Alternative ELR Capacity Value Study: Methodology and Updated Results

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Overview of Presentation

- Background
- Discussion and comparison of the NYISO and MMU approaches for estimating ELRs' capacity value
  - ✓ Includes a summary of updates since our January 24 presentation
- Detailed description of the MMU approach, which was developed to address concerns with the NYISO study, including:
  - ✓ Overview of MARS Emergency Operating Procedures
  - ✓ Deployment strategies evaluated for ELRs
  - ✓ Examples of deployment strategies for ELRs
- Results from the MMU study
- Conclusions
- Appendix

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Background

- There has been much discussion on the approach employed within the NYISO's capacity study.
- We have employed an alternate approach to inform:
  - ✓ The discussion of the methodology used in the NYISO study;
  - ✓ The NYISO ELR proposal; and
  - ✓ Modeling improvements that GE might be considering for future MARS updates.
- Ultimately, the goal should be to establish a capacity value for ELRs that reflects their true value in maintaining reliability.
- Under both approaches, this value is estimated by comparing how ELRs affect the Loss of Load Expectation ("LOLE") versus conventional resources when random system contingencies occur.

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Comparison of the Approaches for Estimating ELR Capacity Value

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Planning Models and Reliability

- Resource adequacy planning models evaluate reliability needs by:
  - ✓ Identifying thousands of random contingencies (in a Monte Carlo simulation);
  - ✓ Simulating the system's response to each contingency scenario to determine whether load would be lost; and
  - ✓ Calculating the LOLE (the probability of shedding load) based on the results of these scenarios.
- NYISO uses GE-MARS for its planning studies.
  - ✓ MARS currently does not accurately represent scheduling of ELRs in the NYISO real-time market.
  - ✓ The NYISO Study approach (using MARS) and the MMU approach both address this shortcoming of MARs in different ways.
- This presentation discusses the differences in the approaches and the implications for the NYISO proposal.

NYISO's ELR Capacity Value Study

Since MARs could not be used to directly estimate the reliability value of the ELRs, a simplified approach is used for the NYISO study that raises the following concerns:

1) The NYISO's study uses a post-processing method that is different from the normal simulation process used in MARS.
   - ✓ It does not fully simulate the emergency operating procedures ("EOPs") taken in response to system contingencies, which affects the estimated capacity value of ELRs.
2) The NYISO's study treats ELRs as energy-only and deploys them in blocks for consecutive hours based on perfect foresight.
   - ✓ More realistic approaches would model ELRs without perfect foresight within an appropriate EOP step in MARS.
   - ✓ This is not possible in a post-processor.

NYISO’s ELR Capacity Value Study

3) The NYISO uses an add-and-remove methodology but does not necessarily add and remove capacity at the same locations.
   - ✓ Thus, conventional capacity may be removed at a location that is more or less valuable than the location of the ELRs being added.
   - ✓ Ideally, the value of ELRs should be benchmarked against conventional resources while controlling for locational effects.

4) The NYISO’s study does not quantify the *marginal* effects of additional ELR capacity in the various ELR penetration cases.
   - ✓ The NYISO methodology essentially quantifies the average effects of all ELRs in each penetration scenario.
   - ✓ This approach likely over-estimates the value of ELRs at high penetration levels.
   - ✓ An efficient market compensates sellers based on the marginal value of supply.

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Comparison of MMU & NYISO Study Approaches

- The MMU approach attempts to address these concerns by:
  - ✓ Replicating the MARS logic by utilizing the EOP steps in response to the contingencies;
  - ✓ Calculating the marginal value of a small amount of additional ELRs (100 MW) based on an assumed starting penetration of ELRs;
  - ✓ Controlling for the locational effects when adding ELRs and removing conventional resources;
  - ✓ Allowing ELRs to be utilized as 10-minute reserves, which better captures their value than modeling them only as blocks of energy.
- This approach leads to results that are a reasonable approximation of the results MARs would produce.

Comparison of MMU & NYISO Study Approaches:
Summary of Updates Since January 24 Presentation

- Concern #1: It is unrealistic to assume 100 percent of the 10-minute reserve requirement can be satisfied by ELRs.
  - ✓ We imposed a limit (655 MW or 50 percent of 10-min requirement) on the amount of ELRs that can be deployed in EOP 10
- Concern #2: It is unrealistic to assume *any* of the 10-minute reserve requirement can be satisfied by ELRs.
  - ✓ We performed simulations assuming *all* ELRs are peak shaving.
    - – However, we interpret these as a worst-case scenario rather than an estimate.
- Concern #3: The allocation of peak shaving ELRs to specific hours should be rule-based.
  - ✓ Pre-existing ELRs spread across hours with most frequent load shedding on average.

Updated/New

Comparison of MMU & NYISO Study Approaches

- The table below provides a high-level summary of differences among the MMU's and NYISO's estimates of fractional capacity value and the NYISO's proposal.
  - ✓ See slides 32-35 for additional detail on the MMU's estimates.
  - ✓ NYISO values based on slide 117 of GE's October 9 presentation.
- ELRs' value under the MMU approach is:
  - ✓ Higher at low penetration levels; but
  - ✓ It drops more rapidly as penetration increases because the marginal value falls more quickly than the average value of ELRs.

