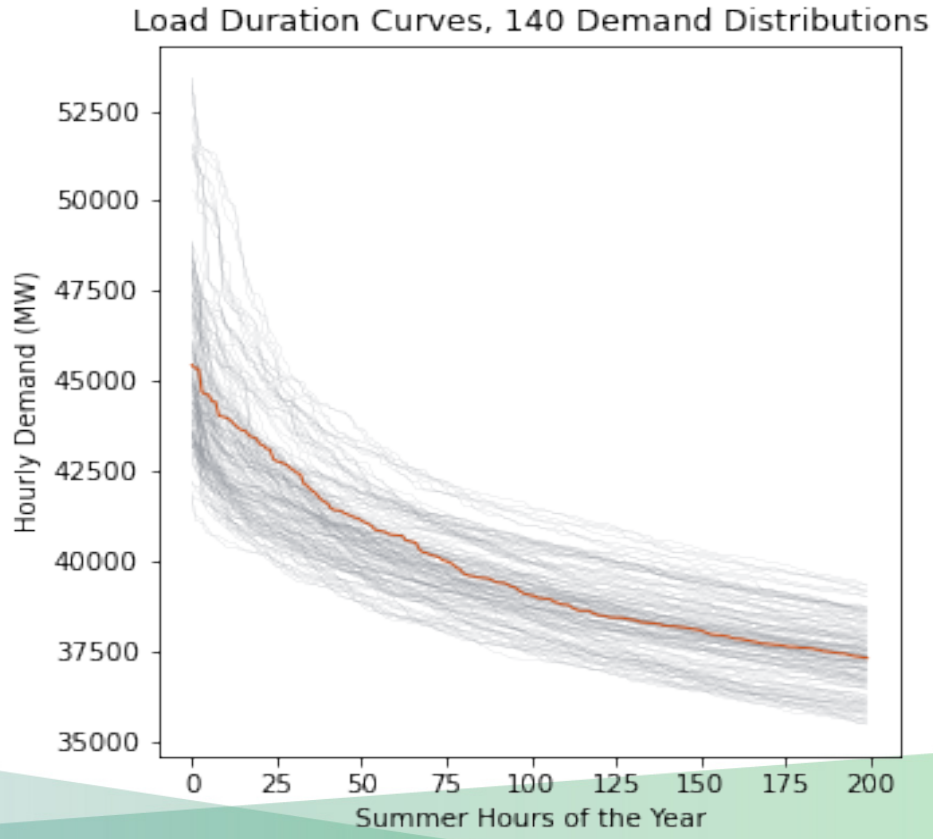
Inputs and Assumptions

General Inputs

- **Demand:** 140 demand distributions, built using assumptions for the 2020 CED. 7 profiles for 20 weather years (2000-2019).
- **Wind and Solar:** CAISO data from 2014-2020, 1 wind and 1 solar profile per year. Modeled as full capacity, with the profiles, not ELCC or NQC values.
- **Hydro:** Modeled as an the applicable NQC value, a hydro budget was determined to have little impact on the model with the given assumptions.
- **Demand Response:** Energy limited to 4 hours budget per day, and 80 hours budget per year.
- **ELCC and Technology Factors:** Made use of the marginal ELCC values and technology factors from the CPUC's Reliability Needs Assessment.

Demand

- 140 demand distributions, built using assumptions for the 2020 CED.
  - 20 weather years (2000-2019)
  - 7 different start day of the week
  - All load modifiers are held constant, but aligned with the day of the week as appropriate
- The distribution of annual peaks centered within half a percent of the adopted CEC 2020 peaks
- Demand profiles were not weather year correlated to other variables.



Wind and Solar

- 7 wind and 7 solar profiles were used
  - CAISO data from 2014-2020, 1 wind and 1 solar profile per year
- Individual plant profiles were added together and normalized to the monthly available capacity for those resources.
- Wind and solar profiles were not weather correlated
- Since this is historic data, outages and curtailment are included in the profiles.

Wind and Solar

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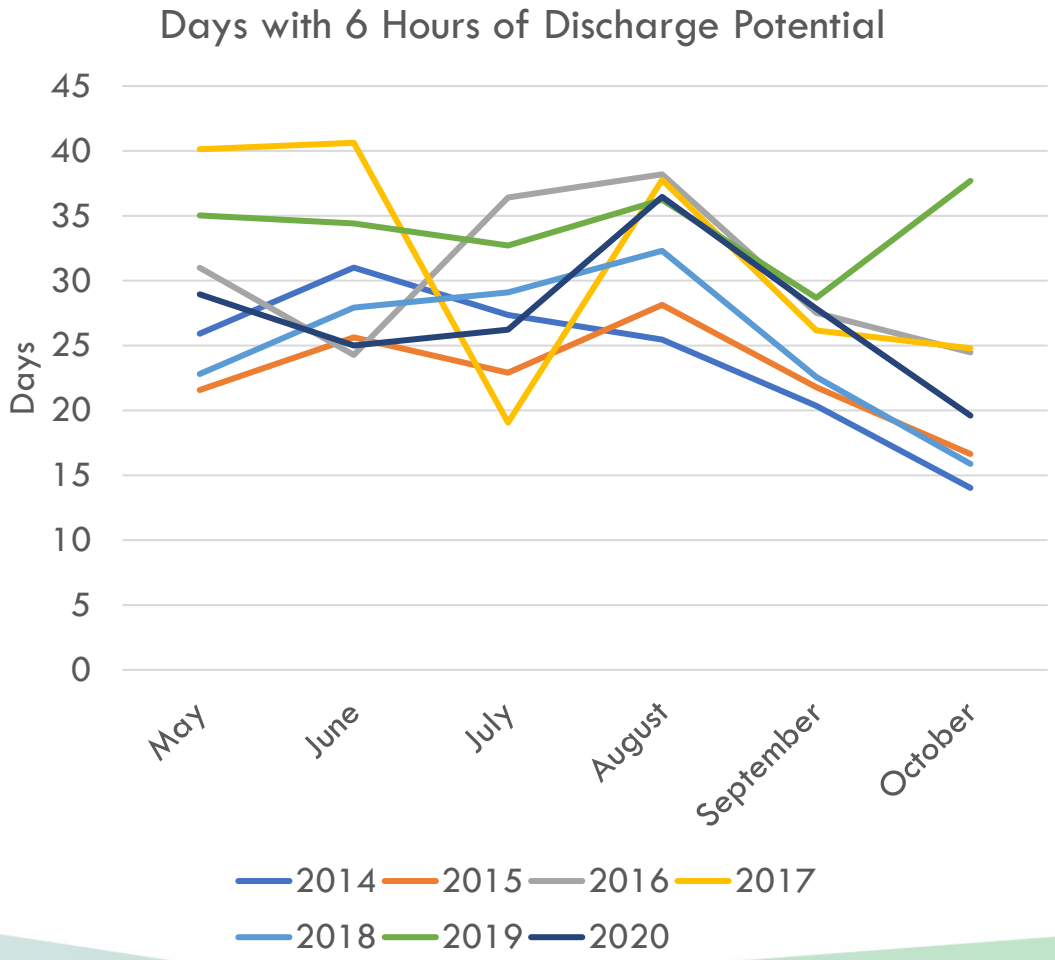
Hydroelectric Plants

- Modeled as able to fully deliver at the NQC value during all hours of the day.
- Adding a monthly hydro budget had little impact on results.
- With a monthly hydro budget 6 hours of full NQC capacity is available most days. See the figure.
- Limiting hydro output to the maximum observed values would impact results and would represent a substantial change from the NQC values in the Reliability Needs Assessment from the CPUC.



Hydroelectric Min Gen Scenarios

- In select scenarios hydro output outside of HE 17-22 were restricted to the median observed minimum generation value for each month from 2014-2020.

Month	Monthly NQC Value (MW)	Min Gen (MW)	Percent of NQC
May	4,520	2,007	44.4%
June	4,649	1,654	35.6%
July	5,101	1,745	34.2%
August	4,649	1,205	25.9%
September	4,714	1,166	24.7%
October	4,391	844	19.2%

Demand Response

- Base Assumption: 2,195 MW
- Dispatch is energy limited
  - 4 hours max generation per day
  - 80 hours max generation per year.
- DR is modeled on the supply side.
  - Total DR capacity is scaled up by 6% to account for the reduction in reserves.

Demand Response and the Reserves

(MW)	**Supply Side DR**	**Demand Side DR**	**Notes**
DR Capacity	100	100	
Demand	1,000	1,000	
Scaled up DR	106	N/A	DR Capacity x 1.06
Reserves	60	N/A	Demand x 0.06
Demand Plus Reserves	1,060	N/A	Demand x 1.06
Total Capacity Need	954	N/A	(Demand x 1.06) - (DR x 1.06)
Demand Less DR	N/A	900	Demand - DR
Reserves	N/A	54	(Demand - DR) x 1.06
Total Capacity Need	N/A	954	(Demand - DR) x 1.06
Total Reserves Carried	60	54	
Total Demand, Less DR	894	900	
Total Capacity Need	954	954	

Note: For loads above 17,000 MW in 2022 (increasing to 34,000 MW in 2026), gas or hydro capacity must be used to meet reserves. Shifting gas or hydro capacity from serving reserves to producing energy does not impact reliability in the model.

Imports

- Import Assumptions align with the CPUC's Reliability Needs Assessment used to inform the 11,500 MW of NQC procurement for Hours Ending 17-23 PST.

	2022	2023	2024	2025	2026
Imports - Unspecified	5,000	5,000	4,000	4,000	4,000
Imports - Specified	1,981	1,981	1,981	1,592	1,600

- Unless noted for a scenario, imports for all other hours are capped at the maximum import capacity of 10,800 MW.
- For select scenarios imports were restricted to the specified and unspecified limits in all hours

Primary ELCC Values

The primary ELCC values used in this study are duplicated below. The CPUC is in the process of adopting NQC values for D.21-06-035, so these are rough estimates.

Technology	Tranche	2022	2023	2024	2025	2026	Min Capacity (MW)	Max Capacity (MW)
Wind		28.5%	28.5%	28.6%	28.6%	28.6%	N/A	N/A
Solar		2.3%	2.3%	1.9%	1.9%	1.9%	N/A	N/A
4 h Battery	1	100.0%	100.0%	100.0%	100.0%	100.0%	-	5,265
4 h Battery	2	88.8%	89.1%	89.5%	89.8%	90.1%	5,265	7,674
4 h Battery	3	76.2%	76.7%	77.1%	77.6%	78.0%	7,674	10,530
4 h Battery	4	66.4%	67.1%	67.8%	68.5%	69.3%	10,530	13,034
4 h Battery	5	54.2%	55.6%	57.0%	58.4%	59.9%	13,034	15,795

Source: CPUC's Reliability Needs Assessment

Revised ELCC Values

The revised ELCC scenarios us the ELCC values published by the CPUC in September 2021.

This study used the 2023 values for 2022.

	2023	2024	2025	2026
Wind CA	13.9%	16.5%	22.6%	21.6%
Solar - Utility Scale and BTM PV	7.8%	6.6%	6.7%	5.7%
4-Hour Battery	96.3%	90.7%	74.2%	69.0%
8-Hour Battery	98.2%	94.3%	82.2%	78.2%

Source: Astrapé Consulting and Energy + Environmental Economics

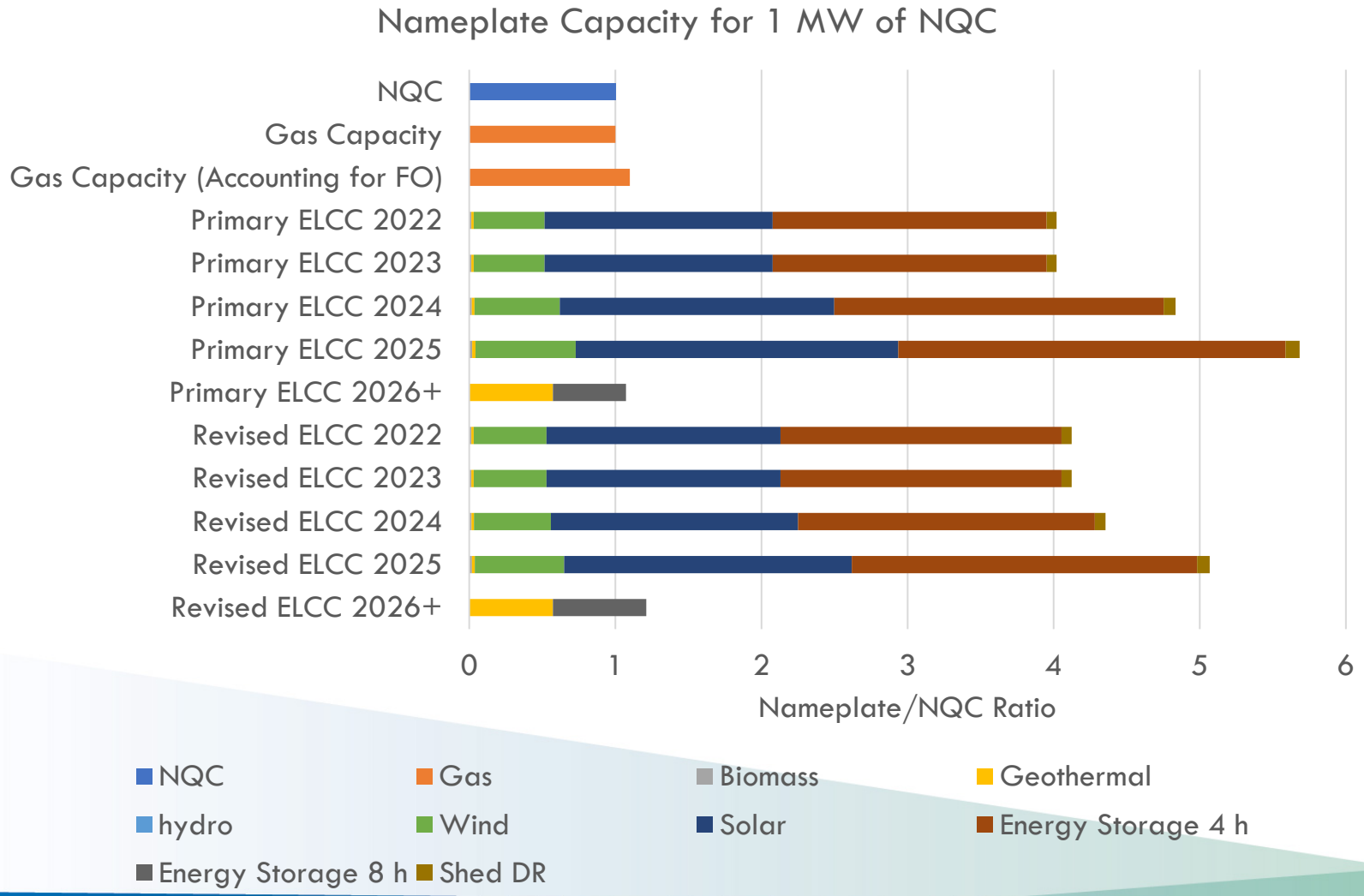
Technology Factors

- Technology factors were used to translate annual capacity values into monthly values.
  - Resources without technology factors were assumed to have a technology factor of 1.
  - Wind and solar technology factors were not use.

Technology	May	June	July	August	September	October
Cogen	80%	88%	84%	87%	83%	75%
Geothermal	82%	78%	90%	88%	87%	87%
Biomass	90%	93%	92%	94%	94%	87%
Hydro	70%	72%	79%	72%	73%	68%

Source: CPUC's Reliability Needs Assessment

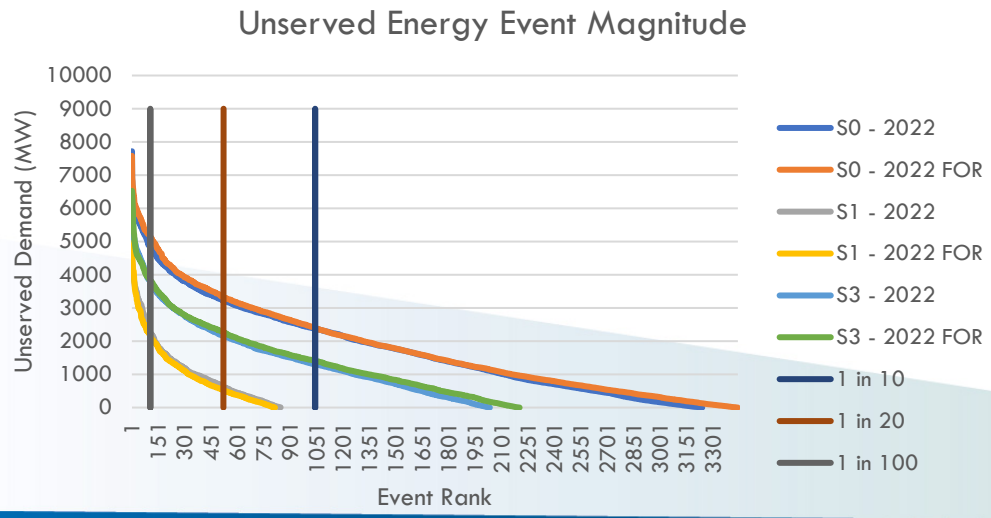
What the ELCC and TF Mean for Capacity



- Preferred resources required 4-5.6x nameplate for 1 MW of NQC.
- The Gas Capacity accounting for forced outages assumes a 9% forced outage rate for gas additions.
  - This value was not used in the study and is only provided for comparison.

Forced Outages

- Outages were applied on a standard unit size.
- Capacity weighted Thermal FOR:
  - 2022: 7.6%
  - 2026: 6.8%
- Tests were performed for different unit sizes.
  - Little impact was noted.

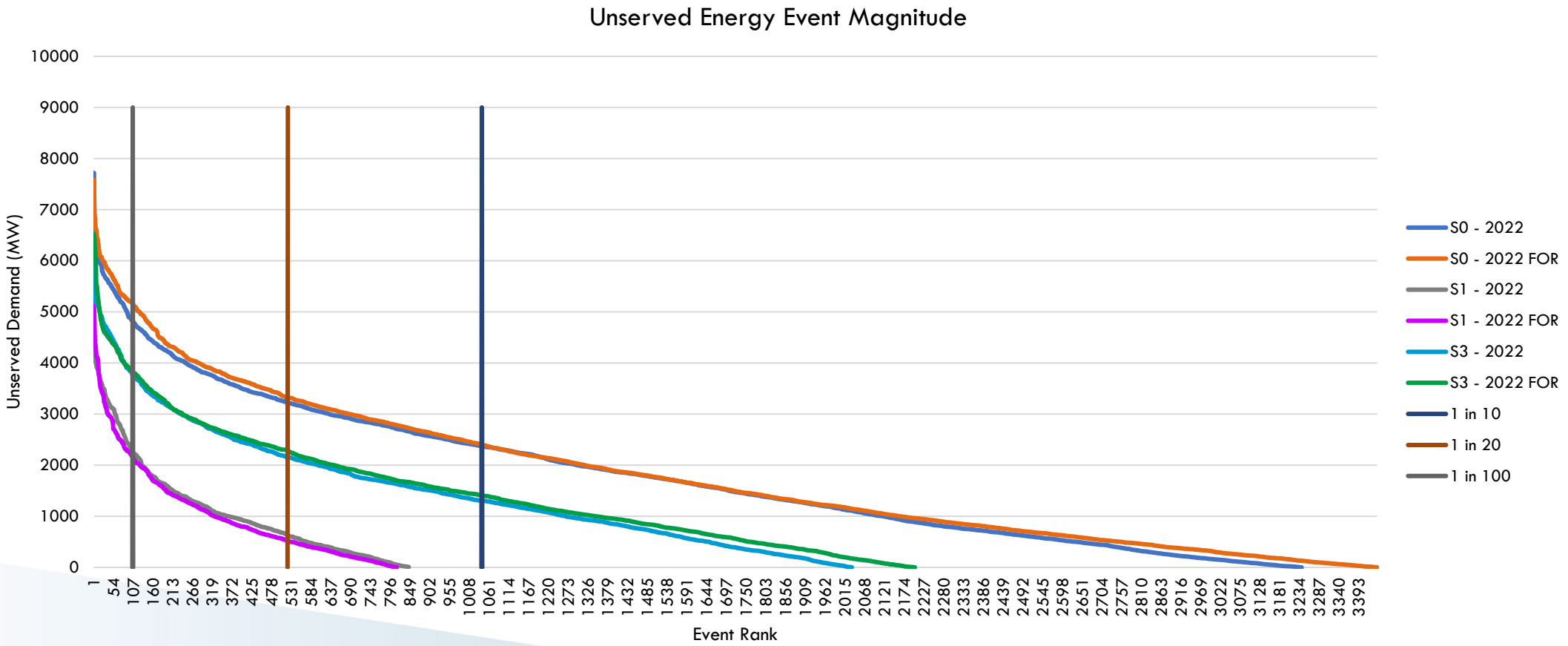


Technology	Forced Outage Rate (%)	Mean Time to Repair (h)	Standard Unit Size (MW)	Test Unit Size (MW)	CAISO Median Unit Size (MW)	CAISO Mean Unit Size (MW)
Combined Cycle	3.69	24	100	600	583	619.0
Gas Turbine	11.66	24	100	125	49.8	125.4
Cogen	13.84	24	100	50	49.8	125.4
Gas-Other	13.84	24	100	40	9.9	40.1
Nuclear	1.92	24	1140	1140	N/A	N/A
Geothermal	7.2	24	25	25	N/A	N/A
Biomass	8	24	10	10	N/A	N/A
Imports - Specified	3.69	24	100	100	N/A	N/A
Energy Storage 4 h	5	24	10	10	N/A	N/A
Energy Storage 8 h	5	24	10	10	N/A	N/A
Pumped Hydro Storage	5.77	24	100	100	N/A	N/A

Forced outage rates source: January 25, 2021 presentation to WECC by Yi Zhang of the CAISO. https://www.wecc.org/_layouts/15/WopiFrame.aspx?sourcedoc=/Administrative/Zhang%20-%20FOR%20PCMS.pdf&action=default&DefaultItemOpen=1

