ISO new england

memo

To: Markets Committee

From: Market Development

Date: July 5, 2013

Subject: Operating Reserve Deficiency Information – At Criteria And Extended Results

In a May 29th 2013 memorandum to the Markets Committee, the ISO provided information on the expected number of operating reserve deficiency hours if the New England system is at planning criteria.[1] Several stakeholders have asked the ISO to provide supplemental information, based on the ISO's planning models, concerning the expected number of operating reserve deficiency hours when the total installed capacity in the New England system is *greater than* the Installed Capacity Requirement (ICR). 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 exceeds criteria requirements by various MW levels (*e.g.*, a capacity 'surplus' of 500 MW, of 1000 MW, and so forth); and

- The frequency distribution (*i.e.* percentiles) of operating reserve deficiency hours annually, given the system's total installed capacity is at criteria or exceeds criteria requirements by various MW levels.

For ease of reference, this memorandum incorporates and extends all results and sensitivities regarding 'at criteria' conditions previously provided in the May 29th memorandum.

Approach

To determine the Installed Capacity Requirement for the Forward Capacity Market, the ISO employs 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 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.

[1] Available at http://www.iso-ne.com/committees/comm_wkgrps/mrkts_comm/mrkts/mtrls/2013/jun452013/a07b_iso_memo_05_29_13.pdf.

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 7th Annual Forward Capacity Auction. These inputs and assumptions are detailed in the ISO's January 2013 report, *ISO New England Installed Capacity Requirement, Local Sourcing Requirement, and Maximum Capacity Limit for the 2016/2017 Capability Year*.[2]

Separately, the ISO provided historical information on the frequency of operating reserve deficiencies in a data file and accompanying memorandum, March 5th, 2013, available from the ISO's web-site.[3]

Summary Results

Table 1 provides summary information regarding (a) the expected number of hours of operating reserve deficiency conditions annually, and (b) the estimated relative frequency of hours of operating reserve deficiency conditions annually. In Table 1, entries in the column titled '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 1.4 in the first row and '5 / 95' column means that, based on the model, there is a 1-in-20 (or 5%) chance that the annual total hours with operating reserve deficiency conditions would equal *1.4 hours or less* when installed capacity equals ICR plus 2500 MW. Similarly, the value of 5.8 in the far-right '95 / 5' column means that, based on the model, there is a 19-in-20 (or 95%) chance that the total hours with operating reserve deficiency conditions would be *5.8 or less* annually.

Table 1. Estimated Hours of System Operating Reserve Deficiencies Annually

Capacity Level	Expected	5 / 95	50 / 50	95 / 5
ICR plus 2500 MW	**2.9**	1.4	2.5	5.8
ICR plus 2000 MW	**4.4**	2.1	3.8	8.9
ICR plus 1500 MW	**6.7**	3.1	6.0	13.0
ICR plus 1000 MW	**10.0**	4.9	8.9	18.7
ICR plus 500 MW	**14.7**	7.6	13.6	26.7
ICR	**21.2**	11.4	19.8	36.2

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 7th Annual Forward Capacity Auction (see text).

[2] At http://www.iso-ne.com/genrtion_resrcs/reports/nepool_oc_review/2013/icr_2016_2017_report_final.pdf

[3] The memorandum and historical data are available at http://www.iso-ne.com/committees/comm_wkgrps/mrkts_comm/mrkts/mtrls/2013/mar11122013/a14_iso_reserves_memo_03_05_13.pdf (*memorandum)*, and http://www.iso-ne.com/committees/comm_wkgrps/mrkts_comm/mrkts/mtrls/2013/mar11122013/a14_iso_rcpf_activation_data_03_05_13.xlsx (*historical data*).