	500 MW Penetration		2 GW Penetration		NYISO
	MMU	NYISO	MMU	NYISO	Proposal
4-Hr ELRs	95-96%	77%	76-78%	68%	75%
2-Hr ELRs	66-68%	61%	38-41%	52%	37.5%

MMU's Approach to Estimating Capacity Value

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MMU's Approach to Estimating Capacity Value

- The MMU developed an alternative approach that is:
  - ✓ Consistent with the logic used by MARS in the EOP steps;
  - ✓ Consistent with scheduling in a market with co-optimization of energy and ancillary services; and
  - ✓ Easier to control—ELRs are benchmarked against conventional resources at the same location as follows:
    - Add X MW of studied resource to a base case, measuring the change in LOLE from the base case as A;
    - Then add X MW of a conventional benchmark resource to the base case, measuring the change in LOLE from the base case as B;
    - Then calculate capacity value as the ratio A:B.
- This approach is described in more detail on the next slides.

MMU's Approach to Estimating Capacity Value

- The MMU approach involves the following steps for each scenario:
  - ✓ Step 1: choose an approved GE-MARS study case as the Base Case
  - ✓ Step 2: modify treatment of existing SCRs to reflect duration limits
    - – MARS assumes a ~70 percent Performance Factor
    - – MARS assumes a maximum of five deployments per month
    - – The MMU approach also accounts for 4-hour duration limit, assuming partial curtailment in other hours based on historic data
  - ✓ Step 3: add ELRs to reflect penetration level of the scenario
    - – Ex: in a 1 GW penetration scenario, we add 900 MW of ELRs in this step, so we can measure the *incremental* value of 100 MW
  - ✓ Step 4: remove perfect capacity to return LOLE to 0.1 days/year
    - – Capacity is removed from each zone in proportion to existing UCAP

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MMU's Approach to Estimating Capacity Value

(continued)

- ✓ Step 5: add X MW of ELRs (with EFORd = 0) to the case and measure change in LOLE.
- ✓ Step 6: add X MW of conventional 24-hour resource (at the same location and EFORd) to the case after Step 4 and measure change in LOLE.
- ✓ Step 7: calculate ELR's capacity value as:

  (LOLE_BASE – LOLE_ELR(X))÷(LOLE_BASE – LOLE_CONV(X))

  For example:

  If LOLE_BASE = 0.100, LOLE_ELR(100MW) = 0.097, LOLE_CONV(100MW) = 0.096

  Then ELR_CapValue = (0.100 – 0.097) ÷ (0.100 – 0.096) = 75%

  (Appendix A shows an alternative logarithmic formula that provides similar results)

Simulating MARS EOPs in the MMU Study

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Simulating MARS EOPs in the MMU Study

- The tool uses pre-EOP stage results from a GE-MARS case, which:
  - ✓ Uses the same network topology and transfer limits.
- Then, consistent with GE-MARS, it simulates each of following EOP steps sequentially:
  - ✓ EOP 1 – Allocation of capacity for system operating reserves
  - ✓ EOP 2-4 – Deployment of SCR load, SCR gen, and EDRP
  - ✓ EOP 5 – Reduction of voltage for reduced load
  - ✓ EOP 6 – Deployment of 30-minute reserves
  - ✓ EOP 7-9 – Additional voltage reduction for load, voltage-related load curtailment, and public appeals for load reduction
  - ✓ Pool-to-Pool Assistance – Pools with surplus capacity to assist pools with deficiency

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Simulating MARS EOPs in the MMU Study

- EOP 10 – Deployment of 10-minute reserves
- EOP 11 – Small adjustments for LCR settings.

- EOPs 1-9 are NYCA-only self-assistance steps.
  - EOP assistances are deployed only for areas within NYCA.
  - Wheeling-through outside pools is not allowed.
- The “Pool-to-Pool Assistance” has 11 assisting steps defined by a priority list.
- EOP 10 and 11 each have two separate steps:
  - Self Assistance – assisting NYCA areas without wheeling-through outside pools; then
  - System Rebalance – for any remaining areas with surplus capacity to assist other deficient areas (including all regions).

Simulating MARS EOPs in the MMU Study

- In each of these EOP steps (including Pool-to-Pool), reserve sharing is used to allocate available surplus capacity.
  - ✓ This is done in proportion to the deficiency of receiving areas.
  - ✓ Transmission limitations are respected.
    - – Constrained areas may have different reserve sharing ratios than un-constrained areas.
- The MMU's simulation tool has the capability of altering capacity margins in targeted areas in the pre-EOP stage.
  - ✓ This allows the MMU to estimate how capacity additions would affect LOLE in a manner that is more consistent with the logic of MARS.

Deployment Strategies Evaluated in MMU Study

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Deployment Strategies Evaluated in MMU Study

- ELRs should be modeled in a manner that:
  - ✓ Does not assume perfect foresight;
  - ✓ Is consistent with NERC and NPCC emergency operating criteria;
  - ✓ Is consistent with how resources would be scheduled in the NYISO's market that co-optimizes energy and ancillary services.
- The MMU study evaluated three deployment strategies:
  - ✓ EOP 10 Deployment – ELRs are scheduled for reserves to satisfy the 10-minute reserve requirement and not deployed until EOP 10.
  - ✓ EOP 6 Deployment – ELRs are scheduled for reserves to satisfy the 30-minute reserve requirement and not deployed until EOP 6.
  - ✓ Peak Shaving – ELRs offer as energy-only resource in peak hours (i.e., hours when load shedding is most frequent on average).

