

# APPENDIX A

## Unified Methodology Description

### 1.0 Introduction

Appendix A describes a procedure to develop the statewide Installed Reserve Margin (IRM) versus Minimum Locational Capacity Requirements (LCRs) curves. Within the New York Control Area (NYCA) there are currently two zones identified as localities to which this procedure would apply. They are the New York City and Long Island zones.

### 2.0 Initial Conditions

2.1. A Multi-Area Reliability Simulation (MARS) base case database exists for the upcoming capability year.

2.2. Localities in the NYCA that require minimum LCR have been

“as forecast” capacities and “as forecast” loads? meaning “forecast capacities and forecast loads?”

2.3. Any capacities that have been added, removed, or shifted to arrive at the base case for the IRM study should be reset to the “as found” case before initiating this procedure. This procedure should start with “as forecast” capacities, and “as forecast” loads.

### 3.0 Preliminary calculations

The procedure described in this appendix requires the calculation of capacities as “perfect” capacity, i.e. UCAP. In order to convert the amount of ICAP to an equivalent UCAP for each zone, the following factors are needed. These factors need to be calculated only once and can be used for the rest of the study.

3.1. Calculation of the Weighted Average Forced Outage Rate (WFOR) for each zone

- If external contracts are modeled as external contracts,

Weighted Average Forced Outage Rate (WFOR<sub>m</sub>) for zone m =

$$\left( \frac{G_1 \cdot FOR_1 + G_2 \cdot FOR_2 + \dots + G_n \cdot FOR_n + SCRs \cdot FOR_{SCRs} + ExternalContracts \cdot FOR_{contracts}}{\text{Where } G_1 + G_2 + \dots + G_n + SCRs + ExternalContracts} \right)$$

$$G_m = \text{Total Resources in Zone } m = \text{Generation}_m + SCRs_m + ExternalContracts_m$$

Note: UDRs are treated as local generation

- If external contracts are modeled by derating the ties,

Weighted Average Forced Outage Rate (WFOR<sub>m</sub>) for zone m =

$$\left( \frac{G_1 \cdot FOR_1 + G_2 \cdot FOR_2 + \dots + G_n \cdot FOR_n + SCRs \cdot FOR_{SCRs}}{G_1 + G_2 + \dots + G_n + SCRs} \right)$$

$$G_m = \text{Total Resources in Zone } m = \text{Generation}_m + SCRs_m$$

- SCRs and external contracts are also included since they are part of the mix of resources that count towards the IRM calculation.

### 3.2. Calculation of the Zonal Excess Ratio (R) for each zone

$$\text{Excess Capacity (UCAP) for Zone } m = \Delta GL_m = G_m \cdot (1 - WFOR_m) - Load_m$$

$$\text{Excess Capacity Ratio (UCAP) for Zone } m = R_m = \frac{\Delta GL_m}{\sum \Delta GL_n}$$

Where Zone m is one of the capacity rich zones, and  $\sum \Delta GL_n$  is the sum of excess capacity (UCAP) for all the capacity rich zones.

Example: If Zones A, C, D are the capacity rich zones, then

$$\text{Excess Capacity Ratio (UCAP) for Zone A} = R_A = \frac{\Delta GL_A}{\Delta GL_A + \Delta GL_C + \Delta GL_D}$$

## 4.0 Procedure for determining target capacities to be removed from capacity rich zones for a desired study reserve margin (SRM)

Add or remove installed capacity (ICAP) from zones west of the Total East Interface that have excess capacity reserves (capacity rich zones) until the statewide capacity to peak load ratio equals the desired study reserve margin (SRM) point.

4.1. The total ICAP to be added or removed to arrive at the desired study reserve margin (SRM) is:

$$\begin{array}{l} \text{Total NYCA Gen (ICAP)} \\ \text{to be Removed or} \\ \text{Added} \end{array} = (1 + \text{SRM}) * \begin{array}{l} \text{Total NYCA} \\ \text{Load} \end{array} - \begin{array}{l} \text{Total NYCA} \\ \text{Generation} \\ \text{(ICAP)} \end{array} - \begin{array}{l} \text{Total NYCA} \\ \text{SCR (ICAP)} \end{array}$$

4.2. A portion of this total ICAP will be added to or removed from capacity rich zones based on their UCAP excess capacities.

