High Renewable Resource Modeling White Paper

New York State Reliability Council –

Installed Capacity Subcommittee

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Executive Summary

New York State has ambitious clean energy milestones that it aims to reach over the coming years and decades. In order to understand the potential impact of fulfilling those goals on electric reliability in the state, the New York State Reliability Council (NYSRC) and New York Independent System Operator, Inc. (NYISO) analyzed a hypothetical case in which the New York Control Area had a high penetration of intermittent renewable resources over the period May 2020 through April 2021 (2020 Capability Year). This analysis consisted of calculating the amount of installed generating capacity necessary to operate the New York State electric grid without the probability of shedding load more than one day in ten years[1] under conditions where a large quantity of intermittent (*i.e.*, non-dispatchable) generation are present.

The study showed that the required NYCA IRM for the 2020 Capability Year would be 42.9% under the high renewable conditions set forth in this study. This IRM level satisfied the NYSRC and Northeast Power Coordinating Council resource adequacy criteria of a Loss of Load Expectation of no greater than 0.1 days per year. This study also determined corresponding *preliminary* Locational Capacity Requirements of 97.9% and 131.6% for New York City on Long Island, respectively. That means 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 High Renewable study shows to meet New York State's reliability standards that the installed capacity quantity for New York will need to increase by 24.3%, from the 118.6% preliminary base case value to 142.9%. The increase in the capacity requirement is driven by the intermittent characteristics of weather-dependent resources, which require backup generator to serve load when those weather-dependent resources are not producing energy.

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, but also by technological advancements that are expanding the possibilities of new resources and lowering their costs. New York State law aims to serve 70% of load with energy generated from renewables by 2030. Our initial

[1] 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.

assessments of how to reliability serve electricity demand with this electricity mix indicates that the primary challenge arises from the variability and intermittency of wind and solar generation. As the penetration of those technologies increases, the grid will likely need 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 need a substantial amount of installed reserve capacity that is available to serve load when wind and/or solar generation output is insufficient for periods that may range from minutes to several days.

Today, intermittent renewable resources participate in the NYISO -administered energy and capacity markets. The intermittent nature of certain renewable resources compared to conventional resources creates challenges with regard to both the planning and operation of the New York State bulk power system. Because of the potential of large-scale integration of renewable resources, NYSRC is working with the NYISO to ensure reliability, and that tools and methods will be available to accurately model renewable resources for measuring grid reliability.

To obtain an understanding of the reliability impacts of future renewable facilities in terms of resource adequacy, this paper provides the results of a Loss of Load Expectation (LOLE) evaluation to determine the New York Control Area (NYCA) Installed Reserve Margin (IRM) assuming a hypothetical large-scale increase of on-shore wind, off-shore wind, and solar facilities in New York. Results of this analysis will help inform the NYSRC and the NYISO to determine the need for new procedures and reliability rules. The paper provides the methodology and modeling assumptions used in this evaluation.

The NYSRC and the NYISO will together continue to look for ways to integrate intermittent renewable resources into New York's wholesale electricity markets while maintaining reliability and resource adequacy for New York electric consumers.

It is vital to note that the large-scale integration of renewable resources will not happen independently of other changes to the bulk grid. In particular, these resources are expected to 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.

Study Overview

The study takes the New York electric system as assumed in the NYSRC 2020 IRM Study Preliminary Base Case ("PBC"), and adds 12,000 MW of renewable capacity to it. The additional capacity does not displace or replace any existing generators.[2] Note, ESRs may have a profound effect on how high renewable penetration impacts New York's reliability, and in fact, the NYSRC and NYISO are exploring methods to incorporate duration-limited resources into the IRM study and LCR study.

[2] Should renewable generation displace existing resources, displaced resources would likely be better performers than the system average (i.e. the resources would have lower individual EFORds than the NYCA system EFORd). If this is the case, then the IRM calculated in this study is thought to be an underestimation.

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Methodology

The NYSRC requested the NYISO to conduct the sensitivity analysis described in this white paper. The NYISO began the evaluation using the PBC assumptions, which satisfies 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 on-shore wind, off-shore wind and in-front-of-the-meter (FTM) solar resources were added to the base case.

