# Evaluation of Wind Modeling in Probabilistic Resource Adequacy Studies

**May 22, 2013**

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## I. Objective

The objective of this paper is twofold. The first objective is to study the use of actual wind production data instead of simulated data. The second objective is to examine the affects of modeling wind by selecting randomly a wind profile/shape within a specified time frame or window. This is a feature which is now available in the GE MARS model. .

## II. Background

To date, wind modeling in the IRM studies has been based on 2002 simulated wind plant shapes that were developed by AWS Truewind for the General Electric Wind Study. These wind shapes were developed from hourly wind readings taken at a given altitude, along with other meteorological information, and forecasting the hourly electric output of a modern wind turbine. Of the 100+ sites studied, the NYISO has used the output of 33 of these sites around NY to simulate output of installed wind farms. There is now available actual wind production data from NYCA generators that can be compared to the simulated data. Also, GE has added functionality to the MARS model which allows for the daily wind shape for each day during a simulation year to be modeled randomly. However, the MARS model allows only a single year wind shape to be input for this purpose.

## III. Using Actual NYCA Wind Production Data for Modeling Wind

Currently, the MARS model uses an hourly load shape based on 2002 hourly loads and simulated wind generation shapes that were based on 2002 meteorological data compiled for the NYSERDA/NYISO wind study conducted by GE Energy. Simulated data was used to ensure the alignment of load and wind. Hourly simulated wind megawatt output by site was also provided for years 2001, 2002, 2003, and for the summer months of years 1999 and 2000.

Over the last several years, the NYISO has collected hourly wind generation output, with an installed base that now exceeds 1,600 MW. The first year that the installed base exceeded a 1,000 MW was 2009 with an installed base of 1,267 MW. The implicit summer capacity value is defined as the wind generation capacity factor between the hours of 1400 and 1800 for the summer months of June through August. The shapes developed for the wind study are based on summer capacity values in the 10% to 11% range. Actual wind generation for the years 2009 through 2012 have resulted in much higher capacity values. Table I presents the summer capacity value or UCAP values experienced for the years 2009 through 2012.

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**Table I: Summer Wind Capacity Values**

| Year | Capacity Value |
|---|---|
| 2009 | 14.4% |
| 2010 | 15.2% |
| 2011 | 18.4% |
| 2012 | 18.2% |

The increasing numbers can be attributed to two factors. One is difference in wind conditions from year-to-year and the other is that new wind turbines entering service are larger and are designed with hubs that are much higher in the air. The result is that more efficient wind plants capture more of the available wind and convert it into electricity. NYCA capacity has increased by approximately 10% between 2010 and 2011 and remained at that level through 2012.

To obtain some insights as to how wind conditions in NY varied during this timeframe, AWS TruePower was asked if they could provide any insights into wind conditions based on the wind plants they monitor in NY. They indicated that just looking at average wind speed could provide misleading results as to potential changes in wind generation potential from year-to-year. Their initial thoughts were that the best approach for monitoring NY wind conditions would be to monitor wind plant performance or output year-to-year. However, there is very limited history available at this point. They were able to provide the NYISO aggregate wind plant capacity factors for the wind plants they monitor in NY for four seasons and the years 2010 through 2012. Table II presents the results provided by AWS TruePower/MESO.

**Table II: Seasonal Wind Capacity Factors**

**For Plants Monitored by AWS TruePower**

| Season/Year | 2010 | 2011 | 2012 | Mean | Standard Deviation |
|---|---|---|---|---|---|
| Winter (Dec-Feb) | 23.3 | 22.8 | 32.7 | 27.0 | 5.8 |
| Spring (Mar-May) | 21.4 | 21.1 | 24.1 | 22.2 | 3.9 |
| Summer (Jun-Aug) | 16.4 | 16.0 | 15.8 | 16.1 | 2.4 |
| Autumn (Sep-Nov) | 27.2 | 24.7 | 21.5 | 24.5 | 5.4 |

The data provided by AWS TruePower/MESO paints a slightly different picture than the capacity value data as to year-to-year variation in wind generator output. This makes the point that you need to look at how the average wind conditions distribute over the hours of the day. In addition, it also shows that wind conditions are at a minimum in the summer and that the summer has the least year-to-year variability. It also shows, based on wind plant capacity factors and the AWS monitored plants, that 2012 had below average wind conditions which is the opposite conclusion that could be drawn from the NYISO capacity value data.

Given that actual wind generation data is now available for NY, this suggests that, at a minimum, updating the wind shapes to capture the NYISO's current fleet of wind generation units should be investigated. The first step was to plot the average summer load shape that results from using the 2002 wind shape for simulating NYCA wind plant output versus the 2012 shape, which is the most recent year of wind generation available for the NYCA. Figure 1 presents those results.

