Citipower and Powercor Distribution Loss Factor (DLF) Calculation Methodology for Large Embedded Generators

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Citipower and Powercor Distribution Loss Factor (DLF) Calculation Methodology for Large Embedded Generators

CitiPower and Powercor are responsible for calculating site specific Distribution Loss Factors (DLF's) for generators over 10 MW which are connected to the distribution system, in accordance with clause 3.6.3 of the National Electricity Code.

Citipower and Powercor have hitherto utilised Formula 2 from the "Guidance Paper: Calculation Methodology for Distribution Loss Factors for the Victorian Jurisdiction" published by the Victorian Essential Services Commission on 14th February 2007 ("ESC Formula 2") for this purpose.

The ESC Formula 2 methodology calculates the DLF for large embedded generatorsas:

DLF = 1 + Losses / (Magnitude of sales - generation volume)

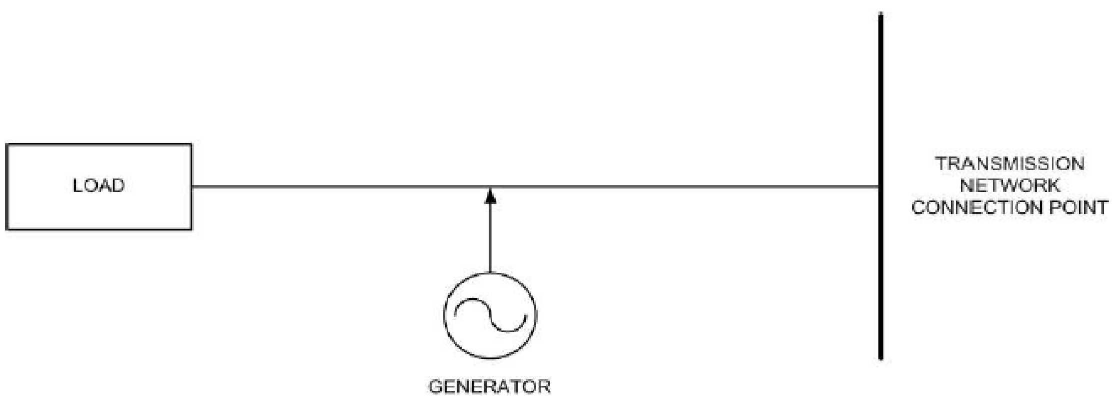
This formula exhibits a singularity at the point where sales volume equals generation volume, which clearly doesn't reflect reality. For specific generation proposals within Citipower/Powercor, this has caused very low DLF's which is impractical and does not incentivise the proponent to commit to the project.

Citipower and Powercor have revised the methodology for calculating DLF's for large embedded generators using an incremental change in losses approach as a more suitable alternative.

The revised Citipower and Powercor methodology calculates DLF for large embedded generators as:

DLF = 1 + (Annual distribution system energy losses without generator – Annual distribution system energy losses with generator) / Annual generation volume

Consider a simple generic connection of a large embedded generator as follows:



The following comments can be made with reference to the generic connection diagram above. In the (hypothetical) situation where generation was always equal to load on the distribution network, energy flow between the generator and the transmission network connection point would be zero, leading to the minimum network loss case and a maximum DLF value. The proposed algorithm above passes this test.

Additionally, in the (hypothetical) situation where generation was always exactly equal to twice the load on the distribution network, then the network losses would be equal with or without generation switched on. The proposed algorithm yields a unity DLF under these circumstances, which would also appear appropriate.

The AER has not published a methodology under the National Electricity Rules, clause 3.6.3 (g)(1), and has advised that they have no concerns with the revised methodology and that CitiPower and Powercor may therefore adopt the revised methodology as an amendment to the former ESV methodology , subject to its publication in accordance with Rule 3.6.3(g)(2).

Henceforth, the algorithm CItipower and Powercor will use to calculate site-specific DLF's for large embedded generators will be:-

DLF = 1 + (Annual distribution system energy losses without generator – Annual distribution system energy losses with generator) / Annual generation volume

Appendix A shows a worked example of the methodology.

CitiPower and Powercor will continue to use the methodology set out in the "Guidance Paper: Calculation Methodology for Distribution Loss Factors for the Victorian Jurisdiction" published by the Victorian Essential Services Commission on 14th February 2007 for calculating site specific DLF's for large customers and Network Average DLF's for general customers and small embedded generators.

