Support for NYISO Capacity Accreditation Project

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V2 (4/28): Corrected table for 150 MW results on slide 11

Overview

Goal: Support the NYISO in the selection of the technique used to determine the capacity credit or capacity value for different resources types, using GE MARS

Today we will provide preliminary capacity value results for different resource types, using:

- Expected Load Carrying Capability (ELCC) technique
- Marginal Reliability Improvement (MRI) technique

Calculations were performed with incremental units of nameplate capacity (ICAP) for the representative unit: 50, 100, 150, and 200 MW

Capacity values are presented as MWs and as percentages of nameplate capacity

Base database

The cases presented today were evaluated for the 2022 NYISO LCR database

This database features the following IRM/LCR value:

IRM	J LCR	K LCR	G-J LCR
19.6%	81.2%	99.5%	89.2%

The report for this database is available here:

https://www.nyiso.com/documents/20142/27428389/LCR2022-Report.pdf/b6dc8eb8-4cde-224d-2b9b-8aa247cac6fc

ELCC technique preliminary results

Effective load-carrying capability (ELCC) technique in this project

To measure the ELCC of a particular resource type, of a concrete size, at a location:

1. Start with the LCR database	Record initial (target) LOLE
2. Add the incremental MWs of the representative unit to the desired location	LOLE is reduced
3. Iteratively, remove perfect capacity	LOLE starts increasing
4. Stop when the NYBA reliability is back to (1)	LOLE is back to the initial LOLE

Thermal units

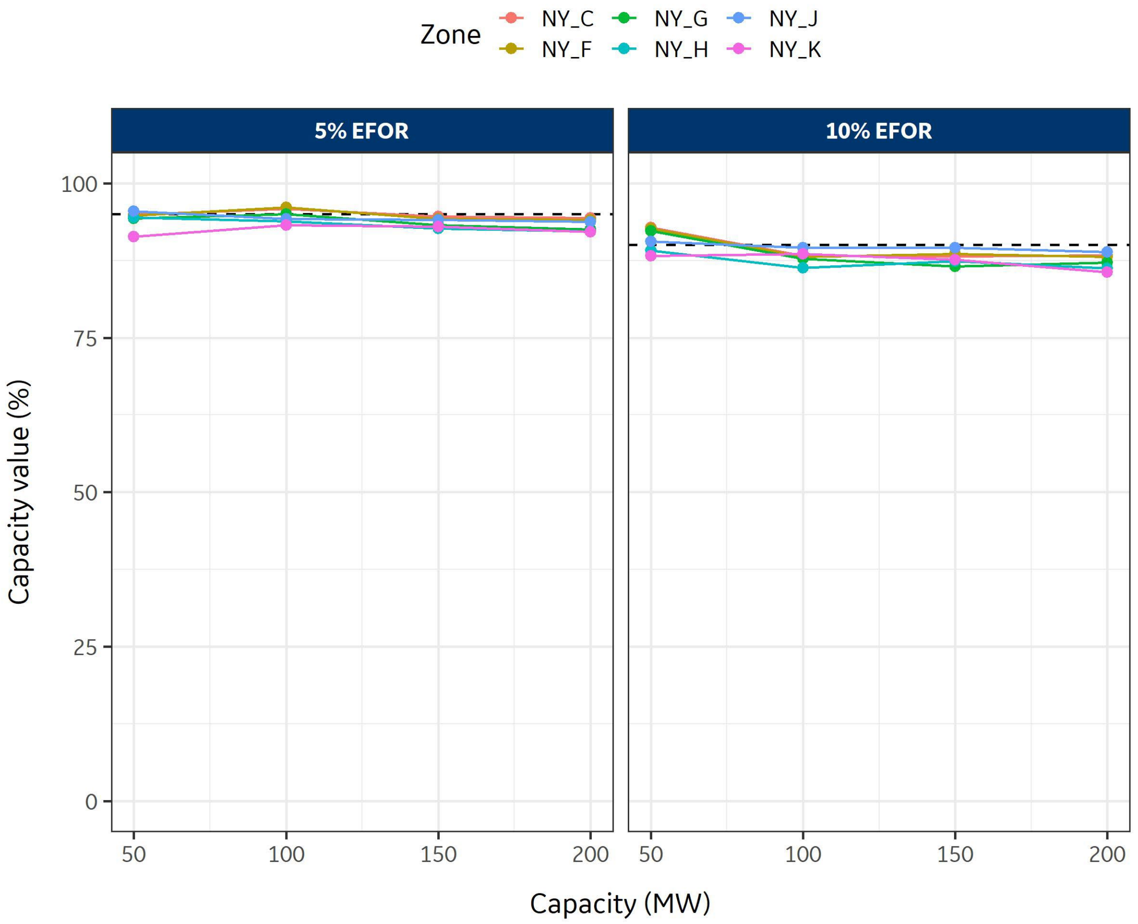
We measured the capacity value of thermal units, located in different zones throughout the NYISO footprint.

Two series of cases were run, with different EFOR values: 5% and 10%

Unit outages were independent of the conditions of any other units

Thermal - ELCC capacity values (MW and %)

		Nameplate capacity (MW)			
EFOR	Zone	50	100	150	200
5	NY_C	47.4	95.9	141.9	188.8
	NY_F	47.4	96.1	141.3	188.1
	NY_G	47.2	95.0	139.8	185.1
	NY_H	47.2	93.8	139.0	184.5
	NY_J	47.7	94.3	141.1	187.6
	NY_K	45.7	93.2	139.5	184.2
10	NY_C	46.4	88.2	132.2	176.7
	NY_F	46.4	88.1	132.8	176.2
	NY_G	46.2	87.8	129.8	174.4
	NY_H	44.6	86.3	131.1	172.5
	NY_J	45.3	89.6	134.4	177.7
	NY_K	44.1	88.6	131.4	171.3



(Dashed lines represent 95% and 90%, respectively)

Landfill biomass units

Next, we measured the capacity value of landfill biomass units.

