The Impacts of High Intermittent Renewable Resources

On the Installed Reserve Margin for New York

(Final EC 252 - Approved on 4/9/20)

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. The addition of 12,000 MW of renewable generation over existing resources in the 2020 study, which include 1,949 MW of solar and onshore wind generation, was modelled.

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 results must be interpreted in qualitative terms because, among other reasons, the conditions at the time 12,000 MW of renewable resources have been added to the system will not be the same as the current system, the distribution of such resources will be different and their impact on retirements of existing resources was not considered.

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 2020 IRM Study preliminary base case value of 118.6% 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.

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[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.

The High Renewable scenario also resulted in a 2.4% increase in the amount of UCAP required as shown in the table below. This is equivalent to an increase in the URM (Unforced Capacity Reserve Margin) of 775 MW with NYCA's peak load for the study of 32,253 MW. Driving factors that contribute to the UCAP increase are the reliability value of intermittent resources with increased penetration levels, the location in which resources are added to the system which may exacerbate transmission constraints as well as the internal non-unique (necessarily based on assumptions) methodology of starting from a case "as is" to reach a minimum requirement case.

The following table summarizes the IRM and URM requirements calculated from the study for NYCA, Zone J and Zone K, and shows significant increases in all cases.

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

Case	NYCA IRM	NYCA URM	Zone J IRM	Zone J URM	Zone K IRM	Zone K URM
PBC	118.6%	105.0%	83.9%	74.2%	102.3%	93.5%
High Renewable	142.9%	107.4%	97.9%	77.2%	131.6%	99.4%
% Delta	24.3%	2.4%	14.0%	3.0%	29.30%	5.9%
MW Delta	7837	775	1631	355	1515	305

An important conclusion of this study is that meeting the 70% renewable goal will require about twice the number of renewables than in the High Renewable case studied which will further increase upward pressure on the IRM. The effect of Energy Storage Resources was not modeled in this study.

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

[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}

Zones J and K. The Zonal ICAP values by resources represented in this sensitivity analysis are provided in Table 1.

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**

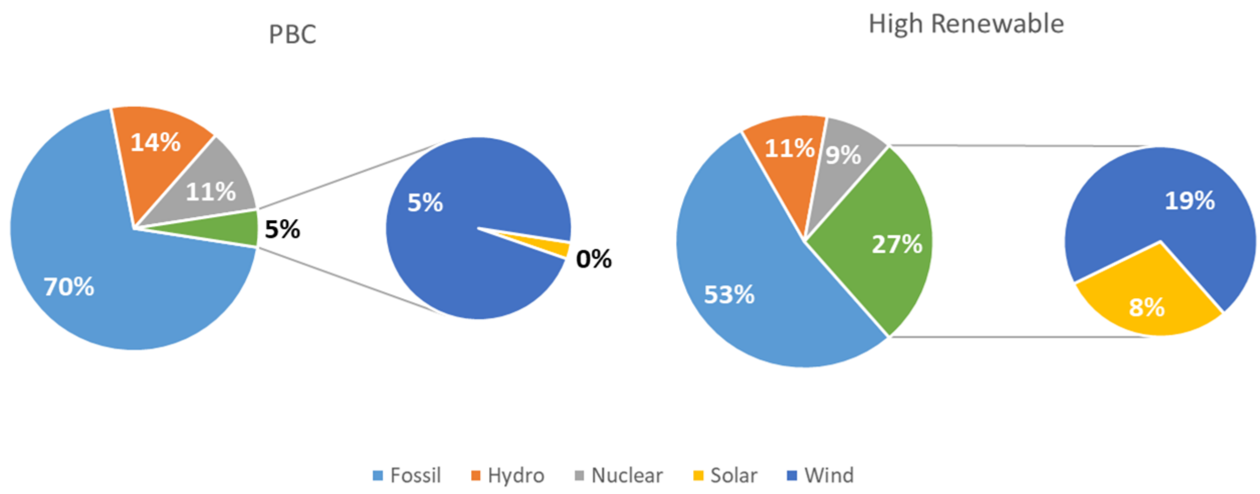
These additions are made to the renewable ICAP present in the 2020 PBC, seen in Table 2. The current system contains minimal FTM PV ICAP resources and no offshore wind resources.

