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 Condensing 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) **+** Planned Outage Extensions (PE) of any Planned Outages (PO).
6.	Unplanned Outage Hours - UOH	Sum of all hours experienced during Forced Outages (U1, U2, U3) **+** Startup Failures (SF) **+** Maintenance Outages (MO) **+** Maintenance Outage Extensions (ME) of any Maintenance Outages (MO).
7.	Forced Outage Hours - FOH	Sum of all hours experienced during Forced Outages (U1, U2, U3) **+** Startup Failures (SF).
8.	Maintenance Outage Hours - MOH	Sum of all hours experienced during Maintenance Outages (MO) **+** Maintenance Outage Extensions (ME) of any Maintenance Outages (MO).
9.	Unavailable Hours - UH	Sum of all Planned Outage Hours (POH) **+** 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 (PE and ME) 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 Forced Derated Hours - EFDH	Each individual Forced Derating (D1, D2, D3) is transformed (D1, D2, D3) 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 Forced Deratings (D1, D2, D3) during Reserve Shutdowns (RS). See 13d, 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, DM of D4)	Each individual Maintenance Derating (D4, DM) 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. Derating Hours **x** Size of Reduction* NMC
13c.	Equivalent Planned Derated Hours - EPDH (PD, DP of PD)	Each individual Planned Derating (PD, DP) 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. Derating Hours **x** Size of Reduction* NMC NOTE: Includes Planned Deratings (PD) during Reserve Shutdowns (RS). See 13d, below.
13d.	Equivalent Scheduled Derated Hours - ESDH (PD, DP of PD, D4 and DM of D4)	Each individual Planned Derating (PD, DP) and Maintenance Derating (D4, DM) 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. Derating Hours **x** Size of Reduction* 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, DM)

Each individual Unplanned Derating (D1, D2, D3, D4, DM) 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.

$$\frac{\text{Derating Hours } \mathbf{x} \text{ Size of Reduction}}{\text{NMC}}*$$

NOTE: Incudes Unplanned Deratings (D1, D2, D3, D4, DM) during Reserve Shutdowns (RS). See 13d, Page F-3.

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

Each individual Forced Derating (D1, D2, D3) or the portion of any 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.

$$\frac{\text{Derating Hours } \mathbf{x} \text{ Size of Reduction}}{\text{NMC}}*$$

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.

$$\frac{\text{Derating Hours } \mathbf{x} \text{ Size of Reduction}}{\text{NMC}}*$$

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. $\frac{\text{Derating Hours } \mathbf{x} \text{ Size of Reduction}^*}{\text{NMC}}$
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 (07). (Since Planned Outage Extensions (PE) 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 (07). (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 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 (07). (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 (07). (Since Maintenance Outage Extensions (ME) 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 calculating pooled (grouping) unit statistics.
3. Weighted (capacity-based) methods for calculating pooling (grouping) unit statistics.
4. Unweighted (time-based) methods for calculating statistics excluding problems outside management control for single unit and pooling unit statistics.
5. Weighted (capacity-based) methods for calculating statistics excluding problems outside management control for pooling unit statistics.

Calculation Notes

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 these cases, a group of units of similar size will show only small differences, but a 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 o~~f~~n 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 these 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.

Data Pooling Notes

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, and 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).

However, the current IEEE 762 Standard's unweighted equations should not be abandoned 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) 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) methods for calculating single unit statistics.

