Proposed Methodology for determining auction capacity requirements and de-rating factors

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Table of Contents

Table of Figures

Executive summary

The role of the CRM is to efficiently procure capacity in accordance with the designated reliability standard. The calculation of the recommended capacity requirement and de-rating factors applicable to each technology are central to this process. A review of the operation of the current de-rating and capacity requirement methodology [1] has identified several opportunities for improvement of the process. These improvements will more accurately assess the contribution to reliability from each technology.

The following changes to the methodology are proposed:

- Adoption of net-demand modelling instead of capacity credit modelling for variable generation technologies such as wind and solar. This change captures the correlation between variable generation and demand and reflects the increasing role of fluctuation in variable generation as a source of capacity adequacy challenges. Finally, it enables the calculation of marginal de-rating factors for variable generation technologies.
- Removal of the storage scaling factor currently applied to storage technologies. This change enables the calculation of marginal de-rating factors for storage technologies

In both cases, the changes are consistent with the underlying principles of the market [2] but are not explicitly provided for in the current methodology.

In addition we advise the following changes in input data methodology for the de-rating methodology:

- Outage Statistic Averaging Method. Outage statistics are capacity weighted to reflect the contribution of individual units when the market does not have a significant capacity surplus
- DSU Outage Statistic Update. DSU outage statistics are assessed on the basis of their own performance, rather than being assigned the system wide average outage rate.
- Scheduling Uncertainty Adjustment. Scheduled outages occurring during weeks with traditionally low capacity margins are reclassified as forced outages as they are not being optimised as the process assumes.
- Extended de-rating factor modelling. The capacity and storage range over which de-rating factors are calculated has been expanded to provide greater coverage and improved signalling for new investment.

These changes do not require consultation as they are supported by the current methodology and the overall principles of the market [2], but as they interact with the change in proposed methodology we provide details as context.

In terms of capacity requirements, the results obtained in indicative analysis are broadly consistent with both the previous approach and GCS, with the proposed methodology additionally providing improved estimates of the contribution to reliability of each technology class. This consistency ensures that the capacity requirement is appropriate while the improved valuation of the contribution to reliability of each technology, enables the market to procure capacity equivalent to a given reliability standard in a more cost effective manner.

Introduction

This paper outlines the proposed changes to the calculation of capacity auction requirements and de-rating factors for the Capacity Market.

The current methodology is described in SEM-18-030a Appendix A [1]. It originates from a number of published consultations and decisions since the creation of the Capacity Market:

- On the 1st of July 2016, NIAUR and CER issued decisions on proposed modifications to licences held by SONI ltd. and EirGrid Plc. These modifications add responsibility for the Capacity Market Code (CMC) to the suite of obligations that are already placed on us under our TSO licences.
- The SEM Committee Decision Paper SEM-15-103 [2] also tasked the TSOs to develop the analytical methods to calculate the capacity requirement and de-rating factors for the Capacity Market.
- On the 8th December 2016, the SEM Committee published an I-SEM CRM Capacity Requirement and De-rating Methodology Decision Paper SEM-16-082 [3]. SEM-16-082a [4] Appendix 1 of the decision paper was a TSO report on the methodology for the capacity requirement and de-rating factors for all units except for interconnectors.
- On the 13th March 2018, the SEM Committee published a consultation (SEM-18-009a [5]) with proposals for the enduring methodology for storage de-rating factors and the de-rating factor approach to be applied to DSUs that have limited duration for their demand reduction.

SEM-15-103 [2] established principles to guide the development of the methodology. The following are those which are relevant to the proposed changes in methodology:

- Scenarios should be developed to cover the factors driving the need for capacity such as the level of demand and wind patterns
- De-rating factors are to be marginal de-rating factors, reflecting how an increment of capacity will impact the level of capacity required from other capacity providers
- De-rating factors should be based on historical performance factors where this data is a reasonable guide to future performance.
- Capacity Requirements are to be specified in terms of de-rated capacity

The current methodology is based on the existing generation adequacy methodology that is employed by the TSOs to produce the annual Generation Capacity Statement. That methodology was adapted to use multiple demand scenarios and to enable the determination of marginal de-rating factors. The current methodology is implemented using ISAC, a convolution-based modelling tool developed to calculate auction capacity requirements as well as associated de-rating factors.

A review of ISAC implementation identified several opportunities to improve model outputs relative to the principles underpinning the capacity market [2].

There have been several updates to input data preparations, each of which is provided for by the current methodology. These updates are complementary to the proposed changes to the methodology and should be viewed in conjunction with those changes. Due to the impact these changes have on the outputs, we provide explicit information regarding these changes.

The review also identified further opportunities in the form of updates to the methodology for determining auction capacity requirements and de-rating factors (DRF’s).

Collectively, the enhanced input data and proposed changes to the methodology:

- align the provision of capacity adequacy and the measurement of the contribution of different technologies as defined by de-rating factors within the context of an increasingly renewable powered system and the risks and opportunities that provides,
- ensure that the capacity requirement and de-rating methodology includes all the relevant considerations that impact on the extent to which Generator Units contribute to reliability.

We proceed with a description of the proposed changes to the methodology before providing summary analysis of the collective effect of both input data updates and proposed methodological changes.

For reference we also supply a summary of the current methodology in Appendix A.

Proposed Enhancements to Methodology

Net Demand Modelling

Introduction

In the current methodology demand is not offset by variable generation such as wind and solar. Instead, wind and solar generation are incorporated in the model as capacity credits. This creates the following anomalies:

- Peak demand to be serviced by units procured in the capacity market is understated.
- Correlations between variable generation and demand are not preserved
- Variability in demand is underestimated with the implication that the opportunity for marginal units to contribute is mis-characterised, resulting in less accurate estimates of de-rating factors.

The assumption of constant output implies a significantly lower level of variability in the demand that is to be serviced by units procured in the capacity market. As variable generation fluctuates and the installed capacity base of variable generation technologies grows relative to the size of the system, occurrences of low variable generation become a significant factor in determining which periods have low margins, and what level of capacity is required to service adequacy standards.

Figure 1 highlights the higher variability of net-demand relative to gross demand, including periods in which net-demand and gross demand are similar due to low variable generation.

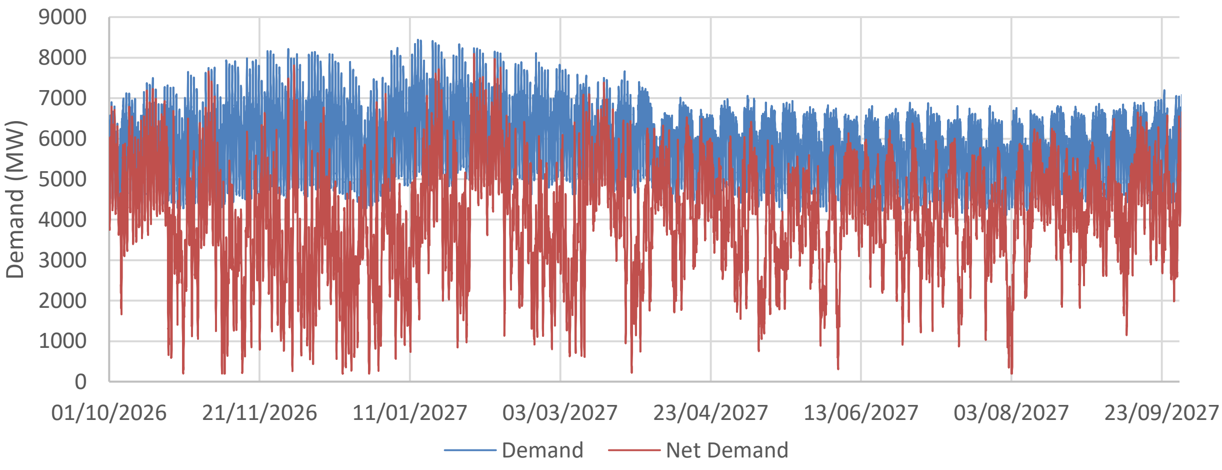


Figure 1. Gross vs Net Demand

Proposed Change to Methodology

The essence of the proposed methodology is as follows:

- Variable generation profiles are to be deducted from demand profiles to form a net demand profile.
- This profile is then used instead of a combination of gross demand and capacity credits to determine auction requirements and de-rating factors.

