Engineering Report 131

Issue 3 2020

Analysis package for assessing the security contribution from distributed generation and electricity storage systems – Users' guide

First published, July 2006

Amendments since publication

Issue	Date	Amendment
Issue 2	December, 2012	Cosmetic revision of Issue 1 to align with the new ENA Engineering Report (EREP) template and Engineering Recommendation G0 Issue 1 2012 *Rules for structure, drafting and presentation of ENA engineering documents*.
		This issue does <u>not</u> include any principal technical changes.
		Details of all other technical, general and editorial amendments are included in the associated Document Amendment Summary for this Issue (available on request from the Operations Directorate of ENA).
Issue 3	12th June 2020	Revision to align with the changes in EREP 130 Issue 3 and other improvements to make the tool easier to apply using the information typically available to design engineers.
		Expansion of the scope to include Energy Storage Systems based on export profiles).
		- Removal of non-intermittent DG security methodology to align with its removal from EREP 130 Issue 3, such that all generation is considered as being intermittent generation.
		- Inclusion of demand profiles (typically available from SCADA) in place of the previous stylised load duration curve.
		- Inclusion of DG profiles (typically available from SCADA) within the spreadsheet rather than in separate .txt file.
		- Winter and Summer F Factor calculation capability added.
		- F Factor correction factors for the use of 30 minute resolution wind generation data is automatically included

Issue	Date	Amendment
		- Removal of 'shift' generation worksheet to align with the removal from EREP 130 Issue 3. - Updated presentation of calculation of DG security contribution to reflect the terminology in EREP 130 Issue 3. - DG security contribution has been developed to explicitly include the security contribution from Non-contracted ES using export profiles.

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Foreword

This Engineering Report (EREP) is published by the Energy Networks Association (ENA) and comes into effect from the date of publication. It has been prepared under the authority of the ENA Engineering Policy and Standards Manager and has been approved for publication by the GB Distribution Code Review Panel (DCRP). The approved abbreviated title of this engineering document is "EREP 131".

This document replaces and supersedes EREP 131, Issue 2.

It is expected that readers of this EREP are conversant with the requirements in EREC P2/7 [N1] and EREP 130 [N2].

Introduction

This Engineering Report (EREP) describes how to use a spreadsheet, which originally was developed as part of the FES funded project for updating Engineering Recommendation P2/5, to form Engineering Recommendation P2/6. The spreadsheet was further developed during the EREP 130 review in 2018/19 to support the application of Engineering Recommendation P2/7. The updated spreadsheet was used to analyse many DG scenarios and to perform the wide range of sensitivity studies required for the review and update of EREP 130 [N8]. It is anticipated that there could be a need to perform studies in the future either to confirm previously tabulated values or to consider specific DG scenarios that are outside the range of the tabulated results in Annex D of EREP 130 [N2]. Such studies are referred to in Annex D of EREP 130 [N2] as Approach 3.

The spreadsheet described in this EREP 131 is only of a simple form and has not been given either the presentation or user support that would be expected with commercial grade software. It is not commercially supported by ENA. It is structured as a simple spreadsheet, automated by Visual Basic for Application code which an engineer with a reasonable knowledge of the approach can use.

The spreadsheet is intended for use only by those users competent in undertaking assessments as outlined in this document. It is not intended to substitute the users' judgment or review of such assessments as there is no guarantee that the spreadsheet will provide correct and accurate outputs in every case. Hence, the user would be expected to judge the appropriateness of the output from the spreadsheet.

The spreadsheet is offered to users without any technical support, apart from the guidance described in this EREP 131. It is subject to update and amendment when deemed necessary by the Distribution Code Review Panel.

The spreadsheet was updated by Imperial College London as part of the development work for the review of EREP 130 [N8] in 2018/19.

In the spreadsheet the security contribution calculation summates the outputs from multiple DG units before calculating expected energy not supplied (EENS). This is different, and more accurate, than Approaches 1 and 2 described in EREP 130 [N2] where the respective security contributions are summated after the individual EENS have been derived. Another difference between the approaches in EREP 130 [N2] is that contribution values in Approaches 1 and 2 are statistically derived from multiple DG units and different Group Demands while Approach 3 will target specific generation connected to a specific Group Demand.

The spreadsheet can also be used to calculate the security contribution from Distributed Generation and Energy Storage systems (based on profiles).

1 Scope

The purpose of this Engineering Report 131 is to support Engineering Recommendation P2/7 [N1] and Engineering Report 130 [N2] by providing guidance on the use of a software package (hereafter referred to as the "spreadsheet") [N3] developed for assessing the security capability of Distributed Generation (DG), in accordance with Approach 3 in EREP 130 [N2]. The spreadsheet has been further developed to apply consistent principles to the assessment of the security contribution from Electricity Storage (ES) based on the ES export profile.

The spreadsheet can be used to calculate the contribution to System Security, in accordance with EREP 130 [N2] from:

- Non-contracted DG, based on the DG export profile; and

- Non-contracted ES, based on the ES export profile.

The table below summarises the security assessment approach in EREP 130 [N2] and the applicability of EREP 131.

	EREP 130		EREP 131	
	Contracted (EREP 130 Clause 8)	**Non-Contracted (EREP 130 Clause 9)**	**Contracted**	**Non-Contracted**
DG	As per contract	EREP 130 Annex D	N/A	EREP 131 Clause 5 – profile based
ES	As per contract	EREP 130 Annex D	N/A	EREP 131 Clause 5 – profile based

2 Normative references

The following referenced documents, in whole or part, are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

[N1] ENA Engineering Recommendation P2/7, System of Security, 2019.

[N2] ENA Engineering Report 130, Guidance on the application of Engineering Recommendation P2, Security of Supply, 2019.

[N3] ENA Engineering Report 131 Spreadsheet, Issue 3, 2020.

[N4] Electricity Act 1989.

[N5] The Electricity (Class Exemptions from the Requirement for a Licence) Order 2001.

[N6] Review of EREP 130 F Factors Supplementary Report: Guidance on the Application of Modelling Approach for Security Contribution of Energy Storage and Demand Side Response. June 2019. Final report by Imperial College London.

[N7] Developing the P2/6 Methodology, April 2004. Final report by UMIST for FES. Project DG/CG/00023/00/00.

[N8] EREP 130 Review, February 2019. Final report by Imperial College London.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE: Defined terms are capitalised where they are used in the main text of this report.

3.1
Contracted
bilateral agreement between a DNO and party providing System Security from a DG facility, a DSR Scheme or an ES facility

[ENA EREP 130, Clause 3.5]

3.2
Declared Net Capability (DNC)
declared gross capability of a DG plant, measured in MW, less the normal total parasitic power consumption attributable to that plant

[ENA EREP 130, Clause 3.6]

NOTE 1: Declared Net Capability (DNC) as used in this Engineering Report should not be confused with declared net capacity (DNC) as used in the Electricity Act [N4] and Statutory Instrument 2001 3270 [N5].

NOTE 2: For the purpose of this definition the term "parasitic power consumption" refers to the electrical demand of the auxiliary equipment, which is an integral part of the DG, essential to the DG's operation. For the avoidance of doubt "parasitic power consumption" does not include demand supplied by the DG to an on-site customer.

NOTE 3: The DNC of Intermittent Generation is taken as the aggregate nameplate capacity of all the units within the DG plant, less any parasitic load.

3.3
Distributed Generation (DG)
generating plant connected to the distribution network, where a generating plant is an installation comprising one or more generating units

[ENA EREC P2/7, Clause 3.5]

3.4
Electricity Storage (ES)
storage facility connected to the distribution network which, behaves as DG when exporting power to the distribution system and, behaves as a Demand Facility when consuming electrical power from the distribution system

[ENA EREP 130, Clause 3.12]

NOTE 1: An example of an ES is a battery installation (treated as a Demand Facility when charging and DG when discharging).

NOTE 2: DG is differentiated from ES as it does not store energy.

NOTE 3: ES is a form of 'other means' as referred to in ENA EREC P2/7.

