The Impacts of High Intermittent Renewable Resources

On the Installed Reserve Margin for New York

DRAFT

New York State Reliability Council
Installed Capacity Subcommittee
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Executive Summary

New York State has clean energy initiatives that will result in thousands of megawatts ("MW") of additions of Front of the Meter photovoltaic ("FTM PV"), onshore wind, and offshore wind generation. The New York State Reliability Council (NYSRC) Executive Committee requested that the Installed Capacity Subcommittee("ICS"), with the support of the New York Independent System Operator, Inc. ("NYISO"), perform an analysis of the potential impact on the Installed Reserve Margin ("IRM") and locational capacity factors[1] from a hypothetical case in which the New York Control Area ("NYCA") has a high immediate penetration of intermittent renewable resources over the period May 2020 through April 2021 (2020 Capability Year). This period was selected because the model had already been developed for setting the 2020 IRM. This analysis calculated the amount of installed generating capacity necessary to operate the New York State electric grid without the probability of the unplanned shedding of load more than one day in ten years[2] under conditions where a large quantity of intermittent (*i.e.,* non-dispatchable) generation is present. This analysis is the first of several that will be needed to fully understand the impacts of increased renewable resource penetration on system reliability.

The study showed that the required NYCA IRM for the 2020 Capability Year would be 42.9% under the high renewable conditions analyzed. This IRM level satisfied the NYSRC and Northeast Power Coordinating Council (NPCC) resource adequacy criterion. The study determined corresponding locational capacity factors of 97.9% and 131.6% for New York City and Long Island, respectively. Together, these results mean that to meet New York's reliability standards, New York will need total installed capacity resources equal to 142.9% of peak load, with additional requirements for resources located in New York City of 97.9% of its peak load and Long Island of 131.6% of its peak load.

The study shows that to meet the resource adequacy criterion, the installed capacity quantity for New York State will need to increase by 24.3 percentage points, from the 118.6% 2020 IRM Study preliminary base case value to 142.9%. The increase in the installed capacity requirement is driven primarily by the intermittent characteristics of weather-dependent resources. The amount of the increase is predominantly a result of the lower availability of intermittent generators, which reduces the average availability of NYCA suppliers. If the introduction of the renewable resources were accompanied by retirement of higher availability traditional dispatchable resources, the average availability of the fleet would further decline, and the IRM and LCRs levels would correspondingly increase.

[1] The term 'locational capacity factors' used here is identified in the IRM Study Report as the 'preliminary LCRs' and is based on the Tan45 methodology. The NYISO establishes final LCRs using other methods.

[2] This design standard is more commonly referred to as the "0.1 days per year Loss of Load Expectation (0.1 LOLE standard)" in technical documents.

In addition, the efficacy of the renewable resources used in this study decreased with increased penetration rates as shown by the drops in UCAP values. The mechanism resulting in this decreased has not yet been determined.

Introduction

New York's electricity industry is transforming rapidly, from traditional, controllable fossil fuel generation to non-emitting, weather-dependent intermittent resources and distributed generation. These changes are driven primarily by State policies and technological advancements. New York State law requires that 70% of load be served from renewable resources by 2030.

Initial assessments of how to reliably serve electricity demand with increased renewables indicate that the primary challenge arises from the variability and intermittency of wind and FTM PV generation. As the penetration of those technologies increases, the grid will likely require more load-following capability, and possibly more fast-response and flexible resources that provide operating reserves to address expected and unexpected changes in net load. The grid will also require a substantial amount of installed reserve capacity that is available to serve load when wind and/or PV generation output is insufficient for periods that may range from hours to several days.

The daily and seasonal variability of eligible intermittent renewable resources compared to conventional resources creates challenges with regard to both the planning and operation of the New York State bulk power system. With the expectation of large-scale integration of renewable resources, the NYSRC is working with the NYISO to ensure that the tools and methods will be available to accurately model renewable resources to measure and maintain grid reliability.

To understand the resource adequacy impacts of increased future renewable facilities, this paper provides the results of a Loss of Load Expectation (LOLE) evaluation to determine the NYCA IRM assuming a hypothetical large-scale increase of onshore wind, offshore wind, and FTM PV generation in New York State. Results of this analysis will help inform the NYSRC in determining the need for new analytical methods, models, and reliability rules. The paper provides the methodology and modeling assumptions used in this evaluation.