1. Planned Outage Factor – POF

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

2. Unplanned Outage Factor – UOF

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

$$UOF = \frac{MOH + FOH \text{ ~~+ ME of MO~~}}{PH} \times 100\%$$ Reason for change: ME of MO is included in MOH

3. Forced Outage Factor – FOF

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

4. Maintenance Outage Factor – MOF

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

5. Scheduled Outage Factor – SOF

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

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

6. Unavailability Factor – UF

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

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

7. Availability Factor – AF

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

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

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

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

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

13. Gross Capacity Factor – GCF

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

14. Net Capacity Factor – NCF

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

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

15. Gross Output Factor – GOF

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

16. Net Output Factor – NOF

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

17. Equivalent Maintenance Outage Factor – EMOF

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

18. Equivalent Planned Outage Factor – EPOF

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

19. Equivalent Forced Outage Factor – EFOF

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

20. Equivalent Scheduled Outage Factor – ESOF

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

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

21. Equivalent Unplanned Outage Factor – EUOF

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

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

(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

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

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

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

where

FOHd = f x FOH

The **FOHd** is the number of hours a unit was in a U1, U2, U3, or SF AND the unit would have operated had it been available.

FOHd can be determined directly if periods of demand are recorded. Demand can be defined as the traditional demand for the generating unit for economic or reliable operation of the system, or it can be any other user-defined condition, such as specific weather condition.

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load level, or energy price. When FOHd is determined directly from recorded periods of demand, service hours (SH) in the above equation should include only those under the specified demand condition
If periods of demand are not recorded, FOHd may be estimated using the demand factor f. The demand factor is applicable to traditional demand for economic or reliable system operation.

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

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

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

24. Equivalent Forced Outage Rate – EFOR

EFOR = FOH + EFDH x 100%
FOH + SH + Synchronous Hrs + Pumping Hrs + EFDHRS

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 x FOH
EFDHd = (EFDH – EFDHRS) if reserve shutdown events reported, or
= (fp x EFDH) if no reserve shutdown events reported – an approximation.
fp = (SH/AH)

The **FOHd** is the number of hours a unit was in a U1, U2, U3, or SF AND the unit would have operated had it been available.

FOHd and EFDHD can be determined directly if periods of demand are recorded. Demand can be defined as the traditional demand for the generating unit for economic or reliable operation of the system, or it can be any other user-defined condition, such as specific weather condition, load level, or energy price. When FOHd and EFDHd are determined directly from recorded periods of demand, service hours (SH) in the above equation should include only those under the specified demand condition
If periods of demand are not recorded, FOHd may be estimated using the demand factor f. The demand factor is applicable to traditional demand for economic or reliable system operation.

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

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)

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

26. Equivalent Planned Outage Rate – EPOR

EPOR = POH + EPDH x 100%
POH + SH + Synchronous Hrs + Pumping Hrs + EPDHRS

27. Equivalent Maintenance Outage Rate – EMOR

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

28. Equivalent Unplanned Outage Rate – EUOR

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

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

29. Average Run Time – ART

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

30. Starting Reliability – SR

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

Mean Service Time to Outage:

31a. Mean Service Time to Planned Outage – MSTPO

$$MSTPO = \frac{\text{Service Hours}}{\text{Number of Planned Outages which occur from in-service state only}}$$

31b. Mean Service Time to Planned Outage – MSTUO

$$MSTUO = \frac{\text{Service Hours}}{\text{Number of Unplanned Outages which occur from in-service state only}}$$

31c. Mean Service Time to Planned Outage – MSTFO

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

31d. Mean Service Time to Maintenance Outage – MSTMO

$$MSTMO = \frac{\text{Service Hours}}{\text{Number of Maintenance Outages which occur from in-service state only}}$$

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

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

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) methods for calculating pooled (grouping) unit statistics.

33. Planned Outage Factor – POF

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

34. Unplanned Outage Factor – UOF

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

35. Forced Outage Factor – FOF

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

36. Maintenance Outage Factor – MOF

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

37. Scheduled Outage Factor – SOF

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

38. Unavailability Factor – UF

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

39. Availability Factor – AF

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

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

40. Service Factor – SF

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

41. Seasonal Derating Factor – SEDF

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

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

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

46. * Net Capacity Factor – NCF

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

**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

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

48. * Net Output Factor – NOF

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

49. Equivalent Maintenance Outage Factor – EMOF

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

50. Equivalent Planned Outage Factor – EPOF

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

51. Equivalent Forced Outage Factor – EFOF

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

52. Equivalent Scheduled Outage Factor – ESOF

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

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

** 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

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

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

54. Forced Outage Rate – FOR

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

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

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

Where

FOHd = f x FOH

The **FOHd** is the number of hours a unit was in a U1, U2, U3, or SF AND the unit would have operated had it been available.

