5/24/2022

Support for NYISO Capacity Accreditation Project

Reposted with MRI results tables

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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 Energy Duration Limited and Large Hydro resources, with:

- 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

Modeling

Two modeling techniques were used for Energy Duration Limited and Large Hydro units to create the results in this presentation.

"Shape base" models:

- The units are pre-dispatched with fixed, daily hourly shapes
- Consistent with the 2022 NYISO IRM and LCR databases

"Dynamic" models:

- The units are used by GE MARS on an "as needed" basis, using the EL3 and ES unit types
- Consistent with a sensitivity in the 2022 NYISO IRM database and the base model in this year's IRM
- Further information on the dynamic models can be found in the 2021 NYSRC white paper: https://nysrc.org/PDF/Reports/IRM%20White%20Papers/ELR%20Modeling%20White%20Paper%20May%202021%20FINAL.pdf

$\overline{\text{E}}$LCC 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

Energy Duration Limited Resources

Existing Energy Duration Limited units are modeled in the IRM/LCR datasets through 8760 hourly shapes that are structured to represent their unit capabilities and to reflect the following characteristics:

- Maximum sustainable output is scheduled during periods of peak load
- Unit charging is scheduled during low price periods, or off-peak consumption periods

The representative Energy Duration Limited units are modeled through fixed shapes or dynamic models.

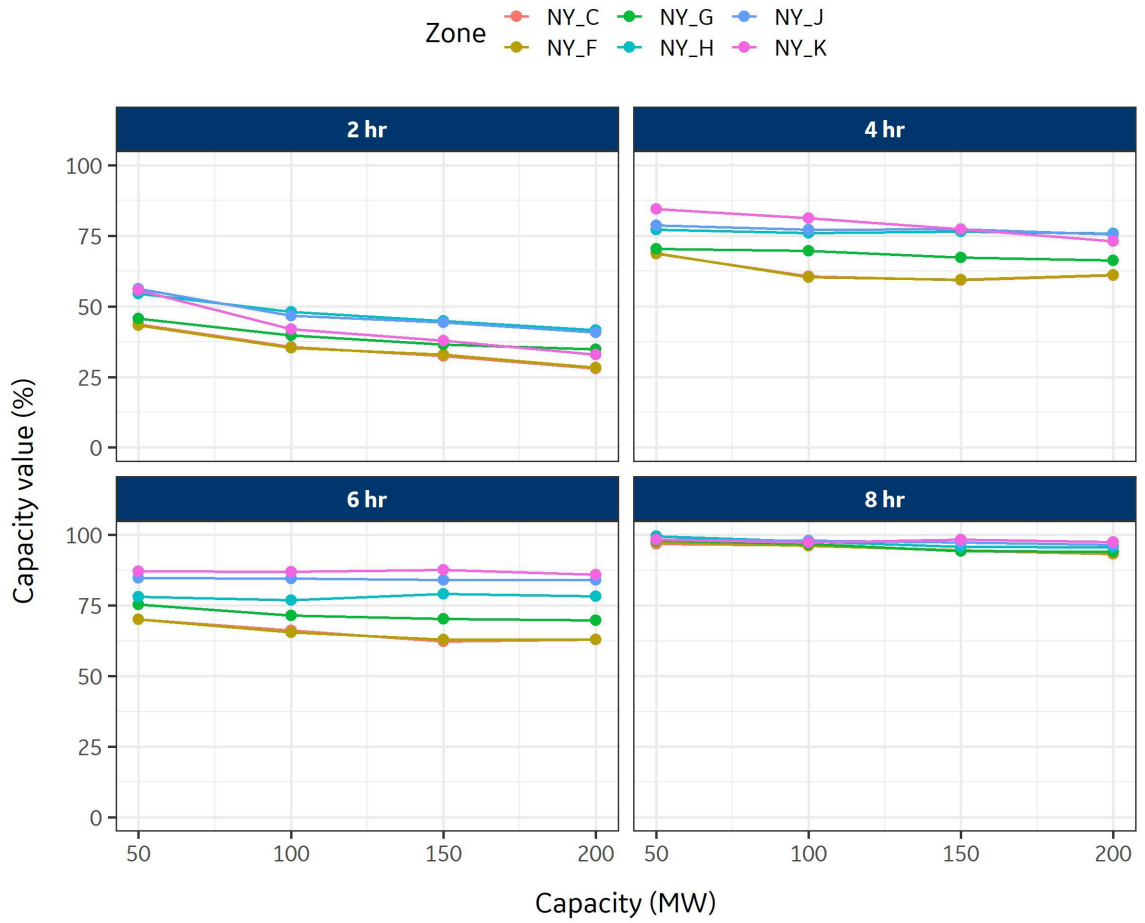
We modeled different durations for Energy Duration Limited units: 2, 4, 6 and 8 hours, with the same characteristics as the existing units in the IRM/LCR datasets

No derates or outages were applied to the units in the simulation.