It is vital to note that the large-scale integration of renewable resources will not happen independently of other changes to the bulk grid, including necessary transmission enhancements to the bulk and local networks to prevent renewable curtailments. In particular, it is expected that these resources will be complemented by energy storage resources ("ESRs"), such as batteries, as they continue to enter New York's bulk electric system. The NYISO and the NYSRC are exploring the ability of ESRs to offset the intermittent nature of renewable resources. This incremental approach may help inform analytic methods.

Study Overview

The study takes the New York electric system as assumed in the NYSRC 2020 IRM Study Preliminary Base Case ("PBC") and increases renewable capacity by a hypothetical 12,000 MW (4,000 each of FTM PV, onshore wind, and offshore wind). The additional capacity does not displace or replace any existing generators.[3]

Methodology

The NYSRC requested the NYISO to conduct the sensitivity analysis described in this white paper. The NYISO began the evaluation using the 2020 IRM Study preliminary base case (PBC) assumption[4], which satisfy the LOLE criterion that the probability of an unplanned disconnection of firm load due to resource deficiencies is, on average, no more than 0.1 days per year. For the purpose of this sensitivity analysis, an additional 4,000 MW each of onshore wind, offshore wind and FTM PV resources were added to the base case.

Location

The locations of Installed Capacity ("ICAP") placement for both FTM PV and onshore wind units were based on the projections of wind and solar installation represented in the New York State Department of Public Service's Clean Energy Standard Final Supplemental Environmental Impact Statement.[5] These projections were scaled up on a zonal basis to the requisite 4,000 MW for each resource type. The placements of offshore wind capacity were split evenly between Zones J and K. The Zonal ICAP values by resources represented in this sensitivity analysis are provided in Table 1.

[3] Should renewable generation displace existing resources, displaced resources would likely perform better than the system average (*i.e.,* the resources would have lower individual EFORds than the existing NYCA system EFORd). If this is the case, then the IRM calculated in this study under-estimates the IRM level that would be needed to meet the LOLE criterion.

[4] http://nysrc.org/pdf/MeetingMaterial/ICSMeetingMaterial/ICS%20Agenda%20222/IRM_2020_Assumption_Matrix_PBC_V2.1_approved[9894].pdf

[5] http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={424F3723-155F-4A75-BF3E-E575E6B0AFDC}

Table 1- ICAP added to PBC Assumptions by Resource Type (MW)

Zone	FTM PV	On-Shore Wind	Off-Shore Wind	Total
A	874	1,030		1,904
B				0
C	406	994		1,400
D		894		894
E		1,082		1,082
F	1,884			1,884
G	448			448
H				0
I				0
J			2,000	2,000
K	388		2,000	2,388
Total	4,000	4,000	4,000	12,000

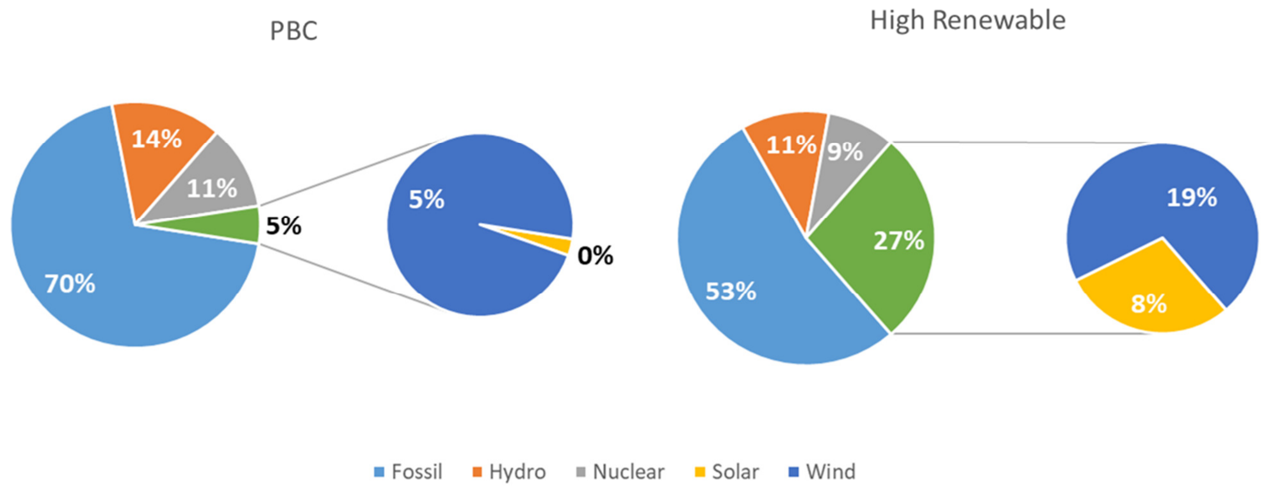
These additions are made to the renewable ICAP present in the 2020 PBC, seen in Table 2. The current system contains minimal FTM PV ICAP resources and no offshore wind resources.