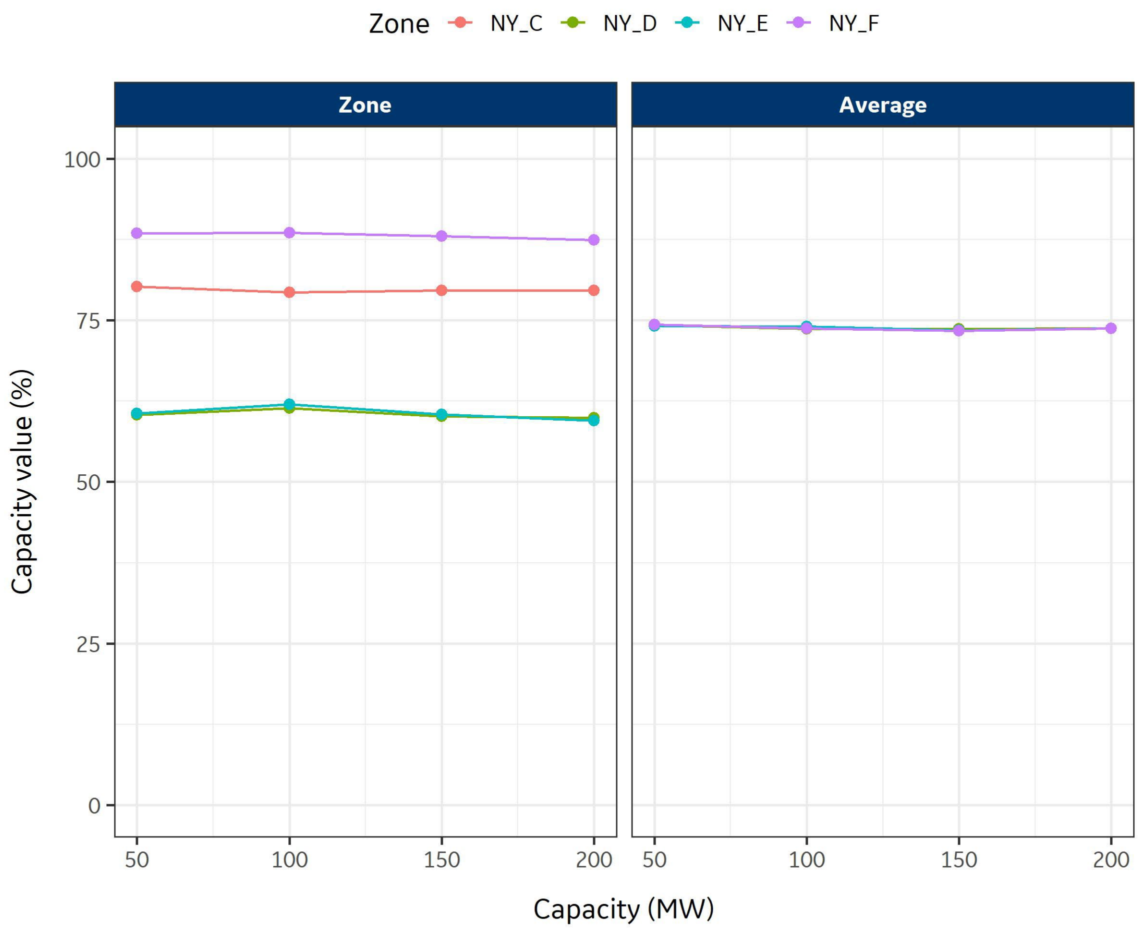
Existing units are modeled in the IRM/LCR datasets through 8760 shapes that capture their historical generation.

We represented the representative unit in two series of cases:

- A representative unit that uses the shapes in a particular NYISO zone ("Zone" case)
- A representative unit that uses the average shape across the NYISO footprint ("Average" case)

Landfill biomass - ELCC capacity values (MW and %)

		Nameplate capacity (MW)			
Shape	Zone	50	100	150	200
Zone	NY_C	40.1	79.3	119.4	159.1
	NY_D	30.2	61.4	90.2	119.9
	NY_E	30.3	62.0	90.6	118.9
	NY_F	44.2	88.5	132.1	174.9
Average	NY_C	37.1	73.7	110.0	147.4
	NY_D	37.1	73.7	110.5	147.5
	NY_E	37.0	74.0	110.2	147.5
	NY_F	37.2	73.7	110.0	147.4



Run-of-river units

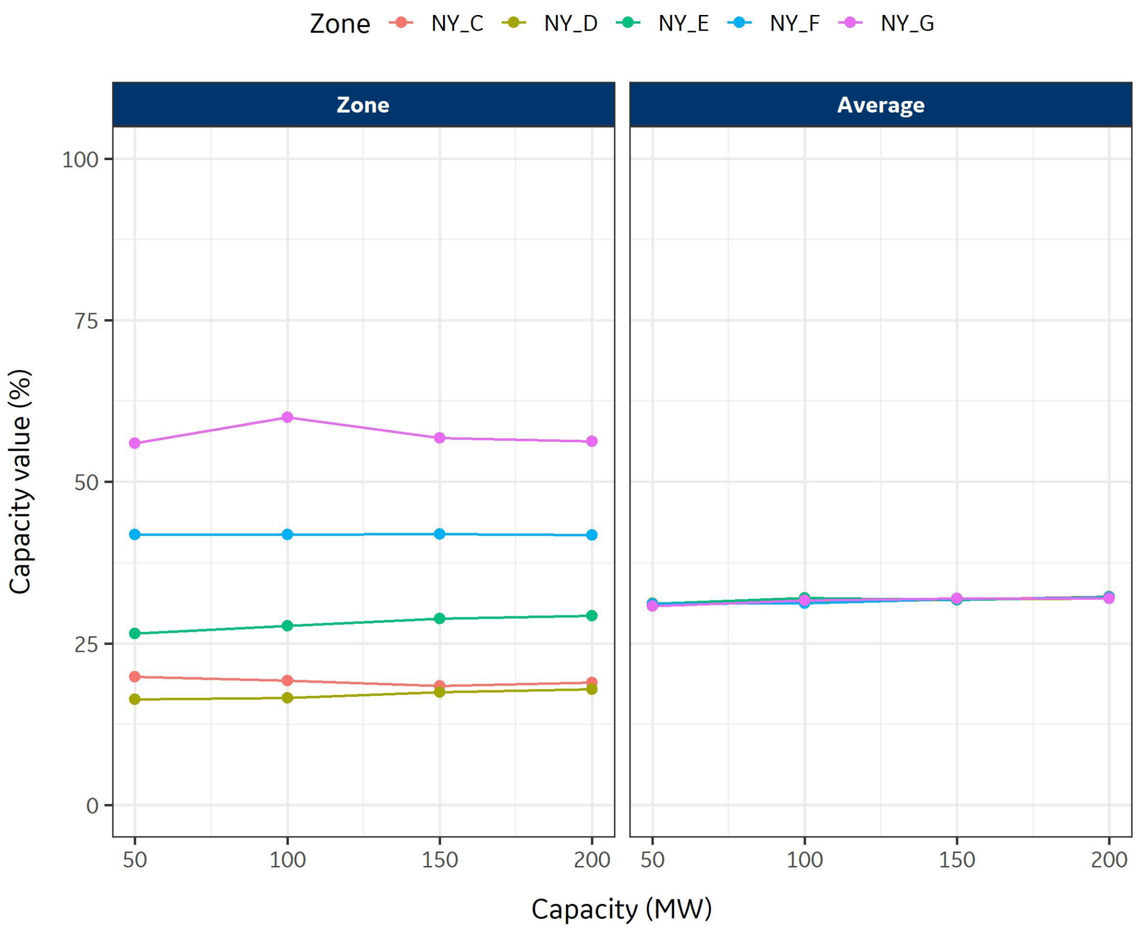
Like landfill units, existing units are modeled in the IRM/LCR datasets through 8760 shapes that capture their historical generation.

