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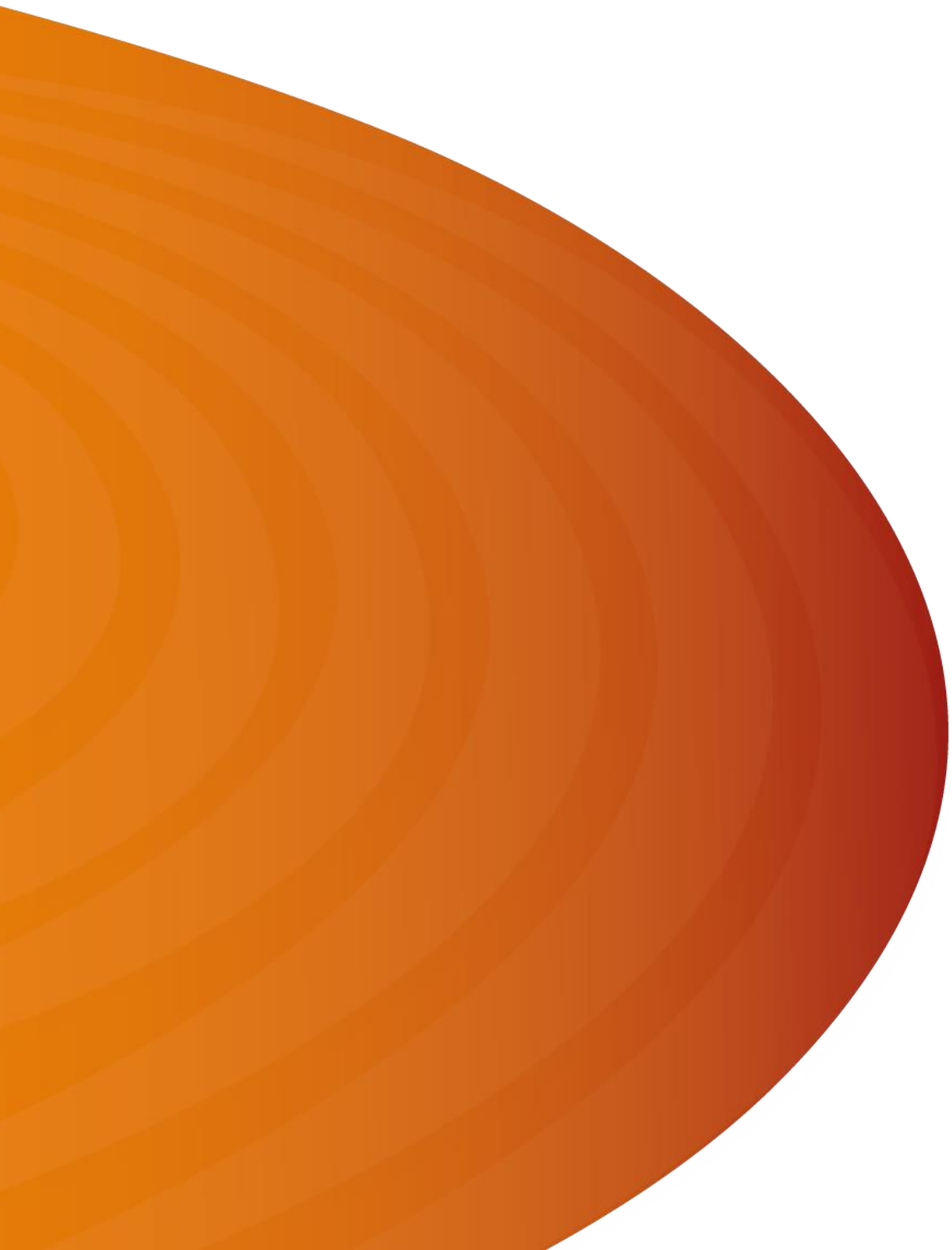
Curtailable Connections

Curtailment figures issued post 1st April 2023



Curtailable Connections

Curtailment Figures issued post April 2023

1. Introduction

Ofgem's Access and Forward-Looking Charges Significant Code Review (SCR) which came into effect on 1st April 2023, brought several changes to the way new applications are assessed. This includes a revised charging boundary for generation and demand applications, the new Curtailable Connection access product and updated approach to calculate curtailment figures. This document covers the following:

- Curtailable Connection access product (Section 2)
- Curtailment Calculation post Access SCR (section 3)
- The difference between Flexible and Curtailable Connections (Section4)
- The difference in the Curtailment Figures issued pre and post April 2023 (Section 5)
- The methodology and assumptions behind the industry aligned curtailment tool (Section 6).

