ISO new england

memo

To:	NEPOOL Markets Committee and Reliability Committee
From:	ISO New England, Inc.
Date:	October 8, 2025
Subject:	Conforming Changes to Equivalent Forced Outage Rate on Demand (EFORd) Calculations

Section 1. Executive Summary

This memorandum discusses the conforming changes needed to move from the existing annual calculation of EFORd values to a methodology that yields seasonal EFORd values. A resource's EFORd is a measure of reliability that describes the probability a generator will be on forced outage or a forced capacity derate when called to run. Since EFORd values provide a measure of resource availability, they are a critical parameter for both measuring resource adequacy risk and for estimating resources' expected contributions to resource adequacy.

With the Capacity Auction Reforms (CAR), the capacity market will shift from procuring capacity annually to procuring it seasonally. To reflect this change, resources' EFORd values will be calculated seasonally starting in Capacity Commitment Period 19. Calculating EFORds seasonally will provide a more accurate estimate of i) resource adequacy risk within each season, and ii) resources' performance during the MRI Hours upon which they will be accredited. [1]

The ISO is only proposing conforming changes to seasonally calculate EFORd values at this time and is not proposing any other changes to the existing process. Specifically, the ISO is not proposing to change the types of outages that contribute to a resource's EFORd or the five-year lookback period for the EFORd calculations, nor is the ISO proposing an exemption process for "atypical" or long-term outages.

The remainder of this memo is split into three sections and four appendices:

- Section 2 discusses the existing process for calculating annual EFORd values.
- Section 3 discusses the proposed process for calculating seasonal EFORd values.
- Section 4 provides empirical analysis that compares generators' annual EFORd values to the ISO's current estimate of their seasonal EFORds.

[1] See the Marginal Reliability Impact (MRI) Framework for Accrediting Capacity Resources memo from the September Markets Committee for additional details on accreditation with the MRI framework and the determination of MRI Hours.

- Appendix A provides statistical tests that compare the annual and seasonal EFORds. The appendix demonstrates that while some generators have seasonal EFORds that differ from their annual EFORd, the differences are not statistically significant across the fleet.

- Appendix B discusses the two approaches that the ISO considered for estimating seasonal EFORds and the factors that led the ISO to recommend the proposed approach. Appendix B includes statistical tests that demonstrate that the two approaches do not yield EFORds that are statistically different across the fleet.

- Appendix C discusses the treatment of atypical or long-term outages.

- Appendix D discusses a Generating Availability Data System (GADS) code pertaining to gas-only fuel limitations that will not be considered "outside management control."

Section 2. Calculation of Annual EFORds Under the Existing Process

Under the existing process, the ISO calculates EFORds using a modified version of the EFORd calculations from the NERC GADS Data Reporting Instructions, Appendix F.[2] The EFORd assigned to resources in the calculation of Installed Capacity Requirement (ICR) and for the purposes of accreditation under CAR is based on resources' GADS data submissions over the last five years. The steps below provide a high level, conceptual overview of the process. Specifics on the calculation of EFORd values can be found in the NERC GADS Data Reporting Instructions; ISO-NE Planning Procedure 14 (PP14) contains additional details on the submission of GADS data.

Section 2.1. Submission of GADS Data for EFORd Calculations

Participants submit data on their resources' outages as defined by PP14. Specifically:

- Conventional generators above 5 MW of nameplate capacity must submit outage information, while conventional generators smaller than 5 MW and pondage hydro/pumped storage generators smaller than 20 MW do not need to submit such information and instead have their EFORd set using the NERC class average EFORd.[3]

- Generators must submit data in the GADS database each month by the 20th of the following month.

Section 2.2. Calculation of EFORd Values

Using the submitted GADS data, the ISO (through PowerGADS, a program provided by its vendor, Integ) generates EFORd values for individual resources. A high-level summary of how these values are calculated is provided below. Where additional detail is needed, specific equations from the NERC GADS Data Reporting Instructions, Appendix F ("NERC, Appendix F" hereafter) will be referenced. Note that ISO-NE's modified version of EFORd excludes GADS cause codes considered to be "outside management control," as defined by Appendix K of the NERC GADS Data Reporting Instructions.

[2] The modifications include the use of Net Dependable Capability (NDC) for weighting instead of Net Maximum Capability (NMC) and the exclusion of Outside Management Control (OMC) events.
[3] See page 3 of PP 14 for a list of resource types considered to be "conventional."

Intuitively, EFORd (Equivalent Forced Outage Rate on demand) provides an estimate of how likely a resource is to be unavailable when called to produce by the ISO. The baseline equation is given below. The numerator provides the frequency with which the resource was unavailable when called upon due to forced outage or forced derate, while the denominator provides the frequency with which the resource was called to produce:[4]

$$EFORd = \frac{FOHd + EFDHd}{FOHd + SH}$$

The EFORd equation has three components, each of which is derived from the GADS data submitted by generators.

- **The first term is the Force Outage hours on demand ($\boldsymbol{FOHd}$).** $FOHd$ provides the number of hours that a unit was on forced outage and the unit would have operated had it been available. This is a modified version of Forced Outage Hours (FOH), which are reported by participants. Some Forced Outage Hours may occur when a resource is unlikely to be called upon, which is an important consideration for a resource's contribution to system reliability. To transform FOH into $FOHd$, the ISO multiplies FOH by the demand factor, f:

  $$FOHd = f \times FOH$$

  The demand factor, f, represents the likelihood that a resource will be called upon by the ISO.[5]

- **The second term in the EFORd equation is the Equivalent Forced Derate Hours on demand *(EFDHd)*.** EFDHd provides the number of hours that a unit was on forced derate and the unit would have operated had it been available. This is a modified version of Equivalent Forced Derate Hours (EFDH), where EFDH is an adjustment of the derate hours reported by participants based on the size of the capacity reduction. To calculate EDFHd, the ISO uses the following NERC equation:

  $$EFDHd = f_p \times EFDH$$

  The partial f-factor, f_p, describes the proportion of time a resource is available.[6]

- **The third term is Service Hours (SH).** The denominator of the EFORd equation includes the same $FOHd$ term described above, as well as the SH, which measures how many hours the resource was in service.

The numerator of the equation provides a measure of how often the resource has been on outage or derate when called to operate, while the denominator gives the sum of the time when a resource is in

[4] See NERC, Appendix F, equation 25.
[5] For details on how f is calculated, see NERC, Appendix F, Equation 25.
[6] For details on how f_p is calculated, see NERC, Appendix F, Equation 25.

service and when it would have been in service if it had not been on outage. This yields EFORd's intuitive interpretation as the fraction of time a resource is on outage when it would be asked to run.

The ISO calculates EFORd values over five years (sixty months). The baseline EFORd equation can be rewritten more granularly to account for this time dimension. For resource i, the equation below extends the baseline equation above so that the EFORd is calculated over five years. As above, the numerator provides the frequency with which the resource was unavailable when called upon due to forced outage or forced derate, while the denominator provides the frequency with which the resource was called to produce.

$$EFORd_{i,5\ years} = \frac{(f_{i,5\ years} \times \Sigma_{t=1}^{5} \Sigma_{m=May}^{Apr} FOH_{imt}) + (f_{p_{i,5\ years}} \times \Sigma_{t=1}^{5} \Sigma_{m=May}^{Apr} EFDH_{imt})}{(f_{i,5\ years} \times \Sigma_{t=1}^{5} \Sigma_{m=May}^{Apr} FOH_{imt}) + (\Sigma_{t=1}^{5} \Sigma_{m=May}^{Apr} SH_{imt})}$$

Where t represents the year (years 1 through 5) and m represents the month of the year (with years running from May to April).

