Design Variations for Onshore Generation Connections

Indicative Assessment of Restrictions

Author: National Grid

Version: 2.0 26/05/2015

1 Scope

This note provides basic guidance to parties intending to submit a connection application in relation to an onshore generation connection. It explains the concept of a Design Variation. It provides a methodology a potential connectee may use to assess the impacts of restrictions that arise from Design Variations and examples for the application of this methodology. It highlights the commercial and contractual implications and potential benefits of these Design Variations.

Please note

- The data provided in this note is indicative. Its use within NGET has been limited to high level cost benefit analysis and constraint assessment studies. The examples provided are for illustrative purpose only.
- Actual generation data vary from site to site and from year to year due factors such as technology, weather, fuel prices, and changes of operational regimes. This may affect the level of restriction for a specific site. The results of any analysis are indicative only.
- The methodology provided is suitable for connections where the restrictions arise because of local system conditions. Restrictions affected by wider system conditions may need to be assessed using other tools.

Ultimately, whilst Design Variations should be discussed with Transmission Licensees, the decision of whether to request a Design Variation and the scope of any Design Variation lies entirely with the User.

2 Introduction

The National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS) sets out a coordinated set of criteria and methodologies that Transmission Licensees use in planning and operating the National Electricity Transmission System (NETS) of Great Britain and Offshore. These criteria provide a baseline for the investment in transmission assets.

The Generation Connection Criteria applicable to the Onshore Transmission System are set out in Section 2 of the NETS SQSS and cover the connections which extend from the generation points of connection and reach into the Main Interconnected Transmission System. The criteria also cover the risks affecting the NETS arising from generation circuits.

Following a connection application from a User for a generation connection, Transmission Licensees apply the deterministic criteria set out in Section 2 to determine the transmission capacity required, and consequently, the transmission reinforcements required to connect the User's plant. The scope of these transmission reinforcements influences he connection date. The cost of these transmission reinforcements determines the User Commitment and the Connection Charge. It also affects the Transmission Network Use of System (TNUoS) Charge.

In order to allow an early connection date, reduce User Commitment, or reduce TNUoS charge, it is possible that a User requests, in their connection application, a Design Variation. This Design Variation allows Transmission Licensees to deviate from the design requirements specified by the deterministic criteria of the NETS SQSS provided that the criteria of the Design Variation specified under Section 2 of the NETS SQSS is met. As a consequence of this Design Variation, the User may have to accept certain restrictions.

The scope of the Design Variation is usually discussed within the application process. In the majority of cases, it is correlated with the size and the load factor of the plant. However, there have been few cases with a User requesting a Design Variation that exposes them to a high level of restrictions. There have also been other cases with a User completely choosing to overlook any benefit that they may gain through a Design Variation.

Although the decision of whether a User applies for a Design Variation or not lies entirely with the User, it was thought helpful to provide this guidance highlighting the pros and cons of a Design Variation and providing some examples on how to assess the implications of this choice. This is to ensure that Users are aware of the potential risks and benefits arising from the Design Variation and can consequently make a more informed decision.

3 Design Variation

3.1 Baseline Designs

A typical design for a generation connection which meets the deterministic criteria set out in the SQSS tends to have the generator connected to a double busbar substation. The substation is connected to the Main Interconnected Transmission System through a double circuit overhead line. Each of the two circuits of the overhead line has a minimum MVA rating that is sufficient to carry the full MW output of the generator at the full leading, or lagging, power factor.

3.2 Typical Configurations of a "Design Variation"

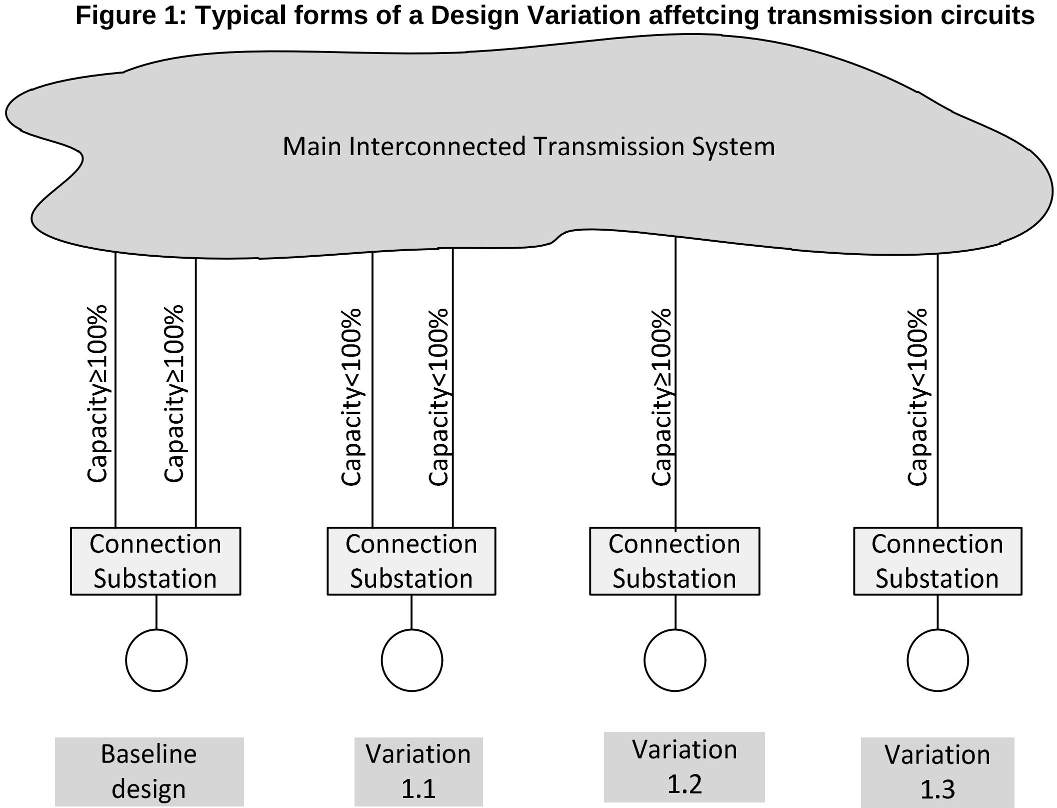
Typical Variations to the baseline design may include a reduction in either the number or the capacity of circuits connecting the substation to which the generator is connect to the Main Interconnected Transmission System. Examples of these variations are shown in Figure 1 and are listed below:

Variation 1.1. a double circuit overhead line with each circuit rated below the generator capacity;

Variation 1.2. a single circuit overhead line rated at least at 100% of the generator capacity; and;

Variation 1.3. a single circuit overhead line rated below the generator capacity[1].

Figure 1: Typical forms of a Design Variation affetcing transmission circuits



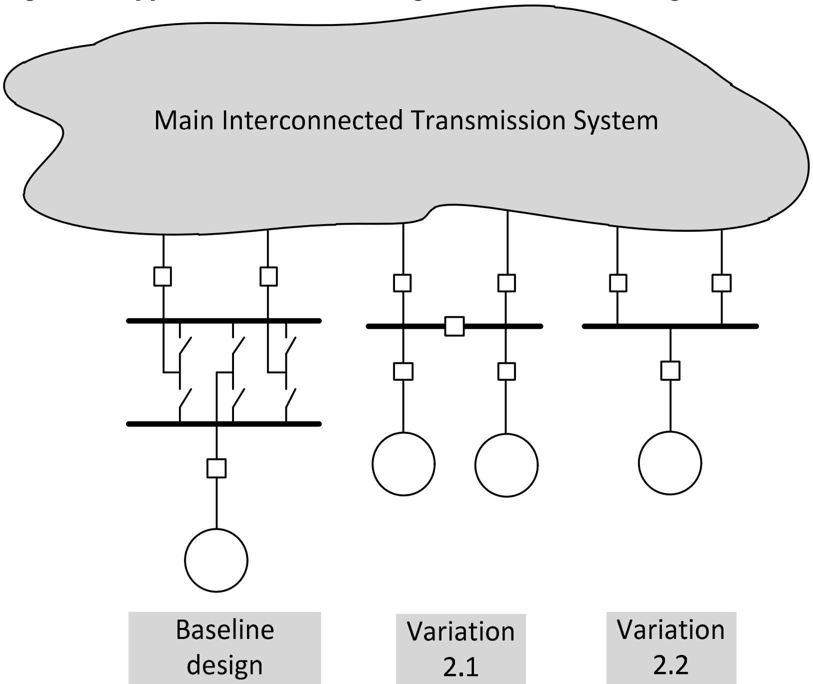
[1] Variation 1.3 is usually requested in cases where a new User requests a connection to an existing circuit to which other Users are already connected or contracted. However, it is not usually offered as an enduring solution.

Typical Variations to the baseline design may include a reduction in the number of busbars or bus sections at the substation to which the generator is connected. The variations considered are shown in Figure 2 and are listed below:

Variation 2.1. a single busbar substation with a bus section circuit breaker; and

Variation 2.2. a single busbar substation[2].

Figure 2: Typical forms of a Design Variation affecting busbars



3.3 Other Forms of Connection Designs and Design Variation

There are several other connection designs that are not shown in Figure 1 or Figure 2. Analysis of any restrictions arising from these configurations will follow the same principles.

3.4 Technical Restrictions on a Design Variation

Transmission Licensees assess Design Variations, including any of the examples provided, against the requirements specified within the NETS SQSS and the policies arising from these requirements on a case by case basis. Where this specific design does not comply with the requirements and policies, e.g. due to negative implications on another User, it will not be offered to a User.

Following a change of system conditions, such that a specific Design Variation no longer complies with the requirements, arrangements will have to be put in place to restore compliance.

3.5 Degrees of Restriction Arising from a "Design Variation"

A Design Variation, in the majority of cases, reduces the transmission capacity available for the User, and consequently the access rights of this User, under certain operating conditions. When these conditions materialise, the output of the User's plant will be restricted. The User will not be compensated for this restriction.

Connection designs shown in Figure 1 and Figure 2 cover three different degrees of restrictions. The degrees of restriction are:

- a partial restriction following an outage, Variation 1.1 and Variation 2.1;

[2] Variation 2.1 offers marginal cost savings, if any, in comparison to the baseline design.

- a 100% restriction following an outage, Variation 1.2 and Variation 2.2; and
- a partial restriction at intact system conditions, Variation 1.3.

There are some connection designs where the restriction occurs following a double circuit fault or a single circuit fault during a planned outage of another circuit. For these designs, planned outages should not result in any restriction. As designs with this level of restriction are not encountered frequently, no examples of them were included.

In the majority of cases, as a restriction arises during a specific operating condition, the capacity available is determined by the rating of the transmission equipment in service during this operating condition. However, in few cases, the capacity available may be also restricted by the ability of User to modify the topology of the User's plant. An example of this is Variation 2.1 where the capacity available under N-1 conditions, i.e. with a single bus section outage, is dependent on the rating of the circuit connected to the remaining bus section as well as to the ability of the User to move generators between the two sections.

For the purpose of an indicative assessment of the level of restriction, and in order to simplify the calculations, variation in transmission capacity available due to seasonal ratings, cyclic ratings, short term overload capabilities, seasonal variations of demand, and changes in reactive power output of the plant can be ignored.

In cases where the capacity available to a User is affected by demand levels or penetration levels of embedded and micro generation, Users may need to make some assumptions about these levels. In addition, some sensitivity analysis might be necessary to assess the risks the User is exposed to due to the uncertainty associated with these levels.

