6/28/2022

Support for NYISO Capacity Accreditation Project

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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:

- Revised results for some shape-based resources
- Description of GE MARS models used for ELR resources

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

Revised results for shape-based resources

Resource types affected

Cases for onshore wind, biomass and run-of-river hydro have been rerun.

The initial cases only used one (instead of five) years of hourly data. They now better align with the representation of existing resource in the IRM/LCR databases.

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

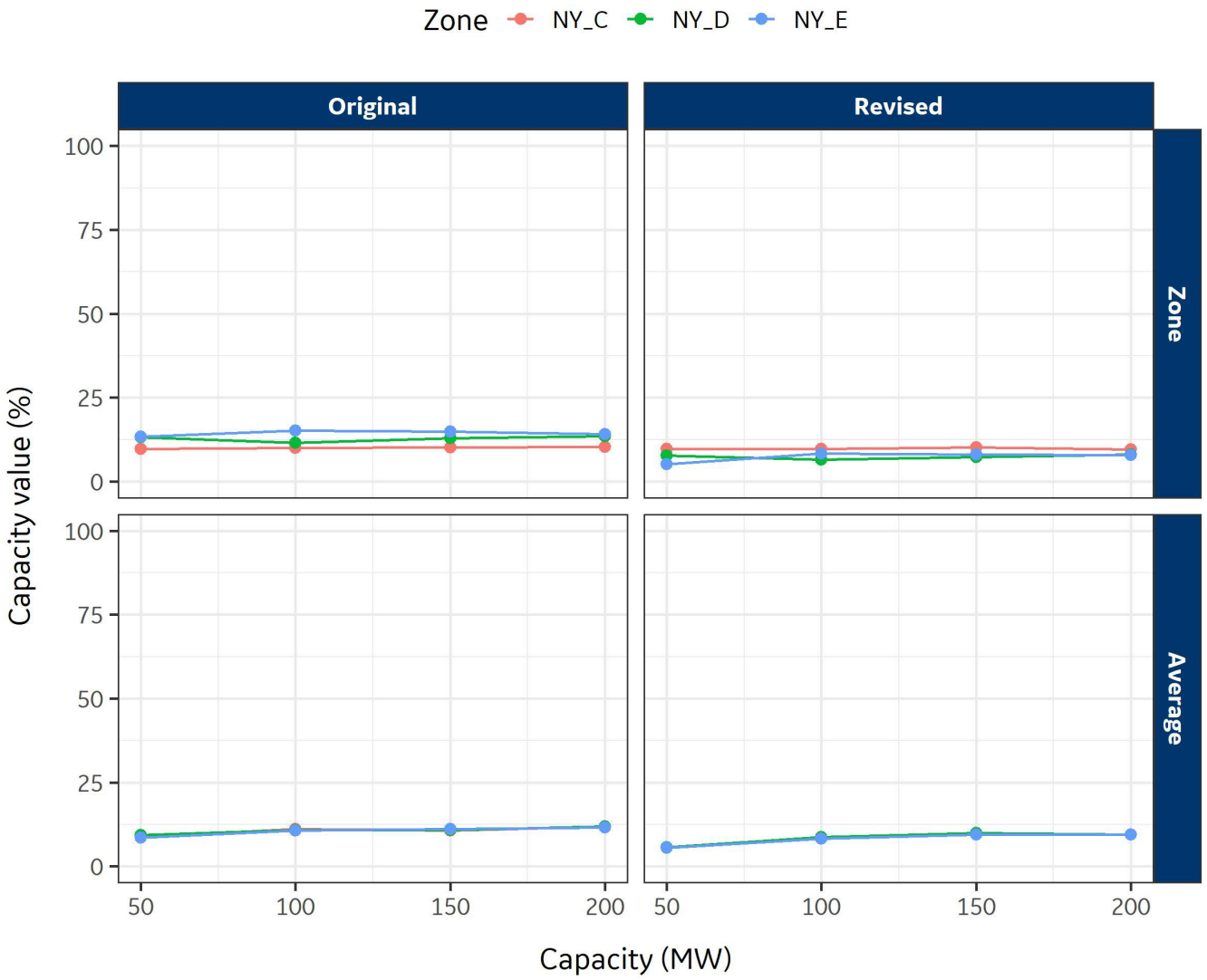
Onshore wind units

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:

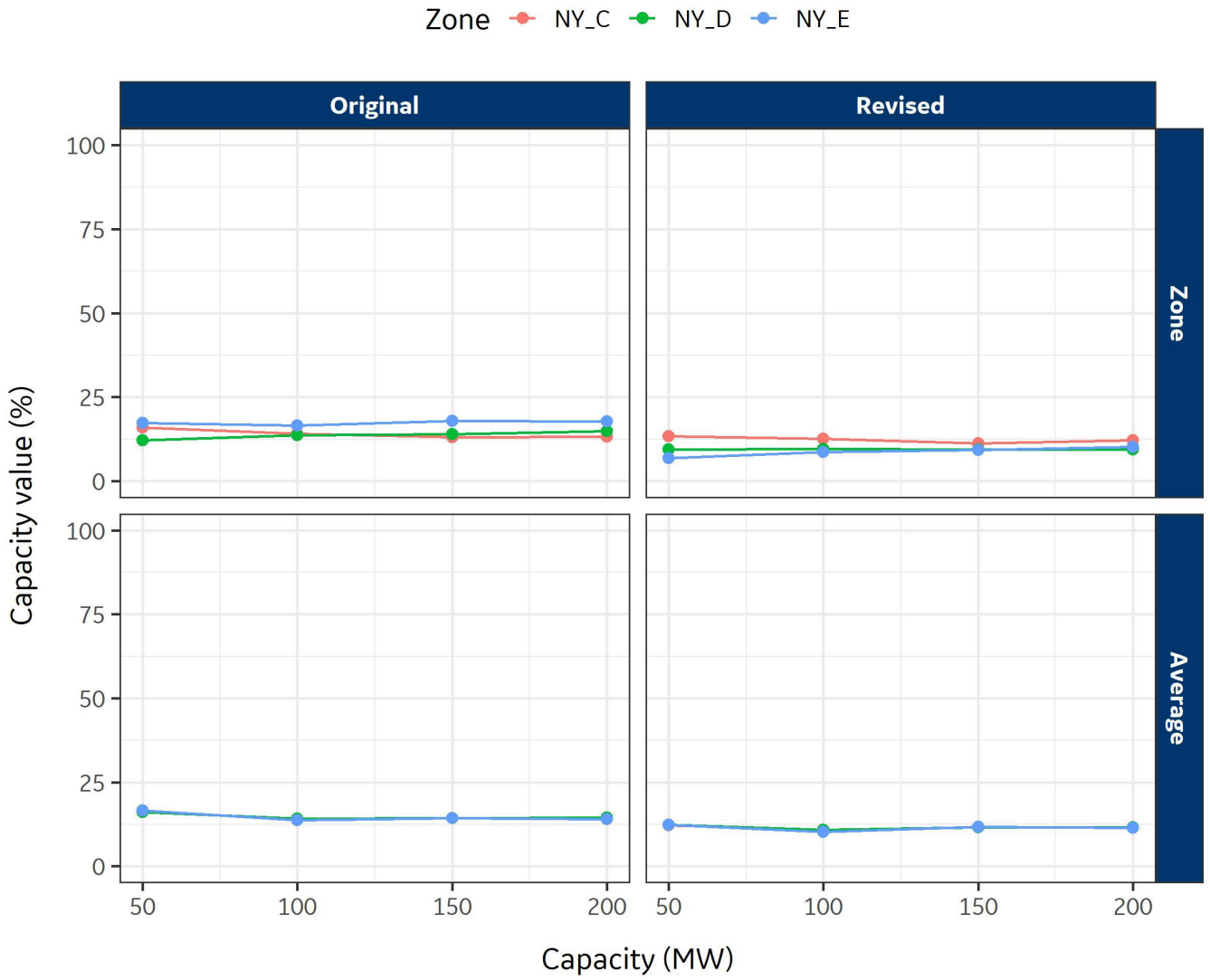
- A representative unit that uses the shapes in a particular NYISO zone ("Zone" case)
- A representative unit that uses the average shape across the NYISO footprint ("Average" case)

Onshore wind - ELCC capacity values (MW and %)



		Nameplate capacity (MW)							
		Original				Revised			
Shape	Zone	50	100	150	200	50	100	150	200
Zone	NY_C	4.9	10.1	15.3	20.8	4.9	9.8	15.2	19.1
	NY_D	6.6	11.5	19.3	27.0	3.9	6.6	10.9	16.2
	NY_E	6.7	15.2	22.3	28.2	2.6	8.4	12.1	15.9
Average	NY_C	4.4	11.1	16.1	23.7	2.8	8.7	14.8	19.0
	NY_D	4.7	10.9	16.2	23.7	2.8	8.7	14.9	18.9
	NY_E	4.3	10.7	16.8	23.2	2.8	8.3	14.1	19.0

Onshore wind - MRI capacity values (MW and %)



		Nameplate capacity (MW)							
		Original				Revised			
Shape	Zone	50	100	150	200	50	100	150	200
Zone	NY_C	8.0	14.2	19.7	26.5	6.7	12.6	16.8	24.4
	NY_D	6.1	13.8	21.0	29.8	4.7	9.6	14.3	18.9
	NY_E	8.7	16.6	26.9	35.6	3.4	8.7	13.9	20.3
Average	NY_C	8.1	14.2	21.5	29.1	6.1	10.8	17.3	23.2
	NY_D	8.0	14.1	21.4	29.0	6.2	10.8	17.4	23.3
	NY_E	8.3	13.7	21.6	28.1	6.2	10.2	17.5	22.8

Landfill biomass units

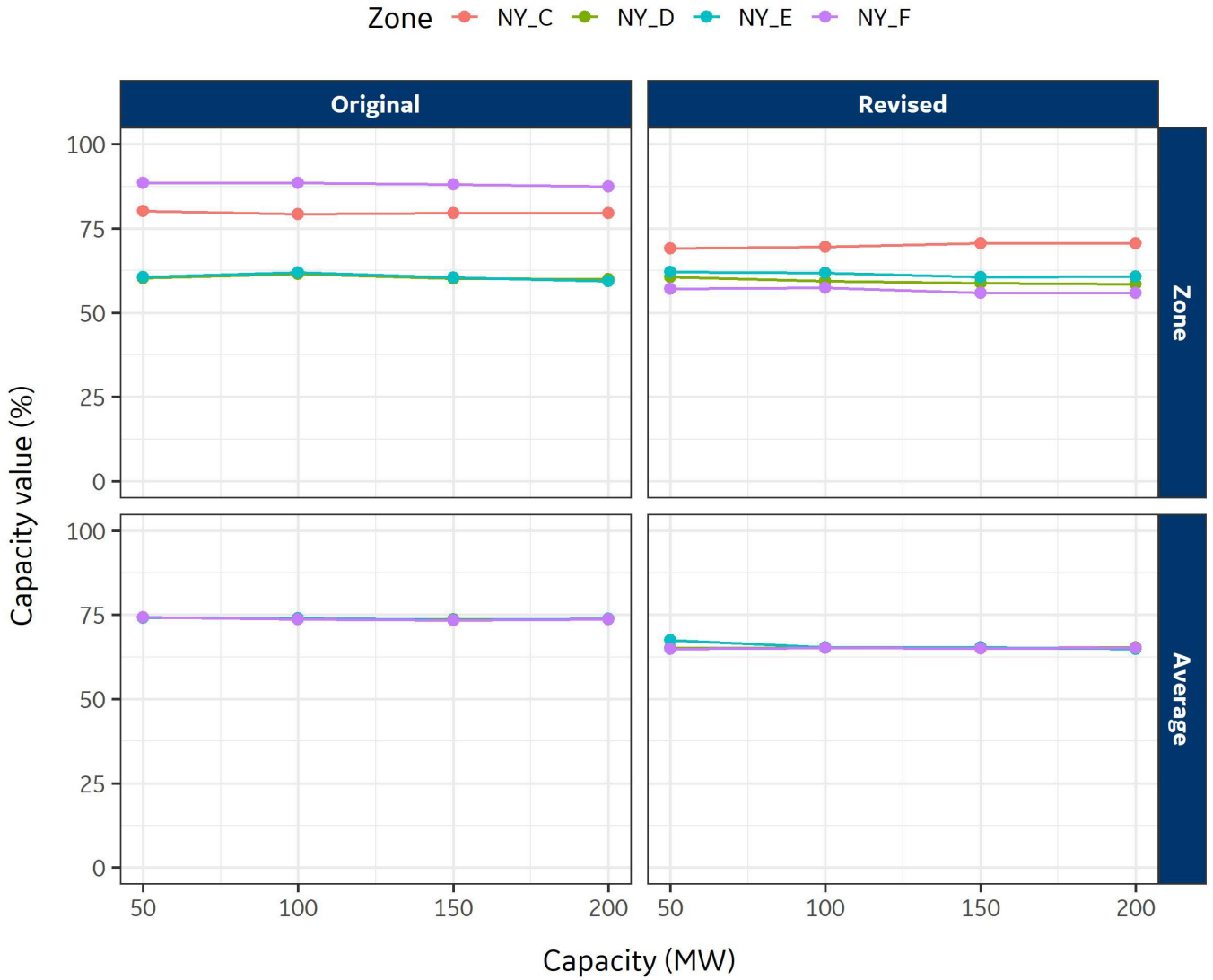
Next, we measured the capacity value of landfill biomass units.