- De-rating factors for variable generation technologies are calculated at the margin as for other technologies.

The enhanced methodology requires:

- Updates to the construction of wind and solar profiles
- Construction of a net-demand profile
- Enhancements to the RES de-rating factor calculation

Variable Generation Profiles

Two different approaches to the modelling of variable generation are required to implement the net demand model while maintaining other important functionality in the model.

Firstly, due to the nature of ISAC modelling of energy limited units, a small portion of the anticipated capacity must be retained and modelled using a capacity credit approach. In ISAC, units store energy whenever variable generation exceeds system requirements. The capacity required to accurately model the benefit of storage units is dependent on the quantity of storage capacity available but makes up a small portion of installed variable generation capacity. From time to time, this quantity will be re-assessed to ensure the model satisfies the requirement of non-interference with storage replenishment.

Secondly, a set of variable generation forecasts are formed using half hourly, all-island variable generation profiles as the basis. The larger component of the forecast installed capacity is multiplied by the corresponding half hourly variable generation profile to produce a variable generation value in MWs for each half hour period of the year. Forecast scenarios are then combined to create an variable generation forecast for each historical year.

Net Demand Profiles:

A set of net demand scenarios is then formed for each demand level and historic year being modelled by subtracting the variable generation forecast from each corresponding demand scenario. These profiles substitute for the traditional demand profiles.

De-rating factors for Variable Generation Technologies:

A set of marginal variable generation profiles are created for each historical year by combining incremental capacity with the corresponding profile. To bound the marginal de-rating factor so that it is applicable to installations currently observed in the system, the incremental capacity level chosen is approximately equal to the largest existing wind/solar unit. The methodology for calculating the marginal de-rating factor matches the current methodology, except the contribution to adequacy of only the incremental variable generation capacity is calculated, rather than the contribution to adequacy of the total anticipated variable generation capacity. The marginal de-rating factor is equal to the contribution of the marginal capacity divided by that marginal capacity.

Commentary

The proposed approach is well aligned with several aspects of the current process. In describing the method of creating the demand scenario, the process refers to the creation of demand forecasts for use in the analysis [1].

> *"Each demand scenario comprises a distinct set of half-hourly demand values for a year reflecting the pattern of demand profile used, with a peak demand and total annual energy requirement from the demand forecast."*

The requirement goes further, to deduct non-market generation from the profile. This approach endorses the use of a net demand profile to address units that are considered unlikely to participate in the market. The proposed change represents an extension of that philosophy, from making allowance for units whose generation is outside the market, to making allowance for units whose generation is generally not responsive to the market.

The methodology also recognises the correlation between weather and demand, and describes the application of a wind profile to a demand scenario:

> *"Wind generator output is correlated to weather conditions and hence to demand. To account for this, the wind profile and demand profile applied to a given demand scenario are both based on the same historical year in the subsequent analysis described below."*

The proposed approach extends this recognition of correlation to a per-period basis as it creates a profile of demand less the forecast variable generation profile for each of the demand scenarios.

Adopting the net-demand approach provides for calculation of marginal de-rating factors for variable generation technologies. The determination of wind and solar de-rating factors presently relies on the determination of the capacity credit for each. Specifically, with respect to DRF calculation, we note the following requirement, expressed in terms of wind but equally applicable to solar:

> *"The wind de-rating factors for each demand scenario are calculated in a first pass using capacity adequate portfolios that do not contain wind. Then the de-rated capacity of wind is fixed in the portfolios for the second pass where all other de-rating factors and scenario capacity requirements are calculated."*

Whereas other technologies have de-rating factors assessed in a marginal fashion, the assessment for wind and solar is currently based on their average contribution, as we do not consider the addition or subtraction of a marginal unit from an adequate portfolio. Instead, the consideration is of the value of all capacity at once. This is not consistent with the over-riding design principle requiring de-rating factors measure the marginal contribution to capacity [1]. The updated methodology aligns the de-rating factor methodology for wind and solar units to that of other technologies.

Both the recognition of the correlation between wind and solar with demand, and the introduction of marginal de-rating factors improve the alignment of the methodology with the principles underpinning the market [2].

As shown in Figure 1, the net demand profile will have different maximum and minimum demand values. This has a significant impact on the shape of the demand profile. The net-demand approach pre-emptively deducts the majority of this capacity when the net demand profile is formed, and in doing so necessitates a similar deduction in non-participating capacity. In the current approach, the deduction for non-participating technology is comprised almost entirely of variable generation capacity. Based on indicative analysis, there is no significant change in the capacity requirement although this result is data dependent.

The net demand profile also provides different opportunities for storage and non-storage units to contribute at the margin. If modelling demand according to the current methodology, the de-rating factor determination suffers from not representing the opportunities available for marginal units. De-rating factors reflect the marginal contribution of a generation technology of a particular capacity and, if a storage unit, storage capacity. Significant renewable generation creates more variability and provides additional opportunities for marginal units to contribute to adequacy. Fluctuations in variable generation generate a more realistic representation of the actual opportunities for units to contribute. This is particularly true for storage units. Figure 2 focuses on the discrepancy between gross and net forecast demand during 16:00 – 20:00 for each day of the capacity market year. These are the periods where we expect storage technologies to be expending their limited energy. On a standalone basis, it is expected that this will increase the de-rating factor for energy limited technologies.

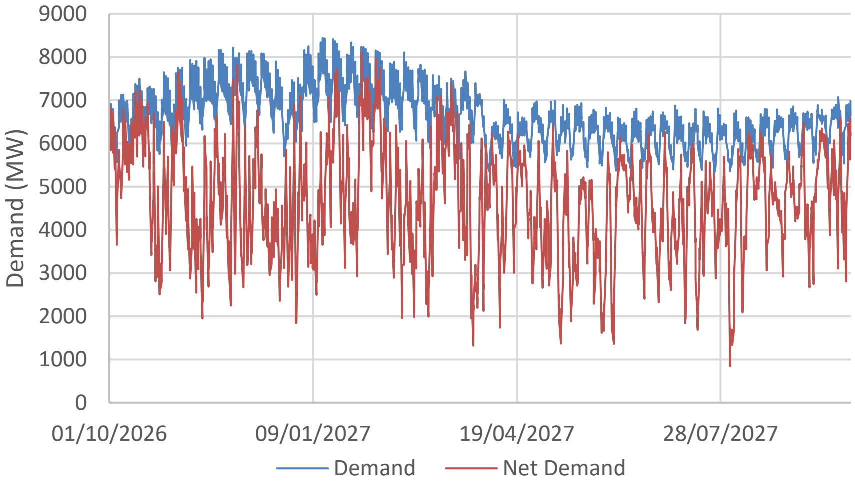
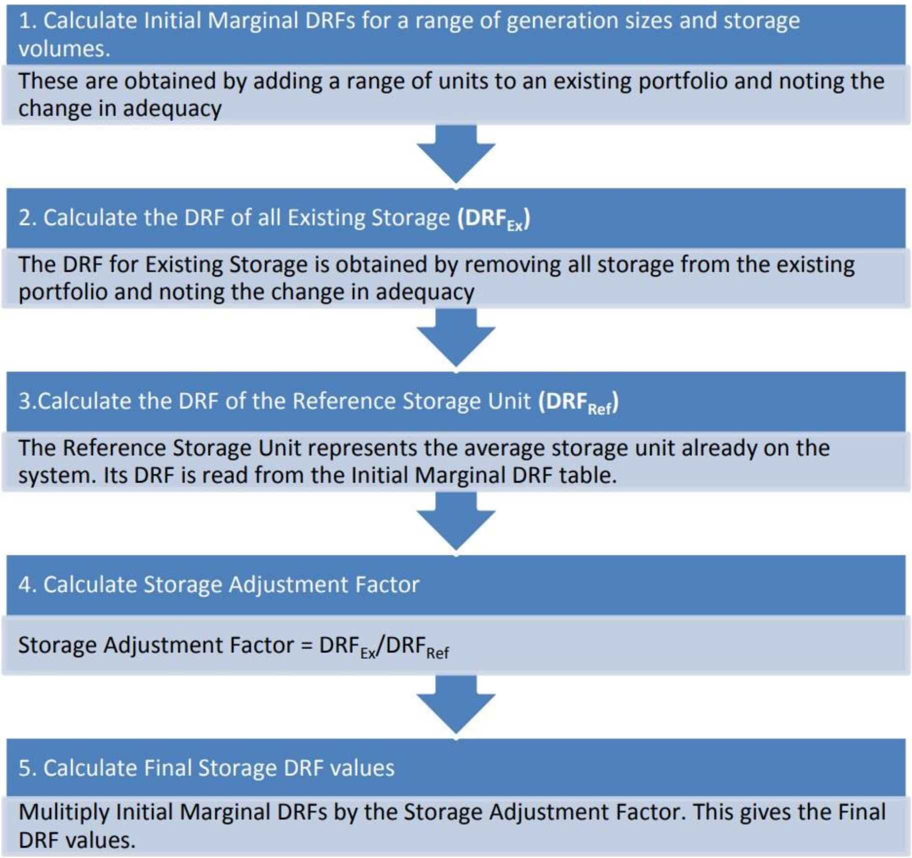