3.5
Non-Contracted
absence of a bilateral agreement between a DNO and party providing System Security from a DG facility, a DSR Scheme or an ES facility

[ENA EREP 130, Clause 3.19]

3.6

Persistence (T_m)

the minimum time for which output from Intermittent Generation must be continuously available for it to be considered to contribute to System Security

[ENA EREP 130, Clause 3.21]

4 Spreadsheet structure

4.1 Spreadsheet structure

There are four key worksheets embedded within the spreadsheet. This section summarises the function of each worksheet.

1   The 'Read Me' worksheet refers the user to EREP 131 for guidance on how to use the spreadsheet

2   The 'F Factor Profiles' worksheet contains input and output for the calculation of the security contribution from DG and ES based on the demand and export profiles. It contains a Recalculate button for calculating a F Factor once the input data has been entered or revised.

3   The 'Demand Profiles' worksheet contains the demand profiles for use in the calculations.

4   The 'Generation Profiles' worksheet contains the DG and ES profiles for use in the calculations.

The cells that a user can change are formatted as Style 'Input' and in the spreadsheet these are shaded in orange. Style 'Output' is used for cells containing results and, in this spreadsheet these are shaded in grey with bold characters.

4.2 Requirements

In order to run the spreadsheet, Microsoft Excel 2000 ® or a later version is required. The Spreadsheet Macro security level (via the Tools menu) should be set to medium or less (Microsoft Office Excel 2003). In Microsoft Excel 2010-2016 and Microsoft Excel for Office 365, Click File, Options, Trust Center, Trust Center Settings, Macro Settings and at least select 'Disable all macros with notification'. After making setting changes the spreadsheet needs to be reopened and 'enabling macros' needs to be selected if the 'macros are disabled' message appears.

5 Calculation of the security contribution of Non-Contracted DG and ES using profiles

5.1 Overview of assessment process

The purpose of the spreadsheet is to calculate the F Factor and hence the security contribution from one or more Non-contracted DG or ES installations, which can be used as part of an EREC P2/7 [N1] security assessment. The security contribution calculation is based on:

- The historic observed export from the DG or ES;

- The historic gross demand profile at the point on the network where the security contribution is required;

- The length of time that the security contribution will be required for, e.g. switching time; and

- The timeframe when the security contribution is required, e.g. winter, summer, or annual.

The calculation process can be summarised as follows:

1. Collect the demand profile data, typically from SCADA, and enter it into the 'Demand Profiles' worksheet;

2. Collect the DG or ES profile data, typically from SCADA and enter it into the 'Generation Profiles' worksheet;

3. Check that there is sufficient generation and demand data to cover the timeframe of the security assessment e.g. winter, summer, or annual;

4. Where the security contribution from a mixture of DG types is being assessed, the security contribution from wind generation should be considered separately to the security contribution from non-wind DG, and the security contribution from the wind and the non-wind DG summated, in step 8. The assessment for wind generation (using 30-minute data) needs to be carried out separately as the correction factors (see Clause 5.5) are applied once the security contribution has been calculated;

5. Calculate the DG security contribution using the 'F Factor Profiles' worksheet;

6. Consider whether the probability not delivering the contribution is acceptable;[1]

7. Finalise the security contribution that can be used as part of an EREC P2/7 [N1] security assessment in accordance with the guidance in Clause 9 of EREP 130 [N2]; and

8. Summate the security contribution from wind and non-wind generation, as necessary.

Clauses 5.3 and 5.4 describe the inputs required to and outputs from the three worksheets. Clause 5.5 sets out the correction factors that should be used when 30 minute profile data is used for wind generation. Clause 5.6 presents a worked example.

5.2 Read Me worksheet

Figure 1 shows a screen shot of the 'Read Me' worksheet. This worksheet gives a short description of the requirements for calculating the DG and ES F Factors using:

- the DG and ES export profile; and

- the gross demand profile at the part of the network where the security contribution is being assessed.

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[1] The 'Probability of delivering contribution' is an output from the calculation; there is no direct means of assessing whether a lower DG security contribution could be delivered with a higher, more acceptable, degree of confidence. It is possible, however, to manually reduce the DNC of the DG or ES and retain the DG or ES profile, which may result in a smaller F Factor, but delivered with a higher degree of confidence.

Where the security contribution from wind generation is being assessed, five-minute export data should ideally be used for accurate results, however in many cases only 30-minute export data will be available and in this case correction factors are used. The correction factors were calculated as part of the analysis documented in the Developing the P2/6 Methodology report [N7] and are reproduced in Clause 5.5. These correction factors are applied in the spreadsheet when the 'Wind (five-minute correction factor applied)' option is selected in the DG or ES drop down menu on the 'F Factors Profile' worksheet, and where the 'Sampling rate (minutes)' field in the 'Generation Profiles' shows that 30-minute data is provided. See section 5.4.

Contribution to System Security from Non-Contracted DG and ES

The contribution to system security from non-contracted distributed generation (DG) and Electricity Storage (ES) can be calculated using this spreadsheet. Section 9 of the ENA Engineering Report 130, Issue 3, 2019 provides guidance and refers reader to Annex D where three potential assessment approaches are defined. Approach 3 refers to this spreadsheet.

Approach 3 relies on a set of input data as described in EREP 131 user's guide:
- Demand profile for period of interest
- DG and/or ES profiles for period of interest
- Period of interest (all available data, winter or summer season)
- Persistence (see EREP 130 Table D.2.3 for indicative values and Section E.3)
- Number of states (typically between 11 and 1001; recommended 101)

For compatibility with the legacy approach, wind farms may need to be specified separately from other DG technology types in order to apply wind profile resolution correction factors. The correction factors are applied if only wind generation technology types are specified with 30 minute profile resolution.

Figure 1 — Read Me worksheet screenshot

The demand profile is entered in the 'Demand Profiles' worksheet, as described in Clause 5.4.

The relevant DG and ES information is entered in the 'Generation Profiles' worksheet as described in Clause 5.4.

The results of the F Factor calculation are presented in 'F Factor Profiles' worksheet, which is described in Clause 5.3.

5.3 F Factor Profiles worksheet

A screen shot of the worksheet is shown in Figure 2. The input cells are identified in an orange colour.[2] The input data is described below.

In the 'Demand profile index or name' field a demand profile index (integer) or a name (string) should be specified. The gross demand profile corresponding to the part of the network where the security assessment is being assessed should be specified in the 'Demand Profiles' worksheet, see Clause 5.4. Any negative values in a demand profile are ignored.

In the 'Persistence, hours' field the required persistence time (T_m) in hours should be specified. See EREP 130 Table D.2.3 and Section E.3 [N2]. When using the spreadsheet the persistence

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2 The input cell colour depends on the colour defined by the Microsoft Excel Input cell style.

time applicable to the scenario being considered should be entered irrespective of whether the DG is considered to be intermittent or non-intermittent, or ES profiles are being assessed.[3]

In the 'Season (all data, winter or summer)' field, the timeframe for which the F Factor is required should be selected.

If 'All data' is selected, then all the provided profile periods will be used to calculate the F Factor.

Where an annual F Factor is to be calculated 'all data' should be selected and 12 months' worth of data should be included in the 'Generation Profiles' and 'Demand Profile' worksheets. Further guidance on the profile data requirements is provided in Appendix 2.

If 'winter' or 'summer' is selected, then the calculation is based on the appropriate season provided that there is sufficient demand and generation profile data available in the 'Generation Profiles' and 'Demand Profiles' tabs respectively. The summer period refers to 1 May – 31 August; the winter period refers to 1 November – 28 February. Further guidance on the profile data requirements is provided in Appendix 2.

In the 'Demand and generation number of states' a number between 11 and 1001 should be specified. This number relates to the number of states in the Capacity Outage Probability Table (COPT) – the greater the number of states, the greater the accuracy of the calculation.[4] A value of 101 is recommended as a reasonable balance between accuracy and computation time.

