Item 7.1.1: Reliability Standard Study Preliminary Results

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Reliability and Markets Committee Meeting

ERCOT Public
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Preliminary Modeling Results for the Reliability Standard Study

- **Purpose**
  - Provide preliminary modeling results from the Reliability Standard Study
- **Voting Items / Requests**
  - No action is requested of the R&M Committee or Board; for discussion only

Key Takeaways:

1. Varying Reserve Margin levels in the analysis provide insight into Frequency, Duration, and Magnitude of events.
2. A single metric for Frequency of events will result in a set of events that have a wide range of Duration and Magnitude.
3. Even at 1 in 10 years Frequency (traditionally used LOLE standard) some events will be extreme, illustrating the short coming of just having a Frequency measurement for reliability.
4. Avoiding all extreme Magnitude and/or Duration events may require inordinately high resource investment.
5. Recommend incorporating a risk tolerance metric, like exceedance probability, to appropriately calibrate the reliability standard.

Modeling Overview

- Simulation year is 2026
- Simulated 24 different Reserve Margin levels, ranging from 9% to 28%
  - Started with November 2022 Capacity Demand and Reserves resources
  - Wind, Solar, and Batteries were included at their Effective Load Carrying Capacity (ELCC)
  - Thermal capacity (mainly coal) removed to start at the 9% Reserve Margin level
  - An increment of generic Combustion Turbine (CT) capacity, 742 MW, added to build up the resource portfolios for simulation
- 1,050 Monte Carlo simulations performed for each resource portfolio
- Initial runs do not fully reflect weatherization standard impacts

Key Takeaway: The model tallies the frequency, magnitude and duration of loss-of-load events; for each resource portfolio, 9.2 million hours are simulated (8,760 hours x 1,050 simulations).

Framework Definitions Used

Event: Defined as an hour during which firm load exceeds available generation capacity plus 1,000 MW of operating reserves; Event is equivalent to loss-of-load (LOL) event in this presentation.

- *FREQUENCY*
  - *LOLE*: Loss of Load Expectation. The expected number of LOL days for 2026 (calculated as the probability-weighted average for 1,050 simulations), where an LOL day means that at least one event occurs during that day. Example: LOLE of 0.1 days in 1 year, or equivalently, 1 day in 10 years

- *MAGNITUDE*
  - *Unserved Energy (UE)*: The hourly unserved energy amount in MWh for an Event (Equivalent to MW/hour); for multi-hour events, only the highest hourly UE is used; *Maximum Magnitude* is the highest hourly unserved energy amount in MWh across 1,050 simulations; for multi-hour events, only the highest hourly UE is used

- *DURATION*
  - The longest period of consecutive Events; *Maximum Duration* is the longest period of consecutive Events across 1,050 simulations

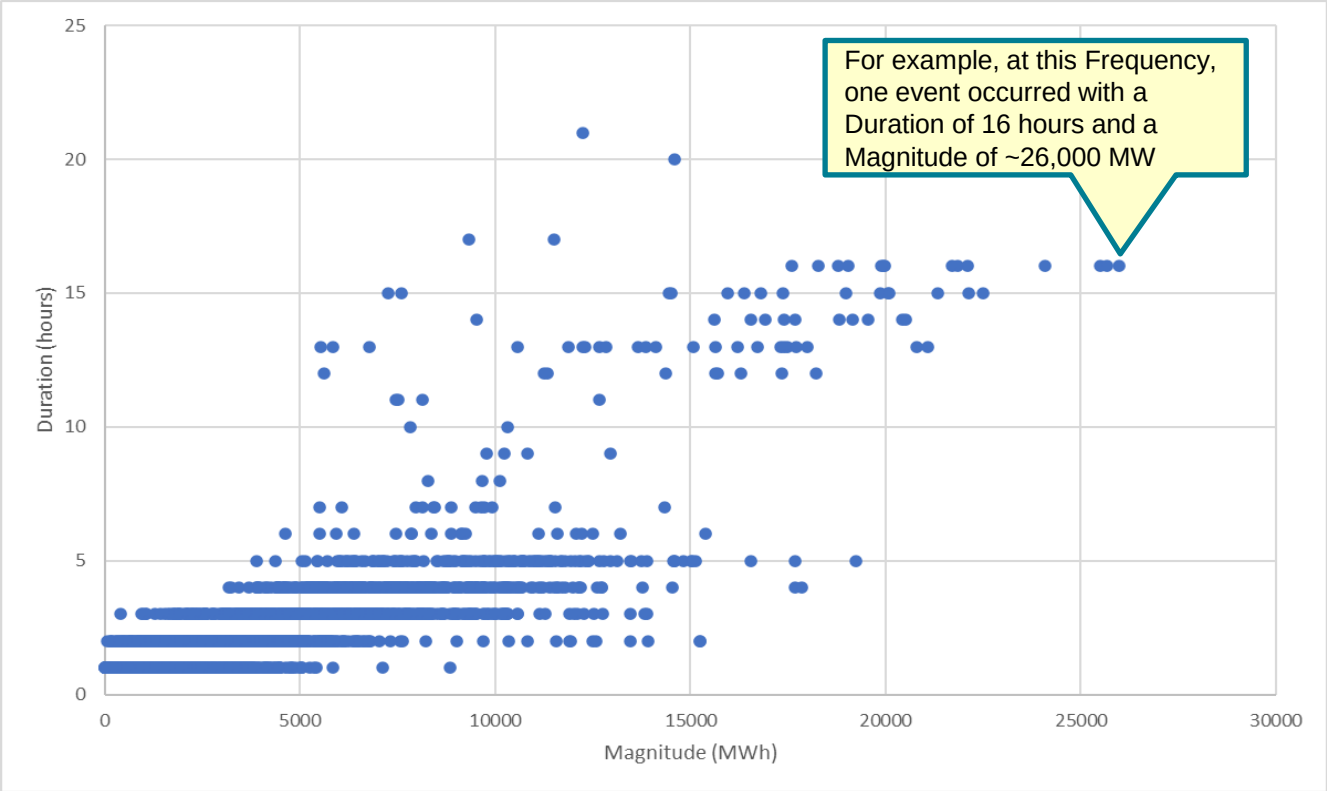
Reserve Margin vs LOLE and Frequency

The following five slides show the Magnitude and Duration of every event observed in simulations for selected frequency levels (LOLE)

- The Reserve Margin (RM) levels, corresponding LOLEs, and generic CT capacity added for each RM are shown in the table below:

Reserve Margin	LOLE (Expected Event Frequency)	LOLE (Expected Event Frequency per Year)	CT Non-Summer Capacity Added (MW)
9.36%	1 day with at least one event every 0.6 years	1.710	-
13.50%	1 day with at least one event every 2.7 years	0.360	3,710
18.46%	1 day with at least one event every 10 years	0.100	8,162
23.43%	1 day with at least one event every 27.7 years	0.036	12,614
28.40%	1 day with at least one event every 142.8 years	0.007	17,066