Deployment Strategies Evaluated in MMU Study: EOP 10 Deployment

- This models ELRs as 10-minute reserve providers and holds them in reserve until EOP 10.
  - ✓ Respects daily MWh-limitation and an hourly MW-limitation.
  - ✓ For each hour when ELR is still available, it is added in the pre-EOP stage and then allocated to provide 10-minute reserves.
  - ✓ If EOP 10 is reached, 10-minute reserves are deployed to eliminate NYCA and non-NYCA deficiencies.
    - – Conventional resources are deployed before ELRs;
    - – ELRs are deployed in order based on remaining charge (e.g., units with 4 hours left are deployed before units with 3 hours left);
    - – During non-loss-of-load hours, this may reduce the energy available in subsequent hours.
- This approach is illustrated on slide 27.

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Deployment Strategies Evaluated in MMU Study: EOP 6 Deployment

- This models ELRs as operating reserve providers and holds them in reserve until EOP 6.
- This deployment strategy works in a manner very similar to the EOP 10 strategy.
  - ✓ However, if EOP 6 is reached, a portion of operating reserves are deployed to eliminate NYCA deficiencies.
  - ✓ During non-loss-of-load hours, this may reduce the energy available in subsequent hours.
- This approach is illustrated on slide 26.

Updated/New

Deployment Strategies Evaluated in MMU Study: Peak Shaving

- This models ELRs as energy-only resources that generate during the hours when load shedding is most frequent on average.
  - ✓ This is not necessarily the tightest hours on any particular day.
  - ✓ Under low-penetration levels:
    - – 4-hour resources generate in the top four hours of the day.
    - – 2-hour resources generate in the top two hours of the day.
  - ✓ Under some high-penetration levels, the generation from 2-hour resources is spread across more than two hours based on the average needs.
  - ✓ For each hour when an ELR generates, it is added in the pre-EOP stage.
- This approach is illustrated on slide 27.

Examples of ELR Deployment in MMU Study

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Examples of ELR Deployment in MMU Study

- The following four tables illustrate how the MMU study simulates the MARS EOPs and deployment of ELRs.
  - ✓ Each table shows the NYCA margin after selected EOP steps in each hour from HB12 to HB19 on a particular afternoon.
  - ✓ The first table shows area margins before ELRs are added.
  - ✓ The other three tables show area margins after the addition of 100 MW of 4-hour ELRs using three different deployment strategies.
- This example shows three hours of load-shedding before ELRs are added, while the deployment of ELRs:
  - ✓ In EOP 6 eliminates load-shedding in 1 of 3 hours,
  - ✓ As peak shaving (for the four most-common load-shedding hours) eliminates load-shedding in all 3 hours, and
  - ✓ In EOP 10 eliminates load-shedding in all 3 hours.

Examples of ELR Deployment in MMU Study
No ELR Case & EOP 6 Deployment Case

	Hour	NYCA Margin After EOP Steps (Excluding Zone A)					ELR Deployed		Final Margin
		EOP 1	EOP 6	EOP 9	Pool-to-Pool	EOP 10	Hourly	Cumulative	
Base (No ELR)	**12**	-2689	-1076	-474	96	1296			1298
	13	-2972	-1359	-752	0	1200			1202
	14	-3766	-2152	-1537	0	1130			1132
	15	-4546	-2932	-2313	-1258	-58			-51
	16	-4524	-2910	-2291	-1265	-74			-69
	17	-4310	-2698	-2082	-1096	-101			-96
	18	-3705	-2095	-1489	-628	0			0
	19	-2763	-1155	-565	-12	0			0
ELR (EOP 6 Deployment)	**12**	-2589	-976	-374	96	1296	100	100	1298
	13	-2872	-1259	-652	0	1200	100	200	1202
	14	-3666	-2052	-1437	0	1200	100	300	1202
	15	-4446	-2832	-2213	-1186	0	100	400	0
	16	-4524	-2910	-2291	-1265	-74	0	400	-69
	17	-4310	-2698	-2082	-1096	-101	0	400	-96
	18	-3705	-2095	-1489	-628	0	0	400	0
	19	-2763	-1155	-565	-12	0	0	400	0

Note: Zone A is excluded here as it has surplus but is export constrained.