4.3. The amount of UCAP to be added to or removed from each capacity rich zone is calculated based on their UCAP excess capacity ratios and their weighted forced outage rates, obtained in Section 3.0. The apportioned UCAP capacity for each capacity rich zone can be calculated using the following formula:

$$X_m = \frac{X}{\sum_n \frac{R_n}{1 - WFOR_n}} R_m$$

Where X is the total amount of ICAP to be added to or removed from capacity rich zones for the desired SRM,  
 $X_m$  is the amount of UCAP to be added to or removed from zone m, which is one of the capacity rich zones  
 $R_m$  and  $WFOR_m$  is the Excess Capacity Ratio (UCAP) and the Weighted Forced Outage Rate for zone m determined using the steps in Section 3.

Example: If Zones A, C, D are the capacity rich zones and X MW of ICAP generation is to be removed from these zones, then the equivalent amount of UCAP to be removed from zone A is:

$$X_A = \frac{X}{\frac{R_A}{1-WFOR_A} + \frac{R_C}{1-WFOR_C} + \frac{R_D}{1-WFOR_D}} R_A$$

- 4.4. The amount of UCAP capacity to be added to or removed from each capacity rich zone is inputted to the respective entry in the MOD-MDMW table of the MARS program, which will added or removed the amount of UCAP from each of the capacity rich zones before simulation. If the generation is to be removed from the zones, the amount should be negative. If the amounts are to be added to the zones, the amount should be positive.
- 4.5. The correct amount of ICAP added to or removed from NYCA should be verified by performing a single iteration MARS run using the capacity adjusted model, checking the total capacity from the MARS 07 output file, and calculating the achieved reserve margin.
- 4.6. Run a MARS simulation until the standard error of the LOLE index is less than or equal to 0.05 or when the maximum number of replications has been reached. (Note, since the NYCA model may converge well before the usual 1500 replications, a minimum number of iteration may be specified to ensure a minimum number of samples is collected.)
- 4.7. Record the NYCA LOLE risk (and the risk in all NYCA zones).

Probably don't need the risk in all

## 5.0 Determination of the initial target capacity for each locality

The initial target capacity for a locality is defined as the maximum capacity that can be added to or removed from the locality to yield a NYCA LOLE risk of 0.1 days/year, while all other zones and localities remain unchanged.

- 5.1. Using the capacity adjusted base case from Section 4 as the base model, if the LOLE for the base case is less than 0.1 days/year, remove a trial amount of ICAP from the locality being considered; if the LOLE for the base case is greater than 0.1 days/year, add a trial amount of ICAP to the locality being considered.
- 5.2. The UCAP amount to be added to or removed from the locality, say zone m, is equal to the trial amount (ICAP), say X, multiplied by  $(1 - WFOR_m)$ . For example, if zone J is the locality being considered, the UCAP amount for zone J to be entered in the MOD-MDMW table would be  $X \cdot (1 - WFOR_J)$ , where  $WFOR_J$  is the weighted forced outage rate for zone J as described in Section 3.
- 5.3. To maintain the same SRM for the study, if capacity is added to or removed from the locality, the same ICAP amount should be removed from or added to the capacity rich zones respectively using the steps outlined in Section 4.
- 5.4. Run a MARS simulation until the standard error of the LOLE index is less than or equal to 0.05 or when the maximum number of replications has been reached.

