Distribution Loss Factor Calculation Methodology Paper

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1 Introduction

Distribution losses are electrical energy losses incurred in the conveyance of electricity over a distribution network. Distribution loss factors (DLFs) are used to notionally describe the average electrical energy losses for electricity transmitted on a distribution network between a distribution network connection and a transmission network connection point or virtual transmission node for the financial year in which they are to be applied. DLFs are used by NEMMCO in the market settlement to adjust the electrical energy attributed to a distribution network connection point, so that market settlements are done on the basis of an adjusted gross energy amount for each connection point. DLFs are also used by retailers for reconciliation with their purchasing against their customer billing processes.

DLFs must be determined in accordance with a methodology under the National Electricity Rules. If the jurisdictional regulator (in NSW this is IPART) has determined a methodology, then that methodology must be applied. If the jurisdictional regulator has not determined a methodology then the relevant Distribution Network Service Provider (DNSP) must determine a methodology

Within NSW, IPART has not determined a distribution loss factor methodology, consequently each DNSP must develop, publish and maintain and methodology in accordance with clause 3.6.3(g) and (h) of the Rules.

This document set outs EnergyAustralia's methodology for calculating Distribution Loss Factors (DLFs). This methodology has been prepared in accordance with the requirements of the National Electricity Rules, in particular having regard to the principles contained in clause 3.6.3(h) of the Rules.

This document is published on EnergyAustralia's website at www.energy.com.au/network_prices and made available upon request to interested persons.

1.1 Requirements of the National Electricity Rules

DLFs must be determined for all connection points either on a site specific basis or collectively in relation to connection point classes

Clause 3.6.3(b)(2) of the Rules requires that distribution loss factors will be either site specific for certain types of connection points or for those which are not required to be site specific, based on voltage or connection point classes. Briefly, site specific DLFs will be determined in relation to:

- A connection point for an embedded generating unit with actual generation of more than 10MW. (For generators with actual generation of less than 10MW a site specific DLF can be calculated if the generator agrees to meet the reasonable costs of the DNSP calculating the DLF);
- A connection point for an end-user with actual or forecast load of more than 40GWh or an electrical demand of more than 10 MW.
- A connection point for a market network service provider; and
- A connection point between two or more distribution networks.

Assignment of Connection Points

Clause 3.6.3(c), (d) (e) and (f) impose requirements in relation to the allocation of connection points to either a single transmission network connection point or to a virtual transmission node and to a class of distribution network connection points.

Principles to Apply to the Methodology

Clause 3.6.3(h) requires that the methodology must be developed having regard to the principles set out in sub clauses (1)—(6). The effect of these principles may be briefly summarised as:

(1) Seeking to ensure that the total amount of energy calculated in relation to a distribution network (as adjusted for losses by the relevant DLF) for a particular financial year is as close as reasonably practicable equal to the total metered or estimated energy flowing through all connections points in the distribution network and the total (actual) electrical energy losses incurred on the distribution network in the financial year;

(2) Being able to demonstrate the extent to which the objective in (1) has been achieved through a reconciliation based on the previous financial year's adjusted gross energy and DLFs ie, by a reconciliation between the aggregate adjusted gross energy at all customer connection points on EA Network's distribution network in the previous financial year (applying the DLF's set for that previous year) and the sum of the total metered energy at those points in that year plus the total (actual) losses incurred on that network in that year.

(3) For non-site specific connection points, determining the DLF by using a volume weighted average of the average electrical energy loss between the transmission network connection point or virtual transmission node to which it is assigned and each distribution network connection point in the relevant class of distribution network connection points for the financial year in which the DLF is to apply;

(4) For site specific connection point, determining the DLF by reference to the average electrical energy loss between the distribution network connection point and the transmission network connection point to which it is assigned in the financial year in which the DLF is to apply.

(5) Using the most recent actual load and generation data available for a consecutive 12 month period to determine the average electrical energy losses referred to in (3) and (4), adjusted if necessary to take into account projected load and or generation growth in the financial year in which the distribution loss factors are to apply;

(6) Treating flows in network elements that solely or principally provide market network services as invariant.

EnergyAustralia notes that these are principles to which regard must be had and are not prescriptive rules to be applied inflexibly. EnergyAustralia's proposed approach is consistent with the above principles, will provide a fair and equitable result and is consistent with ensuring that the application of DLFs results in all energy losses being accounted for and recovered by affected parties in the market.