Examples of ELR Deployment in MMU Study

Peak Shaving Case & EOP 10 Deployment Case

	Hour	NYCA Margin After EOP Steps (Excluding Zone A)					ELR Deployed		Final Margin
		EOP 1	EOP 6	EOP 9	Pool-to-Pool	EOP 10	Hourly	Cumulative	
ELR	**12**	-2689	-1076	-474	96	1296			1298
(Peak Shave -	**13**	-2972	-1359	-752	0	1200			1202
Hour 15-18)	**14**	-3766	-2152	-1537	0	1130			1132
	15	-4446	-2832	-2213	-1186	0	100	100	0
	16	-4424	-2810	-2191	-1193	0	100	200	0
	17	-4210	-2598	-1982	-1027	0	100	300	0
	18	-3605	-1995	-1389	-568	0	100	400	0
	19	-2763	-1155	-565	-12	0			0
ELR	**12**	-2589	-976	-374	96	1296	0	0	1298
(EOP 10	**13**	-2872	-1259	-652	0	1200	0	0	1202
Deployment)	**14**	-3666	-2052	-1437	0	1200	0	0	1202
	15	-4446	-2832	-2213	-1186	0	100	100	0
	16	-4424	-2810	-2191	-1193	0	100	200	0
	17	-4210	-2598	-1982	-1027	0	100	300	0
	18	-3605	-1995	-1389	-568	0	100	400	0
	19	-2763	-1155	-565	-12	0	0	400	0

Note: Zone A is excluded here as it has surplus but is export constrained.

Simulation Results from MMU Study

Simulation Results:
Initial Scenarios Run to Assess Significance of Location

- Base case: A 2017 case at Criterion is the only case for which we have the necessary data.
- To assess the significance of location, we ran six low-penetration (100 MW) scenarios using the EOP 10 deployment strategy:
  - ✓ 4-hour ELR additions: (#1) Zone F, (#2) Zone J, (#3) Zone K
    - Fractional capacity value ranged from 97 to 98 percent
  - ✓ 2-hour ELR additions: (#4) Zone F, (#5) Zone J, (#6) Zone K
    - Fractional capacity value ranged from 59 percent in Zone K to 71 percent in Zone J
- Preliminary conclusion: fractional capacity value varies moderately by location, but other factors are more important.
- In subsequent runs, we carefully *controlled* for location, but we did not quantify the *effect* of location.

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Simulation Results:
Initial Scenarios Run to Assess Deployment Strategies

- The NYCA 10-minute reserve requirement in 1,310 MW.
  - ✓ This limits the amount of ELRs that can be deployed in EOP 10.
  - ✓ Additional ELRs must be deployed in EOP 6 or as peak shaving.
- To assess the performance of deploying ELRs in EOP 6, we ran two scenarios adding 100 MW to a base of 1,865 MW.
  - ✓ These showed extremely low (<25%) fractional capacity value because storage was usually depleted early in the day.
  - ✓ Simple peak shaving strategies performed far better than EOP 6 deployment.
- Conclusion: Deployment of ELRs in EOP 6 would be wasteful and inefficient.
- In subsequent runs, we focused on the performance of EOP 10 deployment and peak shaving.