In the 'DG or ES' fields up to ten DG or ES can be specified using cell drop down list (select a desired cell and click on the down arrow). If the F Factor is being assessed for multiple DG or ES) connected to the same part of the network they should be entered individually along with the relevant 'Profile index or name'. A single security contribution will be calculated for all DGs and ESs connected to the demand group. It is important to note that where the security contribution from a mixture of DG types is being assessed, the security contribution from wind generation (based on export data other than five-minute data) should be considered separately to the security contribution from non-wind DG, and the security contribution summated manually outside the spreadsheet.

In the 'Profile index or name' field a profile should be specified for each DG and ES by an index (integer) or a name (string). DG (excluding Wind), Wind and ES profiles are specified in the 'Generation Profiles' worksheet, see Clause 5.4. Any negative values in a DG profile are assumed to be zero. Where the security contribution from a wind generation installation is being assessed, and the wind generation profile sampling rate is 30 minutes, it is important that the Wind option (rather than the DG (excluding Wind) option) is selected from the drop down menu. This will ensure that the sampling rate correction factor will be applied.[5]

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[3] Selecting a non-zero value for T_m when assessing the security contribution from non-intermittent generation results in a more accurate calculation of the F Factor, although the improvement in accuracy will be marginal. When assessing the security contribution from intermittent generation a T_m value is required. For consistency it is recommended that an appropriate value for T_m is used in all cases.

[4] Further information on the Capacity Outage Probability Table can be found in Developing the P2/6 Methodology [N7] and Appendix 1.

[5] If the DG option is selected for the assessment of wind generation and 30-minute SCADA data is used, the correction factors (Clause 5.5) will not be applied and the calculated security contribution will be greater than it should be.

Demand profile index or name	D1
Persistence, hours	3 hours
Season (all data, winter or summer)	Winter
Demand and generation number of states	101
DG or ES	Profile index or name
DG (excluding Wind)	DG 1 (kW)
ES	ES 1

Please click the Recalculate before reading the results	Recalculate

Contribution		
Aggregate DNC of installed DG and ES	16.0	MW
Maximum value of demand	16.0	MW
Contribution (%)	**88.0%**	
Contribution (MW)	**14.1**	**MW**
Probability of delivering contribution	95.1%	
Probability of not delivering contribution	4.9%	
Expected energy not supplied per total DNC	4.9	MWh/MW

Figure 2 — F Factor Profiles worksheet screenshot

After data has been entered press the Recalculate button to obtain the results. Changing any of the input cells will delete the results, and the Recalculate button must be pressed again. In order to ensure consistency of the results with the input data it is strongly recommended that the Recalculate button is pressed before reading the results. The results of the security contribution calculation are described below.

The 'Aggregate DNC of installed DG and ES' field represents the aggregate DNC of the DG and ES connected within the demand group.

The 'Maximum value of demand' field represents the peak value of the scaled demand profile. This field is set within the spreadsheet to be aggregate DNC of the DG and ES. The value does not relate to the demand on the network being assessed (it relates to the load duration curve of the network being assessed which is scaled, for use in the calculation, to match the aggregate DNC of the DG and ES) and is provided for reference only.

The 'Contribution %' and 'Contribution MW' fields shown in **BOLD** are the evaluated contribution to system security from the DG and ES expressed as a percentage of the aggregate DNC of DG and ES connected i.e. the F Factor and is also expressed in MW. Where the security contribution of multiple DG is being assessed, the calculated security contribution is for the group of DGs which might be greater than the sum of contributions of individual DG security contributions.

The 'Probability of delivering contribution' field represents the cumulative probability of those states in the Capacity Outage Probability Table (COPT)[6] that are capable of supplying the evaluated contribution. This represents the probability that at any point in time the security contribution shown in the 'Contribution' fields will be that value or greater, based on the DG and ES profiles; for example, the probability that the DG export will be equal to or greater than the calculated security contribution value. The counterpart field, 'Probability of not delivering contribution', is the complementary value.[7]

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[6] Further information on the Capacity Outage Probability Table can be found in Developing the P2/6 Methodology [N7] and Appendix 1.

[7] The 'Probability of delivering contribution' is an output from the calculation; there is no direct means of assessing whether a lower DG security contribution could be delivered with a higher, more acceptable, degree of confidence. It is possible, however, to manually reduce the DNC of the DG or ES and retain the DG or ES profile, which may result in a smaller F Factor, but delivered with a higher degree of confidence.

The 'expected energy not supplied per total DNC' field represents the expected energy not supplied (in MWh) during the period of the assessment (e.g. per season) per MW of aggregate DNC of DG and ES connected. It is provided for information only.

Should an input error occur an information box similar to that in Figure 3 will be displayed. The following incorrect data or conditions, if present, will be detected.

1. Specified DG or ES profile could not be found in 'Generation Profiles' worksheet (as shown below);

2. Specified Demand profile could not be found in 'Demand Profiles' worksheet;

3. Persistence is a negative number; and

4. Invalid season reference.

A help message will be displayed within the box associated with the detected error.
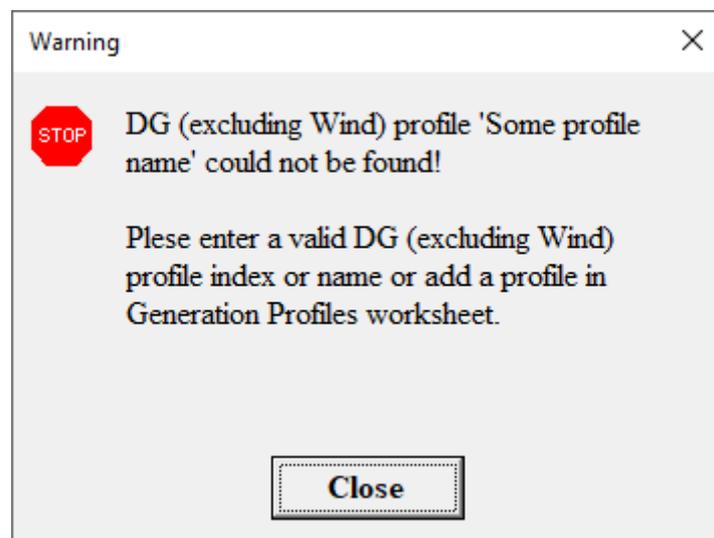
Figure 3 — The error information box

5.4 Demand Profiles and Generation Profiles worksheets

Figure 4 shows part of a 'Generation Profiles' worksheet. The profiles are specified column wise. The first profile is in column two, the second is in column three etc. The 'Demand Profiles' worksheet has the same structure except for the DNC row.

The 'Profile index' field is a sequential index of a profile starting from 1. The profile index is created automatically when a new column of demand data is added and should not be changed by the user.

The 'Profile name' field is a user given profile name which can be used by the user to reference the profile in the 'F Factor Profile' worksheet.

Either the 'Profile index' or 'Profile name' can be used when specifying DG or ES profiles in the 'F Factor Profile' worksheet. See Section 5.3.

The 'DNC, MW' field (in the 'Generation Profiles' worksheet only) is:

- the Declared Net Capability of a DG; or

- the Declared Net Capability export of an ES. This relates to the maximum export from ES, rather than its import capability.

The 'User reference 1' and 'User reference 2' fields can be used as references by the user, e.g. substation or generation site names. They are not used in the calculation.

The 'Sampling rate (minutes)' field contains the sampling rate in minutes for which profile data are inserted below. Where data from a DNO SCADA system is used, this would typically be 30 minutes. Where five-minute data from wind generation along with 30-minute data from a landfill site is assessed, the sampling period for both installations would need to be the same, hence there would be 6 times the number of data items for the wind generator. [8]

The security contribution calculation is based on the Demand Profiles and Generation Profiles being in MW. The 'Unit conversion factor to MW' field contains the factor for conversion of profile values to MW. For example, if the half-hourly profile data is given in kW, MW or kWh the 'Unit conversion factor to MW' field should be 0.001, 1 and 0.002, respectively.

The 'Total export energy, MWh' field contains a spreadsheet formula that sums all export profile values, converted by the conversion factor and sampling rate, giving the total export energy in MWh. It is for user reference and it is not used in the calculation.

The 'Total import energy, MWh' field contains a spreadsheet formula that sums all import profile values, multiplied by the conversion factor and sampling rate, giving the total import energy in MWh. It is for user reference and it is not used in the calculation.