1.2 EnergyAustralia' General Approach in Deriving Non-site specific DLFs

STEP 1 Reconciliation of previous financial year

The starting point for the calculation of DLFs for the following year is firstly carrying out a reconciliation of prior years losses as contemplated by principle (2) above. This involves calculating the actual losses that occurred in each year, which is simply a matter of subtracting 'purchases' from 'sales', leaving losses, see sections 1.4 and 1.5 for a detailed explanation of "purchases" and "sales". Having determined the actual losses, this is compared to what the losses had been projected to be at the time of setting the DLFs for that year. The timing of events will help in understanding the reconciliation process:

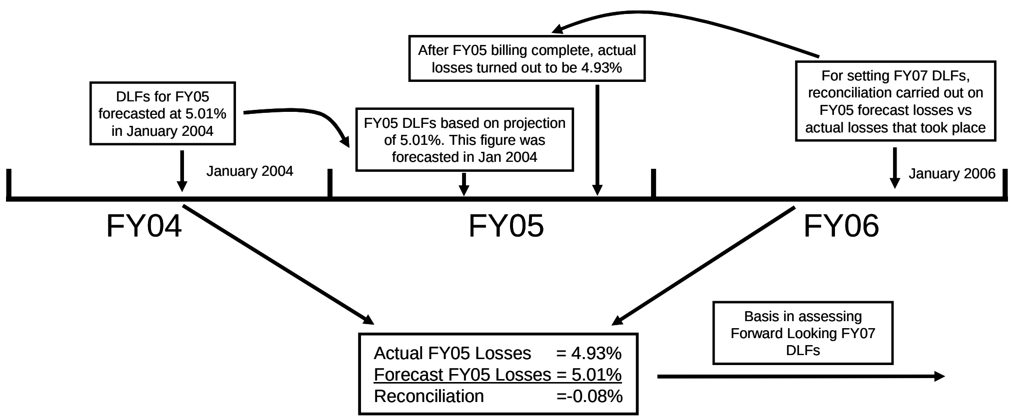


Diagram 1: Timing for DLF Calculation and Subsequent Reconciliation

Diagram 1 above, it can be seen that the setting of FY05 DLFs must be complete before the beginning of that year. So DLFs are forecast for the following year, and this calculation is notionally completed around January each year. For FY05, DLFs were forecast to be 5.01%.

Assessing how this forecast compares with what really took place can only be carried out two years later in January 2006, when billing for FY05 is complete and stable. At this point in time, losses can be determined by comparing purchases and sales. Reconciliation is carried out, and for FY05, losses turned out to be 4.93% This reconciliation process is then used in the estimation of losses for subsequent years.

STEP 2 Estimation of Losses for the year in which the DLFs are to apply

Clause 3.6.3 (h) (5) anticipates the use of the most recently available consecutive 12 month load and generation data to determine losses for the following year, with some adjustment where necessary. Clause 3.6.3 (h) (2) contemplates reconciliation of the previous financial year, which may not be the most recent 12 month period.

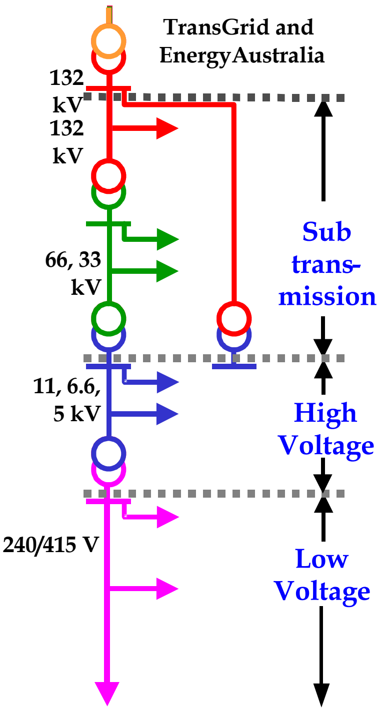
EnergyAustralia therefore estimates losses on the most recent data available and adjusts this data to reflect factors such as anticipated seasonal load variability (consistent with principle 3.6.3 (h) (5) as well as to account for any differences demonstrated by the previous financial year's reconciliation. This is explained in more detail in section 1.7.

STEP 3 Determining the volume weighted average of the average electrical energy loss for connection points

Having established a headline or *top down* figure for total losses, those losses then must be apportioned to various asset classes in the network on a volume weighted average basis. This step, known as a *bottom up* allocation, is described in more detail in Section 2 but in summary, an engineering calculation is done to determine the anticipated losses for each asset category. Once this allocation takes place, any remaining proportion of losses is allocated to unread meters and accrual. This accrual is allocated to the LV network.

As anticipated by clause 3.6.3 (b) (2), Distribution losses for non-site specific connection points are considered in categories, related to the functional part of the network. The various categories are estimated using the approaches shown in Figure 1 on the next page[1].

In this analysis, the effect of transmission losses (in both the TransGrid and EnergyAustralia networks) has been excluded[2]. On 1 February 2000, the boundary of the transmission network changed in NSW, to include EnergyAustralia's transmission assets (previously these assets had been treated as distribution). Both distribution and transmission loss factors have been altered accordingly. The present revision of losses has been updated to account for this change in the transmission boundary with the reclassification of some EA assets to transmission moving in to the current regulatory period of FY04 to FY09.