Table 2 - Existing Renewable ICAP in PBC by Resource Type (MW)

Zone	FTM PV	On-Shore Wind	Off-Shore Wind	Total
A		179		179
B				0
C		513		513
D		678		678
E		522		522
F				0
G				0
H				0
I				0
J				0
K	57			57
Total	57	1,892	0	1,949

Figure 1 provides a comparison of the installed capacity mixes by fuel type for both the PBC and High Renewable scenarios.

Figure 1- ICAP Mix Comparison by Fuel



Data Preparation

For study data, the NYISO leveraged a host of sources for each resource. In order to prepare onshore wind data, the NYISO used five years of billing-quality meter data (January 1, 2014 to December 31, 2018), and utilized data from existing wind facilities with Capacity Resource Interconnection Service (CRIS) rights. This data and process is consistent with the PBC methods. The NYISO then scaled up zonal hourly generation profiles to model 4,000 MW of incremental on-shore wind.

For FTM PV data, the NYISO used normalized Congestion and Resource Integration Study (CARIS) 2019 FTM PV profiles, and scaled up the MW by zone. CARIS data was used because there is limited FTM PV wholesale production data, as most PV resources in New York are currently situated behind the meter and reflected in the net load forecast data. These data are based on National Renewable Energy Lab's (NREL) Solar Power Data for Integration Studies[6]. See the NYISO's 2019 CARIS 1 70x30 Scenario Development presentation for more information[7].

Offshore wind generation profiles were compiled by GE using the NREL Wind Toolkit data[7]. The data used in this study were derived from metrics such as meteorological conditions (*i.e.,* wind speed, temperature pressure) and power production modeled at three locations (NY Harbor in Zone J, and LI Shore and LI East End in Zone K), over the period 2007 to 2012. For more

[6] https://www.nrel.gov/grid/solar-power-data.html

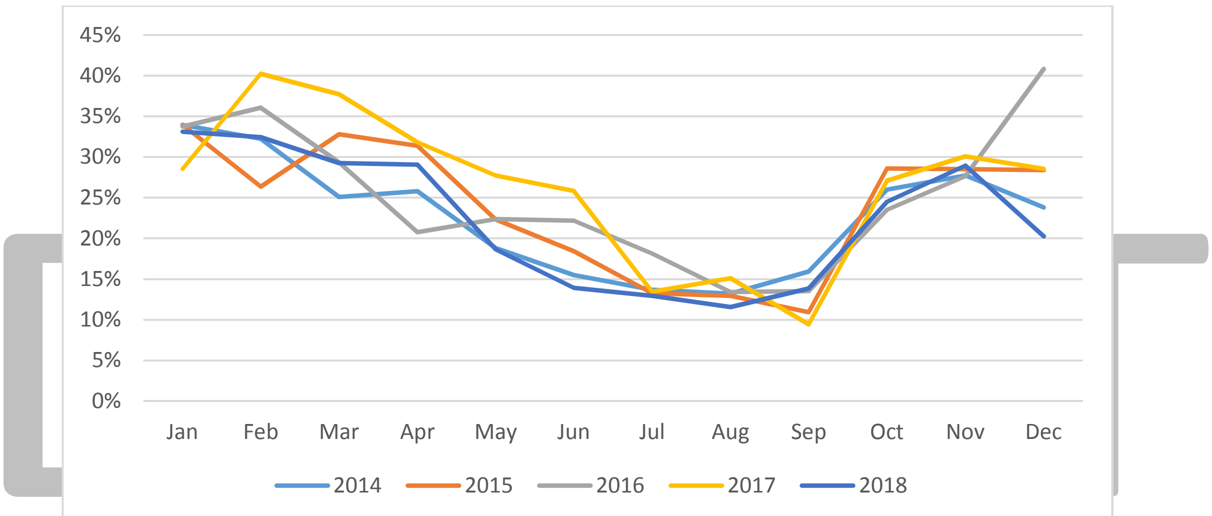
[7] *See* slides 12 – 32 of the following presentation http://nysrc.org/pdf/MeetingMaterial/ICSMeetingMaterial/ICS%20Agenda%20223/AI%205'%20-%20windsolar-v04.pdf

information, see the *2020 IRM High Renewable Sensitivity Assumptions*[8] presented to NYSRC. Note: Due to the variety of sources and years of data, the potential for coincident performance of different generation technologies was not evaluated in this study.

