Valuing Capacity for Resources with Energy Limitations

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Background

In 2012 the NYISO and GE Energy Consulting performed an evaluation of the Contribution to Resource Adequacy of Special Case Resources for the Installed Capacity Subcommittee of the New York State Reliability Council.

This analysis considered:

Penetration

Duration of Use

Persistence of Use

http://www.nysrc.org/pdf/MeetingMaterial/ICSMeetingMaterial/ICS_Agenda135/2012%20SCR%20Study%20Report%20for%20ICS%20-final-05-01-12.pdf

Objective

Build upon the analysis performed for SCRs, expanding the scope to include distributed energy and other resources with energy limitations considering

The impacts of:

Duration of Use

Penetration

Persistence of Use

Diversity of Resources

Performance

Seasonal or Daily Limitations

On Capacity Value as Measured in:

Daily Loss of Load Expectation (LOLE - Days/Year)

Hourly Loss of Load Expectation (LOLE Hours/Year)

Loss of energy Expectation (LOEE)

Definitions

Capacity Value: The amount of perfect capacity in the same location which would provide an equivalent reliability benefit. Capacity Value is independent of transmission constraints. Capacity value for a traditional generator can be approximated by UCAP.

NYCA-wide Reliability Value: The amount of perfect capacity spread throughout NYCA proportional to existing capacity which would provide an equivalent reliability benefit. NYCA-wide Reliability Value incorporates the impact of transmission congestion.

Capacity Value vs NYCA-wide Reliability Value

The objective of this analysis is to develop a methodology for calculating the ***Capacity Value*** of resources with energy limitations, as such, Transmission congestion is not considered.

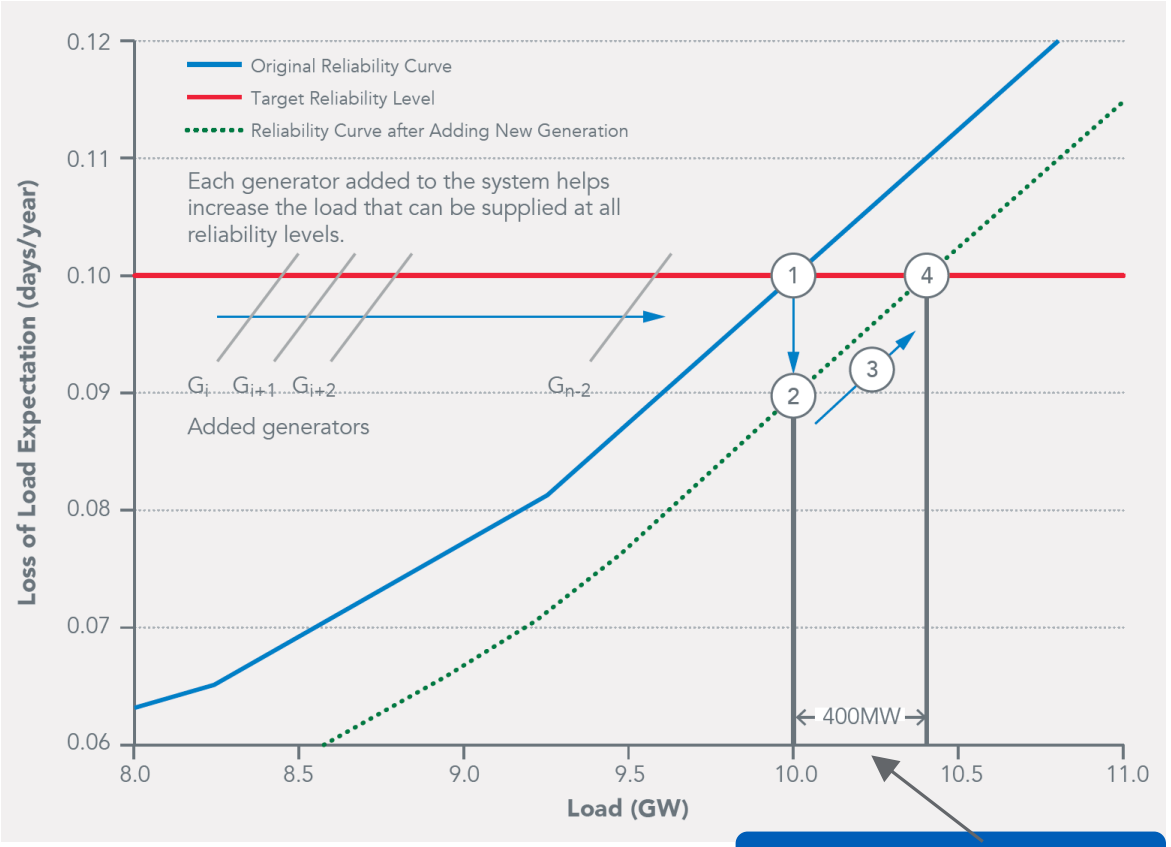
The impact of transmission constraints on NYCA-wide reliability is captured by the Locational Minimum Capacity requirements (LCRs) and the price differential in the ICAP market.

It is assumed that the impact of transmission constraints for resources with energy limitations is consistent with the impact for a traditional generator and that the LCRs and ICAP Market Clearing prices will adequately account for transmission constraints.

Approach

How is Capacity Value Calculated

1. Bring system to a reference point (2018 IRM Base Case with Optimized LCRs)
2. Add a resource, reliability improves
3. Increase system load, reliability decreases
4. Iterate until you match the initial system reliability for the metric you are considering



J. Katz, P. Denholm "Using Wind and Solar to Reliably Meet Electricity Demand, Greening the Grid" http://www.nrel.gov/docs/fy15osti/63038.pdf

Approach

GE Energy Consulting will develop a GE MARS post processing routine to schedule resources subject to the parameters listed previously against the hourly NYCA capacity margin for each replication and load level of the GE MARS simulation.

Each replication's hourly NYCA capacity margin will be adjusted by the schedule, and the reliability indices recalculated.

Capacity will be removed until the relevant reliability index is returned to base case levels.

Resource Scheduling

Selecting the Days to Schedule

- Calculate hourly NYCA capacity margin and available Emergency Assistance for all replications and load levels
- If seasonal limitations are specified, filter the data to only those days where the resource is available
- Select the worst days for scheduling up to the limit on the number of calls
  1) Days with Loss of Load Events
  2) Days without loss of Load Events sorted by the sum of NYCA capacity margin and Available Emergency Assistance

Resource Scheduling

Selecting the Hours to Schedule

From the days selected for scheduling

- If time of day limitations are specified, filter to only those hours the resource is available
- If duration of use limitations are specified, calculate the rolling total capacity margin for the number of hours allowed, schedule the resource for the period with the minimum total
- If energy limitations are specified, schedule the resource for a block of consecutive hours until the available energy is utilized (starting from the worst hour, schedule outwards to the worst adjacent hour)

Capacity Removal

A constant amount of capacity is removed from all hours to calculate capacity value

1) If the resource is scheduled in the hour, remove capacity from NY Areas proportional to the capacity added
2) If the resource is not scheduled and all NY Areas have capacity margins greater than or equal to zero, remove capacity from NY Areas proportional to the surplus
3) If the resource is not scheduled and any NY Area has a capacity margin less than zero, remove capacity proportional to base case UCAP

Loss of Load Event Statistics

Cases Analyzed

2018 IRM Base Case w/ Optimized LCRs

IRM:	18.2%
Zone J LCR:	79.7%
Zone K LCR:	107.5%
GHIJ LCR:	90.8%
Daily LOLE:	0.099 Days / Year
Hourly LOLE:	0.304 Hours / Year
LOEE:	196.7 MWh / Year

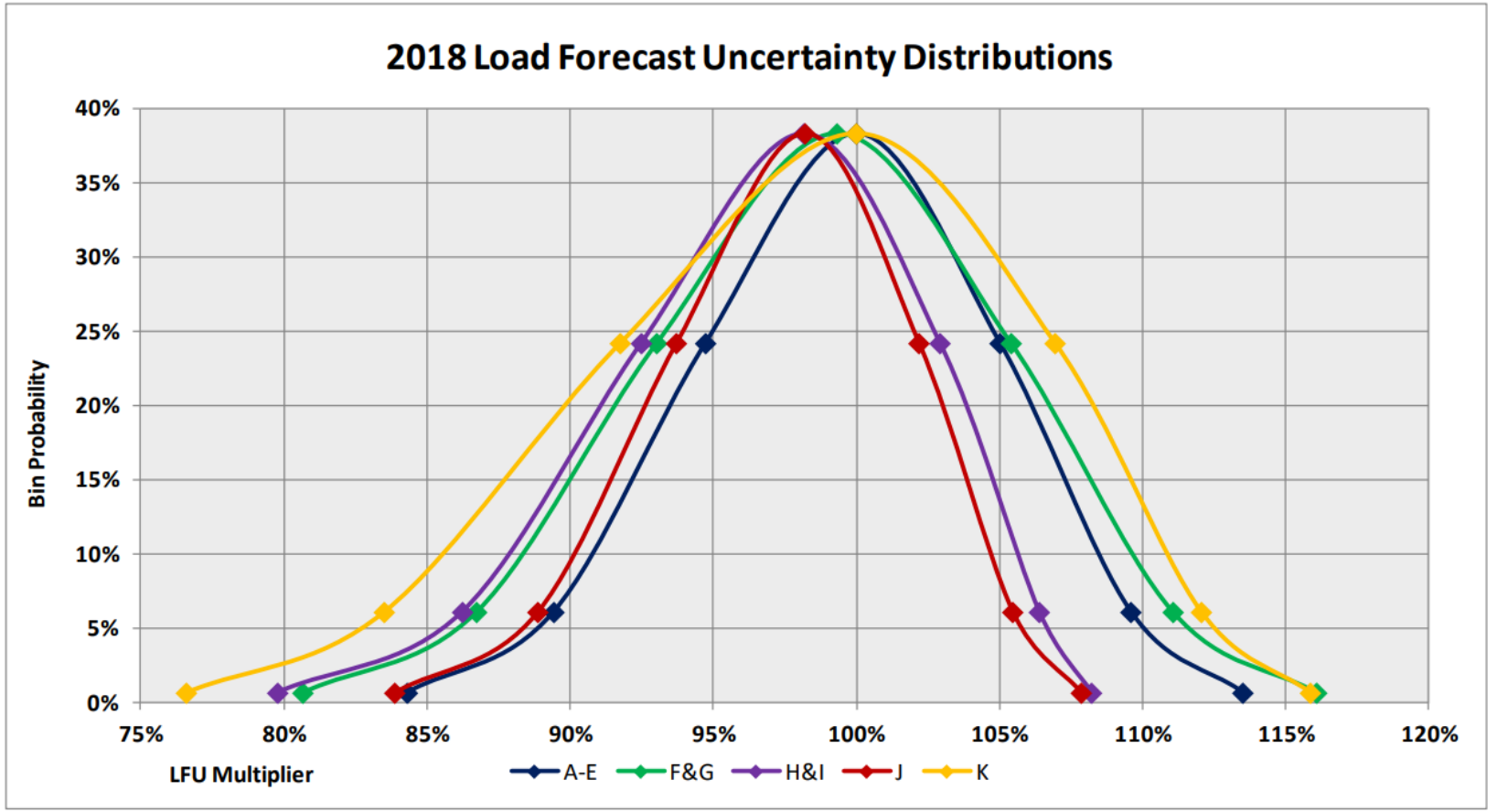
2018 IRM 2000 MW Wind 2000 MW Solar

IRM:	26.3%
Zone J LCR:	80.8%
Zone K LCR:	105.6%
GHIJ LCR:	N/A
Daily LOLE:	0.097 Days / Year
Hourly LOLE:	0.315 Hours / Year
LOEE:	248.5 MWh / Year

GE MARS Load Forecast Uncertainty

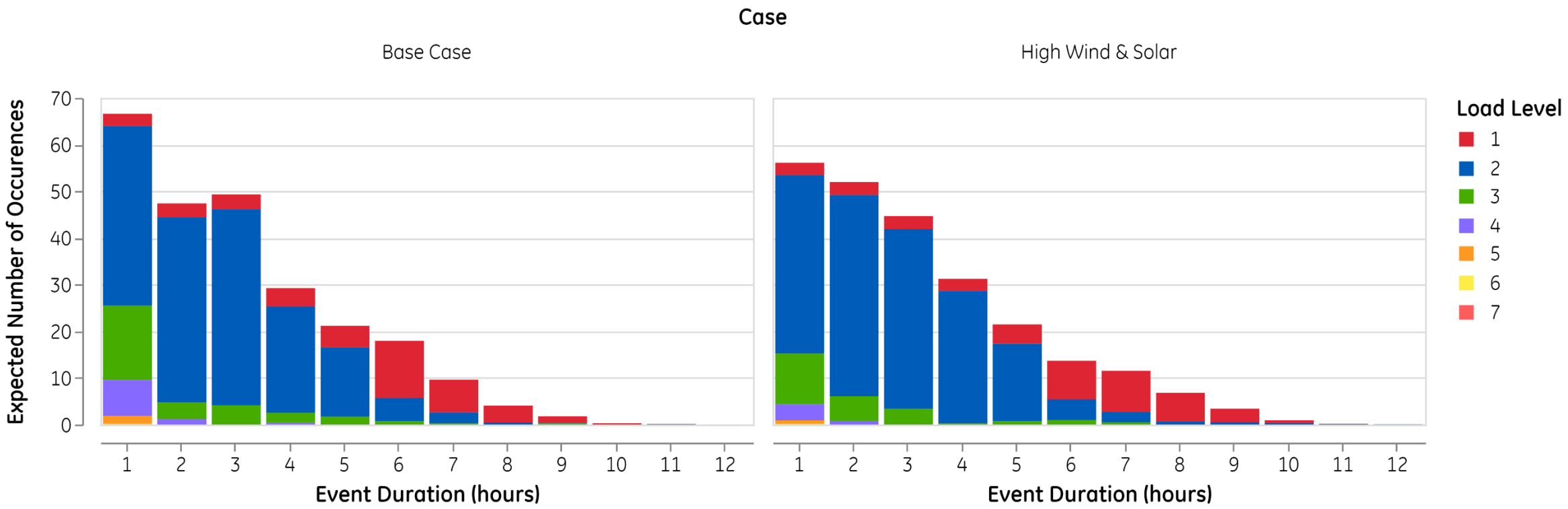
- In GE MARS Load Forecast Uncertainty can be represented by up to 10 distinct “Load Levels”
- For each Load Level, a Historic Load Shape and peak load multiplier is applied
- The results for each load level are weighted together by the assigned probability
- The NYSRC IRM Database models 7 Load Levels (Load Level 1, 2006 Historic Load Profile; Load Level 2, 2002 Historic Load Profile; Load Level 3-7 2007 Historic Load Profile)

Load Forecast Uncertainty - Peak Load Multipliers

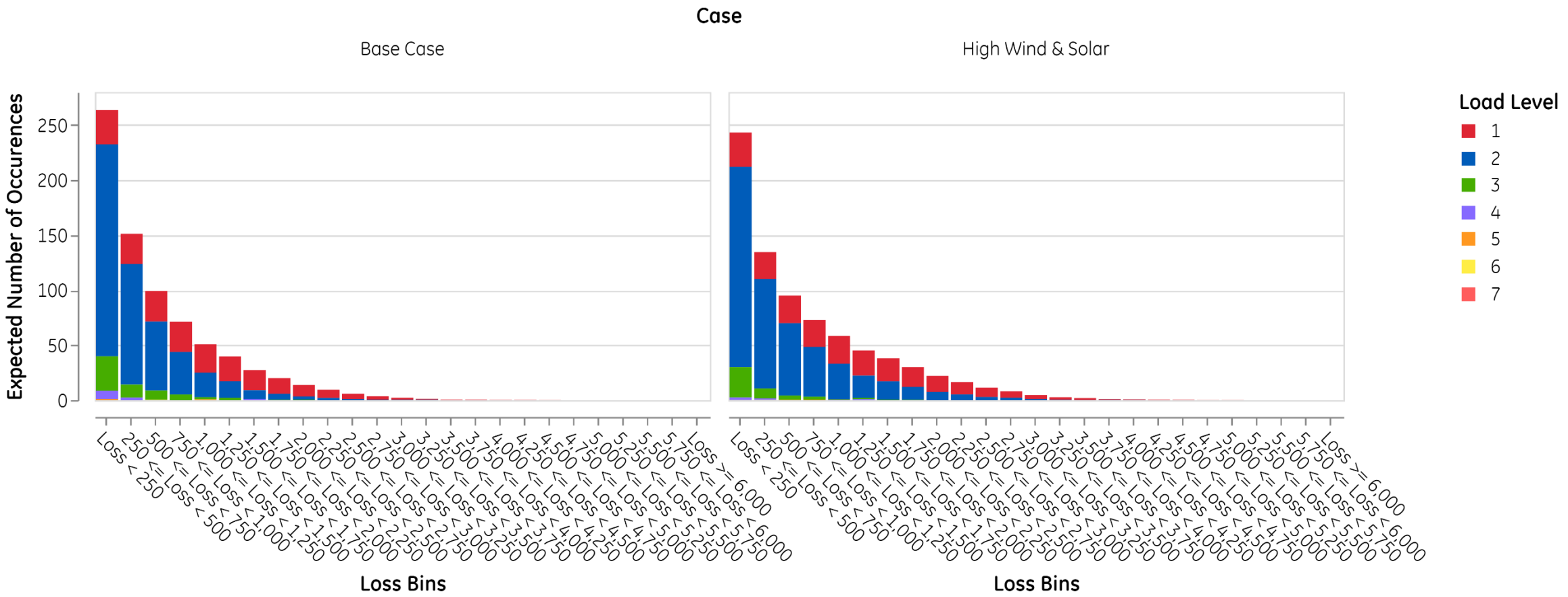


http://www.nysrc.org/pdf/Reports/2018%20IRM%20Study%20Appendices%20%20Final%2012_08_2017_V2.pdf

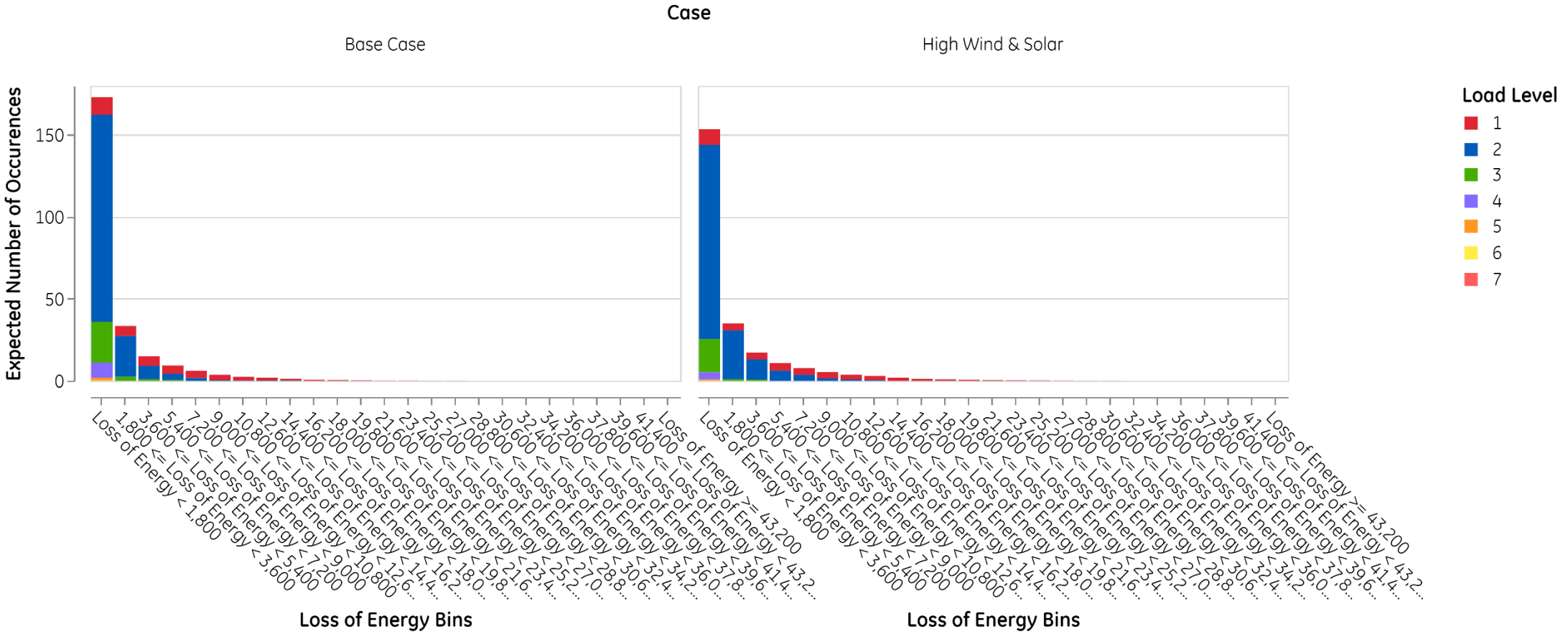
Distribution of Event Duration for Daily Loss of Load Events



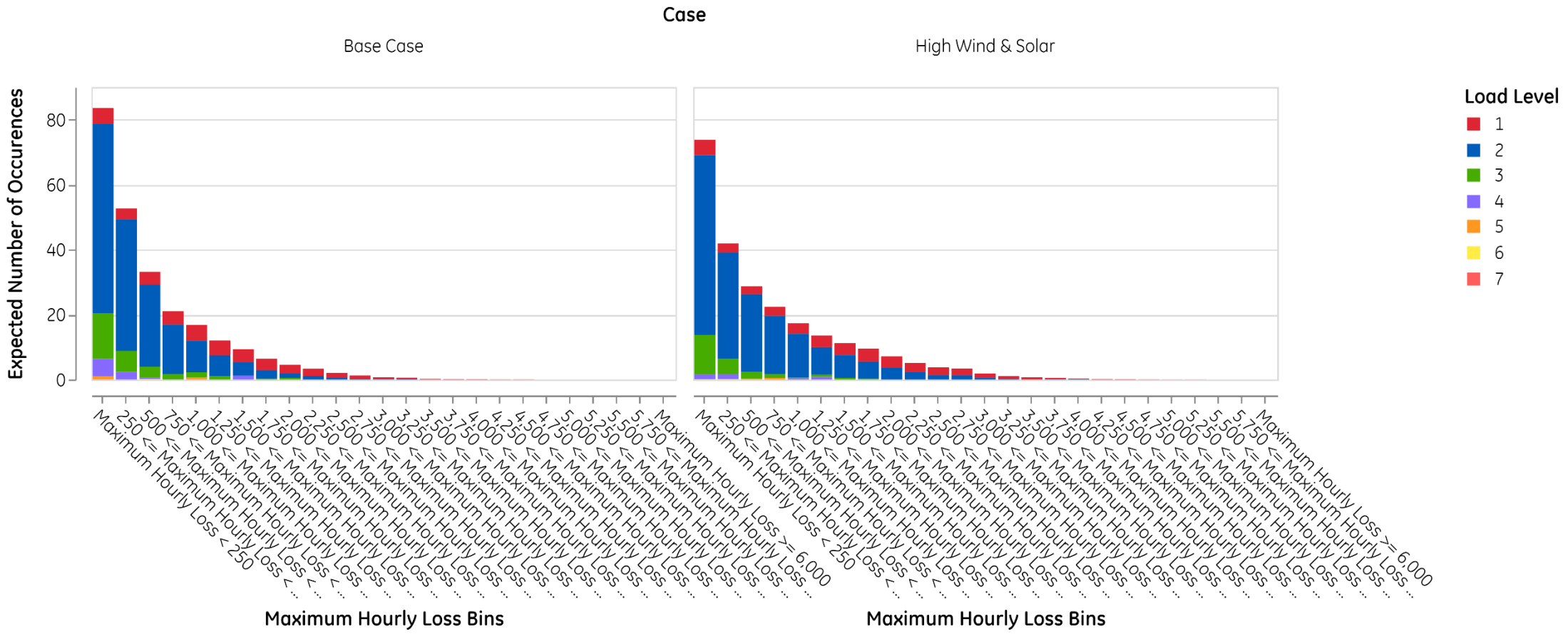
Distribution of Size of Hourly Loss of Load Events