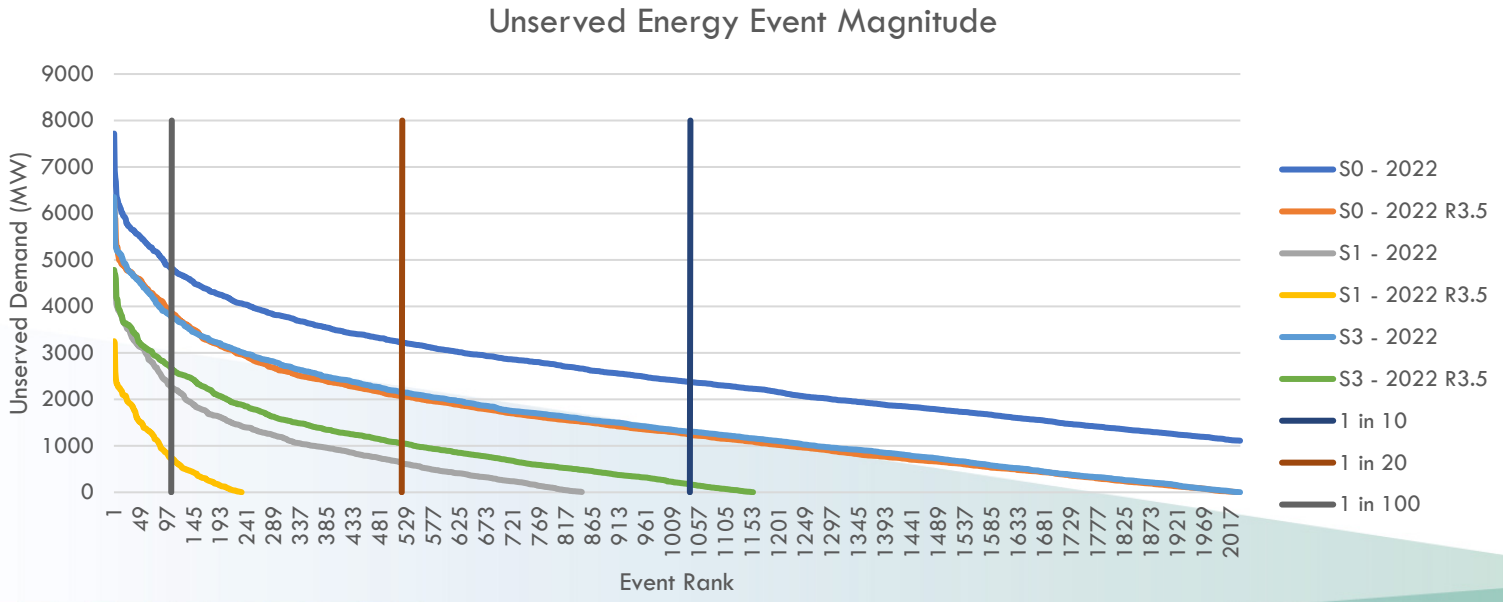
CAISO Unit Size: CEC Staff Analysis

Forced Outage Unit Size Impact



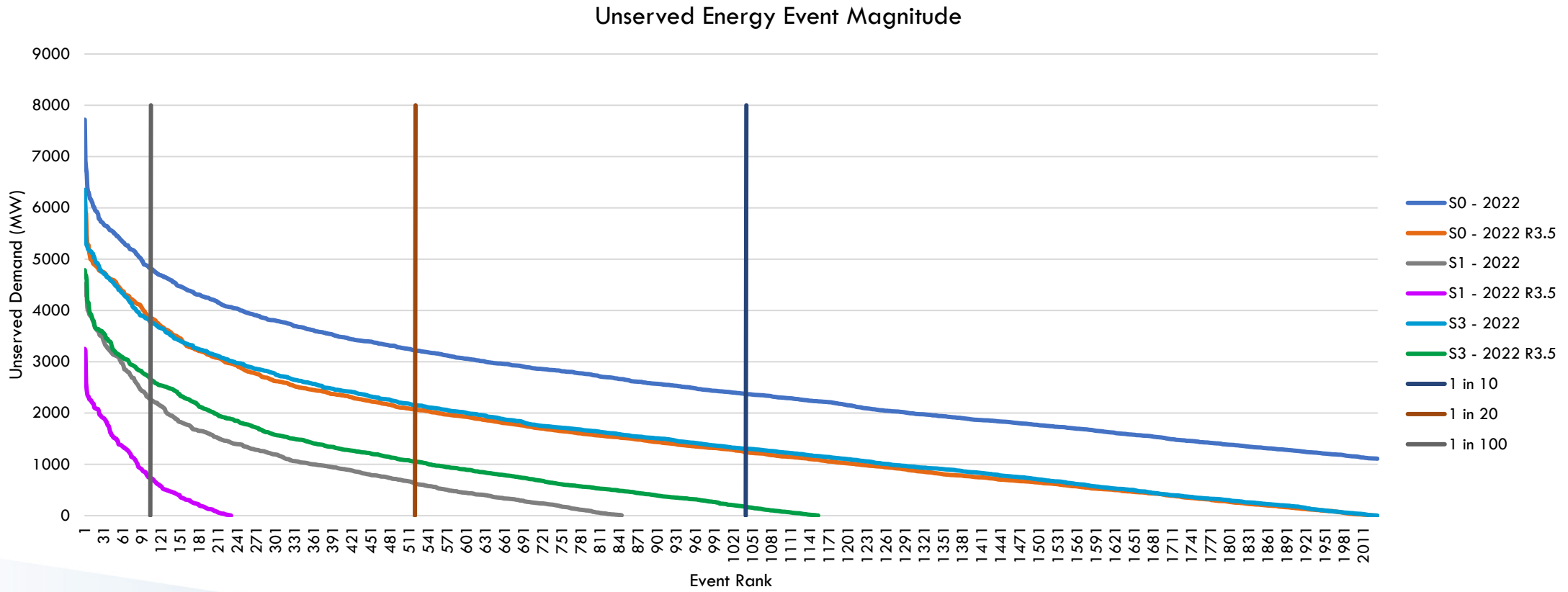
Reserves

Technology (MW)	2022	2023	2024	2025	2026	Price ($)
Combined Cycle	2,500	2,500	2,500	2,500	2,500	2
Gas Turbine	2,500	2,500	2,500	2,500	2,500	2
Hydro	1,000	1,000	1,000	1,000	1,000	3
Energy Storage 4 h	1,000	1,250	1,500	1,750	1,750	1
Energy Storage 8 h	-	-	-	-	250	1



- Reserves were independently modeled at 6%.
  - Tests were done at 3.5%.
- Resources are required to be able to deliver energy for 30 minutes to offer reserves.
- Price was used only to set a dispatch priority.
- Max reserve contribution by resource type is in the table below.

Reserve Requirement Test



Decreasing the minimum reserves before energy goes unserved had a meaningful impact on results. However, to maintain alignment with CPUC modeling practices, a 6% minimum reserve was maintained.

Cumulative Age Based Gas Retirements

- The CPUC's MTR retires 815 MW (NQC) that reaches 40 years of age.
  - This retirement is backed out of several scenarios.

Cumculative (MW NQC)	2022	2023	2024	2025	2026
Gas Turbine	263	263	263	483	578
Cogen	44	60	66	175	237
TOTAL	**307**	**323**	**329**	**659**	**815**

Source: CPUC's Reliability Needs Assessment

Note: Due to an error, the CHP NQC values were used instead of the reconstructed nameplate capacity, decreasing the CHP capacity by 35 MW in 2026. This represents less than 0.05% of the total capacity in all years and was deemed to be a negligible impact on results.

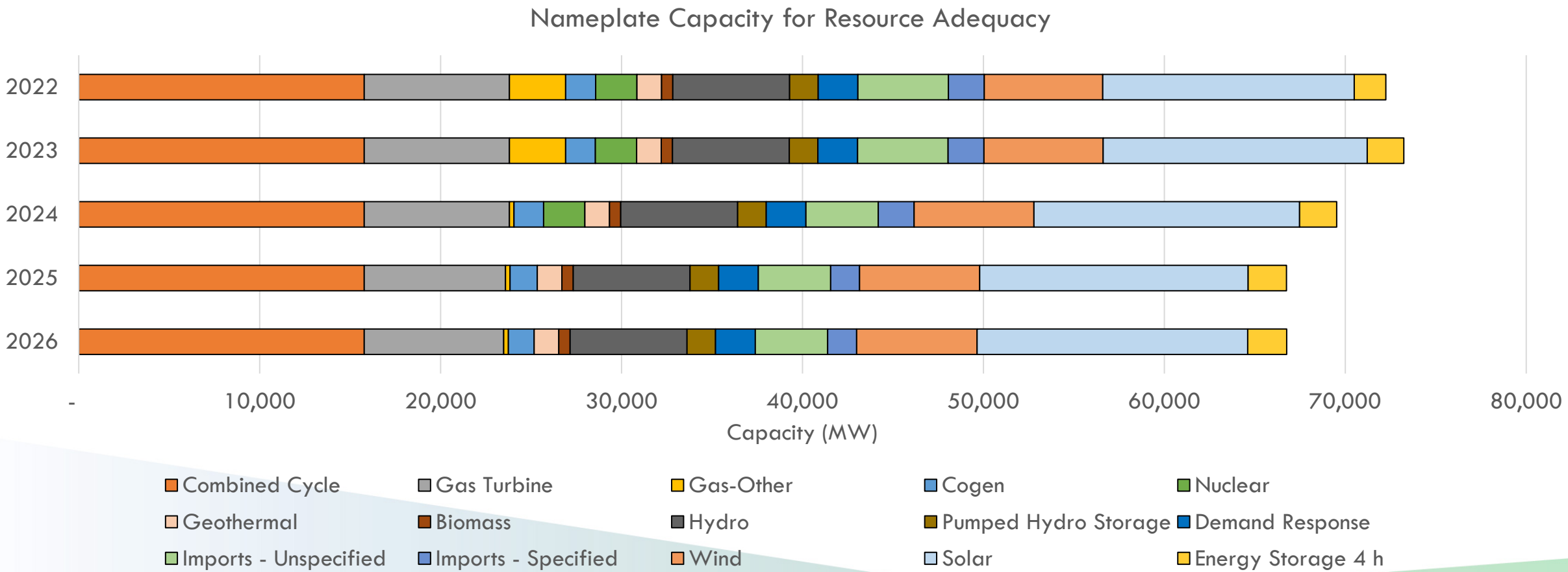
Scenarios

Resource Build Scenarios

We looked at three core scenario groupings base on the type of resource build

1. **No Build** – does not include any new resources beyond the baseline in the CPUC's Reliability Need Assessment plus some of the summer 2021 procurement (D.21-02-028). Identifies the baseline need if no new procurement occurred.
2. **PSP** – Resource builds that include the PSP based resource builds
3. **Order** – builds based on the procurement orders
    1. 1,505 MW NQC from D.19-11-016
    2. 9,500 MW NQC through 2025 from D.21-06-035
    3. 2,000 MW NQC of Long Lead Time Resources in 2026 from D.21-06-035, if not delayed

Base Resources (No Build)



Scenario Adjustments (PSP and Order Only)

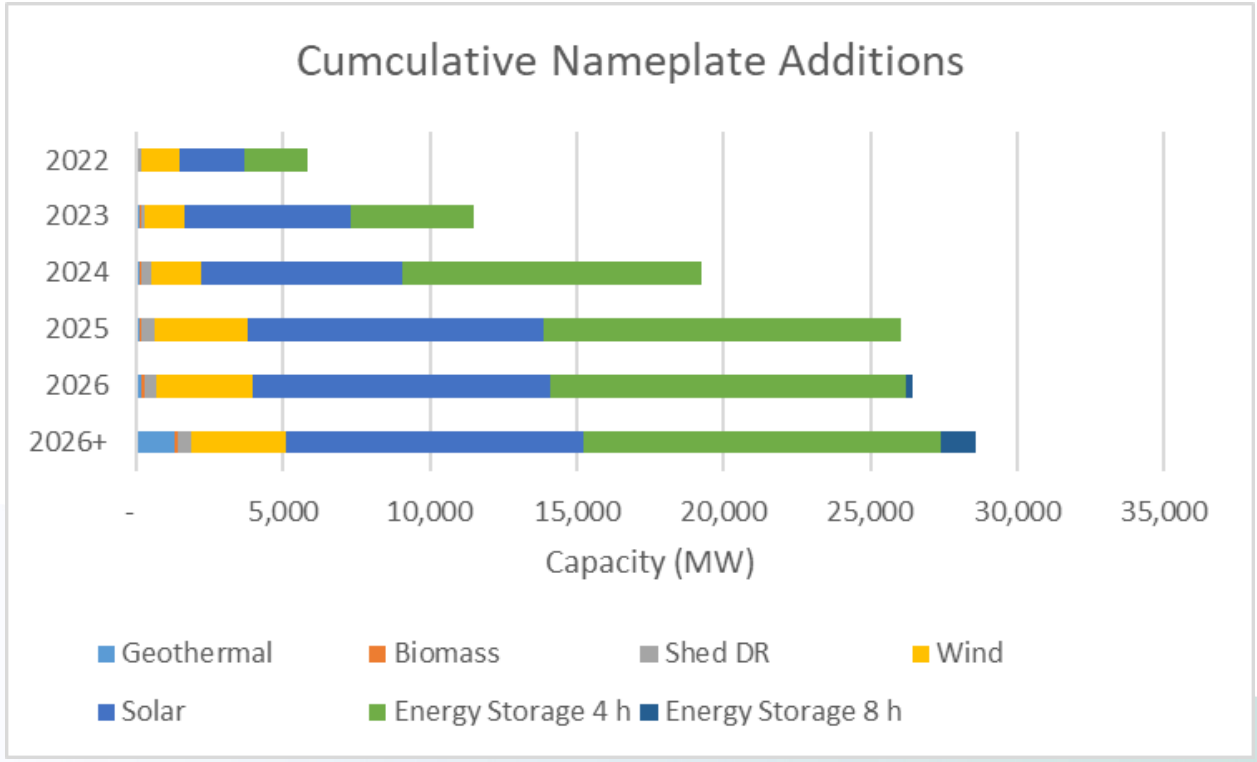
- **+** - These scenarios include the 2,000 MW NQC of long lead time resources in 2026, and are typically included in the results and "2026+"
- **Energy** – These scenarios limit imports in all hours and hold hydro to the min gen level outside of HE 17-22.
- **Gas** – These scenarios add gas capacity at the NQC level of the preferred resources.
  - Gas capacity is assumed to have a 1:1 relationship between NQC and nameplate capacity.
- **R.ELCC** – These scenarios make use of the ELCC values published by the CPUC in September 2021.

Scenario Adjustments (PSP and Order Only)

- **No Ret.** – These scenarios reverse the age-based gas retirements included in the CPUC's Reliability Needs Assessment.
- **# Shift** – These scenarios shift approximately # MW NQC from 2023 to 2022 to eliminate the shortfall in 2022.
- **B20** – These scenarios delay 20 percent of the incremental energy storage each year to the next year.
- **PV#** – These scenarios reduce solar output by # percent in all hours.

PSP Scenario Additions

- The proposed system plan was adapted in two ways:
  - Offshore wind was rolled into onshore wind.
  - 1,727 MW of capacity counted in the PSP and the baseline resources in the CPUC's Reliability Need Assessment were removed from the PSP.



	Old NQC	New NQC
2022	2,753	2,603
2023	4,916	4,970
2024	9,907	10,778
2025	11,712	12,879
2026	12,012	13,128
2026+	14,012	15,128

PSP Overlap with the Base Resources

Nameplate (MW)	**2022**
Energy Storage 4 h	406
Biomass	15
Geothermal	14
Solar	883
Wind	409

- 1,727 MW of capacity counted in the PSP and the baseline resources in the CPUC's Reliability Need Assessment were removed from the PSP.
  - This capacity was removed in 2022 consistent with the information provided by the CPUC.

Order Scenarios NQC Additions

Resource (MW NQC)	**2022**	**2023**	**2024**	**2025**	**2026**	**2026+**
D.19-11-016 NQC Remaining	1,070	435	-	-	-	
	-	2,000	6,000	1,500	-	2,000
	-	-	1,000	2,500	2,500	
	-	-	-	-	-	1,000
	-	-	-	-	-	
	1,070	3,505	8,505	8,505	8,505	8,505
Total	**1,070**	**3,505**	**9,505**	**11,005**	**11,005**	**13,005**

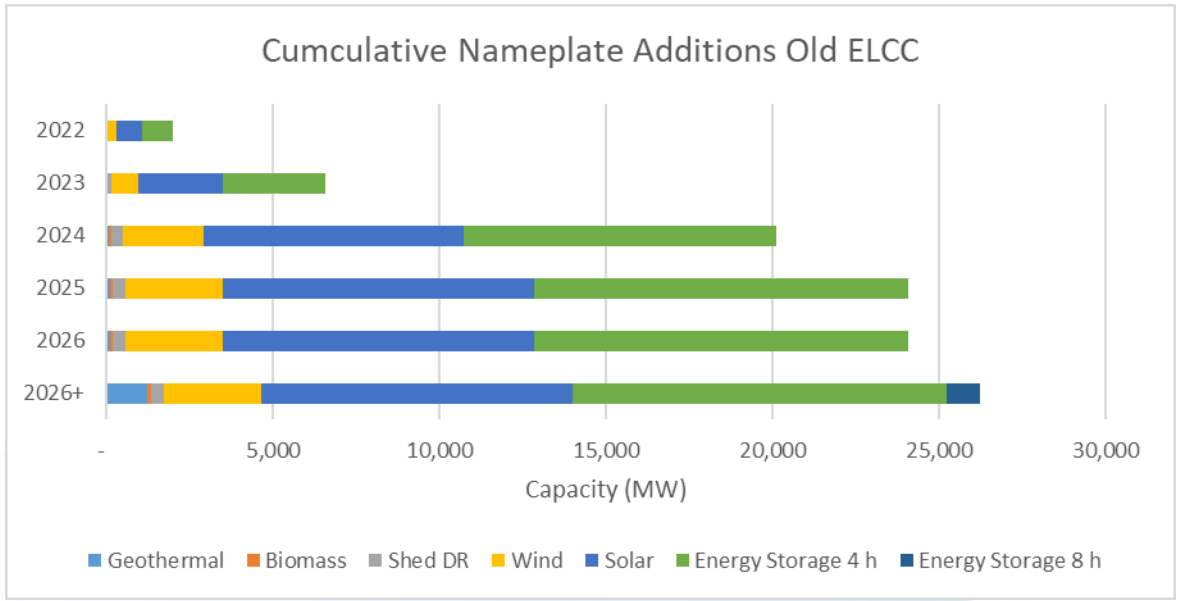
Incremental Additions

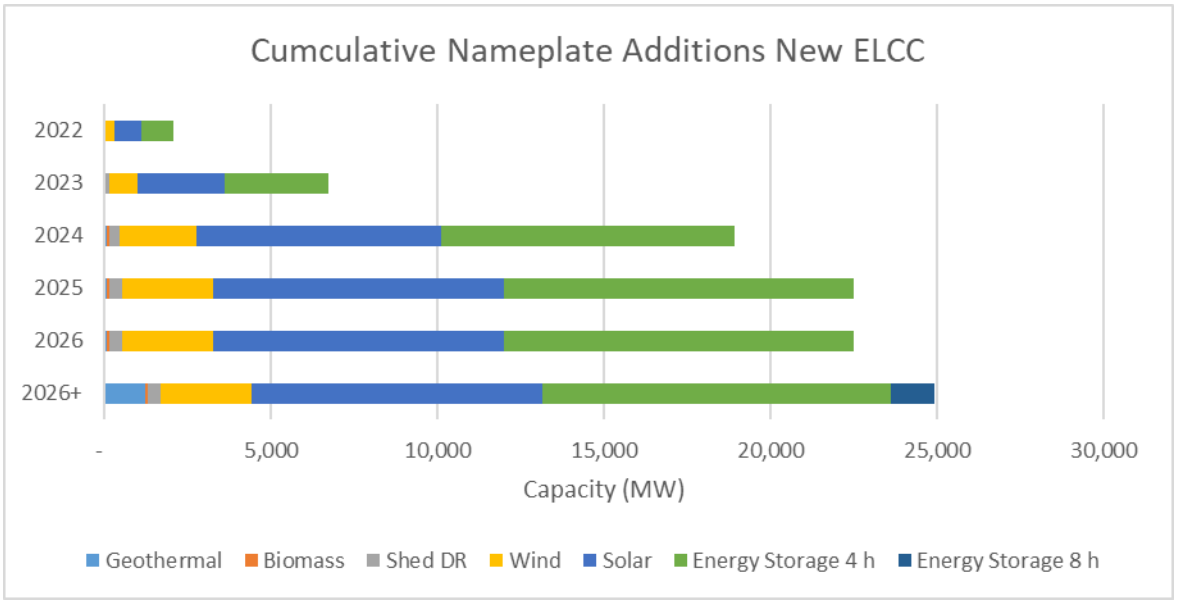
Cumculative Additions

- All remaining D.19-11-016 NQC was assumed to come online consistent with the order dates.
- Hybrid resources were modeled as separate solar and energy storage.
- Geothermal was use as the long lead-time resources with an 80 percent capacity factor. However, using other technologies would have a minimal impact on results due to simplifications in the modeling.

Order Scenario Additions

- Order builds are based on remaining NQC procurement in D.19-11-016 (1,505 MW NQC) and D.21-06-035 (9,500 to 11,500 MW NQC)
- Resources were built consistent with the 2026 resource ratio in the PSP, but only up to the needed NQC value for each year.

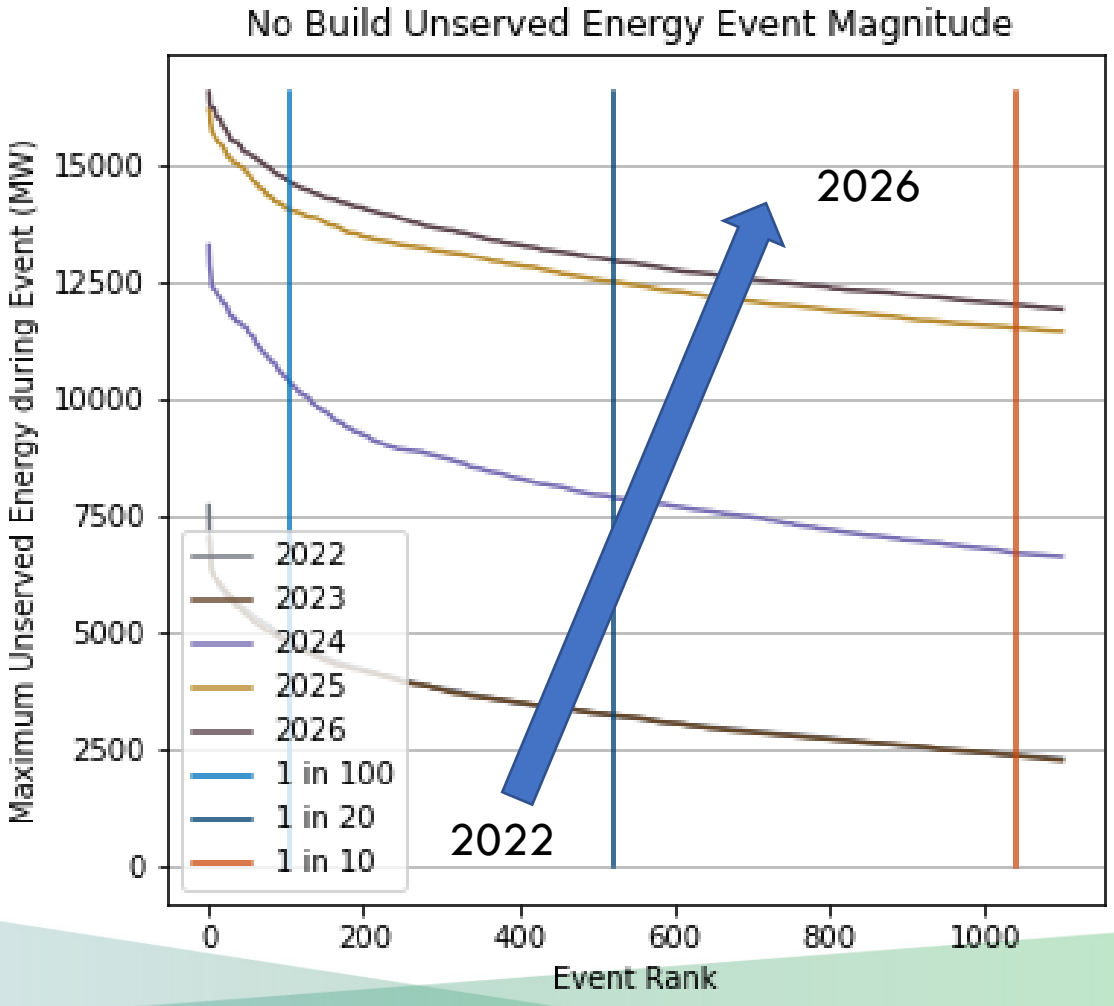




Results

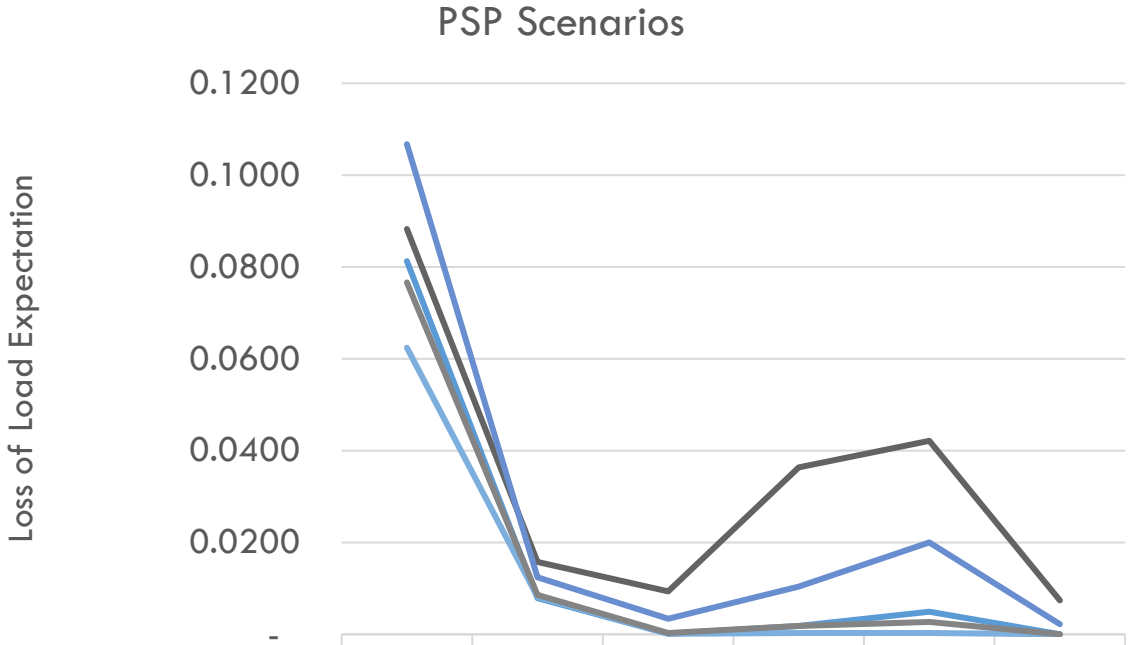
No Build, Establishing a Shortfall

- Without additional capacity reliability gets worse.
- The need in each year is approximately the same as the NQC ordered.
  - The largest mismatch is in 2022

