

## APPENDIX F

### PERFORMANCE INDEXES AND EQUATIONS

#### GENERAL INFORMATION

Appendix F discusses the relationships among the performance indexes calculated from the event and performance data outlined in Sections III and IV. The basis for these relationships is IEEE Standard No. 762 “Definitions for Use in Reporting Electric Generating Unit Reliability, Availability and Productivity.”

#### SUMMARY OF VARIOUS TIME AND ENERGY FACTORS USED BY INDEXES

- |    |                                       |  |
|----|---------------------------------------|--|
| 1. | Service Hours - SH                    | Sum of all Unit Service Hours.   |
| 2. | Synchronous Hours                     | Sum of all hours the unit is in the synchronous condensing mode. The units are considered to be in a non-generating service operation.   |
| 3. | Pumping Hours                         | Sum of all hours the pumped storage unit is in pumping mode. The units are considered to be in a non-generating service operation.   |
| 4. | Available Hours - AH                  | Sum of all Service Hours (SH) + Reserve Shutdown Hours (RSH) + Pumping Hours + Synchronous Condensing Hours.   |
| 5. | Planned Outage Hours - POH            | Sum of all hours experienced during Planned Outages (PO) + Scheduled Outage Extensions (SE) of any Planned Outages (PO).   |
| 6. | Unplanned Outage Hours - UOH          | Sum of all hours experienced during Unplanned (Forced) Outages (U1, U2, U3) + Startup Failures (SF) + Maintenance Outages (MO) + Scheduled Outage Extensions (SE) of any Maintenance Outages (MO). |
| 7. | Unplanned (Forced) Outage Hours - FOH | Sum of all hours experienced during Unplanned (Forced) Outages (U1, U2, U3) + Startup Failures (SF).   |
| 8. | Maintenance Outage Hours - MOH        | Sum of all hours experienced during Maintenance Outages (MO) + Scheduled Outage Extensions (SE) of any Maintenance Outages (MO).   |
| 9. | Unavailable Hours - UH                | Sum of all Planned Outage Hours (POH) + Unplanned (Forced) Outage Hours (FOH) + Maintenance Outage Hours (MOH).  |

10. Scheduled Outage Hours - SOH  
Sum of all hours experienced during Planned Outages (PO) + Maintenance Outages (MO) + Scheduled Outage Extensions (SE) of any Maintenance Outages (MO) and Planned Outages (PO).
11. Period Hours - PH  
Number of hours in the period being reported that the unit was in the active state.
12. Equivalent Seasonal Derated Hours - ESEDH  
Net Maximum Capacity (NMC)  
Net Dependable Capacity (NDC) x Available Hours (AH) / Net Maximum Capacity (NMC).  
$$\frac{(NMC - NDC) \times AH}{NMC}$$
- 13a. Equivalent Unplanned (Forced) Derated Hours - EFDH (D1, D2, D3)  
Each individual Unplanned (Forced) Derating (D1, D2, D3) is transformed into equivalent full outage hour(s). This is calculated by multiplying the actual duration of the derating (hours) by the size of the reduction (MW) and dividing by the Net Maximum Capacity (NMC). These equivalent hour(s) are then summed.  
$$\frac{\text{Derating Hours} \times \text{Size of Reduction}^*}{NMC}$$
- NOTE: Includes Unplanned (Forced) Deratings (D1, D2, D3) during Reserve Shutdowns (RS). See 11d, Page F-3.

\* Size of Reduction is determined by subtracting the Net Available Capacity (NAC) from the Net Dependable Capacity (NDC). In cases of multiple deratings, the Size of Reduction of each derating will be determined by the difference in the Net Available Capacity of the unit prior to the derating and the reported Net Available Capacity as a result of the derating

13b. Equivalent Maintenance Derated Hours - EMDH (D4, DE of D4)

Each individual Maintenance Derating (D4, DE) is transformed into equivalent full outage hour(s). This is calculated by multiplying the actual duration of the derating (hours) by the size of reduction (MW) and dividing by the Net Maximum Capacity (NMC). These equivalent hour(s) are then summed.

$$\frac{\text{Derating Hours} \times \text{Size of Reduction}^*}{\text{NMC}}$$

13c. Equivalent Planned Derated Hours - EPDH (PD, DE of PD)

Each individual Planned Derating (PD, DE) is transformed into equivalent full outage hour(s). This is calculated by multiplying the actual duration of the derating (hours) by the size of reduction (MW) and dividing by the Net Maximum Capacity (NMC). These equivalent hour(s) are then summed.

$$\frac{\text{Derating Hours} \times \text{Size of Reduction}^*}{\text{NMC}}$$

NOTE: Includes Planned Deratings (PD) during Reserve Shutdowns (RS). See 11d, Page F-3.

13d. Equivalent Scheduled Derated Hours - ESDH (PD, DE of PD, D4 and DE of D4)

Each individual Planned Derating (PD, DE) and Maintenance Derating (D4, DE) is transformed into equivalent full outage hour(s). This is calculated by multiplying the actual duration of the derating (hours) by the size of reduction (MW) and dividing by the Net Maximum Capacity (NMC). These equivalent hour(s) are then summed.

$$\frac{\text{Derating Hours} \times \text{Size of Reduction}^*}{\text{NMC}}$$

\* Size of Reduction is determined by subtracting the Net Available Capacity (NAC) from the Net Dependable Capacity (NDC). In cases of multiple deratings, the Size of Reduction of each derating will be determined by the difference in the Net Available Capacity of the unit prior to the derating and the reported Net Available Capacity as a result of the derating

13e. Equivalent Unplanned Derated Hours - EUDH  
(D1, D2, D3, D4, DE)

Each individual Unplanned Derating (D1, D2, D3, D4, DE) is transformed into equivalent full outage hour(s). This is calculated by multiplying the actual duration of the derating (hours) by the size of reduction (MW) and dividing by the Net Maximum Capacity (NMC). These equivalent hour(s) are then summed.

$$\frac{\text{Derating Hours} \times \text{Size of Reduction}^*}{\text{NMC}}$$

NOTE: Includes Unplanned Deratings (D1, D2, D3, D4, DE) during Reserve Shutdowns (RS).  
See 11d below.

13f. Equivalent Unplanned (Forced) Derated Hours During Reserve Shutdowns - EFDHRS  
(D1, D2, D3)

Each individual Unplanned (Forced) Derating (D1, D2, D3) or the portion of any Unplanned (Forced) derating which occurred during a Reserve Shutdown (RS) is transformed into equivalent full outage hour(s). This is calculated by multiplying the actual duration of the derating (hours) by the size of the reduction (MW) and dividing by the Net Maximum Capacity (NMC). These equivalent hour(s) are then summed.

$$\frac{\text{Derating Hours} \times \text{Size of Reduction}^*}{\text{NMC}}$$

13g. Equivalent Planned Derated Hours During Reserve Shutdowns - EPDHRS  
(PD)

Each individual Planned Derating (PD) or the portion of any Planned derating which occurred during a Reserve Shutdown (RS) is transformed into equivalent full outage hour(s). This is calculated by multiplying the actual duration of the derating (hours) by the size of the reduction (MW) and dividing by the Net Maximum Capacity (NMC). These equivalent hour(s) are then summed.

$$\frac{\text{Derating Hours} \times \text{Size of Reduction}^*}{\text{NMC}}$$

13h. Equivalent Maintenance Derated Hours During Reserve Shutdowns - EMDHRS  
(D4)

Each individual Maintenance Derating (D4) or the portion of any Maintenance derating which occurred during a Reserve

Shutdown (RS) is transformed into equivalent full outage hour(s). This is calculated by multiplying the actual duration of the derating (hours) by the size of the reduction (MW) and dividing by the Net Maximum Capacity (NMC). These equivalent hour(s) are then summed.

$$\frac{\text{Derating Hours} \times \text{Size of Reduction}^*}{\text{NMC}}$$

14. Number of Planned Outages (PO) which occur from in-service state only
- A count of the number of all Planned Outages (PO) reported on the GADS Event Report (97). (Since Scheduled Outage Extensions (SE) of Planned Outages are considered part of the original Planned Outage (PO), they are not included in this count.)
15. Number of Unplanned Outages (MO, U1, U2, U3) which occur from in-service state only
- A count of the number of all Unplanned Outages (U1, U2, U3, MO) reported on the GADS Event Report (97). (IEEE Standard 762 does not include Startup Failures (SF) in this count.)
- \* Size of Reduction is determined by subtracting the Net Available Capacity (NAC) from the Net Dependable Capacity (NDC). In cases of multiple deratings, the Size of Reduction of each derating will be determined by the difference in the Net Available Capacity of the unit prior to the derating and the reported Net Available Capacity as a result of the derating

- |  |   |
|--|---|
| 16. Number of Unplanned (Forced) Outages (U1, U2, U3) which occur from in-service state only | A count of the number of all Unplanned (Forced) Outages (U1, U2, U3) reported on the GADS Event Report (97). (IEEE Standard 762 does not include Startup Failures (SF) in this count.)  |
| 17. Number of Maintenance Outages (MO) which occur from in-service state only                | A count of the number of all Maintenance Outages (MO) reported on the GADS Event Report (97). (Since Scheduled Outage Extensions (SE) of Maintenance Outages are considered part of the original Maintenance Outage (MO), they are not included in this count.) |

\* Size of Reduction is determined by subtracting the Net Available Capacity (NAC) from the Net Dependable Capacity (NDC). In cases of multiple deratings, the Size of Reduction of each derating will be determined by the difference in the Net Available Capacity of the unit prior to the derating and the reported Net Available Capacity as a result of the derating.

