METHODOLOGY FOR THE DETERMINATION OF DISTRIBUTION LOSS FACTORS

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TABLE OF CONTENTS

1 Introduction

The National Electricity Rules[1] require that a methodology is developed, published and maintained for the determination of distribution loss factors (NEM Rules Clause 3.6.3 (g)). The methodology may be developed by the 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 Integral Energy for its electrical distribution network.

The methodology draws on both the NEM Rules requirements and 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).

2 Overall Methodology

This methodology sets out the process for determining distribution loss factors (DLFs) that can be applied to customer's metered energy to recover upstream network losses. In general, loss factors are calculated for each hierarchical level (or tier) of Integral Energy's network to apply across the entire Integral 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 losses and shunt must be determined and included in this overall loss factors.

The methodology used in this report has been altered in some areas compared to that used by Integral Energy in previous years. These changes are outlined in section 2.8, below.

2.1 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 NEM Rules 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. That is, the base data for calculation of 2008-09 DLFs is the data for 2006-07

2.2 Reconciliation of Forecast and Actual Losses

As required by NEM Rules 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.

2.3 Identification of connection points requiring site specific DLFs

In accordance with the NEM Rules Clause 3.6.3 (b) (2) (i), site specific DLFs must be calculated for all customers with a consumption of greater than 40GWh and/or 10MW demand. Embedded Generators with a peak output of greater than 10MW must also have specific DLFs calculated.

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[1] This document is based on Version 18 of the National Electricity Rules (NEM Rules).

A listing of customers with potential to meet these criteria is obtained from Integral Energy's retail business and checked to identify those customers which meet the criteria. The assessment is based on actual data not forecasts.

The Rules also provide 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 (3.6.3 (b1). Integral Energy will calculate a DLF for any customer who makes such a request and agrees to fund the cost involved.

2.4 Forward-looking data

The intention in the NEM Rules 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 Integral Energy's forecasting group. The 15 minute metering 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 data by the peak demand alone does not produce network loads representative of the coming year. Hence, the forecast metering data is also normalised in order 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 Integral Energy's planning group. Adjustments to the metering data are simulated to reflect the advised plans for network changes.

2.5 Treatment of Theft

Provision must be made in the data for non-technical losses, in particular electricity theft. Integral 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.

2.6 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.

2.7 Customer classes for loss calculation

The Rules 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 3.6.3 (d), (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.

Integral Energy does not currently apply geographic pricing zones so connection points are assigned to particular voltage categories for calculation of DLFs. The categories used are derived from those specified by IPART, that is:

- 132kV network (addition to IPART categories)
- Transmission substation
- Sub-transmission network
- Zone substation
- High Voltage network (22 and 11kV, sometimes also referred to as medium voltage)
- Distribution substation
- Low voltage network

The loss factors calculated in this report are to be applied to customer's metered energy. Therefore, the kWh 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 BSP and progressively subtracting loads and losses at each level.

Integral Energy's network is more complicated due to the following factors:

- In some cases, 132/11kV Zone Substations bypass Transmission Substations and the 33/66kV sub-transmission network
- A number of 66kV sub-transmission feeders and 66/11kV zone substations are connected directly to Bulk Supply Point's (BSP) thus bypassing transmission substations, and
- Integral Energy has a significant quantity of embedded generation connected at 33 or 66kV.

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.

2.8 Calculation of losses

In previous years, the method used to calculate series energy losses across the network has been to first calculate the loss on the relevant part of the system under peak load conditions using Integral Energy's load flow package (DINIS). The associated energy losses were then determined from these losses during the time of peak demand by use of an appropriate Loss Load Factor (LLF)

In order to overcome issues associated with the accuracy of peak demand forecasts and changes in network configuration throughout the year, an enhanced modelling approach has been developed in the preparation of the 2008/09 Distribution Loss Factors.

For site specific (SS) or tariff customers (TC) 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 15 minute metering data. 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 15 minute metering data from the previous financial year into the load flow routine. As noted above in section 2.4, this metering 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. During the course of the 2006/07 financial year, there were 35040 individual 15 minute metering data points. Therefore, the loss factor *LF* for TC or SS customer *K* is given by:

$$LF_K = \frac{\sum_{N=1}^{35040} L_{SERIES} + L_{SHUNT}}{\sum_{N=1}^{35040} E}$$

Where:

N is the 15 minute metering interval
LF is the loss factor for the customer
L_{SERIES} is the total series losses attributable to the customer
L_{SHUNT} is the total shunt losses attributable to the customer
E is the energy consumed by the customer during the interval *N*.

