Ausgrid

Review of factors contributing to variations in operating and capital costs structures of Australia DNSPs

Final Report

November 2012

Executive Summary

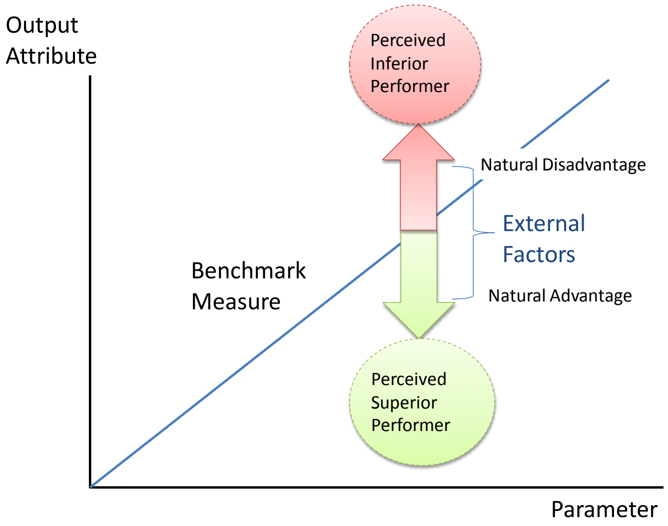
Commonly, and not surprisingly, there is an expectation that it should be a relatively simple matter to establish benchmarks comparing the performance of Distribution Network Service Providers (DNSPs) from an economic and service level perspective. A seemingly logical conclusion is that such benchmarking can provide significant input into the regulatory framework. Across Australia, DNSPs' businesses differ significantly in a number of key ways, largely reflecting different regions, history and demography. By way of contrast, CitiPower in Melbourne services 308,000 customers in an area of just 157 sq. km around the Melbourne CBD whereas Ergon Energy services 662,000 customers over 1.7million sq. km – a customer density difference of 5000:1. Clearly, drawing conclusions from the comparative benchmarking of these organisations is fraught with danger. What is less clear is the danger inherent in benchmarking organisations such as Ausgrid, Energex, United Energy, CitiPower and Jemena that do have greater similarity.

Ausgrid has engaged Evans & Peck to identify factors, if any, that may bring into question the validity of such benchmarking, or at least necessitate adjustments to more realistically reflect the operating and environmental circumstances that differentiates DNSPs.

Whilst the purpose of this report was not to undertake detailed benchmarking, in order to identify some of the benchmark "modifiers" it is first necessary to consider some of the benchmarks commonly applied to DNSPs. Evans & Peck has considered the normalised measures that are typically used for high level comparisons between businesses as well as more elemental measures of network investment and expenditure performance. This provides analysis of the scale factors and the various asset-customer-expenditure relationships that contribute to the need for capital investment in network infrastructure. Whilst some care was taken in selecting data used for 'benchmarking', the primary aim here was not to quantify but rather highlight factors that may contribute to variations in operating and capital costs.

The availability and accessibility of a consistent and comparable set of data is problematic, particularly at a distributor level. However, acknowledging that there are inherent difficulties in comparative benchmarking, Evans & Peck Considered a range of factors at a state level (consolidating TNSP and DNSP data unless otherwise specified) which have led to a number of worthwhile observations that can be made with a number of central themes emerging. If the information were available, further analysis might depict even greater diversity when considering individual customer class or sub regions within distributors, and provide more granularity in the conclusion.

Network costs are shaped by many major cost drivers including the scale of the network, the level of reliability, environmental conditions, the risk appetite of the network owning corporations and historical management strategies applied to each network. Much of the network was built over 40 years ago, and still performs the same functions as those parts of the network built over the last few weeks. This report includes a number of high level measures of performance relevant to distribution networks by identifying and describing measures frequently used by regulators.



As depicted in the above diagram, in isolation and without considering the impact of the operating and environmental circumstances that differentiate DNSPs, these measures can be interpreted in a way that derives a perceived result that does not adequately reflect true performance. Throughout this analysis, a number of indicators arose:

- Irrespective of the measure, the Victorian Urban DNSPs always appear to trend to superior performance.
- On any measure relating to line length, Ausgrid performs poorly.
- On physical measures such as demand / customer and energy / customer, Ausgrid is generally in line with benchmark, but the measures tend to indicate Victorian Urban DNSPs need less installed capacity per customer than benchmark.

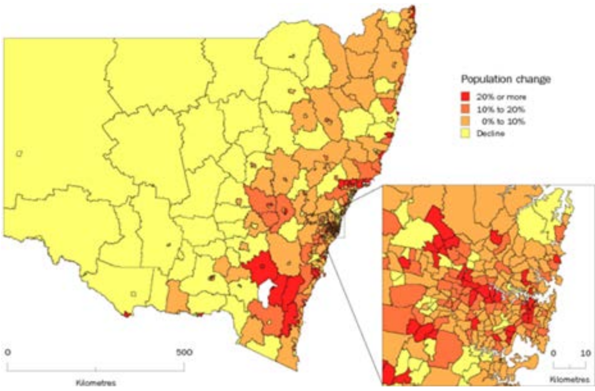
We considered a range of characteristics and have subsequently reported on a number of key comparison. Whilst there are complex factors which make it difficult to support the assertion that any network is actually 'similar' to another network, and accepting that there is probably no single measure to describe the scale given the complexities discussed throughout this report, the length of the network can be viewed as a readily available high level measure of network scale for the purpose of determining cost drivers. This analysis points to benchmark modifiers in two specific areas:

- A general theme that it requires less resource to distribute electricity in Victoria when compared to other Eastern states, and in particular the urban areas.
- A specific theme that suggests Ausgrid applies more line resources, in financial terms, to distribution than would be expected.

A reasonable synopsis is that historical factors that have led to different reticulation systems for transmission, sub-transmission and distribution voltages. The significantly lower length of overhead line per customer, reflecting the higher concentration of the Victorian population along the transmission line routes, reduces the need for intermediate sub-transmission infrastructure to reach population centres. Similarly, the significantly lower underground cable per customer in Victoria when compared to the other mainland states reflects denser and/or less complicated urban environments.

This also translates to the relative value of the network when measured on a value per km measure where Ausgrid's value is significantly higher than average. This is an area where Ausgrid's notional benchmark performance is poor. It would appear that the capital intensity of Ausgrid's lines is very high, largely driven by the disproportionate amount of high value sub-transmission. We would expect this to also extend to substation assets if these were included in the denominator of a composite asset. Similarly, the number of transformation steps of voltage from the transmission through to the LV network is considerably higher in NSW and Queensland when compared to Victoria, along with the size and the type of transformers. On balance we would expect these factors (and others) to have a positive impact on Victorian benchmarks, particularly in terms of the existing Asset Base on a per customer base, and on Capex. Given the lower asset base, this also flows through to Opex.

There were also a number of environmental factors considered as their impact on distribution networks can vary significantly from state to state and from distributor to distributor, which in turn has a significant impact on the cost of the infrastructure. The environmental factors extend to a number of climatic and weather observations influencing the design and planning requirements of the network along with general exposure to these conditions impacting overall network performance. The most significant factor and perhaps the most common thread is related to the population in terms of both location and density as this determines both the size and type of network and to some extent the classification of customers translating to line lengths and value per customer.



The mean population growth over the Ausgrid coverage area was 9.24% between 2001 and 2011 and while Blacktown recorded the largest increase in population, the fastest-growing LGAs in NSW included Canada Bay and Auburn, located along the Parramatta River in inner western Sydney. Overall growth is concentrated in high density brown field areas where highly urbanised conditions makes both constructing new assets and maintaining existing assets more expensive and where the retirement of older assets and infrastructure might be required as it is not reasonable or economically feasible to redeploy them.

Evans & Peck has qualitatively summarised a range of factors in the following table. We have either categorised them as having a "natural cost advantage", where their natural circumstances make them appear better than reality; having a "natural cost disadvantage"; where their natural circumstances make them appear worse than reality; neutral (no obvious cost advantage) or "unknown" where there was insufficient information available to make an observation. The initial observation that can be made is that NSW is most similar to Queensland in the majority of categories' and is probably better for comparison than the other states. A second notable observation from the table is the extent that "natural cost advantage" conditions exist in in Victoria.

On almost every measure, with the exception of bushfire vulnerability, it appears that Victoria in general, and Melbourne in particular, is an easier place to distribute electricity than other states within the NEM.

Conventional Benchmarks	Ausgrid	NSW	Vic	QLD	SA	Tas
Statistical Comparisons						
Line Length Comparisons	Disadvantage	Disadvantage	Advantage	Disadvantage	Advantage	Advantage
Customer Comparisons	Disadvantage	Disadvantage	Advantage	Disadvantage	Advantage	Advantage
Efficiency Measures (Value RAB)	Disadvantage	Disadvantage	Advantage	Advantage	Disadvantage	Advantage
Intensity Measures (Volume)	Disadvantage	Disadvantage	Advantage	Advantage	Advantage	Advantage
Infrastructure Burden Measures	Advantage	Disadvantage	Advantage	Disadvantage	Advantage	Neutral

Benchmark Modifiers	Ausgrid	NSW	Vic	QLD	SA	Tas
Historical Factors	Disadvantage	Disadvantage	Advantage	Disadvantage	Disadvantage	Advantage
Network Scale (Line Length) / Voltage Class	Disadvantage	Disadvantage	Advantage	Disadvantage	Disadvantage	Advantage
Network Value	Disadvantage	Disadvantage	Advantage	Disadvantage	Disadvantage	Advantage
Installed Capacity and Energy Transformed	Disadvantage	Disadvantage	Advantage	Disadvantage	Disadvantage	Disadvantage
Transformation Steps and Transformers	Disadvantage	Disadvantage	Advantage	Disadvantage	Disadvantage	Disadvantage
Asset Age Profile	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Load Factor and Load Duration	Neutral	Neutral	Advantage	Disadvantage	Advantage	Disadvantage
Customer Growth	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral
Load Growth	Disadvantage	Disadvantage	Advantage	Disadvantage	Disadvantage	Advantage
Capital Contributions	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Distribution Reliability						
Reliability Standards	Advantage	Advantage	Advantage	Disadvantage	Neutral	Neutral
NSW Reliability Review	Neutral	Neutral	Advantage	Disadvantage	Unknown	Unknown
Environmental Factors						
Green Field vs Brown Field	Disadvantage	Unknown	Unknown	Unknown	Unknown	Unknown
Topography	Advantage	Advantage	Advantage	Disadvantage	Unknown	Unknown
Native Vegetation	Disadvantage	Neutral	Advantage	Neutral	Unknown	Unknown
Population Density	Disadvantage	Neutral	Advantage	Advantage	Unknown	Unknown
Population Change (Growth)	Disadvantage	Disadvantage	Advantage	Disadvantage	Unknown	Unknown
Shape Factors	Disadvantage	Advantage	Advantage	Advantage	Unknown	Unknown
Bushfire Vulnerability	Disadvantage	Disadvantage	Disadvantage	Advantage	Neutral	Neutral
Temperature	Disadvantage	Disadvantage	Advantage	Disadvantage	Advantage	Unknown
Major Weather Events	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

Cost Driver Legend:

Natural Cost Advantage | Neutral | Natural Cost Disadvantage | Unknown

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1 Background and Approach

In Australia, each state and territory has electricity transmission networks with cross border connections linking networks to support the National Electricity Market. Whilst operating as an interconnected network, each portion of the Transmission and Distribution System is separately owned and managed by a number of different public and private corporations.

- Ownership is not common.
- Business models vary between companies including outsourcing.

Network costs are shaped by many major cost drivers including the scale of the network, the level of reliability, environmental conditions within which it operates, the risk appetite of the network owning corporations and historical management strategies applied to each network. Much of the network was built over 40 years ago, and still performs the same functions as those parts of the network built over the last few weeks.

This report includes high level measures of performance relevant to distribution networks by identifying and describing a number of measures frequently used by regulators. In isolation, without considering the impact of the operating and environmental circumstances that differentiate DNSPs, these measures can be interpreted in a way that derives a perceived result that does not adequately reflect true performance. Figure 1.1 demonstrates the issue. In this case, performance above the benchmark line is considered “poor”, and below is considered “good”. All things being equal, this would be the case. However, there may well be a range of factors, each of them subtle in impact that results in individual entities migrating away from a “level playing field” performance position – for both better and worse. The purpose of this report is to identify, at least qualitatively, some of the factors that may be relevant when comparing DNSPs in the NEM, and in Victoria, NSW and QLD in particular.

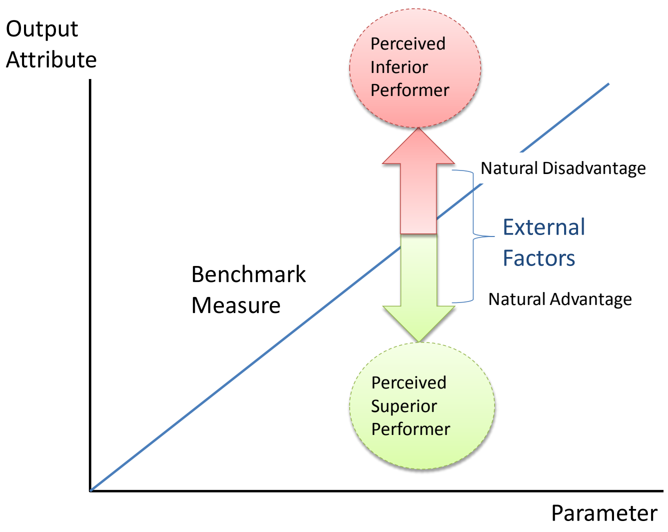


Figure 1-1: Impact of External Factors on Benchmarking

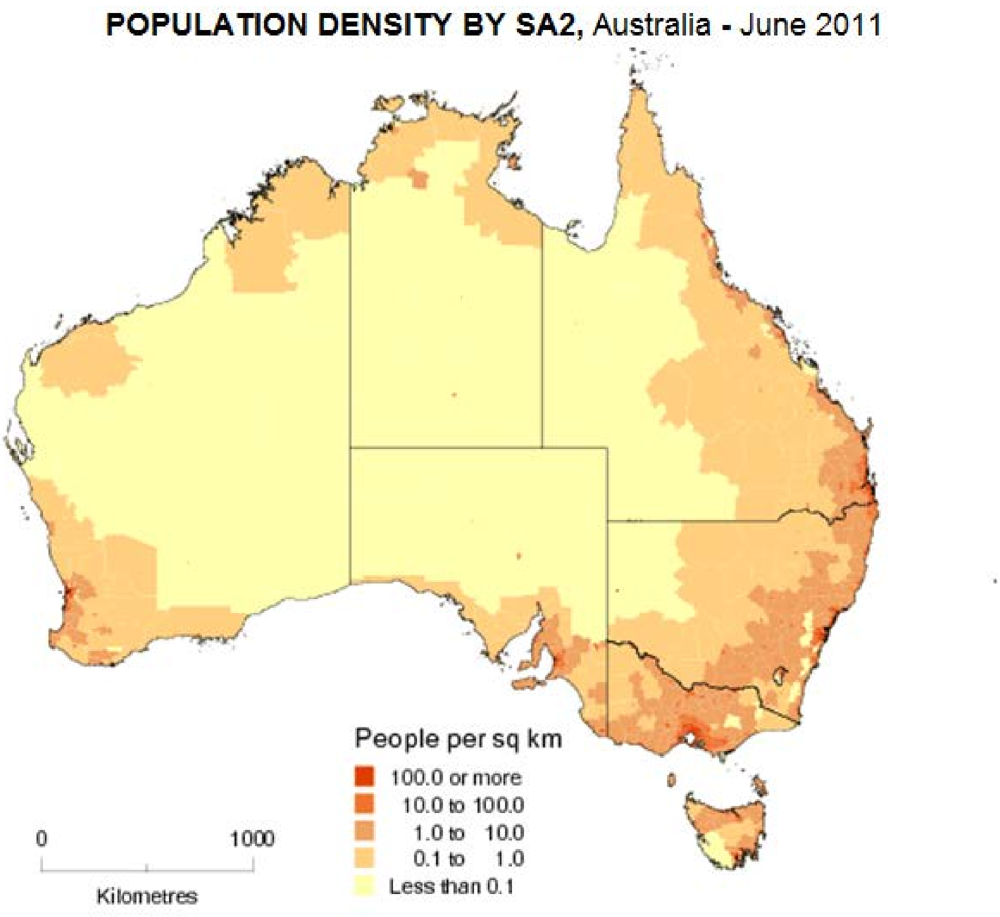
Benchmark modifiers described in Section 3 effectively demonstrate that popular benchmarks based on selective partial indicators do not accurately account for underlying business conditions and historical factors which otherwise contribute greatly to the true cost performance.

2 Sample Benchmarks

Whilst the purpose of this report was not to undertake a detailed benchmarking, in order to identify some of the benchmark “modifiers” it is first necessary to consider some of the benchmarks commonly applied to DNSPs. Evans & Peck has considered the normalised measures that are typically used on high level comparisons between businesses as well as more elemental measures of network investment and expenditure performance. This provides analysis of the scale factors and the various asset-customer-expenditure relationships that contribute to the need for capital investment in Australian network infrastructure.

2.1.1 Composite Measures

Population density varies greatly across Australia, ranging from very low in remote areas to very high in inner-city areas. The ABS reports that Australia's average population density at June 2011 was 2.9 people per square kilometre (sq. km). Among the states and territories, and indeed across each region, the population density also varies greatly as depicted in the diagram below.



Population distribution in DNSP service areas results in a wide diversity of customer density. This is demonstrated in the table below. At one end of the extreme is CitiPower, serving the inner suburbs of Melbourne with Ergon Energy, serving the vast majority of Queensland at the other. CitiPower has a population density of some 5000 times that of Ergon Energy.

Distributor	Customer Density (Customers/sq km)
CitiPower	1963
United	431
Jemena	326
Ausgrid	72
ActewAGL	67
Energex	52
Endeavour Energy	35
SP AusNet (distribution)	8
ETSA	5
PowerCor	5
Aurora	4
Essential Energy	1
Ergon	0.4

Table 1: Population Density by DNSP Service Area

Intuitively, it is obvious that such a variance in customer density will have an influence on the cost drivers of the distribution network. Taking this a step further as an initial comparison, customer density has frequently been used as an exogenous attribute when comparing DNSPs due to the understanding that 'connection' density is a key factor in normalising for the efficiency with which each customer need, such as connection and energy supply is met by the DNSPs.

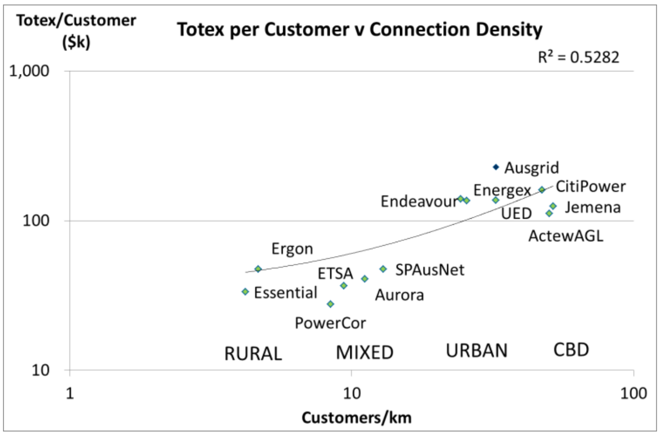


Figure 2-1: Total Cost/km and Customer Density

Figure 2-1: Total Cost/km and , shows a statistically "relevant"[1] relationship between connection density and current day expenditure – "Totex", being an abbreviated combination of Operating Expenditure "Opex" and Capital Expenditure "Capex". Within this framework, it is relatively easy to

[1] Albeit with an R^2 of 0.53

overlay customer groupings Rural, Urban, CBD and combinations thereof, and have individual DNSPs conform to a pre-conceived ranking. The issue at hand is whether or not “benchmark modifiers” are relevant in explaining why Ausgrid (for example) shows a slightly higher than benchmark cost structure, and United Energy / Jemena have costs below the benchmark.

Whilst some care was taken in selecting data used for benchmarking, the primary aim here was not to quantify but rather highlight factors that may contribute to variations in operating and capital cost structures. If the information were available, further analysis might depict even greater diversity when considering individual customer class or sub regions within distributors, and provide a more granularity in the analysis.

In order to start to understand some of the drivers of sub and super optimal benchmark performance, Evans & Peck has initially focussed on line length. Figure 2-2: Capex per km and Customer Density and Figure 2-3: Opex per km and Customer Density reveal a potential correlation (albeit with low correlation coefficients) between expenditure and line length normalised to reflect customer density.

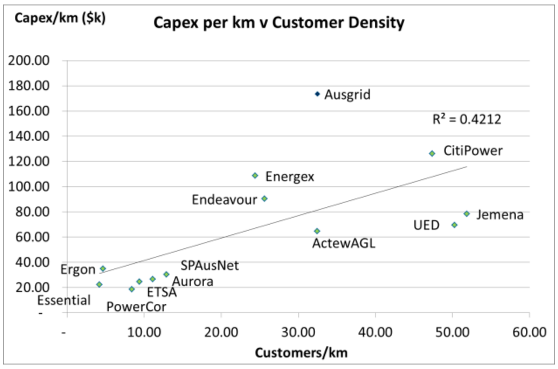


Figure 2-2: Capex per km and Customer Density

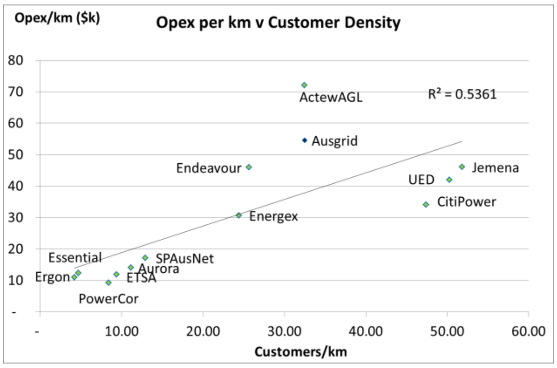


Figure 2-3: Opex per km and Customer Density

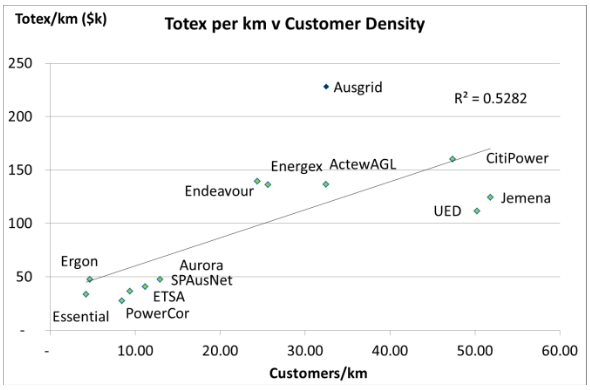


Figure 2-4: Totex per km and Customer Density

As a general trend the NSW, ACT and QLD Urban DNSPs lie well above the regression line and the Victorian DNSPs at or superior to benchmark. Ausgrid performs poorly on this measure. This indicates that there may be an additional cost driver that is affecting these relative positions.

Figure 2-5: Capex per Customer vs Customer Density, Figure 2-6: Opex per Customer vs Customer Density and Figure 2-7: Totex per Customer vs Customer Density indicate the expenditure per customer, which provides a normalised basis to compare the costs of providing the service normalising for the number of customers. Again, Evans & Peck notes that this measure does not account for the condition of the assets or the growth rates (or uncertainty) of demand.

Whilst regression coefficients are low, the Victorian Urban DNSPs appear more efficient than benchmark, there is a greater separation in the performance of Ausgrid and Energex, with Ausgrid continuing to benchmark poorly.