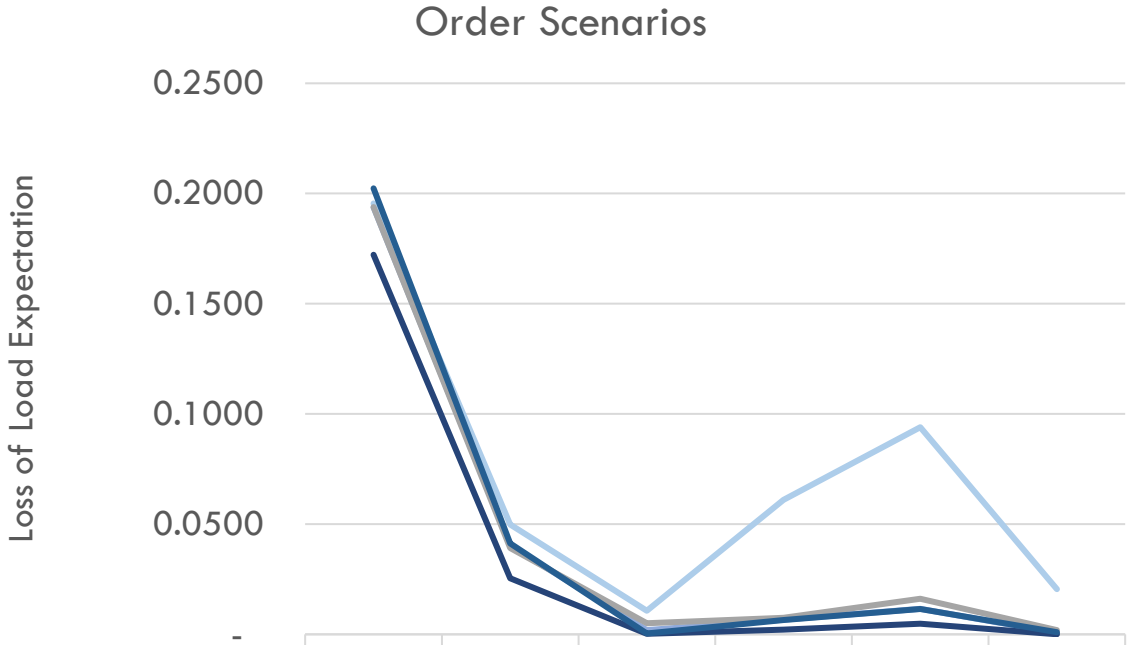


Value	2022	2023	2024	2025	2026	2026+
LOLE	0.3114	0.3031	2.3689	14.6389	17.8386	N/A
1 in 10	2,372	2,391	6,711	11,540	12,022	N/A
1 in 20	3,215	3,246	7,893	12,525	12,968	N/A
1 in 100	4,817	4,774	10,351	14,065	14,662	N/A

Loss of Load Expectation

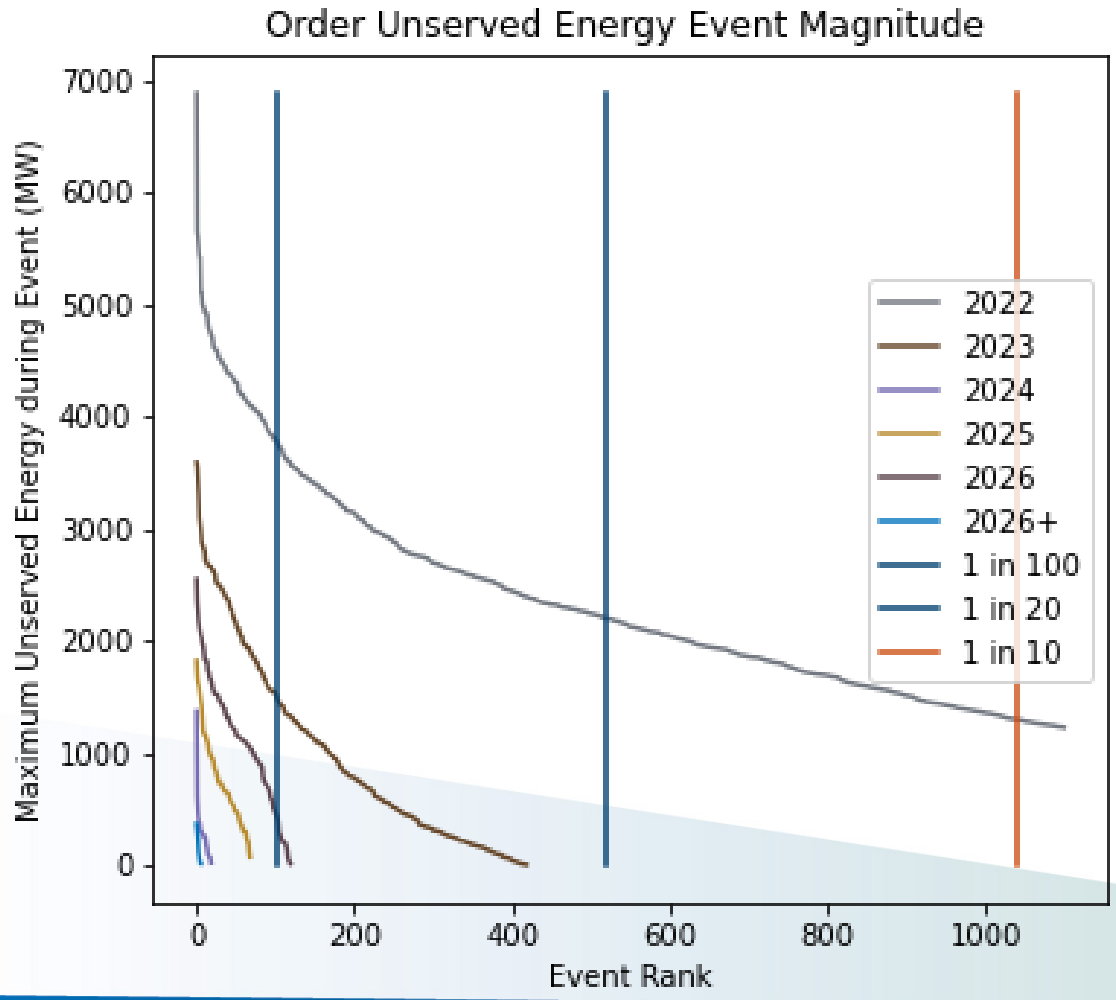


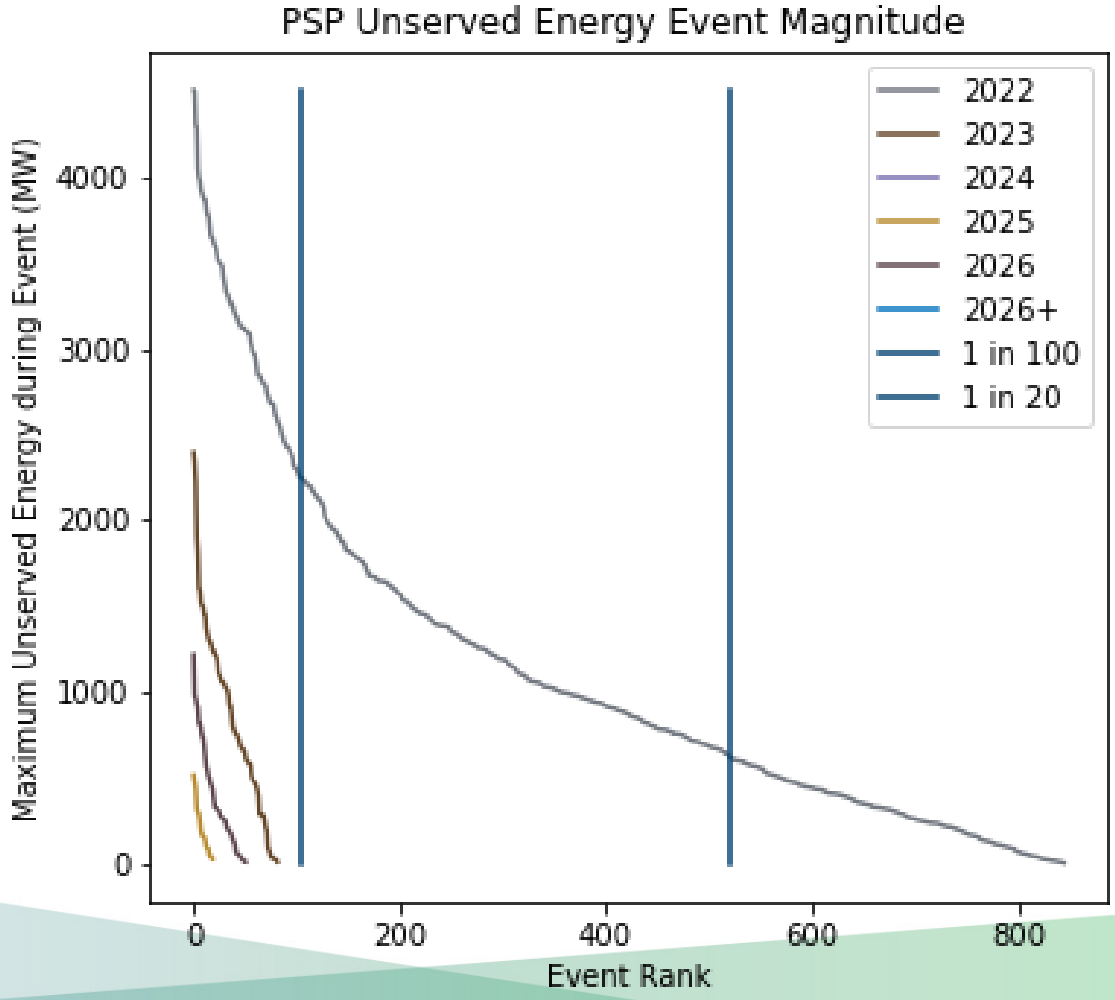
	2022	2023	2024	2025	2026	2026 +
PSP	0.0813	0.0079	0.0001	0.0018	0.0049	-
PSP, Gas	0.0883	0.0158	0.0093	0.0363	0.0421	0.0074
PSP, Gas, R.ELCC	0.1067	0.0124	0.0034	0.0104	0.0200	0.0022
PSP, No Ret.	0.0624	0.0082	0.0001	0.0003	0.0003	-
PSP, Energy	0.0766	0.0086	0.0003	0.0018	0.0027	-



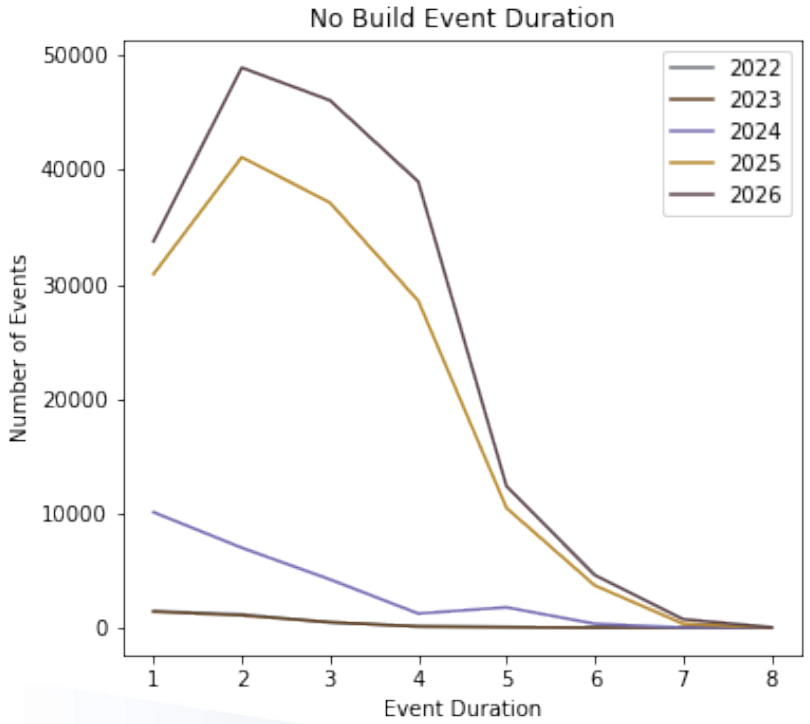
	2022	2023	2024	2025	2026	2026 +
Order	0.1938	0.0403	0.0019	0.0066	0.0115	0.0007
Order, Gas	0.1955	0.0498	0.0107	0.0610	0.0939	0.0205
Order, R.ELCC	0.1938	0.0391	0.0050	0.0075	0.0162	0.0019
Order, No Ret.	0.1722	0.0254	0.0002	0.0021	0.0048	-
Order, Energy	0.2023	0.0413	0.0004	0.0064	0.0114	0.0010

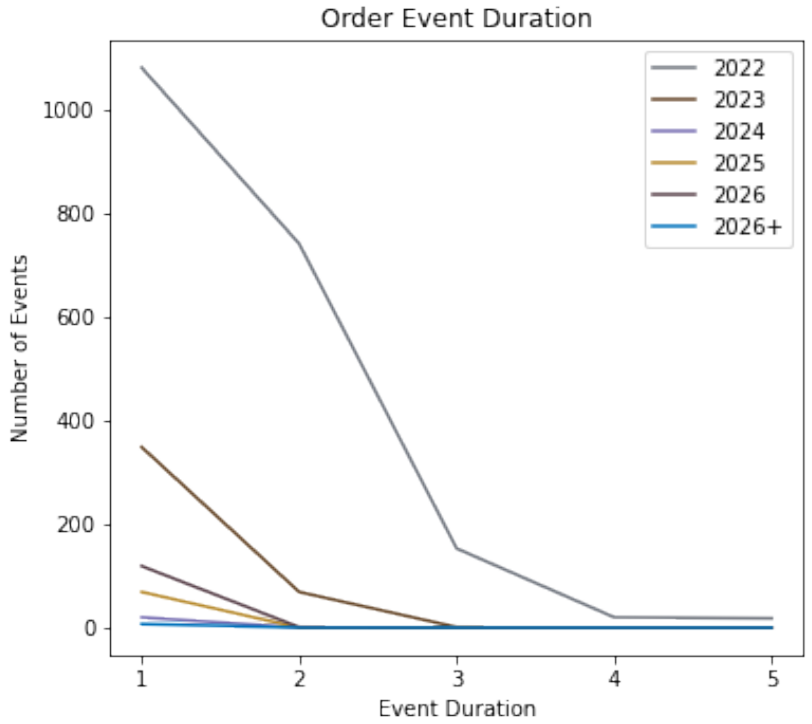
Base Scenarios

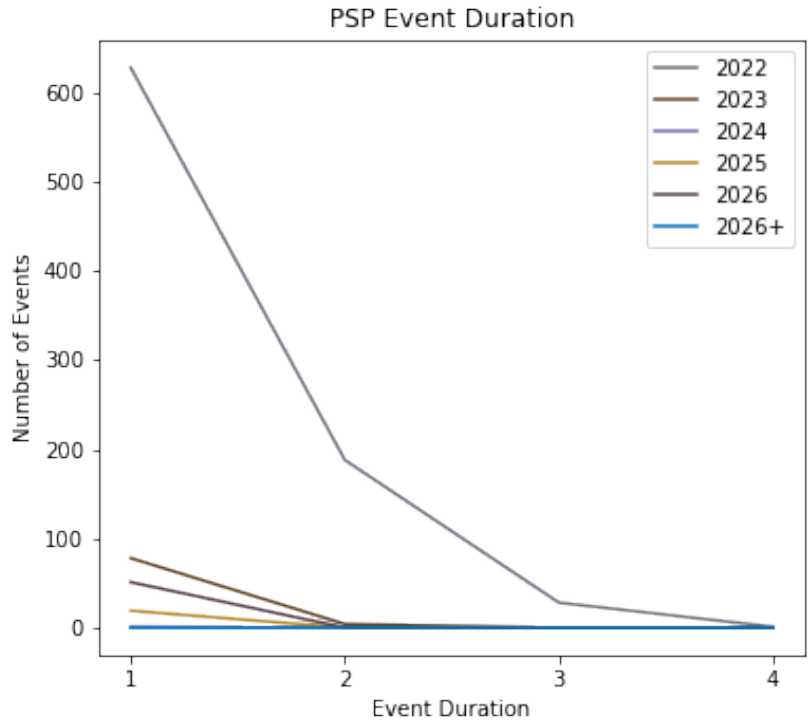




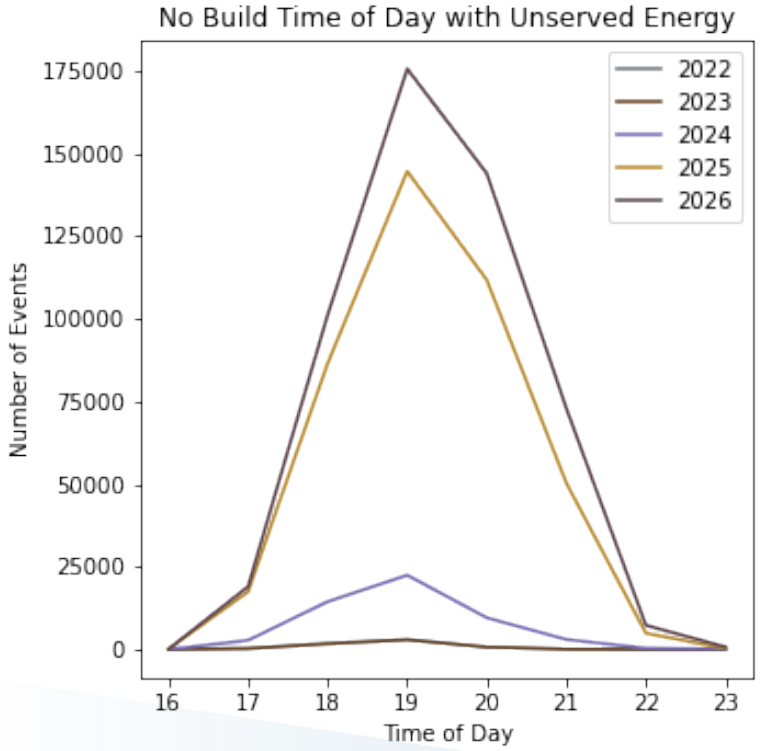
Outage Durations

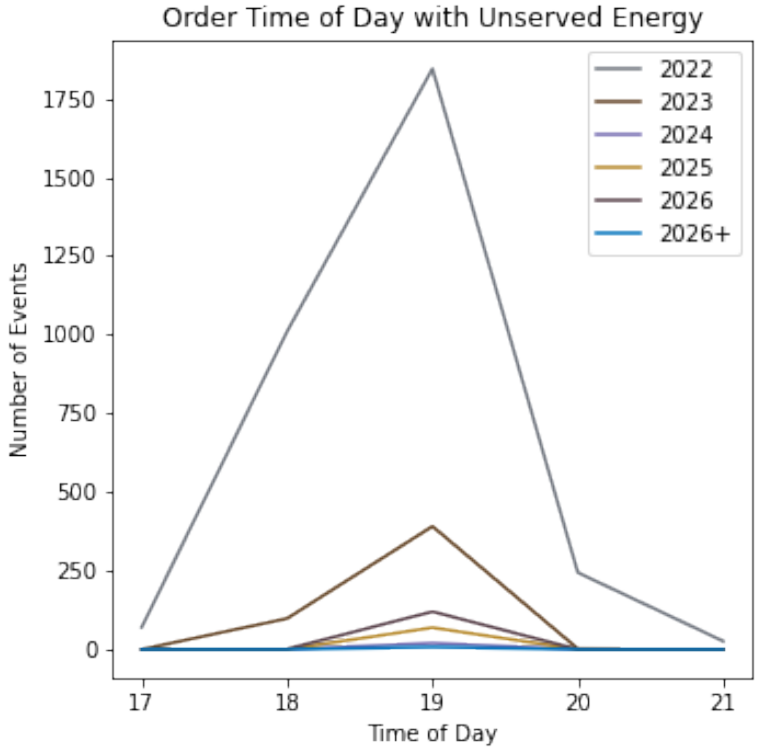


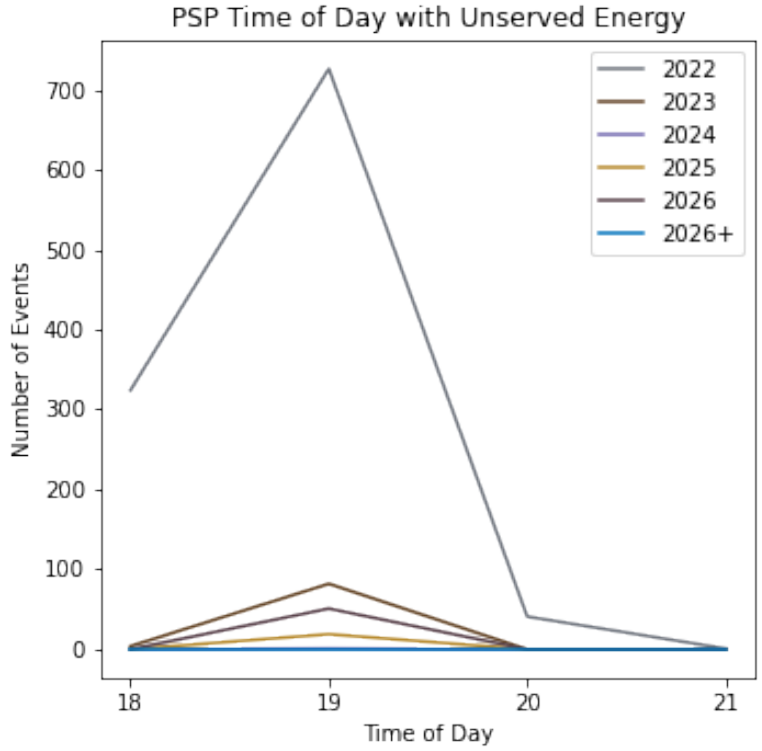




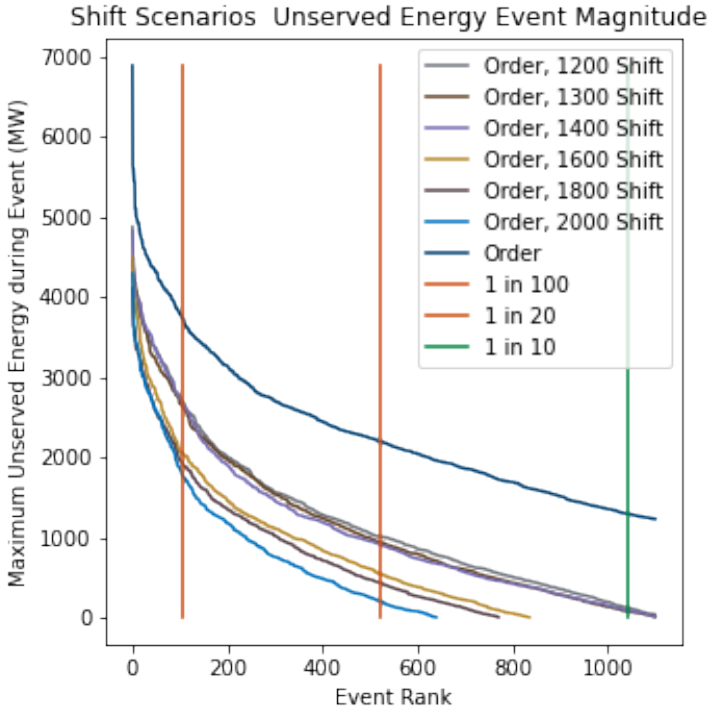
What time of Day is the Issue

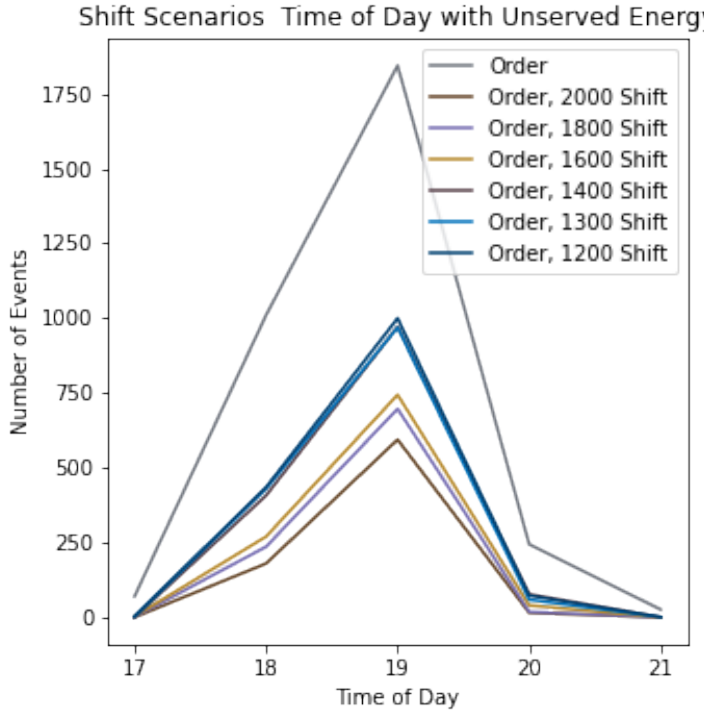


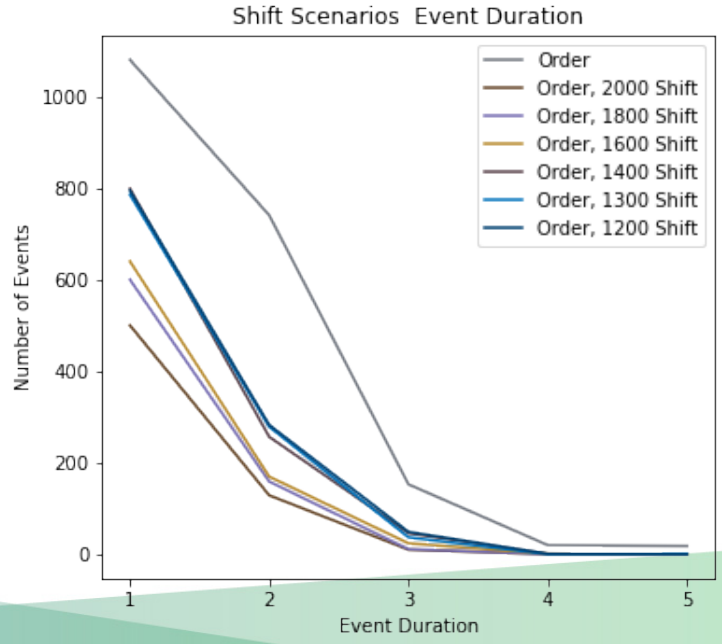




Order, Shift Scenarios (2022 only)