Loss Element	Series Loss	Shunt Loss
Transmission (parallel 132 kV)	TPRICE simulatio	transformer substation and typical shunt
Radial 132 kV network		negligible
132/66 & 132/33 substations		transformer substation and typical shunt
ST networks		negligible
Zone substations		transformer substation and typical shunt
HV network	sample studies, peak and loss load	negligible
Distribution substations	transformer count, load and loss load	transformer and typical shunt
LV Network	Loadflow on a sample LV networks	negligible
Meters and load control	negligible	device count typical shunt
Non technical losses	N/	residual calculated purchases less sales

Figure** 1 **- Loss factor estimation

1 *Series* (or copper) losses occur in the network connection between generator(s) and load(s) due to the resistance to electrical flow and vary with the power supplied to the load. Series losses tend to follow a "square law", in that the series loss in a simple network is proportional to the square of the current supplied to the load. *Shunt* (or iron) losses are a "leakage" of energy (mainly associated with the connection of transformers and other equipment to the network) and occur regardless of the flow of power to the load.

2 In its glossary, the National Electricity Code defines transmission assets to include those assets of 66 kV or higher voltage, which operate in parallel with the main transmission network. EnergyAustralia owns and operates 132 kV transmission assets in the Sydney and Newcastle areas.

The next step is to allocate a portion of each asset class's losses to customer classes. For example, a certain amount of losses relates to 33kV underground and overhead feeders. Some of those losses are caused by domestic customers load further below in the network. The allocation of asset losses to customer class is carried out based on a pro rata energy allocation as well as considering each customer class peak, shoulder and off peak energy mix and their average power factor. Having carried out this allocation, the calculation of DLFs at this point is then a simple case of taking the losses, dividing by the total energy for that customer class and adding one.

1.3 Loss estimation

This section describes how the losses in the EnergyAustralia distribution network are estimated. The losses on the network comprise "technical" losses, which to a greater or lesser degree are amenable to engineering estimation. There is also a proportion of lost energy described as non-technical losses, which includes that lost due to fraud but also that arising from metering, data and information deficiencies. Historical losses on an electricity network can be readily determined by simply subtracting energy exiting the system from energy entering the system. The difference is energy lost.

1.4 Energy entering the network

Energy entering the network, commonly known as being "purchased" (though EnergyAustralia network does not in fact purchase energy) or delivered to the EnergyAustralia Network from TransGrid is readily accountable from the meters at points of bulk supply, as these are used for both market settlements and transmission network pricing. There are also supplies to EnergyAustralia from:

- Integral (at Carlingford 66 kV and Guildford 33 kV);
- Delta Electricity (Vales Point 33 kV);
- Macquarie Generation (Liddell 33 kV); and
- Embedded generators (at 132, 33 and 11 kV).

For example, the total energy "purchased" in FY04 was 27,563 GWh (refer to Table 2). This excludes the Hydro Aluminium smelter at Kurri, BHP Billiton at Newcastle and energy flowing through the transmission network to Country Energy via Kurri and Tomago at 132kV and 66 kV. If all these loads are included then the total energy delivered through the EnergyAustralia Network for FY04 was 30,484 GWh.

In the reconciliation of distribution loss factors, actual historical energy quantities are used. The loads of large customers are individually modeled from meter data.

1.5 Energy exiting the network

Calculating energy exiting the network or 'sold', though conceptually simple, is quite labour intensive, requiring the measurement and aggregation of over 1.5 million connection points on the EnergyAustralia network. It requires tracking each connection point, ensuring a meter is installed and is in good working order, that it is read regularly, that the reading is billed and invoiced correctly. All of this is also required for customer billing and therefore determining the volume exiting the network is done through the use of billing invoices of all 1.5 million network customers. Because of the lagging nature of meter reading being spread out over a 3 month cycle, determining exit volumes requires at least a 5 month delay from the end of the financial year. This guarantees that a reliable 'sales' volume has been calculated.

1.6 The overall level of network losses

Past Approach to estimated distribution losses and setting loss factors

Until 2002, estimates of distribution losses for the EnergyAustralia network were based upon purchases ('inputs') and sales ('outputs') information obtained before late 1996, as the introduction of contestability led to some uncertainty over sales totals. The overall level of losses for the EnergyAustralia network up to 1996 was 4.51% of purchases, and had been monitored for the four-year period from FY92 to FY96.

However, recent history has shown a rising trend in losses, as shown in Table 1.