If a unit has a nameplate of 100 MW and a duration of 4 hours, it can produce up to 100 MW and 400 MWh in a day.

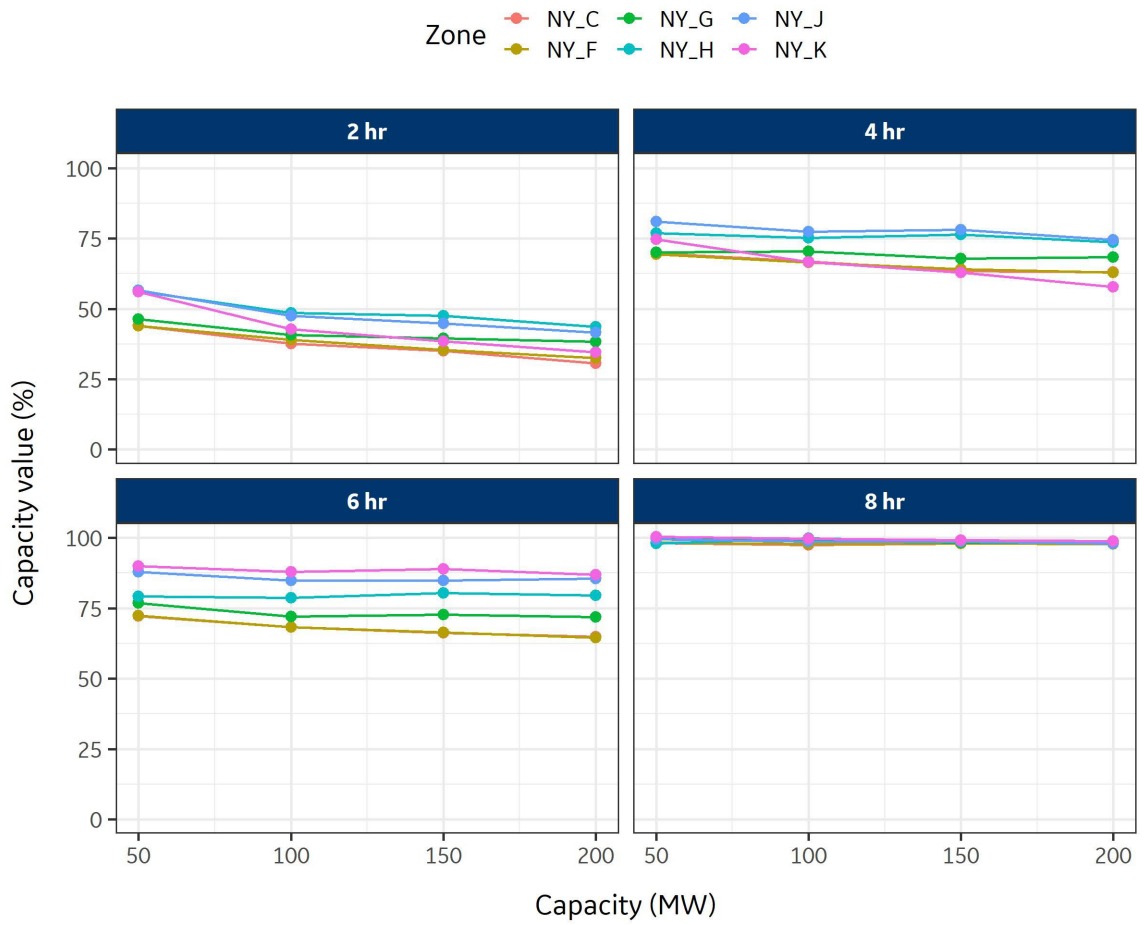
Energy Duration Limited – Shape-based model capacity values (MW and %)

