Consumer Impact Analysis: Energy Storage Integration

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Agenda

- Project Description
- Background
- Energy Market Impacts
- Capacity Market Impacts
- Other Impacts
- Next Steps

Project Description

- Although certain types of ESRs can participate in the NYISO-administered wholesale markets today, existing market products offer limited opportunities to provide Energy and Ancillary Services, which is inconsistent with the NYISO's goal to integrate the full range of storage resources into the wholesale markets. Existing programs also do not account for operating constraints that have important performance implications for ESRs, such as Upper Storage Limit, Minimum Load level, and Transition Time[1]
- To address these shortcomings, the NYISO, as part of its *Energy Storage Integration* project, is developing a participation model that will better enable the NYISO to economically schedule eligible ESRs for Energy, Capacity, and Ancillary Services in NYISO-administered wholesale markets[2]
- This presentation addresses the consumer impact of ESRs. However, we expect this analysis to be the basis of the DER impact analysis also since both ESRs and DERs will have a similar effect on energy and capacity markets

1. Energy Storage Integration: Market Design Concept Proposal, pg. 4 12/2017 @ http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2017-12-20/2017%20ESR%20Market%20Design%20Concept%20Proposal.pdf
2. Energy Storage Integration: Market Design Concept Proposal, pg. 4 12/2017 @ http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2017-12-20/2017%20ESR%20Market%20Design%20Concept%20Proposal.pdf

Background

- **In 2017, the NYISO developed a market design concept for a participation model that will enable ESRs to offer their full capabilities into the NYISO's wholesale Energy, Capacity, and Ancillary Services markets[3]**
  - The ESR Participation Model was prioritized as a Key Project with a deliverable of Market Design Complete in Q3 of 2018.
- **On February 15, 2018, FERC issued Order No. 841, directing "each RTO/ISO to revise its tariff to establish a participation model consisting of market rules that, recognizing the physical and operational characteristics of electric storage resources, facilitates their participation in the RTO/ISO markets"[4]**
  - The compliance filing deadline for Order No. 841 is December 3, 2018, with an implementation deadline of December 3, 2019

3. See NYISO, *Energy Storage Integration: Market Design Concept Proposal* (Dec. 20, 2017) at http://www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2017-12-20/2017%20ESR%20Market%20Design%20Concept%20Proposal.pdf
4. Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators, Order No. 841, 162 FERC ¶ 61,127, at P3 (Feb. 15, 2018) ("Order No. 841") as amended by the Feb. 28, 2018 Errata Notice ("Order No. 841 Errata").

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Consumer Impact Analysis (IA) Evaluation Areas

- Present the potential impact on all four evaluation areas

RELIABILITY From an operational perspective, additional supply, especially one that is flexible, could be a reliability benefit	COST IMPACT/ MARKET EFFICIENCIES The increase in use of storage should reduce consumer costs
ENVIRONMENT/ NEW TECHNOLOGY The increase in use of storage, especially during system peak times should reduce emissions	TRANSPARENCY No impact expected

Energy Market

- **Since we don't know how much storage will be available, we provide estimates over a range of expected values**
- **To approximate the short run energy market impact of storage, upstate and downstate historic energy prices are used**
  - Include all price intervals during 2017 for a location upstate and downstate
  - Consider how various quantities of energy storage would impact the real-time price spikes based on duration, efficiency and availability
  - Use the change in hourly integrated real-time prices to approximate changes (up or down) to hourly Day-Ahead Market prices
  - Determine the consumer impact using the historic day ahead load and the hourly changes to Day Ahead Market prices

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Energy Market Analysis

- **Price volatility provides opportunities for ESRs to arbitrage energy:**
  - Inject energy when prices spike
  - Withdraw energy when prices are lowest
- **To analyze consumer impacts, a spreadsheet analysis was conducted to test the impact that ESR energy arbitrage could have on energy market LBMPs.**
  - Two generator buses with high price volatility were selected:
    - Upstate: 9-Mile
    - Downstate: Ravenswood 3
  - 2017 RTD LBMP's were used.
- **Revised prices were developed using study assumptions about ESR size and opportunity costs**
  - LBMPs were multiplied by 2017 hourly time weighted Load data for both Upstate (Zones A-F) and Downstate (Zones G-K) to estimate consumer impacts for multiple scenarios.

Energy Market Analysis

- **Unknowns about where and how ESRs will be deployed in the NYISO markets required key assumptions:**
  - Duration- 4 h
    - In order to become ICAP suppliers under current market rules, ESRs must be capable of 4 hours of sustained injection.
  - Location – High volatility load pockets
    - Price volatility provides best opportunities for arbitrage.
  - Availability –
    - Unlikely that ESRs will be willing to perform every day of the year.
    - Unlikely that ESRs will be positioned to capture every price spike throughout a day/month/year.
    - Tested different availability factors between 20% and 40%.
  - Roundtrip Efficiency
    - ESRs will not be perfectly efficient. Tested 60, 70, and 80% roundtrip efficiency.
  - Technology type
    - ESRs will be fast ramping and able to take advantage of price spikes when they occur.
  - Capacity- 500 MW, 1,000 MW, 1,500 MW, 2,500 MW
    - 5%, 10%, 15%, and 25% peak price shaving in load pockets used as a proxy for opportunity costs that may be offered by new storage capacity.

Energy Market Analysis

- Compute the amount of 5-minute intervals expected to be impacted by storage
  - 4 hours*12 RTD intervals*365 days
- Apply an availability factor (20% - 40%) to the above calculation to determine the top intervals impacted
- In addition to the availability factor, apply an efficiency factor (60% - 80%) to determine the bottom intervals impacted
- Adjust the prices of the impacted 5-minute intervals based on the amount of storage MW (500 MW – 2500 MW) and average them into hourly values
  - See slides 10 and 11
- Subtract the adjusted hourly values from the original hourly averages (price delta)
- Multiply the price delta with its respective hourly average load value to compute the consumer impact for both upstate and downstate locations
  - See slides 13 through 19