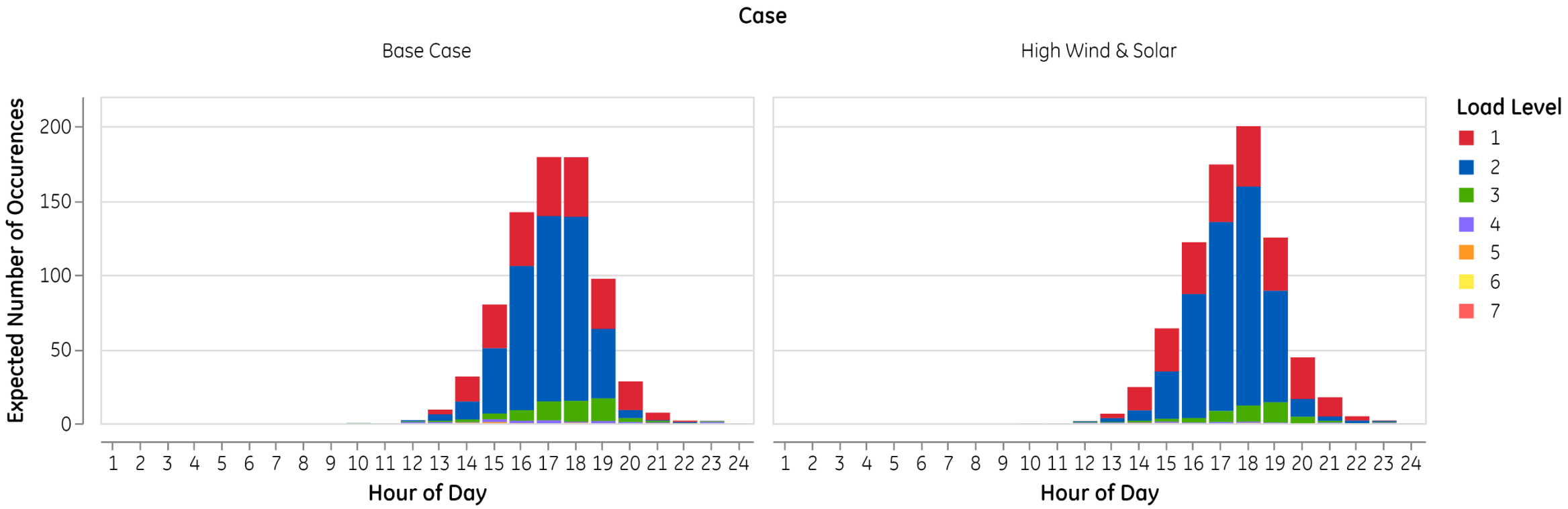
Distribution of Loss of Energy for Daily Loss of Load Events



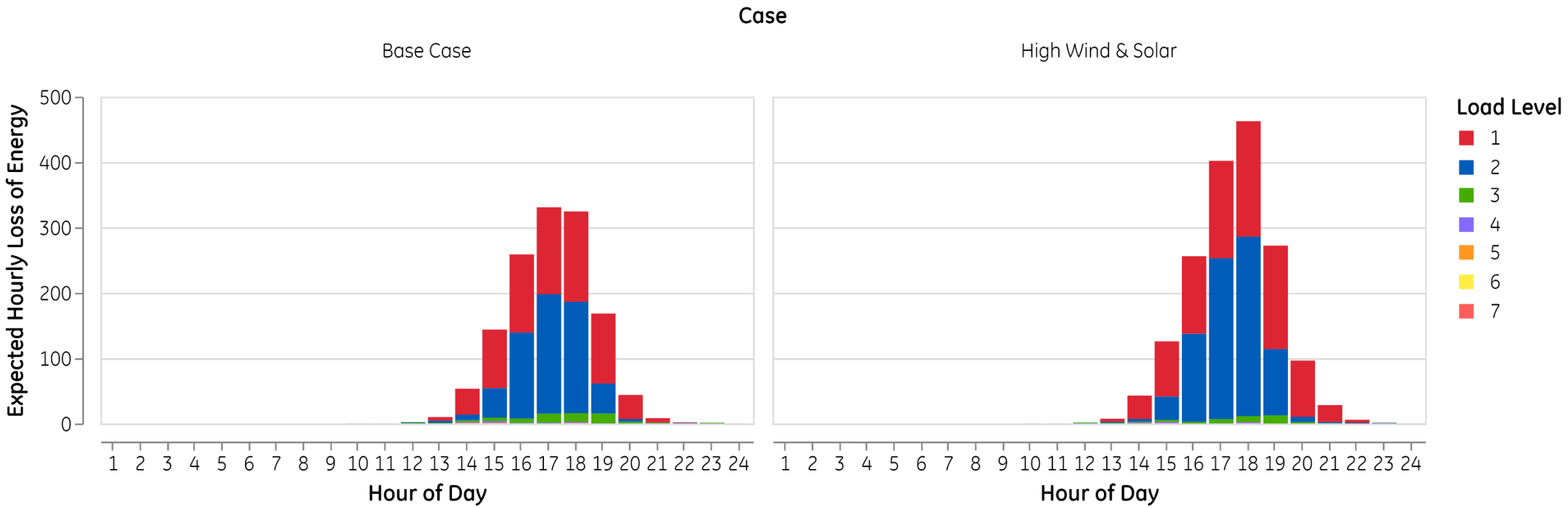
Distribution of Maximum Hourly Size of Daily Loss of Load Events



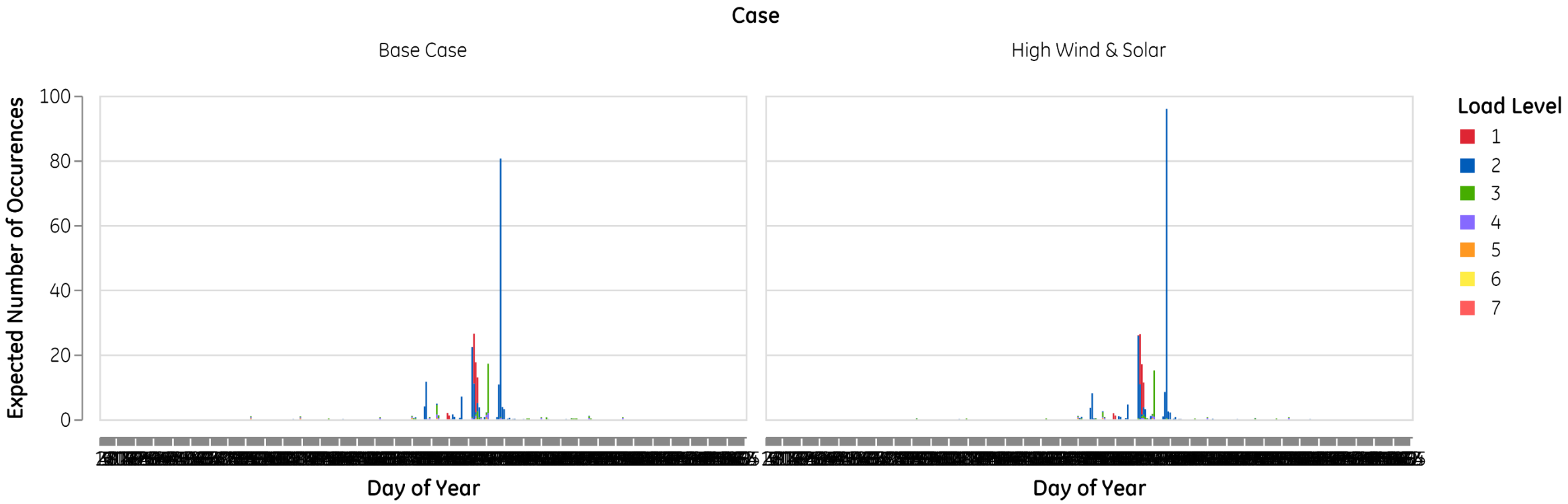
Distribution of Loss of Load Events by Time of Day



Expected Loss of Energy by Time of Day



Distribution of Loss of Load Events by Day of the Year



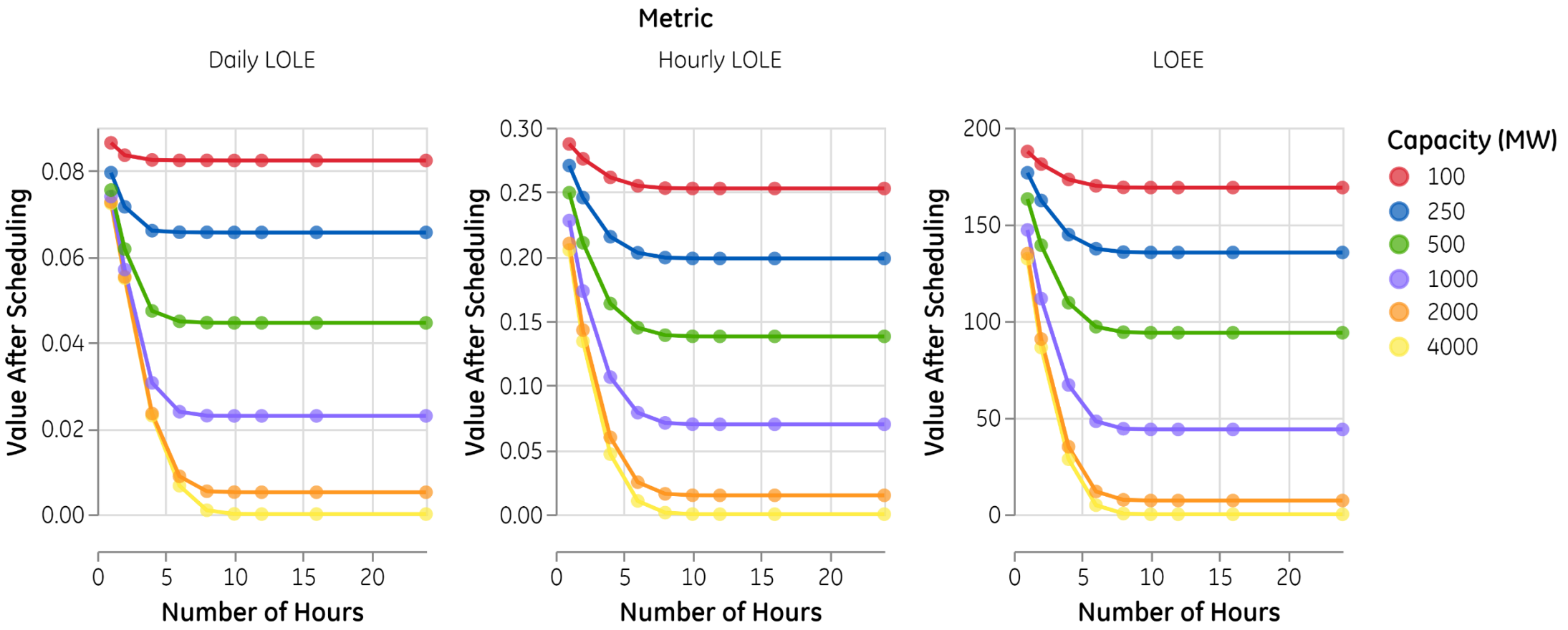
Base Case Capacity Value Results

Duration and Penetration

- 1, 2, 4, 6, 8, 10, 12, 16, and 24 hour durations analyzed
- 100, 250, 500, 1,000, 2,000, and 4,000 MW penetrations analyzed

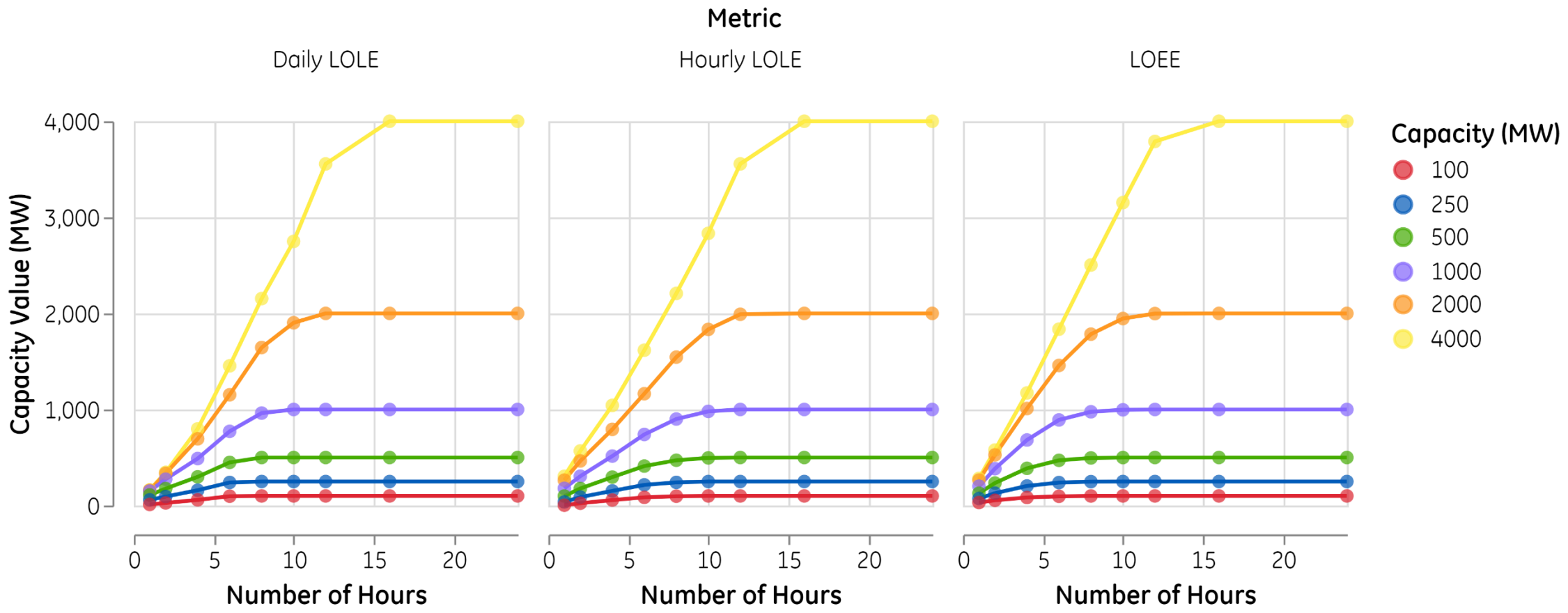
- No diversity assumed (all capacity is called simultaneously)
- No persistence limit assumed (available 365 days / year)
- Perfect availability assumed (0% forced outage rate)

Reliability Metrics After Scheduling Resources



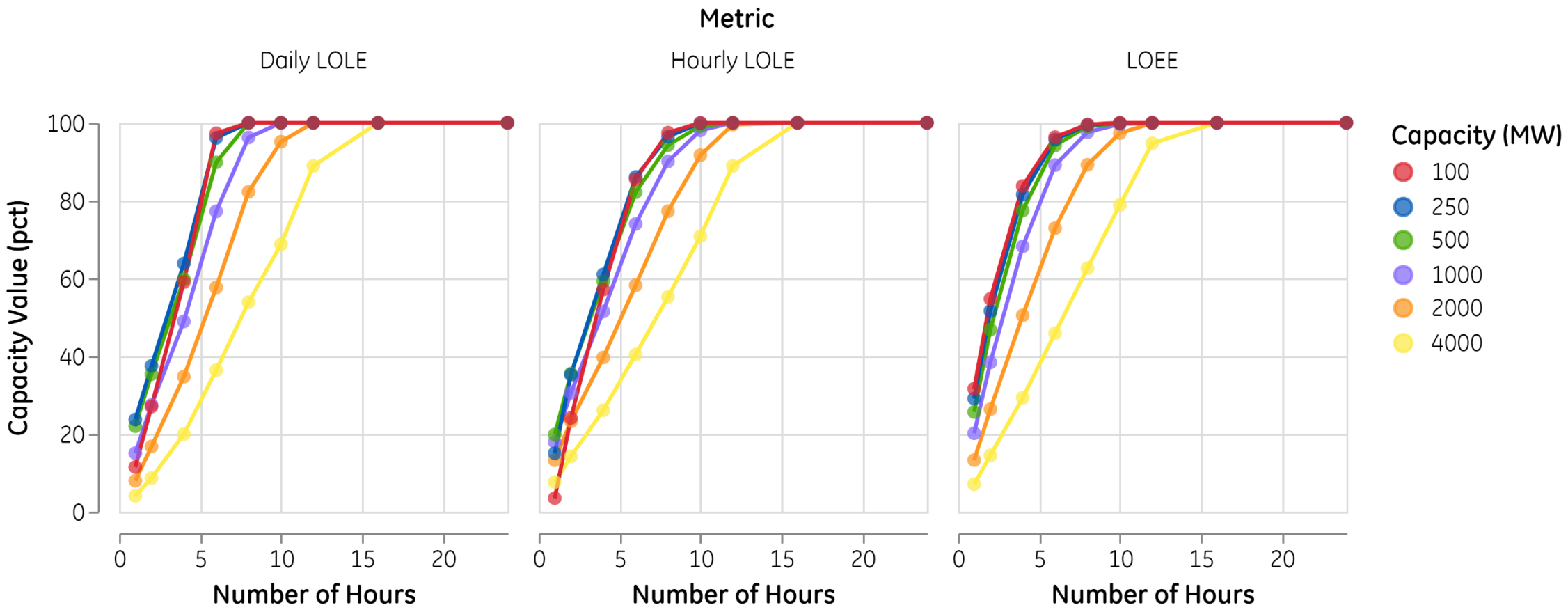
Duration of Use

Absolute Capacity Value (MW)



Duration of Use

Fractional Capacity Value (%)

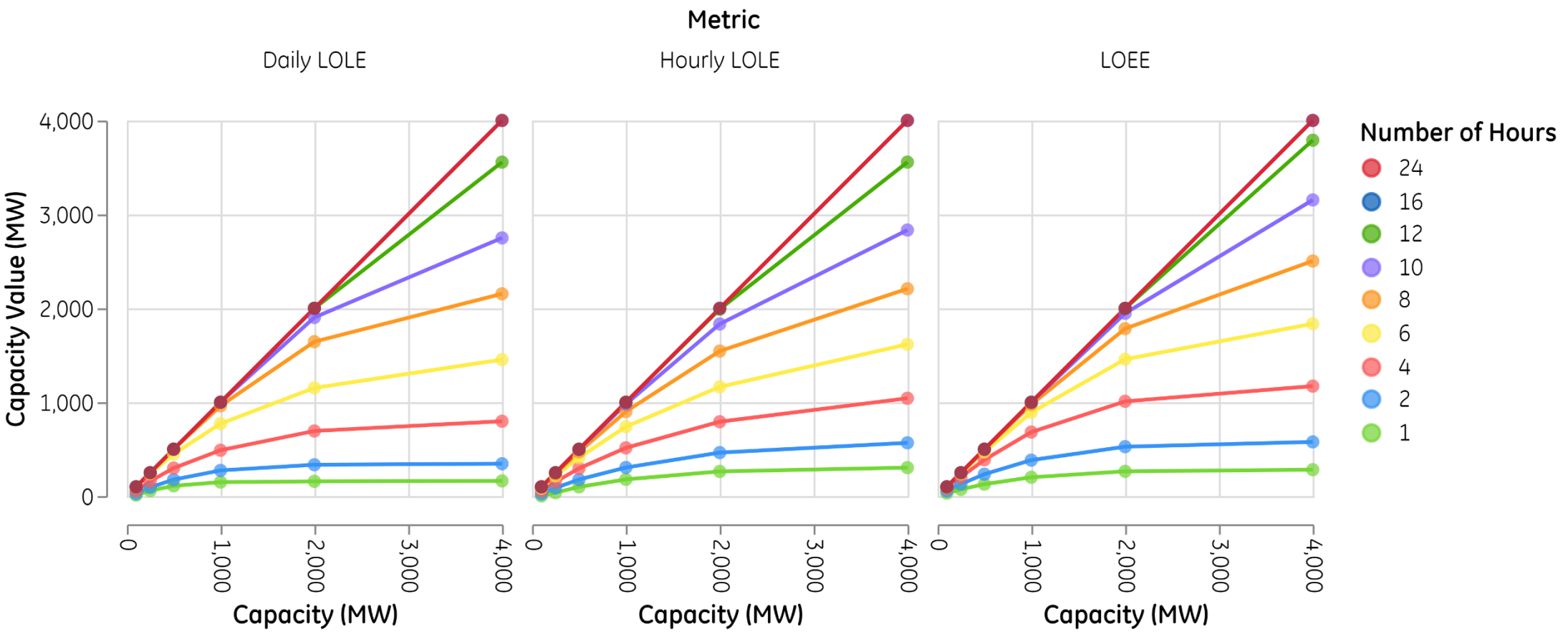


Duration of Use
Observations

- All capacities examined reach 100% between 8 and 16 hours, with all but the largest penetrations reaching 100% by 10 hours
- The higher the penetration, the longer the duration must be for Capacity Value to reach 100%
- Capacity Value in terms of Hourly LOLE and LOEE saturate to 100% with slightly smaller durations

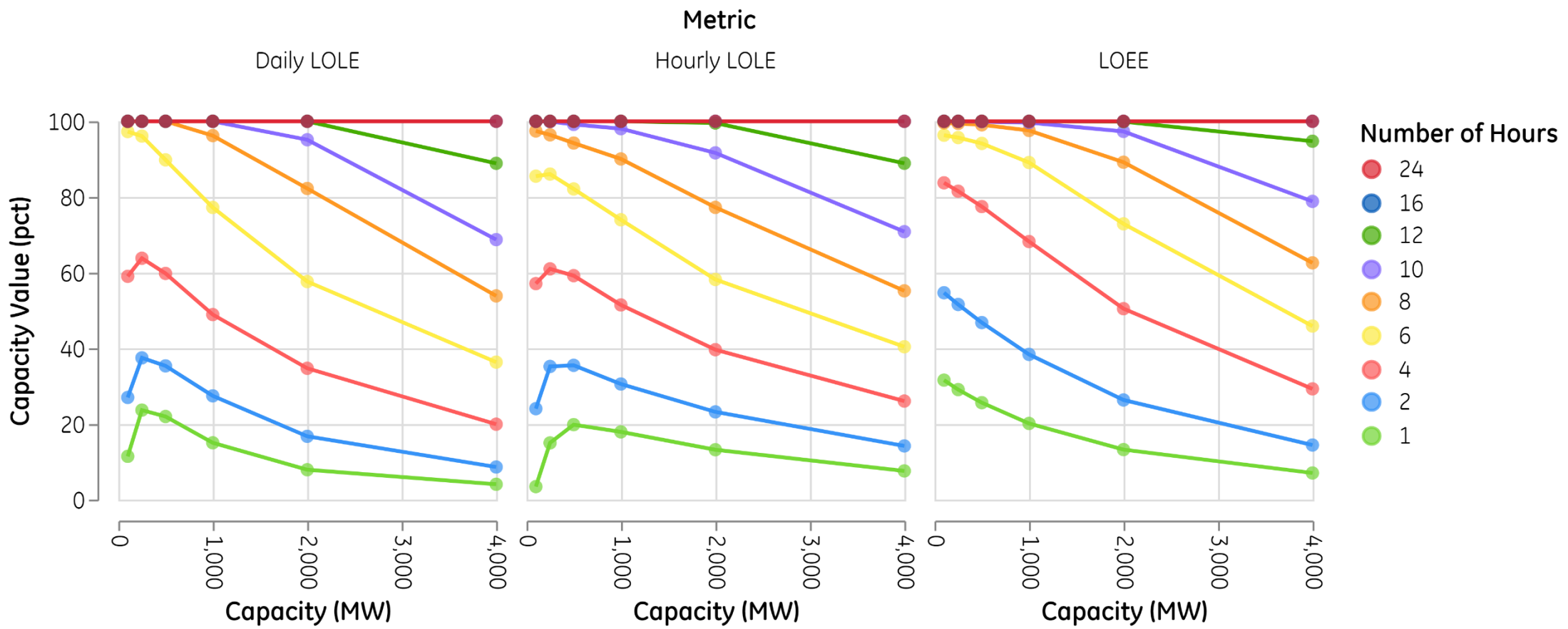
Penetration

Absolute Capacity Value (MW)



Penetration

Fractional Capacity Value (%)



Penetration
Observations

- Capacity Value in absolute terms increases as penetration increases
- Using the daily and hourly LOLE metrics, the Fractional Capacity Value increases as penetration increases up to a threshold point before decreasing
- The Fractional Capacity Value in LOEE terms decreases as penetration increases
- The daily and hourly LOLE threshold point is different for different resource durations, and decreases as the duration increases
- Because Daily and Hourly LOLE are binary metrics, the threshold point is believed to be driven by the distribution of event duration and size. This is supported by the fact that a similar threshold is not seen for LOEE.