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 information,

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

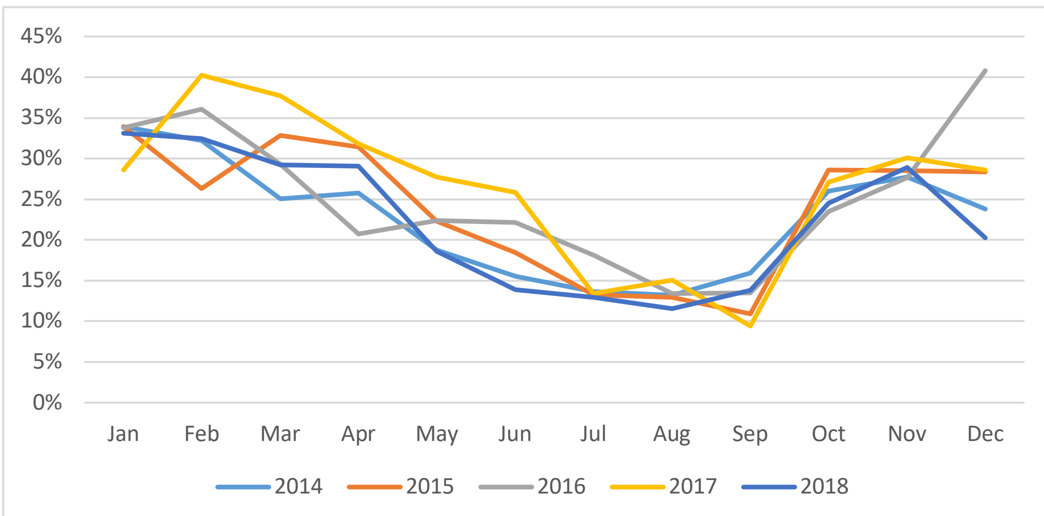
[7] *See* slides 12 – 32 of the following presentation http://nysrc.org/pdf/MeetingMaterial/ICSMeetingMaterial/ICS%20Agenda%20223/AI%205'%20-%20windsolar-v04.pdf

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



[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- Solar PV Capacity Factor from 2PM to 6PM