- 5.5. If the NYCA LOLE is below 0.1 days/year, remove additional capacity from the locality being considered and add the same ICAP amount to the capacity rich zones using the steps in Section 4.
- 5.6. If the NYCA LOLE is above 0.1 days/year, add additional capacity to the locality being considered and remove the same ICAP amount from the capacity rich zones using the steps in Section 4.
- 5.7. Repeat steps in Sections 5.1 to 5.6 until the NYCA LOLE reaches 0.1 days/year or within an acceptable range. Record the total amount of ICAP added to or removed from the locality being considered. This is the initial target capacity for the locality.
- 5.8. If a NYCA LOLE of 0.1 days/year cannot be achieved either by shifting capacity to or from the locality, the desired SRM is not achievable and a new SRM should be selected and repeat steps in Section 4.
- 5.9. If a NYCA LOLE of 0.1 days/year is achieved for the locality, repeat the steps in Section 5.1 to 5.8 for each identified locality and record the amount of ICAP capacity shift for each of these zones. These are the initial target capacities for the zones. (Make sure that before considering a new locality, reset the model to the original capacity adjusted base case, i.e. with the desired reserve margin, as described in Section 5.1)

## **6.0 Determination of the capacity multiplier for each locality**

The capacity multiplier for an identified locality is the initial target capacity, obtained in Section 5, divided by the sum of the initial target capacities for all the identified localities. For example, if zones 1 and 2 are the only two localities identified, and the initial target capacities for zones 1 and 2 are 300 MW and 100 MW respectively, then the capacity multiplier for zone 1 would be  $300/400$  or 0.75, while the capacity multiplier for zone 2 would be  $100/400$  or 0.25.

## **7.0 Determination of the actual capacity removal or addition for each locality**

- 7.1. Using the capacity adjusted base case from Section 4 as the base model, i.e. a proper amount of capacity has been removed from or added to the capacity rich zones to achieve the desired SRM, based on the initial LOLE risk obtained in Section 4.7, estimate a total trial amount of ICAP to be added to or removed from the identified localities.
- 7.2. This trial amount of capacity will be removed from or added to the identified localities using the capacity multipliers obtained in previous steps. For example, using the example in Section 5.0, if 1000 MW is to be removed from zones 1 and 2, then the amount of ICAP to be removed from zone 1 would be  $1000 * 0.75$  or 750 MW, and for zone 2, 250 MW respectively.
- 7.3. The equivalent amount of UCAP for each locality is then entered into the respective entries in the MARS' MOD-MDMW table for each identified locality. The equivalent amount of UCAP for each locality is given by:  $UCAP = ICAP * (1 - WFOR)$ .
- 7.4. To maintain the desired SRM, the same amount of capacity must be added to or removed from the capacity rich zones. The amount of equivalent UCAP to be added to

each of the capacity rich zones given the total amount of ICAP can be obtained using the same steps described in Section 4.3.

- 7.5. Run a MARS simulation until the standard error of the LOLE index is less than or equal to 0.05 or when the maximum number of replications has been reached. Record the NYCA LOLE risk.
- 7.6. If the NYCA LOLE risk is below 0.1 days/year, remove additional capacities from the identified localities. Repeat Sections 7.1 to 7.5 until the NYCA LOLE reaches 0.1 days/year or within an acceptable range.
- 7.7. If the NYCA LOLE risk is above 0.1 days/year, remove less capacities from (or add capacities to) the identified localities. Repeat Sections 7.1 to 7.5 until the NYCA LOLE reaches 0.1 days/year or within an acceptable range.
- 7.8. Once the NYCA LOLE reaches 0.1 days/year or within the acceptable range, record the amount of ICAP removed from or added to each identified locality. The remaining amount of ICAP in each identified locality can be calculated by subtracting the respective amount from the total generation in the locality.

## 8.0 Determination of the locational capacity requirement (LCR) for each identified locality

The location capacity requirement (LCR) for the desired SRM for each identified locality is the ratio, expressed as a percentage, of the remaining amount of ICAP in each identified locality, obtained in Section 7.8, to the peak load forecast of the locality.

## 9.0 Determination of the LCR-IRM curves

Repeat Sections 4.0 to 8.0 to provide the resulting LCRs for a range of reserve margins. The results will be used to plot the LCR-IRM curves and determine the desired NYCA LCR-IRM as described in Appendix B.

## 10.0 Illustration of the capacity shifting methodology

Several examples are provided below to illustrate the methodology described in Sections 3 to 9.