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:

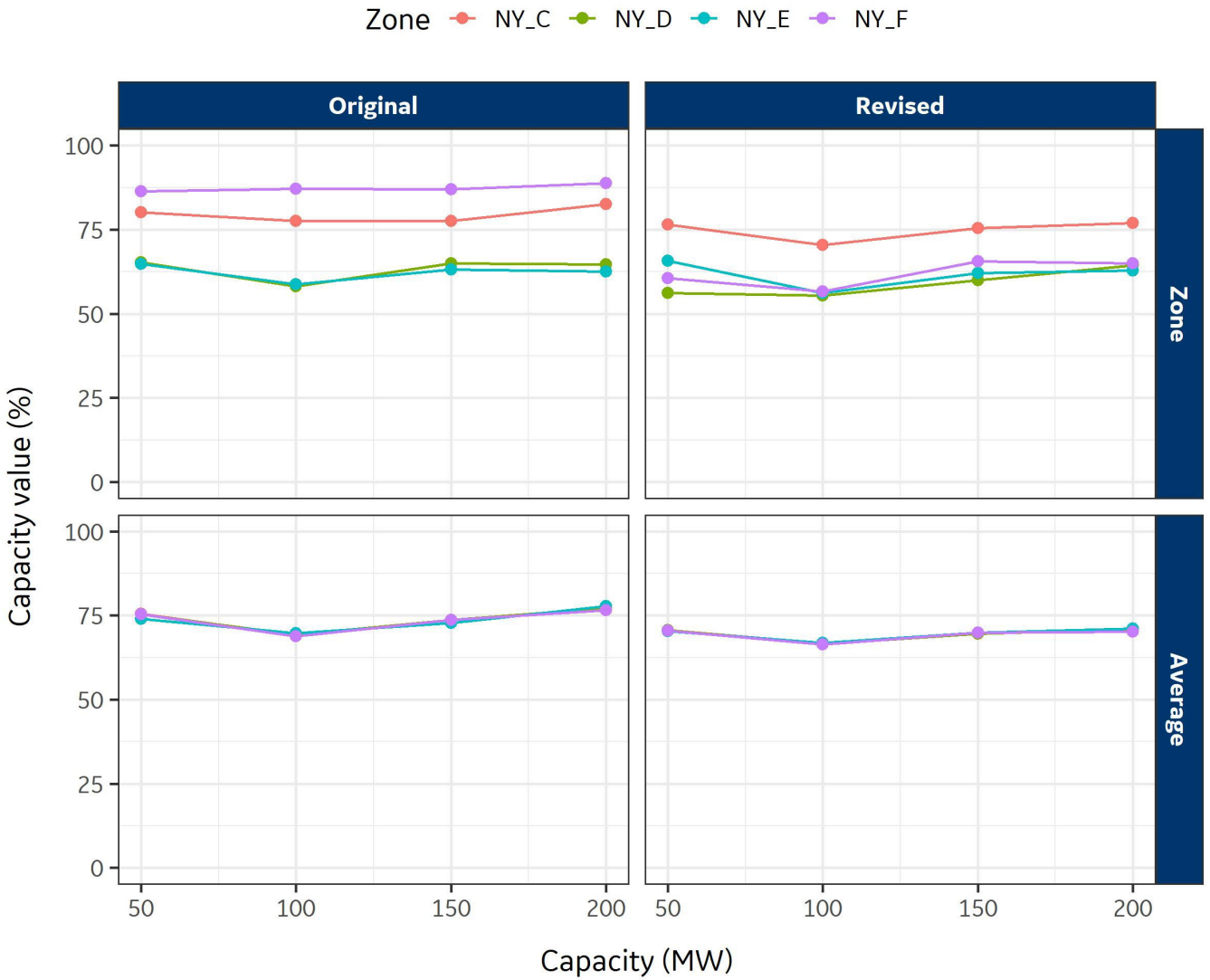
- A representative unit that uses the shapes in a particular NYISO zone ("Zone" case)
- A representative unit that uses the average shape across the NYISO footprint ("Average" case)

Landfill biomass - ELCC capacity values (MW and %)