Performance Data and Unforced Capacity Ratings

NYISO currently credits incremental renewable generation based upon their Unforced Capacity ("UCAP") ratings, which in turn are derived from their average capacity factors during peak summer hours. Figures 2 through 4 below present projected performance data of each type of resource, which were derived from the data discussed above for hours between 2 p.m. and 6 p.m. for each month[9].

Figure 2- Onshore Wind Capacity Factor from 2PM to 6PM



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[8]http://nysrc.org/pdf/MeetingMaterial/ICSMeetingMaterial/ICS%20Agenda%20223/AI%205'%20-%20windsolar-v04.pdf

[9] Results were calculated in accordance with guidelines set forth in section 4.5 of the NYISO Installed Capacity Manual https://www.nyiso.com/documents/20142/2923301/icap_mnl.pdf/234db95c-9a91-66fe-7306-2900ef905338?t=1569860506857

Figure 3- BTM (Solar) PV Capacity Factor from 2PM to 6PM

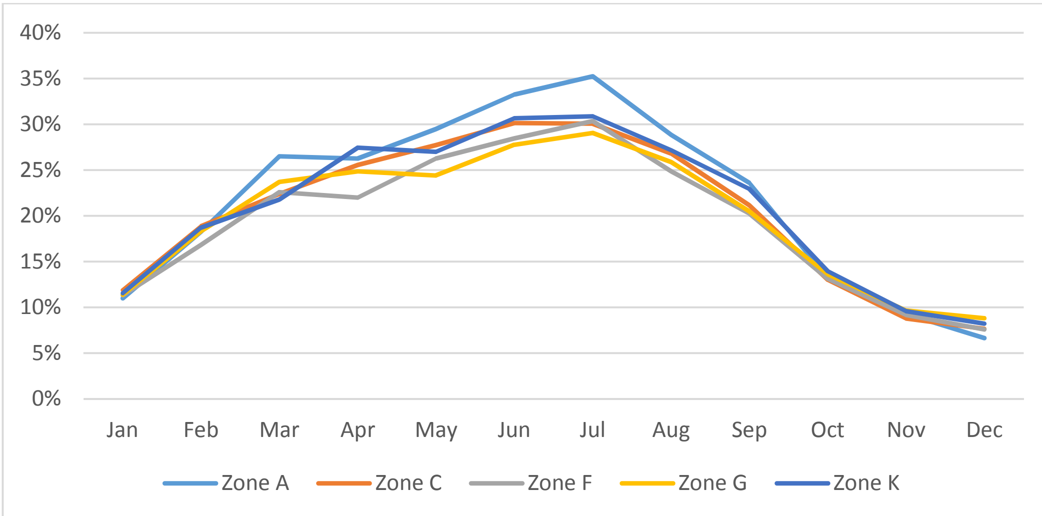
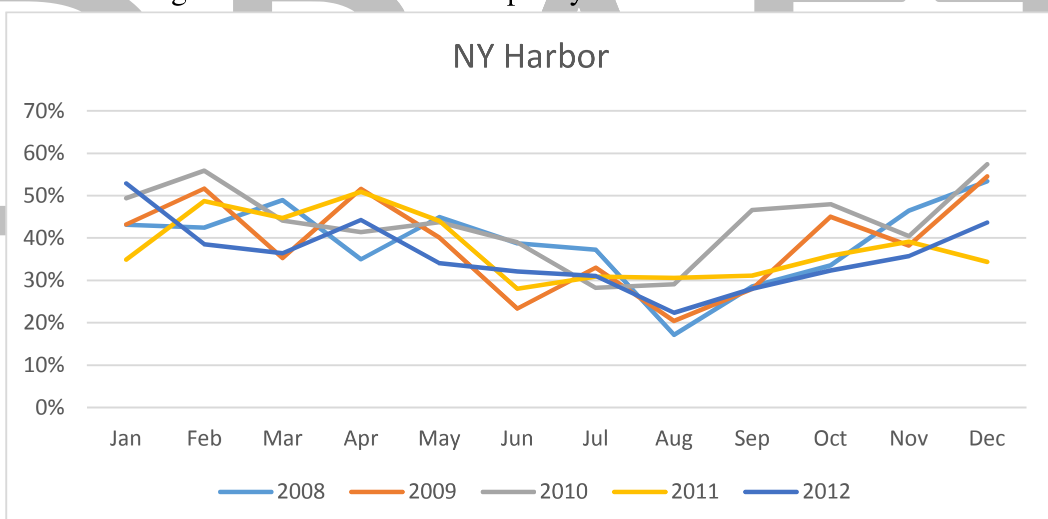
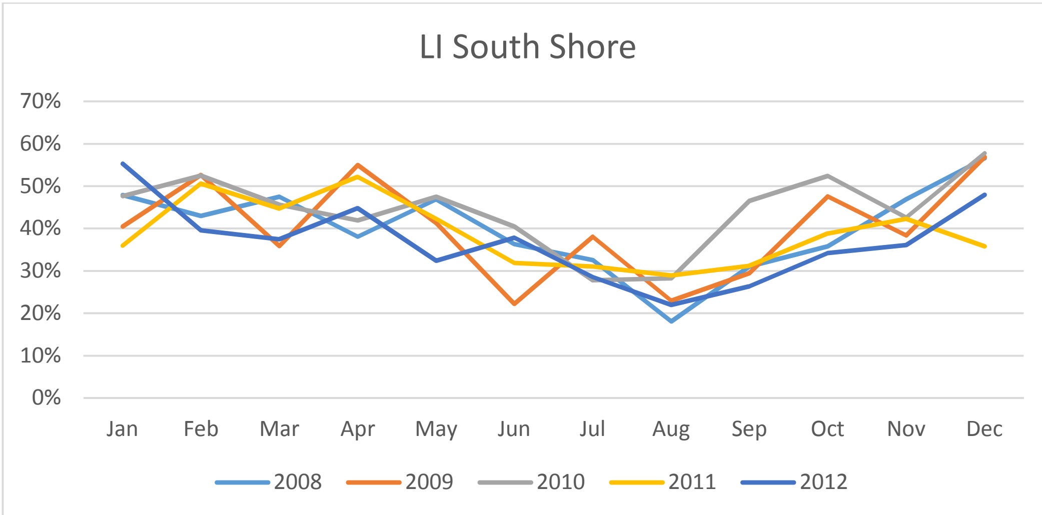
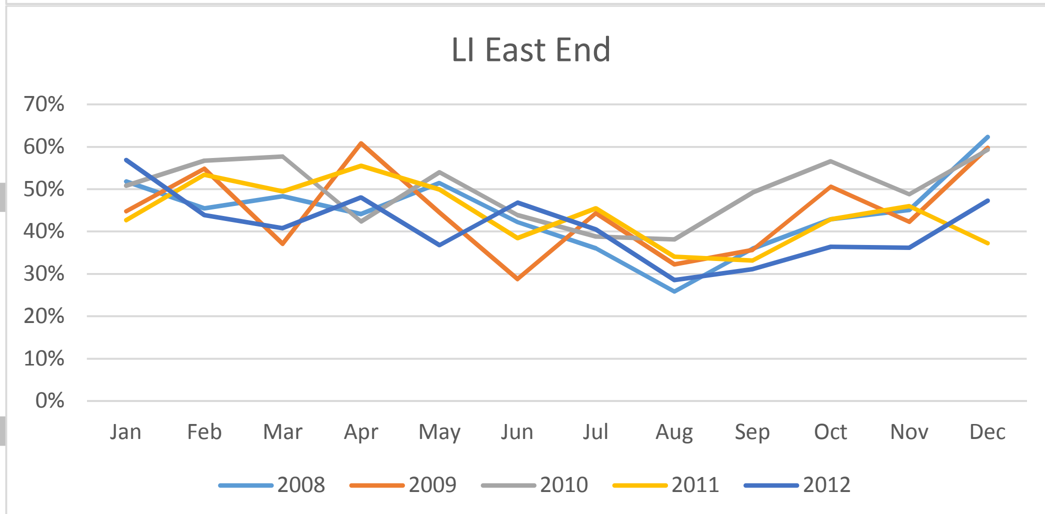


Figure 4- Offshore Wind Capacity Factor from 2PM to 6PM







The NYISO calculated corresponding summer zonal EFORds and UCAP ratings for these resources in accordance with guidelines set forth in section 4.5 of the NYISO Installed Capacity Manual. The data are provided in Tables 3 and 4 below.

