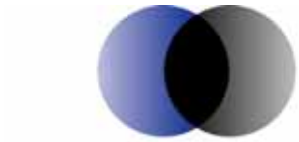
Aurora Energy 2009-10 Distribution Loss Factors

DLF calculations and methodology

Prepared for Aurora Energy for submission to the AER

March 2009



ACIL Tasman

Economics Policy Strategy

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Executive summary

ACIL Tasman Pty Ltd (ACIL Tasman) has been engaged by Aurora Energy Pty Ltd, ABN 85 082 464 622, in its capacity as distribution network service provider (Aurora) to forecast distribution loss factors (DLF) for 2009-10, based on actual metered data for 2007-08. Tasmania joined the National Electricity Market (NEM) in May 2005. The National Electricity Rules (the Rules) apply to all registered industry participants including Tasmania's sole distribution network service provider (DSNP), Aurora.

Aurora provided data for the DLF calculations in an Excel workbook developed by ACIL Tasman, named "DLF Calculator 2009_10.xls". Data issues and identified anomalies have been raised and resolved with Aurora staff. These related largely to issues around the metered data for Purchases and Aurora sales data, particularly PAYG data.

In Tasmania, the methodology has been developed and maintained by Aurora[1]. The Office of the Tasmanian Energy Regulator (OTTER) prior to 2008, and the Australian Energy Regulator (AER) last year approved DLFs calculated in accordance with this developed methodology.

The overall DLFs for the Aurora network are shown in Table 6 in Appendix A.

ACIL Tasman:

- have applied the same methodology used for the 2008-09 report to forecast the DLFs by both network segment and region; 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 2009-10 as set out in Table 2, Table 3, Table 4 and Table 5 for each region;
- the approval of the site specific DLFs for the five (5) major customers for 2009-10 as set out in Table 5; and
- that Aurora complete the implementation of the proposed Meter Data Management System (MDMS) to provide for increased data accuracy used in estimating the DLFs for 2010-11 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

This report follows the same methodology adopted for the report for the 2008-09 DLF forecast. We have worked with the Aurora personnel to assess the data for consistency and reliability and acknowledge the assistance from the graduate engineer assigned to provide the network data for 2007-08.

1.1 Background

Aurora's distribution network is connected to the transmission system, owned by Transend Networks Pty Ltd (Transend), 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.

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.

As a result of a review of the Rules, the AER has taken over responsibility from the Jurisdictional Regulator, and as such requires Aurora to submit its proposed DLFs for the 2009-10 financial year to the AER for approval and subsequent submission to NEMMCO.

1.2 Scope

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

- Develop a spreadsheet model for computation of and report on the DLFs for the 2009-10 financial year, in accordance with the relevant rules and the agreed methodology, based on data supplied by Aurora for 2007-08. 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, in particular a graduate engineer, 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 2009_10" to be used by Aurora to add data from the FLRS (Feeder Load Reporting System), requiring the manipulation of very large quantities of data e.g. 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[2].
- 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 the proposed MDMS, 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);

[2] This recommendation will become redundant when the MDMS is available

- Special treatment for embedded generation or large customers; and
- Non-technical losses (including unbilled energy, metering error and theft) are approved by AER at 0.5%.

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

Following ACIL Tasman's recommendation in the review of 2008-09 DLFs, DLFs for 2009-10 have been determined for seven (7) regions in total, as follows:

- Hobart;
- Tamar (incorporates Launceston);
- East Coast;
- North West;
- West Coast;
- Derwent (incorporates the Highlands area); and
- Southern (area south of Hobart).

These geographical regions are based on the distribution network configurations from both Aurora Zone Substations and Transend's Terminal Substation assets in order to minimise the influence between regions with respect to energy flows and distribution system switching.

The loads and consumption data for substations within a region may be subject to significant variations due to network configuration rearrangements, particularly in the Hobart and Tamar regions that are currently undergoing very significant augmentation and load shifting between adjacent zone and terminal substations. Evaluation of the load and consumption data and the subsequent system analysis and data adjustments to recognise normal operating conditions have minimized these variations.

