NYISO's Methodology for Error Analysis of the IRM Study

March 5, 2014

1. Introduction

In the IRM study, a 95% level confidence interval in terms of the IRM range is provided in the Error Analysis. The current methodology that NYISO used to obtain this IRM range is by benchmarking LOLE at the 1000th iteration point of the Monte Carlo Simulation. This is because LOLE is the index of the reliability criterion and the IRM value is dependent on the LOLE value. In other words, the confidence interval of IRM is determined by the corresponding confidence interval of LOLE.

2. NYISO's Methodology to Obtain the Confidence Interval

In some technical areas such as load forecast, the parametric data can have adequate historical records to determine and verify its real distribution. The LOLE value of the IRM study assumes that the LOLE values follow a normal distribution. In statistics, the normal distribution is characterized by a symmetric bell-shaped curve which is defined by the probability density function as shown in Equation (1).

$$f(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \quad (1)$$

wherein

x - specific value taken by the random variable

μ - mean value of the random variable

σ^2 - variance of the random variable

For a normal distribution, the 95% level confidence interval is bounded by a range centered on the mean value and with a distance of about two standard deviations (SD) on each side from the center. Because NYSRC adopts LOLE of 0.1 day/year as the reliability criterion, NYISO benchmarks LOLE of 0.100 day/year as the center in all cases. Then the two ends of this 95% level confidence interval ($CI_{95\%}$) of LOLE are determined by Equation (2) as follows.

$$CI_{95\%} = (0.100 \text{ day/year}) \pm 2SD \quad (2)$$

The relationship between SD and the standard error is shown in Equation (3). For example, with a standard error of 0.025, the SD is 0.0025 day/year and the two ends of the LOLE confidence interval will be 0.095 day/year and 0.105 day/year, respectively.

$$SD = (0.100 \text{ day/year}) \times (\text{standard error}) \quad (3)$$

For the IRM=17.0% in the 2014 IRM study base case, NYISO first benchmarked the 1000th iteration point with LOLE=0.100 day/year. At this point, the standard error is around 0.023 and the two ends of the 95% level confidence interval are 0.095 day/year and 0.105 day/year with an accuracy of three decimals. Then NYISO used the standard sensitivity method by adding or removing NYCA capacity in Load Zones A through K and reran the simulation of the IRM base case. This capacity adjustment continued until at the 1000th iteration the LOLE was equal to 0.095 day/year for one end of the confidence interval and an LOLE of 0.105 day/year was obtained for the other end of the confidence interval. After the LOLE confidence interval is achieved, it is translated into the IRM confidence interval. For the 2014 IRM study, the corresponding IRM values associated with these two ends yielded 17.2% and 16.8%, respectively.

3. Explanation of Different Confidence Intervals

For the 2014 IRM study base case, an LOLE of 0.100 day/year was determined at the 1,000th iteration. At this point, the standard error equaled 0.023. In Figure 1, the confidence interval at the point where the standard error was 0.025 is shown in red. This point occurred between the 800th and the 900th iteration. Since the LOLE was not equal to 0.100 day/year at this point, the resulting graph is different than the 17.0% IRM value achieved at the 1,000th iteration. This initial IRM confidence interval was shown having 16.9% at the center and 16.7% and 17.1% at the ends. If the proposed 2014 IRM value of 17.0% is inappropriately put into this confidence interval with a standard error of 0.025, the resulting diagram is sure to appear asymmetrically. The black curve indicates a more accurate picture of the results. This curve was performed at the 1,000th iteration where the standard error was 0.023, the LOLE was 0.100 day/year, and the IRM was calculated to be 17.0%

