Methodology Report

Determination of Distribution Loss Factors

10/07/25

Version release history

Release date	By	Summary of changes
30 January 2008	System Development	
3 February 2023	Asset Performance & Planning	Non-substantive changes Refresh of document visuals and DNSP naming Updates to relevant rules and requirements
10 July 2025	Energy Planning	A section added at the end to cater for initial site specific DLF calculations for eligible grid connected batteries and generators prior to commissioning.

Contents

Introduction

The National Electricity Rules (NER)[1] require that a methodology is developed, published, and maintained for the determination of distribution loss factors (NER clause 3.6.3 (g)). The methodology may be developed by the Australian Energy Regulator (AER), but where the AER has not done so, a Distribution Network Service Provider (DNSP) must develop the methodology. This document sets out the methodology developed by Endeavour Energy for its electrical distribution network.

The methodology draws on both the NER requirements, the requirements set out in a Guideline prepared by the Independent Pricing and Regulatory Tribunal of NSW prior to the regulatory responsibility transferring to AER ("Assessment and Approval Process of Distribution Loss Factors proposed by DNSPs", dated November 2007) and the requirements set out in the *AER process for approval of DNSPs DLF calculations for 2012-13 and beyond* section of the AER's *2012-13 Distribution Loss Factor approval process*.

This document updates the document visuals, DNSP name and IT system updates mentioned in the 30 January 2008 version of the methodology report. Pursuant to the 2023 publication of this report, a section has been added to address the calculation of site specific DLFs for qualifying grid connected batteries and generators in advance of commissioning when actual load and generation profile data is not available. No other substantive changes have been made to the methodology described in this report.

[1] This document is based on the Version 193 of the National Electricity Rules (NER).

Overall Methodology

This methodology sets out the process for determining distribution loss factors (DLFs) that can be applied to customer metered energy to recover upstream network losses. In general, loss factors are calculated for each hierarchical level (or tier) of Endeavour Energy's network to apply across the entire Endeavour Energy franchise area.

Losses in the supply network fall into two categories: the first is series losses, which are dependent on the load being supplied, and the second is shunt losses, which are independent of the load, and are confined to the transformers on the network. Both series and shunt losses must be determined and included in this overall loss factors.

Most recent actual load and generation data

In calculating loss factors, actual load and generation data for the most recently completed financial year will be used, in line with NER clause 3.6.3 (h) (5). This means that the data used will be for the financial year two years before the year when the new DLFs will be applied. For example, the calculation of the 2022-23 DLFs utilises the real load and generation data for 2021-2022.

Reconciliation of forecast and actual losses

As required by NER clause 3.6.3 (h) (2), a reconciliation of forecast and actual losses for the previous financial year must be carried out. This involves taking the complete billing data set for that year and applying the DLFs for that year to the data to determine the expected system losses. A comparison between the actual losses as calculated from the billing data and the losses calculated by using the DLFs at each tier of the network is then prepared and included in the DLF proposal report for the coming year.

Identification of connection points requiring site-specific DLFs

In accordance with the NER clause 3.6.3 (b) (2), site-specific DLFs must be calculated for all customers with a consumption of greater than 40GWh and/or peak demand greater than 10MW in one year. Embedded Generators with a peak output of greater than 10MW in one year must also have specific DLFs calculated.

A listing of customers with potential to meet these criteria is obtained from customer records and checked to identify those customers who meet the criteria. The assessment is based on actual data, not forecasts.

The NER also has provisions for a generator with output less than 10MW or 40GWh per year to request and pay the cost of having a site-specific DLF calculated and applied (NER clause 3.6.3 (b1)). Endeavour Energy will calculate a DLF for any customer who makes such a request and agrees to fund the cost involved.

Forward-looking data

The intention in the NER is that loss factors are to be forward-looking, rather than simply based on historical data. There are two elements to consider in achieving this.

Firstly, the actual energy data used for the calculation must be adjusted to take account of forecast load growth. Peak load forecasts are obtained from Endeavour Energy's forecasting group. The metering interval data from the previous financial year is then scaled such that the peak demand matches the forward-looking forecast demand for the relevant customer. However, in recent years, the peak demand growth at most locations has been exceeding the energy growth. Therefore, scaling the metering interval data by the peak demand alone does not produce network loads representative of the coming year. Hence. the forecast metering interval data is also normalised to obtain a load flow energy consumption that matches the forecast energy demand. The scaling factor is determined through an iterative process to achieve the correct forecast energy demand.