Figure 2. Gross vs Net Demand during peak gross demand periods

Storage Scaling Factor

Introduction

The current process for determining storage de-rating factors is outlined in Figure 3.



1. Calculate Initial Marginal DRFs for a range of generation sizes and storage volumes.

These are obtained by adding a range of units to an existing portfolio and noting the change in adequacy

2. Calculate the DRF of all Existing Storage **(DRF_{Ex})**

The DRF for Existing Storage is obtained by removing all storage from the existing portfolio and noting the change in adequacy

3.Calculate the DRF of the Reference Storage Unit **(DRF_{Ref})**

The Reference Storage Unit represents the average storage unit already on the system. Its DRF is read from the Initial Marginal DRF table.

4. Calculate Storage Adjustment Factor

Storage Adjustment Factor = DRF_{Ex}/DRF_{Ref}

5. Calculate Final Storage DRF values

Mulitiply Initial Marginal DRFs by the Storage Adjustment Factor. This gives the Final DRF values.

Figure 3. Storage de-rating factor calculation methodology

Whereas the contribution to capacity adequacy by other technologies is assessed according to their marginal contribution to capacity adequacy, the current methodology provides for adjustment of the raw de-rating factor for storage technologies by a storage adjustment factor, equal to the ratio of the reference storage unit's de-rating factor when evaluated as a deduction, to the same when evaluated as an addition at the margin [1]:

> *"The de-rating curve for storage units for the first transitional auction will be based on a reference de-rating factor derived from existing storage capacity and a set of storage-duration curves. These curves will be determined by analysing the additional demand which can be served by storage units of a range of MW sizes and reservoir capacities. The reference de-rating factor used for new storage technologies (i.e. other than pumped storage) will use the outage characteristics of the System-wide Technology Class;"*

Proposed Approach

The storage scaling factor will no longer be applied in future auctions.

Commentary

The current approach to calculating storage de-rating factors represents a departure from the marginal analysis approach [6].

The use of the Storage Adjustment Factor means that the resulting de-rating factors are much closer to an average de-rating factor rather a marginal one. It has already been described how the currently used storage de-rating factors overestimate the benefit of new storage to capacity adequacy. Due to the large amount of storage capacity connecting to the system, this approach (which applies the Storage Adjustment Factor) is no longer appropriate if we are to bring the resulting de-rating factors closer to the 'marginal' de-rating principle. A similar opinion was expressed in [7], where it was noted consideration should be given to:

> *"… moving to a more 'marginal' approach for de-rating factors for energy limited storage. This means keeping the initial de-rating factors without scaling up with the storage adjustment factor".*

The effect is to misstate the marginal contribution of storage technologies to capacity adequacy. For each technology class, the average contribution to adequacy is typically greater than the marginal contribution to adequacy, so that the adjustment tends to scale the de-rating factor higher, overstating the marginal contribution of storage technologies relative to other technologies and thereby over-stating the relative value of storage based units in the auction through higher de-rating factors. When the awarded units are eventually commissioned, they may not provide the expected relief, either in absolute or opportunity cost terms, having been selected over other technologies.

The removal of the storage scaling factor aligns the methodology with the principle of marginal de-rating [2].

Input Data Enhancement

Outage Statistic Averaging Method

Introduction

At the inception of the market, several methodologies were assessed for calculating average availability statistics for the technology classes. These included a simple average, a capacity weighted average, an output weighted average and a run-hour weighted average. For initial auctions, a run-hour weighting methodology was selected as giving greater weighting to the more frequently running units was considered to give a good trade-off between the various issues considered and has the advantage of reducing the contribution of units that had high availability but were run infrequently, limiting the impact these have on the class weighting.

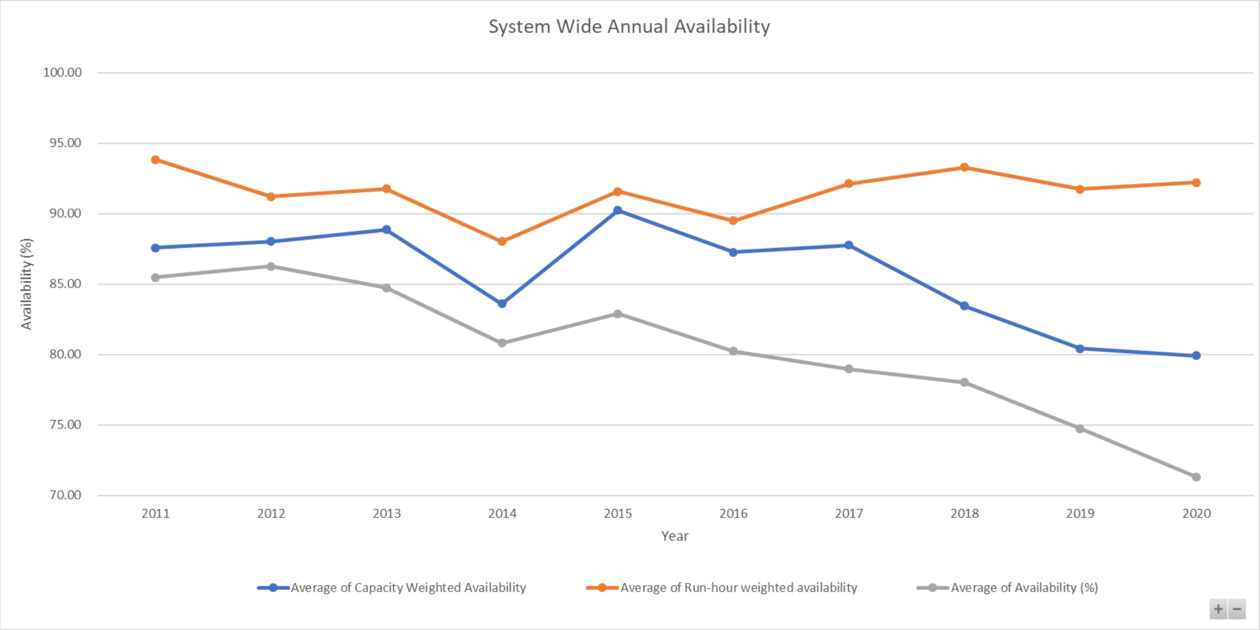


Figure 4. System wide availability under different weightings

While the run-hour weighting approach may provide a good estimate of overall outage rates throughout the year, the capacity adequacy process is primarily driven by those half hour periods which exhibit system stress.