1.4 Material reviewed

The following documents were used to prepare the forecast 2009-10 DLFs:

- Aurora Energy, Distribution Loss Factor Calculation Methodology, July/August 2004;
- The National Electricity Rules – Clause 3.6.3 and associated clauses and definitions; and
- Energy growth forecasts were obtained from the revised report, "2008 Distribution Network Connection Ten-Year Consumption and Maximum Demand Forecast" (dated 24/2/09) produced by Utility Engineering Solutions and used to forecast energy sales for 2009-10 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 found during this study.

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 demand growth ranges from a decrease of 0.09% pa for West Coast to an increase of 3.03% pa for Southern Region. For the entire network, forecast energy growth is **1.61% pa**, resulting in total energy sales increasing from 4,421 GWh in 2007-08 (actual[3]) to 4,564 GWh in 2009-10 (forecast);
- Aurora historical purchases from Transend – data for 2006/07 were markedly increased by 105 GWh from 4507 GWh to 4612 GWh;
- Aurora historical 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 2007-08 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.

[3] Includes Sales of 206 GWh for Major Customers; represents 2.28% sales growth over previous year (excluding sales of Major Customers which are assumed constant)

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.

There is an issue relating to the data supplied by Aurora for their Transend Purchases. For 2007/08, Purchases of 4,676 GWh represent a 3.76% increase on the original Purchase data of 4,507 GWh in 2006/07 (recently revised to 4612.4 GWh). When embedded generation is added to Transend Purchases, total purchases increased from 4,536 GWh in 2006/07 to 4,712.5 GWh in 2007/08 (a 3.9% increase). This Purchases data is inconsistent with Aurora sales growth of around 2.3% for the same period.

Due to the above under-reporting of Purchases in 2006/07, which was used to derive losses for 2006/07 (and the forecast losses for 2008-09) the DLF forecast for 2008-09 was reported as lower than if the revised Purchases data had been used.

Aurora have advised that improved metering explains the reported variation in Transend Purchases.

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 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. For example, for Feeder 97014, losses reportedly fell from 81MWh in 2006/07 to 25MWh in 2007/08 (despite

sales growth). Aurora have confirmed there was an error for the losses in 2006/07.

Data points identified were consequently individually validated within the FLRS database.

While ACIL Tasman have adopted the 10 year load growth forecasts developed by Utility Engineering Solutions for Aurora (1.7% pa) to forecast sales and purchases for 2009-10 based on actual data for 2007-08, we recognise that the current global economic crisis may result in lower growth than the longer term forecast. If so, there will be little impact on the forecast DLFs.

3 Methodology

3.1 Definition of segments

The 2009-10 DLFs are calculated for the following five network segments:

- Sub-transmission
- 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 (387 feeders and 28,730 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 2009-10 as used by Aurora in previous years, namely a series of steps as follows:

1. Total energy flowing into the Aurora Distribution network is derived for the 2009-10 year by applying the annual growth rate to Transend purchases in 2007-08 (two years' growth at 1.70% per year) and adding the purchases for site specific customers and from embedded generators, both of which are assumed to be constant (no growth)
2. Calculate the site specific losses.
   These losses are calculated from metered quantities 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 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 load flow 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 and is the same for each Region as allocated by proportion of sales.
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 is 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:

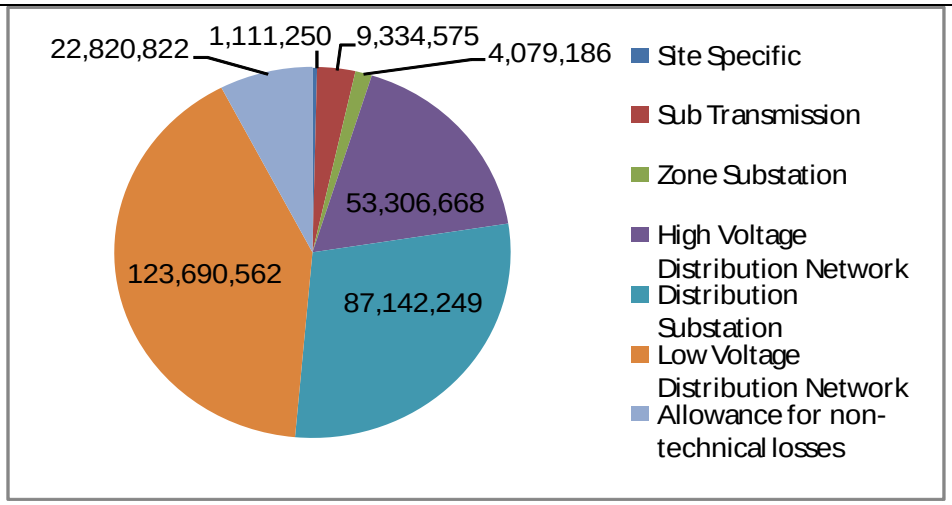
   Cumulative $DLF_n = (1+DLF_1)*\ldots *(1+DLF_{n-1})*(1+DLF_n) - 1$

   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 2009-10, calculated for each distribution network segment and the estimated non technical losses. The total distribution network losses for 2009-10 are estimated at 301,485,311 kWh, which is equivalent to 1.64% pa higher than the actual losses for 2007-08 and compares well with the 1.61% pa increase in forecast sales growth.

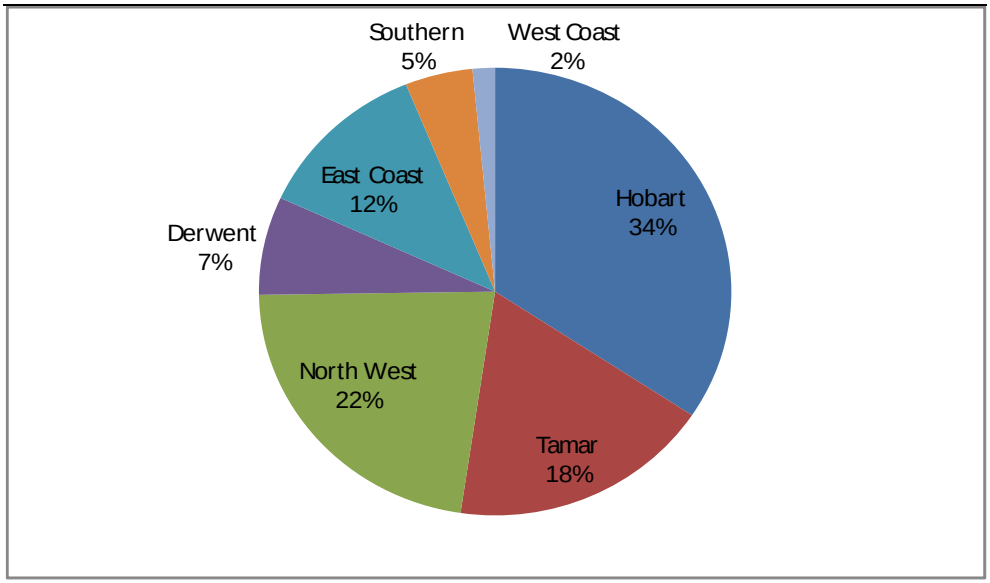
Figure 1 **Forecast energy losses (kWh) for 2009-10 – by Network segment**



Data source: ACIL Tasman analysis

Figure 2 shows the forecast losses for 2009-10 by Region as a percentage of total network losses.

Figure 2 **Forecast energy losses (% Total) for 2009-10 – by Region**



Data source: ACIL Tasman analysis

Hobart, Tamar and North West regions account for 34.3%, 18.0% and 22.4% of the total forecast losses respectively.

Aurora's forecast DLFs for 2009-10 are shown in Table 1 (Hobart and Tamar regions), Table 2 (North West and Derwent regions), Table 3 (East Coast and Southern regions) and Table 4 (West Coast region).