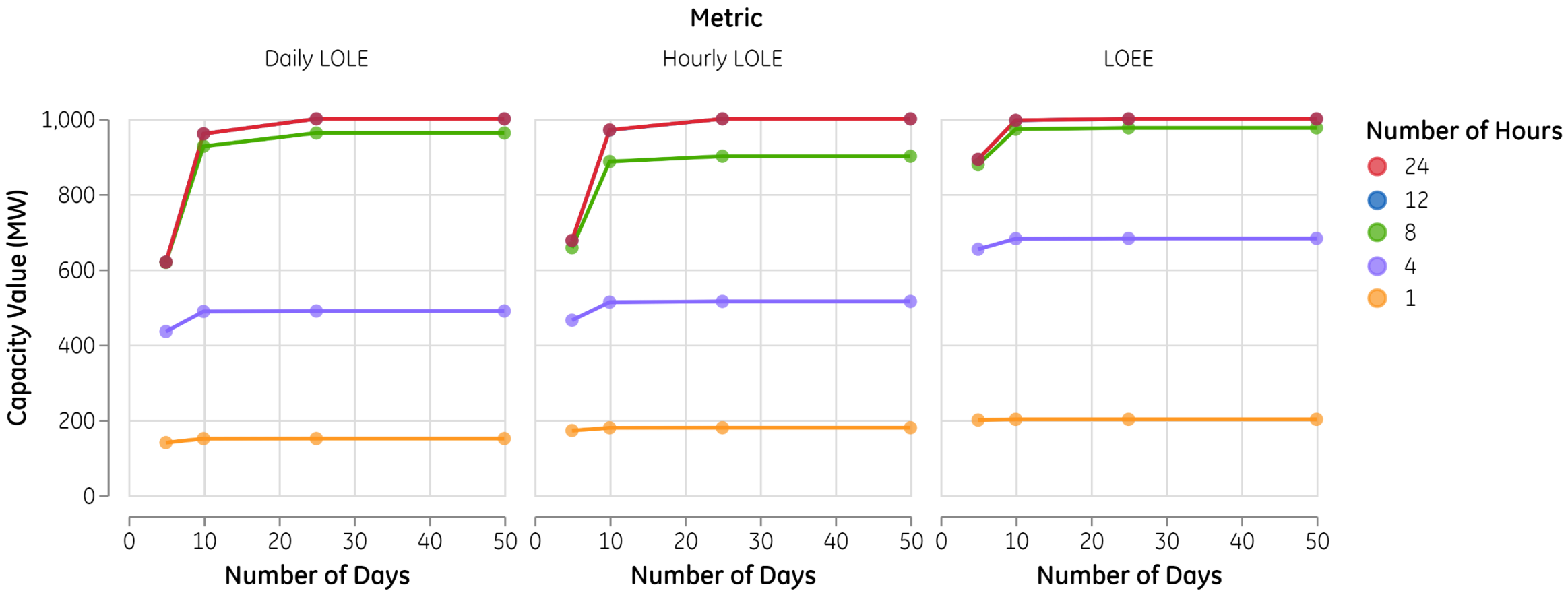
Persistence (Number of Days per Year)

- 1, 4, 8, 12, and 24 hour durations analyzed
- 5, 10, 25, and 50 day persistence limits analyzed

- 1,000 MW penetration assumed
- No diversity assumed (all capacity is called simultaneously)
- Perfect availability assumed (0% forced outage rate)

Persistence

Absolute Capacity Value (MW) of a 1,000 MW Resource



Persistence
Observations

- Full Capacity Value is achieved with between 10 and 25 days per year of availability depending on penetration and duration.
- Unless the limitation on the number of calls per year is very low, the impact of limiting resource persistence is minimal

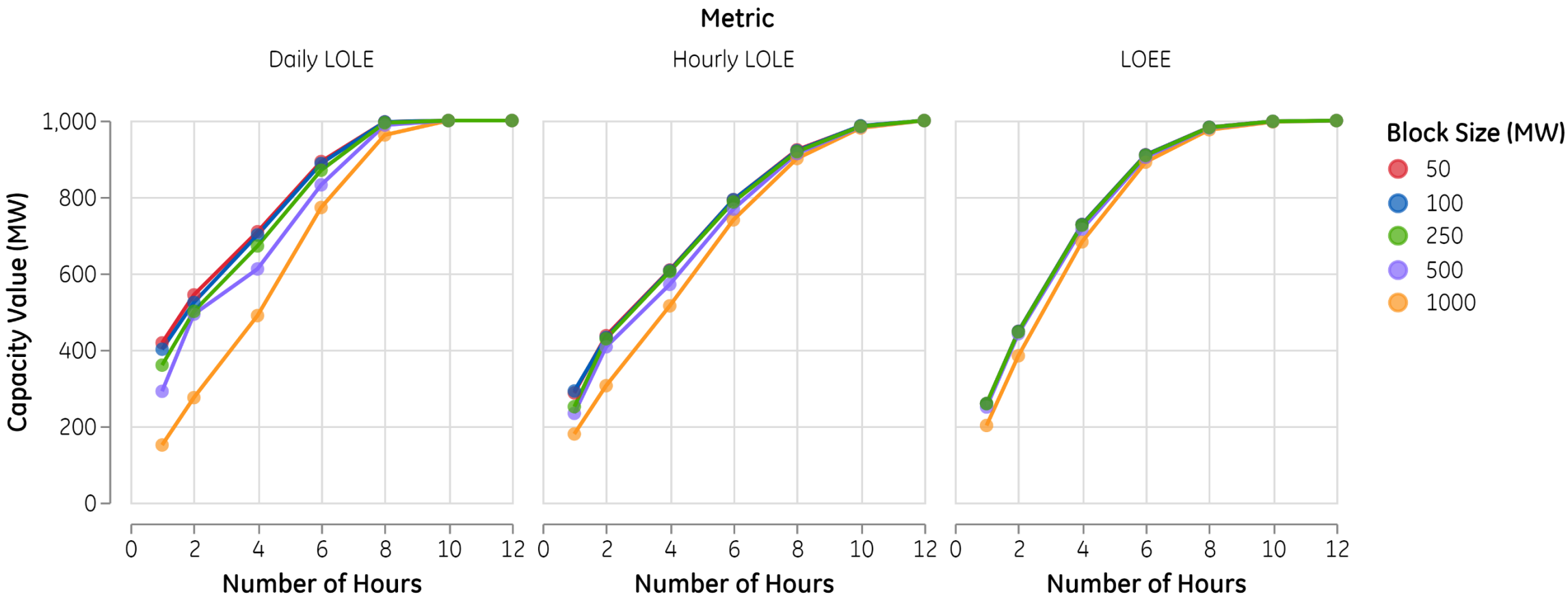
Diversity – 1,000 MW Penetration

- 1, 2, 4, 6, 8, 10,and 12 hour durations analyzed
- Resource scheduled in 50, 100, 250, and 500 MW blocks

- 1,000 MW penetration assumed
- No persistence limit assumed (available 365 days / year)
- Perfect availability assumed (0% forced outage rate)

Diversity

Absolute Capacity Value (MW) of a 1,000 MW Resource



Diversity – All penetrations, 50 MW Block size

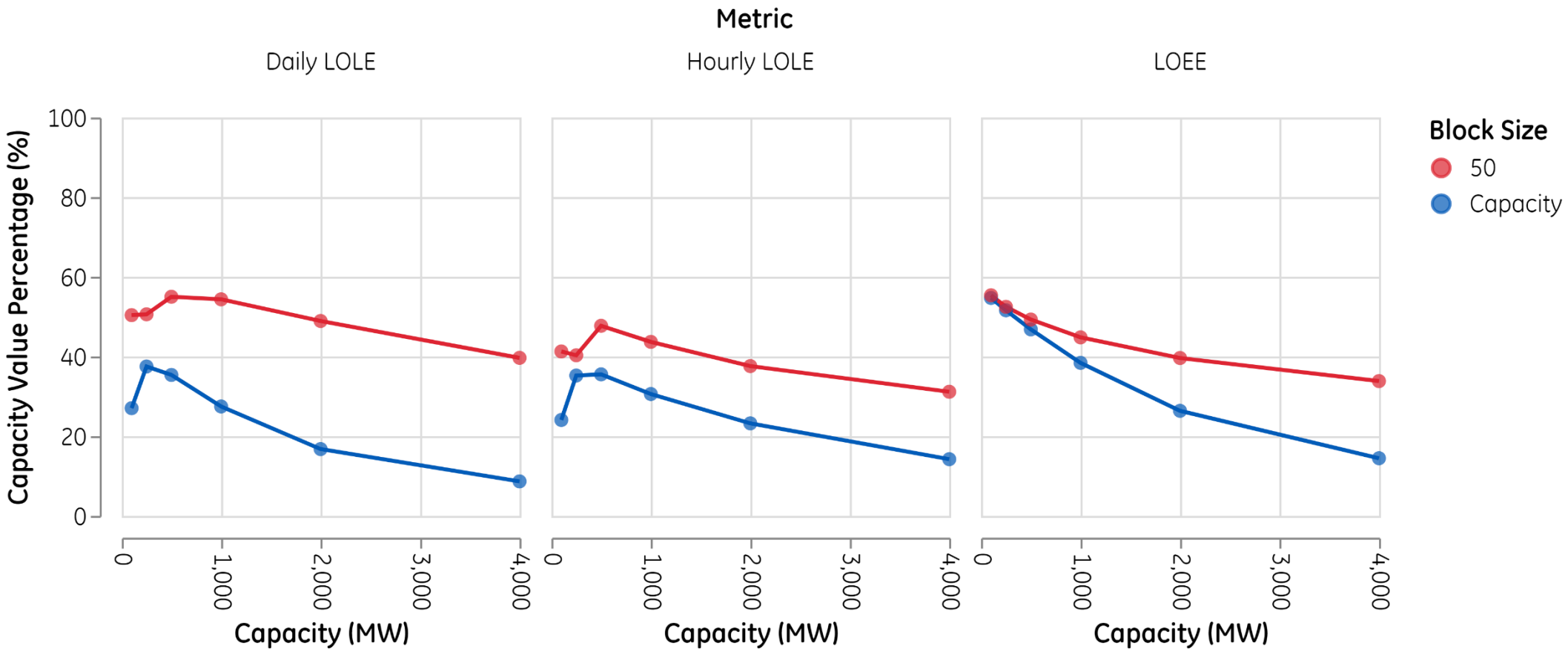
- 1, 2, 4, 6, 8, 10, 12, 16, and 24 hour durations analyzed
- 100, 250, 500, 1,000, 2,000, and 4,000 MW penetration

- Resource scheduled in 50 MW blocks
- No persistence limit assumed (available 365 days / year)
- Perfect availability assumed (0% forced outage rate)

* Full results available in backup

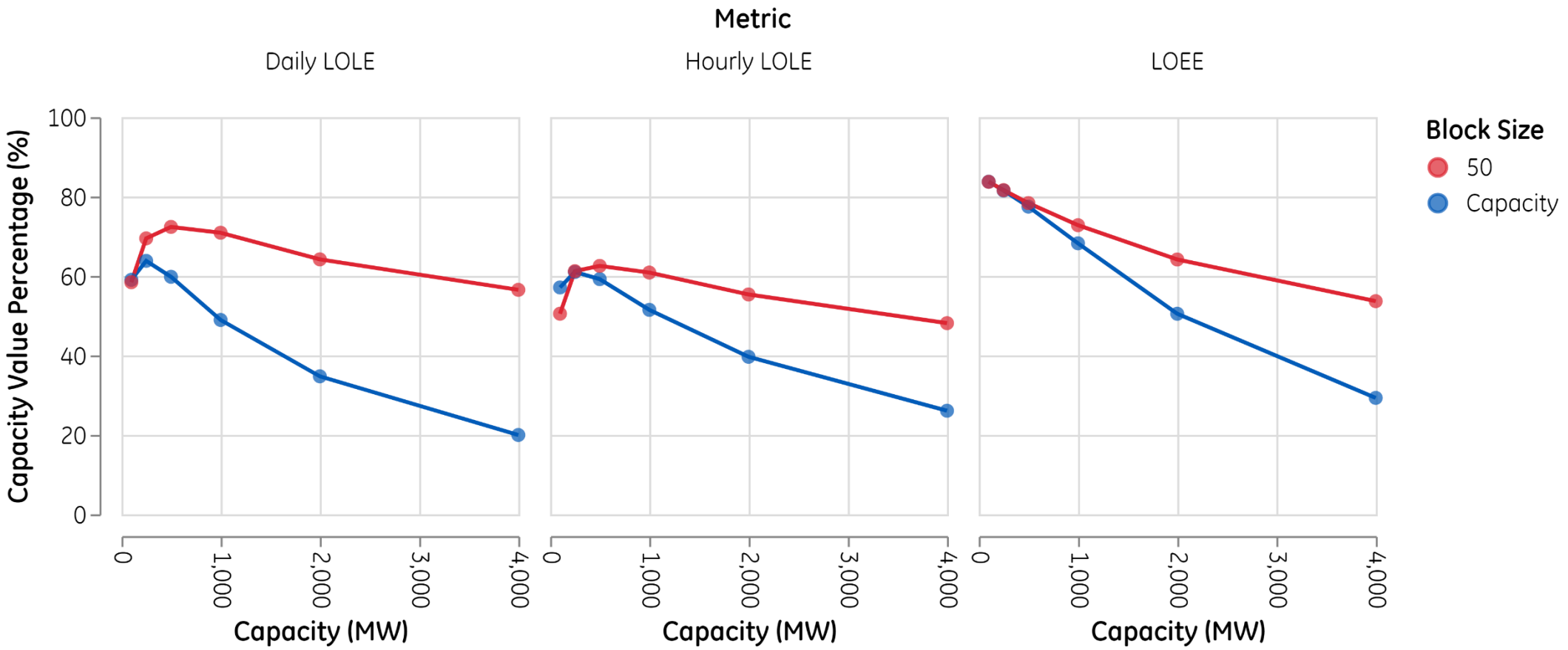
Diversity

Fractional Capacity Value (%) of a Two (2) Hour Resource



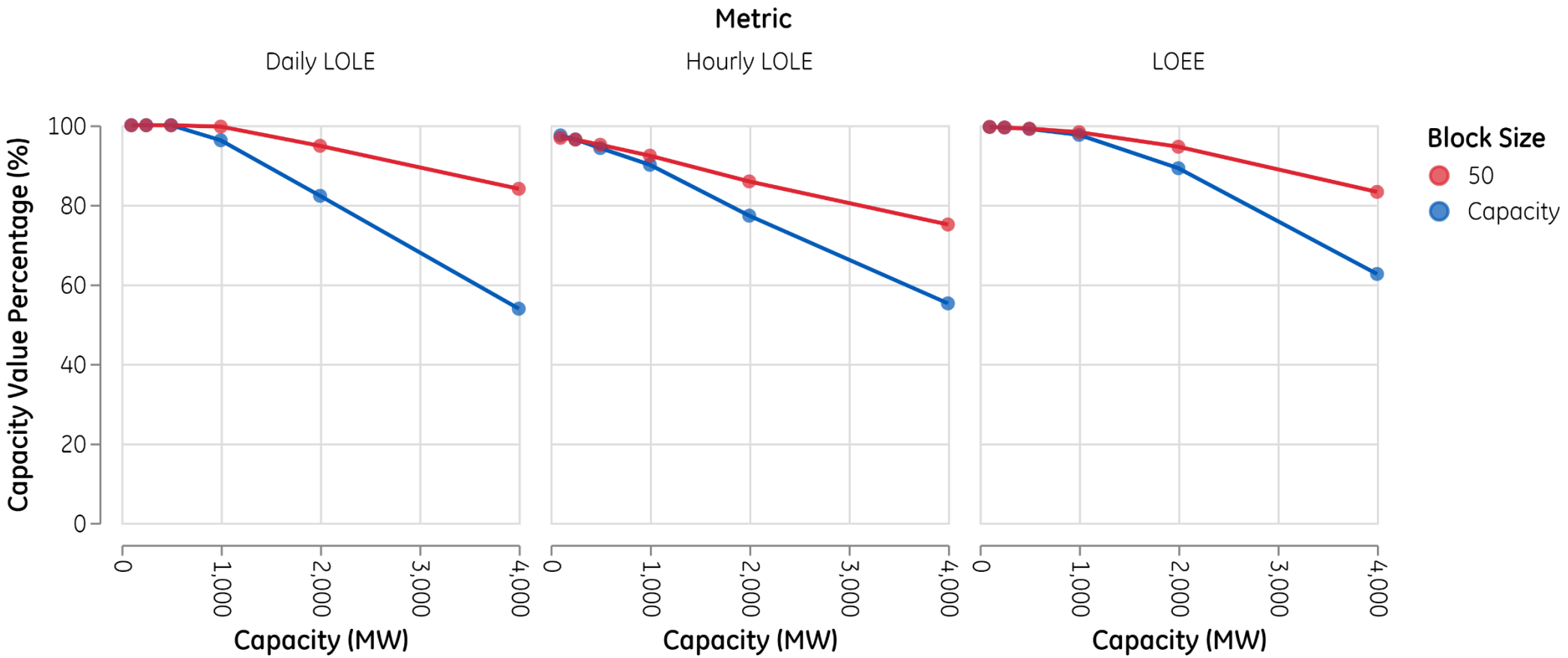
Diversity

Fractional Capacity Value (%) of a Four (4) Hour Resource



Diversity

Fractional Capacity Value (%) of an Eight (8) Hour Resource



Diversity
Observations

- Resource diversity increases Capacity Value because the resources are scheduled sequentially, meaning each block is scheduled accounting for the impact of previously scheduled blocks.
- The increase is most pronounced for the Capacity Value calculated
  1) Using the Daily LOLE metric
  2) For shorter duration resources
  3) For larger penetrations
- As an example: with a 4 Hour duration, 1,000 MW penetration scheduled in 50 MW blocks has more absolute Capacity Value (709 MW) than 2,000 MW with no diversity (694 MW)

Performance

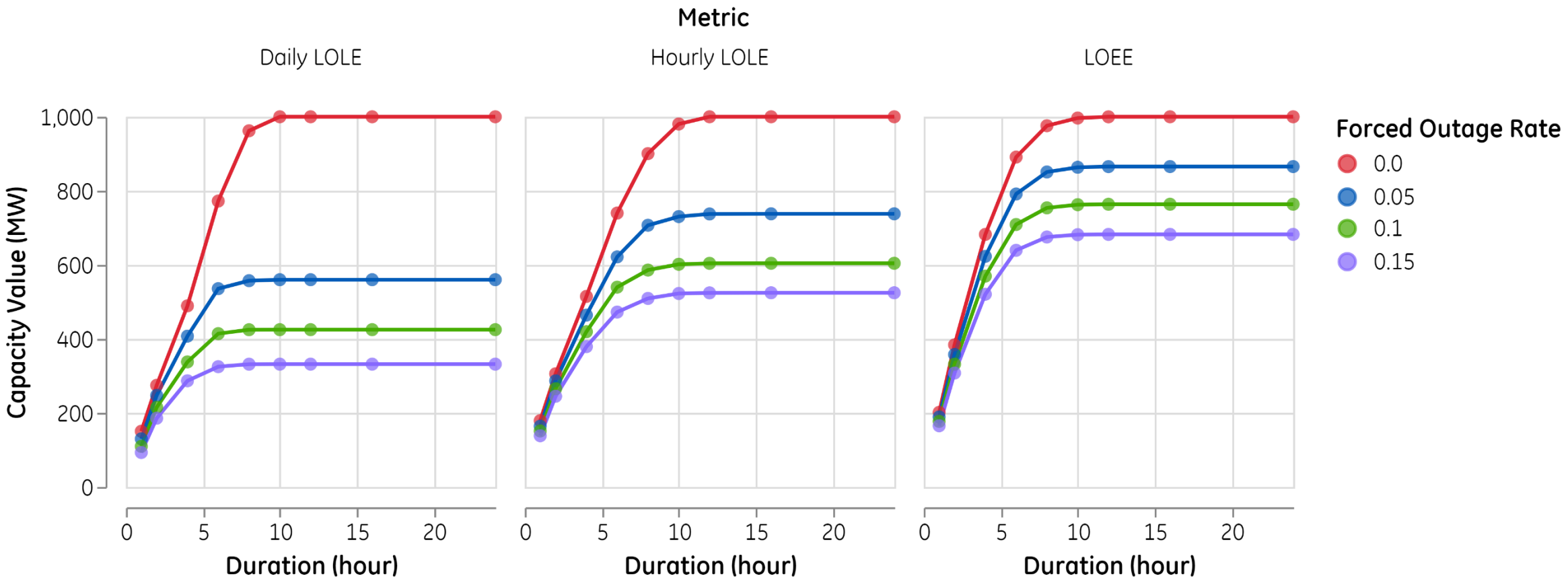
- 1, 2, 4, 6, 8, 10, 12, 16, and 24 hour durations analyzed
- 100, 250, 500, 1,000, 2,000, and 4,000 MW penetrations analyzed
- 5%, 10%, and 15% forced outage rates analyzed - on / off two state modelling on an hourly basis

- No diversity assumed (all capacity is called simultaneously)
- No persistence limit assumed (available 365 days / year)