Hence in the case of the values in the 'Generation Profiles' worksheet:

- For DG, the Total export energy, MWh' relates to the energy exported for the period that the profile data relates to; and

- For ES, the Total export energy, MWh' relates to the energy exported for the period that the profile data relates to, and the Total import energy, MWh' relates to the energy imported for the period that the profile data relates to.

When the demand profile data and generation profile data have been populated, the user can check that the demand profiles have an associated 'Total import energy' value, and that generation profiles have an associated 'Total export energy' value.

Users might want to check that the 'Total export energy' and 'Total import energy' values look reasonable:

- For a demand profile, the 'Total export energy' should be zero and the 'Total import energy' should be a relatively high value;

- For a generation profile, the 'Total export energy' should be a relatively high value and the 'Total import energy' should be zero; and

- For ES the 'Total export energy' should be similar to the 'Total import energy', assuming the ES has a high efficiency.

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[8] If only 30-minute data is available for the windfarm, the security assessment would need to be carried out separately, then summated.

The 'Minimum profile value, MW' field contains a spreadsheet formula that finds the minimum profile value and converts it in to MW. It is for user reference and it is not used in the calculation.

The 'Maximum profile value, MW' field contains a spreadsheet formula that finds the maximum profile value and converts it in to MW. It is for user reference and it is not used in the calculation.

The 'Sign' field could be +1 or -1 indicating the sign of the profile values. A sign value of +1 should be used where the demand import profile data / generation export profile is represented by positive values. A sign value of -1 should be used where the demand import profile data / generation export profile data is represented by negative profile values; the spreadsheet will convert such data to align with the data signage convention.

The 'Number of Periods' field represents the number of periods for which profile data is given. The number of profile data items needs to match the value in the 'Number of Periods' field. It is important that the user checks this, as the results could be invalid if the Number of Periods is not equal the number profile data entries.

The 'Start period' field contains the timestamp of the first profile period. Subsequent period timestamps differ by the specified sampling rate. This information is used to select the appropriate data where a winter or summer assessment is carried out.

The 'Demand Profile' and 'Generation Profile' worksheets need to be populated with sufficient profile data so that a meaningful F Factor can be calculated. As a minimum, the following is recommended (refer to Appendix 2 for further details):

- When carrying out a winter or summer assessment, a complete set of demand and generation profile data relating to one assessment season should be entered; and

- When carrying out an 'annual' assessment, a complete set of demand and generation profile data relating to the assessment period, typically one of more years, should be entered.

Data relating to one particular year is considered to be from any year; for example the spreadsheet will calculate a F Factor if the demand profile relates to 2017 and the generation profile relates to 2018; the user will need to consider whether a F Factor calculated from such data would be meaningful, for example, if the demand was materially different in 2017 compared to 2018.

Whilst the spreadsheet does check for some profile data alignment issues, and a message box similar to the one in Figure 3 will be shown for those issues, it is important that the user checks that there is sufficient overlapping data so that a meaningful F Factor can be calculated. Further guidance on the profile data that should be used is given in Appendix 2.

In the 'Demand Profiles' worksheet, the demand profile values should be the gross demand profile at the point on the network where the security contribution is being assessed. The gross demand may need to be calculated, based on the net demand and the export from generation, before being entered into this worksheet.

	A	B	C	D	E	F
1	Profile index	1	3	4	5	
2	Profile name	DG 1 (kW)	DG 1 (MW)	ES 1	DG Wind	
3	DNC, MW	15	15	1	5	
4	User reference	Example DG profil	Example DG profil	Example ES profil	Example DG Wind	
5	Sampling rate (minutes)	30	30	30	30	
6	Unit conversion factor to MW	0.001	1	0.001	1	
7	Total export energy, MWh	113,478	113,478	2,229	17,848	
8	Total import energy, MWh	0	0	2,162	0	
9	Minimum profile value, MW	0	0	-1	0	
10	Maximum profile value, MW	15	15	1	5	
11	Sign	1	1	1	1	
12	Number of Periods	17,520	17,520	17,520	17,520	
13	Start period	30/10/2015	30/10/2015	30/10/2015	01/10/2011	
14	1	14,702	14.7	649	4.968	
15	2	14,662	14.7	-793	4.9255	
16	3	14,669	14.7	301	4.9785	
17	4	14,696	14.7	300	4.9575	
18	5	14,626	14.6	883	4.963	
19	6	14,731	14.7	-288	4.963	
20	7	14,744	14.7	60	4.814	
21	8	14,689	14.7	562	3.75	
22	9	14,594	14.6	70	3.17	
23	10	14,591	14.6	933	2.548	
24	11	14,504	14.5	-702	2.186	

Figure 4 — Screenshot of an example of a profile worksheet; Generation Profiles and Demand Profiles worksheets have the same structure except DNC which is relevant for the Generation Profiles worksheet only

5.4.1 Data entry

Data is input in to the orange[9] cells. The spreadsheet includes data for a number of example profiles. Data relating to the examples can be overwritten, but it is generally better to create new profiles when undertaking a security assessment. The following guidance applies to creating new profiles the 'Generation Profiles' and 'Demand Profiles' worksheets.

- Inserting a profile name into the orange coloured 'Profile name' field in a new column will colour the cells for sampling rate (with a default value of 30), unit conversion factor (with a default value of 1), sign (with a default value of 1), number of periods (blank) and start period (blank). In addition a profile index in Row 1 will be inserted automatically (which is not coloured).

- Inserting a value in the 'Number of Periods' field will colour the relevant number of cells starting from row 14 in the same column. Also, formulas will be inserted into rows 7-10 in the same column (which are not coloured).

- Inserting a value in rows 14 or any cell below will colour the cell in row 2 in the subsequent column prompting user to insert a new profile if desired.

There is no programmatical limit to the number of profiles that can be added, just the number of available columns in Excel and the reduction in speed as the size of the Excel file increases.

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[9] The input cell colour depends on the colour defined by the Microsoft Excel Input cell style.

5.5 Data scaling

In the "Developing the P2/6 Methodology" report [N7] sensitivity studies were carried out with data capture intervals down to one minute in order to understand how short-term fluctuations in wind output would affect the contribution for different values of T_m. From this work, the recommended sample rate to take account of this was deemed to be five minutes. As five-minute data is not generally available, a table of 'Correction Factors' for wind farm contribution, for typical values of T_m, was created and presented in Table 20 of the 'Developing the P2/6 Methodology' report [N7]. This table is replicated in Figure 5.

Wind profile resolution	Correction factors in % for T_m (h) of:						
	T_m(h)	½	2	3	18	24	120
5 min	C_f (%)	97	93	92	85	84	42

Figure 5 — Correction factors from 30-minute data for a single wind farm

Note that the correction increases with T_m.

Where only 30-minute data is available from a windfarm (which is typically the case where the data is derived from SCADA systems), in order to apply the correction factors, the 'Wind' option should be selected in the DG or ES drop down menu on the 'F Factors Profile' worksheet. These correction factors are only applied in the spreadsheet calculation if the security contribution of only wind generation is included in the assessment, i.e. where all the generation being assessed is wind and the 'Wind' option is selected in the DG or ES drop down menu on the 'F Factors Profile' worksheet.

The table below summarises the option in the DG or ES drop down menu in the 'F Factors Profile' worksheet that should be selected depending on the DG types assessed.

Generation types being assessed		Required option in the 'DG or ES' drop down menu
Non-wind		DG (excluding Wind)
Wind – 5 minute data		Wind
Wind – 30 minute data		Wind
Non-wind	& Wind – 5 minute data	Non–wind select: DG (excluding Wind) Wind - 5 minute data select: Wind
Non-wind	& Wind – 30 minute data	Non-wind security contribution and Wind - 30 minute data security contribution need to be assessed separately *
Wind – 5 minute data	& Wind – 30 minute data	Wind - 5 minute data security contribution and Wind – 30 minute data security contribution needs to be assessed separately *

* Where the security contribution needs to be considered separately they should be summated manually outside the spreadsheet.