### 10.1. Calculation of Weighted Forced Outage Rates (WFOR) for a zone

- Example 1: Zone D with 1000MW wind generation
  - Load = 754 MW
  - Wind Generation = 1,000 MW (EFOR = 0.9)
  - Regular Generation = 1,271 MW (EFOR = 0.052)

$$WFOR_D = \frac{\sum_{i=1}^n G_{iD} \cdot EFOR_{iD}}{\sum_{i=1}^n G_{iD}} = \frac{(1271) \cdot (0.0520) + (1000) \cdot (0.9000)}{(1271) + (1000)} = 0.4253$$

- Example 2: Zone D with 10,000MW wind generation  
Load = 754 MW  
Wind Generation = 10,000 MW (EFOR = 0.9)  
Regular Generation = 1,271 MW (EFOR = 0.052)

$$WFOR_D = \frac{\sum_{i=1}^n G_{iD} \cdot EFOR_{iD}}{\sum_{i=1}^n G_{iD}} = \frac{(1271) \cdot (0.0520) + (10000) \cdot (0.9000)}{(1271) + (10000)} = 0.8043$$

## 10.2. Calculation of zonal perfect (UCAP) excess capacities

- Example 1: Zones A, C, and D (with 1,000MW wind generation)

	<b>A</b>	<b>C</b>	<b>D</b>
<b>Load</b>	2701	3114	754
<b>Gen</b>	5014	6707	2271
<b>WFOR</b>	0.0593	0.0290	0.4253
<b><math>\Delta GL_i</math></b>	2015	3399	551

- Example calculation for zone D.  
 $\Delta GL_D = G_D \cdot (1 - WFOR_D) - Load_D = (1271 + 1000) \cdot (1 - 0.4253) - 754 = 551$
- Example 2: Zones A, C, and D (with 10,000MW wind generation).

	<b>A</b>	<b>C</b>	<b>D</b>
<b>Load</b>	2701	3114	754
<b>Gen</b>	5014	6707	11271
<b>WFOR</b>	0.0593	0.0290	0.8043
<b><math>\Delta GL_i</math></b>	2015	3399	1451

- Example calculation for zone D.  
 $\Delta GL_D = G_D \cdot (1 - WFOR_D) - Load_D = (1271 + 10000) \cdot (1 - 0.8043) - 754 = 1451$

## 10.3. Calculation of zonal excess capacity ratios

- Example 1: Zones A, C, and D (with 1,000MW wind generation)

	<b>A</b>	<b>C</b>	<b>D</b>
<b><math>\Delta GL_i</math></b>	2015	3399	551
<b><math>R_i</math></b>	33.78%	56.98%	9.24%

- Example calculation for zone D.

$$R_D = \frac{\Delta GL_D}{\Delta GL_A + \Delta GL_C + \Delta GL_D} = \frac{551}{2015 + 3399 + 551} = \frac{551}{5965} = 9.24\%$$

- Example 2: Zones A, C, and D (with 10,000MW wind generation).

	<b>A</b>	<b>C</b>	<b>D</b>
$\Delta GL_i$	2015	3399	1451
$R_i$	29.35%	49.51%	21.14%

- Example calculation for zone D.

$$R_D = \frac{\Delta GL_D}{\Delta GL_A + \Delta GL_C + \Delta GL_D} = \frac{1451}{2015 + 3399 + 1451} = \frac{1451}{6865} = 21.14\%$$

#### 10.4. Calculation of UCAP to be added to or removed from each zone (values to be inputted to the MOD-MDMW table in MARS)

- Example 1: 1000 MW is to be removed from Zones A, C, and D (with 1,000MW wind generation)

	<b>A</b>	<b>C</b>	<b>D</b>
<b>WFOR</b>	0.0593	0.0290	0.4253
$R_i$	33.78%	56.98%	9.24%
<b>MDMW Entry<sub>i</sub></b>	-305.27	-514.87	-83.49

- Example calculation for zone D.

$$X_{UCAP_D} = \frac{X_{Total\ ICAP\ to\ be\ removed}}{\left( \frac{R_A}{1 - EFOR_A} + \frac{R_C}{1 - EFOR_C} + \frac{R_D}{1 - EFOR_D} \right)} \cdot R_D$$

$$= \frac{1000}{\left( \frac{0.3378}{1 - 0.0593} + \frac{0.5698}{1 - 0.0290} + \frac{0.0924}{1 - 0.4253} \right)} \cdot 0.0924 = 89.49$$

- Since it is a removal of capacity, this number will be entered in the MOD-MDMW table as -89.49MW
- Example 2: 1000 MW is to be removed from Zones A, C, and D (with 10,000MW wind generation).