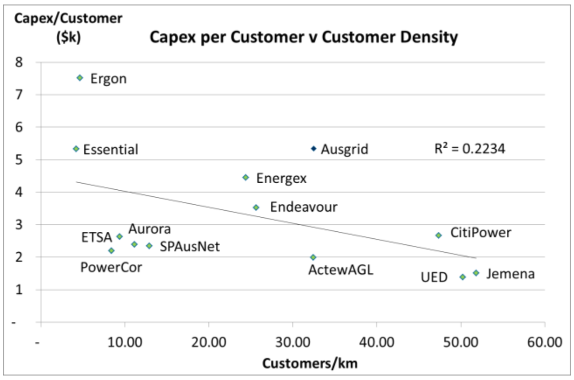


Figure 2-5: Capex per Customer vs Customer Density

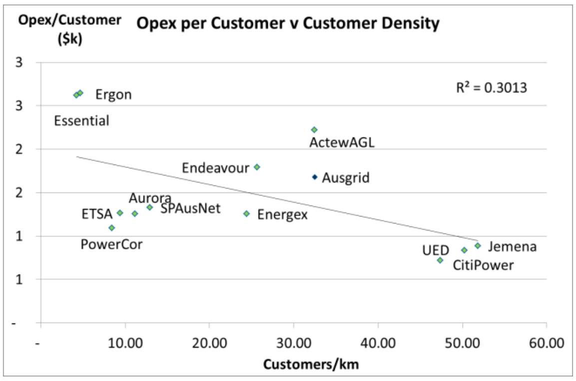


Figure 2-6: Opex per Customer vs Customer Density

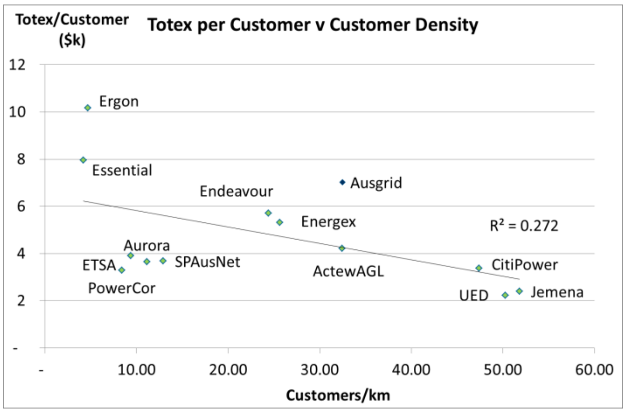


Figure 2-7: Totex per Customer vs Customer Density

Whilst these relationships initially provide a high level view on network comparability, it is necessary to drill down on a range of factors that mean that it is neither possible nor appropriate to draw conclusions without further modification. Such factors may, among other things, be due to differences in:

- Capitalisation and accounting allocation policies
- Network configuration
- Asset type, ratings and planning criteria
- Current and historical asset management practices
- Loading profile of assets
- Environmental factors
- Reliability performance and target
- Current and historical jurisdictional building code requirements

- State and city based development policy (new land releases/infill)

As a result, Evans & Peck considered that it is prudent to examine a range of lower level component measures to identify the real cost drivers that affect different businesses. These are discussed in Component Measures below.

2.2 Component Measures

To investigate the overall effect of different influences on network cost drivers, we have examined a range of lower level relationships to consider the relative:

- *efficiency* of the historical and new investment/expenditure compared to the value of the asset base;
- *intensity* of historical and new investment/expenditure compared to the volume of assets; and
- *infrastructure burden* that the value/volume of assets required to meet demand places on the customer base.

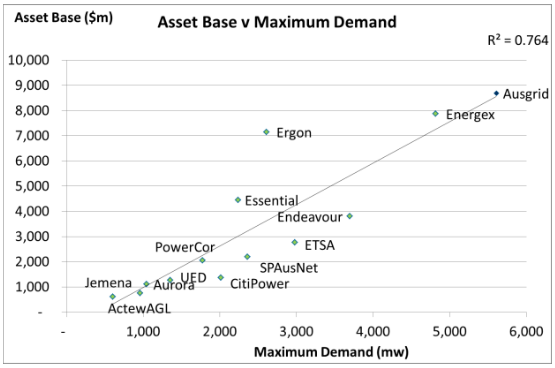
In many cases there are strong scale relationships between variables regardless of the network type (rural, urban, and mixed) whilst other relationships are distorted by the specific influences of network type, size or value. Most importantly, this analysis illustrates that cost drivers differ between networks in ways that are not reflected in the high level comparisons that have historically been used to support regulatory decisions.

2.2.1 Efficiency (Value of Asset Base)

The normalised scale measures above (network length, customer base) do not take into account the investment history of the network, nor its condition, growth rate and uncertainty of demand. The Regulated Asset Base provides an additional scale factor that, in part, brings to account some of these factors.

Whilst it is acknowledged that the Asset Base is dependent on the timing and scale of historical network investment (and can be distorted by changes in expected lives and depreciation rates) it nonetheless provides a measure of the relative efficiency with which the historical investment is providing network services to customers.

Asset Base vs Demand and Energy



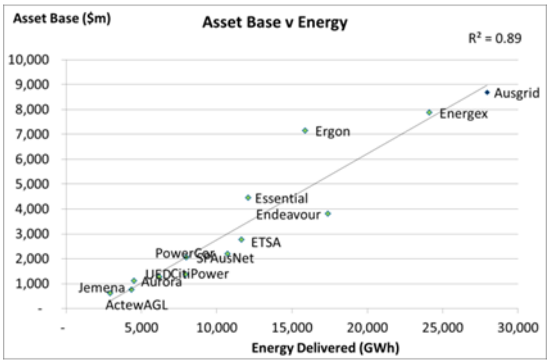
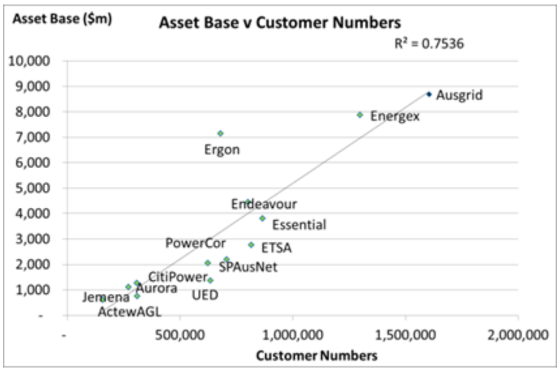


Figure 2-8: Asset Base vs. Maximum Demand **Figure 2-9: Asset Base vs. Energy**

The maximum demand and energy consumption relationships shown in Figure 2-8: Asset Base vs. Maximum Demand and Figure 2-9: Asset Base vs. Energy. The correlation co-efficients are quite high (0.76 and 0.89), whilst both Energex and Ausgrid lie on or near the benchmark the Victorian Urban DNSPs are below the benchmark line. As intuitively expected, the Rural DNSPs in NSW and QLD are above benchmark. High performance (below line) on these measures may be indicative of an approaching need for increased investment in asset augmentation (if growth occurs) and replacement as fully utilised older (and fully depreciated) assets that no longer contribute to the value of the asset base eventually require replacement.

Asset Base v Customer Numbers and Line Length



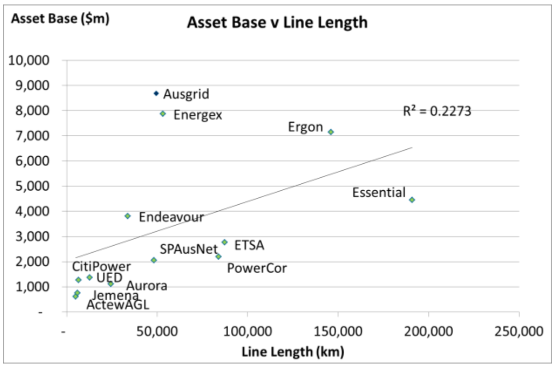
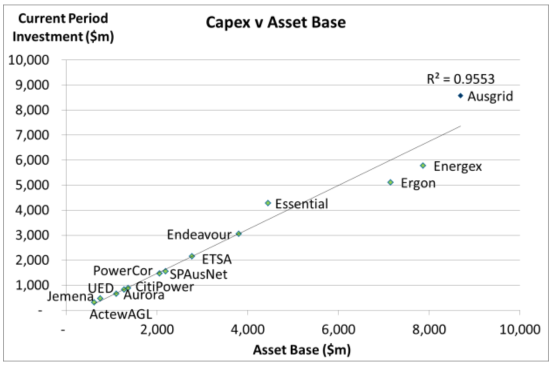


Figure 2-10: Asset Base vs Customer Numbers **Figure 2-11: Asset Base vs Line Length**

Figure 2-10: Asset Base vs Customer Numbers and Figure 2-11: Asset Base vs Line Length indicates the relationship between the value of the asset base; and the number of customers and line length. The Asset Base – Customer relationship shows a reasonably strong correlation and Ausgrid performance consistent with the benchmark, it again points to better performance in Victoria. Whilst exhibiting a significantly weaker correlation, the standout for Ausgrid is the relationship between Asset Base and line length which points to a large unfavourable variance by Ausgrid and most NSW / QLD DNSPs. The extent to which Ausgrid falls above the regression line, suggests to Evans & Peck that it is serving customers using line assets of greater value than typically experienced by its peer DNSPs. Again, the Victorian DNSPs are favourable to the benchmark.

Capital and Operating Expenditure vs. Asset Base



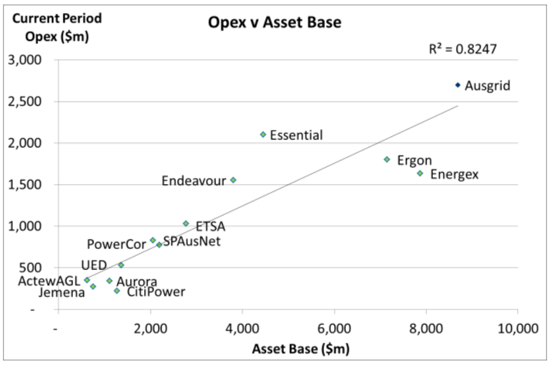


Figure 2-12: Capex v Asset Base

Figure 2-13: Opex vs Asset Base

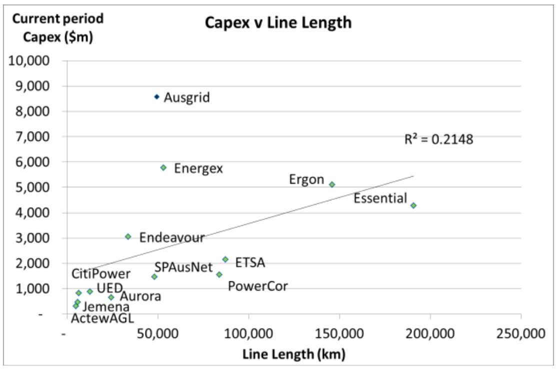
The capex and opex relationships shown in Figure 2-12: Capex v Asset Base and Figure 2-13: Opex vs Asset Base illustrate the efficiency of investment into the network and the expenses incurred in operating and maintaining the network. Ausgrid, Essential, Endeavour, ETSA and SP AusNet all fall on or above the regression line for both Opex and Capex. This indicates that these businesses are investing significant capital and operating budget into their networks. The higher results for the Capex and Opex to Asset Base may be an indicator of inefficiency, or it may simply indicate that these businesses are managing an ageing asset base through:

a) an increase in capital expenditure to meet future growth;
b) an increase in capital expenditure to increase compliance with planning standards;
c) an increase is replacement capital expenditure; and
d) an increase in operating expenditure to maintain an older asset base.

2.2.2 Intensity Measures (Volume of Assets)

The relationships between new expenditure, historical investment, customer numbers and line length shown in Figure 2-14: Capex vs Line Length and Figure 2-15: Opex vs Line Length indicate how intensely the assets are being used, maintained and invested in. They also allow the differences between networks that are comprised of fewer, higher value assets (Ausgrid, Energex) and networks that are comprised of many lower value assets (Essential, Ergon).

Capital and Operating Expenditure



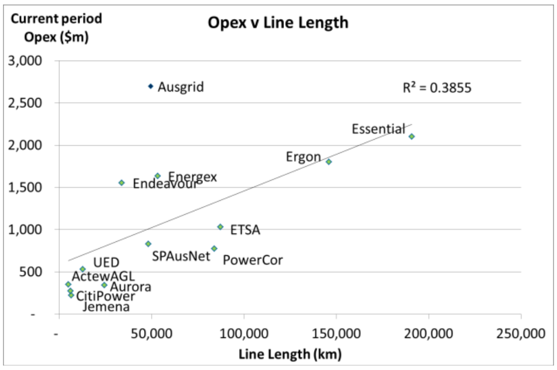
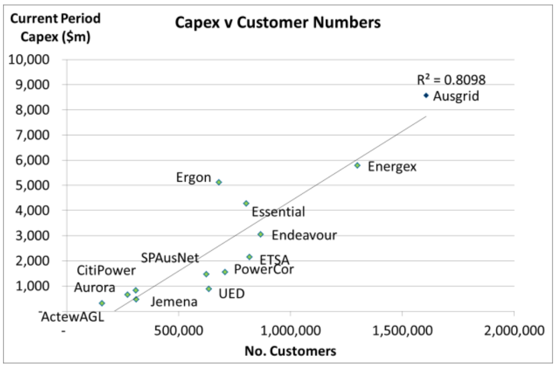


Figure 2-14: Capex vs Line Length

Figure 2-15: Opex vs Line Length

The Capex and Opex relationships with line length are relatively weak due to the differences in the nature of assets used by networks serving major cities and those serving country areas. Notwithstanding the weakness of correlation, Ausgrid and Energex are currently investing significantly more per km of line, and the urban Victorian DNSPs less than would otherwise be predicted for networks of a similar size.

Asset Base and Customer Numbers



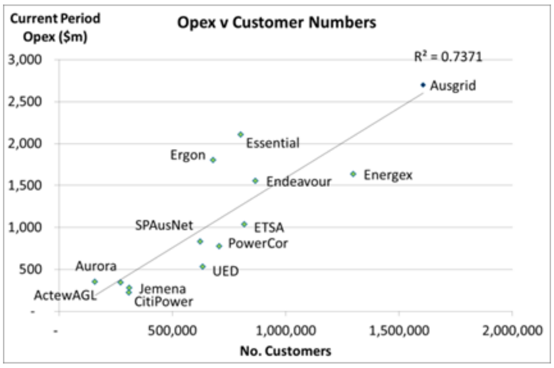


Figure 2-16: Capex vs Line Length

Figure 2-17: Opex vs Line Length

Figure 2-16: Capex vs Line Length and Figure 2-17: Opex vs Line Length indicate a strong correlation. Whilst the NSW / QLD position with respect to the benchmark lines are now split, Ausgrid is more in line with the benchmark, but there is a continuing trend for the Victorian DNSPs to achieve better than benchmark results.

2.2.3 Infrastructure Burden Measures

In a further attempt to isolate potential differentiators, we have looked at the “physical” measures of the network.

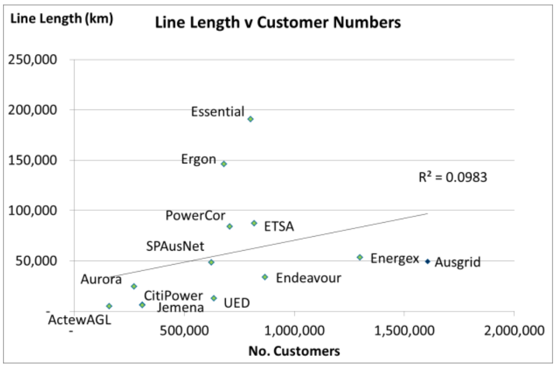
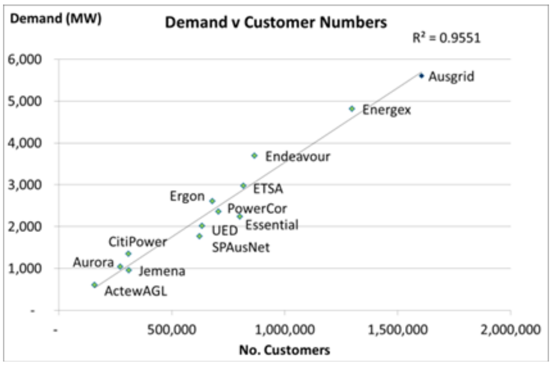


Figure 2-18: Line Length v Customer Numbers

Figure 2-18: Line Length v Customer Numbers demonstrates the infrastructure burden measure of network length to customers, which measures the length of line each customer supports has a very weak overall correlation again due to differences in the nature of assets used by networks serving the predominately rural, urban or CBD customer classes. Correlation is very poor, but in this case Ausgrid, Endeavour, Energex and all of the Victorian urban distributors urban that exhibit predominately Urban/CBD customer classes (CitiPower, UED and Jemena) all ‘perform’ relatively well when compared to the predominately rural networks for Essential Energy, PowerCor and Ergon. The scattered nature of the results reflect the more diverse factors impacting each of the DNSPs.



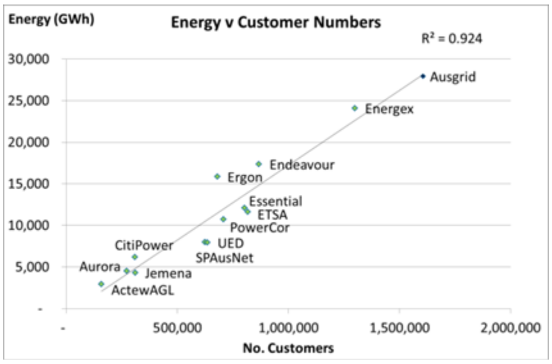


Figure 2-19: Demand vs Customer Numbers **Figure 2-20: Energy vs Customer Numbers**

Figure 2-19: Demand vs Customer Numbers (representing network capacity to support each customer) and Figure 2-20: Energy vs Customer Numbers (representing the consumption required by each customer) have a very high degree of correlation, and whilst Ausgrid is right on benchmark, the Victorian distributors tend to be below benchmark, indicating the need for slightly less installed capacity per customers than benchmark.

Implications for Benchmark Modifiers

In the foregoing analysis we have endeavoured to establish some basis benchmarks that may give some direction to the benchmark modifiers that may explain some or all of the differences between DNSPs performance and nominal “benchmark” performance.

Throughout this analysis, a number of indicators arose:

- Irrespective of the measure, the Victorian Urban DNSPs always trend to superior performance.
- On any measure relating to line length, Ausgrid performs poorly. This clearly requires further investigation.
- On physical measures such as demand / customer and energy / customer, Ausgrid is generally in line with benchmark, but the measures tend to indicate Victorian Urban DNSPs need less installed capacity per customers than benchmark.

Therefore, this analysis points to benchmark modifiers in two specific areas:

- A general theme that it requires less resource to distribute electricity in Victoria, and in particular the urban areas.
- A specific theme that suggests Ausgrid applies more line resources, in financial terms, to distribution than would be expected.

These observations have provided some guidance in the areas of investigation in the balance of this report.

3 Benchmark Modifiers

3.1.1 Network Scale (Line Length) and Voltage Class

The length of power lines provides an indication of the scale of a distribution and transmission network, whilst the Voltage Class provides a proxy for the mixture of the capacity of the components of the network. Both factors are important inputs to the cost drivers for an electricity network. For example, a large underground metropolitan network and a small over-head rural network may share a similar total line length; however the type, location, capacity, customer density and planning complexity of the networks mean that the cost drivers for both networks will vary considerably.

Australian distribution networks are a mix of urban and rural areas with a combination of overhead and underground lines. As a result the extent of the distribution networks based on kilometres of both overhead line and underground cable is a useful measure to compare the scale of a network. Whilst the proportion of assets in each voltage class provides an indication on how effectively the assets can be used to serve the geographic spread of the customer base.

There is diversity in operating voltage levels of the various businesses across Australia; with significant differences in the mix of transmission, sub-transmission and distribution assets.

Based on the network voltage categories as below:

- Transmission: Supply Voltages greater than 132kV
- Sub–Transmission: Supply Voltages from 33kV up to and including 132kV
- Distribution: Supply Voltages less than 22kV

Figure 22 shows the extent of the transmission, sub-transmission and distribution networks implied by total line length to New South Wales having the most, followed by Queensland and then Victoria.

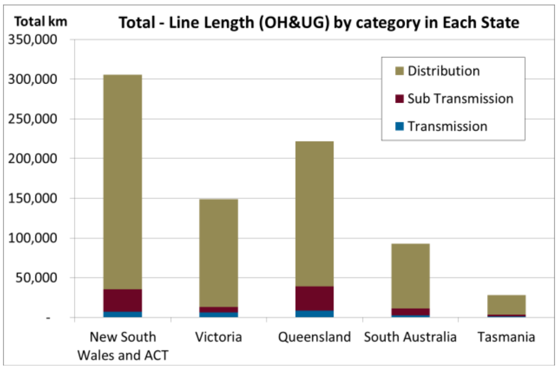
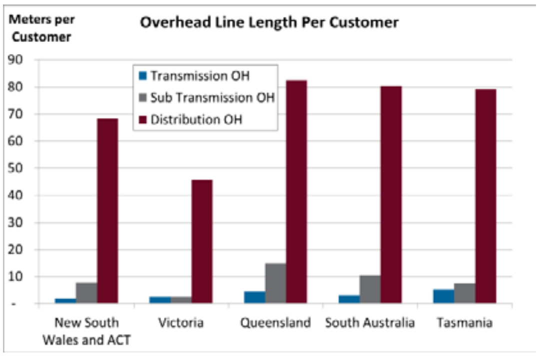


Figure 3-1: Total Line Length (Overhead and Underground)

Figure 3-1: Total Line Length (Overhead and Underground) shows that QLD and NSW have a much higher proportion of sub-transmission lines than the southern states. This reflects both the history of development and the geographically distributed population centres along the east coast along with a number of significant inland regional cities.

Economic theory identifies that the scale of an operation influences production cost, with larger scale operations enjoying scale efficiencies (and therefore lower costs) than smaller operations of a similar nature. Within electricity networks, there are a number of complex factors which mean that it is difficult to support the assertion that any network is actually 'similar' to another network. Accepting that there is probably no single measure to describe the scale given the complexities discussed throughout this report, the length of the network should simply be viewed as a readily available high level measure of network scale for the purpose of determining cost drivers.



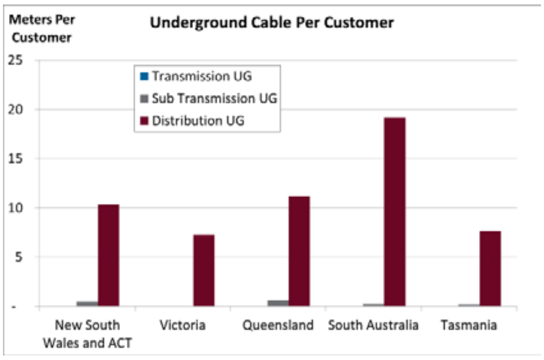
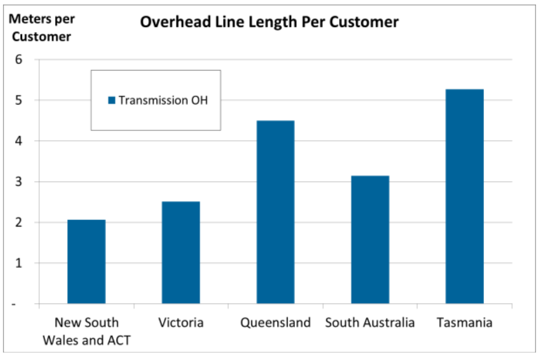


Figure 3-2: OH Length Per Customer

Figure 3-3: UG Cable Per Customer

We note that the significantly lower length of overhead line per customer reflects the higher concentration of the Victorian population along the transmission line routes, reducing the need for intermediate sub-transmission infrastructure to reach population centres. Similarly, the significantly lower underground cable per customer in Victoria when compared to the other mainland states reflects denser and/or less complicated urban environments.