Table 3- Zonal Production Factors of by Resource Type

Zone	**BTM PV**	**On-Shore Wind**	**Off-Shore Wind**
A-C	31%	15%	
D		14%	
E		17%	
F	28%		
G	28%		
J			29%
K	30%		34%
NYCA	**29%**	**16%**	**32%**

Table 4- UCAP added to PBC Assumptions by Resource Type(MW)

Zone	BTM PV	On-Shore Wind	Off-Shore Wind	Total UCAP
A-C	401	312		**713**
D		123		**123**
E		186		**186**
F	525			**525**
G	123			**123**
J			588	**588**
K	113		673	**788**
Total	**1,164**	**621**	**1,261**	**3,046**

Table 5 illustrates the effect that the addition of intermittent resources has on zonal and system-wide EFORds.

Table 5- System Zonal EFORds by Study

Area	PBC EFORds	High Renewable EFORdS
A	5%	28%
B	7%	7%
C	11%	24%
D	34%	50%
E	55%	69%
F	8%	37%
G	15%	23%
H	4%	4%
I	0%	0%
J	10%	21%
K	10%	27%
NYCA	**12%**	**26%**

Results

The high renewable resources case Tan45 analysis yielded an Installed Reserve Margin (IRM) of 42.9%, with corresponding locational capacity factors in Zones J and K of 97.9% and 131.6%, respectively.

Included in this analysis is a metric called the Unforced Capacity Reserve Margin, or URM. This value is the IRM translated to an UCAP basis considering the NYCA-wide forced outage ratings, based on the average of all capacity suppliers' forced outage ratings. The URM reported below uses forced outage rates consistent with the IRM study. For example, the forced outage rate is based on five-year performance data. The URM relates to the IRM through the following equation:

$$URM\ Requirement = \left[\left(1 + \frac{IRM\ Requirement\ (\%)}{100}\right) \times \left(1 - \frac{System\ EFORd\ (\%)}{100}\right) - 1\right] \times 100\%$$

$$URM = [(1 + 0.429) \times (1 - 0.264) - 1] \times 100\%$$

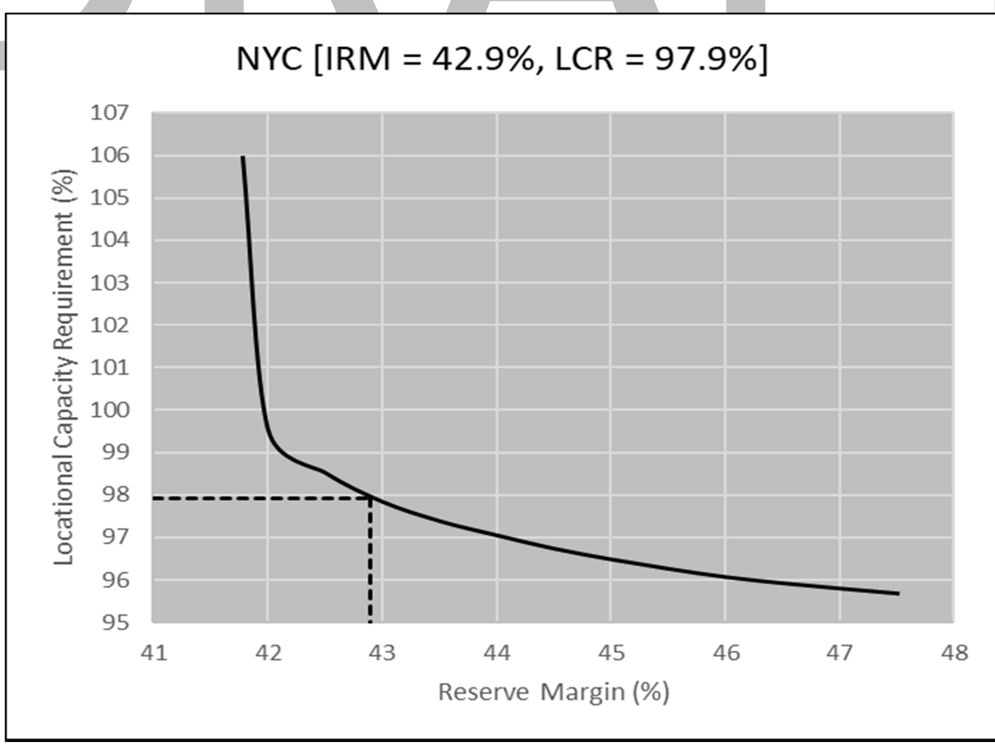
$$URM = 105.1\%$$

In comparison to the PBC's results, the High Renewable study yields a significantly higher IRM, in addition to significantly higher corresponding locational capacity factors. The IRM and LCRs are measured in terms of Installed Capacity. The URM, which is measured in terms of UCAP, rises slightly. Detailed comparison of the results of the two studies can be seen in Table 6.

