Western Assessment of Resource Adequacy

MAVRIC Model Explanation

WECC uses the Multi-area Variable Resource Integration Convolution (MAVRIC) model to conduct its energy-based, probabilistic analysis in the Western Assessment of Resource Adequacy. This document describes the MAVRIC model.

The MAVRIC model was developed to capture many of the functions needed in the Western Interconnection for probabilistic modeling. The Western Interconnection has many transmission connections between demand and supply points, with energy transfers being a large part of the interconnection operation. A model was needed that could factor in dynamic imports from neighboring areas. The Western Interconnection has a large geographical footprint, with winter-peaking and summer-peaking load-serving areas, and a large amount of hydro capacity that experiences large springtime variability. The ability to study all hours of the year on a timely run-time basis was essential for the probabilistic modeling of the interconnection. Additionally, the large portfolio penetration of variable energy resources (VER), and the different generation patterns depending on the geographical location of these resources, called for correlation capability in scenario planning. MAVRIC is a convolution model that calculates resource adequacy through loss-of-load probabilities (LOLP) on each of the stand-alone (without transmission) load-serving areas. The model then calculates the LOLP through balancing the system with transmission. Finally, MAVRIC can supply hourly demand, VER output, and baseload generation profiles that can be used in production cost and scenario planning models.

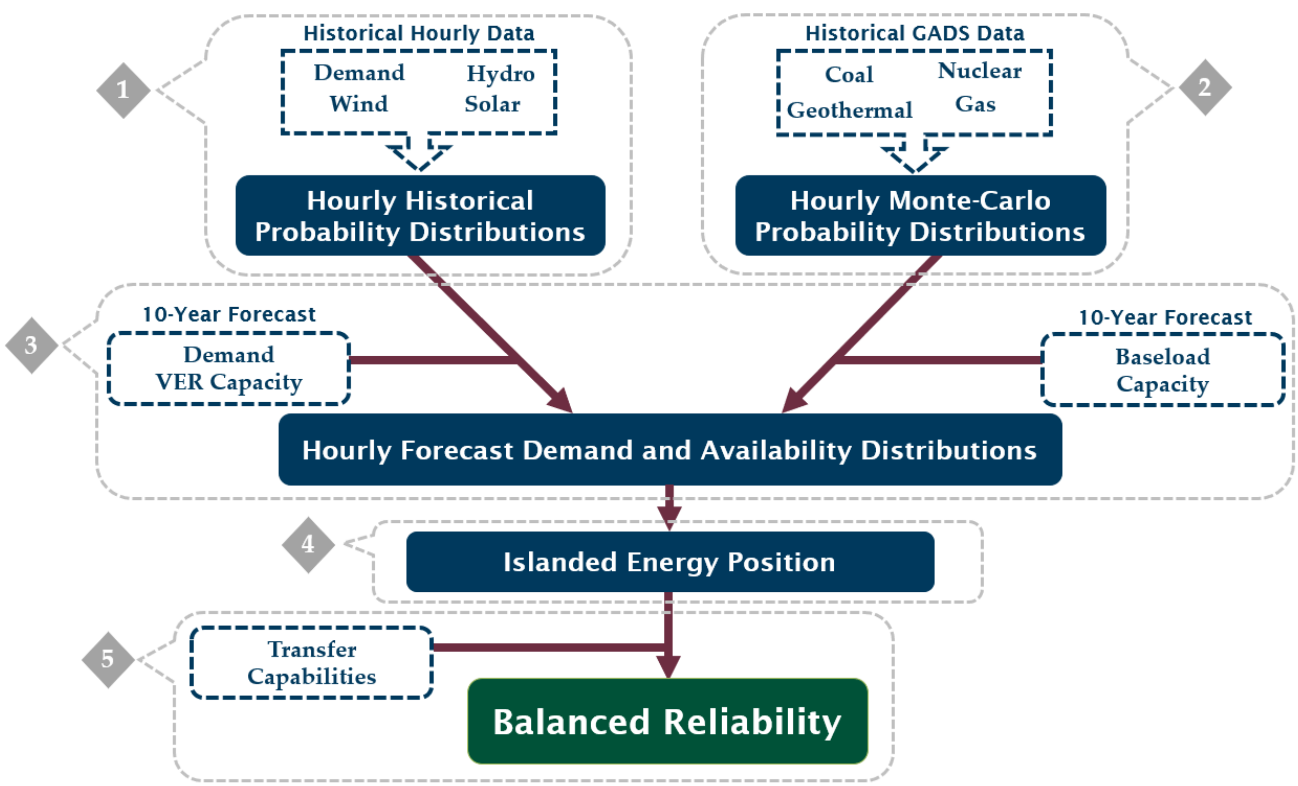

Figure 1: MAVRIC Process Flowchart

To calculate the LOLP of each of the load-serving areas, probability distributions are needed for each generating resource in the Western Interconnection, as well as for the demand of each Balancing Authority (BA).