Secondly, the data will need to be modified to take account of planned developments in the network, for example transfer of loads to a new zone substation. Data on planned developments is obtained from Energy Energy's planning group. Adjustments to the metering interval data are simulated to reflect the advised plans for network changes.

Treatment of residential solar PV

Rooftop solar is added to the residual energy consumption, which is assumed to be fully consumed in the low voltage network, i.e., no energy flowing into distribution substations and higher. This assumption was made as Endeavour Energy has currently not modelled the low voltage network.

Treatment of theft

Provision must be made in the data for non-technical losses, in particular, electricity theft. Endeavour Energy has identified theft as a separate line item and has taken a value of 0.50% of total sales (as recommended by the former DLF Working Group) and applies this to the calculations. It is assumed that all theft occurs at low voltage and the overall theft apportionment is therefore allocated to the low voltage network.

The adjustments from applying DLFs should equal actual losses

The aggregate of the adjusted gross energy amounts for the distribution network using the DLFs should equal as closely as possible the sum of the measured energy flowing at connection points and the actual losses in the network (clause 3.6.3 (h) (1)).

As part of the calculation, losses are calculated at each hierarchical level of the network. An estimation of total losses in the distribution network is also made. It is then assumed that losses in the low voltage network equal the difference between the total loss estimate and the losses accumulated at each higher level in the network. This approach meets the objective of this requirement.

Customer classes for loss calculation

The NER require that each distribution connection point must be assigned to a class of distribution network connection points based on the location of, voltage of, and pattern of electrical energy flows (clause 3.5.3 (d) and clause 3.5.3 (e)). So far as practicable, this assignment must be consistent with the geographic boundaries of the pricing zones for use in distribution pricing and the voltage levels incorporated within those pricing zones.

Endeavour Energy does not currently apply geographic pricing zones, so connection points are assigned to voltage categories for calculation of DLFs. The categories used are:

- Transmission network (132kV lines)
- Transmission substation
- Sub-transmission network (66kV and 33kV lines)
- Zone substation
- High voltage network (22kV and 11kV lines, sometimes also referred to as medium voltage)
- Distribution substation
- Low voltage network (lines)

The loss factors calculated in this report are to be applied to customers metered energy. Therefore, the energy losses at any level of the network must be expressed as a percentage of the energy delivered at that level of the network, irrespective of whether it is delivered to customers at that level or to customers at lower levels of the network. In a simple hierarchical network this is a matter of starting with the energy supplied from the Bulk Supply Point (BSP) and progressively subtracting loads and losses at each level. Note that the calculation of losses is complicated by the following factors:

- Sub-transmission feeders directly connected to BSPs, bypassing the transmission network and transmission substations
- Zone substations that bypass transmission substations and the sub-transmission network
- Large embedded generation connected at 33kV and 66kV
- Residential rooftop solar

Due to the complicated nature of the network noted above, it is not possible to simply add successive loss factors to arrive at an overall loss factor. Rather, account must be taken of the different paths by which the energy may reach the user.

Consequently, the resulting cumulative loss factors are derived by dividing the network losses attributable to only the tariff customers, within each level of the network, by the energy delivered to that same level of the network.

The applicable proportion of network losses is calculated using the linear estimation of each load flow solution, as described below. Similarly, the delivered energy is derived through a subtraction of the loads and losses at each level.

Calculation of losses

For site-specific (SS) or tariff customers connected to zone substations or higher voltage levels, the loss factor calculations are achieved by calculating the losses attributable to the customer within each hierarchical tier of the network using metering interval data. Endeavour Energy typically uses 15-minute time intervals for metering data, totalling 35,040 intervals for a non-leap year. However, to minimise time, complexity and resource requirements, interval data may be re-sampled to a lower resolution but no lower than 30 minutes to account for variability in intermittent embedded generation. Note that the methodology used by Endeavour Energy, particularly the calculation of loss factors for customers connected at zone substations or higher voltage levels, requires large computational time to complete. Endeavour Energy may resample the metering data to other time intervals but no greater than 30 minutes (to account for intermittent embedded generation) to reduce the complexity of the computation.

From the resulting series of load flow solutions, the DLF for the site-specific or tariff customers can then be determined from the sum of the series and shunt network losses attributable to that customer, divided by the energy consumed by that customer.

The series losses are calculated by incorporating the metering interval data from the previous financial year into the load flow routine. As noted in the *Forward-looking data* section above, this metering interval data is scaled such that the peak demand matches the forward-looking forecast demand for the relevant customer.