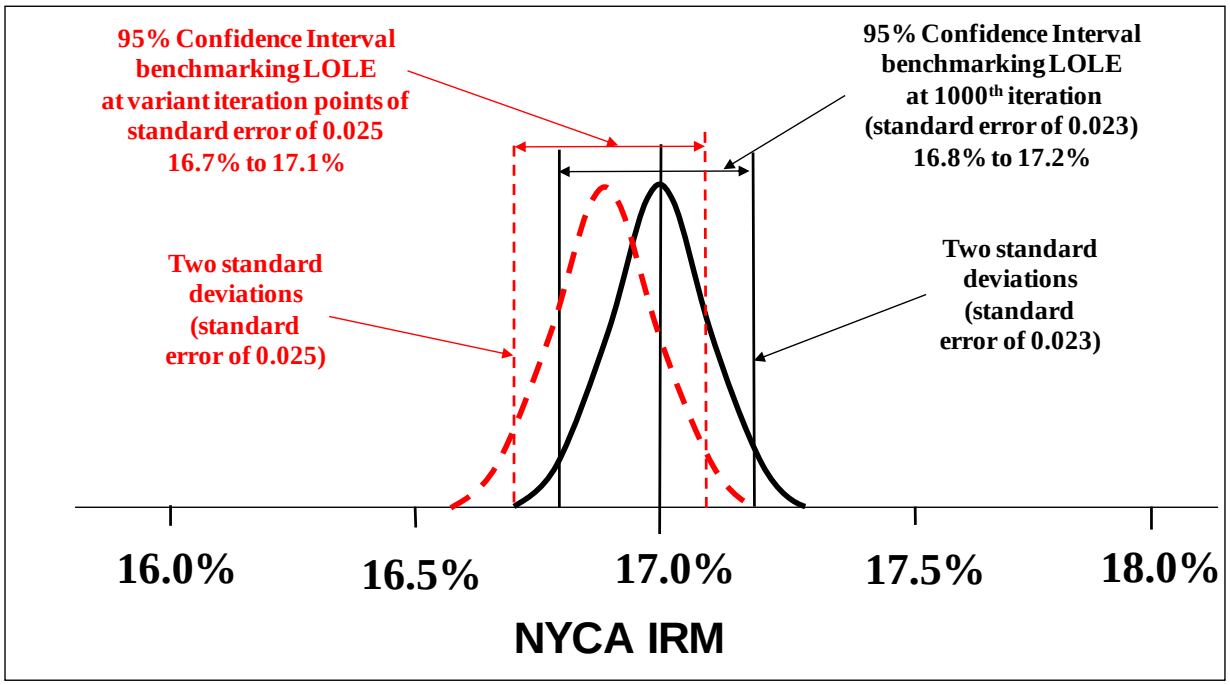

Figure 1 - The 95% confidence interval of 2014 IRM

4. Appropriate Number of Iterations in Monte Carlo Simulation

The Monte Carlo Simulation run of an IRM study case will enter a period of damping oscillation before it finally converges to its steady state. Theoretically, the steady state can only be achieved after infinite time of simulation. Thus, an approximation is necessary for practical simulation applications. The standard error is often referred to as convergence criterion or is used to determine the appropriate number of iterations to stop simulation.

A small standard error is preferred in approximation of the Monte Carlo simulation. However, the number of iterations associated with the simulation time increases rapidly as the standard error becomes smaller. For example, it has been tested that more than 5,000 iterations are needed for just one simulation run of a 2014 IRM study case to achieve a standard error of 0.01. So, it is necessary to balance these two opposite factors. Although there is no absolute criterion for values of the standard error in Monte Carlo Simulation, 0.05 and 0.025 can be considered as two appropriate objective levels in the IRM study.

For a normal LOLE distribution with the mean value of 0.100 day/year, the 95% level confidence interval with the standard error of 0.05 would be [0.090, 0.110] day/year, which is ±10% variation range of the 0.100 day/year criterion value. Similarly, the 95% level confidence interval with the standard error of 0.025 would be [0.095, 0.105] day/year, which is ±5% variation range of the 0.100 day/year criterion value. These two levels of tolerable variation range of criterion are widely used and can be observed in many industry standards. So, the standard error of 0.05 specified in the NYSRC Policy 5-7 has sound background and is acceptable as the minimum requirement for the IRM study.