We represented the representative unit in two series of cases:

- A representative unit that uses the shapes in a particular NYISO zone ("Zone" case)
- A representative unit that uses the average shape across the NYISO footprint ("Average" case)

Run-of-river - ELCC capacity values (MW and %)

		Nameplate capacity (MW)			
Shape	Zone	50	100	150	200
Zone	NY_C	9.9	19.3	27.6	37.9
	NY_D	8.2	16.6	26.2	35.8
	NY_E	13.3	27.7	43.2	58.6
	NY_F	20.9	41.9	62.9	83.6
	NY_G	28.0	60.0	85.2	112.5
Average	NY_C	15.6	31.3	47.7	64.5
	NY_D	15.6	31.4	47.7	64.0
	NY_E	15.6	32.0	47.6	64.3
	NY_F	15.6	31.2	47.8	64.2
	NY_G	15.4	31.7	47.9	64.0



Onshore wind units

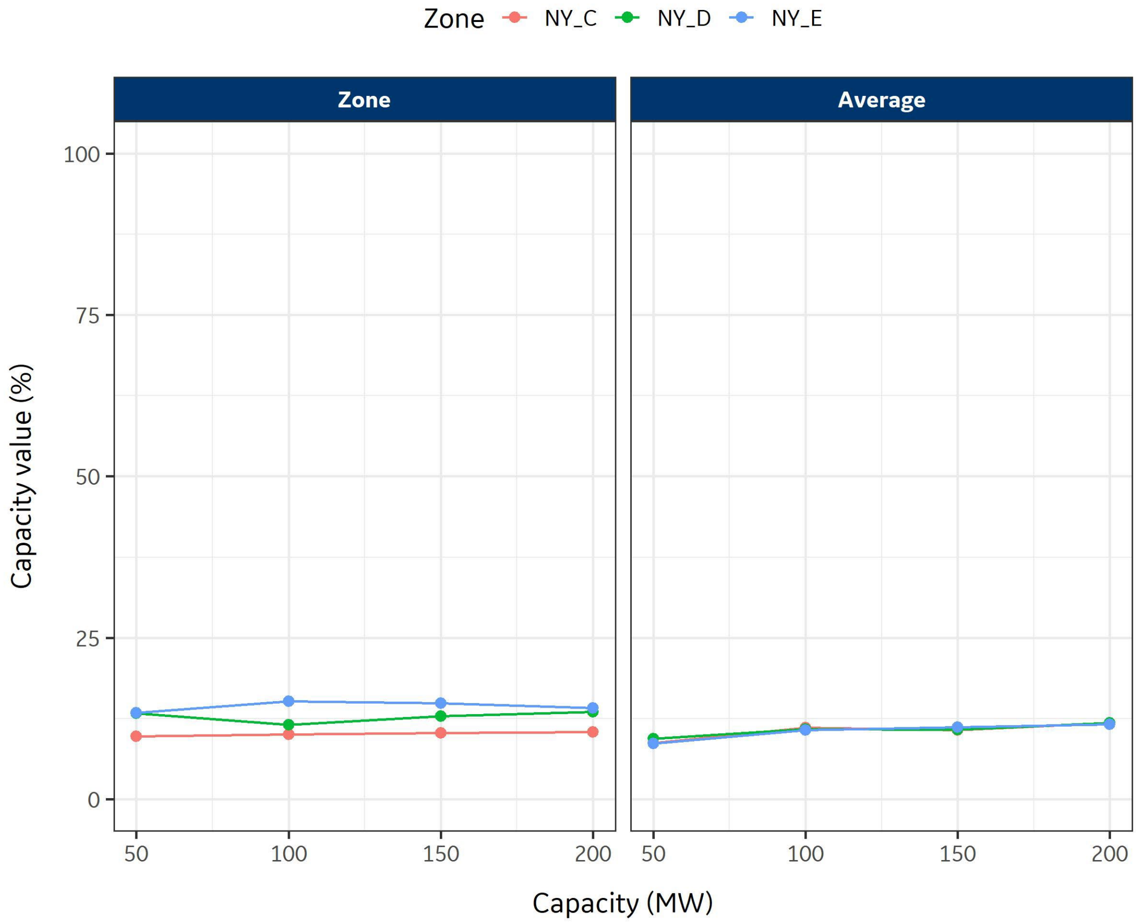
Existing units are modeled in the IRM/LCR datasets through 8760 shapes that capture their historical generation.

We represented the representative unit in two series of cases:

- A representative unit that uses the shapes in a particular NYISO zone ("Zone" case)
- A representative unit that uses the average shape across the NYISO footprint ("Average" case)

Onshore wind - ELCC capacity values (MW and %)

		Nameplate capacity (MW)			
Shape	Zone	50	100	150	200
Zone	NY_C	4.9	10.1	15.3	20.8
	NY_D	6.6	11.5	19.3	27.0
	NY_E	6.7	15.2	22.3	28.2
Average	NY_C	4.4	11.1	16.1	23.7
	NY_D	4.7	10.9	16.2	23.7
	NY_E	4.3	10.7	16.8	23.2



Offshore wind units

The IRM/LCR datasets do not include offshore wind units.

For these preliminary results, we used hourly profiles developed by GE Energy Consulting for the Phase 1 High Renewable Study, performed for the NYSRC. A description of the process is available:

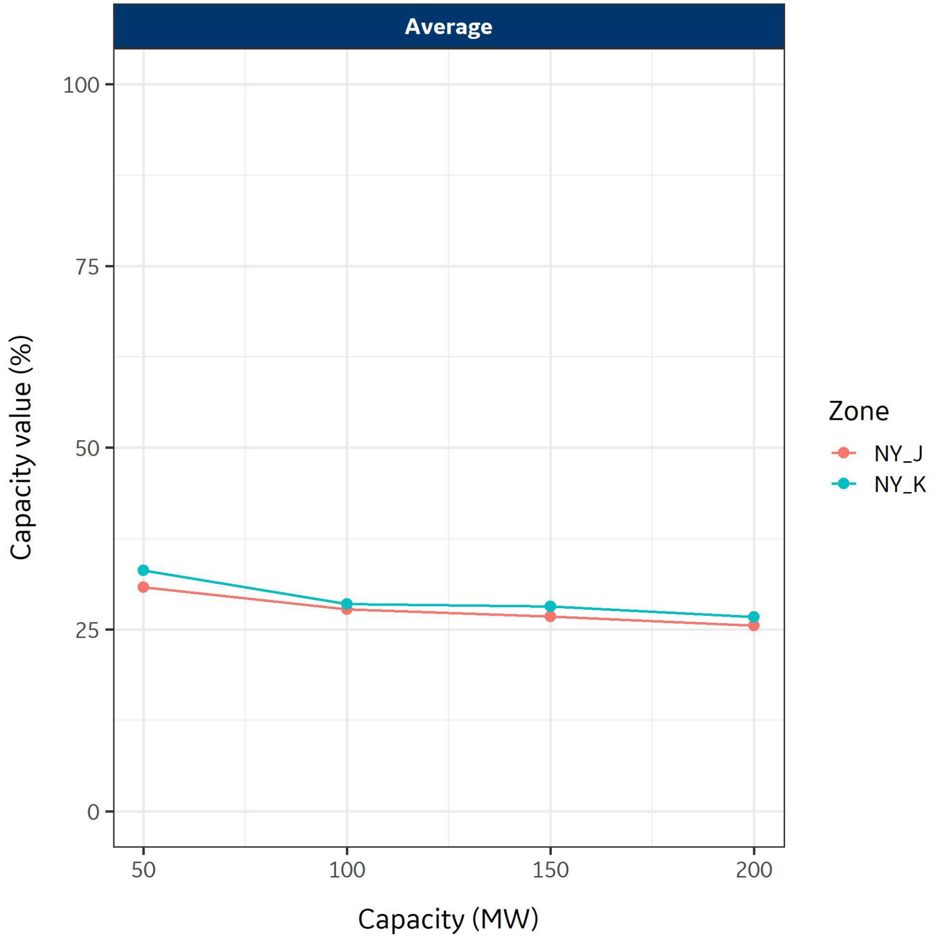
https://www.nysrc.org/pdf/MeetingMaterial/ICSMeetingMaterial/ICS Agenda 223/AI5' - windsolar-v04.pdf

We used the average profile across the three locations developed for the Phase 1 High Renewable Study.