2. Curtailable Connections

A Curtailable Connection is a non-firm access arrangement available from 1st April 2023, that allows a customer to connect quicker by agreeing that the use of some or all that connection capacity may be restricted by the DNO at certain times when the network is congested.

The amount of Curtailment that a customer can be subject to, will be measured relative to a defined '**Curtailment Limit'**, and the ability for the DNO to Curtail that Customer will cease after an agreed '**Curtailment end date'** unless the Customer has applied for an enduring constrained connection. Once energised, the curtailment is monitored and reported to the customer and if this Curtailment Limit is exceeded over a 12 month period from the date of energisation, the DNO will pay the curtailed customer at a published set price for this excess curtailment.

The ability for a DNO to Curtail that Customer will cease after an agreed **Curtailment End Date**, determined based on the time required by UK Power Networks to reinforce the network to allow an unconstrained network access.

3. Curtailment Limit

From 1st of April, all DNOs are required to issue a Curtailment Limit together with the Connection Offer. The methodology to determine the Curtailment Limit has been agreed at industry level and has been captured in DCUSA DPC404, to ensure consistency of results between DNOs and to bring transparency on the assumptions behind the curtailment figures issued to customers.

The Curtailment Limit is produced based on the access lost (kVA), rather than energy lost (kWh), that a site under Curtailable Connections can be subject to due to the curtailment instruction issued by DNO at times when the network is congested.

The Curtailment Limit (or full import/export Curtailment Hours) is calculated by comparing the total reduction in access experienced by a Curtailable Connection customer due to curtailment actions, with the maximum access they would have without curtailment, as shown in the formula below.

$$Hours\ of\ Curtailment\ (Curtailment\ Limit) = \sum_{i=1}^{n} \frac{Curtailment\ Volume\ \times Curtailment\ Duration}{Full\ Import/Export\ Capacity}$$

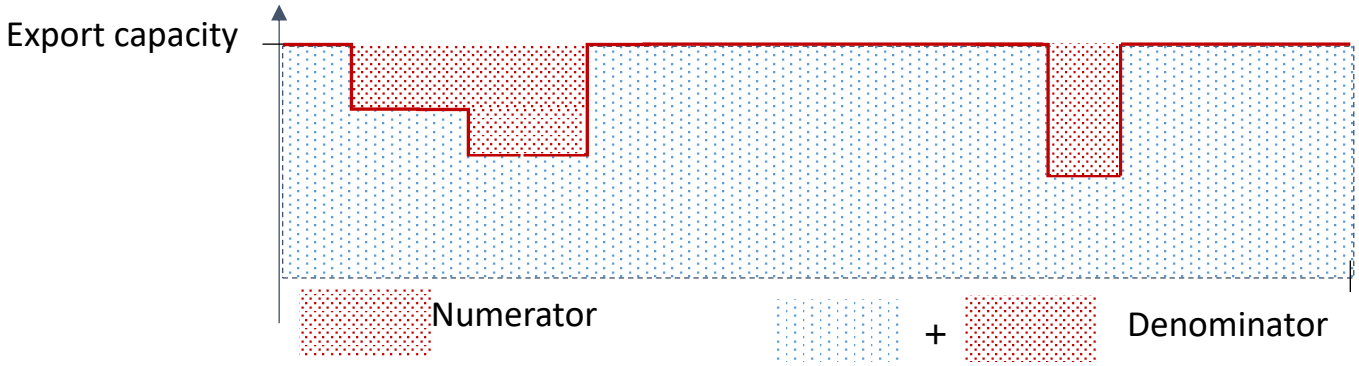


Figure 1: Access reduction due to curtailment

Parameters making up the Hours of Curtailment calculation are described below:

- **Curtailment Volume:** Reduction in output due to curtailment instruction, calculated as the Maximum Export/Import Capacity minus the Curtailment Setpoint.
- **Curtailment Duration:** For each curtailment event, the duration of each period of curtailment determined from the time at which the Company instructs the Customer to curtail its Maximum Export/Import Capacity to the time at which the Company notifies the Customer that there is no longer a requirement to curtail.
- **n =** the number of Curtailment Instructions in a year.
- **i=1 =** for each curtailment event
- **Full Export capacity:** the total Curtailable Export/Import Capacity of the site.

