EXPLANATORY NOTE ON EVALUATION OF DISTRIBUTION LOSS FACTORS 2007-2008

30 January 2007

The power is in your hands

TABLE OF CONTENTS

1 Introduction

The National Electricity Rules require that Distribution Network Service Providers (DNSPs) obtain the approval of the Independent Pricing and Regulatory Tribunal (the Tribunal) as the relevant jurisdictional regulator for Distribution Loss Factors (DLFs) for the DNSPs network.

This report nominates the DLFs for Integral Energy's electrical distribution network for the 2007/2008 financial year. It also outlines the methodology, assumptions and base data used for the calculation of the loss factors.

The methodology used in this calculation is based on the requirements set out in the Tribunal's report "Assessment and Approval Process of Distribution Loss Factors proposed by DNSPs for 2007/08", dated December 2006 (the Report). The methodology used is very similar to that used by Integral Energy in previous years but, in line with Section 4.3 of the Report, the "most recently available consecutive 12 month actual load and generation data" has been used in the calculations. Integral Energy has, in past submissions, employed a 3-year average billing data approach. This was considered to be more representative, as it tends to reduce or "smooth out" the impact of variations in billing accruals from year to year where these occur. This submission uses a single year of complete energy data (2005/2006), with no accrual estimates.

The proposed DLFs are "forward looking", as required by Section 4.1 of the Report and use both demand and energy forecast data as provided by Integral Energy's Forecasting Section.

2 Summary of Results

	2007/2008		2006/2007		2004/05 & 2005/06	
Network Level	Effective Section Loss Factor %	Cumulative Loss Factor %	Effective Section Loss Factor %	Cumulative Loss Factor %	Effective Section Loss Factor %	Cumulative Loss Factor %
132 kV Network	0.59%	0.59%	0.62%	0.62%	0.53%	0.53%
Transmission Substation	0.45%	1.04%	0.45%	1.06%	0.52%	1.05%
Subtransmission Network	0.58%	1.83%	0.58%	1.83%	0.60%	1.82%
Zone Substation	0.58%	2.22%	0.61%	2.26%	0.61%	2.27%
High Voltage Distribution Network	0.98%	3.22%	1.19%	3.48%	1.30%	3.60%
Distribution Substation	2.31%	6.39%	2.47%	6.86%	2.48%	6.78%
Low Voltage Distribution Network	1.99%	8.55%	1.64%	8.43%	1.45%	8.33%

Table 1 - Generic Loss Factors

Notes:

1. All % loss factors quoted in the above table are given as the % of energy delivered at that level of the network, whether to customers at that level, or to lower levels.
2. In this study section loss factors do not add numerically to give cumulative loss factors due to the effects of compounding and network configuration.
3. An allowance for theft and non-technical losses of 0.5% of total sales has been made.

Examination of both current (ie 2006/07) and the proposed generic DLFs shows that there is no significant difference between the results. There are, however, some small reductions in the DLFs for Zone Substation, High Voltage Distribution Network and Distribution Substation values. These changes are considered to be a combination of improved load flow techniques and Loss Load Factor (LLF) data, as well as the factoring in of capital works, particularly at the Zone Substation and High Voltage Distribution Network levels. There is a marginal reduction in the proposed DLF for the LV network.

In addition, and in accordance with the National Electricity Rules, all customers with a consumption of greater than 40GWh and/or 10MW demand have had site specific Loss Factors calculated.

Site specific Loss Factors for Embedded Generators with a peak output of greater than 10MW have also been calculated. The methodology for the calculation of these DLFs is based on that outlined in the Discussion Paper “Calculation of Distribution Loss Factors for Embedded Generators”, prepared by United Energy on behalf of the Victorian Distribution Loss Factor Working Group and published on 13 October 2003.

3 Reconciliation of Forecast and Actual Losses

As indicated in Section 4.2 of the Report, a reconciliation of forecast and actual losses has been carried out. This involved taking a complete billing data set, in this instance over two (2) years, and applying the estimated DLFs to the data to determine the expected system losses. This is then compared with the actual losses as calculated from the billing data and a comparison made. The results are shown in Table 2 below.