A future revision of these calculations will include updated profiles that are being developed for the NYISO IRM team

Offshore wind - ELCC capacity values (MW and %)

		Nameplate capacity (MW)			
Shape	Zone	50	100	150	200
Average	NY_J	15.4	27.8	40.2	51.0
	NY_K	16.6	28.5	42.3	53.4



Solar units

The most recent IRM/LCR datasets do not include explicit generation from solar units.

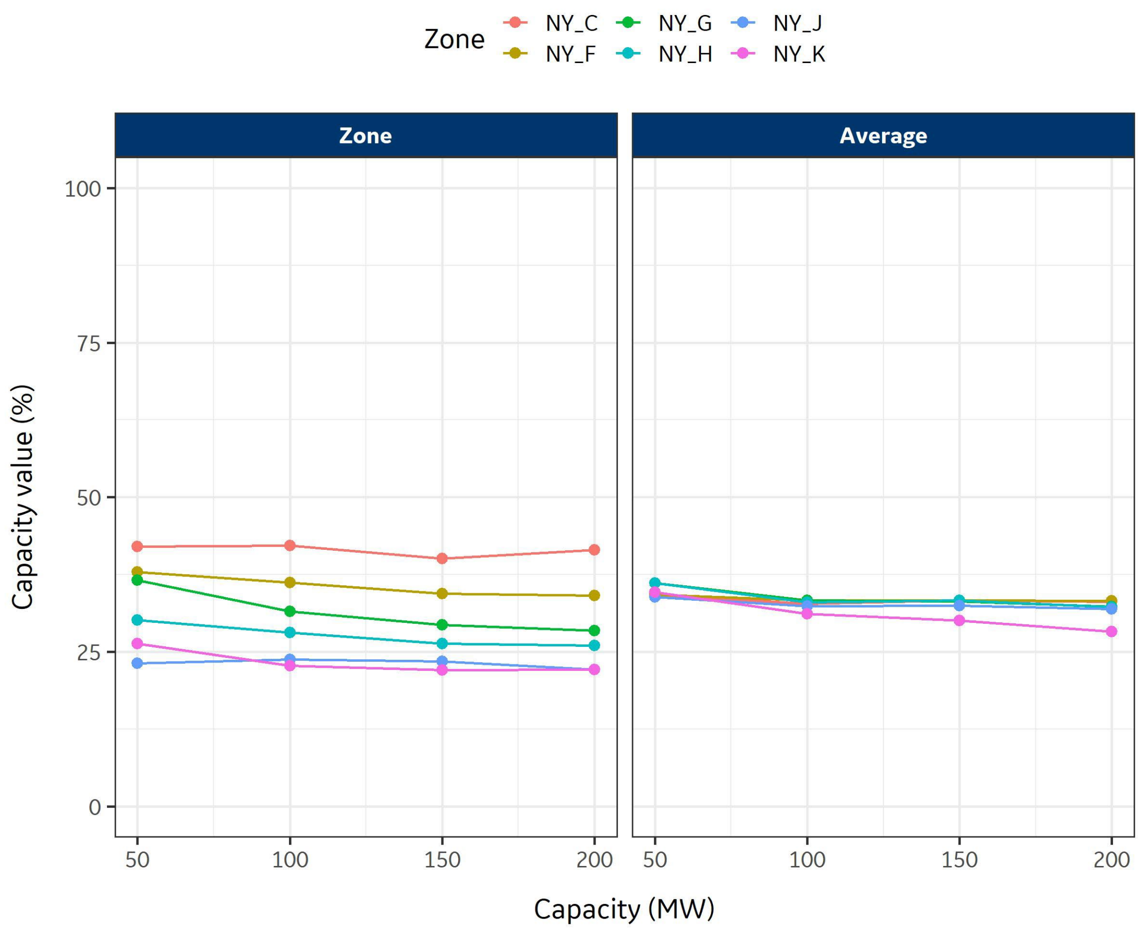
For this preliminary analysis, solar behind-the-meter (BTM) profiles by zone from the NYISO RNA model were used. A future update will improve the underlying generation data.

We represented the representative unit in two series of cases:

- A representative unit that uses the shapes in a particular NYISO zone ("Zone" case)
- A representative unit that uses the average shape across the NYISO footprint ("Average" case)

Solar - ELCC capacity values (MW and %)

		Nameplate capacity (MW)			
Shape	Zone	50	100	150	200
Zone	NY_C	21.0	42.1	60.1	83.0
	NY_F	18.9	36.2	51.6	68.1
	NY_G	18.3	31.5	44.0	56.8
	NY_H	15.1	28.2	39.5	52.0
	NY_J	11.6	23.7	35.2	44.3
	NY_K	13.2	22.8	33.1	44.3
Average	NY_C	17.1	32.8	50.0	66.2
	NY_F	17.1	33.3	50.0	66.5
	NY_G	18.1	33.3	49.8	64.7
	NY_H	18.0	33.0	49.9	64.5
	NY_J	16.9	32.4	48.7	63.8
	NY_K	17.3	31.2	45.1	56.5



MRI technique preliminary results

Marginal Reliability Improvement (MRI) technique

ELCC calculations involve an iterative process and can be computationally and time intensive.

We are exploring the MRI technique as a faster alternative

The slides in this section compare ELCC results (top row of each graph) to the equivalent MRI results (bottom row of the graph)

Please refer to the ELCC section for a description of each case

Marginal Reliability Improvement (MRI) technique

Steps:

1. Start with the LCR database and record the LOLE ($LOLE_i$)
2. Add the incremental MWs of the representative unit to be measured and record the LOLE ($LOLE_m$)
3. Replace the incremental MWs of the representative unit with perfect capacity of the same size in the same location and record the LOLE ($LOLE_p$)