FOHd can be determined directly if periods of demand are recorded. Demand can be defined as the traditional demand for the generating unit for economic or reliable operation of the system, or it can be any other user-defined condition, such as specific weather condition, load level, or energy price. When FOHd is determined directly from recorded periods of demand, service hours (SH) in the above equation should include only those under the specified demand condition

If periods of demand are not recorded, FOHd may be estimated using the demand factor f. The demand factor is applicable to traditional demand for economic or reliable system operation.

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

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)

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

56. Equivalent Forced Outage Rate – EFOR

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

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 x FOH

EFDHd = (EFDH – EFDHRS) if reserve shutdown events reported, or
= (fp x EFDH) if no reserve shutdown events reported – an approximation.

fp = (SH/AH)

The FOHd is the number of hours a unit was in a U1, U2, U3, or SF AND the unit would have operated had it been available.

FOHd and EFDHd can be determined directly if periods of demand are recorded. Demand can be defined as the traditional demand for the generating unit for economic or reliable operation of the system, or it can be any other user-defined condition, such as specific weather condition, load level, or energy price. When FOHd and EFDHd are determined directly from recorded periods of demand, service hours (SH) in the above equation should include only those under the specified demand condition

If periods of demand are not recorded, FOHd may be estimated using the demand factor f. The demand factor is applicable to traditional demand for economic or reliable system operation.

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

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)

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

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

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

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

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

63b. Mean Service Time to Unplanned Outage – MSTUO

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

63c. Mean Service Time to Forced Outage – MSTFO

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

63d. Mean Service Time to Maintenance Outage – MSTMO

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

Mean Outage Duration:

64a. Mean Planned Outage Duration (MPOD)

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

64b. Mean Unplanned Outage Duration (MUOD)

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

64c. Mean Forced Outage Duration (MFOD)

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

64d. Mean Maintenance Outage Duration (MMOD)

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

Weighted (capacity-based) methods for calculating pooling (grouping) unit statistics.

65. Weighted Forced Outage Factor – WFOF

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

66. Weighted Maintenance Outage Factor – WMOF

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

67. Weighted Planned Outage Factor – WPOF

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

68. Weighted Unplanned Outage Factor – WUOF

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

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

69. Weighted Scheduled Outage Factor – WSOF

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

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

70. Weighted Unavailability Factor – WUF

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

71. Weighted Availability Factor – WAF

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

72. Weighted Service Factor – WSF

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

73. Weighted Seasonal Derating Factor – WSEDF

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

74. Weighted Unit Derating Factor – WUDF

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

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

75. Weighted Equivalent Unavailability Factor – WEUF

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

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

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

76. Weighted Equivalent Availability Factor – WEAF

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

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

77. * Gross Capacity Factor – GCF

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

78. * Net Capacity Factor – NCF

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

79. * Gross Output Factor – GOF

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

80. * Net Output Factor – NOF

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

.

81. Weighted Equivalent Maintenance Outage Factor – WEMOF

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

82. Weighted Equivalent Planned Outage Factor – WEPOF

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

83. Weighted Equivalent Forced Outage Factor – WEFOF

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

84. Weighted Equivalent Scheduled Outage Factor – WESOF

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

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

** 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

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

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

(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

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

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

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

Where

FOHd = f x FOH

The FOHd is the number of hours a unit was in a U1, U2, U3, or SF AND the unit would have operated had it been available.