Location

The location of ICAP placement for both solar PV and on-shore wind units was 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[3]. These projections were scaled up on a zonal basis to the requisite 4,000 MW for each resource type. The placement of offshore ICAP was split evenly between Zones J and K. The Zonal ICAP values by resource represented in this sensitivity analysis can be found in Table 1. Zones B, H, and I were not included this table because they have neither existing nor projected renewable ICAP.

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

Zone	Solar	On-Shore	Off-Shore	Total
A	874	1,030		**1,904**
C	406	994		**1,400**
D		894		**894**
E		1,082		**1,082**
F	1,884			**1,884**
G	448			**448**
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. There is currently minimal FTM solar ICAP resources and no off-shore wind resources. Zones B, H, and I were not included this table because they have neither existing nor projected renewable ICAP.

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

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

Zone	Solar	On-Shore	Off-Shore	Total
A	0	179	0	**179**
C	0	513	0	**513**
D	0	678	0	**678**
E	0	522	0	**522**
F	0	0	0	**0**
G	0	0	0	**0**
J	0	0	0	**0**
K	57	0	0	**57**
Total	**57**	**1,892**	**0**	**1,949**

Data Preparation

For the data utilized for this study, the NYISO leveraged a host of sources for each resource. In order to prepare on-shore wind data, the NYISO used five years of billing-quality meter data (January 1st, 2014 to December 31st, 2018), and utilized data from wind facilities that had CRIS rights. This is the data and process used to prepare the PBC. The NYISO then scaled up production curves to model 4,000 MW of incremental on-shore wind.

For solar data, the NYISO used normalized CARIS 2019 solar PV profiles, and scaled up the MW by zone. CARIS data was used because there is limited FTM wholesale production data, as most solar resources in New York are situated behind the meter and reflected in the net load forecast data. This data is based on NREL's *Solar Power Data for Integration Studies*[4]. See the NYISO's *2019 CARIS 1 70x30 Scenario Development*[5] presentation for more information.

Offshore wind data were prepared in conjunction with NREL and GE. The data used in this study was 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, see the *2020 IRM High Renewable Sensitivity Assumptions*[6] presented to NYSRC.

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

[5] https://www.nyiso.com/documents/20142/8263756/07%20CARIS1_70x30ScenarioDevelopment.pdf/ab02dbff-69b0-0b2f-04da-8e9d0bd74b76

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

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Note: Due to the variety of sources and years of data, coincident performance of technology was not considered in this study.

Performance Data and Unforced Capacity Ratings

Projected performance data of each resource were derived from the data discussed above, and used to determine the market based reliability value of the resources. Monthly capacity factors for these resources were calculated in accordance with guidelines set forth in section 4.5 of the NYISO Installed Capacity Manual[7]. These values can be seen in the Figures 1 through 3 below.

