

Methodology to Shift Resources From and to Zones A,C,D,J, and K.

The following is an example of the recommended methodology to add, remove, and shift resources from/to zones A, C, and D when using the MOD-MDMW table in the GE-MARS model for the IRM calculations. These calculations do not include the impact of external resources or firm contracts into these areas:

Definitions:

1) Zonal Weighted Average Forced Outage Rate

If external contracts are modeled as external contracts:

Weighted Average Forced Outage Rate for Zone i (WFOR)_i =

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

G_i = Total Resources in Zone i = Generation_i + SCR_s_i + ExternalContracts_i

Note: UDRs are treated as local generation.

If external contracts are modeled by derating the ties:

Weighted Average Forced Outage Rate for Zone i (WFOR)_i =

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

G_i = Total Resources in Zone i = Generation_i + SCR_i

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

2) Zonal Perfect Excess Capacity = $\Delta GL_i = G_i \cdot (1 - WFOR_i) - Load_i$

3) Zonal Excess Ratio for Zone A = $R_A = \frac{\Delta GL_A}{\Delta GL_A + \Delta GL_C + \Delta GL_D}$

The zonal excess ratio needs to be calculated in terms of perfect capacity (UCAP) because it is not possible to remove large amounts of capacity from a zone that has a large average FOR (like in the case of wind), since there is not enough effective excess capacity to be removed before the zone becomes resource deficient.

For example, if 1000 MW of wind generation is installed in Zone D, the maximum amount of perfect generation that can be removed from this zone increases by only approximately 100 MW or 10% of 1000 MW.

4) Example of adding or removing X MW amount of real generation in the MOD-MDMW table for zones A, C, and D:

$$X_p = X_{Ap} + X_{Cp} + X_{Dp}$$

Where

X_p = Amount of the perfect generation (UCAP) that needs to be added to or removed from zones A, C & D

X_{Ap} = Amount of perfect gen. (UCAP) that needs to be added to or removed from Zone A

X_{Cp} = Amount of perfect gen. (UCAP) that needs to be added to or removed from Zone C

X_{Dp} = Amount of perfect gen. (UCAP) that needs to be added to or removed from Zone D

The amount of UCAP for each zone is calculated based on the zonal excess Ratio, R_i and the relationship between the UCAP amount for a zone and the total UCAP to be removed can be expressed below:

$$X_{Ap} = X_p R_A$$

$$X_{Cp} = X_p R_C$$

$$X_{Dp} = X_p R_D$$

Let X = Amount of total real generation (ICAP) that needs to be added to or removed from zones A, C and D, and

X_A = Amount of real generation (ICAP) that needs to be added to or removed from Zone A

X_C = Amount of real generation (ICAP) that needs to be added to or removed from Zone C

X_D = Amount of real generation (ICAP) that needs to be added to or removed from Zone D

Where $X = X_A + X_C + X_D$

$$\text{Since } X_A = \frac{X_{Ap}}{(1-WFOR_A)}; X_C = \frac{X_{Cp}}{(1-WFOR_C)}; X_D = \frac{X_{Dp}}{(1-WFOR_D)}$$

$$X = \frac{X_{Ap}}{(1-WFOR_A)} + \frac{X_{Cp}}{(1-WFOR_C)} + \frac{X_{Dp}}{(1-WFOR_D)}$$

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

$$\therefore X_{Ap} = X_p R_A; X_{Cp} = X_p R_C; X_{Dp} = X_p R_D$$

$$X = X_p \left(\frac{R_A}{(1-WFOR_A)} + \frac{R_C}{(1-WFOR_C)} + \frac{R_D}{(1-WFOR_D)} \right)$$

Therefore

$$X_p = \frac{X}{\left(\frac{R_A}{(1-WFOR_A)} + \frac{R_C}{(1-WFOR_C)} + \frac{R_D}{(1-WFOR_D)} \right)}$$

This equation provides the conversion between the UCAP amount and the ICAP amount of capacity to be added to or removed from zones A, C and D.

Since

$$X_{Ap} = X_p R_A$$

$$X_{Ap} = \frac{X}{\left(\frac{R_A}{(1-WFOR_A)} + \frac{R_C}{(1-WFOR_C)} + \frac{R_D}{(1-WFOR_D)} \right)} R_A$$

$$X_{Cp} = \frac{X}{\left(\frac{R_A}{(1-WFOR_A)} + \frac{R_C}{(1-WFOR_C)} + \frac{R_D}{(1-WFOR_D)} \right)} R_C$$

$$X_{Dp} = \frac{X}{\left(\frac{R_A}{(1-WFOR_A)} + \frac{R_C}{(1-WFOR_C)} + \frac{R_D}{(1-WFOR_D)} \right)} R_D$$

X_{Ap} , X_{Cp} , and X_{Dp} are the amount of Perfect Capacity to be inputted to the MOD-MDMW table for zones A, C and D respectively.

This equation provides a means to calculate the amount of UCAP that need to be inputted to the MOD-MDMW table for each of the zone given that a specified total amount of ICAP is to be removed from or added to these zones.

Two examples (with zone D having 1000MW and 10000MW of wind generation) are provided below to determine the amount of perfect capacities (equivalent to 1000MW ICAP) to be inputted in the MDMW table for zones A, C and D

Example 1: Zone D generation (with 1000MW of wind generation)

A	C	D	A	C	D	A	C	D
Load	Load	Load	Gen	Gen	Gen	EFORd	EFORd	EFORd
2701	3114	754	5014	6707	2271	0.0593	0.0290	0.4253

** Zone D has a very high EFORD because it was assumed that out of the 2271MW generation in zone D, 1000MW is wind generation (with a EFORD = 0.9) and the remaining 1271MW generation is traditional generation with an EFORD = 0.052.