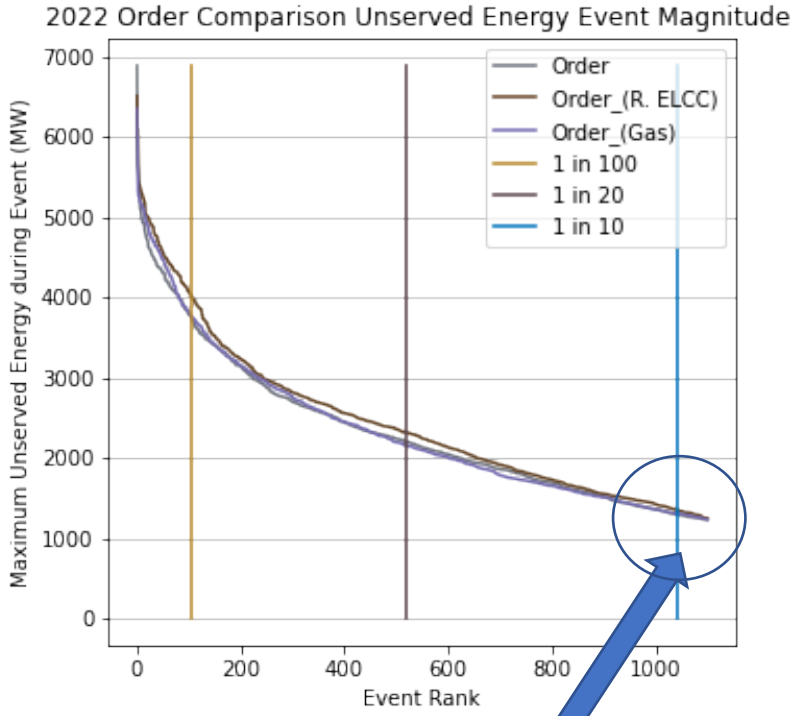






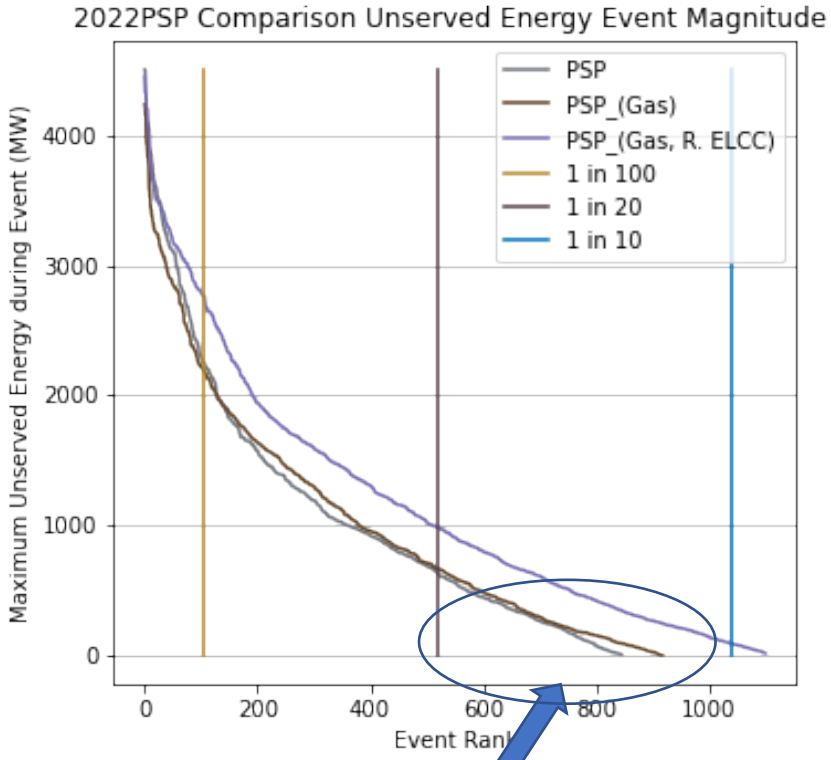
2022	1,200 MW	1,300 MW	1,400 MW	1,600 MW	1,800 Mw	2,000 MW
LOLE	0.1086	0.1062	0.1062	0.0804	0.0741	0.0615
1 in 10	122	74	88	-	-	-
1 in 20	1,010	938	908	543	431	202
1 in 100	2,702	2,652	2,691	2,062	1,945	1,805

2022 ELCC and Gas Comparison



Order

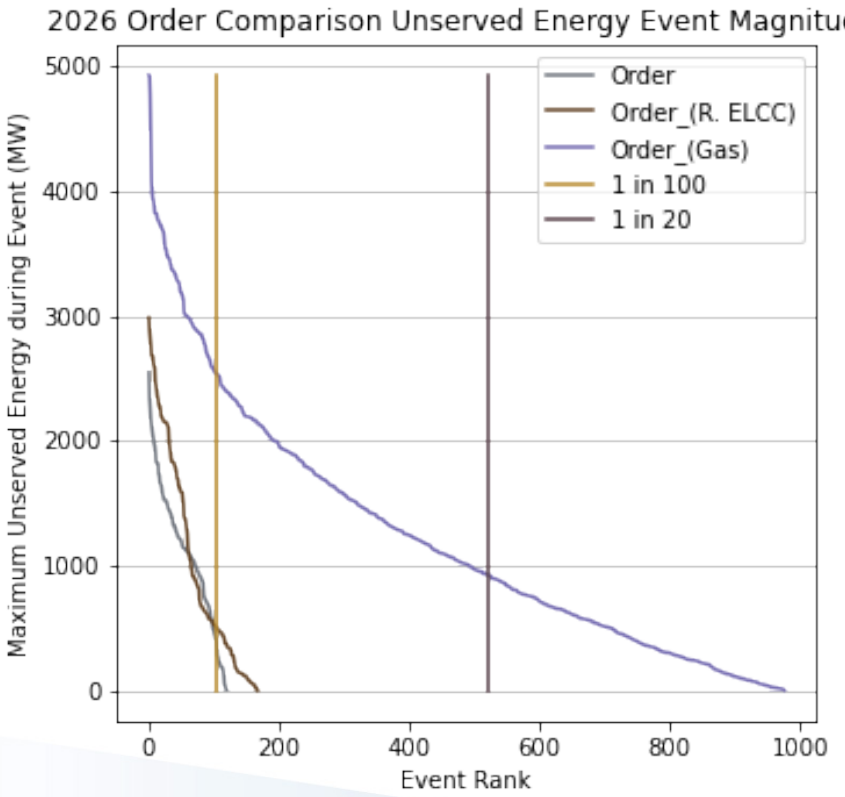
PSP



Negligible difference with ~50 MW difference in the preferred resource build, and ~1,000 MW less gas capacity by nameplate

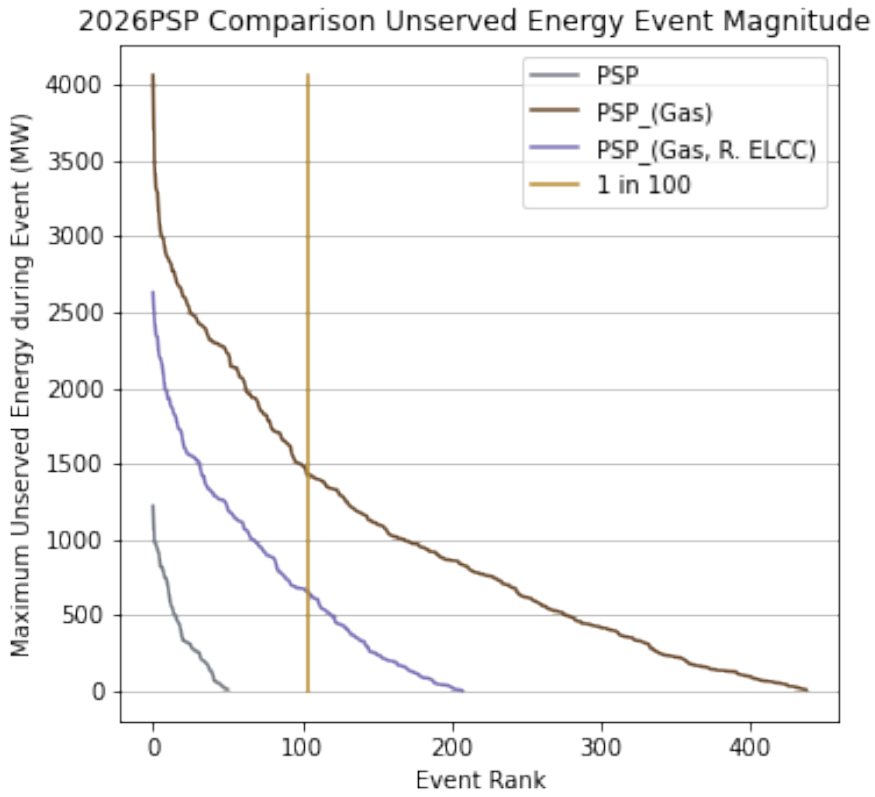
Significant difference when reducing the gas capacity by 150 MW.

2026 ELCC and Gas Comparison



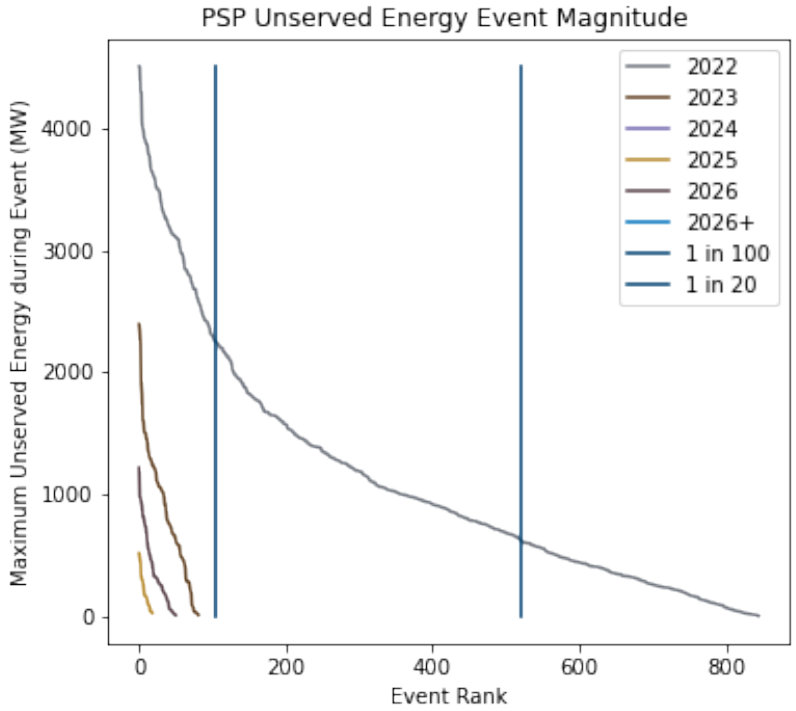
Order

PSP



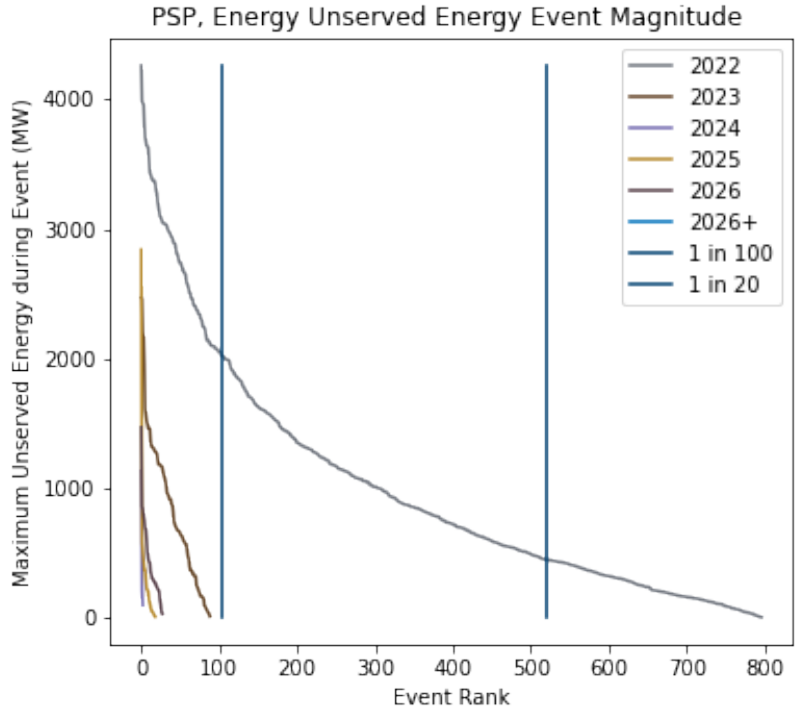
- Everything is reliable, but the difference between the scenarios is much more pronounced than for 2022.

PSP, Energy Limit Scenarios



PSP Base

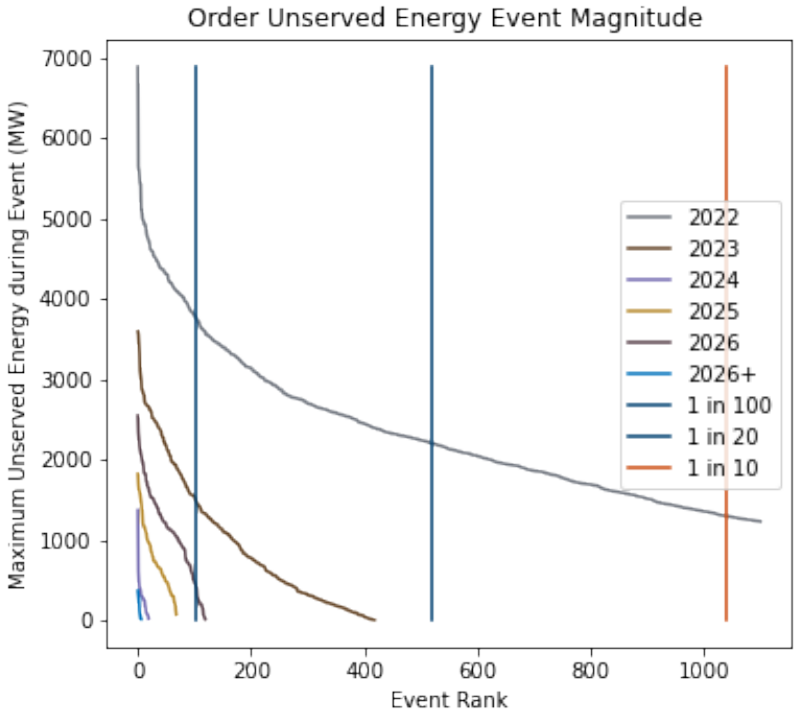
PSP, Energy Limited Case



Value	2022	2023	2024	2025	2026	2026+
LOLE	0.0813	0.0079	0.0001	0.0018	0.0049	-
1 in 10	-	-	-	-	-	-
1 in 20	620	-	-	-	-	-
1 in 100	2,253	-	-	-	-	-

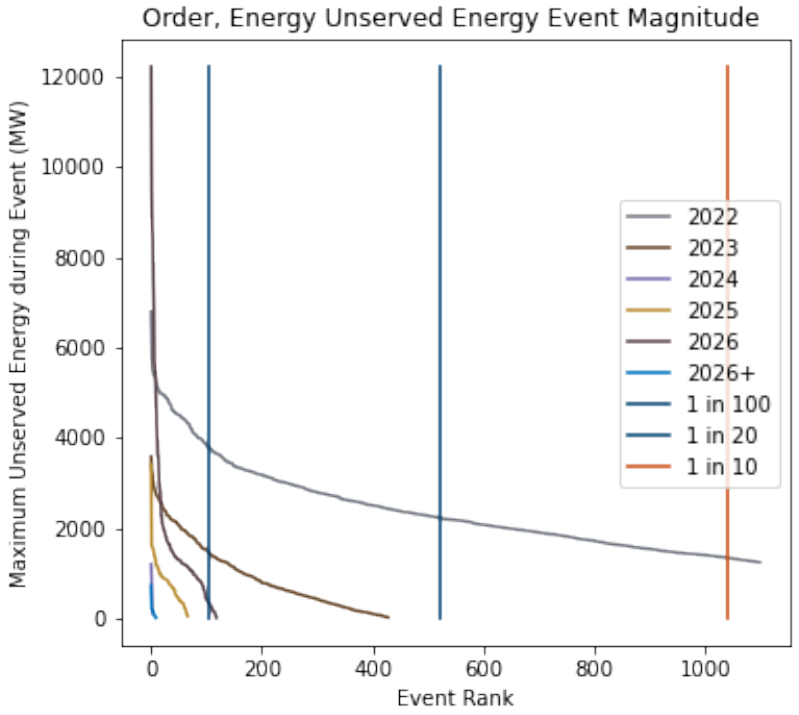
Value	2022	2023	2024	2025	2026	2026+
LOLE	0.0766	0.0086	0.0003	0.0018	0.0027	-
1 in 10	-	-	-	-	-	-
1 in 20	447	-	-	-	-	-
1 in 100	2,015	-	-	-	-	-

Order, Energy Limit Scenarios



Order Base

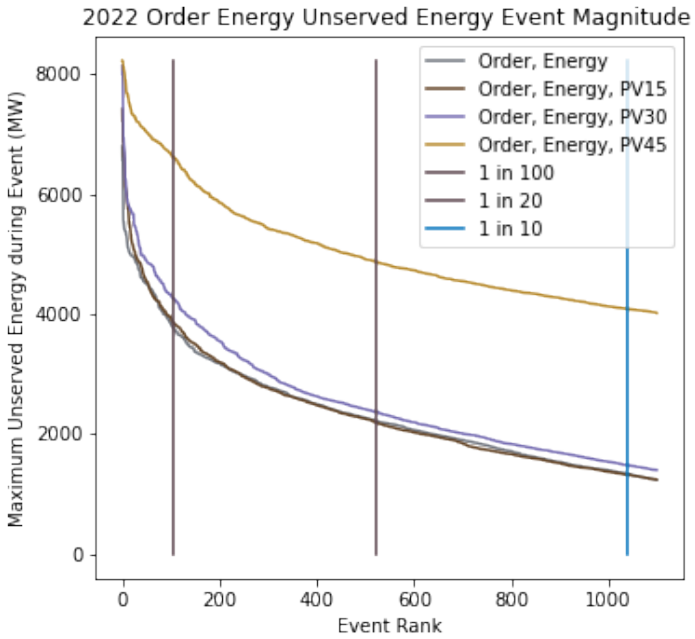
Order, Energy Limited Case



Value	2022	2023	2024	2025	2026	2026+
LOLE	0.1938	0.0403	0.0019	0.0066	0.0115	0.0007
1 in 10	1,296	-	-	-	-	-
1 in 20	2,196	-	-	-	-	-
1 in 100	3,753	1,468	-	-	377	-

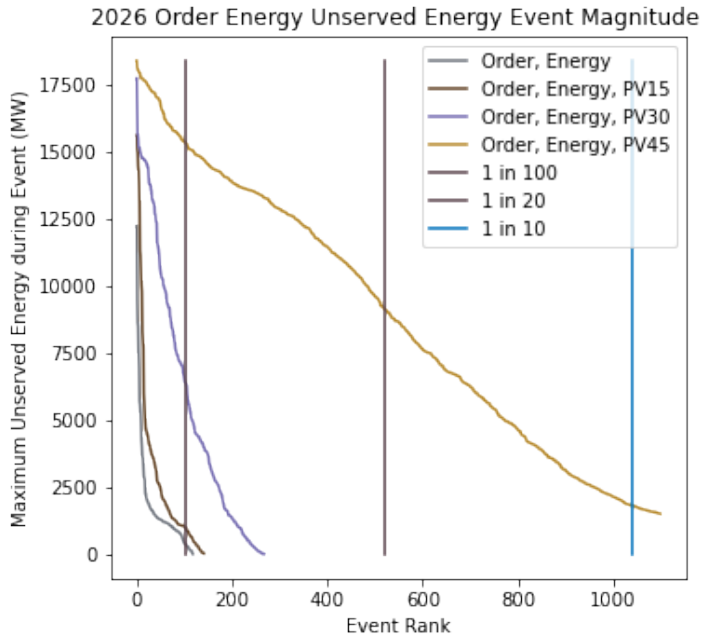
Value	2022	2023	2024	2025	2026	2026+
LOLE	0.2023	0.0413	0.0004	0.0064	0.0114	0.0010
1 in 10	1,338	-	-	-	-	-
1 in 20	2,223	-	-	-	-	-
1 in 100	3,785	1,477	-	-	333	-

Reduced PV Energy (2022 and 2026)



2022

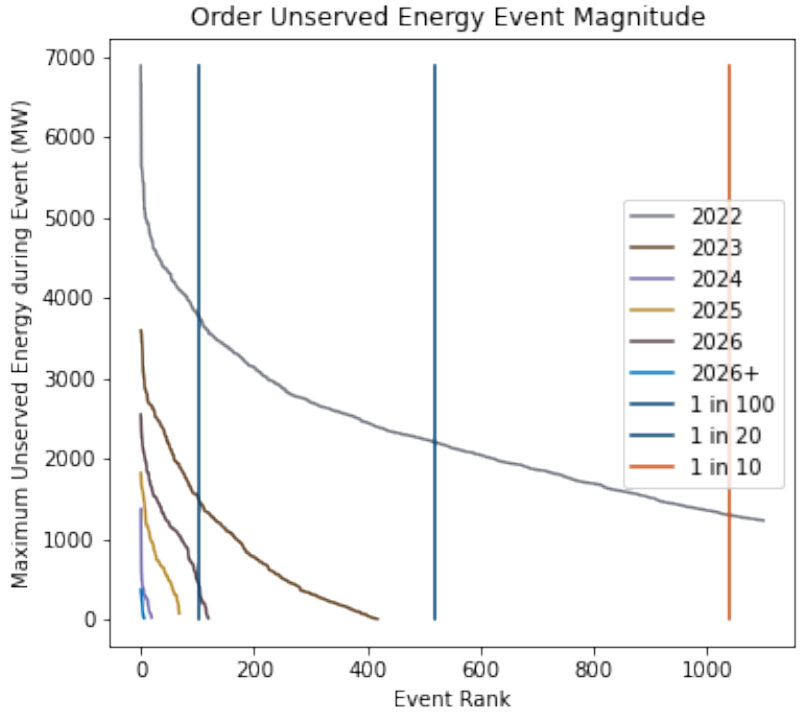
2026



2022	PV0	PV15	PV30	PV45
LOLE	0.2023	0.2024	0.2090	0.7122
1 in 10	1,338	1,325	1,485	4,083
1 in 20	2,223	2,199	2,374	4,872
1 in 100	3,785	3,871	4,265	6,614

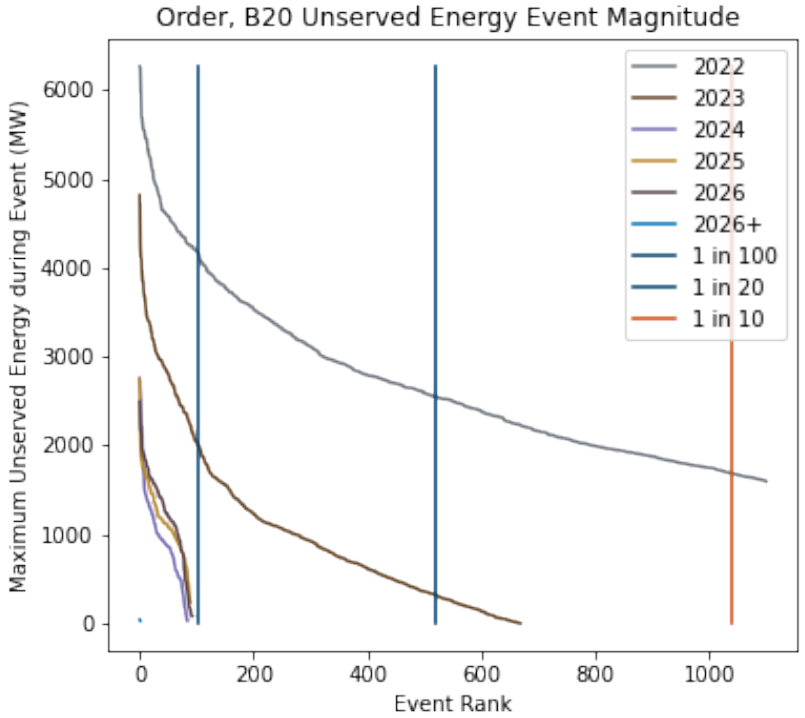
2026	PV0	PV15	PV30	PV45
LOLE	0.0114	0.0137	0.0259	0.1687
1 in 10	-	-	-	1,848
1 in 20	-	-	-	9,216
1 in 100	333	960	6,387	15,302

Battery Supply Chain Disruptions (Order, B20)



No Disruptions

Delay of 20% of Incremental Energy Storage



Value	2022	2023	2024	2025	2026	2026+
LOLE	0.1938	0.0403	0.0019	0.0066	0.0115	0.0007
1 in 10	1,296	-	-	-	-	-
1 in 20	2,196	-	-	-	-	-
1 in 100	3,753	1,468	-	-	377	-

Value	2022	2023	2024	2025	2026	2026+
LOLE	0.2330	0.0643	0.0082	0.0087	0.0089	0.0002
1 in 10	1,685	-	-	-	-	-
1 in 20	2,546	315	-	-	-	-
1 in 100	4,146	1,991	-	-	-	-

Takeaways

Takeaways

- There is a large capacity need without the resources envisioned in D.19-11-016, D.21-06-035, and/or the proposed PSP.
- Assuming no additional gas retirement beyond what is considered in the analysis:
  - If the resource build in the PSP is realized, reliability concerns are diminished beginning in 2022 through 2026.
  - Capacity ordered through D.19-11-016 and D.21-06-035 are insufficient to address the potential capacity shortfall in 2022, should be sufficient to diminish reliability concerns from 2023 through 2026.