The capacity value is $\frac{LOLE_i - LOLE_m}{LOLE_i - LOLE_p}$

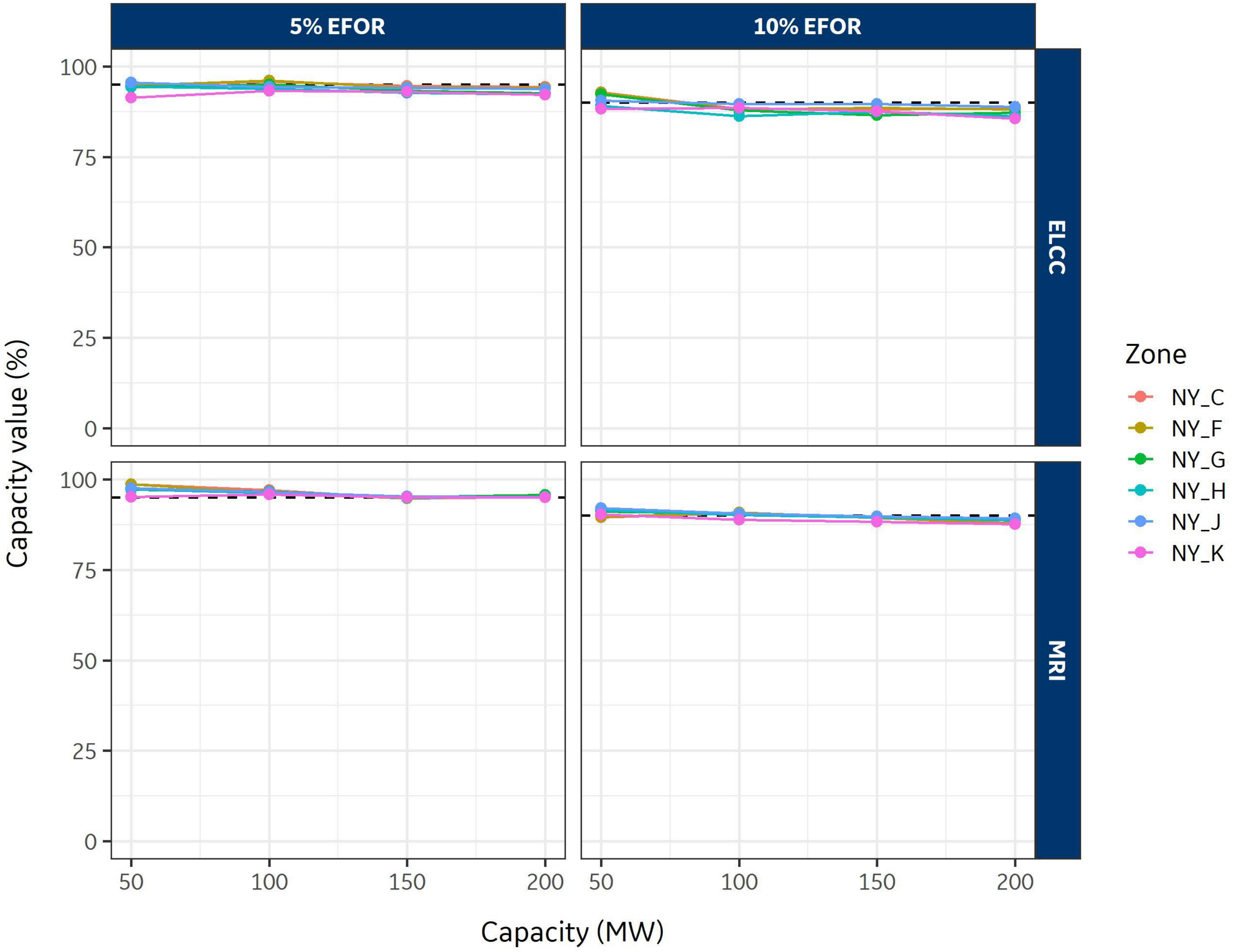
The capacity value formula can also be described as:

$$\frac{\Delta LOLE_{resource}}{\Delta LOLE_{perfect\ capacity}}$$

Where $\Delta LOLE_{resource}$ is the change in the initial LOLE from the addition of the incremental MWs of the representative unit and $\Delta LOLE_{perfect\ capacity}$ is the change in the initial LOLE from the addition of perfect capacity of the same size in the same location.

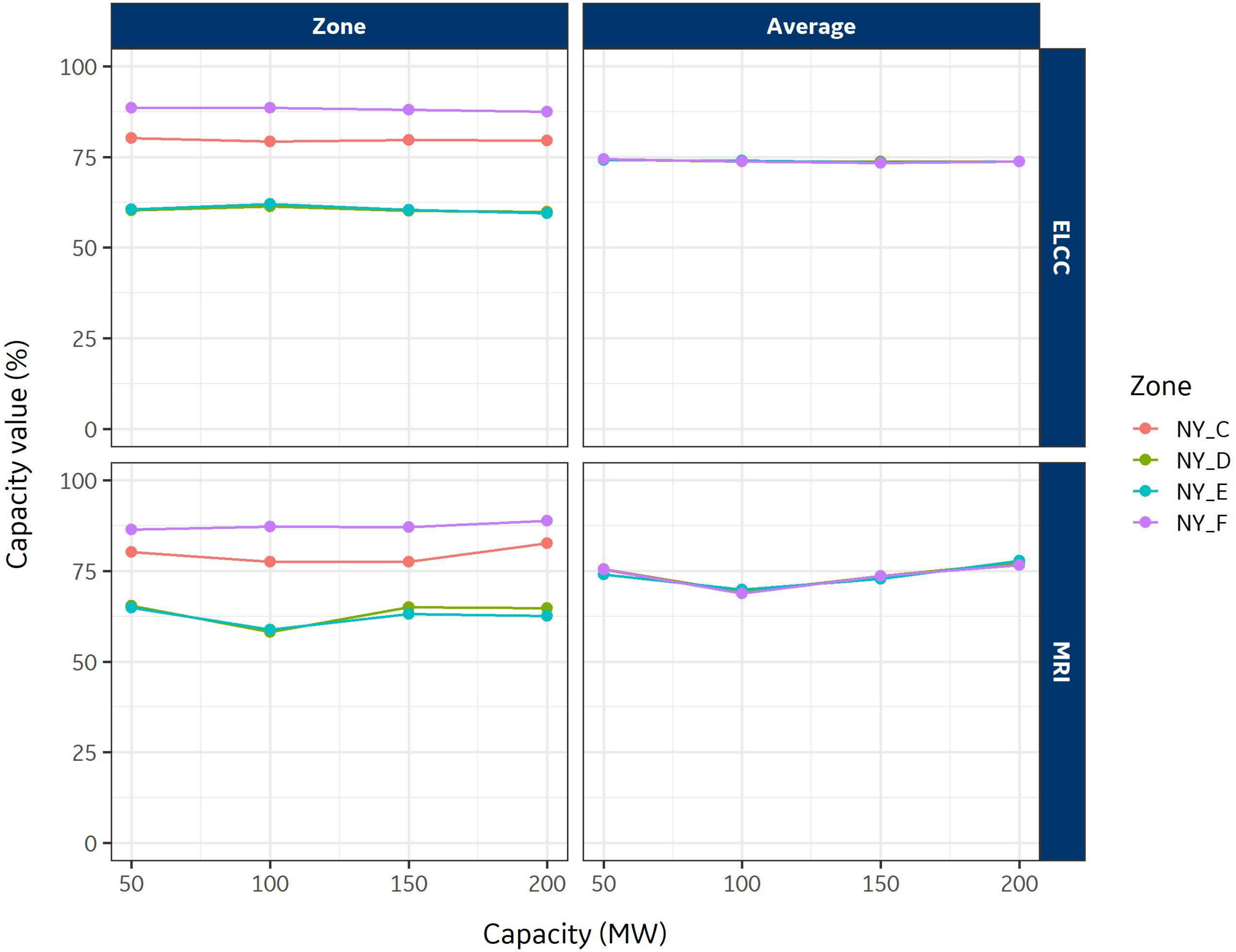
The MRI technique produces capacity values bounded by 0 and 1 as the system with the incremental MWs of the representative unit cannot be more reliable than the system with perfect capacity of the same size in the same location (*i.e.*, $\Delta LOLE_{resource}$ will be less than or equal to $\Delta LOLE_{perfect\ capacity}$)