As capacity becomes tighter, units with lower run hours will be required to run longer, moving the average towards a capacity weighted average. This is even more the case when we consider the limiting examples that we are primarily interested in. These are periods of greater system stress; at which time the reliability of the whole system stack is a more accurate determinant of performance. At such times it is reasonable to assume that a large portion of units will be likely to operate and will therefore contribute to reliability, in proportion to their MW capacity rather than their annual run hours.

Enhanced Approach

Due to run-hour weighted availability statistics not adequately capturing outage rates, a capacity weighted technology class average has been adopted.

The average capacity weighted forced outage rate is calculated for each technology class using:

$$\frac{\sum_{unit} \sum_{year} (Capacity)_{unit} \times (Average\ Forced\ Outage\ Rate)_{unit}}{\sum_{unit} \sum_{year} (Capacity)_{unit}}$$

where "unit" denotes the capacity market units in that technology class and "year" denotes each of the years of capacity market unit data used.

The capacity weighted system-wide forced outage rate is calculated using the same process as above by using a system-wide class that includes all units.

A similar approach is used to calculate the capacity weighted scheduled outage rates.

No change is proposed for ambient outage rates. These are profiled weekly across the year for the gas turbine units, reflecting the relationship between generator efficiency and temperature.

Commentary

Currently, outage statistics are calculated using run-hour weighted averages. Availability data is sourced on a per-technology basis, generally over a five-year period, and averaged within each technology class according, with weightings in proportion to the run hours of each unit considered.

The current methodology [1] sets out the basic requirement for outage statistics below:

> *"… monthly averages are converted to a percentage capacity reduction and are averaged over 12 calendar months to give an average annual percentage capacity reduction due to each of forced outage, scheduled outage and ambient outage for each unit and for each of the years of historical data considered."*

The current methodology also acknowledges the approach to calculating the average outage rates will need to adapt to reflect the performance of the system, and provides for change, particularly if the capacity situation is tighter, which it demonstrably is:

> *"If the capacity situation becomes tighter, then these units will likely be required to run more, and this could increase their forced outage rates. This in turn would imply a higher de-rated capacity requirement. While it is considered that the run-hour weighting approach is most suitable for the current system, the approach to calculating will need to adapt to best reflect the performance characteristics of the system."*

Using capacity weighted outage rate over run hour weighted provides a more accurate estimate of outage probability in that technology class, particularly in accounting for the current downward trend in availability.

As a standalone measure for a single technology, the change in outage statistics averaging methodology is expected to increase auction capacity requirements while decreasing de-rating factors. As noted in [7], the movement of de-rating factors is complicated by relative movements that impact the opportunity available to particular technologies. This is particularly the case for energy limited technologies with a limited range of operating hours throughout the day.

While the methodology recommends the use of historical performance data in determining de-rating factors, there is flexibility to consider other evidence where there is sufficient evidence to satisfy the SEM Committee that the past is not representative of the future [1].

At present, the adoption of this approach has mostly addressed a significant concern in the current modelling regime; that outage averaging over five years does not capture the significant downward trend in these metrics. Depending on the future trend exhibited in outage statistics, consideration of outage statistic trends may be appropriate to reflect more realistic de-rating factors.

DSU Outage Statistics

Introduction

DSU availability has traditionally been modelled using system wide statistics. The difference shown in Figure 5, is statistically significant. Availability statistics for DSUs, run hour limited DSUs and system wide are shown in Figure 5. Given that DSU availability and the demand sites that compose them are impacted by a range of factors, including the market arrangements in place at the time, it was not clear whether the outage statistics pre-Oct 2018 were fully representative of the capability of DSUs to contribute to reliability under the new SEM arrangements. On this basis, it was considered reasonable that system wide availability statistics be applied to DSUs in the determination of their de-rating factors and that a Decremental Tolerance be applied in the qualification process to allow DSU operators to nominate the level of reliability that they could deliver. As we now have five years of outage statistics under the new arrangements, it is appropriate to review this approach. This is provided for under the current methodology.

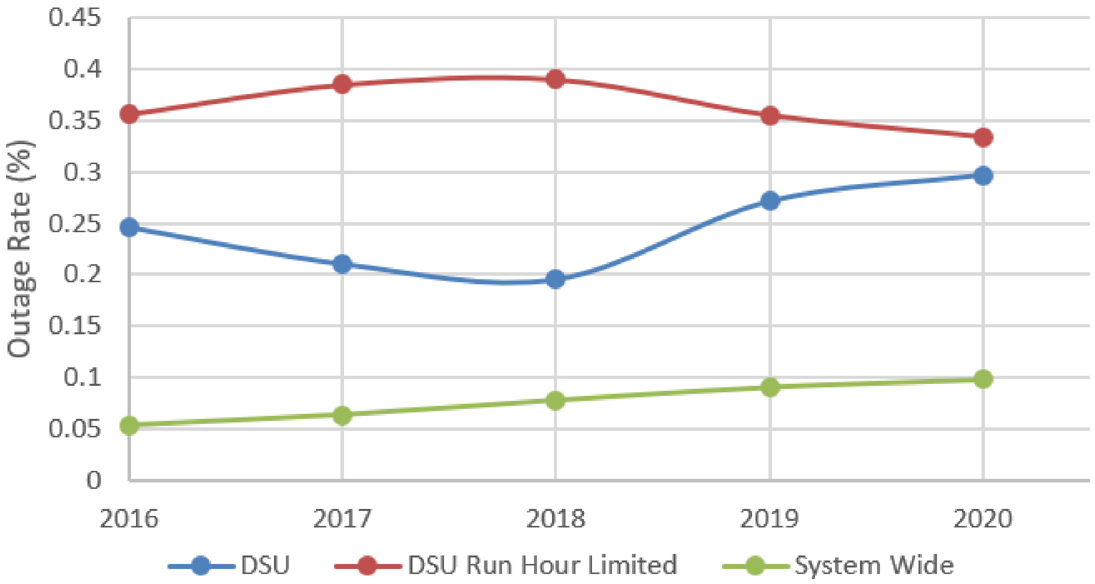


*Figure 5. Illustrative DSU vs system wide declared forced outage rates**

**Note: The above outage rates have been used to test the methodology and may not be representative of the final DSU availability statistics used for each auction.*

Enhanced Approach

Due to the increasing number of demand-side units (DSUs) and run hour limited DSUs on the system, and that there is a now five years of outage statistics under the new SEM arrangements available, the TSOs consider that the availability statistics of DSUs are representative of DSUs' contribution to reliability. On this basis, DSUs are no longer assigned system-wide outage statistics.

Commentary

The current methodology [1] describes the approach to be taken when assigning outage statistics to new technology classes or technology classes which lack sufficient historical data to accurately form a view of their availability.

> *"For the initial auctions, DSUs and potential new storage units (that are not pumped hydro units) will be treated as new technology and assigned the system-wide outage statistics. In addition, where they are duration limited this will also be taken into account. These unit types will eventually form their own categories once their availability data is deemed to be representative of their operation in the SEM under the I-SEM design."*

This change aligns the treatment of DSUs with other technology classes as envisaged by the above statement from the methodology.

The use of higher historical outage rates creates two opposing effects when determining the de-rating factor for DSUs. Like all other technology types, the first order effect is that lower reliability implies a lower de-rating factor. However, the decreased reliability of DSUs does increase the opportunity available to these units when evaluated at the margin of an adequate portfolio.

Scheduling Uncertainty

Introduction

Given that scheduled outage programmes are not available four years in advance, ISAC determines a scheduled outage programme based on an optimization of scheduled outage statistics for each unit. This tends to result in a Generation Outage Programme that is not representative as it tends to avoid scheduling outages during winter months. In practice we do not have control over when generators choose to schedule outages and they can occur over winter months. Therefore, some outages are scheduled during winter months, which necessarily overlap with times of peak demand and system stress. This can be seen in Figure 6, which shows scheduled outages for 2021 and includes scheduled outages that have occurred at times of low system margin.