		Nameplate capacity (MW)			
Duration (h)	Zone	50	100	150	200
2	NY_C	21.8	35.6	48.6	56.0
	NY_F	21.6	35.2	49.5	56.6
	NY_G	22.9	39.7	54.8	69.7
	NY_H	27.3	48.0	67.2	83.2
	NY_J	28.1	46.7	66.5	81.6
	NY_K	27.9	41.9	56.9	65.8
4	NY_C	34.3	60.7	89.1	122.2
	NY_F	34.4	60.3	89.3	122.4
	NY_G	35.2	69.7	101.0	132.4
	NY_H	38.6	76.0	114.6	151.4
	NY_J	39.3	77.1	116.0	150.8
	NY_K	42.3	81.2	116.0	146.0
6	NY_C	35.1	66.2	93.5	126.0
	NY_F	35.0	65.5	94.5	126.0
	NY_G	37.7	71.5	105.4	139.6
	NY_H	39.0	76.9	118.7	156.7
	NY_J	42.3	84.6	126.2	168.2
	NY_K	43.6	87.0	131.3	171.8
8	NY_C	48.4	96.3	141.7	186.6
	NY_F	48.8	96.1	141.9	187.0
	NY_G	49.0	96.9	141.4	188.1
	NY_H	49.7	97.7	143.7	191.1
	NY_J	49.2	98.0	146.0	192.9
	NY_K	49.2	97.3	147.5	195.0



Energy Duration Limited – Dynamic model capacity values (MW and %)

		Nameplate capacity (MW)			
Duration (h)	Zone	50	100	150	200
2	NY_C	22.0	37.7	52.5	61.3
	NY_F	21.9	39.0	53.1	65.1
	NY_G	23.1	40.8	59.2	76.5
	NY_H	28.1	48.6	71.3	87.2
	NY_J	28.3	47.6	67.1	83.0
	NY_K	28.1	42.8	57.8	69.2
4	NY_C	34.9	66.8	95.1	126.0
	NY_F	34.7	66.5	96.2	125.6
	NY_G	35.0	70.4	101.7	136.8
	NY_H	38.5	75.1	114.6	147.3
	NY_J	40.5	77.3	117.2	149.0
	NY_K	37.4	66.6	94.4	115.4
6	NY_C	36.1	68.3	99.3	129.7
	NY_F	36.2	68.3	99.5	129.0
	NY_G	38.4	72.0	109.2	143.6
	NY_H	39.6	78.7	120.7	159.2
	NY_J	44.0	84.9	127.4	170.9
	NY_K	45.0	88.0	133.3	173.9
8	NY_C	49.1	97.4	147.0	195.6
	NY_F	49.2	97.7	147.1	195.6
	NY_G	49.8	99.0	147.5	196.7
	NY_H	49.0	99.9	148.0	196.7
	NY_J	49.8	98.7	147.9	196.1
	NY_K	50.2	99.7	148.8	197.5