## PERFORMANCE INDEXES

The following sections describe performance indexes used to measure the performance of generating units. The sections are divided into:

- 1) Unweighted (time-based) methods for calculating single unit statistics.
- 2) Unweighted (time-based) methods for pooled (grouping) unit statistics
- 3) Weighted (capacity-based) methods for pooling (grouping) unit statistics.
- 4) Weighted (capacity-based) statistics excluding problems outside management control. (See Appendix K for more details.) This fourth section is used Europe and other places in the world for measuring the productivity of plant personnel.

### SOME WORDS ABOUT CALCULATIONS

Please note that when you are calculating a single generating unit's performance statistics, it does not matter if you use unweighted- or weighted-based statistics. The answer will generally be the same. The real difference between the unweighted and weighted statistics is in pooling (or grouping) of a set of generating units. In such cases, a group of units of similar size will show little or no differences but a for group of units where the MW size is very different (greater than 50 MW), the statistics will be very different.

With unweighted statistics, all units are considered equal in outage impact. In the unweighted equations, no MW size is introduced into the equations and the results are based on time, not energy produced (or not produced.) In such cases, a 50 MW gas turbine and a 1,000 MW nuclear unit have the same impact of the resulting statistics.

With weighted statistics, the larger MW size unit in the group has more impact on the final statistics than a smaller generating unit. That is because the MW size of the unit (NMC) is part of the equation. In such cases, a 1,000 MW nuclear unit would have 20 times impact on the final outcome of the calculation than would its 50 MW gas turbine companion.

### MORE WORDS ABOUT DATA POOLING

When grouping a fleet of units of dissimilar size and/or duty cycle, weighting puts the proper relative weight of each unit's contribution into the fleet's composite indexes.

Using the unweighted equations currently in the IEEE 762 Standard (Section 7), an older, smaller, little-run unit will have just as much weight as a newer, larger, base-load unit. The effect of this could unrealistically and disproportionately swing the fleet unweighted averages too high (for a very high availability on a small unit) or too low (for a very low availability on a small unit).

The current IEEE 762 Standard's unweighted equations should not be abandoned, however, even for group statistics. There are valid applications for this method as well. (One being purely to evaluate equipment reliability and availability regardless of size).

The weighted calculations, although primarily needed for grouping units' performance indexes, may apply to individual units as well. The effect will be minimal, but over the months or years, many units' net maximum capacities (NMC) do change somewhat.

*SPECIAL NOTE: To weight an equation, one does not simply take each unit's EFOR, for example, and multiply the EFOR by the NMC, add them up and divide by the sum of the NMCs. Each term in the equation must be multiplied by the NMC and then all the products are summed over all the units.*

## UNWEIGHTED (TIME-BASED) PERFORMANCE INDEXES SINGLE UNIT CALCULATIONS

1. Planned Outage Factor – POF

$$\text{POF} = \frac{\text{POH}}{\text{PH}} \times 100\%$$

2. Unplanned Outage Factor - UOF

$$\text{UOF} = \frac{\text{UOH}}{\text{PH}} \times 100\%$$

$$\text{UOF} = \frac{\text{MOH} + \text{FOH} + \text{SE of MO}}{\text{PH}} \times 100\%$$

3. Forced Outage Factor - FOF

$$\text{FOF} = \frac{\text{FOH}}{\text{PH}} \times 100\%$$

4. Maintenance Outage Factor - MOF

$$\text{MOF} = \frac{\text{MOH}}{\text{PH}} \times 100\%$$

5. Scheduled Outage Factor - SOF

$$\text{SOF} = \frac{\text{SOH}}{\text{PH}} \times 100\%$$

$$\text{SOF} = \frac{\text{POH} + \text{MOH}}{\text{PH}} \times 100\%$$

6. Unavailability Factor - UF

$$UF = \frac{UH}{PH} \times 100\%$$

$$UF = \frac{POH + MOH + FOH}{PH} \times 100\%$$

7. Availability Factor - AF

$$AF = \frac{AH}{PH} \times 100\%$$

$$AF = \frac{SH + RSH + \text{Synchronous Hours} + \text{Pumping Hours}}{PH} \times 100\%$$

8. Service Factor - SF

$$SF = \frac{SH}{PH} \times 100\%$$

9. Seasonal Derating Factor - SEDF

$$SEDF = \frac{ESEDH}{PH} \times 100\%$$

10. Unit Derating Factor - UDF

$$UDF = \frac{EPDH + EUDH}{PH} \times 100\%$$

$$UDF = \frac{EPDH + EMDH + EFDH}{PH} \times 100\%$$

11. Equivalent Unavailability Factor - EUF

$$EUF = \frac{UOH + POH + EUDH + EPDH}{PH} \times 100\%$$

$$EUF = \frac{FOH + SOH + EFDH + ESDH}{PH} \times 100\%$$

$$EUF = \frac{FOH + MOH + POH + EFDH + EMDH + EPDH}{PH} \times 100\%$$

12. Equivalent Availability Factor - EAF

$$\text{EAF} = \frac{\text{AH} - \text{EPDH} - \text{EUDH} - \text{ESEDH}}{\text{PH}} \times 100\%$$

$$\text{EAF} = \frac{\text{AH} - \text{EPDH} - \text{EFDH} - \text{EMDH} - \text{ESEDH}}{\text{PH}} \times 100\%$$

13. Gross Capacity Factor - GCF

$$\text{GCF} = \frac{\text{Gross Actual Generation}}{\text{PH} \times \text{GMC}} \times 100\%$$

14. Net Capacity Factor - NCF

$$\text{NCF} = \frac{\text{Net Actual Generation}}{\text{PH} \times \text{NMC}} \times 100\%$$

Note: *Net capacity factor calculated using this equation can be negative during a period when the unit is shutdown.*

15. Gross Output Factor - GOF

$$\text{GOF} = \frac{\text{Gross Actual Generation}}{\text{SH} \times \text{GMC}} \times 100\%$$

16. Net Output Factor - NOF

$$\text{NOF} = \frac{\text{Net Actual Generation}}{\text{SH} \times \text{NMC}} \times 100\%$$

17. Equivalent Maintenance Outage Factor -- EMOF

$$\text{EMOF} = \frac{(\text{MOH} + \text{EMDH})}{\text{PH}} \times 100\%$$

18. Equivalent Planned Outage Factor – EPOF

$$\text{EPOF} = \frac{(\text{POH} + \text{EPDH})}{\text{PH}} \times 100\%$$

19. Equivalent Forced Outage Factor -- EFOF

$$\text{EFOF} = \frac{(\text{FOH} + \text{EFDH})}{\text{PH}} \times 100\%$$

20. Equivalent Scheduled Outage Factor -- ESOF

$$\text{ESOF} = \frac{(\text{SOH} + \text{ESDH})}{\text{PH}} \times 100\%$$

$$\text{ESOF} = \frac{(\text{MOH} + \text{POH} + \text{EMDH} + \text{EPDH})}{\text{PH}} \times 100\%$$

21. Equivalent Unplanned Outage Factor -- EUOF

$$\text{EUOF} = \frac{(\text{UOH} + \text{EUDH})}{\text{PH}} \times 100\%$$

$$\text{EUOF} = \frac{(\text{MOH} + \text{FOH} + \text{EMDH} + \text{EFDH})}{\text{PH}} \times 100\%$$

(NOTE: This EUOF is identical to the Unit Capability Loss Factor except this equation includes all events, including those outside plant management control.)