A significant degree of approximation may be required to estimate the capacity available to the User if this capacity is dependent on conditions on the wider system, e.g. outages on circuits that are remote to the User's plant affecting flows on one of the circuits affected by the Design Variation. If this degree of approximation is not acceptable, it might be necessary to use other statistical analysis methods to study the system as a whole.

3.6 Management of Restrictions

The general practice is to use automatic facilities, e.g. intertrips or automatic deloading schemes, to enforce restrictions as the need arises. Ideally, these automatic facilities should be designed with some flexibility such that they can be armed for the correct level of restriction. That is, no power output will be restricted unnecessarily.

The practicalities of implementing the automatic facilities required for a specific Design Variation, e.g. due to complexity or reliability issues, may limit the scope of the Design Variation.

4 Transmission System Outages

The majority of restrictions take place when there is a transmission system outage. That is when some transmission equipment is required to be taken out of service.

Transmission system outages may be either planned or unplanned outages. Planned outages take place when the Transmission Licensee needs to access this equipment in line with their maintenance schedules or construction programmes. Unplanned outages take place due to transmission faults.

The outage information provided here is based on generic data. It provides a reasonable generalised view and is suitable for an indicative assessment of restrictions. Where more accurate, region specific, or even route-specific, data is required, information should be sought from NGET.

4.1 Circuit Outages

Each circuit is assumed to be on a planned outage for 2 weeks per annum (4%) during summer months. Moreover, each circuit is assumed to suffer a further ½ week per annum (1%) unplanned outage, which occur at any time of the year.

Double circuit outages – outages affecting two circuits on the same tower line – are not considered in this analysis for two reasons. They are low probability events; and the restrictions arising from them are, in most cases, independent of whether there is a Design Variation or not.

4.2 Busbar Outages

Each busbar is assumed to be on a planned outage for 1 week per annum (2%) during summer months.

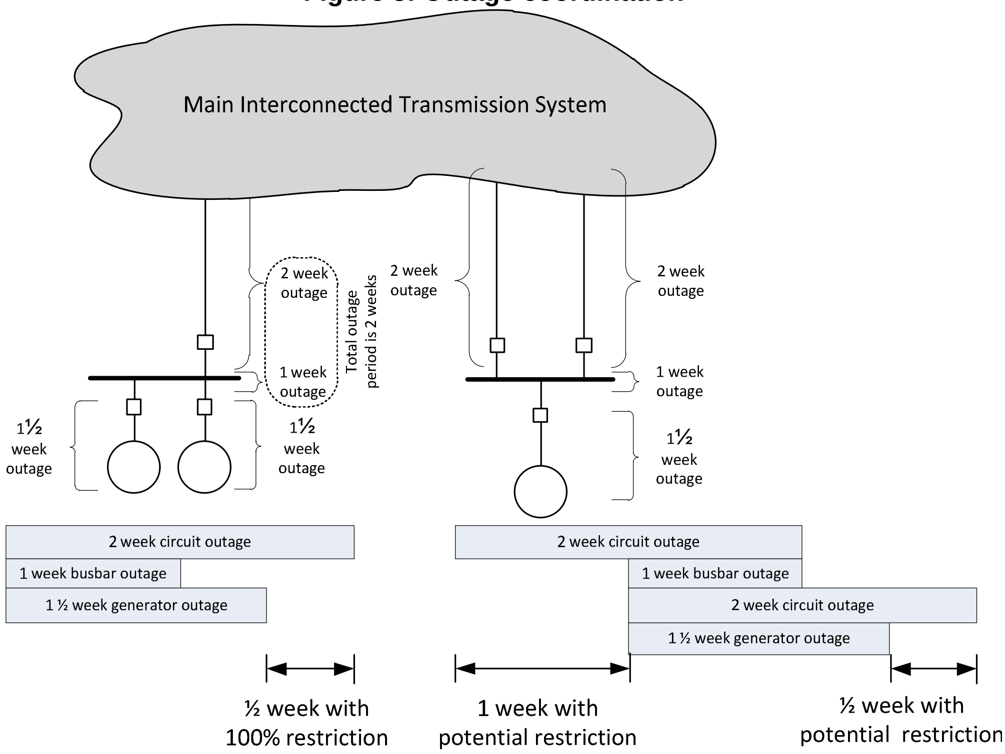
Busbar faults are not considered in this analysis for two reasons. They are low probability events; and the restrictions arising from them are independent of whether there is a Design Variation or not.

4.3 Outage Coordination

The outage planning process aims to coordinate transmission system outages in order to minimise the impact of outage on the transmission system.

The outage planning process also endeavours to align transmission system outages with generator outages in order to minimise the impact on the generator. However, this is subject to constraints on resources and construction programmes. It is also impacted by the number of parties involved in the process.

Figure 3: Outage coordination



Examples of outage coordination are shown in Figure 3. This Figure shows two connections and a timeline for an optimal outage programme for each connection. In Connection 1, the busbar maintenance will be done during the circuit outage such that the overall outage period is two weeks only. Moreover, the 1½ week outage of the generators will be aligned with the transmission outage which would limit the impact to a ½ week of restriction only. In Connection 2, the ideal configuration will have all the outages overlapping over a period of three weeks. This limits exposure to restrictions to 1 ½ weeks only.

Where estimates on the level of alignment between transmission and generator outages are available, these estimates should be used to scale down the duration of a panned outage. For example, if 20% alignment is assumed, a two-week outage will be scaled down to (100%-20%) × 2 weeks. That is the effective duration of the outage would be 1.6 weeks.

As a worst case scenario, 0% alignment between transmission outages and generator outages should be assumed.