Large Hydro units

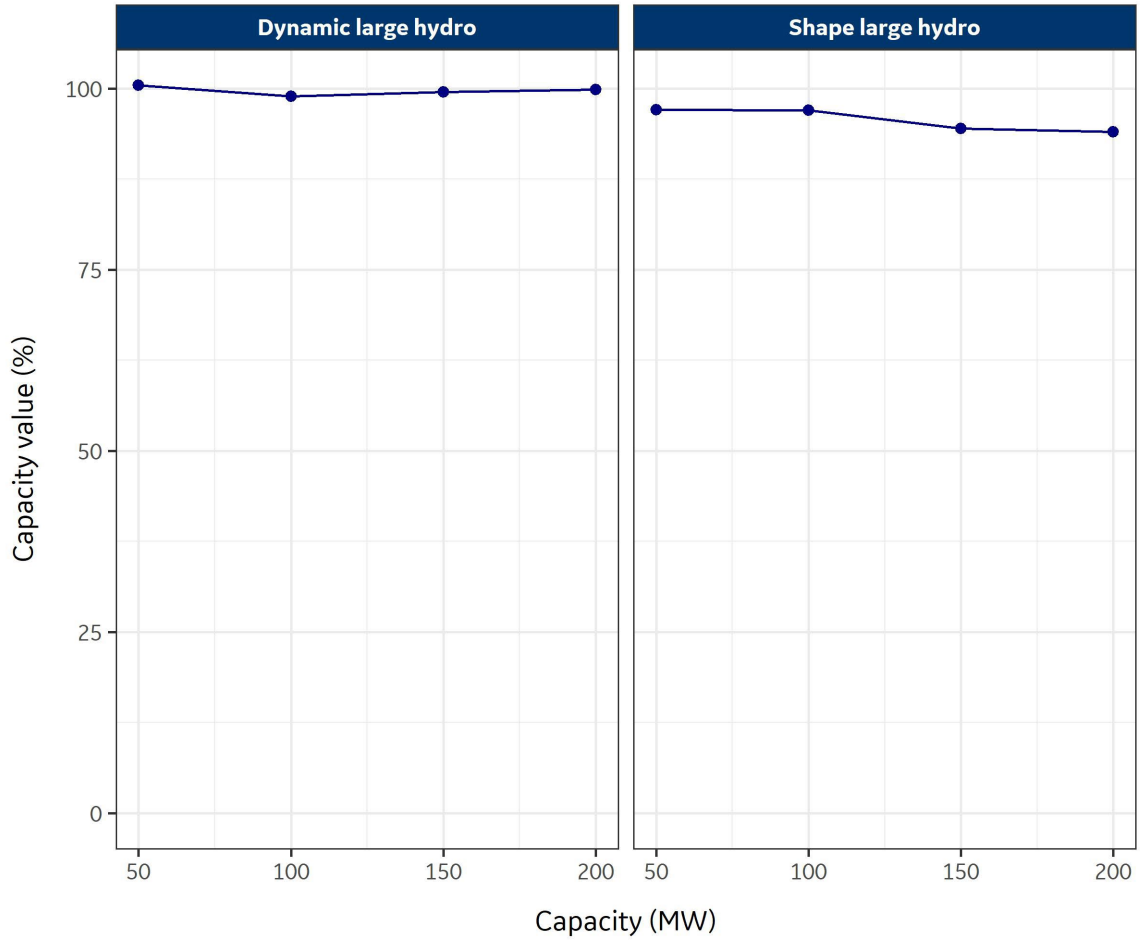
Existing Large Hydro units are modeled in the IRM/LCR datasets based on the units' specific capabilities and historical operation patterns.

The representative Large Hydro units are modeled through generic fixed shapes or dynamic models.

The generic shapes and representation for the representative units are based on the assumptions in the NYISO 2022 IRM and LCR model

Large Hydro - ELCC capacity values (MW and %)

	Nameplate capacity (MW)			
Model	50	100	150	200
Dynamic large hydro	50.0	98.9	149.2	199.6
Shape large hydro	48.5	97.0	141.7	188.0



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 ($LOLE_p$)

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

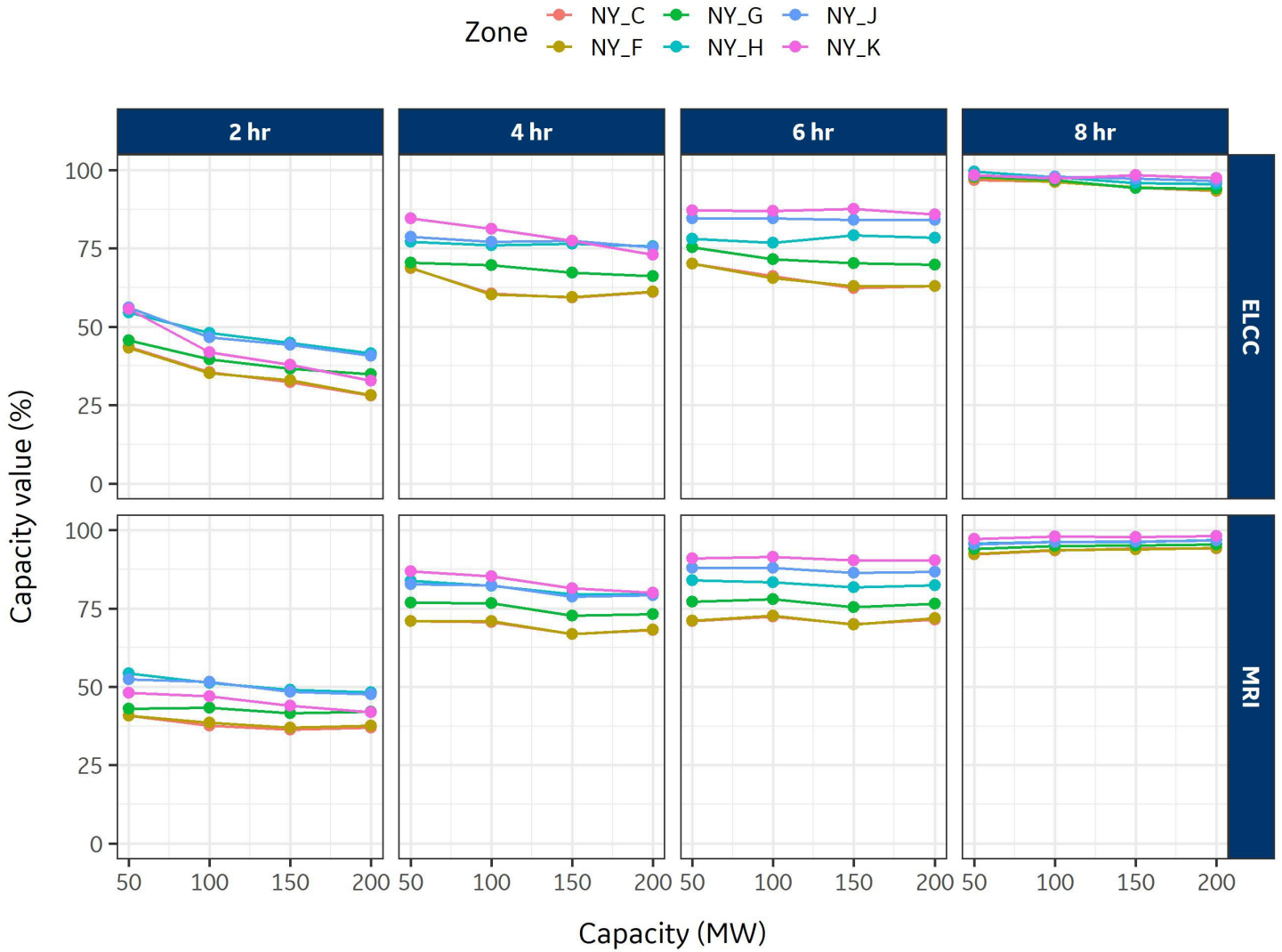
The capacity value formula can also be described as:

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

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 $\Delta LOLE_{perfect\ capacity}$)

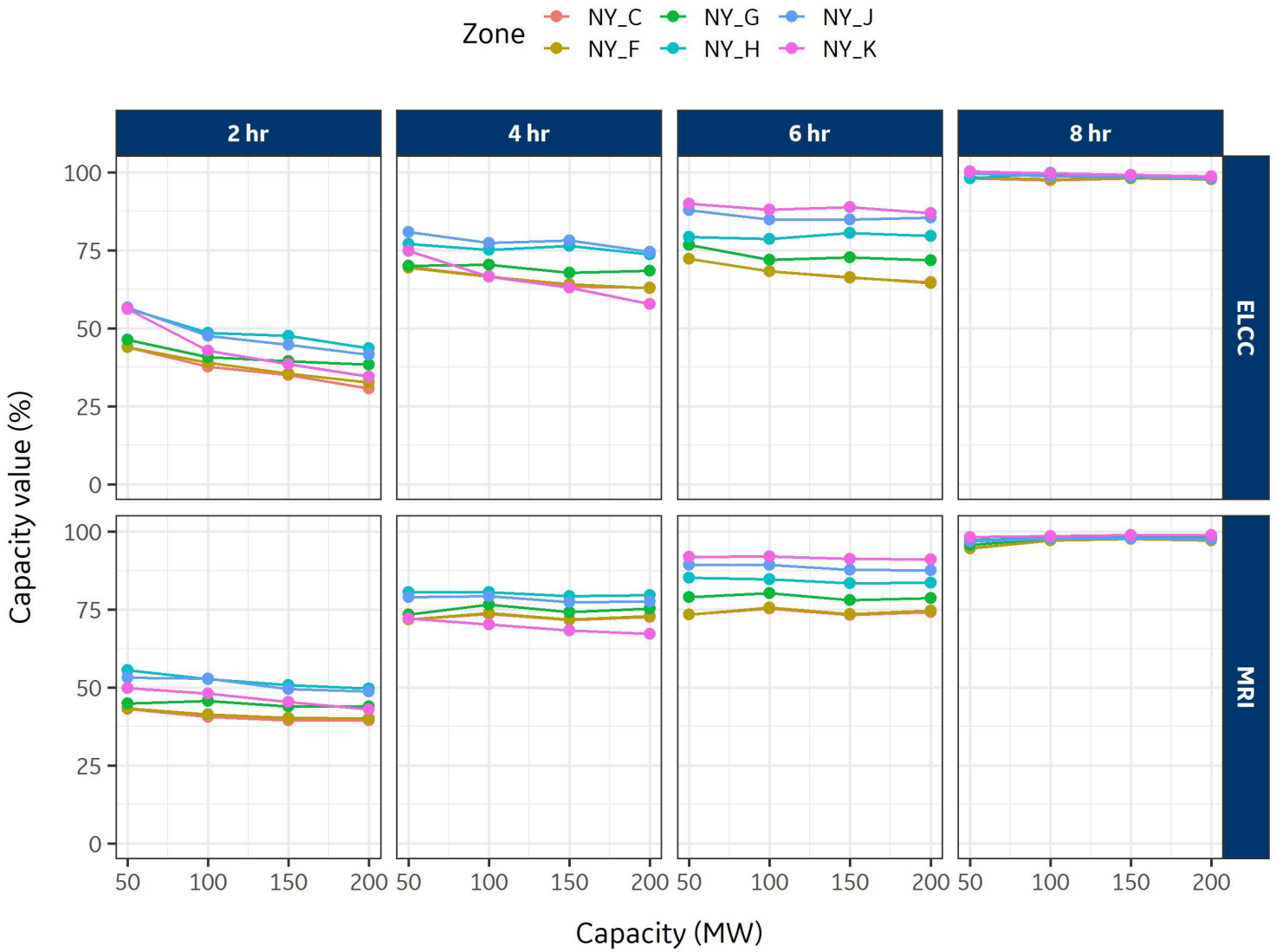
Energy Duration Limited Shapes – Capacity value (%) with ELCC and MRI techniques