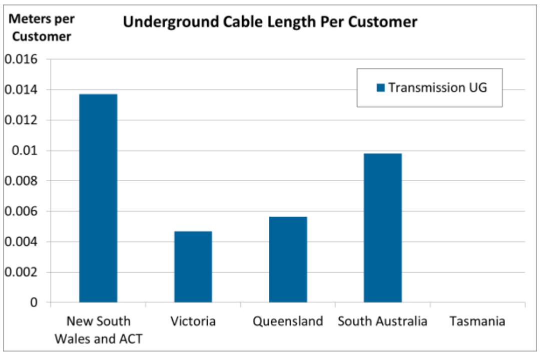
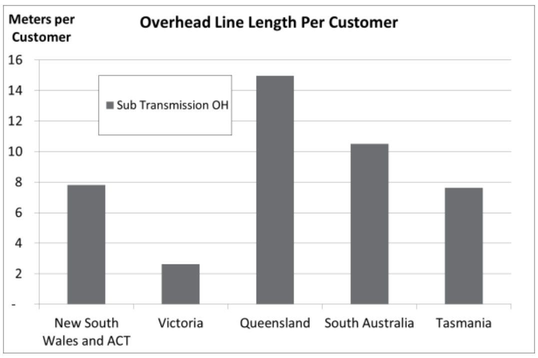


Figure 3-4: Transmission OH Per Customer

Figure 3-5: Transmission UG Per Customer



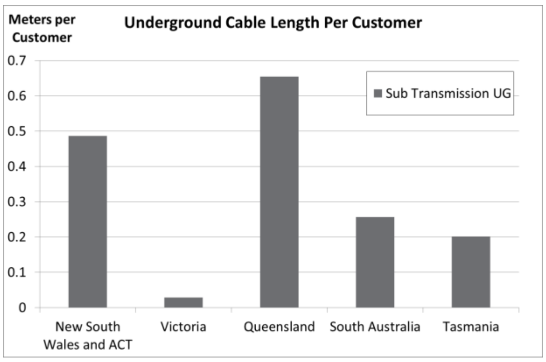
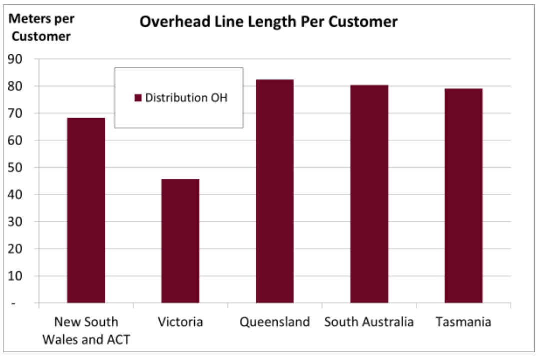


Figure 3-6: Subtransmission OH Per Customer **Figure 3-7: Subtransmission UG Per Customer**



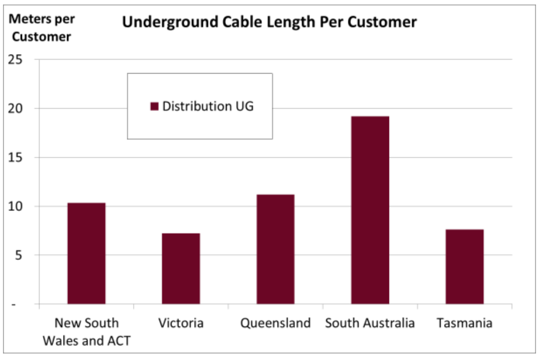


Figure 3-8: Distribution OH Per Customer **Figure 3-9: Distribution UG Per Customer**

Whilst there was some difficultly in deriving a consistent data set for all distributors, the state level information provides useful insights.

In summary:

- Normalising network length based on customer numbers, the combined Transmission, Sub-transmission and Distribution line length and cable length per customer in Victoria are comparatively smaller than the other Eastern states which tends to reflect higher customer density.

The sub components by class were also broken out for more detailed analysis.

- At transmission level voltages (>132kV), Victoria has the least amount of underground, with NSW having almost three times as much as Victoria.
- Virtually all of the underground sub-transmission cables are owned by the distributors.
- Victoria has little sub-transmission cable.
- Victoria has an order of magnitude smaller amount of sub-transmission voltage overhead (132kV, 110kV, 66kV,) which is a reflection of the lack of a sub-transmission network and also the relatively compact nature of the state.
- Queensland has the greatest amount of sub-transmission followed by NSW which is also a reflection of the extensive geographical coverage.
- At Distribution Voltages, Victoria has much shorter length per customer for both overhead and underground which also highlights the higher customer density.
- Queensland and NSW again have similar amounts of underground distribution cable.

	Ausgrid	NSW	Vic	QLD	SA	Tas
Line Length and Voltage Class						

Cost Driver: Natural Cost Advantage; Neutral; Natural Cost Disadvantage; Unknown

Table 2: Summary - Line Length and Voltage Class

3.1.2 Network Value

Comparing the relative proportion of both overhead line and underground cables by voltage category and by state, demonstrates the diversity in operating voltages across Australia; along with significant differences in the mix of transmission, sub transmission and distribution assets.

In in absolute terms, the ratio of overhead to underground is relatively consistent across most states.

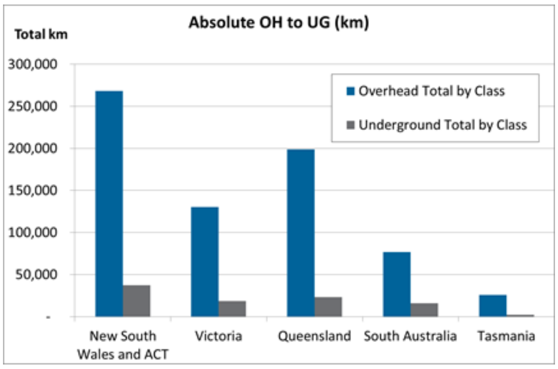


Figure 3-10: Overhead to Underground

In summary:

- All states have a significant portion of the LV distribution network underground.
- While Victoria has the least amount of underground across all categories in the Eastern states, it does have a large proportion of their HV Distribution underground.
- The Victorian distribution system (22kV) has more capacity than a comparable 11kV network and all things being equal (operation, maintenance and refurbishment) is more cost effective.

While the engineering principles allowing more capacity at higher voltages for the same conductor size is well understood, the price points for the different voltages is moving, and in particular 22kV versus 11kV are moving. That is, the price of electrical distribution equipment such as distribution transformers, overhead conductors, underground cables and distribution switchgear, has been considered to be sufficiently similar for both 11 kV and 22 kV systems that their costs had often been used interchangeably for a long time. More recent observations suggest that any corollary pricing relationship that may once have existed between 11kV and 22kV in the past, almost certainly no longer exists as 22kV equipment is becoming cheaper.

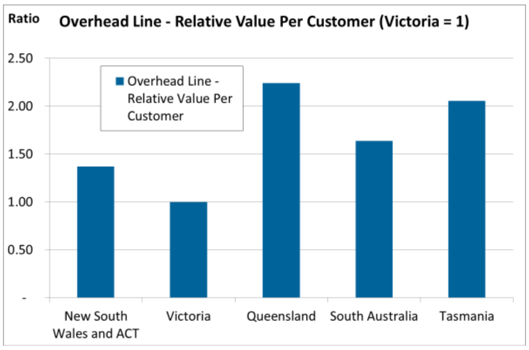
Evans and Peck also notes that Ausgrid is undertaking investigation into the development of a 33kV distribution system (where appropriate) for similar reasons, i.e. 33kV cable has three times the capacity (for the same size) as 11kV cable therefore, zones of the same size require only one third as many cables (leaving the zone) and up to 40% less cable overall (Alternatively zones can be built three times bigger).

Using indicative cost information provided an approximate weighting was established and summarised in Table 3: Relative OH and UG Weighting below:

Voltage	OH Weighting	UG Weighting
500kV	25	400
330kV	15	200
275kV	13	176
220kV	12	160
132kV	8	80
110kV	8	80
66kV	8	56
44kV	3	24
33kV	3	24
22kV	2	16
11kV & Below	2	16
SWER	1	8
LV	1	8

Table 3: Relative OH and UG Weighting

Using these approximations and by weighting the values starting at one for LV and then normalising the result against the Victorian value, we derive the following figures to demonstrate relative value of overhead line and underground cable per customer by state.



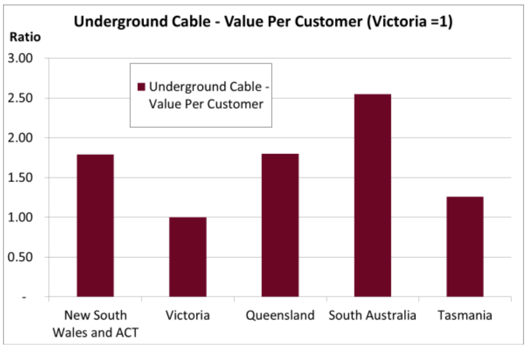


Figure 3-11: OH Relative Value Per Customer **Figure 3-12: UG Relative Value Per Customer**

South Australia has the highest relative value of UG per customer due to historical planning policy initiatives[2] that have not been implemented at the same scale in other states. Victoria has fewer

[2] The volume of underground cable in South Australia is high due to the planning requirements in place since 1970 for new developments to be served underground and ongoing undergrounding program for existing lines through the Power Lines Environment Committee, which has been operating since 1990.

assets which reflect in both the overhead and underground relative value per customer. The relative value of UG per customer is around twice for NSW and QLD compared to Victoria. On a value per customer basis, Victoria has a lower value of both underground and overhead attributable to each customer.

If we incorporate both overhead and underground components together to provide a weighted total view based on the ratios provided in, also excluding transmission voltages (voltages greater than 132kV, this yields the following comparison.

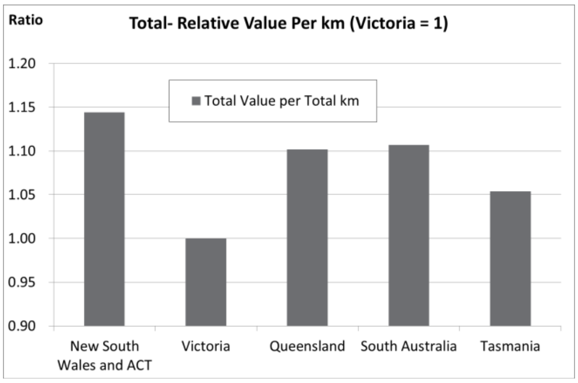


Figure 3-13: Total Relative Value

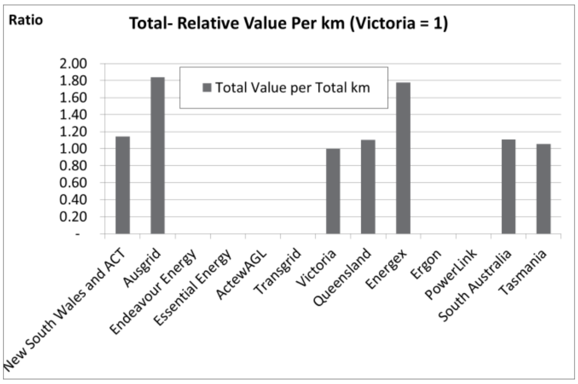


Figure 3-14: Total Relative Value (Ausgrid)

Importantly, on a value per km measure, New South Wales, Queensland and South Australia are higher than the state based averages. Incorporating data for both Ausgrid's and Energex's as shown in Figure 3-14: Total Relative Value (Ausgrid), both are significantly higher than average. As identified in Section 2, this is an area where Ausgrid's notional benchmark performance is poor. It would appear that the capital intensity of Ausgrid's lines is very high, largely driven by the disproportionate amount of high value sub-transmission. We would expect this to also extend to sub-station assets if these were included in the denominator of a composite asset (such as RAB / MW supplied or Capex / MW supplied).

We have therefore ranked this measure as unfavourable to Ausgrid, and a particularly strong benchmark modifier.

This is also reflected in the connection density described using the number of customers per kilometre. Connection density, whether measured as connections, capacity or energy flows per km of network length, is a significant cost driver.

The connection density in Victoria is significantly higher than the other states implying that investment required for an additional connection would be less due to the physical assets that would already be in place to support incremental changes.

	Ausgrid	NSW	Vic	QLD	SA	Tas
Network Value						

Cost Driver: Natural Cost Advantage   Neutral   Natural Cost Disadvantage   Unknown

Table 4: Summary - Network Value

3.1.3 Installed Capacity and Energy Transformed

Comparing the Transformer Capacity Installed per Average MW sent out as shown in the figure below:

- At a transmission level, NSW and Victoria are similar and slightly higher than Queensland.
- At a sub-transmission level voltages, the gap could be considered enormous with Victoria is less than half that of NSW and Queensland again indicating the lack of overall sub-transmission assets.
- The installed transformer capacity is similar across distribution level assets.

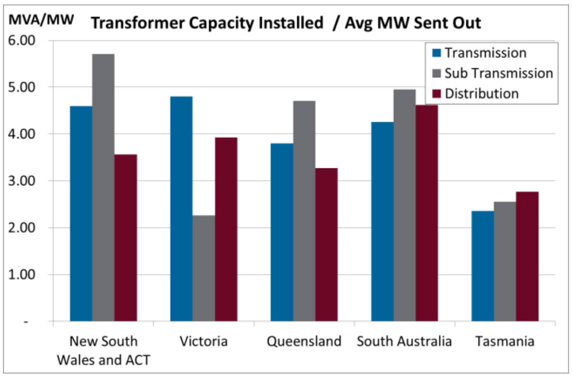


Figure 3-15: Tx Capacity per Average MW Sent Out

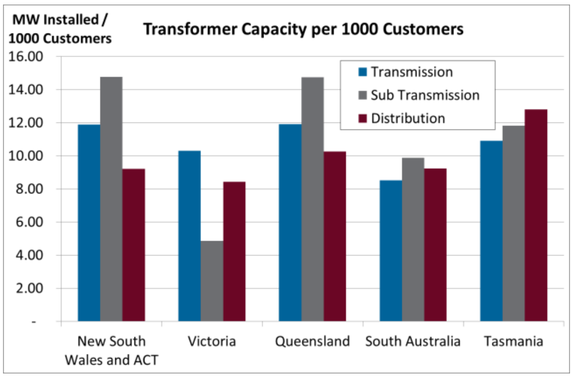


Figure 3-16: Tx Capacity per 1000 Customers

With reference to the transformer capacity per customer:

- At a transmission level NSW and ACT, and Queensland are similar with installed capacity per customer slightly higher than Victoria
- For Sub-transmission, NSW and Queensland are similar with approximately three (3) times the transformer capacity installed per 1000 Customers when compared to Victoria. This is again attributable to the lack of Sub-transmission network in Victoria.

Evans & Peck also notes that the overall mix of overhead to underground will have an impact on installed capacity as kiosks transformers are substantially de-rated by the enclosure and HRC fuse rating limits, compared with the corresponding size of open air i.e. pole mounted transformers. Publically available information with adequate detail was not available to carry out more detailed analysis/comparison in this case.

	Ausgrid	NSW	Vic	QLD	SA	Tas
Installed Capacity and Energy Transformed						
Cost Driver: Natural Cost Advantage	Neutral		Natural Cost Disadvantage			Unknown

Table 5: Summary - Installed Capacity and Energy Transformed

3.1.4 Transformation steps and Transformers

Voltages vary between states along with the categorisation of voltages into classes, (Transmission, Sub-transmission or Distribution), however the arrangements can broadly be represented in the following diagrams.

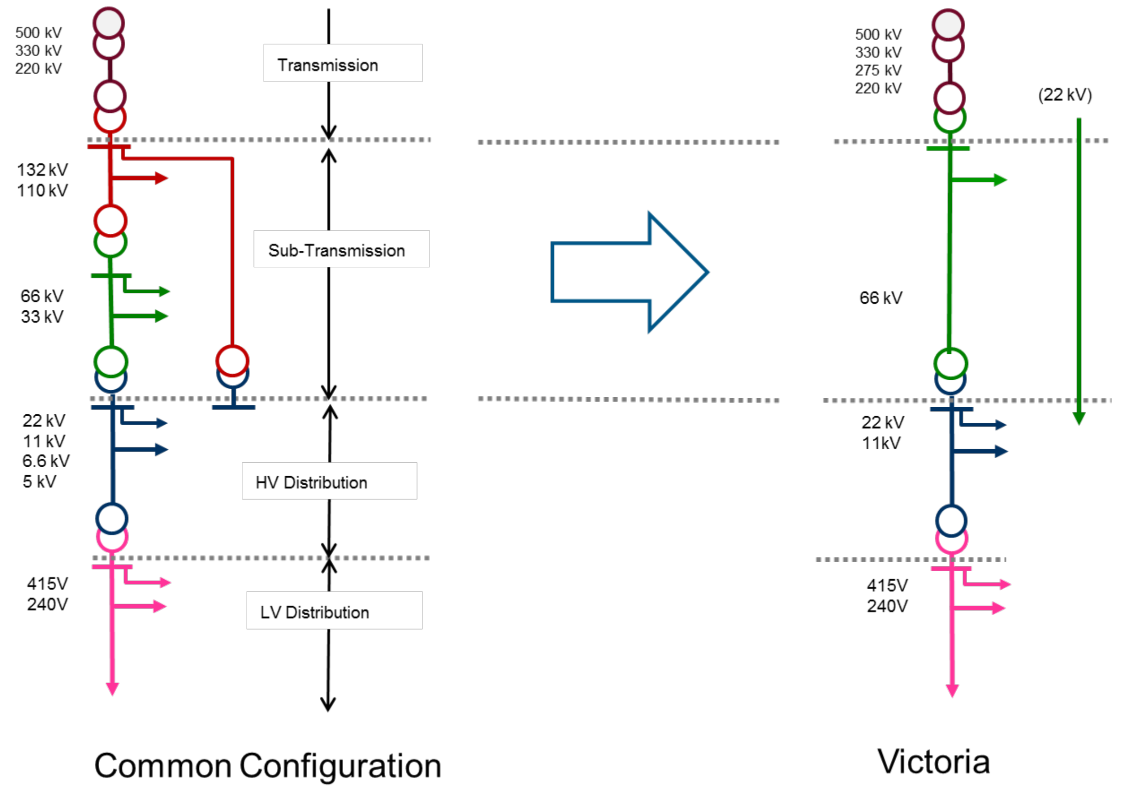


Figure 3-17: Typical Distribution Network Arrangement

The number of transformation steps of voltage from the transmission through to the LV network is considerably higher in NSW and Queensland when compared to Victoria. This is captured at a summary level in the following table.

Transformation Steps	NSW & ACT	Victoria	Queensland	South Australia	Western Australia	Tasmania	Northern Territory
Transmission to Subtransmission	3	4	2	1	2	1	0
Sub Transmission to High Voltage	4	**1**	4	3	3	3	2
High voltage to Distribution OH	4	4	4	3	4	4	4

Table 6: Transformation Steps

While there is a mix of voltages in the various categories between states, the number of transformation steps in Victoria at the sub-transmission level again indicates the lack of an intermediate step between Transmission and Distribution, that is very small Sub-transmission Assets resulting in the Victorian system being much simpler than NSW. Indeed, by way of example CitiPower receives up to 20 per cent of its total energy straight from SP Ausnet at 22kV.

We also considered more detailed analysis of the sales by class between the states might be appropriate. Apart from the immediate problem of the lack a publically available and consistent data set, a cursory review undertaken by Evans & Peck of sales by class comparing Victoria (CitiPower, Jemena, United) to NSW (Ausgrid) yielded that there was not a strong case for differentiation in these numbers.

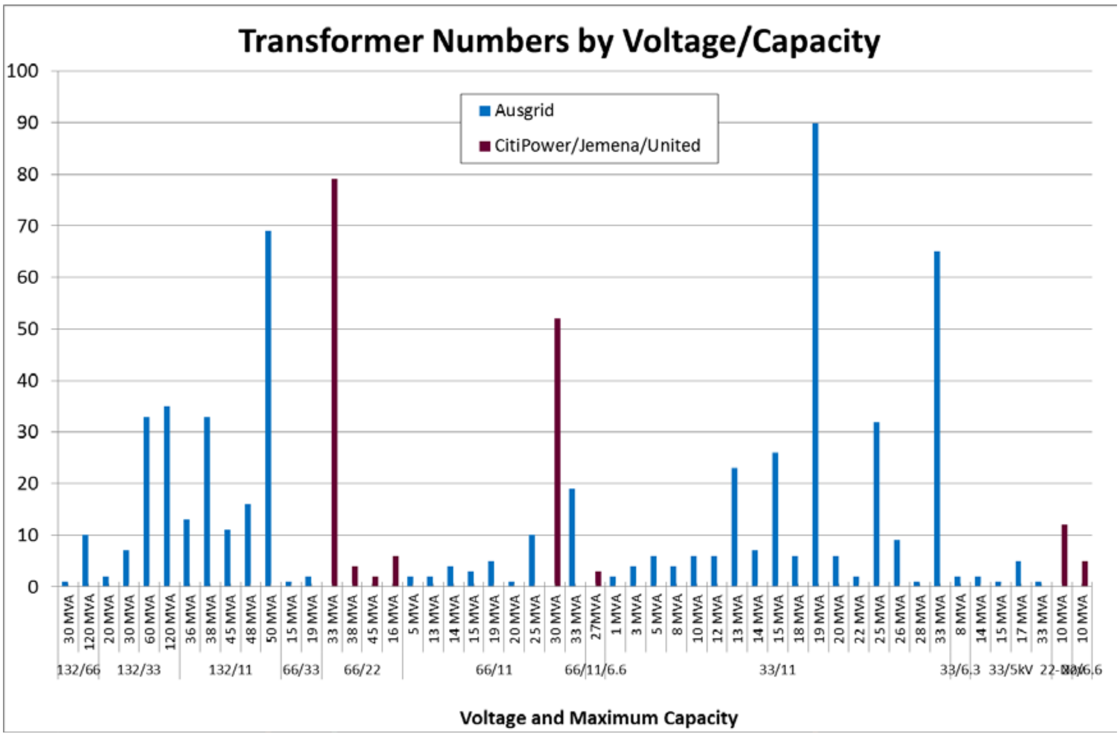


Figure 3-18: Transformer Numbers by Voltage/Capacity

The count of transformers in both Size Groups and Voltage Groups again highlights the complexity of the sub-transmission network in NSW. Detailed information across all distributors was not readily available, however, a comparison of Ausgrid against an approximation of the Victorian Metropolitan distributors information (CitiPower, Jemena and United) yields the following comparison:

For Victoria:

- All of the transmission to sub-transmission terminal stations (mostly 220kV / 66kV) are owned by SP-AusNet as the TNSP, not the DNSPs. This is not the case in NSW / QLD where the DNSPs own many bulk substations.
- Most Vic zone substation transformers are 66/22kV or 66/11kV transformer which demonstrates a vastly different position Ausgrid in terms of Power Transformers. There are mostly rated at 30-35 MVA or less.
- This also flows to probabilistic planning as the load (MW) at risk on quite high percentage overload for a smaller transformer, is relatively small in terms of generation requirements. The Victorian Urban DNSPs only have four zone substation transformers that are above

35MVA, the vast majority are below. A 30MVA so a transformer which is overloaded by 10% puts only 3MVA at risk and therefore would only require 3MVA of backup generation.

- It is comparatively simple to carry strategic spares for transformers of this size and they can be replaced relatively quickly.
- Victoria has a mixture of 2 and 3 transformer zone substations with none having more than 3.

For Ausgrid:

- The Victorian example is contrasted with Ausgrid who have more than 200 Power Transformers above 30 MVA, half of those again are above 50MVA.
- In the event of failure, the load at risk greater and the amount of backup generation is also greater.
- Compounding this, Ausgrid have found it difficult to get large HV connected generators in place. i.e. Enfield resulted in Ausgrid having 25 sites ranging from 300kVA - 1.2MVA.scattered through the suburbs .
- 10% over on N-1 results in substantially more Energy at risk.

On balance we would expect these factors to have a positive impact on Victorian benchmarks, particularly in terms of the existing Asset Base on a per customer base, and on Capex. Given the lower asset base, this then flows through to Opex.