Thermal – Capacity value (%) with ELCC and MRI techniques

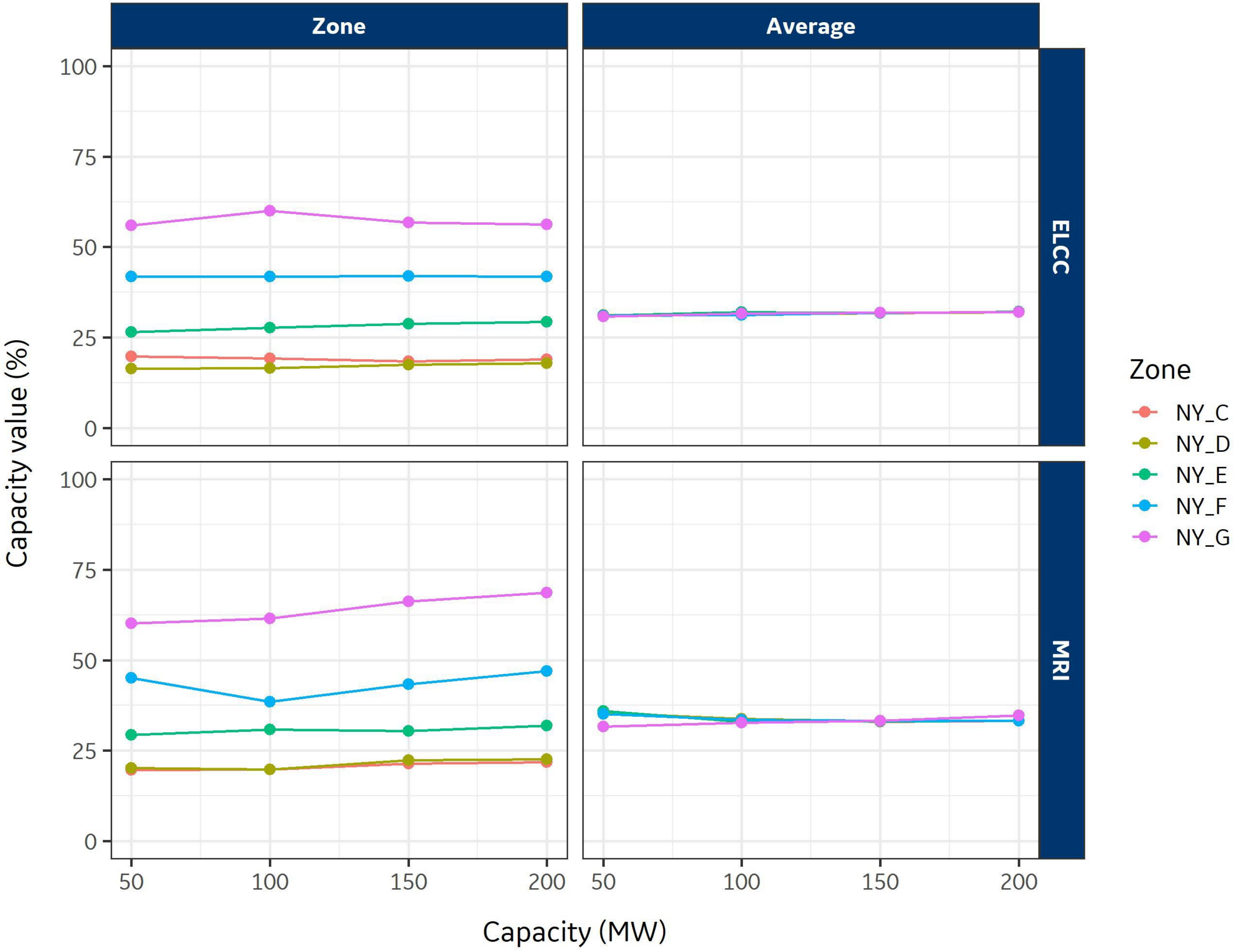


(Dashed lines represent 95% and 90%, respectively)

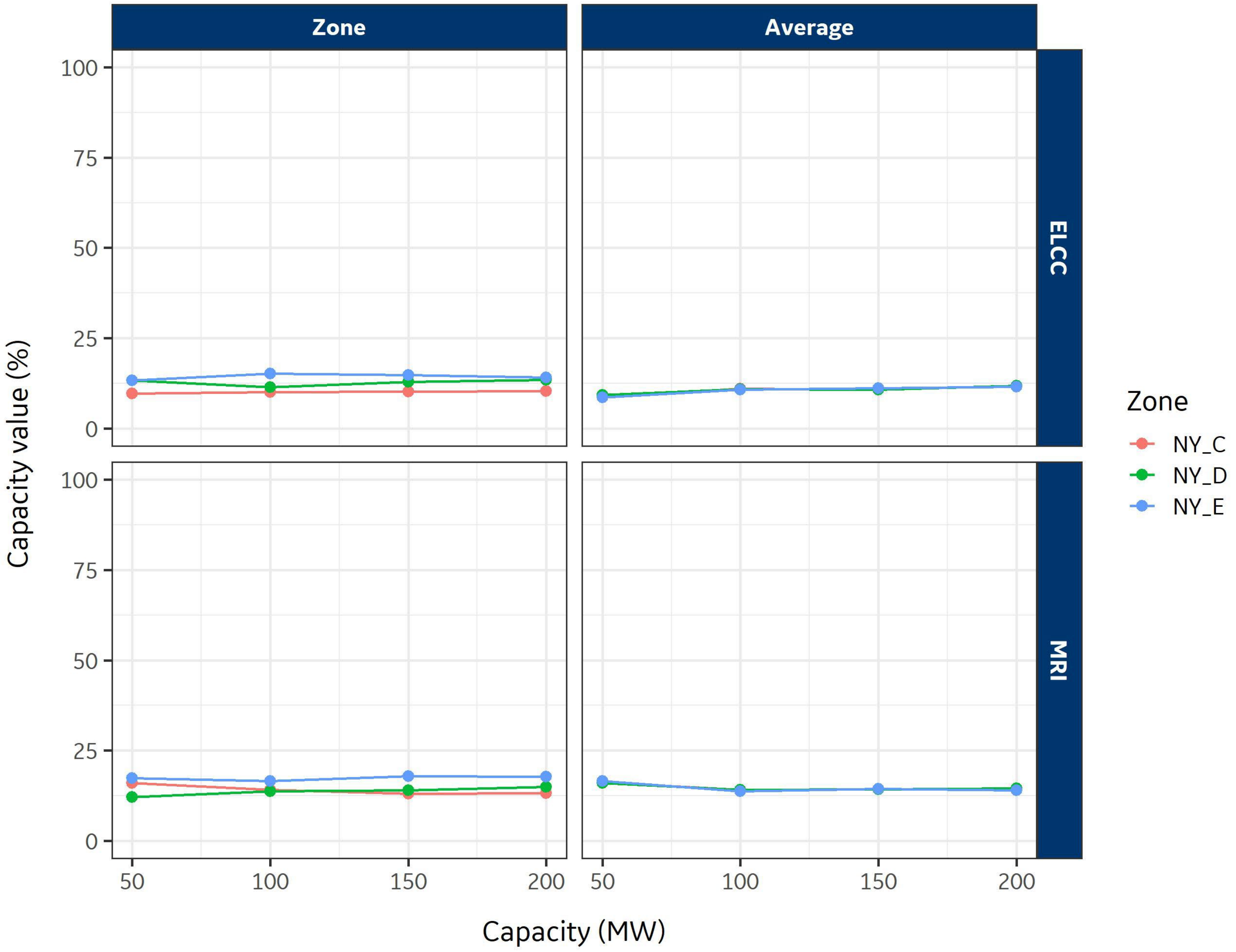
Landfill biomass – Capacity value (%) with ELCC and MRI techniques