Energy Duration Limited Shapes – Capacity value (MW) with MRI techniques

		Nameplate capacity (MW)			
Duration (h)	Zone	50	100	150	200
2	NY_C	20.4	37.6	54.6	73.9
	NY_F	20.4	38.5	55.6	75.3
	NY_G	21.5	43.3	62.4	84.0
	NY_H	27.1	51.3	73.6	96.5
	NY_J	26.2	51.6	72.6	95.4
	NY_K	24.0	46.9	65.9	83.7
4	NY_C	35.5	70.7	100.3	136.1
	NY_F	35.4	71.0	100.3	136.6
	NY_G	38.5	76.7	109.0	146.3
	NY_H	41.9	82.3	119.2	159.0
	NY_J	41.4	82.4	118.1	158.4
	NY_K	43.4	85.2	122.1	160.0
6	NY_C	35.5	72.3	104.9	142.8
	NY_F	35.6	72.6	104.8	143.8
	NY_G	38.5	78.0	113.1	153.0
	NY_H	42.0	83.3	122.7	164.8
	NY_J	44.0	88.0	129.5	173.3
	NY_K	45.5	91.4	135.5	180.5
8	NY_C	46.2	93.5	141.1	188.3
	NY_F	46.2	93.7	140.7	188.5
	NY_G	47.0	94.9	142.5	190.9
	NY_H	47.9	96.2	144.4	193.6
	NY_J	47.7	96.2	144.4	193.4
	NY_K	48.6	97.9	146.8	196.1