22. Forced Outage Rate - FOR

$$\text{FOR} = \frac{\text{FOH}}{\text{FOH} + \text{SH} + \text{Synchronous Hrs} + \text{Pumping Hrs}} \times 100\%$$

23. Forced Outage Rate Demand- FORd (See Notes 1 and 2 at the end of this section)

$$\text{FORd} = \frac{\text{FOHd}}{[\text{FOHd} + \text{SH}]} \times 100\%$$

where

$$\text{FOHd} = f \times \text{FOH}$$

$$f = \left( \frac{1}{r} + \frac{1}{T} \right) / \left( \frac{1}{r} + \frac{1}{T} + \frac{1}{D} \right)$$

r = Average Forced outage deration = (FOH) / (# of FO occurrences)  
D = Average demand time = (SH) / (# of unit actual starts)  
T = Average reserve shutdown time = (RSH) / (# of unit attempted starts)

24. Equivalent Forced Outage Rate - EFOR

$$EFOR = \frac{FOH + EFDH}{FOH + SH + Synchronous\ Hrs + Pumping\ Hrs + EFDHRS} \times 100\%$$

25. Equivalent Forced Outage Rate demand – EFORD (
- See Notes 1 and 2 at the end of this section
- )

$$EFORD = \frac{[FOHd + (EFDHd)]}{[SH + FOHd]} \times 100\%$$

where

$$FOHd = f \times FOH$$

$$EFDHd = (EFDH - EFDHRS) \text{ if reserve shutdown events reported, or} \\ = (fp \times EFDH) \text{ if no reserve shutdown events reported – an approximation.}$$

$$fp = (SH/AH)$$

$$f = \left( \frac{1}{r} + \frac{1}{T} \right) / \left( \frac{1}{r} + \frac{1}{T} + \frac{1}{D} \right)$$

$r = \text{Average Forced outage duration} = (FOH) / (\# \text{ of FO occurrences})$   
 $D = \text{Average demand time} = (SH) / (\# \text{ of unit actual starts})$   
 $T = \text{Average reserve shutdown time} = (RSH) / (\# \text{ of unit attempted starts})$

26. Equivalent Planned Outage Rate -- EPOR

$$EPOR = \frac{POH + EPDH}{POH + SH + Synchronous\ Hrs + Pumping\ Hrs + EPDHR} \times 100\%$$

27. Equivalent Maintenance Outage Rate -- EMOR

$$EMOR = \frac{MOH + EMDH}{MOH + SH + Synchronous\ Hrs + Pumping\ Hrs + EMDHRS} \times 100\%$$

28. Equivalent Unplanned Outage Rate -- EUOR

$$EUOR = \frac{(UOH + EUDH)}{UOH + SH + Synchronous\ Hrs + Pumping\ Hrs + EUDHRS} \times 100\%$$

$$EUOR = \frac{FOH + EFDH + MOH + EMDH}{FOH + MOH + SH + Synchronous\ Hrs + Pumping\ Hrs + EFDHRS + EMDHRS} \times 100\%$$

29. Average Run Time - ART

$$\text{ART} = \frac{\text{SH}}{\text{Actual Unit Starts}} \times 100\%$$

30. Starting Reliability - SR

$$\text{SR} = \frac{\text{Actual Unit Starts}}{\text{Attempted Unit Starts}} \times 100\%$$

**Mean Service Time to Outage:**

31a. Mean Service Time to Planned Outage - MSTPO

$$\text{MSTPO} = \frac{\text{Service Hours} + \text{Synchronous Condensing Hours} + \text{Pumping Hours} \\ \text{(which occur from in-service state only)}}{\text{Number of Planned Outages} \\ \text{(which occur from in-service state only)}}$$

31b. Mean Service Time to Unplanned Outage - MSTUO

$$\text{MSTUO} = \frac{\text{Service Hours} + \text{Synchronous Condensing Hours} + \text{Pumping Hours} \\ \text{(which occur from in-service state only)}}{\text{Number of Unplanned Outages} \\ \text{(which occur from in-service state only)}}$$

31c. Mean Service Time To Forced Outage - MSTFO

$$\text{MSTFO} = \frac{\text{Service Hours} + \text{Synchronous Condensing Hours} + \text{Pumping Hours} \\ \text{(which occur from in-service state only)}}{\text{Number of (Unplanned) Forced Outages} \\ \text{(which occur from in-service state only)}}$$

31d. Mean Service Time to Maintenance Outage - MSTMO

$$\text{MSTMO} = \frac{\text{Service Hours} + \text{Synchronous Condensing Hours} + \text{Pumping Hours} \\ \text{(which occur from in-service state only)}}{\text{Number of Maintenance Outages} \\ \text{(which occur from in-service state only)}}$$

**Mean Outage Duration:**

32a. Mean Planned Outage Duration - MPOD

$$\text{MPOD} = \frac{\text{Planned Outage Hours (which occur from in-service state only)}}{\text{Number of Planned Outages (which occur from in-service state only)}}$$

32b. Mean Unplanned Outage Duration - MUOD

$$\text{MUOD} = \frac{\text{Unplanned Outage Hours (which occur from in-service state only)}}{\text{Number of Unplanned Outages (which occur from in-service state only)}}$$

32c. Mean Forced Outage Duration - MFOD

$$\text{MFOD} = \frac{\text{Unplanned (Forced) Outage Hours (which occur from in-service state only)}}{\text{Number of Unplanned (Forced) Outages (which occur from in-service state only)}}$$

32d. Mean Maintenance Outage Duration - MMOD

$$\text{MMOD} = \frac{\text{Maintenance Outage Hours (which occur from in-service state only)}}{\text{Number of Maintenance Outages (which occur from in-service state only)}}$$

**UNWEIGHTED (TIME-BASED) PERFORMANCE INDEXES  
POOLING UNIT CALCULATIONS**

33. Planned Outage Factor – POF

$$\text{POF} = \frac{\sum \text{POH}}{\sum \text{PH}} \times 100\%$$

34. Unplanned Outage Factor – UOF

$$\text{UOF} = \frac{\sum (\text{FOH} + \text{MOH})}{\sum \text{PH}} \times 100\%$$

35. Forced Outage Factor – FOF

$$\text{FOF} = \frac{\sum \text{FOH}}{\sum \text{PH}} \times 100\%$$

36. Maintenance Outage Factor – MOF

$$\text{MOF} = \frac{\sum \text{MOH}}{\sum \text{PH}} \times 100\%$$

37. Scheduled Outage Factor – SOF

$$\text{SOF} = \frac{\sum (\text{POH} + \text{MOH})}{\sum \text{PH}} \times 100\%$$

38. Unavailability Factor – UF

$$\text{UF} = \frac{\sum (\text{POH} + \text{MOH} + \text{FOH})}{\sum \text{PH}} \times 100\%$$

39. Availability Factor – AF

$$\text{AF} = \frac{\sum \text{AH}}{\sum \text{PH}} \times 100\%$$

$$\text{AF} = \frac{\sum (\text{SH} + \text{RSH} + \text{Synchronous Hours} + \text{Pumping Hours})}{\sum \text{PH}} \times 100\%$$

40. Service Factor – SF

$$\text{SF} = \frac{\sum \text{SH}}{\sum \text{PH}} \times 100\%$$

41. Seasonal Derating Factor – SEDF

$$\text{SEDF} = \frac{\sum \text{ESEDH}}{\sum \text{PH}} \times 100\%$$

42. Unit Derating Factor – UDF

$$UDF = \frac{\Sigma (EUDH + EPDH)}{\Sigma PH} \times 100\%$$

$$UDF = \frac{\Sigma (EFDH + EMDH + EPDH)}{\Sigma PH} \times 100\%$$

43. Equivalent Unavailability Factor – EUF

$$EUF = \frac{\Sigma (POH + UOH + EUDH + EPDH)}{\Sigma PH} \times 100\%$$

$$EUF = \frac{\Sigma (SOH + FOH + ESDH + EFDH)}{\Sigma PH} \times 100\%$$

$$EUF = \frac{\Sigma (POH + MOH + FOH + EFDH + EMDH + EPDH)}{\Sigma PH} \times 100\%$$

44. Equivalent Availability Factor – EAF

$$EAF = \frac{\Sigma (AH - EUDH - EPDH - ESEDH)}{\Sigma PH} \times 100\%$$

$$EAF = \frac{\Sigma (AH - EFDH - EMDH - EPDH - ESEDH)}{\Sigma PH} \times 100\%$$

45. \* Gross Capacity Factor – GCF

$$GCF = \frac{\Sigma (\text{Gross Actual Generation})}{\Sigma (\text{GMC} \times \text{PH})} \times 100\%$$

46. \* Net Capacity Factor – NCF

$$NCF = \frac{\Sigma (\text{Net Actual Generation})}{\Sigma (\text{NMC} \times \text{PH})} \times 100\%$$

\* NOTE: Special energy-weighted equations are not necessary for “energy terms” (GCF, NCF, GOF, NOF), because these factors are inherently energy-weighted. These equations are the same as 7.12 – 7.15. But when calculating for a group of units (or a unit that has a varying capacity value over time), do not simply average these factors. Follow the equations.

47. \* Gross Output Factor – GOF

$$\text{GOF} = \frac{\Sigma (\text{Gross Actual Generation})}{\Sigma (\text{GMC} \times \text{SH})} \times 100\%$$

48. \* Net Output Factor – NOF

$$\text{NOF} = \frac{\Sigma (\text{Net Actual Generation})}{\Sigma (\text{NMC} \times \text{SH})} \times 100\%$$

49. Equivalent Maintenance Outage Factor -- EMOF

$$\text{EMOF} = \frac{\Sigma (\text{MOH} + \text{EMDH})}{\Sigma \text{PH}} \times 100\%$$

50. Equivalent Planned Outage Factor -- EPOF

$$\text{EPOF} = \frac{\Sigma (\text{POH} + \text{EPDH})}{\Sigma \text{PH}} \times 100\%$$

51. Equivalent Forced Outage Factor -- EFOF

$$\text{EFOF} = \frac{\Sigma (\text{FOH} + \text{EFDH})}{\Sigma \text{PH}} \times 100\%$$

52. Equivalent Scheduled Outage Factor -- ESOF

$$\text{ESOF} = \frac{\Sigma (\text{SOH} + \text{ESDH})}{\Sigma \text{PH}} \times 100\%$$

$$\text{ESOF} = \frac{\Sigma (\text{MOH} + \text{POH} + \text{EMDH} + \text{EPDH})}{\Sigma \text{PH}} \times 100\%$$

\* NOTE: Special energy-weighted equations are not necessary for “energy terms” (GCF, NCF, GOF, NOF), because these factors are inherently energy-weighted. These equations are the same as 7.12 – 7.15. But when calculating for a group of units (or a unit that has a varying capacity value over time), do not simply average these factors. Follow the equations.