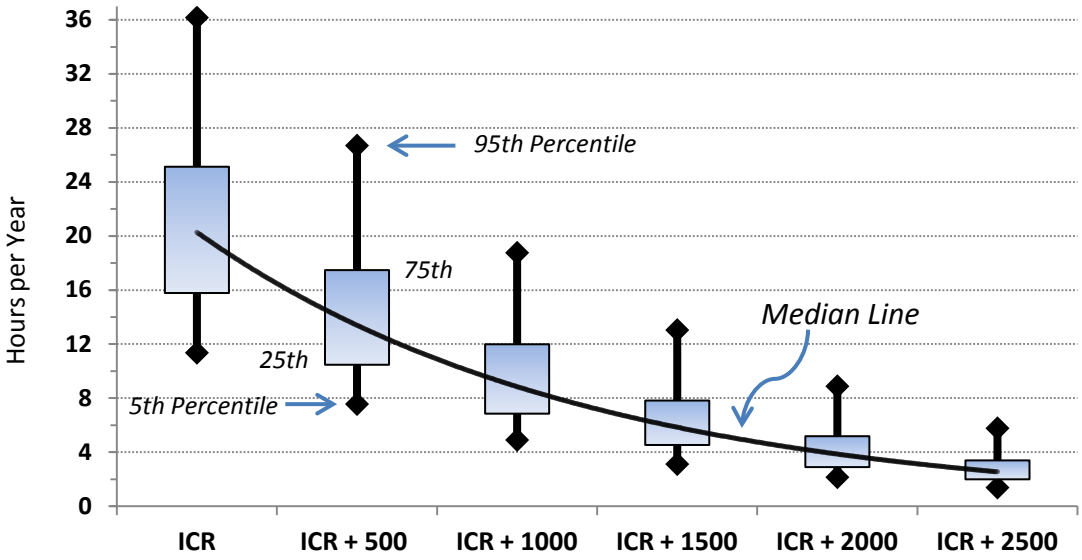

Figure 1. Estimated Hours of System Operating Reserve Deficiencies Annually

Figure 1 presents a graphical representation of the data in Table 1, extended to include additional percentiles. 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 bars show the 5th and 95th percentile values from Table 1, and the smooth line interpolates the median hours data from Table 1.

A. Observations

These data provide useful information along several lines. First, as the level of installed capacity in the New England system decreases from the surplus level present today (which exceeds 2500 MW), the expected number of hours with operating reserve deficiency conditions increases gradually at first, then more quickly as the system becomes close to its criteria capacity requirement.

Second, it is useful to observe that in the case where installed capacity equals 'ICR + 2500 MW', the expected number of hours with operating reserve deficiencies is 2.9 per year. This is close to the actual number of hours in the New England system (using current RCPF values) for the past three years, or 3.2 per year. (*See* March 5th memorandum on *Operating Reserve Deficiency Information – Historical Data*, note 2 above).[4]

[4] The fact that the expected hours in the 'ICR plus 2500 MW' scenario closely matches recent years' historical experience suggests that the effect of having a surplus in excess of 2500 MW in recent years (which would tend to reduce deficiency hours below those shown in Table 1) is similar to the impact of integrating RTDR into the energy and reserve markets, as assumed in Table 1 and Figure 1, on annual deficiency hours. We discuss this RTDR impact below.

Remark on Assumptions. As noted previously, the estimated number of hours with operating reserve deficiencies depends on many system inputs and assumptions. In particular, the results summarized in Table 1 and Figure 1 assume:

- All Real-Time Demand Response (RTDR) resources are able to supply reserves, or are available to supply energy prior to a reserve deficiency. This is consistent with the ISO's proposal and plans for the full integration of active demand response resources into the energy markets in 2017, but it differs from current RTDR dispatch practices as an action under Emergency Operating Procedures (OP-4 Load Relief).

- Tie Benefits (imports during capacity deficiency conditions) are available into the New England system *after* declaration of a reserve deficiency under Emergency Operating Procedures (OP-4 Load Relief). This assumption is consistent with the ISO's planning process used to develop ICR and related values and Loss of Load Expectation results.

Additional results regarding the impact of these two assumptions on the expected number of hours with operating reserve deficiency conditions are provided further below and in the Appendix.