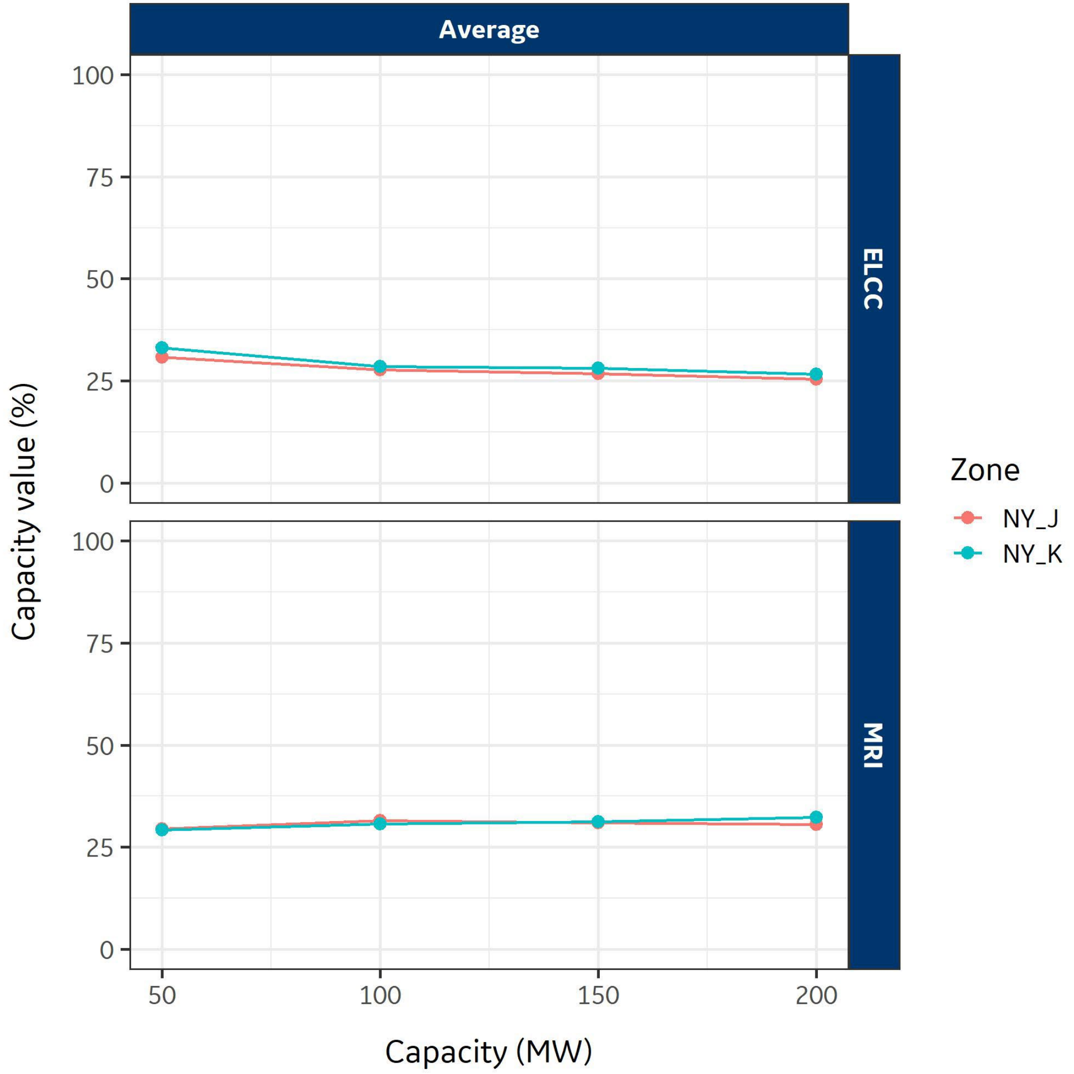
Run-of-river – Capacity value (%) with ELCC and MRI techniques



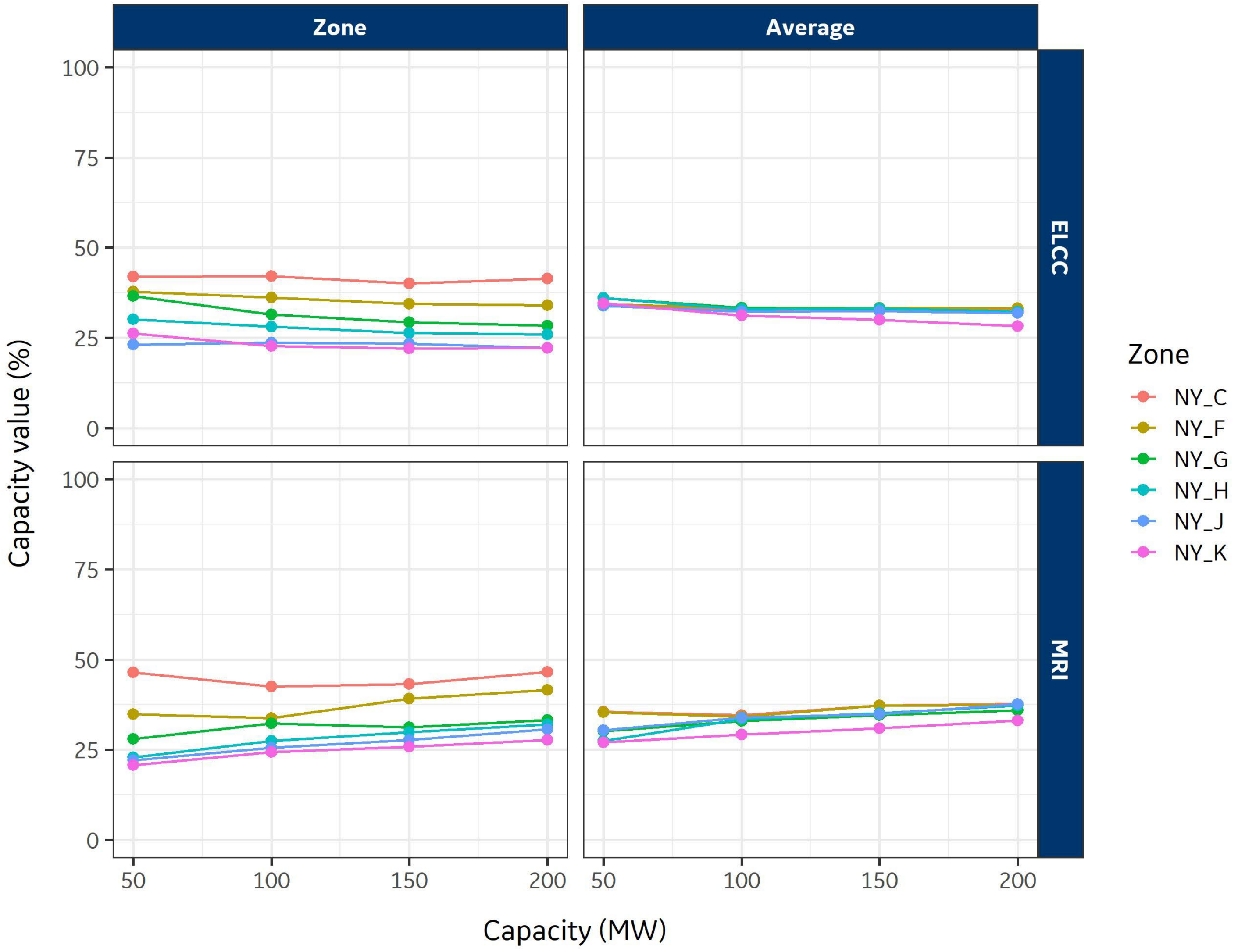
Onshore wind – Capacity value (%) with ELCC and MRI techniques