53. Equivalent Unplanned Outage Factor -- EUOF

$$\text{EUOF} = \frac{\Sigma (\text{UOH} + \text{EUDH})}{\Sigma \text{PH}} \times 100\%$$

$$\text{EUOF} = \frac{\Sigma (\text{MOH} + \text{FOH} + \text{EMDH} + \text{EFDH})}{\Sigma \text{PH}} \times 100\%$$

54. Forced Outage Rate – FOR

$$\text{FOR} = \frac{\Sigma \text{FOH}}{\Sigma (\text{FOH} + \text{SH} + \text{Synchronous Hours} + \text{Pumping Hours})} \times 100\%$$

55. Forced Outage Rate demand – FORd (
- See Notes 1 and 2 at the end of this section*
- )

$$\text{FORd} = \frac{\Sigma \text{FOHd}}{\Sigma \text{FOHd} + \text{SH}} \times 100\%$$

Where

$$\text{FOHd} = f \times \text{FOH}$$

$$f = \left( \frac{1}{r} + \frac{1}{T} \right) / \left( \frac{1}{r} + \frac{1}{T} + \frac{1}{D} \right)$$

$r$  = Average Forced outage deration = (FOH) / (# of FO occurrences)  
 $D$  = Average demand time = (SH) / (# of unit actual starts)  
 $T$  = Average reserve shutdown time = (RSH) / (# of unit attempted starts)

56. Equivalent Forced Outage Rate – EFOR

$$\text{EFOR} = \frac{\Sigma (\text{FOH} + \text{EFDH})}{\Sigma (\text{FOH} + \text{SH} + \text{Synchronous Hours} + \text{Pumping Hours} + \text{EFDHRS})} \times 100\%$$

57. Equivalent Forced Outage Rate demand – EFORD (See Notes 1 and 2 at the end of this section)

$$EFORD = \frac{[\Sigma [FOHd + (EFDHd)]]}{\Sigma (SH + FOHd)} \times 100\%$$

where

$$FOHd = f \times FOH$$

$$\begin{aligned} EFDHd &= (EFDH - EFDHRS) \text{ if reserve shutdown events reported, or} \\ &= (fp \times EFDH) \text{ if no reserve shutdown events reported – an approximation.} \end{aligned}$$

$$fp = (SH/AH)$$

$$f = \left( \frac{1}{r} + \frac{1}{T} \right) / \left( \frac{1}{r} + \frac{1}{T} + \frac{1}{D} \right)$$

$r = \text{Average Forced outage deration} = (FOH) / (\# \text{ of FO occurrences})$   
 $D = \text{Average demand time} = (SH) / (\# \text{ of unit actual starts})$   
 $T = \text{Average reserve shutdown time} = (RSH) / (\# \text{ of unit attempted starts})$

58. Equivalent Planned Outage Rate -- EPOR

$$EPOR = \frac{\Sigma (POH + EPDH)}{\Sigma (POH + SH + Synchronous Hours + Pumping Hours + EPDHRS)} \times 100\%$$

59. Equivalent Maintenance Outage Rate -- EMOR

$$EMOR = \frac{\Sigma (MOH + EMDH)}{\Sigma (MOH + SH + Synchronous Hours + Pumping Hours + EMDHRS)} \times 100\%$$

60. Equivalent Unplanned Outage Rate -- EUOR

$$EUOR = \frac{\Sigma (UOH + EUDH)}{\Sigma (UOH + SH + Synchronous Hours + Pumping Hours + EUDHRS)} \times 100\%$$

$$EUOR = \frac{\Sigma (FOH + MOH + EFDH + EMDH)}{\Sigma (FOH+MOH+SH+ Synchronous Hours+Pumping Hours+EFDHRS+EMDHRS)} \times 100\%$$

61. Average Run Time - ART

$$ART = \frac{\Sigma SH}{\Sigma (\text{Actual Unit Starts})} \times 100\%$$

62. Starting Reliability - SR

$$SR = \frac{\Sigma (\text{Actual Unit Starts})}{\Sigma (\text{Attempted Unit Starts})} \times 100\%$$

**Mean Service Time to Outage:**

63a. Mean Service Time to Planned Outage - MSTPO

$$MSTPO = \frac{\Sigma (\text{Service Hours} + \text{Synchronous Condensing Hours} + \text{Pumping Hours})}{\Sigma (\text{Number of Planned Outages})}$$

(which occur from in-service state only)

63b. Mean Service Time to Unplanned Outage - MSTUO

$$MSTUO = \frac{\Sigma (\text{Service Hours} + \text{Synchronous Condensing Hours} + \text{Pumping Hours})}{\Sigma (\text{Number of Unplanned Outages})}$$

(which occur from in-service state only)

63c. Mean Service Time To Forced Outage - MSTFO

$$MSTFO = \frac{\Sigma (\text{Service Hours} + \text{Synchronous Condensing Hours} + \text{Pumping Hours})}{\Sigma (\text{Number of (Unplanned) Forced Outages})}$$

(which occur from in-service state only)

63d. Mean Service Time to Maintenance Outage - MSTMO

$$MSTMO = \frac{\Sigma (\text{Service Hours} + \text{Synchronous Condensing Hours} + \text{Pumping Hours})}{\Sigma (\text{Number of Maintenance Outages})}$$

(which occur from in-service state only)

**Mean Outage Duration:**

64a. Mean Planned Outage Duration - MPOD

$$\text{MPOD} = \frac{\Sigma (\text{Planned Outage Hours})}{\Sigma (\text{Number of Planned Outages})}$$

(which occur from in-service state only)

64b. Mean Unplanned Outage Duration - MUOD

$$\text{MUOD} = \frac{\Sigma (\text{Unplanned Outage Hours})}{\Sigma (\text{Number of Unplanned Outages})}$$

(which occur from in-service state only)

64c. Mean Forced Outage Duration - MFOD

$$\text{MFOD} = \frac{\Sigma (\text{Unplanned (Forced) Outage Hours})}{\Sigma (\text{Number of Unplanned (Forced) Outages})}$$

(which occur from in-service state only)

64d. Mean Maintenance Outage Duration - MMOD

$$\text{MMOD} = \frac{\Sigma (\text{Maintenance Outage Hours})}{\Sigma (\text{Number of Maintenance Outages})}$$

(which occur from in-service state only)

## WEIGHTED (CAPACITY-BASED) PERFORMANCE INDEXES POOLING UNIT CALCULATIONS

65. Weighted Forced Outage Factor – WFOF

$$\text{WFOF} = \frac{\sum (\text{FOH} \times \text{NMC})}{\sum (\text{PH} \times \text{NMC})} \times 100\%$$

66. Weighted Maintenance Outage Factor – WMOF

$$\text{WMOF} = \frac{\sum (\text{MOH} \times \text{NMC})}{\sum (\text{PH} \times \text{NMC})} \times 100\%$$

67. Weighted Planned Outage Factor – WPOF

$$\text{WPOF} = \frac{\sum (\text{POH} \times \text{NMC})}{\sum (\text{PH} \times \text{NMC})} \times 100\%$$

68. Weighted Unplanned Outage Factor – WUOF

$$\text{WUOF} = \frac{\sum [(\text{UOH}) \times \text{NMC}]}{\sum (\text{PH} \times \text{NMC})} \times 100\%$$

$$\text{WUOF} = \frac{\sum [(\text{FOH} + \text{MOH}) \times \text{NMC}]}{\sum (\text{PH} \times \text{NMC})} \times 100\%$$

69. Weighted Scheduled Outage Factor – WSOF

$$\text{WSOF} = \frac{\sum [(\text{SOH}) \times \text{NMC}]}{\sum (\text{PH} \times \text{NMC})} \times 100\%$$

$$\text{WSOF} = \frac{\sum [(\text{POH} + \text{MOH}) \times \text{NMC}]}{\sum (\text{PH} \times \text{NMC})} \times 100\%$$

70. Weighted Unavailability Factor – WUF

$$\text{WUF} = \frac{\sum [(\text{POH} + \text{MOH} + \text{SOH}) \times \text{NMC}]}{\sum (\text{PH} \times \text{NMC})} \times 100\%$$

71. Weighted Availability Factor – WAF

$$\text{WAF} = \frac{\sum (\text{AH} \times \text{NMC})}{\sum (\text{PH} \times \text{NMC})} \times 100\%$$

72. Weighted Service Factor – WSF

$$\text{WSF} = \frac{\sum (\text{SH} \times \text{NMC})}{\sum (\text{PH} \times \text{NMC})} \times 100\%$$

