Performance of Generating Plant Committee

Case Study of the Month - September 2002

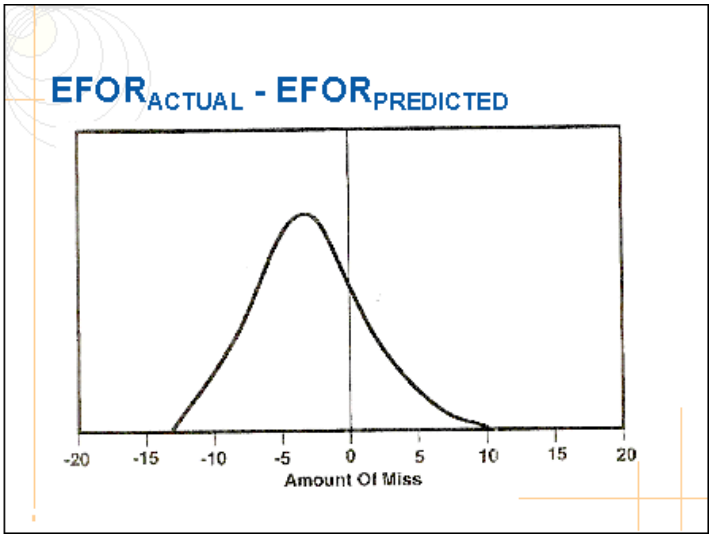
Predicting Unit Reliability

Prepared by Robert Richwine

When I headed the Reliability Engineering Department at a large (30,000 + MW) electric utility, we had the responsibility of annua estimating future reliabilities of over 100 generating units for the Planning Department to use in expansion models and production co models (we generally used Equivalent Forced Outage Rate (EFOR) as a measure of reliability). One day the Director of Planning asked me:

"How accurate are your estimates? If they predict too low a reliability (high EFOR) we may be building unnecessary plants, but if predictions are too high (low EFOR) we could be putting people in the dark due to insufficient generation."

I replied that we had been making these estimates for many years and that I thought they were pretty accurate. But I really didn't k Therefore we decided to investigate by comparing the actual EFOR's for the most recent year against the predictions we had made previous year (this is a practical example of Statistical Process Control). The frequency distribution in Figure 1 below is the result.



We were ***terrible!***
Not only did we have a very wide variation in the results, but more significantly we had a bias of almost 4 percentage points! That meant that we had been dramatically understating the system's reliability, and that we were probably planning too much (4 percentage point 30,000 MW is 1200 MW) new generation. The reason for these high EFOR estimates was that during this period the company's plants were consistently improving their reliabilities, but we were not adequately incorporating this into our forecasting methods. We had beer using historic statistical averages without incorporating new information (aggressive and successful improvement programs) into c forecasts. We realized that the past was important but that we needed to consider more factors.

The basic principle we followed was that if we could understand and quantify the relationship between past conditions and the resulting past reliability (which factors influenced each unit's reliability and to what degree) and then anticipate what conditions the unit wou encounter in the future, we could develop an equation to more accurately predict the unit's future reliability.

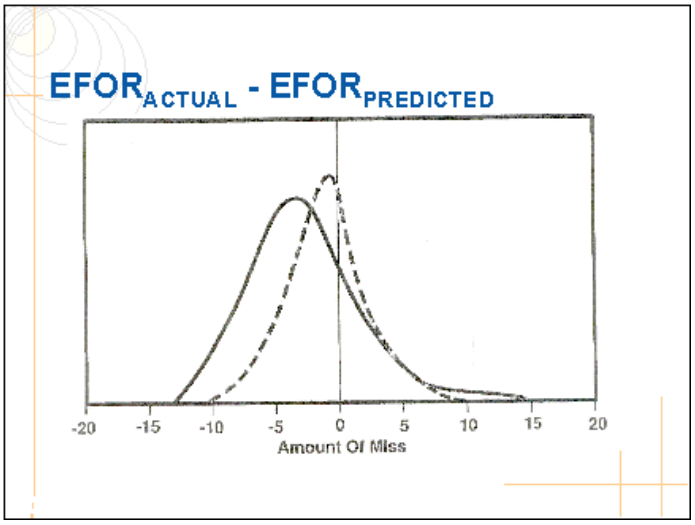
BASIC PRINCIPLE

$$\frac{\text{Past\_Conditions}}{\text{Past Reliability}} \sim \frac{\text{Future Conditions}}{\text{Future Reliability}}$$

We began a project using multi-variable linear regressions to try to develop this new prediction equation (today we might use neural network techniques). After evaluating numerous possible influencing factors, we found that the most important were:

1. the previous year's reliability (no surprise - this is what we had been doing)
2. previous year's duty cycle
3. current year Operations and Maintenance activities including outage time and spending
4. previous year's O & M spending (there was a lagging effect - up to two years)
5. certain design characteristics such as fuel and major equipment manufactures

After we developed the new prediction equation, we applied it to the original prediction year (which was not used in the developmer equation) and subtracted the new predictions from the actual EFOR's for that year. The results are shown in the dashed line freq distribution in Figure 2 below (the solid line is the original distribution).



Clearly our new equation was much better! We had substantially reduced the variability, but much more importantly, the new process almost completely eliminated the bias. Now our Planning Department could develop their generation plan and estimate production cost with a much higher degree of confidence.

A summary of this and other similar techniques can be found in references 1 and 2.

References

1. **"Predicting Unit Availability: A Top-Down Perspective"**, published by the North American Electric Reliability Council's (NERC) Generating Availability Trend Evaluation (GATE) Working Group, 1991.
2. **"Predicting Unit Reliability"**, published by NERC's GATE Working Group, 1995.