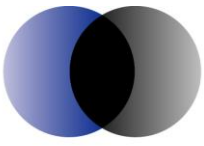
Aurora Energy 2008-09 Distribution Loss Factors

DLF calculations and review of methodology

Prepared for Aurora Energy for submission to the AER

March 2008



ACIL Tasman

Economics Policy Strategy

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Executive summary

ACIL Tasman Pty Ltd (ACIL Tasman) has been engaged by Aurora Energy (Aurora) to forecast distribution loss factors (DLF) for 2008-09, based on actual metered data for 2006-07. Tasmania joined the National Electricity Market (NEM) in May 2005. The Rules, which replaced the National Electricity Code in July 2005, apply to all registered industry participants including Tasmania's sole distribution network service provider (DSNP), Aurora Energy.

Aurora provided data for the DLF calculations in an Excel workbook developed by ACIL Tasman, named "DLF Calculator_2008_09.xls". Data issues and identified anomalies have been raised and resolved with Aurora staff.

In Tasmania, the methodology has been developed and maintained by Aurora[1]. The Office of the Tasmanian Energy Regulator (OTTER) has previously approved DLFs calculated in accordance with this developed methodology.

The overall DLFs for the Aurora network are shown in Table 7 in Appendix A.

ACIL Tasman:

- have adopted this methodology to calculate the DLFs by both network segment and region; and
- have assisted with improvements in data collection and analysis; and
- are satisfied that the calculated DLFs are compliant with Clause 3.6.3 of the Rules.

ACIL Tasman recommends:

- the approval of the DLFs for Tasmania for 2008-09 as set out in Table 2, Table 3, Table 4 and Table 5.
- the approval of the site specific DLFs for the four (4) major customers for 2008-09 as set out in Table 6; and
- that Aurora retains the network configuration for the year for which actual data is used to derive losses rather than the current network configuration which may be inappropriate for load flow analysis; and
- that Aurora implement the a Meter Data Management System (MDMS) to provide for increased data accuracy used in estimating the DLFs for 2009-10 and beyond.

[1] Aurora Energy, "Distribution Loss Factor Calculation Methodology", Report # 4246/3 prepared by A. Baitch of BES (Aust) Pty Ltd, July/August 2004.

1 Introduction

1.1 Background

Aurora's distribution network is connected to Transend's transmission system at 40 connection sites throughout Tasmania, where the voltage is reduced from 110kV to 44, 33, 22 and 11kV.

The actual distribution connection points, and the asset boundaries between the distribution and transmission networks, for the sub-transmission and distribution feeders, emanating from these connection sites, are on the load side of the 'Transend owned' feeder circuit breaker equipment.

The boundary between the transmission and distribution networks in Tasmania is somewhat unique. Transformers and switchgear at 110 kV substations are treated as transmission connection assets, in contrast to other states where these assets would be considered as distribution connection assets.

Clause 3.6.3 (g) of the Rules requires a DNSP to determine DLFs for all connection points on its distribution network in accordance with either:

- the methodology developed, published and maintained by the Jurisdictional Regulator for the determination of DLF; or
- the methodology developed, published and maintained by the DNSP for the determination of DLF, where the Jurisdictional Regulator has not published a methodology.

In March 2007 ACIL Tasman reviewed the methodology and its application to calculate 2007-08 DLFs proposed by Aurora for OTTER, after undertaking similar reviews in a number of previous years.

The Rules require a DNSP to determine each year the DLFs to apply in the next financial year and provide these to NEMMCO for publication by 1 April. Before doing so, the DNSP must obtain the Jurisdictional Regulator's approval for those DLFs.

The Australian Energy Regulator (AER) has advised Aurora that they have replaced OTTER as the Jurisdictional Regulator. Aurora needs to submit its proposed DLFs for the 2008-09 financial year to the AER for approval before 1 April 2008.