B. Technical Note on Statistical Models for Reserve Deficiency Hours

At any given level of installed capacity, the relative frequency of operating reserve deficiency hours produced by the ISO's planning model has a particular 'shape', or *probability distribution.* This distribution is well-approximated by a risk model known as the *Generalized Extreme Value* (GEV) distribution. Figure 2 provides a graphical interpretation of this distribution for the case when total installed capacity equals ICR plus 1000 MW. The 'bars' in Figure 2 show the relative frequency of operating reserve deficiency hours annually from the ISO's system model simulations, in one-hour increments, and the 'smooth' curve shows the GEV distribution that approximates the underlying data.[5]

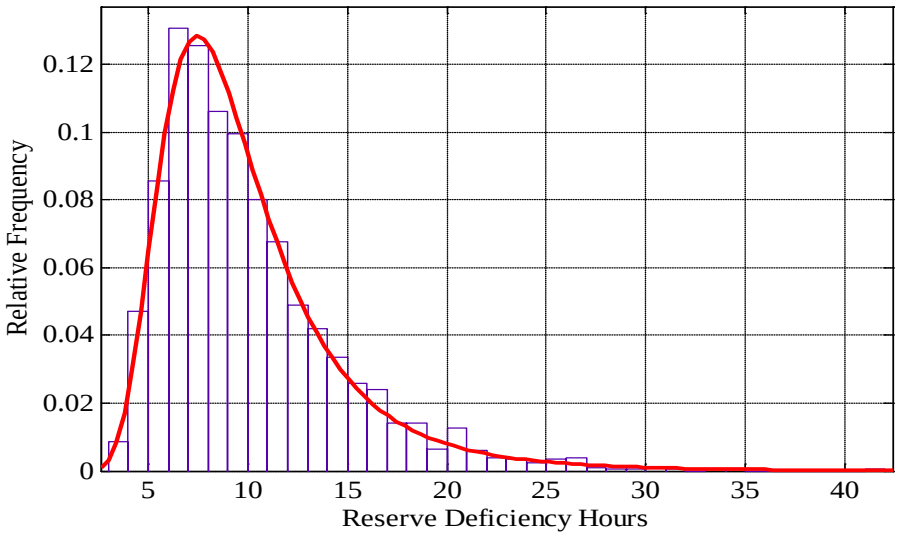

Figure 2. GEV Model at ICR plus 1000 MW

[5] Market participants interested in the raw percentiles may contact ISO Market Development for these data.

Sensitivity Results and Interpretation

A. Real-Time Demand Response

Presently, RTDR is called after declaration of an operating reserve shortage (per Operating Procedure No. 4, Action 2). With the integration of RTDR into the energy and reserve markets in 2017, RTDR will be available for dispatch prior to the system entering an operating reserve deficiency. In addition, RTDR that is available but not yet dispatched can contribute to the system's reserve requirements.

The integration of RTDR into the energy and reserve markets is expected to reduce the number of hours with operating reserve deficiency conditions annually. Table 2 provide estimates of how the planning model's estimated number of reserve deficiency hours (if the system is at criteria) varies with the amount of RTDR available prior to, versus subsequent to, entering a reserve deficiency.

Table 2 also shows how the results vary with assumptions concerning Tie Benefits, which are discussed in subsection B further below. The scenario in the top-row, right-column of Table 2 corresponds to the assumptions used in Table 1 and Figures 1 and 2 above.

The top row of Table 2 shows that if all RTDR contributes to meeting load or reserve requirements *prior to* entering a reserve deficiency, the expected number of hours with a system-level operating reserve deficiency ranges from 6 to 21. While the amount of RTDR that will be available prior to a reserve deficiency under the full integration of RTDR is difficult to establish with certainty (as that process will not be implemented until 2017), this scenario corresponds to ISO objectives in integrating RTDR into the ISO's energy and reserve markets.