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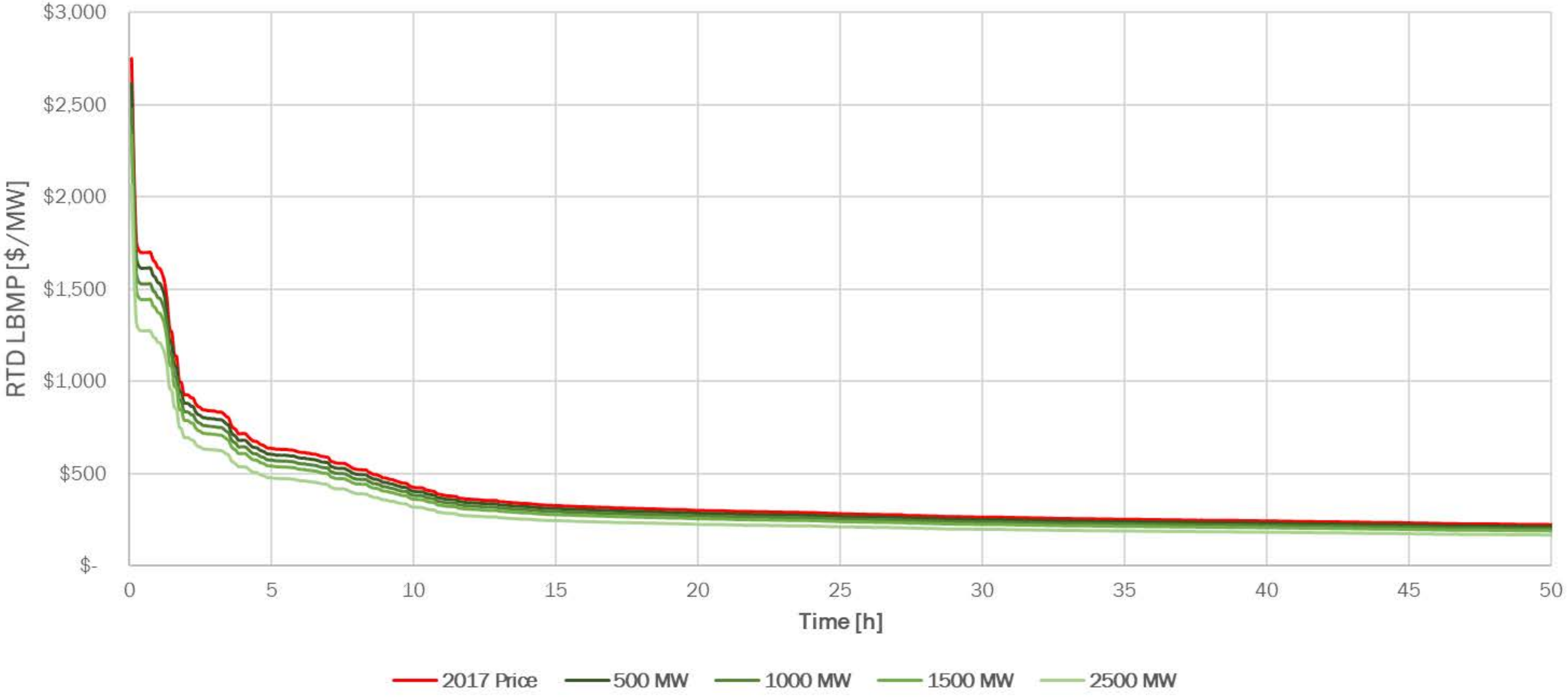
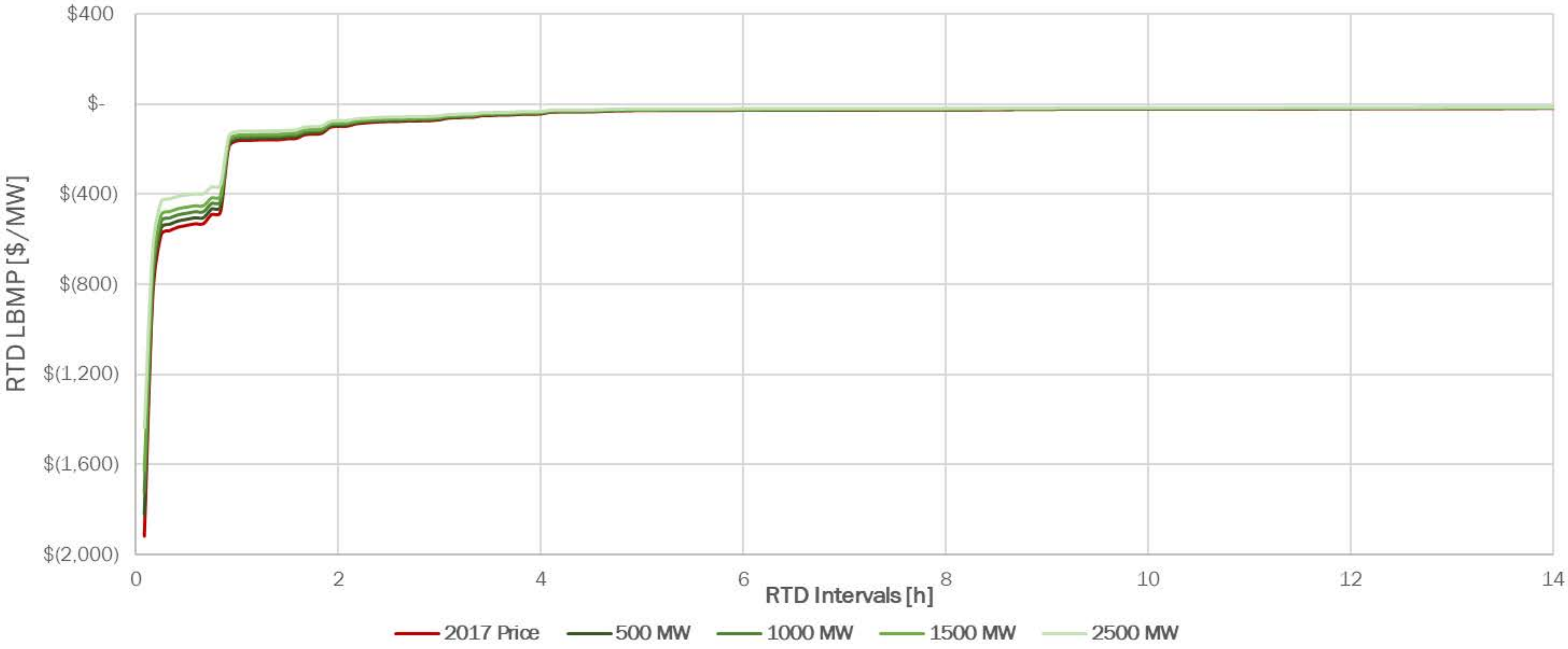
Energy Market Analysis

- Example of peak price shaving for Downstate case with Efficiency: 70% and Availability: 30%



Energy Market Analysis

- Lowest prices were increased for the amount of time needed for energy withdrawals.
- Example for Downstate case with Efficiency: 70%, Availability: 30%