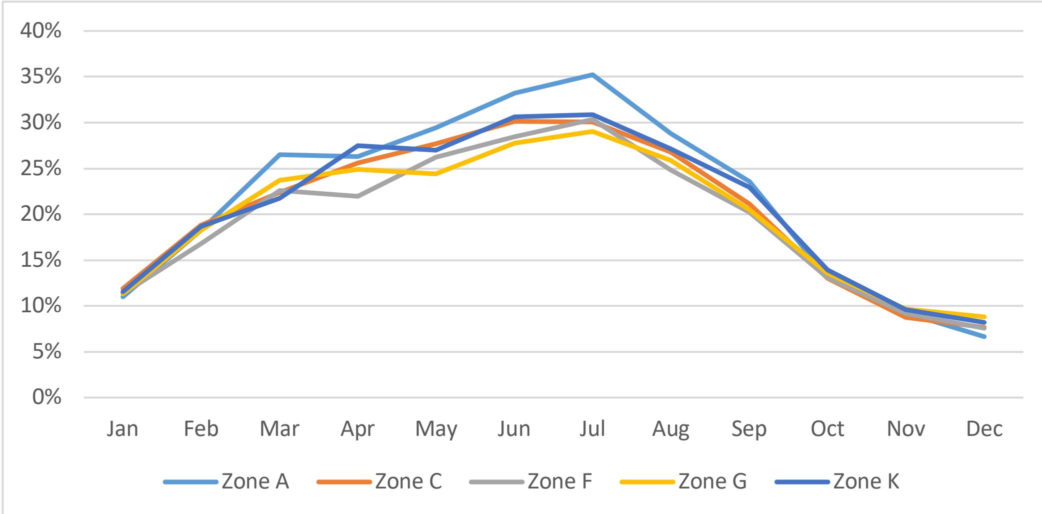
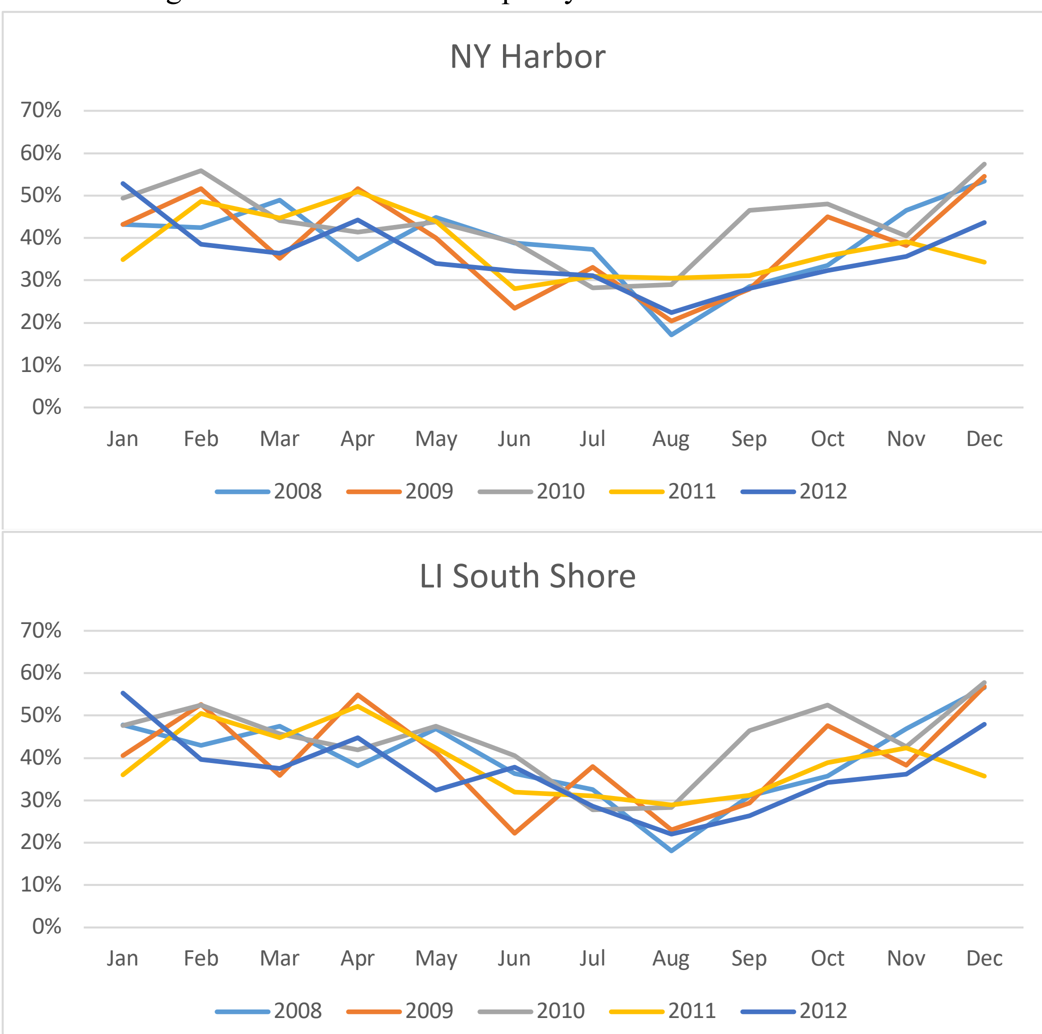