Appendix A

Introduction

The application of site specific DLF's for embedded generators is an important part of the electricity market in terms of how these generators should be rewarded for their outputs. Citipower and Powercor have revised the methodology previously adopted in Victoria[1] and will use an incremental approach when calculating the site specific DLF for embedded generators. This approach ensures that the DLF will better reflect the **actual** impact of wind farm in terms of distribution losses.

Consider a 63 MW wind farm connection to a 66kV loop supplied from a 220/66 kV terminal station and, in turn, supplying one 66/22 kV zone substation as shown below in Figure 1

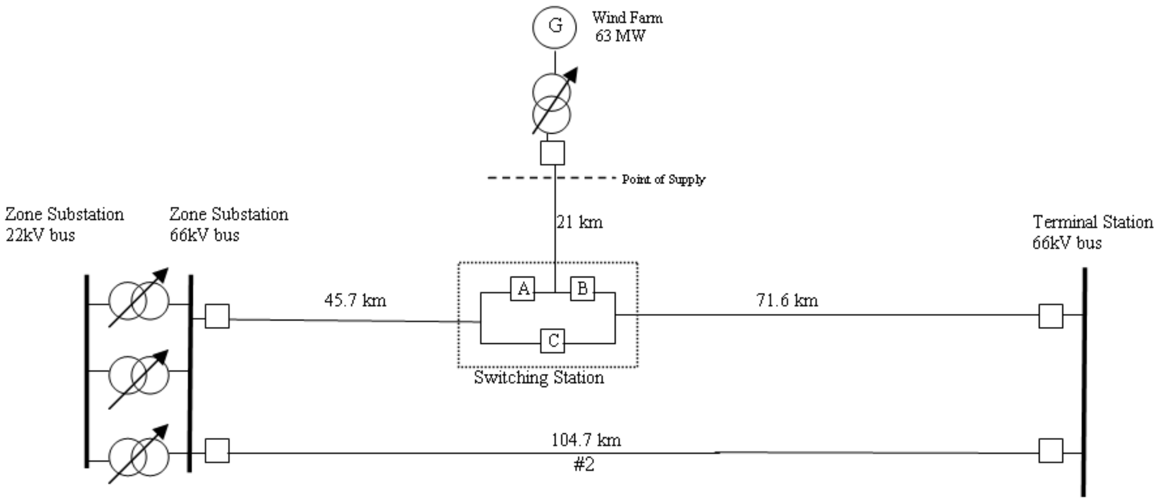


Figure 1: Connection arrangement for a 63 MW wind farm.

Method

Step 1 - Establish Loss Characteristics of the Distribution Network

- The zone substation annual load duration curve is shown below in order to extract useful information

[1] Refer to section 2.1 of the Essential Services Commission's "Guidance Paper: Calculation Methodology for Distribution Loss Factors (DLFs) for the Victorian Jurisdiction" dated 14 February 2007.