In Step 1 (MAVRIC Process Flowchart), probability distributions for the demand variability are determined by aligning historical hourly demand data to each of the BAs in the database. The first Sundays of each historical year are aligned so that weekends and weekdays are consistent. Each hour is then compared to a rolling seven-week average for the same hour of the same weekday. This establishes the difference between the historical hour and the average. MAVRIC uses each of these percentages to calculate a percentile probability for a given hour based on the variability of the three weeks before and three weeks after the given hour for each of the historical years. The output of this step is a series of hourly percentile profiles with different probabilities of occurring.

Figure 2 represents the probabilities for one hour. The peak is the expected deterministic forecast and is set at 100%. The profiles above or to the right of the peak are greater than 100%, and those below or to the left are lower than 100% depending on the variability for each hour.

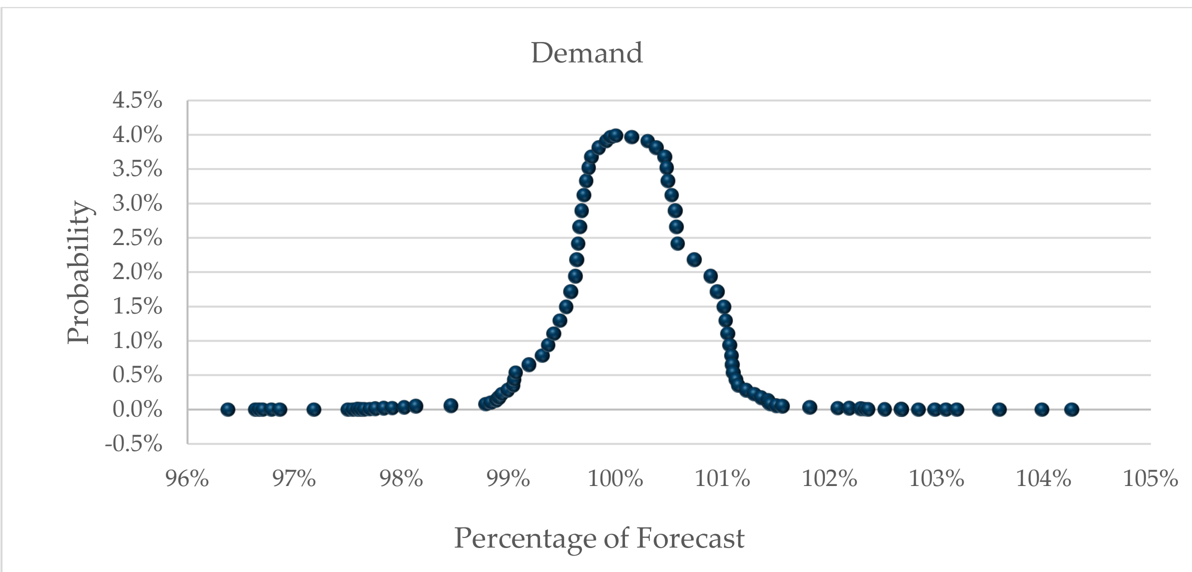

Figure 2: Demand Probability Disruption Sample

Determining the availability probability distributions for the VERs (water, wind, and solar-fueled resources), is conducted like the demand calculations, but with two notable differences. The first and most significant difference is the time frame used in calculating the VER availability probability distributions. For VER fuel sources, the day of the week does not influence variability, as weather is always variable. Therefore, the need to use the data from the same day of the week is not necessary. This allows the VER distributions to be condensed to a rolling seven-day window using the same hour for each of the seven days of the scenario. The other difference is that the historical generation data is compared against the available capacity to determine the historical capacity factor for that hour to be used in the percentile probability calculation. The output of this process is a series of hourly percentile profiles with different probabilities of occurring. A random hour profile for each of the VER types is shown in Figure 3. Wind and hydro run-of-river units are positively skewed, while solar and hydro storage units are negatively skewed, meaning their distributions "lean" to the left and right, respectively.