5 Probabilistic Modelling of Plant Output

5.1 Basic Concepts

The probability distribution for the power output of a specific plant is a plot depicting the likelihood of a specific generator to run at different levels of output. Such distribution is constructed by simulating a large number of operating points, grouping them in different bins with each bin covering a range of outputs, counting the number of points in each bin, and dividing the result by the total number of points.

A cumulative distribution for the power output of a specific plant describes the probability that the output of the plant is less than or equal to a specific value. This cumulative distribution is found by integrating the probability distribution curve or simply adding up the probability values from the probability distribution curve.

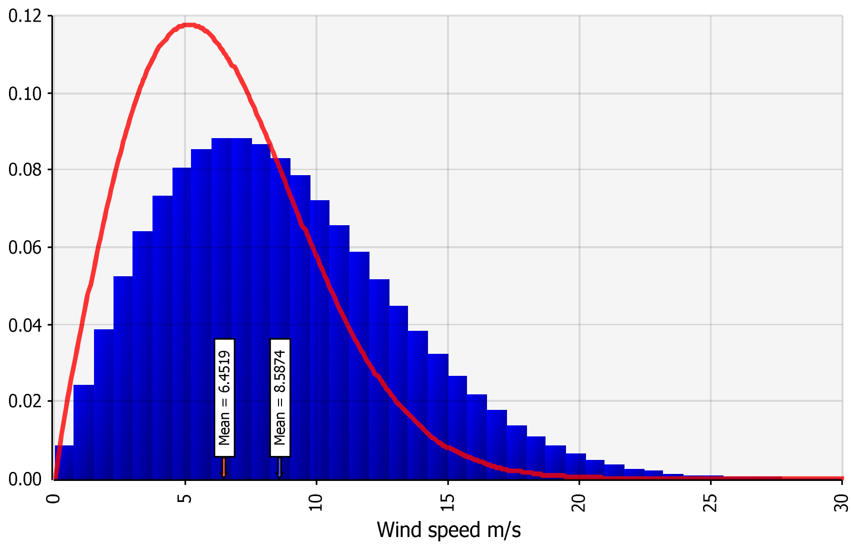
The plant load factor is equal to the ratio between the actual energy produced by the plant over that specific period and the maximum energy that could have been produced if the plant was to run at maximum output for the entire period. This load factor is calculated from the probability distribution by summing the product of the output times the probability of the plant running at that output level.

Examples of a probability distribution, cumulative distribution, and calculation of the load factor for a typical windfarm are shown in Table 1, Figure 6 and Figure 7.

5.2 Modelling of Wind Generation

Figure 4 shows typical wind speed distributions[3] for summer, shown as a line trace, and winter, shown as an area.

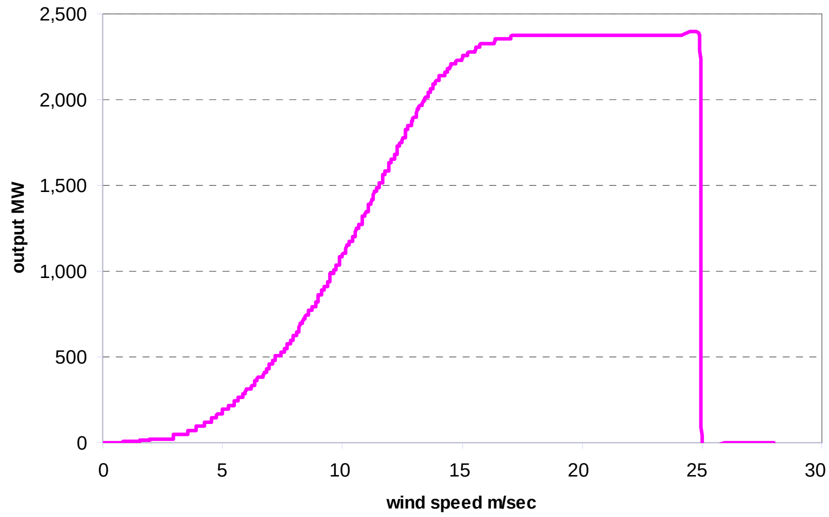
Figure 4: Seasonal Wind Speed Distribution



The relation between the MW output of a windfarm and the wind speed depends on several factors such as the windfarm layout and the turbine/generator technology and wind direction. However, for an indicative assessment of restrictions, a generic MW/Wind Speed curve is sufficient. A typical example for this curve is shown in Figure 5.

[3] Weibull distributions (with shape parameter 2) are used to simulate wind speeds. The parameters are back-derived from wind speed data, provided by Pőyry, seen by a typical well-sited onshore windfarm.

Figure 5: Power Curve



The curve in Figure 5 corresponds to a 2.4GW windfarm. For, windfarms of different capacities, this curve should be scaled up or down to reflect the total capacity of the turbines – not the capacity contracted.

A typical probability distribution of the percentage output of a windfarm is shown in Figure 6 for the winter period probability distribution and in Figure 7 for the summer period. The numerical values are also given in Table 1. These distributions were calculated using the wind speed probability distribution shown in Figure 4 and the MW/wind speed curve for that windfarm shown in Figure 5.

There is a significant difference between the MW output of a windfarm during summer period and that during the winter period. Hence, implications of potential restrictions on the output of a windfarm should be evaluated for an appropriate number of seasons independently.

5.3 Modelling of Other Forms of Intermittent Generation

Other types of intermittent generation are modelled using the same concepts and tools used for modelling wind generation.

5.4 Modelling of Conventional Generation

For the purpose of an indicative assessment of restrictions, it is sufficient to assume that a conventional plant of a known load factor will be running at 100% of its rated capacity for a percentage of time equal to its load factor. For example, a 70% load factor CCGT would be off for 30% of the time and would run at 100% of its rated capacity for 70% of the time. The probability distribution corresponding to this pattern of operation is given in Table 2.