In practice, NYISO is aiming at achieving high quality of the data and thus considering the standard error at the 0.025 level. However, by nature of Monte Carlo Simulation, the number of iterations corresponding to the standard error of 0.025 is not a fixed figure. For the 2014 IRM study base case, this number is somewhere between 800 and 900 iterations. The variation of this number of iterations makes it very difficult for the parallel computation logic of the High Performance Computer (HPC) which NYISO is currently using for the IRM study. Hence, NYISO has adopted the practice of benchmarking 1000 iterations for simulation runs combined with a standard error of about 0.025.

Figure 2 illustrates the relationship between LOLE values and the 95% level confidence interval with above standard error of 0.023 for the 2014 IRM study base case. We can see from Figure 2 that this confidence interval determined by the 1000th iteration is capable of covering the points associated with much larger number of iterations. For example, the LOLE result at the 5000th iteration is 0.098 day/year. This is within only one standard deviation (SD) of the center LOLE value of 0.100 day/year, which is far better than the interval range of two SDs. So, it is appropriate that NYISO has adopted this 95% level confidence interval for the 2014 IRM study base case.

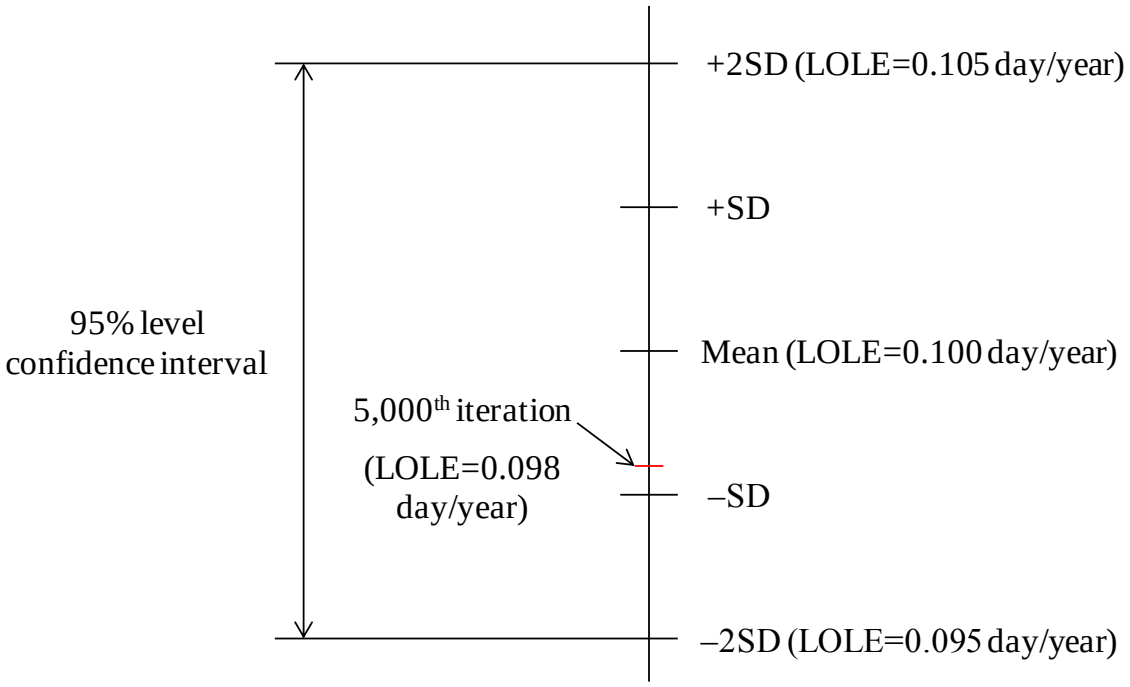

Figure 2 - Relationship between LOLE values and the 95% level confidence interval

5. Conclusion and Recommendation

In summary, NYISO is benchmarking the LOLE result from the IRM simulation at the 1000th iteration point of Monte Carlo Simulation to determine the 95% level of Confidence Interval in terms of IRM. NYISO is achieving a standard error of about 0.025. The NYISO continues to recommend 1000 iterations as the standard for the IRM study.