Figure 4- Offshore Wind Capacity Factor from 2PM to 6PM



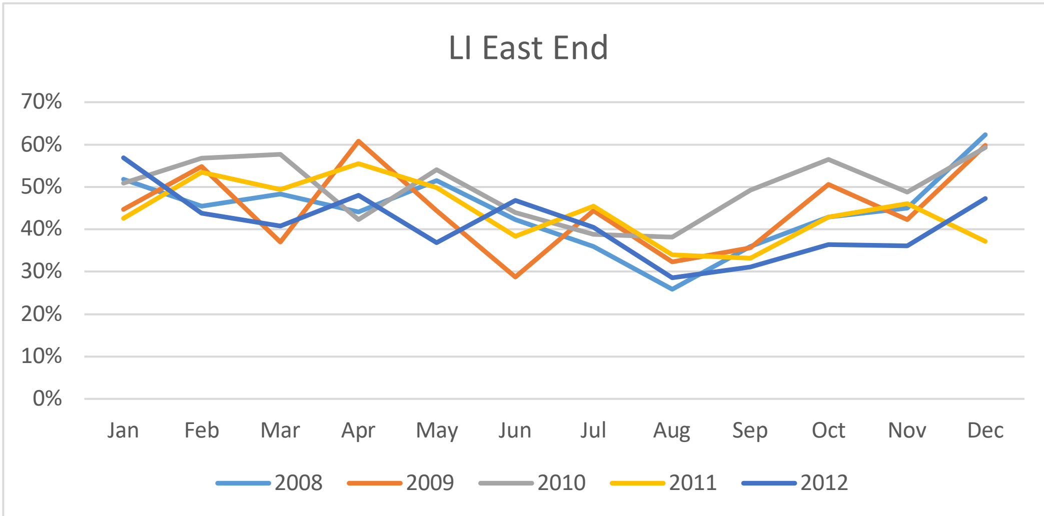

LI East End
70%
60%
50%
40%
30%
20%
10%
0%
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2008
2009
2010
2011
2012

Table 3 shows the summer zonal capacity factors as described above, while Table 4 shows the UCAP (MW) values of the added renewable resources.

Table 3- Zonal Production Factors by Resource Type

Zone	FTM 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	FTM 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. For example, the forced outage rate is based on five-year performance data. The URM relates to the IRM through the following equation:

