Evoenergy Distribution Loss Factor Methodology

February 2018

1. Background

The National Electricity Rules (NER) section 3.6.3 requires that Distribution Network Service Providers (DNSPs) must calculate distribution loss factors (DLFs) annually, and have them approved by the Australian Energy Regulator (AER). DLFs are used in the market settlement process and are published on AEMO's website at http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Loss-factor-and-regional-boundaries. This document sets out Evoenergy's methodology for the calculation of DLFs in accordance the requirements of clause 3.6.3 of the NER.

2. Evoenergy's Network

The Evoenergy network consists of an interconnected 132 kV transmission network supplying a number of 132/11 kV zone substations and one 66/11 kV zone substation. There are three bulk supply points supplying the Evoenergy network, all owned and operated by TransGrid Limited as follows:

- Canberra 330/132 kV bulk supply substation.
- Williamsdale 330/132 kV bulk supply substation.
- Queanbeyan 132/66 kV bulk supply substation.

Evoenergy's assets include 132 kV transmission lines, 66 kV sub-transmission lines, 132/11 kV and 66/11 kV zone substations, 22 kV and 11 kV distribution feeders, 22/0.415 kV and 11/0.415 kV distribution substations, low voltage 400 V circuits and equipment such as distribution pillars and pits to provide connection points to customers.

11 kV feeders from zone substations supply some customers at high voltage, and distribution customers at low voltage via distribution substations.

In February 2018 there were three generation customers meeting the criteria for Site Specific Customers (SSCs) as set out in NER 3.6.3(b)(2)(i)(A), and two load customers meeting the criteria for SSCs as set out in NER 3.6.3(b)(2)(i)(B). These five customers were all connected to the 11 kV distribution network.

Distribution Loss Factors (DLFs) are calculated at the following voltage levels in accordance with NER 3.6.3(b)(2)(ii):

- Subtransmission, where customers are supplied at 66 kV or higher,
- High Voltage Substations, where customers' connection point is at the 11 kV busbar of zone substations,
- High Voltage Lines, where customers' connection point is on the HV distribution network, typically at 11 kV,
- Low Voltage Substations, where customers are connected directly to the low voltage switchboard of distribution substations,
- Low Voltage Line, where customers are connected to the low voltage distributon network.

Since thers are no Evoenergy customers connected at the Transmission or Subtransmission or High Voltage Substation levels, these DLF values are not published. The calculated value of High Voltage Lines DLF is published as Evoenergy's High Voltage DLF.

Because of the complexities involved with low voltage customer classes and accurately determining their system location the two Low Voltage DLFs, LV Substations and LV Lines are combined and published as a single Low Voltage DLF in line with Evoenergy's practice over many years.

3. Methodology

The methodology for calculation of DLFs documented here is in accordance with the National Electricity Rules, in particular section 3.6.3.

3.1 Use of Form Factor or Loss Load Factor

Traditionally DLFs have been calculated using forecast peak loads and recorded load factors. Loss load factors have then been calculated, estimated or measured from the available data and applied to the peak losses to estimate average losses. This approach suffers from inaccuracies when short term switching in the network results in brief periods of high load.

A more reliable approach using average load forecasts and form factor has been suggested by Leith Elder of the University of Wollongong and is detailed in reference document 1. This approach is preferred and is typically used to calculate average DLFs as described in section 3.3 below. In most cases, comparative calculations using peak load and average load show relatively small differences only in the results.

3.2 DLF Calculations for Site Specific Customers

In February 2018, Evoenergy had two customers connected to its network meeting the SSC criteria of 10 MW of maximum demand or 40 GWh of annual consumption. Both are connected to the 11 kV feeder network.

Input data for the calculation of Site Specific Customer DLFs includes:

- recorded load for the most recently completed financial year,
- forecast consumption in the financial year for the which the DLFs are to apply,
- Advanced Distribution Management System (ADMS) network model of the areas with Site Specific Customer connections.

The input data above allows a calculation to determine the expected losses at forecast peak or average load on the network. Appropriate adjustments, using either loss load factors or form factors, are made to these results to calculate the expected total annual energy losses attributed to each SSC for the financial year in question.

DLFs for SSCs are calculated using the apportionment method, considering losses in both the distribution networks which supply them.

3.3 Average DLF Calculation

Customers who are not classified as SSCs have DLFs calculated on an average basis inaccordance with their level of connection to the network. The four network levels for which DLFs are calculated are:

- High Voltage Substation
- High Voltage Line
- Low Voltage Substation
- Low Voltage Line

In accordance with previous practice in the ACT, only two non-SSC DLFs are published:

- High Voltage, which is identical to the calculated High Voltage Line DLF.
- Low Voltage, which is a weighted average of the calculated Low Voltage Substation and Low Voltage Line DLFs.

