Distribution Loss Factor Methodology

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# Table of Contents

1. **Background** 3  
2. **Essential Energy’s Network** 3  
3. **Causes of Losses in Essential Energy’s Network** 4  
4. **Calculation Methodology** 4  
   4.1 Purchase and Sales Data 5  
   4.2 DLF Calculation for site specific customers and Generators 5  
   4.3 Average DLF Calculation 5  
5. **Reconciliation of Losses** 7  
6. **Modification History** 7
1. Background

Distribution Loss Factors (DLFs) are applied to retail energy purchases to account for electricity distribution losses between transmission connection points and end use meters. DLFs must be determined in accordance with the requirements of the National Electricity Rules (the Rules). This document sets out Essential Energy’s methodology for calculating DLFs, in accordance with the principles and requirements set out in clause 3.6.3 of the Rules. Clause 3.6.3 of the Rules can be accessed at: http://www.aemc.gov.au/rules.php

Essential Energy’s DLFs are used by electricity retailers in the market settlement process to add to the energy consumed by the customer, an amount equivalent to the average energy losses for the applicable network price category. Loss factors are not to be applied to network charges and are available on AEMO’s website at: http://www.aemo.com.au/electricityops/0171-0004.html

2. Essential Energy’s Network

Essential Energy’s electricity network can be dissected into seven major system categories: 132 kV lines, 132 kV to 66 kV transformation substations, 66 kV lines, 66 kV to 11 kV transformation substations (“zone substations”), 11 kV lines, 11 kV to 415 V transformation substations (“distribution substations”), low voltage network and customer metering and control equipment.

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 high voltage (HV) distribution network, typically at 11 kV;
> Low Voltage Substations, where customers are connected directly to the low voltage switchboard of distribution substations; and
> Low Voltage Line, where customers are connected to the low voltage distribution network.

In addition to the five average DLFs calculated above, DLFs for site specific customers (SSCs) are calculated in accordance with NER 3.6.3(b)(2)(i) for loads or generators with demand or generation of 10 MW or more, or consumption or generation of greater than 40 GWh forecast in the financial year the DLF is to apply.

Electrical energy enters the network in varying quantities at each voltage. There are 74 connections supplying energy from transmission service providers (TransGrid and Powerlink), ten connections supplying energy from other distributors, and 17 connections to embedded generators.

Energy leaves the network to supply consumers at each voltage level. Approximately 80 per cent of the energy supplied is at a low voltage level (400 V 3-phase or 230 V single-phase).
3. Causes of Losses in Essential Energy’s Network

Losses are the result of electricity being converted to heat due to the conductor’s resistance. The flow through the conductor results in a “pressure” drop which is in direct proportion to the flow. The energy lost is equal to the product of the pressure drop and the flow, which gives rise to the energy lost being proportional to the square of the flow (electrical current). Non-technical losses, such as electricity theft, also contribute to total network losses. Non-technical losses are expected to be relatively minor as a proportion of total losses, and therefore, the calculation of DLFs is based on the total network losses (i.e. both technical and non-technical).

The ability of the conductor to dissipate the heat determines its capacity. Essential Energy builds and maintains its network to provide the most economic balance of asset cost and the cost of losses. Methods used to reduce losses include:

> Using higher voltages to transfer energy over longer distances;
> Making sure the voltage never drops by more than 5 per cent over any part of the low voltage network;
> Replacing low capacity single phase networks that use voltage boosters to maintain voltage, with three phase networks;
> Specifying low loss transformers for all new work;
> Managing peak demand by offering controlled load tariffs and time of use tariffs;
> Rigorous processes in place to reduce theft including inspecting customer switchboards, testing meters where there is an unusual change in consumption, and purchasing meters that report voltage anomalies and tampering; and
> Upgrading transformers that are approaching their load limit.

4. Calculation Methodology

In accordance with the Rules, Essential Energy calculates DLFs based on voltage levels, as described in section 2 above. DLFs are based on the most recently available continuous twelve month’s data, and forecasts for the year in which the DLFs will apply. Essential Energy uses a combination of load-flow samples, purchase and sales data, and engineering data to calculate the proposed loss factors.

The relative loss through each asset category has been assessed by taking a typical subset of the relevant network at typical loadings and calculating the loss percentage. Modern load flow software or similar methodologies are used together with a scaled system load profile. The consumption and apportioned losses of the SSCs is netted off the calculated system totals to derive the correct DLFs at each level.

DLFs for SSCs are calculated individually using accurate models of the network that supplies them and forecasts of their consumption for the financial year for which the DLF will apply, as required by clause 3.6.3 of the Rules.

Finally, losses in the low voltage lines are set as the balancing item. This is done by multiplying forecast annual energy consumption at each network level, and each SSC, by its DLF and comparing the total with the energy that enters the network. The Low Voltage Line DLF is then adjusted so that the forecast losses in the network are achieved. This approach is adopted since there is virtually no direct metering of the energy that enters the low voltage network at the terminals of distribution substation transformers.
4.1 Purchase and Sales Data

The consumption data for each premise connected to Essential Energy's network is extracted from the billing system after all billing for the period has been completed. Only invoices generated within a twelve month period are included. Reversed invoices, demand units and service charge units are excluded. Wherever the days over which the energy was consumed is not 365 days, it is linearly prorated to 365 days.