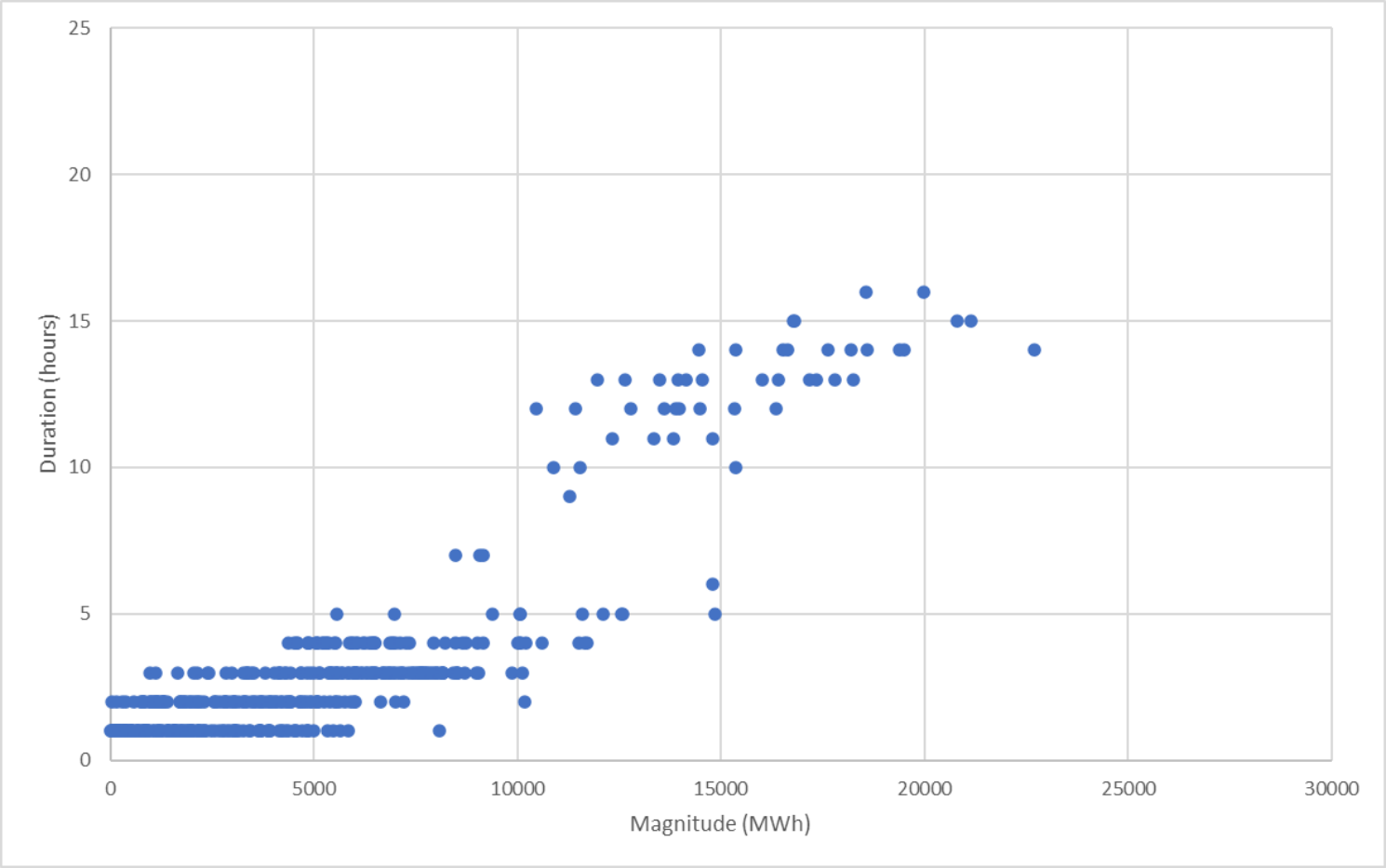
Magnitude vs. Duration at a Frequency of one Event every 0.6 years, (9.36% Reserve Margin)



- 0.072% of the hours simulated were Events (when Load > Generation + 1,000 MW Reserves)

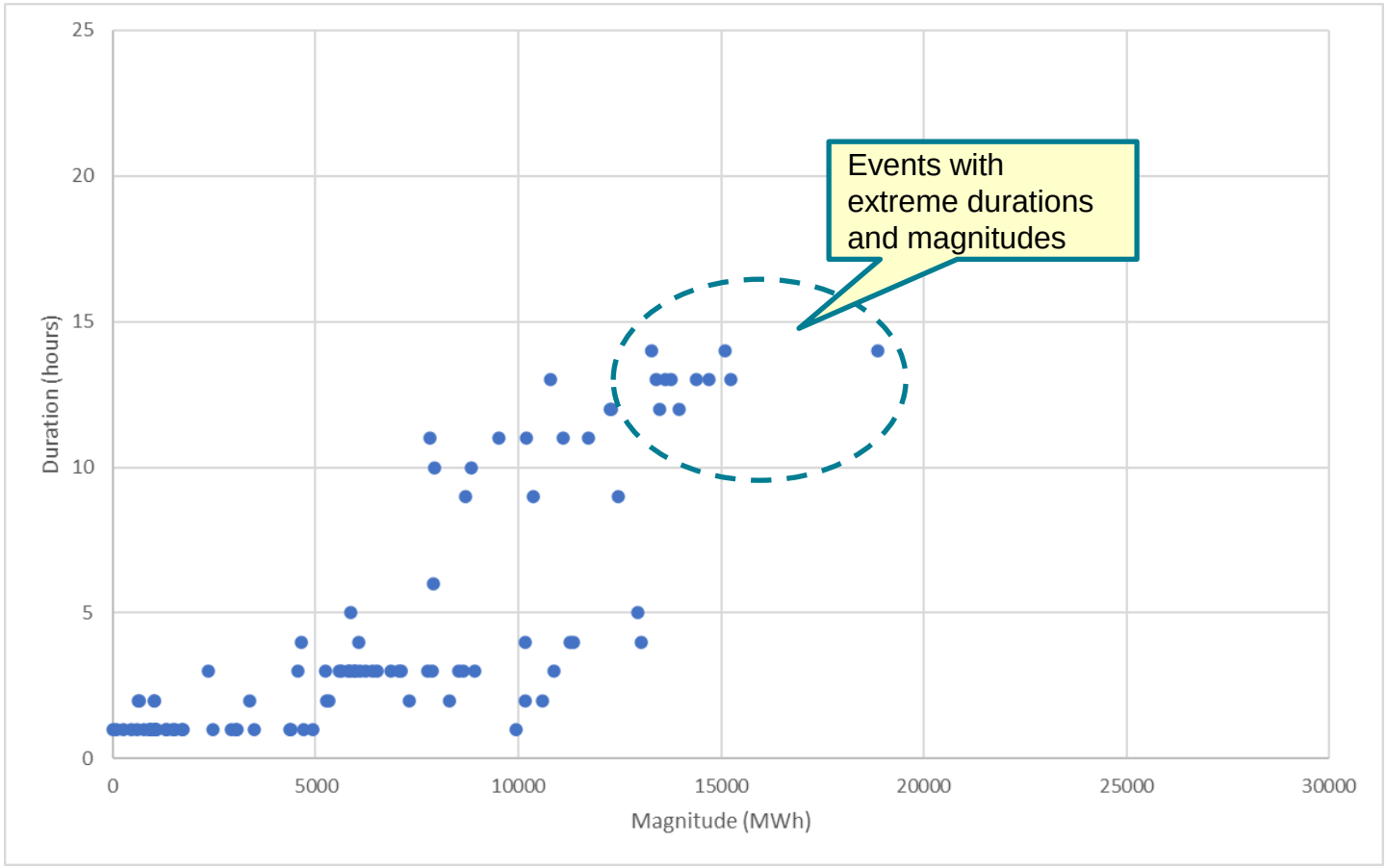
Key Takeaway: A single metric for event frequency, like Loss of Load Expectation (LOLE), will result in a set of events with a wide range of Duration and Magnitude.