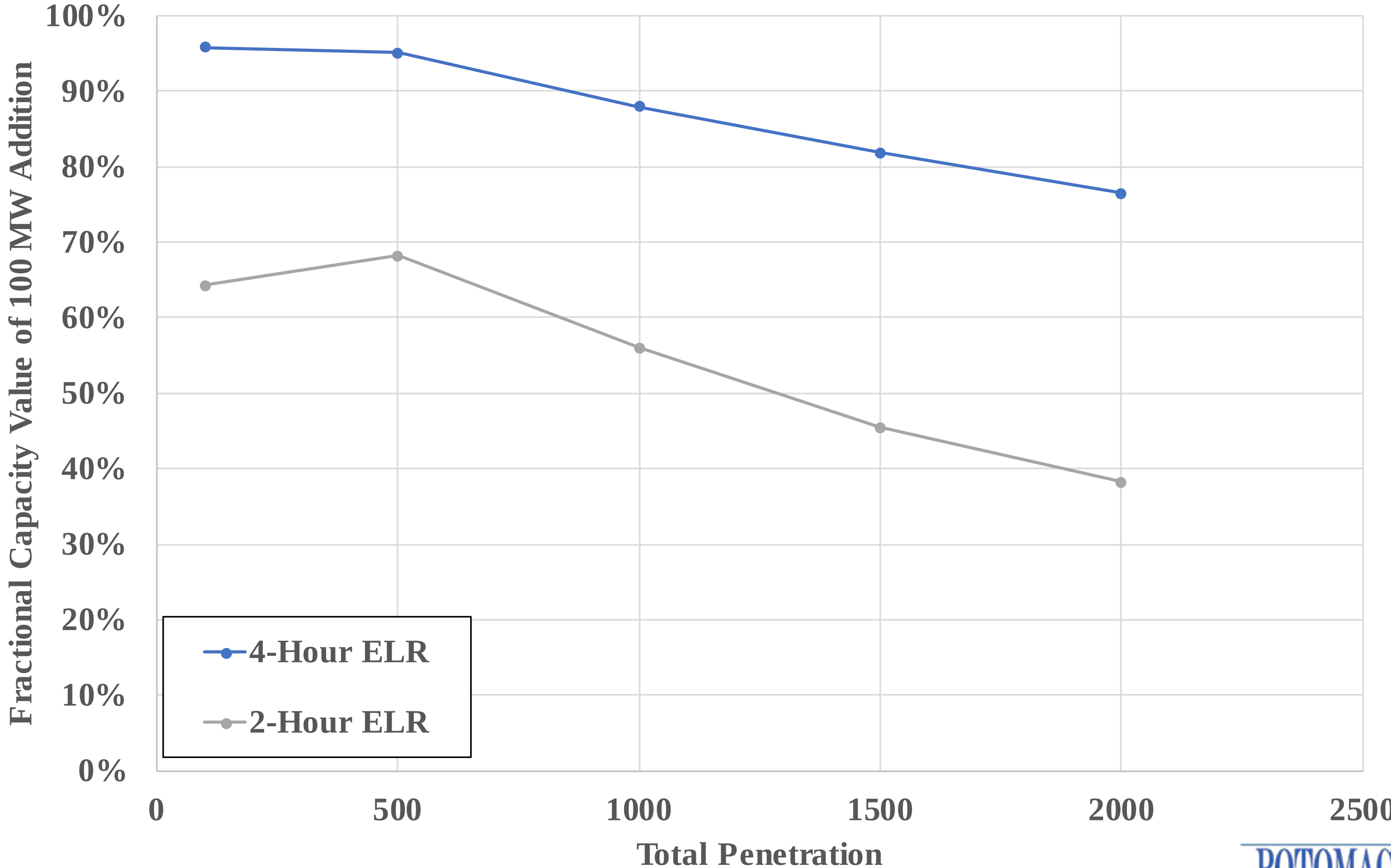
Updated/New

Incremental Fractional Capacity Value:
Modeling of Pre-Existing Penetration

- Our simulations test how the capacity value of ELRs is affected by:
  - ✓ The duration of pre-existing ELR penetration, and
  - ✓ Whether pre-existing ELRs are used in EOP 10 or as peak shaving.
- The following assumptions were used in the MMU simulations:
  - ✓ Two scenarios limit use of ELRs in EOP 10 to 50 percent of the 10-minute reserve requirement.
  - ✓ The NYISO requested two scenarios that evaluate the effect of deploying ELRs strictly as peak shaving resources.

Pre-Exist (MW)	Breakdown of Pre-Existing ELRs (EOP 10 / Peak Shave)			
	4-Hour (slide 32)	2-Hour (slide 33)	4-Hour (slide 34)	2-Hour (slide 35)
400	400 / 0	200 / 200	0 / 400	0 / 400
900	655 / 245	450 / 450	0 / 900	0 / 900
1400	655 / 745	655 / 745	0 / 1400	0 / 1400
1900	655 / 1245	655 / 1245	0 / 1900	0 / 1900

Incremental Fractional Capacity Value Results:
Pre-Existing Penetration of 4-hr ELRs