$$URM = \frac{UCAP_{@0.1LOLE}}{Peak\ Load}$$

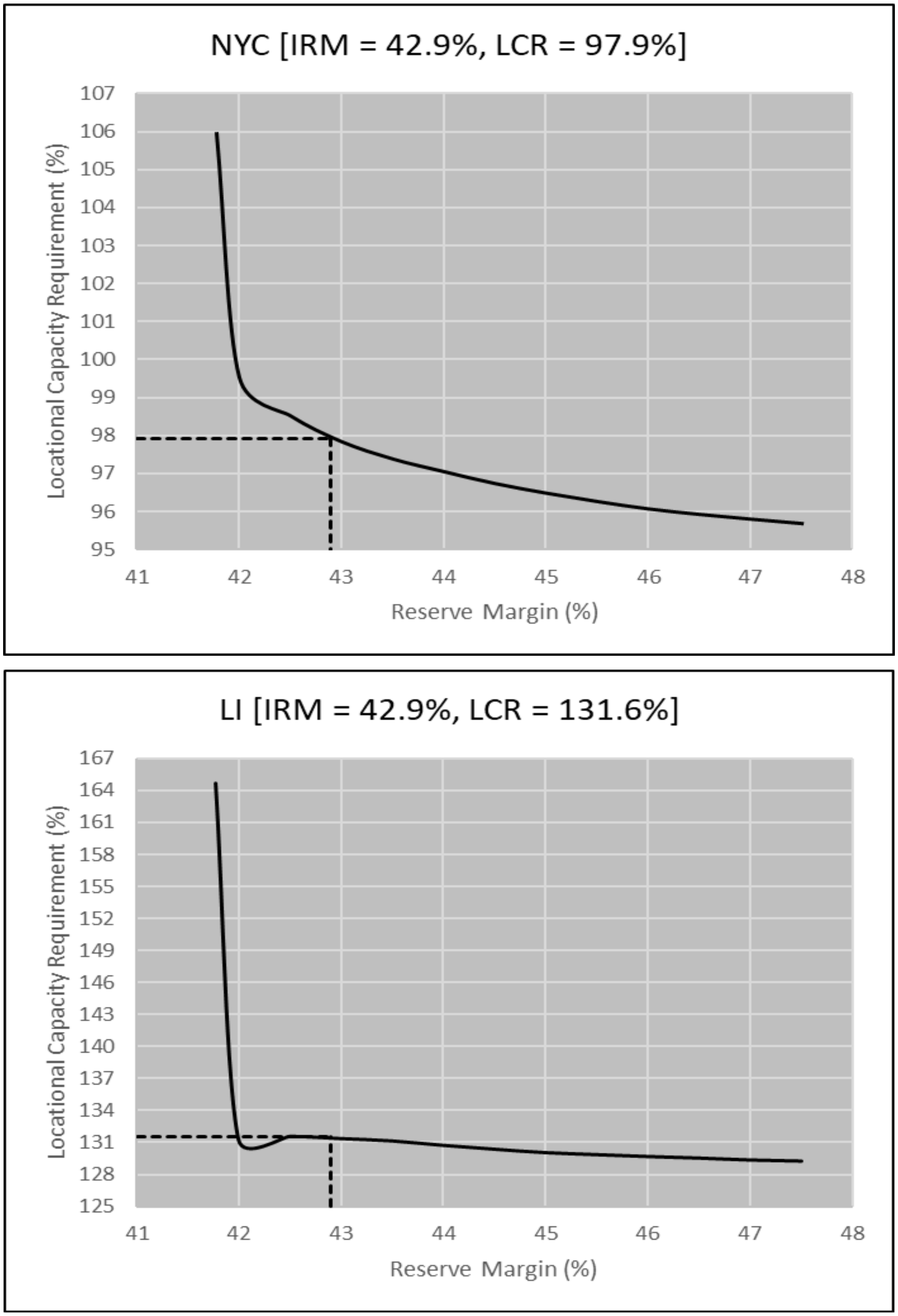
In comparison to the PBC's results, the High Renewable study yields a significantly higher IRM, in addition to significantly higher corresponding locational capacity factors. The IRM and LCRs are measured in terms of Installed Capacity. The URM, which is measured in terms of UCAP, rises significantly in all cases. 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	NYCA IRM	NYCA URM	Zone J IRM	Zone J URM	Zone K IRM	Zone K URM
PBC	118.6%	105.0%	83.9%	74.2%	102.3%	93.5%
High Renewable	142.9%	107.4%	97.9%	77.2%	131.6%	99.4%
% Delta	24.3%	2.4%	14.0%	3.0%	29.30%	5.9%
MW Delta	7837	775	1631	355	1515	305

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.

Figure 5- High Renewable Tan45 Curves



The impacts on capacity that result under the Preliminary Base Case (PB) and High Intermittent Renewable Resources (HR) scenario are shown in Tables 7a (ICAP) and 7b (UCAP). Table 7a shows five related ICAP metrics for NYCA, Zone J and Zone K in New York while Table 7b shows similar UCAP metrics.

Table 7a- Statewide ICAP changes from PBC to High Renewable Case

NYCA	Preliminary Base Case (PB)	High Renewable Sensitivity (HR)	Deltas
NYCA Peak Load (MW)	32,253	32,253	0
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
IRM (% of Peak Load)	118.6%	142.9%	+24.3%
Zone J			
Zone J Peak Load (MW)	11,651	11,651	0
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
IRM (% of Peak Load)	83.9%	97.9%	+14.0%
Zone K			
Zone K Peak Load (MW)	5,173	5,173	0
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
IRM (% of Peak Load)	102.3%	131.6%	+29.3%

The top row of Table 7a for the NYCA and each locality shows the peak load for the PB and HR cases. The second row shows the as-found quantity of ICAP modeled in the study. For example, row two of the NYCA section shows that in the PB case the NYCA contained 42,465 MW of ICAP, and in the HR case the NYCA contained 54,465 MW of ICAP. The addition of renewable

[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

resources causes the increase in the total as-found NYCA ICAP from 42,465 MW to 54,465 MW, an increase of 12,000 MW.

The third row of Table 7a for NYCA shows that currently 38,251 MW of capacity are needed in the PB case to meet the LOLE reliability criterion, and that under the HR case, 46,088 MW would be needed to meet the LOLE criterion, an increase of 7,837 MW.