Table 1: A History of EnergyAustralia DLFs

Year	Overall Losses Factor Used to Derive DLFs	Actual Losses after Year Completed
FY00	4.51%	Not available
FY01	4.51%	4.89%
FY02	4.51%	4.85%
FY03	4.55%	5.26%
FY04	4.60%	5.36%
FY05	5.01%	4.93%
FY06	5.32%	5.36%
FY07	5.32%	Year not complete
FY08	5.36% (proposed)	-

The year-on-year variation of (purchases-sales), as can be seen from Table 1, is significant, due to the effect of seasonal loading, particularly relating to the winter/summer cycle of heating/cooling load for SME and domestic customers. The other key effect in this instability is related to comparing "entering" energy, measured up to the hour, against 'exit' energy, smeared across a quarterly billing cycle. This makes it difficult to determine DLFs which provide a result consistent with the principle in clause 3.6.3(h)(1), ie. of seeking to ensure that the total amount of energy calculated in relation to a distribution network (as adjusted for losses by the relevant DLF) for a particular financial year is as close as reasonably practicable equal to the amount of electrical energy flowing through all connections points in the distribution network and the total electrical energy losses incurred on the distribution network in the financial year.

For this reason, EA applied a methodology from FY00 to FY04 whereby the distribution losses were calculated on the basis of a 5 year rolling average. For FY05, this method was modified to be carried out on a 3 year rolling average. This methodology was accepted by IPART and the consequent DLF's were approved by IPART.

In calculating DLFs from FY06 to FY07 however, EnergyAustralia moved away from the rolling average methodology as this approach had shown not to be responsive enough and had introduced a consistent under signaling of losses from FY01 to FY05, this is also demonstrated in Table 1 and Table 2. To address the under signaling, rather than an average, the most up to date full year losses for FY04 of 5.32% was used as a basis for calculating DLFs for FY06 (extra billing data demonstrated an overall loss factor of 5.36% for FY04). This methodology was consistent with the principle set out in 3.6.3(h)(5) and was accepted by IPART and the subsequent DLFs were approved.

The most recent history of EnergyAustralia's shortfall in signaling losses is calculated in Table 2 below.

Table 2: Accumulated Losses Energy not Accounted for in DLFs

Year	Energy Missed due to Under-Estimation	Result
FY01	26,461GWh x (4.89% - 4.51%)	100.6 GWh
FY02	26,646GWh x (4.85% - 4.51%)	90.0 GWh
FY03	26,861GWh x (5.26% - 4.55%)	190.7 GWh
FY04	27,563GWh x (5.36% - 4.60%)	209.5 GWh
FY05	27,824 GWh x (4.93% - 5.01%)	-22.3 GWh
FY06	28,763 GWh x (5.36% - 5.32%)	11.5 GWh
	Total	**580 GWh**

1.7 Reconciliation Mechanism and Subsequent Adjustment for Non-Site Specific Factors

Proposed Approach to Loss Estimation for Financial Year 2007-08

As indicated in Section 1.2 above, Step 2 of EnergyAustralia's methodology involves an estimation of the losses for the year in which the DLF's are to apply. The estimation is calculated as follows:

- Estimated losses based on most recent actual load and generation data available for a consecutive 12 month period, being 5.36%
- Figure in 1) is adjusted to take into account forecast load variability other instability in data due to timing of available data for sales. Such adjustment is based on the historical variation of losses and shortfalls set out in Table 1 and 2 as well as the reconciliation from the previous year.

Estimated losses (the *top down* figure) for financial year 07-08 is forecast at 5.36%.

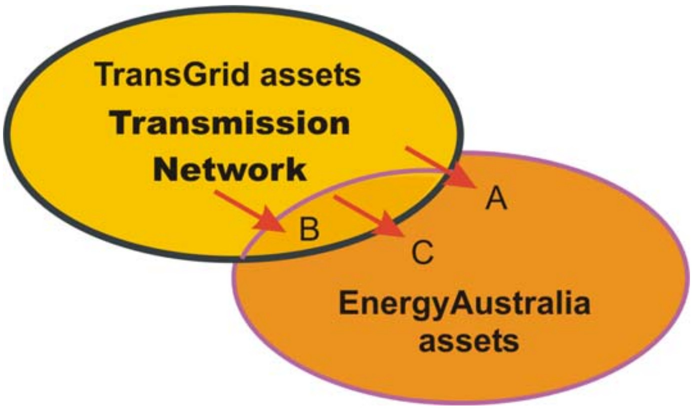
This approach addresses shortfalls from previous rolling average methodology and avoids any price shocks to customers.

1.8 Transmission losses

The EnergyAustralia network includes parallel 132 and 66 kV assets that support the TransGrid network. These assets have been identified and agreed with the Australian Energy Regulator and incorporated into the NEMMCO model used to calculate Transmission Loss Factors (TLFs). In forward years, some assets can become transmission, and the loss associated with these assets is then included in the calculation of TLFs by NEMMCO, and removed from the calculation of distribution losses. These assets are prospectively transferred for the purposes of deriving TLFs. Figure 2 illustrates the network boundaries and metering locations. The energy lost in the EnergyAustralia transmission network (B - C) therefore is deducted from the energy "purchased" at the TransGrid bulk supply points to EnergyAustralia transmission and distribution networks (A + B), to determine the energy delivered via the distribution network (A + C).