For each metering interval, one load flow solution is obtained to determine the total network losses and the accumulated network losses within each hierarchical tier. From this, the loss factor (LF) for tariff customer *K* or site-specific customer *K* is given by:

$$LF_K = \frac{\sum_{N=1}^{T_N} L_{S,K,N} + L_{P,K,N}}{\sum_{N=1}^{T_N} P_{K,N}}$$

where:

K = Loss factor for customer K
N = An interval of the year
T_N = Total number of intervals in a year (e.g., 35,040 for 15-minute intervals)
$L_{S,K,N}$ = Series losses attributed to the customer K for interval N
$L_{P,K,N}$ = Shunt losses attributed to the customer K for interval N
$P_{K,N}$ = Real power demand of customer K for interval N

The proportion of the series network losses that are attributable to the customer is calculated through linear estimation of the load flow solution at each of the metering data time intervals.

Similarly, the proportion of the shunt network losses which are attributable to each customer is calculated in accordance with the relative load placed on that transformer by the customer. Within substations, transformer no-load losses have been calculated from manufacturer's data (where available) as:

$$Shunt\ energy\ losses\ (kWh) = shunt\ losses\ (kW) * 8,760\ (hours)$$

For example, if a transformer in one year supplied 20GWh of network demand and 10GWh site-specific customer demand, two thirds of the transformer's shunt losses would be allocated to the network "pool" and remaining third to the site-specific customer. Since these losses are independent, of the transformer loading, loss load factors (LLFs) are not applied.

Distribution network losses for the 22kV and 11kV systems are calculated by carrying out load flow calculations on each zone substation's distribution network at peak loading and applying appropriate LLFs to estimate the annual energy losses:

$$Series\ energy\ losses\ (kWh) = series\ peak\ losses\ (kW) * 8,760\ (hours) * LLF$$

The peak distribution losses were modelled in the DIgSILENT Power Factory load flow package using location specific demand forecasts. The LLF is the ratio between the instantaneous losses incurred at peak load and the average instantaneous losses over a year. It is based on the square of the load and is calculated as follows:

$$LLF = \frac{1}{T_N} * \sum_{N=1}^{T_N} \frac{P_N^2}{\hat{P}^2}$$

where:

N = An interval of the year
T_N = Total number of intervals in a year (e.g., 35,040 for 15-minute intervals)
P_N = Average real power load for interval N
$\hat{P}$ = Peak interval real power load of the year

Finally, the losses in the LV network are then taken to be the residual losses calculated as the difference in the total projected input energy, including that from Bulk Supply Points (BSPs) and embedded generators and the total billed data in the network.

Calculation of site-specific loss factors

Location specific loss factors are calculated for those customers whose demand exceeds 10MW and/or whose consumption is greater than 40MWh in one year (see the *Identification of connection points requiring site-specific DLFs* section above). The calculations use data specific to each customer's load profile and the assets used to supply them. The losses and energy allocated to the significant customers are then removed from the generic pool. The remaining losses and energy are used to determine the general network loss factors by calculating the pool of losses incurred within a particular level of the network and dividing them by the total energy delivered by that level.

It should be noted that the overall network DLFs take account of the effect of all other embedded generation on the network. Metering interval data for each of these sites is included in the previous load flow calculations.

Embedded generators which generate at a peak greater than 10MW in one year are also allocated a site-specific DLF. The methodology centres on the difference in network losses between the conditions where the generator operating and not operating over an annual cycle. The loss factor for generator *G* is then equal to:

$$LF_G = \frac{\sum_{N=1}^{T_N} (L_{G,O,N} - L_{G,I,N})}{\sum_{N=1}^{T_N} P_{G,N}}$$

where:

LF_G = Loss factor for generator G
N = An interval of the year
T_N = Total number of intervals in a year (e.g., 35,040 for 15-minute intervals)
$L_{G,O,N}$ = Total network losses when generator G is out of service for interval N
$L_{G,I,N}$ = Total network losses when generator G is in-service for interval N
$P_{G,N}$ = Real power generation exported by generator G for interval N

Calculation summary

In summary, the calculation methodologies are presented in the table below. Additional detail on the calculations for each of the tiers of the network is presented in the following sections.