The fourth row of Table 7a for NYCA is the difference between the third and second row and shows how much Installed Capacity (ICAP) can be removed from the as-found system without violating the LOLE criterion. An expectation is that 16,213 MW (12,000 + 4,213) of ICAP could be removed in the High Renewable Case if the intermittent resources added had the same performance characteristics as the as-found generation in the Preliminary Base Case. However, the results indicate that only 8,376 MW of ICAP could be removed in the HR case for an increase of 4,163 MW over the PB case value. This result is largely due to the lower availability (EFORd) of the intermittent generation and other factors discussed below.

The fifth row of Table 7a shows the IRM for NYCA and each locality obtained by dividing the capacity needed to meet the LOLE reliability criterion (row 3 values) by the peak load (row 1 values).

Table 7b shows similar results in terms of UCAP. It is noted that the total amount of UCAP in the Preliminary Base Case and the High Renewable Case should theoretically be similar considering the use of appropriate EFORd de-rating factors for each class of resource. However, Table 7b, row 3 indicates a NYCA increase in the High Renewable UCAP requirement of 775 MW. UCAP results for Zones J and K are also shown in Table 7b.

Table 7b- Statewide UCAP changes from PBC to High Renewable Case

NYCA	Preliminary Base Case (PB)	High Renewable Sensitivity (HR)	Deltas
NYCA Peak Load (MW)	32,253	32,253	0
As Found UCAP (MW)	37,465	40,509	+3,044
UCAP @ LOLE =0.1 (MW)	33,876	34,651	+775
UCAP Removed (MW)	3,589	5,857	+2,268
URM (% of Peak Load)	105.0%	107.4%	+2.4%
Zone J			
Zone J Peak Load (MW)	11,651	11,651	0
As Found UCAP (MW)	9,158	9,746	+588
UCAP @ LOLE =0.1 (MW)	8,643	8,998	+355
UCAP Removed (MW)	515	748	+233
URM (% of Peak Load)	74.2%	77.2%	+3.0%
Zone K			
Zone K Peak Load (MW)	5,173	5,173	0
As Found UCAP (MW)	5,597	6,386	+789
UCAP @ LOLE =0.1 (MW)	4,837	5,142	+305
UCAP Removed (MW)	760	1,244	+484
URM (% of Peak Load)	93.5%	99.4%	+5.9%

This data shows that, for this HR scenario, adding 12,000 MW of intermittent renewables increases the NYCA, Zone J and Zone K IRMs by 24.3%, 14.0% and 29.3% respectively, and increases the NYCA, Zone J and Zone K URMs by 2.4%, 3.0% and 5.9% respectively. Most of the increase in the IRMs is a result of the lower availability of the intermittent resources that were added in the study.

The drivers of the increased UCAP requirements include 1) The methodology-dependent dynamic reliability value of intermittent resources required to meet loss of load events 2) the location of renewable resources added to the system which can cause transmission constraints 3) the location of the added renewable resources also impacts the ratios by which the tangent 45 method removes and shifts capacity to bring the system to LOLE criterion which can further exacerbate transmission constraints and 4) the fact that the IRM process requires that the system "as is" is taken to a minimum requirement state for which there is no unique or perfect path to achieve this, with each depending on a set of assumptions.

Conclusions

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 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). The results must be interpreted in qualitative terms because, among other reasons, the conditions at the time 12,000 MW of renewable resources have been added to the system will not be the same as the current system, the distribution of such resources will be different and their impact on retirements of existing resources was not considered. With this caveat, the analysis concluded:

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. This NYSRC high renewable resources study also showed an increase in the unforced capacity reserve margin (URM) for NYCA of 2.4 percentage points, and corresponding increases in URM of 3.0 and 5.9 percentage points for New York City and Long Island, respectively.
3. 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.
4. 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.

Recommendations

1. It is recommended that the increased IRM and UCAP values required to meet reliability standards in the high renewables case in this analysis be further examined in order to determine the impact of EFORd assumptions and other factors, and refine the model, as required.
2. 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.

3. The State 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.
4. 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.

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 (97.9%) 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 method for computing the availability of intermittent renewable resources should be examined further.