The Percentage of curtailment is then calculated dividing the Hours of Curtailment by the numbers of hours in a year[1].

$$Curtailment\ \% = \frac{Hours\ of\ Curtailment}{8760\ h}$$

Generation application triggering constraints will receive an Export Curtailment Limit, Storage applications triggers import and/or export constraints will receive an import and/or export Curtailment limit.

As an example, the full curtailment hours of a Wind Farm with a Curtailable Export Capacity of 20MVA, that has been curtailed 50 times in a year always for a duration of 1 hour to a setpoint of 2MW (18 MW export reduction), will be as follow:

$$Curtailment\ hours = \sum_{i=1}^{n=50} \frac{18MW\ \times 1h}{20MW} = 90\ hours$$

$$Curtailment\ \% = \frac{90\ h}{8760\ h} = 1.02\%$$

[1] The illustration shows 8760 hours, a standard year that does not include that additional day in a leap year. The denominator will be adjusted if the connection's 12-month period includes this additional day.

4. Flexible Connections (ED1) vs Curtailable Connections (ED2)

Before 1st April 2023 UK Power Networks had been offering 'Flexible Connection' solutions to generation customers triggering networks constraints, facilitated by UK Power Networks' Distributed Energy Resources Management System (DERMS). For applications received from 1st April 2023, UK Power Networks has been issuing Curtailable Connection offers to applications triggering distribution constraints in line with industry changes.

Applications that have an unconstrained network access to distribution system capacity, that are subject to transmission constraints (e.g. SGT reverse power flow), will be issued a Flexible Connections offer, which come with no curtailment liability.

Applications triggering both distribution and transmission constraints, will have both Curtailable Connection and Flexible Connections clauses in their offer.

From a technology perspective there is no difference between a Flexible and a Curtailable connection: they are both managed by UK Power Networks' DERMS system based on the same scheme design methodology and Principle of Access (PoA) and have the same monitoring and control requirements as captured in EDS 08 5060.

From a commercial perspective, UK Power Networks will be contractually bound to the Curtailment Limit issued in the Curtailable Connection offers. Once connected, the curtailment is monitored and reported to the customer and if this Curtailment Limit is exceeded over a 12-month period, UK Power Networks will pay the curtailed customer at a published set price for this excess curtailment. Curtailment associated with Flexible Connections (i.e. offered pre 1st April 2023) is not contractually binding.

The LIFO stack at any given site could contain both flexible and curtailable connections, the treatment around LIFO positioning is not altering as part of these changes.

5. Difference between Curtailment Figures issued pre and post April 2023

This section aims to highlight the key differences between the curtailment figures issued in curtailment reports before and after 1st April 2023 in line with industry changes.

5.1. Curtailment Figures

Curtailment figures associated with connections requests made before 1st April 2023 were provided to give a view on the estimated energy reduction that a site under Flexible Connections was operationally going to be subject to due to distribution constraints.

Curtailment figures associated with connections requests made from 1st April 2023 are used to set a cap to the access reduction driven by distribution constraints that a site under Curtailable Connection agreement can operationally be subject to throughout the year, before being eligible for curtailment compensation.

5.2. Tool used to calculate Curtailment Figures

Before 1st April 2023 a DIgSilent Power Factory based tool was used to produce the curtailment figures captured in the Curtailment Report. This is a load flow-based tool which, after having populated the network model with connected and accepted applications, their LIFO stack position etc., calculates the setpoint reduction required to eliminate network overloads at the constraints for each half hour in a year, based on sensitivity factors to the constraints and LIFO stack order.

Upon the introduction of Curtailable Connections, all DNOs are using an industry-aligned spreadsheet as mandated in DCUSA DPC404. This ensures consistency of curtailment methodology for customers across GB and provides transparency around the assumptions used. An explanation of the key input parameters

used in the curtailment methodology is captured in Section 5 of this document and full details are available at DCP 404 Working Group - DCUSA, "Attachment 1_DCP 404 Legal text".