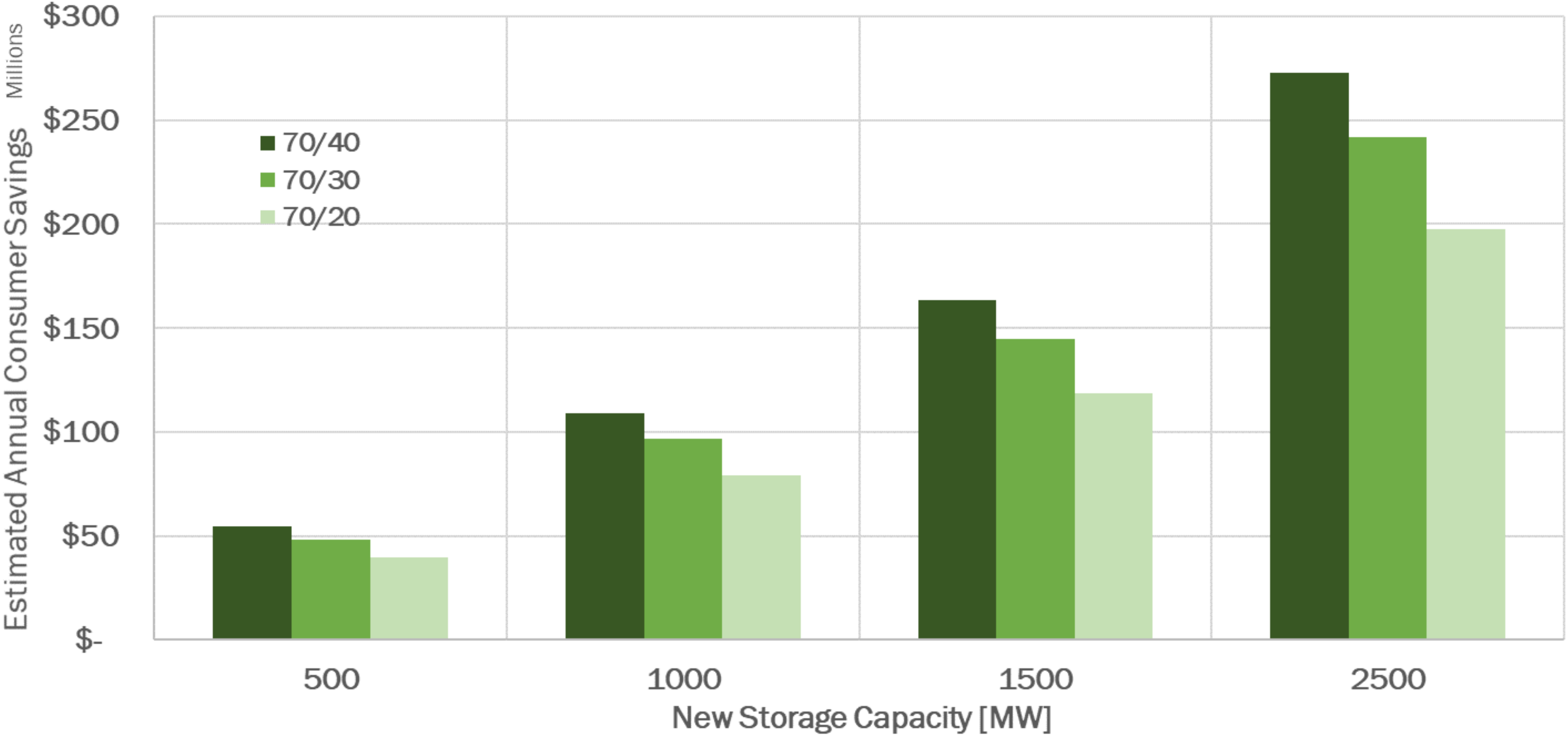


Energy Market Impact

- The tables and graphs that follow show the energy market impact for various levels of storage MW additions (500MW, 1000MW, 1500MW & 2500MW)
- The impact for Upstate and Downstate are shown separately for different levels of assumed efficiency (60%, 70% & 80%)
- We also provide a sensitivity analysis for different levels of availability (40, 30%, & 20%)

Energy Market Results - Statewide

- Statewide results for cases with Efficiency: 70% and Availability: 40%, 30%, or 20%



Energy Market Results - Statewide

- Statewide results for cases with Efficiency: 70% and Availability: 40%, 30%, or 20%

ESTIMATED STATEWIDE CONSUMER IMPACT					
Peak Price Shaving Assumptions				Est. Annual Savings	
Efficiency	Availability	% Shaved	Capacity [MW]		
70%	40%	5%	500	$ 54,518,719	1.2%
		10%	1000	$ 109,037,437	2.4%
		15%	1500	$ 163,556,156	3.6%
		25%	2500	$ 272,593,593	6.0%
	30%	5%	500	$ 48,329,235	1.1%
		10%	1000	$ 96,657,614	2.1%
		15%	1500	$ 144,986,421	3.2%
		25%	2500	$ 241,644,035	5.3%
	20%	5%	500	$ 39,531,129	0.9%
		10%	1000	$ 79,061,402	1.7%
		15%	1500	$ 118,592,104	2.6%
		25%	2500	$ 197,653,506	4.3%

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Energy Market Results- Downstate

- Zones G-K results for cases with Efficiency: 70% and Availability: 40%, 30%, or 20%

ESTIMATED DOWNSTATE CONSUMER IMPACT					
Peak Price Shaving Assumptions				Est. Annual Savings	
Efficiency	Availability	% Shaved	Capacity [MW]		
70%	40%	5%	500	$ 38,272,236	1.2%
		10%	1000	$ 76,544,472	2.5%
		15%	1500	$ 114,816,708	3.7%
		25%	2500	$ 191,361,179	6.2%
	30%	5%	500	$ 34,214,791	1.1%
		10%	1000	$ 68,429,583	2.2%
		15%	1500	$ 102,644,374	3.3%
		25%	2500	$ 171,073,956	5.6%
	20%	5%	500	$ 27,969,836	0.9%
		10%	1000	$ 55,939,672	1.8%
		15%	1500	$ 83,909,508	2.7%
		25%	2500	$ 139,849,179	4.5%

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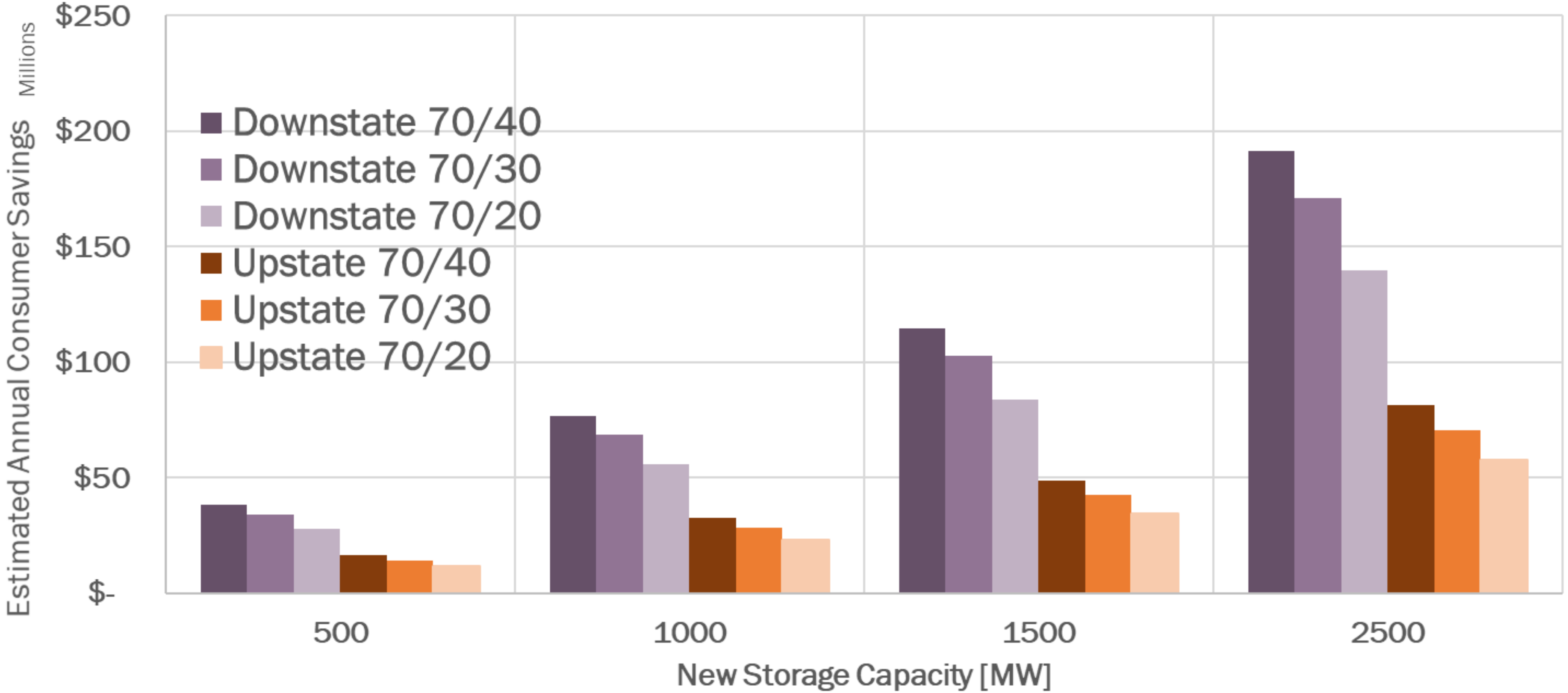
Energy Market Results- Upstate

- Zones A-F results for cases with Efficiency: 70% and Availability: 40%, 30%, or 20%

ESTIMATED UPSTATE CONSUMER IMPACT					
Peak Price Shaving Assumptions				Est. Annual Savings	
Efficiency	Availability	% Shaved	Capacity [MW]		
70%	40%	5%	500	$16,246,483	1.20%
		10%	1000	$32,492,965	2.50%
		15%	1500	$48,739,448	3.70%
		25%	2500	$81,232,414	6.20%
	30%	5%	500	$14,114,444	1.10%
		10%	1000	$28,228,031	2.20%
		15%	1500	$42,342,047	3.30%
		25%	2500	$70,570,079	5.60%
	20%	5%	500	$11,561,293	0.90%
		10%	1000	$23,121,730	1.80%
		15%	1500	$34,682,596	2.70%
		25%	2500	$57,804,327	4.50%