5.5 Modelling of Generation Groups

For the purpose of an indicative assessment of restrictions, a generation groups comprising generating units of identical technology can be modelled as a single unit with a capacity equal to the sum of the capacities of individual units.

Modelling of a generation group that comprises generating units of different technologies requires knowledge of their typical operational regimes and the likelihood of them running at the same time. This information will need to be processed to produce a probability distribution for the aggregated power output of the group.

Figure 6: Probability distribution for the percentage output of a windfarm Winter

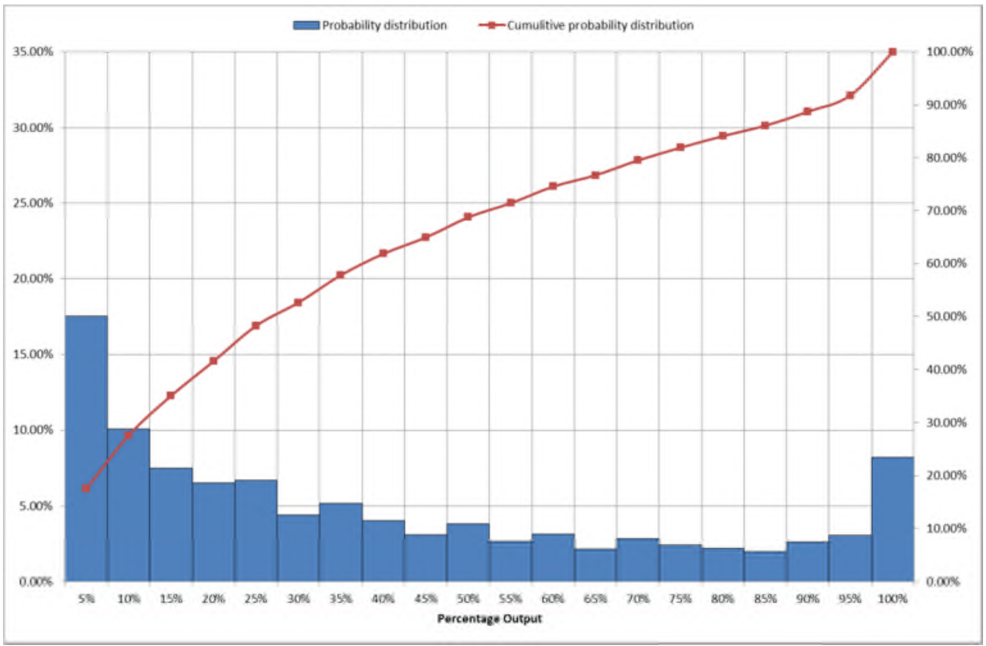


Figure 7: Probability distribution for the percentage output of a windfarm Summer