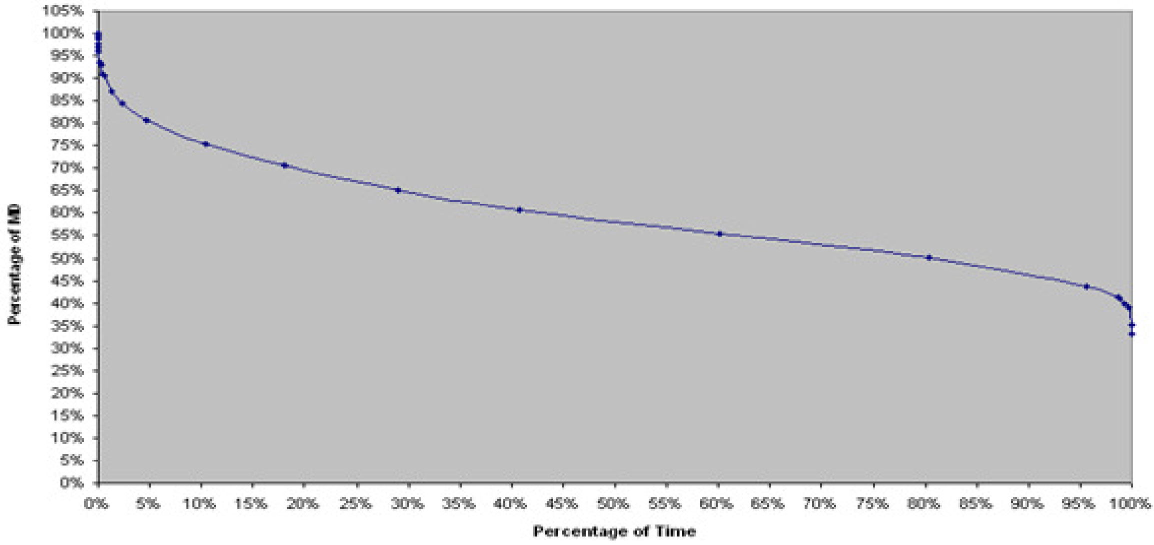


Figure 2: Zone Substation Load Duration Curve

- The equal area criterion was used to estimate the total loss energy across the whole year.
- Using this method the following Demand/Duration weighting factors were extracted:

Demand	Duration
87%	3%
78%	6%
72%	9.5%
62%	48%
49%	33.5%

Table 1: Proposed weighting to be used for load flow analysis

- These values can be used to adequately represent losses on 66kV system for the whole year.
- Hence, the demand/duration weighting values from table 1 can be plotted on the load duration curve as show in figure 3 to emulate a representation of losses at any given load.

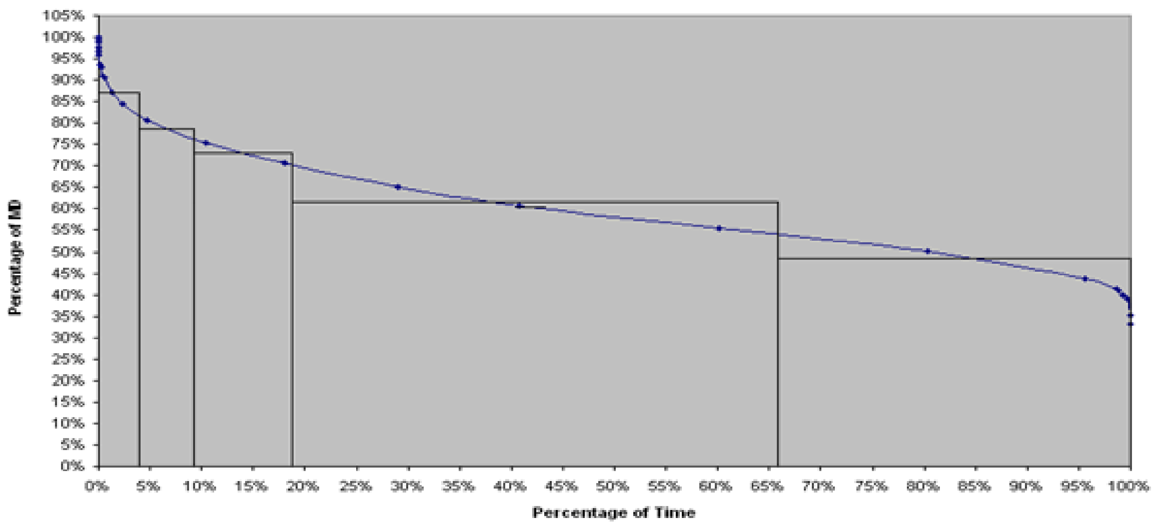


Figure 3: Correct loss equivalence representation

- A generation duration curve, as shown in figure 4, represents the percentage of time that generation level is exceeded.