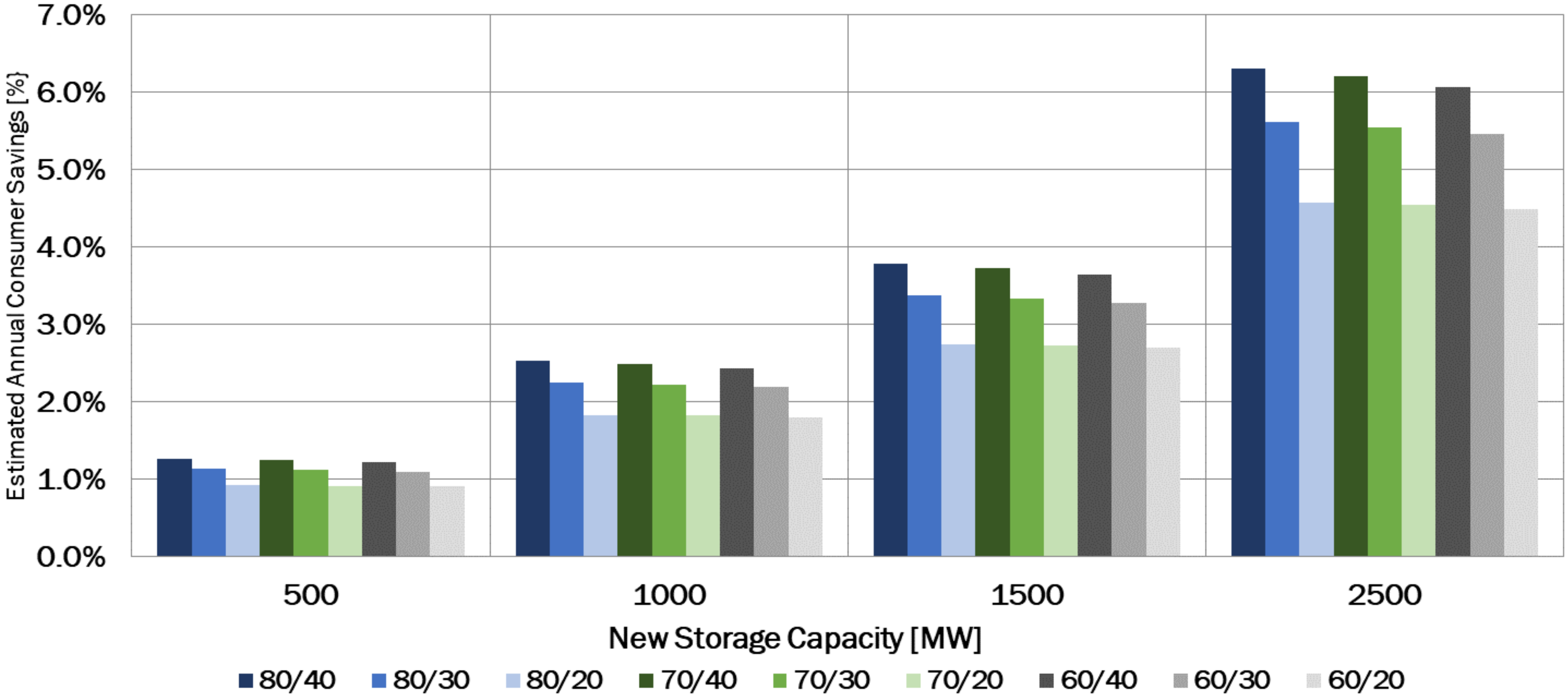
Energy Market Results- Upstate vs Downstate

- Comparison of results for cases with Efficiency: 70% and Availability: 40%, 30%, or 20%



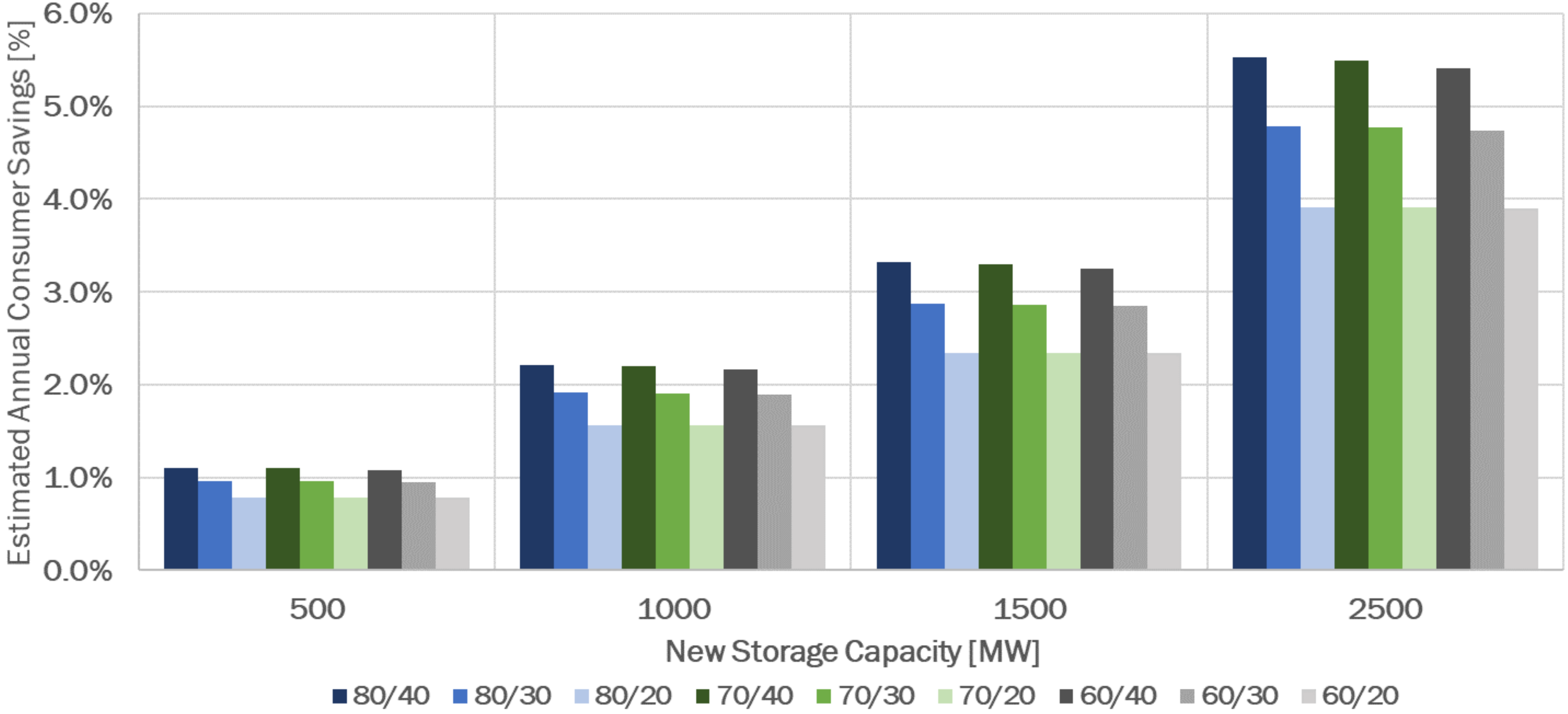
Energy Market Results- Downstate

- Comparison of results for cases with Efficiency: 80%, 70%, or 60% and Availability: 40%, 30%, or 20%



Energy Market Results- Upstate

- Comparison of results for cases with Efficiency: 80%, 70%, or 60% and Availability: 40%, 30%, or 20%



Energy Market Results- Conclusion

- **Roundtrip efficiency is less impactful than Availability.**
  - Higher availability will lead to higher consumer impact for ESRs.
  - Changes in roundtrip efficiency will have little impact on consumer costs
    - ESRs are not expected to influence prices significantly when withdrawing energy.
- **Although net injections from ESRs are negative, their consumer impact is expected to be positive.**
- **Uncertainty remains with respect to where ESRs will locate, how they will bid, their capacity and availability.**
  - These factors and others will ultimately shape the impact that ESRs have on consumer costs.