73. Weighted Seasonal Derating Factor – WSEDF

$$\text{WSEDF} = \frac{\sum (\text{ESEDH} \times \text{NMC})}{\sum (\text{PH} \times \text{NMC})} \times 100\%$$

74. Weighted Unit Derating Factor – WUDF

$$\text{WUDF} = \frac{\sum [(\text{EUDH} + \text{EPDH}) \times \text{NMC}]}{\sum (\text{PH} \times \text{NMC})} \times 100\%$$

$$\text{WUDF} = \frac{\sum [(\text{EFDH} + \text{EMDH} + \text{EPDH}) \times \text{NMC}]}{\sum (\text{PH} \times \text{NMC})} \times 100\%$$

75. Weighted Equivalent Unavailability Factor – WEUF

$$\text{WEUF} = \frac{\sum [(\text{POH} + \text{UOH} + \text{EUDH} + \text{EPDH}) \times \text{NMC}]}{\sum (\text{PH} \times \text{NMC})} \times 100\%$$

$$\text{WEUF} = \frac{\sum [(\text{SOH} + \text{FOH} + \text{ESDH} + \text{EFDH}) \times \text{NMC}]}{\sum (\text{PH} \times \text{NMC})} \times 100\%$$

$$\text{WEUF} = \frac{\sum [(\text{POH} + \text{MOH} + \text{FOH} + \text{EFDH} + \text{EMDH} + \text{EPDH}) \times \text{NMC}]}{\sum (\text{PH} \times \text{NMC})} \times 100\%$$

76. Weighted Equivalent Availability Factor – WEAFF

$$\text{WEAF} = \frac{\sum [(\text{AH} - \text{EUDH} - \text{EPDH} - \text{ESEDH}) \times \text{NMC}]}{\sum (\text{PH} \times \text{NMC})} \times 100\%$$

$$\text{WEAF} = \frac{\sum [(\text{AH} - \text{EFDH} - \text{EMDH} - \text{EPDH} - \text{ESEDH}) \times \text{NMC}]}{\sum (\text{PH} \times \text{NMC})} \times 100\%$$

77. \* Gross Capacity Factor – GCF

$$\text{GCF} = \frac{\sum (\text{Gross Actual Generation})}{\sum (\text{GMC} \times \text{PH})} \times 100\%$$

78. \* Net Capacity Factor – NCF

$$\text{NCF} = \frac{\sum (\text{Net Actual Generation})}{\sum (\text{NMC} \times \text{PH})} \times 100\%$$

79. \* Gross Output Factor – GOF

$$\text{GOF} = \frac{\Sigma (\text{Gross Actual Generation})}{\Sigma (\text{GMC} \times \text{SH})} \times 100\%$$

80. \* Net Output Factor – NOF

$$\text{NOF} = \frac{\Sigma (\text{Net Actual Generation})}{\Sigma (\text{NMC} \times \text{SH})} \times 100\%$$

81. Weighted Equivalent Maintenance Outage Factor -- WEMOF

$$\text{WEMOF} = \frac{\Sigma [(\text{MOH} + \text{EMDH}) \times \text{NMC}]}{\Sigma (\text{PH} \times \text{NMC})} \times 100\%$$

82. Weighted Equivalent Planned Outage Factor -- WEPOF

$$\text{WEPOF} = \frac{\Sigma [(\text{POH} + \text{EPDH}) \times \text{NMC}]}{\Sigma (\text{PH} \times \text{NMC})} \times 100\%$$

83. Weighted Equivalent Forced Outage Factor -- WEFOF

$$\text{WEFOF} = \frac{\Sigma [(\text{FOH} + \text{EFDH}) \times \text{NMC}]}{\Sigma (\text{PH} \times \text{NMC})} \times 100\%$$

84. Weighted Equivalent Scheduled Outage Factor -- WESOF

$$\text{WESOF} = \frac{\Sigma [(\text{SOH} + \text{ESDH}) \times \text{NMC}]}{\Sigma (\text{PH} \times \text{NMC})} \times 100\%$$

$$\text{WESOF} = \frac{\Sigma [(\text{MOH} + \text{POH} + \text{EMDH} + \text{EPDH}) \times \text{NMC}]}{\Sigma (\text{PH} \times \text{NMC})} \times 100\%$$

\* NOTE: Special energy-weighted equations are not necessary for “energy terms” (GCF, NCF, GOF, NOF), because these factors are inherently energy-weighted. These equations are the same as 7.12 – 7.15. But when calculating for a group of units (or a unit that has a varying capacity value over time), do not simply average these factors. Follow the equations.

85. Weighted Equivalent Unplanned Outage Factor -- WEUOF

$$\text{WEUOF} = \frac{\Sigma [(\text{UOH} + \text{EUDH}) \times \text{NMC}]}{\Sigma (\text{PH} \times \text{NMC})} \times 100\%$$

$$\text{WEUOF} = \frac{\Sigma [(\text{MOH} + \text{FOH} + \text{EFDH} + \text{EMDH}) \times \text{NMC}]}{\Sigma (\text{PH} \times \text{NMC})} \times 100\%$$

(NOTE: This is identical to the Weighted Unit Capability Loss Factor except this equation includes all events, including those outside plant management control.)

86. Weighted Forced Outage Rate – WFOR

$$\text{WFOR} = \frac{\Sigma (\text{FOH} \times \text{NMC})}{\Sigma [(\text{FOH} + \text{SH} + \text{Synchronous Hours} + \text{Pumping Hours}) \times \text{NMC}]} \times 100\%$$

87. Weighted Forced Outage Rate demand – WFORd (
- See Notes 1 and 2 at the end of this section*
- )

$$\text{WFORd} = \frac{\Sigma [\text{FOHd} \times \text{NMC}]}{\Sigma [(\text{SH} + \text{FOHd}) \times \text{NMC}]} \times 100\%$$

Where

$$\text{FOHd} = f \times \text{FOH}$$

$$f = \left( \frac{1}{r} + \frac{1}{T} \right) / \left( \frac{1}{r} + \frac{1}{T} + \frac{1}{D} \right)$$

$r$  = Average Forced outage deration = (FOH) / (# of FO occurrences)  
 $D$  = Average demand time = (SH) / (# of unit actual starts)  
 $T$  = Average reserve shutdown time = (RSH) / (# of unit attempted starts)

88. Weighted Equivalent Forced Outage Rate – WEFOR

$$\text{WEFOR} = \frac{\Sigma [(\text{FOH} + \text{EFDH}) \times \text{NMC}]}{\Sigma [(\text{FOH} + \text{SH} + \text{Synchronous Hours} + \text{Pumping Hours} + \text{EFDHRS}) \times \text{NMC}]} \times 100\%$$

89. Weighted Equivalent Forced Outage Rate demand – WEFORd (*See Notes 1 and 2 at the end of this section*)

$$\text{WEFORd} = \frac{\sum [(\text{FOHd} + (\text{EFDHd}) \times \text{NMC})]}{\sum [(\text{SH} + \text{FOHd}) \times \text{NMC}]} \times 100\%$$

where

$$\text{FOHd} = f \times \text{FOH}$$

$$\text{EFDHd} = (\text{EFDH} - \text{EFDHRS}) \text{ if reserve shutdown events reported, or} \\ = (\text{fp} \times \text{EFDH}) \text{ if no reserve shutdown events reported – an approximation.}$$

$$\text{fp} = (\text{SH}/\text{AH})$$

$$f = \left( \frac{1}{r} + \frac{1}{T} \right) / \left( \frac{1}{r} + \frac{1}{T} + \frac{1}{D} \right)$$

$r$  = Average Forced outage deration = (FOH) / (# of FO occurrences)  
 $D$  = Average demand time = (SH) / (# of unit actual starts)  
 $T$  = Average reserve shutdown time = (RSH) / (# of unit attempted starts)

90. Weighted Equivalent Planned Outage Rate -- WEPOR

$$\text{WEPOR} = \frac{\sum [(\text{POH} + \text{EPDH}) \times \text{NMC}]}{\sum [(\text{POH} + \text{SH} + \text{Synchronous Hours} + \text{Pumping Hours} + \text{EPDHRS}) \times \text{NMC}]} \times 100\%$$

91. Weighted Equivalent Maintenance Outage Rate -- WEMOR

$$\text{WEMOR} = \frac{\sum [(\text{MOH} + \text{EMDH}) \times \text{NMC}]}{\sum [(\text{MOH} + \text{SH} + \text{Synchronous Hours} + \text{Pumping Hours} + \text{EMDHRS}) \times \text{NMC}]} \times 100\%$$

92. Weighted Equivalent Unplanned Outage Rate -- WEUOR

$$\text{WEUOR} = \frac{\sum [(\text{UOH} + \text{EUDH}) \times \text{NMC}]}{\sum [(\text{UOH} + \text{SH} + \text{Synchronous Hours} + \text{Pumping Hours} + \text{EUDHRS}) \times \text{NMC}]} \times 100\%$$

