Distribution Loss Factor Methodology

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essential energy

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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: https://www.aemc.gov.au/regulation/energy-rules/national-electricity-rules/current

Essential Energy's average 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. Site specific DLFs are applied to large loads and generators by AEMO when calculating the energy consumed from or generated into the market.

Loss factors are not to be applied to network charges and are available on AEMO's website at:

https://www.aemo.com.au/energy-systems/electricity/wholesale-electricity-market-wem/data-wem/loss-factors

Loss factors provide an important investment signal regarding the location of the connection, the load and generation connected to each network section and the distance to the nearest transmission connection point.

2. Essential Energy's 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 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 69 transmission connections supplying energy from transmission service providers (TransGrid and Powerlink), ten connections supplying energy from other distributors, and more than 35 connections to large 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 and meter inaccuracies, 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;
- Managing voltage drop within the low voltage network according to appropriate standards;
- 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.

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.

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. Forecasts of all load and generation connected to each subtransmission network (a section of network that connects the Transmission network to Zone Substations, usually at 132 or 66kV) are used in calculating DLFs for SSCs. The load flow modelling is done using forecast half hourly system states.

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. Energy generated from small embedded generation (such as roof top solar) is considered at each supply point. 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. Losses at lower voltages, including those related to small embedded generators, are not allocated to SSCs.

The models of sub-transmission systems used for calculating SSC losses include all connection points in the sub-transmission system, with connection points at lower voltages aggregated to zone substations. This includes all small embedded generators downstream of the zone substation. All loads in the sub-transmission system are captured in the Transmission Connection Point load profile.

The load flow model calculates the losses attributable to each connection point in the sub-transmission system simultaneously for each system state. Exports from small embedded generation into the sub-transmission system will increase the net reverse flow along the feeder to the Transmission Connection Point, which will increase the losses attributable to both the solar farm SSC and the exporting zone substation relative to a system state where rooftop PV is not being exported into the sub-transmission system.

The losses from exports attributed to the low voltage customers downstream of the zone substation are not being allocated to the SSC. These losses are treated separately and will form a part of the lower voltage DLFs.

The likely future increase in two way flows in all network sections will not change the method used for calculating SSC DLFs. Essential Energy maintain the half hourly method is robust for any network flow state.

4.2 DLF Calculation for site specific load and generation customers

Input data for the calculation of SSC DLFs includes:

> Recorded half-hourly load and generation for the most recently completed financial year;
> Half hourly forecast consumption and generation output in the financial year for the which the DLFs are to apply; and

- PSS®Sincal network models of the sub-transmission areas with SSC connections.

The forecast load for the network (excluding SSCs) use previous year's half hourly load multiplied by forecast change in consumption, therefore all intervals are adjusted proportionally. For SSCs, where available individual forecast are used, otherwise the previous year's profile is used.

The input data above allows a load flow simulation to be carried out for every half hour of the target year. This analysis is carried out for each subtransmission network with SSCs connected. A marginal loss factor is calculated at each SSC for each half hour. From this a half hourly DLF is calculated, and all the applicable half-hourly DLFs for an SSC are combined using a MW weighted average to give the overall annual DLF for each SSC.

The addition of generation in weak networks tends to raise the connection point voltage. In cases where the voltage at an SSC connection point is higher than the limits allowed in the NER, reactive power voltage control is added to the network model so that all voltages remain within the applicable limits.

A DLF is calculated from a marginal loss factor using the formula:

$$DLF = \sqrt{1 + (Load\ Factor) * (MLF - 1)}$$

Since spot DLFs (the DLF for each half hour) are calculated for a short time, usually half an hour, the load is assumed to be constant, so that load factor is 1. The formula above can be simplified to calculate spot DLF for one half hour:

$$Spot\ DLF = \sqrt{Spot\ MLF}$$

Each of the spot DLFs can then be combined using MW weighting to calculate the annual DLF:

$$Annual\ DLF = \frac{\sum_{t=1}^{n} Spot\ DLF_t * MW_t}{\sum_{t=1}^{n} MW_t}$$

Where n = the number of half hours in the year.

Using the DLFs calculated in this way it is possible to allocate part of the losses in each subtransmission network to SSCs. The remaining losses are then allocated to the overall average DLF calculation process.

This methodology has been updated in February 2021 to provide more accurate DLFs for generators and large load customers (SSCs). As discussed above, this change means that the DLF for each SSC is calculated using half hourly system states, similar to the method used by AEMO in modelling transmission loss factors. This change was made to provide more certainly and predictability for generators connected to, or in the process of connecting to, Essential Energy's network as a result of feedback from engagement undertaken during 2020 and early 2021.

Essential Energy recognises that the impact to generators and large load customers when a material change in DLFs occurs from year to year may be significant, and will consider transitional arrangements such as phasing in changes over three years.

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

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:

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

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:

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

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:

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

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:

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

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 small embedded generators is netted out of the sales at low voltage lines when calculating average DLFs and taken into account in total load at connection points when calculating DLFs for all SSCs.

6. Modification History

Date	Description
February 2019	Wording updated to reflect treatment of non-technical losses, refer to section 3
February 2020	Updated to reflect more accurate method of calculation losses for SSCs with generation, refer to section 4.2.
February 2021	Updated to reflect change in methodology of using half hourly system states for the calculation of all SSC DLFs.