Network element	Voltage level/s	Series losses	Transformer	
			Series losses	Shunt losses
Transmission network (lines)	132kV	Summation of time interval load flow solutions using normalised metering data	-	-
Transmission substation	132kV/66kV 132kV/33kV	-	Summation of time interval load flow solutions using normalised metering data, in conjunction with transformer manufacturer data	Proportional fixed losses from transformer manufacturer data
Sub-transmission network (lines)	66kV 33kV	Summation of time interval load flow solutions using normalised metering data	-	-
Zone substation	132kV/22kV 132kV/11kV 66kV/22kV 66kV/11kV 33kV/11kV	-	Summation of time interval load flow solutions using normalised metering data, in conjunction with transformer manufacturer data	Proportional fixed losses from transformer manufacturer data

Network element	Voltage level/s	Series losses	Transformer	
			Series losses	Shunt losses
HV network (lines)	22kV 12.7kV 11kV	Use of load flow at peak with LLF calculated on metering data	-	-
Distribution substation	22kV/400V 22kV/12.7kV 12.7kV/230V 11kV/12.7kV 11kV/400V	-	Use of load flow at peak with typical LLFs, in conjunction with transformer generic manufacturer data	Proportional fixed losses from transformer generic manufacturer data
LV network (lines)	400V 230V	No calculations performed. Residual energy from above, based on billing data, apportioned to LV network.	-	-

Transmission network (lines)

Endeavour Energy's 132kV network supplies transmission substation, 132kV/22kV and 132kV/11kV zone substations, and 132kV customers. Forecast metering data is used to determine the average time interval line losses using a load flow calculation. This metering data is normalised to account for both the forecast peak demand and the forecast energy consumption from the network.

The 132kV line losses are then accrued from the load flow calculations conducted for each metering time interval. In the case of site specific 132kV customers, the 132kV line losses attributable to that customer are calculated from a linear estimation of the load flow solution, at each time interval.

Transmission Substations

Transformer series losses are calculated by applying the forecast load data to the network load flow model. The transformer losses are then accrued from those obtained in each metering time interval.

Actual shunt losses are used where available for substations. The average shunt losses for the known transformers, as a percentage of rating, are applied to the remainder.

Sub-transmission network (lines)

The sub-transmission line series losses are also calculated by applying the forecast load data to the network load flow model. The line series losses are then accrued from those obtained at this level of the network in each metering time interval.

Zone Substations

As in the case of transmission substations, the transformer series losses are calculated by applying the forecast load data to the network load flow model. The transformer losses are then accrued from the losses in each metering time interval.

Actual shunt losses are used where available for substations. The average shunt losses for the known transformers, as a percentage of rating. are applied to the remainder.

High voltage network (22kV & 11kV lines)

The high voltage peak distribution line losses for the whole distribution network are modelled by applying the forecast peak demands to the DIgSILENT Power Factory load flow model for each of the zone substation networks. The losses for each zone substation network are then calculated using the LLF for that zone substation in the last metering period, applied to the peak line losses of feeders supplied from the zone substation.

In cases where a site-specific customer is supplied by a high voltage distribution feeder, the losses attributable to the general tariff customers are first determined by calculating the LLF for the last metering period, while excluding the site-specific customer from the load flow model. The calculation is then repeated using the site-specific customer's own LLF for the last metering period and a load flow model which excludes the general tariff customers.

Distribution substations

Losses incurred within distribution substations are assessed by using an average load and generic transformer characteristics due to the large number of distribution transformers in the Endeavour Energy network. The numbers of each size of transformer are determined from Endeavour Energy's asset database (SAP).

Transformers of 100kVA or greater are generally fitted with maximum demand indicators (MDIs) and so maximum loadings can be monitored. The latest MDI reading for each individual transformer is used to determine an average utilisation for each transformer category or rating. For those transformers with no corresponding MDI data, a lower utilisation of 50% is assumed.

Low voltage network (lines)

Currently, Endeavour Energy has currently not modelled the low voltage network due to lack of complete load information and modelling data. As the low voltage is not modelled, it is difficult to model low voltage network losses directly. To determine low voltage network losses, total losses are first calculated by subtracting energy purchases from energy sales. All other calculated network losses, including theft, are then subtracted from total losses to give the low voltage network losses.

Energy consumption in the low voltage network is the residual energy calculated by subtracting energy consumption at all other network levels from the total energy imported from BSPs and embedded generation into Endeavour's network. Rooftop solar is also added to the residual energy consumption, which is assumed to be fully consumed in the low voltage network, i.e., no energy flowing into distribution substations and higher. This assumption was made as Endeavour Energy has currently not modelled the low voltage network.