1.2 Scope

The scope of this engagement with Aurora is limited to the following:

- Aurora requires the consultant to review the current methodology for the calculation of DLFs for Aurora for 2008-09, identifying errors, anomalies or gaps in order to resolve these with Aurora. The applied methodology should take account of recommendations previously made by ACIL Tasman in its audit of the DLF calculations for 2007-08;
- Develop a spreadsheet model for computation of and report on the DLFs for the 2008-09 financial year, in accordance with the relevant rules and the agreed methodology, based on data supplied by Aurora for 2006-07. The forecast DLFs and report will be made available to the AER and NEMMCO to meet Aurora's National Electricity Rule requirements.
- The report is also expected to comment on Aurora's compliance with clause 3.6 of the National Electricity Rules in the determination of DLFs.
- ACIL Tasman is expected to coordinate activities necessary to carry out the assessment of losses to an acceptable level of accuracy, and to provide the knowledge of the process to and train identified Aurora employees, namely graduate engineers as part of their Graduate program.

This report is ACIL Tasman's draft report in relation to this engagement and covers all aspects required by Aurora as set out in the scope above.

1.3 Issues

We have identified a number of issues that need to be considered by Aurora.

- ACIL Tasman developed a spreadsheet model, "DLF Calculator_2008_09" to be used by Aurora to add data from the FLRS (Feeder Load Reporting System), requiring the manipulation of very large quantities of data eg. around 30,000 transformers. With many intermediate calculations, including output from DINIS (load flow software), there is the potential for error from data re-entry. It is recommended that the data extraction process is automated to improve the reliability of data transferred to the DLF model.
- It is recommended that any intermediate data is transferred to the DLF model and required data extracted there to allow for an adequate data trail from the source data.
- In the absence of a meter management system, Aurora has made a number of assumptions in the methodology and in applying the methodology. These assumptions include:
  - excluding the impacts of kVAr flows on distribution system losses;
  - assuming constant system voltages in calculating the losses across transformers;

  - assuming average network-wide results for distribution transformers (eg. LLF, no load loss and full load series loss);
- Special treatment for embedded generation or large customers; and
- Non-technical losses (including unbilled energy, metering error and theft) are approved by OTTER at 0.5%.

OTTER has approved the grouping of various transmission points in both Hobart and Launceston to form two virtual transmission nodes. Hence Aurora has calculated loss factors in those two regions on that basis.

Following ACIL Tasman's recommendation in the review of 2007-08 DLFs, Aurora has expanded the "Other" region into 5 regions, as shown in Table 1.

Table 1 **Regions adopted for 2008-09 DLF review (previously "Other")**

Region	Areas
East Coast	East Coast, North East, Midlands North and South East
Derwent	Derwent Clyde and Highlands
Southern	Southern
West Coast	West Coast
North West	Central North and North West

Data source: Aurora Energy

Accordingly, DLFs for 2008-09 have been determined for seven (7) regions in total – the above five plus Hobart and Tamar (incorporates Launceston).

1.4 Material reviewed

The following documents were used to prepare the forecast 2008-09 DLFs:

- Aurora Energy, Distribution Loss Factor Calculation Methodology, July/August 2004;
- The National Electricity Rules – Clause 3.6.3 and associated clauses and definitions;
- Office of the Tasmanian Energy Regulator Decision and Statement of Reasons - Distribution Loss Factor Calculations Treatment of Non-Technical Losses, March 2006; and
- Energy growth forecasts were obtained from Aurora's, "2007 Distribution Network Connection Ten-Year Consumption and Maximum Demand Forecast" (p7) and used to forecast energy sales for 2008-09 for each of the above Regions.

In addition, ACIL Tasman worked with Aurora staff to review the collected data and to address any issues/abnormalities.

2 Aurora's data

ACIL Tasman has relied on Aurora for the accurate sourcing and calculation of data items including:

- Historical and forecast energy usage and losses for specific customers used to calculate site specific DLFs;
- The forecast energy growth rate; forecast growth ranges from 0.12% pa for West Coast to 3.65% pa for Midlands North. For the entire network, forecast growth is **2.35% pa**, resulting in energy sales increasing from 4,547 GWh in 2006-07 (actual) to 4,751 GWh in 2008-09 (forecast);
- Aurora historical and forecast purchases from Transend;
- Aurora historical and forecast sales at each voltage level on both a state-wide and regional (postcode) basis;
- For the sub-transmission system, shunt and full load series losses (kW), Load Factors (LF) and Loss Load Factors (LLF);
- For the zone substations, shunt and full load series losses (kW), maximum demand (MD) and LLF;
- For the distribution feeders, feeder loadings, Line Loss, LF and LLF;
- For the distribution transformers, assumed LLF, average full load series loss, load utilisation factor and no load loss in %.