Section 2.2.1. Calculating EFORd Values for Resources with Missing Data Under Existing Rules

For resources without performance data for the five years (sixty months) used to calculate EFORd values, the ISO uses NERC class averages to fill in data for missing months.[7] Specifically:

- If a resource is entirely new (i.e., has no historical performance data), then it receives the NERC class average EFORd for its class.
- If the resource has some, but not all, of the five years of data, its EFORd will be a weighted average of its historical data with the NERC class average.

The following simple example illustrates how the ISO incorporates NERC class averages for missing data when calculating EFORd values. Consider the EFORd calculation process for a resource, Thermal1, that has only one year (twelve months) of historical performance data. For those twelve months, Thermal1's EFORd was 10%. Suppose that the NERC class average for Thermal1's class at the time of the calculation was 5%.[8] Then, the ISO would calculate:

$$EFORd_{Thermal1,5Years} = \frac{12}{60} \times 10\% + \frac{48}{60} \times 5\% = 6\%$$

Thermal1 receives 12 months of its own EFORd and 48 months of the NERC class average EFORd, yielding final EFORd value of 6%. Over time, the fraction of Thermal1's EFORd that comes from NERC class averages will diminish as more of its own data is used in its EFORd calculation.

Section 3. Planned Process for Calculating Seasonal EFORds

The ISO proposes to use seasonal, rather than annual, EFORd values. Conceptually, the mechanics of the EFORd calculation will be identical to those described in Section 2, except that rather than summing

[7] NERC class averages are available here. Note that, unlike the EFORd values calculated in ISO-NE, the NERC class average values do not exclude outside management control events.
[8] Because of the lag in data collection and publication, NERC class averages are delayed by one year. For instance, when calculating an EFORd in 2025, the most recent NERC data will be the five-year average from 2020-2024.

the input values over all twelve months for each of the five years of interest, the ISO will now only sum six months of data corresponding to the relevant season in each year.

The ISO's proposed seasons run from Summer (May through October) and Winter (November through April).[9] A summer EFORd, for example, will be calculated over 30 months using only May through October data for the last five years:[10]

$$EFORd_{i,5Summers} = \frac{(f_{i,5Summers} \times \sum_{t=1}^{5} \sum_{m=May}^{Oct} FOH_{imt}) + (f_{p_{i,5Summers}} \times \sum_{t=1}^{5} \sum_{m=May}^{Oct} EFDH_{imt})}{(f_{i5Summers} \times \sum_{t=1}^{5} \sum_{m=May}^{Oct} FOH_{imt}) + (\sum_{t=1}^{5} \sum_{m=May}^{Oct} SH_{imt})}$$

This EFORd calculation is distinct from a simple average of five one-summer EFORd values,[11] and instead "stitches together" each resource's input data from across the 30 relevant months. The ISO calls this approach the "continuous" approach for estimating seasonal EFORd values. The only difference between this continuous seasonal calculation and the current annual calculation is that the seasonal calculation uses only 30 months from the respective season, while the annual calculation uses all sixty months. Empirical comparisons between seasonal and annual EFORd values are given in Section 4.

The following simple numerical example provides a conceptual demonstration of the difference between seasonal and annual EFORd values. In this example, there is a single resource, Thermal2. There are two years, each with two seasons consisting of two months, to simplify the exposition. In each month, Thermal2 has some service hours (given in column 4: SH) and some forced outage hours on demand (given in column 5: FOHd). Equivalent forced derate hours on demand (column 6: EFDHd) are set to zero throughout for simplicity.

[9] Find discussion on the summer and winter season definitions here.
[10] Note that the demand factors are also calculated over the same set of 30 summer months. For details on how f and f_p are calculated, see NERC, Appendix F, Equation 25.
[11] The ISO compares simple average and continuous EFORd approaches in Appendix B and explains therein why it is proposing the continuous method.

Table 1: Calculating Annual and Seasonal EFORds for Thermal2

Year	Season	Month	SH	FOHd[1]	EFDHd
1	Summer	1	115	5	0
1	Summer	2	80	10	0
1	Winter	3	75	30	0
1	Winter	4	30	20	0
2	Summer	1	100	10	0
2	Summer	2	65	15	0
2	Winter	3	20	50	0
2	Winter	4	25	50	0
	Total		510	190	0

[1] This table implicitly assumes that f is constant for each period to simplify the example. As shown in the equation above, when multiple periods are used to calculate EFORd, a single f across the period is applied to each period's FOH, rather than calculating $FOHd$ using a period-specific value.

Using the seasonal and annual EFORd equations defined above, EFORd values for summer, winter, and annual periods can be calculated:

$$EFORd_{Thermal2,Annual} = \frac{190 + 0}{190 + 510} = \frac{190}{700} = 27.1\%$$

$$EFORd_{Thermal2,Summer} = \frac{(5 + 10 + 10 + 15) + (0 + 0 + 0 + 0)}{(5 + 10 + 10 + 15) + (115 + 80 + 100 + 65)} = \frac{40}{400} = 10\%$$

$$EFORd_{Thermal2,Winter} = \frac{(30 + 20 + 50 + 50) + (0 + 0 + 0 + 0)}{(30 + 20 + 50 + 50) + (75 + 30 + 20 + 25)} = \frac{150}{300} = 50\%$$

This example provides important insights into the proposal to use seasonal EFORd:

- First, Thermal2's outage rate is significantly different between summer and winter: it is unavailable 10% of the time it is called to run in the summer, but 50% of the time in winter. Reflecting these stark differences within a seasonal accreditation framework will be valuable for understanding risks to system reliability. If the available capacity in a season does not accurately represent the probability resources will be on forced outages when called to produce, the estimated seasonal reliability parameters (including LOLE and EUE) could be inaccurate. Additionally, reflecting seasonal differences in EFORd will also help to compensate resources in a manner that reflects their resource adequacy contribution in each season. (If a resource is more likely to be on outage in one season vs. another, their seasonal capacity market compensation should reflect that fact.)

- Second, the annual EFORd is not a simple average of the summer and winter EFORd values, which would have been 30%. This is because the denominators in the two seasonal calculations ($SH + FOHd$) differ. Thermal2 has an annual EFORd that is lower than the simple average

because it is more frequently demanded in summer, when its outage rate is lower. This intuition is explored in more detail in Appendix B.

Section 3.1. Calculating EFORds for Resources with Missing Data Under New Rules

Under the new process, resources without a complete history of 30 months of data for a given season (i.e., five years of seasonal data) will receive class average EFORd values for those missing months in a manner conceptually similar to that described in Section 2.2.1. That is, they will receive a weighted average of their own EFORd based on whatever historical data is available, and a class average EFORd for the period they were not commercial.

However, rather than relying on NERC class averages, the ISO will calculate class averages of the New England fleet of resources to use for the months where resources do not have data. This will ensure that the class averages are representative of the New England fleet of resources for each technology type. It will also allow the ISO to match the exclusion of OMC events from the class average. Note that precise class definitions will be discussed in a future month.

Consistent with PP14, resources with small enough nameplate capacities to not submit GADS outage data will receive these class averages.

Section 4. Estimated Differences between Annual and Seasonal EFORds

The ISO will use seasonal EFORd in place of annual EFORd for accreditation and modeling in the RAA process. This section considers the extent to which seasonal and annual EFORds may differ by comparing them over a five-year period. [12]

Table 2 below provides the average annual and seasonal EFORd at the asset level for all technology types in the New England system.