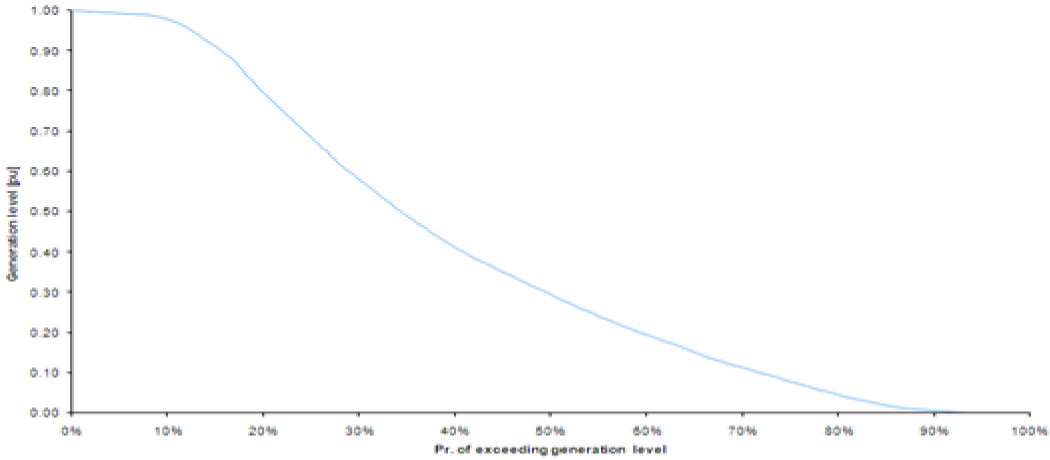


Figure 4: Generation duration curve

The annual generation volume equals the area underneath the generation duration curve shown in Figure 4 above and for this example = 212.474 MWh

- Equal area criterion was once again used in order to determine various combinations of the wind farm output.

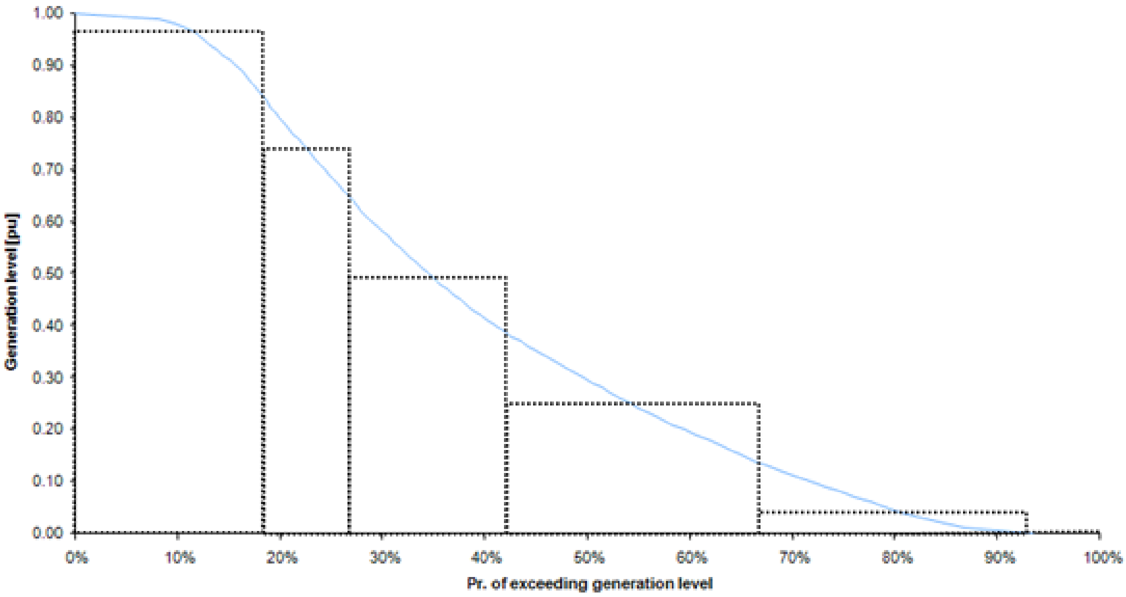


Figure 5: Generation duration curve weighting factors using the equal area criterion

- Hence, the generation duration weighting can be extracted as follows:

Generation	Duration
0%	7%
5%	26%
25%	25%
50%	15%
75%	9%
96.5%	18%

Table 2: Generation duration weighting

- So using the values from table 1 and 2 it can be seen that a total of thirty different studies must be conducted in order to determine the losses on the 66kV system.

Results

- Load flow analyses were conducted for each scenario and the absolute 66kV power loss results (in MW) were obtained and tabulated as shown below in table 3.