		Nameplate capacity (MW)							
		Original				Revised			
Shape	Zone	50	100	150	200	50	100	150	200
Zone	NY_C	40.1	79.3	119.4	159.1	34.6	69.5	105.9	141.1
	NY_D	30.2	61.4	90.2	119.9	30.3	59.4	88.2	117.0
	NY_E	30.3	62.0	90.6	118.9	31.1	61.8	90.8	121.5
	NY_F	44.2	88.5	132.1	174.9	28.6	57.4	83.8	111.9
Average	NY_C	37.1	73.7	110.0	147.4	32.5	65.3	97.7	130.5
	NY_D	37.1	73.7	110.5	147.5	32.6	65.2	97.6	130.6
	NY_E	37.0	74.0	110.2	147.5	33.7	65.3	97.9	129.8
	NY_F	37.2	73.7	110.0	147.4	32.5	65.2	97.6	130.5

Landfill biomass - MRI capacity values (MW and %)



		Nameplate capacity (MW)							
		Original				Revised			
Shape	Zone	50	100	150	200	50	100	150	200
Zone	NY_C	40.1	77.6	116.3	165.2	38.3	70.4	113.1	153.9
	NY_D	32.7	58.1	97.5	129.5	28.1	55.4	89.9	128.8
	NY_E	32.4	58.8	94.6	125.2	32.9	56.2	93.1	125.9
	NY_F	43.2	87.2	130.5	177.8	30.3	56.7	98.4	130.1
Average	NY_C	37.7	69.1	110.4	154.3	35.3	66.7	104.3	141.9
	NY_D	37.7	69.2	110.4	154.4	35.3	66.6	104.3	141.8
	NY_E	37.0	69.8	109.2	155.5	35.1	66.8	104.7	142.2
	NY_F	37.7	68.8	110.5	153.2	35.3	66.4	104.7	140.4

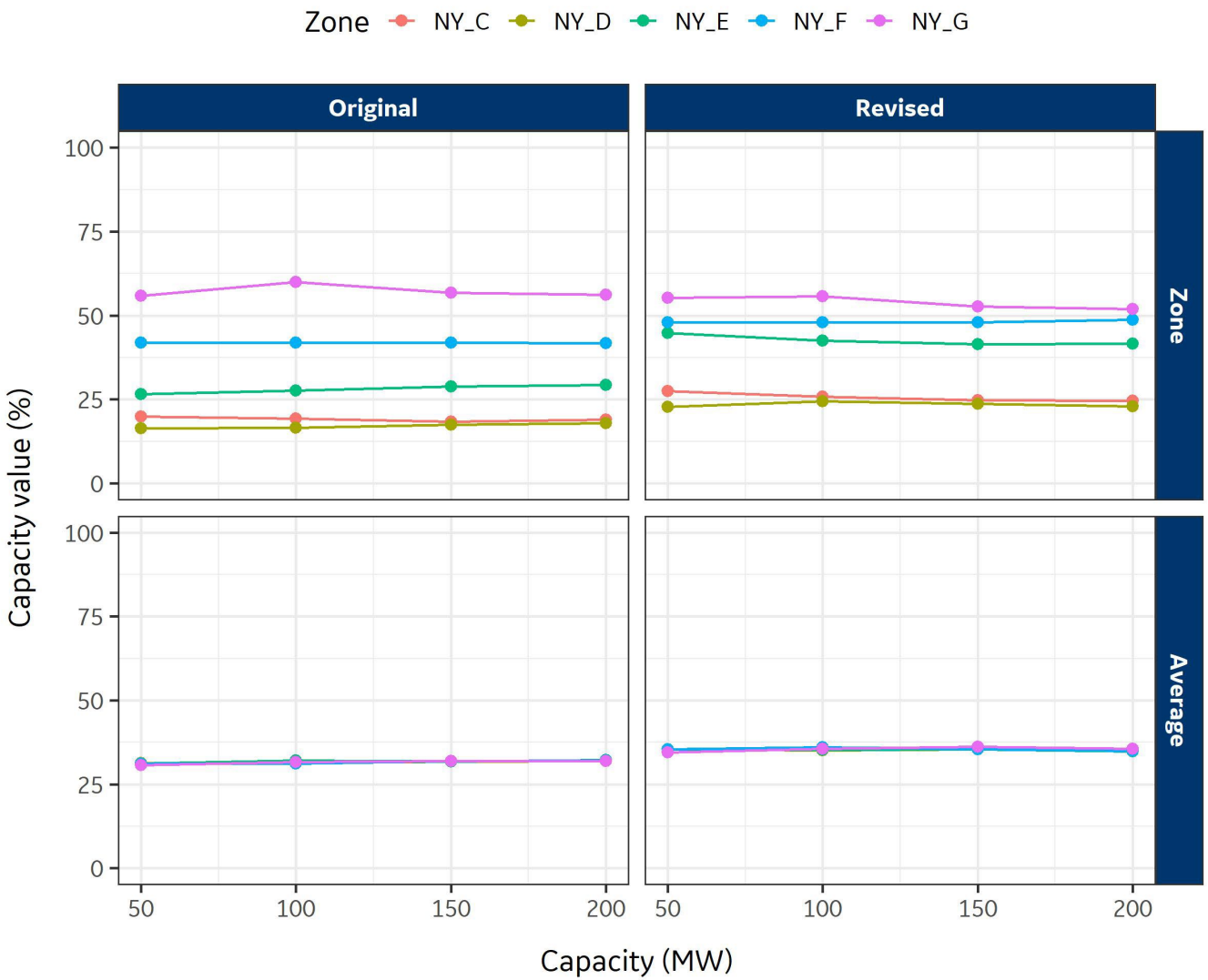
Run-of-river units

Like the previous types, 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:

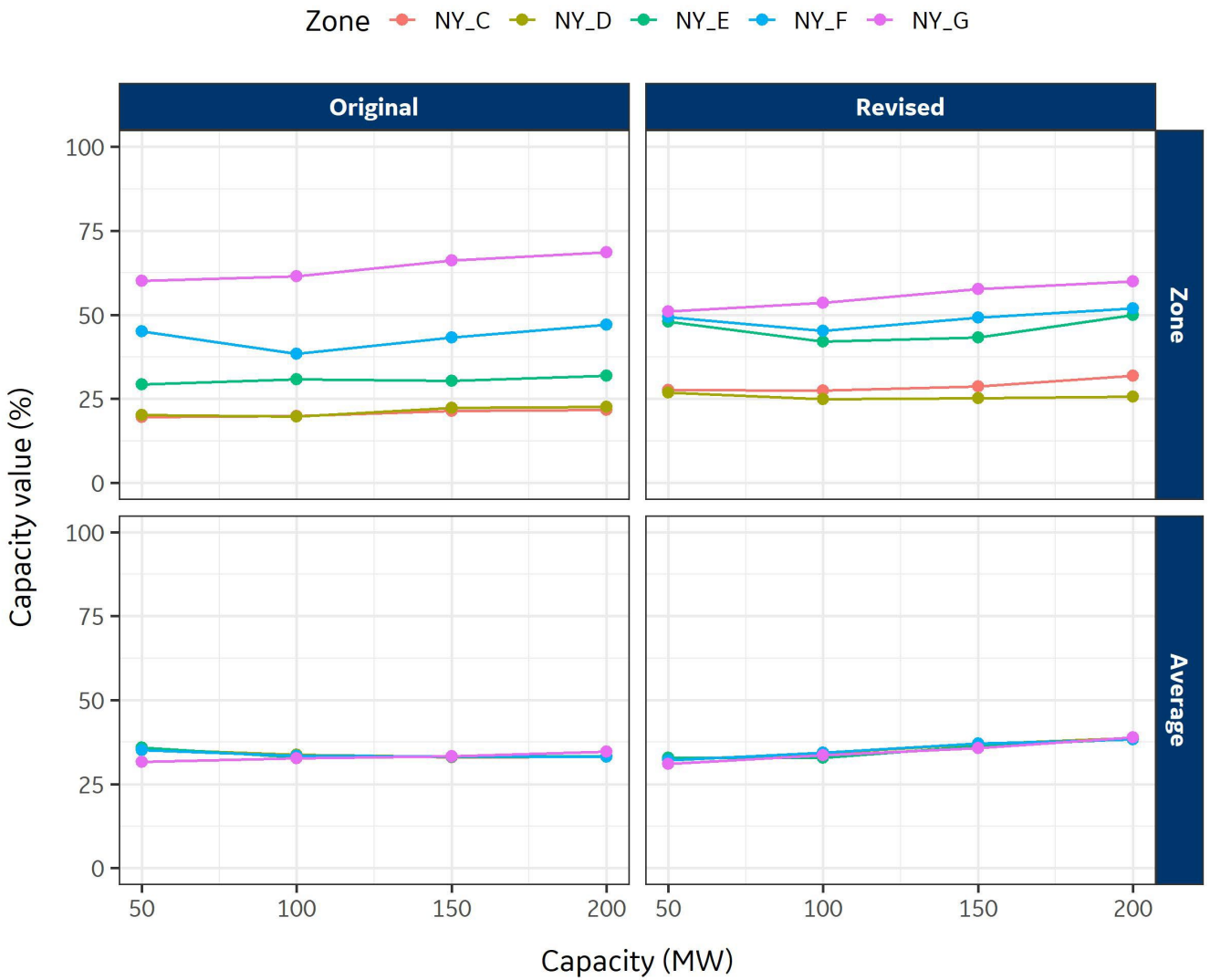
- A representative unit that uses the shapes in a particular NYISO zone ("Zone" case)
- A representative unit that uses the average shape across the NYISO footprint ("Average" case)

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



		Nameplate capacity (MW)							
		Original				Revised			
Shape	Zone	50	100	150	200	50	100	150	200
Zone	NY_C	9.9	19.3	27.6	37.9	13.8	25.9	37.2	49.2
	NY_D	8.2	16.6	26.2	35.8	11.4	24.5	35.6	46.0
	NY_E	13.3	27.7	43.2	58.6	22.4	42.5	62.2	83.2
	NY_F	20.9	41.9	62.9	83.6	24.0	48.1	72.0	97.5
	NY_G	28.0	60.0	85.2	112.5	27.7	55.8	79.1	104.0
Average	NY_C	15.6	31.3	47.7	64.5	17.7	35.2	53.2	69.9
	NY_D	15.6	31.4	47.7	64.0	17.7	35.2	53.1	70.0
	NY_E	15.6	32.0	47.6	64.3	17.7	35.3	53.1	69.6
	NY_F	15.6	31.2	47.8	64.2	17.7	36.0	53.1	69.9
	NY_G	15.4	31.7	47.9	64.0	17.3	35.6	54.4	71.2

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



		Nameplate capacity (MW)							
		Original				Revised			
Shape	Zone	50	100	150	200	50	100	150	200
Zone	NY_C	9.8	19.9	32.2	43.6	13.8	27.5	43.1	63.9
	NY_D	10.1	19.8	33.5	45.3	13.5	24.9	37.9	51.2
	NY_E	14.7	30.9	45.5	63.9	24.0	42.1	64.9	100.1
	NY_F	22.5	38.4	65.0	94.1	24.7	45.3	73.9	103.8
	NY_G	30.1	61.5	99.4	137.2	25.5	53.6	86.6	120.0
Average	NY_C	17.7	33.8	49.5	66.4	16.1	34.2	55.4	77.5
	NY_D	17.7	33.7	49.6	66.4	16.1	34.3	55.5	77.6
	NY_E	18.0	33.0	49.8	66.6	16.4	32.8	54.5	76.9
	NY_F	17.6	33.5	49.9	66.4	16.0	34.3	55.6	76.5
	NY_G	15.8	32.8	49.9	69.4	15.5	33.5	53.6	77.7

Summary – Revised shape-based results

Changes in results are marginal:

- Slightly lower capacity values for onshore wind
- Less variability for landfill units when using different shape, slightly lower capacity for average shape cases
- Slightly higher capacity values for most run-of-river cases

Modeling of ELRs with newer GE MARS capabilities

Modeling for cases presented last month

Two modeling techniques were used for Energy Duration Limited and Large Hydro units to create the results presented at the 05/24/22 ICAPWG.