Takeaways

- Thermal capacity was not determined to provide a greater system reliability benefit than a portfolio of preferred resources with equivalent NQC.
- An annual one-year delay of 20% of storage procurement has a noticeable impact on reliability in 2022 but does not result in an unreliable system in 2023-6.
- Energy sufficiency does not appear to be a limiting factor for system reliability in 2023-6, given the anticipated resource portfolio.

Questions?

Appendix 1: Supplemental Scenario Information and Resource Tables

Base Resources (No Build)

Nameplate (MW)	2022	2023	2024	2025	2026
Combined Cycle	15,781	15,781	15,781	15,781	15,781
Gas Turbine	8,023	8,023	8,023	7,802	7,707
Gas-Other	3,109	3,109	255	255	255
Cogen	1,659	1,640	1,633	1,502	1,428
Nuclear	2,280	2,280	2,280	-	-
Geothermal	1,359	1,360	1,361	1,361	1,362
Biomass	620	622	624	626	627
Hydro	6,457	6,457	6,457	6,457	6,457
Pumped Hydro Storage	1,579	1,579	1,579	1,579	1,579
Demand Response	2,195	2,195	2,195	2,195	2,195
Imports - Unspecified	5,000	5,000	4,000	4,000	4,000
Imports - Specified	1,981	1,981	1,981	1,592	1,600
Wind	6,548	6,591	6,622	6,644	6,658
Solar	13,902	14,589	14,679	14,836	14,955
Energy Storage 4 h	1,747	2,024	2,055	2,116	2,156
Total	72,240	73,232	69,524	66,746	66,759

PSP Scenario Additions

- The proposed system plan was adapted in two ways:
  - Offshore wind was rolled into onshore wind.
  - 1,727 MW of capacity counted in the PSP and the baseline resources in the CPUC's Reliability Need Assessment were removed from the PSP.

Nameplate (MW)	2022	2023	2024	2025	2026	2026+
Geothermal	-	100	100	100	170	1,319
Biomass	19	50	68	92	92	92
Shed DR	151	151	353	441	441	441
Wind	1,310	1,332	1,662	3,144	3,264	3,264
Solar	2,211	5,666	6,867	10,117	10,117	10,117
Energy Storage 4 h	2,159	4,198	10,211	12,147	12,147	12,147
Energy Storage 8 h	-	-	-	-	196	1,196
Total	5,850	11,497	19,261	26,041	26,427	1,852
NQC	2,753	4,916	9,907	11,712	12,012	14,012

Procurement Scenario Additions

- Procurement builds are based on remaining NQC procurement in D.19-11-016 (1,505 MW NQC) and D.21-06-035 (9,500 to 11,500 MW NQC)
- Resources were built consistent with the 2026 resource ratio in the PSP, but only up to the needed NQC value for each year.
- Uses the Marginal ELCC Values from the CPUC's Reliability Needs Assessment

Nameplate (MW)	2022	2023	2024	2025	2026	2026+
Geothermal	8	25	77	92	92	1,241
Biomass	7	23	71	85	85	85
Shed DR	34	111	340	408	408	408
Wind	242	794	2,427	2,908	2,908	2,908
Solar	780	2,554	7,811	9,356	9,356	9,356
Energy Storage 4 h	936	3,066	9,378	11,233	11,233	11,233
Energy Storage 8 h	-	-	-	-	-	1,000
Total	2,007	6,573	20,105	24,082	24,082	26,231
NQC	1,070	3,505	9,505	11,005	11,005	13,005

Procurement Scenario Additions, New ELCC

- Procurement builds are based on remaining NQC procurement in D.19-11-016 (1,505 MW NQC) and D.21-06-035 (9,500 to 11,500 MW NQC)
- Resources were built consistent with the 2026 resource ratio in the PSP, but only up to the needed NQC value for each year.
- Uses the ELCC values published by the CPUC in September 2021

Nameplate (MW)	2022	2023	2024	2025	2026	2026+
Geothermal	8	26	73	86	86	1,231
Biomass	7	24	67	79	79	79
Shed DR	35	114	321	381	381	381
Wind	248	814	2,286	2,714	2,714	2,714
Solar	800	2,619	7,355	8,733	8,733	8,733
Energy Storage 4 h	960	3,145	8,831	10,485	10,485	10,485
Energy Storage 8 h	-	-	-	-	-	1,279
Total	2,058	6,742	18,932	22,478	22,478	24,902
NQC	1,070	3,505	9,505	11,005	11,005	13,005

Appendix 2: Additional Results

LOLE Summary

- Empty cells represent year and scenario combinations that were not run.

Scenario Name	2022	2023	2024	2025	2026	2026+
No Build	0.3114	0.3031	2.3689	14.6389	17.8386	
PSP	0.0813	0.0079	0.0001	0.0018	0.0049	-
PSP, Gas	0.0883	0.0158	0.0093	0.0363	0.0421	0.0074
PSP, Gas, R.ELCC	0.1067	0.0124	0.0034	0.0104	0.0200	0.0022
PSP, No Ret.	0.0624	0.0082	0.0001	0.0003	0.0003	-
PSP, Energy	0.0766	0.0086	0.0003	0.0018	0.0027	-
Order	0.1938	0.0403	0.0019	0.0066	0.0115	0.0007
Order, 1200 Shift	0.1086					
Order, 1300 Shift	0.1062					
Order, 1400 Shift	0.1062					
Order, 1600 Shift	0.0804					
Order, 1800 Shift	0.0741					
Order, 2000 Shift	0.0615					
Order, Gas	0.1955	0.0498	0.0107	0.0610	0.0939	0.0205
Order, R.ELCC	0.1938	0.0391	0.0050	0.0075	0.0162	0.0019
Order, No Ret.	0.1722	0.0254	0.0002	0.0021	0.0048	-
Order, Energy	0.2023	0.0413	0.0004	0.0064	0.0114	0.0010
Order, Energy, PV15	0.2024				0.0137	
Order, Energy, PV30	0.2090				0.0259	
Order, Energy, PV45	0.7122				0.1687	
Order, B20	0.2330	0.0643	0.0082	0.0087	0.0089	0.0002
Order, R.ELCC, B20	0.2228	0.0551	0.0106	0.0120	0.0146	0.0017

1 in 10 Summary

- Empty cells represent year and scenario combinations that were not run.

Scenario Name	2022	2023	2024	2025	2026	2026+
No Build	2,372	2,391	6,711	11,540	12,022	N/A
PSP	-	-	-	-	-	-
PSP, Gas	-	-	-	-	-	-
PSP, Gas, R.ELCC	90	-	-	-	-	-
PSP, No Ret.	-	-	-	-	-	-
PSP, Energy	-	-	-	-	-	-
Order	1,296	-	-	-	-	-
Order, 1200 Shift	122					
Order, 1300 Shift	74					
Order, 1400 Shift	88					
Order, 1600 Shift	-					
Order, 1800 Shift	-					
Order, 2000 Shift	-					
Order, Gas	1,305	-	-	-	-	-
Order, R.ELCC	1,350	-	-	-	-	-
Order, No Ret.	1,028	-	-	-	-	-
Order, Energy	1,338	-	-	-	-	-
Order, Energy, PV15	1,325				-	
Order, Energy, PV30	1,485				-	
Order, Energy, PV45	4,083				1,848	
Order, B20	1,685	-	-	-	-	-
Order, R.ELCC, B20	1,675	-	-	-	-	-

1 in 20 Summary

- Red cells are where the LOLE exceeds 0.1
- Yellow cells have an LOLE between 0.05 and 0.1
- Empty cells represent year and scenario combinations that were not run.

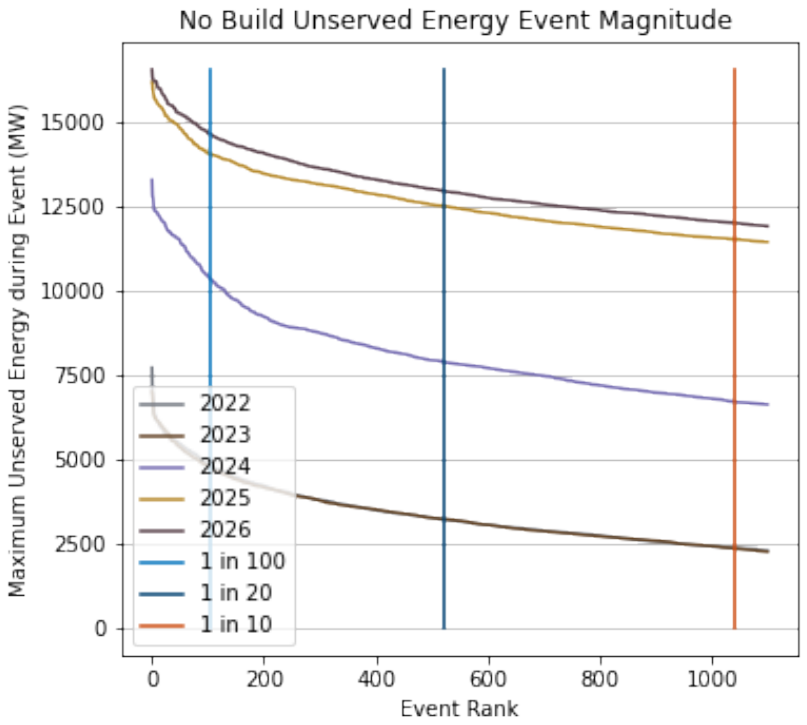
Scenario Name	2022	2023	2024	2025	2026	2026+
No Build	3,215	3,246	7,893	12,525	12,968	N/A
PSP	620	-	-	-	-	-
PSP, Gas	668	-	-	-	-	-
PSP, Gas, R.ELCC	982	-	-	-	-	-
PSP, No Ret.	242	-	-	-	-	-
PSP, Energy	447	-	-	-	-	-
Order	2,196	-	-	-	-	-
Order, 1200 Shift	1,010					
Order, 1300 Shift	938					
Order, 1400 Shift	908					
Order, 1600 Shift	543					
Order, 1800 Shift	431					
Order, 2000 Shift	202					
Order, Gas	2,153	-	-	271	930	-
Order, R.ELCC	2,314	-	-	-	-	-
Order, No Ret.	1,932	-	-	-	-	-
Order, Energy	2,223	-	-	-	-	-
Order, Energy, PV15	2,199				-	
Order, Energy, PV30	2,374				-	
Order, Energy, PV45	4,872				9,216	
Order, B20	2,546	315	-	-	-	-
Order, R.ELCC, B20	2,453	98	-	-	-	-

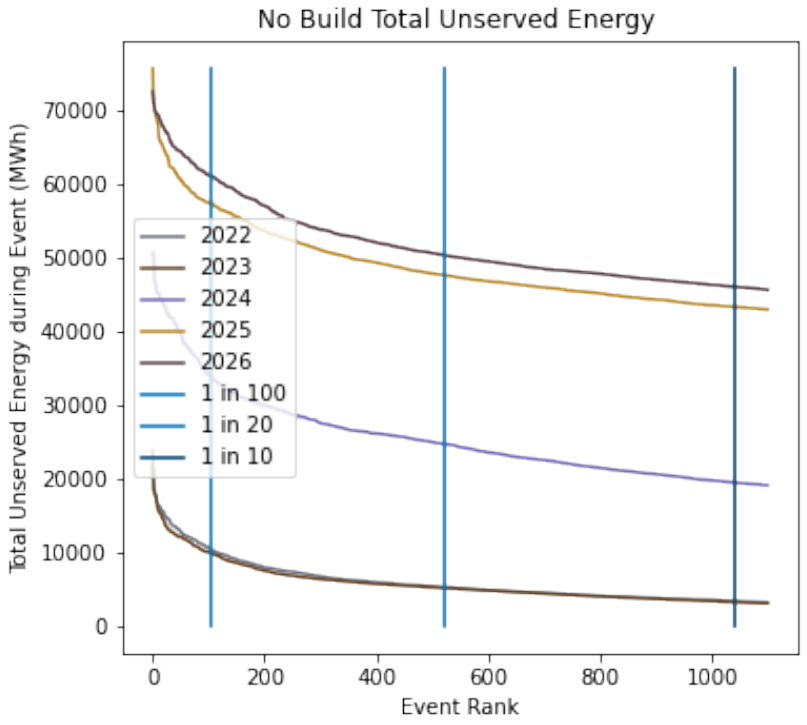
1 in 100 Summary

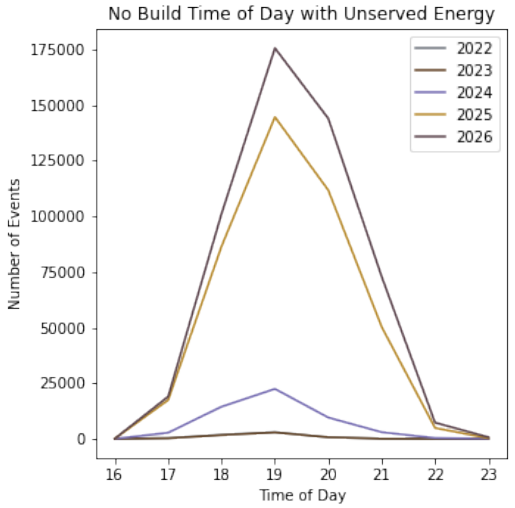
- Empty cells represent year and scenario combinations that were not run.

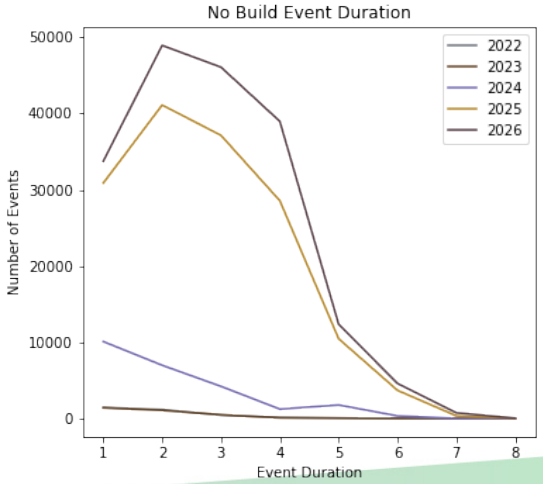
Scenario Name	2022	2023	2024	2025	2026	2026+
No Build	4,817	4,774	10,351	14,065	14,662	N/A
PSP	2,253	-	-	-	-	-
PSP, Gas	2,192	393	-	1,301	1,427	-
PSP, Gas, R.ELCC	2,774	184	-	25	658	-
PSP, No Ret.	2,016	-	-	-	-	-
PSP, Energy	2,015	-	-	-	-	-
Order	3,753	1,468	-	-	377	-
Order, 1200 Shift	2,702					
Order, 1300 Shift	2,652					
Order, 1400 Shift	2,691					
Order, 1600 Shift	2,062					
Order, 1800 Shift	1,945					
Order, 2000 Shift	1,805					
Order, Gas	3,781	1,632	44	1,893	2,533	855
Order, R.ELCC	4,021	1,259	-	-	495	-
Order, No Ret.	3,580	948	-	-	-	-
Order, Energy	3,785	1,477	-	-	333	-
Order, Energy, PV15	3,871				960	
Order, Energy, PV30	4,265				6,387	
Order, Energy, PV45	6,614				15,302	
Order, B20	4,146	1,991	-	-	-	-
Order, R.ELCC, B20	3,995	1,865	69	171	428	-

No Build



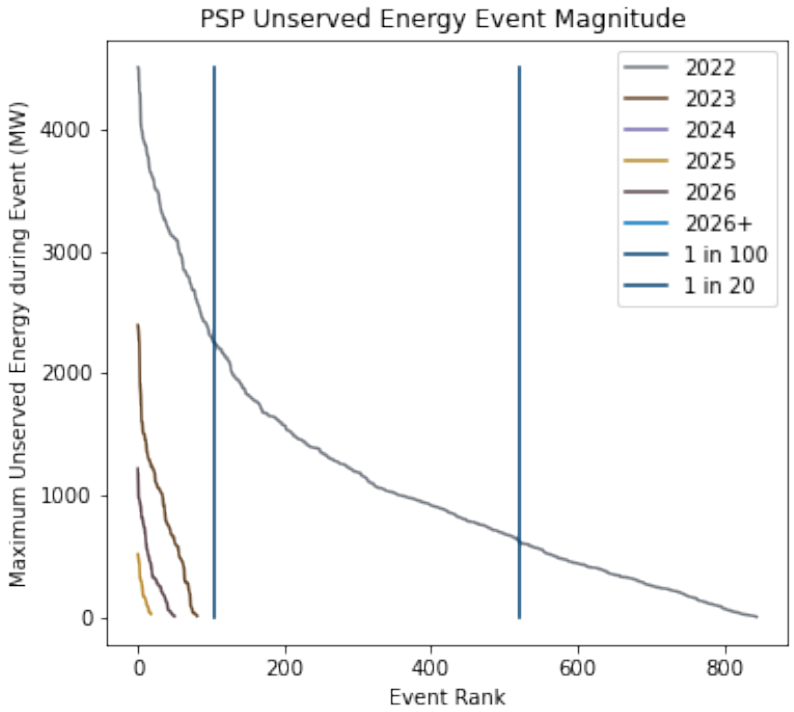


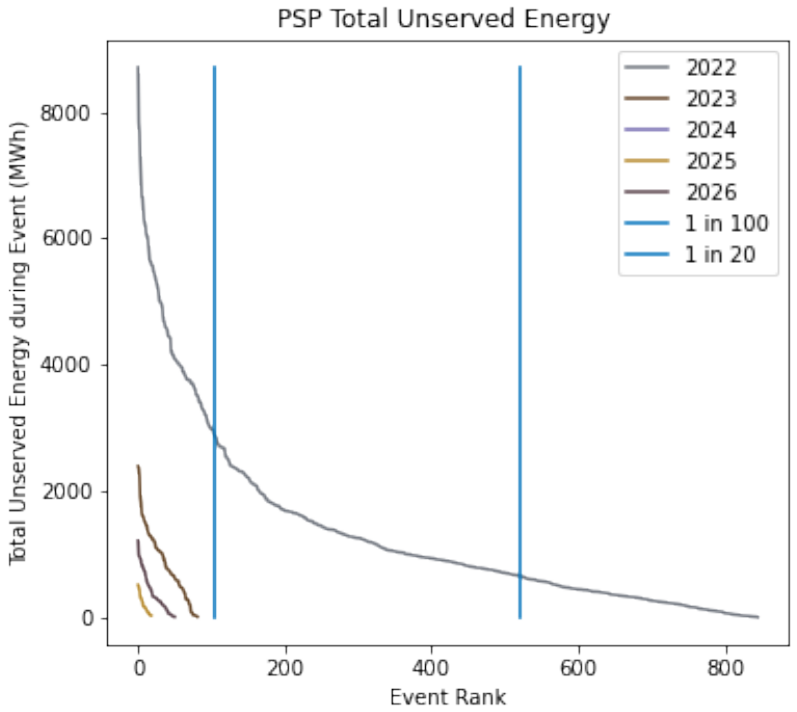


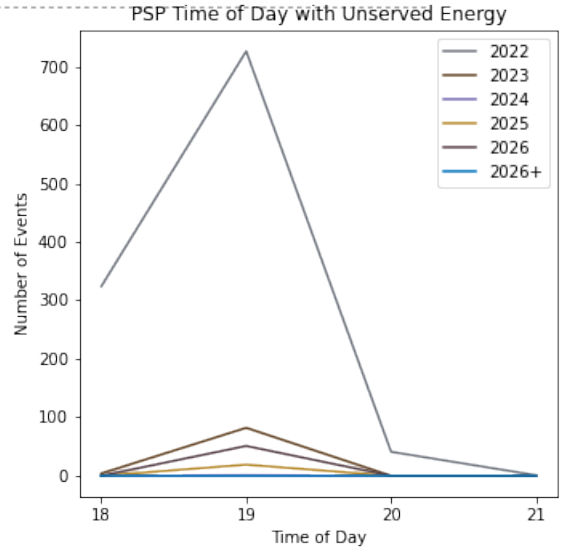


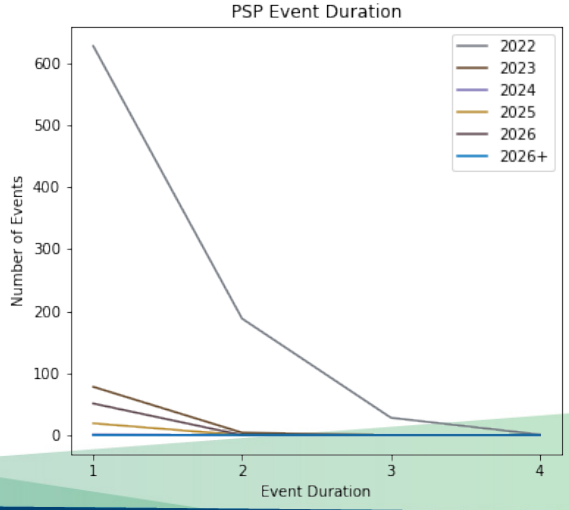
Value	2022	2023	2024	2025	2026	2026+
LOLE	0.3114	0.3031	2.3689	14.6389	17.8386	N/A
1 in 10	2,372	2,391	6,711	11,540	12,022	N/A
1 in 20	3,215	3,246	7,893	12,525	12,968	N/A
1 in 100	4,817	4,774	10,351	14,065	14,662	N/A