Table 6- Resources Necessary to Meet 0.1 LOLE Standard as Percentage of Peak Load

Case	Statewide	URM	NYC	NYC URM	Long Island	LI URM
PBC	118.6%	104.7%	83.9%	75.5%	102.3%	92.1%
High Renewable	142.9%	105.1%	97.9%	77.8%	131.6%	95.5%

Figure 5- High Renewable Tan45 Curves



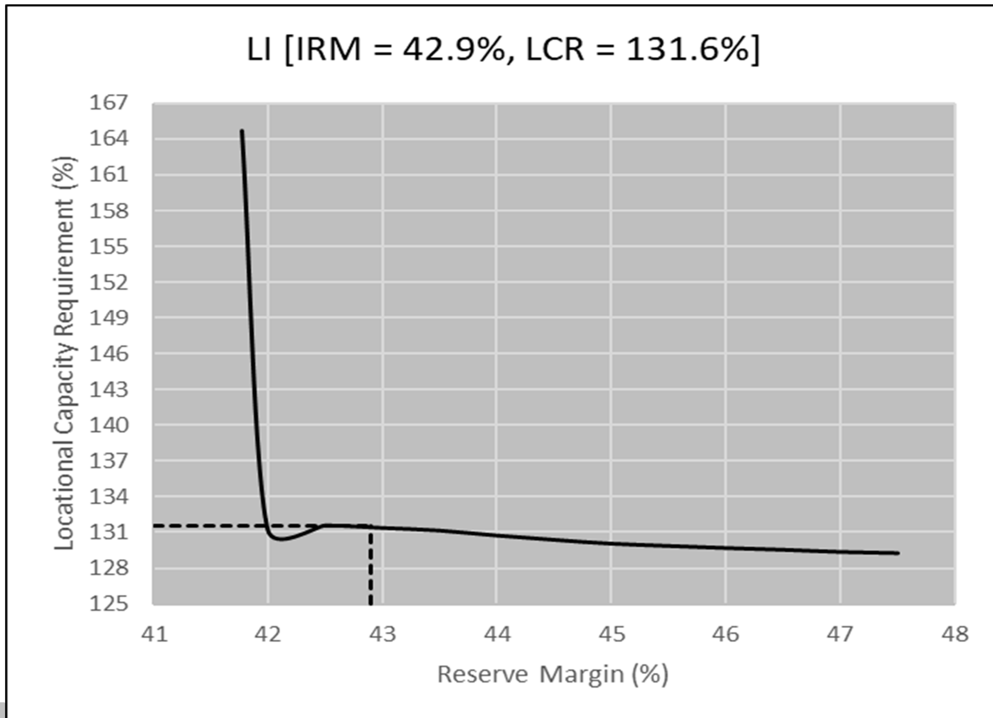


Figure 5 displays the Tan45 curves for both Zones J and K. The flatness of both curves suggests that, in this scenario, certain minimum levels of downstate capacity will be required (e.g., >130% of peak load in Long Island and >95% of peak load in New York City) regardless of the NYCA-wide reserve margin. These minimum capacity levels are substantially higher than historic Locational Minimum Installed Capacity Requirements for each Locality. The study also shows that the amount of needed UCAP will have a slight increase with the addition of significant renewables.

Additional metrics to gauge the reliability value changes in this scenario can be found in Table 7.

Table 7- Statewide changes from PBC to High Renewable Case

NYCA	Preliminary Base Case	High Renewable Sensitivity	Deltas
As Found[10] ICAP (MW)	42,465	54,465	+12,000
ICAP @ LOLE =0.1 (MW)	38,251	46,088	+7,837
ICAP Removed (MW)	4,213	8,376	+4,163
UCAP Removed (MW)	3,720	6,162	+2,442

[10] "As found" here refers to the sum of subtotal capacity of all internal NYCA generating units, contracts and net capacity imports with external control areas, and capacity associated with special care resources

Zone J			
As Found ICAP (MW)	10,348	12,348	+2,000
ICAP @ LOLE =0.1 (MW)	9,775	11,406	+1,631
ICAP Removed (MW)	573	942	+369
UCAP Removed (MW)	515	749	+233
Zone K			
As Found ICAP (MW)	6,133	8,521	+2,388
ICAP @ LOLE =0.1 (MW)	5,292	6,807	+1,515
ICAP Removed (MW)	841	1,714	+873
UCAP Removed (MW)	760	1,244	+484

This data shows that, for this scenario, adding 12,000 MW of intermittent renewables allows the approximate removal of an additional 4,200 MW of existing non-renewable ICAP and 2,400 MW of existing non-renewable UCAP from the NYCA system. Further, the addition of 4,388 MW of intermittent renewables downstate allows the removal of approximately 1,200 MW of ICAP and 700 MW of UCAP.