Figure 1- Onshore Wind Capacity Factor from 2PM to 6PM

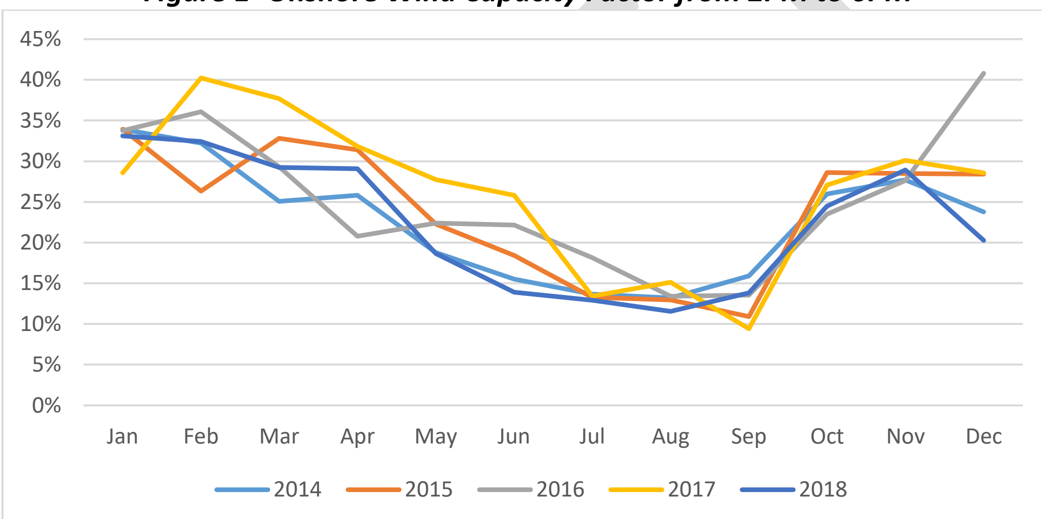
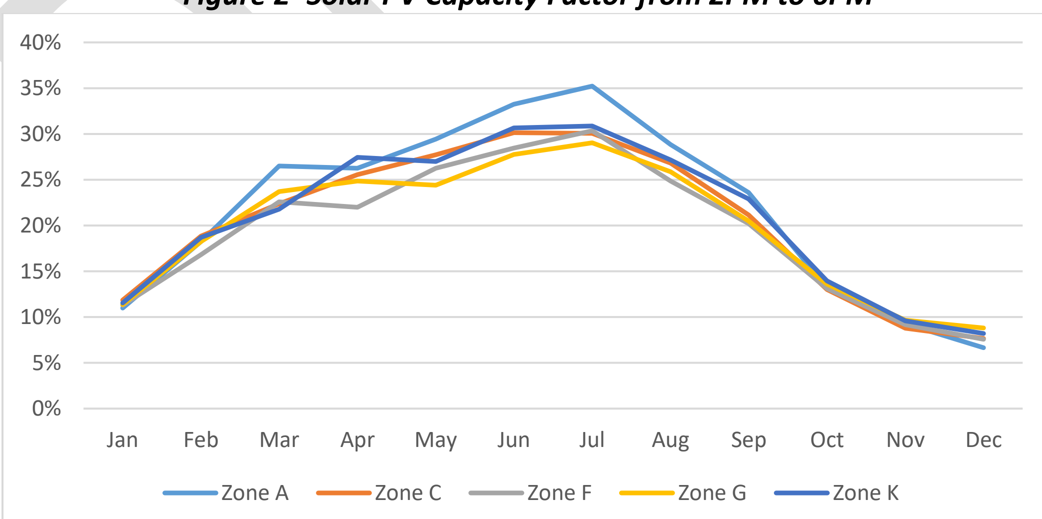
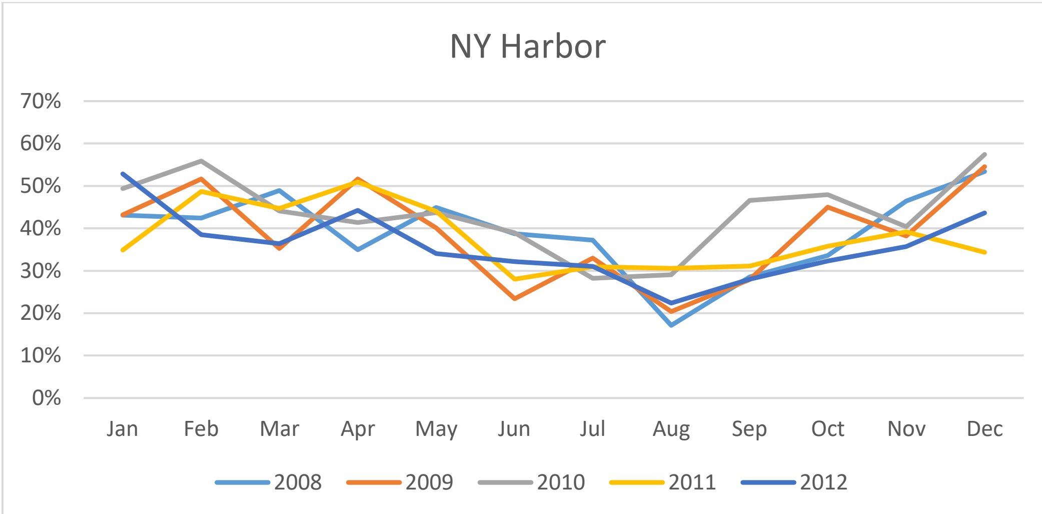