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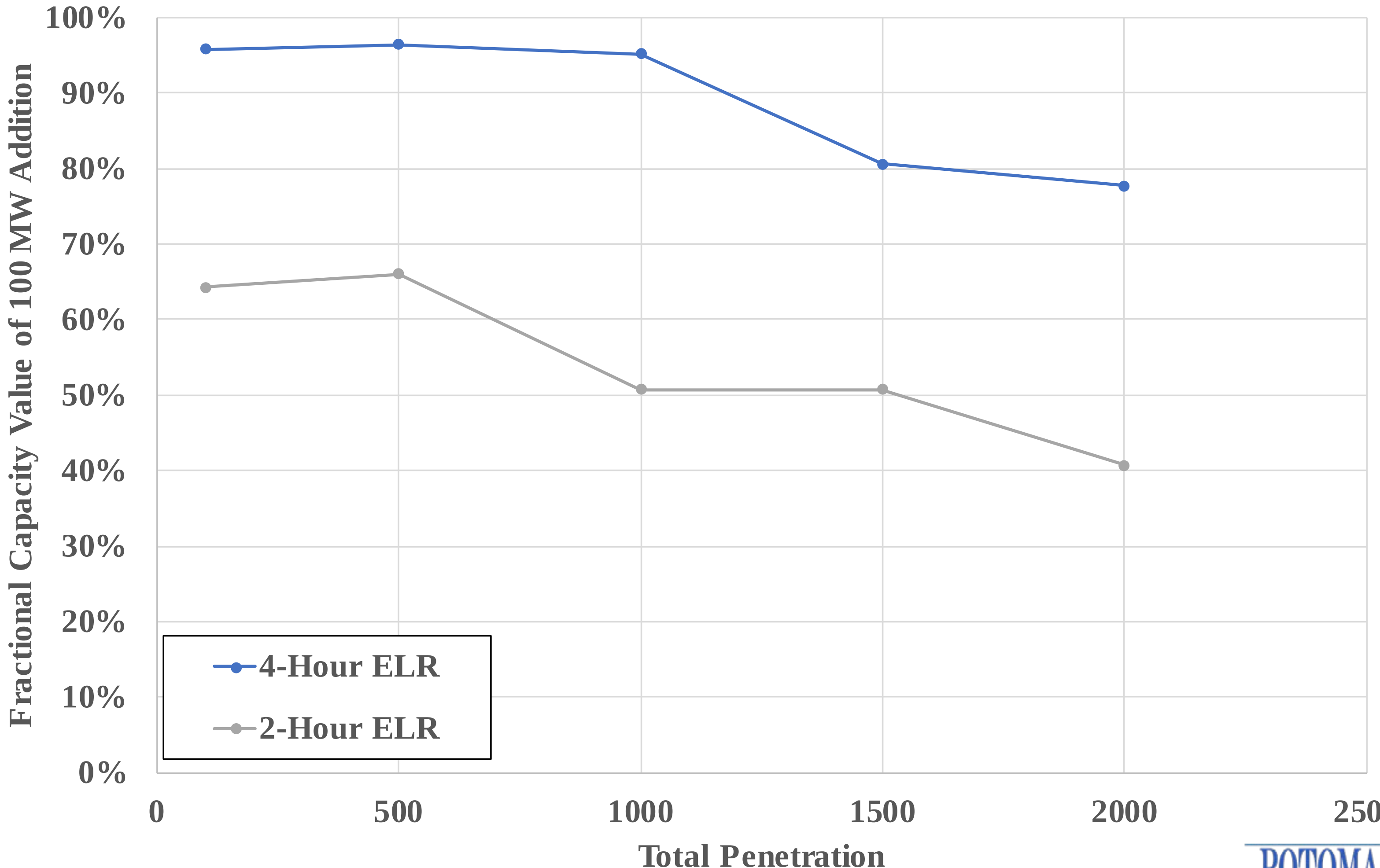
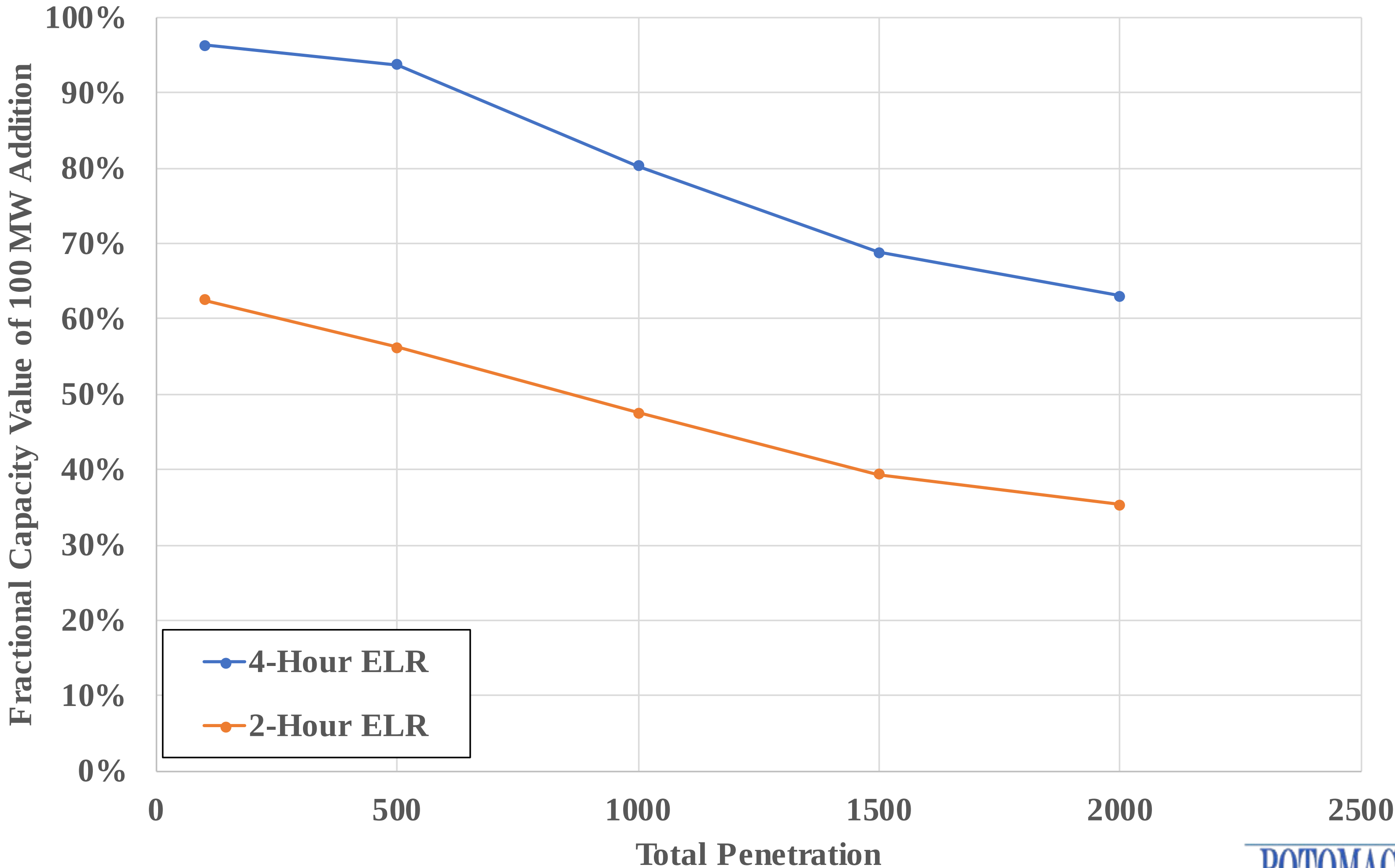
Incremental Fractional Capacity Value Results:
Pre-Existing Penetration of 2-hr ELRs