"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

Overview of updated MARS unit types

The NYISO representation of ELRs uses two MARS unit types:

- Energy limited type 3 (EL3)
- Energy storage (ES)

Both models share significant portions of the modeling, but capture different unit types

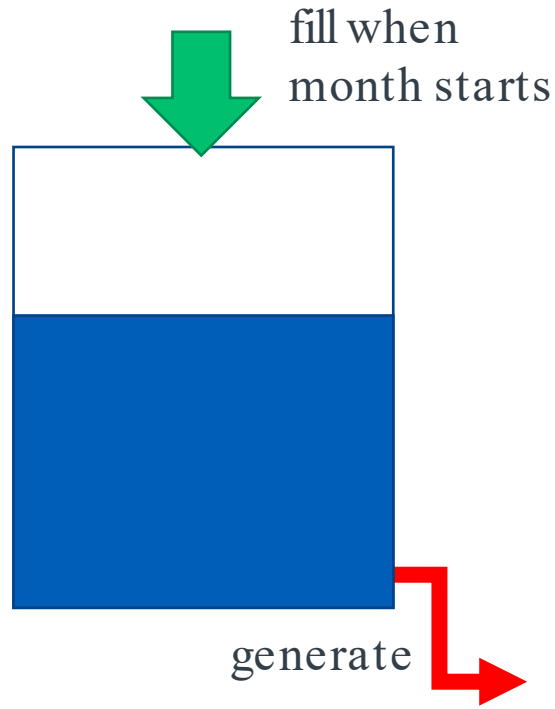
Unlike other unit types in MARS, the availability of EL3 and ES units is decided on an "as needed" basis; the units respond to the system conditions of each replication

The following slides summarize their implementation

Energy-limited type 3 (EL3) model

Used to represent units that have:

- Energy budget (MWh) to be used in a month
- Maximum generation output (MW)
- Optionally, minimum generation (MW), *e.g., run of river output*
- Optionally, ability to transfer unused energy from one month to another



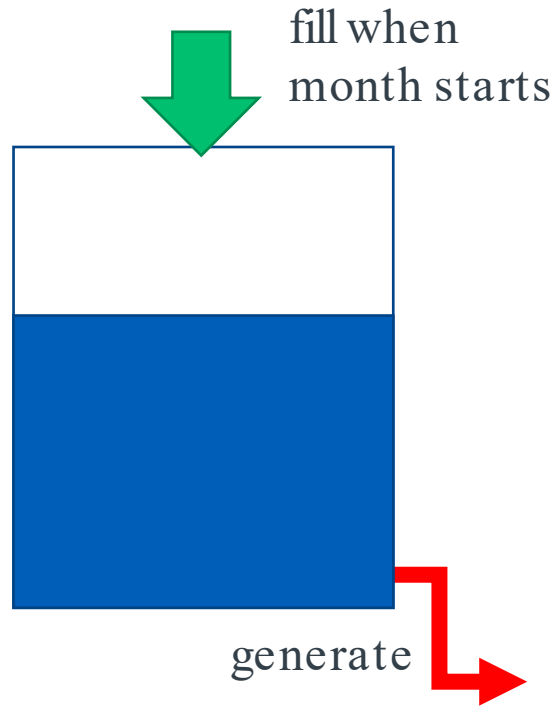
Think of a storage tank that you fill at the beginning of the month and you use when you need it

Energy-limited type 3 (EL3) model – additional constraints

Additional constraints may include

- Limit hours/days per year
- Limit hours/days per month
- Limit hours/energy per day

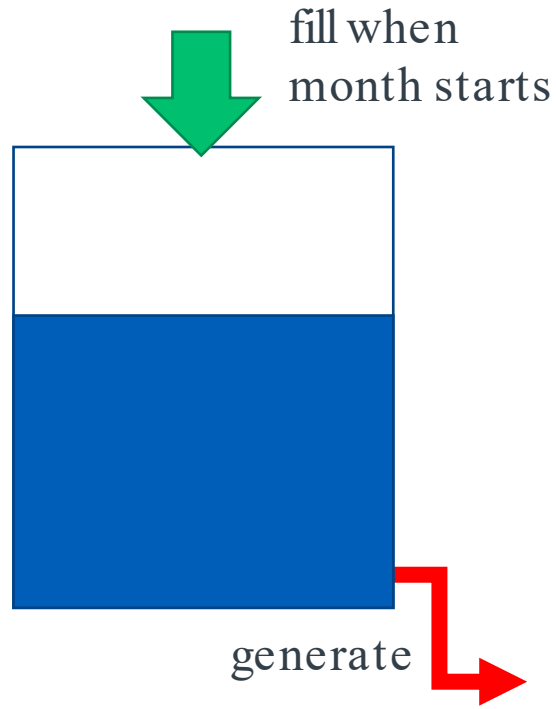
These are optional but can be used to capture specific operational constraints or contract restrictions



Think of a storage tank that you fill at the beginning of the month and you use when you need it

Energy-limited type 3 (EL3) model – when is it called?