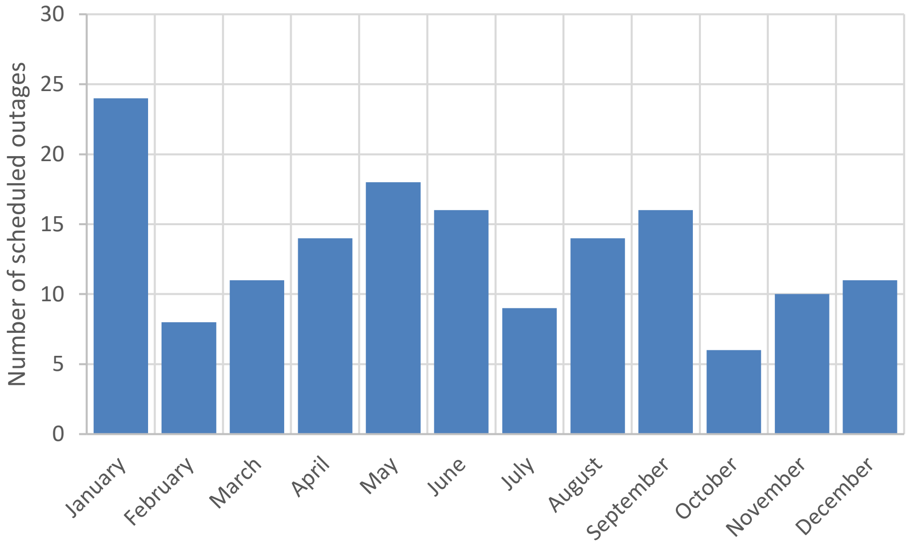


Figure 6. 2021 Scheduled Outage Distribution

Enhanced Approach

Scheduled outages whose timing is not able to be optimised to suit system requirements are to be treated as forced outages. In practice this means that the portion of scheduled outages that do occur at times of high system stress will no longer be considered ‘scheduled’ and will not be positioned optimally as part of the ISAC algorithm. The Transmission Outage Season, which runs from the last Monday in February to the last Friday in November, is used as a proxy for whether outages can be considered schedulable, and any generator outage that falls outside of the Transmission Outage Season is to be designated as an unscheduled outage.

To assist definition of that portion of outages which are not schedulable, a ‘scheduling uncertainty adjustment’ is introduced. The adjustment is defined as the capacity weighted percentage of all generation scheduled outage duration that occurs outside of the transmission outage season and is calculated over a five-year period. This adjustment is applied directly to the outage statistics used in the Capacity Requirement and de-rating factor calculation and does not require a post modelling adjustment.

The proportion of outages unable to be scheduled optimally is then added to the FOR and subtracted from the SOR for all of the previous calculations.

The new adjusted scheduled outage rate (adjusted SOR) and adjusted forced outage rate (adjusted FOR) is:

$$Adjusted\ SOR = SOR * (1 - Scheduling\ uncertainty\ adjustment)$$

$$Adjusted\ FOR = FOR + SOR - Floor(52 * Adjusted\ SOR, 1)/52$$

Commentary

In principle, outages whose timing is not controllable relative to actual peaks in demand, share more in common with forced outages that occur suddenly than scheduled outages occurring in summer.

The methodology defines the approach to scheduling outages in the capacity market process.

> *“The Adequacy Calculator schedules each outage at the time of the greatest surplus of available generation over demand given the outages already scheduled (i.e. maximises the minimum margin for each outage)”*

ISAC is faithful to this approach, scheduling outages based on the maintenance of the maximum margin between peak demand and available capacity. The methodology then describes the required positioning of scheduled outages relative to peak demand:

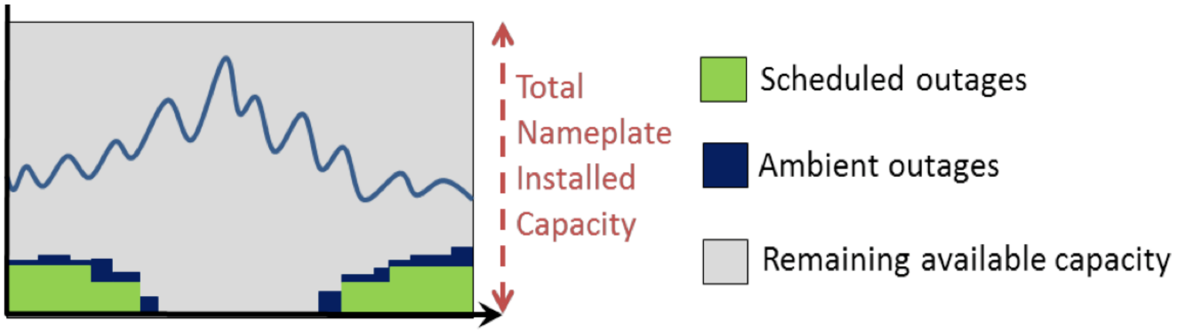


Figure 7. Outage scheduling methodology

Both Figure 7 and the current methodology [1] implicitly require that outages be schedulable and be schedulable away from times of peak demand. It is therefore inappropriate to account for outages that are not schedulable away from peak times using this characterization.

The effect of this updated approach is lower scheduled outage rates and increased forced outage rates. The effect of lower scheduled outage rates is muted as the system can accommodate these outages at times of lower system stress. The effect on increased forced outage rates is the same as identified in the commentary surround the updated averaging method. That is, we expect a first order decrease in DRF's, while acknowledging second order effects arise as all technology classes are subject to the effects of this change.

Extended De-Rating Factor Modelling

Introduction

The current de-rating factor process truncates the de-rating factors awarded. De-rating factors are only provided for a limited range of:

- Capacity levels
- Storage levels

As de-rating factors are supplied in advance of auction qualification, they should reasonably cover all possible applications so that de-rating factors are not undefined, or defined according to the limiting value published, which may be inappropriate given the non-linear structure of de-rating factors. While investors in units of significant size may be likely to notify their intention, it is preferable that this not require further adjustment to the de-rating process to accommodate larger sized units.

With respect to storage, de-rating factors are only calculated for energy limited units with up to six hours storage reducing the incentive to invest in configurations with higher storage.

Proposed Approach

The range of capacity levels will be considered will be doubled. Capacity will not be modelled with the same granularity across the entire range of capacity values. At higher levels of capacity, greater reliance will be placed on interpolation, noting that at higher levels of capacity, the de-rating curves are much closer to linear.

For storage technologies, a similar approach will be implemented. The range of storage capacity will be extended to 10 hours. Storage capacity will also not be modelled with same granularity with greater reliance placed on the interpolation process discussed in the previous section.

Commentary

The methodology for the calculation of the capacity requirement and de-rating factors [1] states that "The notional unit will have the outage statistics of one of the technology categories and will be of a specific MW capacity" without specifying the step size to be used and the recent consultation [7] requested that EirGrid increase the maximum capacity that de-rating factors are calculated to due to the potential addition of the Celtic Interconnector to the system. The extended de-rating table will provide de-rating factors up to 800MW.

The methodology [1] also requires storage results to be calculated for 30-minute intervals and states that “linear interpolation applies for durations between 30-minute intervals”. The proposed methodology will maintain this feature while extending the maximum reservoir size and capacity.

Indicative Analysis

The following analysis provides a summary of indicative differences arising from adjustment of input data preparation and the adoption of the proposed methodology.