Energy Market Analysis

- Spreadsheet used for calculations is available with today's meeting materials.
- Results from 18 cases are available on "Results" tab.
- Users can change variables to explore consumer impact on "Downstate Calculator" and "Upstate Calculator" tabs.
  - Cells in green are unlocked and may be changed to update results.
  - Workbook is not password protected, can be unlocked for additional flexibility if desired.

USER INPUT	
Injection Duration (h)	4
Roundtrip Efficiency:	60%
Availability:	40%

RTD End Timestamp	Unique ID	RTD Gen Bus LBMP	5-min Adjusted LBMP			
			5%	10%	15%	25%
1/1/2017 0:05	4707	$ 0.59	$ 0.62	$ 0.65	$ 0.68	$ 0.74
1/1/2017 0:10	8157	$ 2.66	$ 2.79	$ 2.93	$ 3.06	$ 3.33

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Capacity Market

- Since we don’t know how much storage will be available, we provide estimates over a range of expected values
- The cost impact of storage on capacity prices depends on the amount of MW available to the wholesale market
- We assume that most of the storage resources will participate in the wholesale market as capacity providers

Analysis Assumptions

- To illustrate the cost impact, we assume a range of storage resources 500MW, 1,000MW, 1,500MW and 2,500MW entering the wholesale market
- These resources were added at the five-year average NERC EFORd for pump storage which was 6.02%
- Since the impact of storage MW on the IRM and LCRs has not been determined, we assume a range of impacts on LCRs for the different levels of storage resources we are looking at in our analysis
  - In establishing capacity requirements, it is assumed that a storage resource has either a 0%, 25%, or 50% of the nameplate MW increase on the capacity requirements
- We assume that two-thirds of storage is located in Zone J and one-third in Zone K
  - For example, in the 1,500 MW case at 25%, we add 1,000 MW of storage resources to the supply stack in NYC, and increase requirements for NYC by 250 MW (25% * 1,000 MW), and we add 500 MW of storage resources to the supply stack in LI, and increase the requirements for LI by 125 MW (25% * 500 MW)

Short term Cost Impact

- For the short-run, we model the 2018 Capability Year
  - For the winter supply stack, we use the winter 2017/18 actual data
  - The short-run impact analysis will assume no additional changes to generation
- The tables and graphs that follow show the short-run capacity cost impact of various levels of storage MW additions (500MW, 1000MW, 1500MW & 2500MW)
- The impacts shown in the short run may not be sustainable, as retirements and other changes will result from the influx of large amounts of capacity additions. We address this in the long run analysis, that assumes a supply level based on the historic level of excess
- Both the state-wide impact and the impact on individual Localities, LI, NYC, GHI and ROS are shown separately
- We also provide a sensitivity analysis for the assumed comparability of storage resources with traditional resources to account for the impact of storage on IRM and LCRs for all the different levels of storage discussed above (0%, 25% & 50% impact on capacity requirements)

Short Term Consumer Impact ($ Million) -- 50% Impact on Capacity Requirements

Short Term Consumer Impact ($Million)	Base Case	500 MW, 50%	1000 MW, 50%	1500 MW, 50%	2500 MW, 50%
LI	$334	$265	$219	$185	$115
NYC	$587	$456	$347	$286	$156
GHI	$328	$254	$190	$152	$78
ROS	$323	$266	$209	$155	$46
Total	$1,572	$1,240	$965	$779	$396
Short Term Consumer Impact NYCA Δ ($Million)	Base Case	500 MW, 50%	1000 MW, 50%	1500 MW, 50%	2500 MW, 50%
Δ	$1,572	-$332	-$607	-$794	-$1,177

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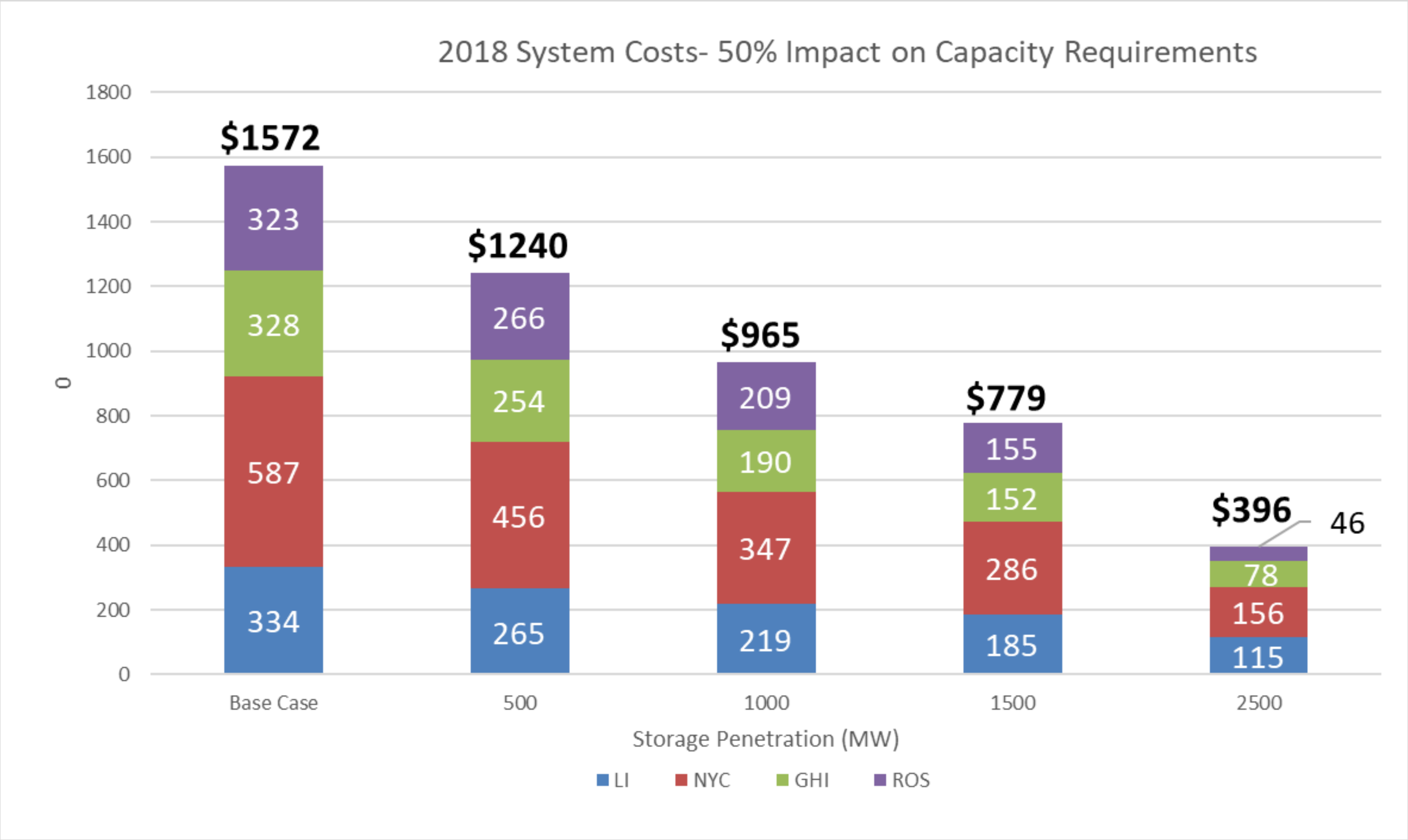

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Short Term Consumer Impact ($ Million) -- 25% Impact on Capacity Requirements

Short Term Consumer Impact ($Million)	Base Case	500 MW, 25%	1000 MW, 25%	1500 MW, 25%	2500 MW, 25%
LI	$334	$228	$170	$109	$1
NYC	$587	$365	$260	$151	$1
GHI	$328	$206	$142	$80	$1
ROS	$323	$232	$141	$51	$2
Total	$1,572	$1,031	$713	$392	$5
Short Term Consumer Impact NYCA Δ ($Million)	Base Case	500 MW, 25%	1000 MW, 25%	1500 MW, 25%	2500 MW, 25%
Δ	$1,572	-$541	-$859	-$1,180	-$1,567

