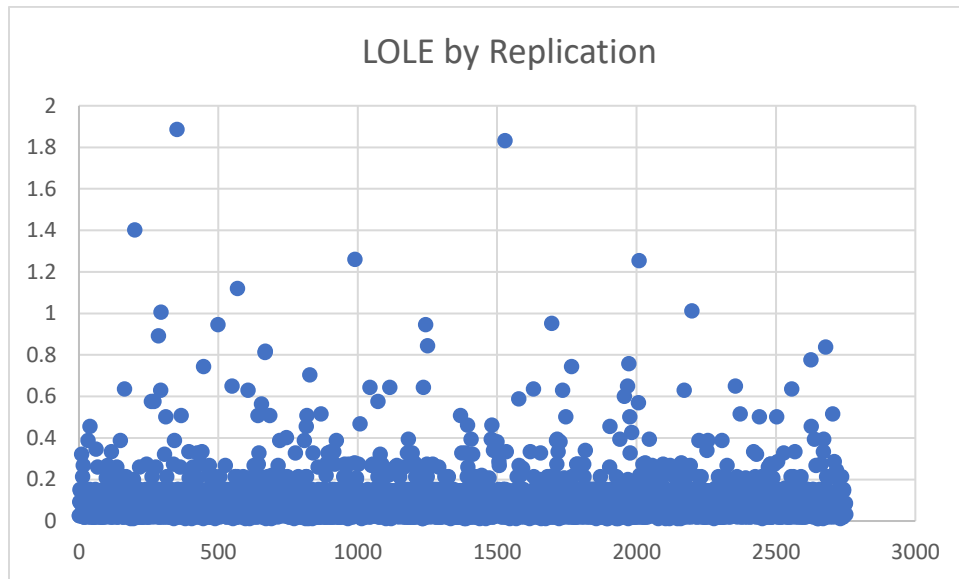
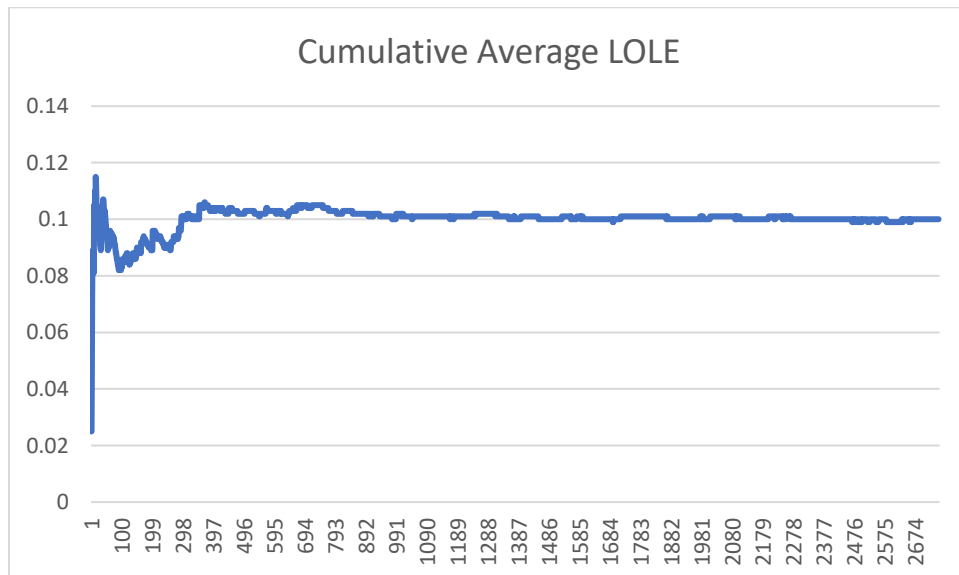