* Full results available in backup

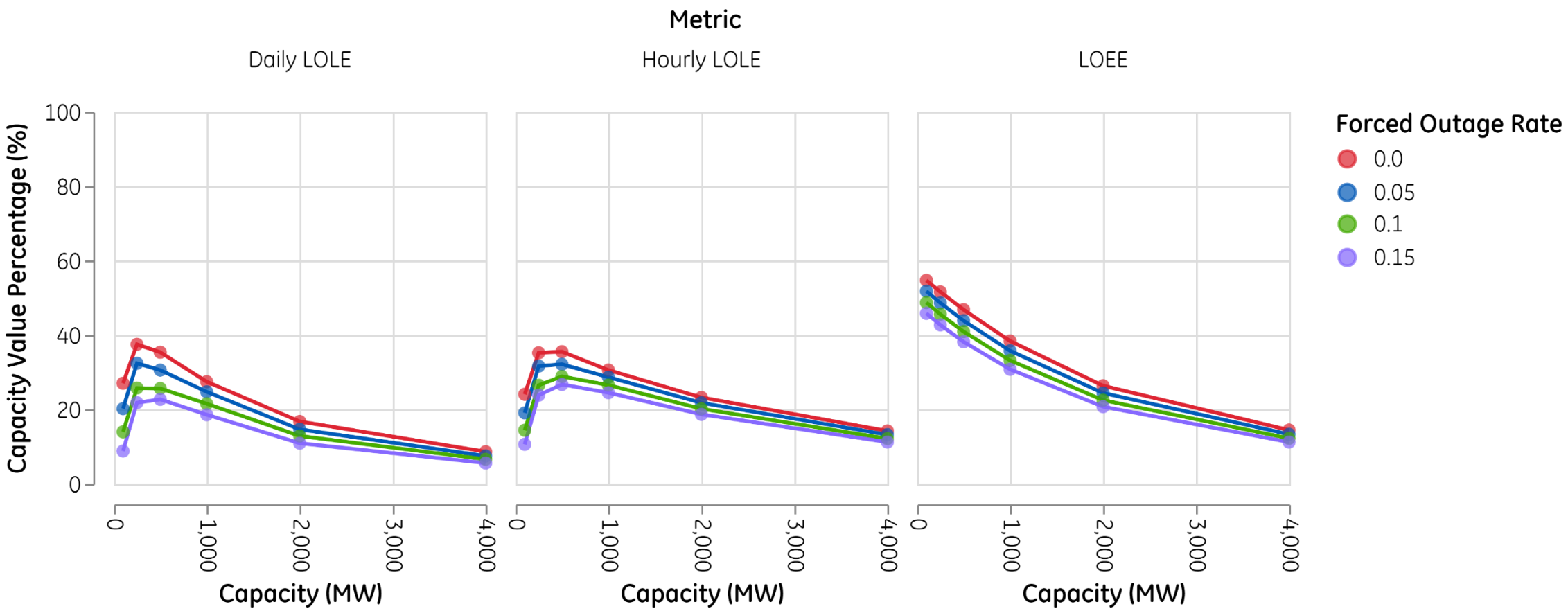
Performance

Absolute Capacity Value (MW) of a 1,000 MW Resource



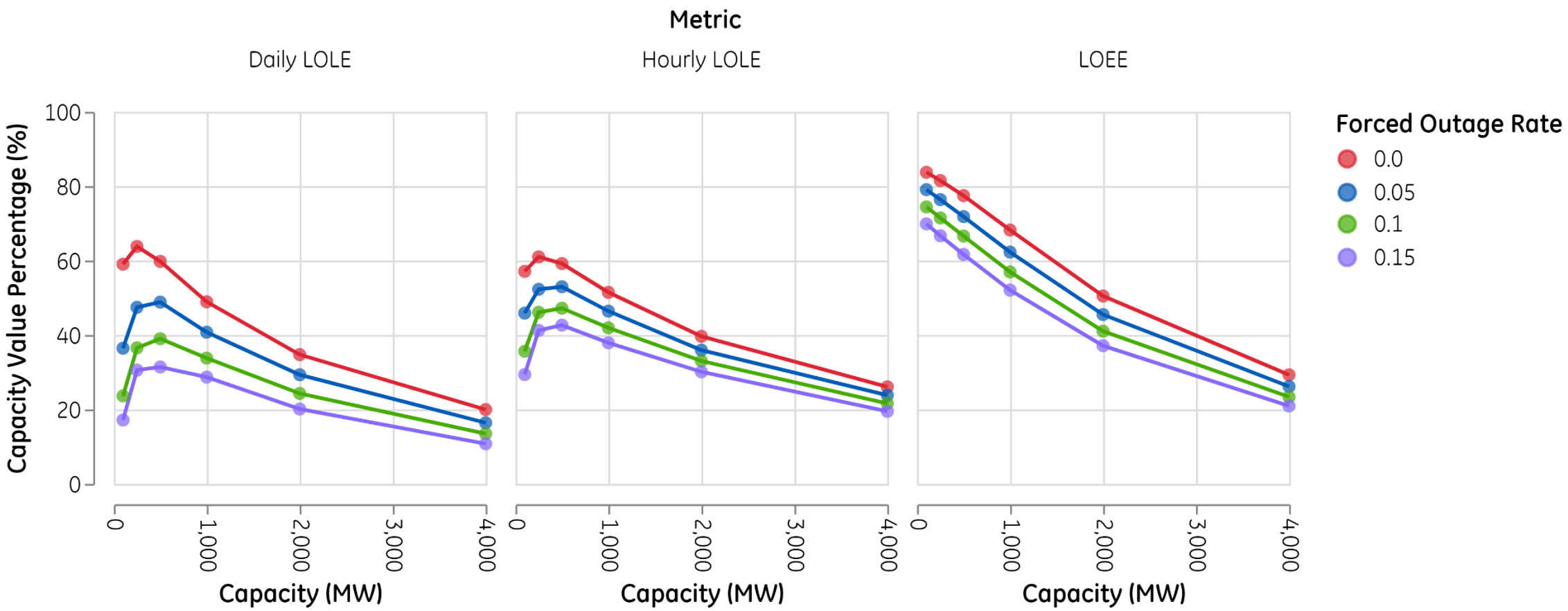
Performance

Fractional Capacity Value (%) of a Two (2) Hour Resource



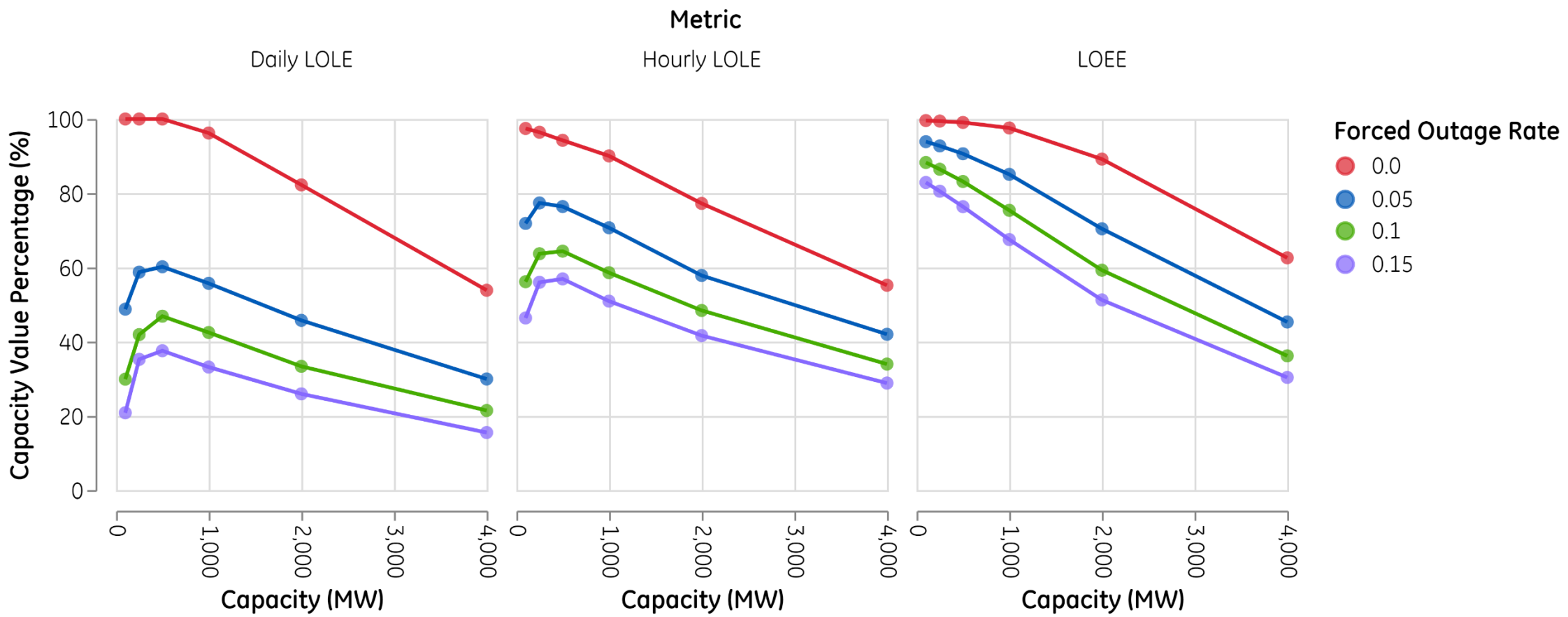
Performance

Fractional Capacity Value (%) of a Four (4) Hour Resource



Performance

Fractional Capacity Value (%) of an Eight (8) Hour Resource



Performance
Observations

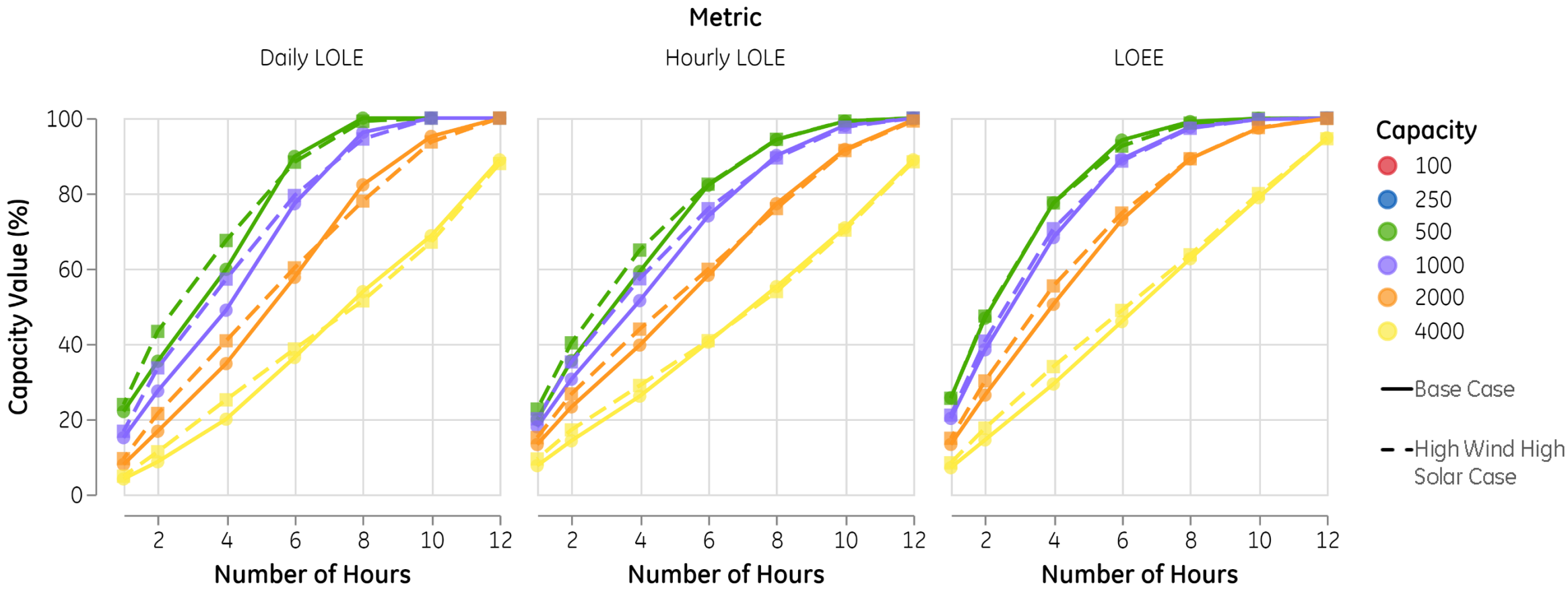
- Because the random draws are done on an hourly basis the impact on daily LOLE is more pronounced. Further analysis may be needed to analyze the impacts of daily outages.

High Wind High Solar Capacity Value Results

* Full results available in backup

Duration of Use – Base Case vs High Wind High Solar Case

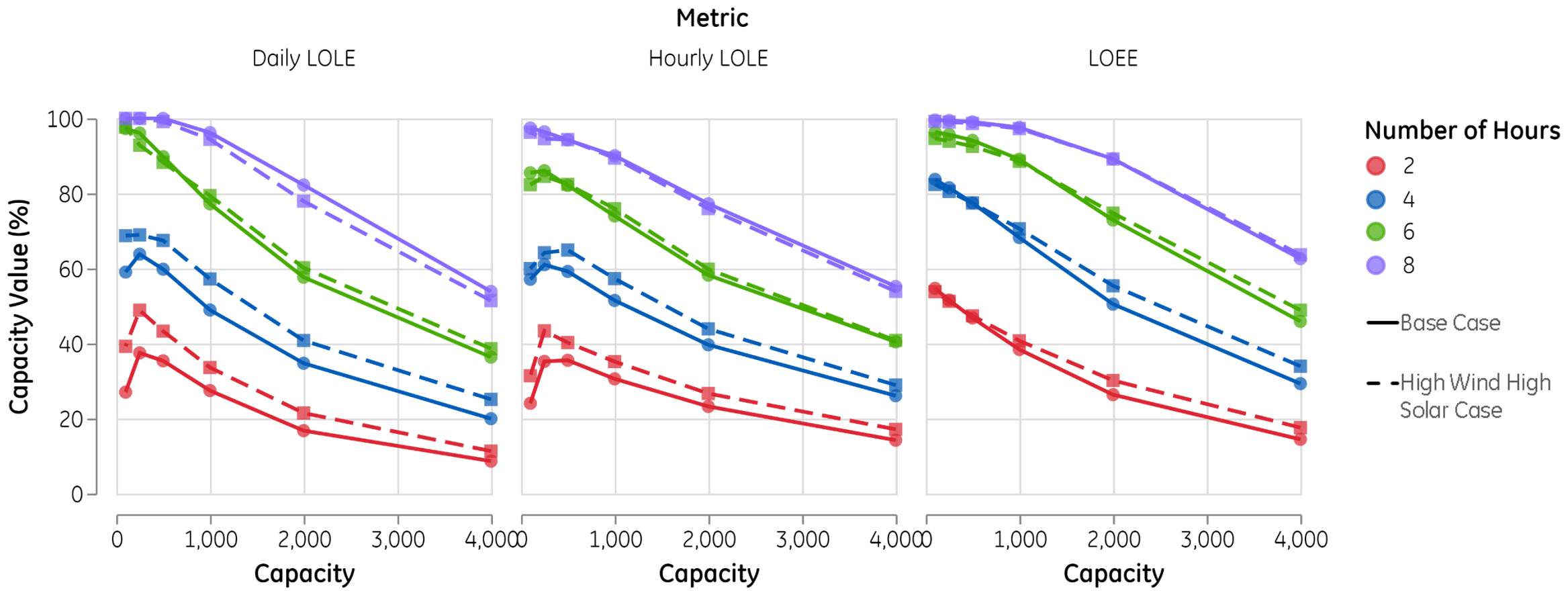
Fractional Capacity Value (%)



NOTE: Capacity Value Only Shown for up to 12 hour duration, full results available in backup

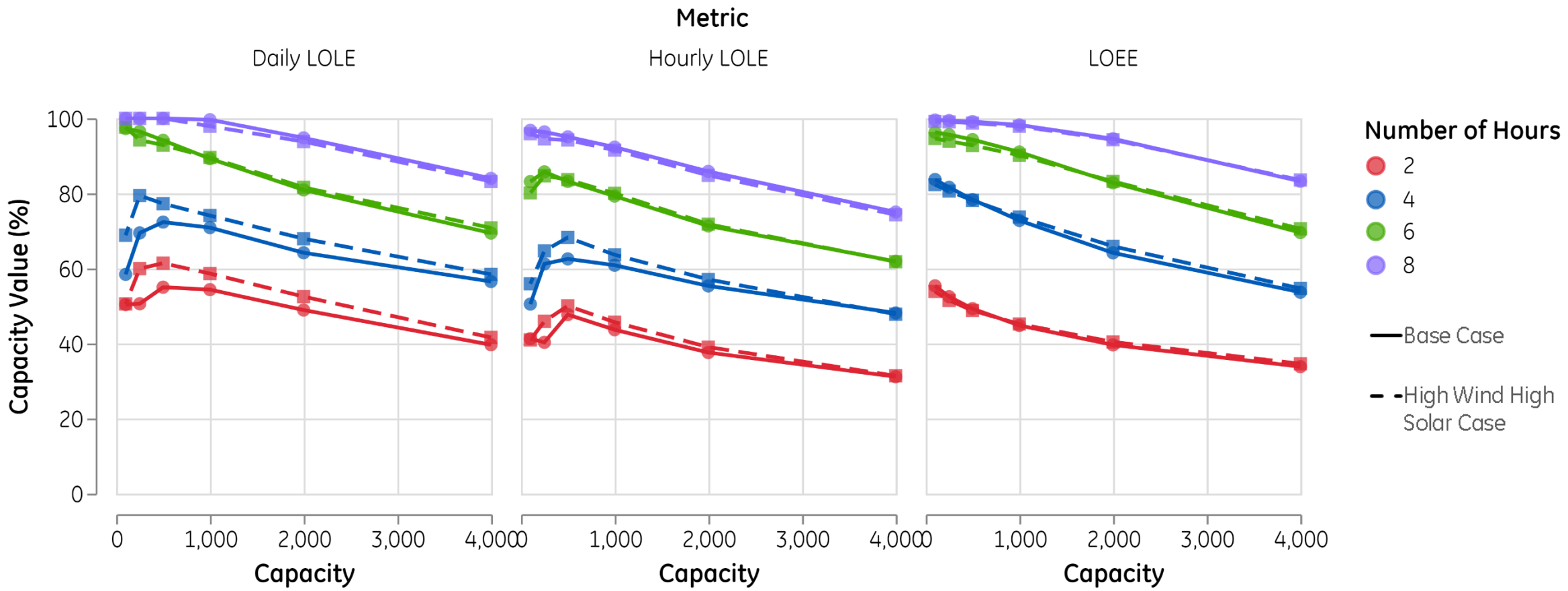
Penetration – Base Case vs High Wind High Solar Case

Fractional Capacity Value (%)



Diversity – Base Case vs High Wind High Solar Case

Fractional Capacity Value (%)



Performance – Base Case vs High Wind High Solar Case

Observations

- For resources with short duration capabilities (less than 6 hour duration), Capacity Value is marginally higher on the High Wind High Solar Case than it is on the Base Case
- For longer duration capability resources (greater than 6 Hour duration), the Capacity value is similar between the two cases
- The increase in Capacity Value observed in the High Wind High Solar Case is less for diverse resources scheduled in 50 MW blocks
- Slides 20 and 21 indicate that loss of load events are more concentrated during hours ending 16-19 in the High Wind High Solar Case. This may explain why shorter duration capable resources are more valuable in the high wind high solar case, as well as why diversity provides less benefit.

Conclusions and Study Limitations

Conclusions

- Without modelling diversity, the higher the penetration, the longer the duration must be for Capacity Value to reach 100%
- All capacities examined reach 100% Capacity Value with between 8 and 16 hour duration; all but the largest penetrations reaching 100% by 10 hours
- Using the daily and hourly LOLE metrics, the Fractional Capacity Value increases as penetration increases up to a threshold point before decreasing
- This threshold point is driven by the distribution of event duration and size. This is supported by the fact that a similar threshold is not seen for LOEE.
- Unless the limitation on the number of calls per year is very low, the impact of limiting resource persistence is minimal

Conclusions

- Resource diversity can significantly increase Capacity Value for high penetrations
- For resources with short durations, Capacity Value is marginally higher on the High Wind High Solar Case than it is on the Base Case
- The increase in Capacity Value observed in the High Wind High Solar Case is less for diverse resources scheduled in 50 MW blocks

Study Limitations

- This analysis focuses on duration limitations (number of consecutive hours called); energy limitations (MWh available, not necessarily consecutively) may yield different results.
- Consistent with the NYISO's capacity market design principles, which assume capacity value is independent of start time, we assume perfect foresight when scheduling resources. The impact of start time is not known.
- The results are unclear as to what the impact of increased wind and solar above the high wind high solar case are on the capacity value of the resources analyzed.
- Capacity Value of these resources was evaluated on an at-criteria system, it is uncertain what the impact of overall system reliability would be on resource capacity value.

Backup

09 October 2018

Approach

How is Capacity Value Calculated

1. Bring system to a reference point (2018 IRM Base Case with Optimized LCRs)
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3. Increase system load, reliability decreases
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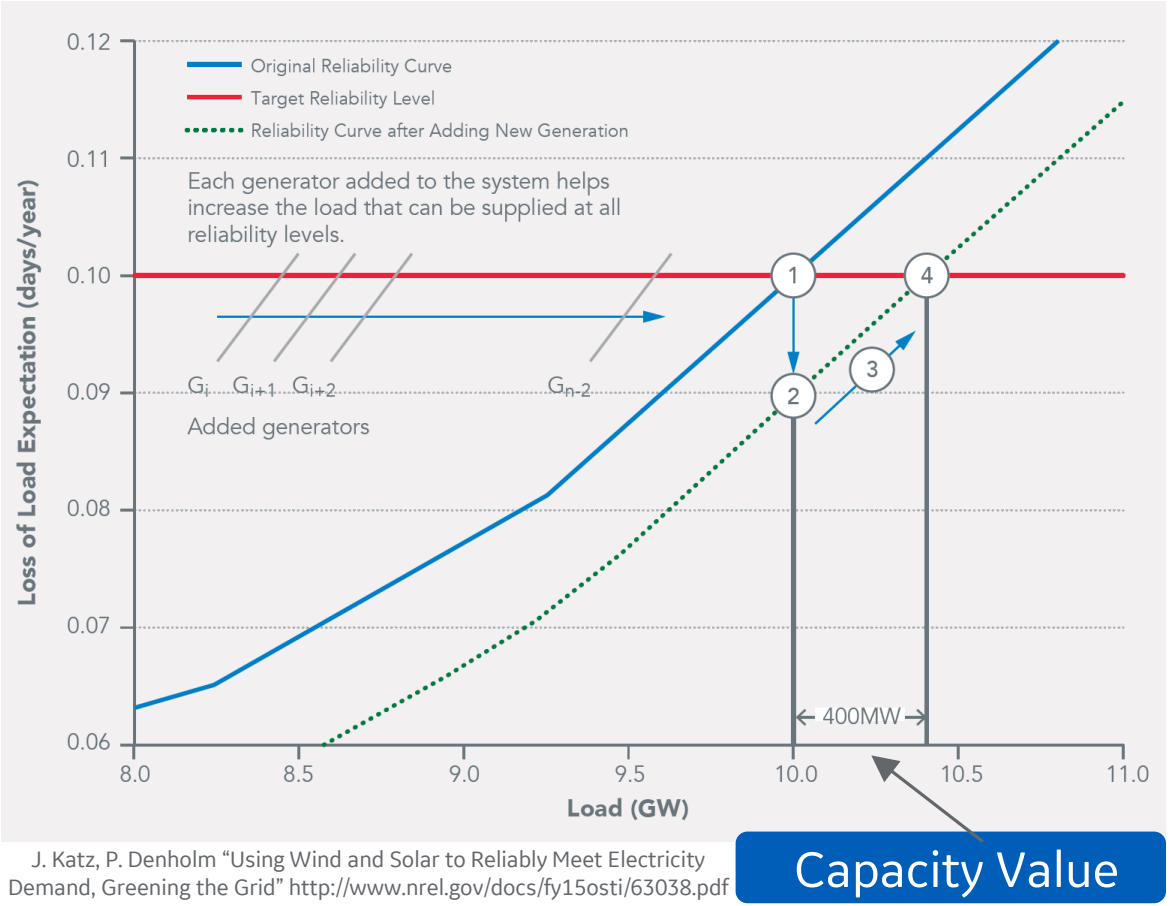

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Capacity will be removed until the relevant reliability index is returned to base case levels.

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Selecting the Days to Schedule

- Calculate hourly NYCA capacity margin and available Emergency Assistance for all replications and load levels
- If seasonal limitations are specified, filter the data to only those days where the resource is available
- Select the worst days for scheduling up to the limit on the number of calls
  1) Days with Loss of Load Events
  2) Days without loss of Load Events sorted by the sum of NYCA capacity margin and Available Emergency Assistance

Resource Scheduling

Selecting the Hours to Schedule

From the days selected for scheduling

- If time of day limitations are specified, filter to only those hours the resource is available
- If duration of use limitations are specified, calculate the rolling total capacity margin for the number of hours allowed, schedule the resource for the period with the minimum total
- If energy limitations are specified, schedule the resource for a block of consecutive hours until the available energy is utilized (starting from the worst hour, schedule outwards to the worst adjacent hour)

Resource Scheduling

Forced Outages and Intermittency

A probability density function (PDF) can be used to specify the probability a unit is at a given percentage of its output.

The scheduling tool will determine, based on this PDF and a randomly drawn number, what the output will be in any hour.

The PDF used can be specified by hour of the day and by month.