Magnitude vs. Duration at a Frequency of one event every 2.7 years, (13.50% Reserve Margin)



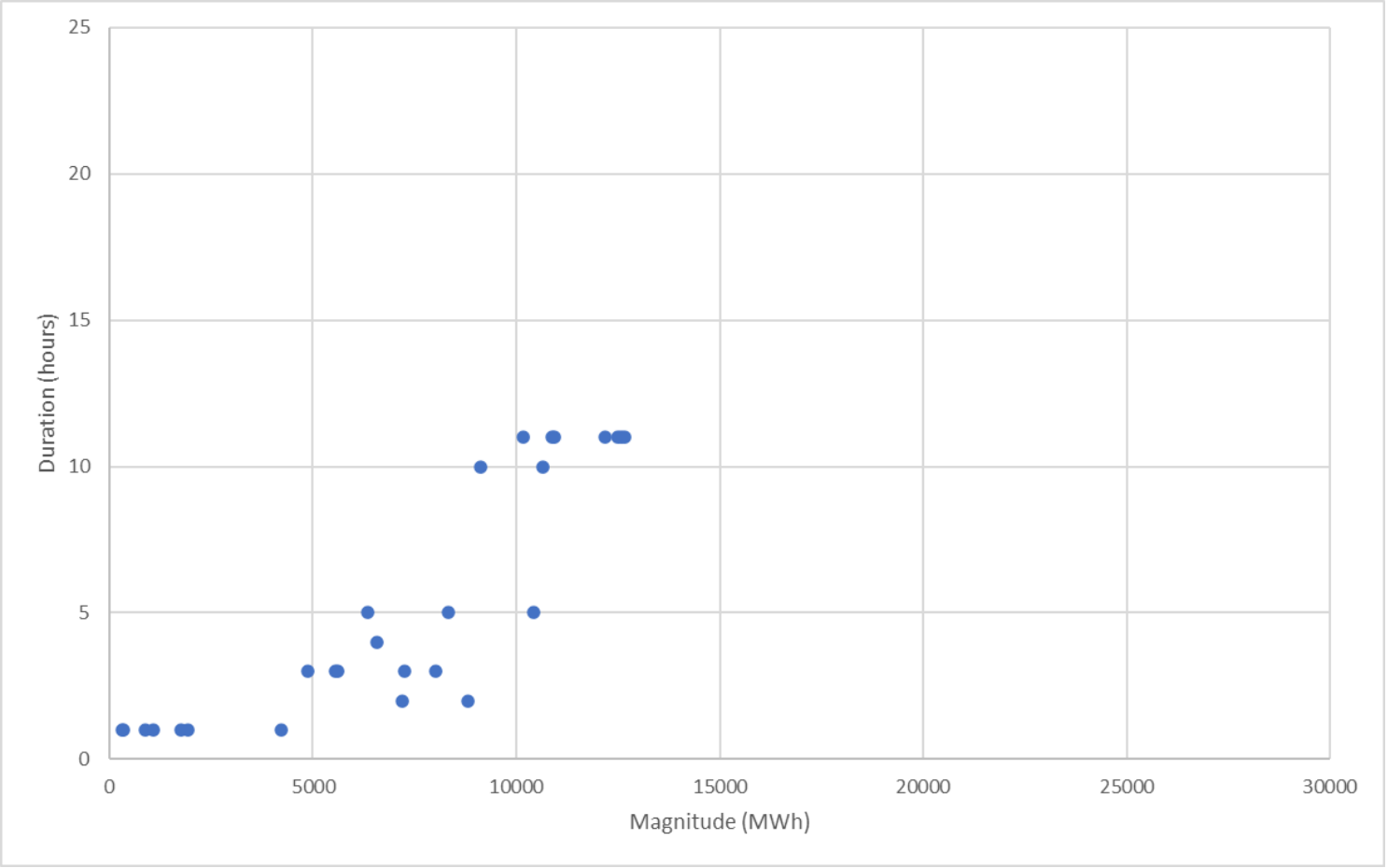
- 0.016% of the hours had an Event (~1,470 Event hours)

Magnitude vs. Duration at a Frequency of one event every 10 years, (18.46% Reserve Margin)



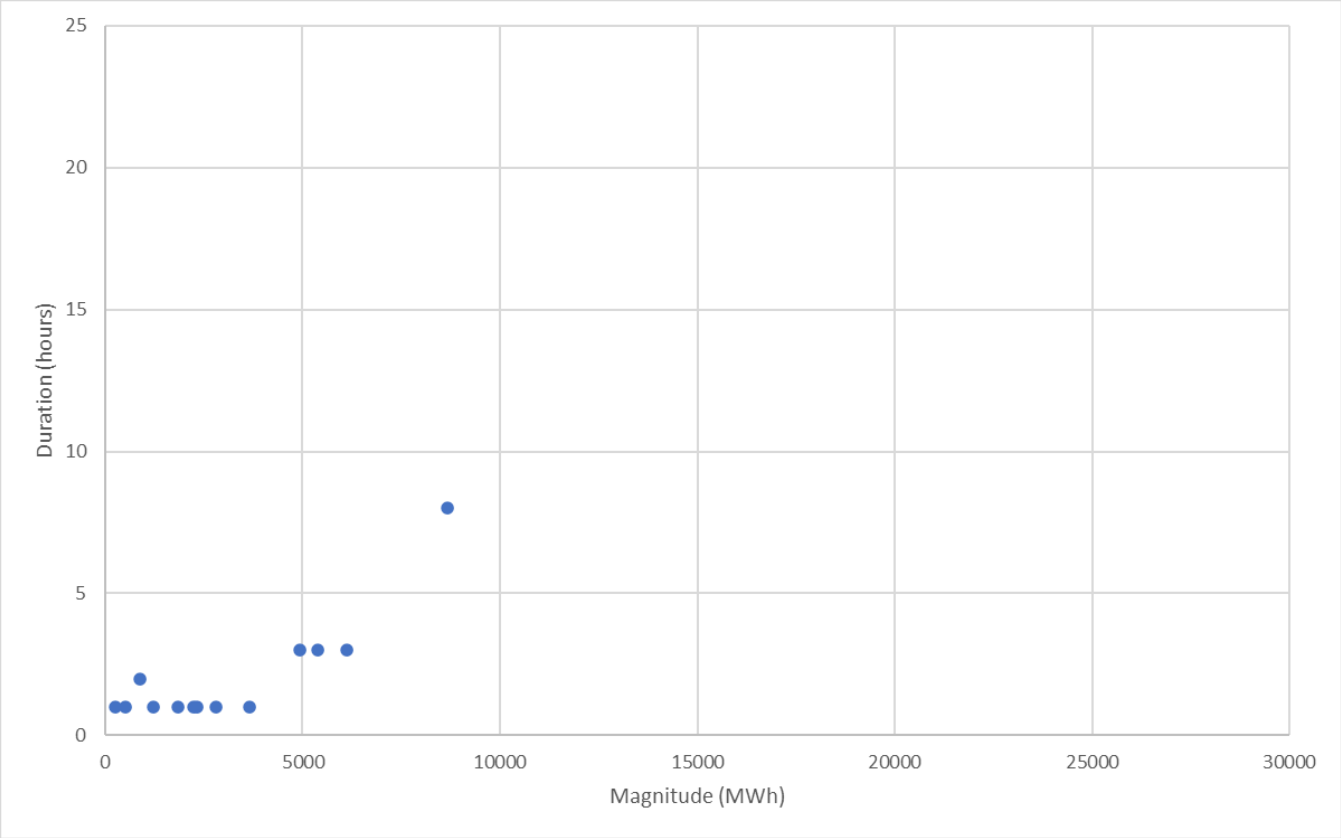
Key Takeaway: Even at 1 in 10 years Frequency, many events are extreme, illustrating the short-coming of just having a Frequency measurement for Reliability