DRF Analysis

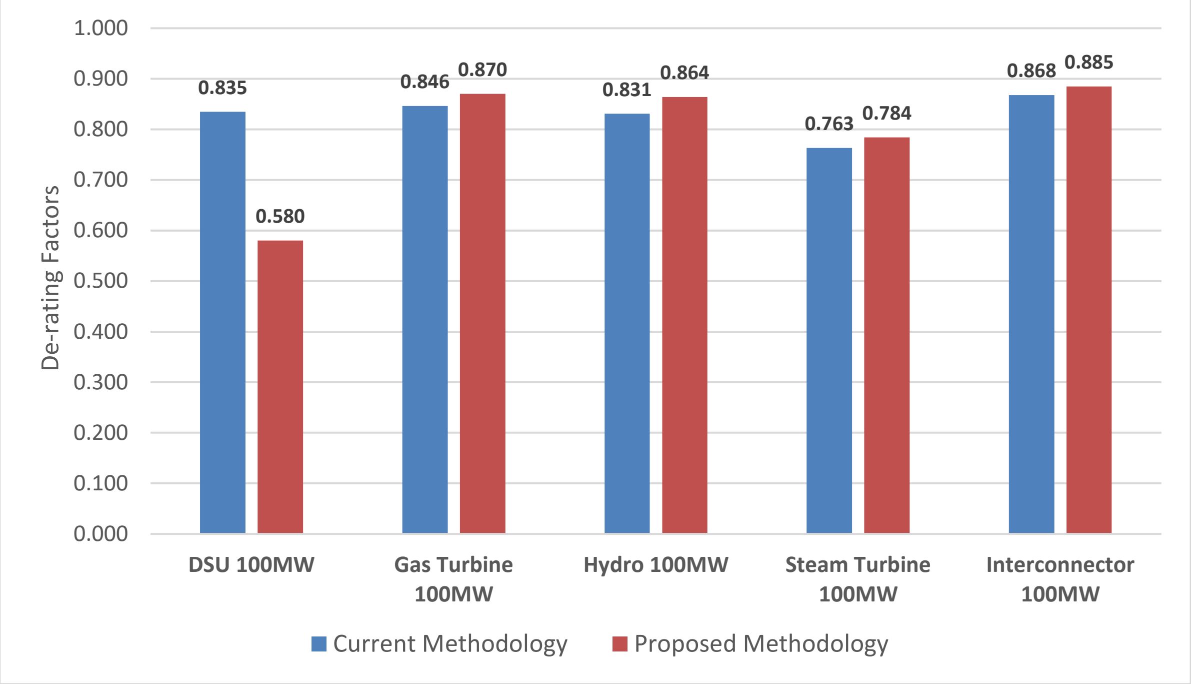


Figure 8. De-rating factors for non-storage technology classes

Figure 8 indicates that by applying the proposed methodology, de-rating factors for non-storage technology units produced by ISAC are higher than the current methodology except for the de-rating factors for unlimited DSUs, which are capable of operating 24-hours per day, and are modelled as generators in the ISAC framework. DSU de-rating factors have fallen significantly due to the adoption of actual outage statistics, rather than assuming system-wide averages.

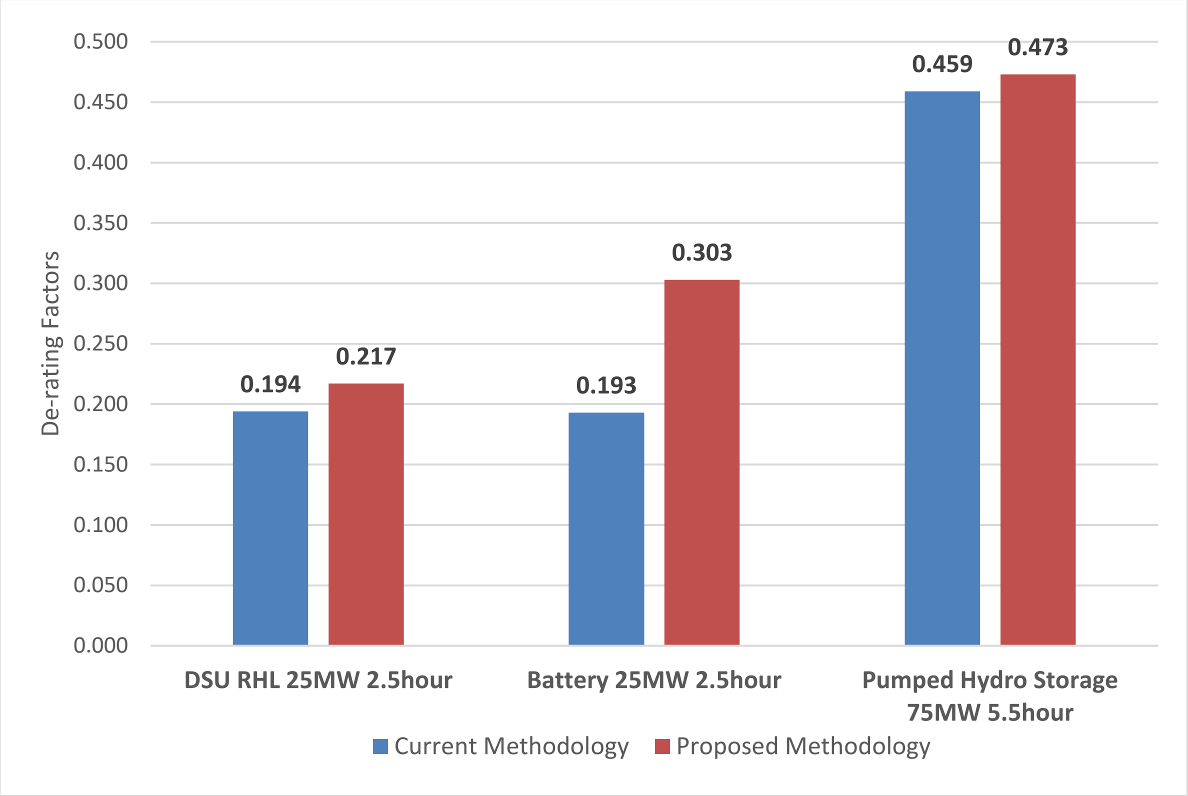


Figure 9. De-rating factors for storage technology classes

Figure 9 shows that the de-rating factors for representative examples of each storage technology classes in the proposed methodology are higher than that in the current methodology. There are two underlying factors driving these results.

Firstly, net demand modelling, which leads to more variability in the demand profile faced, provides greater opportunities for storage units to contribute to system adequacy. This effect increases all de-rating factors but especially storage classes. Counteracting that effect to some degree or another, each type of storage technology has higher outage statistics.

This effect can be decomposed further. The outage statistics of the marginal unit are negatively correlated to the de-rating factor of the unit. However, the impact of higher outage statistics on existing units providing a similar generation benefits marginal de-rating factors. In effect, this reverses some of the observed “cannibalization” process that arises whenever additional capacity with a similar generation profile to existing units is added. All three technologies shown are modelled using the same paradigm in ISAC. The effect of the change is a function of changes in outage statistics for the specific technology relative to other members of the group and the degree to which the generation profiles of each are correlated. In this example, Battery storage, while also being assessed as less reliable, contribute more to reliability than DSU units. In the case of Pumped Hydro Storage, the jump is more muted because the unit considered has 5.5 hours of storage and operates across a wider range of hours so that its performance is less correlated with existing storage technologies.

Auction Requirement

Table 1 summarises the raw ISAC output from a sample model using each approach.

	Current Methodology	**Proposed Methodology**
Least-Worst Regrets Scenario Demand Level:	DL8	DL8
Registered Rated Capacity (MW)	9316	8926
Wind De-rating Factor	0.079	0.058
Solar De-rating Factor	0.179	0.131

Table 1. Results comparison between current and proposed methodologies

These summary results show:

- The Least-worst Regrets demand scenario is the same for both methodologies. This is not guaranteed. It is possible that, in response to the more variable net-demand profile which implies a peakier profile, the proposed methodology may select a more conservative demand level to base requirements on.
- Both wind and solar de-rating factors are lower as a result of the marginal de-rating approach used to define these. The current methodology calculates an average de-rating factor.
- Registered rated capacity requirements are lower with the proposed methodology. This is primarily because the proposed methodology is servicing a net demand profile where wind and solar generation is deducted, compared to the current methodology where the capacity requirement includes wind and solar capacity credits in the portfolio.
- For the avoidance of doubt, we expect both methodologies would identify consistent de-rated capacity requirements once all TSO calculations are complete considering operational and security requirements.

Appendix A: Current Methodology

The existing methodology for defining the marginal de-rating factors is described in I-SEM CRM T-1 CY2019/20 Capacity Auction Parameters and Enduring De-rating Methodology Decision (SEM-18-030) [6] and in Appendix A TSO Capacity Requirement and De-rating Factors Methodology, June 2018 (SEM 18-030a) [1] .