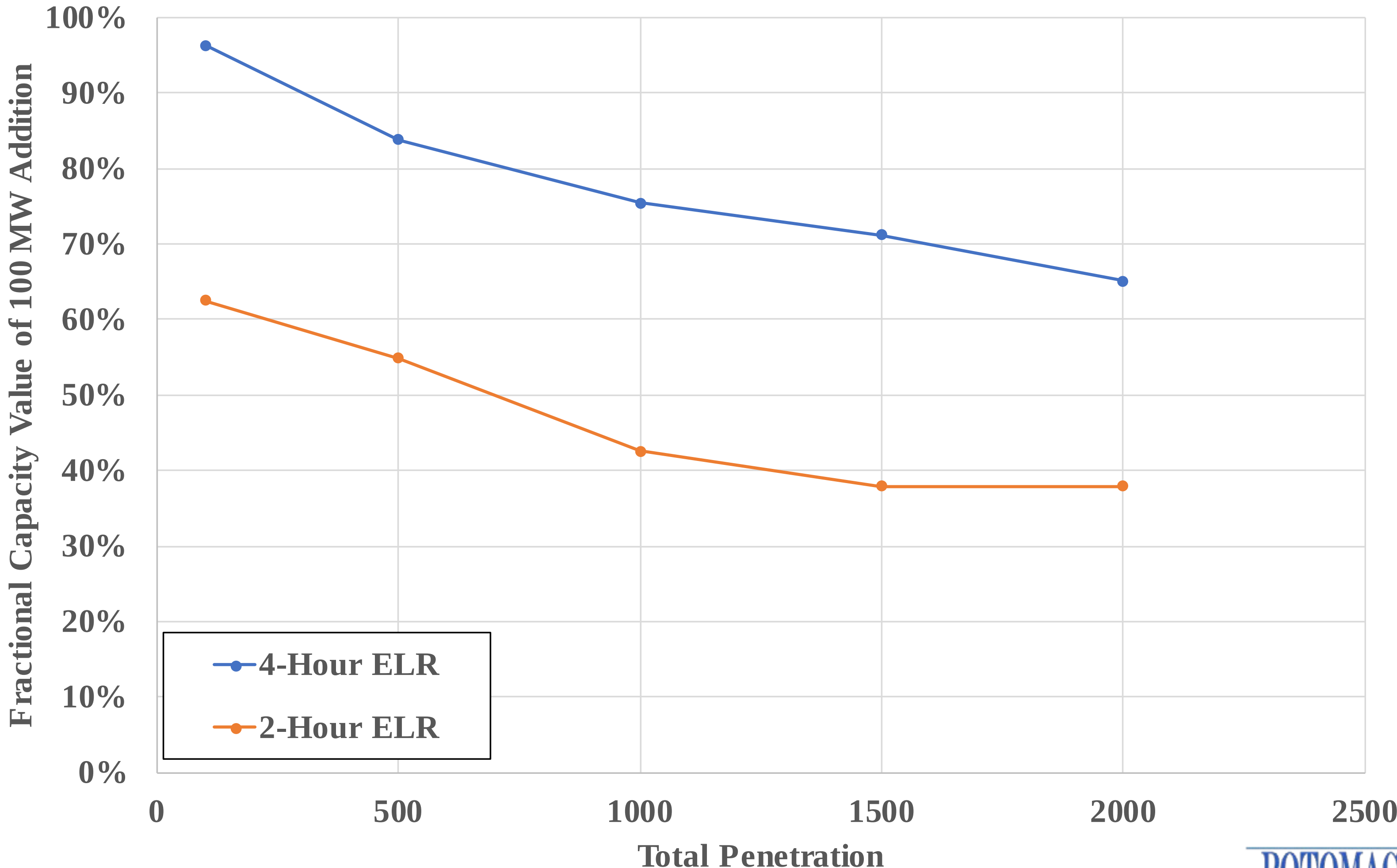


Incremental Fractional Capacity Value Results:
Pre-Existing Penetration of 4-hr ELRs – Peak Shaving Only



Updated/New

Incremental Fractional Capacity Value Results:
Pre-Existing Penetration of 2-hr ELRs – Peak Shaving Only



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Conclusions

Conclusions:
MMU Simulation Results

- Location may not affect fractional capacity value significantly.
  - ✓ However, it is important to control for the location of the ELR.
- Deployment in EOP 6 (when 30-minute reserves are depleted) is unrealistic and should not be considered further.
- For an addition of 4-hour ELRs, fractional capacity value ranges:
  - ✓ From 95 to 96 percent for penetration levels up to 500 MW
  - ✓ From 76 to 78 percent for 2 GW of penetration
- For an addition of 2-hour ELRs, fractional capacity value ranges:
  - ✓ From 64 to 68 percent for penetration levels up to 500 MW
  - ✓ From 38 to 41 percent for 2 GW of penetration
- At high penetration levels, capacity value falls because:
  - ✓ ELRs must be added as peak shaving (rather than EOP 10); and
  - ✓ Load shedding is less concentrated in the highest load hours.