- MARS first considers the balance of capacity/load
- Area and pool exchanges are considered
- If there is a shortage, the EL3 unit will attempt to dispatch:
  - Subject to limits of available capacity/energy
  - Subject to limits of use
  - Subject to transmission limits

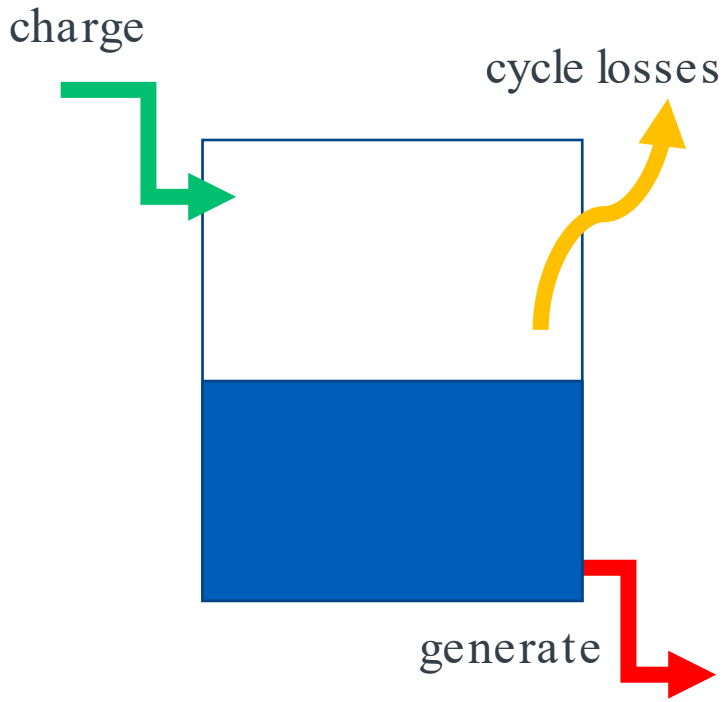


Think of a storage tank that you fill at the beginning of the month and you use when you need it

Energy storage (ES) model

Used to represent units that have:

- Capacity storage (MWh)
- Maximum generation output (MW)
- Ability to refill the storage (MW) when not generating
- Optionally, round-trip efficiency (%) to represent losses in the charge/generate cycle



Think of a storage tank that you fill at the beginning of the month and you use when you need it

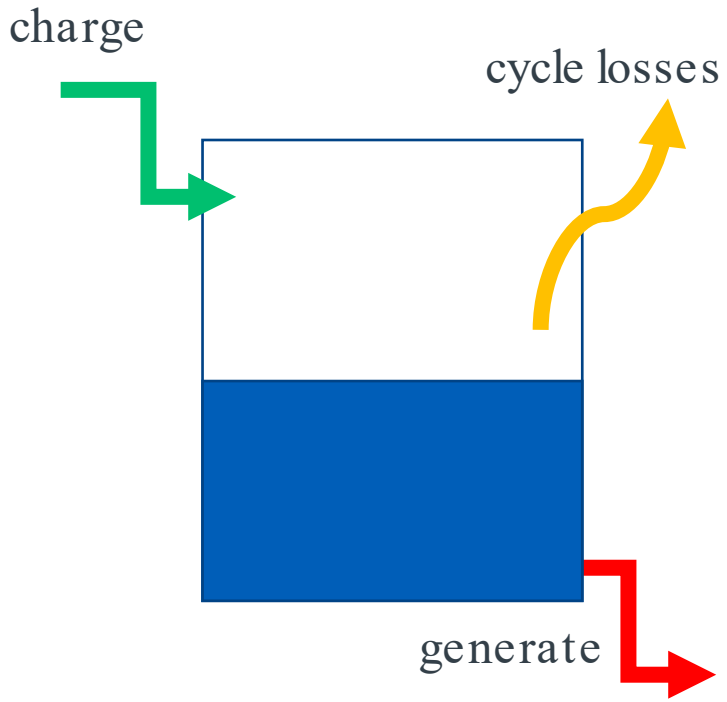
Energy storage (ES) model – when is it called?

Same time that EL3 units are considered, limited to:

- Capacity and energy balance
- Transmission constraints
- Usage limits (if defined)

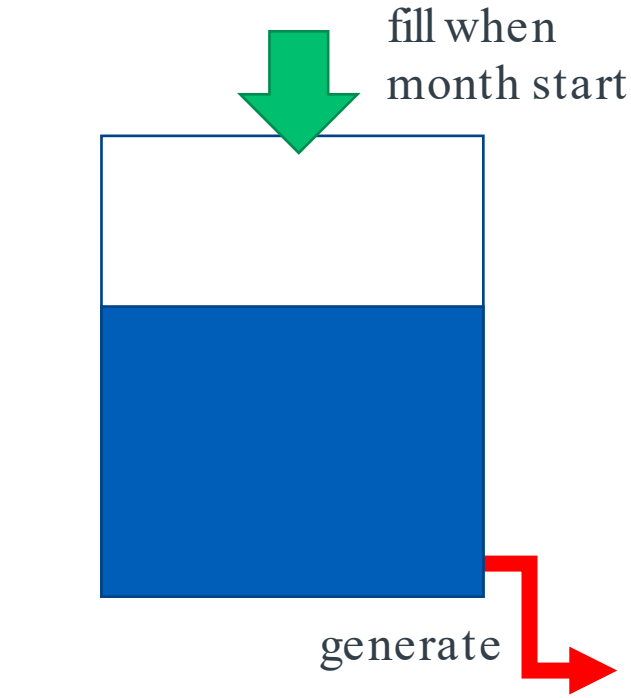
If not used for an hour and there is available excess capacity, it will attempt to charge

- Limited to charging capacity, transmission
- Charge from excess capacity
- Don't use EOP or reserves



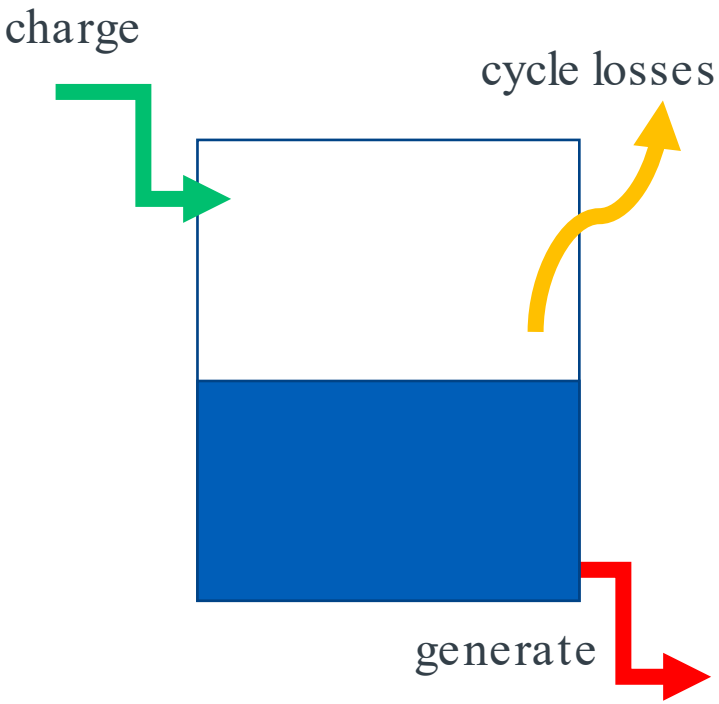
Think of a storage tank that you fill at the beginning of the month and you use when you need it