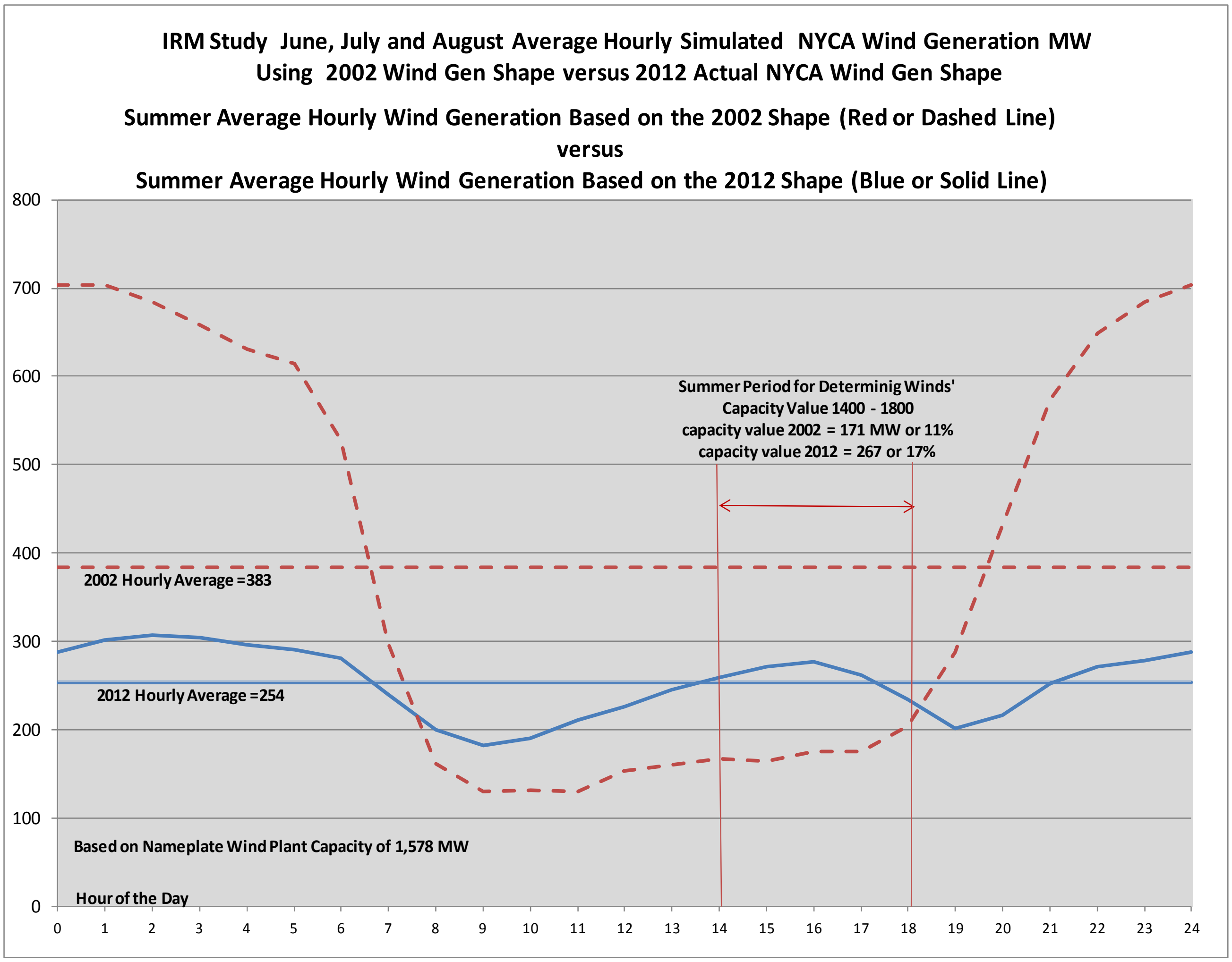


**Figure 1: Plot of Average Daily Wind Generation**

The plot of the average summer hourly wind generation based on the 2002 shape versus 2012 shape presents results that are very different. The 2012 shape is based on actual NYISO wind plant production, while the 2002 shape is derived from simulated wind plant data that was developed for the NYSERDA/NYISO wind study published in 2005. The shape based on actual 2012 wind plant generation results is a much flatter load shape with a much lower average hourly wind generation (254 MW VS. 383 MW), but a higher summer capacity value (267 MW VS 171

MW), which on average results in an additional 96 MW of wind generation being available in the 1400 to 1800 hour timeframe.