PSP



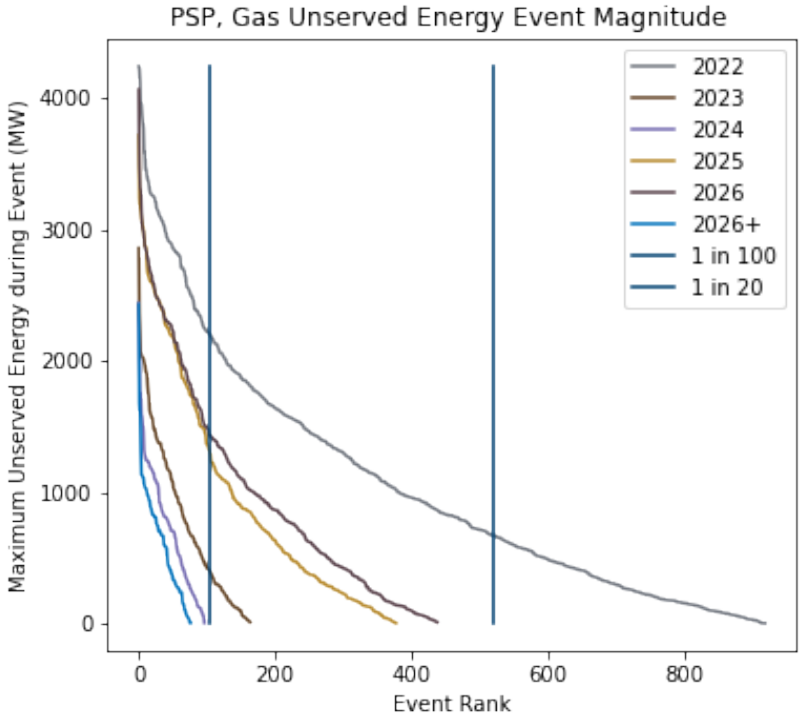


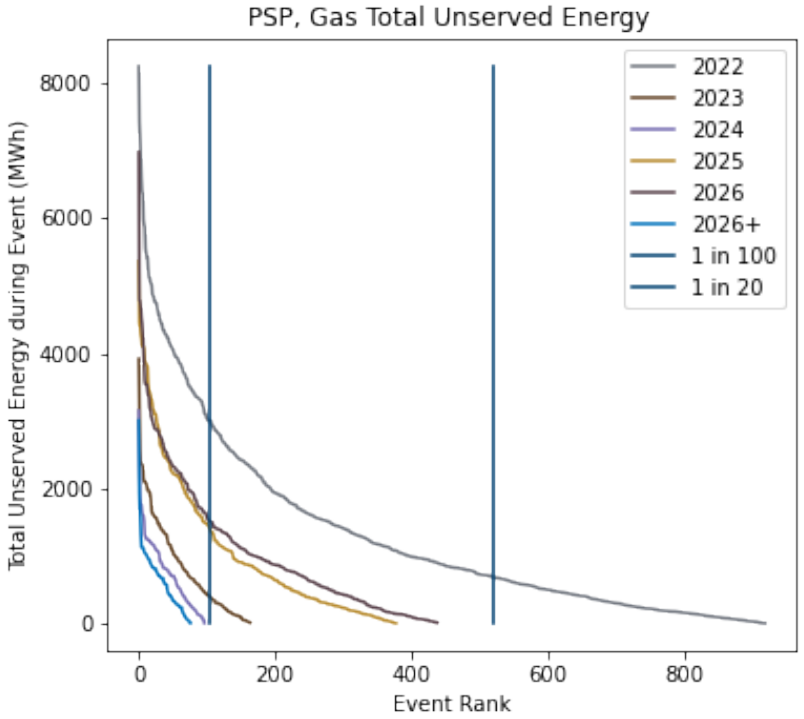


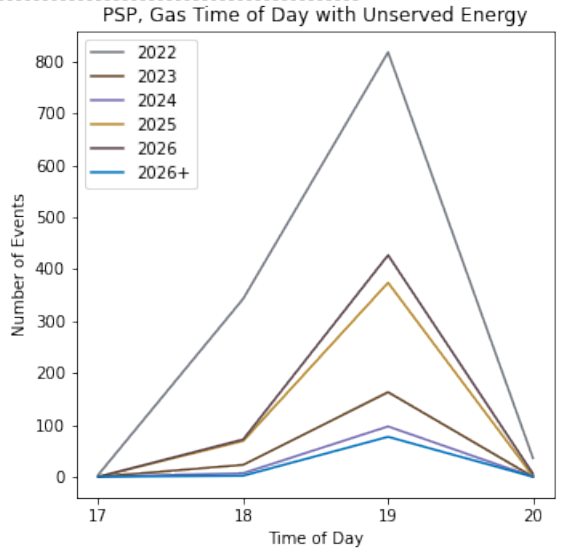


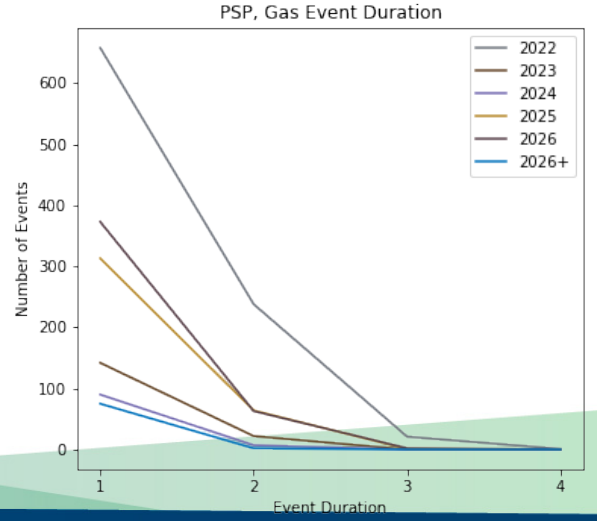
Value	2022	2023	2024	2025	2026	2026+
LOLE	0.0813	0.0079	0.0001	0.0018	0.0049	-
1 in 10	-	-	-	-	-	-
1 in 20	620	-	-	-	-	-
1 in 100	2,253	-	-	-	-	-

PSP, Gas



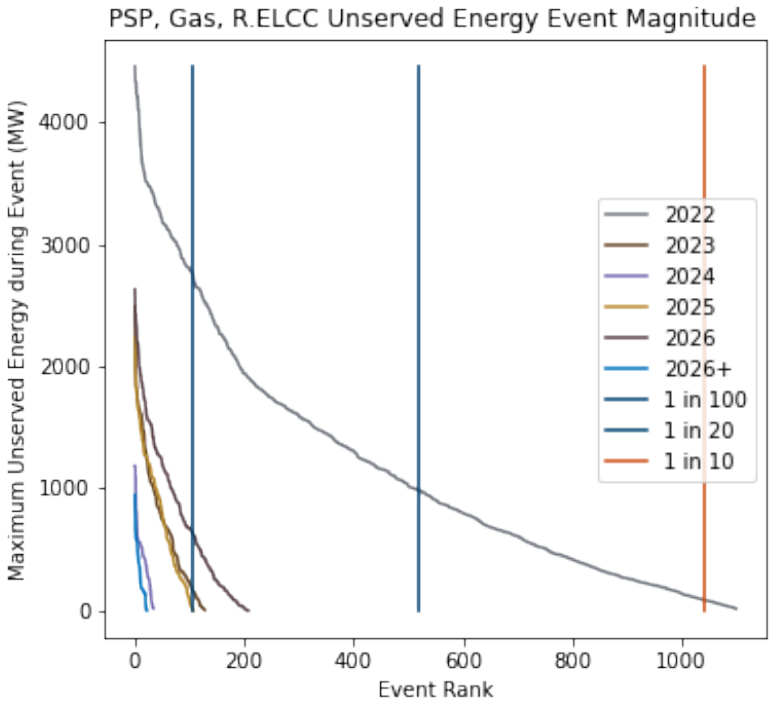


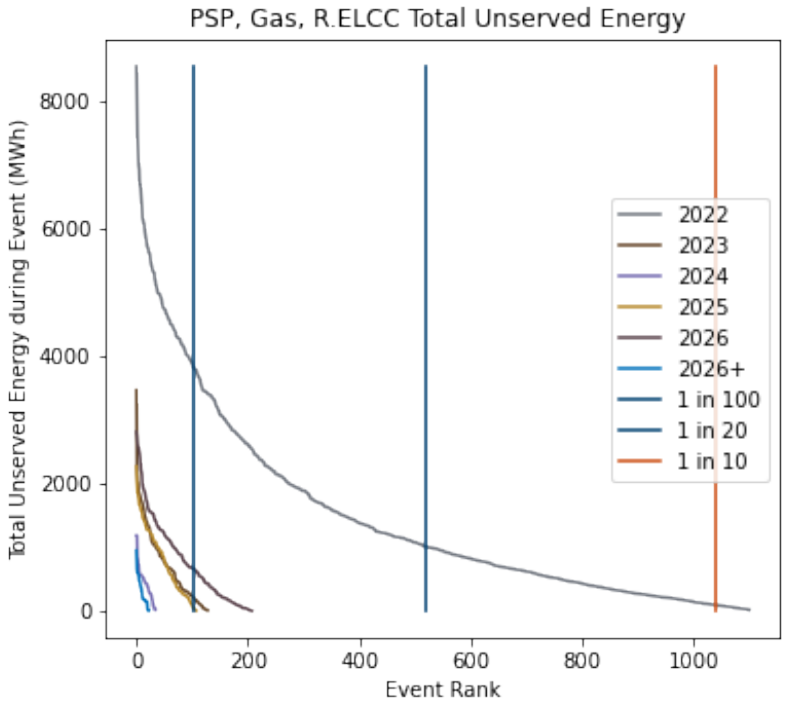


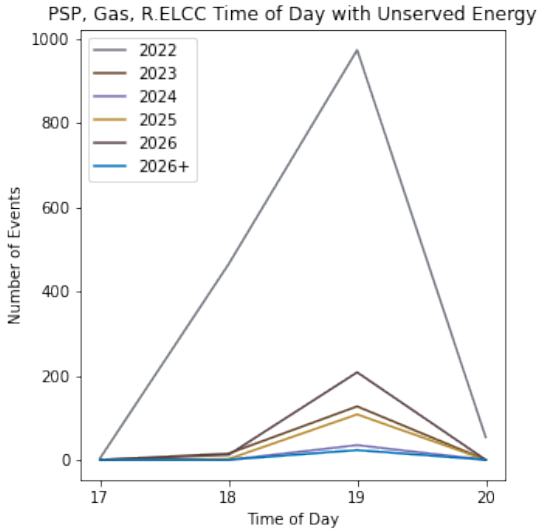


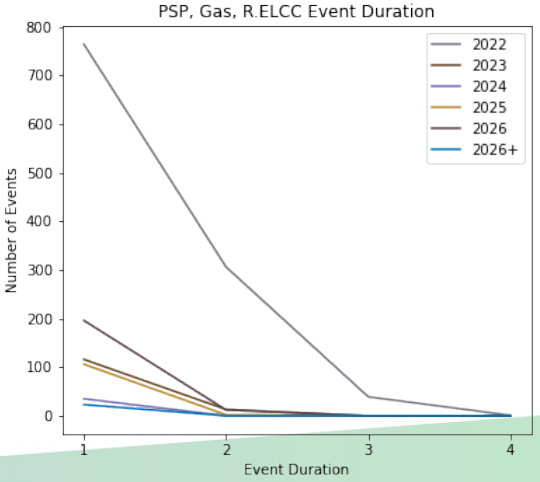
Value	2022	2023	2024	2025	2026	2026+
LOLE	0.0883	0.0158	0.0093	0.0363	0.0421	0.0074
1 in 10	-	-	-	-	-	-
1 in 20	668	-	-	-	-	-
1 in 100	2,192	393	-	1,301	1,427	-

PSP, Gas, R.ELCC



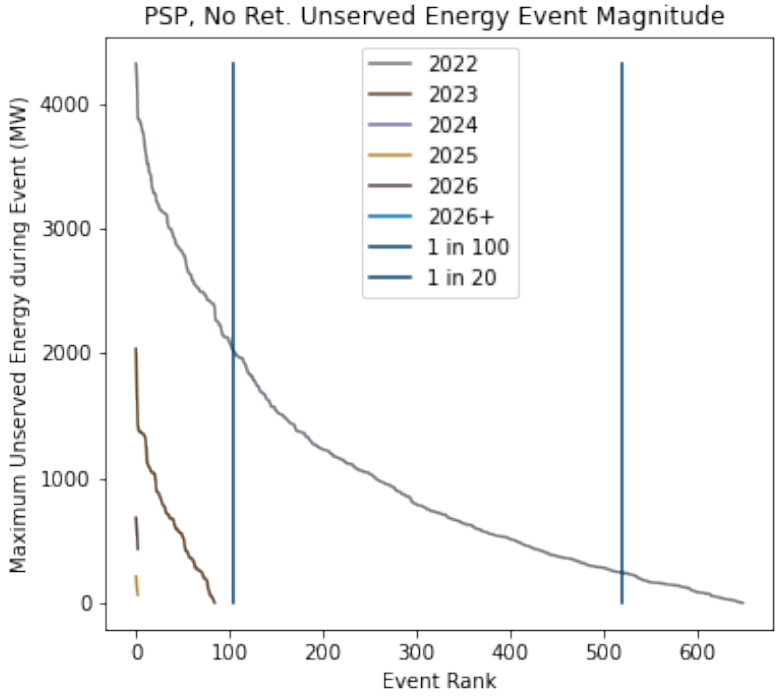


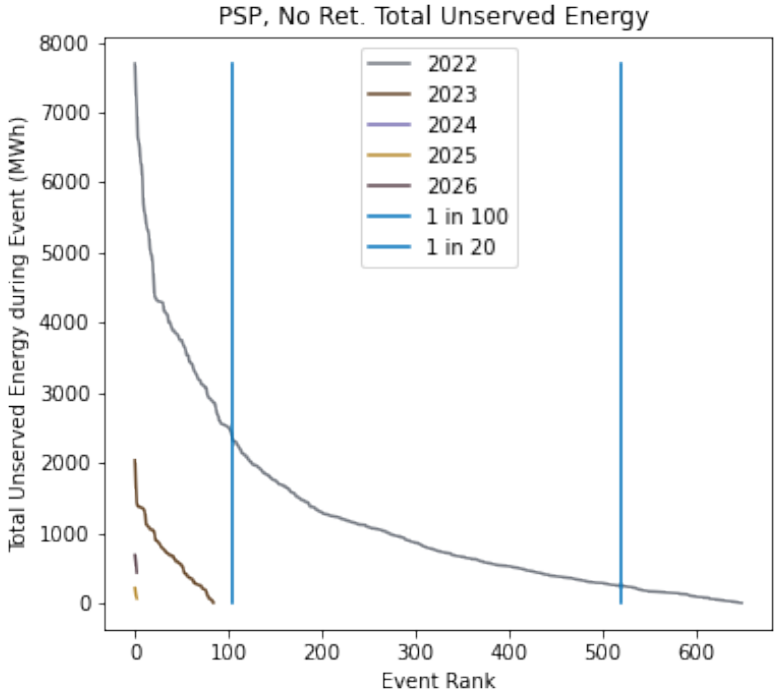


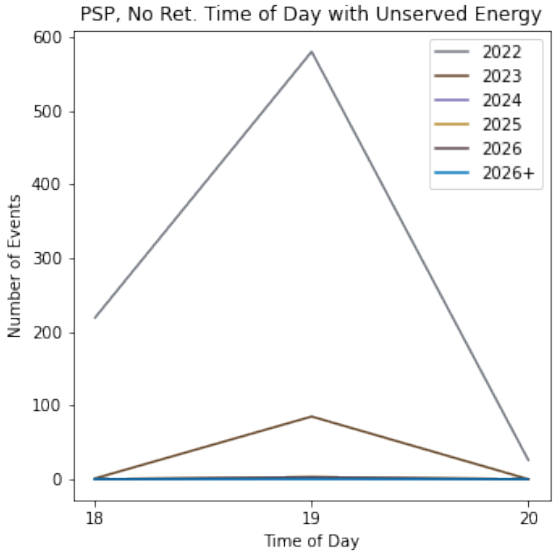


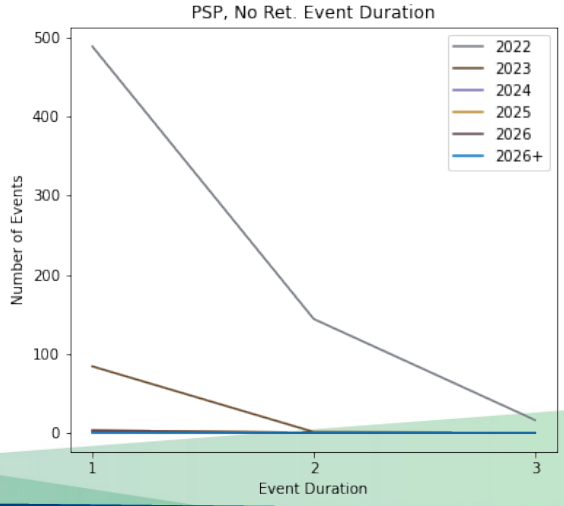
Value	2022	2023	2024	2025	2026	2026+
LOLE	0.1067	0.0124	0.0034	0.0104	0.0200	0.0022
1 in 10	90	-	-	-	-	-
1 in 20	982	-	-	-	-	-
1 in 100	2,774	184	-	25	658	-

PSP, No Ret.



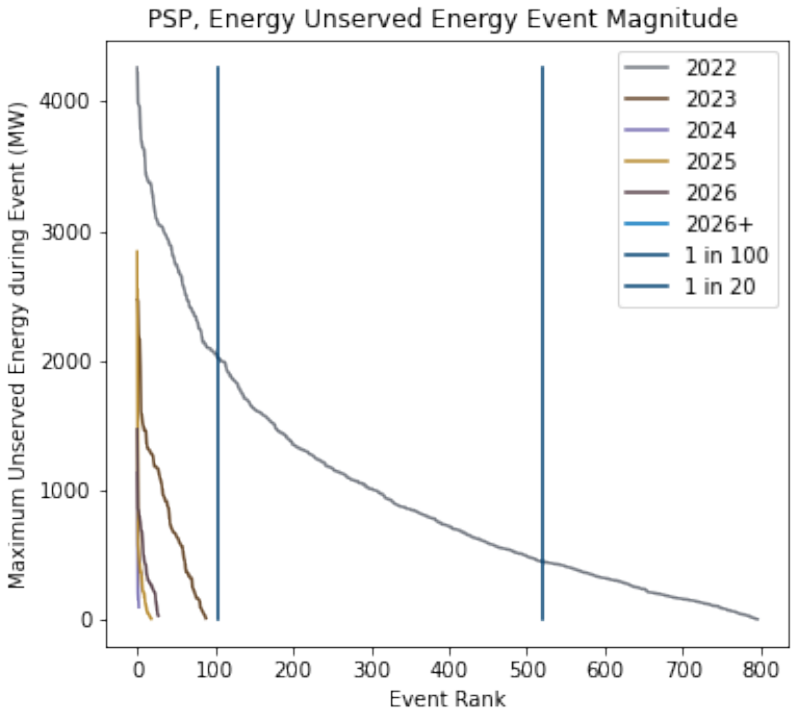


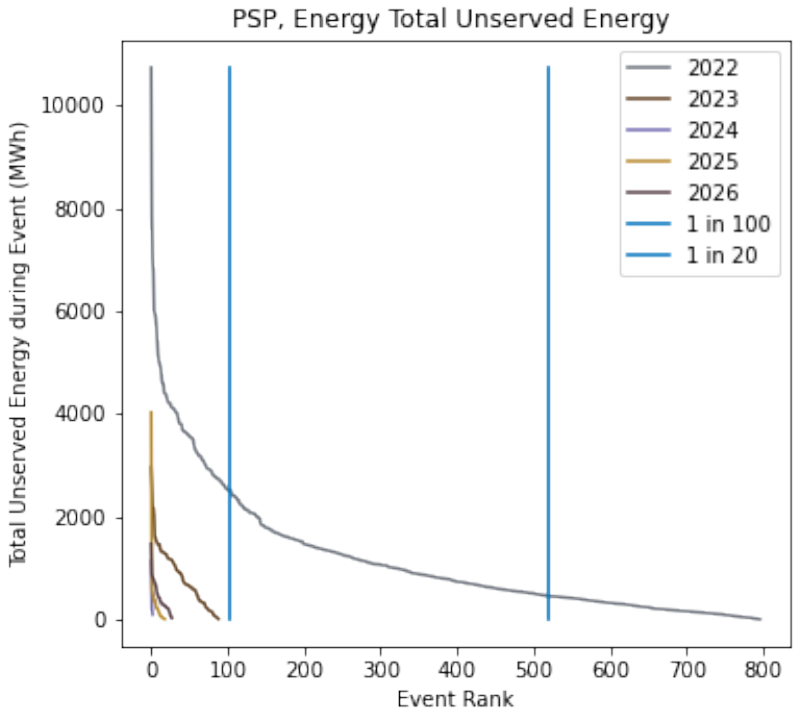


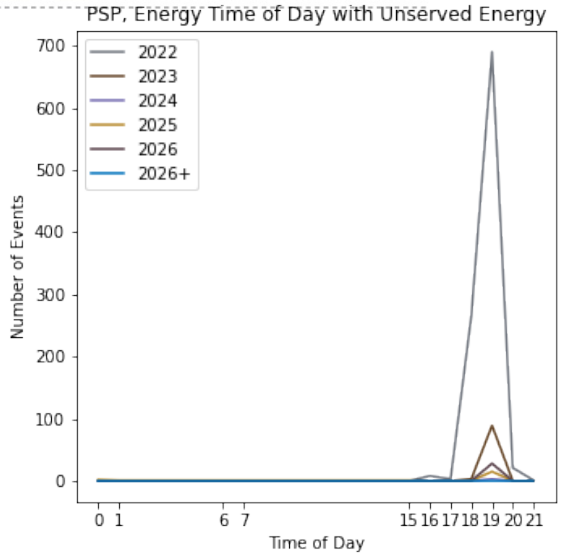


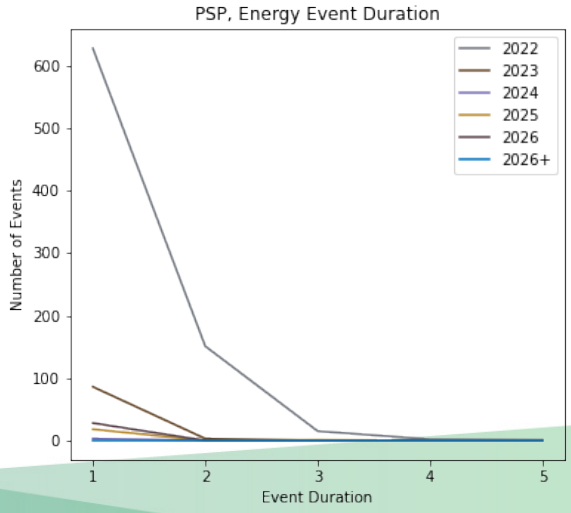
Value	2022	2023	2024	2025	2026	2026+
LOLE	0.0624	0.0082	0.0001	0.0003	0.0003	-
1 in 10	-	-	-	-	-	-
1 in 20	242	-	-	-	-	-
1 in 100	2,016	-	-	-	-	-