5.6 Worked Example

Suppose that only one 15 MW DG is connected to a P2/7 Class of Supply C (12-60 MW) demand group. The DG profile is provided as 'DG 1' in 'Generation Profiles' worksheet, see Figure 4, and demand group gross demand profile is provided as 'D1' in the 'Demand Profiles' worksheet. The DG is non-intermittent generation and the security contribution is required to be calculated for the winter season to cater for a switching operation that could take 3 hours to implement i.e. a T_m of 3 hours.

Method

Ensure that the generation profile is provided in the 'Generation Profiles' worksheet. If not, insert a new profile with relevant data like ones shown in Figure 4.

Ensure that the demand profile is provided in the 'Demand Profiles' worksheet. If not, insert a new profile with relevant data. In the 'F Factor Profiles' worksheet enter values in Input cells as shown in Figure 6.

Demand profile index or name	D1	
Persistence, hours	3	hours
Season (all data, winter or summer)	Winter	
Demand and generation number of states	101	
DG or ES	Profile index or name	
DG (excluding Wind)	DG 1 (kW)	

Figure 6 — Screenshot of 'F Factor Profiles' worksheet showing relevant input values for the worked example

Click the Recalculate button and the security contribution together with other relevant parameters will be displayed on the worksheet as shown in Figure 7. In this example, the winter F Factor of the DG is 89.3%, the DNC of DG is 15 MW and the security contribution is 13.4 MW. It is this value that would be used as part of a EREC P2/7 [N1] security assessment. It is worth noting that the probability of delivering at least the security contribution of 13.4 MW is high, at 99.4%.

Contribution		
Aggregate DNC of installed DG and ES	15.0	MW
Maximum value of demand	15.0	MW
Contribution (%)	89.3%	
Contribution (MW)	13.4	**MW**
Probability of delivering contribution	99.4%	
Probability of not delivering contribution	0.6%	
Expected energy not supplied per total DNC	3.1	MWh/MW

Figure 7 — Screenshot of 'F Factor Profiles' worksheet showing contribution results for the worked example

Appendix 1
## (Informative)

Overview of the F Factor calculation methodology

A1.1   General

This appendix provides an overview of the process for calculating a DG F Factor. It is based on the material described in the Developing the P2/6 Methodology report [N7].

A1.2   Step 1 Establish the Capacity Outage Probability Table from the DG export profile

In this example the DG is observed to have 5 distinct output states C1 – C5, which occur in each of the 10 time periods. The time periods would typically be 8760 half hour periods representing one year, and typically more than five capacity states would be considered.
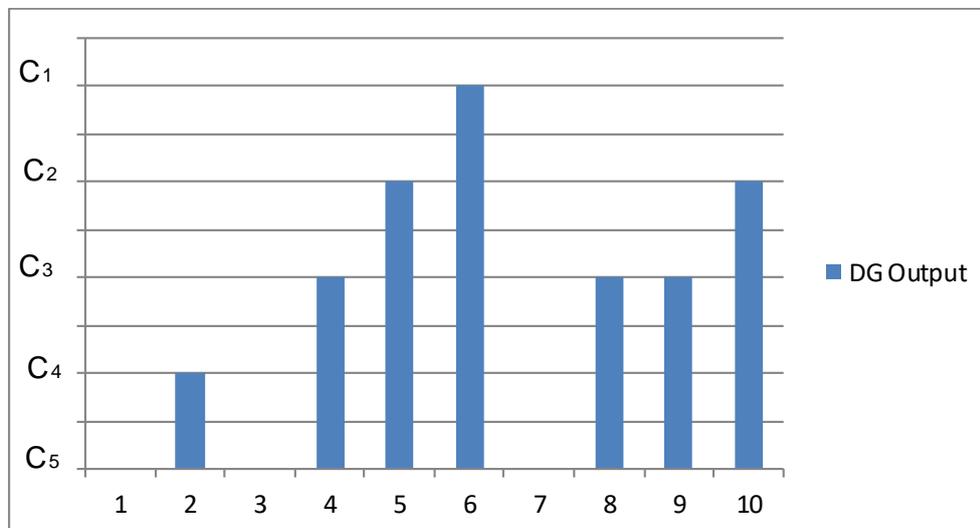
From this the Capacity Outage Probability Table can be established.

Capacity	Probability
C_1	$P_1 = 0.1$
C_2	$P_2 = 0.2$
C_3	$P_3 = 0.3$
C_4	$P_4 = 0.1$
C_5	$P_5 = 0.3$
Total	1.0