EL3 vs. ES: possible usage to model ELRs



Hydro without pumping

Demand response contracts



Pumped hydro storage

Battery

NYISO implementation

Last year, NYISO and GE studied how to best deploy EL3 and ES units in the IRM/LCR databases

This included the examination of different parameters, summarized in the white paper:
https://nysrc.org/PDF/Reports/IRM%20White%20Papers/ELR%20Modeling%20White%20Paper%20May%202021%20FINAL.pdf

The contribution of these unit to reliability was largest when:

- The units are deployed before EOPs and external assistance is considered in the model
- When we set a "generation window" that starts at 1pm

5/24/2022

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CAUTION CONCERNING FORWARD-LOOKING STATEMENTS:

This document contains "forward-looking statements" – that is, statements related to future events that by their nature address matters that are, to different degrees, uncertain. For details on the uncertainties that may cause our actual future results to be materially different than those expressed in our forward-looking statements, see http://www.ge.com/investor-relations/disclaimer-caution-concerning-forward looking-statements as well as our annual reports on Form 10-K and quarterly reports on Form 10-Q. We do not undertake to update our forward-looking statements. This document also includes certain forward-looking projected financial information that is based on current estimates and forecasts. Actual results could differ materially. to total risk-weighted assets.]

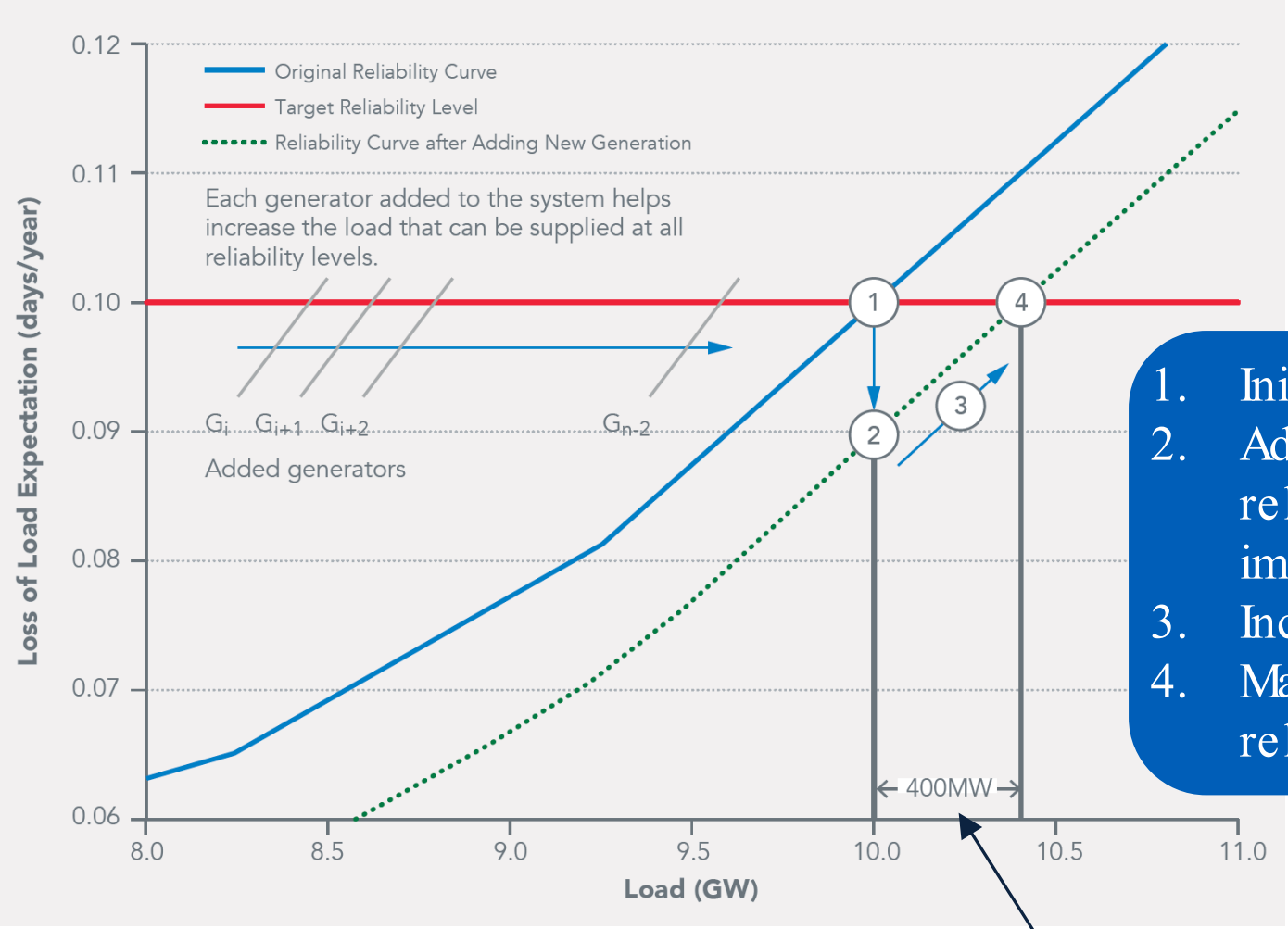
NON-GAAP FINANCIAL MEASURES:

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