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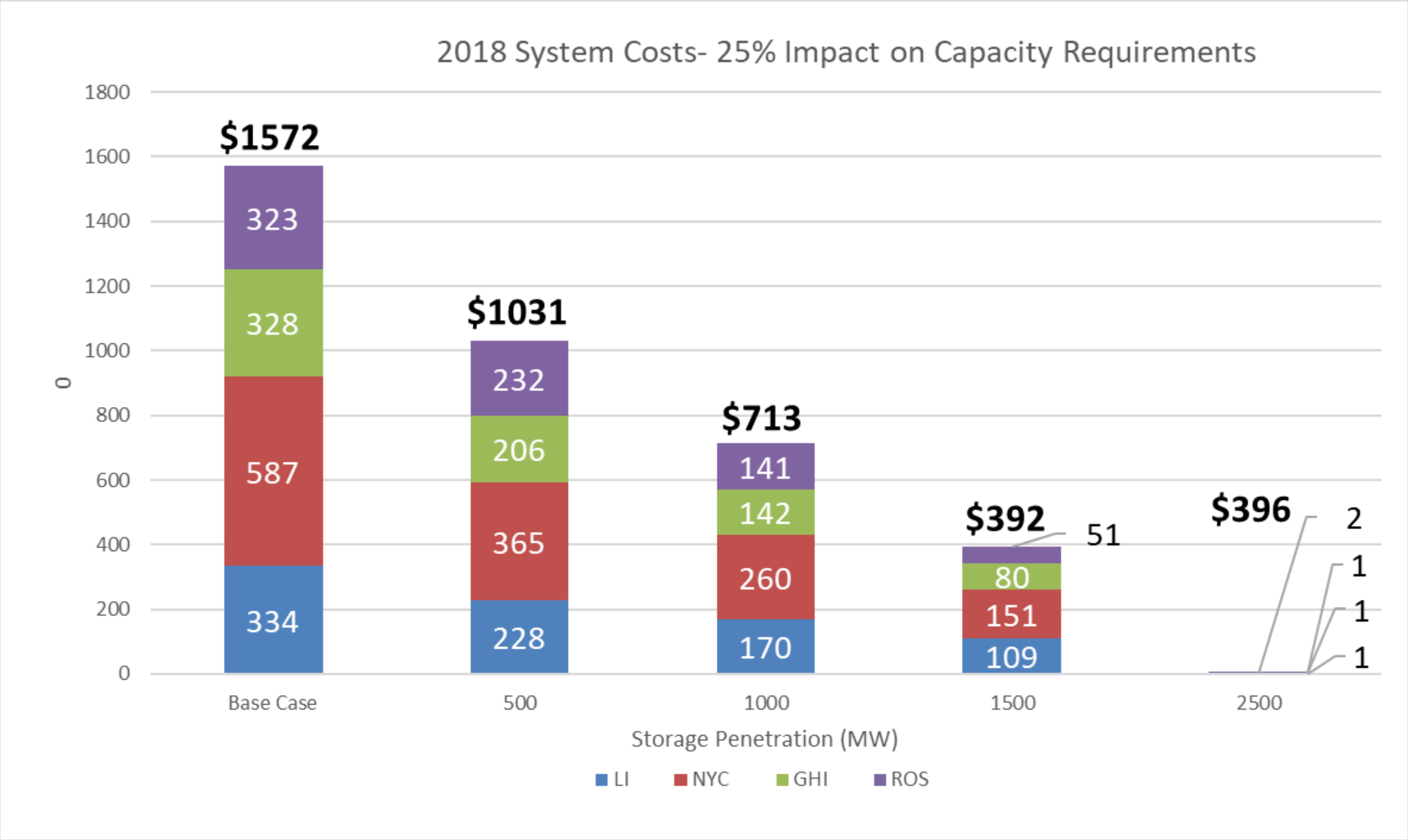

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Short Term Consumer Impact ($ Million) -- 0% Impact on Capacity Requirements

Short Term Consumer Impact ($Million)	Base Case	500 MW, 0%	1000 MW, 0%	1500 MW, 0%	2500 MW, 0%
LI	$334	$204	$119	$30	$1
NYC	$587	$321	$171	$12	$1
GHI	$328	$181	$94	$6	$1
ROS	$323	$198	$72	$2	$2
Total	$1,572	$903	$455	$50	$5
Short Term Consumer Impact NYCA Δ ($Million)	Base Case	500 MW, 0%	1000 MW, 0%	1500 MW, 0%	2500 MW, 0%
Δ	$1,572	-$669	-$1,117	-$1,522	-$1,567

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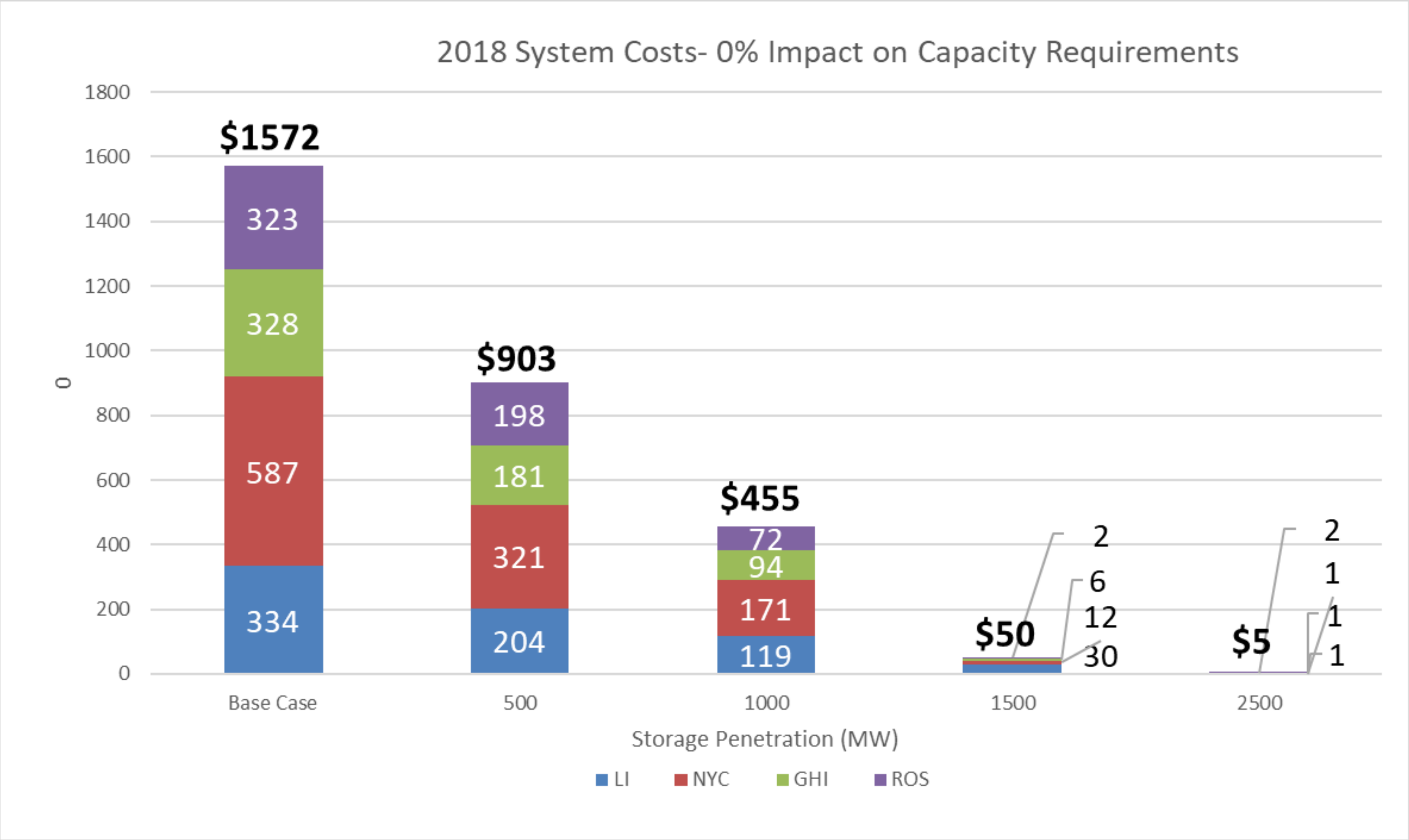