Magnitude vs. Duration at a Frequency of one event every 27.7 years, (23.43% Reserve Margin)



- 0.002% of the hours evaluated had an Event (184 Event hours)

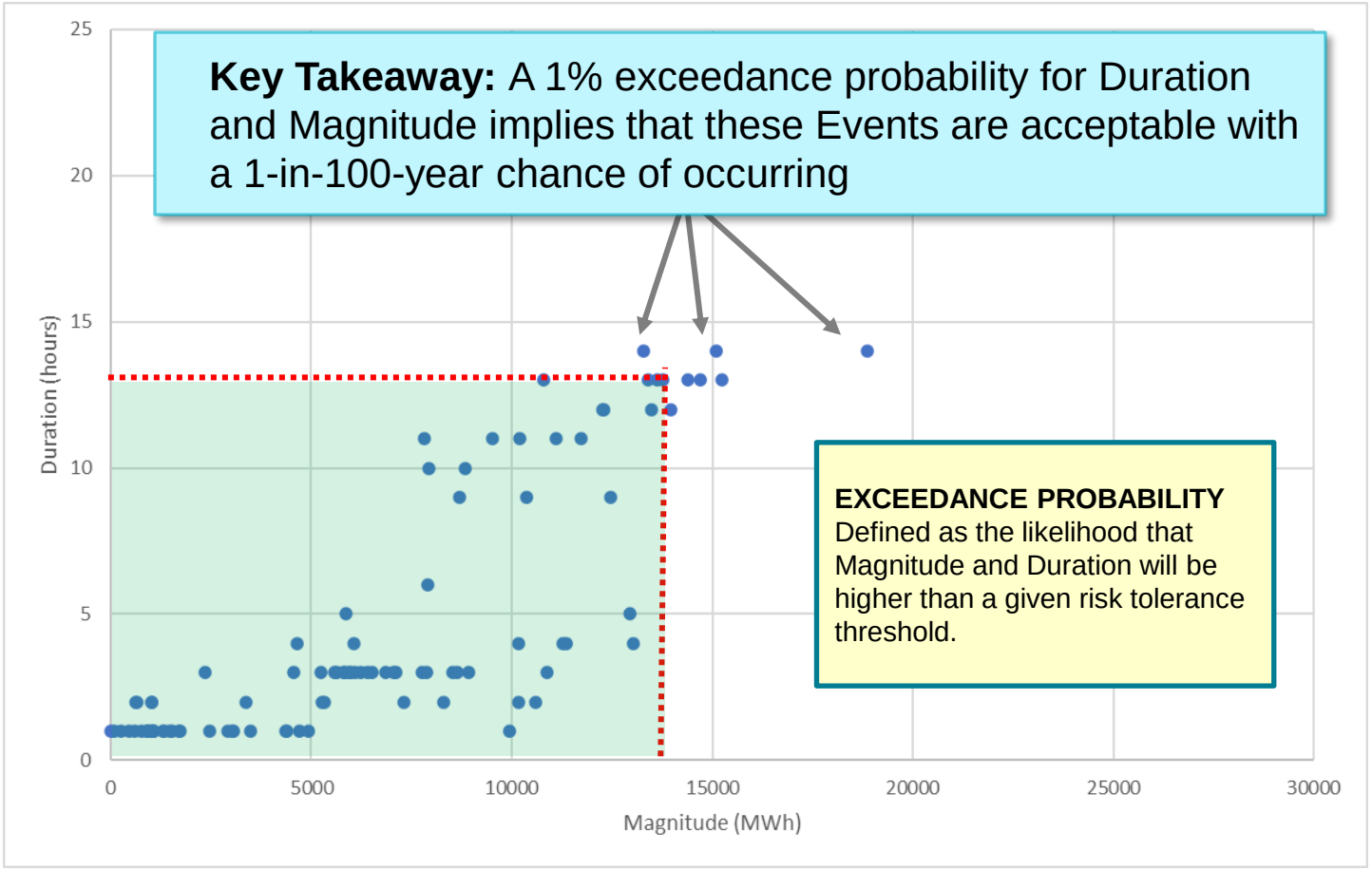
Magnitude vs. Duration at a Frequency of one event every 142.7 years (28.40% Reserve Margin)



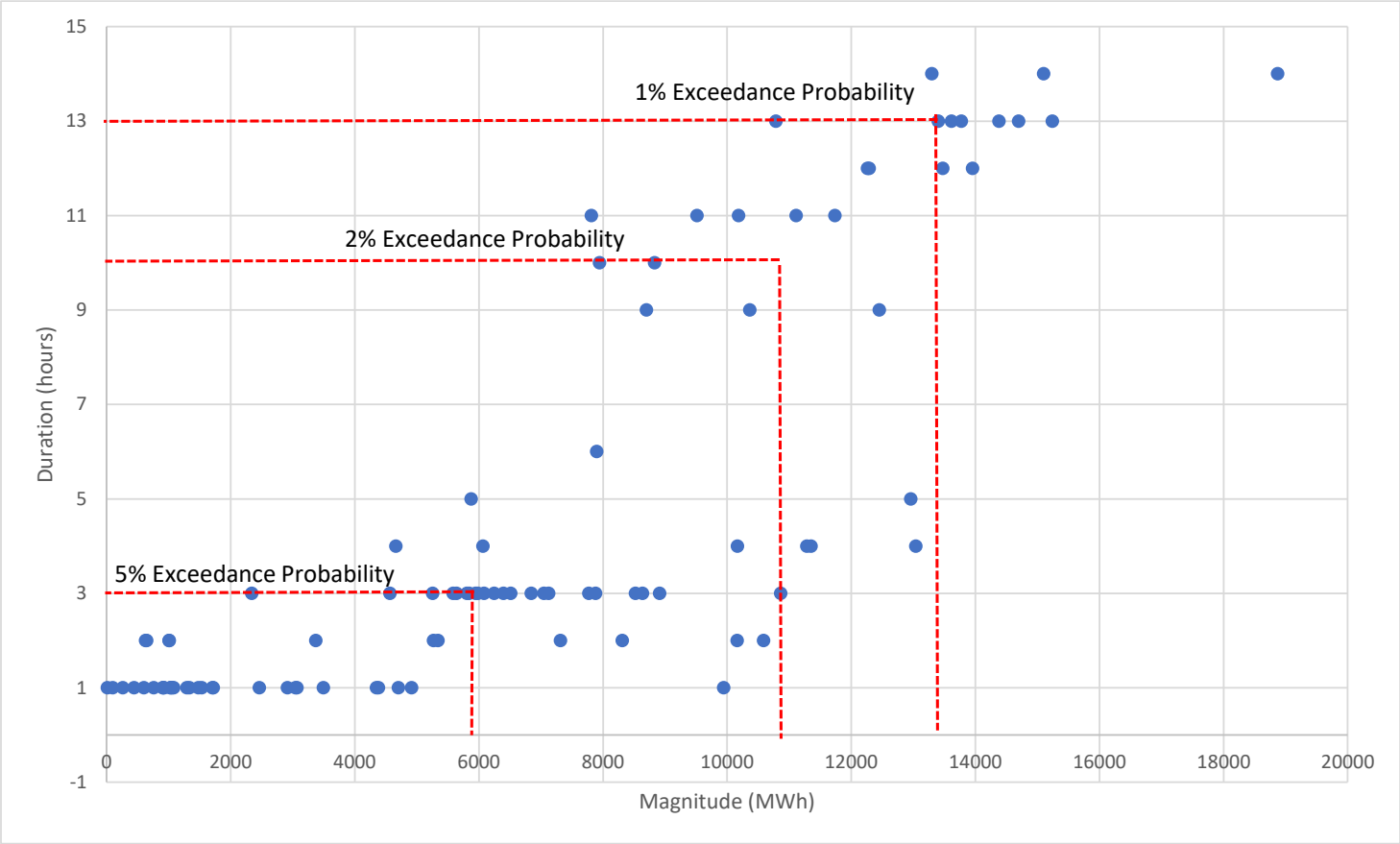
- 0.00029% of the hours had an Event

Key Takeaway: Even at this low LOLE, there are event outliers.