It should be noted that the metering used for market settlements was transferred to the transmission network boundary (A and C) in November 2006.

Figure 2 - Transmission network boundary



The losses in EnergyAustralia's transmission assets were derived by comparing the meter data and B with the data at A & C. The series losses in each element of the EnergyAustralia transmission network amounts to 0.43% of the "purchased" energy on average. This percentage can shift marginally due to the variable pattern of generation and interstate flows;

Any change in EnergyAustralia's transmission losses is subtracted from the overall system losses to derive the 'distribution only' losses figure.

2 Breakdown of Technical Losses

Having established a *top down* figure for total losses in the entire distribution network, losses must now be allocated across the different voltage levels at which each of the customer classes connect to the network, known as a *bottom up* allocation. Since electricity generally flows from higher voltages to lower voltages in a distribution system, the calculation of losses across voltage levels necessarily requires an assessment of the total losses at each voltage level. Once this is established, an apportionment of that loss volume must be made, not only to customers connected at that voltage, but also customer connected below but who have had their energy delivered through that voltage. This next section sets out EnergyAustralia's methodology to carry this out.

2.1 Calculation of Site Specific Loss Factors

EnergyAustralia calculates site specific loss factors using the cost allocation software TPrice. TPrice is used in the NEM for the allocation of transmission costs and the calculation of Transmission Loss Factors by NEMMCO.

EnergyAustralia uploads the full topology of the network down to the 11kV busbar of each zone substation and then also down to each customer of greater than 10MW usage, in to TPrice. This covers line impedances, connections, transformer impedances and standard operating conditions. Each customers load profile from metering data is uploaded, and each zone substation has a deemed load profile applied and uploaded in to TPrice as well. TPrice then runs a loadflow for each hour of the year. Any loadflow must calculate losses as part of its calculation of energy flows, since a loadflow cannot converge to a solution without all power flows balancing.

TPrice then collates the results and calculates the total losses attributable to each large customer. It does this by allocating upstream shared losses on a total energy basis. For example, consider a substation that a large customer connected but with other load connected as well. Consider that TPrice has determined electrical losses on the substation of 100MWh over the year and substation saw 20,000MWh of load pass through it during the year. The large customer connected downstream used 500MWh, then the losses through the zone substation attributed to the large customer are:

100MWh x 500/20,000 = 2.5MWh

This method is applied to all upstream assets such that the large customer receives a portion of losses all the way along the supply chain.

2.2 Subtransmission network series losses

TPRICE analysis[3] is used to derive the series losses for each subtransmission asset and the average series losses for loads of greater than 10 MW[4]. Each 66 and 33 kV location represents a major customer connected to the subtransmission network, whilst 11 kV locations can be large customers but are mostly zone substations, where the downstream load of both high voltage and low voltage customers is aggregated. This analysis is updated periodically to account for any major changes in network topology and usage patterns.

2.3 Subtransmission network shunt losses

Estimates of the average shunt losses in 132, 66 and 33 kV transformers are combined with the number of in-service transformers to determine the annual energy losses. An estimate is also made of the energy consumed by Zone substation auxiliaries, including transformer fans and pumps. Results are revised annually via a simple uplift to account for increases in the asset base. The calculation is revised periodically to adjust for any major changes in asset mix and loading.

2.4 High voltage network series losses

A representative sample of zone substation high voltage networks was analysed in FY01, to arrive at the total losses in this portion of the network. There were 9 Sydney and 8 Newcastle zones in the sample. Each sample location was analysed using loadflow, to determine the losses at peak load. Results have been revised annually via a simple uplift to account for increases in the asset base. This analysis is recalculated periodically to adjust for major changes in asset mix, topology and loading.

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[3] Load flow analysis, using 8760 hourly records for the latest year. Hourly loads mostly estimated from average load profiles at zone substations, scaled to match the load profiles at transmission exit points. Those loads greater than 10 MW were taken directly from metering records.

[4] TPRICE calculates marginal loss factors directly, as the weighted average of the marginal loss at each load, for each hour of simulation. Average loss factors for each hour are calculated by apportioning the series losses in each element of the network using the pricing allocation. In this simulation, the energy method of pricing allocation has been used.

2.5 Distribution substation series losses

The analysis of distribution transformer losses begins by taking stock of available records of distribution transformer design rating information. Transformer design information has series losses at nameplate rating. This information is then used to calculate load loss factors for each transformer.

Loading data is required next. In most of the EnergyAustralia area, distribution substations are equipped with manual reset maximum demand indicators (MDIs) and these readings are recorded periodically within EnergyAustralia's asset management systems. This data is queried and the average of recorded single-phase MDI readings is expressed as a percentage of the sum of the transformer nameplate ratings. The average utilisation figure derived from this calculation is generally around 67%, and this is used to calculate peak losses across all distribution transformers.