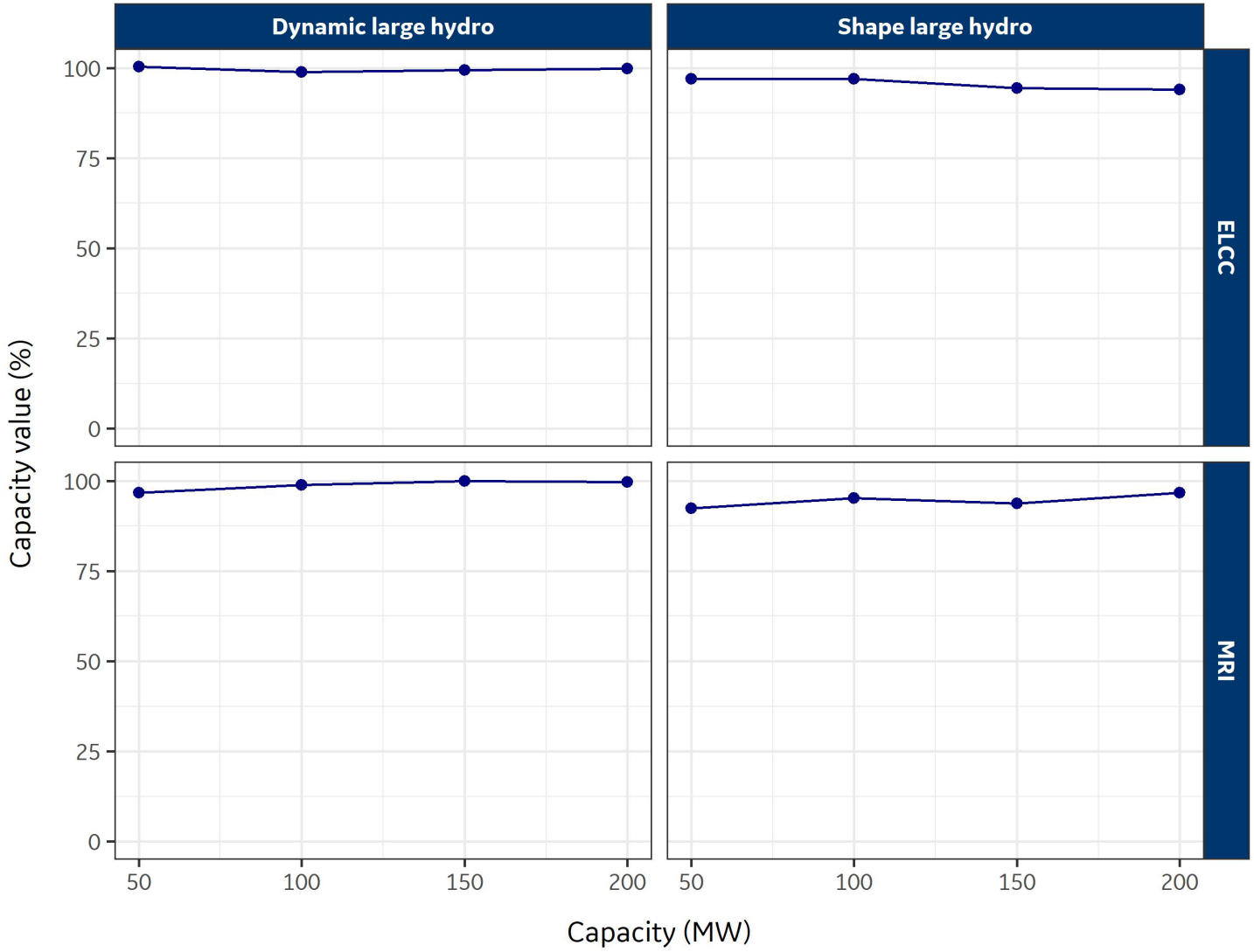
Energy Duration Limited Dynamic – Capacity value (%) with ELCC and MRI techniques



Energy Duration Limited Dynamic – Capacity value (MW) with MRI techniques

		Nameplate capacity (MW)			
Duration (h)	Zone	50	100	150	200
2	NY_C	21.6	40.6	59.1	79.1
	NY_F	21.6	41.4	60.5	80.3
	NY_G	22.5	45.6	65.9	88.0
	NY_H	27.8	52.7	76.2	99.5
	NY_J	26.6	52.8	74.3	97.4
	NY_K	24.9	48.0	68.2	86.0
4	NY_C	35.9	73.6	107.5	145.2
	NY_F	35.9	73.8	107.8	145.9
	NY_G	36.7	76.6	111.4	150.8
	NY_H	40.3	80.6	118.9	159.2
	NY_J	39.5	79.3	116.1	155.1
	NY_K	36.1	70.3	102.4	134.3
6	NY_C	36.7	75.4	109.9	148.6
	NY_F	36.7	75.6	110.3	149.3
	NY_G	39.5	80.3	117.0	157.5
	NY_H	42.6	84.8	125.2	167.4
	NY_J	44.6	89.4	131.6	175.1
	NY_K	46.0	92.1	137.0	182.2
8	NY_C	47.3	97.1	146.5	194.4
	NY_F	47.3	97.2	146.5	194.4
	NY_G	47.9	97.7	146.8	195.6
	NY_H	48.6	98.0	147.2	196.3
	NY_J	48.5	97.9	146.8	195.4
	NY_K	49.1	98.6	148.3	197.7

Large Hydro – Capacity value (%) with ELCC and MRI techniques



Large Hydro– Capacity value (MW) with MRI techniques

	Nameplate capacity (MW)			
Type	50	100	150	200
Dynamic large hydro	46.6	94.0	145.0	194.0
Shape large hydro	39.7	84.6	129.8	185.7