1% Duration and Magnitude Exceedance Probability Concept based on a Frequency of One Event every 10 years



Exceedance Probabilities Comparison: 1%, 2% and 5% based on 1-in-10 years Frequency



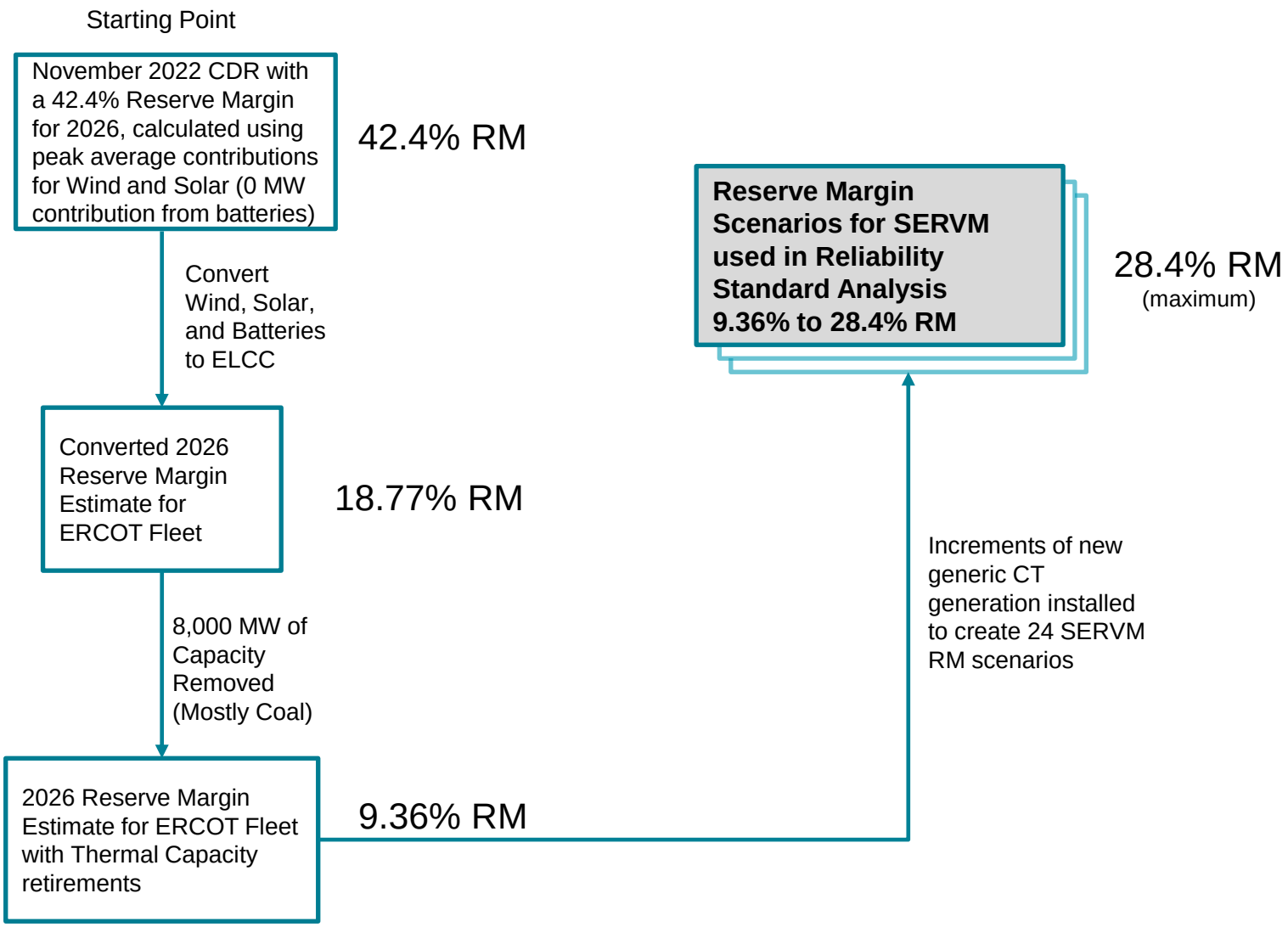
Key Takeaway: An exceedance probability should be considered for the Reliability Standard; the PUC would need to determine an acceptable risk tolerance threshold.

Next Steps

- Solicit guidance from the Commission on project direction
- Present preliminary modeling results to Market Participants
- Prior to executing further simulations, make the following model changes:
  - Incorporate weatherization standard impacts into the model
  - Build a more accurate low temperature vs. thermal outage relationship in the model to improve the representation of winter season impacts to the thermal fleet
  - Potentially incorporate the recently proposed ORDC multi-step floor pricing approach
  - Align modeled costs to the customer costs realized in E3's market design study
  - Incorporate the impacts of the Firm Fuel Supply Service
  - Report findings resulting from PUC and Market Participant feedback to the Board in August 2023.

Appendix

Generation Capacity Used in SERVM Modeling



Generic Combustion Turbine Attributes

Characteristic	Unit	Simple Cycle
Plant Configuration		
Turbine		GE 7HA.02
Configuration		1 x 0
Heat Rate (HHV)		
Base Load		
Non-Summer	(Btu/kWh)	9,138
Summer	(Btu/kWh)	9,274
Installed Capacity		
Base Load		
Non-Summer	(MW)	371
Summer	(MW)	352
CONE	($/kW-yr)	93.5
Maintenance Rate	(%)	5
EFOR	(%)	1.98

Sources and Notes:

Technical and performance parameters use region EMAAC as most closely resembling ERCOT in altitude and ambient conditions from Newell, *et al.* (2018a).

Based on ambient conditions of 92°F Max. Summer (55.5% Humidity) and 59°F Non-Summer.