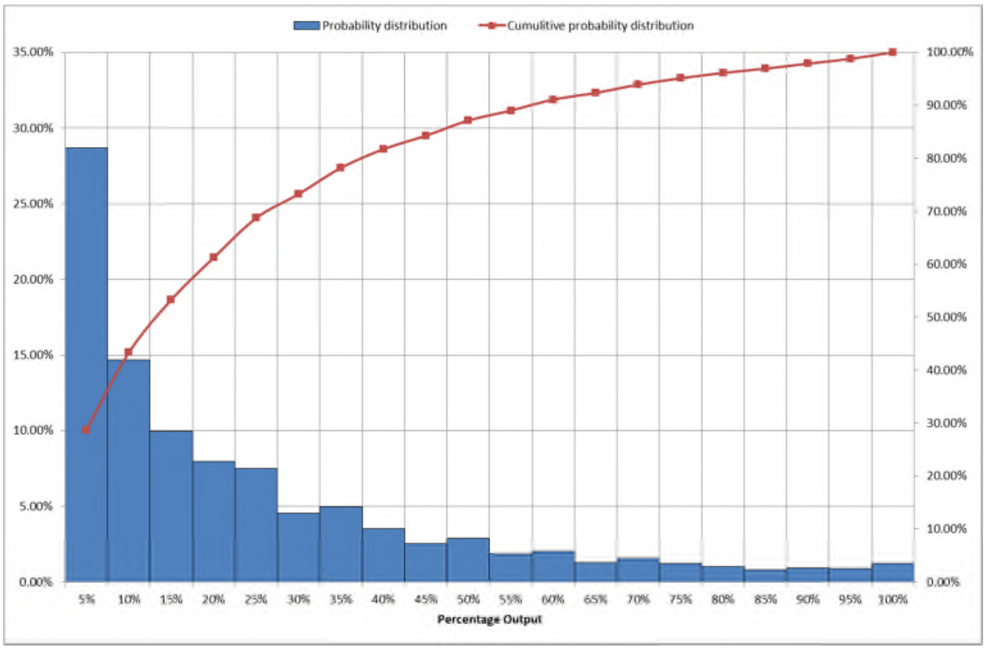


Table 1: Probability distribution for the percentage output of a windfarm

Output range		Probability		Cumulative Probability		% Output x Probability	
From	To	Winter	Summer	Winter	Summer	Winter	Summer
0	5%	17.50%	28.68%	17.50%	28.68%	2.5% ×17.50% = 0.44%	2.5% ×28.68% =0.72%
5%	10%	10.07%	14.67%	10.07% + 17.50% = 27.57%	14.67% + 28.68% = 43.35%	7.5% ×10.07% = 0.76%	7.5% ×14.67% = 1.10%
10%	15%	7.49%	9.95%	7.49% + 27.57% = 35.06%	9.95% + 43.35% = 53.30%	12.5% ×7.49% = 0.94%	12.5% ×9.95% = 1.24%
15%	20%	6.51%	7.96%	41.57%	61.26%	1.14%	1.39%
20%	25%	6.68%	7.47%	48.25%	68.73%	1.50%	1.68%
25%	30%	4.39%	4.53%	52.64%	73.26%	1.21%	1.25%
30%	35%	5.17%	4.95%	57.81%	78.21%	1.68%	1.61%
35%	40%	4.03%	3.53%	61.84%	81.74%	1.51%	1.32%
40%	45%	3.10%	2.55%	64.94%	84.29%	1.32%	1.08%
45%	50%	3.79%	2.87%	68.73%	87.16%	1.80%	1.36%
50%	55%	2.67%	1.87%	71.40%	89.03%	1.40%	0.98%
55%	60%	3.14%	2.04%	74.54%	91.07%	1.81%	1.17%
60%	65%	2.16%	1.28%	76.70%	92.35%	1.35%	0.80%
65%	70%	2.82%	1.55%	79.52%	93.90%	1.90%	1.05%
70%	75%	2.41%	1.21%	81.93%	95.11%	1.75%	0.88%
75%	80%	2.20%	1.00%	84.13%	96.11%	1.71%	0.78%
80%	85%	1.99%	0.82%	86.12%	96.93%	1.64%	0.68%
85%	90%	2.62%	0.94%	88.74%	97.87%	2.29%	0.82%
90%	95%	3.06%	0.91%	91.80%	98.78%	2.83%	0.84%
95%	100%	8.20%	1.22%	100.00%	100.00%	8.00%	1.19%
			Average Output = Σ(%Output x Probability)			36.96%	21.94%

Table 2: Probability distribution for the percentage output of a CCGT with 70% load factor

Output level	Probability	Cumulative Probability
0	30%	30%
100%	70%	100%
Average	70%	

6 Assessment of Restrictions

6.1 Power Restricted, Energy Restricted and Annual Energy Restricted

As an operational condition that causes a restriction takes place, the User whose plant is subject to that restriction will have to reduce the MW output of the plant to a value that is equal to the capacity available during this operational condition. The User will be subject to that restriction for the entire period during which this operational condition prevails.

This reduction in the MW output of the plant is the Power Restricted. The integration of this Power Restricted over the entire time period associated with the operational condition causing the restriction is the Energy Restricted.

The Annual Energy Restricted is equal to the sum of the Energy Restricted associated with individual operational conditions arising over the course of a year of operation. Its value is a measure of the severity of restrictions imposed on the User's plant.

6.2 A Methodology to Estimate the Annual Energy Restricted

In order to estimate the Annual Energy Restricted the following steps are followed.

1. Determine the probability distribution, the cumulative distribution, and the average output of the plant.
2. Determine the capacity available during all conditions under consideration.
3. Determine the probability that the power output of the generator is below the export capacity available. This is done using the cumulative probability distribution curve as shown by Figure 8.
4. Determine the average Power Restriction. This is done using the probability distribution with the only bins considered being those associated with output levels in excess of the capacity available. For each of these bins, the Power Restriction, which is equal to the level of output minus the capacity available, is multiplied by the probability associated with this level. The sum of this product is equal to the average Power Restriction. This is illustrated by Figure 8 and Table 3.
5. Determine the number of hours/year for which the outage condition under consideration is expected to take place.
6. The Annual Energy Restricted associated with any specific operational condition will be the product of number of hours this operational condition is expected to take place times the average Power Restriction.

6.3 Examples

The steps given in Section 6.2 were used to calculate the restrictions seen by a typical windfarm – probability distribution given in Table 1 – and a 70% load factor CCGT - probability distribution given in Table 2 – for all connection designs shown in Figure 1 and Figure 2.

The capacity available for all the configurations shown in Figure 1 and Figure 2 are summarised in Table 4. For simplicity only two levels of restrictions, corresponding to 0% capacity available and 50% capacity available, were considered. Other levels of restrictions are evaluated using the same methodology.

Figure 8: Determination of the probability that a restriction is/is not required and calculation of the average Power Restricted – 30% cpacity available assumed

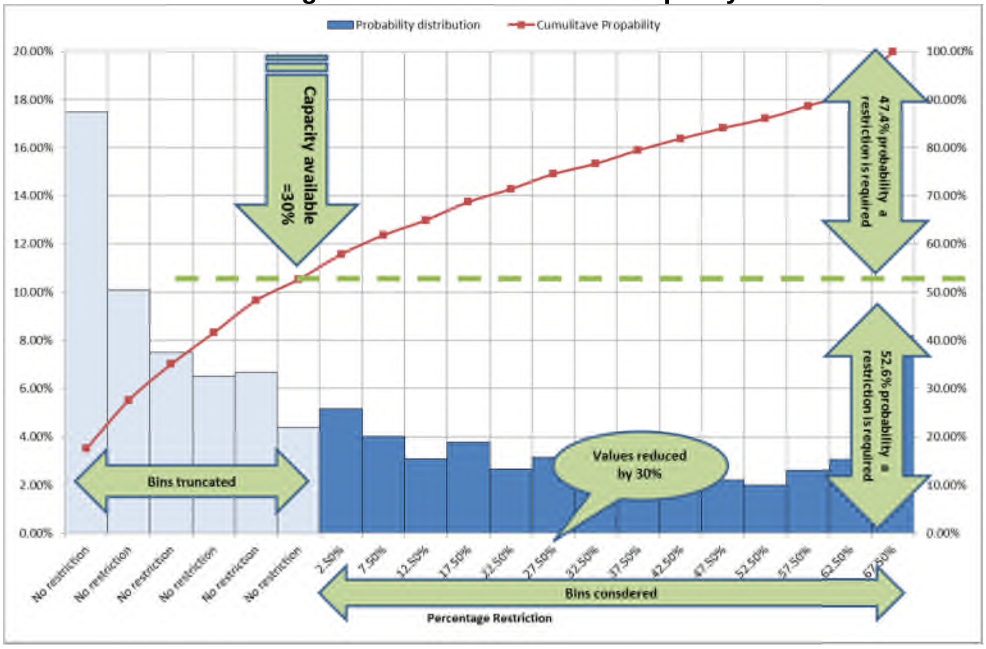


Table 3: Determination of the average Power Restricted – 30% cpacity available assumed