The proportion of the series network losses which are attributable to the customer is calculated through linear estimation of the load flow solution at each of the 15 minute 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) x 8760 hours

For example, if one transformer supplied both a 20 GWh pa of network load and a 10 GWh pa customer with a location specific loss factor, the transformer shunt losses would be allocated 2/3 to the network "pool" and 1/3 to the 10 GWh customer. Since these losses are independent of the transformer loading, no LLF is applied.

Distribution network losses for the 11/22kV systems are calculated in the traditional way by carrying out load flow calculations on each ZS network at peak loading, determining a LLF as described below, and thereby estimating the losses from that process. For customers supplied from 11/22kV distribution feeders, the additional distribution series losses are calculated using a LLF for each zone substation. In this case, the distribution series losses are defined as:

Series Energy Losses (kWh) = peak losses (kW) x 8760 hours x LLF

The peak distribution losses were modelled in the DINIS load flow package using location specific demand forecasts for the 2008/2009 year. 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 can be expressed as follows:

$$LLF = \sum_{N=1}^{35040} (\text{load}_N{}^2 / \text{peak load}^2) / 35{,}040$$

where:	35,040	= the number of 15 minute load recordings in one year
	load_N	= the 15 minute average load in the nth period.
	peak load	= the highest 15 minute average load in 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 (BSP) and embedded generators, and the total billed data in the network.

2.8.1 Calculation of site specific loss factors

Location specific loss factors are calculated for those customers whose demand is in excess of 10MW, and/or whose consumption is greater than 40GWh per annum (see section 2.3, 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, such as that at Maribeni (Guildford) and Appin/Tower Collieries. Metering data for each of these sites is included in the previous load flow calculations.

Embedded generators which generate at a peak of >10MW 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:

$$LF_G = \frac{\sum_{N=1}^{35040} \left(L_{GEN\_OUT} - L_{GEN\_IN}\right)}{\sum_{N=1}^{35040} E_G}$$

Where:

- LF_G is the loss factor for the generator
- L_{GEN_IN} is the total network losses when the generator is modelled in service, in accordance with the 2006/07 generation profile
- L_{GEN_OUT} is the total network losses when the generator output is set to zero during the metering interval *N*.
- E_G is the energy sent out by the generator during the metering interval *N*

2.8.2 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	Series Loss	Transformer	
			Series Loss	Shunt Loss
Transmission Network	132kV	Summation of 15 minute load flow solutions using normalised metering data.		
Transmission Substation	132/66/33kV		Summation of 15 minute load flow solutions using normalised metering data, in conjunction with manufacturer's data.	Use of manufacturer's data (fixed losses for each type of transformer)
Sub Transmission Network	66kV, 33kV	Summation of 15 minute load flow solutions using normalised metering data.		
Zone Substation	132/11kV, 132/22kV, 66/11kV, 33/11kV		Summation of 15 minute load flow solutions using normalised metering data, in conjunction with manufacturer's data.	Use of manufacturer's data (fixed losses for each type of transformer)
HV Network	22kV, 11kV	Use of load flow at peak with LLF calculated on metering data where available (or SCADA data)		
Distribution Substation	22/0.415kV, 11/0.415kV		Use of load flow at peak with manufacturer's generic data on impedance and typical LLF for distribution transformers.	Use of generic manufacturer's data (fixed losses for each type of transformer)
LV Network	415/240V	No calculations performed. Residual energy from above, based on billing data, apportioned to LV network.		

Table 1 – Summary of Network Loss Allocation Methodologies

2.8.3 132kV Lines

Integral Energy's 132kV network supplies transmission substations, 132/11kV zone substations and 132kV customers. Forecast metering data is used to determine the 15 minute average line losses using a load flow calculation. This metering data is normalised to account for both the forecast 2008/09 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 15 minute metering 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.

2.8.4 Transmission Substations

Transformer series losses are calculated by applying the forecast 2008/2009 load data to the network load flow model. The transformer losses are then accrued from those obtained in each 15 minute metering 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.

2.8.5 Sub-transmission 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 15 minute metering interval.

2.8.6 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 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.

2.8.7 Medium Voltage Lines (11kV, 22kV)

The medium voltage peak distribution line losses for the whole distribution network are modelled by applying the forecast 2008/09 peak demands to the DINIS load flow model for each of the Zone Substation networks. The losses for each Zone Substation network are then calculated using the 2006/2007 LLF for that zone substation, applied to the peak line losses of feeders supplied from the particular substation.

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

2.8.8 Distribution Substations

Losses incurred within distribution substations are assessed by using an average load and generic transformer characteristics due to the large number (28,585) of distribution transformers in the Integral Energy network. The numbers of each size of transformer are determined from Integral Energy's Asset Database (Ellipse) as at March 2007.

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.

2.8.9 Low Voltage Lines

Due to the lack of load information and modelling data it is not possible to model LV network losses directly. To determine LV 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 LV network losses.