### Mean Service Time to Outage:

- 93a. Weighted Mean Service Time to Planned Outage - MSTPO

$$\text{WMSTPO} = \frac{\sum [(\text{Service Hours} + \text{Synchronous Condensing Hours} + \text{Pumping Hours}) \times \text{NMC}]}{\sum [(\text{Number of Planned Outages}) \times \text{NMC}]}$$

(which occur from in-service state only)

93b. Weighted Mean Service Time to Unplanned Outage - MSTUO

$$\text{WMSTUO} = \frac{\Sigma [(\text{Service Hours} + \text{Synchronous Condensing Hours} + \text{Pumping Hours}) \times \text{NMC}]}{\Sigma [(\text{Number of Unplanned Outages}) \times \text{NMC}]}$$

(which occur from in-service state only)

93c. Weighted Mean Service Time To Forced Outage - MSTFO

$$\text{WMSTFO} = \frac{\Sigma [(\text{Service Hours} + \text{Synchronous Condensing Hours} + \text{Pumping Hours}) \times \text{NMC}]}{\Sigma [(\text{Number of (Unplanned) Forced Outages}) \times \text{NMC}]}$$

(which occur from in-service state only)

93d. Weighted Mean Service Time to Maintenance Outage - MSTMO

$$\text{WMSTMO} = \frac{\Sigma [(\text{Service Hours} + \text{Synchronous Condensing Hours} + \text{Pumping Hours}) \times \text{NMC}]}{\Sigma [(\text{Number of Maintenance Outages}) \times \text{NMC}]}$$

(which occur from in-service state only)

**Mean Outage Duration:**

94a. Weighted Mean Planned Outage Duration - MPOD

$$\text{WMPOD} = \frac{\Sigma [(\text{Planned Outage Hours}) \times \text{NMC}]}{\Sigma [(\text{Number of Planned Outages}) \times \text{NMC}]}$$

(which occur from in-service state only)

94b. Weighted Mean Unplanned Outage Duration - MUOD

$$\text{WMUOD} = \frac{\Sigma [(\text{Unplanned Outage Hours}) \times \text{NMC}]}{\Sigma [(\text{Number of Unplanned Outages}) \times \text{NMC}]}$$

(which occur from in-service state only)

94c. Weighted Mean Forced Outage Duration - MFOD

$$\text{WMFOD} = \frac{\Sigma [(\text{Unplanned (Forced) Outage Hours}) \times \text{NMC}]}{\Sigma [(\text{Number of Unplanned (Forced) Outages}) \times \text{NMC}]}$$

(which occur from in-service state only)

94d. Weighted Mean Maintenance Outage Duration - MMOD

$$\text{WMMOD} = \frac{\Sigma [(\text{Maintenance Outage Hours}) \times \text{NMC}]}{\Sigma [(\text{Number of Maintenance Outages}) \times \text{NMC}]}$$

(which occur from in-service state only)

### **UNWEIGHTED (TIME-BASED) PERFORMANCE INDEXES OUTSIDE MANAGEMENT CONTROL UNIT CALCULATIONS SINGLE UNIT AND POOLING UNIT CALCULATIONS**

**(Note: The equations for calculating unweighted (time-based) performance using outside management control (OMC) are identical to those shown earlier in this Appendix. The only differences are that the selected OMC cause codes are treated as non-curtailling events when analyzing the event records during the time of evaluation. In other words, the OMC events are ignored and not used in the calculations.**

**The list of OMC cause codes, conditions and method for removing OMC events from the calculations is described in Appendix K.**

95. OMC Planned Outage Factor – XPOF

(See equations 1 and 33 of this Appendix)

96. OMC Unplanned Outage Factor - XUOF

(See equations 2 and 34 of this Appendix)

97. OMC Forced Outage Factor - XFOF

(See equations 3 and 35 of this Appendix)

98. OMC Maintenance Outage Factor - XMOF

(See equations 4 and 36 of this Appendix)

99. OMC Scheduled Outage Factor - XSOF

(See equations 5 and 37 of this Appendix)

100. OMC Unavailability Factor - XUF

(See equations 6 and 38 of this Appendix)

101. OMC Availability Factor - XAF  
(See equations 7 and 39 of this Appendix)
102. OMC Service Factor - XSF  
(See equations 8 and 40 of this Appendix)
103. OMC Unit Derating Factor - XUDF  
(See equations 10 and 42 of this Appendix)
104. OMC Equivalent Unavailability Factor - XEUF  
(See equations 11 and 43 of this Appendix)
105. OMC Equivalent Availability Factor - XEAF  
(See equations 12 and 44 of this Appendix)
106. OMC Equivalent Maintenance Outage Factor -- XEMOF  
(See equations 17 and 49 of this Appendix)
107. OMC Equivalent Planned Outage Factor – XEPOF  
(See equations 18 and 50 of this Appendix)
108. OMC Equivalent Forced Outage Factor -- XEFOF  
(See equations 19 and 51 of this Appendix)
109. OMC Equivalent Scheduled Outage Factor -- XESOF  
(See equations 20 and 52 of this Appendix)
110. OMC Equivalent Unplanned Outage Factor -- XEUOF  
(See equations 21 and 53 of this Appendix)
111. OMC Forced Outage Rate - XFOR

(See equations 22 and 54 of this Appendix)

112. OMC Forced Outage Rate Demand- XFORD *(See Notes 1 and 2 at the end of this section)*

(See equations 23 and 55 of this Appendix)

113. OMC Equivalent Forced Outage Rate - XEFOR

(See equations 24 and 56 of this Appendix)

114. OMC Equivalent Forced Outage Rate demand – XEFORD *(See Notes 1 and 2 at the end of this section)*

(See equations 25 and 57 of this Appendix)

115. OMC Equivalent Planned Outage Rate -- XEPOR

(See equations 26 and 58 of this Appendix)

116. OMC Equivalent Maintenance Outage Rate -- XEMOR

(See equations 27 and 59 of this Appendix)

117. OMC Equivalent Unplanned Outage Rate -- XEUOR

(See equations 28 and 60 of this Appendix)

118. OMC Average Run Time - XART

(See equations 29 and 61 of this Appendix)

**WEIGHTED (CAPACITY-BASED) PERFORMANCE INDEXES  
OUTSIDE MANAGEMENT CONTROL UNIT CALCULATIONS  
POOLING UNIT CALCULATIONS**

**(Note: The equations for calculating weighted (capacity-based) performance using outside management control (OMC) are identical to those shown earlier in this Appendix. The only differences are that the selected OMC cause codes are treated as non-curtailling events when analyzing the event records during the time of evaluation. In other words, the OMC events are ignored and not used in the calculations.**

**The list of OMC cause codes, conditions and method for removing OMC events from the calculations is described in Appendix K.**

119. OMC Weighted Forced Outage Factor – XWFOF

(See equation 65 of this Appendix)

120. OMC Weighted Maintenance Outage Factor – XWMOF

(See equation 66 of this Appendix)

121. OMC Weighted Planned Outage Factor – XWPOF

(See equation 67 of this Appendix)

122. OMC Weighted Unplanned Outage Factor – XWUOF

(See equation 685 of this Appendix)

123. OMC Weighted Scheduled Outage Factor – XWSOF

(See equation 69 of this Appendix)

124. OMC Weighted Unavailability Factor – XWUF

(See equation 70 of this Appendix)

125. OMC Weighted Availability Factor – XWAF

(See equation 71 of this Appendix)

126. OMC Weighted Service Factor – XWSF

- (See equation 72 of this Appendix)
127. OMC Weighted Unit Derating Factor – XWUDF  
(See equation 74 of this Appendix)
128. OMC Weighted Equivalent Unavailability Factor – XWEUF  
(See equation 75 of this Appendix)
129. OMC Weighted Equivalent Availability Factor – XWEAF (also known as Unit Capability Factor in Europe and other parts of the world)  
(See equation 76 of this Appendix)
130. OMC Weighted Equivalent Maintenance Outage Factor -- XWEMOF  
(See equation 81 of this Appendix)
131. OMC Weighted Equivalent Planned Outage Factor -- XWEPOF  
(See equation 82 of this Appendix)
132. OMC Weighted Equivalent Forced Outage Factor -- XWEFOF  
(See equation 83 of this Appendix)
133. OMC Weighted Equivalent Scheduled Outage Factor -- XWESOF  
(See equation 84 of this Appendix)
134. OMC Weighted Equivalent Unplanned Outage Factor – XWEUOF (also known as Unit Capability Loss Factor in Europe and other parts of the world.)  
(See equation 85 of this Appendix)
135. OMC Weighted Forced Outage Rate – XWFOR  
(See equation 86 of this Appendix)

136. OMC Weighted Forced Outage Rate demand – XWFORD (*See Notes 1 and 2 at the end of this section*)  
(See equation 87 of this Appendix)
137. OMC Weighted Equivalent Forced Outage Rate – XWEFOR  
(See equation 88 of this Appendix)
138. OMC Weighted Equivalent Forced Outage Rate demand – XWEFORd (*See Notes 1 and 2 at the end of this section*)  
(See equation 89 of this Appendix)
139. OMC Weighted Equivalent Planned Outage Rate -- XWEPOR  
(See equation 90 of this Appendix)
140. OMC Weighted Equivalent Maintenance Outage Rate -- XWEMOR  
(See equation 91 of this Appendix)
141. OMC Weighted Equivalent Unplanned Outage Rate -- XWEUOR  
(See equation 92 of this Appendix)

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## NOTE #1 FOR APPENDIX F

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**INTRODUCTION TO NOTE #1:**

The information below comes from IEEE 762 Annex F. This section reviews several different methods for pooling EFOR<sub>d</sub> only. Because of the nature of this equation, it can be pooled in several different methods as shown below.