The methodology is based on a multi-scenario adequacy analysis comprising the following steps:

- develop a set of possible demand futures for a given future year, which will differ in terms of total annual energy and peak demand as well as half hourly profiling within the year,
- using convolution, develop a collection of different 'adequate' generation portfolios, which achieve the LOLE adequate standard,
- estimate the de-rating factor from the addition of a 'marginal' notional unit added to an already adequate generation portfolio – various notional units are tested for different technologies and sizes,
- perform the "least-worst" regrets analysis to choose the demand scenario with the lowest maximum total regret,
- average de-rated capacity requirements over that demand scenario to form an indicative capacity requirement, and
- produce output comprising marginal de-rating curves for storage and non-storage technologies, along with an indicative capacity requirement.

Demand scenarios

Demand scenarios are constructed by combining annual demand forecasts (total annual energy and peak) and demand profiles.

Annual demand forecasts are formed from low and high forecasts contained in the latest All-Island Generation Capacity Statement [8] (GCS). These define the lower and upper bounds of the demand forecast. These extreme levels are complemented by creating eight intermediate decile demand levels, resulting in a total of ten annual demand forecasts.

Half-hourly demand profiles are based on historical All-Island demand profiles. Each half hourly profile is applied to each of the 10 demand levels, providing a wide range of demand scenarios, each comprising a level with one of the many demand shapes.

Demand is also adjusted to account for non-market (de minimis) generation capacity. This generation is assumed not to participate in the energy market but nevertheless does generate and effectively reduce the level of demand required to be serviced by other capacity. The level of non-market generation is in line with the non-market generation assumed in the GCS [8].

Generation portfolios

Each portfolio is initialised with the generation units included in Appendix 3 of the GCS [8].

Forced outage statistics are calculated using run-hour weighted averages. Availability data is sourced on a per-technology basis, generally over a five-year period. For each technology class, a weighted average of availability is calculated using weightings in proportion to the run hours of each unit considered. EDIL data is relied upon for determining availability, while run hours are determined by inspection of the SEM settlement database.

The average run-hour weighted forced outage rate is calculated for each technology class as follows:

$$\frac{\sum_{unit}\sum_{year}(Annual\ run\ hours)_{unit} \times (Average\ Forced\ Outage\ Rate)_{unit}}{\sum_{unit}\sum_{year}(Annual\ run\ hours)_{unit}}$$

where “unit” denotes the capacity market units in that technology class and “year” denotes each of the years of capacity market unit data used.

For technology classes that do not have sufficient availability data to reliably estimate outage rates, system wide outage rates are used. DSUs and run hour limited DSUs are currently assigned system wide outage statistics. The system-wide run-hour weighting is calculated using the same process as above by using a system-wide class that includes all units.

In addition to forced outages, scheduled outages and ambient outages are also considered.

Scheduled outages are those outages, such as for maintenance, that are planned and assumed to be taken at times that are maximally convenient for the operation of the system. The proportion of time spent in scheduled outages is converted into weeks for application in ISAC.

Ambient outages are profiled across the year for the gas turbine units. These ambient outages are mainly temperature related and are minimal during the winter peak. ISAC applies ambient outages in months where they historically occur. These reduce the capacity available from individual generating units.

A similar run-hour weighted approach is used to calculate the averages for scheduled and ambient outages.

Capacity Adequate Portfolios

The methodology requires creation of random generation portfolios from a set of candidate generators. This process acknowledges that there may be several different pathways in which the market may evolve. AdCal, an ‘adequacy calculator’ is used to assess whether a given portfolio satisfies the prescribed LoLE adequacy standard.

The Adequacy Calculator performs the following steps in determining the adequacy or otherwise of the portfolio:

- Applies any reduction in available capacity as a result of ambient effects across the months/periods based on historical evidence,
- Schedules maintenance (scheduled outages) for the different generating units over the periods with the highest surplus (though scheduled outages are continuous blocks); and
- Determines the loss of load probability in each half-hour given the forced outage rates for the different technologies that are not on scheduled maintenance. It does so by convolving the

reliability functions of all individual units in the portfolio to form a probability density function for LOL which can then be combined over all half hours to generate an expected LOL, or LOLE.

Given the output of the adequacy calculator, the portfolio is adjusted to ensure that it is adequate. Units are added and removed from these portfolios until they meet the LoLE adequacy standard for the relevant demand scenario. For example, if the set of existing generators does meet the adequacy requirement, then additional notional capacity is added to the portfolio and adequacy is rechecked. The process continues until the portfolio attains the adequacy standard.

The additional notional capacity is chosen at random from a set of hypothetical units of varying technology classes, each with the same assumed properties as existing units of the same type. By choosing from a variety of unit sizes, the aggregate pool of units has similar expected availability as the existing generators.

A number of these capacity adequate portfolios (CAPs) are created for each demand scenario to ensure a variety of possible market evolutions are sampled

Variable Generation

Capacity and Generation Forecasts

Wind and solar generation forecasts are constructed based on multiplying the forecast installed wind and solar capacity and their corresponding half hourly generation profiles for each of the relevant historic years.

The forecast installed wind and solar capacity data used in setting the Capacity Market capacity requirement and in determining de-rating factors is sourced from EirGrid and SONI's current GCS or equivalent document.

Installed wind and solar capacities are based on forecast in the current GCS. They are used to create wind and solar profiles and then to calculate wind and solar credits, which are included in generation portfolio during the calculation of marginal de-rating factors. The non-market wind capacity for IE is derived from the ratio of small scale wind to total wind. For NI, non-market wind capacity is sourced directly from the GCS. Both IE and NI non-market wind capacity is deducted from demand profile during the calculation of marginal de-rating factors.

Capacity Credits and De-rating Factors

Based on a set of adequate portfolios that do not include variable generation, the capacity credit and de-rating factors for variable generation technologies are calculated. For each demand scenario and for each technology, the total capacity is added to an adequate portfolio and the capacity credit calculated.

The capacity credit and the de-rating factor, which is found by dividing the capacity credit by the amount of the incremental capacity, are only applicable to the demand scenario used in their calculation. Once determined, the de-rated capacity of each variable generation technology is fixed in the corresponding portfolio before the second pass in which other de-rating factors and scenario capacity requirements are calculated.

The published de-rating factor relies on the final choice of demand level later in the process. It is the average of the de-rating factors from all demand scenarios featuring the chosen demand level.

Multi-Scenario Adequacy Analysis

The capacity market process is based on the analysis of multiple scenarios. Demand scenarios combine demand levels and profiles. For each of these combinations, the process also models many portfolios. These portfolios reflect a sampling of the many possible ways the system might evolve as capacity is added and removed.

For each demand scenario, a portfolio is formed with existing capacity and the wind and solar capacity credits corresponding to the demand scenario. These portfolios are then made adequate using the approach detailed above, and form the basis for the rest of the analysis.

De-rating factors for Non-Storage Technologies

Given a set of adequate portfolios, marginal de-rating factors are determined for non-storage technologies across a range of capacity sizes. The following schematic shows the process for estimating the de-rating factors.