- The three columns are split up by "5-Year Annual," "5-Season Summer," and "5-Season Winter" EFORd.
- The 5-Year Annual timeframe is May 2019 through April 2024. Within this timeframe, there are five summer and winter seasons. For the summer season, the Summer EFORd uses PowerGADS outage data from May through October in 2019, 2020, 2021, 2022, and 2023; one winter season is comprised of data from two different calendar years for each season – e.g., November 2019 through April 2020 . The seasonal EFORd calculation uses the continuous methodology as described in Section 3.
- To calculate the numbers in the table, each asset's 5-Year EFORd and 5-Season EFORd is calculated separately and then averaged. These averages are not weighted by the resources' capacities.

[12] The ISO used asset-level data to estimate seasonal EFORd values. All subsequent graphs and tables with the continuous seasonal EFORd should be considered preliminary pending a more complete production implementation of these calculations. Only assets that were in operation in at least one summer and one winter season were included in the evaluation. If an asset had fewer than five seasons of data, the ISO did not fill in any missing months with a class average.

Table 2 shows that the average asset-level EFORd value with the five-year annual methodology is 10.12%. That is, the average asset has roughly a 10% probability of being unavailable due to forced outage when called to perform. In aggregate, the average differences between the annual EFORd and the seasonal EFORd are small. The summer tends to have a smaller EFORd, whereas the winter tends to have a larger EFORd.

Table 2: Average Annual, Summer, and Winter EFORds

Average 2024 EFORd at the Asset Level		
Using 5 years (May 2019 - April 2024) of PowerGADS data		
5-Year Annual	5-Season Summer	5-Season Winter
10.12	9.8	10.59
Summer Season (May - October); Winter Season (November - April)		

Next, the ISO considers the distribution of the annual and seasonal EFORd by the resource technology types.

Figures 1-3 are box and whisker plots of annual and seasonal EFORd by resource technology type. Figure 1 provides the distribution of annual EFORds by asset type. Figures 2 and 3 are similar but illustrate the distribution of the seasonal EFORd and the differences between the seasonal and annual EFORd. The details on how to read the figures are provided below:

- The x-axis lists the four categories of assets that are modeled with outage rates: combined cycles (CC), combustion turbines (CT), steam turbines (ST), and all other assets that have an outage rate (Other).

- The y-axis lists equivalent forced outage rates on demand, excluding outside management control events (EFORd). These EFORd were calculated using data from May 2019 through April 2024. EFORd can range from 0% (reflecting a resource that never goes on forced outage (or forced derate) except for outside management control events) to 100% (reflecting a resource that is always on forced outage when called to produce).

- Each dot within each column represents the EFORd for one asset in that column's class. E.g., a dot in the teal box provides the EFORd for one steam turbine asset. Note that the dots are "jittered" (spaced out horizontally) to make individual asset EFORd values easier to see.

- Each column's box-and-whisker plot provides data on the distribution of EFORd values within that class:

    - The bottom of each box provides the 25th percentile EFORd for that class.

    - The solid line running through the middle of each box provides the median EFORd for that class.

- The top of each box provides the 75th percentile EFORd for that class.
- The lines (or "whiskers") that extend from the boxes reflect all the assets that are not between the 25th and 75th percentiles of that class but that are not outliers.
- The bold dots reflect asset EFORd values that are outliers for their class, where outliers are any observation that is outside of the range 1.5 x (75th percentile – 25th percentile.) Thus, the high value outliers have EFORds greater than the 75th percentile for that class plus 1.5 x (75th percentile – 25th percentile.)

Figure 1: Box and Whisker Plot of Annual EFORd by Class

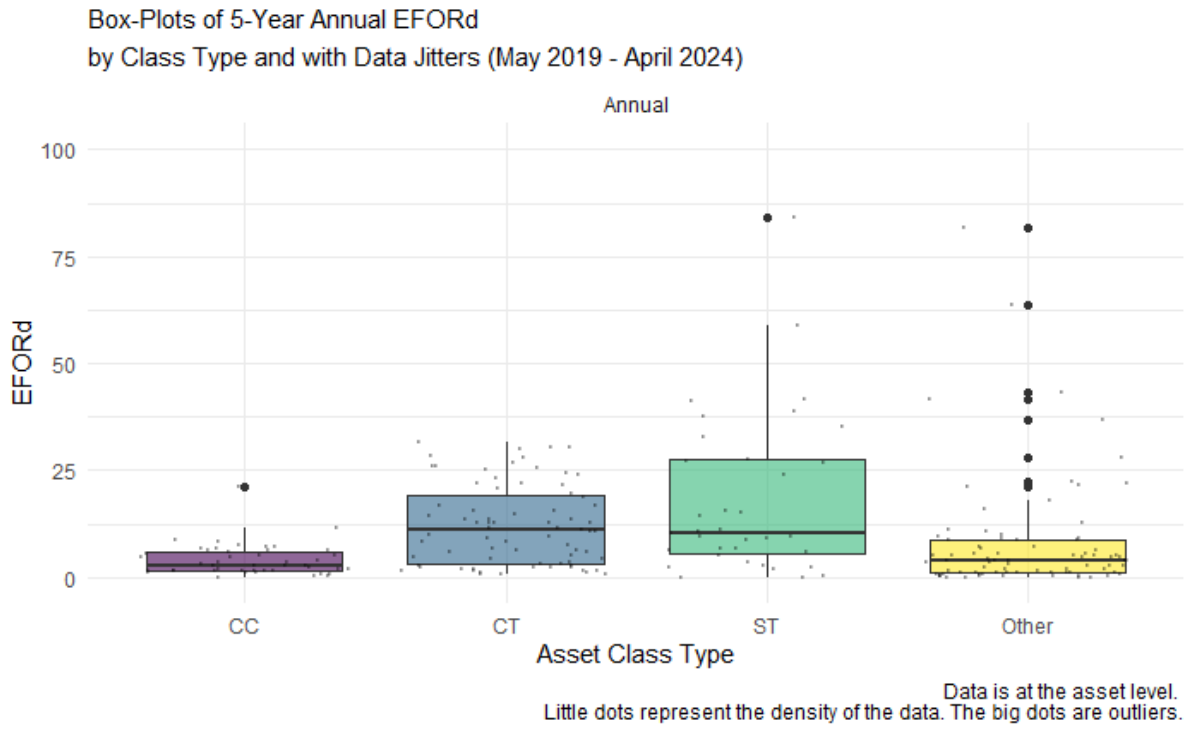


Figure 2 splits up the seasonal EFORd by the summer and winter seasons in the left and right panels, respectively.

