memo

To: Power Supply Planning Committee

From: Fei Zeng, Principal Engineer - Resource Adequacy

Date: December 19, 2016

Subject: Operating Reserve Deficiency Information

In May and July of 2013, the ISO provided memorandums to the Markets Committee with information on the expected number of operating reserve deficiency hours if the New England System were at and more surplus than its planning criteria[1]. These results were calculated using the ISO planning models and assumptions for the Installed Capacity Requirement (ICR) calculation for the 7th Annual Forward Capacity Auction. In 2016, several stakeholders asked the ISO to provide an update to the 2013 study using the latest available information. Requests have also been made to evaluate the expected number of operating reserve deficiency hours when the total installed capacity in the New England system is below the ICR in addition to being at or higher than ICR levels the 2013 study investigated. This memorandum responds to these requests.

Specifically, this memo provides quantitative information regarding:

- The expected number of operating reserve deficiency hours annually, given the system's total installed capacity at, lower and higher than ICR by various MW levels in 400 MW increments;
- The frequency distribution (*i.e.* percentiles) of operating reserve deficiency hours annually, given the system's total installed capacity is at, lower and higher than ICR by various MW levels; and
- A comparison of the 2013 and 2016 study results.

Approach and Assumptions

To determine the ICR for the Forward Capacity Market, the ISO employs the General Electric Multi-Area Reliability Simulation Program (GE MARS), a probabilistic simulation model. This model provides estimates of the expected number of events per year in which supply would be insufficient to meet demand

[1] Available at

https://www.iso-ne.com/static-assets/documents/committees/comm_wkgrps/mrkts_comm/mrkts/mtrls/2013/jul10112013/a12a_iso_memo_07_05_13.pdf

https://www.iso-ne.com/committees/comm_wkgrps/mrkts_comm/mrkts/mtrls/2013/jun452013/a07b_iso_memo_05_29_13.pdf during the capacity commitment year (known as the Loss of Load Expectation, or LOLE). In addition to estimating LOLE, the same model provides estimates of the expected number of hours per year in which load can be satisfied but there would be insufficient capacity to meet the system's operating reserve requirements.

The MARS model, applying Monte Carlo simulation techniques, evaluates the annual (or a chosen period) bulk power system resource adequacy by simulating the availability of resources and the assumed demand on an hourly basis. If the amount of available resources in the system is not adequate to meet the system load and operating reserve requirement for the hour of interest, the program registers a shortage hour. At the end of the simulation, the total number of shortage hours for the year (or a chosen period) is summed up and reported. Here, we want to emphasize that while the model provides the number of hours of operating reserve shortage, it does not provide the number of events that resulted in these shortage hours. By way of example, let's assume that there are 20 hours of annual operating reserve shortage, this value could represent 20 non-continuous discrete shortage hours on one end, or one shortage of 20 hours duration on the other end, or shortages of different hours of duration in between. The "expected hours" of operating reserve shortage are calculated, after thousands of Monte Carlo iterations, as the average number of shortage hours during a year. As a reliability tool used mainly for assessing the installed resource adequacy of the system, the MARS model captures the randomness of the resources' outages. It doesn't, however, consider the operational parameters associated with the resources such as ramp rate, minimum up/down times, maximum number of starts per day, etc. or operational requirements associated with unit commitment/economic dispatch. Therefore, the shortage hours reported in this study do not reflect any shortage hours that could arise relating to operational risks like under commitment due to load forecast error in operations, or loss of critical transmission or fuel supply facilities, etc.

All of the results in this memorandum are derived from the ISO's probabilistic simulation model. The model's results are based on the ICR calculation inputs and assumptions for the 11th Annual Forward Capacity Auction. These inputs and assumptions are detailed in the ISO's FERC filing of Installed Capacity Requirement, Hydro Quebec Interconnection Capability Credits and Related Values for the 2020-2020-2021 Capacity Commitment Period,[2] and an ISO presentation to the Power Supply Planning Committee on October 13, 2016 entitled "*Estimated Hours of System Operating Reserve Deficiency – Final Results*".[3]

With the integration of Demand Resources into the energy and reserve markets in 2018, Real-Time Demand Response resources are assumed available for dispatch prior to the system entering an operating reserve deficiency. This is consistent with the 2013 study. Real-Time Emergency Generation (RT-EG) resources, which were modeled in the 2013 study as emergency resources called after a declaration of a reserve deficiency (Action 6 of Operating Procedure No. 4 (OP 4), *Actions During a Capacity Deficiency*[4]), will no longer be able to operate under recent reversals to the Environmental Protection Agency's (EPA) rules that allowed Real-Time Emergency Generation Resources to operate for purposes of emergency demand response. Therefore, RT-EG resources are no longer considered in the 2016 Operating Reserve Deficiency study.