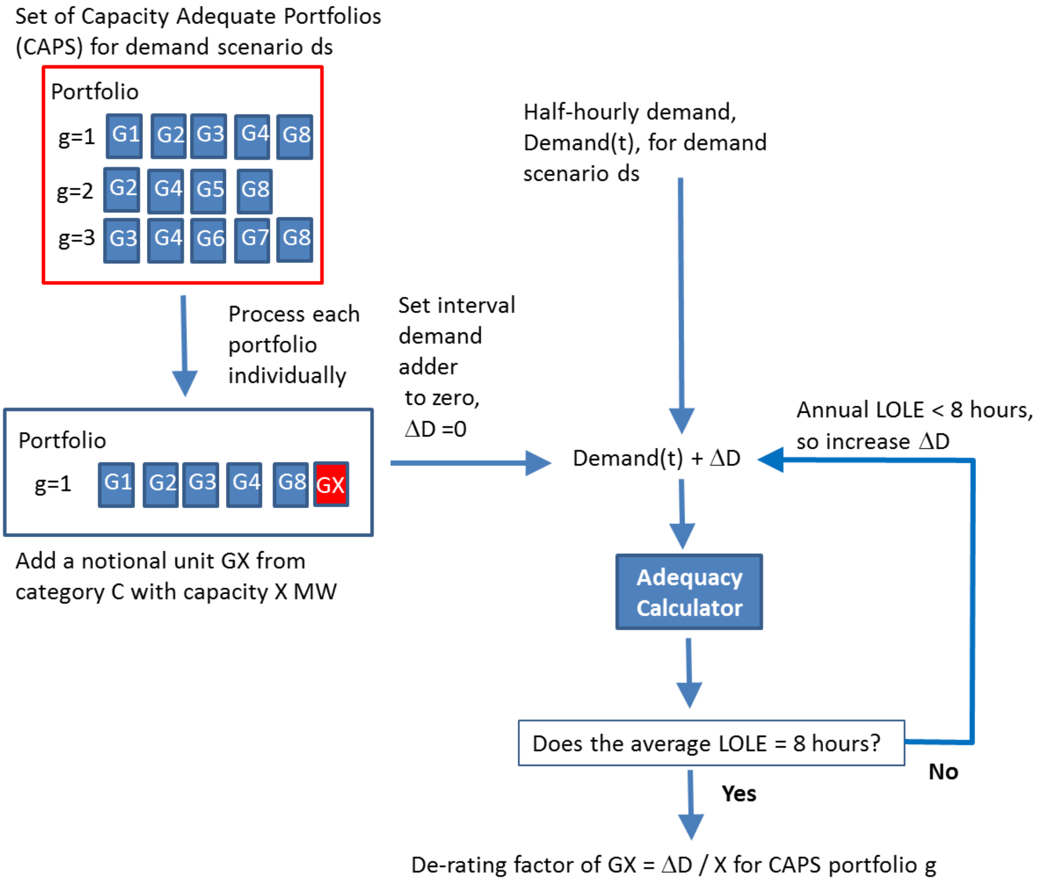


Figure 10. De-rating factor calculation schematic

For a given unit size, the marginal de-rating factor for a given technology is defined as the ratio of the change in demand required to maintain the adequacy standard and the capacity of the unit added. Collectively the de-rating factors for a particular technology define a de-rating factor curve as show in Figure 11.

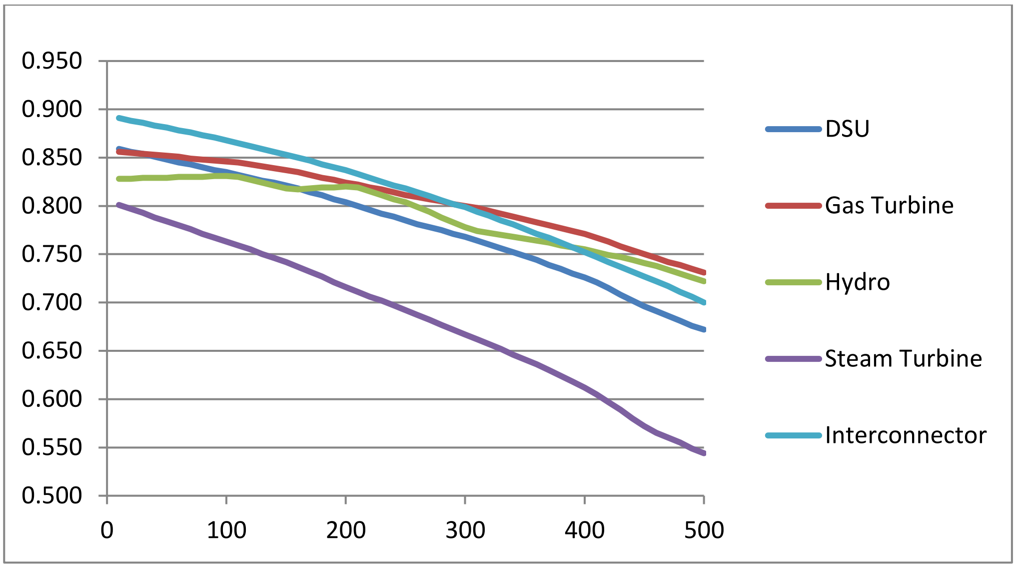


Figure 11. De-rating factor curves

These de-rating factors are then applied to the set of capacity adequate portfolios to define the capacity requirement.

Initial Storage De-rating factors

De-rating factors for storage units are also calculated within the above step. This is done for existing storage units at their size in the initial portfolio to facilitate de-rating of all portfolios.

Choosing a demand scenario

The process considers a variety of demand levels between the maximum and the minimum forecast. For the purposes of defining a capacity requirement it is necessary to choose a demand level to which the capacity requirement can be calibrated.

If the de-rated capacity requirement for the lowest demand scenario is implemented then the capacity adequate portfolios associated with it may fall significantly short of meeting the LOLE adequacy standard in the event the highest demand scenario actually occurs. This could result in load shedding at times when there is inadequate capacity to serve the higher than expected demand. The cost of each unit of shortage is assessed to be the VoLL. The market will not have overspent procuring capacity but energy shortage cost will be high.

Conversely, if the de-rated capacity requirement for the highest demand scenario is implemented then the capacity adequate portfolios associated with it may significantly exceed the LOLE adequacy standard if the lowest demand scenario actually occurs. The market would have paid for excess capacity which it does not require. The cost of the excess capacity is assessed at Net CoNE. The market will have avoided high energy shortage costs but the cost of additional capacity will be high.

A Least-Worst Regrets approach is used to find a de-rated capacity requirement that seeks to minimise the combined cost of over procuring capacity and incurring high demand curtailment costs. The least-worst regrets analysis calculates the maximum total regret cost for each demand scenario and selects the demand forecast level with the lowest maximum total regret cost.

Marginal de-rating factors for storage technologies

The process for determining de-rating factors for storage technologies is similar to the process for non-storage technologies, noting the addition of storage capacity as an additional dimension to generation capacity. The methodology accounts for:

- impact of storage duration on de-rating factors with high duration storage having a higher de-rating factor; and
- impact of size of the storage unit (in MW) with de-rating factors dropping with size.

For a unit with a given generation/storage capacity, the process is illustrated in Figure 3:

The raw de-rating factors for each generation/storage capacity combination for each technology are defined in the same fashion as other de-rating factors by adding a unit, measuring the change in adequacy and dividing the result by the generation capacity of the unit.

The raw de-rating factors are then subject to further adjustment via the storage adjustment factor. This is the ratio of the DRF for existing capacity as calculated by removing from the system, and the DRF applicable to the same capacity were it to be added to the system. The application of the storage adjustment factor returns the marginal de-rating to the average de-rating factor for existing storage. The factor is applied to all storage technology de-rating factors, also returning these to close to average de-rating factors.

Selecting the Capacity Requirement and De-rating Factors

Once the demand forecast level has been decided by the Least-Worst Regrets calculation, de-rating factors are averaged across all demand scenarios at the Least-Worst Regrets demand level. These average values are used for the capacity market qualification and auction process.

The final de-rating factor choice leads to the determination of an auction requirement. The scenario capacity requirements are averaged across all demand scenarios at the Least-Worst Regrets demand level to give the Capacity Requirement that will be used for the capacity market qualification and auction. It is for this reason that the auction requirement and the de-rating factors to be applied to auction participants must be consistent if the required registered capacity is to be procured.

Auction capacity requirement

Adjusted ISAC requirement

The auction capacity requirement is arrived at by considering all technologies available to the system. Where units are below the de Minimis threshold they are incorporated as a demand reduction. More significantly, variable generation technologies such as wind and solar is not procured through the capacity market, although this capacity contributes to defining the auction capacity requirement.

The auction capacity requirement should only reference capacity that is participating in the capacity market auction. Generation that is expected to be outside the market is classified as non-participating. This non-participating capacity is deducted from the initial capacity requirement arising from ISAC output.

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