Figure 2: Box and Whisker Plots of Seasonal EFORd by Class

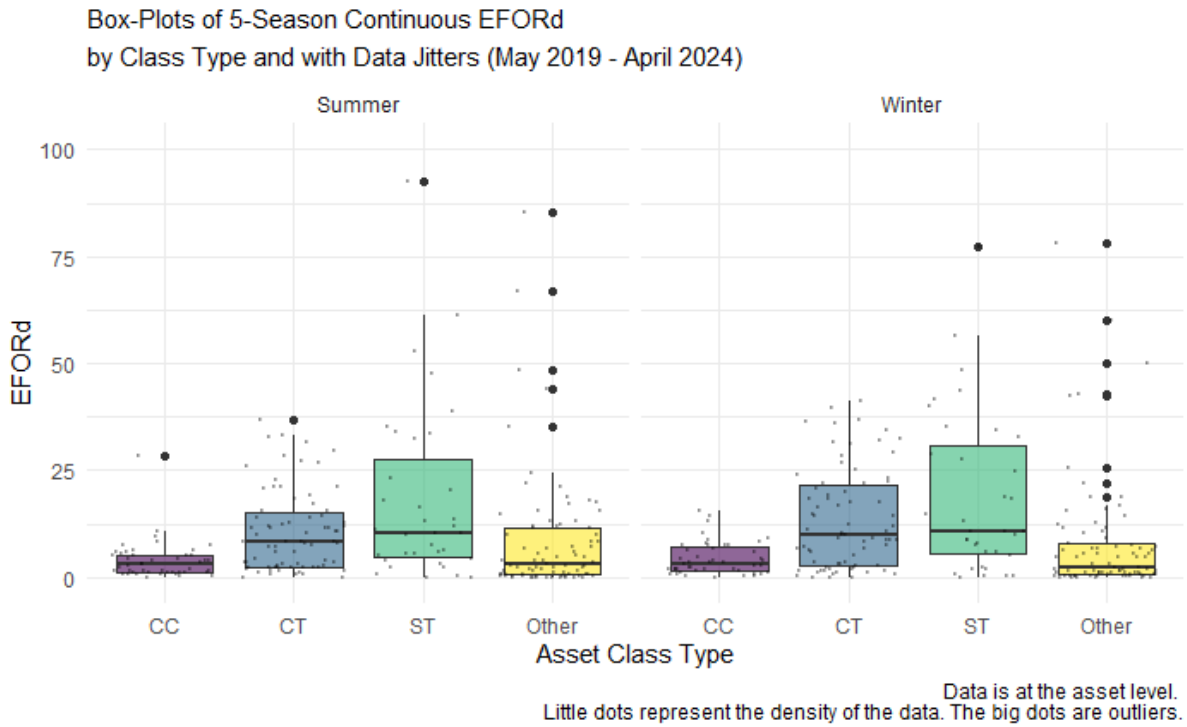
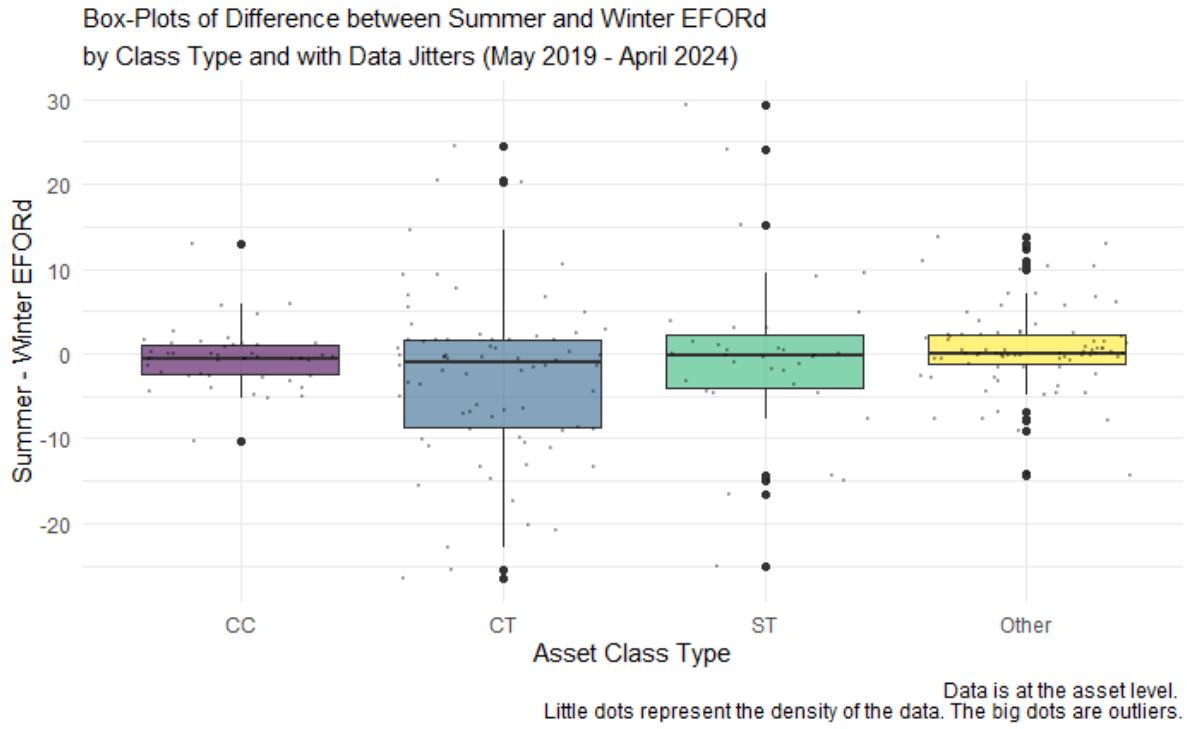


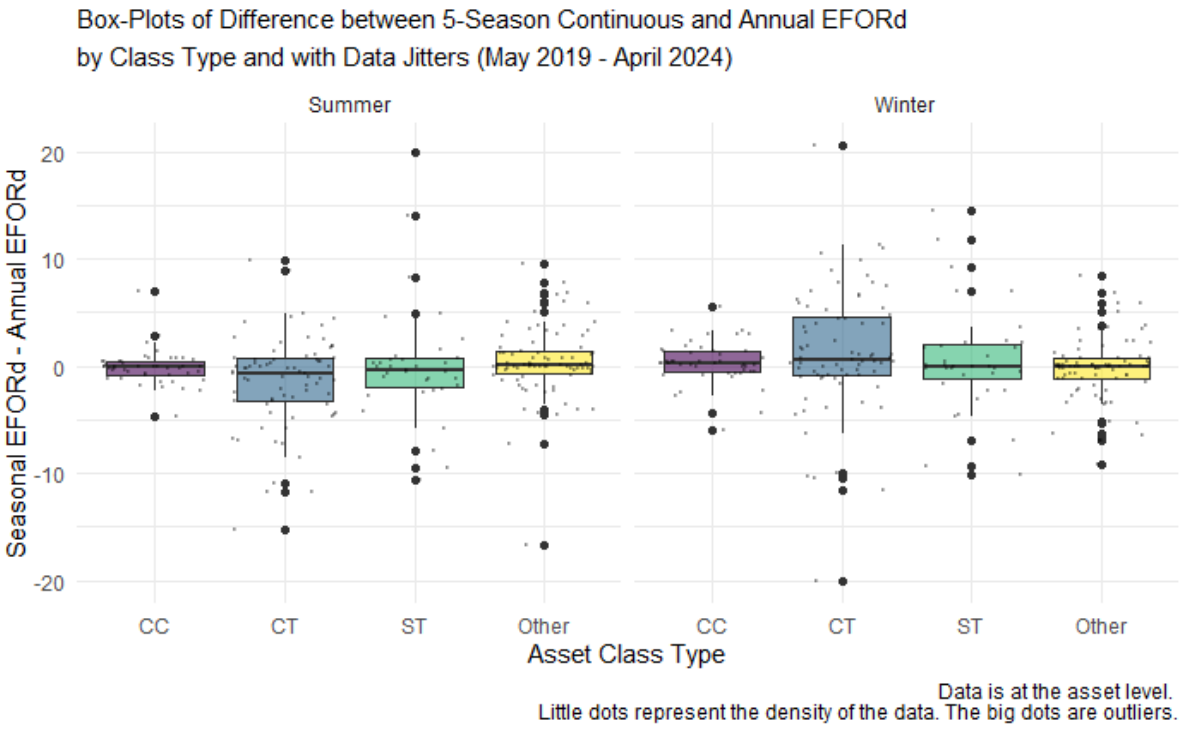
Figure 3: Box and Whisker Plot of Differences between Summer and Winter EFORd by Class



Finally, Figure 4 provides a box and whisker plot of the differences between resources' annual EFORds and their estimated seasonal EFORds. Note that some resources tend to have a better (lower) EFORd in the summer season, whereas others perform better in the winter. Across the entire fleet, the distribution

of differences suggests that most generators have a smaller summer EFORd and a larger winter EFORd. For additional information on estimated differences between summer, winter, and annual EFORds, see Appendix A.