FOHd can be determined directly if periods of demand are recorded. Demand can be defined as the traditional demand for the generating unit for economic or reliable operation of the system, or it can be any other user-defined condition, such as specific weather condition, load level, or energy price. When FOHd is determined directly from recorded periods of demand, service hours (SH) in the above equation should include only those under the specified demand condition

If periods of demand are not recorded, FOHd may be estimated using the demand factor f. The demand factor is applicable to traditional demand for economic or reliable system operation.

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

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)

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

88. Weighted Equivalent Forced Outage Rate – WEFOR

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

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

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

where

FOHd = f x FOH

EFDHd = (EFDH – EFDHRS) if reserve shutdown events reported, or

= (fp x EFDH) if no reserve shutdown events reported – an approximation.

fp = (SH/AH)

The FOHd is the number of hours a unit was in a U1, U2, U3, or SF AND the unit would have operated had it been available.

FOHd and EFDHd can be determined directly if periods of demand are recorded. Demand can be defined as the traditional demand for the generating unit for economic or reliable operation of the system, or it can be any other user-defined condition, such as specific weather condition, load level, or energy price. When FOHd and EFDHd are determined directly from recorded periods of demand, service hours (SH) in the above equation should include only those under the specified demand condition

If periods of demand are not recorded, FOHd may be estimated using the demand factor f. The demand factor is applicable to traditional demand for economic or reliable system operation.

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

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)

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

90. Weighted Equivalent Planned Outage Rate – WEPOR

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

91. Weighted Equivalent Maintenance Outage Rate – WEMOR

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

92. Weighted Equivalent Unplanned Outage Rate – WEUOR

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

Mean Service Time to Outage:

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

$$WMSTPO = \frac{\Sigma\,[(\text{Service Hours}) \times NMC]}{\Sigma\,[(\text{Number of Planned Outages which occur from in-service state only}) \times NMC]}$$

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

$$WMSTUO = \frac{\Sigma\,[(\text{Service Hours}) \times NMC]}{\Sigma\,[(\text{Number of Unplanned Outages which occur from in-service state only}) \times NMC]}$$

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

$$WMSTFO = \frac{\Sigma\,[(\text{Service Hours}) \times NMC]}{\Sigma\,[(\text{Number of Forced Outages which occur from in-service state only}) \times NMC]}$$

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

$$WMSTMO = \frac{\Sigma\,[(\text{Service Hours}) \times NMC]}{\Sigma\,[(\text{Number Maintenance Outages which occur from in-service state only}) \times NMC]}$$

Mean Outage Duration:

94a. Weighted Mean Planned Outage Duration – MPOD

$$WMPOD = \frac{\Sigma\,[(\text{Planned Outage Hours which occur from in-service state only}) \times NMC]}{\Sigma\,[(\text{Number of Planned Outages which occur from in-service state only}) \times NMC]}$$

94b. Weighted Mean Unplanned Outage Duration – MUOD

$$WMUOD = \frac{\Sigma\,[(\text{Unplanned Outage Hours which occur from in-service state only}) \times NMC]}{\Sigma\,[(\text{Number of Unplanned Outages which occur from in-service state only}) \times NMC]}$$

94c. Weighted Mean Forced Outage Duration – MFOD

$$WMFOD = \frac{\Sigma\,[\text{Forced Outage Hours which occur from in-service state only}) \times NMC]}{\Sigma\,[(\text{Number of Forced Outages which occur from in-service state only}) \times NMC]}$$

94d. Weighted Mean Maintenance Outage Duration – MMOD

$$WMMOD = \frac{\Sigma\,[(\text{Maintenance Outage Hours which occur from in-service state only}) \times \text{NMC}]}{\Sigma\,[(\text{Number Maintenance Outages which occur from in-service state only}) \times \text{NMC}]}$$

Unweighted (time-based) methods for calculating statistics excluding problems outside management control for 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-curtailing 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 59of 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) methods for calculating statistics excluding problems outside management control for pooling unit statistics.