Observations

Final observations

These results complement the initial subset of results presented at the 04/28/22 ICAPWG. Analysis is ongoing for additional resource types

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)

Additional analysis in underway to better understand differences in results across different locations

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

5/24/2022

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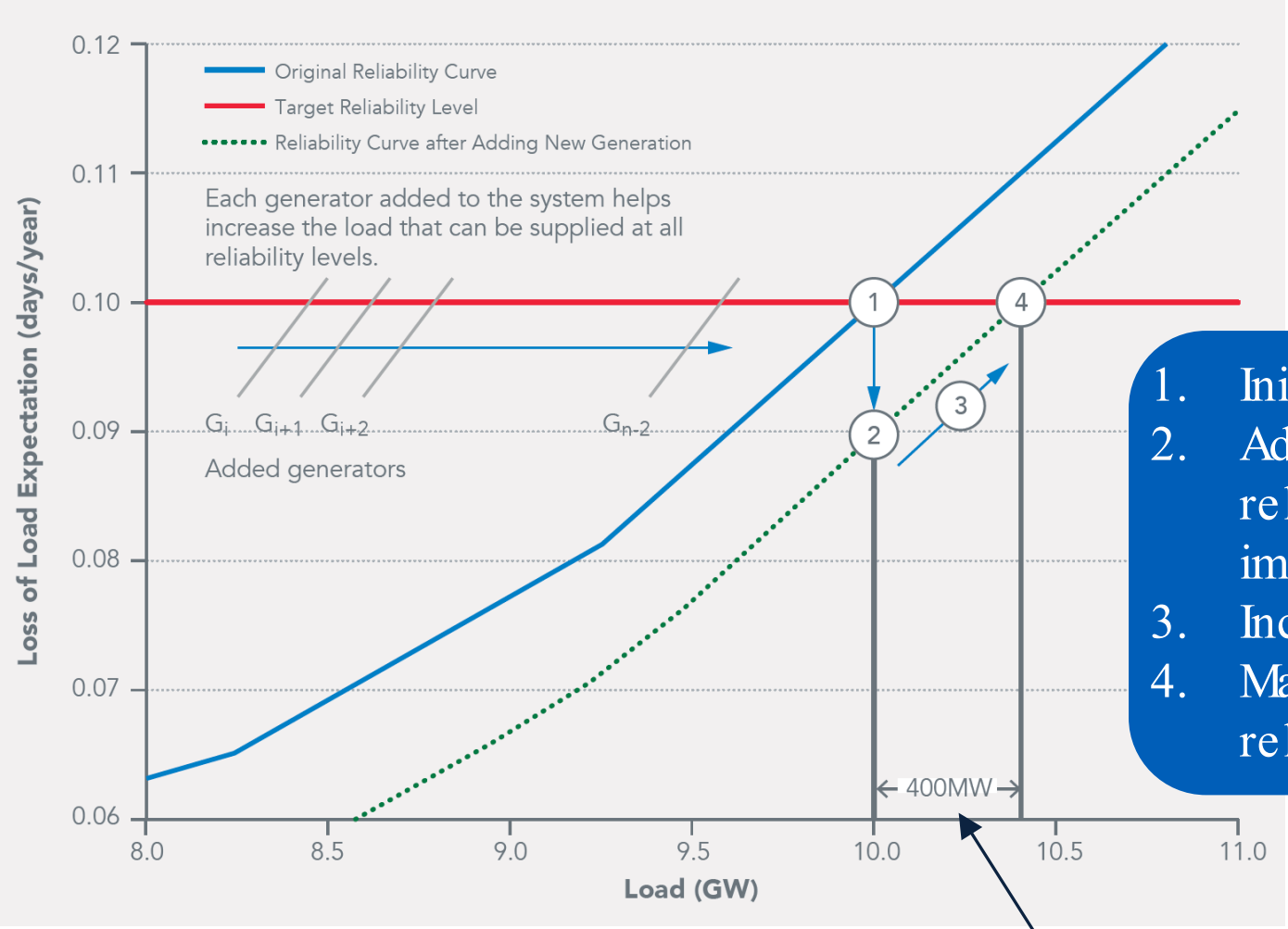
In this document, we sometimes use information derived from consolidated financial data but not presented in our financial statements prepared in accordance with U.S. generally accepted accounting principles (GAAP). Certain of these data are considered "non-GAAP financial measures" under the U.S. Securities 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