Resource Scheduling

Calculating Net Capacity Margin for Ranking

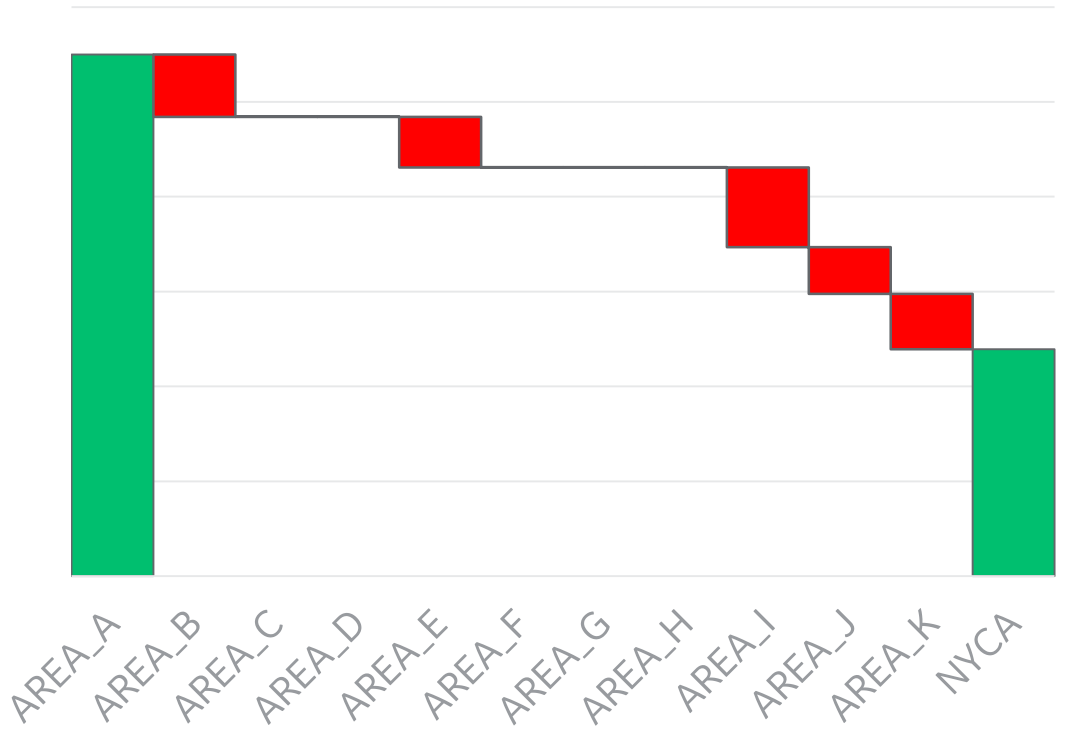
Discussion

Because loss of load events can occur due to transmission constraints, it is possible for NYCA to have a positive net margin and a loss of load

For such hours, only the negative area's margins will be counted towards ranking days / hours for scheduling

It is assumed that if there is a loss of Load event no Emergency Assistance is available

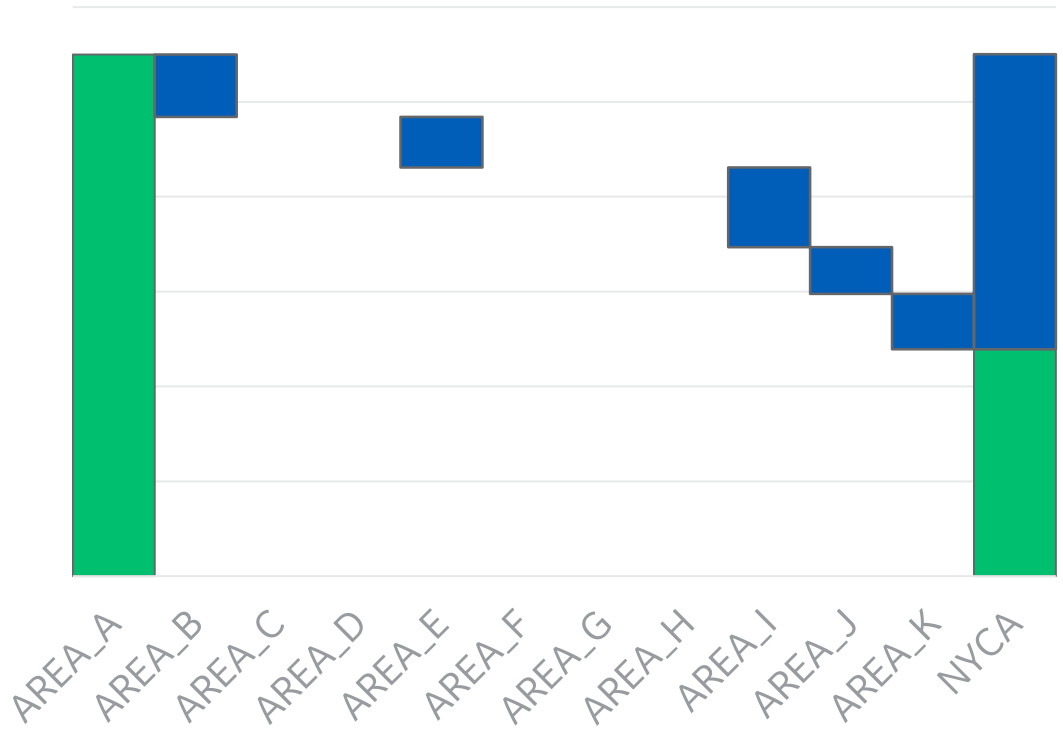
Sample Loss of Load Event Caused by Transmission



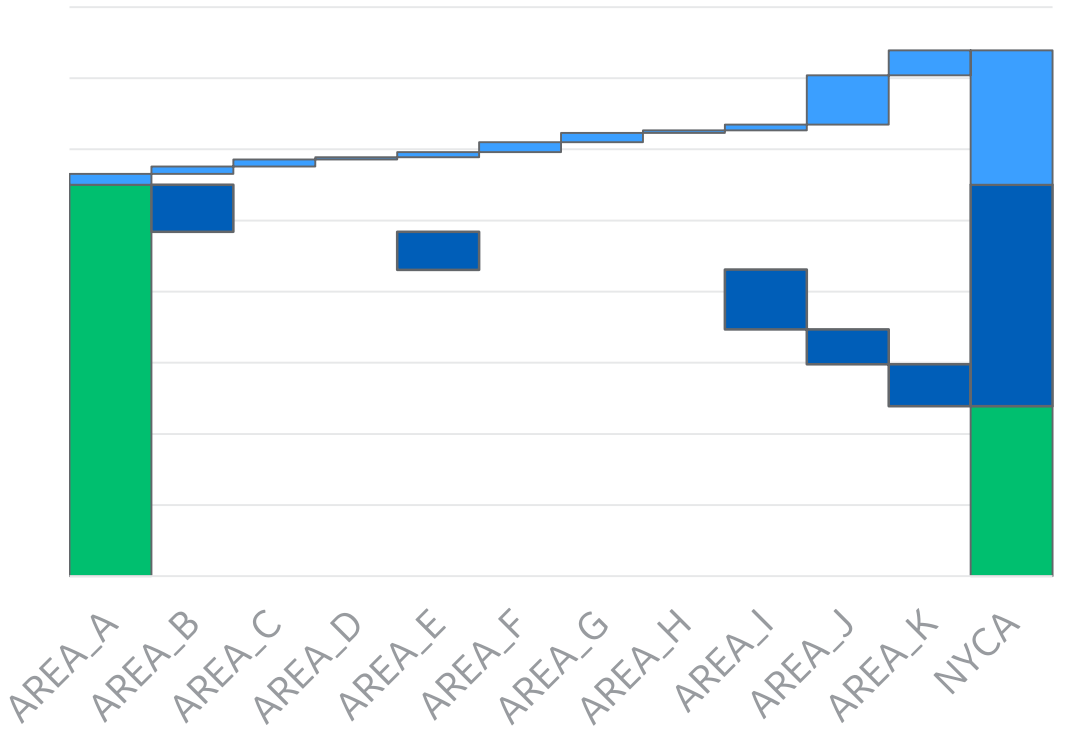
Resource Scheduling

Distribution of capacity among NY Areas

Negative Areas will be scheduled first



Capacity will then be scheduled proportional to load



Capacity Removal

A constant amount of capacity is removed from all hours to calculate capacity value

1) If the resource is scheduled in the hour, remove capacity from NY Areas proportional to the capacity added
2) If the resource is not scheduled and all NY Areas have capacity margins greater than or equal to zero, remove capacity from NY Areas proportional to the surplus
3) If the resource is not scheduled and any NY Area has a capacity margin less than zero, remove capacity proportional to base case UCAP

Capacity Removal

A combination of the three approaches may be employed if the capacity removal is larger than the resource addition in that hour (*i.e.* if the resource is partially on outage, or if a diverse resource is added and not all blocks are scheduled)

After removing capacity, if there is Emergency Assistance available which could reduce a loss of load, decrease the loss by the amount of available Emergency Assistance.

Loss of Load Event Statistics

Distribution of Event Duration for Daily Loss of Load Events

		Load Level														
		Base Case								High Wind High Solar						
		1	2	3	4	5	6	7	All	1	2	3	4	5	6	7	All
Event Duration (Hours)	1	2.7	38.4	16.0	7.7	1.7	0.2	0.0	**66.6**	2.6	38.2	10.9	3.4	0.7	0.2	0.0	**56.1**
	2	3.0	39.6	3.6	1.1	0.0	0.0	0.0	**47.4**	2.8	43.1	5.3	0.8	0.0	0.0	0.0	**52.0**
	3	3.2	42.1	4.1	0.0	0.0	0.0	0.0	**49.3**	2.7	38.5	3.4	0.0	0.0	0.0	0.0	**44.7**
	4	4.0	22.7	2.2	0.4	0.0	0.0	0.0	**29.3**	2.6	28.4	0.2	0.0	0.0	0.0	0.0	**31.2**
	5	4.6	14.8	1.7	0.0	0.0	0.0	0.0	**21.2**	4.1	16.6	0.7	0.0	0.0	0.0	0.0	**21.5**
	6	12.3	5.0	0.7	0.0	0.0	0.0	0.0	**18.0**	8.3	4.4	1.0	0.0	0.0	0.0	0.0	**13.7**
	7	7.0	2.4	0.2	0.0	0.0	0.0	0.0	**9.6**	8.9	2.2	0.5	0.0	0.0	0.0	0.0	**11.5**
	8	3.6	0.4	0.0	0.0	0.0	0.0	0.0	**4.1**	6.1	0.7	0.0	0.0	0.0	0.0	0.0	**6.8**
	9	1.4	0.1	0.2	0.0	0.0	0.0	0.0	**1.8**	2.9	0.5	0.0	0.0	0.0	0.0	0.0	**3.4**
	10	0.3	0.0	0.0	0.0	0.0	0.0	0.0	**0.3**	0.6	0.3	0.0	0.0	0.0	0.0	0.0	**0.9**
	11	0.1	0.1	0.0	0.0	0.0	0.0	0.0	**0.1**	0.1	0.1	0.0	0.0	0.0	0.0	0.0	**0.2**
	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0	0.1	0.0	0.0	0.0	0.0	0.0	**0.1**

Distribution of Size of Hourly Loss of Load Events

Hourly Event Size (MW)	Load Level	Base Case								High Wind High Solar							
		1	2	3	4	5	6	7	All	1	2	3	4	5	6	7	All
< 250		31.3	192.6	31.2	7.7	1.0	0.0	0.0	**263.7**	31.3	182.1	27.6	2.3	0.0	0.1	0.0	**243.3**
250	500	27.3	109.6	11.8	2.3	0.0	0.0	0.0	**151.1**	24.5	99.4	8.9	1.5	0.0	0.1	0.0	**134.5**
500	750	27.7	62.7	8.2	0.4	0.0	0.2	0.0	**99.2**	25.1	65.8	3.9	0.0	0.2	0.0	0.0	**95.0**
750	1,000	27.6	38.7	5.1	0.0	0.0	0.0	0.0	**71.4**	24.6	45.3	2.7	0.0	0.5	0.0	0.0	**73.0**
1,000	1,250	25.9	22.2	1.9	0.0	0.7	0.0	0.0	**50.8**	24.9	32.5	0.5	0.4	0.0	0.0	0.0	**58.3**
1,250	1,500	22.6	15.2	1.9	0.0	0.0	0.0	0.0	**39.7**	22.8	20.3	1.2	0.8	0.0	0.0	0.0	**45.1**
1,500	1,750	18.4	7.8	0.0	1.1	0.0	0.0	0.0	**27.3**	21.0	16.5	0.5	0.0	0.0	0.0	0.0	**38.0**
1,750	2,000	14.4	5.4	0.2	0.0	0.0	0.0	0.0	**20.0**	17.8	11.8	0.2	0.0	0.0	0.0	0.0	**29.9**
2,000	2,250	10.5	2.9	0.5	0.0	0.0	0.0	0.0	**13.8**	14.8	7.3	0.0	0.0	0.0	0.0	0.0	**22.1**
2,250	2,500	7.5	1.9	0.0	0.0	0.0	0.0	0.0	**9.4**	11.2	5.2	0.0	0.0	0.0	0.0	0.0	**16.4**
2,500	2,750	4.8	0.9	0.0	0.0	0.0	0.0	0.0	**5.8**	8.4	2.8	0.0	0.0	0.0	0.0	0.0	**11.2**
> 2,750		7.2	0.7	0.0	0.0	0.0	0.0	0.0	**7.9**	15.8	3.6	0.0	0.0	0.0	0.0	0.0	**19.5**

Distribution of Loss of Energy for Daily Loss of Load Events

Daily Event Energy (MWh)	Load Level	Base Case								High Wind High Solar							
		1	2	3	4	5	6	7	All	1	2	3	4	5	6	7	All
< 1,800		10.6	126.4	24.9	9.2	1.7	0.2	0.0	**173.0**	9.6	118.5	20.3	4.2	0.7	0.2	0.0	**153.5**
1,800	3,600	6.2	24.8	2.4	0.0	0.0	0.0	0.0	**33.4**	4.3	29.8	1.0	0.0	0.0	0.0	0.0	**35.0**
3,600	5,400	5.8	8.2	1.0	0.0	0.0	0.0	0.0	**15.0**	4.2	12.4	0.7	0.0	0.0	0.0	0.0	**17.3**
5,400	7,200	5.1	3.8	0.5	0.0	0.0	0.0	0.0	**9.3**	4.7	6.2	0.0	0.0	0.0	0.0	0.0	**10.8**
7,200	9,000	4.4	1.7	0.0	0.0	0.0	0.0	0.0	**6.1**	4.2	3.6	0.0	0.0	0.0	0.0	0.0	**7.8**
9,000	10,800	3.3	0.4	0.0	0.0	0.0	0.0	0.0	**3.7**	3.9	1.5	0.0	0.0	0.0	0.0	0.0	**5.4**
10,800	14,400	3.9	0.3	0.0	0.0	0.0	0.0	0.0	**4.2**	5.5	1.2	0.0	0.0	0.0	0.0	0.0	**6.6**
14,400	16,200	1.1	0.1	0.0	0.0	0.0	0.0	0.0	**1.3**	1.8	0.0	0.0	0.0	0.0	0.0	0.0	**1.8**
16,200	18,000	0.6	0.0	0.0	0.0	0.0	0.0	0.0	**0.6**	1.2	0.0	0.0	0.0	0.0	0.0	0.0	**1.2**
18,000	19,800	0.5	0.0	0.0	0.0	0.0	0.0	0.0	**0.5**	0.9	0.1	0.0	0.0	0.0	0.0	0.0	**0.9**
19,800	21,600	0.2	0.0	0.0	0.0	0.0	0.0	0.0	**0.2**	0.6	0.0	0.0	0.0	0.0	0.0	0.0	**0.6**
> 21,600		0.3	0.0	0.0	0.0	0.0	0.0	0.0	**0.3**	1.0	0.0	0.0	0.0	0.0	0.0	0.0	**1.0**

Distribution of Maximum Hourly Size of Daily Loss of Load Events

Daily Event Maximum Hourly Size (MW)	Load Level															
	Base Case								High Wind High Solar							
	1	2	3	4	5	6	7	All	1	2	3	4	5	6	7	All
< 250	4.8	58.4	14.0	5.4	1.0	0.0	0.0	**83.5**	4.7	55.4	12.1	1.5	0.0	0.1	0.0	**73.7**
250 500	3.3	40.5	6.5	2.3	0.0	0.0	0.0	**52.6**	2.8	32.5	4.8	1.5	0.0	0.1	0.0	**41.9**
500 750	4.0	25.2	3.4	0.4	0.0	0.2	0.0	**33.1**	2.5	23.8	2.2	0.0	0.2	0.0	0.0	**28.7**
750 1,000	4.1	15.2	1.7	0.0	0.0	0.0	0.0	**21.0**	2.9	17.9	1.2	0.0	0.5	0.0	0.0	**22.4**
1,000 1,250	4.8	9.8	1.5	0.0	0.7	0.0	0.0	**16.7**	3.3	13.4	0.2	0.4	0.0	0.0	0.0	**17.3**
1,250 1,500	4.6	6.4	1.0	0.0	0.0	0.0	0.0	**12.0**	3.6	8.4	0.7	0.8	0.0	0.0	0.0	**13.5**
1,500 1,750	4.0	4.1	0.0	1.1	0.0	0.0	0.0	**9.3**	3.6	7.0	0.5	0.0	0.0	0.0	0.0	**11.2**
1,750 2,000	3.5	2.6	0.2	0.0	0.0	0.0	0.0	**6.4**	4.0	5.3	0.2	0.0	0.0	0.0	0.0	**9.5**
2,000 2,250	2.6	1.4	0.5	0.0	0.0	0.0	0.0	**4.5**	3.5	3.6	0.0	0.0	0.0	0.0	0.0	**7.1**
2,250 2,500	2.2	1.1	0.0	0.0	0.0	0.0	0.0	**3.3**	3.0	2.2	0.0	0.0	0.0	0.0	0.0	**5.1**
2,500 2,750	1.5	0.5	0.0	0.0	0.0	0.0	0.0	**2.1**	2.4	1.3	0.0	0.0	0.0	0.0	0.0	**3.7**
> 2,750	2.5	0.4	0.0	0.0	0.0	0.0	0.0	**3.0**	5.7	2.2	0.0	0.0	0.0	0.0	0.0	**7.9**

Distribution of Loss of Load Events by Time of Day

		Load Level														
		Base Case							High Wind High Solar							
		1	2	3	4	5	6	7	All	1	2	3	4	5	6	7	All
Hour of the Day	10	0.0	0.1	0.2	0.0	0.0	0.0	0.0	**0.3**	0.0	0.1	0.0	0.0	0.0	0.0	0.0	**0.1**
	11	0.0	0.1	0.0	0.0	0.0	0.0	0.0	**0.1**	0.0	0.1	0.0	0.0	0.0	0.0	0.0	**0.1**
	12	0.1	0.8	0.5	0.8	0.0	0.0	0.0	**2.2**	0.1	0.5	0.5	0.4	0.0	0.0	0.0	**1.5**
	13	3.3	4.2	1.0	0.8	0.0	0.0	0.0	**9.2**	3.0	2.5	0.5	0.4	0.0	0.0	0.0	**6.4**
	14	16.9	12.0	1.9	0.4	0.2	0.1	0.0	**31.5**	15.7	7.0	1.0	0.4	0.2	0.1	0.0	**24.4**
	15	29.5	43.9	3.9	1.9	0.7	0.1	0.0	**80.0**	29.0	31.9	1.9	0.8	0.2	0.1	0.0	**63.9**
	16	36.3	97.1	7.0	1.5	0.2	0.0	0.0	**142.2**	34.9	83.5	3.1	0.4	0.0	0.0	0.0	**121.9**
	17	39.8	124.8	12.8	1.9	0.0	0.0	0.0	**179.3**	38.8	127.2	7.5	0.8	0.0	0.0	0.0	**174.2**
	18	40.1	123.9	14.0	0.8	0.2	0.1	0.0	**179.1**	40.6	147.5	10.9	0.8	0.2	0.1	0.0	**200.0**
	19	33.7	46.8	15.2	1.5	0.0	0.0	0.0	**97.3**	35.9	75.0	13.8	0.4	0.0	0.0	0.0	**125.0**
	20	19.3	5.5	2.7	0.8	0.0	0.0	0.0	**28.2**	28.1	11.9	4.4	0.0	0.0	0.0	0.0	**44.4**
	21	5.0	0.5	1.0	0.4	0.2	0.0	0.0	**7.1**	13.0	3.0	1.2	0.4	0.0	0.0	0.0	**17.6**
	22	1.0	0.5	0.2	0.0	0.0	0.0	0.0	**1.8**	2.9	1.6	0.2	0.0	0.0	0.0	0.0	**4.7**
	23	0.1	0.2	0.5	0.8	0.0	0.0	0.0	**1.6**	0.4	0.7	0.5	0.4	0.0	0.0	0.0	**1.9**
	24	0.0	0.1	0.0	0.0	0.0	0.0	0.0	**0.1**	0.0	0.1	0.0	0.0	0.0	0.0	0.0	**0.1**

Expected Loss of Energy by Time of Day

		Load Level														
		Base Case							High Wind High Solar							
		1	2	3	4	5	6	7	All	1	2	3	4	5	6	7	All
Hour of the Day	10	0.0	0.2	0.0	0.0	0.0	0.0	0.0	**0.2**	0.0	0.2	0.0	0.0	0.0	0.0	0.0	**0.2**
	11	0.0	0.2	0.0	0.0	0.0	0.0	0.0	**0.2**	0.0	0.1	0.0	0.0	0.0	0.0	0.0	**0.1**
	12	0.1	0.8	0.8	0.5	0.0	0.0	0.0	**2.1**	0.1	0.4	0.7	0.4	0.0	0.0	0.0	**1.7**
	13	5.4	3.3	0.9	0.3	0.0	0.0	0.0	**9.8**	4.6	1.8	0.6	0.3	0.0	0.0	0.0	**7.4**
	14	40.0	8.3	2.5	1.7	0.8	0.1	0.0	**53.5**	35.7	4.0	1.4	1.2	0.4	0.0	0.0	**42.7**
	15	89.9	44.9	5.4	2.7	0.8	0.1	0.0	**143.8**	84.5	35.5	3.0	2.0	0.6	0.1	0.0	**125.7**
	16	119.6	131.5	7.0	0.7	0.0	0.0	0.0	**258.7**	118.6	134.5	2.6	0.0	0.0	0.0	0.0	**255.8**
	17	133.1	182.8	14.3	0.8	0.0	0.0	0.0	**331.0**	149.2	246.0	6.4	0.3	0.0	0.0	0.0	**402.0**
	18	138.2	170.1	13.6	1.7	0.7	0.1	0.0	**324.4**	176.6	274.2	9.6	1.4	0.5	0.0	0.0	**462.3**
	19	107.0	46.0	14.9	0.3	0.0	0.0	0.0	**168.2**	158.3	101.4	12.3	0.0	0.0	0.0	0.0	**272.1**
	20	36.7	4.2	2.6	0.3	0.0	0.0	0.0	**43.8**	85.9	8.2	2.3	0.0	0.0	0.0	0.0	**96.4**
	21	6.7	0.4	0.8	0.5	0.0	0.0	0.0	**8.4**	25.9	1.6	0.5	0.2	0.0	0.0	0.0	**28.2**
	22	1.1	0.6	0.1	0.0	0.0	0.0	0.0	**1.8**	4.4	1.3	0.1	0.0	0.0	0.0	0.0	**5.7**
	23	0.1	0.3	0.6	0.3	0.0	0.0	0.0	**1.4**	0.5	0.4	0.4	0.2	0.0	0.0	0.0	**1.5**
	24	0.0	0.1	0.0	0.0	0.0	0.0	0.0	**0.1**	0.0	0.1	0.0	0.0	0.0	0.0	0.0	**0.1**

Distribution of Loss of Load Events by Month

		Load Level															
		Base Case								High Wind High Solar							
		1	2	3	4	5	6	7	All	1	2	3	4	5	6	7	All
Month	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	3	0.0	0.1	0.2	0.4	0.2	0.0	0.0	**0.9**	0.0	0.1	0.2	0.0	0.0	0.0	0.0	**0.3**
	4	0.0	0.1	0.2	0.4	0.2	0.0	0.0	**0.9**	0.0	0.1	0.2	0.0	0.0	0.0	0.0	**0.3**
	5	0.0	0.1	0.2	0.0	0.0	0.0	0.0	**0.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	6	0.0	0.5	1.0	0.8	0.2	0.1	0.0	**2.6**	0.0	0.8	0.7	0.4	0.2	0.1	0.0	**2.3**
	7	3.2	47.4	4.1	2.3	0.2	0.1	0.0	**57.3**	3.1	44.2	2.2	0.8	0.2	0.1	0.0	**50.5**
	8	38.9	117.0	20.1	4.2	0.7	0.1	0.0	**181.0**	38.7	127.6	17.4	2.3	0.2	0.1	0.0	**186.3**
	9	0.0	0.3	1.9	0.4	0.0	0.0	0.0	**2.6**	0.0	0.2	0.5	0.4	0.0	0.0	0.0	**1.0**
	10	0.0	0.1	1.0	0.8	0.0	0.0	0.0	**1.9**	0.0	0.1	0.7	0.4	0.0	0.0	0.0	**1.2**
	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0	0.1	0.0	0.0	0.0	0.0	0.0	**0.1**
	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**

Base Case Capacity Value Results

Reliability Metrics

LOLE - Daily Loss of Load Expectation (Days / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	0.086	0.084	0.082	0.082	0.082	0.082	0.082	0.082	0.082
250	0.080	0.072	0.066	0.066	0.066	0.066	0.066	0.066	0.066
500	0.075	0.062	0.047	0.045	0.045	0.045	0.045	0.045	0.045
1,000	0.074	0.057	0.031	0.024	0.023	0.023	0.023	0.023	0.023
2,000	0.073	0.055	0.023	0.009	0.005	0.005	0.005	0.005	0.005
4,000	0.072	0.055	0.023	0.007	0.001	0.000	0.000	0.000	0.000