The purchase data for each supply point is extracted from systems managed by Essential Energy’s meter data agent. The data is extracted as half hour energy, tested for missing data or other inconsistencies, assigned as incoming or outgoing, and summated by voltage level.

4.2 DLF Calculation for site specific customers and Generators

Input data for the calculation of SSC DLFs includes:

- Recorded load for the most recently completed financial year;
- Forecast consumption in the financial year for which the DLFs are to apply; and
- PSS®Sincal network models of the sub-transmission areas with SSC 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, which produces robust results even in highly compensated networks, or the marginal loss factor method as appropriate. The marginal loss factor method of calculating DLF for SSC generators is adopted, since the apportionment method for these customers is often not practical.

In February 2020 an update to Essential Energy’s DLF methodology was introduced. For SSCs with generation, in cases where generator output varies widely through the day (e.g. solar photo-voltaic (PV) installations), a selection of representative system states combining generation output and system load are used as the basis for calculation, rather than the forecast peak or average load used for other SSCs. The selection of representative system states must consider all relevant factors including time of day, time of year, expected operation and availability of plant and be sufficient in number for the average calculation to be reasonably representative of annual losses. The DLFs calculated for each system state are combined by weighted average energy flow to give the final SSC DLF.

This approach provides more accurate DLFs for generators with daily variability, however, as the change to calculating SSC DLFs may be material, a transitional approach to implementation will be adopted. The change will be applied over a three year period, with one third of the change applied to 2020-21 DLFs, two thirds applied for 2021-22 and the full change to be reflected in 2022-23 DLFs.

4.3 Average DLF Calculation

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

- Sub-transmission
- High Voltage Substation
Calculation of the sub-transmission and HV Substation DLFs is carried out as part of the same process. A representative sample of sub-transmission network models is analysed. These network models represent Essential Energy’s network from the bulk supply connection to the zone substation 11 kV or 22 kV busbars.

Forecast zone substation peak loads, and peak load losses in both sub-transmission lines and zone substation transformers are recorded. Where the data are available, average loads and losses at average load are employed. Loss load factors and/or form factors are calculated from recorded load data from the most recently completed financial year. Forecasts of these values are then made for the financial year of interest.

The DLF for the sub-transmission network is calculated using the formula:

\[
\text{Subtransmission DLF} = 1 + \frac{\sum \text{(Subtrans Losses)} - \sum \text{(Subtrans Losses due to SSCs)}}{\sum \text{(Sales through Subtrans)} - \sum \text{(Sales through Subtrans to SSCs)}}
\]

The High Voltage Substation DLF represents the losses in the network up to the zone substation 11 kV or 22 kV busbars. Its calculation is similar to that of the sub-transmission DLF:

\[
\text{HV Substation DLF} = 1 + \frac{\sum \text{(Subtrans + Zone Tx Losses)} - \sum \text{(Subtrans + Zone Tx Losses due to SSCs)}}{\sum \text{(Sales through Zone Txs)} - \sum \text{(Sales through Zone Subs to SSCs)}}
\]

HV Line DLF is calculated using a sample of distribution network models.

Similar methods of deriving forecast peak load and energy sales figures are used as described above in the sub-transmission area. The loss load factor or form factor applied to each zone substation’s distribution is forecast using the best data available.

The formula used to calculate HV Line DLF is:

\[
\text{HV Line DLF} = 1 + \frac{\sum \text{(Subtrans + Zone Tx + HV Line Losses)} - \sum \text{(Subtrans + Zone Tx + HV Line Losses due to SSCs)}}{\sum \text{(Sales through Subtrans + Zone Tx + HV Lines)} - \sum \text{(Sales through Subtrans to SSCs)}}
\]

In order to perform this calculation, it is necessary to calculate total system losses and sales at sub-transmission, HV Substation and HV line levels. This is done by simple extrapolation of the sub-transmission area and HV Line analysis described above. It is also necessary to have data on the split in sales between HV Lines and HV Substations.

The distribution network models include values for both copper and iron losses of distribution transformers, allowing a value for low voltage (LV) substation losses to be determined. In addition, a breakdown of sales at LV Substation and LV Lines is required from sales data, to determine the proportion of LV load which is subject to losses in LV Lines.

LV Substations DLF is calculated using the formula:
\[ LV\ SubsDLF = \frac{\sum (Subtrans + Zone\ Tx + HV\ Line + LVSubs\ Losses) - \sum (Losses\ due\ to\ SSCs)}{\sum (Sales\ through\ Subtrans + Zone\ Tx + HV\ Lines + LVSubs) - \sum (Sales\ through\ Subtrans\ to\ SSCs)} + 1 \]

The impact of solar PV generation connected to Essential Energy’s network must be considered in calculating DLFs. The amount of solar PV energy imported to the network is subtracted from the forecast LV Line sales energy value when calculating the LV Line DLF. This is because most PV energy will be consumed at adjacent premises and generates negligible losses on the network.

The LV Line DLF is calculated as the balancing item to ensure that forecast purchase is equal to the sum of sales times DLF at each level of the network.

5. Reconciliation of Losses

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

Note that small embedded generation export, such as roof top PV 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.

6. Modification History

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<thead>
<tr>
<th>Date</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>February 2019</td>
<td>Wording updated to reflect treatment of non-technical losses, refer to section 3</td>
</tr>
<tr>
<td>February 2020</td>
<td>Updated to reflect more accurate method of calculation losses for SSCs with generation, refer to section 4.2.</td>
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