**PLEASE NOTE THAT after much consideration, NERC GADS will use Method 2 in all its EFOR<sub>d</sub> calculations.** The reason for method 2 is:

- ✓ Consistency – all other GADS equations sum hours in both the denominator and numerator before division.
- ✓ Allow calculations of smaller groups. By allowing sums, smaller groups of units can be used to calculate EFOR<sub>d</sub> without experiencing the divide by zero problem (see Note #2 for Appendix F).

### FROM IEEE 762, ANNEX F:

#### EFOR<sub>d</sub> Pooling Sample

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**A comparison of 3 EFOR<sub>d</sub> pooling methodologies.**

Method (I): Pooled individual Unit Demand Studies

This method can give more weight to individual units with extreme EFOR<sub>d</sub> that have very few service hours, but with longer study time periods the difference between the results of Methods I and II should be less.

Method (II): Group Demand Studies

This method may be more applicable in studying group statistics on units with known similar demand patterns, especially for forecasting and modeling. By calculating the f-factors over the group's total FOH, SH, RSH, and starts, the f-factor is "smoothed" and not subject to be unduly influenced by an one or more single units statistics that may have very high or very low hours or starts.

Method (III): Capacity Weighted Average of individually calculated EFOR<sub>d</sub> used by PJM to calculate pool average "unforced capacity" values for capacity market purposes.

In order to clearly demonstrate how these methods are used, two sets of comparison will be needed – the first uses the unweighted, time-based calculations as shown in Appendix F. The second will use a weighted version of these pooling methods.

**Time-Based Pooling**

This comparison of the three (3) pooling methodologies is based on the sample data and calculations found in the following two tables. The first table shows the raw data reported by 5 steam turbine generating units. The second table shows the interim values of the calculations used to produce the

individual EFOR<sub>d</sub> for each unit. In the interest of simplicity each unit reported sufficient data to allow the EFOR<sub>d</sub> calculation without the need for any substituted values.

### Raw data used as sample

| Unit         | Capacity (MW) | SH    | RSH  | AH    | ACTUAL STARTS | ATTEMPTED STARTS | EFDH   | FOH  | FO Events |
|--------------|---------------|-------|------|-------|---------------|------------------|--------|------|-----------|
| 48           | 55            | 4556  | 1963 | 6519  | 31            | 31               | 110.51 | 407  | 5         |
| 49           | 57            | 4856  | 2063 | 6918  | 34            | 34               | 146.99 | 773  | 12        |
| 50           | 60            | 6460  | 516  | 6978  | 17            | 18               | 131.03 | 340  | 14        |
| 51           | 53            | 3942  | 3694 | 7635  | 36            | 36               | 19.92  | 504  | 11        |
| 52           | 55            | 6904  | 62   | 6968  | 14            | 16               | 35.81  | 138  | 12        |
| <b>TOTAL</b> | 280           | 26718 | 8298 | 35018 | 132           | 135              | 444.26 | 2162 | 54        |

### Calculated Values used in EFOR<sub>d</sub> formula

| Unit  | 1/r    | 1/t    | 1/D    | F      | f x FOH  | fp       | fp x EFDH | EFOR <sub>d</sub> x MW | EFOR <sub>d</sub> |
|---|--------|--------|--------|--------|----------|----------|-----------|------------------------|-------------------|
| 48  | 0.0123 | 0.0158 | 0.0068 | 0.8049 | 327.608  | 0.6989   | 77.233    | 4.5594                 | 8.290%            |
| 49  | 0.0155 | 0.0165 | 0.0070 | 0.8205 | 634.247  | 0.7019   | 103.178   | 7.6560                 | 13.432%           |
| 50  | 0.0412 | 0.0349 | 0.0026 | 0.9666 | 328.630  | 0.9258   | 121.303   | 3.9766                 | 6.628%            |
| 51  | 0.0218 | 0.0097 | 0.0091 | 0.7756 | 390.920  | 0.5163   | 10.285    | 4.9075                 | 9.259%            |
| 52  | 0.0870 | 0.2581 | 0.0020 | 0.9942 | 137.194  | 0.9908   | 35.481    | 1.3488                 | 2.452%            |
| <b>METHOD 1 SUMMED</b>                      |        |        |        |        | 1818.598 |          | 347.480   |                        | 7.591%            |
| Method 2<br>Calculated from reported totals | 0.0250 | 0.0163 | 0.0049 | 0.8930 | 1930.734 | 0.762979 | 338.961   |                        | 7.922%            |
| Method 3<br>Summed                          |        |        |        |        |          |          |           | 22.4483                | 8.017%            |

Using this data, the 3 pooling methods can be shown as follows – Note that methods 1 and 2 are unweighted, time-based calculations.

- **Method 1** uses the sums of SH and the calculated values (f x FOH), (fp x EFDH) giving a pooled EFOR<sub>d</sub> of 7.591%.

$$\circ \frac{(1818.598 + 347.480)}{(1818.598 + 26718)} = 7.591\%$$

- **Method 2** uses the sums of the reported data to represent the average unit and then calculates the pooled EFOR<sub>d</sub> to be 7.922%

$$\circ \frac{(1930.734 + 338.961)}{(1930.734 + 26718)} = 7.922\%$$

- **Method 3** weights the individual EFORD values with the unit capacity (EFORD x MW) and uses the total capacity to calculate a numeric average EFORD as 8.017%.
  - $\frac{22.4483}{280} = 8.017\%$

### **Weighted Pooling**

This method weights all time values by the Net Max Capacity of the individual unit. The raw data is the same as in the first example. Here a third table is added to show the weighted values used in the calculations.

#### **Weighted Values used in EFORD formula**

| Unit   | wSH     | wFOH   | wEFDH    | F      | wFOHd      | fp       | wEFDHd   | wEFORD  |
|--|---------|--------|----------|--------|------------|----------|----------|---------|
| 48   | 250580  | 22385  | 6078.05  | 0.8049 | 18018.42   | 0.69888  | 4247.829 | 8.290%  |
| 49   | 276792  | 44061  | 8378.43  | 0.8205 | 36152.06   | 0.701937 | 5881.130 | 13.432% |
| 50   | 387600  | 20400  | 7861.80  | 0.9666 | 19717.79   | 0.925767 | 7278.193 | 6.628%  |
| 51   | 208926  | 26712  | 1055.76  | 0.7756 | 20718.75   | 0.516306 | 545.096  | 9.259%  |
| 52   | 379720  | 7590   | 1969.55  | 0.9942 | 7545.65    | 0.990815 | 1951.460 | 2.452%  |
| <b>METHOD 1<br/>SUMMED</b>                     | 1503618 |        |          |        | 102152.67  |          | 19903.71 | 7.601%  |
| Method 2<br>Calculated from<br>reported totals | 1503618 | 121148 | 25343.59 | 0.8930 | 108185.164 | 0.763    | 19337.16 | 7.912%  |
| Average wEFORD                                 |         |        |          |        |            |          |          | 8.012%  |

Weighted values in the above table are denoted with preceding w to indicate that the value has been weighted by its NMC. Below we substitute the weighted value for the expanded multiplication – wFOR<sub>d</sub> in place of (FOR<sub>d</sub> x NMC)

- **Method 1** uses the sums of wSH and the weighted values (f x FOH x NMC), (fp x EFDH x NMC) giving a pooled wEFORD of 7.601%.
  - $\frac{\sum (wFOHd + wEFDHd)}{\sum (wFOHd + wSH)} = wEFORD \text{ (pooled)}$
  - $\frac{(102152.67 + 19903.71)}{(102152.67 + 1503618)} = 7.601\%$

- **Method 2** uses the sums of the weighted reported data to represent the weighted average unit and then calculates the pooled EFORd to be 7.912%

$$\circ \frac{\left( (f \times (\sum wFOH)) + (fp \times (\sum wEFDH)) \right)}{(\sum wSH + (fp \times \sum wFOH))} = wEFOR_d(\text{pooled})$$

$$\circ \frac{((0.8930 \times 121148) + (0.7630 \times 25343.59))}{(1503618 + (0.7630 \times 121148))} = 7.912\%$$

- **Average wEFORd** uses the sum of the weighted unit EFOR<sub>d</sub> values to calculate the numerical average.  
Notes: From Section 7.12.2 EFOR<sub>d</sub> = (FOH<sub>d</sub> + EFDH<sub>d</sub>) \* 100 / (FOH<sub>d</sub> + SH)  
From section 9, To energy-weight an equation, one does not simply take each unit's EFOR, for example, and multiply the EFOR by the NMC, add them up and divide by the sum of the NMCs. Each term in the equation must be multiplied by the NMC. Further, to calculate the sum of each term, EACH unit must be multiplied by its NMC, then all those products summed over ALL THE UNITS, before the rest of the calculation is performed.

$$\text{Weighted individual EFOR}_d = (wFOH_d + wEFDH_d) * 100 / (wFOH_d + wSH)$$

### Another Sample

Compare this sample to the samples above, and you will see that the relationship between the methods does not remain constant and is dependant on the distribution of the data.