Most of the increase in the IRM and LCRs is a result of the lower availability of the intermittent resources that were added in the study.

It was observed that the change in UCAP was not consistent with the expectation that there should be no change in needed UCAP. For example, the study assumed 3,046 MW of UCAP added to the NYCA under existing unforced capacity rating methodologies, but this approach only allowed for the elimination of 2,442 MW of existing UCAP to meet the resource adequacy criterion.

Likewise, New York City and Long Island were assumed to increase by 588 MW and 788 MW of UCAP respectively, but those additions only enabled eliminating 233 MW and 344 MW of UCAP in Zones J and K respectively to meet the resource adequacy criterion.

Conclusions

1. This NYSRC high renewable resources study shows that adding a hypothetical 12,000 MW (4,000 MW each of FTM PV, onshore wind, and offshore wind) increases the installed reserve margin needed to meet New York State’s reliability standards by 24.3 percentage points, from the 18.6% 2020 IRM Study preliminary base case value to 42.9%. This study also determined corresponding increases in locational capacity factors of 14.0 and 29.3 percentage points for New York City and Long Island, respectively.

2. New York’s requirement of meeting 70% of its energy needs from renewable resources by the year 2030 will require additions of roughly twice the amount of intermittent resources considered in this analysis.
3. The increase in the Installed Reserve Margin is driven by the intermittent characteristics of weather-dependent resources. The amount of the increase is predominantly a result of the lower availability of intermittent generators reducing the average availability of NYCA suppliers. If the introduction of the additional renewable resources was accompanied by the retirement of higher availability traditional dispatchable resources, the average availability of the fleet would decline more, and the IRM and LCRs would correspondingly increase.
4. The efficacy of the renewable resources used in this study decreased with increased penetration rates as shown by the drops in UCAP values. The mechanism for this decreased has not yet been determined.

Recommendations

1. The study shows that 3,046 MW of UCAP resources would be added to the NYCA under existing unforced capacity rating methodologies, but that this addition allowed for the elimination of only 2,442 MW of UCAP to return the system to criteria. Likewise, NYC and Long Island were assumed to add 588 MW and 788 MW of UCAP respectively for the analysis, but those additions only enabled eliminating 233 MW and 344 MW of UCAP respectively to return the system to criteria. These results indicate that the reliability value of the added intermittent resources was less than expected and indicates a need for further analysis to understand what is driving the result.
2. The State also has plans for substantial Energy Storage Resources (ESR) that was not evaluated as part of this study. As MARS capability of modeling storage resources is improved, modeling of ESR should be added to future studies.
3. This study was performed using non-coincident annual generation shapes for FTM PV, onshore wind, and offshore wind. As more annual generation data is developed, these resource shapes should be aligned so that the study can evaluate the reliability risk of coincident periods of low renewable generation.
4. This study should be performed periodically as a function of experience with intermittent resources and plans for future developments. Additionally, the analysis should be refined as clean energy plans are further developed that include electrification of the entire economy, aggressive energy efficiency and higher customer load response, transmission expansion and reinforcements, and increases in renewable resources and energy storage and modeling of those resources.

Appendix – Additional Thoughts on Future Actions

- This analysis did not consider the need for additional transmission for transferring renewable energy to the grid. The comparatively high NYC (97.5%) and LI (131.6%) LCRs from the analysis illustrate this need. Future studies should consider this issue.
- The NYSRC and NYISO will need to examine the NYCA system risks that could occur under extreme but realistic contingencies associated with wind and solar resources because of the high level of uncertainty of weather and other factors that could impact their availability.
- Increasing ramping requirements will be needed because of the variability of high levels of renewable resources. We need to identify the resources necessary to meet such ramping concerns.
- The white paper should highlight the significant adverse UCAP impacts associated with high renewable penetration (*see* Recommendation 1 above), particularly in downstate New York.
- The method for computing the availability of intermittent renewable resources should be examined further.