Modeling Treatment of Extreme Winter Storm Events

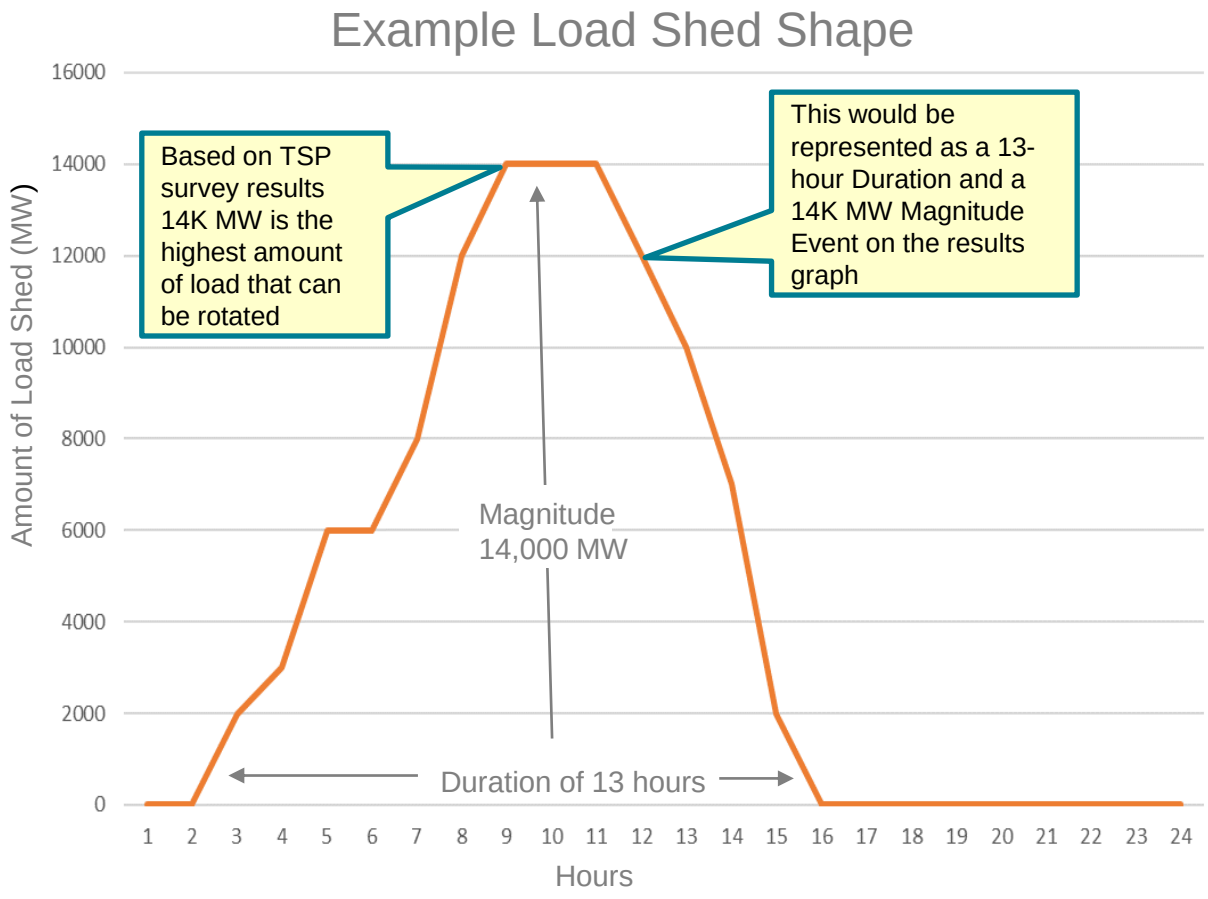
- The risk of weather-induced thermal outages (including those related to fuel limitations) is expressed as a “low-temperature versus outage magnitude” curve
- The curve incorporates 2011 winter event data to represent an extreme winter outage scenario that factors in recent weatherization efforts
  - Unplanned thermal outage levels during Winter Storm Uri are assumed to be too extreme for this purpose
  - However, fuel limitation outages from Winter Storm Uri are reflected
- Weatherization impacts are not explicitly included in the temp vs. outage curve
  - Weatherization should reduce both extreme outage occurrences as well as the overall outage frequency
  - ERCOT is analyzing recent weather events to determine curve modifications that reflect expected unit performance based on weatherization standard compliance

Reserve Margin Levels vs LOLE vs Capacity Added

Number of CTs Added	Reserve Margin	LOLE (Days per Year)	Summer Capacity for Added CTs (MW)	Non-Summer Capcity for Added CTs (MW)
0	9.36%	1.710	0	-
2	10.18%	1.276	704	742
4	11.01%	0.888	1,408	1,484
6	11.84%	0.677	2,112	2,226
8	12.67%	0.475	2,816	2,968
10	13.50%	0.360	3,520	3,710
12	14.32%	0.302	4,224	4,452
14	15.15%	0.220	4,928	5,194
16	15.98%	0.170	5,632	5,936
18	16.81%	0.146	6,336	6,678
20	17.64%	0.116	7,040	7,420
22	18.46%	0.100	7,744	8,162
24	19.29%	0.080	8,448	8,904
26	20.12%	0.070	9,152	9,646
28	20.95%	0.057	9,856	10,388
30	21.78%	0.049	10,560	11,130
32	22.60%	0.040	11,264	11,872
34	23.43%	0.036	11,968	12,614
36	24.26%	0.028	12,672	13,356
38	25.09%	0.027	13,376	14,098
40	25.92%	0.018	14,080	14,840
42	26.74%	0.015	14,784	15,582
44	27.57%	0.014	15,488	16,324
46	28.40%	0.007	16,192	17,066

Rough Equivalent of the expected 2026 Reserve Margin

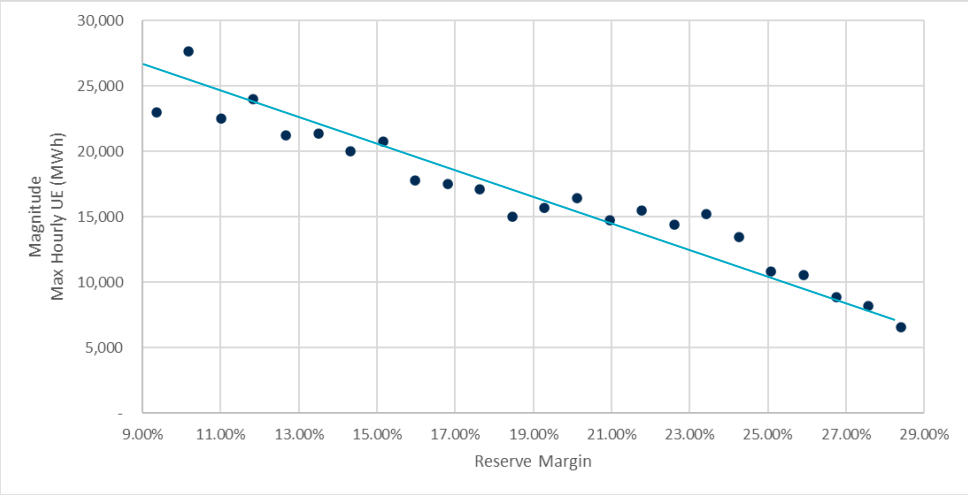
Potential 13-hour Duration and 14K-MW Magnitude Load Shed Shape