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-curtailing 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)

Note #1 for Appendix F

INTRODUCTION TO NOTE #1:
The information below comes from IEEE 762 Annex F. This section reviews several different methods for pooling EFORd 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 EFORd 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 EFORd without experiencing the divide by zero problem (see Note #2 for Appendix F).

FROM IEEE 762, ANNEX F:
EFORd Pooling Sample

A comparison of three EFORd pooling methodologies.

Method (I): Pooled individual Unit Demand Studies

This method can give more weight to individual units with extreme $EFOR_d$ 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 $EFOR_d$ 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. Table 1 shows the raw data reported by 5 steam turbine generating units. Table 2 shows the interim values of the calculations used to produce the individual $EFOR_d$ for each unit In the interest of simplicity each unit reported sufficient data to allow the $EFOR_d$ calculation without the need for any substituted values.

Raw data used as sample:

Table 1: Raw Data Used as a 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
Total	280	26718	8298	35018	132	135	444.26	2162	54

Table 2: Calculated Values Used in EFORd Formula									
Unit	1/r	1/t	1/D	F	f x FOH	fp	fp x EFDH	EFORd x MW	EFORd
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%
Method 1 Summed					1818.598		347.480		7.591%
Method 2 Calculated from reported totals	0.0250	0.0163	0.0049	0.8930	1930.734	0.762979	338.961		7.922%
Method 3 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 EFORd of 7.591%.

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

- **Method 2** uses the sums of the reported data to represent the average unit and then calculates the pooled EFORd to be 7.922%

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

- **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 Capactiy of the individual unit. The raw data is the same as in the first example. Here Table 3 is added to show the weighted values used in the calculations.

Table 3: 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%
Method 1 Summed	1503618				102152.67		19903.71	7.601%
Method 2 Calculated from reported totals	1503618	121148	25343.59	0.8930	108185.164	0.763	19337.16	7.990%
Average wEFORd								8.012%

Weighted values in Table 3 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 – $wEFOR_d$ in place of (FOR_d 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 $wEFOR_d$ of 7.601%.
  - $$\frac{\sum(wFOHd + wEFDHd)}{\sum(wFOHd + wSH)} = wEFORd(pooled)$$
  - $$\frac{(102152.67 + 19903.71)}{(102152.67 + 1503618)} = 7.601\%$$
- **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%
  - $$\frac{\left(\left(f \times \left(\sum wFOH\right)\right) + \left(fp \times \left(\sum wEFDH\right)\right)\right)}{\left(\sum wSH + \left(fp \times \sum wFOH\right)\right)} = wEFOR_d(pooled)$$
  - $$\frac{((0.8930 \times 121148) + (0.7630 \times 25343.59))}{(1503618 + (0.7630 \times 121148))} = 7.990\%$$

3. **Average wEFORd** uses the sum of the weighted unit $EFOR_d$ values to calculate the numerical average.

   Notes: From Section 7.12.2 $EFOR_d = (FOH_d + EFDH_d) * 100 / (FOH_d + SH)$
   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.

   Weighted individual $EFOR_d = (wFOH_d + wEFDH_d) * 100 / (wFOH_d + wSH)$

Another Sample

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

Table 4: Raw Data Used as a 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
Total	725	734	36392	37123	152	153	0	4636	7

Table 5: Calculated Values used in EFORd 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%
Method 1 Summed					131.959		0.000		**15.238%**
Method 2 Calculated from reported totals	0.002	0.004	0.207	0.027	124.488	0.020	0.000		**14.501%**
Method 3 Summed								105.299	**37.607%**

Table 6: Weighted Values Used in EFORd 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%
Method 1 Summed	100260.000				22194.884		0.000	**18.125%**
Method 2 Calculated from reported totals	100260.000	788625.000	0.000	0.027	21176.435	0.020	0.000	**17.438%**
Average wEFORd								**12.493%**

Note #2 for Appendix F

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 cannot 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

(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 7. 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 7: 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.