The wind shape in the final 2013/2014 IRM base case was replaced with the 2012 shape. The following results are based on the final IRM base case of 17.1%. Here the IRM is 17.1% with LCRs of 83.7% for zone J and 102.0% for zone K. Starting at an LOLE of 0.100 days/year under the above conditions, the 2002 simulated wind data was replaced by 2012 wind production data. The LOLE improved to a value of 0.096 days/year. Rebalancing upstate zones to achieve 0.100 LOLE dropped the IRM from17.10% to 16.85%) or an increase in load carrying capability of approximately 80 MW.

The first observation is that, even though the 2002 shape results in a much higher average overall hourly wind generation than the 2012, the 2012 which has a higher capacity value results in a decrease in LOLE. The decrease in LOLE translates to a 0.25% drop in IRM and a 80 MW benefit or increase in load carrying capability. These results are consistent with the difference in load shape. The resulting conclusion is that the shape for modeling wind generation derived from actual NYISO wind generation production should replace that currently being used.

## IV. Random Wind Shape Modeling

A new feature that has been added to MARS allows for a daily wind shape to be selected randomly within a range of daily wind shapes. In addition to investigating the new feature, a secondary question was to determine for the purpose of modeling wind generation in reliability studies whether the year selected for modeling wind generation needed to be aligned with or the same as the year selected to model the load shape. The premise of using this feature is that the relationship between wind generation and load during peak hours has very little correlation and essentially behaves as a random variable. Therefore, having the year used for modeling load aligned with the year for simulating wind is not essential. The result of very little correlation would also be an important consideration in the use of the new feature that allows the use of different load shapes for each load forecasting uncertainty (LFU) bin. Since MARS allows only one wind shape to be input, this would eliminate any concern that it is essential to have the wind and load shapes based on the same year. The NYISO analyzed wind data for the years 2009 through 2012 to determine the correlation between load and wind generation. Figure 2 below presents a plot of wind generation as a per unit of nameplate and load as a per unit of the weather normalized peak for the top thirty daily peaks for each of the years. The top 30 peak days are analyzed because of their importance from an LOLE perspective as determined in the SCR study.