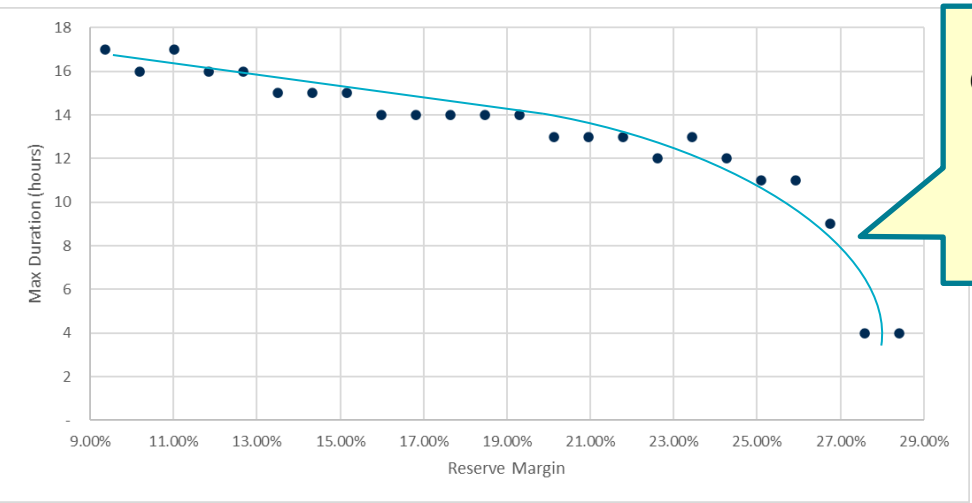
Summer Rotation Percentages

TSP	Target Rotation Time (min)
American Electric Power	30
Brazos Electric Power Cooperative	30
Brownsville Public Utilities Board	30
Bryan Texas Utilities	60
Centerpoint Energy	depends
City of Austin dba Austin Energy	10
City of College Station	15
Garland Power and Light	15
Lubbock Power & Light	30
CPS Energy	15
Denton Municipal Electric	30
Greenville	20
Golden Spread	60
Lamar County Electric Cooperative	20
Lower Colorado River Authority	30
Oncor Electric Delivery Company LLC	15-30
Rayburn Electric Cooperative	15-30
South Texas Electric Cooperative	30
Texas-New Mexico Power Company	25

Maximum Magnitude and Maximum Duration Comparison



- These charts show plots of the maximum Magnitude and Maximum Duration Event for each LOLE (Reserve Margin)
- The shapes of the Max Magnitude and Max Duration curves are distinctly different



Higher LOLEs are more effective at reducing the severity of the worst Duration Event than the severity of the worst Magnitude Event

Overview of Exceedance Probability Approach

Exceedance Probability is defined as the likelihood that Magnitude and Duration will be higher than a given risk tolerance threshold

For example, a 1% Exceedance Probability means that the expected frequency of Magnitude and Duration exceeding certain levels should occur no more than 1 day in 100 years, or 0.01 day in a year

Calculation Steps:

1. For each Frequency level, rank all the Events independently by Magnitude from highest to lowest, and Duration from longest to shortest

2. Select an exceedance probability; for example, 1%, or a 1-in-100 chance

3. Determine the ranking that corresponds to the exceedance probability; the Magnitude and Duration values associated with that ranking are the risk tolerance thresholds

Exceedance Probability Example

For the 0.116 LOLE portfolio, the 1,050 simulations resulted in 114 events that are independently ranked by severity. Given a 1% exceedance probability, the risk tolerance ranking is: 0.01 x 1,050 = 10.5 (rounded to 10)

After ranking the events, the table indicates that having Events equal to or greater than a 14,171 MWh Magnitude and 13-hour Duration is an acceptable risk

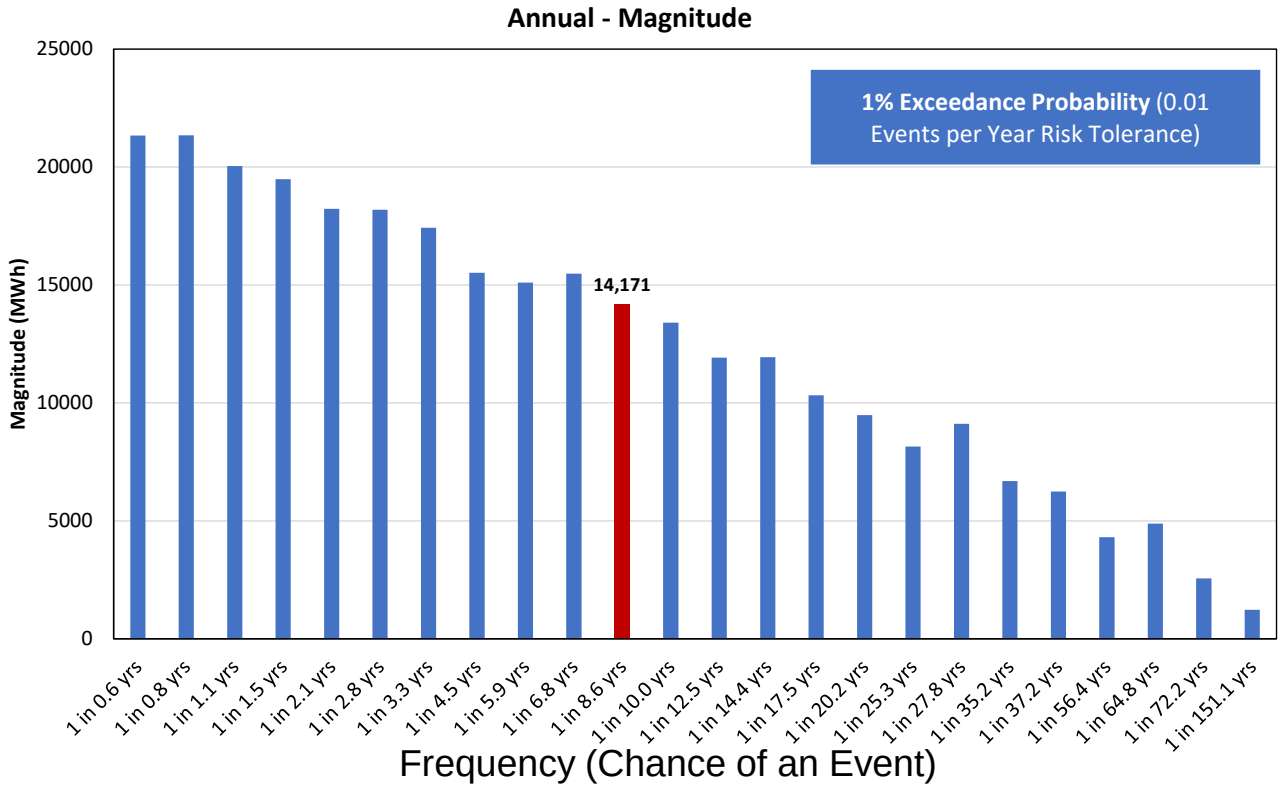
Rank	Magnitude (MWh)	Duration (hrs)
1	19,208	14
2	18,304	14
3	17,816	14
4	16,058	14
5	16,041	14
6	15,894	13
7	15,663	13
8	15,621	13
9	15,029	13
10	**14,171**	**13**
11	13,260	13
12	13,228	12

Application of Exceedance Probability Approach for each LOLE portfolio

- Extending the example on the previous slides, the following two charts show the Magnitude and Duration, respectively, for each of the 24 LOLE resource portfolios based on a 1% Exceedance Probability
  - The LOLEs are expressed as the chance of an Event in x years
  - The example's 0.116 LOLE is highlighted