When the ISO has activated RTDR in the recent past under OP-4, approximately 600 MW has responded. For comparison purposes, the bottom row of Table 2 indicates that if 600 MW of RTDR contributes to meeting system load or reserve requirements only *after* the system enters reserve deficiency conditions, the expected number of hours (if the system is at criteria) would be higher, ranging from 10 to 32 per year.

Table 2. Annual Expected Hours of System Operating Reserve Deficiencies At Criteria, Showing Sensitivity to Various RTDR and Tie Benefit Conditions

		Amount of Tie Benefits Available Prior or Subsequent to Entering Reserve Deficiency Conditions		
		All Prior	**900 MW Prior**	**All Subsequent**
Amount of RTDR Available Prior or Subsequent to Entering Reserve Deficiency Conditions	**All Prior**	5.8	10.9	21.2
	600 MW Subsequent	9.5	17.1	32.1

Notes: Expected system-level operating reserve deficiency hours with New England system 'at criteria', using the ICR and capacity planning model assumptions for the 7th Annual Forward Capacity Auction (see text).

Note that Table 2 presents results only for the case where the system is assumed to be at planning criteria. The Appendix provides additional data tables for the cases where the system has surplus capacity above ICR, corresponding to the various capacity levels shown previously in Table 1.

B. Tie Benefits

In the event of a capacity deficiency in New England, Tie Benefits reflect the amount of emergency assistance that is assumed will be available to the ISO from neighboring Balancing Areas, without jeopardizing system reliability in the neighboring Balancing Areas. The planning model employed to calculate the ICR assumes approximately 1800 MW of Tie Benefits. In practice, some of this quantity may be scheduled by Market Participants as (net) imports into New England *prior* to the system entering a reserve deficiency. Whether these imports are available prior to, versus subsequent to, entering a reserve deficiency affects the number of operating reserve deficiency hours per year.

Table 2 indicates the expected number of hours of operating reserve deficiency per year if the system is at criteria for several different assumptions about whether, and how much, total Tie Benefits are available as net imports scheduled prior to a reserve deficiency:

- The first column assumes all Tie Benefits flow into New England *prior* to the ISO taking emergency actions to import power during a reserve deficiency;
- The second column assumes net imports of 900 MW, which is approximately half of the total Tie Benefit MW, are scheduled into New England *prior* to a reserve deficiency; the balance are available only *after* entering reserve deficiency conditions.
- The third column corresponds to the condition in which all Tie Benefits are available only *after* the New England system enters a reserve deficiency.

The ISO's planning process used to develop ICR and related values assumes Tie Benefits are available under Emergency Operating Procedures (OP-4 Load Relief) after declaration of a reserve deficiency.[6] This corresponds to the results shown in the third column of Table 2.

It is possible that net import schedules by Market Participants may result in contributions to system load prior to entering a reserve deficiency. Because of the sensitivity of the results above to this possibility, Table 2 should be interpreted as providing an indicative range for the number of operating reserve deficiency hours that may be expected if the system is at planning criteria. Actual hours will depend, among other things, on import scheduling practices by Market Participants approaching stressed system conditions.

Summary and Caveats

Since the start of the Forward Capacity Market, the New England system has had more capacity than the system's Installed Capacity Requirement. These excess capacity conditions should be expected to produce fewer hours of operating reserve deficiency conditions annually than would occur if the level of installed capacity is at planning criteria (that is, equal to the Installed Capacity Requirement).

[6] *See* note 2, p. 28 ff.

As indicated in the March 5th memorandum, the New England system has averaged approximately three hours of operating reserve deficiencies annually from 2010-2012 (based on current RCPF values). The results in Tables 1 and 2 indicate that if there is no excess capacity (*i.e.*, the system is at planning criteria), the number of hours may be expected to be significantly higher than what the New England system has experienced in recent years.