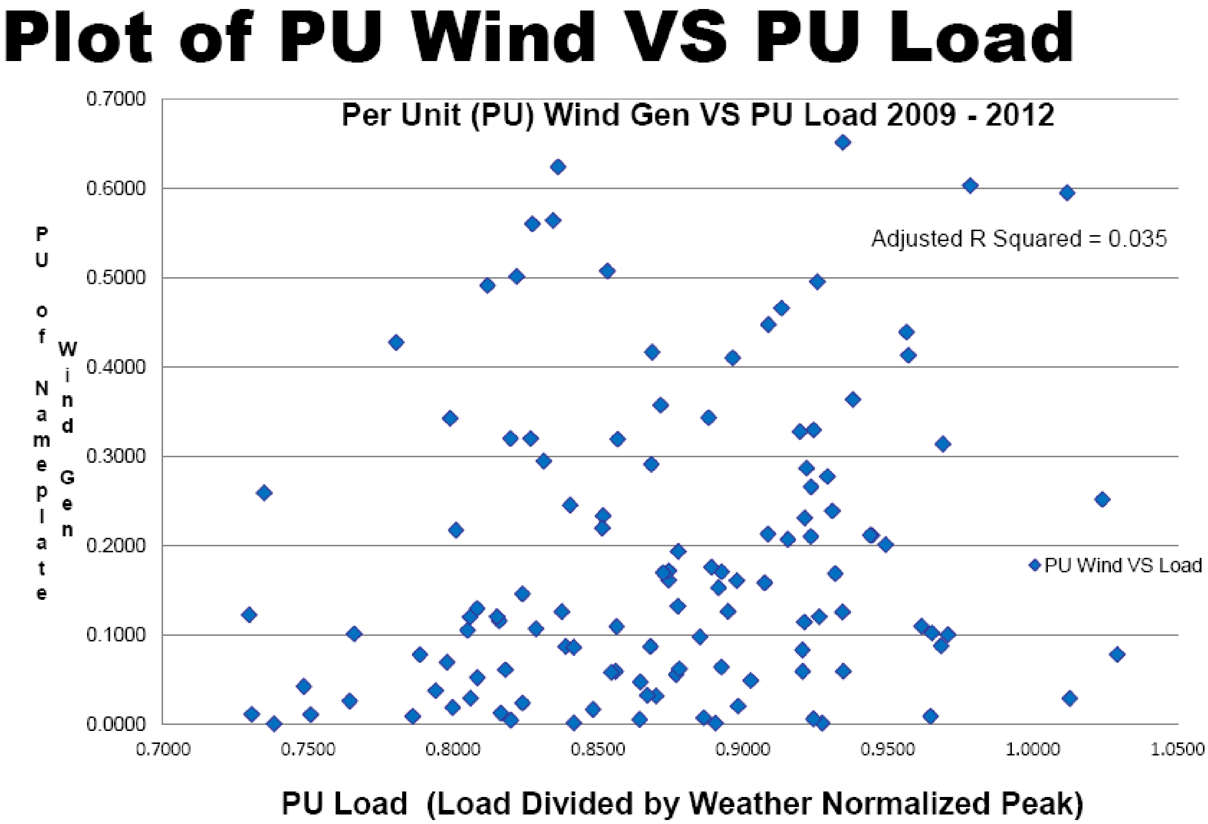


**Figure 2: Per Unit Wind versus Load**

This data was also analyzed on a per year-by-year basis showing actual MW and presented to the ICS at their January 25, 2013 meeting. The full presentation is included in this document as Appendix A. The conclusion from this analysis is that there is essentially zero correlation between the wind generation and load, and therefore having the year for modeling loads and the year for simulating wind generation aligned is not essential for MARS modeling. This conclusion is based on the lack of relationship observed from actual NYISO wind generation and load. It also means that using the new feature in MARS, which allows daily wind shapes to be selected randomly, can be run independently of whatever year that is being used to model the loads.

## V. Random Wind Modeling Test Results

GE added new functionality as described previously to MARS that allows for wind generation to be modeled randomly by selecting a wind shape for a particular day randomly within a specified window of day shapes. Also, GE had added the capability to utilize different year load shapes for each load forecasting uncertainty (LFU) bin. The underlying premise of being able to use this new wind feature is that the correlation between wind and load is de minimis. Examination presented above revealed that the daily peak hour wind generation does not correlate strongly, if at all, with the daily load. Since the year used in modeling wind doesn't need to be cotemporaneous with the year used for load modeling, the random feature of MARS for modeling wind could be used and should be investigated. It also means that this new feature could be used with multiple year load shapes.

Using the new feature in MARS and starting from the IRM base case updated with the 2012 wind data, the model was allowed to randomly pick a daily load shape up to 5 days before and 5 days after the actual calendar day for each plant. Turning on this random feature caused the LOLE to remain unchanged at 0.100 days/year. An additional analysis was performed allowing a +/- 10 day window around each day. Again, the results were unchanged.

These results are not surprising given how the random modeling feature functions in MARS. It samples shapes from the specified window whether it be +/- 5 or +/- 10 days and in effect creates an average or smoothed profile for the year from within which it is sampling. However, the averages, in particular the capacity value between the hours of 1400 and 1800 for June, July and August remains essentially unchanged for the sampling windows selected which explains why no material change in LOLE is observed when the random feature is turned on.

## VI. Conclusions

Comparing the 2002 simulated wind generation versus the one based on 2012 actual wind generation resulted in entirely different average shapes. From a reliability modeling perspective, the shape that results in a higher summer capacity value will provide the greatest reliability benefit. The random feature in MARS did not result in any change in LOLE since it samples shapes from a single year that is input and therefore no change in capacity value results. The primary conclusions from the analysis presented herein are: 1) The correlation between load and wind generation is de minimis; 2) the need to align the particular year used to model load and the year to model the wind generation is not a critical consideration for LOLE modeling; 3) being able to only input one wind shape per wind generation unit is not a limitation in modeling multiple load shapes; and 4) the random feature in MARS works as designed but does not provide any additional value for conducting reliability simulations.

## VII. Recommendations

1. The NYISO is recommending that the modeling of wind be based on a wind shape derived from actual NYCA wind generation.

2. The analysis presented herein has demonstrated that the correlation between load and wind generation is de minimis and that wind generation from hour-to-hour and day-to-day exhibits the time series characteristics of a random walk. A random walk is defined as a process where the current value of a variable is composed of the past value plus an error term defined as white noise. The implication of a process of this type is that the best prediction for the next period is the current value. Therefore, the NYISO is recommending that the 2014 IRM study model wind generation based on wind generation from the year 2012. The 2015 IRM study would base its simulation of wind generation on 2013 actual wind generation and so on for the foreseeable future. Use of the most current year of data (e.g., 2012) would capture the current mix of NYISO wind plants.

3. The NYISO is recommending that the new random modeling feature for wind not be adopted at this time because, based on the NYISO's testing, it doesn't appear to provide any additional information for conducting reliability simulations and would require further evaluation.

4. Given the fact that only one wind shape year for each wind generating unit can be input into MARS, the NYISO is recommending that this fact should not be a consideration or a barrier to adopting the multiple load shape functionality now available in MARS.

# *Appendix A*

See attached power point presentation entitled: Analysis of Wind Plant Generation versus Load For the Thirty Highest Daily Peaks 2009-2012