Output level From	Output level To	Probability	Level of Power Restricted (From)	Level of Power Restricted (To)	% Restriction × Probability
0	5%	17.50%	No restriction		0.00%
5%	10%	10.07%	No restriction		0.00%
10%	15%	7.49%	No restriction		0.00%
15%	20%	6.51%	No restriction		0.00%
20%	25%	6.68%	No restriction		0.00%
25%	30%	4.39%	No restriction		0.00%
30%	35%	5.17%	0	5%	2.5% × 5.17% = 0.13%
35%	40%	4.03%	5%	10%	7.5% × 4.03% = 0.30%
40%	45%	3.10%	10%	15%	12.5% × 3.10% = 0.39%
45%	50%	3.79%	15%	20%	0.66%
50%	55%	2.67%	20%	25%	0.60%
55%	60%	3.14%	25%	30%	0.86%
60%	65%	2.16%	30%	35%	0.70%
65%	70%	2.82%	35%	40%	1.06%
70%	75%	2.41%	40%	45%	1.02%
75%	80%	2.20%	45%	50%	1.05%
80%	85%	1.99%	50%	55%	1.04%
85%	90%	2.62%	55%	60%	1.51%
90%	95%	3.06%	60%	65%	1.91%
95%	100%	8.20%	65%	70%	5.54%
Average Power Restricted= Σ (% Restriction × Probability)					16.77%

With 0% capacity available, the probability that the power output is below the capacity available is 0% and the average Power Restricted is equal to the average output of the plant as given in Table 1 for the windfarm and in Table 2 for the CCGT.

With 50% capacity available, the probability that the power output is below the capacity available is 68.73% for a windfarm during winter months, 87.16% for a windfarm during summer months, and 70% for a CCGT all year round. The calculations of the average Power Restricted with 50% capacity available are shown in Table 5 for the windfarm and in Table 6 for the CCGT.

The total number of hours associated with the system conditions that might trigger restrictions for the configurations considered were calculated using the outage information given in Section 4. This includes the time at which the system is expected to operate at N-1 condition for all configurations and the time at which the system is expected to run intact for Variation 1.3 only. 0% coordination was assumed to take place between generator outages and transmission outages. The calculations and the results are shown in Table 7.

Table 8 illustrates the calculation of the average Annual Energy Restricted for the windfarm and the CCGT for all the connection configurations considered.

The values of the Annual Energy Restricted in Table 8 are given in MWh/MW of installed capacity. The total restriction in MWh is calculated by multiplying this value times the installed capacity. The values of the Annual Energy Restricted expressed as a percentage of the expected annual energy yield of the plant are also given in Table 8.

6.4 Observations

A generator with a high load factor, e.g. a CCGT, is more affected by restrictions than a generator with low load factor, e.g. a windfarm.

A generator with a high load factor will see very few benefits from a connection design with some redundancy if this redundancy is not associated with an increase in capacity available at intact conditions.

Where restrictions arise only during outage conditions, the average Annual Energy Restricted is a small fraction of the expected annual energy yield. However, as the capacity of the plant increases, the cost associated with this small percentage increases.

Where restrictions arise at intact system conditions, average annual energy restricted will add up to a significant percentage of the annual expected energy yield.

7 Contractual and Commercial Implications

7.1 Restrictions on Availability

Where the User has requested a Design Variation, the Bilateral Agreement between NGET and the User will include a set of “Restrictions on Availability” clauses. These clauses will cover all operational conditions where the Design Variation limits the User’s ability to generate. The Bilateral Agreement may also include a set of intertipping schemes or any other special automatic facilities that will automatically restrict the output of the User’s plant as required.

If any of the conditions requiring a restriction arises, the output of the User’s plant will be restricted at no cost to NGET with no compensation paid to the User. As a result, the User will be exposed to some loss of revenue due to the reduction in the energy produced, loss of revenue due to being not able to provide Balancing Services, loss of any subsidies (e.g. ROCs), and any additional charges that the Generator incurs due to being out of balance.

Table 4: Capacity Available Under the relevant operational conditions

Variation	Capacity Available	
	Intact	N-1
Baseline design	100%	100%
Variation 1.1	100%	50%
Variation 1.2	100%	0%
Variation 1.3	50%	0%
Variation 2.1	100%	0%
Variation 2.1	100%	50%

Table 5: Probability distribution for the percentage restriction for a windfarm subject to a 50% capacity restriction

Output range		Range of restriction		Probability		% Restriction x Probability	
from	To	from	To	Winter	Summer	Winter	Summer
0%	50%	No curtailment		68.73%	87.16%	0×68.73% = 0%	0 ×87.16%= 0%
50%	55%	0	5%	2.67%	1.87%	2.5%×2.67% = 0.07%	2.5% ×1.87%= 0.05%
55%	60%	5%	10%	3.14%	2.04%	7.5%×3.14% = 0.24%	7.5% ×2.04%= 0.15%
60%	65%	10%	15%	2.16%	1.28%	12.5%×2.16% =0.27%	12.5% ×1.28%=0.16%
65%	70%	15%	20%	2.82%	1.55%	0.49%	0.27%
70%	75%	20%	25%	2.41%	1.21%	0.54%	0.27%
75%	80%	25%	30%	2.20%	1.00%	0.61%	0.28%
80%	85%	30%	35%	1.99%	0.82%	0.65%	0.27%
85%	90%	35%	40%	2.62%	0.94%	0.98%	0.35%
90%	95%	40%	45%	3.06%	0.91%	1.30%	0.39%
95%	100%	45%	50%	8.20%	1.22%	3.90%	0.58%
Average restriction = Σ (%Restriction × Probability)						9.04%	2.76%