Table 1 - Capacity Outage Probability Table

A1.3   Step 2 Calculate the EENS for the DG

The load duration curve for the demand group is shown below. The peak value of the demand is scaled to be the same as the DNC of the DG.
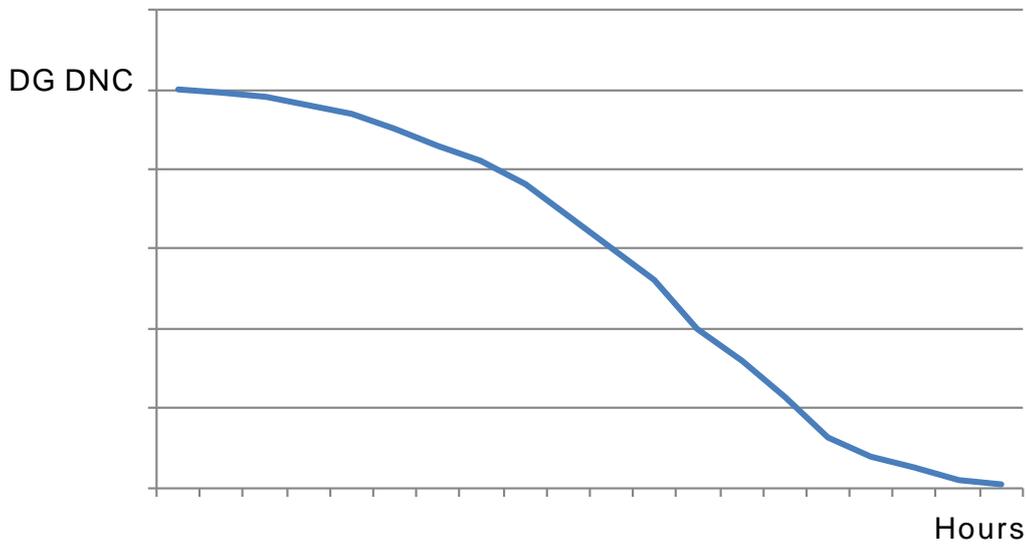
The Energy Not Supplied is then assessed for each of the capacity states C_1 to C_5 in the Capacity Outage Probability Table.
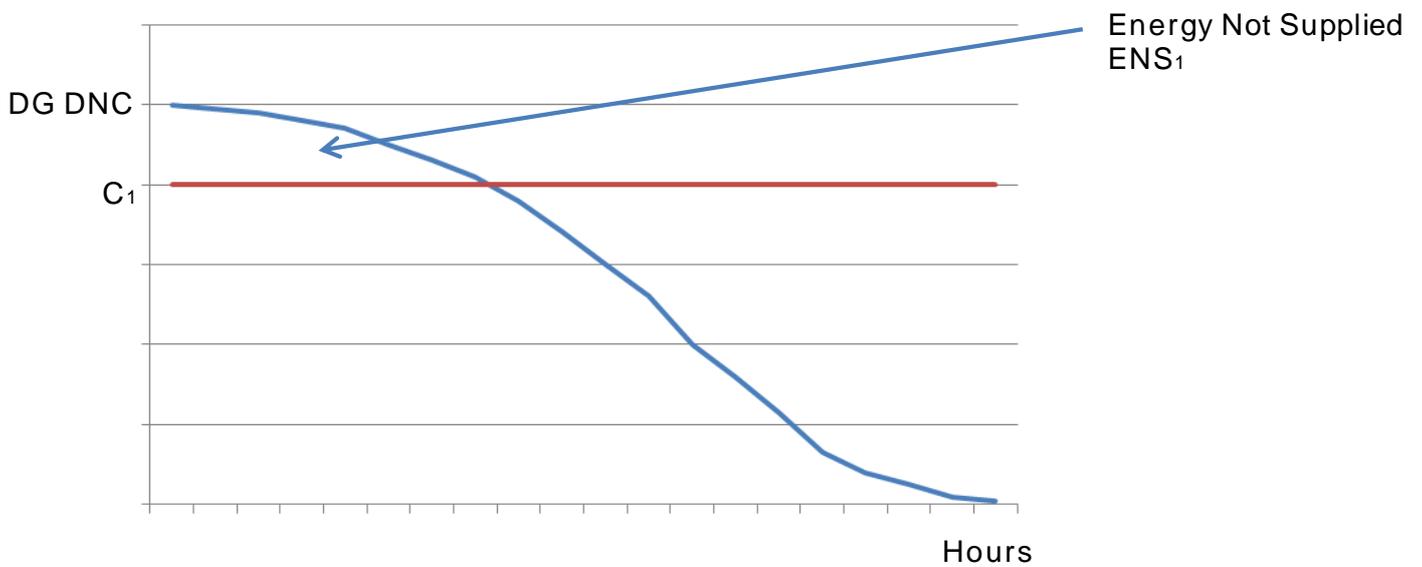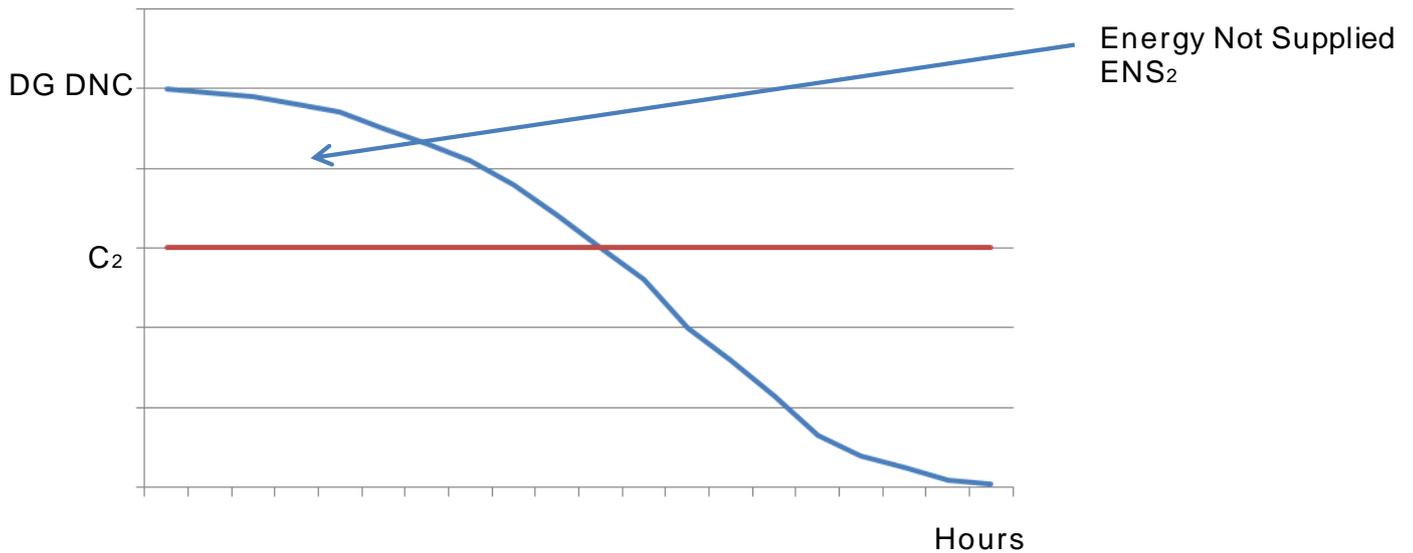
Table 1 is then extended to record the ENS for each of the capacity states C_1 to C_5. These are summated to establish the Expected Energy Not Supplied if the DG was to supply a demand with the same peak value of the DG DNC and with a demand shape defined by the load duration curve of the group demand.

Capacity	Probability		Energy Not Supplied	Expected Energy Not Supplied
C_1	$P_1 = 0.1$		ENS_1	$P_1 \times ENS_1$
C_2	$P_2 = 0.2$		ENS_2	$P_2 \times ENS_2$
C_3	$P_3 = 0.3$		ENS_3	$P_3 \times ENS_3$
C_4	$P_4 = 0.1$		ENS_4	$P_4 \times ENS_4$
C_5	$P_5 = 0.3$		ENS_5	$P_5 \times ENS_4$
Total	1.0			$\sum = EENS$

Table 2 - Extended Capacity Outage Probability Table

A1.4   Step 3 Calculate the circuit capacity with the same EENS

This step is to calculate the capacity of a perfect reliable circuit that, when supplying a demand with a maximum set to the DNC of the DG and defined by the load duration curve of the demand group, has the same Expected Energy Not Supplied.
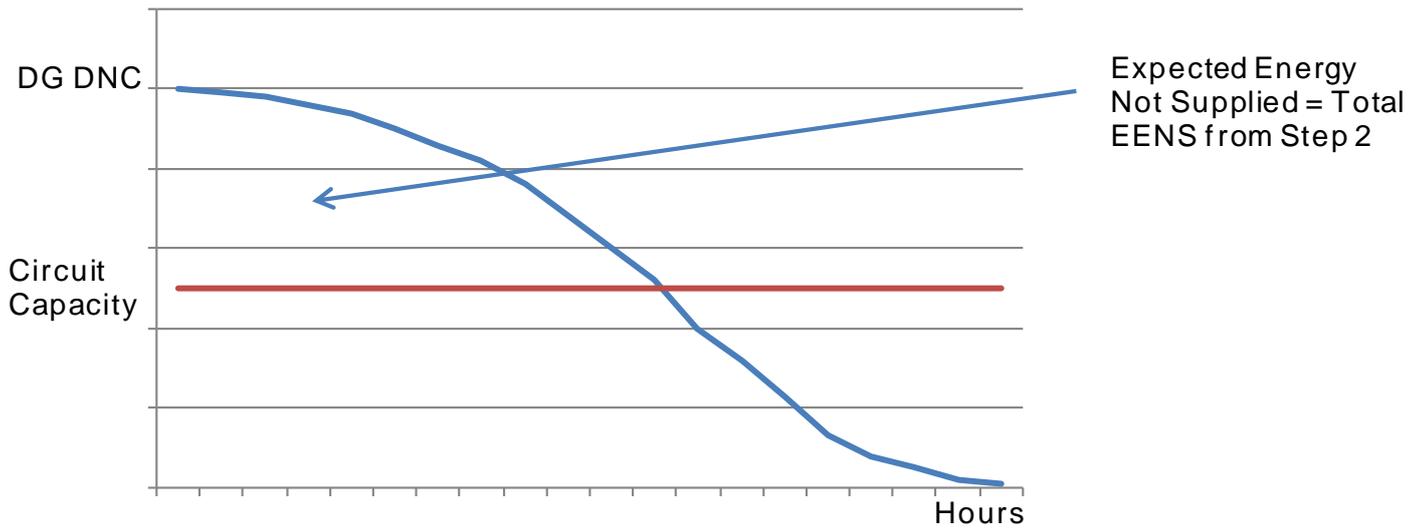
The Circuit Capacity, C_C represents the capacity of a circuit that results in the same EENS as if the DG supplying the demand. The F Factor is therefore:

$$\text{F Factor} = C_C \,/\, (\text{DG DNC})$$

A1.5 Step 4 Calculate the probability that the DG will have an output ≥ CC
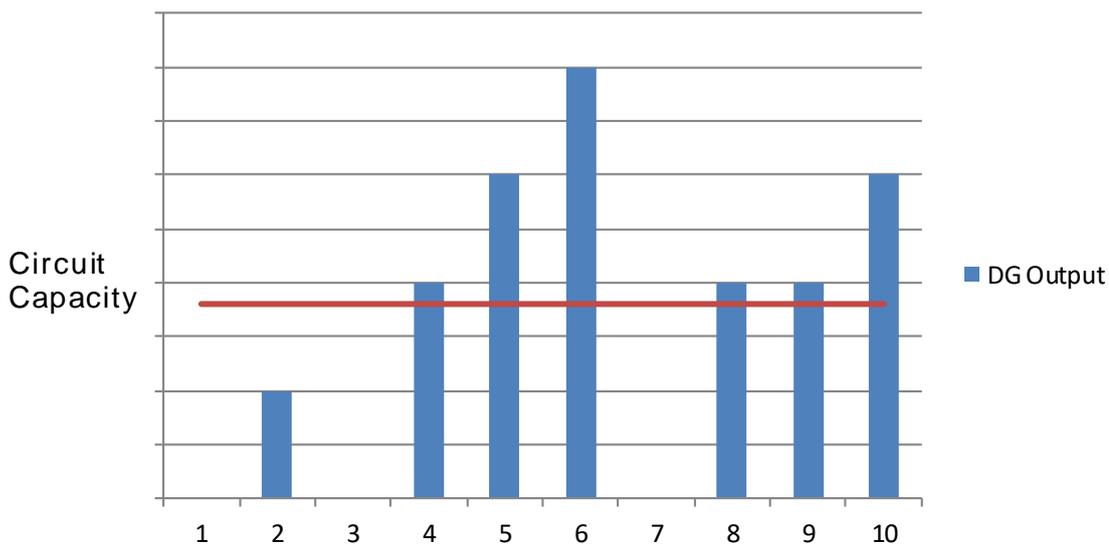
In this case the DG output is at or above the circuit capacity for 6 of the 10 time periods, so the probability that the DG delivers at least the calculated security contribution is 60%.

Note

This four step process is a simplified summary of the process used in the spreadsheet. The process accounts for the persistence time T_m by only considering, in the creation of the

capacity outage probability table, the output from the DG which lasts for the T_m period of longer. If the output doesn't last for T_m, the capacity is considered to be at the next lowest capacity state in the capacity outage probability table, and the test is then repeated.

Appendix 2
(Informative)

Explanation of the data 'overlapping' requirements

A2.1 General

It is important that the demand profile data and the generation profile data used in a F Factor calculation align sufficiently so that a meaningful F Factor can be calculated. The data requirements for a 'summer' and 'winter' security contribution assessment are relatively straightforward, however; an 'all data' assessment is more flexible and enables a more bespoke security assessment to be carried out.

Where the demand profile data set and generation profile data set(s) all have the same start date and end date, the spreadsheet will calculate the F Factor correctly. However, the spreadsheet has the flexibility to accommodate different data requirements, examples of which are described in this appendix.

The examples in this appendix illustrate the data requirements by referring to DG but the requirements apply equally to ES.

A2.2 Winter security contribution assessment

The diagram below illustrates the timeframe for which demand data and generation data is required to calculate a winter F Factor for two generators, DG1 and DG2.

Where data is available for multiple winter seasons, an F Factor can be calculated for each of the winter seasons using the spreadsheet, and the average or lowest manually calculated as appropriate.
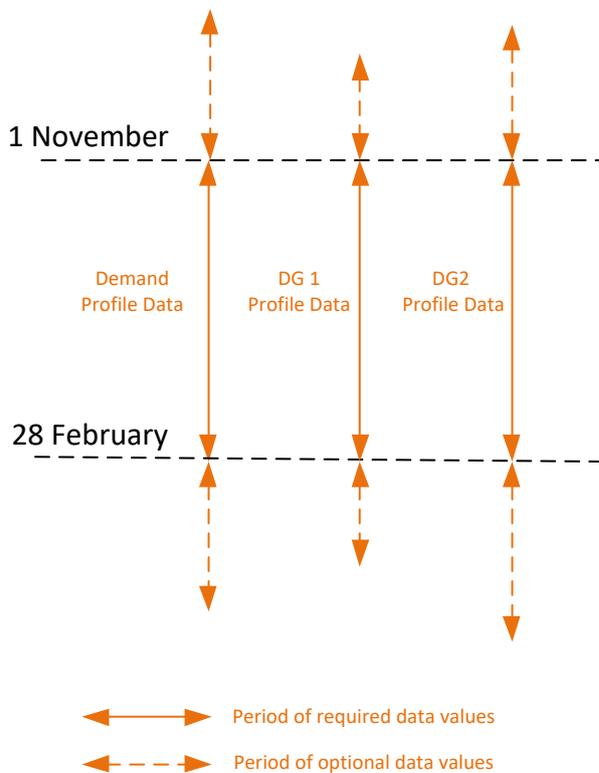

The diagram above illustrates the data sets that can be used to calculate the F Factor, however the spreadsheet can accommodate the following:

- The Demand Profile Data could relate to any year, and does not need to be the same year as the DG Profile Data. However all the DG Profile Data needs to be for the same year;

- If there are two winter seasons in the profile, only the first data set will be used;

- Where the security assessment includes ES, the Demand Profile Data, the DG Profile Data, and ES Profile Data all need to relate to the same year; and

- The sampling rate needs to be the same for Demand and ES Profile Data.

A2.3   Summer security contribution assessment

The diagram below illustrates the period for which demand data and generation data is required to calculate a summer F Factor for two generators, DG1 and DG2.

Where data is available for multiple summer seasons, an F Factor can be calculated for each of the summer seasons using the spreadsheet, and the average or lowest manually calculated as appropriate.
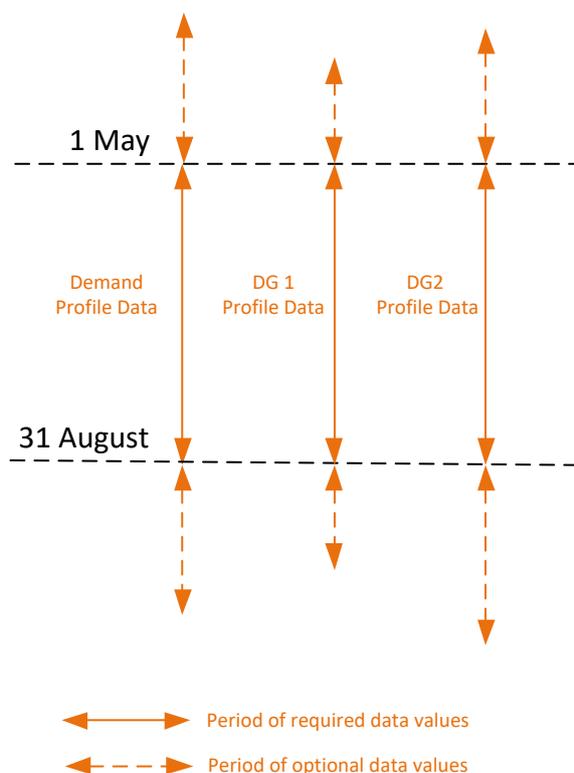
The diagram above illustrates the data sets that can be used to calculate the F Factor, however the spreadsheet can accommodate the following:

- The Demand Profile Data could relate to any year, and does not need to be the same year as the DG Profile Data. However, all the DG Profile Data needs to be for the same year;

- If there are two summer seasons in the profile, only the first data set will be used;

- Where the security assessment includes ES, the Demand Profile Data, the DG Profile Data and ES Profile Data all need to relate to the same year; and

- The sampling rate needs to be the same for Demand and ES Profile Data.

A2.4   Annual security contribution assessment

The diagram below illustrates the period for which demand data and generation data is required to calculate a F Factor for two generators, DG1 and DG2 for a specific 12 month period.