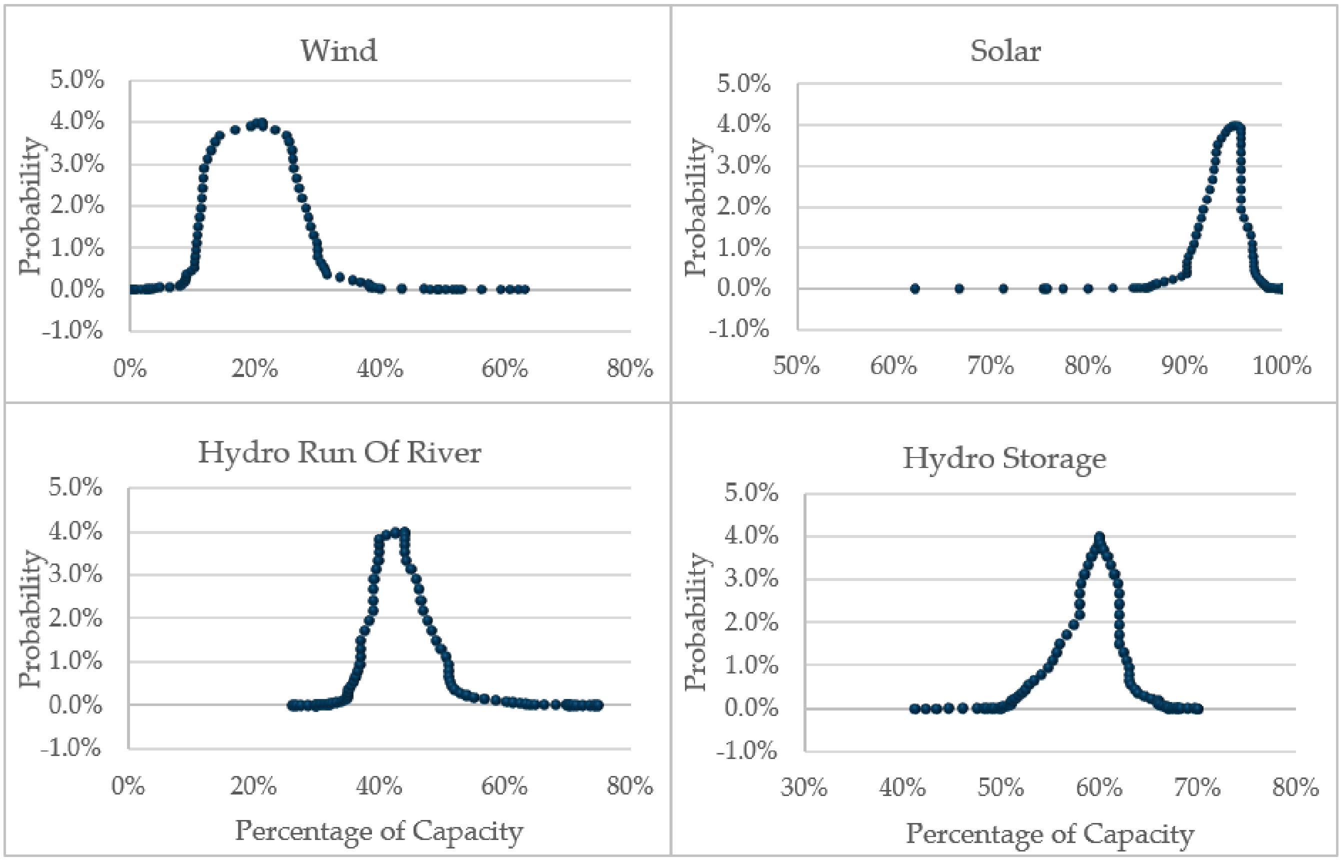

Figure 3: VER Probability Distribution Samples

Hydro facilities with storage capability are highly correlated with demand data. Although the fuel source, rain or snow runoff, is variable and not influenced by the day of the week, the ability to store the fuel leads to different operating characteristics between weekdays and weekend days. Therefore, the availability distributions for these resources are calculated the same as the demand distributions.

The distributions of the baseload resources, nuclear, coal-fired, gas-fired, and in some cases, biofuel and geothermal resources (Step 2—MAVRIC Process Flowchart), is determined by using the historical rate of unexpected failure and the time to return to service from the NERC Generation Availability Data System (GADS). Generator operators submit data of their generating units that summarizes expected and unexpected outages that occur. The annual frequency and recovery time for the unexpected outages is used to calculate the availability probability distributions for baseload resources. Through Monte-Carlo random sampling, MAVRIC performs 1,000 iterations for each resource, calculating the available capacity on an hourly basis for all hours of a given year. The model randomly applies outages to units throughout the year, adhering to the annual frequency of outage rates for those units. Once a unit is made unavailable, the model adheres to the mean time to recovery—meaning, for a certain period of hours after the unexpected failure, that unit remains unavailable. The total available baseload capacity for each load-serving area for each hour is then computed and stored as a sample in a database. After 1,000 iterations, the data points of availability for each hour are used to generate availability probability distributions. The output of this process is consistent with the VER distributions, in that a series of hourly percentile profiles with different probabilities of occurring is produced. A random hour profile is represented in Figure 4. The peak is the expected deterministic forecast and shows a distribution that is very negatively skewed, meaning the tail to the left is longer than the right.