Calculation of the all Average DLFs is carried out as part of the same process. A network model, representing Evoenergy's entire network is analysed. This network model represents Evoenergy's network from the bulk supply connection at the 132 kV busbar of zone substations to the low voltage terminals of distribution transformers.

Forecast zone substation peak and average loads for the year for which DLFs are to be calculated are used as inputs to this process. Estimated diversity between the zone substation and bulk supply point load peaks can be calculated from the previous financial year's actual 30 min load profiles for all zone substations.

As discussed above in section 3.1, the DLFs to be applied are normally calculated using losses at average load and forecast form factor. The values obtained using forecast peaks and loss load factor may be used if the appropriate data for average loads cannot be obtained.

The High Voltage Substation DLF represents the losses in the network up to the zone substation 11 kV busbars. Since the connection to the transmission network is at the 132 kV busbar at each zone substation, the only losses accounted for in this DLF are those in zone substation transformers.

$$HV\ Substation\ DLF = 1 + \frac{\sum(Zone\ Tx\ Losses) - \sum(Zone\ Tx\ Losses\ due\ to\ SSCs)}{\sum(Sales\ through\ Zone\ Txs\ ) - \sum(Sales\ to\ Zone\ Tx\ connected\ SSCs)}$$

Since no customers are connected directly to HV Substation busbars in the Evoenergy network, it is not necessary to publish this DLF.

HV Line DLF is calculated using a sample of the distribution network models. Forecast peak loads for all feeders are normally available. Forecast average loads for each feeder may be derived using the recorded load factor of the associated zone substation in the previous financial year, and adjusted proportionally to take into account the forecast total energy sales for the financial year for which DLFs are being calculated. Loss Load Factor and Form Factor values used to calculate DLFs are derived in a similar way.

The formula used to calculate HV Line DLF is:

$$HV\ Line\ DLF = 1 + \frac{\sum(Zone\ Tx + HV\ Line\ Losses) - \sum(Zone\ Tx + HV\ Line\ Losses\ due\ to\ SSCs)}{\sum(Sales\ through\ Zone\ Tx\ \&\ HV\ Lines) - \sum(Sales\ to\ Zone\ Tx\ \&\ HV\ Line\ connected\ SSCs)}$$

In order to perform this calculation, it is necessary to calculate total system losses and sales at HV Substation and HV Line levels. The values for HV Substations are calculated when determining its DLFs above. The values for HV Lines are determined by simple extrapolation from the feeders analysed.
Evoenergy publishes a single Low Voltage DLF which is the weighted average of the Low Voltage Substations and Low Voltage Lines DLFs. There are two parameters that would normally have a large impact on the values of these two DLFs if the two Low Voltage DLFs were calculated separately: these are the relative sales through the two network levels, and the losses incurred through distribution transformers. However, since the two Low Voltage DLFs are combined these two values have no impact on the final published Low Voltage DLF, and they may be chosen arbitrarily. Estimates of 30% of sales at LV Subs and 1% of energy lost through distribution transformers have been adopted.

LV Substations DLF is calculated using the formula:

$$LV\ SubsDLF = 1 + \frac{\sum(Zone\ Tx + HV\ Line + LVSubs\ Losses) - \sum(Losses\ due\ to\ SSCs)}{\sum(Sales\ through\ Zone\ Tx + HV\ Lines + LVSubs) - \sum(Sales\ to\ SSCs)}$$

In calculating the Low Voltage Line DLF, the solar PV generation connected to Evoenergy's network is accounted for. The total forecast solar PV energy is subtracted from the forecast LV Line sales value when calculating the LV Line DLF.

The low voltage line DLF is calculated as the balancing item to ensure that forecast purchase is equal to the product of sales and DLF at each level of the network.

Low Voltage DLF is derived as the weighted average of LV Substation DLF and LV Line DLF.

4. Reconciliation of Losses

In accordance with NER 3.6.3(h)(2), reconciliation of the previous financial year's losses is carried out. This is done by first summating all purchases in MWh, then summating the toal adjusted gross energy which is calculated based on the sales and DLF's that applied in the financial year for which the reconciliation is being planned. SSC sales are accounted for separately using their DLFs as they applied during that year.

Note that small embedded generation, such as roof top solar photovoltaic are not considered to impact on total losses in the network since their energy export is typically consumed in nearby installations. Accordingly, total generation from small PV and other embedded generators is netted out of the sales at low voltage lines.

5. Procedure

Once the DLFs are calculated and reconciled, a report is prepared, detailing the calculated site specific DLFs, together with the average DLFs at each voltage level in the system. This report must be submitted for approval to the Australian Energy Regulator (AER). Once approved, the AER forwards the DLFs to AEMO. The approved DLFs are then published by AEMO on its website by the 1st April each year.

Appendix A. Reference Documents

1. The Problem with Loss Load Factors – Leith Elder, Visiting Professorial Fellow, School of Electrical, Computer & Telecommunication Engineering, University of Wollongong.