2.1 Data collection for the 2006-07 financial year

Data regarding the transmission network flows and losses were mainly extracted from Aurora's FLRS database - used to calculate the LF and the LLF for each distribution feeder.

This database contains the Average, Root Mean Square (RMS) and MD loading in kW for the distribution feeders. The FLRS database is uploaded daily with data from Transend Networks and Aurora's SCADA system in Hobart.

The MD loading data was also used to determine distribution line losses and utilisation factors from load flows on each of the distribution feeders. Coincident MD data was manually extracted from the FLRS database to determine the Coincident Factor. The extracted data had to be checked and, in some cases, manually adjusted to correct for erroneous data.

Due to load transfers within substations and between distribution feeders, the MD on many of the feeders had to be checked and, in some cases, adjusted. This was to ensure that the change in load was taken into account and that no load was included more than once. As a result of these changes, the Average

and RMS loadings had to be re-calculated on the respective feeders to reflect the transfer of load.

The data for the sub transmission segment was also extracted out of the FLRS database and have been checked manually. The shunt losses for each sub transmission feeder are negligible since the charging capacitance for the conductors are so small. As a result, the shunt losses are primarily determined from the iron losses in the zone transformer core.

Sub-transmission line losses were calculated from load flows.

2.2 Data Processing and Validation by ACIL Tasman

Modelling by ACIL Tasman has been undertaken such that manual data manipulation was minimal.

Raw data extracted from Aurora's various systems was directly integrated into the spreadsheet model wherever possible in order to minimise data input errors. The data extracted was disaggregated on a regional/postcode level and as such had to be aggregated into the seven defined regions within the model. Furthermore, the data has been validated against past data, using sensitivity analysis, with the output edited in order to ensure data quality and to identify specific data points for further investigations. Data points identified were consequently individually validated within the FLRS database.

3 Methodology

3.1.1 Definition of segments

The 2008-09 DLFs are calculated for the following five network segments:

- Sub-transmission[2]
- Zone substation (15 zone substations, 8 in the greater Hobart area and another 7 in various rural locations, which reduce the voltage from 44, 33 or 22 kV to 22 or 11kV)
- HV distribution network (316 feeders[3] and 28,727 distribution substations, which further reduce the voltage to a nominal 230/400 volts to supply the majority of Aurora's customers.)
- Distribution sub-station, and
- LV distribution network.

ACIL Tasman considers that this is an appropriate network breakdown and that it is consistent with the principles set out in NER Clause 3.6.3 (h). We also note that the breakdown is consistent with network segments used by DNSPs in other NEM jurisdictions.

3.2 Calculating losses by steps

ACIL Tasman has adopted the same methodology for calculating DLFs for 2008-09 as used by Aurora in previous years, namely a series of steps as follows:

1. Initially total energy flowing into the Aurora Distribution network is derived for the 2008-09 year by applying the annual growth rate to actual data from 2006-07 (two years' growth) and adding the known business plans for the site specific customers.
2. Calculate the site specific losses. These losses are calculated from metered parameters and forecast annual consumption – typically assumed as unchanged from year to year. These losses are used to derive loss factors for each of the customer specific sites. Residual energy flows are determined by subtracting the sales to specific customers. Specific

[2] Aurora, in conjunction with Transend, have for the past 7 years been implementing, an overall augmentation program for the existing Hobart urban sub-transmission network specifically in the central (CBD) and some of the northern suburbs. This program known as the Hobart Area Supply Upgrade (HASU) Program includes major reconfiguration of the sub-transmission network, augmentation from 22kV to 33kV and reconfiguration of the respective 11kV distribution network. The program has now been completed with the last major works being commissioned in early 2007.

[3] 20 – CBD; 154 – Urban and 142 – Other/Rural

customer losses are not subtracted from residual sales at this point as they are included variously at the sub-transmission, zone and HV network segments as allocated losses.