Reliability Metrics

LOLH - Hourly Loss of Load Expectation (Hours / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	0.287	0.276	0.261	0.255	0.253	0.253	0.253	0.253	0.253
250	0.271	0.246	0.215	0.203	0.199	0.199	0.199	0.199	0.199
500	0.250	0.211	0.164	0.145	0.139	0.138	0.138	0.138	0.138
1,000	0.228	0.173	0.106	0.079	0.071	0.070	0.070	0.070	0.070
2,000	0.210	0.143	0.060	0.025	0.016	0.015	0.015	0.015	0.015
4,000	0.205	0.134	0.047	0.010	0.001	0.000	0.000	0.000	0.000

Reliability Metrics

LOEE - Loss of Energy Expectation (MWh / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	187.7	181.2	173.2	169.9	169.1	169.0	169.0	169.0	169.0
250	176.7	162.4	144.7	137.4	135.6	135.5	135.4	135.4	135.4
500	163.1	139.2	109.5	97.0	94.2	93.9	93.9	93.9	93.9
1,000	147.1	111.6	66.9	48.1	44.3	43.9	43.9	43.9	43.9
2,000	134.9	90.7	35.0	11.8	7.5	7.2	7.1	7.1	7.1
4,000	132.2	86.3	28.5	4.8	0.4	0.1	0.1	0.1	0.1

Duration and Penetration Fractional Capacity Value (%)

LOLE - Daily Loss of Load Expectation (Days / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	11.46	27.02	59.03	97.28	100.00	100.00	100.00	100.00	100.00
250	23.68	37.48	63.81	96.09	100.00	100.00	100.00	100.00	100.00
500	21.99	35.36	59.79	89.81	100.00	100.00	100.00	100.00	100.00
1,000	15.04	27.45	48.92	77.23	96.22	100.00	100.00	100.00	100.00
2,000	7.92	16.75	34.73	57.65	82.25	95.13	100.00	100.00	100.00
4,000	4.07	8.64	19.95	36.35	53.86	68.74	88.89	100.00	100.00

Duration and Penetration Fractional Capacity Value (%)

LOLH - Hourly Loss of Load Expectation (Hours / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	3.46	24.05	57.11	85.50	97.44	100.00	100.00	100.00	100.00
250	15.01	35.21	61.00	86.05	96.43	99.91	100.00	100.00	100.00
500	19.83	35.51	59.21	82.12	94.26	99.17	100.00	100.00	100.00
1,000	17.92	30.57	51.47	73.98	90.05	98.05	100.00	100.00	100.00
2,000	13.20	23.21	39.64	58.20	77.25	91.66	99.54	100.00	100.00
4,000	7.60	14.21	26.06	40.42	55.20	70.83	88.90	100.00	100.00

Duration and Penetration Fractional Capacity Value (%)

LOEE - Loss of Energy Expectation (MWh / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	31.60	54.69	83.74	96.33	99.58	100.00	100.00	100.00	100.00
250	29.09	51.59	81.52	95.70	99.44	99.96	100.00	100.00	100.00
500	25.64	46.80	77.46	94.15	99.07	99.91	100.00	100.00	100.00
1,000	20.15	38.39	68.23	89.11	97.58	99.66	99.99	100.00	100.00
2,000	13.24	26.35	50.48	72.91	89.19	97.33	99.90	100.00	100.00
4,000	7.06	14.45	29.29	45.89	62.59	78.84	94.74	100.00	100.00

Persistence

Absolute Capacity Value (MW) of a 1,000 MW Resource

		Duration (Number of Hours per Day)														
		Daily LOLE					Hourly LOLE					LOEE				
		1	4	8	12	24	1	4	8	12	24	1	4	8	12	24
Persistence (Number of Days Per Year)	5	139.59	434.85	618.51	619.43	619.43	171.75	464.70	657.32	676.37	676.81	199.73	653.40	878.19	892.23	892.33
	10	150.17	488.10	927.07	960.26	960.26	179.06	512.82	886.40	969.92	970.36	201.47	681.59	972.49	996.01	996.17
	25	150.39	489.24	962.17	1,000.00	1,000.00	179.20	514.72	900.52	1,000.00	1,000.00	201.51	682.26	975.80	999.88	1,000.00
	50	150.39	489.24	962.17	1,000.00	1,000.00	179.20	514.72	900.52	1,000.00	1,000.00	201.51	682.26	975.80	999.88	1,000.00

Diversity

Absolute Capacity Value (MW) of a 1,000 MW Resource

		Duration (Number of Hours per Day)																			
		Daily LOLE							Hourly LOLE							LOEE						
		1	2	4	6	8	10	12	1	2	4	6	8	10	12	1	2	4	6	8	10	12
Diversity (Scheduled Block Size – MW)	50	417.82	543.52	708.89	892.66	996.55	1,000.00	1,000.00	286.77	436.67	608.58	792.86	923.42	985.90	1,000.00	258.82	448.01	727.90	910.38	982.54	997.98	999.90
	100	401.12	523.70	700.38	887.67	996.55	1,000.00	1,000.00	291.82	432.01	606.99	792.90	921.17	986.22	1,000.00	258.84	447.86	727.67	910.11	982.47	997.98	999.90
	250	359.50	500.50	671.55	869.86	994.26	1,000.00	1,000.00	250.71	428.61	604.49	786.72	918.60	984.78	1,000.00	258.76	446.69	726.10	908.68	981.93	997.86	999.90
	500	291.03	492.88	611.43	831.56	988.24	1,000.00	1,000.00	233.19	407.43	570.95	768.13	913.66	983.62	1,000.00	249.77	441.80	715.66	903.92	980.60	997.61	999.90
	1,000	150.39	274.46	489.24	772.32	962.17	1,000.00	1,000.00	179.20	305.71	514.72	739.82	900.52	980.47	1,000.00	201.51	383.93	682.26	891.09	975.80	996.57	999.88

Fractional Capacity Value (%) of a Resource Scheduled in 50 MW Blocks

LOLE - Daily Loss of Load Expectation (Days / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	37.17	50.38	58.42	97.28	100.00	100.00	100.00	100.00	100.00
250	40.19	50.59	69.47	96.53	100.00	100.00	100.00	100.00	100.00
500	46.84	55.00	72.36	94.16	100.00	100.00	100.00	100.00	100.00
1,000	41.78	54.35	70.89	89.27	99.65	100.00	100.00	100.00	100.00
2,000	35.37	48.91	64.19	80.93	94.82	99.94	100.00	100.00	100.00
4,000	28.06	39.65	56.51	69.43	84.01	94.43	100.00	100.00	100.00

Fractional Capacity Value (%) of a Resource Scheduled in 50 MW Blocks

LOLH - Hourly Loss of Load Expectation (Hours / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	16.21	41.26	50.49	83.15	96.82	100.00	100.00	100.00	100.00
250	26.41	40.30	61.21	85.75	96.41	99.60	100.00	100.00	100.00
500	30.04	47.70	62.54	83.20	95.09	99.35	100.00	100.00	100.00
1,000	28.68	43.67	60.86	79.29	92.34	98.59	100.00	100.00	100.00
2,000	24.57	37.58	55.34	71.34	85.87	95.53	99.84	100.00	100.00
4,000	20.01	31.14	48.12	61.90	75.03	87.90	98.36	100.00	100.00

Fractional Capacity Value (%) of a Resource Scheduled in 50 MW Blocks

LOEE - Loss of Energy Expectation (MWh / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	32.38	55.36	83.71	96.31	99.57	100.00	100.00	100.00	100.00
250	30.35	52.47	81.63	95.66	99.43	99.96	100.00	100.00	100.00
500	28.31	49.27	78.36	94.37	99.15	99.91	100.00	100.00	100.00
1,000	25.88	44.80	72.79	91.04	98.25	99.80	99.99	100.00	100.00
2,000	23.29	39.61	64.15	82.83	94.59	99.03	99.96	100.00	100.00
4,000	20.43	33.82	53.65	69.57	83.24	94.08	99.56	100.00	100.00

Fractional Capacity Value (%) of a Resource with a 5% Forced Outage Rate

LOLE - Daily Loss of Load Expectation (Days / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	8.65	20.20	36.44	47.99	48.75	48.79	48.79	48.79	48.79
250	19.17	32.40	47.44	58.33	58.74	58.76	58.76	58.76	58.76
500	19.03	30.56	48.84	59.23	60.19	60.33	60.33	60.33	60.33
1,000	12.99	24.72	40.74	53.57	55.72	55.99	55.99	55.99	55.99
2,000	7.13	14.65	29.31	41.00	45.75	46.46	46.46	46.46	46.46
4,000	3.63	7.49	16.40	25.78	29.95	31.03	31.26	31.26	31.26

Fractional Capacity Value (%) of a Resource with a 5% Forced Outage Rate

LOLH - Hourly Loss of Load Expectation (Hours / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	1.50	19.06	45.88	64.56	71.87	73.12	72.89	72.89	72.89
250	13.18	31.64	52.28	69.82	77.38	78.96	78.93	78.93	78.93
500	17.26	32.14	52.98	69.23	76.41	78.18	78.50	78.52	78.52
1,000	16.41	28.66	46.42	62.14	70.69	73.04	73.75	73.79	73.79
2,000	12.25	21.76	35.93	49.49	57.83	61.33	62.11	62.14	62.14
4,000	7.07	13.21	23.81	33.84	42.00	46.12	47.49	47.56	47.56

Fractional Capacity Value (%) of a Resource with a 5% Forced Outage Rate

LOEE - Loss of Energy Expectation (MWh / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	29.95	51.78	79.08	90.92	93.89	94.27	94.29	94.29	94.29
250	27.49	48.62	76.40	89.38	92.75	93.20	93.25	93.25	93.25
500	24.15	43.86	71.83	86.49	90.64	91.31	91.38	91.38	91.38
1,000	18.91	35.76	62.29	79.13	85.08	86.35	86.54	86.55	86.55
2,000	12.39	24.40	45.49	62.09	70.42	73.07	73.63	73.65	73.65
4,000	6.60	13.32	26.16	37.74	45.31	48.57	49.51	49.54	49.54

Fractional Capacity Value (%) of a Resource with a 10% Forced Outage Rate

LOLE - Daily Loss of Load Expectation (Days / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	4.35	13.97	23.61	28.84	29.91	29.95	29.95	29.95	29.95
250	13.90	25.75	36.54	40.97	41.92	41.90	41.90	41.90	41.90
500	15.35	25.63	39.00	45.75	46.86	46.98	46.98	46.98	46.98
1,000	10.96	21.52	33.78	41.41	42.48	42.49	42.49	42.49	42.49
2,000	5.88	12.87	24.29	31.49	33.36	33.52	33.53	33.53	33.53
4,000	3.00	6.59	13.46	19.11	21.46	21.87	21.90	21.90	21.90

Fractional Capacity Value (%) of a Resource with a 10% Forced Outage Rate

LOLH - Hourly Loss of Load Expectation (Hours / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	0.00	14.40	35.63	50.57	56.16	57.08	57.28	57.28	57.28
250	10.59	26.49	46.10	59.74	63.70	64.96	65.23	65.23	65.23
500	15.34	28.86	47.20	60.09	64.39	65.41	65.61	65.70	65.70
1,000	15.12	26.53	41.93	53.97	58.59	60.15	60.41	60.42	60.42
2,000	11.42	20.16	33.02	43.16	48.41	49.97	50.26	50.27	50.27
4,000	6.54	12.15	21.58	29.42	33.97	35.88	36.41	36.43	36.43

Fractional Capacity Value (%) of a Resource with a 10% Forced Outage Rate

LOEE - Loss of Energy Expectation (MWh / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	0.00	10.62	29.36	40.89	46.39	47.18	47.62	47.62	47.62
250	8.54	23.82	41.24	52.25	56.00	56.62	57.14	57.13	57.13
500	13.54	26.71	42.65	53.49	56.92	57.85	58.11	58.14	58.14
1,000	13.83	24.49	37.90	47.24	50.93	52.26	52.43	52.45	52.45
2,000	10.41	18.65	30.10	37.90	41.64	42.65	42.81	42.83	42.83
4,000	5.98	11.23	19.48	25.90	28.84	29.81	30.01	30.01	30.01

Fractional Capacity Value (%) of a Resource with a 15% Forced Outage Rate

LOLE - Daily Loss of Load Expectation (Days / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	2.03	8.81	17.14	20.61	20.84	20.86	20.86	20.86	20.86
250	11.77	21.80	30.56	34.66	35.24	35.24	35.24	35.24	35.24
500	12.97	22.69	31.40	36.78	37.57	37.58	37.58	37.58	37.58
1,000	9.30	18.57	28.68	32.49	33.16	33.17	33.17	33.17	33.17
2,000	4.96	10.92	20.10	24.78	25.95	26.09	26.09	26.09	26.09
4,000	2.53	5.58	10.77	14.48	15.53	15.79	15.81	15.81	15.81

Fractional Capacity Value (%) of a Resource with a 15% Forced Outage Rate

LOLH - Hourly Loss of Load Expectation (Hours / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	0.00	10.62	29.36	40.89	46.39	47.18	47.62	47.62	47.62
250	8.54	23.82	41.24	52.25	56.00	56.62	57.14	57.13	57.13
500	13.54	26.71	42.65	53.49	56.92	57.85	58.11	58.14	58.14
1,000	13.83	24.49	37.90	47.24	50.93	52.26	52.43	52.45	52.45
2,000	10.41	18.65	30.10	37.90	41.64	42.65	42.81	42.83	42.83
4,000	5.98	11.23	19.48	25.90	28.84	29.81	30.01	30.01	30.01

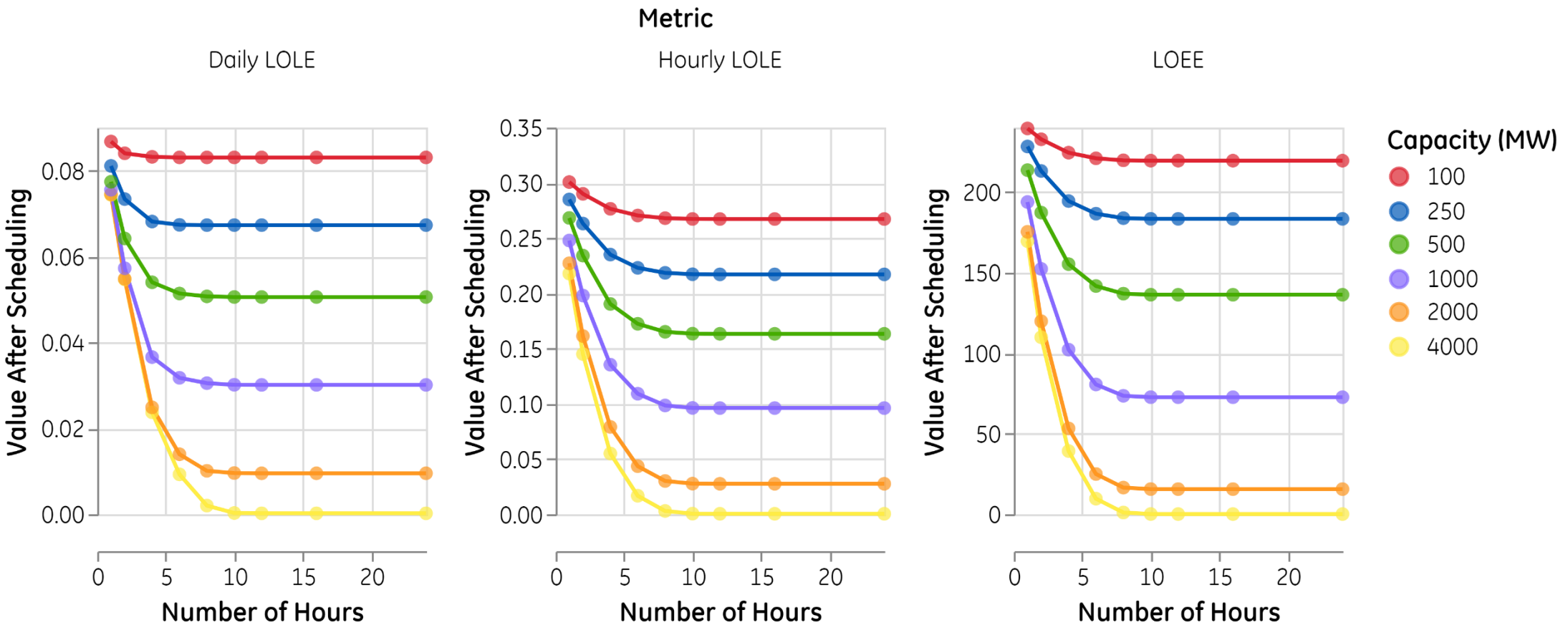
Fractional Capacity Value (%) of a Resource with a 15% Forced Outage Rate

LOEE - Loss of Energy Expectation (MWh / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	26.61	45.82	69.87	80.23	82.90	83.22	83.24	83.24	83.24
250	24.32	42.72	66.69	77.68	80.54	80.90	80.93	80.93	80.93
500	21.23	38.17	61.65	73.23	76.39	76.84	76.89	76.89	76.89
1,000	16.53	30.77	52.06	63.92	67.52	68.15	68.23	68.23	68.23
2,000	10.76	20.73	37.12	47.52	51.24	52.05	52.18	52.18	52.18
4,000	5.70	11.22	20.92	27.72	30.37	31.03	31.15	31.15	31.15

High Wind High Solar Capacity Value Results

Reliability Metrics After Scheduling Resources



Reliability Metrics

LOLE - Daily Loss of Load Expectation (Days / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	0.087	0.084	0.083	0.083	0.083	0.083	0.083	0.083	0.083
250	0.081	0.073	0.068	0.067	0.067	0.067	0.067	0.067	0.067
500	0.077	0.064	0.054	0.051	0.051	0.051	0.051	0.051	0.051
1,000	0.076	0.057	0.037	0.032	0.031	0.030	0.030	0.030	0.030
2,000	0.074	0.055	0.025	0.014	0.010	0.010	0.010	0.010	0.010
4,000	0.074	0.055	0.024	0.009	0.002	0.000	0.000	0.000	0.000

Reliability Metrics

LOLH - Hourly Loss of Load Expectation (Hours / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	0.301	0.290	0.277	0.270	0.268	0.267	0.267	0.267	0.267
250	0.285	0.263	0.235	0.223	0.219	0.217	0.217	0.217	0.217
500	0.268	0.234	0.190	0.172	0.165	0.164	0.163	0.163	0.163
1,000	0.248	0.198	0.135	0.109	0.099	0.096	0.096	0.096	0.096
2,000	0.227	0.161	0.079	0.044	0.030	0.028	0.028	0.028	0.028
4,000	0.218	0.145	0.055	0.017	0.003	0.001	0.001	0.001	0.001

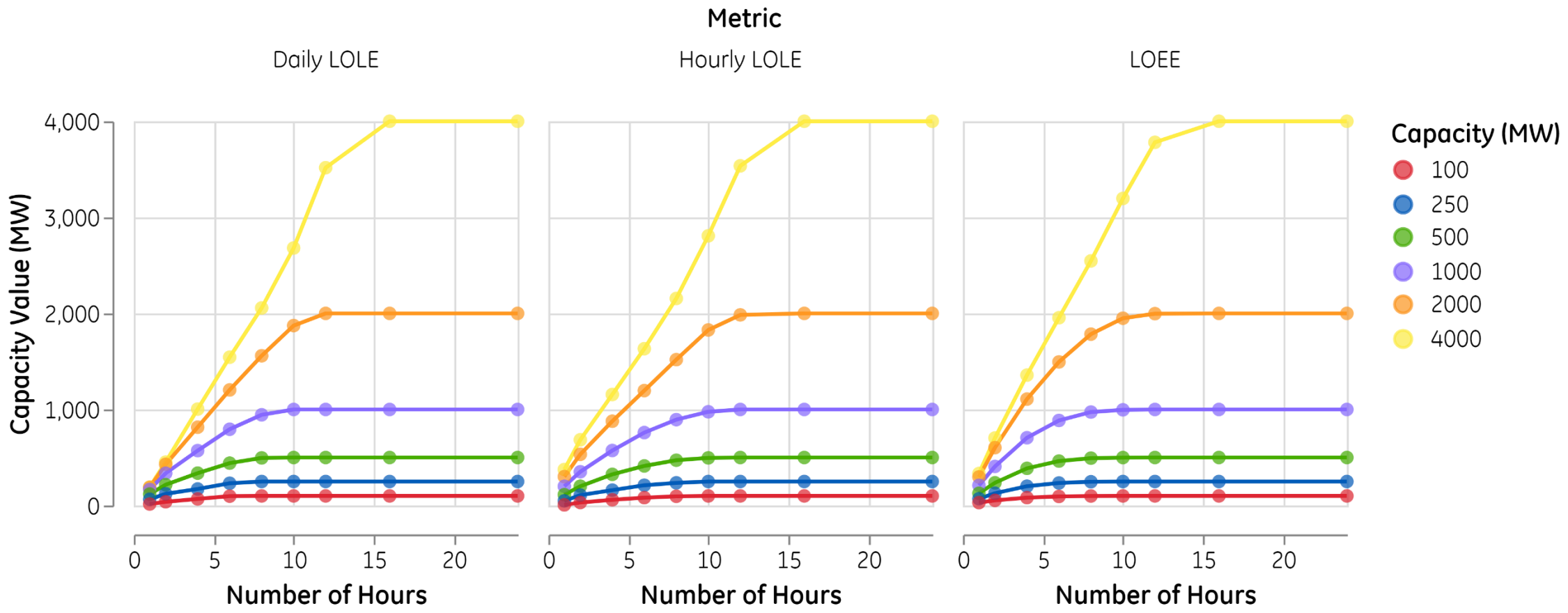
Reliability Metrics

LOEE - Loss of Energy Expectation (MWh / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	239.5	232.8	224.5	221.0	219.7	219.5	219.5	219.5	219.5
250	228.3	213.1	194.5	186.6	183.8	183.4	183.4	183.4	183.4
500	213.7	187.3	155.3	141.7	137.0	136.3	136.3	136.3	136.3
1,000	193.9	152.4	102.2	80.6	73.6	72.7	72.7	72.7	72.7
2,000	175.4	119.9	53.3	25.1	16.6	15.7	15.7	15.7	15.7
4,000	169.6	109.9	39.3	9.7	1.1	0.2	0.2	0.2	0.2

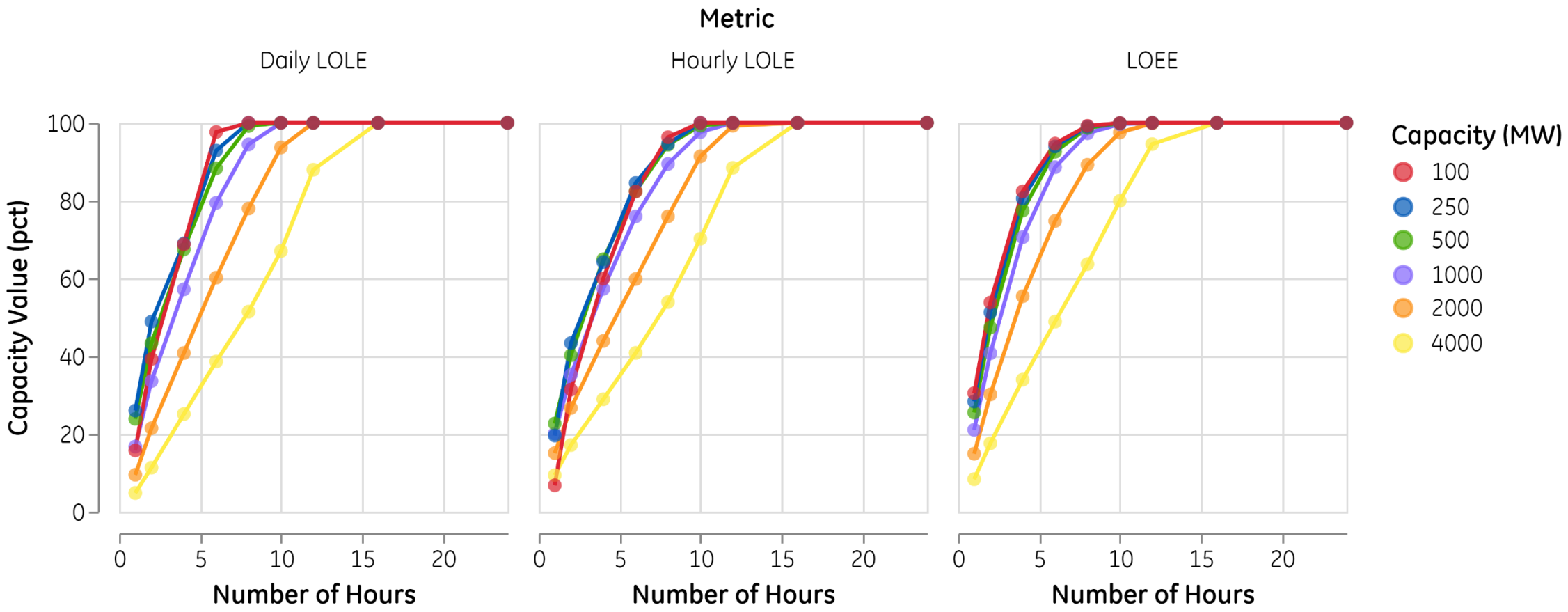
Duration of Use

Absolute Capacity Value (MW)