Financial Year	Forecast Loss kWh	Actual Loss kWh	Difference kWh	Energy Distributed kWh	Forecast error as % of Energy Distributed
2004/05	986,762,741	936,547,686	50,215,055	16,744,384,543	0.3%
2005/06	1,020,888,259	978,559,243	42,329,016	17,204,938,460	0.25%

Table 2 – Reconciliation of Forecast to Actual Losses

Note that financial year 2005/06 is the last complete set of available billing data.

4 Overall Methodology

This report presents loss factors that can be applied to customer’s metered energy to recover upstream network losses. In general, loss factors have been calculated for each hierarchical level 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 losses have been determined and included in this study.

In general, the method used to calculate series energy losses 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), and then calculate the associated energy losses, by use of an appropriate Loss Load Factor (LLF) as:

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

Peak losses were modelled using location specific demand forecasts for the 2007/2008 year. In this round of calculations for Integral Energy’s network, complete modelling of the transmission

(132kV), subtransmission (66kV and 33kV) and distribution (22kV and 11kV) networks has been completed to maximise the accuracy in the loss estimation at each level of the network.

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

LLFs were calculated for all Bulk Supply Points (BSP's), major generators, transmission substations, zone substations and major customers. These LLFs are evaluated using metering data where available at each location, or alternatively, SCADA data where metering data is not available.

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

Since these losses are independent of the transformer loading, no LLF is applied.

Where an asset is shared between the generic system load and a customer, or between more than one customer, that asset's losses have been calculated and allocated in proportion to the energy supplied to each load. For example, if one line supplied both 20 GWh pa of network load and a 10 GWh pa customer with a location specific loss factor, the line losses would be allocated 2/3 to the network "pool" and 1/3 to the 10 GWh customer.

In accordance with the National Electricity Rules location specific loss factors have been calculated for those customers whose demand is in excess of 10MW, and/or whose consumption is greater than 40GWh per annum. 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.

Embedded generators which generate at a peak of >10MW have also been allocated a site specific DLF. As stated previously, the methodology for this is derived from the paper "Calculation of Distribution Loss Factors for Embedded Generators", prepared by United Energy (Victoria) on behalf of the Victorian Distribution Loss Factor Working Group, dated 13 October 2003. The methodology centres on the difference in losses in the network being considered between the conditions where the generator operating and not operating over an annual cycle. The generator DLF is then calculated as follows:

$$\text{DLF} = 1 + \frac{\textbf{Total Reduction in Energy Loss}}{\textbf{Metered Energy Generated}}$$

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 sections 5 to 11 of this report.

Network Element	Voltage Level	Series Loss	Transformer	
			Series Loss	Shunt Loss
Transmission Network	132kV	Use of load flow at peak with LLF calculated on metering data where available (or SCADA data)		
Transmission Substation	132/66/33kV		Use of load flow at peak with manufacturer's data on impedance and LLF	Use of manufacturer's data (fixed losses for each type of transformer)
Sub Transmission Network	66kV, 33kV	Use of load flow at peak with LLF calculated on metering data where available (or SCADA data)		
Zone Substation	132/11kV, 132/22kV, 66/11kV, 33/11kV		Use of load flow at peak with manufacturer's data on impedance and LLF	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 apportioned to LV network.		

Table 3 – Summary of Network Loss Allocation Methodologies

4.1 Energy Transferred

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 33/66kV subtransmission

- A number of 66kV subtransmission feeders and 66/11kV zone substations are connected directly to BSP's thus bypassing transmission substations, and
- Integral Energy has a significant quantity of embedded generation connected at 33 or 66kV.

These factors have been taken into account in the calculation of the energy delivered at each level of the network and hence in the percentage loss factors.

4.2 Accumulation of Loss Factors

Due to the complicated nature of the network noted above, it has not been 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. This approach has been taken, with the resulting cumulative loss factors being the energy weighted average of the particular loss factor for each alternative path. For example, if there were two paths, one having a loss factor of 1% and the other 2%, with half the energy passing through each path, then the loss factor would be 1.5%.

4.3 Treatment of Theft

This study has identified theft as a separate line item and has taken a value of 0.50% of total sales (as recommended by the DLF Working Group) and applied this to the calculations. It has been assumed that all theft occurs at low voltage and the overall theft apportionment is therefore allocated to the low voltage network. Consequently, this equates to 0.80% of low voltage sales.