Figure 4: Box and Whisker Plot of Differences between Annual and Seasonal EFORds



Appendix A. Statistical Tests on the Difference Between Seasonal and Annual EFORd

This appendix provides statistical tests that compare the differences between annual and seasonal EFORd values across the fleet. The ISO's goal was to determine the extent to which the ISO expects EFORds to change at the fleet level with a move from annual to seasonal EFORds. To conduct these statistical tests, the ISO first constructs an empirical cumulative distribution function (ECDF) using the asset-level EFORd data. The ECDF provides the probability that a randomly selected asset EFORd is less than or equal to a particular EFORd value. For example, if the height of the ECDF at 50 is 0.75, this would suggest that 75% of the assets had an EFORd less than 50%.

The ECDF of the summer, winter, and annual EFORds is shown in the figure below, Figure 5. The yellow line is the ECDF of the summer EFORds, the blue line is the ECDF of the winter EFORds, and the light grey line is the ECDF of the annual EFORds.

Figure 5: Empirical CDFs for Seasonal and Annual EFORds

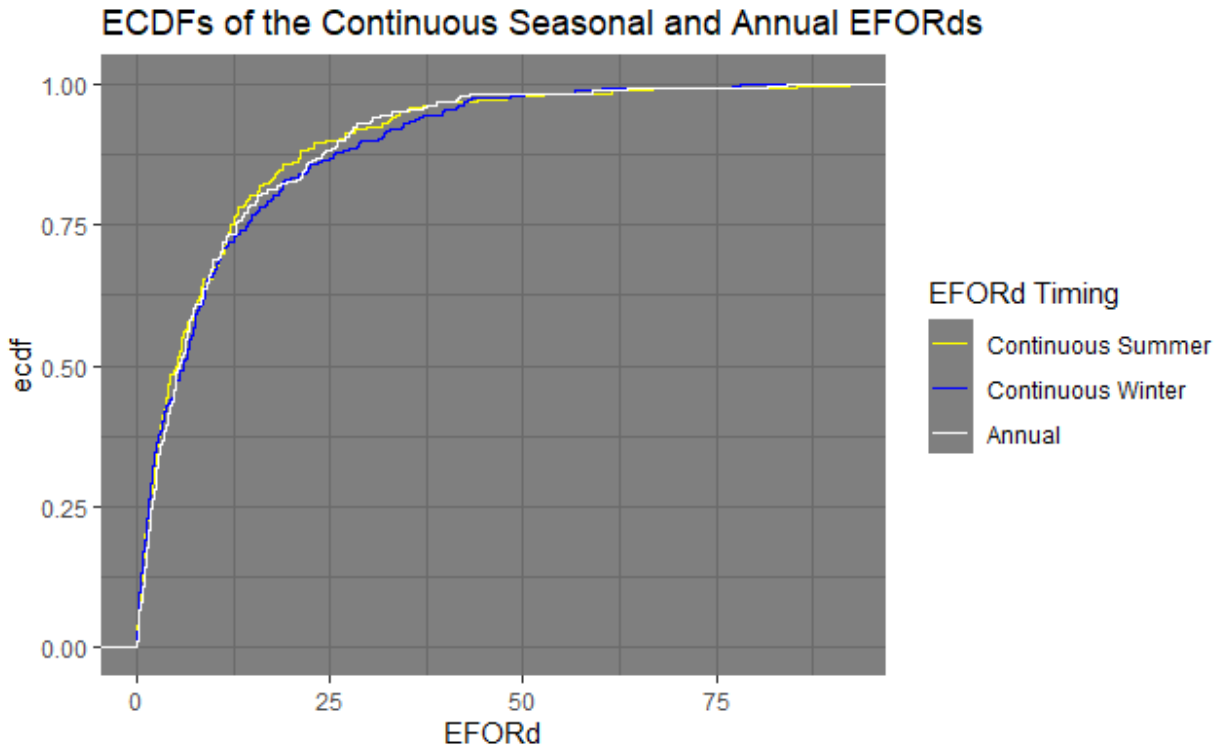


Figure 5 suggests that annual EFORd values tend to skew lower than winter-specific EFORd values (the grey line is often to the left of the blue line.) For instance, the probability that the annual EFORd in the ISO's dataset is 28 or less is about 90%, where the probability that the winter EFORd is 28 or less is about 87%. For the summer, this relationship flips: the yellow line is often to the left of the grey line.

Whether or not these distributions are statistically the same cannot be verified from visually observing the distributions. The next section provides statistical tests comparing the empirical distributions of continuous and annual EFORds.

Appendix A.1. Statistical Test of Differences in EFORd Distributions

The ISO performed statistical analysis to understand how different the EFORd values are when calculated at the seasonal or annual level. The ISO employed two-sample Kolmogorov-Smirnov Tests to evaluate whether the distributions of seasonal and annual EFORd values are statistically different from one another. The Kolmogorov-Smirnov Test (K-S Test) calculates the maximum distance between the empirical cumulative density functions and compares this value to a test statistic.[13] The null hypothesis is that the two empirical distributions come from the same underlying data generating process.

To provide intuition for the test, suppose that two coins are flipped ten times. The first coin lands on heads five times and tails five times. The second coin lands on heads nine times and tails one time. The K-S test uses such data to test how likely it is that two coins with the same fundamental probability of landing on heads would yield such different results. If the null hypothesis is rejected, it suggests that the coins are likely to have different underlying probabilities (e.g., one is an "unfair" coin). Rejecting the null hypothesis becomes easier with more observations: comparing five heads and five tails to nine heads and one tail is different than comparing fifty heads and fifty tails to ninety heads and ten tails.

In the context of EFORd, the K-S Test examines whether using seasonal EFORd values creates a fundamentally different distribution of EFORd values for the New England fleet relative to using annual EFORd values. The results of the tests are shown below.[14]

Table 3: K-S Test Results for Differences between Seasonal and Annual EFORds

K-S Test Results Between Seasonal Continuous and Annual EFORd

Using 5 years (May 2019 - April 2024) of PowerGADS data

Distribution 1	Distribution 2	P-Value
Continuous Summer	Annual	0.727
Continuous Winter	Annual	0.650

Summer (May-October); Winter (November-April)

[13] More precisely, for empirical CDFs F_1, F_2 of size n, m, respectively, the test calculates $D_{1,2} = \sup_x |F_1(x) - F_2(x)|$. The test rejects the null hypothesis that the two empirical distributions arise from the same underlying data generating process if $D_{1,2} > \sqrt{-\frac{1+\frac{m}{n}}{2m} \ln\left(\frac{\alpha}{2}\right)}$ for a given confidence level α (e.g., 0.05). For more information, see Kolmogorov–Smirnov test - Wikipedia.

[14] The ISO conducted a K-S test that also compared the ECDFs of the continuous winter and summer EFORDs. The p-value of this K-S test is 0.727, resulting in the failure to reject the null hypothesis that the seasonal EFORd distributions are different. Note that the p-value of the K-S test between the distributions of the continuous summer and continuous winter EFORds is precisely the same as the p-value of the K-S test between the distributions of the continuous summer and annual EFORds. Though unlikely, although not impossible, the p-values being the same is likely a consequence of using a small sample with the EFORds belonging to the same assets in all the compared distributions.