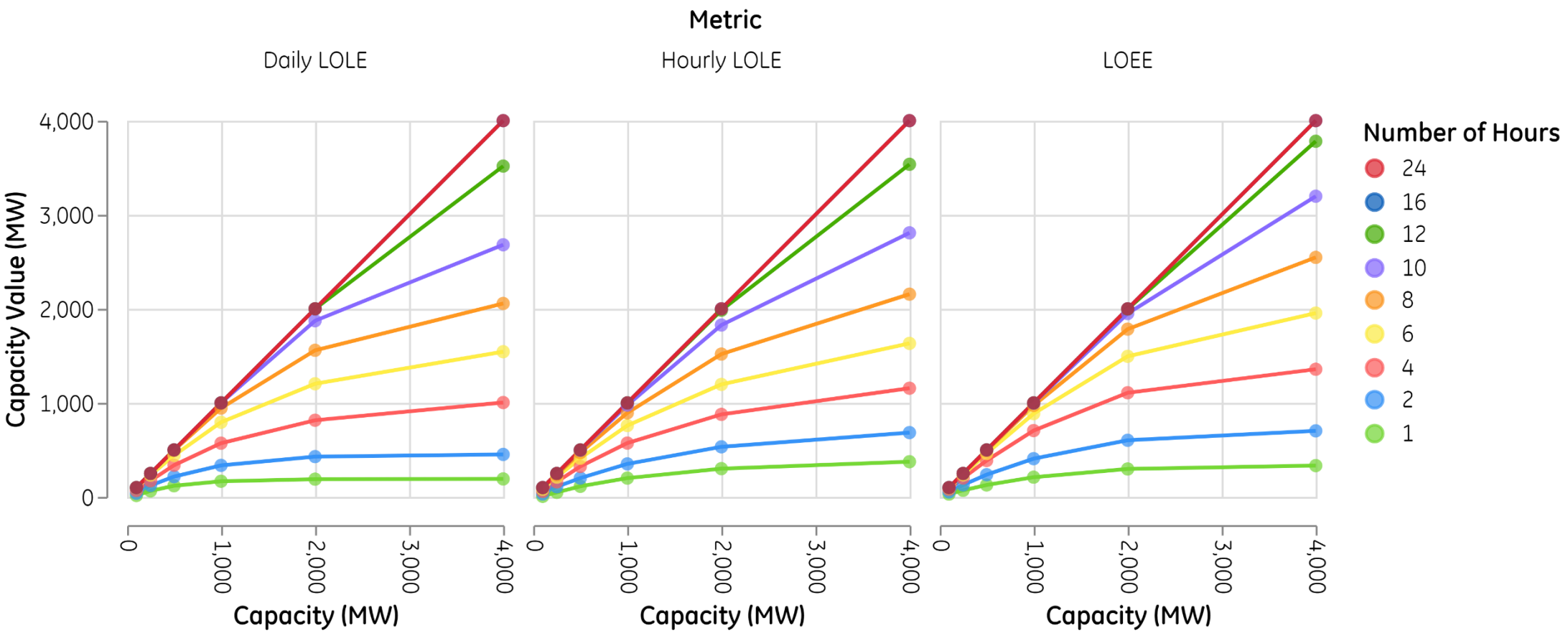
Duration of Use

Fractional Capacity Value (%)



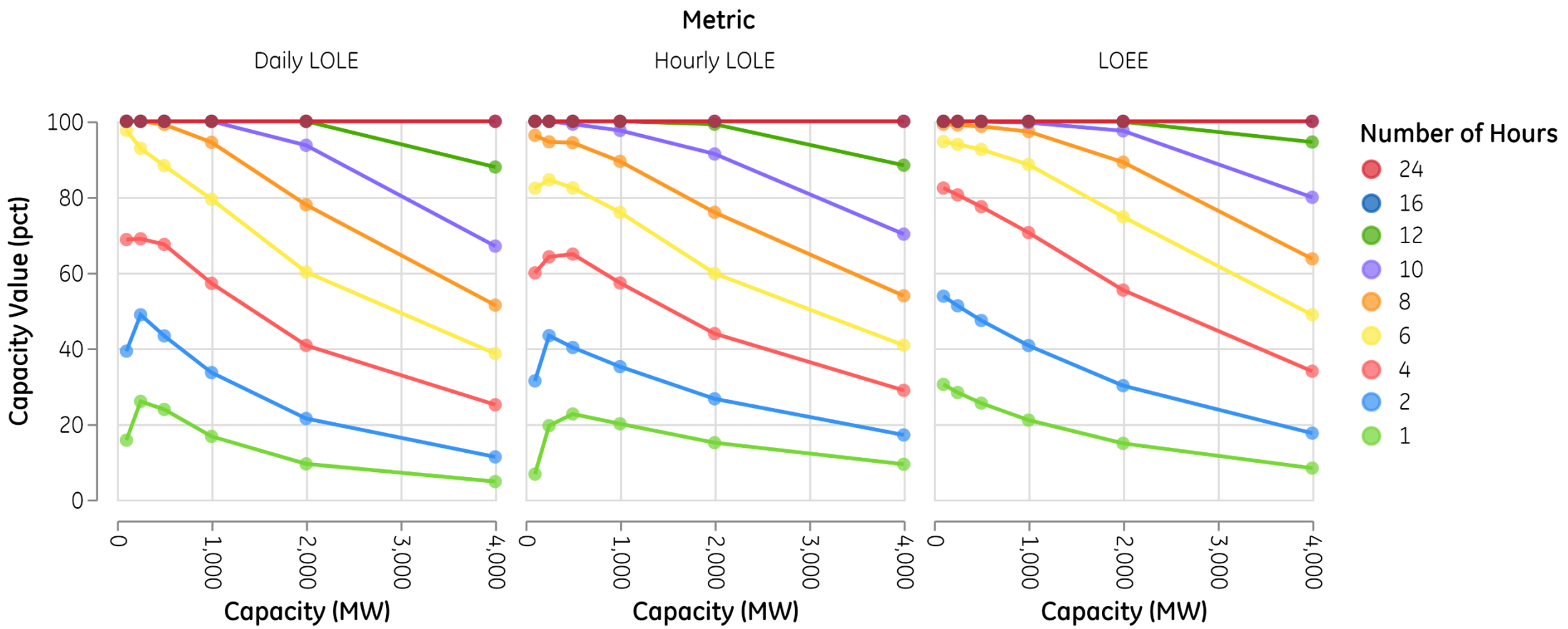
Penetration

Absolute Capacity Value (MW)



Penetration

Fractional Capacity Value (%)



Duration and Penetration Fractional Capacity Value (%)

LOLE - Daily Loss of Load Expectation (Days / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	15.74	39.25	68.74	97.63	100.00	100.00	100.00	100.00	100.00
250	25.98	48.87	68.95	92.86	100.00	100.00	100.00	100.00	100.00
500	23.86	43.29	67.45	88.28	99.18	100.00	100.00	100.00	100.00
1,000	16.73	33.59	57.19	79.40	94.44	100.00	100.00	100.00	100.00
2,000	9.47	21.45	40.78	60.17	77.94	93.66	100.00	100.00	100.00
4,000	4.80	11.30	25.10	38.60	51.42	67.02	87.91	100.00	100.00

Duration and Penetration Fractional Capacity Value (%)

LOLH - Hourly Loss of Load Expectation (Hours / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	6.76	31.39	59.94	82.31	96.30	100.00	100.00	100.00	100.00
250	19.57	43.35	64.19	84.54	94.57	100.00	100.00	100.00	100.00
500	22.65	40.22	64.90	82.41	94.35	99.24	100.00	100.00	100.00
1,000	20.07	35.17	57.29	75.93	89.41	97.60	100.00	100.00	100.00
2,000	15.06	26.66	43.89	59.82	75.94	91.37	99.23	100.00	100.00
4,000	9.37	17.11	28.90	40.81	53.89	70.18	88.39	100.00	100.00

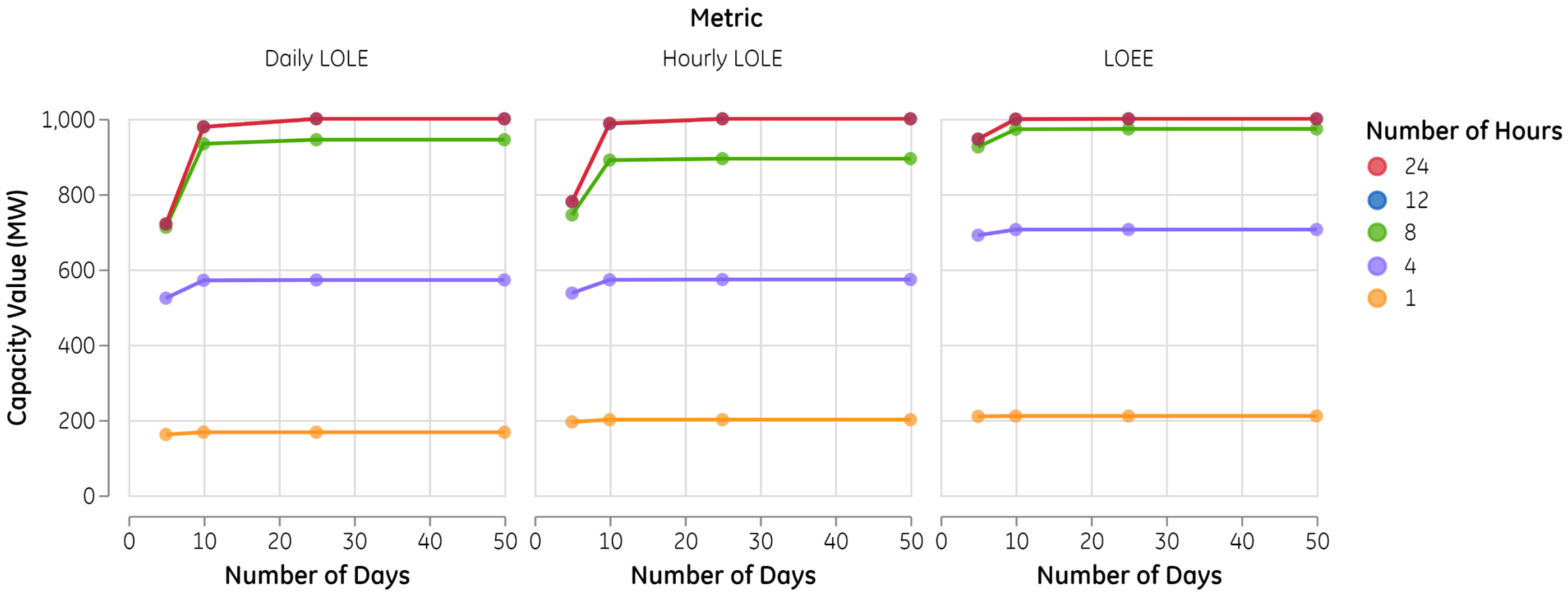
Duration and Penetration Fractional Capacity Value (%)

LOEE - Loss of Energy Expectation (MWh / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	30.46	53.78	82.36	94.64	99.21	99.95	100.00	100.00	100.00
250	28.34	51.24	80.54	93.92	99.02	99.94	100.00	100.00	100.00
500	25.50	47.37	77.43	92.56	98.68	99.90	100.00	100.00	100.00
1,000	21.04	40.72	70.58	88.57	97.30	99.64	99.99	100.00	100.00
2,000	14.88	30.13	55.39	74.74	89.19	97.49	99.86	100.00	100.00
4,000	8.34	17.58	33.94	48.87	63.66	79.91	94.51	100.00	100.00

Persistence

Absolute Capacity Value (MW) of a 1,000 MW Resource



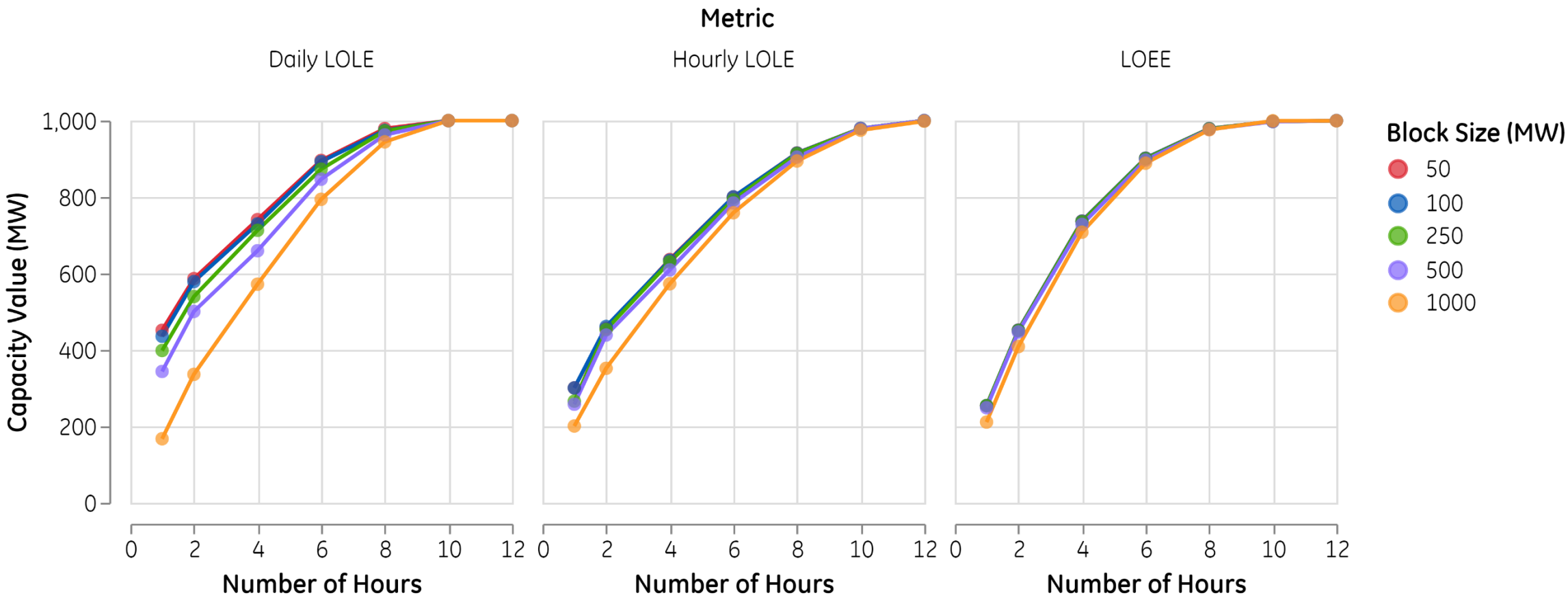
Persistence

Absolute Capacity Value (MW) of a 1,000 MW Resource

		Duration (Number of Hours per Day)														
		Daily LOLE					Hourly LOLE					LOEE				
		1	4	8	12	24	1	4	8	12	24	1	4	8	12	24
Persistence (Number of Days Per Year)	5	161.27	523.49	711.76	720.77	720.77	194.79	536.95	744.66	779.62	780.03	209.24	690.65	925.26	946.17	946.25
	10	167.31	570.82	933.69	978.60	978.60	200.67	572.29	890.30	987.19	988.14	210.35	705.69	972.32	999.13	999.26
	25	167.31	571.85	944.40	1,000.00	1,000.00	200.66	572.92	894.12	1,000.00	1,000.00	210.35	705.80	972.96	999.92	1,000.00
	50	167.31	571.85	944.40	1,000.00	1,000.00	200.66	572.92	894.12	1,000.00	1,000.00	210.35	705.80	972.96	999.92	1,000.00

Diversity

Absolute Capacity Value (MW) of a 1,000 MW Resource



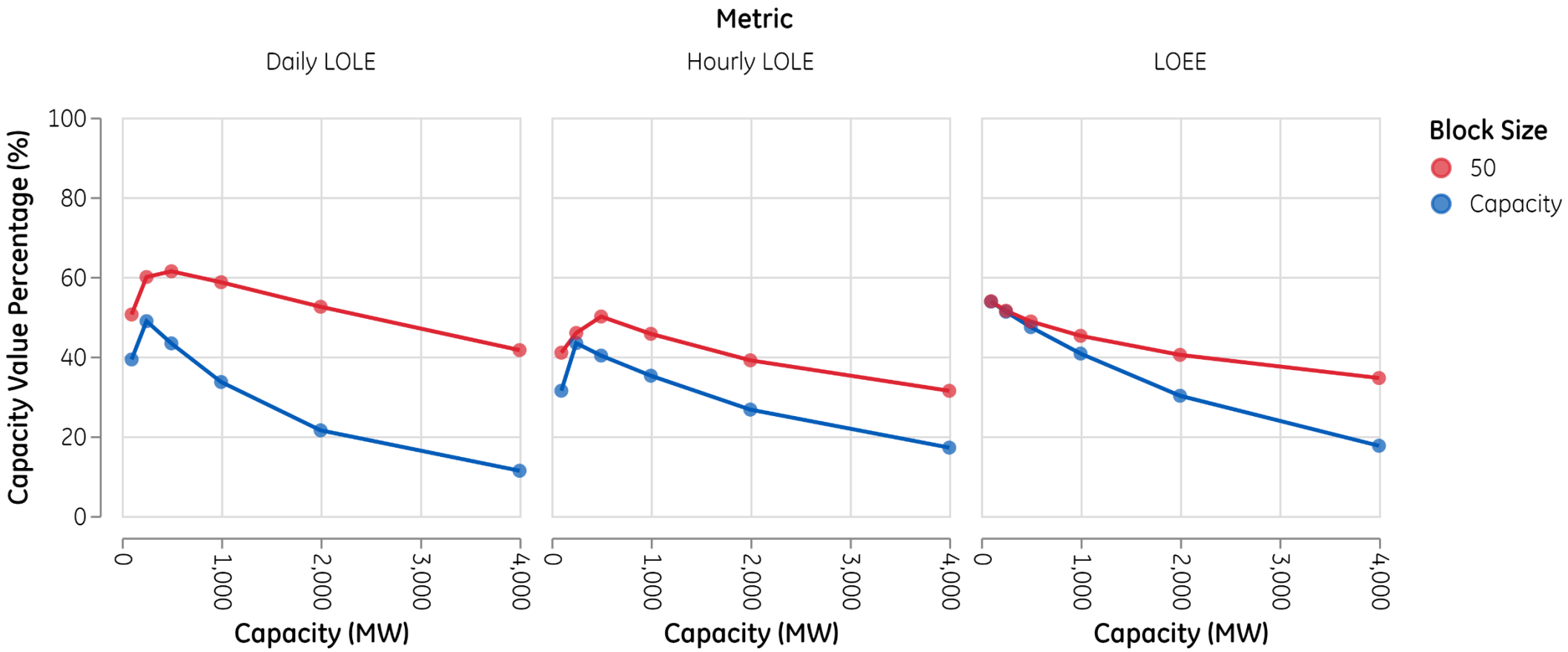
Diversity

Absolute Capacity Value (MW) of a 1,000 MW Resource

		Duration (Number of Hours per Day)																			
		Daily LOLE							Hourly LOLE							LOEE						
		1	2	4	6	8	10	12	1	2	4	6	8	10	12	1	2	4	6	8	10	12
Diversity (Scheduled Block Size – MW)	50	451.25	586.41	740.96	895.89	979.22	1,000.00	1,000.00	300.43	456.85	636.43	800.21	915.35	979.66	1,000.00	254.00	451.84	737.08	901.73	979.05	997.89	999.94
	100	435.54	578.59	729.66	892.69	974.37	1,000.00	1,000.00	300.35	461.30	634.38	800.36	914.89	979.74	1,000.00	254.20	451.52	736.77	901.66	978.99	997.87	999.94
	250	398.32	539.54	712.85	872.83	973.02	1,000.00	1,000.00	265.73	452.85	630.15	792.59	913.43	979.66	1,000.00	253.89	450.44	735.25	900.39	978.43	997.76	999.94
	500	343.49	500.52	659.43	846.70	962.57	1,000.00	1,000.00	257.64	438.83	609.18	784.41	904.40	979.42	1,000.00	248.51	446.99	728.25	896.73	977.03	997.53	999.93
	1,000	167.31	335.91	571.85	794.01	944.40	1,000.00	1,000.00	200.66	351.68	572.89	758.83	894.32	974.92	998.52	211.02	408.50	707.94	888.54	976.19	999.50	999.57