3. Calculate the Sub-Transmission segment losses. These losses are calculated from metered quantities and DINIS load flow modelling. Once the losses have been calculated any losses already allocated to specific customer sites are subtracted, with the remainder being used to determine the sub-transmission loss factor as a percentage of residual flows. Finally, the sub-transmission losses are subtracted from the residual flows before moving to the next step.
4. Calculate the Zone Substation (ZS) segment losses. These losses are calculated from metered quantities supported by modelling. These losses include both shunt (wires) and series (transformers) losses as required under the methodology. As some of the ZS losses are already allocated to specific customer sites, these are subtracted from the total losses calculated for this section. The remaining losses are used to determine the ZS loss factor as a percentage of residual flows. Finally the ZS losses are subtracted from the residual flows before moving to the next step.
5. Calculate the HV Distribution segment losses. These losses are calculated from metered quantities and distribution feeder modelling. As some of the HV Distribution losses are already allocated to specific customer sites, these are subtracted from the total losses calculated for this segment. The remaining losses are used to determine the ZS loss factor as a percentage of residual sales. Aurora has a number of customers directly connected to the HV Distribution as well as some embedded generators. Hence the HV customer sales and the HV Distribution losses are subtracted from the residual flows and the embedded generation is added to the residual flows before moving to the next step.
6. Calculate the Distribution Substation segment losses. Distribution Substation losses are calculated from an assumed LLF of 25%, averaged over the entire network and actual utilisation factors calculated for each feeder. Losses are calculated by summing across all distribution transformer assets in Tasmania. The Distribution Substation loss factor is then calculated as a percentage of residual flows. As Aurora has a number of customers directly connected to the LV system, both the LV direct customer sales and the Distribution Substation losses are subtracted from the residual flows before moving to the next step.
7. Calculate the LV Distribution segment losses. The losses in the LV Distribution are based on the energy balance for the whole system. The losses are calculated by determining the total system losses by subtracting energy sold (metered) and non-technical losses from energy purchased (includes embedded generation). The LV Distribution losses are then determined as the residual losses after subtracting all other segment losses calculated in each of the previous steps. The LV Distribution loss factor is then calculated as a percentage of residual flows.

8. Losses are then allocated to each of the regions using either a proportion of sales in each region for LV segment losses or transformer capacity for HV and transformer segment losses. Loss factors are calculated for each segment in each region from the allocated losses/residual sales in the region. The sales information for each segment by region are derived from Aurora's retail billing system information that provides sales by tariff class. The tariff classes are mapped to the appropriate segment. It is assumed that the proportion of sales by region in each segment remains constant.
9. Finally the cumulative loss factor to be applied to each segment in each region is calculated by combining the segment loss factor with each upstream loss factor as follows:

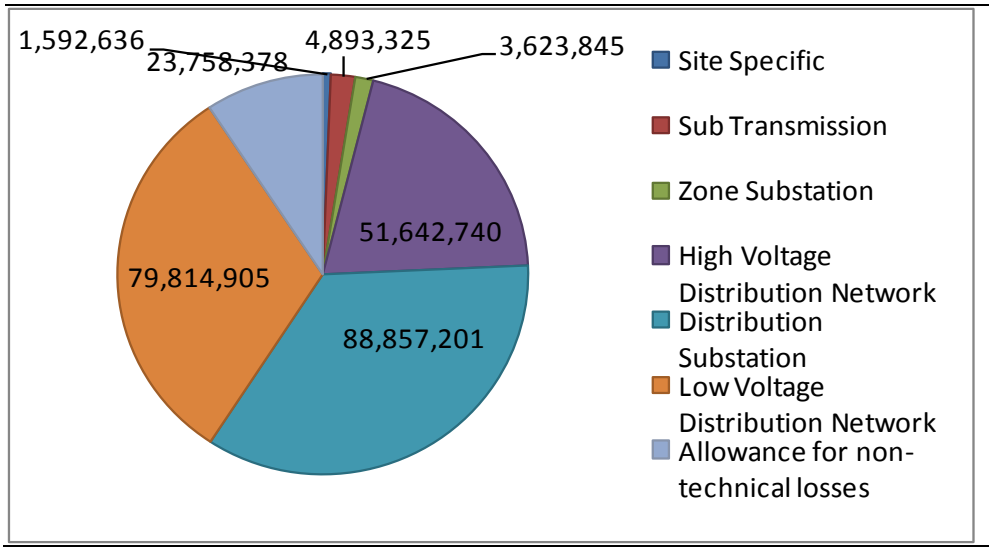
   $$\text{Cumulative } DLF_n = (1+DLF_1)*\ldots *(1+DLF_{n-1})*(1+DLF_n) - 1$$

   where 1 to n represent the current and upstream segment DLFs used in the calculation with 1 representing the sub-transmission segment through to n representing the current segment.