	Ausgrid	NSW	Vic	QLD	SA	Tas
Transformation Steps and Transformers						

Cost Driver: Natural Cost Advantage | Neutral | Natural Cost Disadvantage | Unknown

Table 7: Summary - Number of Transformation Steps/Transformers

3.1.5 Asset Age Profile

It is clear that there is an inextricable link between asset age profile and the investment required for both renewal and replacement capital expenditure and also operating expenditure through specific maintenance requirements, however, using publicly available information surrounding asset age and the associated profiles we were unable to carry out an effective review or draw specific comparisons.

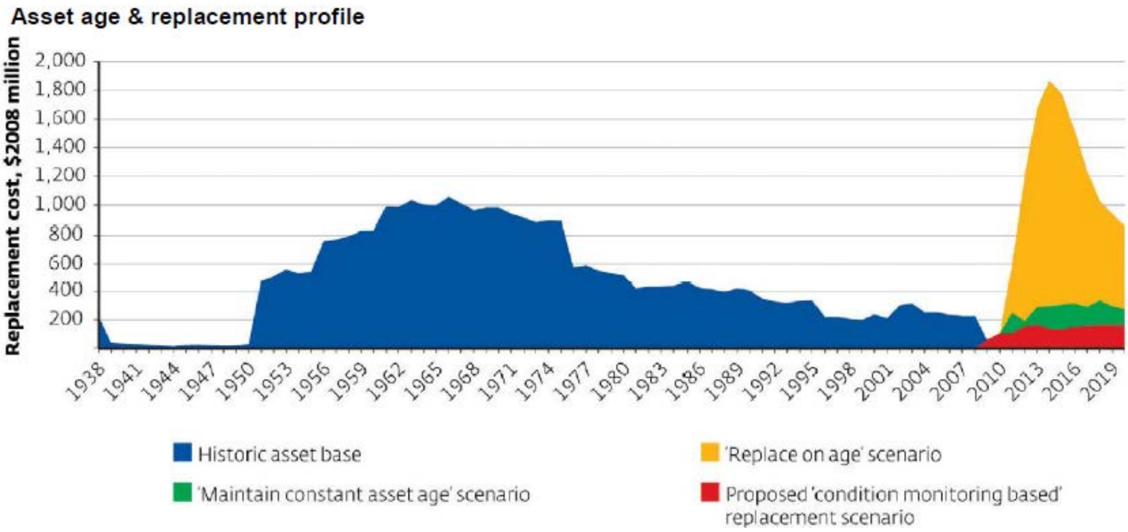


Figure 3-19: Typical Asset Age and Replacement Profile

While each distributor has its own unique characteristics, the above figure presented by ETSA[3] in their regulatory proposal to the AER is broadly representative of the decisions facing most network businesses across Australia in depicting an aging asset based and striking the right balance of strategies for replacement into the future.

There seems to be an opportunity for Ausgrid to more effectively demonstrate the link between asset age profile and both Capex and Opex requirements in a comprehensive way (down to individual asset classes). This may be particularly prudent for Ausgrid (NSW) given relative proportion and criticality of assets. The link between growth and replacement Capex is equally important given the increasing proportion (75%) of area plans is replacement which is no longer supported by growth.

- For Capex, asset age profile is an area that would benefit from considerable attention as throughout much of the regulatory literature, there is clear acknowledgment of the link between asset age profile for both replacement Capex and the trade-offs associated with opex when connected to significant growth related Capex, however, despite considerable commentary there has been no independent arms-length analysis that can be referenced or relied upon. The introduction of the AER's Repex model in the most recent determinations and the subsequent discussion suggests that any debate in this area needs to be thorough and well substantiated.

[3] Regulatory Proposal to the AER, 2010 – 2015, AER Public Forum, 6 August 2009

- For opex (maintenance), there is also a large amount of debate (not empirical evidence) in the public domain directly relating to this, however, the debate is not so much that there is a link between asset age profile and maintenance cost, moreover, the debate is about quantification/ parameterisation of the actual relationship itself. It has been noted by SKM[4] that when replacement programs are such that the average age of the network gradually shifts, there will be an impact on operating costs due to the relative shift in proportions of older and newer assets. Therefore, SKM considered that asset age is a factor that should properly be considered in determining efficient and prudent levels of opex.

The following highlights have been extracted from the wide ranging yet inconclusive discussion in the regulatory domain.

3.1.5.1 NSW

The most recent NSW determination[5], the AER imposed a $12 million reduction in network maintenance costs on EnergyAustralia(Ausgrid) relating to the exponential escalation of maintenance costs due to asset ageing that was proposed.

Whilst through the process of analysis, in the draft decision, the AER accepted EnergyAustralia's position that, other things being equal, the level of maintenance expenditure needed on a network will increase as the network ages, the AER relied on observation raised by Wilson Cook[6] and SKM[7] regarding the determination of the relationship between asset age and maintenance and the application of that to determine future maintenance workloads, concluding that the proportion of such assets in a DNSPs total asset base is generally quite low.

3.1.5.2 Victoria

The impact of asset age profile in Victoria has been documented for some time. In the Essential Services Commission Electricity Distribution Price Review, 2006-10, CitiPower comments were noted around the fact the key driver of asset renewal and replacement expenditure is the ageing of the asset population with just under half of CitiPower's existing asset base (by replacement cost) being installed in the period from the late 1950s to the mid-1970s. The results was that over 12 per cent of CitiPower's assets will have reached the end of their engineering asset lives by the end of the regulatory period, of which the majority will require replacing.

Eastern Energy stated that despite its age, the majority of Eastern Energy's equipment is in a serviceable condition with some items having passed their expected life still operating satisfactorily.

Despite the commentary and associated expenditure forecasts distributors' submissions around the need to increase network investment expenditure to address the ageing of assets the Office of the Regulator General made only minor adjustments in this review for expenditure on the core network

[4] Distribution Network Asset Age Projections and Impact on Network Operating Costs Final Report, SKM, 15 May 2009
[5] New South Wales distribution determination, 2009–10 to 2013–14, Final Decision, 28 April 2009
[6] Wilson Cook, EnergyAustralia review, p. 27
[7] SKM, Response to Wilson Cook commentary on O&M/age profile modelling, p. 11

services claiming that they were confident this would not compromise the distributors' capacity to meet their improved service performance targets.

This was in part justified based on the fact that most of the distributors had significantly underspent their original capital and operating expenditure forecasts despite growth in both peak demand and total energy consumption for the period [2001-05].

In the most recent Victorian decision[8], the AER introduced the "repex model" to assist its assessment of replacement expenditure forecasts as a benchmarking analysis tool. The revised Victorian DNSPs' regulatory proposals contained significant comment regarding the AER's approach to the calibration of the repex model, choice of asset lives and inputs and outputs derived from the model.

In applying this model, the AER noted the prevalence of such models in other regulatory regimes (most notably Ofgem in the UK) with the purpose independently testing whether the volumes of replacement activity for an asset category are consistent with broad assumptions about asset age and condition. The AER states that its repex model is not a substitute the detailed technical analysis and the skilled application of technical judgement to estimating future needs, but rather is a benchmarking tool which estimates a quantity of replacement activity that might be expected given a population of assets of a particular type and age.

The primary use of the repex model was to identify for further investigation the categories of asset replacement expenditure where the volumes proposed for replacement are significantly greater than the model alone would suggest. Where the volumes predicted by the repex model are found to be consistent with the volumes proposed by a DNSP, prima facie, having considered other Capex factors, the particular forecast should be considered reasonable and appropriate.

3.1.5.3 Queensland

In Energex's 2010 Regulatory Proposal[9], Energex advised that there are large quantities of assets that are approaching the end of their forecast life and will require refurbishment or replacement depending on service conditions. The methodology employed by Energex is CBRM on the basis that is used throughout the world by electricity utilities to deliver effective asset-related risk management which incorporates the probability of failure based on a range of factors (age of asset and expected life; actual performance; operational experience; environmental conditions; and manufacturer and specification).

These principles are also reflected in Energex's key internal documents, the Substation Asset Management Policy (SAMP) and the Mains Asset Management Policy to ensure compliance with legislative obligations and also to develop opex forecasts.

Energex also describes an asset renewal strategy to identify capital expenditure required to replace higher risk assets and address the age profile of Energex's infrastructure and co-ordinates growth, replacement and refurbishment.

8

9 ENERGEX Regulatory Proposal for the period July 2010 – June 2015, July 2009

	Ausgrid	NSW	Vic	QLD	SA	Tas
Asset Age Profile						
Cost Driver: Natural Cost Advantage	Neutral	Natural Cost Disadvantage	Unknown			

Table 8: Summary - Asset Age Profile

Insufficient information currently exists to quantify the extent of this benchmark modifier. We would expect this to have an impact on all of the Capex / Opex benchmarks. As a consequence, we have ranked it as unknown at this point.

3.1.6 Load Factor and Load Duration

The most significant influence on the average use of system is load factor, defined as the ratio of average energy demand (load) to the maximum demand (peak load) during a period.

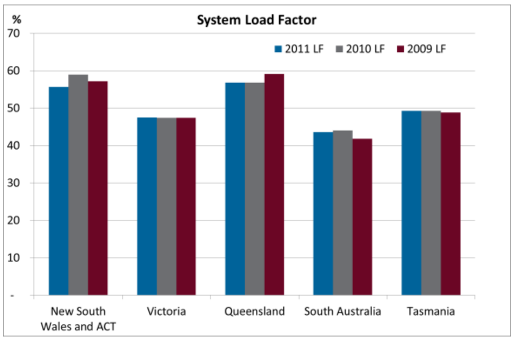


Figure 3-20: System Load Factor

Load factors vary considerably with the type of end user, however, at a high level there a some general observations that can be made.

- The lower the Load Factor, the more peaky the Load Duration Curve (LDC) and the more relevant Probabilistic planning.
- The greater the use of the system relative to the underlying investment, the lower the price to the end user.
- The amount of load on the network (represented by load factor), combined with the rate of load growth on the network, will impact the need for system augmentation.
- A lower load factor could imply an inefficient use of system (capacity), or conversely a network with a high replacement cost for its energy throughput.
- A high load factor implies a more efficient use of system (capacity), however, this could also imply greater difficulty in taking equipment out of service for maintenance and repair with compromising system reliability and security (the impact system configuration aside)

3.1.6.1 Load Duration

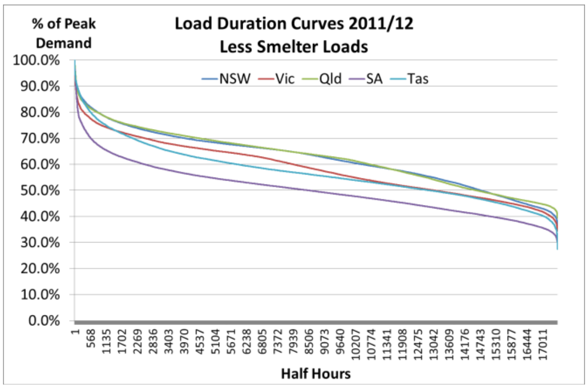


Figure 3-21: Load Duration Curves

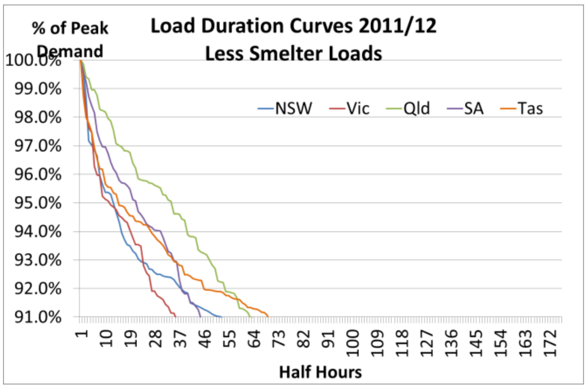


Figure 3-22: Expanded Load Duration Curve

NSW and Queensland have a very similar load duration curve.

Expanding the first portion of the load duration curve to achieve a greater level of granularity, if you were to operate at 10% above peak (N-1), the energy exposure (where the loading is above firm rating) would equate to approximately 91% on the load duration curve which occurs for a very small percentage of time (around 17 hours in the Victorian example). The very sharp peak provides the justification for probabilistic planning as while probabilistic planning accepts there are conditions under which all the load cannot be supplied with a network element out of service, the impact/risk/exposure is less with a peaky load profile.

For these reasons alone, this clearly demonstrates that probabilistic planning has the best outcome in Victoria, 2nd best in SA, followed by NSW and Queensland (interpreting energy exposure based on 2011/12 NEM Data). That is, with probabilistic planning in place, NSW (Ausgrid) would accrue energy at risk more quickly than in Victoria.

This is also demonstrated in the following figure which is the MWh lost whilst operating overloaded at N-1, and incurring a network element outage.

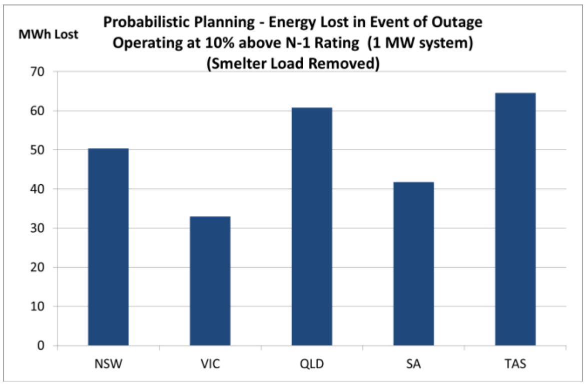


Figure 3-23: Probabilistic Planning – Energy Lost

In summary, we are of the view that these factors are a favourable benchmark modifier for Victoria. In addition to requiring less capacity per customer, the load shape allows grater application of probabilistic planning.

	Ausgrid	NSW	Vic	QLD	SA	Tas
Load Factor and Load Duration	Neutral	Neutral	Natural Cost Advantage	Natural Cost Disadvantage	Natural Cost Advantage	Natural Cost Disadvantage

Cost Driver: Natural Cost Advantage   Neutral   Natural Cost Disadvantage   Unknown

Table 9: Summary - Load Factor and Load Duration

3.1.7 Customer Growth

Customer driven connection assets are required to be constructed for each new customer connected to the network. This work is partly funded by the distributor and partly by the new connecting customer or developer.

- A new customer connection and residential/commercial developments will generally result in immediate investment of capital required for distribution network extensions, for the high voltage and low voltage distribution assets.
- Each smaller load connection also has a flow-on incremental impact on upstream augmentation needs including upgrades and new asset construction.
- A new large commercial/business customer connection will often have a greater impact as it also includes the cost of installing a new distribution substation but will also attract a customer (capital) contribution.

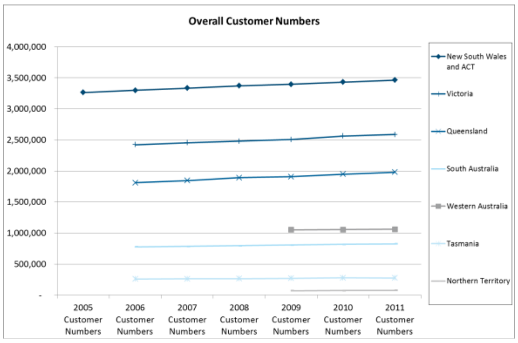


Figure 3-24: Customer Growth

Customer growth is <u>generally</u> consistent across all states.

	Ausgrid	NSW	Vic	QLD	SA	Tas
Customer Growth						
Cost Driver: Natural Cost Advantage	Neutral	Natural Cost Disadvantage		Unknown		

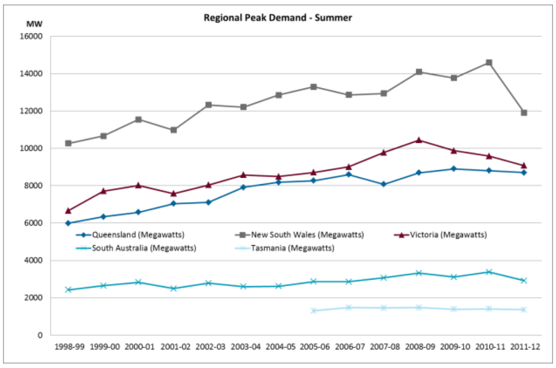
Table 10: Summary – Customer Growth

3.1.1 Load Growth

After a long period of consistent load growth, electricity demand across all regions in the National Electricity Market has reduced over the last four years. The exact causes of reduced demand are difficult to single out, but the following factors have been identified:

- higher retail prices;
- growth in solar generation because of subsidisation; and
- increased energy efficiency.

The following charts depict both the declining summer and winter peaks.



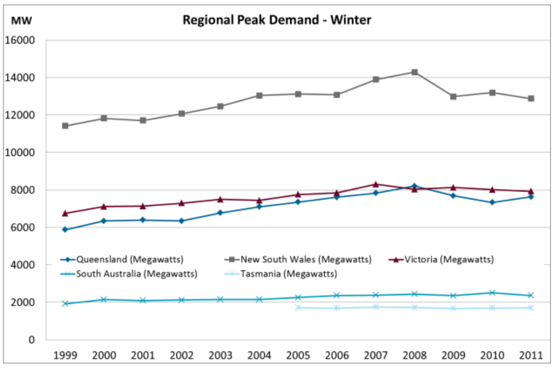


Figure 3-25: Regional Peak Demand – Summary **Figure 3-26 - Regional Peak Demand - Winter**

In March this year, the Australian Energy Market Operator revised its demand forecast for 2011-12 down by 5% in an update to the August 2011 Electricity Statement of Opportunities.

A key factor, potentially impacting both the asset base (RAB) and Capex has been the timing of the transition from winter to summer peaking. In NSW and QLD, this has occurred since 1999, whereas it occurred much earlier in Victoria and South Australia. The shift from a short evening winter peak to longer afternoon – early evening summer peak driven by high ambient temperatures results in a significant de-rating of both lines and sub-stations. On hotter days, the load profiles of residential loads tend to “fill out” and combine with the flatter profile of commercial and light industrial loads to produce an earlier time of peak. This occurrence of an afternoon peak during the hottest part of summer is more onerous on the distribution network than the evening winter peaks, as ratings of electrical equipment are reduced at higher ambient temperatures. As the summer peak is driven by air conditioning usage, the network must be maintained to provide enough summer capacity. This may require upgrading equipment that would otherwise meet a winter peak of the same magnitude. The building of “summer capability” may have impacted both the RAB (to the extent that the capability is newer and therefore less depreciated) and Capex as capacity continues to be built in response to both demand growth and declines in ratings. In other words, the effective growth rate in “utilisation” NSW and QLD may be higher, even though the headline growth is not.

Another factor is whether the growth has occurred due to connection of new customers or increasing demand from existing customers. Where existing customers are increasing their demand, it becomes necessary to augment or replace the existing assets to meet the new demand.

In cases where it is not prudent to retain or redeploy the existing assets, any residual service life that could have been realised is lost.

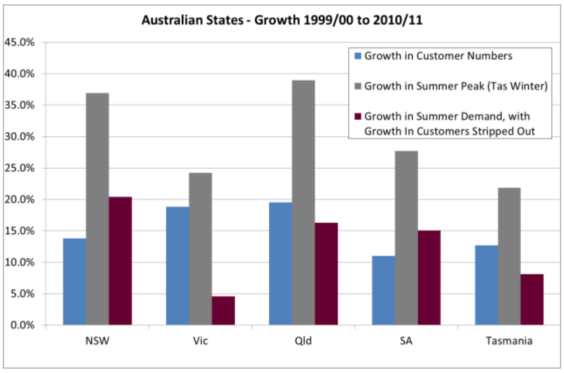


Figure 3-27: Growth in Summer Peak - Excluding Customer Growth

When normalised for the growth in customer numbers, it is seen that at under 5%, Victoria has had an unusually low growth in summer peak demand attributable to the existing customer base. This compares to growth rates of 15-20% for existing customers in NSW, QLD and South Australia and results in a greater need to augment or upgrade existing assets (in many cases prior to the end of its economic life) in order to meet growing demand from existing customers. As a general principle, we would expect “brownfield” augmentation in inner suburbs to be more expensive than green-field development in new areas. As a consequence, we have ranked these items as favourable to Victoria.

	Ausgrid	NSW	Vic	QLD	SA	Tas
Load Growth						

Cost Driver: Natural Cost Advantage · Neutral · Natural Cost Disadvantage · Unknown

Table 11: Summary - Load Growth

3.1.2 Capital Contributions

In most cases the construction of "shared" assets in an urban area are exclusively managed by the distributor, however, dedicated assets can result in different arrangements. In NSW, in accordance with Section 25 of the NSW Electricity Supply Act 1995, a customer wishing to have premises connected to the network for the first time, alter an existing connection to the network (e.g. for reasons of increased demand), or arrange the reticulation of a subdivision, is required to fund all or a portion of the costs (the capital contribution) of the work based on the following general principles:

1. A customer will pay the direct costs of the assets dedicated to that development for establishing the connection up to a defined point on the network.
2. Customers (except for some large load customers) connected to an urban network will in general not be required to fund network augmentation.
3. Some customers (rural customers and large load customers) may also be required to fund, as a further capital contribution, all or a portion of network augmentation beyond the linkage point.

Where contributions are made, the general purpose is to:

- Provide pricing signals to ensure that appropriate investment decisions are made; and
- Fund the assets required to provide for the needs of new customers.

The difficulty in conducting any level of detailed analysis at present is that distributors do not use a common methodology to determine capital contributions. Their differences in approach to calculating capital contributions result from differences in:

- the extent to which connection and upgrading costs are recovered through general prices or through capital contributions; and
- the share of the new assets to be paid by new customers.

The relative proportion of capital contributions is constant in both NSW and Victoria despite increases in overall capital suggesting correlation with constant customer growth ("connections").

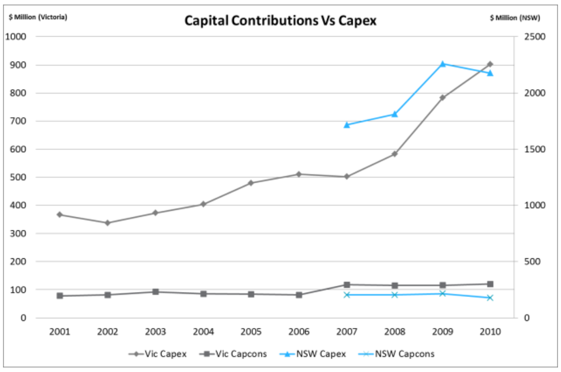


Figure 3-28: Capital Contribution and Capex

Evans & Peck notes that Ausgrid's proportion of capital contributions are much lower than other NSW DNSPs, however, there was insufficient information available (within the scope of this study) to draw any conclusions from this.

Year	ActewAGL	Ausgrid	Endeavour	Essential	NSW Total	Vic Total
Reported Capex	64.5	1057	401.6	652.8	2175.9	902.6
Capital Contributions/Capex	10%	4%	11%	12%	8%	13%

Table 12: Proportion of Capital Contributions (Compared to Total Capex)

	Ausgrid	NSW	Vic	QLD	SA	Tas
Capital Contributions						

Cost Driver: Natural Cost Advantage; Neutral; Natural Cost Disadvantage; Unknown

Table 13: Summary - Capital Contributions

3.2 Reliability Standards

The strategic development of the network and the medium and long-term capital investment requirements of Ausgrid to maintain adequate capacity and security of supply to meet customer needs are incorporated in the network planning process and among other things, specifically includes reliability planning criteria.

These criteria differ across asset classes, feeder categories, voltage levels and location in the network reflecting the different conditions and type of equipment in service. The criteria adopted have significant implications on the level of capital expenditures because it dictates network configuration and the types of switchgear, controls (manual or automated) and protection equipment used.