Each row of Table 3 shows the result of a separate test. The first row compares the distribution of continuous summer EFORd values to the annual EFORd values. The test yields a p-value of 0.727. This value is well above the conventional rejection threshold of 0.05, failing to reject the null hypothesis that the two distributions arise from the same underlying data generating process. The second row compares winter EFORd values to the same set of annual EFORd values, yielding a p-value of 0.655. While smaller, it is still well above the conventional rejection threshold of 0.05.

The ISO's proposed shift from annual to seasonal EFORd values, then, does not appear to expose resources to an entirely different distribution of EFORd values. Although seasonal EFORd values may differ from annual EFORd values for a small set of resources, the distributions of seasonal and annual EFORds are not statistically different across the entire fleet.

Appendix B. Comparison of Potential Seasonal EFORd Approaches

As a conforming change to better align with a seasonal market, the ISO is proposing to give resources separate summer and winter EFORd values using five seasons (30 months) of data. The ISO considered two methods of calculating these seasonal EFORd values.

The first method is the "simple average" method. Under this approach, the ISO would calculate a separate EFORd value for each of the last five seasons. Then, the ISO would take a simple average of those five EFORd values to calculate the final EFORd. Thus, for each year $t \in \{1, 2, 3, 4, 5\}$, each season $s \in \{Summer, Winter\}$, and each month $m \in \{January, \dots, December\}$, the ISO would use resource i's one-season EFORd as calculated in PowerGADS by:[15]

$$EFORd_{i,OneSeason,t} = \frac{f_{ist} \times \sum_{m \in Season} FOH_{imst} + f_{p_{ist}} \times \sum_{m \in Season} EFDH_{imst}}{f_{ist} \times \sum_{m \in Season} FOH_{imst} + \sum_{m \in Season} SH_{imst}}$$

Then, to arrive at the final seasonal EFORd values, the ISO would calculate:

$$EFORd_{i,Summer,Simple} = \frac{1}{5} \times \sum_{t=1}^{5} EFORd_{i,Summer(OneSeason),t}$$

$$EFORd_{i,Winter,Simple} = \frac{1}{5} \times \sum_{t=1}^{5} EFORd_{i,Winter(OneSeason),t}$$

The second method is the Continuous method which is consistent with the ISO's current methodology. Here, the ISO will calculate a single EFORd value for each season, using input data from all periods as was introduced and explained in Section 3, above. That is, rather than calculate seasonal EFORd values for the individual seasons, as is the case with the simple average method above, the continuous method calculates the seasonal EFORd value for a resource using all of a resource's seasonal information at once. See the equations below.

[15] These calculations assume that the resource was commercial for all five of the relevant seasons for simplicity. Section 3 discusses how the ISO will handle resources with limited historical data in more detail.

$$EFORd_{i,Summer,Continuous} = \frac{f_{i,Summer} \times \sum_{t=1}^{5} \sum_{m \in Summer} FOH_{imst} + f_{p_{i,Summer}} \times \sum_{t=1}^{5} \sum_{m \in Summer} EFDH_{imst}}{f_{i,Summer} \times \sum_{t=1}^{5} \sum_{m \in Summer} FOH_{imst} + \sum_{t=1}^{5} \sum_{m \in Summer} SH_{imst}}$$

$$EFORd_{i,Winter,Continuous} = \frac{f_{i,Winter} \times \sum_{t=1}^{5} \sum_{m \in Winter} FOH_{imst} + f_{p_{i,Winter}} \times \sum_{t=1}^{5} \sum_{m \in Winter} EFDH_{imst}}{f_{i,Winter} \times \sum_{t=1}^{5} \sum_{m \in Winter} FOH_{imst} + \sum_{t=1}^{5} \sum_{m \in Winter} SH_{imst}}$$

The ISO considered the practical and conceptual advantages for each method. The ISO believes that the continuous method better reflects a resource's true availability over the course of its performance history compared with the simple average method. To see this, consider the following three hypothetical resources in a simple, two-period example below.

Table 4: Simple Average vs. Continuous EFORd Calculation

Resource	Year	SH	FOHd	EFDHd	One-Period EFORd	Simple Average EFORd	Continuous EFORd
Thermal A1	2017	50	25	0	33.3%	50.0%	35.8%
Thermal A1	2018	2	4	0	66.7%		
Thermal A2	2017	50	25	0	33.3%	21.7%	30.6%
Thermal A2	2018	9	1	0	10.0%		
Thermal A3	2017	50	25	0	33.3%	22.2%	21.2%
Thermal A3	2018	80	10	0	11.1%		

Each row in this table is a separate resource-year observation. The first row shows Thermal A1's performance during 2017. In that year, it had 50 Service Hours (SH), and 25 Forced Outage Hours on demand (FOHd). All resources experience no derates (EFDHd = 0) for simplicity. The one-period EFORd column applies the EFORd calculation to those numbers: $\frac{25+0}{25+50} = 0.333 = 33.3\%$. The final two columns calculate EFORd in different ways across each resource's two rows. The "Simple Average EFORd" column takes a simple average of two year's values from the "One-Period EFORd" column, while the "Continuous EFORd" column calculates the EFORd continuously using the SH, FOHd, and EFDHd inputs.

In this example, all three resources perform identically in 2017, with 50 service hours and a value of 25 for the FOHd. However, in 2018, performance differs across the three resources. Thermal A1 is called on infrequently (SH + FOHd is small), and it is mostly on outage when it is called, giving it a very high EFORd value for that season. The simple average of 50% does not reflect the fact that its relatively poor performance in 2018 occurred over the course of very few hours during which it was called on to perform, while it showed a better availability rate across many more hours in 2017. Thermal A1's

continuous EFORd accounts for this: the continuous EFORd is similar to the 2017 one-season EFORd because 2018 provides so few hours of data.

Thermal A2, like Thermal A1, is called on in far fewer hours in 2018 than in 2017. Unlike Thermal A1, it performs very well in those few hours during which it was called. The continuous EFORd accounts for the fact that its strong availability performance in 2018 is built on very few hours, while the simple average approach does not.

Thermal A3, like Thermal A2, has a much stronger performance in 2018 than in 2017. Unlike either Thermal A1 or Thermal A2, however, Thermal A3 is called upon for a similar number of total hours in 2017 and 2018 (SH + FOHd are similar in both years). In this case, the simple average and continuous approaches yield similar EFORds. The two measures yield comparable results when resources are called upon with similar frequency across years. However, when resources experience large variations in how frequently they are called on to perform, the two approaches to calculating EFORd can differ significantly.