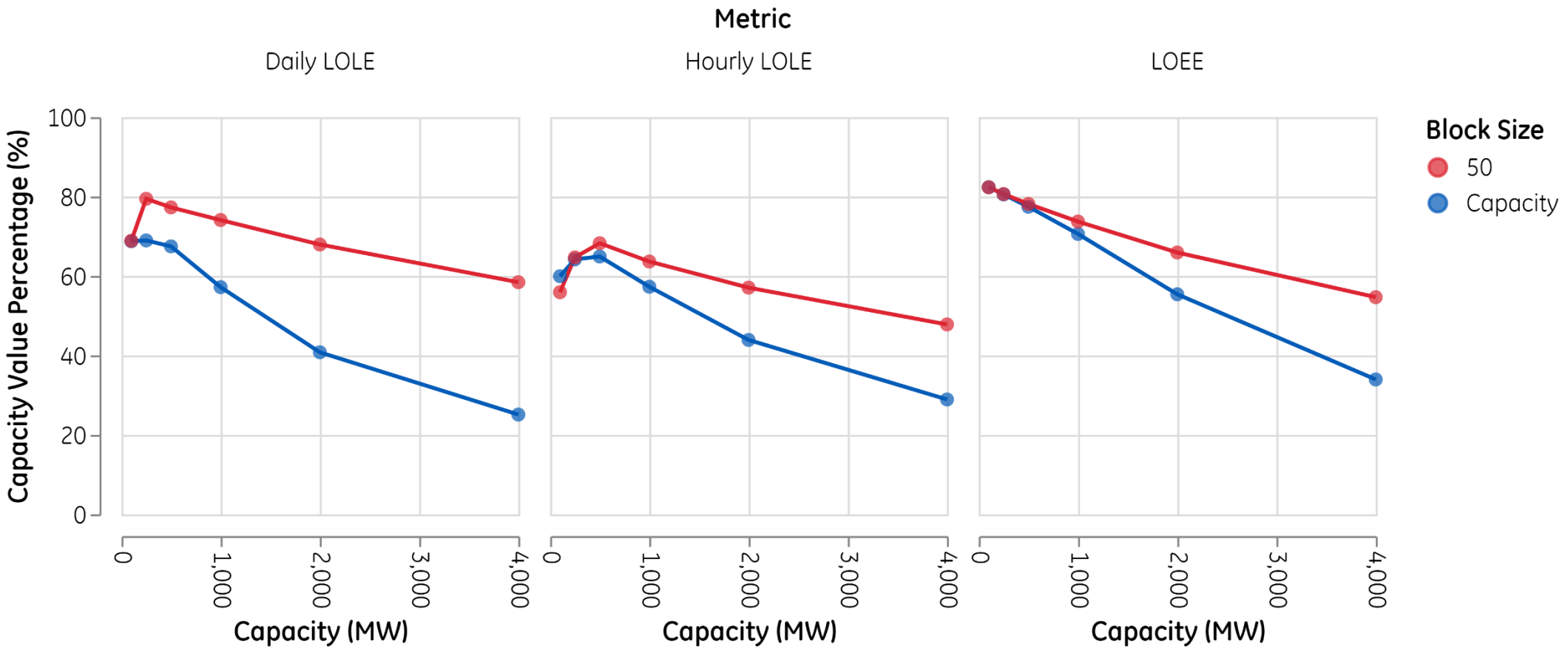
Diversity

Fractional Capacity Value (%) of a Two (2) Hour Resource



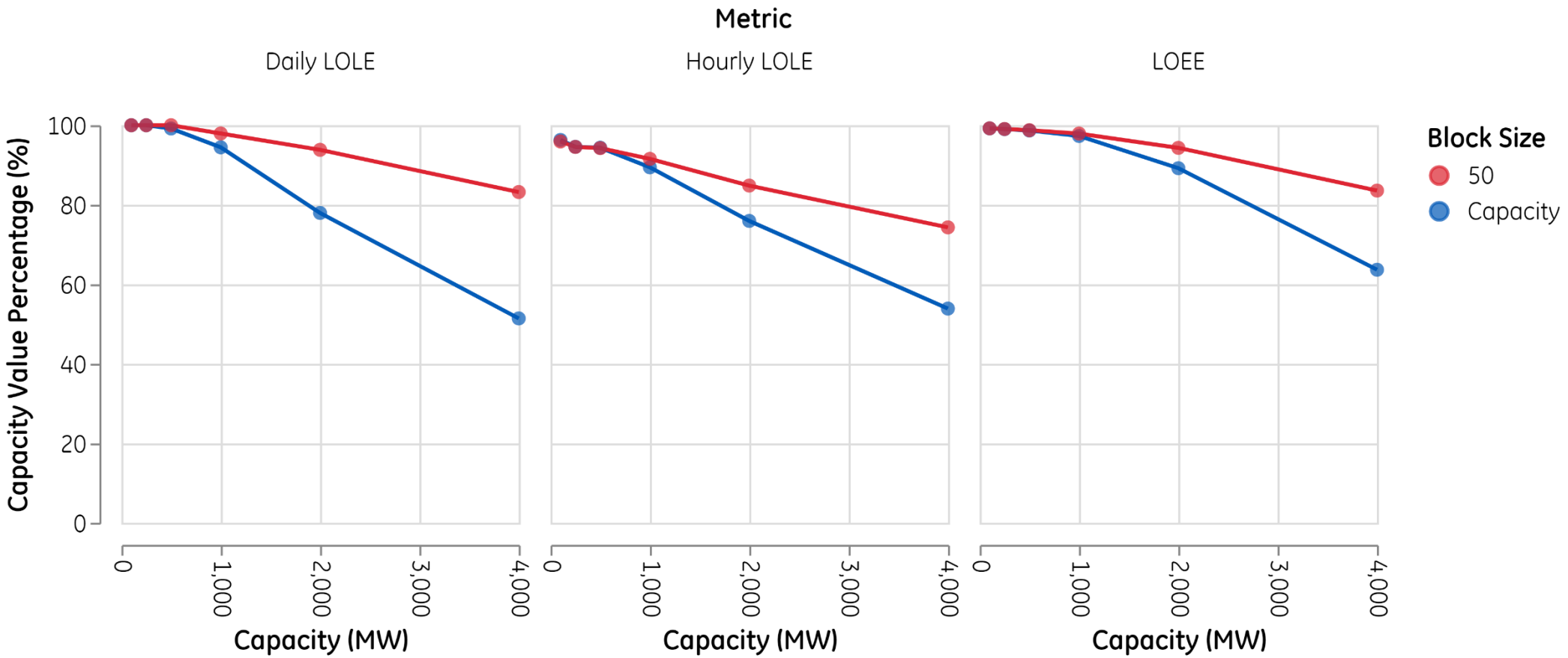
Diversity

Fractional Capacity Value (%) of a Four (4) Hour Resource



Diversity

Fractional Capacity Value (%) of an Eight (8) Hour Resource



Fractional Capacity Value (%) of a Resource Scheduled in 50 MW Blocks

LOLE - Daily Loss of Load Expectation (Days / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	50.36	50.54	68.85	97.63	100.00	100.00	100.00	100.00	100.00
250	40.34	59.95	79.44	94.23	100.00	100.00	100.00	100.00	100.00
500	50.08	61.40	77.28	92.89	100.00	100.00	100.00	100.00	100.00
1,000	45.13	58.64	74.10	89.59	97.92	100.00	100.00	100.00	100.00
2,000	37.71	52.49	67.93	81.62	93.81	99.12	100.00	100.00	100.00
4,000	29.92	41.60	58.43	70.80	83.20	93.59	99.54	100.00	100.00

Fractional Capacity Value (%) of a Resource Scheduled in 50 MW Blocks

LOLH - Hourly Loss of Load Expectation (Hours / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	20.70	40.95	55.91	80.14	95.91	100.00	100.00	100.00	100.00
250	30.21	45.91	64.68	84.70	94.54	99.65	100.00	100.00	100.00
500	30.34	50.03	68.26	83.68	94.24	99.53	100.00	100.00	100.00
1,000	30.04	45.69	63.64	80.02	91.54	97.97	100.00	100.00	100.00
2,000	25.63	39.04	57.06	71.82	84.82	95.32	99.75	100.00	100.00
4,000	20.76	31.38	47.80	61.79	74.31	87.08	97.73	100.00	100.00

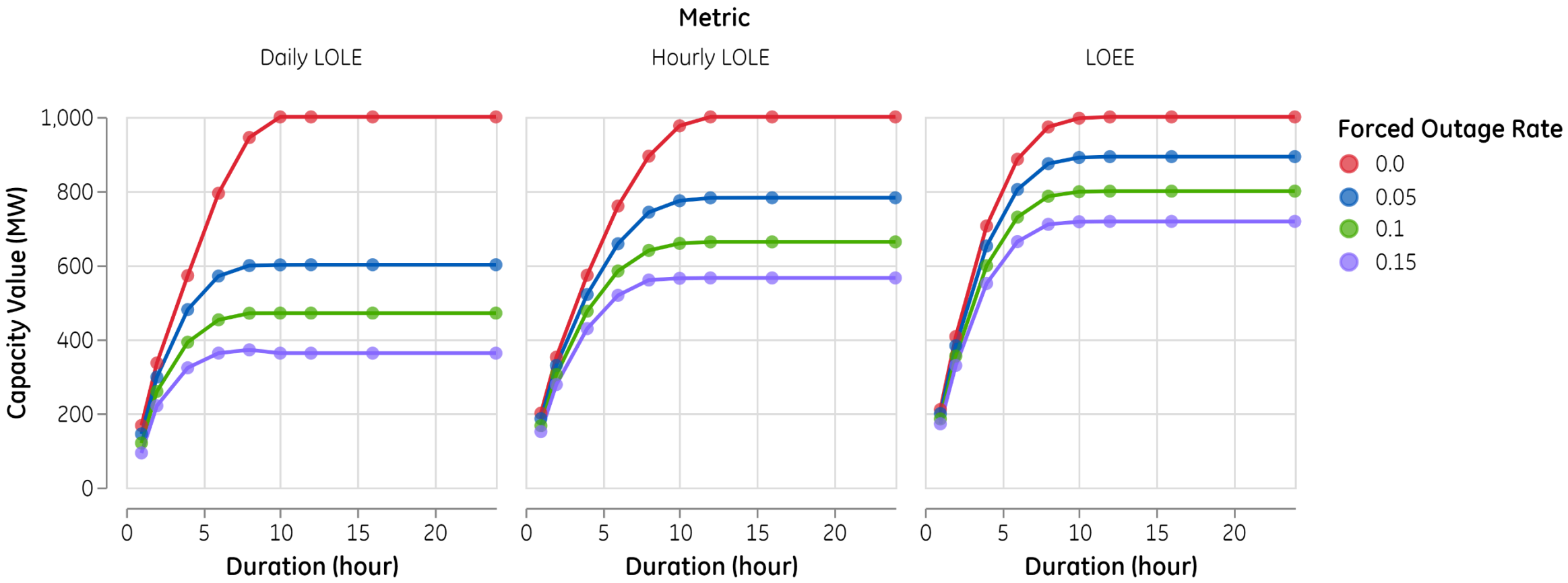
Fractional Capacity Value (%) of a Resource Scheduled in 50 MW Blocks

LOEE - Loss of Energy Expectation (MWh / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	30.91	53.86	82.34	94.63	99.22	99.96	100.00	100.00	100.00
250	29.13	51.49	80.64	93.94	99.06	99.95	100.00	100.00	100.00
500	27.40	48.79	78.15	92.81	98.75	99.91	100.00	100.00	100.00
1,000	25.40	45.18	73.71	90.17	97.91	99.79	99.99	100.00	100.00
2,000	23.25	40.40	65.92	83.21	94.31	99.02	99.96	100.00	100.00
4,000	20.67	34.59	54.66	70.57	83.57	94.08	99.48	100.00	100.00

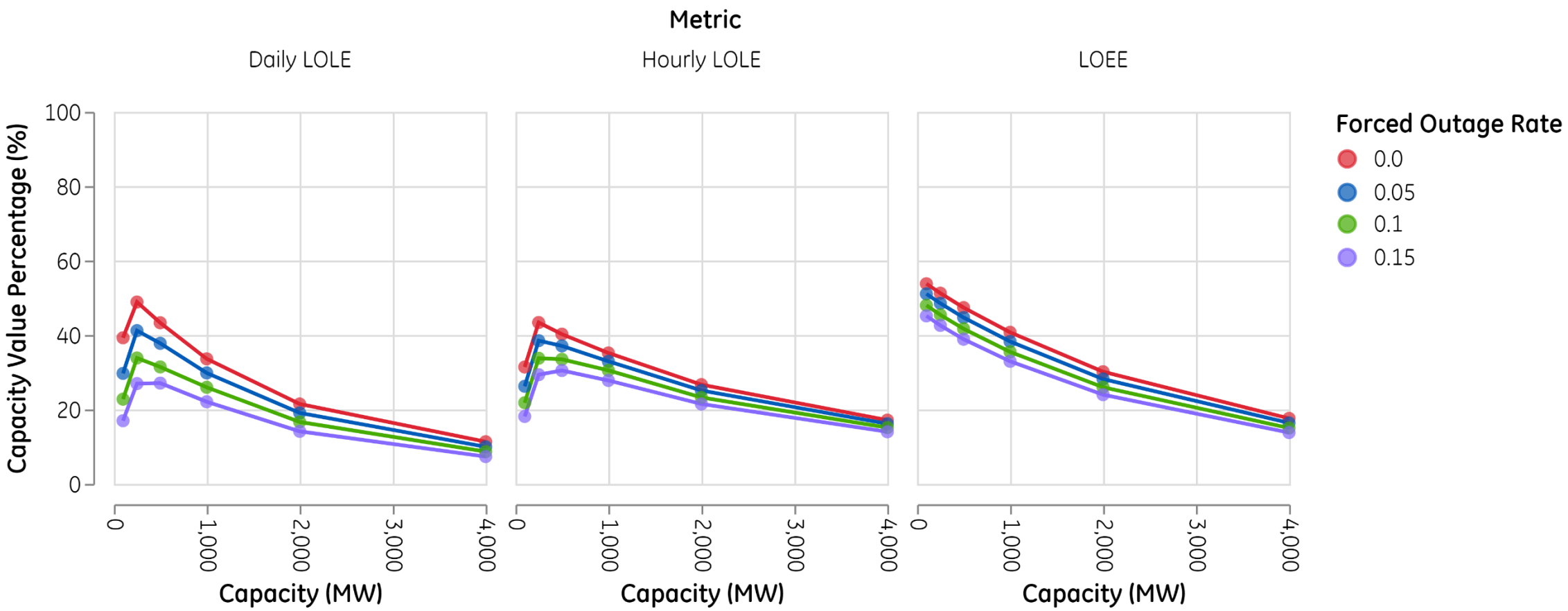
Performance

Absolute Capacity Value (MW) of a 1,000 MW Resource



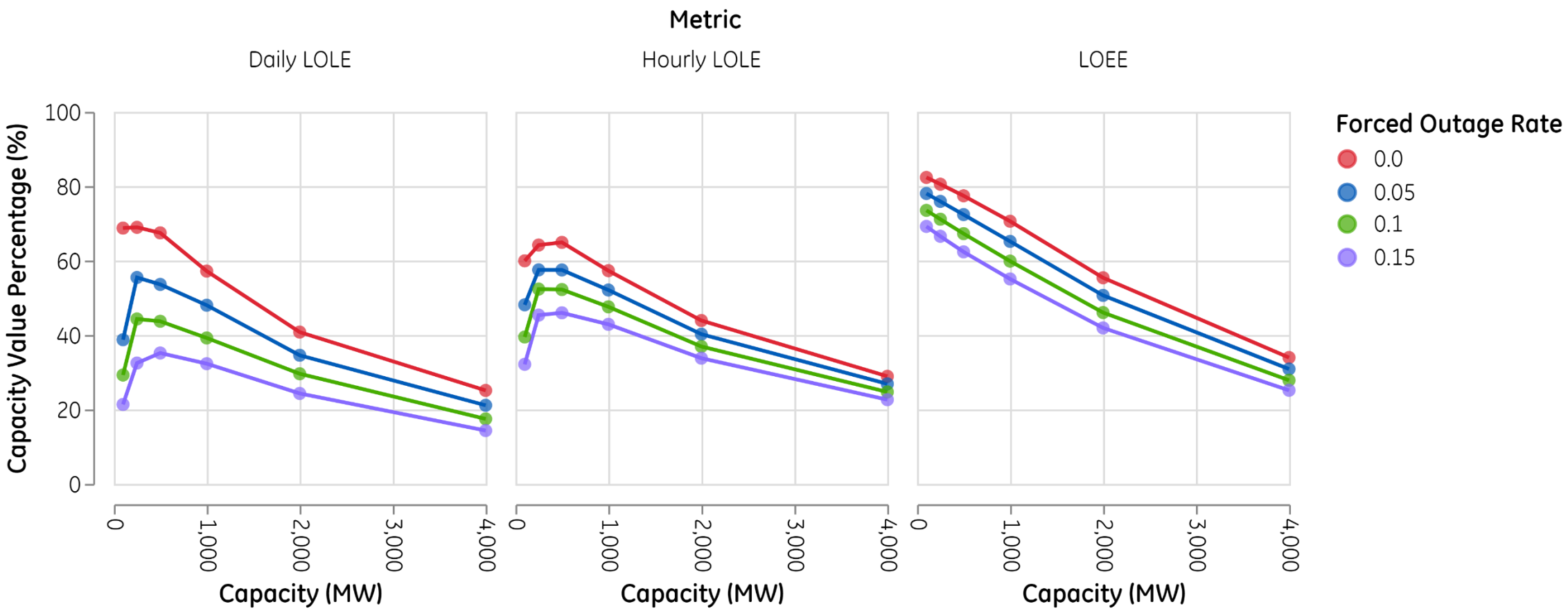
Performance

Fractional Capacity Value (%) of a Two (2) Hour Resource



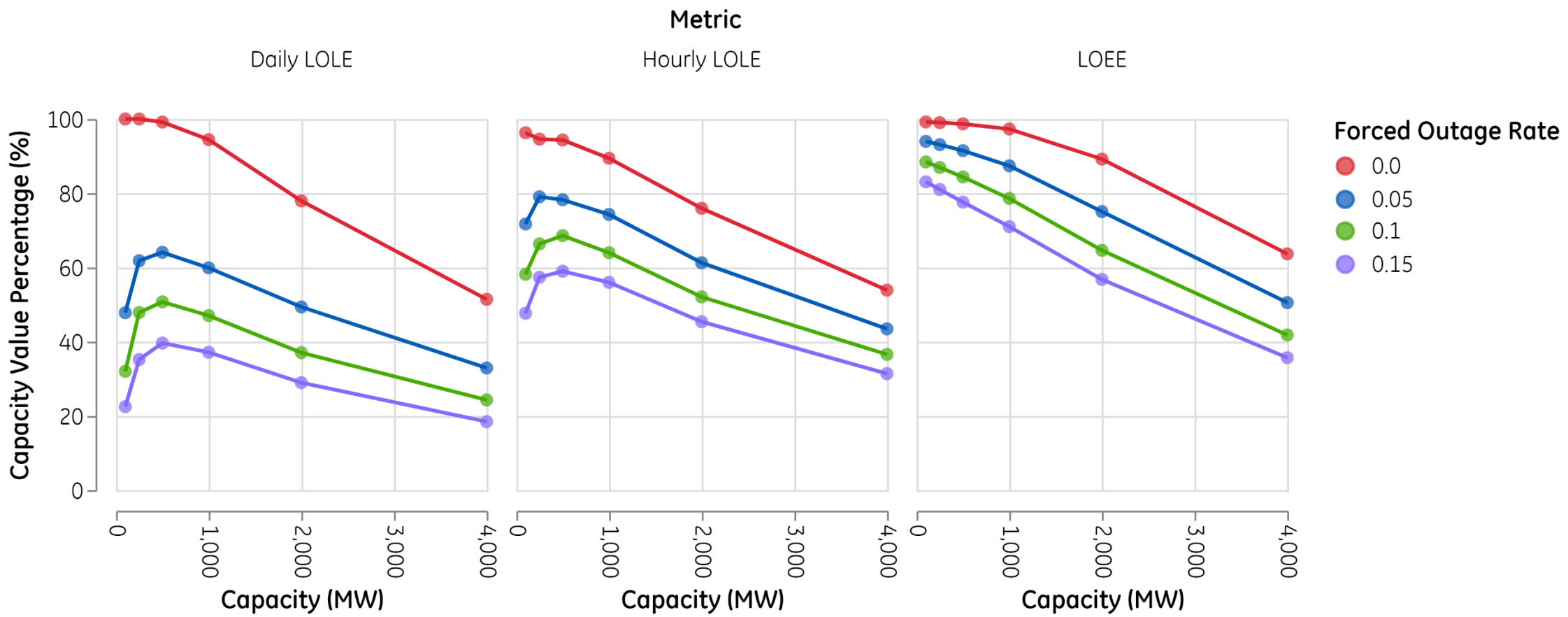
Performance

Fractional Capacity Value (%) of a Four (4) Hour Resource



Performance

Fractional Capacity Value (%) of an Eight (8) Hour Resource



Fractional Capacity Value (%) of a Resource with a 5% Forced Outage Rate

LOLE - Daily Loss of Load Expectation (Days / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	10.74	29.68	38.73	47.21	47.81	47.81	47.81	47.81	47.81
250	20.03	41.18	55.46	60.67	61.83	61.83	61.83	61.83	61.83
500	20.51	37.76	53.60	62.44	64.06	64.09	64.09	64.09	64.09
1,000	14.44	29.80	48.00	57.05	59.89	60.07	60.11	60.11	60.11
2,000	8.35	19.06	34.55	44.89	49.36	50.31	50.40	50.40	50.40
4,000	4.25	9.94	21.10	28.70	32.92	34.73	35.13	35.13	35.13

Fractional Capacity Value (%) of a Resource with a 5% Forced Outage Rate

LOLH - Hourly Loss of Load Expectation (Hours / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	3.08	26.21	48.12	64.64	71.74	74.67	75.29	75.32	75.32
250	16.66	38.48	57.51	71.23	79.03	81.36	82.32	82.34	82.34
500	20.47	37.07	57.49	71.41	78.23	80.39	80.77	80.81	80.81
1,000	18.56	32.92	52.09	65.78	74.28	77.38	78.16	78.18	78.18
2,000	14.15	25.09	40.22	52.77	61.27	66.50	67.79	67.84	67.84
4,000	8.82	16.14	26.86	35.85	43.45	48.71	50.58	50.69	50.69

Fractional Capacity Value (%) of a Resource with a 5% Forced Outage Rate

LOEE - Loss of Energy Expectation (MWh / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	29.04	51.06	78.04	89.62	93.97	94.68	94.72	94.73	94.73
250	26.99	48.51	75.92	88.32	93.09	93.92	93.98	93.98	93.98
500	24.25	44.70	72.37	85.98	91.47	92.51	92.59	92.60	92.60
1,000	19.94	38.25	65.17	80.40	87.38	89.05	89.27	89.28	89.28
2,000	14.08	28.16	50.65	65.95	75.06	78.61	79.36	79.39	79.39
4,000	7.88	16.36	30.85	42.19	50.53	55.30	56.77	56.85	56.85

Fractional Capacity Value (%) of a Resource with a 10% Forced Outage Rate

LOLE - Daily Loss of Load Expectation (Days / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	5.22	22.75	29.24	31.51	32.02	32.02	32.02	32.02	32.02
250	16.48	33.82	44.31	47.55	47.88	47.88	47.88	47.88	47.88
500	16.47	31.41	43.69	49.69	50.72	50.63	50.63	50.63	50.63
1,000	12.00	25.94	39.20	45.24	47.02	47.06	47.06	47.06	47.06
2,000	6.69	16.62	29.58	35.28	37.04	37.45	37.44	37.44	37.44
4,000	3.39	8.65	17.44	22.43	24.31	24.78	24.89	24.89	24.89

Fractional Capacity Value (%) of a Resource with a 10% Forced Outage Rate

LOLH - Hourly Loss of Load Expectation (Hours / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	0.00	21.78	39.46	52.82	58.16	59.77	60.14	60.18	60.18
250	13.38	33.75	52.35	61.41	66.36	68.05	68.56	68.56	68.56
500	18.44	33.47	52.22	63.11	68.58	69.71	69.91	69.92	69.92
1,000	16.67	30.48	47.57	58.42	63.97	65.86	66.26	66.28	66.28
2,000	13.07	23.22	36.91	46.57	52.06	54.02	54.66	54.71	54.71
4,000	8.14	15.09	24.69	31.50	36.57	39.10	39.73	39.76	39.76

Fractional Capacity Value (%) of a Resource with a 10% Forced Outage Rate

LOEE - Loss of Energy Expectation (MWh / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	27.18	47.98	73.51	84.38	88.43	89.10	89.14	89.14	89.14
250	25.19	45.42	71.13	82.57	86.95	87.70	87.75	87.75	87.75
500	22.59	41.67	67.25	79.53	84.38	85.26	85.32	85.33	85.33
1,000	18.51	35.47	59.86	72.95	78.58	79.81	79.97	79.97	79.97
2,000	13.02	25.95	46.04	58.43	64.62	66.51	66.86	66.87	66.87
4,000	7.25	14.98	27.83	36.60	41.80	43.89	44.36	44.38	44.38

Fractional Capacity Value (%) of a Resource with a 15% Forced Outage Rate

LOLE - Daily Loss of Load Expectation (Days / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	2.96	16.95	21.33	22.37	22.50	22.69	22.69	22.69	22.69
250	10.95	26.94	32.46	35.04	35.19	35.28	35.28	35.28	35.28
500	13.86	27.07	35.16	39.55	39.63	39.64	39.64	39.64	39.64
1,000	9.32	22.05	32.29	36.26	37.14	36.24	36.24	36.24	36.24
2,000	5.40	14.10	24.29	27.82	28.96	29.09	29.09	29.09	29.09
4,000	2.79	7.32	14.31	17.44	18.45	18.71	18.75	18.75	18.75

Fractional Capacity Value (%) of a Resource with a 15% Forced Outage Rate

LOLH - Hourly Loss of Load Expectation (Hours / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	0.00	18.11	32.12	41.99	47.67	49.30	49.61	49.64	49.64
250	10.59	29.33	45.35	53.58	57.35	58.52	58.78	58.81	58.81
500	15.78	30.46	45.97	55.39	58.99	60.35	60.48	60.45	60.45
1,000	15.09	27.77	42.87	51.85	55.98	56.44	56.55	56.55	56.55
2,000	12.04	21.45	33.77	41.30	45.38	46.86	47.20	47.20	47.20
4,000	7.44	13.98	22.61	28.15	31.39	32.83	33.21	33.23	33.23

Fractional Capacity Value (%) of a Resource with a 15% Forced Outage Rate

LOEE - Loss of Energy Expectation (MWh / Year)

Penetration (MW)	Duration (Number of Hours per Day)								
	1	2	4	6	8	10	12	16	24
100	25.47	45.13	69.20	79.35	83.07	83.72	83.76	83.76	83.76
250	23.54	42.58	66.55	77.07	81.01	81.73	81.77	81.77	81.77
500	21.03	38.86	62.35	73.38	77.60	78.39	78.45	78.45	78.45
1,000	17.18	32.93	55.07	66.35	71.01	71.72	71.80	71.80	71.80
2,000	12.07	23.96	41.90	52.14	56.77	57.97	58.17	58.17	58.17
4,000	6.72	13.77	25.14	32.16	35.69	36.84	37.06	37.07	37.07