	<b>A</b>	<b>C</b>	<b>D</b>
<b>WFOR</b>	0.0593	0.0290	0.8043
$R_i$	29.35%	49.51%	21.14%
<b>MDMW Entry<sub>i</sub></b>	-154.32	-260.27	-111.14

- Example calculation for zone D.

$$X_{UCAP_D} = \frac{1000}{\left( \frac{0.2935}{1 - 0.0593} + \frac{0.4951}{1 - 0.0290} + \frac{0.2114}{1 - 0.8043} \right)} \cdot 0.2114 = 111.14$$

- Since it is a removal of capacity, this number will be entered in the MOD-MDMW table as -111.14MW

### 10.5. Verification of results

- Example 1: Total and zonal ICAP and UCAP removal for Zones A, C, and D (with 1,000MW wind generation)

	<b>A</b>	<b>C</b>	<b>D</b>	<b>Total</b>
<b>WFOR</b>	0.0593	0.0290	0.4253	
<b>MDMW Entry<sub>i</sub> (UCAP)</b>	-305.27	-514.87	-83.49	-903.61
<b>ICAP Amount</b>	-324.51	-530.24	-145.25	-1000.00

- Example calculation for zone D.

$$X_{ICAP_D} = \frac{X_{UCAP_D}}{1 - WFOR_D} = \frac{-83.47}{1 - 0.0593} = 145.25$$

- The total amount of UCAP removed from A, C and D is 903.61MW and when converted back to ICAP yields exactly 1,000MW as was expected.
- Example 2: Total and zonal ICAP and UCAP removal for Zones A, C, and D (with 10,000MW wind generation).

	<b>A</b>	<b>C</b>	<b>D</b>	<b>Total</b>
<b>WFOR</b>	0.0593	0.0290	0.8043	
<b>MDMW Entry<sub>i</sub> (UCAP)</b>	-154.32	-260.27	-111.14	-525.70
<b>ICAP Amount</b>	-164.04	-268.05	-567.91	-1000.00

- Example calculation for zone D.

$$X_{ICAP_D} = \frac{X_{UCAP_D}}{1 - WFOR_D} = \frac{-111.14}{1 - 0.8043} = 567.91$$

- The total amount of UCAP removed from A, C and D is 525.70MW and when converted back to ICAP yields exactly 1,000MW as was expected.
- The total UCAP removed in example 2 is less than that in example 1 because the weighted forced outage rate for zone D is much higher, increased from 0.4253 (with 1,000MW of wind generation) to 0.8043 (with 10,000MW of wind generation), due to the larger amount of unreliable wind generation (EFOR = 0.9).

### 10.6. Summary of the methodology to shift capacities from the localities to capacity rich zones

- Let X be the total capacity (MW) to be removed from zones J and K and added to capacity riched zones of A, C, and D; let X<sub>J</sub> and X<sub>K</sub> be the amount of ICAP to be removed from zones J and K based on the capacity multipliers calculated in Section 6.
- Step 1: Calculate X<sub>J</sub>.(1 – WFOR<sub>J</sub>) and X<sub>K</sub>.(1 – WFOR<sub>K</sub>); these are the UCAP values for zones J and K to be inputed to the MOD-MDMW table for the removal of the specified capacities. These values should be negative.
- Step 2: Calculate the UCAP split for the capacity rich zones, A, C and D for a total ICAP addition of X MW as described in Section 3. These values are

inputed to the MOD-MDMW table for the addition of these capacities to the zones. These values should be positive and should be added on top of whatever the original entries are. The original entries most likely contains some negative values as a result of removing capacities from zones A, C and D to arrive at the study reserve margin.