4.4 Site Specific DLFs

In addition, a total of 25 site specific DLFs have been calculated. Site specific DLFs for embedded generators >10MW have also been calculated. These are located at Maribeni (formerly Sithe Guildford) and Appin and Tower Collieries.

4.5 General comments on changes to DLFs

General comments driving changes to DLFs are summarised below:

- Improved system load flow modelling – constant improvements to the accuracy of base data and the accuracy of system models have been made since the previous Loss Study calculations for the 2006/07 year.
- Better system operation – care has been taken to ensure that the transmission network was modelled in the configuration that is most representative of the way in which the system is generally operated in practice.
- Load flow models for the 2007/08 year were executed with the network configured according to current capital program commitments, that is, a significant number of new Zone Substations (7) have been added, together with their associated transmission and subtransmission reconfigurations. This can result in improvements in DLFs in lower parts of the network and a slight increase in the losses associated with the 132kV network as this network has remained essentially unchanged.
- Effect of capacitor program – substantial effort has been put in to returning out-of-service or failed capacitors at Transmission Substations to service and to installing capacitor banks on the 11kV busbar at Zone and Transmission Substations. It has been assumed in the modelling exercise that all required capacitors at Transmission and Zone Substations have been returned to service.

5 132kV Lines

Integral Energy's 132kV network supplies transmission substations, 132/11kV zone substations and 132kV customers. Peak line losses were modelled using the DINIS load flow analysis package and 2007/2008 forecast peak transmission substation loads.

Loss load factors (LLF) were calculated from 15 minute load points for the 2005/2006 year for each BSP and applied to the peak losses of feeders supplied from each to calculate energy losses. In the case of 132kV customers, the specific feeder losses and the LLF for the actual customer load profile were used.

6 Transmission Substations

Transformer peak load losses were calculated using 2007/2008 forecast peak transmission substation loads and DINIS. Actual shunt losses were used for 65% of transmission substations. The average shunt losses for the known transformers, as a percentage of rating, were applied to the remainder.

LLFs were calculated from 15-minute load points for the 2005/2006 year for each transmission substation, based on actual transformer metering in most cases. In the few cases where this was not available, the summated loads supplied from that transmission substation were used to calculate the LLF.

7 Subtransmission Lines

Peak line losses were modelled using DINIS based on 2007/2008 forecast peak zone substation and 33/66kV customer loads.

The LLFs used were those as calculated for transmission substations, applied to the peak line losses of feeders supplied from the particular transmission substation.

8 Zone Substations

As in the case of transmission substations, transformer peak load losses were calculated using 2007/2008 forecast peak zone substation loads and DINIS. Actual shunt losses were used for 75% of substations. The average of the known shunt losses, as a percentage of rating, were applied to the remainder.

LLFs were calculated from 15-minute load points for the 2005/2006 year for each zone substation.

9 Medium Voltage Lines (11kV, 22kV)

Medium Voltage peak line losses for the whole distribution network were modelled using DINIS for the Zone Substation networks and actual loads for 2005/2006. The losses for each Zone Substation network were then calculated using the 2005/2006 LLF for that zone substation, as determined in Section 7 above.

10 Distribution Substations

Losses incurred within distribution substations were assessed by using an average load and generic transformer characteristics due to the large number (27,601) of distribution transformers in the Integral Energy network. The numbers of each size of transformer were determined from Integral Energy's Asset Database (Ellipse) as at June 2006.

Transformers of 100kVA or greater are generally fitted with Maximum Demand Indicators (MDIs) and so maximum loadings can be monitored. These substations were assigned a load of 70.24% of rating, based on the Integral Energy Networks Utilisation Report. It was assumed that all transformers of less than 100kVA had a lower utilisation of 50%. These figures have not been altered due to a lack of complete MDI data being available.

Transformer full load loss values ranged from 1.5% of rating for the smallest transformers down to 0.9% for the largest. Shunt losses ranged from 0.5% of rating for smaller units down to 0.25% for the larger ones. A LLF of 0.306 has been used for distribution transformers. This LLF represents the average LLF for the whole of the Integral Energy network.

11 Low Voltage Lines

Due to the lack of load information and modelling data it is not possible to model LV network losses directly. Instead, losses were assessed using an assessment of energy purchases less energy sales, theft and other losses.