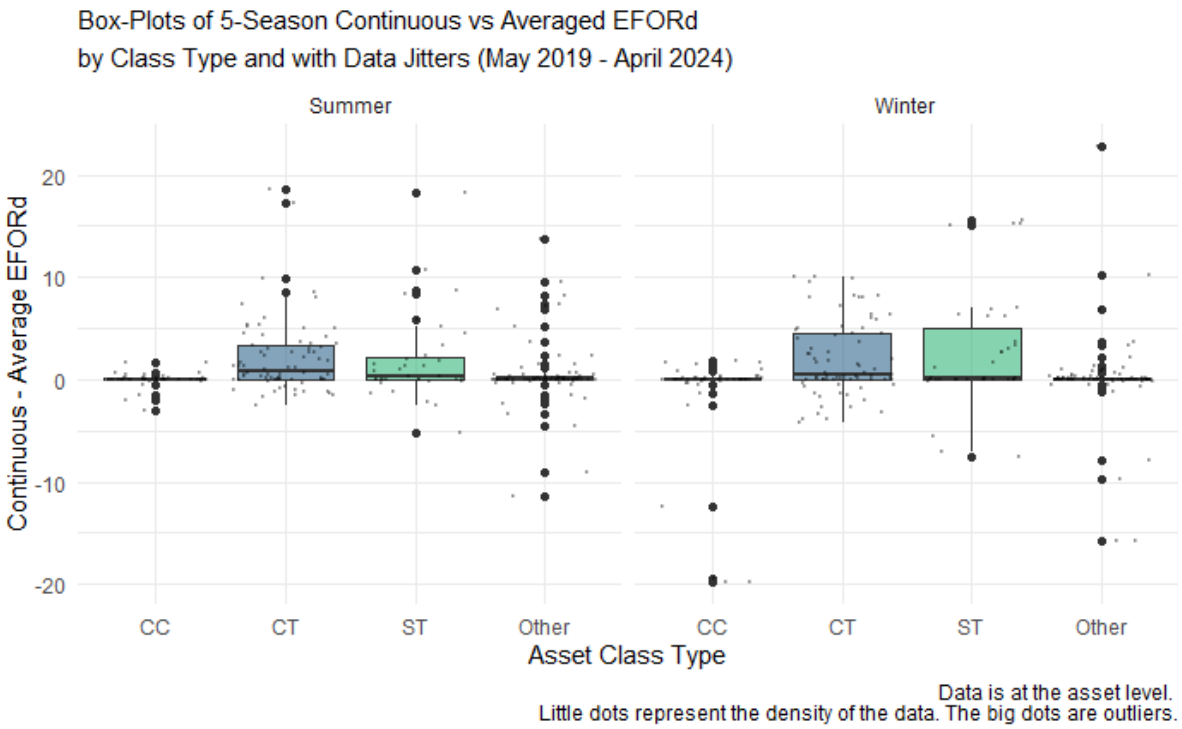
Appendix B.1. Empirical Exercises

The ISO performed several empirical exercises to determine whether the New England fleet of assets modeled with forced outage rates would be significantly affected by using either the simple average or continuous EFORd approaches. (Recall that, while in implementation, seasonal EFORds would be calculated at the resource level, the figures and tables in this memo present EFORds at the asset level.) To do this, the ISO calculated simple average and approximated continuous EFORd values for all assets. These values were calculated for the five-year period between May 2019 and April 2024.

Simple average seasonal EFORd values were calculated using six-month EFORd values in PowerGADS. For instance, summer simple averages were calculated by using six-month EFORd values for May 2019 through October 2019, May 2020 through October 2020, etc., and then taking the simple average of the five values for each asset. To calculate the continuous EFORd values, the ISO used the input data (SH, FOH, etc.) for each of the six-month seasons and approximated the EFORd calculations performed by PowerGADS.

The figures below are box-and-whisker plots of the difference between the continuous EFORd and simple average EFORd for summer and winter, respectively, by technology type.

Figure 6: Box and Whisker Plot of Differences between Continuous and Simple Average Seasonal EFORds



In these figures, a positive value means that the continuous EFORd is larger than the simple average EFORd. A negative value implies the reverse. For most assets, the differences are small, with the bulk of the distribution being very close to zero. However, there are several assets with large differences, both positive and negative.

On average, continuous EFORd values are somewhat larger than simple average EFORd values (more of the values are positive than negative.) This fact can be seen clearly by plotting the empirical cumulative density functions (ECDFs) for the distributions of continuous and simple average EFORd values.[16]

[16] These ECDFs will order all the EFORd values for a given season for the New England fleet from smallest to largest. For each value, the function will return the proportion of the data less than that value. Thus, the ECDF of, say, 0.1, will return the proportion of assets with an EFORd value less than 0.1 in the data.

Figure 7: Empirical CDF of Continuous and Simple Average Summer EFORds

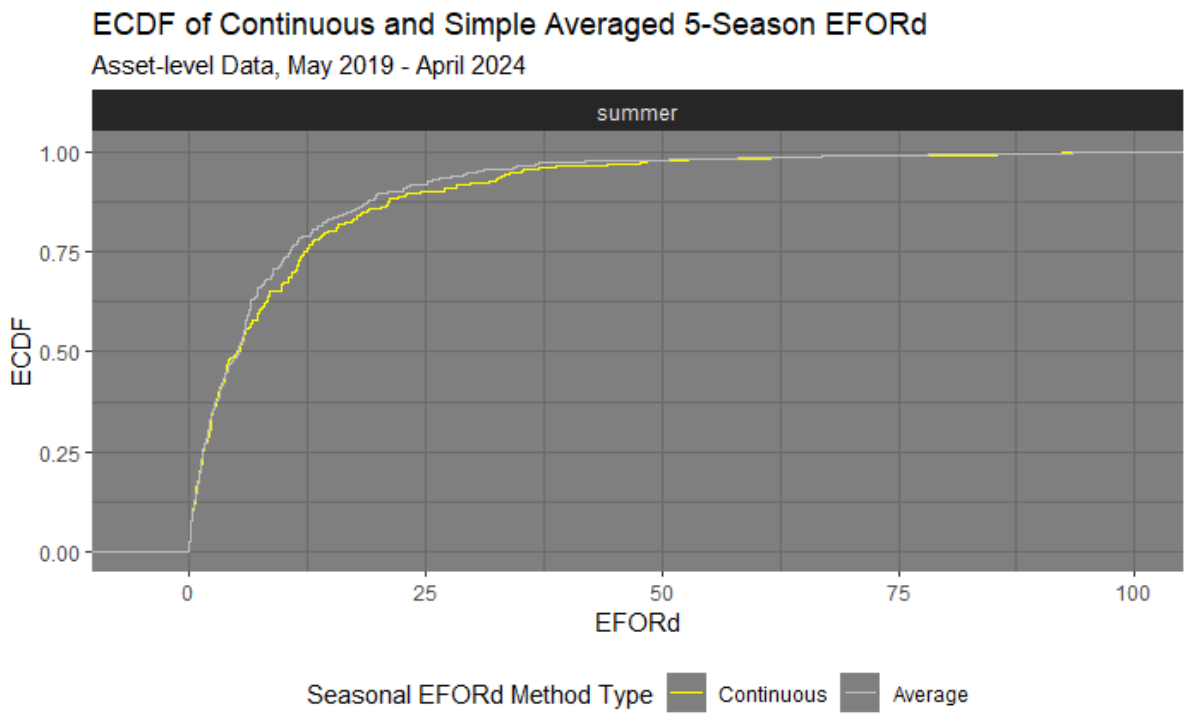
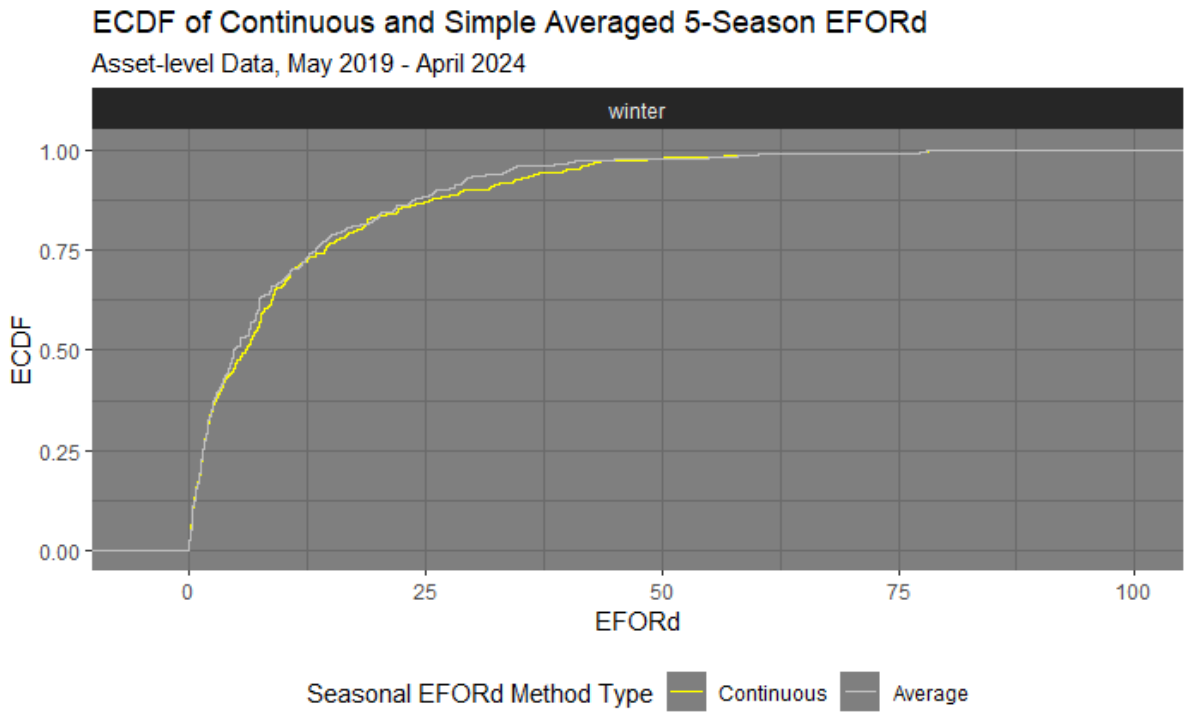