There are a number of caveats that should be observed in interpreting these results. Planning models are simplified representations of the power systems that capture some, but not all, uncertainties that affect the number and duration of operating reserve deficiencies. Some of the factors that planning models do not capture will tend to bias the results on one direction, while other factors may do the opposite. For example, planning models do not replicate the daily unit commitment process and the possibility of short-term load forecast error, which may lead the results above to underestimate the number of hours of operating reserve deficiencies at any given installed capacity level. Alternatively, improvements in fleet average performance over time, and additionally in response to initiatives such as FCM Performance Incentives, are not reflected in the current planning models and may lead the results above to overestimate the number of hours of operating reserve deficiencies.

For these reasons, the statistics provided above should be interpreted as an indicative range, rather than as firm estimates, of the extent of operating reserve deficiencies that may occur if New England's excess capacity conditions diminish in future years.

Appendix

This Appendix provides additional tables with the RTDR and Tie Benefit sensitivities, for assumed total installed capacity levels equal to: ICR plus 500 MW, ICR plus 1000 MW, and so forth, up to ICR plus 2500 MW. For interpretation and discussion, see main text.

Table 3. Annual Expected Hours of System Operating Reserve Deficiencies at **ICR + 500 MW**

		Amount of Tie Benefits Available Prior or Subsequent to Entering Reserve Deficiency Conditions		
		All Prior	**900 MW Prior**	**All Subsequent**
Amount of RTDR Available Prior or Subsequent to Entering Reserve Deficiency Conditions	**All Prior**	3.8	7.3	14.7
	600 MW Subsequent	6.3	11.8	22.8

Notes: Expected system-level operating reserve deficiency hours using capacity planning model assumptions for the 7th FCA (see text).

Table 4. Annual Expected Hours of System Operating Reserve Deficiencies at **ICR + 1000 MW**

		Amount of Tie Benefits Available Prior or Subsequent to Entering Reserve Deficiency Conditions		
		All Prior	**900 MW Prior**	**All Subsequent**
Amount of RTDR Available Prior or Subsequent to Entering Reserve Deficiency Conditions	**All Prior**	2.6	4.8	10.0
	600 MW Subsequent	4.2	7.9	15.9

Notes: Expected system-level operating reserve deficiency hours using capacity planning model assumptions for the 7th FCA (see text).

Table 5. Annual Expected Hours of System Operating Reserve Deficiencies at **ICR + 1500 MW**

		Amount of Tie Benefits Available Prior or Subsequent to Entering Reserve Deficiency Conditions		
		All Prior	**900 MW Prior**	**All Subsequent**
Amount of RTDR Available Prior or Subsequent to Entering Reserve Deficiency Conditions	**All Prior**	1.7	3.2	6.7
	600 MW Subsequent	2.8	5.2	10.9

Notes: Expected system-level operating reserve deficiency hours using capacity planning model assumptions for the 7th FCA (see text).

Table 6. Annual Expected Hours of System Operating Reserve Deficiencies at **ICR + 2000 MW**

		Amount of Tie Benefits Available Prior or Subsequent to Entering Reserve Deficiency Conditions		
		All Prior	**900 MW Prior**	**All Subsequent**
Amount of RTDR Available Prior or Subsequent to Entering Reserve Deficiency Conditions	**All Prior**	1.2	2.1	4.4
	600 MW Subsequent	1.9	3.5	7.3

Notes: Expected system-level operating reserve deficiency hours using capacity planning model assumptions for the 7th FCA (see text).

Table 7. Annual Expected Hours of System Operating Reserve Deficiencies at **ICR +2500 MW**

		Amount of Tie Benefits Available Prior or Subsequent to Entering Reserve Deficiency Conditions		
		All Prior	**900 MW Prior**	**All Subsequent**
Amount of RTDR Available Prior or Subsequent to Entering Reserve Deficiency Conditions	**All Prior**	0.8	1.5	2.9
	600 MW Subsequent	1.3	2.3	4.8

Notes: Expected system-level operating reserve deficiency hours using capacity planning model assumptions for the 7th FCA (see text).