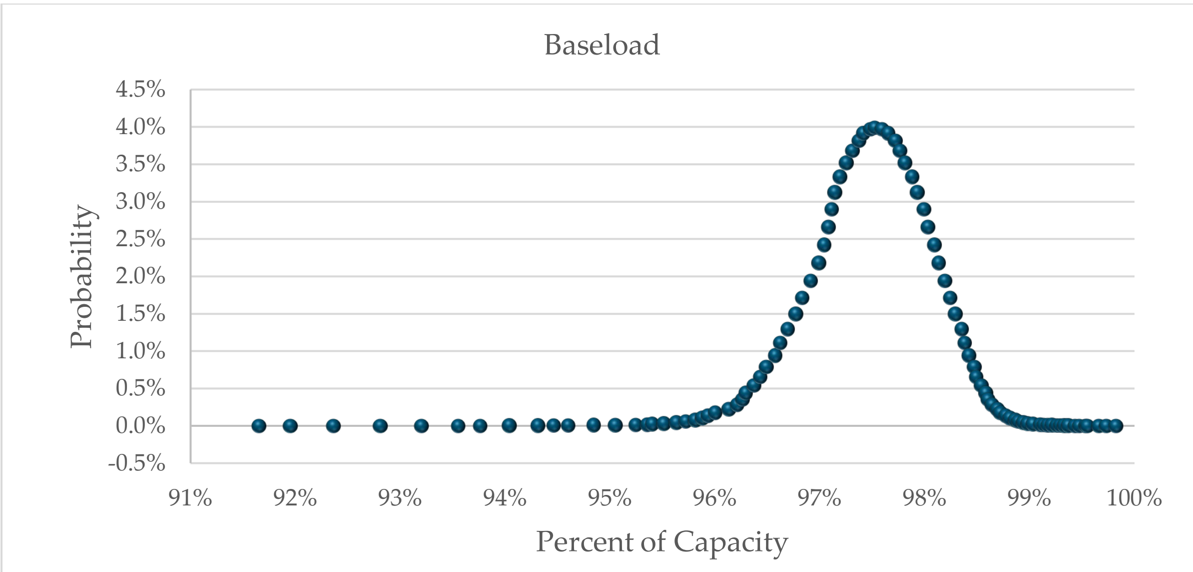

Figure 4: Baseload Probability Distribution Sample

MAVRIC then combines the 10-year forecast demand and resource capacity to represent the hourly forecast demand and availability distributions (Step 3—MAVRIC Process Flowchart). The 50th percentile of the demand distributions is set equal to 100%, with the other percentiles of the distribution ranging above and below to represent the variability in that hour (See Figure 2). The hourly demand forecast in megawatts multiplied by each of the percentiles of the probability distribution is then used to create a distribution of hourly megawatt forecast. For generation, each of the probability distributions represent capacity factor levels of availability (See Figure 3). Therefore, by taking an expected capacity of each of the different types of resources and multiplying by each of the profiles, a distribution of hourly megawatt forecast is derived. Once the availability distributions are combined, MAVRIC compares them (Step 4—MAVRIC Process Flowchart).

Step 4 represents the comparison of the hourly demand distributions with the generation availability distributions for each of the load-serving areas. For each hour, the distributions are compared to determine the amount of "overlap" in the upper tail of the demand distribution with the lower tail of the generation availability distribution. The amount of overlap and the probabilities associated with each percentile of the distributions represents the LOLP. This would be the cumulative probability associated with the overlap. If the probability is greater than the selected threshold, there is a resource adequacy shortfall in that area for that hour. A resource adequacy threshold planning reserve margin can be determined to identify the planning reserve margin needed to maintain a level of LOLP at or less than the threshold.

If there are hours determined from the calculations in Step 4 in which the LOLP is greater than the resource adequacy threshold, MAVRIC analyzes whether imports can satisfy the deficiency (Step 5—MAVRIC Process Flowchart). MAVRIC goes through a step-by-step balancing logic in which excess energy—energy above an area's planning reserve margin to maintain the resource adequacy threshold—can be used to satisfy another area's resource adequacy shortfalls. This depends on neighboring areas having excess energy and there being enough transfer capability between the two areas allowing the excess energy to flow to the area of deficit. MAVRIC analyzes first-order transfers (external assistance from an immediate neighbor) and second-order transfers (external assistance from a neighboring entity's immediate neighbors), in all cases checking for sufficient transfer capacity. After balancing all areas in the system for a given hour, MAVRIC then moves to the next hour and balances the system where needed. The end result is an analysis of the entire system reflecting the ability of all load-serving areas to maintain a resource adequacy planning reserve margin equal to or less than the threshold. Analysis is then done on any areas in which the threshold margin cannot be maintained even after external assistance from excess load-serving areas.