5.3. Time vs Energy % Curtailment

The curtailment figures issued for Flexible Connections were an estimate of the **energy lost** throughout the year due to curtailment instructions and was calculated by dividing the curtailed profiled of the site (kWh) by the estimated un-curtailed profile of the site (kWh) throughout the whole year.

The contractual curtailment figures issued for Curtailable Connections are an estimate of the access lost throughout the year due to curtailment instructions. The hours of curtailment are calculated by comparing the total reduction in access experienced by a Curtailable Connection customer due to curtailment actions, with the maximum access they would have without curtailment. A curtailment figure is then calculated by dividing the hours of curtailment by the numbers of hours in a year.

5.4. Curtailment Baselining

The curtailment figures issued with Flexible Connection offers are based on energy (kWh) lost due to curtailment events, which were calculated using an estimate of the un-curtailed profile from the site as a baseline, based on UK Power Networks' standard technology specific profiles. Standard technology specific profiles used are solar, wind, storage, thermal and any combination of them for mixed sites.

The Flexible Connection curtailment figures are estimated using the full export capacity (kVA) of the site as a baseline, with the exception of solar sites where the full capacity is only used during daytime.

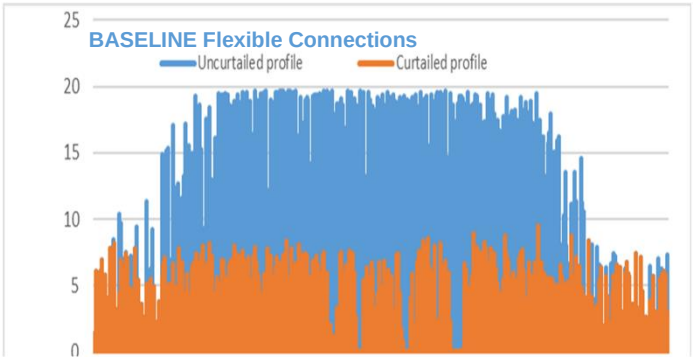


Figure 2: Technology Specific profiles used as the curtailment baseline (before 1st of April).

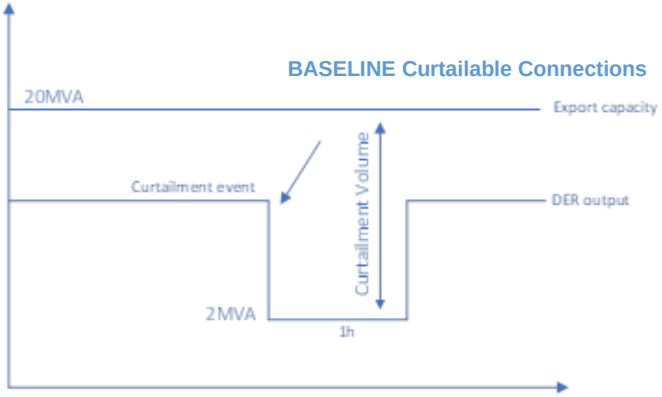


Figure 3: Full Export Capacity used as the curtailment baseline (post 1st of April)

5.5. Inflight Offers and Acceptances

Both in the curtailment figures issued before and after 1st of April, all inflight offers and acceptances are considered to connect. However, before 1st April 2023 they were modelled based on their technology profiles and based on their actual sensitivities to network constraints, whereas after 1st April 23 they are modelled based on their full import/export capacity and are considered to have 100% contribution to the constraint at all times.

5.6. Accepted and not yet Connected Flexible Connections

Curtailment figures issued before 1st of April 2023, modelled the accepted not yet connected Flexible Connections (pre 1st of April) above in the LIFO stack with their expected curtailed profile, considering that their export is expected to be limited throughout the year due to distribution constraints. Figures produced post 1st April 2023 instead consider that all accepted not yet connected Flexible Connections (pre 1st of April) to always have 100% contribution to the constraint, beside solar where the contribution is considered only during daytime.

5.7.Sensitivity Factors

Moreover, before 1st April 2023 accepted not yet connected Flexible Connections were modelled based on their actual sensitivity factors to the constraints, whereas curtailment figures issued post 1st April 2023 considers 100% sensitivity factor.

The key difference between curtailment figures issued before and after 1st of April 2023 described above have been summarised in **Error! Not a valid bookmark self-reference.** below.

Table 1: Key differences between curtailment figures issued before and after 1st of April 2023.