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Long Term Cost Impact

- For the long-run, we use the 2022/23 Capability Year base case, utilizing:
  - the requirement percentages developed in the short term impact analysis
  - the 2018 Demand Curve values
- For the supply level, we use the historic excess defined as a percentage of excess above the requirement observed within the last three Capability Years in each of the different Localities
- The tables and graphs for the long-run analysis follow the same format as the short-run analysis
- We provide the cost impact for different levels of storage MWs and show the impacts both on a state-wide and individual Locality basis
- We also provide a sensitivity analysis based on different levels of assumed impact of storage on capacity requirements

Long Term Consumer Impact ($ Million) -- 50% Impact on Capacity Requirements

Long Term Consumer Impact ($Million)	Base Case	500 MW, 50%	1000 MW, 50%	1500 MW, 50%	2500 MW, 50%
LI	$494	$501	$509	$516	$532
NYC	$1,101	$1,121	$1,141	$1,161	$1,202
GHI	$322	$322	$322	$321	$322
ROS	$722	$721	$721	$719	$719
Total	$2,638	$2,665	$2,693	$2,718	$2,774
Long Term Consumer Impact NYCA Δ ($Million)	Base Case	500 MW, 50%	1000 MW, 50%	1500 MW, 50%	2500 MW, 50%
Δ	N/A	$28	$56	$80	$137

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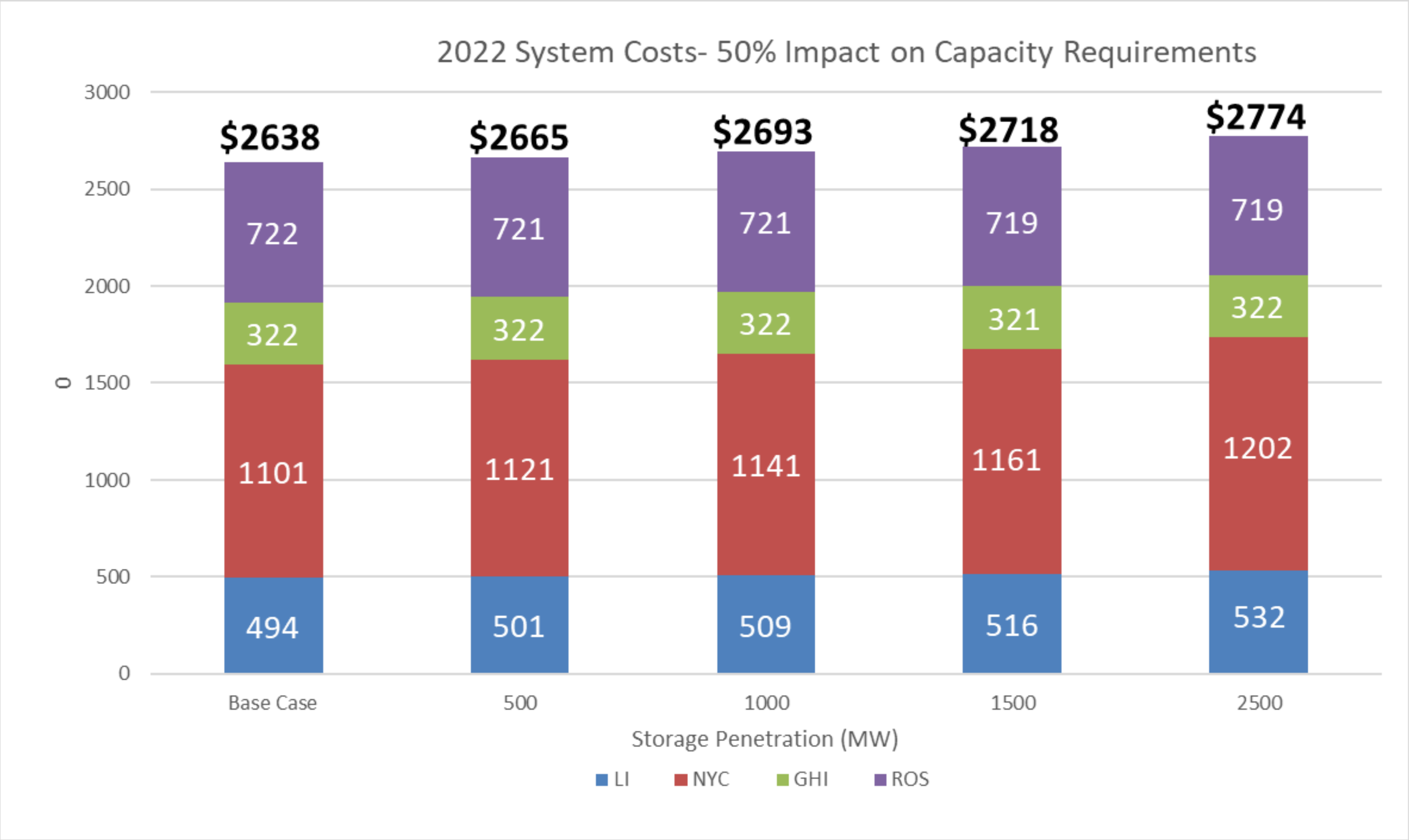

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Long Term Consumer Impact ($ Million) -- 25% Impact on Capacity Requirements

Long Term Consumer Impact ($Million)	Base Case	500 MW, 25%	1000 MW, 25%	1500 MW, 25%	2500 MW, 25%
LI	$494	$497	$501	$505	$513
NYC	$1,101	$1,111	$1,121	$1,131	$1,151
GHI	$322	$322	$322	$321	$321
ROS	$722	$722	$721	$720	$720
Total	$2,638	$2,652	$2,664	$2,677	$2,706
Long Term Consumer Impact NYCA Δ ($Million)	Base Case	500 MW, 25%	1000 MW, 25%	1500 MW, 25%	2500 MW, 25%
Δ	N/A	$14	$27	$39	$68