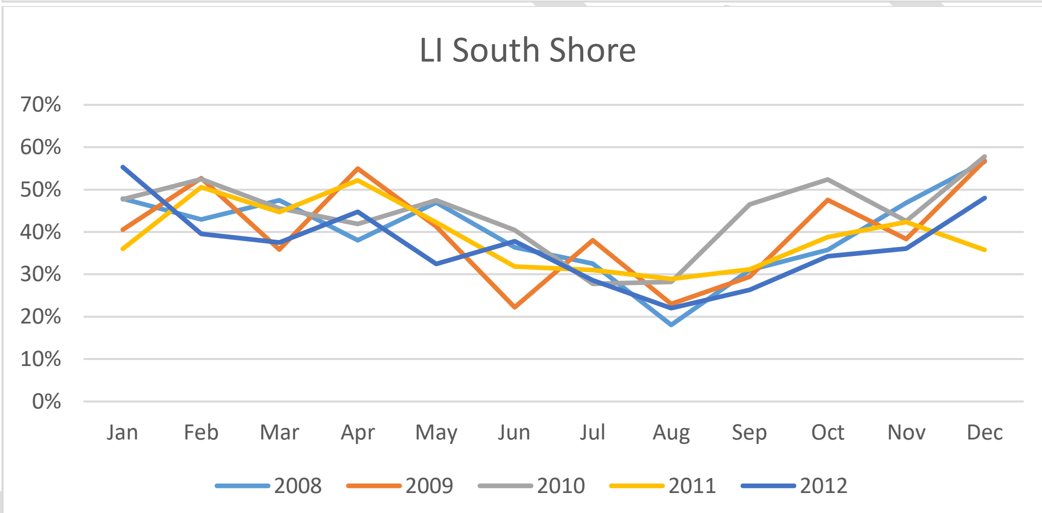
Figure 2- Solar PV Capacity Factor from 2PM to 6PM

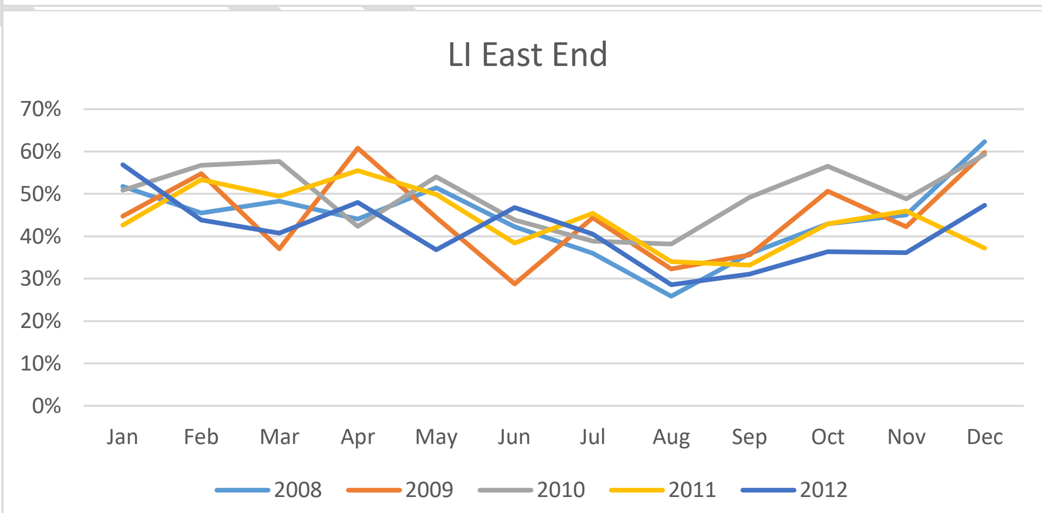


[7] https://www.nyiso.com/documents/20142/2923301/icap_mnl.pdf/234db95c-9a91-66fe-7306-2900ef905338?t=1569860506857

Figure 3- Offshore Wind Capacity Factor from 2PM to 6PM







The corresponding zonal EFORds and UCAP ratings for these resources were calculated in accordance with guidelines set forth in section 4.5 of the NYISO Installed Capacity Manual. Zones B, H, and I were not included this table because they have neither existing nor projected renewable ICAP.