	SCR curtailment (Curtailable Connections)	Legacy curtailment (Flexible Connections)
Time vs Energy % curtailment	Time based curtailment: Hours of curtailment over total hours in a year.	Energy based Curtailed: energy lost (kWh) due to curtailment over expected yearly energy production from the site (based on technology specific profiles)
DER baseline for curtailment calculation	The baseline for the curtailment volume calculation is the full export capacity of the site, with the exception of Solar that is baselined with full export capacity only during day-time.	The baseline for curtailment volume calculation is a standard technology specific un-curtailed profile (PV, Wind, Storage, Thermal).
Constraints	Based on the most onerous constraint	Considers all constraints linked to the customer
Ratings	Minimum rating (Summer)	Seasonal Ratings
Inflight offers and acceptances	All inflight offers and acceptances are considered to connect and to have 100% contribution to the constraint at all times.	All inflight offers and acceptances are modelled based on their technology specific profiles and are based on their actual sensitivity factors to the constraints.
Accepted not yet connected non-firm Connections	Accepted not yet connected Flexible Connections are considered to have 100% contribution to the constraint at all times. The curtailed profiles from these sites due to distribution constraint is not considered.	Accepted not yet connected Flexible Connections are modelled based on their curtailed profile and based on their actual sensitivity factor to the constraints.

Curtailable Connections

Curtailment Figures issued post April 2023

6. SCR Curtailment Tool

From 1st of April, all DNOs are required to issue a curtailment limit based on an industry agreed methodology captured in DCUSA DPC404 and published by the ENA. The methodology has then been captured in a curtailment tool that all DNOs must use to produce the Curtailment Limit. The inputs to the SCR curtailment tool and the curtailment calculations are explained below in this section.

6.1. Inputs for Demand Curtailment Studies

Figure 4 shows the inputs required in the SCR curtailment spreadsheet to calculate the import curtailment limit. Numbers in blue are input from the DNO, numbers in red are calculations.

- **Network Asset Demand Capacity** is the capacity of the asset that has been identified to trigger the most curtailment. The asset capacity is determined based on the DNO's relevant design, planning and security of supply policies. This normally corresponds to the N-1 capacity of the site;
- **Inflight Demand Acceptances**, is the aggregated Maximum Import Capacity of all demand acceptances that utilise the asset being assessed but have yet to be connected/energised and hence are not included in the current maximum demand;
- **Largest Inflight Demand Offers**, is the aggregate Maximum Import Capacity of the two largest connection offers that utilise the asset being assessed that have been issued to a Customer but have yet to be accepted;
- **Other Inflight Demand Offers**, is the aggregated Import Capacity of all other connection offers that utilise the asset being assessed that have been issued to a Customer but have yet to be accepted;
- **Demand Confidence Factor**, is the confidence factor representing the likelihood of the Other Inflight Demand Offers being accepted by Customers, which has the value 50%;
- **New Demand Connection Capacity**, is the requested Import Capacity of the connection for which the Curtailment Limit is being calculated;
- **Curtailment Threshold** is the percentage of the Network Asset Demand Capacity, which, if exceeded by the Committed Demand Capacity or Committed Generation Capacity, will determine the number of hours where curtailment may be required, which is set at 95%.

DEMAND DATA				
Network Asset Demand Capacity	12,000		kVA	
				Usage Factor
Inflight Demand Acceptances	2,500		kVA	100%
Largest Inflight Demand Offers	1,000		kVA	100%
Other Inflight Demand Offers	2,000		kVA	100%
Demand Confidence Factor	50%			
Inflight Demand Connection Capacity	4,500		kVA	
New Demand Connection Capacity	5,000		kVA	100%
Curtailment Threshold	95%			
Import Curtailment Limit	5106		Hours	
Partial Profile				
Hours in Profile	8,760	Hours		
Percentage Curtailed	58.29%	Hours		
Import Curtailment Limit (for partial profile)	5,106	Hours		

Figure 4: Inputs for Import Curtailment Limit

The underlying true demand to calculate the Import Curtailment Limit is calculated based on the historical annual half-hourly true (gross) demand profile, which shall be calculated by subtracting historical generation and battery storage profiles to the historical half-hourly measured/observed data.

6.2. Import Curtailment Limit Calculation

The underlying true demand profile described above is then sorted in descending order to produce the underlying true demand duration curve.