To determine LV network losses, total losses were first calculated by subtracting energy purchases from energy sales. All other calculated losses, including theft, were then subtracted from total losses to give the LV network losses.

12 Location Specific Loss Factors

Location specific loss factors were calculated for a total of 25 significant customer connection points. The factors were calculated using the same methodology as the general loss calculations, using customer specific LLFs and network losses.

In most cases the major customers shared upstream network assets with other general Integral Energy Network customers. As noted previously, the energy losses for these shared assets were calculated and allocated to the loads in proportion to the energy delivered to each load by each asset. The location specific loss factors were then calculated using the total energy losses allocated to a particular load divided by the energy delivered to that load. These quantities were then subtracted from the overall network pool, which was used to calculate the general Loss Factors.

Summary DLF Tables

Table 1 – Integral Energy's Proposed 2007-08 DLFs for Tariff Classes

Tariff Class	Applied in 2006/07	To Apply in 2007/08
132 kV Network	0.62%	0.59%
Transmission Substation	1.06%	1.04%
Subtransmission Network	1.83%	1.83%
Zone Substation	2.26%	2.22%
High Voltage Distribution Network	3.48%	3.22%
Distribution Substation	6.86%	6.39%
Low Voltage Distribution Network	8.43%	8.55%

Table 2 – Integral Energy's Proposed 2007-08 DLFs for Embedded Generators and CRNP Customers

NMI	DLF Code	Location	Applied in 2006/07	To Apply in 2007/08
Embedded Generators				
NEEE000748	HTX2	Subtransmission	0.0064%	1.721%
NEEE000749	HTX3	Subtransmission	0.48%	4.59%
NEEE000750	HTX4	Subtransmission	1.27%	1.91%
NTTTWWRGBA	HIC2	Subtransmission	0.61%	-
Existing CRNP Customers				
NEEE000760 NEEE000762 NEEE000764 NEEE000766 NEEE000768	HTV4	Subtransmission	1.14%	1.969%
NEEE000046	HTV2	Subtransmission	0.53%	0.468%
NEEE001656	HTV1	Subtransmission	0.28%	0.273%
NEEE000758 NEEE000759	HIC1	Subtransmission	5.05%	2.936%
NEEEW04150 NEEEW04151 NEEEW04152 NEEEW04153 NEEEW04154	HTF2	Subtransmission	1.16%	0.725%
NEEEW0001 NEEEW0002	HTF1	Subtransmission	0.20%	0.630%
NEEE000757	HTV3	Subtransmission	0.025%	0.145%
NEEE000049	HHV1	HV Network	1.22%	1.690%
NEEE001885	HTY1	Subtransmission	0.49%	1.000%
NEEE000032	HTY2	Subtransmission	0.55%	1.094%
NEEE000770 NEEE000771	HTY3	Subtransmission	0.95%	1.222%
NEEE000005	HHY1	HV Network	1.73%	1.869%
NEEE000066	HTY4	Subtransmission	1.56%	2.344%
NEEE000006	HTY5	Subtransmission	3.07%	2.667%
NEEE001814	HHY2	Subtransmission	0.50%	0.377%
NEEE001596	HHY3	HV Network	2.61%	1.037%
NEEE001632	HTY6	Subtransmission	3.32%	2.090%
NEEE000014	HTY7	Subtransmission	1.72%	0.871%
NEEE000506	HHY4	HV Network	1.30%	1.072%
NEEE000707	HHY5	HV Network	3.78%	2.921%
NEEE000888	HTY8	Subtransmission	3.36%	3.241%
NEEE000011	HHY6	HV Network	1.92%	1.868%
NEEE001591	HSTL	Subtransmission	-	0.463%
NEEE000881	HTY9	Subtransmission	1.83%	0.0%
NEEE004637 NEEE004639	HHY7	HV Network	2.26%	3.22%#
NEEE001892	HTX1	Subtransmission	2.84%	2.269%

NEEE004637 & NEEE004639 falls outside of the requirements for the allocation of a site specific DLF based on 2005/06 billing data. The average DLF appropriate to the voltage level of their supply point in the network was allocated (ie the generic DLF for HV Network customers).