PSP, Energy



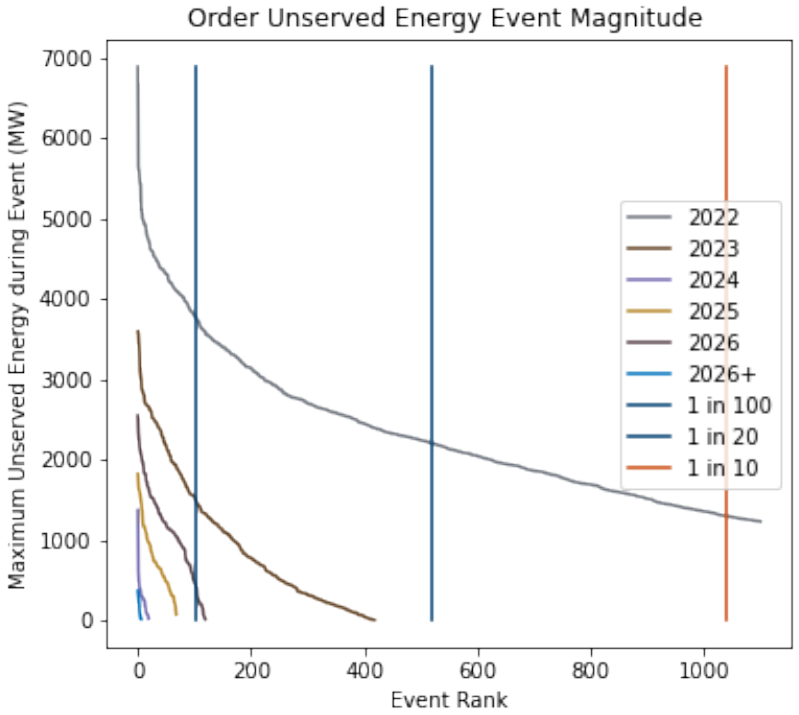


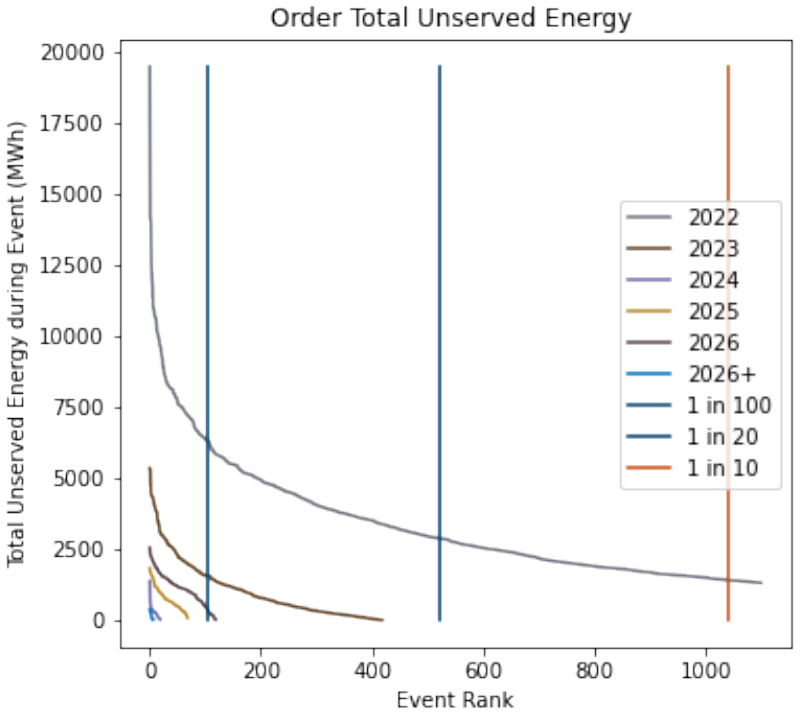


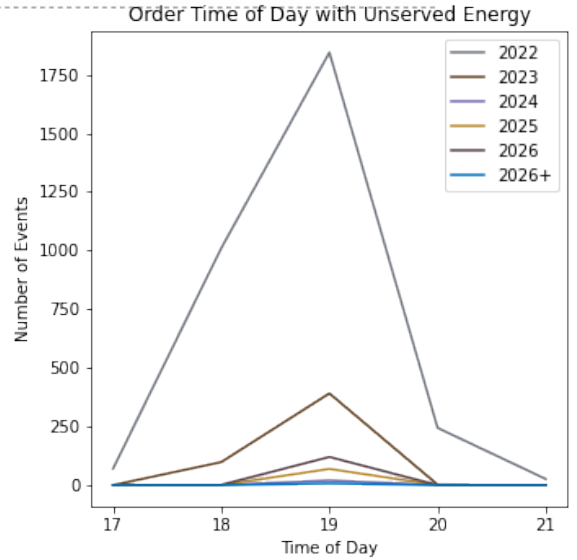


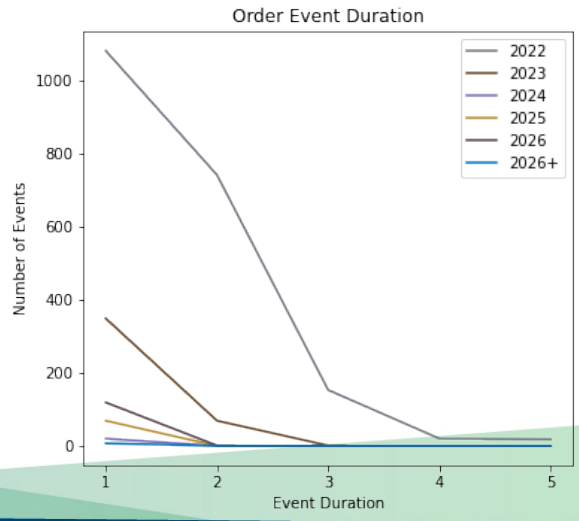
Value	2022	2023	2024	2025	2026	2026+
LOLE	0.0766	0.0086	0.0003	0.0018	0.0027	-
1 in 10	-	-	-	-	-	-
1 in 20	447	-	-	-	-	-
1 in 100	2,015	-	-	-	-	-

Order



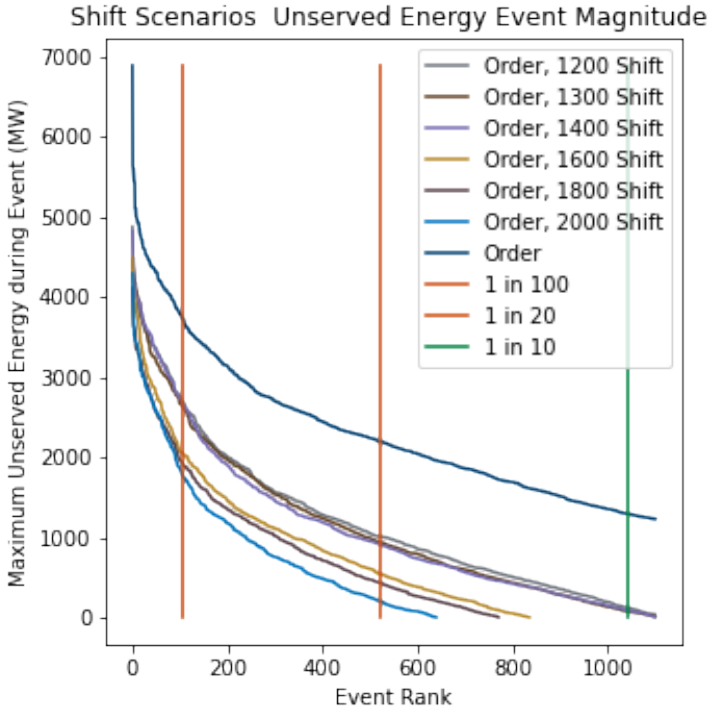


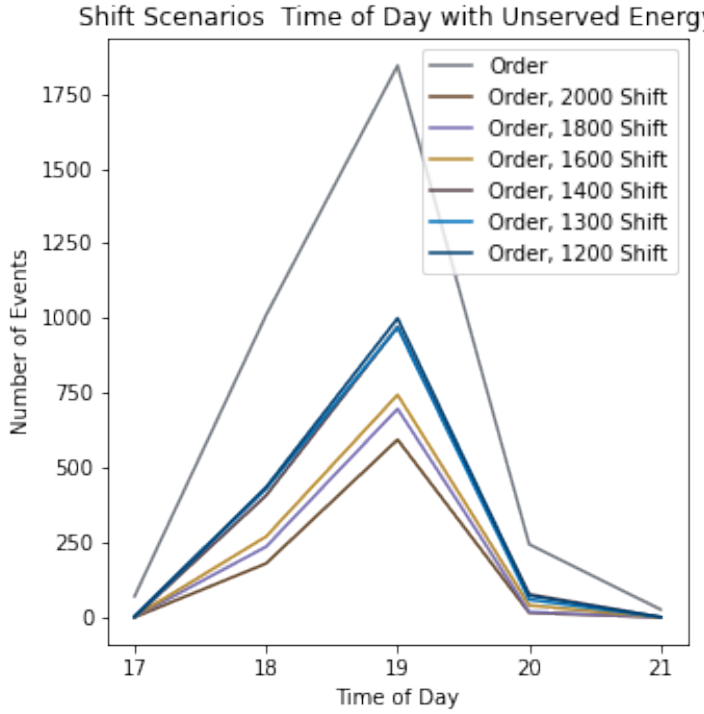


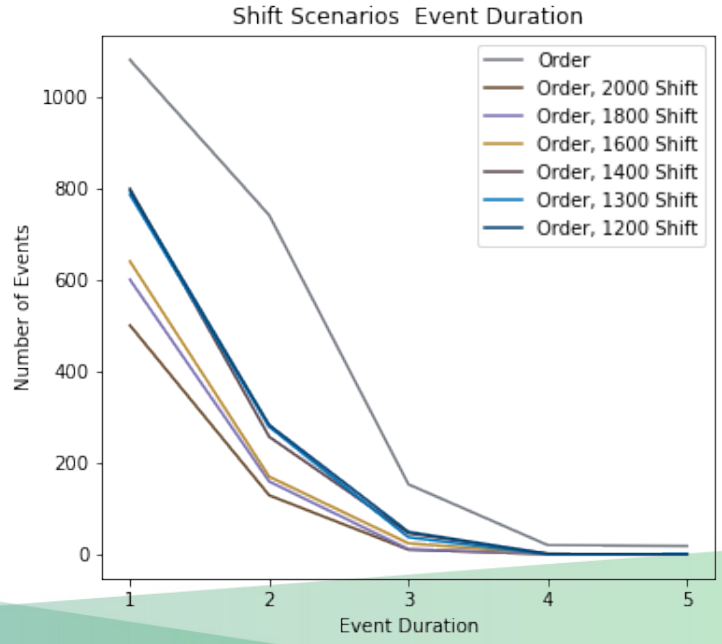


Value	2022	2023	2024	2025	2026	2026+
LOLE	0.1938	0.0403	0.0019	0.0066	0.0115	0.0007
1 in 10	1,296	-	-	-	-	-
1 in 20	2,196	-	-	-	-	-
1 in 100	3,753	1,468	-	-	377	-

Order, # Shift (2022 only)

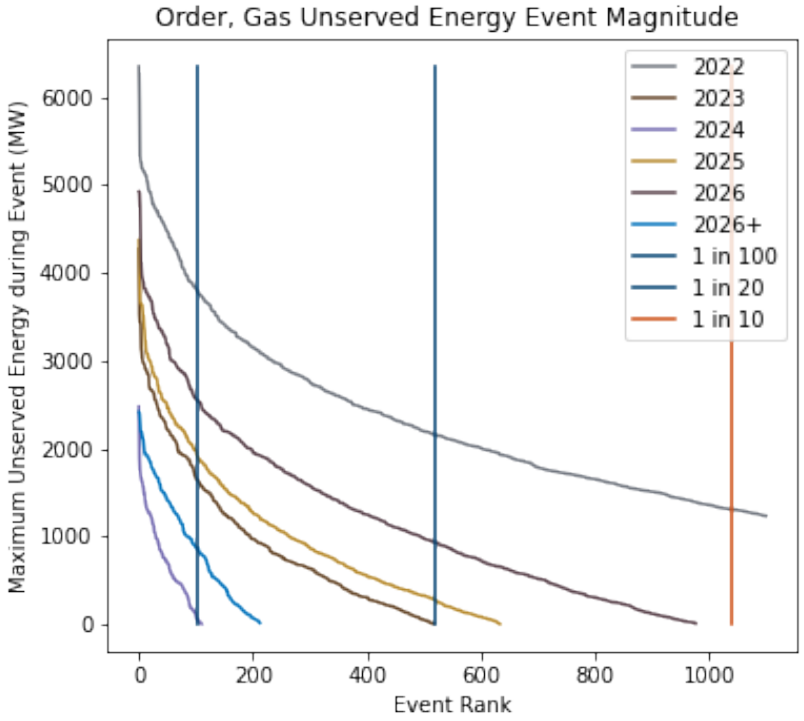


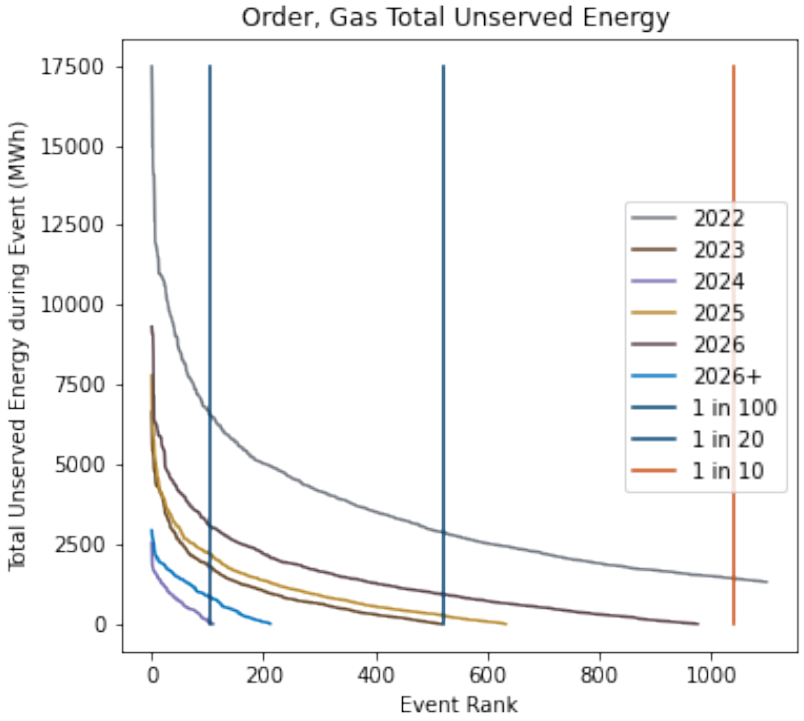


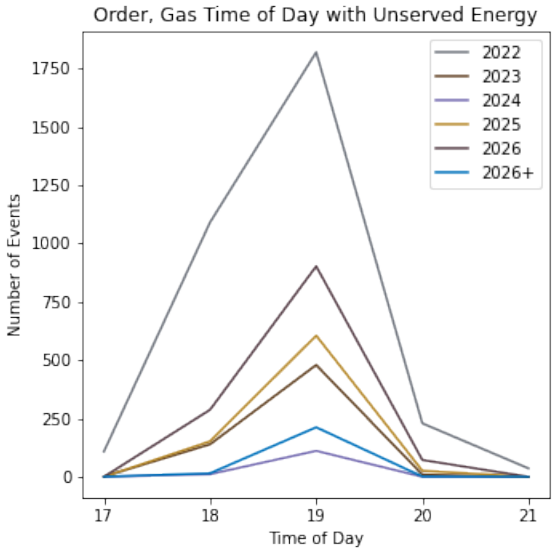


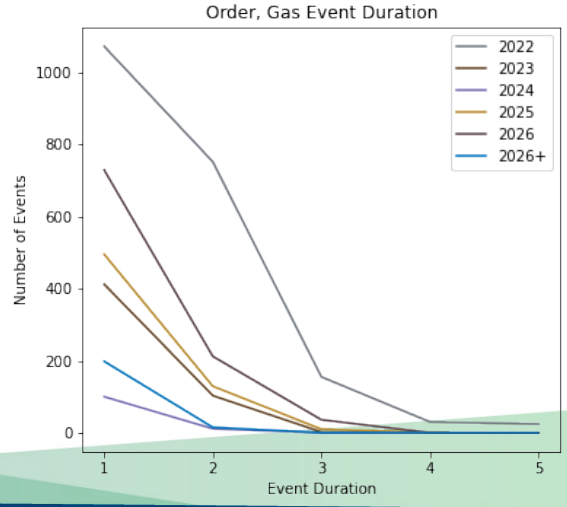
2022	1,200 MW	1,300 MW	1,400 MW	1,600 MW	1,800 Mw	2,000 MW
LOLE	0.1086	0.1062	0.1062	0.0804	0.0741	0.0615
1 in 10	122	74	88	-	-	-
1 in 20	1,010	938	908	543	431	202
1 in 100	2,702	2,652	2,691	2,062	1,945	1,805

Order, Gas



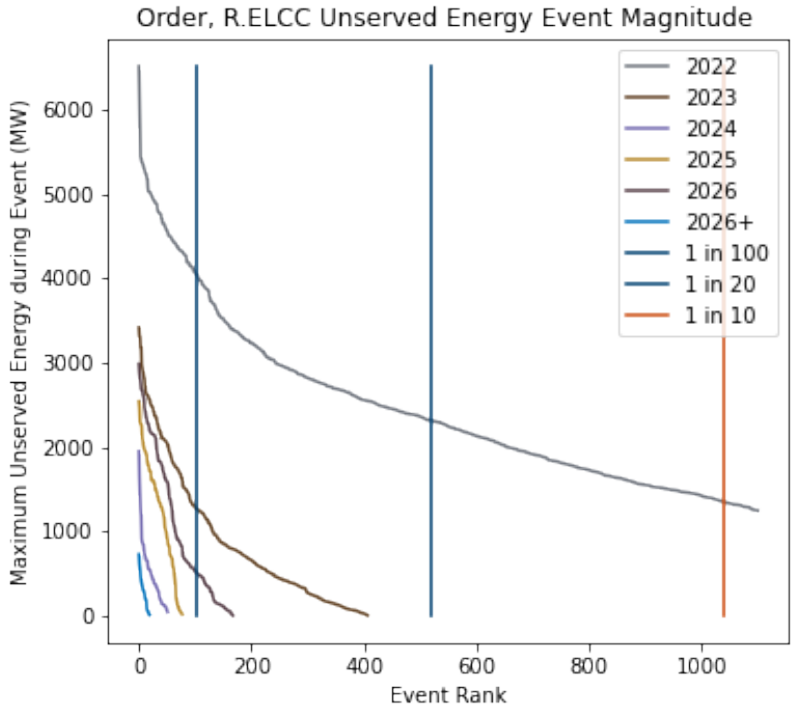


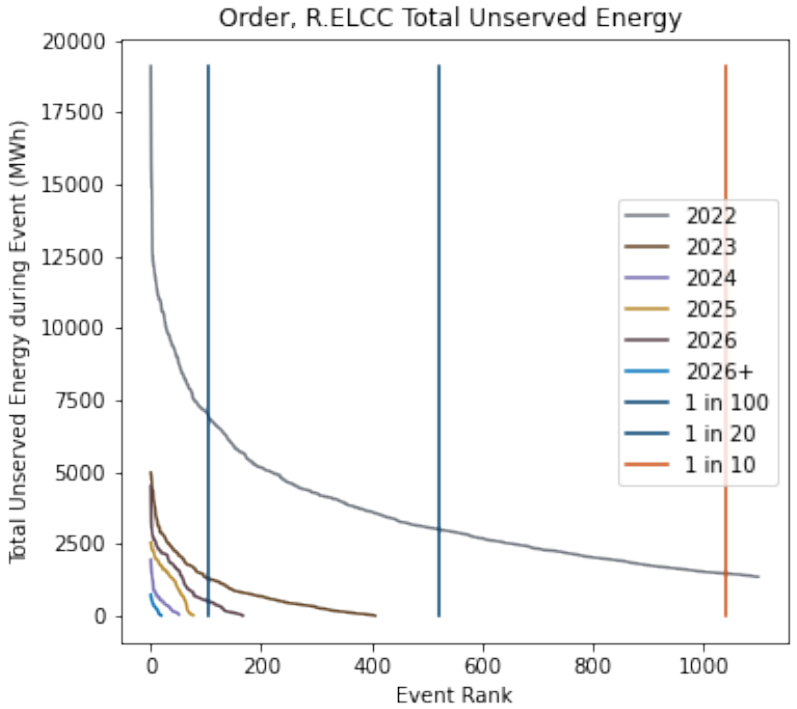


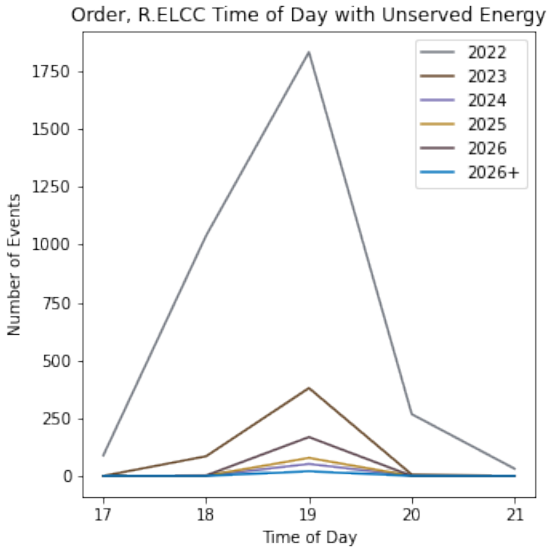


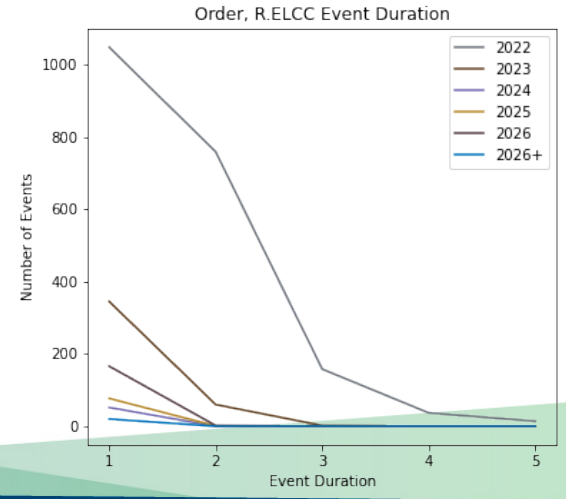
Value	2022	2023	2024	2025	2026	2026+
LOLE	0.1955	0.0498	0.0107	0.0610	0.0939	0.0205
1 in 10	1,305	-	-	-	-	-
1 in 20	2,153	-	-	271	930	-
1 in 100	3,781	1,632	44	1,893	2,533	855

Order, R.ELCC



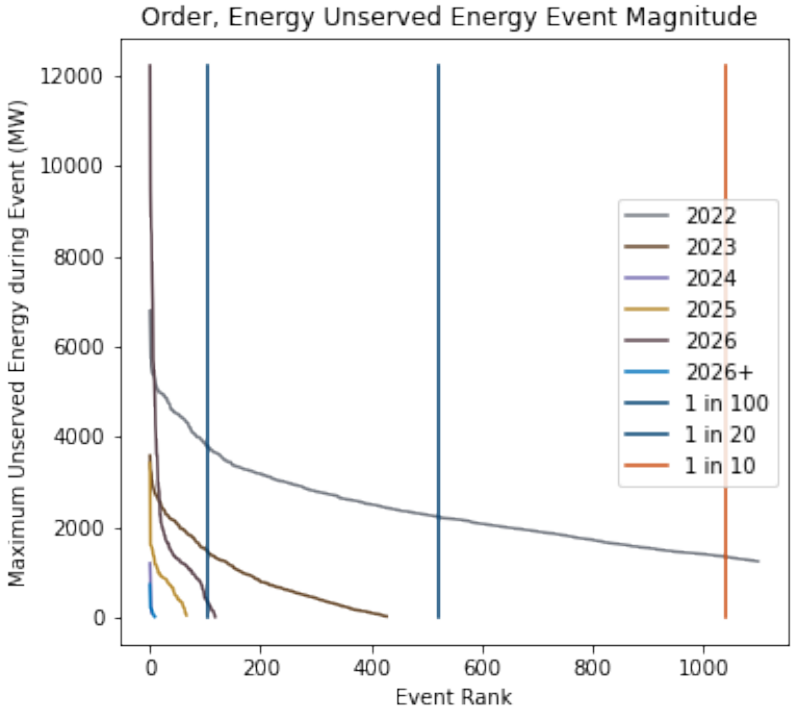


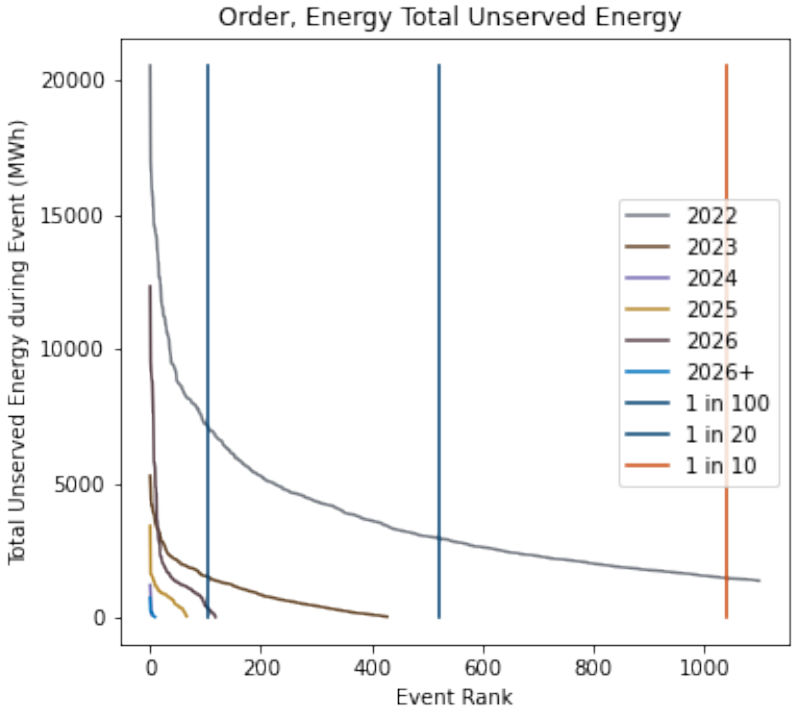


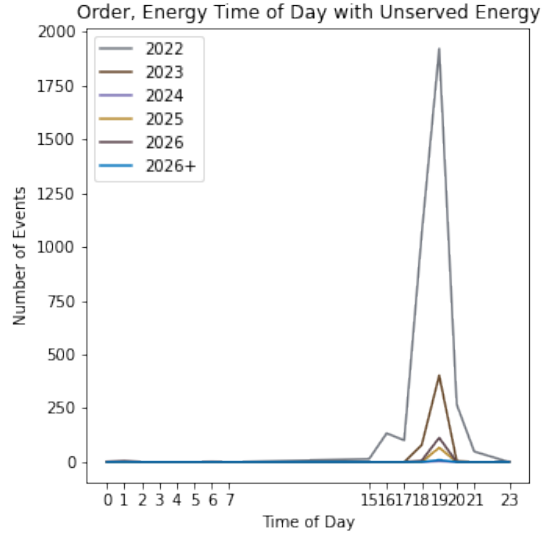


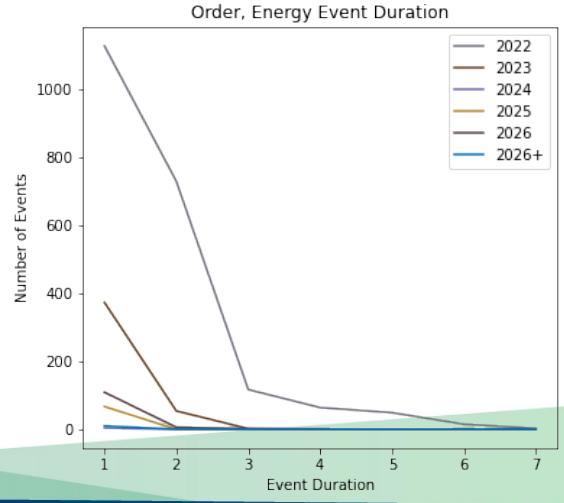
Value	2022	2023	2024	2025	2026	2026+
LOLE	0.1938	0.0391	0.0050	0.0075	0.0162	0.0019
1 in 10	1,350	-	-	-	-	-
1 in 20	2,314	-	-	-	-	-
1 in 100	4,021	1,259	-	-	495	-