The peak losses in distribution substations are converted to an annual energy loss using an annual system loss load factor of 0.347.

A count of the records of in-service distribution transformers (for which individual shunt losses were also recorded) yields a ready estimate of their shunt losses.

This analysis is recalculated periodically for any major changes in asset mix, topology and loading.

2.6 Meters and load control device shunt losses

Meter losses are calculated based on nameplate information and carrying out a meter count from relevant IT systems. Note that the meter potential coil (or power supply) connection is on the input side of the meter and therefore its losses are not recorded in the meter consumption.

2.7 Non technical losses

Non technical losses include fraud but also can arise from metering, data and information system deficiencies. A consistent flow of reports from staff and the public giving rise to investigation. EnergyAustralia uses approximately 150 compact recording instruments (theft monitors). These are installed in the street to check the meter readings at premises under investigation. Recently, this process was expedited by taking special meter readings at such premises, allowing many checks to be completed in a matter of weeks rather than a full 3-monthly billing cycle.

Non-technical losses are simply the left over portion of losses that cannot be attributed to the electrical network. Once technical losses have been determined from the methodology outlined above, it can be expected that a small amount of overall system losses is unaccounted, and must therefore be attributed to fraud, meter reading errors and other minor billing errors. All non technical losses are assumed to take place on the low voltage network and therefore are attributed to this class of customer.

2.8 Low voltage network

In January 2004, EnergyAustralia completed a technical assessment of the losses on the LV network. A survey of selected portions of LV network was carried out across EnergyAustralia's network. Energy data loggers were installed at 18 low voltage distributors which were spread across the EA network area and remained in place for periods of up to six months. Five minute consumption data was measured and retrieved from each location. The load data was then imported into a loadflow package, the feeder impedances modeled in the software and a load flow was carried out for each five minute load period, over the full six month of load data. Once the losses of each LV distributor were determined, the losses in each conductor in the LV distributor were weighted against its relative occurrence in the network (weighted from the GIS system which contains the whole LV network). This analysis gave a weighted loss on sales on the LV network of 1.81% (on purchases). It was assumed before this study that total losses on sales for the LV network was only 0.42%, so this study caused a substantial revision of expected losses in the low voltage network.

3 Summary of Losses

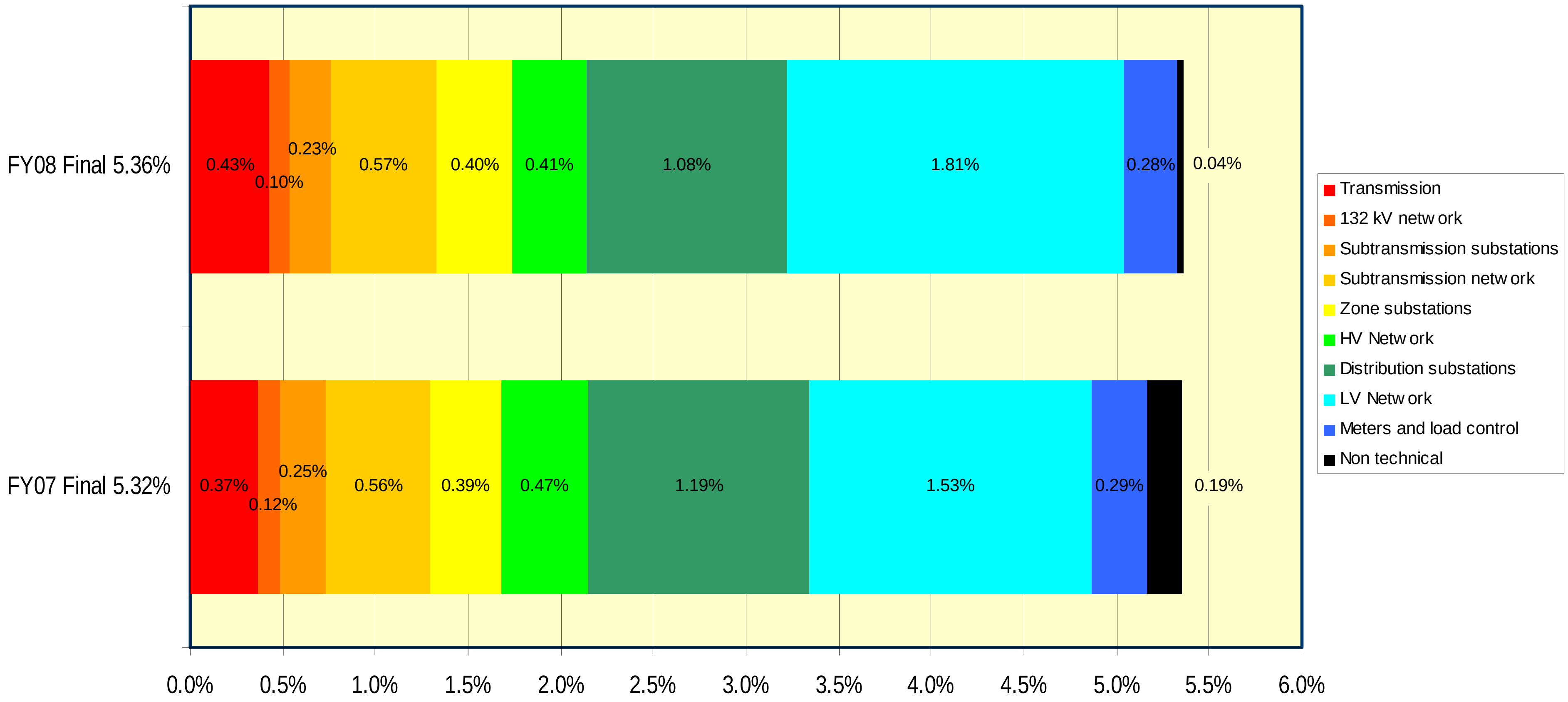
Table 3 and Figure 3 below summarise the inputs, losses and outputs of the EnergyAustralia transmission and distribution network.