The Australian Energy Market Commission (AEMC) is currently reviewing the NSW distribution licence conditions to assist the NSW Government to decide whether the licence conditions should be amended to reflect different reliability outcomes. At this stage the AEMC's draft advice for public consultation surrounds the trade-offs between cost and reliability performance for four scenarios for distribution reliability outcomes in NSW, and whether changes to the NSW licence conditions should be made to provide for an alternative level of distribution reliability in NSW.

While the observations made in this report have been taken into account during our observations, it should be noted that a national work stream to consider merit in a nationally consistent framework for distribution reliability will be published in late 2012.

Currently processes for planning and augmenting distribution network are similar between DNSPs and states, however, the criteria in system planning and security standards for initiating projects vary significantly.

The current requirements for distribution reliability are implemented and enforced through the NSW electricity distribution licence conditions, which have been determined by the NSW Minister for Energy under the Electricity Industry Supply Act 1995 (NSW). The NSW distribution licence conditions contain four broad categories of requirements:

- Design Planning Criteria;
- Reliability Standards;
- Individual Feeder Standards; and
- Customer Service Standards.

3.2.1 Design Planning Criteria

The NSW design planning criteria is deterministic and largely based on N-1, 1% (P50) specify the level of redundancy that different parts of the network must be built to achieve, along with requirements to restore supply within defined timeframes where there is an outage.

The design planning criteria vary across different parts of the network, with the level of redundancy (or back up supply arrangements) dependent on the total amount of the customer load being serviced and the geographic area.

3.2.1.1 NSW Design Planning Criteria

Key aspects of the current design planning criteria in NSW include:

- Load Type - based on geographic areas this condition distinguishes between the level of redundancy required for customers in the CBD, urban and rural areas.
- Security Standard – this defines the level of redundancy differs for different network elements i.e. the number of network elements which can be out of operation without interruption to supply.
- Forecast/Expected Demand - the required level of redundancy based on the size of the customer load.
- Customer interruption (or restoration) times - the time in which supply must restored following an outage for different parts of the network.
- Customer load at risk – the amount that the peak demand can exceed capacity in some circumstances to account for the low probability that outages may occur at times of peak load.

The NSW Design Planning criteria are shown in Appendix A.

3.2.1.2 Victorian DNSP Planning Criteria:

The planning standards adopted in Victoria are probabilistic which recognises that extreme loading conditions may occur for only a few hours in each year and that, with some deterministic examples overlaid such as the use of cyclic or emergency ratings.

- This involves using an assessment of forecast maximum demand against N and N-1 ratings to calculate the “Energy at Risk” and “Hours at Risk” in cases where the forecast maximum demand is greater than the plant ratings (under outage conditions) – based on measured Load duration curves.
- Estimation of the probability of an outage coincident with the forecast maximum demand to give the “Probability Weighted Energy at Risk”. Forced outage rates are based on industry statistics for each equipment category.
- Estimate of the cost to the community of the resultant probability weighted energy at risk based on estimates for the Value of Customer Reliability (VCR).
- Using these costs, a sector weighted cost for VCR for each site can be determined based on estimated customer composition.
- The sector weighted cost is then multiplied by the probability weighted energy at risk to provide the expected cost of un-served energy. If the expected cost of un-served energy is greater than the annualised cost of the network augmentation then the project can be justified as the expected cost to the community with no augmentation is greater than the cost of the augmentation.

3.2.1.3 Queensland Planning Criteria

The Queensland planning criteria is also deterministic like NSW, however, recognises that significant load can be shed for period of time while switching is carried out and/generators are installed.

For example:

- Commercial and Industrial N-1 (a) sheds up to 12MVA of residential load for 3-4 Hours.
- Predominantly domestic N-1 (c) off for 3-4 Hours.

Queensland has also had a Minimum Service Standard regime in place which has necessitated significant improvement since 2005. This has required both ENERGEX and Ergon Energy to improve reliability performance by around 25% over the last two regulatory periods in order to comply with their distribution licences under the Queensland Electricity Code.

The Queensland Planning criteria are shown in Appendix B.

3.2.1.4 National Distribution Reliability Review

It is prudent to mention the NSW reliability licence conditions and the current review by the AEMC[10] and also the pending outcomes of the National Review. Following a request for advice from the Ministerial Council on Energy, the AEMC has produced a draft report indicating that there are potential cost savings for customers from lower levels of distribution investment to meet reliability requirements would outweigh the potential costs to customers from poorer reliability performance.

The draft advice based on considering four scenarios (three lower and one higher level of reliability outcome, conversely relates to three lower and one higher costs and price for distribution reliability) highlights the following:

- The possible cost savings for consumers are relatively modest.
- Costs relating to distribution reliability only form a relatively small driver of overall distribution prices.
- A new value of VCR has been calculated for NSW at $94.990/MWh.

Until recently, there has been no real common base to compare the different planning methodologies, however, in the AEMC review of Distribution Reliability Outcomes and Standards, the calculation of a NSW VCR has been adapted from the Victorian VCR methodology (previously there was none).

	Ausgrid	NSW	Vic	QLD	SA	Tas
Reliability Standards						

Cost Driver: Natural Cost Advantage Neutral Natural Cost Disadvantage Unknown

Table 14: Summary - Reliability Standards

[10] DRAFT REPORT - NSW WORKSTREAM Review of Distribution Reliability Outcomes and Standards

3.2.2 Reliability Outcomes

The reliability standards set out requirements for the maximum duration and frequency of unplanned outages, by feeder type, for each network.

These standards are referred to as the System Average Interruption Duration Index (SAIDI) and the System Average Interruption Frequency Index (SAIFI). Different SAIDIs and SAIFIs apply for the following feeder types, which are based around customer density:

- CBD;
- Urban;
- Short-rural; and
- Long-rural.

The reliability standards relate to the average performance that must be achieved across each feeder type and also differs between states.

- NSW – Unplanned with Exclusions
- Victoria – Unplanned with Exclusion
- Queensland – Planned and Unplanned with Exclusion

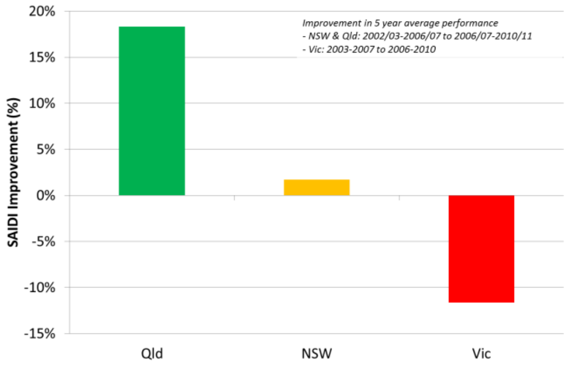


Figure 3-29: 5 year average reliability improvement 2002/03-2006/07 to 2006/07-2010/11

The high level observations that can be made noting that this represents the five year moving average of the combined planned an unplanned results over the period, from the start of the period to the most recent annual SAIDI observation.

- NSW has maintained reliability with a slight improvement of around 2%.
- For Queensland, overall reliability has improved by around 18%.
- Victorian Reliability has deteriorated by around 15%.

In developing this graphic, we have made an assumption that the relative proportion of customers between DNSPs within each state has remained relatively constant.

Improvements in the level of reliability infers a difference to the capital required to maintain safety security and reliability of the System. For an organisation the size of ENERGEX for example, as a "rule of thumb" guide Evans & Peck estimates that a one minute improvement in SAIDI would necessitate around $1million per annum in additional OPEX, or around 10 times this in CAPEX.

	Ausgrid	NSW	Vic	QLD	SA	Tas
Reliability Outcomes						

Cost Driver: Natural Cost Advantage | Neutral | Natural Cost Disadvantage | Unknown

Table 15: Summary – Reliability Outcomes

3.3 Environmental Factors

Environmental conditions to which distribution networks are subjected vary significantly from state to state and from distributor to distributor, which in turn has a significant impact on the cost of the infrastructure. Some examples which may apply are:

- Climate and severity can affect failure rates and associated costs.
- The presence of corrosive atmospheres such as salt (coastal) and acid sulphate soils impacts maintenance costs and replacement decisions.
- Geological conditions have an impact on the cost of construction including the nature and design of footings for overhead structures.
- Rugged terrain makes installation and maintenance more costly and restoration slower.
- Rocky terrain and high resistivity soils make the installation of earth grid more complex in order to provide effective protection.
- Line design requirement vary according to climatic influence.
- Large distances between generation and load increases the extent of the network (longer lines cost more than shorter ones), making it more costly in the first instance but also increases its potential for exposure during operation.
- Remoteness can impact on maintenance costs and response times in the case of unplanned outages.

Similarly, the local legislative, business and community environment also impose a series of considerations which impact both operating and capital cost drivers such as: legislative requirements including health, safety and environment; skills required incorporating qualifications, work and operating procedures; award conditions incorporating, wage rates and constraints such as stand-down; traffic requirements varying between CBD, Urban and night-time only access; and related operating constraints due to network loading or system configuration.

3.3.1 Green-Field versus Brown-Field

Superimposed on these environmental factors are also specific impacts which particularly relate to highly urbanised conditions that makes both constructing new assets and maintaining existing assets more expensive. In this case the broad generalisation is the green-field environment being any new site that is relatively unencumbered and free from obstruction which could be in a new development area or in an existing area surrounded by established buildings and infrastructure. This is compared to a brown-field environment which as an existing site, is often difficult to access, can be highly obstructed, can contain existing infrastructure/live services which need to remain in service and generally poses greater overall risk to projects.

In the case of <u>green-field</u>, there are some obvious advantages which include but are not limited to:

- Maximum design flexibility to meet project requirements;
- New assets require less maintenance; and
- Designed to meet current and future needs.

Similarly there are also disadvantages:

- Additional development costs through upstream network augmentation requirements;
- Approval time frames may be longer for new sites;

- Site conditions may be greatly varied; and
- The community is not accustomed to, or prepared for, the site being used for new infrastructure.

The converse of this in brown-field developments are advantages such as:

- May include existing environmental licences and council approvals;
- Existing infrastructure may be utilised without major upgrades; and
- Total project may cost less.

Finally, disadvantages related to brown-field developments might include:

- Land costs are much higher;
- Underground cables are much more likely to be used, to accommodate the lack of land availability and improve visual amenity, however, underground cables are more expensive;
- The scarcity and cost of land also encourages the use of compact design which influences equipment specification such as the requirement for enclosed substation and gas insulated switchgear, again increasing the cost;
- Design and operation efficiency is often compromised to suit existing constraints;
- Site location may be highly urbanised and therefore pose construction and future operating constraints i.e. traffic congestion etc.;
- Existing sites may have live cables or other in-service infrastructure to work around;
- Older structures may not meet structural requirements to support new infrastructure;
- Existing buildings may not comply with AS or BCA requirements thereby imposing extra cost to comply with current standards;
- Higher risk of cost blow-outs for unforeseen situations;
- Site/substations/structure may have other environmental issues i.e. contamination;
- Sites may be subject to demolition and/or relocation costs to make the site usable;
- Often difficult to find the ideal site; and
- Higher maintenance cost.

Whilst all of the environmental conditions need to be considered in carrying out any level of comparison, the observations which flow from the spatial analysis in section 3.4 demonstrate Ausgrid’s exposure to brown-field developments due to the population growth and density in specific areas determining the type of network and the treatment of older assets which cannot be practically re-deployed.

A specific example of Ausgrid’s susceptibility to cost impact for brown-field development relates to re-instatement where brown-field development restorations and temporary re-instatement are currently accounting for more than 20% of the cable replacement programme. The reinforced concrete pavement costs in the Sydney Metro area are typically higher than other areas in NSW and also other states. Ausgrid has captured evidence of these costs imposed by many of the Sydney councils across its network area and also by RMS (who are generally recognised as the largest user of concrete pavements in Australia). Although these pavements have a long design life, they are generally up to three times the cost of a flexible pavement to remove and reinstate.

In contrast to Sydney, rigid pavements are rare to find in rural areas except for the major highways constructed/upgraded since the early 1990s. The nature and design of network infrastructure in more remote areas (overhead) also allows other means for traversing roads and highways therefore avoiding these costs.

With respect to other states:

- QLD & WA do use concrete pavements on motorways but less so on other roads;
- Vic Roads still use flexible pavements for most works; and
- Road restorations in Victoria are also cheaper than other states as most heavy duty pavements are able to be constructed without stabilising materials (cement or lime) due to the high quality of natural quarry products available in the state.

Similarly for Authority Fees, under the Local Government Act NSW councils charge a fee for 'opening' the road and then charge a per square metre rate to restore the pavement. These rates are typically >50% higher than if the utility engaged a qualified contractor directly to do the work. In contrast Brisbane City council does not charge any fees, Melbourne City council charges a small fee permit fee but allows the contractor to restore the pavements themselves at their cost.

3.4 Spatial Analysis

Spatial constraints also have significant bearing on development and operational costs for electricity networks and while they are numerous and varied in nature and extent, the following aspects are of particular interest.

3.4.1 Topography

The slope of land presents constraints to electricity infrastructure development where that slope is considerable. The following figures incorporate the 50m contours for the major population areas in NSW, Queensland and Victoria.

While it should be noted that there are slightly different scales on each diagram, the scale and density of contours in each case means that even at the smallest line width, they all run into each other to create a shaded grey area, i.e. greater variation in geography.

The major population areas in Victoria are extraordinarily flat with little native vegetation.

	Ausgrid	NSW	Vic	QLD	SA	Tas
Topography						

Cost Driver: Natural Cost Advantage   Neutral   Natural Cost Disadvantage   Unknown

Table 16: Summary - Topography

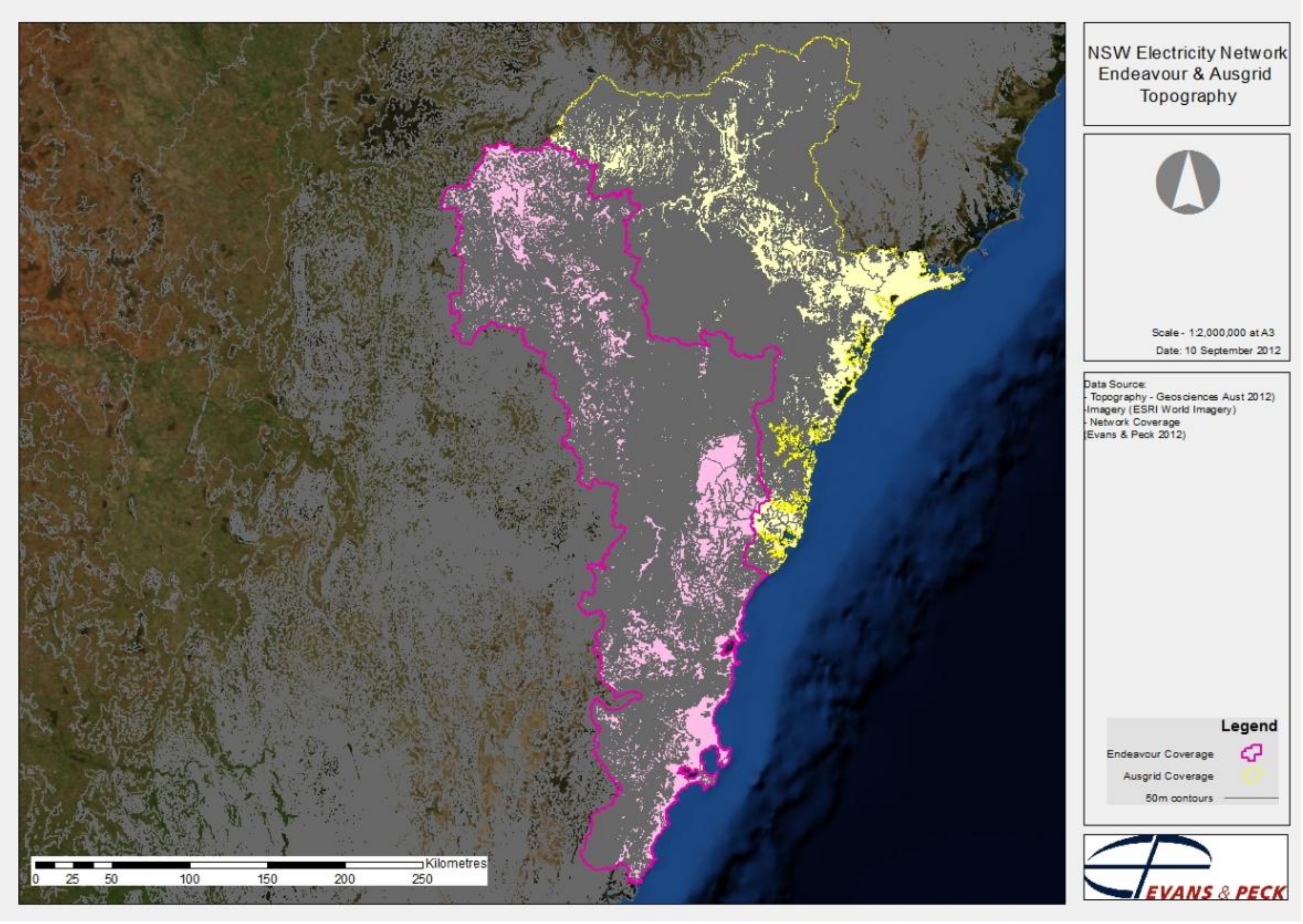


Figure 3-30: NSW Topography - Ausgrid

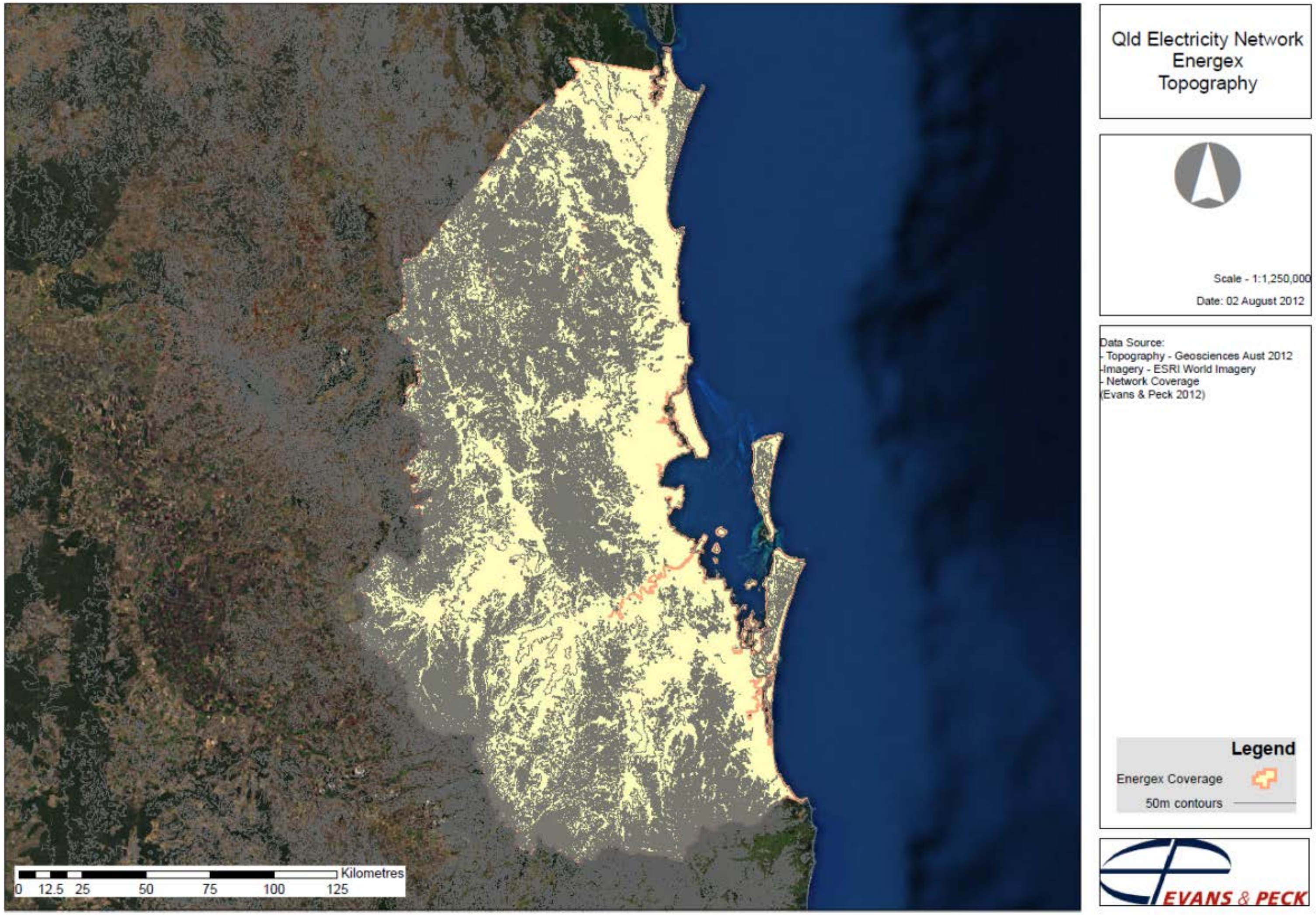


Figure 3-31: QLD Topography – Energex

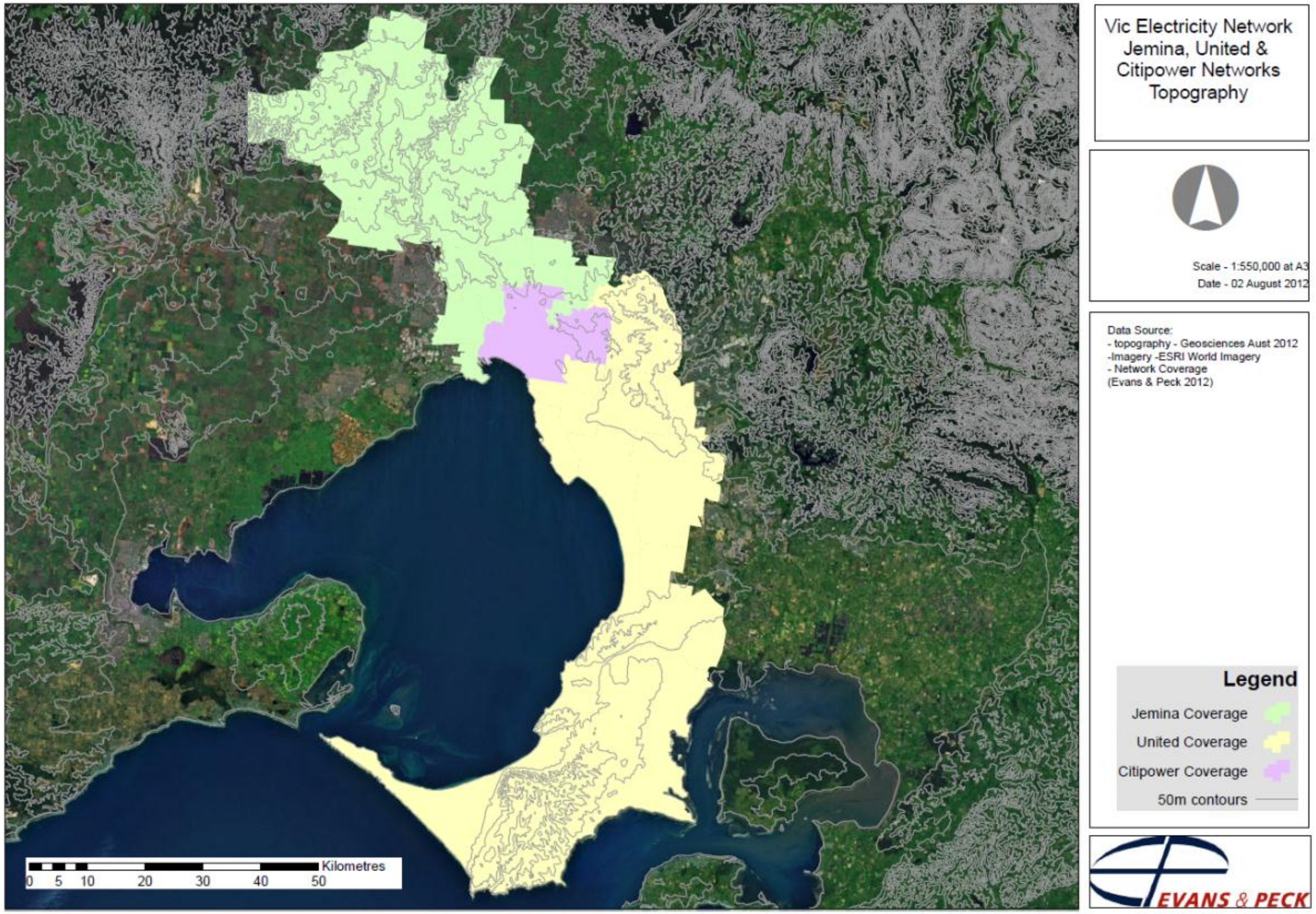


Figure 3-32: Vic Topography - CitiPower, Jemena, United

3.4.2 Native Vegetation and Environmentally Sensitive Areas

Most green spaces may be traversed with electrical infrastructure and do not generally pose a significant constraint to development, however, Native Vegetation and National Parks represent one such constraint across which electrical infrastructure is highly unlikely to be developed.