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Conclusions:
Concerns Related to Scheduling of ELRs as 10-Minute Reserve

- NYISO considers it more realistic to value ELRs as peak shaving (rather than as deployable in EOP10).
- The co-optimization of energy and ancillary services and the incentives for ELRs will lead some to be scheduled as 10-minute reserves, making them deployable in EOP10.
  - ✓ However, we acknowledge that some ELRs will be deployed before EOP10 in response to RT conditions (e.g., contingencies not anticipated in the DAM, local transmission constraints, etc).
  - ✓ Thus, if ELRs are not scheduled reliably through the normal RT market processes, the NYISO will have to rely on manual OOM actions to manage large amounts of ELRs to satisfy energy needs.
  - ✓ To address this concern, we limited the amount of ELRs that could be scheduled for EOP10 treatment to 50 percent of the 10-minute reserve requirement.

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Conclusions:
Concerns Related to Scheduling of ELRs as 10-Minute Reserve

- To evaluate its concern, the NYISO requested that we run simulations to estimate the value of ELRs if they are operated as peak shaving only. We found that:
  - ✓ When 4-hour ELRs are peak shaving only, capacity value drops:
    - To 84-94 percent at 500 MW of penetration
    - To 63-65 percent at 2 GW of penetration
  - ✓ When 2-hour ELRs are peak shaving only, capacity value drops:
    - To 55-56 percent at 500 MW of penetration
    - To 35-38 percent at 2 GW of penetration

Conclusions

- Based on our simulations, which assume up to 50 percent of the 10-minute reserve requirement could be satisfied by ELRs:
  - ✓ The value of ELRs is initially higher than under the NYISO's modeling approach; but
  - ✓ The value of ELRs drops more rapidly as penetration increases than in the NYISO's estimates because:
    - ELRs are less effective as peak shaving than EOP 10 resources; and
    - The marginal value of capacity falls more quickly than the average value of ELRs.
  - ✓ The fractional capacity values proposed by the NYISO for 4-hour and 2-hour ELRs:
    - Are reasonable for high penetration levels; and
    - May under-compensate resources at low penetration levels.

Appendix

Alternative Way to Measure Capacity Value

- Garver described a liner exponential relationship between LOLE and system reserve margin in his study in 1966 (see slide 19).
  - ✓ Following the same approach described in slide 6, fractional capacity value can be measured as:

$$[\ln(\text{LOLE\_BASE}) - \ln(\text{LOLE\_ELR}(X))] / [\ln(\text{LOLE\_BASE}) - \ln(\text{LOLE\_CONV}(X))]$$

  - ✓ However, this formula produces very similar results as measured using the simple linear relationship. (see slide 20)

Linear Exponential Function Between LOLE and System Reserves

Figure from L. L. Garver, "Effective Load Carrying Capability of Generating Units", 1966

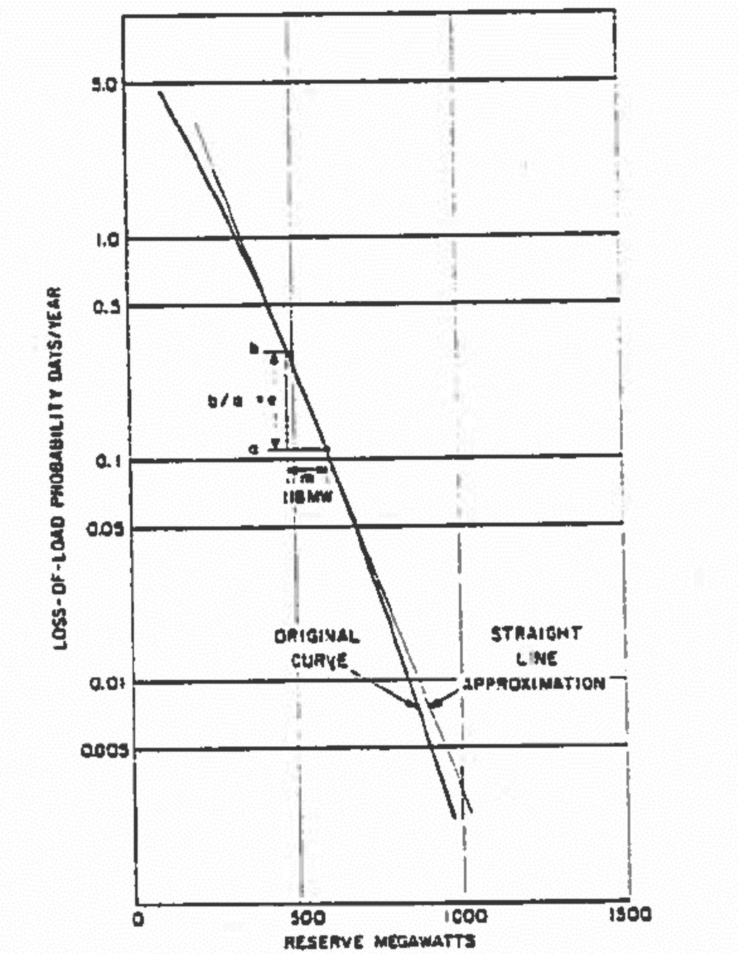

Fig. 3. Approximation of annual risk function by linear exponential function.

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