Table 6: Probability distribution for the percentage restriction for a 70% load factor CCGT subject to a 50% capacity restriction

Output	Restriction	Probability	% Restriction x Probability
0%	No restriction	30%	0×30% = 0%
100%	50%	70%	50% ×70%= 35%
Average Power Restricted = Σ (%Restriction × Probability)			35%

Table 7: Calculation of the outage duration

		Variation 1.1	Variation 1.2	Variation 1.3		Variation 2.1	Variation 2.2
	Operating condition	**N-1**	**N-1**	**Intact**	**N-1**	**N-1**	**N-1**
Summer	Planned duration of the condition (hours)	2× 336	336	4002	336	2× 168	168
	Expected level of outage coordination	0%	0%	0%	0%	0%	0%
	Unplanned duration of the condition (hours)	2 × 42	42	0	42	0	0
	Total duration of the condition - (hours)	2 × 42 + 2× 336 × (100% - 0%) = 756	378	4002	378	336	168
Winter	Planned duration of the condition (hours)	0	0	4338	0	0	0
	Expected level of outage coordination	0%	0%	0%	0%	0%	0%
	Unplanned duration of the condition (hours)	2 × 42	42	0	42	0	0
	Total duration of the condition - (hours)	2 × 42 + 0 × (100% - 0%) = 84	42	4338	42	0	0
Total		**756 + 84 = 840**	**420**	**8340**	**420**	**336**	**168**

Table 8: Calculation of the average Annual Energy Restricted

		Variation 1.1	Variation 1.2	Variation 1.3			Variation 2.1	Variation 2.2
	Operating condition	**N-1**	**N-1**	**Intact**	**N-1**	**Total**	**N-1**	**N-1**
	Capacity Available	50%	0%	50%	0%		50%	0%
A Typical Windfarm								
Summer	Average curtailment	2.76%	21.94%	2.76%	21.94%		2.76%	21.94%
	Duration of the condition - (hours)	756	378	4002	378		336	168
	Energy curtailed (MWh/MW installed)	2.76% × 756 = 20.87	82.93	110.46	82.93	193.39	9.27	36.86
Winter	Average curtailment	9.04%	36.96%	9.04%	36.96%			
	Duration of the condition - (hours)	84	42	4338	42			
	Energy curtailed (MWh/MW installed)	9.04% × 84 = 7.59	15.52	392.16	15.52	407.68		
Total	Energy curtailed (MWh/MW installed)	20.87 + 7.59 = **28.56**	**98.46**			**601.07**	**9.27**	**36.86**
	Energy curtailed (% of the annual energy production)	**1.1%**	**3.8%**			**23.3**	**0.4%**	**1.4%**
A 70% load factor CCGT example								
	Average curtailment	35%	70%	35%	70%		35%	70%
	Duration of the condition - (hours)	840	420	8340	420		336	168
	Energy curtailed (MWh/MW installed)	35%× 840 = **294**	**294**	2919	294	**3213**	**117.6**	**117.6**
	Energy curtailed (% of the annual energy production)	**4.8%**	**4.8%**			**52.4%**	**1.9%**	**1.9%**

7.2 One-Off Costs

In some cases, a Design Variation will require additional operational arrangements, such as intertripping schemes, that wouldn't usually be required if there were no Design Variation. The costs associated with these operational arrangements are usually charged for as One-Off costs.

In less frequent cases, the Design Variation may require additional investment in transmission equipment that is not required by the baseline design. The costs associated with the additional investment are usually charged for as One-Off costs.

The value of the One-Off Costs will vary from one project to another depending on the scope of the design variation. In many cases these costs are very low in comparison to the capital cost of the project. An estimate of these costs is usually provided to the User as a part of their connection offer.

7.3 TNUoS Charge – Local Tariff

The TNUoS charge for a generator is determined by the capacity of the Generator and three different tariffs. These are a local tariff, a wider tariff, and a non-locational residual tariff. The local tariff comprises a circuit local tariff and a substation local tariff.

Both components of the local tariff are affected by the connection design. The circuit local tariff for a connection that complies with the deterministic criteria of the NETS SQSS is 1.8 times higher than that for connection where a circuit outage results in a restriction. The substation local tariff for a double busbar substation is 1.6 to 2.2 times higher than that of a connection to a single busbar substation.

Further details on TNUoS charge are provided by The Statement of Use of System Charges. This is available online at http://www2.nationalgrid.com/UK/Industry-information/System-charges/Electricity-transmission/Transmission-Network-Use-of-System-Charges/Statement-of-Use-of-System-Charges/.

7.4 Connection Dates

A Design Variation will usually result in a reduction of the scope and capacity of the transmission reinforcements required for the connection. This reduction will potentially facilitate an early completion date.

7.5 Value of a Design Variation

The value of a Design Variation, from a User perspective, is dependent on the balance between the expected financial impacts of restrictions and One Off costs on one side and the saving in TNUoS and any value that can be tagged to the early connection date on another side.

8 Summary

The scope of transmission projects required to connect a new generator is determined via the application of the NETS SQSS. The scope of these projects can be reduced if the User requests a Design Variation. This will generally result in a reduction in TNUoS charge and an early completion date. On the other hand, it will reduce the security of the connection and leave the User exposed to some restrictions on their output.

A methodology for indicative assessment of the Annual Energy Restricted was described. Typical values for the factors affecting this assessment were included.

The data used is generic data that has been used previously by NGET for high level cost benefit analysis. Users may wish to use site specific data if available.

This note is intended to provide guidance and illustrative examples only. There are some observations on the results but no definite conclusions were provided as of what level of security is appropriate for a specific plant.

It is the responsibility of the User to request the level of security and redundancy that is adequate to their plant.