Native Vegetation areas in this context is described by a polygon incorporating:

- Forest or Shrub (An area of land with woody vegetation greater than 10% foliage cover, minimum size 250,00 sq meters).
- Mangrove (A dense growth of mangrove trees which grow to a uniform height on mud flats in estuarine or salt waters. The land upon which the mangrove is situated is a nearly level tract of land between the low and high water lines, Minimum size 390.625 sq meters).
- Rainforest (Vegetation community which contains key rainforest species, with foliage cover greater than 70%, Minimum size 390.625 sq meters).

This description does not include smaller or sparsely vegetated areas, however, it is uniform across Australia. In summary the green coloration (as defined above) is an indicator that there is something to deal with. With reference to Figure 3-33: NSW Vegetation - Ausgrid, Figure 3-34: QLD Vegetation - Energex, and Figure 3-35: Vic Vegetation – CitiPower, Jemena, United:

- For Ausgrid, there is not a lot of native vegetation in CBD but a lot of native vegetation in the broader service territory.
- Urban Victoria has only very small pockets of native vegetation.
- Brisbane has less native vegetation coverage than Sydney.

	Ausgrid	NSW	Vic	QLD	SA	Tas
Vegetation/ Environmentally Sensitive Areas						

Cost Driver: Natural Cost Advantage | Neutral | Natural Cost Disadvantage | Unknown

Table 17: Summary – Native Vegetation/ Environmentally Sensitive Areas

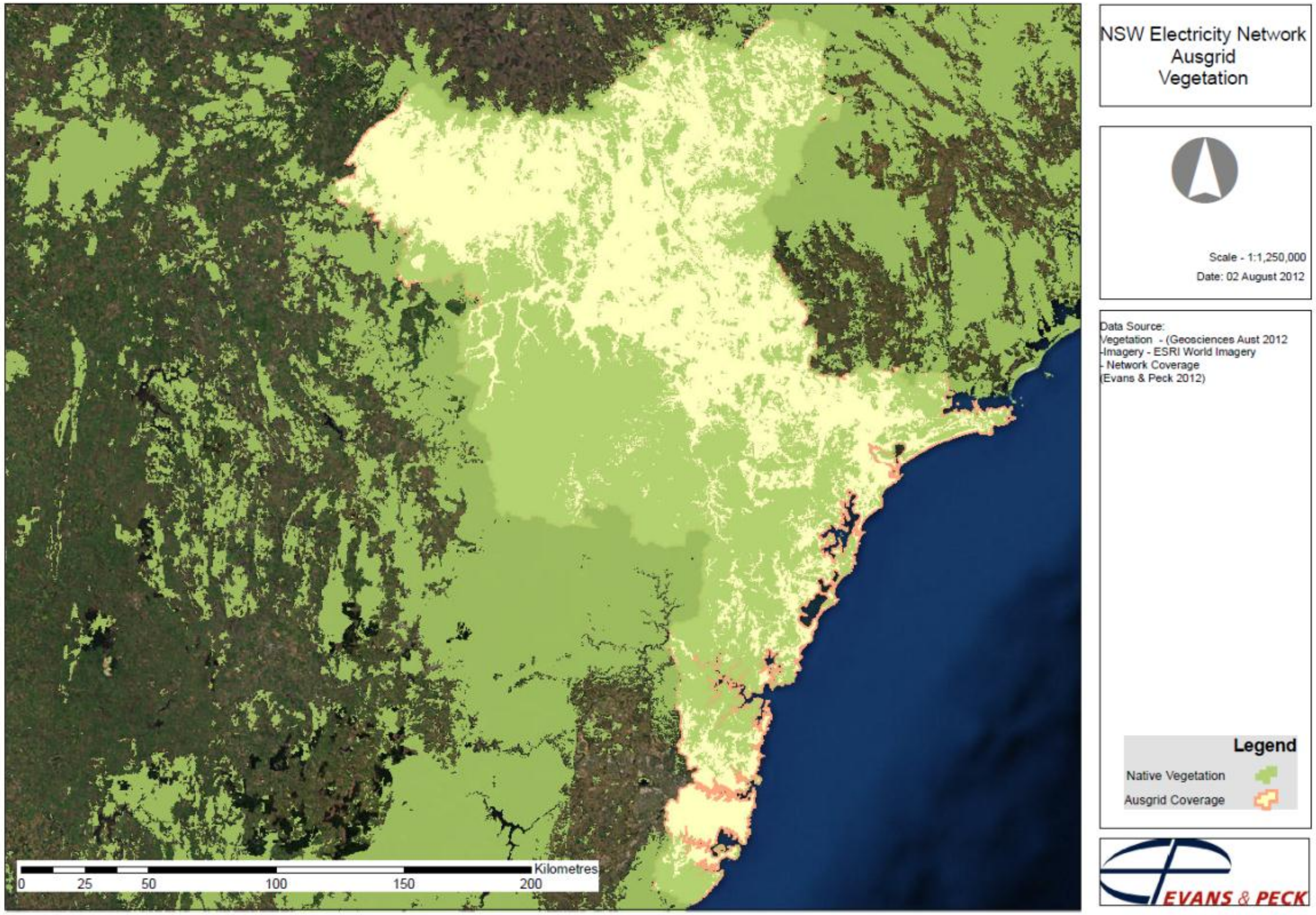


Figure 3-33: NSW Vegetation - Ausgrid

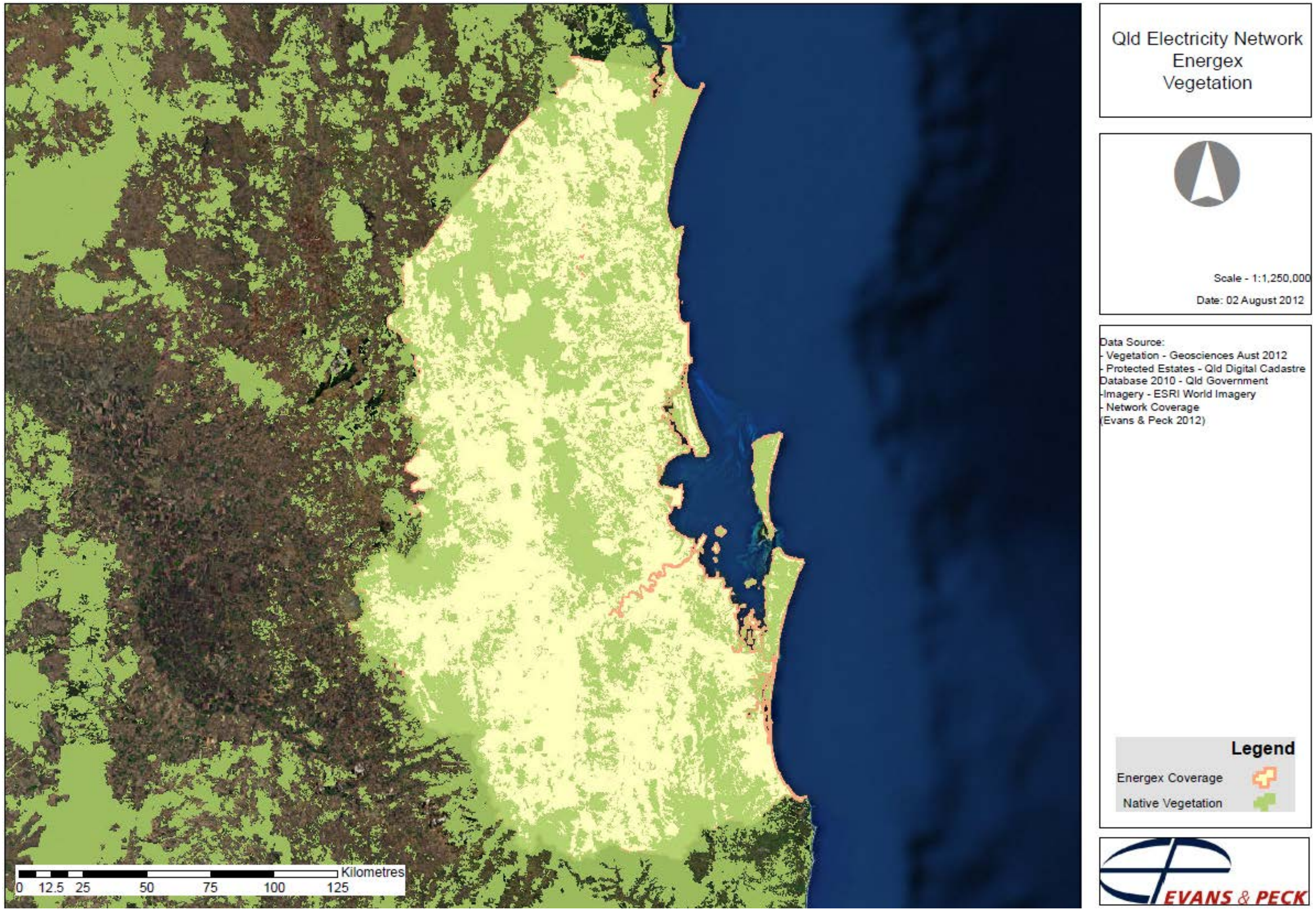


Figure 3-34: QLD Vegetation - Energex

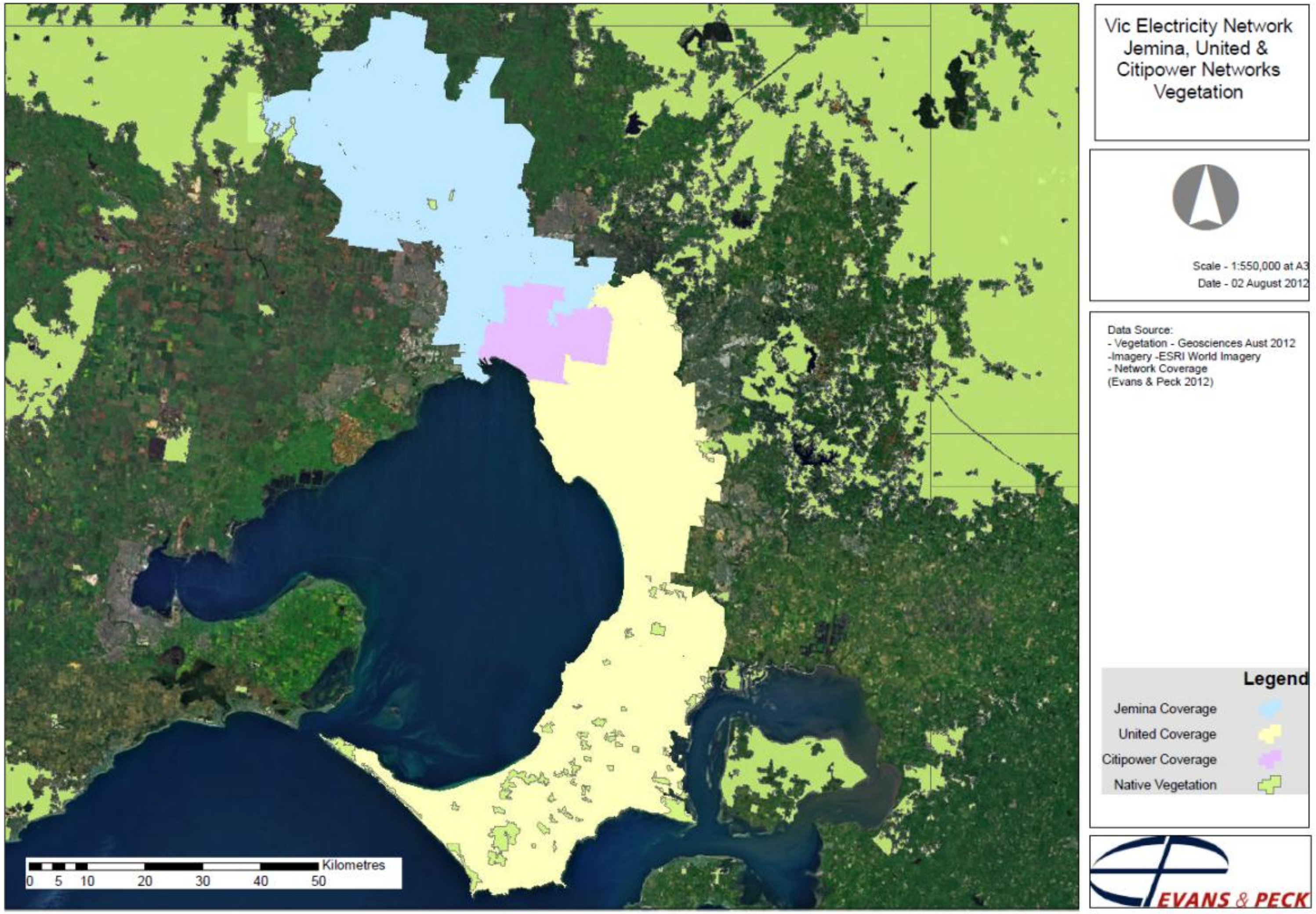


Figure 3-35: Vic Vegetation – CitiPower, Jemena, United

3.4.3 Population Density

As discussed in the Background and Approach, population density varies greatly across Australia, ranging from very low in remote areas to very high in inner-city areas. The ABS provides a good source of reliable data around population density. Starting with Australia's population density at June 2011, which was 2.9 people per square kilometre (sq km), across the Eastern States, Victoria has the highest density (excluding ACT) with 25 people per sq km, Followed by New South Wales with 9.1, Tasmania with 7.5 and Queensland with a population density less than the national average.

As you would also expect, the population density was highest in the capital cities, particularly in Sydney which has six of the top ten most densely-populated SLAs, including Sydney East, which had the highest population density in Australia (8,900 people per sq km).

In addition to Figure 3-36: Population Density by SLA, Sydney - 2010-11, specific network coverage areas shown in Figure 3-37: Population Density – Ausgrid, Figure 3-38: Population Density - Ausgrid (Sydney Region) and Figure 3-39: Population Density - Victoria Urban, in line with the ABS statistics Sydney has emerged as more dense in population per square km than Melbourne with a natural spread over the south and west. The impact of this is discussed further in the following section when incorporating population growth.

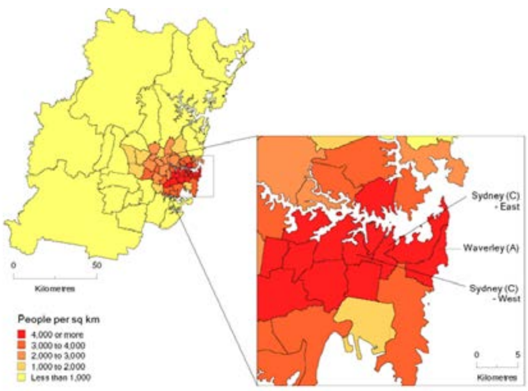


Figure 3-36: Population Density by SLA, Sydney - 2010-11

	Ausgrid	NSW	Vic	QLD	SA	Tas
Population Density						

Cost Driver: Natural Cost Advantage | Neutral | Natural Cost Disadvantage | Unknown

Table 18: Summary - Population Density

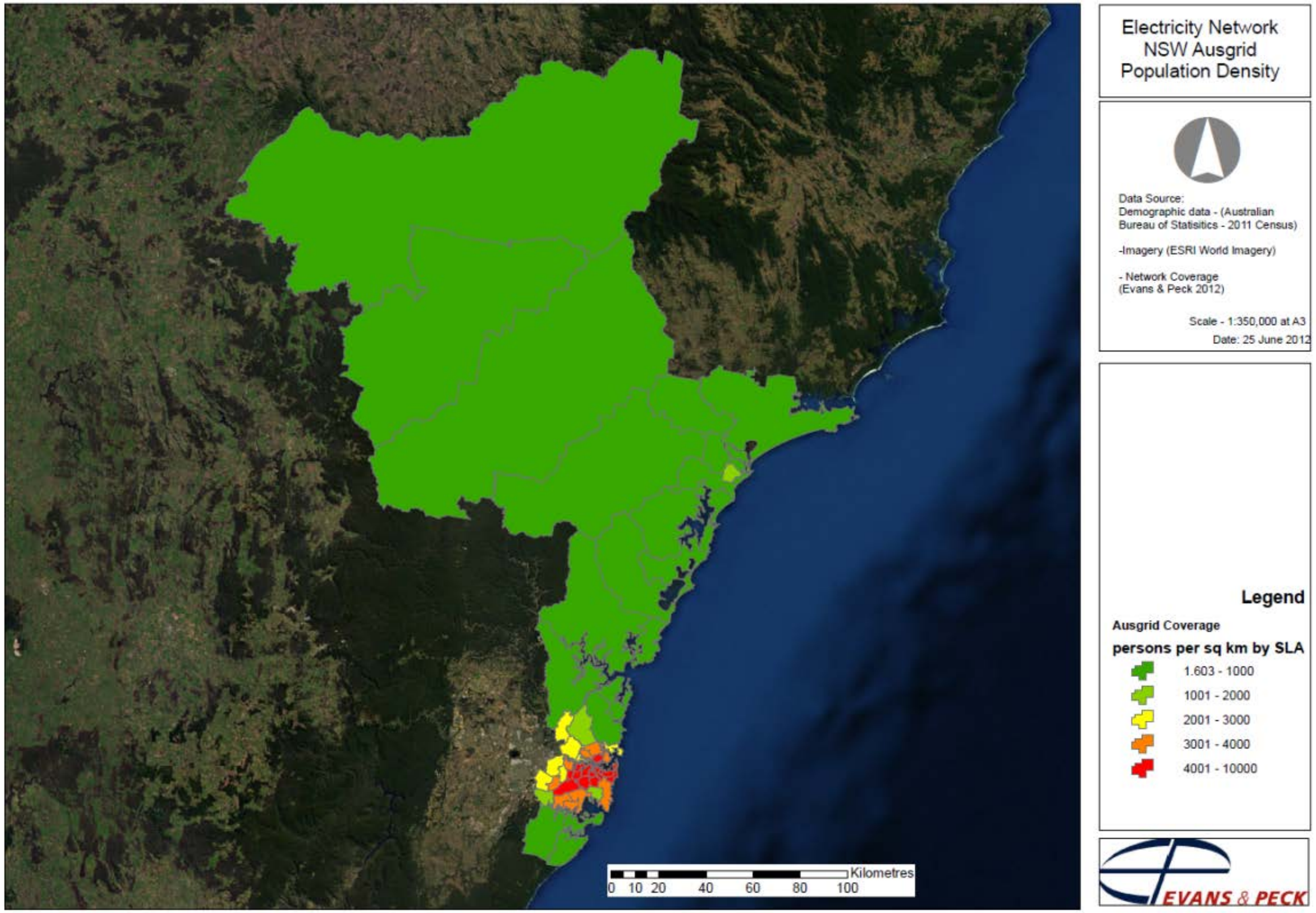


Figure 3-37: Population Density – Ausgrid

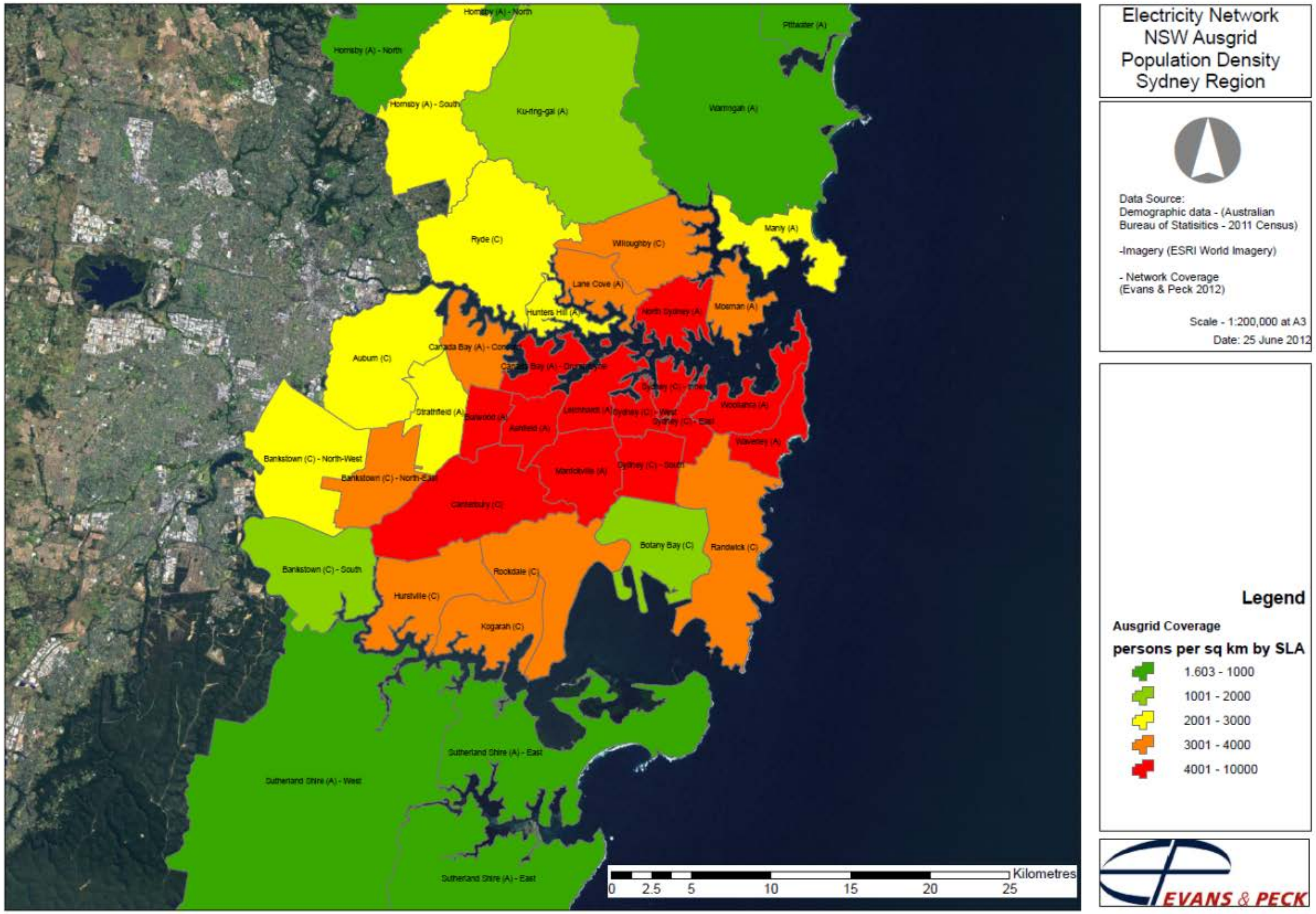


Figure 3-38: Population Density - Ausgrid (Sydney Region)