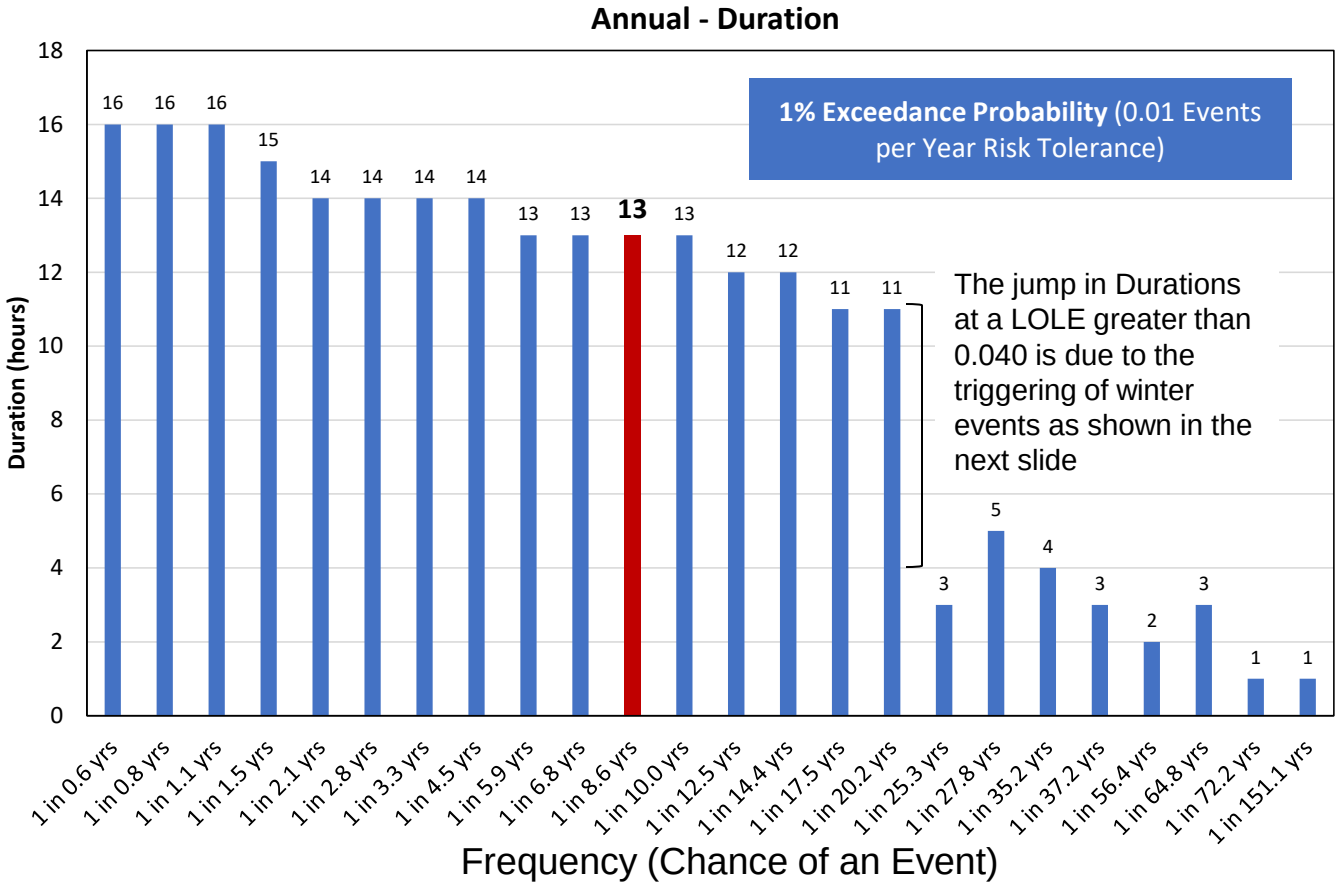
- The third chart compares Durations for the summer and winter seasons

Magnitude for each LOLE at a 1% Exceedance Probability



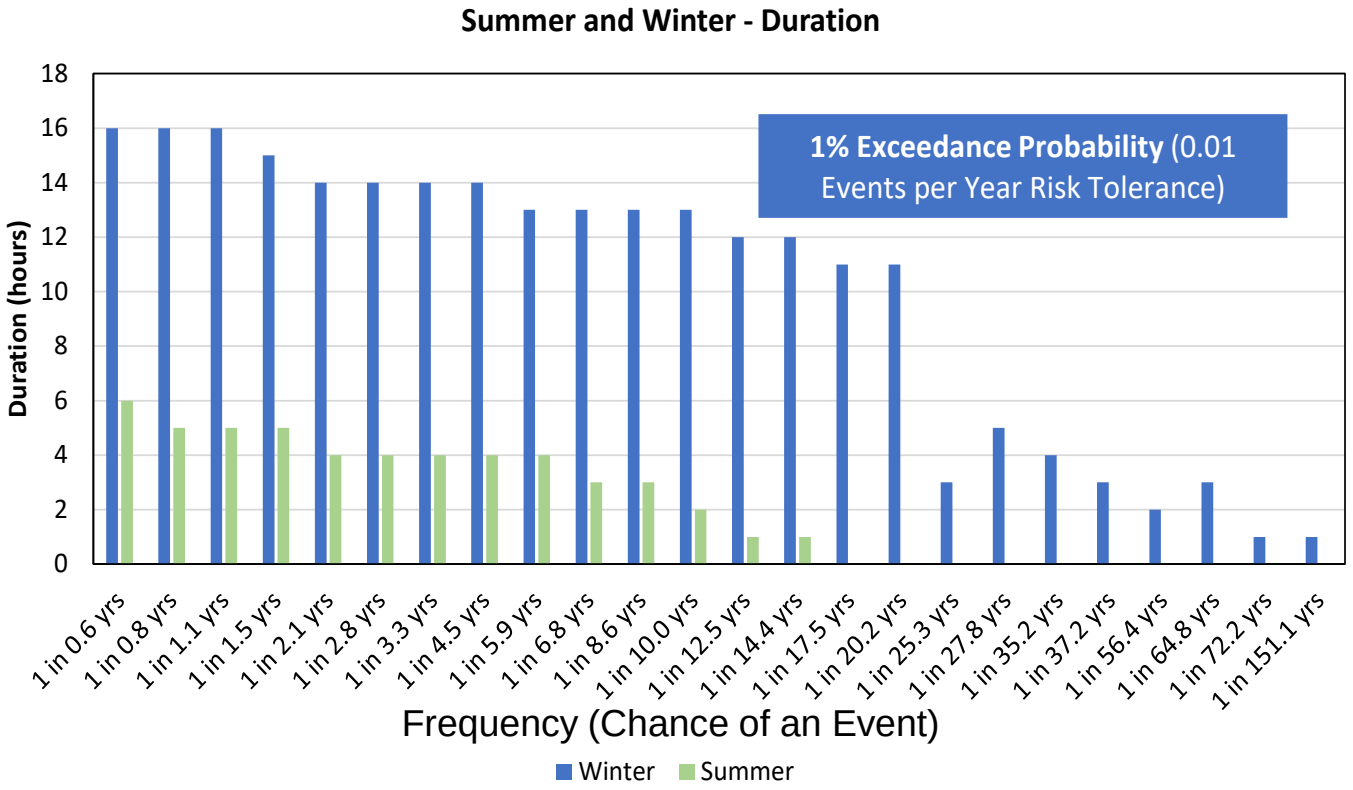
- The Magnitude at a 1% Exceedance Probability is 14,171 MWh; in contrast, the Max Magnitude at the same 0.116 LOLE (17.64% RM) is ~17,500 MWh
- The Magnitudes do not consistently decrease with a lower LOLE, although there are fewer instances of this behavior than for Max Magnitude (Slide 17)

Duration for each LOLE at a 1% Exceedance Probability



- The Duration at a 1% Exceedance Probability is 13 hours; in contrast, the Max Duration at the same 0.116 LOLE (17.64% RM) is 14 hours

Summer and Winter Durations for each LOLE at a 1% Exceedance Probability



- The number of Events with multi-hour Durations is significantly higher for the winter than the summer; at a Frequency of greater than one Event in 14.4 years no summer Events occurred, whereas for the winter, Events occurred at all LOLEs