Figure 8: Empirical CDF of Continuous and Simple Average Winter EFORds



In each of these figures, the yellow line shows the ECDF of the continuous EFORd values and the gray line shows the ECDF of the simple average EFORd values. In both cases, the yellow line tends to be underneath the gray line, indicating that more of the simple average EFORd values are below a given value than continuous EFORd values. In other words, the simple average method tends to calculate lower EFORd values than the continuous method, though the differences are small on average.

Visual comparison of the two ECDFs, however, is not sufficient to determine whether the simple average and continuous EFORd values are statistically different. For this, the ISO performs Two-Sample Kolmogorov-Smirnov Tests to analyze differences in the distribution.[17] The results of these tests are shown in Table 5 below.

Table 5: K-S Test Comparing Continuous and Simple Average Approaches

K-S Test Results Between Seasonal Continuous and Averaged EFORd

Using 5 years (May 2019 - April 2024) of PowerGADS data

Distribution 1	Distribution 2	P-Value
Continuous Summer	Average Summer	0.573
Continuous Winter	Average Winter	0.801

Summer (May-October); Winter (November-April)

Each row of Table 5 provides the result of a separate test. The first row compares the distribution of continuous summer EFORd values to the simple average summer EFORd values. The test yields a p-value of 0.573 (Summer) and 0.801 (Winter). These values are well above the conventional rejection threshold of 0.05, failing to reject the null hypothesis that the two sets of distributions arise from the same underlying data generating process.

Interpreting these test results, one cannot reject the hypothesis that the continuous and simple average methods create EFORd values with identical distributions. While there is some variation between the two methods due to calculation differences, choosing one over the other does not statistically change the distribution of EFORd values for the New England fleet. Given the other considerations above, the ISO is proposing to use continuous EFORd values.

Appendix C. Treatment of Atypical or Long-term Outages

As part of the Resource Capacity Accreditation (RCA) stakeholder process, some stakeholders noted an interest in excluding some "atypical" or long-term outages from EFORd values. At this time, the ISO is not proposing an exemption process for such outages, beyond that which already exists for outages classified as OMC. The ISO's current thinking is motivated by the following considerations:

1. Atypical and long-term outages do occur, and when they occur, they impact resources' ability to contribute to resource adequacy. As a result, the risk of such outages should be reflected both in

[17] For a description of the K-S Test, see Appendix A.1, above.

the Resource Adequacy Assessment (RAA) process that yields key auction parameters like the Installed Capacity Requirement (ICR), and in resources' accredited capacity values that determine their capacity market compensation. If the atypical or long-term outages were excluded from EFORd calculations, the ISO would systematically overcount the amount of capacity we expect to be available. This would undermine the capacity market's objective to procure sufficient capacity to meet the region's resource adequacy standard.

2. Exempting atypical or long-term outages could negatively impact resources' incentives to return to service in a timely manner. For example, if long-term outages were exempted from EFORd calculations, a resource could be incentivized to extend its outage so that the outage could be classified as "long-term" and thus be exempt from the resource's EFORd calculation. Alternatively, a resource that is already on long-term outage may not be incentivized to return to service as quickly as possible if its current outage has no impact on its EFORd.

The ISO welcomes feedback on this item in the coming months as it moves to finalize its proposal.

Appendix D. Treatment of GADS Codes Related to Gas Fuel Unavailability

As part of the RCA stakeholder process, some stakeholders noted that the GADS cause code "9131" is related to a potential inability to acquire fuel and is not considered outside management control. Stakeholders suggested that, as a result, it was possible that gas-only resources could both have their EFORd impacted by an inability to access fuel and be subject to the gas constraint. (For more information on the how the RCA proposal intended to account for the regional gas constraint, and how the ISO proposes to account for the gas constraint as part of CAR, please see the ISO's January 2024 memo on the topic.)

The ISO is not proposing to change which GADS cause codes are considered outside management control as part of CAR, and so the ISO's current thinking is that code 9131 would continue to be counted in EFORd calculations.

This decision was informed, in part, by an examination of the extent to which the inclusion or exclusion of code 9131 in EFORd calculations would affect resources' EFORd values. Over the sample period used in this memo's analysis (May 2019 through April 2024) there were only a handful of events reported as cause code 9131 across the entire fleet. In the table below, the ISO reports the percentage of all forced outage and equivalent derate hours that can be attributed to cause code 9131 by technology type for generators that only use gas for their fuel.

The first column lists the different gas technology types that reported code 9131 – combined cycles (CC) and combustion turbines (CT.) The second and third columns report the percentage of both derate and forced outage hours due to cause code 9131. The numbers in this table are calculated by taking the sum of the total equivalent derate hours or forced outages due to cause code 9131, dividing by the total sum of equivalent derate hours or forced outages for all generators that use only gas for their fuel in the same technology type, rounding to the fourth significant figure, and then multiplying by 100.

Table 6 shows that only a small percentage of forced outage hours and equivalent derate hours were due to cause code 9131. In fact, less than one percent of all forced outage and derate hours were due to 9131 across both the technology types. CT resources had the largest percentage of forced outage rates due to 9131 (0.84%) and CC had the smallest (0.42%). Only CC generators had to derate their

production due to a lack of gas, though the contribution of 9131 on total derate hours remains small (0.14%).

Table 6: Percent of Derate and Forced Outage Hours Attributable to Code 9131

Contribution of Cause Code 9131 to Derate and Forced Outage Hours Across all CC and CT Generators that Only Use Nat Gas for their Fuel		
Technology Type	Percentage of Derate Hours (%)	Percentage of Forced Outage Hours (%)
CC	0.14	0.42
CT	0.00	0.84
Using 5 years (May 2019 - April 2024) of PowerGADS data		