4 Results

Figure 1 shows the forecast losses (kWh) for 2008-09, calculated for each distribution network segment and the estimated non technical losses. The total distribution network losses for 2008-09 are estimated at 254,183,031 kWh, which is equivalent to 2.29% pa higher than the actual losses for 2006-07 and compares well with the 2.35% pa increase in forecast sales growth.

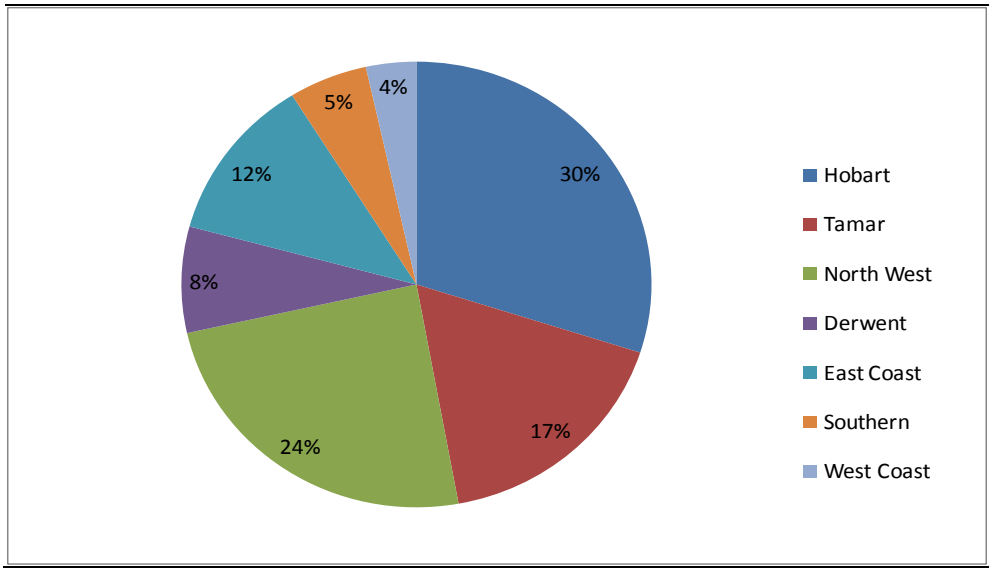
Figure 1 **Forecast energy losses (kWh) for 2008-09 – by Network segment**



Data source: ACIL Tasman analysis

Figure 2 shows the forecast losses for 2008-09 by Region.

Figure 2 **Forecast energy losses (% Total) for 2008-09 – by Region**



Data source: ACIL Tasman analysis

Hobart, Tamar and North West regions account for 30%, 17% and 24% of the total forecast losses respectively.

Aurora's forecast DLFs for 2008-09 are shown in Table 2 (Hobart and Tamar regions), Table 3 (North West and Derwent regions), Table 4 (East Coast and Southern regions) and Table 5 (West Coast region).

Table 2 **Distribution Loss Factors for 2008-09 – Hobart and Tamar regions**

2008-09	Hobart		Tamar	
Network Level	Loss Factor %	Cum Loss Factor %	Loss Factor %	Cum Loss Factor %
Subtransmission Network	0.36%	0.36%	0.00%	0.00%
Zone Substation	0.26%	0.62%	0.00%	0.00%
High Voltage Distribution Network	1.11%	1.74%	1.14%	1.14%
Distribution Substation	1.89%	4.24%	1.95%	3.70%
Low Voltage Distribution Network	2.29%	6.63%	2.29%	6.07%
Allowance for non-technical losses **a**	0.56%		0.57%	

a Non-technical losses applied to Cumulative Distribution sub-station and LV distribution only

Data source: ACIL Tasman analysis

Table 3 **Distribution Loss Factors for 2008-09 – North West and Derwent regions**