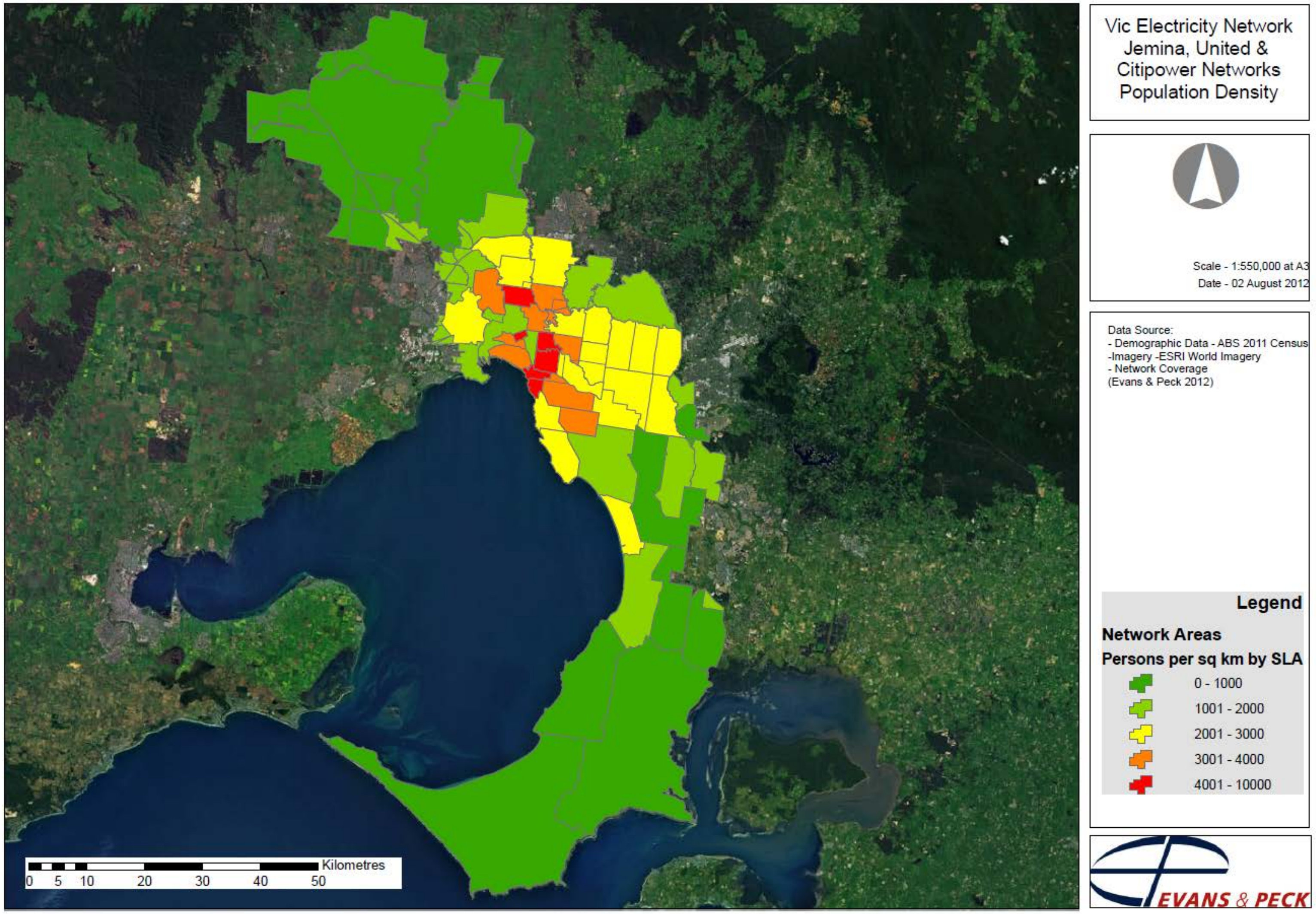


Figure 3-39: Population Density - Victoria Urban

3.4.4 Population Change (Growth)

At a national and state level, small increases in population growth do not necessarily provide immediate insight in relation to growth and its more immediate impact on infrastructure requirements.

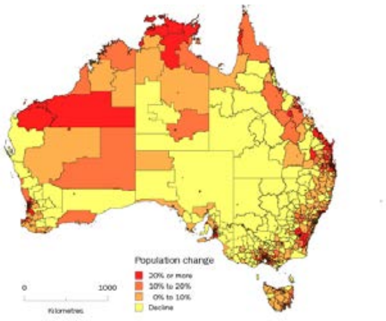


Figure 3-40: Load Duration Curves

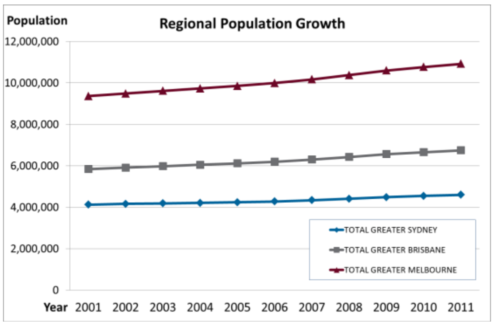


Figure 3-41: Expanded Load Duration Curve

The comparison of the Australian Bureau of Statistics (ABS) census data between the 2001 and 2011 provides some broad context around population change with all states and territories experiencing population growth and the largest increases in the most populous state with Queensland having the greatest growth (845,200 people), followed by Victoria (729,800) and New south Wales (636,300).

The ABS data also notes that many of the areas that experienced large growth were outer suburban areas located on the fringes of capital cities where more land tends to be available for subdivision and development, accompanied by specific areas in each city which experienced inner city growth and urban infill along transport corridors.

Highlights over the 2001-2011 periods are:

- Three-quarters of all population growth in New South Wales was in Greater Sydney.
- The SA2[11]s in NSW with the largest growth were Parklea - Kellyville Ridge (up 18,700 people) and Kellyville (11,900), both in the capital city's north west-growth corridor.
- Greater Melbourne had the largest growth of all the capital cities (up 647,200 people) in the ten years ending June 2011.
- The five SA2s with the largest growth in the country were all on the outskirts of Melbourne
- Greater Brisbane's population increase was the second fastest capital city growth in Australia, growing by 25% (432,300 people).
- Growth in the outer suburbs of Greater Melbourne contributed the most to Victoria's population growth.

[11] ■Statistical Areas Level 2 (SA2s). SA2s are medium-sized general purpose areas which aim to represent communities that interact together socially and economically. SA2s are based on officially gazetted suburbs and localities. In urban areas SA2s largely conform to one or more whole suburbs, while in rural areas they generally define the functional zone of a regional centre. [SA3s are aggregations of whole SA2s, SA4s are made up of whole SA3s, GCCSAs are built from whole SA4s, LGAs are ABS approximations of officially gazetted LGAs as defined by each state and territory local government department]

At a more granular level we believe that there is sufficient insight to identify varying cost drivers between each state and in particular, between distributors.

Further comparisons of ABS data for the 2001-2011 period indicate all 43 LGAs in Sydney SD[12] increased in population with the 11 LGAs with the largest growth in NSW in 2001-11 all within Sydney SD. Sydney SD represented 63% of the total state population and had the highest annual growth rate (1.3%) of any SD in NSW.

The mean population growth over the Ausgrid coverage area (summation of LGA data) was 9.24% between 2001 and 2011 and while Blacktown recorded the largest increase in population, the fastest-growing LGAs in NSW included Canada Bay and Auburn, located along the Parramatta River in inner western Sydney.

There was also some significant growth in the nursery suburbs, i.e. the largest population growth outside Sydney SD was in the coastal LGAs of Lake Macquarie and neighbouring Newcastle in the Hunter region. A lot of growth in high density, brown-field areas with the implication being higher cost augmentations.

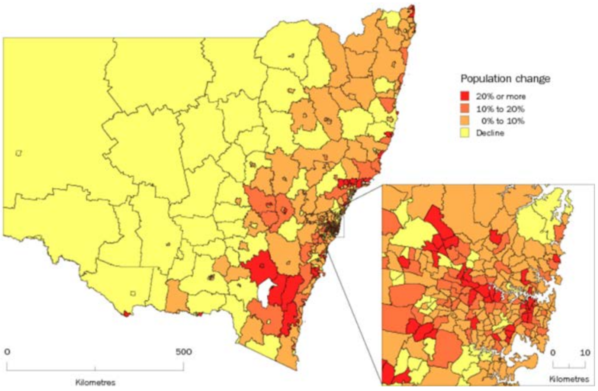


Figure 3-42: SLA Population Change, New South Wales - 2001-11

Figure 3-42: SLA Population Change, New South Wales - 2001-11and Figure 3-45: NSW Population Change further below provide a good representation of this change for both the inner west and central coast regions when mapped over Ausgrid's service territory. In Victoria, the largest population growth continued to occur in the outer suburban fringes of Melbourne. From 2001-11, Wyndham located to the south-west of Melbourne's city centre, had the largest growth of all Victorian LGAs, with all three SLAs within Wyndham LGA experiencing large growth. Whittlesea located to the north of Melbourne, had the second largest growth, followed by Melton to the west of Melbourne.

[12] A Statistical Division (SD) is an Australian Standard Geographical Classification (ASGC) defined area which represents a large, general purpose, regional type geographic area. They consist of one or more Statistical Subdivisions (SSDs) and cover, in aggregate, the whole of Australia without gaps or overlaps. They do not cross state or territory boundaries and are the largest statistical building blocks of states and territories. In New South Wales, proclaimed New South Wales Government Regions generally coincide with. In the remaining states and territories, SDs are designed in line with the ASGC general purpose regional spatial unit definition.

Figure 3-43: SLA Population Change, Victoria - 2001-11, shows the high growth in nursery areas a long way out of Melbourne, (with the exception of 66% growth at Docklands) indicates green-field types developments that have little congestion, no existing services to deal with, no reinstatement costs, flexibility in site location (via mass release land and developer installed infrastructure). In addition, much of the growth has been in the vicinity of the 500kV backbone transmission system, and whilst some augmentation of transmission sub-station capacity has been required at locations such as Cranbourne, there has not been a need for significant new lines.

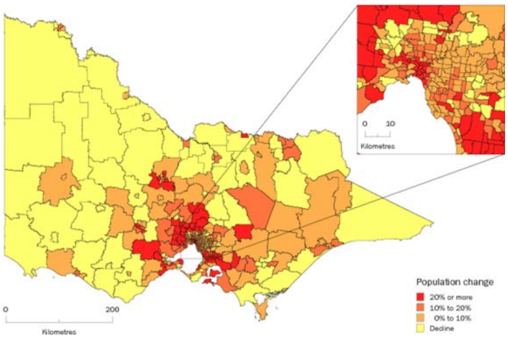


Figure 3-43: SLA Population Change, Victoria - 2001-11

South-East Queensland (Brisbane, Gold Coast, Sunshine Coast and West Moreton) population growth as shown in Figure 3-44: SLA Population Change, Queensland - 2001-11 was more widespread and accounted for around two-thirds of the total population growth in Queensland and between June 2001 and June 2011.

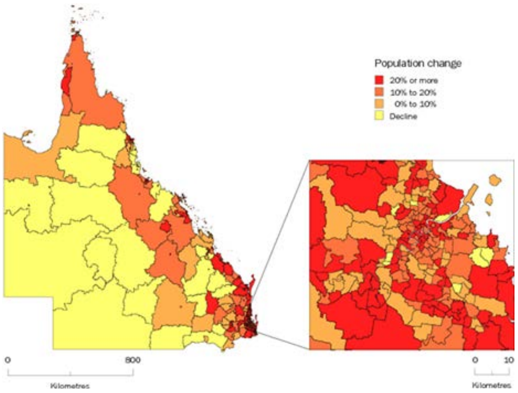


Figure 3-44: SLA Population Change, Queensland - 2001-11

	Ausgrid	NSW	Vic	QLD	SA	Tas
Population Change						
Cost Driver: Natural Cost Advantage	Neutral	Natural Cost Disadvantage				Unknown

Table 19: Summary - Population Change

Note: The legend reflecting population change in the following figures is not the same as those sourced from the ABS (above) i.e. the colours do not represent a consistent definition. Therefore, care is required when undertaking any comparison.

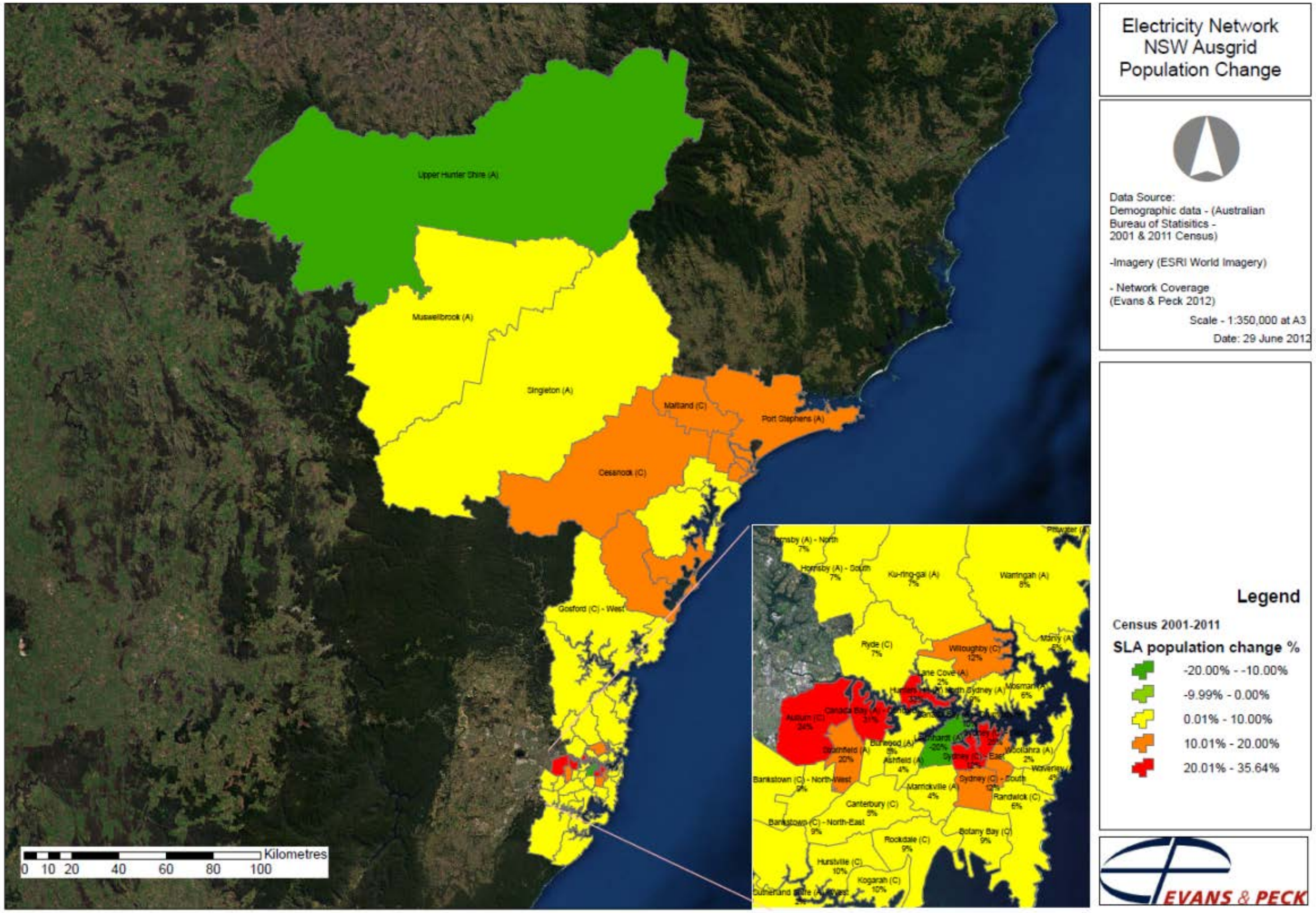


Figure 3-45: NSW Population Change

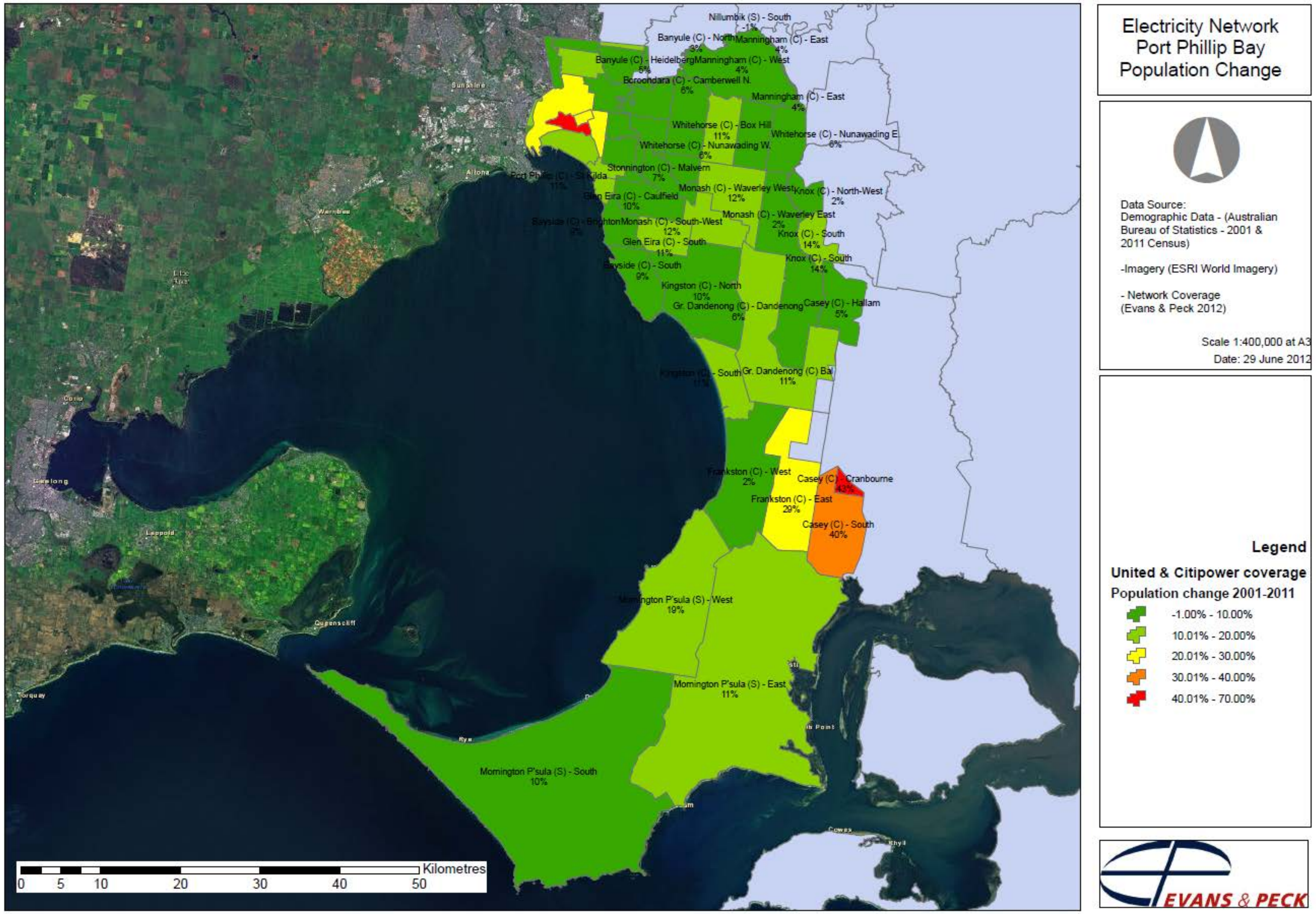


Figure 3-46: Vic Population Change – Urban

3.4.5 Shape Factors (protected estates, waterways, coastline, national parks)

The presence of water bodies will shape urban development, and to some extent determine the electricity network. Bays, harbours and large rivers are constraints to development that may necessitate additional transmission and distribution infrastructure to circumvent these water bodies.

Figure 3-47: NSW Protected Estate - Ausgrid, shows Ausgrid covers a large service area which is not contiguous but fragmented by harbours and rivers, bounded by water, national parks or vegetation, creating more than four segregated areas or pockets. Ausgrid is also challenged by the amount of coverage under vegetation which is also protected estate.

Comparatively, neither Energex (Figure 3-48: QLD Protected Estate - Energex) nor the Victoria Metropolitan distributors have this impact to such an extent, particularly in the higher density areas.

	Ausgrid	NSW	Vic	QLD	SA	Tas
Shape Factors	Natural Cost Disadvantage	Natural Cost Advantage	Natural Cost Advantage	Natural Cost Advantage	Neutral	Neutral