Order, Energy



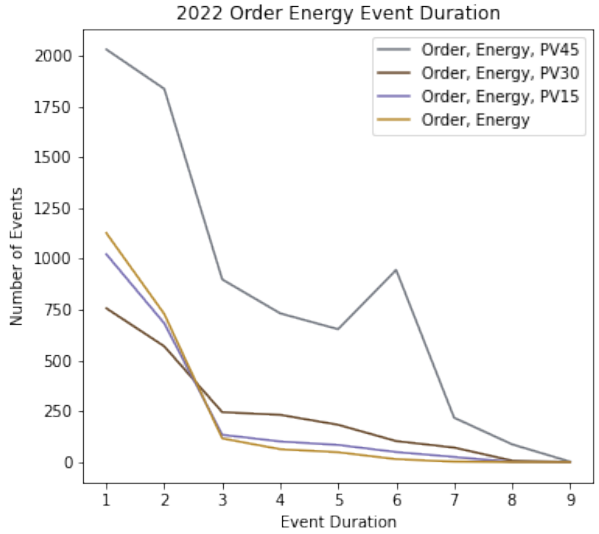




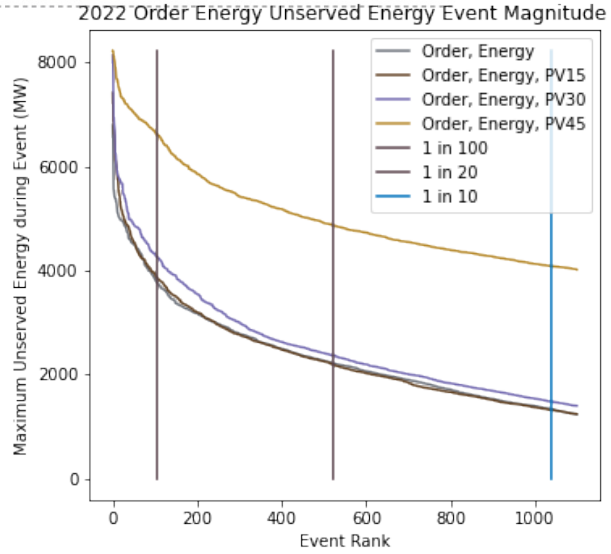


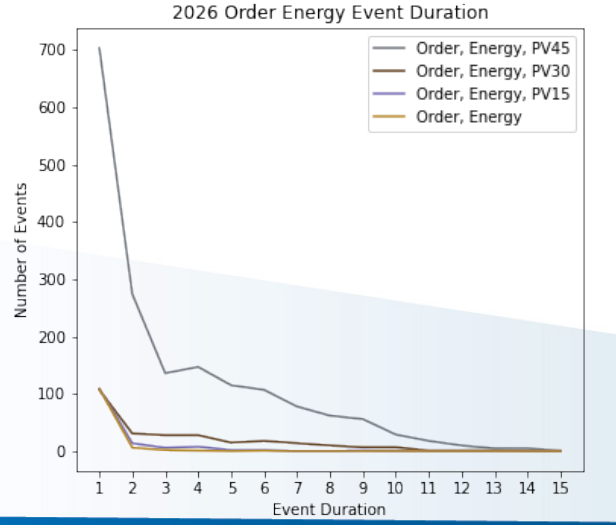
Value	2022	2023	2024	2025	2026	2026+
LOLE	0.2023	0.0413	0.0004	0.0064	0.0114	0.0010
1 in 10	1,338	-	-	-	-	-
1 in 20	2,223	-	-	-	-	-
1 in 100	3,785	1,477	-	-	333	-

Order, Energy, PV# (2022 and 2026 Only)

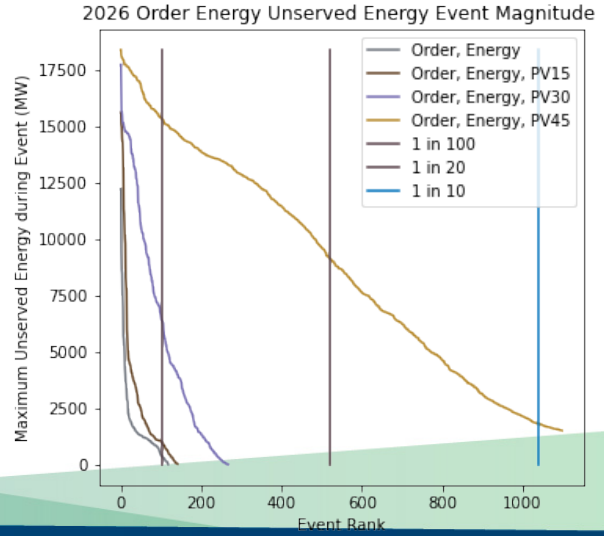


2022	PV0	PV15	PV30	PV45
LOLE	0.2023	0.2024	0.2090	0.7122
1 in 10	1,338	1,325	1,485	4,083
1 in 20	2,223	2,199	2,374	4,872
1 in 100	3,785	3,871	4,265	6,614

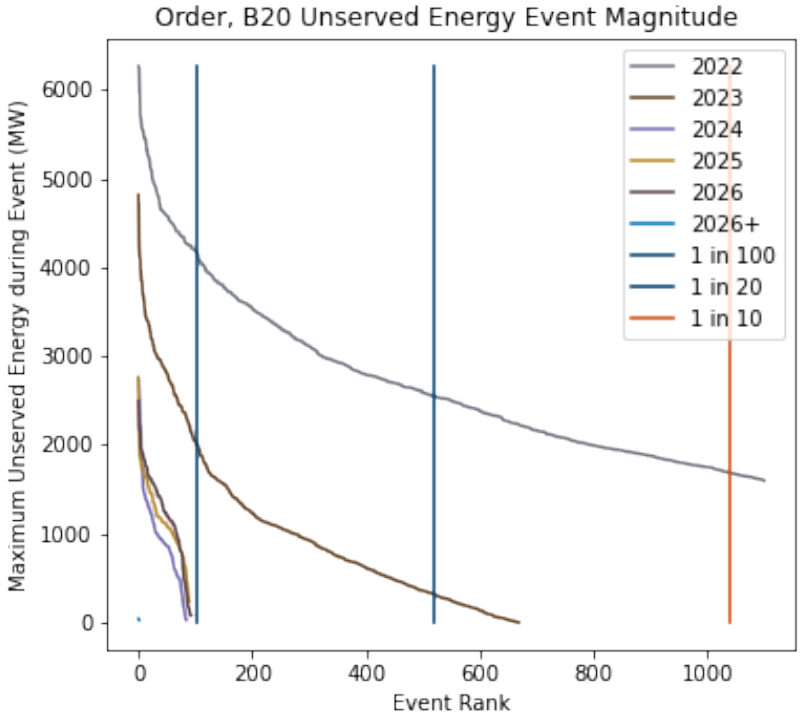


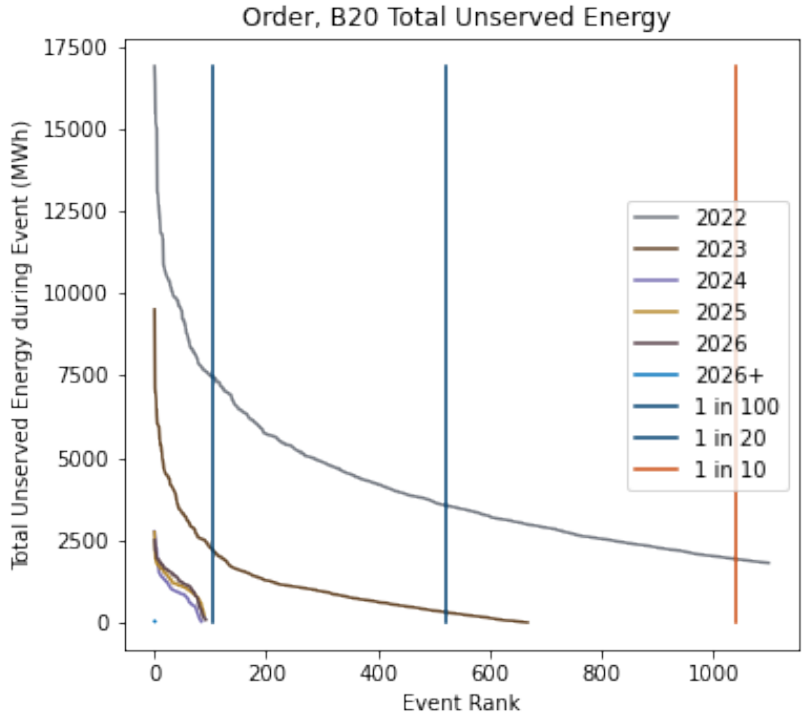


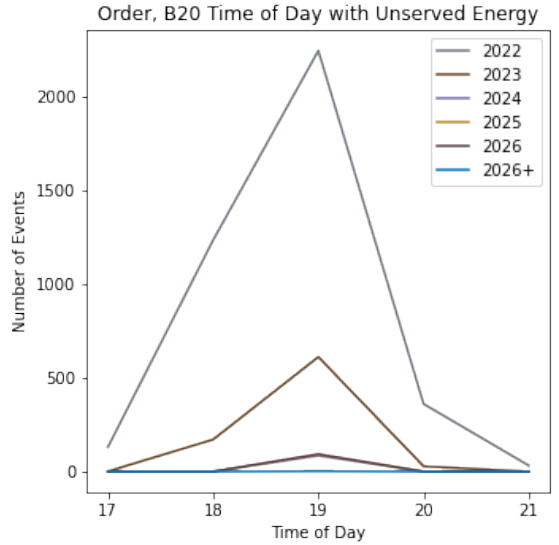
2026	PV0	PV15	PV30	PV45
LOLE	0.0114	0.0137	0.0259	0.1687
1 in 10	-	-	-	1,848
1 in 20	-	-	-	9,216
1 in 100	333	960	6,387	15,302

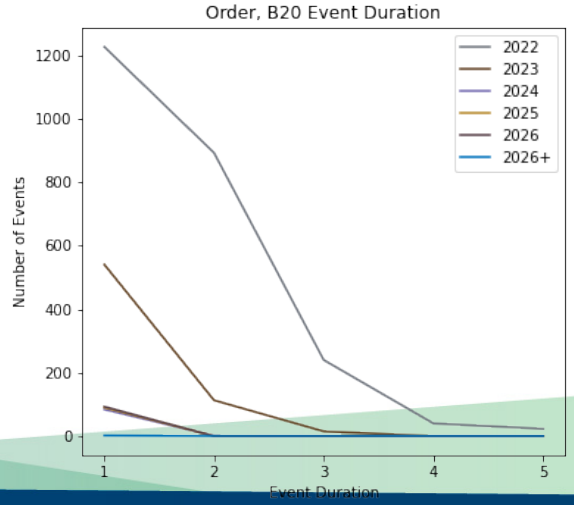


Order, B20



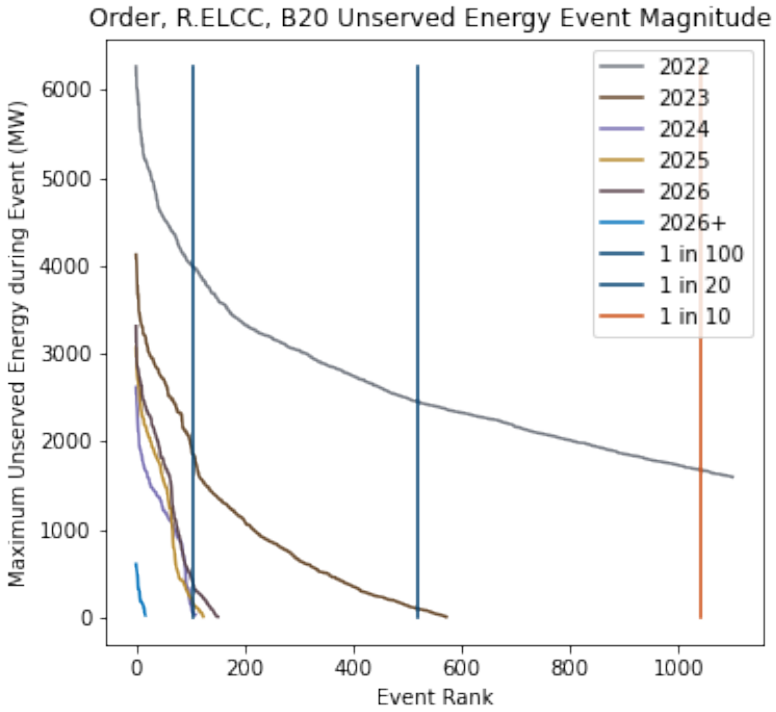


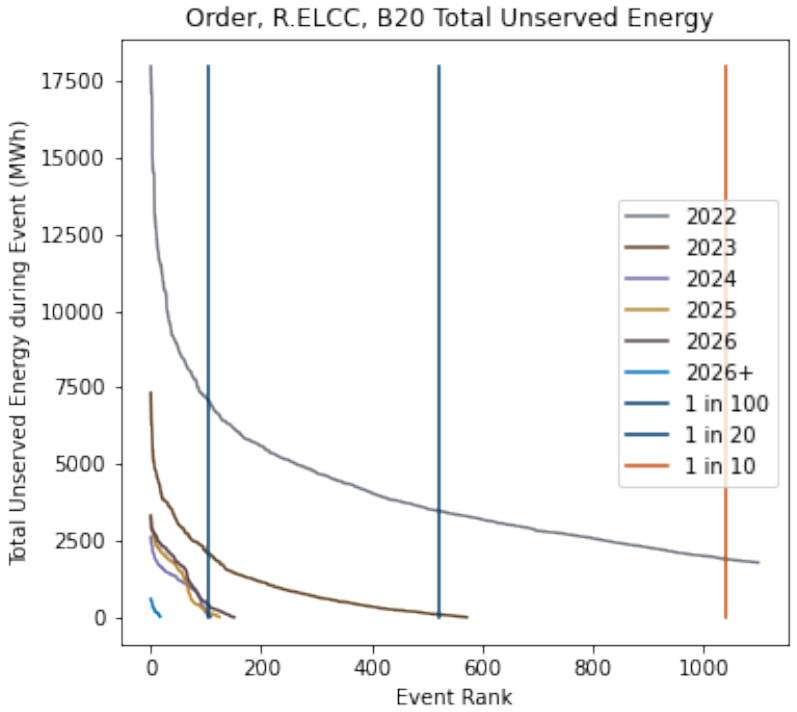


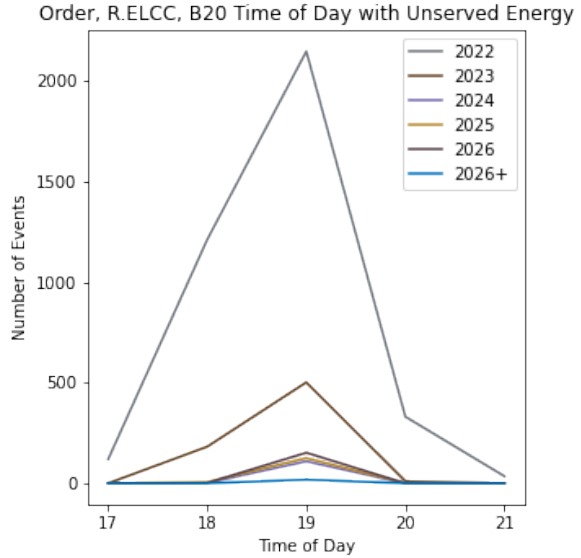


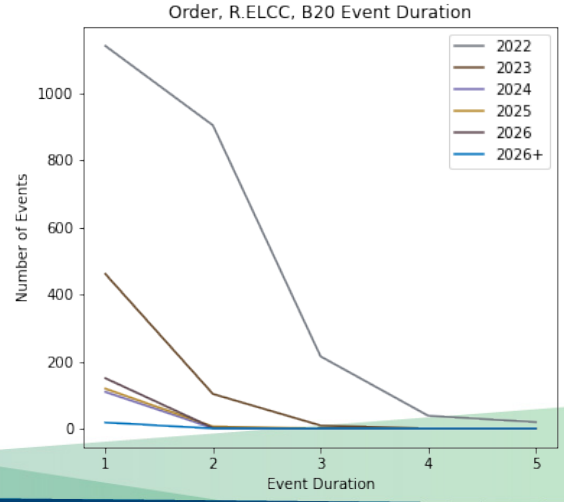
Value	2022	2023	2024	2025	2026	2026+
LOLE	0.2330	0.0643	0.0082	0.0087	0.0089	0.0002
1 in 10	1,685	-	-	-	-	-
1 in 20	2,546	315	-	-	-	-
1 in 100	4,146	1,991	-	-	-	-

Order, R.ELCC, B20



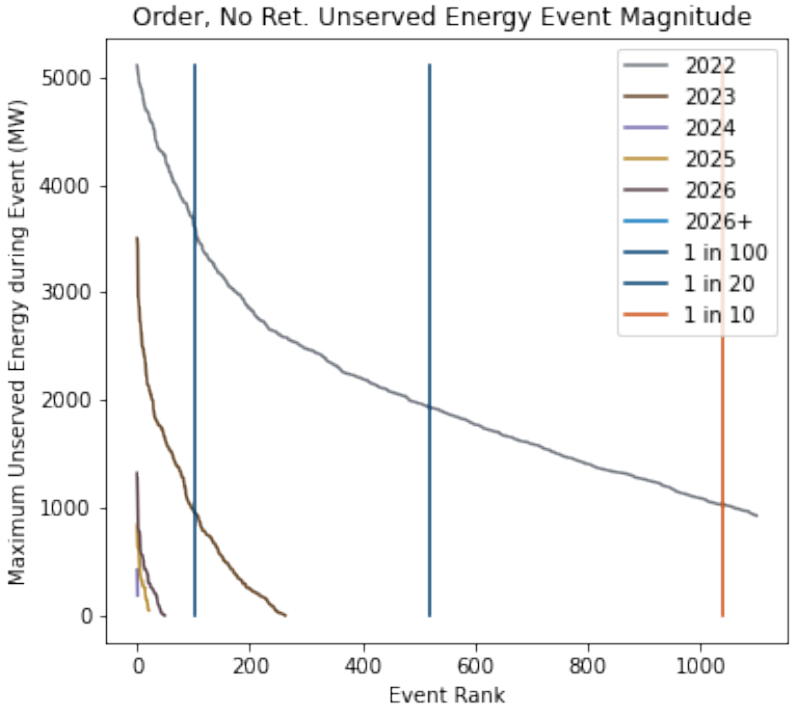


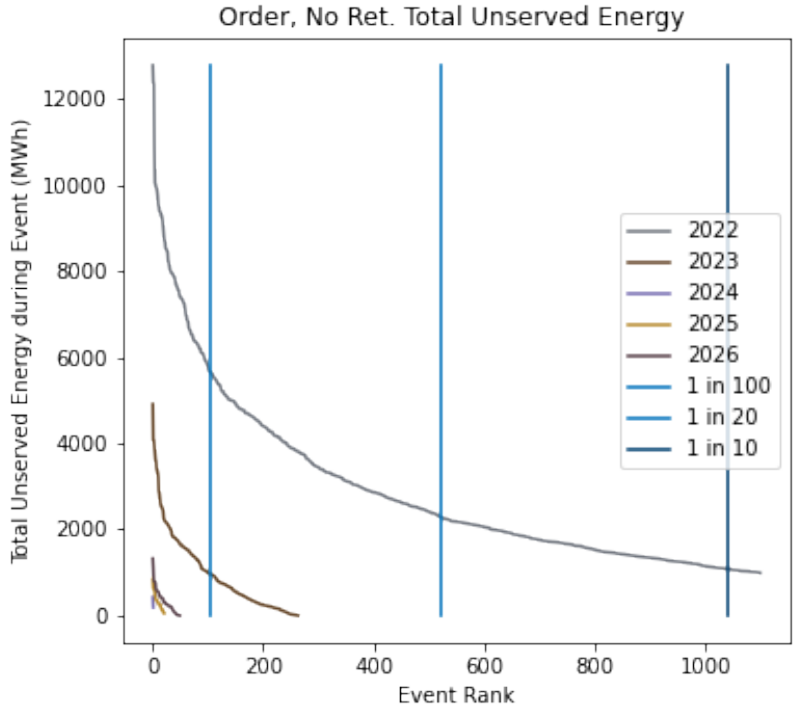


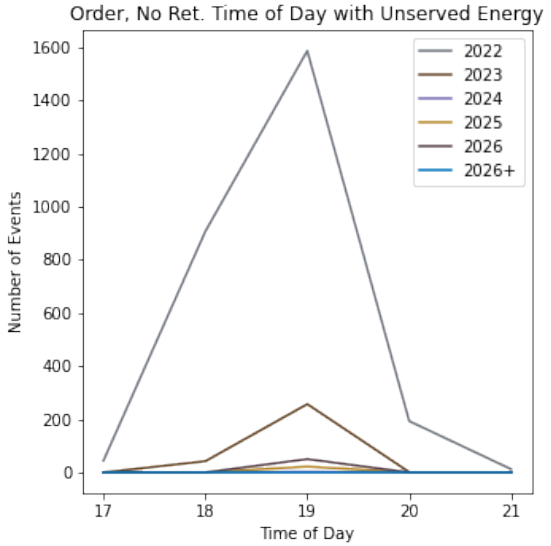


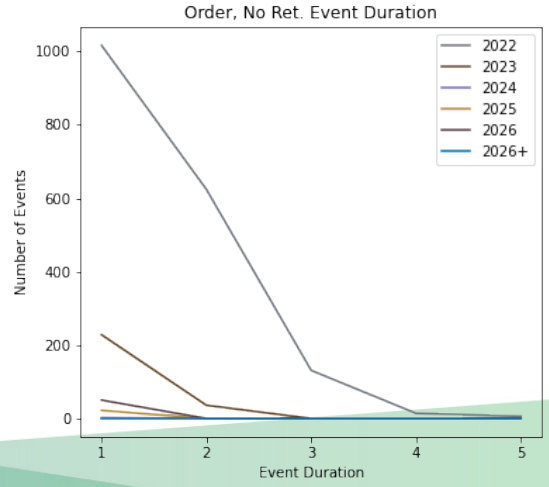
Value	2022	2023	2024	2025	2026	2026+
LOLE	0.2228	0.0551	0.0106	0.0120	0.0146	0.0017
1 in 10	1,675	-	-	-	-	-
1 in 20	2,453	98	-	-	-	-
1 in 100	3,995	1,865	69	171	428	-

Order, No Ret.









Value	2022	2023	2024	2025	2026	2026+
LOLE	0.1722	0.0254	0.0002	0.0021	0.0048	-
1 in 10	1,028	-	-	-	-	-
1 in 20	1,932	-	-	-	-	-
1 in 100	3,580	948	-	-	-	-