Offshore wind – Capacity value (%) with ELCC and MRI techniques



Solar– Capacity value (%) with ELCC and MRI techniques



Observations

Final observations

GE Energy Consulting is performing analysis of additional resource types, which will be presented later

In general, ELCC and MRI calculations do not appear to be greatly influenced by the size of the representative unit (lines in graphs are predominantly flat)

Units modeled with the same conditions (e.g., using average shapes), location has little to no influence in the result, for the cases studied

MRI estimates are close to the respective ELCC results and only require 1 simulation, instead of 6-10. On average, a single simulation usually takes 2.5-3 hours

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2/24/2022

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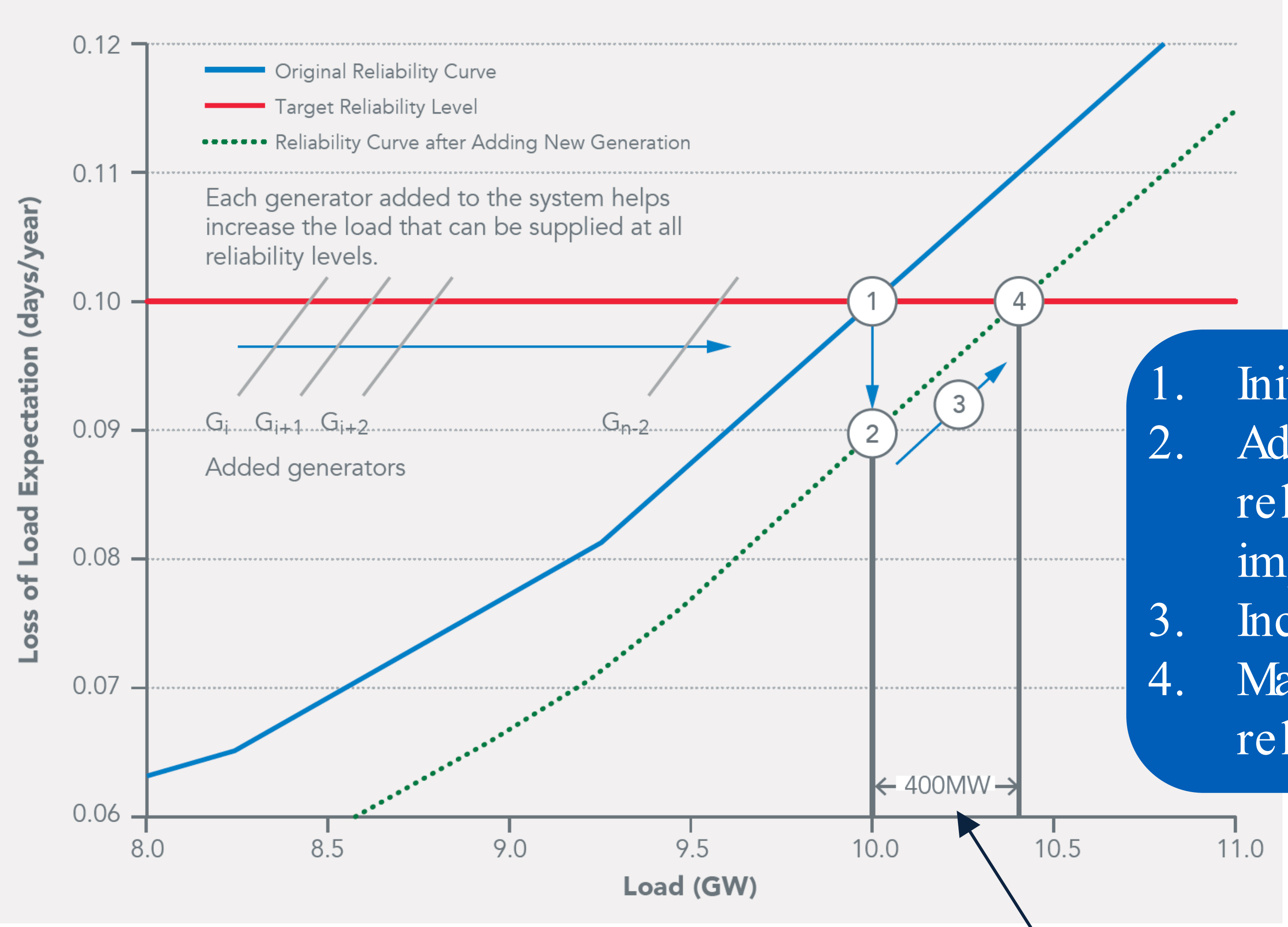
In this document, we sometimes use information derived from consolidated financial data but not presented in our financial statements prepared in accordance with U.S. generally accepted accounting principles (GAAP). Certain of these data are considered "non-GAAP financial measures" under the U.S. Securities and Exchange Commission rules. These non-GAAP financial measures supplement our GAAP disclosures and should not be considered an alternative to the GAAP measure. The reasons we use these non-GAAP financial measures and the reconciliations to their most directly comparable GAAP financial measures are posted to the investor relations section of our website at www.ge.com. [We use non-GAAP financial measures including the following:

- Operating earnings and EPS, which is earnings from continuing operations excluding non-service-related pension costs of our principal pension plans.
- GE Industrial operating & Vertical earnings and EPS, which is operating earnings of our industrial businesses and the GE Capital businesses that we expect to retain.
- GE Industrial & Verticals revenues, which is revenue of our industrial businesses and the GE Capital businesses that we expect to retain.
- Industrial segment organic revenue, which is the sum of revenue from all of our industrial segments less the effects of acquisitions/dispositions and currency exchange.
- Industrial segment organic operating profit, which is the sum of segment profit from all of our industrial segments less the effects of acquisitions/dispositions and currency exchange.
- Industrial cash flows from operating activities (Industrial CFOA), which is GE's cash flow from operating activities excluding dividends received from GE Capital.
- Capital ending net investment (ENI), excluding liquidity, which is a measure we use to measure the size of our Capital segment.
- GE Capital Tier 1 Common ratio estimate is a ratio of equity

Additional slides

Effective load-carrying capability (ELCC) technique



1. Initial system
2. Add resource, reliability improves
3. Increase load
4. Match initial reliability target

Capacity value

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

Convergence criteria

ELCC cannot be calculated directly, an iterative process is needed to get an estimate.

The technique used (bisection search) keeps track of guesses above and below the target LOLE (in purple and yellow, respectively)

The process converges when:

- The evaluated LOLE is withing the LOLE tolerance band (0.0005 days/year, or third decimal)
- The best guesses above and below the LOLE target are less than 1 MW apart