Grid connected Batteries and Generators – initial DLF prior to commissioning

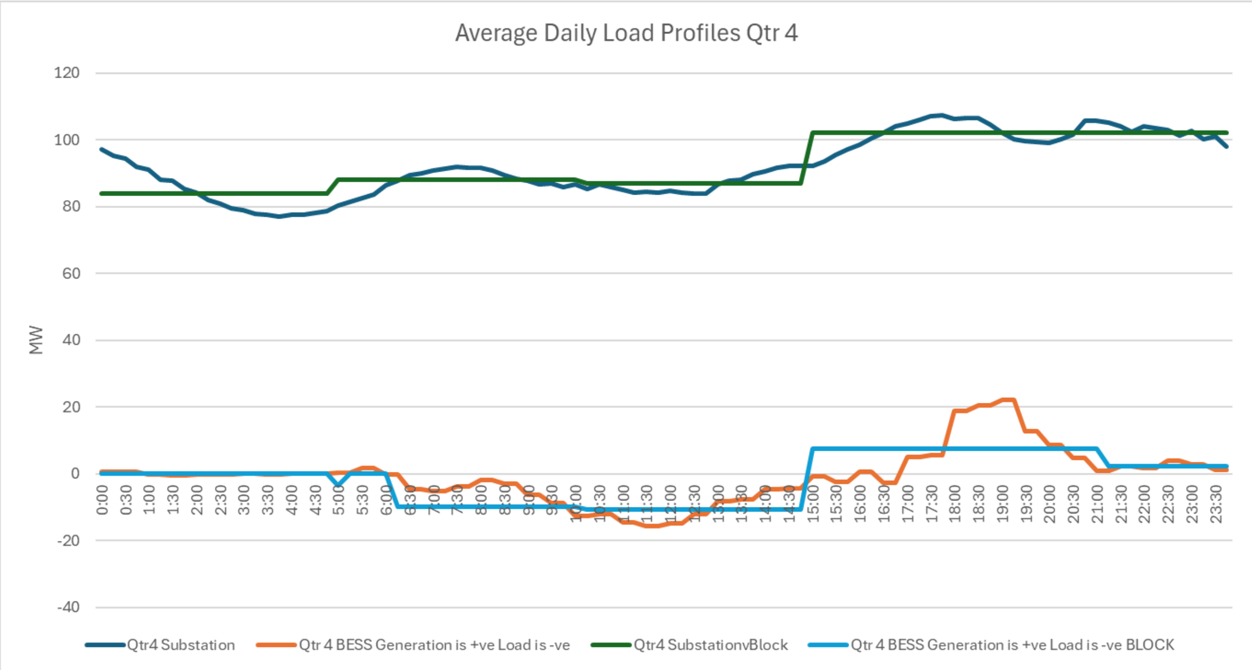
The following methodology is to be used to determine the initial site-specific DLF for an eligible grid connected battery or generator prior to commissioning. Once commissioned and a reasonable duration of interval data is available, the methodology described above in preceding sections is to be followed.

This methodology requires 12 months' worth of load data (MW and MVAr) to be available for the network that the battery/generator is going to connect to. Expected load/generation interval data, ideally provided by the proponent is also required. For the initial DLF calculation one hour average load data is sufficient, although 30 minute or 15 minute data could be used as well.

The average daily load profile (MW & MVAr) for every month of the year is calculated by determining the average load (MW & MVAr) for each of the 24 hours in a day for the month in question. The load data is segregated into four quarters, Q1 to Q4. The average hourly load data is determined for these four quarters to derive an average daily load profile per quarter.

The load/generation profile data is given similar treatment by determining the average daily input and output profile (MW & MVAr) for every quarter of the year by determining the average output/input (MW & MVAr) for each of the 24 hours in a day for the month in question. If MVAr data is not available, the connection point power factor may be used. The load/generation data is segregated into four quarters, Q1 to Q4. The average hourly load data is determined for these four quarters to derive an average daily generation/load profile per quarter.

The average daily load profile with the average daily generation/battery load for each of the four quarters superimposed as shown below. For simplification and to reduce the number of load flows required, the load profile is transformed into load blocks by drawing a line that best fits through the load and generation/battery data, essentially creating block loads and generation/battery values.



Load flow studies are performed for each hour to determine demand losses (MW) on the connecting network with and without the generation/battery for each of the four quarters.

The demand losses are then converted to annual energy losses (MWh) with and without the effect of the generator/battery. This is performed by adding the demand losses for each hour of the day for each quarter and then multiplying by the number of days in the quarter. This gives the energy losses for each of the four quarters. The energy losses for each of the four quarters are then added to obtain the annual energy losses in MWh.

The prospective Site specific DLF is then calculated using the formula:- DLF = 1 + (Annual Energy Losses without Generation/Battery - Annual Energy Losses with Generation/Battery)/(Annual Battery Consumption Volume - Annual Generation Volume).

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