Example 2: Zone D generation (with 10000MW of wind generation)

A	C	D	A	C	D	A	C	D
Load	Load	Load	Gen	Gen	Gen	EFORD	EFORD	EFORD
2701	3114	754	5014	6707	11271	0.0593	0.0290	0.8043

If 1000MW (ICAP) is to be removed from zones A, C and D, then the amount of perfect capacities for A, C, and D to be inputted to the MDMW table can be calculated using the above equations:

$$\text{Zonal Perfect Excess Capacity} = \Delta GL_i = G_i \cdot (1 - FOR_i) - Load_i$$

For example, for zone A,

$$\Delta GL_A = G_A \cdot (1 - FOR_A) - Load_A$$

Example 1: (Zone D with 1000MW wind generation)

$$\Delta GL_D = 2271 \cdot (1 - 0.4253) - 754 = 551$$

A	C	D
ΔGL	ΔGL	ΔGL
2015	3399	551

$$\Delta GL_A + \Delta GL_C + \Delta GL_D = 2015 + 3399 + 551 = 5965$$

$$R_A = \frac{\Delta GL_A}{\Delta GL_A + \Delta GL_C + \Delta GL_D} = \frac{2015}{5965} = 33.78\%$$

A	C	D
R_A	R_C	R_D
33.78%	56.98%	9.24%

Example 2: (Zone D with 10000MW wind generation)

$$\Delta GL_D = 11271 \cdot (1 - 0.8043) - 754 = 1451$$

A	C	D
ΔGL	ΔGL	ΔGL
2015	3399	1451

$$\Delta GL_A + \Delta GL_C + \Delta GL_D = 2015 + 3399 + 1451 = 6865$$

$$R_A = \frac{\Delta GL_A}{\Delta GL_A + \Delta GL_C + \Delta GL_D} = \frac{2015}{6865} = 29.35\%$$

A	C	D
R_A	R_C	R_D
29.35%	49.51%	21.14%

Therefore the amount of X_{Ap} to be inputted to the MDMW table when removing a 1000 MW of generation in zones A, C, and D is: (these amount should be negative as it is supposed to decrease the generation – or increase the load)

$$X_{Ap} = \frac{X}{\left(\frac{R_A}{(1-EFOR_A)} + \frac{R_C}{(1-EFOR_C)} + \frac{R_D}{(1-EFOR_D)} \right)} R_A$$

Example 1: Zone D (with 1000MW wind generation)

$$X_{Ap} = \frac{1000}{\left(\frac{0.3378}{(1-0.0593)} + \frac{0.5698}{(1-0.0290)} + \frac{0.0924}{(1-0.4253)} \right)} (0.3378) = 305.27$$

MDMW Entries		
A	C	D
X_{Ap}	X_{Cp}	X_{Dp}
-305.27	-514.87	-83.47

Total UCAP removed from A, C and D = -305.27 - 514.87 - 83.47 = - 903.6MW

Example 2: Zone D (with 10000MW wind generation)

$$X_{Ap} = \frac{1000}{\left(\frac{0.2935}{(1-0.0593)} + \frac{0.4951}{(1-0.0290)} + \frac{0.2114}{(1-0.8043)} \right)} (0.2935) = 154.32$$

MDMW Entries		
A	C	D
X_{Ap}	X_{Cp}	X_{Dp}
-154.32	-260.27	-111.11

Total UCAP removed from A, C and D = -154.32 - 260.27 - 111.11 = - 525.7MW

The total UCAP removed is less than that in Example 1 because the Weighted FOR is much higher due to the large amount of wind generation with high FOR (0.9) – Zone D EFOR increases from 0.4253 (for 1000MW of wind generation) to 0.8043 (for 10000MW of wind generation).

Note that in example 2, in order to removed the same UCAP amount as example 1 the amount of ICAP generation need to be greater.

Procedure to Shift X MW of real (ICAP) generation from Zone J to Zones A, C, and D using the MOD-MDMW table in MARS:

- 1) Subtract $X \cdot (1 - FOR_j)$ to the MOD-MDMW table in Zone J (positive value to reflect an increase in generation in the MOD-MDMW table)

- 2) Calculate the UCAP split for zones A, C and D using the method described above for the amount of ICAP removed from Zone J, these amount should be positive

- 3) Add these amount (positive amount) to the amounts for A, C and D in the MOD-MDMW
Generally, the generation in A, C and D should have been removed to ensure that the State has the required IRM, therefore the values in the MOD-MDMW table for A, C and D after that operation should be negative; adding the amount calculated from step (2) will therefore reduce the negative values of these entries.

APPENDIX

Checking the examples above:
Zonal ICAP removed:

Example 1: (Zone D with 1000MW wind generation)

$$X_A = \frac{X_{Ap}}{(1 - EFOR_A)} = \frac{305.27}{(1 - 0.0593)} = 324.51$$

ICAP Amount		
A	C	D
X_A	X_C	X_D
324.51	530.24	145.25

Total ICAP removed = 324.51 + 530.24 + 145.25 = 1000 MW, which is exactly equal to the total ICAP to be removed.

Example 2: (Zone D with 10000MW wind generation)

$$X_A = \frac{X_{Ap}}{(1 - EFOR_A)} = \frac{154.32}{(1 - 0.0593)} = 164.04$$

ICAP Amount		
A	C	D
X_A	X_C	X_D
164.04	268.05	567.91

Total ICAP removed = 164.04 + 268.05 + 567.91 = 1000 MW, which is exactly equal to the total ICAP to be removed.