Iteration Results

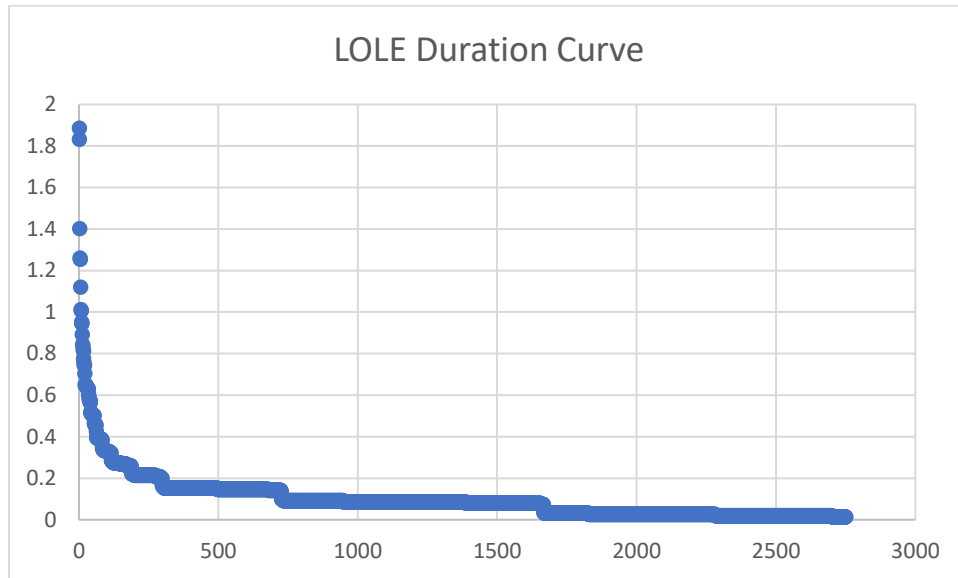
By design, the 2023-24 IRM study final base case (FBC) had an average Loss of Load Expectation (LOLE) of 0.100 events/year. However, that doesn't tell the whole story. The Monte Carlo logic simulated the system for 2,750 replication years and the annual values ranged from a minimum of 0.012 events/year to a maximum of 1.885 events/year. The figure below shows the value of the LOLE for each of the replication years.



The next curve shows the cumulative average over the course of the replications. After some initial fluctuations the value can be seen to settle out after about 1,000 replications and is fairly constant after 2,750 replications.



The plot below shows a duration curve of the 2,750 values. While the average value is 0.100 there are hundreds of replications where the value was much higher.



Additional Metrics. In addition to calculating the LOLE in Event-days/year the model also calculated the Hourly Loss of Load Expectation (HLOLE) in Event-hours/year and the Expected Unserved Energy (EUE) in MWh/year. In addition, the expected Duration in hours/event can be determined by dividing the HLOLE by the LOLE and the expected Magnitude in MW/event can be calculated as EUE/HLOLE. The table below shows the minimum, maximum and average values for these metrics. Although the average duration of outages was roughly 4 hours, events exceeding 9 hours occurred.

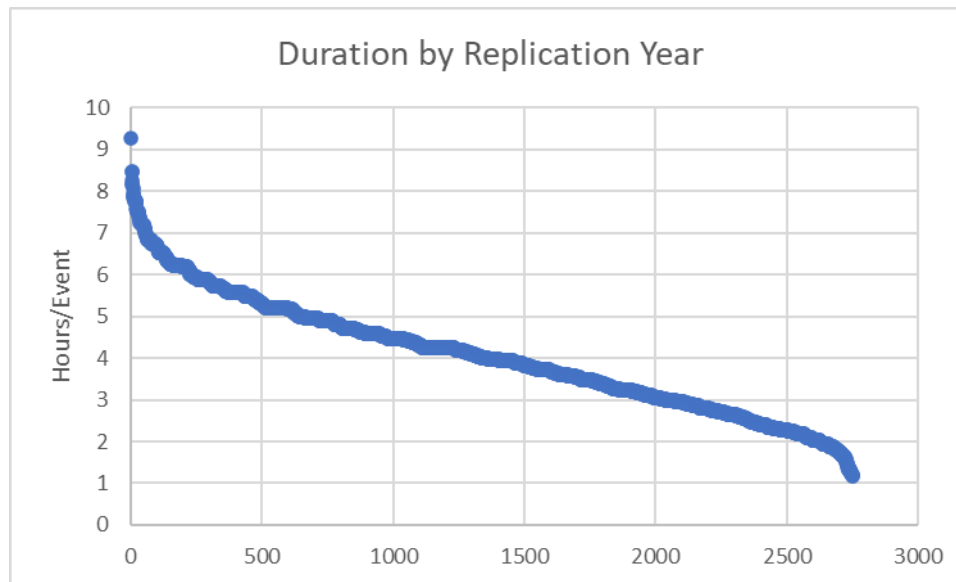
		2750 Replications		
Metric	Units	Minimum	Maximum	Average
LOLE	Event-days/year	0.012	1.885	0.0996
HLOLE	Event-hours/year	0.031	8.588	0.3584
EUE	MWh/year	4.52	3860.42	192.35
Duration	Hours/Event	1.17	9.29	4.05
Magnitude	MW/Event	80.92	1306.15	594.92

The table below shows the results for the first 10 replications. The Duration and Magnitude were estimated from each iteration. The average of the ten duration values was 3.71 hours/event. If the value is calculated from the average LOLE and HLOLE over the ten iterations the result is $3.28 = 3.46/1.05$. The value in the table above was calculated as the average of the 2,750 duration values.