Table 3- Zonal Production Factors of by Resource Type

Zone	Solar	On-Shore	Off-Shore
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	Solar	On-Shore	Off-Shore	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 below illustrates the effect that the addition of intermittent resources has on zonal and system-wide EFORds.

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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 case Tan45 analysis yielded an Installed Reserve Margin (IRM) of 42.9%, with corresponding margins in Zones J and K of 97.9% and 131.6%, respectively.

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
High Renewable	142.9%	105.1%	97.9%	77.8%	131.6%	95.5%
PBC	118.6%	104.7%	83.9%	75.5%	102.3%	92.1%

****URM is defined below***

In comparison to the PBC's results, the High Renewable study yields a significantly higher IRM, in addition to significantly higher corresponding locational margins. One metric that did not change significantly is the URM. Detailed comparison of the results of the two studies can be seen in Table 6.

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

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

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

$$URM = 105.1\%$$

Figure 4- High Renewable Tan45 Curves

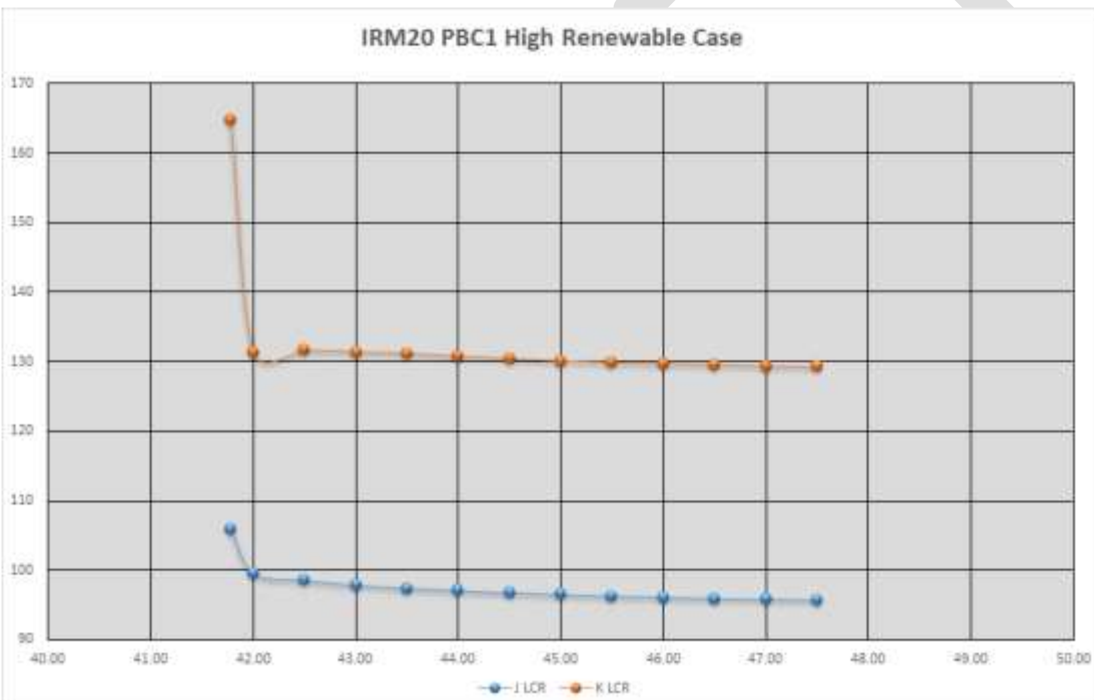

Figure 4 displays the Tan45 curves for both Zones J and K. The flatness of both curves suggests that, in this scenario, certain minimum levels of downstate capacity will be required (e.g., >130% of peak load in Long Island and >95% of peak load in New York City) regardless of the NYCA-wide reserve margin. These minimum capacity levels are substantially higher than historic Locational Minimum Installed Capacity Requirements for each Locality. At the same time, minimum capacity levels required in downstate are likely to depend on the resources added to NYC and LI (2,000 MW of offshore wind was assumed to interconnect into each LI and NYC for this analysis).

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[8] 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
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 ICAP and 2,400 MW of 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 downstate.

[8] "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