2008-09	North West		Derwent	
Network Level	Loss Factor %	Cum Loss Factor %	Loss Factor %	Cum Loss Factor %
Subtransmission Network	0.00%	0.00%	0.00%	0.00%
Zone Substation	0.00%	0.00%	0.00%	0.00%
High Voltage Distribution Network	1.31%	1.31%	1.09%	1.09%
Distribution Substation	2.34%	4.35%	1.82%	3.46%
Low Voltage Distribution Network	2.29%	6.74%	2.29%	5.83%
Allowance for non-technical losses **a**	0.65%		0.52%	

a Non-technical losses applied to Cumulative Distribution sub-station and LV distribution only

Data source: ACIL Tasman analysis

Table 4 **Distribution Loss Factors for 2008-09 – East Coast and Southern regions**

2008-09	East Coast		Southern	
Network Level	Loss Factor %	Cum Loss Factor %	Loss Factor %	Cum Loss Factor %
Subtransmission Network	0.00%	0.00%	0.00%	0.00%
Zone Substation	0.00%	0.00%	0.00%	0.00%
High Voltage Distribution Network	1.52%	1.52%	0.94%	0.94%
Distribution Substation	2.61%	4.79%	1.60%	3.10%
Low Voltage Distribution Network	2.29%	7.19%	2.29%	5.45%
Allowance for non-technical losses **a**	0.60%		0.52%	

a Non-technical losses applied to Cumulative Distribution sub-station and LV distribution only

Data source: ACIL Tasman analysis

Table 5 **Distribution Loss Factors for 2008-09 – West Coast regions**

2008-09	West Coast	
Network Level	Loss Factor %	Cum Loss Factor %
Subtransmission Network	0.00%	0.00%
Zone Substation	0.00%	0.00%
High Voltage Distribution Network	4.20%	4.20%
Distribution Substation	10.16%	15.99%
Low Voltage Distribution Network	2.29%	18.64%
Allowance for non-technical losses **a**	1.04%	

a Non-technical losses applied to Cumulative Distribution sub-station and LV distribution only

Data source: ACIL Tasman analysis

5 Conclusions and Recommendations

ACIL Tasman confirms that the calculation of DLFs for 2008-09 complies with the requirements of Rules Clause 3.6.3.

The proposed site specific loss factors for 2008-09 are listed in Table 6[4].

Table 6 **2008-09 site specific DLFs recommended for approval**

Major Customer	NMI	Region	DLF Code	DLF
Australian Cement (Goliath)	8000003585	North West	PACH	1.0000
Renison	8000003578	West Coast	ABSM	1.0075
Simplot	8000000656	North West	PSPU	1.0036
Henty Goldfields	8000003868	West Coast	PHGM	1.0000

Data source: ACIL Tasman analysis

Further to ACIL Tasman's recommendation in the 2007-08 review, Aurora has indicated that it is soon to implement a MDMS system which will allow considerable enhancement of the calculation and presentation of its DLFs in future years. The MDMS will provide ready access to past metering data in any chosen regional, system or customer configuration which will allow greater flexibility in defining and calculating DLFs.

Aurora has previously indicated that the implementation of MDMS will allow for a fresh approach to calculation of DLFs for 2009-10 which will involve (inter alia):

- looking at simplifying the calculation "black box" or at least removing the errors;
- reviewing the methodology;
- looking at a more accurate loss allocation to regions - this will be significantly easier with an understanding of links between assets and the geospatial tools; and
- ensuring the process, methodology and procedures are documented and clearly understood to assist graduate engineers with the annual task.

[4] Note that Cadburys was not eligible for site specific DLF as demand was < 40 GWh

A Distribution Network DLF

Table 7

2008-09	Overall Network	
Network Level	Loss Factor %	Cum Loss Factor %
Subtransmission Network	0.10%	0.10%
Zone Substation	0.08%	0.18%
High Voltage Distribution Network	1.23%	1.42%
Distribution Substation	2.15%	4.21%
Low Voltage Distribution Network	2.29%	6.59%
Allowance for non-technical losses a	0.59%	

a Non-technical losses applied to Cumulative Distribution sub-station and LV distribution only

Data source: ACIL Tasman analysis