Table 3: Energy Balance for Network, based on FY04 Volumes for Reference Purposes

#	NETWORK ASSETS	ENERGY "PURCHASED"			LOSS IN MWh			ENERGY DELIVERED
		TRANSGRID MWh	GENERATORS MWh	TOTAL MWh	SERIES MWh	SHUNT MWh	TOTAL MWh	MWh
1	132 kV transmission network(TransGrid -> EAT)	20,328,803		20,328,803	130,000		130,000	2,772,158
2	132 kV transmission network (EAT -> Dist)	7,560,653		7,560,653				
3	132 kV S/T network (TransGrid -> Dist)	9,181,204	956,394	10,137,598	31,570		31,570	240,044
4	132/66 kV substations			-	20,440	1,718	22,158	35,439
5	66 kV transmission network (EAT -> Country)						-	19,808
6	66 kV S/T network (Integral -> Dist)	677,785		677,785	9,730		9,730	403,350
7	132/33 kV substations			-	23,010	22,760	45,770	1,214,654
8	66/33 kV substations			-	340	663	1,003	
9	33 kV network (EAT -> Dist)	7,517,385	222,749	7,740,134	162,290		162,290	1,129,832
10	33 kV network (Integral, Delta & VPS-> EA Dist)	301,570		301,570			-	
	33 kV transmission network (EAT -> Country)						-	50,106
11	132/11 kV substations			-	19,200	10,619	29,819	
12	66/11 kV substations			-	3,360	5,799	9,159	
13	33/11 kV substations			-	40,940	42,353	83,293	425,634
14	HV Network (EAT -> Dist)	2,662,946		2,662,946	122,578		122,578	1,372,019
	11 kV transmission network (EAT -> Country)						-	
15	Distribution substations			-	157,698	170,006	327,704	2,564,722
16	LV Network		836	836	548,390		548,390	20,004,374
17	Meters and load control			-		86,076	86,076	
18	Shrinkage (0.17%)			-		11,998	11,998	
	Total for Distribution Network	**27,771,542**	**1,179,978**	**28,951,520**	**1,139,546**	**351,991**	**1,491,538**	**27,459,982**
	Total incl EnergyAustralia Trans	**30,489,362**	**1,179,978**	**31,669,340**	**1,269,546**	**351,991**	**1,621,538**	**30,232,141**

The pie chart in Figure 3 illustrates the general location of losses across the EnergyAustralia network.

Figure** 3: **Location of Losses in the EnergyAustralia Network



4 Tariff Class Averaging

Between the tariff groups of low voltage customers, there is a significant variation in consumption patterns and power factors. To manage this, loss factors are assigned to tariff classes rather than to just voltage levels where a number of tariffs exist. Thus the domestic customer classes (including controlled load) are averaged, as are the LV and HV business customers. The averages apply across the whole of EnergyAustralia's territory.

4.1 Time Variation of Losses

Losses for the tariff customer classes are estimated for peak, shoulder and off peak periods[5], taking into account the square law relationship of series losses. The loss factors for peak, shoulder and off peak are then used in conjunction with the tariff group energy consumption patterns to develop overall loss percentages.

4.2 Accounting for Power Factor

This issue arises predominantly in relation to streetlight loads, which have a markedly different power factor (around 0.40) compared with the remaining load (around 0.95 average). The contribution of individual loads to the total series loss has therefore been adjusted by taking into account the angle between the load and the average. This results in a "scaling factor" which increases the streetlight distribution loss factor[6].