		WIND FARM OUTPUT					
		0%	5%	25%	50%	75%	96.5%
	Weighting	7%	26%	25%	15%	9%	18%
ZONE SUB LOAD 87%	3.0%	3.26	3.26	1.86	2.47	5.13	9.31
ZONE SUB LOAD 78%	6.0%	2.43	2.53	1.37	2.38	5.49	9.51
ZONE SUB LOAD 72%	9.5%	2.06	2.07	1.18	2.26	5.42	9.68
ZONE SUB LOAD 62%	48.0%	1.45	1.49	0.89	2.32	5.76	10.03
ZONE SUB LOAD 49%	33.5%	0.90	1.00	0.65	2.33	5.99	10.59

Table 3: Absolute power losses for the wind farm

- The following three steps have been used in order to determine the Distribution Loss Factor (DLF) using the incremental approach.

Step 2 - Calculate Distribution Losses without Generation

- From table 3 the average energy loss ***without*** generation can be calculated by multiplying each weighting factor by its corresponding 0% generation power loss as shown in Table 4:

Weighting	0% Generation	Demand Loss (MW)
3.0%	3.26	0.0978
6.0%	2.43	0.1458
9.5%	2.06	0.1957
48.0%	1.45	0.6960
33.5%	0.90	0.3015
		1.4368

Table 4: Calculation of the annual average demand loss without generation

Therefore, average demand loss without generation is 1.4368 MW. Annual energy loss ***without*** generation is given by multiplying this value by the number of hours in a year (8760 hrs):

Annual Energy Loss *without* generation = 1.4368 * 8760 = 12,586 MWh

Step 3 - Calculate Distribution Losses with Generation

- The weighting factors for each combination of wind farm output and zone substation load were calculated and are shown below. These weighting factors represent the percent of time a given combination of wind farm output and zone substation load might occur.

		WIND FARM OUTPUT					
		0%	5%	25%	50%	75%	96.5%
	Weighting	7%	26%	25%	15%	9%	18%
ZONE SUB LOAD 87%	3.0%	0.0021	0.0078	0.0075	0.0045	0.0027	0.0054
ZONE SUB LOAD 78%	6.0%	0.0042	0.0156	0.0150	0.0090	0.0054	0.0108
ZONE SUB LOAD 72%	9.5%	0.0067	0.0247	0.0238	0.0143	0.0086	0.0171
ZONE SUB LOAD 62%	48.0%	0.0336	0.1248	0.1200	0.0720	0.0432	0.0864
ZONE SUB LOAD 49%	33.5%	0.0235	0.0871	0.0838	0.0503	0.0302	0.0603

Table 5: Assumed weighting factors

- These weighting factors were then multiplied by the power loss values from table 3. As a result, table 6 shows the demand loss for each combination of zone substation load and wind farm generation.

		WIND FARM OUTPUT					
		0%	5%	25%	50%	75%	96.5%
	Weighting	7%	26%	25%	15%	9%	18%
ZONE SUB LOAD 87%	3.0%	0.0068	0.0254	0.0140	0.0111	0.0139	0.0503
ZONE SUB LOAD 78%	6.0%	0.0102	0.0395	0.0206	0.0214	0.0296	0.1027
ZONE SUB LOAD 72%	9.5%	0.0137	0.0511	0.0280	0.0322	0.0463	0.1655
ZONE SUB LOAD 62%	48.0%	0.0487	0.1860	0.1068	0.1670	0.2488	0.8666
ZONE SUB LOAD 49%	33.5%	0.0211	0.0871	0.0544	0.1171	0.1806	0.6386

SUM = 3.4052 MW

Table 6: Normalised demand loss for the wind farm

- As shown, the average demand loss is 3.4052 MW. Therefore, the annual energy loss with generation is given by multiplying this value by the number of hours in a year (8760 hrs):

Annual Energy Loss with generation = 3.4052 * 8760 = 29,830 MWh

Step 4 - Calculate DLF using the revised approach:

$$DLF = 1 + \frac{(\text{Annual Energy Losses without Generation} - \text{Annual Energy Losses with Generation})}{(\text{Annual Generation Volume})}$$

- Calculated annual energy loss ***without*** generation = 12,586 **MWh from step 2**
- Calculated annual energy loss with generation = **29,830 MWh from step 3**
- Annual estimated generation volume for wind farm = **212,474 MWh**

Therefore, DLF = 1 + (12,586 – 29,830)/212,474

DLF = 0.9188