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[2] At https://www.iso-ne.com/static-assets/documents/2016/11/icr_filing_for_2020-2021_ccp.pdf

[3] At https://www.iso-ne.com/static-assets/documents/2016/10/PSPC10132016_A2_2020-21_Reserve_Deficiencies_Hours_Final.pdf

[4] At https://www.iso-ne.com/static-assets/documents/rules_proceds/operating/isone/op4/op4_rto_final.pdf

Tie Benefits (emergency assistance from neighboring Control Areas to the New England system during capacity deficiencies) are assumed available after a declaration of a reserve deficiency under OP 4. This is consistent with the 2013 study.

Summary of Results

Table 1 provides summary information regarding (a) the expected number of hours of operating reserve deficiency annually, and (b) the estimated relative frequency of hours of operating reserve deficiency conditions annually. In Table 1, entries in the column labeled '5 / 95' indicate the lower 5th percentile of the simulation results for the number of hours with system operating reserve deficiency conditions; entries in the '50 / 50' column indicate the median hours; and entries in the '95 / 5' column show the 95th percentile.

For example, the value 0.8 in the first row and column labeled '5/95' means that, based on the model, there is a 1-in-20 (or 5%) chance that the annual number of hours with operating reserve deficiency conditions would equal 0.8 *hours or less* when the amount of installed capacity equals ICR plus 3200 MW. Similarly, the value of 4.4 in the far-right column labeled '95/5' means that, based on the model, there is a 19-in-20 (or 95%) chance that the number of hours with operating reserve deficiency conditions would be *4.4 or less* annually.

Table 1: Estimated Hours of System Operating Reserve Deficiencies Annually

Capacity Level	Expected	5 / 95	50 / 50	95 / 5
ICR + 3200 MW	**2.1**	0.8	1.9	4.4
ICR + 2800 MW	**2.8**	1.1	2.5	5.4
ICR + 2400 MW	**3.5**	1.4	3.3	6.5
ICR + 2000 MW	**4.4**	2.0	4.1	7.6
ICR + 1600 MW	**5.4**	2.7	5.1	8.8
ICR + 1200 MW	**6.6**	3.6	6.4	10.3
ICR + 800 MW	**8.0**	4.6	7.7	12.3
ICR + 400 MW	**9.6**	5.7	9.0	14.9
ICR	**11.3**	7.1	10.4	18.2
ICR - 400 MW	**13.5**	8.5	11.9	22.9
ICR - 800 MW	**16.3**	9.9	14.3	29.7
ICR - 1200 MW	**20.0**	11.4	17.4	36.1
ICR - 1600 MW	**25.0**	13.1	22.2	45.5

Notes: Estimated system-level operating reserve deficiency hours 'at criteria' plus specified additional installed capacity, using the ICR and capacity planning model assumptions for the 11th Annual Forward Capacity Auction (see text).

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Figure 1: Plot of Estimated Hours of System Operating Reserve Deficiencies Annually