To calculate an annual F Factor, the 'all data' option should be selected in the 'F Factor Profiles' worksheet.
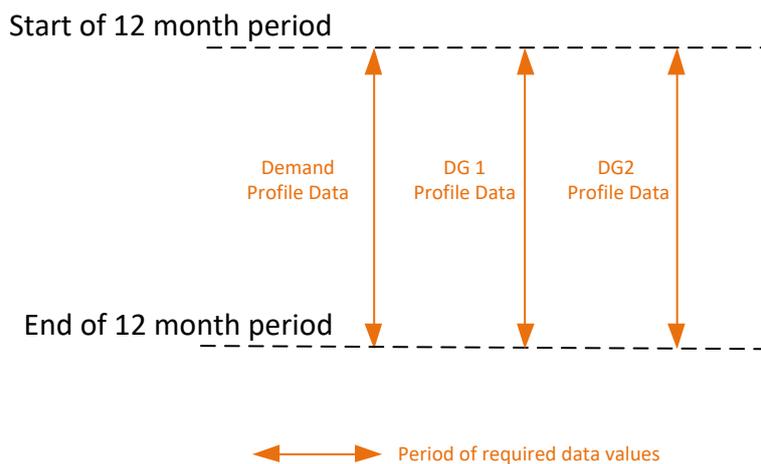
The diagram above illustrates the data sets that can be used to calculate the F Factor, however the spreadsheet can accommodate the following:

- The Demand Profile Data and DG Profile Data could relate to any 12 month period, and do not need to be the same 12 month period.

- Where the security assessment includes ES, the Demand Profile Data, the DG Profile Data and ES Profile Data all need to relate to the same 12 month; and

- The sampling rate needs to be the same for Demand and ES Profile Data.

A2.5   Bespoke security contribution assessment

The 'all data' option can be used to calculate bespoke F Factor assessments including:

- An 'autumn' or 'spring' F Factor, where the security assessment for a defined season is required;

- A 'maintenance period' F Factor, where the security assessment for a defined period of time when maintenance is being planned is required; and

- An 'all year' assessment where data for multiple years is available. In most cases using data from multiple years will give a more robust security calculation, provided that the there are no material changes to the DNO network, demand or generation.

A2.5.1   Spring, Autumn security contribution assessment

The diagram below illustrates the period for which demand data and generation data is required to calculate a spring / autumn F Factor for two generators, DG1 and DG2.
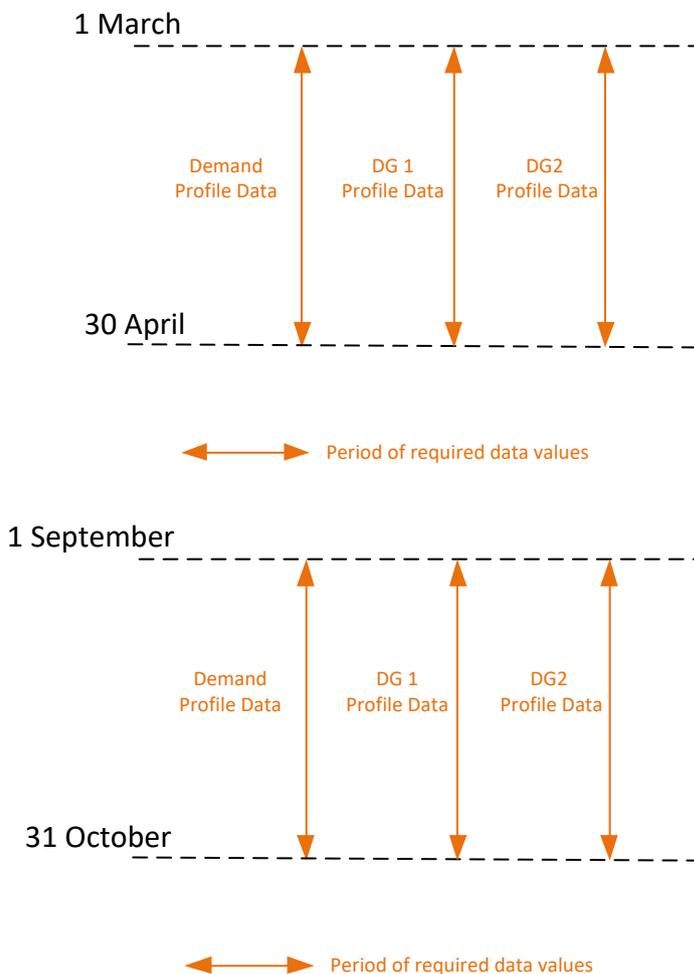

The diagram above illustrates the data sets that can be used to calculate the F Factor, however the spreadsheet can accommodate the following:

- The Demand Profile Data could relate to any year, and does not need to be the same year as the DG Profile Data. However, all the DG Profile Data needs to be for the same year;

- Where the security assessment includes DSR Schemes and / or ES, the Demand Profile Data, the DG Profile Data and ES Profile Data all need to relate to the same year; and

- The sampling rate needs to be the same for Demand and ES Profile Data.

A2.5.2   Maintenance Period security contribution assessment

The diagram below illustrates the period for which demand data and generation data is required to calculate a maintenance period F Factor for two generators, DG1 and DG2.
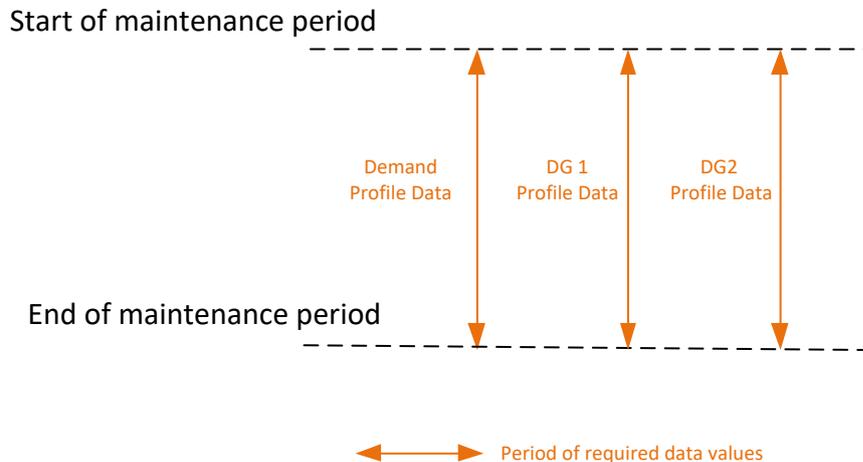
Start of maintenance period

Demand
Profile Data

DG 1
Profile Data

DG2
Profile Data

End of maintenance period

Period of required data values

The diagram above illustrates the data sets that can be used to calculate the F Factor, however the spreadsheet can accommodate the following:

- The Demand Profile Data could relate to any year, and does not need to be the same year as the DG Profile Data. However, all the DG Profile Data needs to be for the same year;

- Where the security assessment includes ES, the Demand Profile Data, the DG Profile Data and ES Profile Data all need to relate to the same year; and

- The sampling rate needs to be the same for Demand and ES Profile Data.

A2.5.3   Multi-year security contribution assessment

The diagram below illustrates the period for which demand data and generation data is required to calculate an annual F Factor using data from multiple years for two generators, DG1 and DG2.
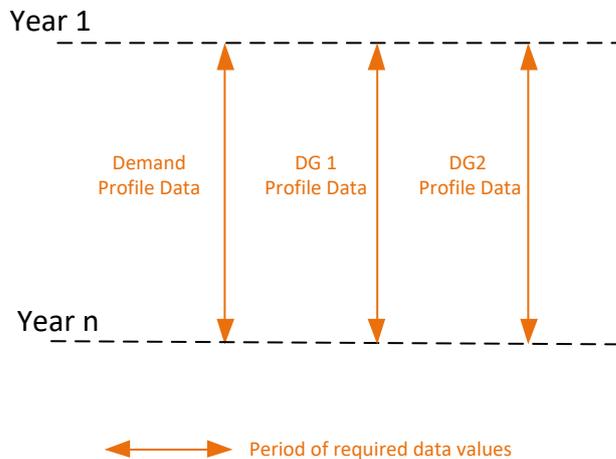
The diagram above illustrates the data sets that can be used to calculate the F Factor, however the spreadsheet can accommodate the following:

- The Demand Profile Data could relate to any number of years (or part of years), and does not need to be the same duration as the DG Profile Data. However, all the DG Profile Data needs to relate to the same start date and end date;

- Where the security assessment includes ES, the Demand Profile Data, the DG Profile data and ES Profile data all need to relate to the same year; and

- The sampling rate needs to be the same for Demand and ES Profile data.