4.3 Geographic variation of Loss Factors

The variability of loss factors at the subtransmission network level was estimated in 2002 from TPRICE analysis and is repeated below. Distribution losses in the network are characterised by high values at a few (mainly geographically remote) locations. The following table includes the likely range of distribution losses to LV connected customers.

Table 3: Geographic variation of loss factors

Voltage level	Lower bound	Average	Upper bound
Subtransmission	1.0	1.009	1.1
High Voltage	1.0	1.013	1.4
Low Voltage	1.02	1.055	1.5

It should be noted that a very few large customers are connected at the subtransmission level, as these points are mainly substations from which they are supplied.

5 The peak, shoulder and off peak periods are now defined as follows:

- *Peak* is from 2.00 p.m. - 8.00 p.m. on working weekdays;
- *Shoulder* is from 7.00 a.m. - 2.00 p.m. and 8.00 p.m. - 10.00 p.m. on working weekdays for business customers and includes the period from 7.00 a.m. - 10.00 p.m. for residential customers; and
- *Off peak* is at all other times.

6 The power factor and consumption pattern adjustments are made, with a typical power factor of 0.4 for street lights being assumed. A scaling factor was calculated as the MVA contribution by each LV class to the overall MVA of LV loads. This approach is described in Attachment 1.

Attachment 1 – Accounting for Load Power Factor

This section describes how the power factor of components of the LV load supplied by the network should be taken into account in determining their loss factor. Some components of the load, such as streetlights, have a much lower power factor than other loads.

The situation may be understood with reference to the P-Q diagram below. Line OZ represents the LV load on the network. The load comprises MVA load components a, b, and c with power angles of α, β and χ respectively. The MW load components are a', b' and c'.

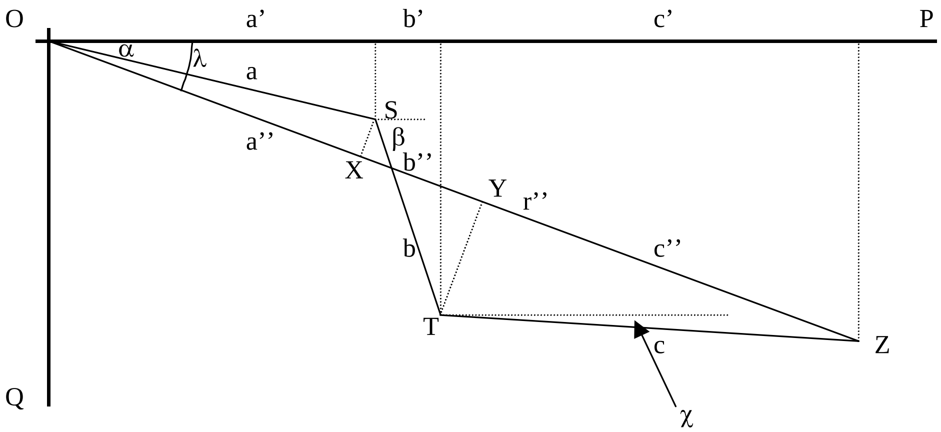


Figure 4: Vector diagram indicating load power factor

Line OZ is the total MVA load and is the vector sum OSTZ of load components a, b and c. It has a value of r" and power angle λ.

Now, the series losses in the network are driven by the total MVA load. The relative contributions to the total loss by the three loads in this example are OX, XY and YZ.

The MVA contribution of each component of load depends upon the cosine of difference between its angle and the angle of the total load. If the angles of the total MVA load is :

$$r'' = a'' + b'' + c''$$

$$= a*\cos(\lambda - \alpha) + b*\cos(\lambda - \beta) + c*\cos(\lambda - \chi)$$

$$= a'*\cos(\lambda - \alpha)/\cos(\alpha) + b'*\cos(\lambda - \beta)/\cos(\beta) + c'*\cos(\lambda - \chi)/\cos(\chi)$$

The above equation is used to determine the contribution to the total MVA load by each component.

By way of example, consider there are just two load components, with a' being 19,000 MWh with power factor 0.95 (20,000 MVAh at angle 18.19°) and b' 135 MWh with power factor 0.40 (337.5 MVAh at angle 66.42°). The total load r" is the vector sum of these quantities, 20,226.4 MVAh at angle 18.91°.

The contributions to the total MVAh load r" are as follows:

$a'' = 19{,}000*\cos(18.91° – 18.19°)/\cos(18.19°) = 19{,}998.45$

$b'' = 135*\cos(66.42° – 18.19°)/\cos(66.42°) = 227.95$

These contributions expressed as a multiple of the MWh load are as follows:

$a''/a = 19{,}998.45/19{,}000 = 1.05$

$b''/b = 227.95/135 = 1.69$

In the calculation of distribution loss factors, these ratios are used as scaling factors to apportion the contribution to series component of losses.