The Maximum Import Capacity of Inflight Demand Acceptances and the Largest Inflight Demand Offers, plus the Other Inflight Demand Offers multiplied by the Demand Confidence Factor is then added to the underlying true demand. The Maximum Import Capacity of the new connection for which the Curtailment Limit is being calculated is also added to the underlying true demand.

This is then divided by the Network Asset Demand Capacity to represent it as a percentage of the firm capacity of the asset.

The Import Curtailment Limit is then determined by assessing the number of hours for which the Committed Demand Capacity relative to the Network Asset Demand Capacity exceeds the Curtailment Threshold.

6.3. Inputs for Generation Curtailment Studies

Figure 5 shows the inputs required in the SCR curtailment spreadsheet to calculate the export curtailment limit. The table is populated with an example. Numbers in blue are input from the DNO, numbers in red are calculations.

- **Network Asset Generation Capacity** is the capacity of the asset that has been identified to trigger the most curtailment. The asset capacity is determined based on the DNO's relevant design, planning and security of supply policies. This normally corresponds to the N-1 capacity of the site;
- **Inflight Generation Acceptances** is the aggregated Maximum Export Capacity of all generation acceptances that utilise the asset being assessed but have yet to be connected/energised and hence are not included in the current maximum generation/minimum demand. The aggregated values are categorised as either PV Generation or Non-PV Generation capacity;
- **Largest Inflight Generation Offers**, is the aggregate Maximum Export Capacity of the two largest connection offers that utilise the asset being assessed that have been issued to a customer but do not have to be accepted. The aggregated values are categorised as either PV Generation or Non-PV Generation capacity;
- **Other Inflight Generation Offers**, being the aggregated Maximum Export Capacity of all other connection offers that utilise the asset being assessed that have been issued to a customer but have yet to be accepted. The aggregated values shall be categorised as either PV Generation or Non-PV Generation;
- **Generation Confidence Factor**, is the confidence factor representing the likelihood of the Other Inflight Generation Offers being accepted by the Customer, which has the value 50%;
- **New Generation Connection Capacity** is the requested Maximum Export Capacity of the connection for which the Curtailment Limit is being calculated. This is categorised as either PV Generation or Non-PV Generation;

  Curtailment Threshold is the percentage of the Network Asset Generation Capacity, which, if exceeded by the Committed Demand Capacity or Committed Generation Capacity, will determine the number of hours where curtailment may be required, which is set at 95%.

The underlying true demand to calculate the Export Curtailment Limit is calculated based on the historical annual half-hourly measured/observed data at the constraint, or by adding the historical annual half-hourly generation feeding to the constraint (generation is treated as negative values) to the historical true demand profile at the constraint.

GENERATION DATA				
Network Asset Generation Capacity	-20,000		kVA	
	Non-PV	PV		Usage Factor
Inflight Generation Acceptances	-5,000	0	kVA	100%
Largest Inflight Generation Offers	-1,000	0	kVA	100%
Other Inflight Generation Offers	-1,000	0	kVA	100%
Generation Confidence Factor	50%			
Inflight Generation Connection Capacity	-6,500	0	kVA	
New Generation Connection Capacity	-10,200		kVA	100%
Curtailment Threshold	95%			
Generation Curtailment Threshold	1528		Hours	
Partial Profile				
Hours in Profile	8,760	Hours		
Percentage Curtailed	17.44%	Hours		
Import Curtailment Limit (for partial profile)	1,528.0	Hours		

Figure 5: Inputs for Export Curtailment Limit

The Maximum Export Capacity (expressed as a negative value) of Inflight Generation Acceptances and the Largest Inflight Generation Offers, plus the Other Inflight Generation Offers multiplied by the Generation Confidence Factor is then added to the underlying true demand. The Maximum Export Capacity (expressed as a negative value) of the new connection for which the Curtailment Limit is being calculated is also added to the underlying true demand. PV Generation is only added to half-hourly periods where it is daylight by multiplying the PV Generation data by the representative daylight profile.

This is then divided by the Network Asset Generation Capacity to represent it as a percentage of the firm capacity of the asset.

The Export Curtailment Limit is then determined by assessing the number of hours the committed Generation Capacity relative to the Network Asset Generation Capacity exceeds the Curtailment Threshold.