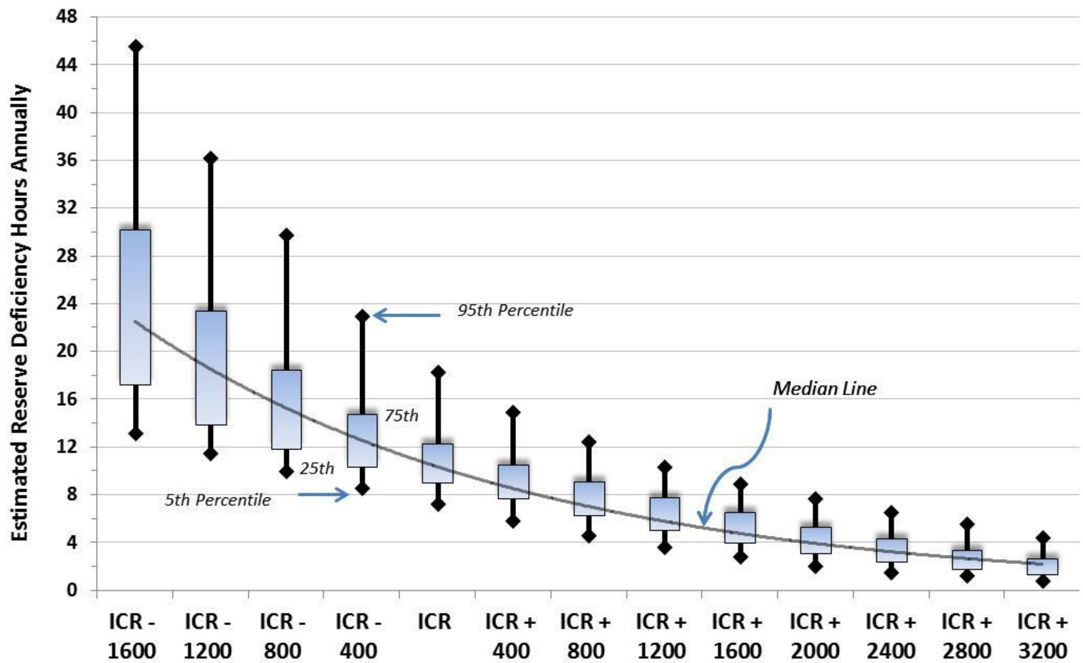

Figure 1 is a '*box-and-whisker*' plot of the data in Table 1 with the values for the 25th and 75th percentiles included in addition to the 5th, 50th and 95th percentiles shown in Table 1. In Figure 1, each shaded '*box*' indicates the upper and lower quartiles (25th and 75th percentiles) for the distribution of the total number of hours of operating reserve deficiency conditions annually, at each level of installed capacity. The extended '*whiskers*' show the 5th and 95th percentile values from Table 1, and the smooth line interpolates the median[5] ('50/50') hours data from Table 1.

Observations

Similar to the 2013 study, the results of this study demonstrate that as the level of installed capacity in the New England system decreases from the most surplus condition studied (ICR + 3200 MW) to the most deficient condition studied (ICR – 1600 MW), the estimated number of hours with operating reserve deficiency conditions increases gradually at first, then more quickly as the system becomes close to or below its criteria capacity requirement.

Figure 2 compares the expected number of hours of operating reserve deficiency between this study and the 2013 study. The estimated annual hours of operating reserve deficiencies for the 2020-2021commitment period are generally lower. This is mainly attributed to the assumption changes relating to the RT-EG demand resources, which were modeled as approximately 793 MW of OP 4 resources activated after a reserve deficiency in the 2013 study. These resources are no longer assumed available in this current study due to the recent changes to the EPA rules. The result of this assumptions change is equivalent to moving these resources from an OP 4 resource to a non OP 4 resource category. Having more non OP 4 resources

[5] The median value represents the middle value of the shortage hours in a year in which one half of the numbers are above the median and the other half are below. The expected value is the average value of the shortage hours in a year.

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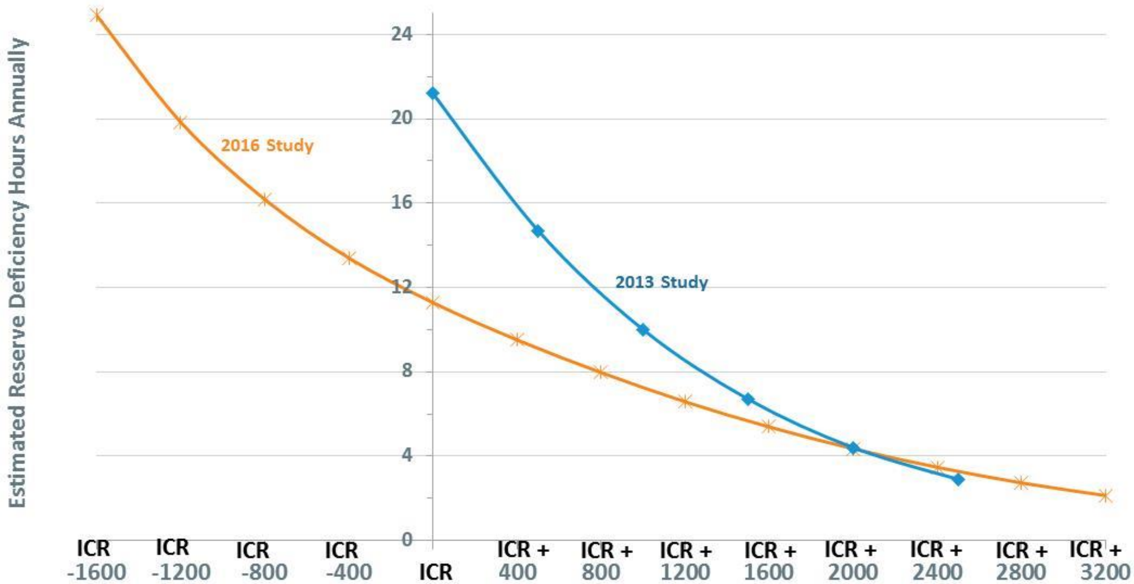
to meet load and operating reserve requirements before needing to invoke OP 4 means that the frequency needed to activate OP 4 would be reduced.

Figure 2: Comparison of the 2013 and 2016 Studies Results of Estimated Hours of Reserve Deficiencies



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