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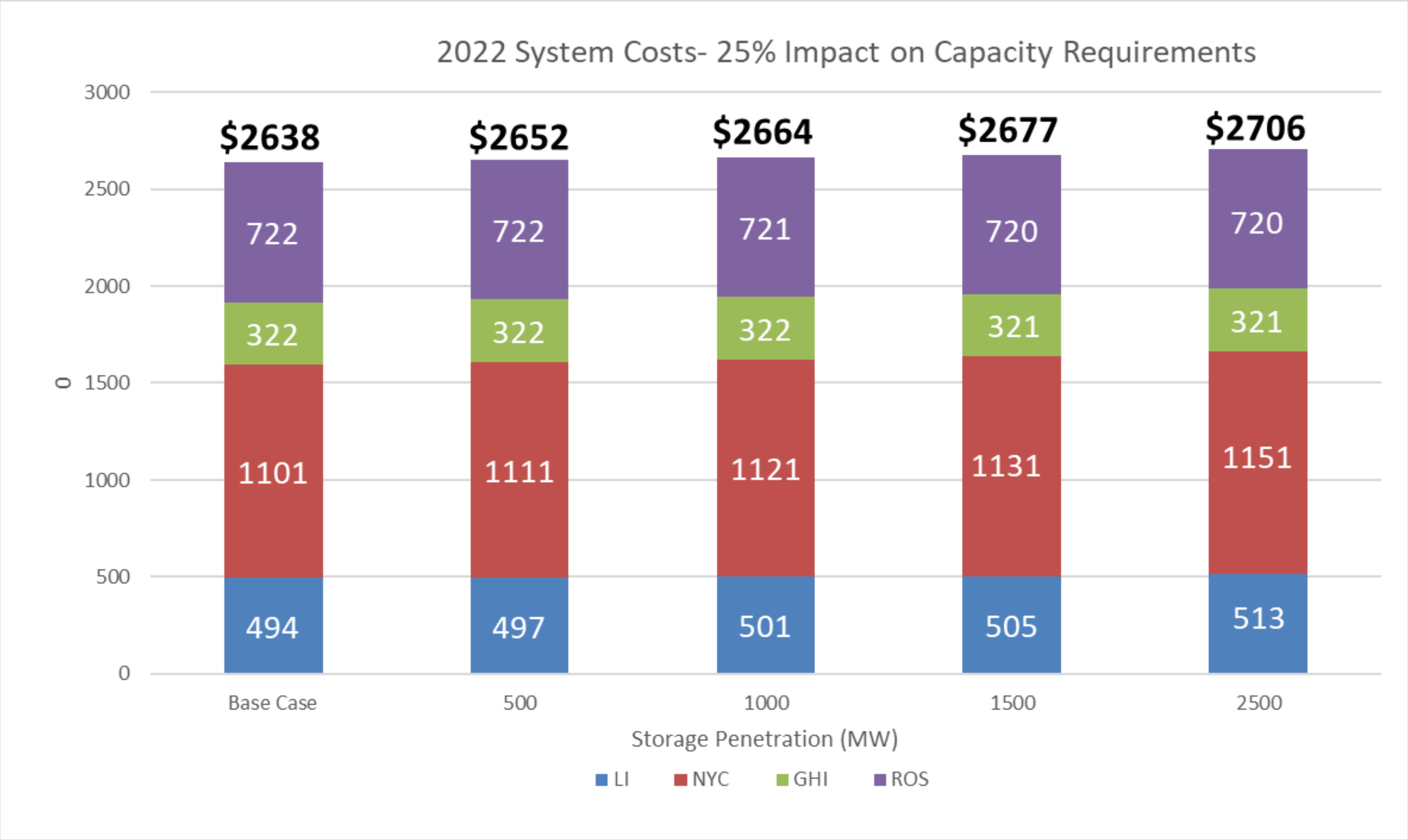

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Long Term Consumer Impact ($ Million) -- 0% Impact on Capacity Requirements

Long Term Consumer Impact ($Million)	Base Case	500 MW, 0%	1000 MW, 0%	1500 MW, 0%	2500 MW, 0%
LI	$494	$494	$494	$494	$494
NYC	$1,101	$1,101	$1,100	$1,100	$1,101
GHI	$322	$321	$321	$321	$321
ROS	$722	$722	$722	$721	$722
Total	$2,638	$2,638	$2,637	$2,636	$2,638
Long Term Consumer Impact NYCA Δ ($Million)	Base Case	500 MW, 0%	1000 MW, 0%	1500 MW, 0%	2500 MW, 0%
Δ	N/A	$0	-$1	-$2	$0

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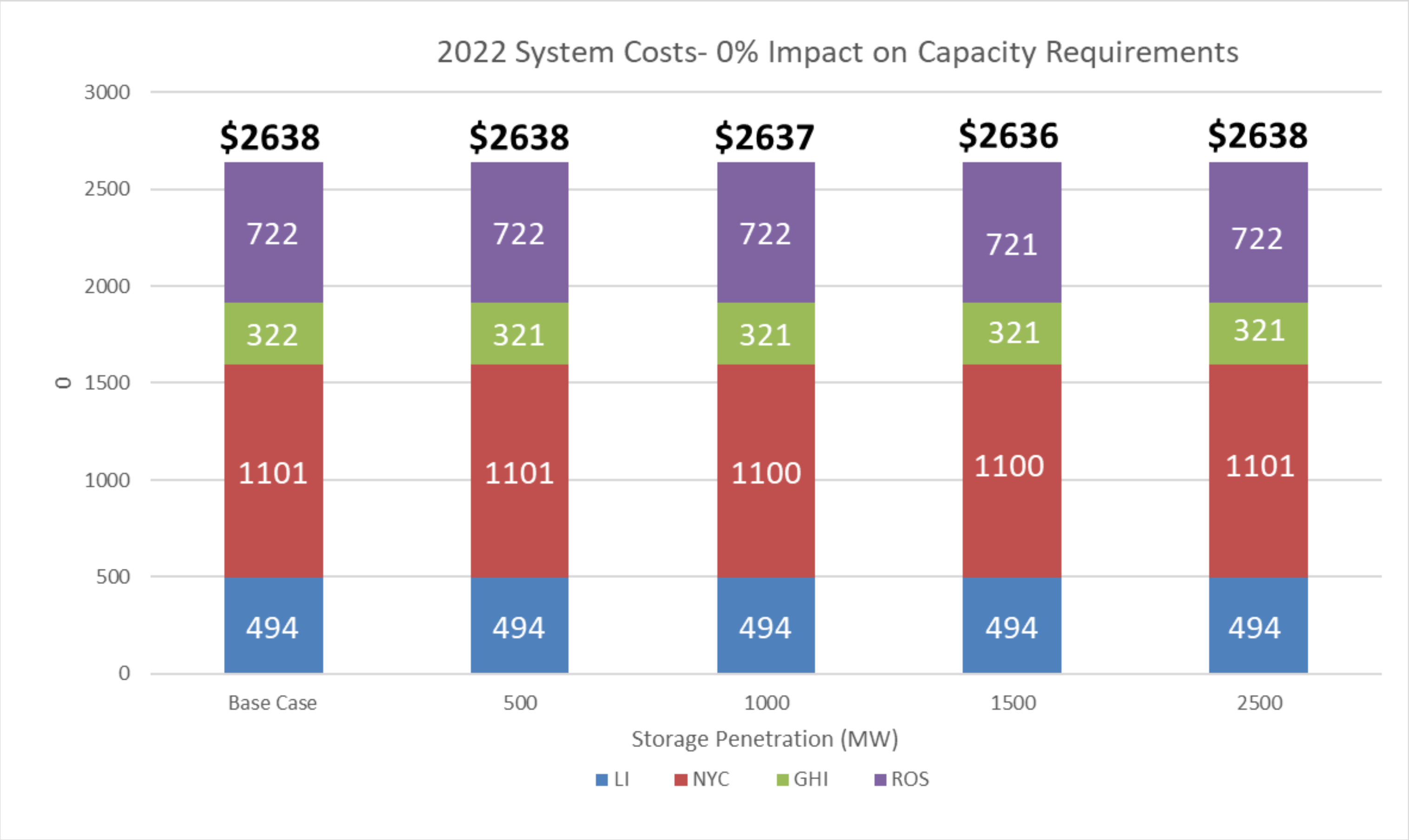

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Environmental Impacts

- **The increase in use of storage, especially during system peak times should reduce emissions**
  - It is anticipated that ESRs will withdraw energy from the grid at times of low LBMPs which generally correspond with low emission periods and discharge at times of high load volumes which would displace higher cost, likely higher emitting units.
- **Storage enabling greater adoption of renewables should further increase decarbonization**
- **Pairing storage with renewable should also reduce renewable curtailment and have a positive environmental impact**
- **Increased use of storage to provide ancillary services will add to carbon reduction**

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Reliability Impacts

- From an operational perspective, additional supply is a reliability benefit
- Depending on location within the system, ESRs may be in a position to provide local reliability services
- The flexibility of ESRs (withdrawing and charging) could be a reliability benefit
- Timing of withdrawal could add complexity in certain locations on the grid

Impact on Transparency

- No impact expected

Feedback?

- Email additional feedback to:
- deckels@nyiso.com

Questions?

We are here to help. Let us know if we can add anything.

The Mission of the New York Independent System Operator, in collaboration with its stakeholders, is to serve the public interest and provide benefits to consumers by:

- Maintaining and enhancing regional reliability
- Operating open, fair and competitive wholesale electricity markets
- Planning the power system for the future
- Providing factual information to policy makers, stakeholders and investors in the power system

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