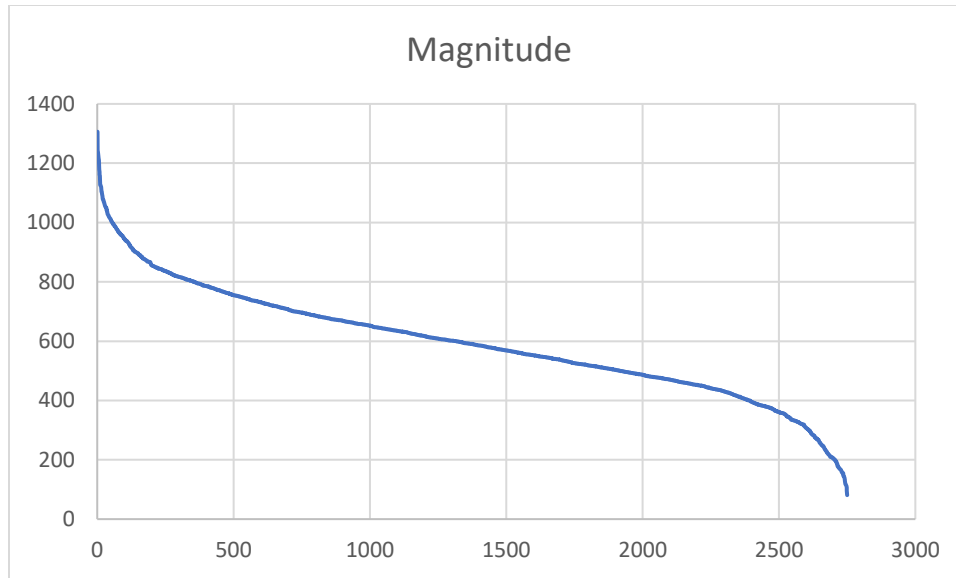
ITERATION	LOLE Events/year	HLOLE Event hours/year	EUE MWh/year	Duration =HLOLE/LOLE Hours/Event	Magnitude =EUE/HLOLE MW/Event
1	0.025	0.112	87.45	4.480	780.8
2	0.025	0.124	85.9	4.960	692.7
3	0.092	0.27	139.47	2.935	516.6
4	0.152	0.604	338.97	3.974	561.2
5	0.146	0.252	97.29	1.726	386.1
6	0.092	0.418	303.65	4.543	726.4
7	0.085	0.197	94.16	2.318	478.0
8	0.085	0.433	260.48	5.094	601.6
9	0.031	0.13	86.46	4.194	665.1
10	0.321	0.922	300.08	2.872	325.5

Average 0.105 0.346 179.39 3.71 573.39
 Calculated from average 3.28 518.17

The average duration for the replication years ranges from 1.2 hours to 9.3 hours with an average value of 4 hours/event. These are averages over the replication year so they don't capture the full potential range, but they do give a better estimate. As the graph below shows a 4-hour storage would be insufficient to cover the outage in over 50% of the cases.



In a similar manner the expected Magnitude of the outage was determined for each replication. Although the average was 573 MW over the 2,750 values the maximum exceeded 1300 MW.



As a validation that a sufficient number of replications were performed the analysis was repeated for 8,500 replications. Although the averages and ranges varied slightly they were basically consistent.

Metric	Units	2750 Replications			8500 Replications		
		Minimum	Maximum	Average	Minimum	Maximum	Average
LOLE	Event-days/year	0.012	1.885	0.0996	0.006	2.194	0.0967
HLOLE	Event-hours/year	0.031	8.588	0.3584	0.019	9.363	0.3466
EUE	MWh/year	4.52	3860.42	192.35	4.52	3860.42	187.39
Duration	Hours/Event	1.17	9.29	4.05	1.17	10.12	4.02
Magnitude	MW/Event	80.92	1306.15	594.92	71.09	1626.71	595.43

Conclusion. Although the new calculated and derived metrics add important new insights into the reliability of the system the range of the values across all of the replications adds an even greater dimension. It will be important to calculate not only these new metrics in future studies, but also the distribution of the values for base cases and sensitivities.