Table 1 **Distribution Loss Factors for 2009-10 – Hobart and Tamar regions**

2009-10	Hobart	Tamar

Network Level	Loss Factor %	Cum Loss Factor %	Loss Factor %	Cum Loss Factor %
Subtransmission Network	0.59%	0.59%	0.00%	0.00%
Zone Substation	0.26%	0.85%	0.00%	0.00%
High Voltage Distribution Network	1.13%	1.99%	1.33%	1.33%
Distribution Substation	1.81%	3.83%	2.16%	3.52%
Low Voltage Distribution Network	3.84%	7.83%	3.84%	7.50%
Allowance for non-technical losses **a**	0.57%		0.60%	

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

Data source: ACIL Tasman analysis

Table 2 **Distribution Loss Factors for 2009-10 – North West and Derwent regions**

2009-10	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	1.37%	1.37%	1.65%	1.65%
Distribution Substation	2.33%	3.73%	2.70%	4.39%
Low Voltage Distribution Network	3.84%	7.71%	3.84%	8.40%
Allowance for non-technical losses **a**	0.69%		0.55%	

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 2009-10 – East Coast and Southern regions**

2009-10	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	1.84%	1.84%	1.60%	1.60%
Distribution Substation	3.03%	4.92%	2.63%	4.28%
Low Voltage Distribution Network	3.84%	8.95%	3.84%	8.29%
Allowance for non-technical losses **a**	0.59%		0.53%	

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 2009-10 – West Coast region**

2009-10	West Coast	
Network Level	Loss Factor %	Cum Loss Factor %
Subtransmission Network	0.39%	0.39%
Zone Substation	0.00%	0.39%
High Voltage Distribution Network	0.82%	1.22%
Distribution Substation	3.42%	4.67%
Low Voltage Distribution Network	3.84%	8.70%
Allowance for non-technical losses **a**	1.00%	

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

Data source: ACIL Tasman analysis

4.1 Conclusions and Recommendations

Network losses in 2007-08 of 292 GWh equate to 6.6% of total sales by Aurora.

The proposed site specific loss factors for 2009-10 are listed in Table 5[4].

Table 5 **2009-10 site specific DLFs recommended for approval**

Major Customer	NMI	Region	DLF Code	DLF
Australian Cement (Railton)	8000003585	North West	PACH	1.0000
Simplot (Ulverstone)	8000000656	North West	PSPU	1.0015
Beaconsfield Gold (Beaconsfield)	8000003691	Tamar	PBGM	1.0019
Bluestone Mine (Renison)	8000003578	West Coast	PBSM	1.0020
Henty Goldfields	8000003868	West Coast	PHGM	1.0000

Data source: ACIL Tasman analysis

ACIL Tasman confirms that the calculation of DLFs for 2009-10 complies with the requirements of Rules Clause 3.6.3.

Further to ACIL Tasman's recommendation in the 2008-09 DLF forecast study, Aurora has advised that it is implementing a Meter Data Management System (MDMS). This system will allow for considerable enhancement of the calculation and presentation of both its DLFs in future years and associated load growth forecasting. 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 indicated that the implementation of MDMS will allow for a fresh approach to calculation of DLFs for 2010-11 which will involve (inter alia):

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

[4] Note that latest annual sales of 40 GWh are applied to determine inclusion as Major Customer eg. Cadburys reassigned as a Tariff 6 customer as sales were < 40 GWh

A Distribution Network DLF

Table 6 **Aurora overall DLF forecast by network segment for 2009-10**

2009-10	Overall Network	
Network Level	Loss Factor %	Cum Loss Factor %
Subtransmission Network	0.21%	0.21%
Zone Substation	0.09%	0.30%
High Voltage Distribution Network	1.35%	1.65%
Distribution Substation	2.24%	3.92%
Low Voltage Distribution Network	3.84%	7.92%
Allowance for non-technical losses **a**	0.60%	

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

Data source: ACIL Tasman analysis