#### Raw data used as sample

| Unit         | Capacity (MW) | SH  | RSH   | AH    | ACTUAL STARTS | ATTEMPTED STARTS | EFDH | FOH  | FO Events |
|--------------|---------------|-----|-------|-------|---------------|------------------|------|------|-----------|
| 41           | 100           | 183 | 8576  | 8759  | 35            | 35               | 0    | 1    | 1         |
| 42           | 150           | 198 | 8562  | 8760  | 31            | 31               | 0    | 0    | 0         |
| 43           | 125           | 186 | 6867  | 7052  | 37            | 38               | 0    | 9    | 2         |
| 44           | 170           | 105 | 4128  | 4233  | 29            | 29               | 0    | 4528 | 3         |
| 45           | 180           | 62  | 8259  | 8319  | 20            | 20               | 0    | 98   | 1         |
| <b>TOTAL</b> | 725           | 734 | 36392 | 37123 | 152           | 153              | 0    | 4636 | 7         |

**Calculated Values used in EFOR<sub>d</sub> formula**

| Unit   | 1/r   | 1/t   | 1/D   | F     | f x FOH | fp    | fp x EFDH | EFORd x MW | EFORd          |
|--|-------|-------|-------|-------|---------|-------|-----------|------------|----------------|
| 41   | 1.000 | 0.004 | 0.191 | 0.840 | 0.840   | 0.021 | 0.000     | 0.457      | 0.457%         |
| 42   | 0.000 | 0.004 | 0.157 | 0.023 | 0.000   | 0.023 | 0.000     | 0.000      | 0.000%         |
| 43   | 0.222 | 0.006 | 0.199 | 0.534 | 4.804   | 0.026 | 0.000     | 3.147      | 2.518%         |
| 44   | 0.001 | 0.007 | 0.276 | 0.027 | 122.623 | 0.025 | 0.000     | 91.581     | 53.871%        |
| 45   | 0.010 | 0.002 | 0.323 | 0.038 | 3.691   | 0.007 | 0.000     | 10.114     | 5.619%         |
| <b>METHOD 1<br/>SUMMED</b>                     |       |       |       |       | 131.959 |       | 0.000     |            | <b>15.238%</b> |
| Method 2<br>Calculated from<br>reported totals | 0.002 | 0.004 | 0.207 | 0.027 | 124.488 | 0.020 | 0.000     |            | <b>14.501%</b> |
| Method 3<br>Summed                             |       |       |       |       |         |       |           | 105.299    | <b>37.607%</b> |

**Weighted Values used in EFOR<sub>d</sub> formula**

| Unit   | wSH        | wFOH       | wEFDH | F     | wFOHd     | fp    | wEFDHd | wEFORd         |
|--|------------|------------|-------|-------|-----------|-------|--------|----------------|
| 41   | 18300.000  | 100.000    | 0.000 | 0.840 | 84.000    | 0.021 | 0.000  | 0.457%         |
| 42   | 29700.000  | 0.000      | 0.000 | 0.023 | 0.000     | 0.023 | 0.000  | 0.000%         |
| 43   | 23250.000  | 1125.000   | 0.000 | 0.534 | 600.509   | 0.026 | 0.000  | 2.518%         |
| 44   | 17850.000  | 769760.000 | 0.000 | 0.027 | 20845.957 | 0.025 | 0.000  | 53.871%        |
| 45   | 11160.000  | 17640.000  | 0.000 | 0.038 | 664.418   | 0.007 | 0.000  | 5.619%         |
| <b>METHOD 1<br/>SUMMED</b>                     | 100260.000 |            |       |       | 22194.884 |       | 0.000  | <b>18.125%</b> |
| Method 2<br>Calculated from<br>reported totals | 100260.000 | 788625.000 | 0.000 | 0.027 | 21176.435 | 0.020 | 0.000  | <b>17.438%</b> |
| Average wEFORd                                 |            |            |       |       |           |       |        | <b>12.493%</b> |

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**NOTE #2 FOR APPENDIX F**

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**INTRODUCTION TO NOTE #2:**

The information below comes from IEEE 762 Annex G. This section reviews why (in some cases) Equivalent Forced Outage Rate – Demand (EFORd) and other demand-related equations can not be calculated or produce a reasonable result. The discussion below demonstrates that a pool of information for a short period of time OR a long period for a single unit is needed so that none of the hour elements are zero and there will not be a divide by zero problem. A “long period” means at least 12 months or more.

This section also shows that a number can be forced but the results are not reasonable. The user of the EFORd calculation must be aware of what may come from a number if the EFORd calculation is forced (see the notes at the end of the section.)

**PLEASE NOTE THAT NERC GADS will follow the recommendations of IEEE in calculating EFORd numbers. This means that in some GADS reports, there will not be an EFORd number because a calculated EFORd would be meaningless.**

**FROM IEEE 762, ANNEX G:****Limiting conditions for Forced Outage Indexes**

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**(Informational)**

Typically performance indexes are calculated using performance data over at least a year. However, if any of the variables SH, FOH, or RSH is zero in a period, one practice has been to assign a default value of 0.001 for computing indexes. Similarly, if any of the variables “number of FOH occurrences”, “number of attempted starts”, or “number of actual starts” is zero in the period, a value of 1 is assigned for computing indexes. The default values can give meaningless indices in some cases as indicated in Table H-1. Discretion based on history and other factors may be used to estimate FORd and EFORd even if they can be calculated using the equations in the standard in some cases.

**Table G.1 – Limiting Conditions for Forced Outage Indexes**

| Case | SH | FOH | RSH | FORd                 | EFORd                |
|------|----|-----|-----|----------------------|----------------------|
| Base | >0 | >0  | >0  | Applicable           | Applicable           |
| 1    | 0  | >0  | >0  | Cannot be determined | Cannot be determined |
| 2    | 0  | 0   | >0  | Cannot be determined | Cannot be determined |
| 3    | 0  | >0  | 0   | Cannot be determined | Cannot be determined |
| 4    | >0 | 0   | >0  | 0                    | EFDH/AH              |
| 5    | >0 | 0   | 0   | 0                    | EFDH/SH              |
| 6    | >0 | >0  | 0   | FOR                  | EFOR                 |
| 7    | 0  | 0   | 0   | Cannot be determined | Cannot be determined |

The following numerical example illustrates the limiting conditions and how the indexes can become meaningless.

| Case | FOH | EFDH | SH  | No. of FO | RSH  | Attempted Starts | Actual Starts | AH   | r  | T    | D     | f factor | fp Factor | FORd% | EFORd%  |
|------|-----|------|-----|-----------|------|------------------|---------------|------|----|------|-------|----------|-----------|-------|---------|
| Base | 50  | 30   | 400 | 5         | 1600 | 80               | 80            | 2000 | 10 | 20   | 5     | 0.4      | 0.2       | 5.1   | 6.5     |
| 1    | 50  | 30   | 0   | 5         | 1600 | 1                | 1             | 2000 | 10 | 1600 | 0.001 | 0.0      | 0.0       | 83.4  | 83.7    |
| 2    | 0   | 30   | 0   | 1         | 1600 | 1                | 1             | 2000 | 0  | 1600 | 0.001 | 0.5      | 0.0       | 33.3  | 34.3    |
| 3    | 50  | 30   | 0   | 5         | 0    | 1                | 1             | 2000 | 10 | 0    | 0.001 | 0.5      | 0.0       | 100.0 | 100     |
| 4    | 0   | 30   | 400 | 1         | 1600 | 80               | 80            | 2000 | 0  | 20   | 5     | 1.0      | 0.2       | 0     | 1.5     |
| 5    | 0   | 30   | 400 | 1         | 0    | 1                | 1             | 2000 | 0  | 0    | 400   | 1.0      | 0.2       | 0     | 1.5     |
| 6    | 50  | 30   | 400 | 5         | 0    | 1                | 1             | 2000 | 10 | 0    | 400   | 1.0      | 0.2       | 11.1  | 12.4    |
| 7    | 0   | 30   | 0   | 1         | 0    | 1                | 1             | 0    | 0  | 0    | 0.001 | 0.7      | 1.0       | 40.0  | 1800040 |

**Notes:**

Zero hours are made 0.001. Attempted and Actual Starts are made 1 when SH or RSH is zero. Number of forced outages is made 1 when FOH is zero.

Terms r, T, D, f, fp, FORd, and EFORd are defined in 7.16.2 and 7.17.2.

Base case is a normal case.

Cases 1, 2, 3, 7: Computed FORd, EFORd are meaningless; they should not be calculated using the equations in this standard.

Cases 4, 5, 6: Computed FORd, EFORd are valid.