4 CSR 240-22.040 Appendix K - EFORd Discussion

GADSNxL
Taking data collection and reporting to the next level

Equivalent Demand Forced Outage Rate: EFORd

Analysis and Reporting calculates all of the standard performance measures and statistics from the event and performance data that are defined in IEEE Standard 762 and in the NERC GADS Data Reporting Instructions Appendix F - Performance Indexes and Equations.

In addition to these standard measurements, Analysis and Reporting also calculates the Equivalent Demand Forced Outage Rate (EFORd) that has been developed to respond to the deregulated capacity and energy markets. The EFORd is used by various Independent System Operators (ISOs) to calculate Unforced Capacities.

The EFORd is not to be confused with the Equivalent Forced Outage Rate (EFOR).

EFOR is defined by the NERC GADS Data Reporting Instructions in Appendix F. This value may be calculated on any time period basis including hourly, daily, weekly, monthly, quarterly, and annually, as well as the time periods based on these individual time periods such as 12-month rolling averages, last 3 years, peak periods, etc. depending on the completeness of the reported event data.

The EFORd calculations have two variations: EFORd (PJM/NYISO) and EFORd (Markov). Both variations are based on the Markov model discussed in detail below and are included in Analysis and Reporting. For a detailed comparison between the PJM/NYISO and the Markov EFORd equations, click on the following link: EFORd Comparison (PDF).

Analysis and Reporting calculates EFORd (PJM/NYISO) exactly as defined by the ISOs. The EFORd (PJM/NYISO) was originally defined by the PJM Interconnection and the NYISO has adopted the PJM formulation.

As defined by the ISOs, the EFORd (PJM/NYISO) calculations have certain restrictions regarding the time periods for which they can be calculated, due to the source data for the terms in the EFORd equations. Since some of the equations' terms use monthly GADS performance data from the Performance 01 and 02 data records, the smallest period and the smallest "block" is the month — all calculations are based on monthly increments.

As defined by the PJM, the EFORd may be calculated on a monthly, quarterly and annual basis, as well as time periods based on these individual time periods such as 12-month rolling averages, last 3 years, etc.

The EFORd (Markov) methodology was recommended by the ad hoc NERC Cycling Unit Assessment Task Force, but has not yet been officially approved by either IEEE or NERC. This model requires that the generating units submit full GADS event data including all Reserve Shutdown events and is based on a more rigorous Markov model.

Since the "general release" version of the Markov model also uses unit attempted and successful starts (GADS Performance 01 record data) in the equations, the EFORd (Markov) also is limited to the month as the smallest period and the smallest "block". As a result, the EFORd (Markov) can be calculated on a monthly, quarterly and annual basis, as well as time periods based on these individual time periods such as 12-month rolling averages, last 3 years, etc.

Currently in development is a specialized version of EFORd (Markov) for units that provide all GADS event and performance data. This model will be included in a future upgrade to Analysis and Reporting and will allow for the calculation of the EFORd for any time period required including hourly, daily, weekly, etc. since it is not based on any GADS Performance 01 or 02 record data.

Markov Model Discussion

The Markov approach simply uses the relative historical average forced outage, reserve shutdown, and service time (duty) durations to calculate a "discount factor," which approximates how much of the reported forced outage time occurred during actual demand conditions.

The current IEEE-Standard 762 EFOR equation, also used by NERC GADS, adequately approximates a demand-related EFOR, but only for baseload units.

Efforts have been taken in the past to solve this dilemma. The Markov approaches used in two 1970s technical papers have been combined and refined (*see references below*). The resulting Markov model is universally suitable to approximate a demand-related EFOR for generating units having any duty cycle.

The Markov model has developed into two different EFORd formulas that are in common use today, which we refer to as the PJM/NYISO and the Markov formulas in the discussion above. One difference between the formulas is due to whether or not all reserve shutdown events are reported. If they are not reported, then certain other data must be used as a proxy to approximate or estimate the missing data.

Both of these EFORd formulations of the Markov approach provide only an approximation and should be considered in that vein when applied as a prediction tool. For applications requiring an exact accounting of demand-related forced outage time (such as contract guarantees), the optimal method of reporting is to record the exact demand time-line with the corresponding outages. This data would have to be recorded on a unit-by-unit basis.

The Markov equation and its two EFORd variations are complex in appearance. However, the Markov approach simply uses the relative historical average forced outage, reserve shutdown and service time (duty) durations to calculate a discount factor, which approximates how much of the reported forced outage time occurred during actual demand conditions.

The following are considered as the advantages of using the Markov-based equations to calculate EFOR.

1. Directly provides an approximate demand-related EFOR, which is a popular index for planning, production, and design facilities in the U.S. and other countries.
2. Applicable to units with any duty cycles. For truly base-load units (continuous demand), the discount factor would approach 1.
3. It discounts the reported forced outage time for those demand-related periods when there is little (or no) urgency to repair. The non demand-related periods, by definition, are not applicable to a demand-related EFOR.

The following are the disadvantages of the Markov approach.

1. Appears complex. It is more complex than the current IEEE Standard 762 EFOR equation. However, it requires no additional data-reporting burden - it uses standard GADS data. Computers handle the calculations.
2. It is an approximation. However, it is a major improvement over the current EFOR equation to estimate a demand-related EFOR. It uses average and relative forced-outage event durations, duty durations, and reserve shutdown event durations to approximate the forced outage discount factor. The only exact way to calculate a demand-related EFOR would be to report the demand time for each generating unit along with the unit's events. This could be a costly effort and potentially subjective (depending on how it is done).

References

- "A Four-State Model for Estimation of Outage Risk for Units in Peaking Service" - Report of the IEEE Task Group on Models for Peaking Service Units. Application of Probability Methods Subcommittee. IEEE Transactions, Volume PAS 91 (1972) Task Group members: A.B. Calsetta, LILCO; P.F. Albrecht, GE; V.M. Cook, consultant, Scarsdale, New York; R.J. Ringlee, Power Technologies, Inc.; J.P. Whooley, PSE&G, all members of IEEE.
- "A Method for Estimating Equivalent Forced Outage Rate of Multistate Peaking Units". IEEE Transactions on Power Apparatus and Systems, Volume PAS 97, No. 6, November/December 1978. M.P. Bhavarju, J.A. Hynds and G.A. Nunan, PSE&G, all members of IEEE.