Cost Driver: Natural Cost Advantage Neutral Natural Cost Disadvantage Unknown

Table 20: Summary - Shape Factors

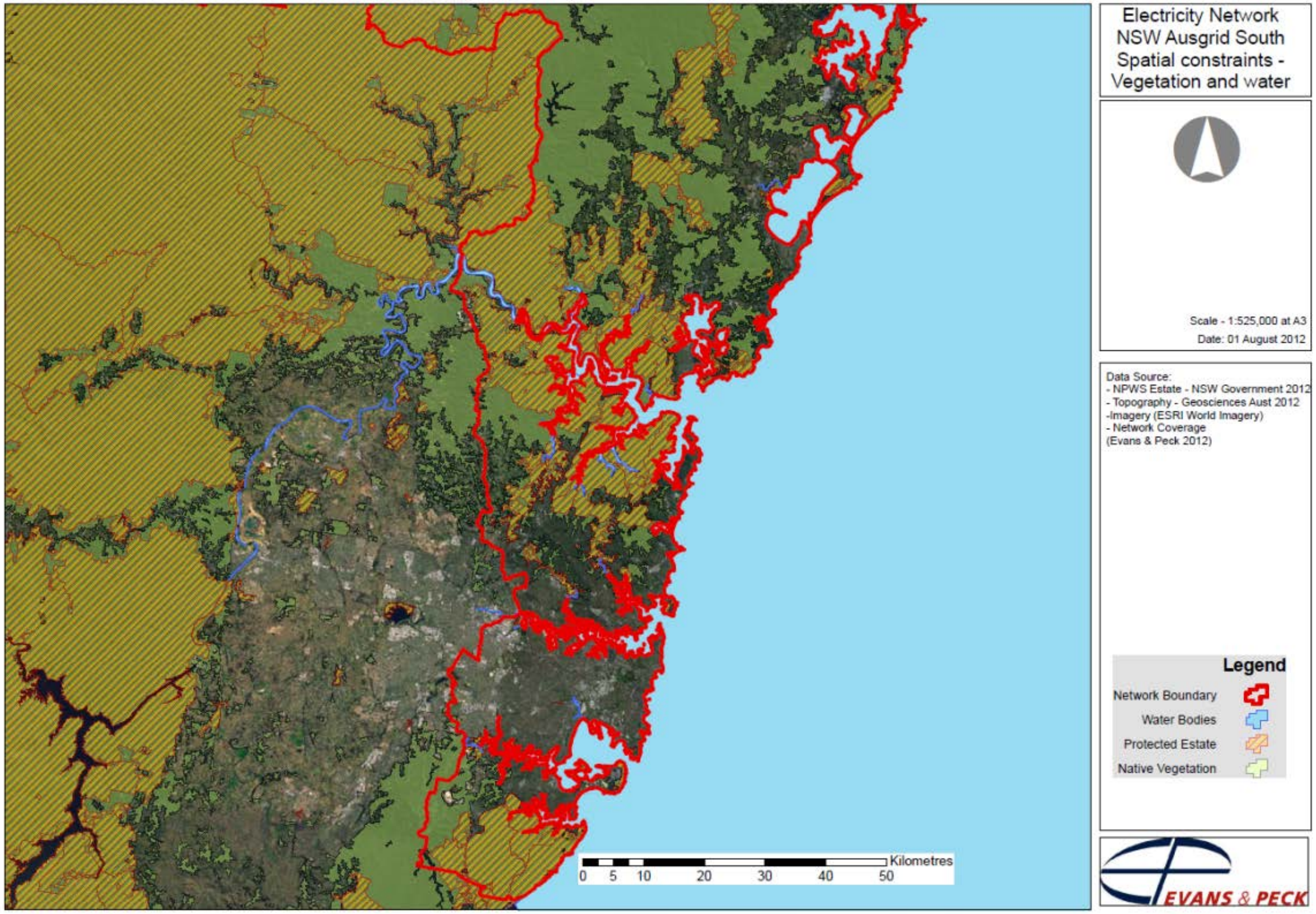


Figure 3-47: NSW Protected Estate - Ausgrid

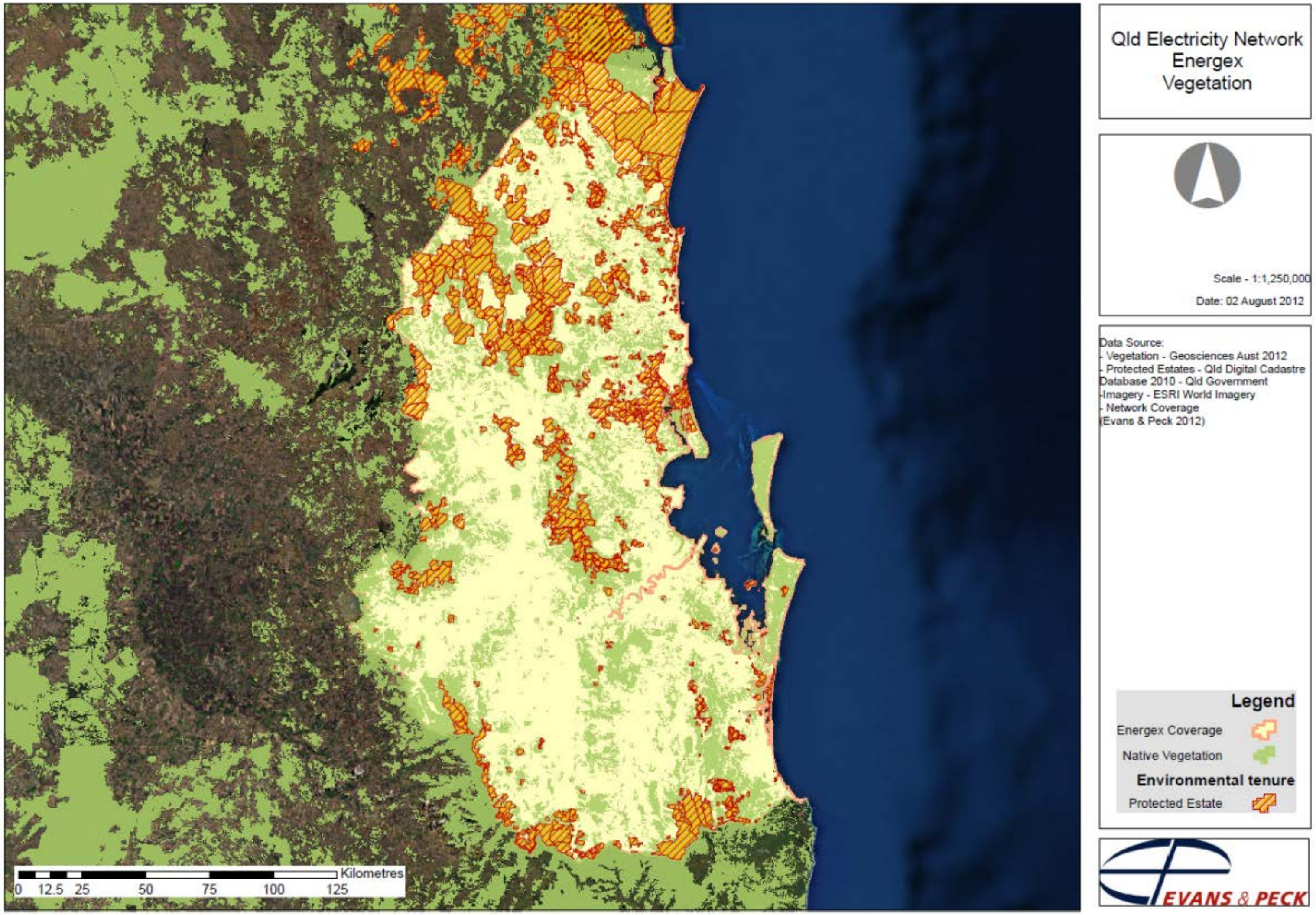


Figure 3-48: QLD Protected Estate - Energex

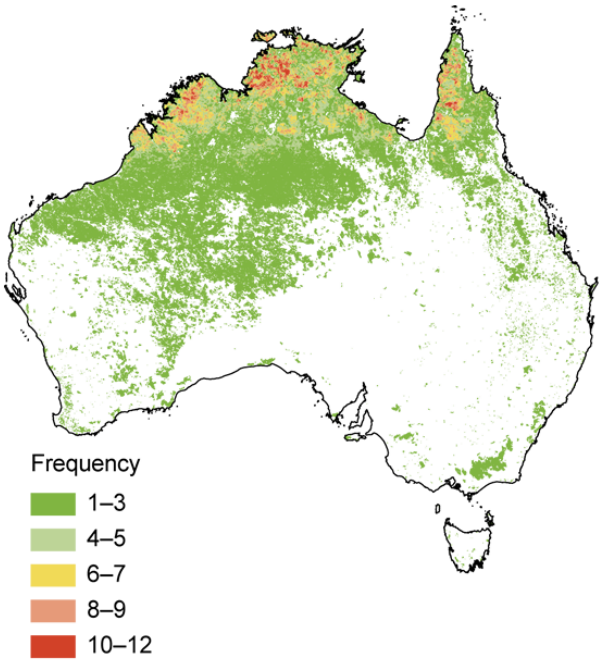
3.4.6 Bushfire Vulnerability

Correlated to the existence of vegetation and protected estates is bushfire vulnerability. While wind, temperature, humidity and rainfall are weather elements that affect the behaviour of bushfires, the vegetation layers are a reasonable means of establishing vulnerability to bushfire in the first instance.

Victoria has the most significant recent history electricity assets causing bushfires as evidenced through the findings of the Royal Commission into the 2009 Bushfires which recommended changes to the operation and management of the distribution system. The changes to reduce the risk of electricity assets causing bushfires in the short term included:

- Reducing the length of the inspection cycle;
- Improving the efficacy of asset inspection;
- Modifying the operation of reclosers;
- Retrofitting vibration dampers to longer spans of power line; and
- Fitting spreaders to power lines to minimise clashing.

Whilst the impact and underlying tragedy of these events are not to be understated or overlooked in any way, it is important to understand that while the greatest impacts on life and property from bushfires have been in Victoria, the bushfire risk more broadly across the Eastern states is greatest across the Northern States of Australia. The following figure illustrates the frequency of occurrence of bushfires over the 12 year period (fires per 12 years).



Source: Generated using data sourced from Firewatch Landgate, Western Australia, www.firewatch.landgate.wa.gov.au

Figure 3-49: Fire Frequency Map of Australia 1997-2009

The more recent drought conditions in south-eastern Australia have been favouring more severe bushfires becoming more frequent.

The Australian Standard, AS 3959—2009 Construction of buildings in bushfire prone areas, provides some further guidance in relation to Fire Danger Index (FDI) values which are provided by the Australasian Fire and Emergency Service Authorities Council (AFAC) and summarised in the table below:

State/region	FDI
Australian Capital Territory	100
New South Wales	
(a) Greater Hunter, Greater Sydney, Illawarra/Shoalhaven, Far South Coast and Southern Ranges fire weather districts	100
(b) NSW alpine areas	50
(c) NSW general (excluding alpine areas, Greater Hunter, Greater Sydney, Illawarra/Shoalhaven, Far South Coast and Southern Ranges fire weather districts	80
Northern Territory	40
Queensland	40
South Australia	80
Tasmania	50
Victoria	
(a) Victoria alpine areas	50
(b) Victoria general (excluding alpine areas)	100
Western Australia	80

Table 21: Jurisdictional and Regional Values for FDI

The FDI is a measure of the chance of a fire starting, its rate of spread, its intensity and the difficulty of its suppression, according to various combinations of air temperature, relative humidity, wind speed and both the long- and short-term drought effects.

This implies that New South Wales and the ACT are equally subjected to the chances of a fire starting as Victoria, whereas there is less likelihood in Queensland.

	Ausgrid	NSW	Vic	QLD	SA	Tas
Bushfire Vulnerability						

Cost Driver: Natural Cost Advantage Neutral Natural Cost Disadvantage Unknown

Table 22: Summary - Bushfire Vulnerability

3.4.7 Temperature

The ABS again provides a good reference point for observations around the changing climactic conditions, particularly, with reference to the changing demand and the shift from a winter peaking to a summer peaking network.

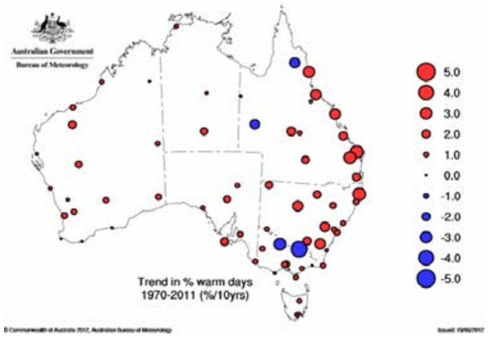


Figure 3-50: Trend in Percentage Warm Days

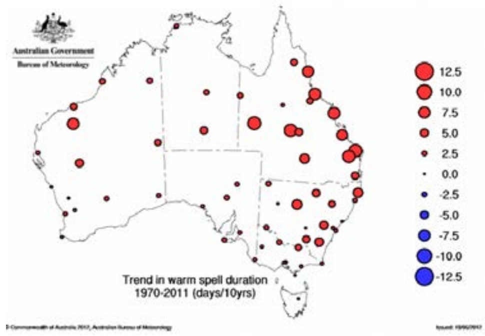


Figure 3-51: Trend in Warm Spell Duration

With the increase in the number and duration of the warm days is greater in NSW and Queensland when compared to Victoria, there is a reasonable argument to suggest that NSW and Queensland are now (and have always been) more exposed to air conditioning penetration increases than Victoria and SA and that AEMO's revised 2012 forecast suggests that the outlook remains worse for the NSW and QLD networks than for SA and Victoria.

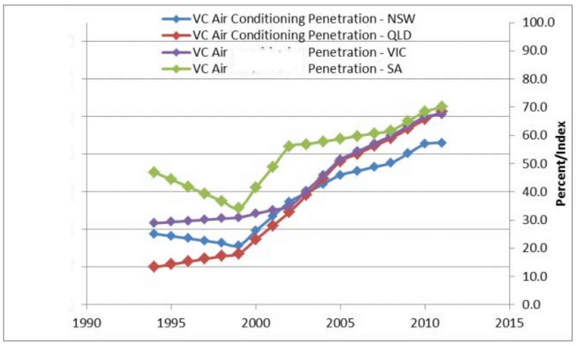


Figure 3-52: Air Conditioning Penetration

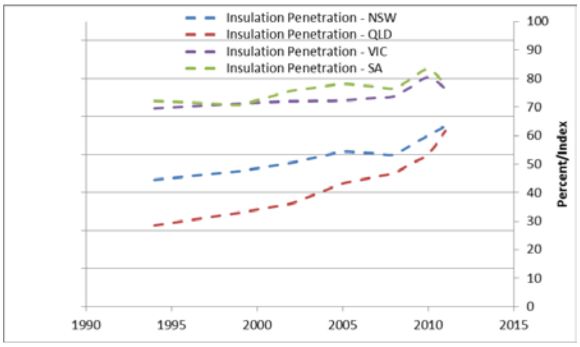


Figure 3-53: Insulation Penetration

Noting that residential air conditioning has been documented by all DNSPs as the principal driver of maximum demand increases over the past decade, Figure 3-52: Air Conditioning Penetration shows the increase in air conditioner market penetration in NSW and QLD has mainly occurred over the 2000-2010 period, however Vic and SA air conditioner market penetration began to increase during the 1990s.

Similarly, there are possibly further benefits in the case of Victoria and South Australia where additional capacity to accommodate air conditioning demand was required earlier with building stock that has much better thermal performance, as highlighted in Figure 3-53: Insulation Penetration. Prior to the mandatory requirements most NSW and QLD homes were typically heated using portable electric resistance heating, solid fuels or gas. As few houses were air conditioned, the climate being relatively mild and energy prices relatively low, insulation was often not economically justifiable.

This resulted in lower air conditioning peaks, compounded by the ability to spread the investment in this additional capacity over two decades rather than one.

	Ausgrid	NSW	Vic	QLD	SA	Tas
Temperature						

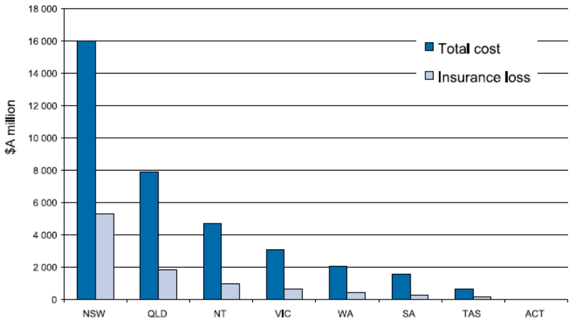
Cost Driver: Natural Cost Advantage Neutral Natural Cost Disadvantage Unknown

Table 23: Summary - Temperature

3.4.8 Major Weather Events

The weather conditions experienced at any location or area, including rainfall, wind, temperature, fog, thunder, humidity, pressure, ocean temperatures and sunshine; combined with seasonal variations, and major events such as severe thunderstorms, tropical cyclones, earthquakes, floods and bushfires, all have a significant impact on infrastructure.

Whilst detailed comparison of the cost impact of major weather events is problematic due to the availability of information and also inconsistency in reported costs through variations in estimation methods, there are some observations worth noting. Figure 3-54: Disaster Cost by State and Territory represents Emergency Management Australia data for the period from 1967-1999 analysed by the Bureau of Transport Economics (BTE)[13], which shows the disaster costs in NSW being more than double that of Queensland and around five times that of Victoria.



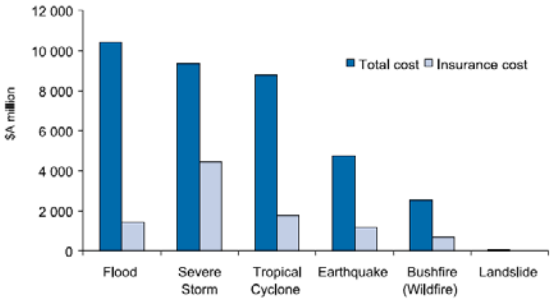


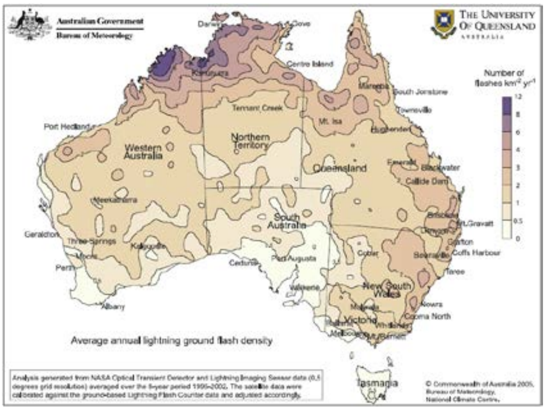
Figure 3-54: Disaster Cost by State and Territory **Figure 3-55: Costs by disaster Type**

The BTE analysis goes on to state that annual costs are strongly influenced by major events, in this period Cyclone Tracey (1974), Newcastle Earthquake (1989) and the Sydney Hailstorm (1999), whereas severe thunderstorms are more common than any other natural hazard and on average are responsible for more damage each year than any other natural hazard as measured by insurance costs represented in Figure 3-55: Costs by disaster Type.

Whilst the geographical spread of severe thunderstorms in Australia is also difficult to determine, the ABS records[14] of thunderstorm impact show that the most damaging thunderstorms have occurred in the south-east quarter of the continent with the most damaging individual thunderstorms having hit south-eastern Queensland and the central NSW coast.

Taking this observation a step further, an extreme weather event involving a severe thunderstorm might be drawn from Figure 3-56 Average Annual Lightning Ground Flash Density and Figure 3-57: Average Annual Thunder Days[15]. While this link may be a little tenuous, this could indicate a greater likelihood of major storms in NSW and Queensland when compared to Victoria.

[13] Australian Journal of Emergency Management, 2001
[14] Australian Bureau of Statistics, Yearbook , 2008
[15] Bureau of Meteorology, www.bom.gov.au



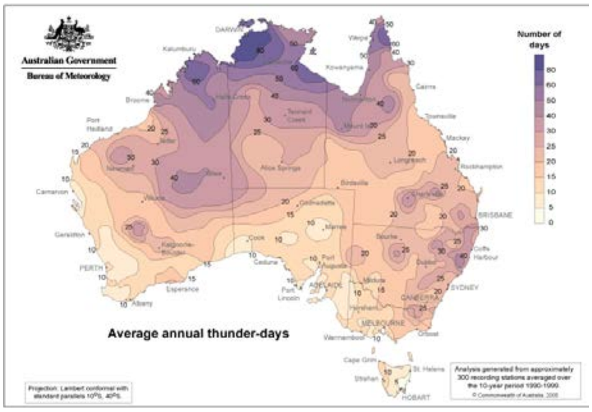


Figure 3-56 Average Annual Lightning Ground Flash Density

Figure 3-57: Average Annual Thunder Days

Evans & Peck notes that while some distributor performance measures are normalised based on the exclusion of “Major Event” data, the relative impact of an event based on the type, and its impact on associated network infrastructure (measured by cost) remains difficult to quantify.

	Ausgrid	NSW	Vic	QLD	SA	Tas
Major Weather Events						

Cost Driver: Natural Cost Advantage; Neutral; Natural Cost Disadvantage; Unknown

Table 24: Summary - Major Weather Events

Appendix A

NSW Design Planning Criteria

Network Element	*Load Type*	*Forecast Demand or Expected Demand*	*Security Standard*	*Customer Interruption Time*
Sub Transmission Line	CBD	Any	N-2[6]	Nil for 1st credible contingency <1 hr for 2nd credible contingency
	Urban & Non-Urban	≥ 10 *MVA*	N-1[1]	< 1 minute
	Urban & Non-Urban	< 10 *MVA*	N[2]	*Best practice repair time*
Sub Transmission Substation	CBD	Any	N-2[6]	Nil for 1st credible contingency <1 hr for 2nd credible contingency
	Urban & Non-Urban	Any	N-1	< 1 minute
Zone Substation	CBD	Any	N-2[6]	Nil for 1st credible contingency <1 hr for 2nd credible contingency
	Urban & Non-Urban	≥ 10*MVA*	N-1[1]	< 1 minute
	Urban & Non-Urban	< 10 *MVA*	N[2]	*Best practice repair time*
Distribution Feeder	CBD	Any	N-1[3]	Nil
	Urban	Any	N-1[4]	< 4 Hours[5]
	Non-Urban	Any	N	*Best practice repair time*
Distribution Substation	CBD	Any	N-1[3]	Nil
	Urban & Non-Urban	Any	N[7]	*Best practice repair time*

1. For a *Sub-transmission line - Overhead* and a Zone Substation:
a. under N-1 conditions, the *forecast demand* is not to exceed the *thermal capacity* for more than 1% of the time i.e. a total aggregate time of 88 hours per annum, up to a maximum of 20% above the *thermal capacity* under N-1 conditions. For Country Energy, in other than regional centres, the *forecast demand* must not exceed the *thermal capacity* under N-1 conditions.

b. under N conditions, a further criterion is that the *thermal capacity* is required to meet at least 115% of forecast demand.

For a *Sub-transmission line – Underground*, any overhead section may be designed as if it was a *Sub-transmission line – Overhead*, providing the *forecast demand* does not exceed the *thermal capacity* of the underground section at any time under N-1 conditions.

2. Under N conditions, *thermal capacity* is to be provided for greater than 115% of *forecast demand*.

3. The actual *Security Standard* is an enhanced N-1. For a second coincident credible contingency on the CBD triplex system, restricted essential load can still be supplied.

4. By 30 June 2014, expected demand is to be no more than 80% of feeder *thermal capacity* (under system normal operating conditions) with switchable interconnection to adjacent feeders enabling restoration for an unplanned *network element* failure. By 30 June 2019, *expected demand* is to be no more than 75% of feeder *thermal capacity*. In order to achieve compliance, feeder reinforcement projects may need to be undertaken over more than one *regulatory period*. In those cases where a number of feeders form an interrelated system (such as a meshed network), the limits apply to the average loading of the feeders within the one system.

5. The timeframe is expected only, and is based on the need to carry out the isolation and restoration switching referred to in note 4. This standard does not apply to interim/staged supplies, i.e. prior to completion of the entire development or to *excluded interruptions* outside the control of the *licence holder*.

6. In the *CBD* area, N-2 equivalent is achieved by the network being normally configured on the basis of N-1 with no interruption of supply when any one line or item of *electrical apparatus* within a *substation* is out of service. The *licence holder* must plan the *CBD* network to cater for two *credible contingencies* involving the loss of multiple lines or items of electrical apparatus within a substation, by being able to restore supply within1 hour. Restoration may be via alternative arrangements (e.g. 11kV interconnections).

7. Urban Distribution substations shared, or available to be shared, by multiple *customer*s are generally expected to have some level of redundancy for an unplanned contingency e.g. via low voltage manual interconnection to adjacent sub-stations enabling at least partial restoration.

Appendix B Queensland

Load Category	Load Threshold	Transmission or Sub-Transmission Lines	Bulk Supply Substations	Zone Substations	Distribution Feeders
CBD or Critical Installations	≥ 1.5 MV.A	N - 2	N - 1(a) (C & I) (10 PoE)	N - 1(a) (C & I) (10 PoE)	N - 1(a) (C & I)
	< 1.5 MV.A				N
Significant Commercial or Industrial (Urban or Non-urban)	≥ 5 MV.A	N - 1(a) (C & I)	N - 1(a) (C & I)	N - 1(a) (C & I)	N
	< 5 MV.A	N	N	N	
Mixed with predominantly Commercial or Industrial (Urban or Non-urban)	≥ 5 MV.A	N - 1(a) mixed	N - 1(a) mixed	N - 1(a) mixed	N
	< 5 MV.A	N	N	N	
Mixed with predominantly Residential (Urban or Non-urban)	≥ 15 MV.A	N - 1(b)	N - 1(b)	N - 1(c)	N
	< 15 MV.A	N	N	N	

Security Standard	Description
N - 2	Defined as a system which can withstand a credible single contingency with no interruption to supply, and can be restored to a secure state (ie. able to withstand a second credible contingency at N-1(a)(C&I) standard) within 1 hour.
N - 1 (a) (C & I)	Defined as a system which has the capability to withstand a credible single contingency involving an outage of the largest and most critical system element (e.g. transformer or feeder) without an interruption to supply of greater than one minute for loads up to 50 PoE (10 PoE for CBD bulk supply and zone substation loads). [1,3]
N – 1 (a) (mixed)	As per N-1(a)(C&I) for loads up to 50 PoE - except that (where it exists) up to 12 MV.A of load from predominantly residential feeders that can be shed automatically (e.g. using POPS) provided it can be restored using the timeframes for the N-1(c) classification standard. [1,3]
N - 1 (b)	As per N-1(a)(C&I) for loads up to 50 PoE - except that it allows up to 40 MV.A of load to shed initially and all load except 12 MV.A of non C&I load to be restored within 30 minutes. All load must be restored within 3 hours for urban network and 4 hours for rural network. [3]
N - 1 (c)	As per N-1(a) except that up to 12 MV.A of load can be shed as long as it can be restored in 3 hours for urban loads and 4 hours for non-urban loads by remote and manual switching. • Urban restorations – 30 min (remote switching) and 3 h (manual switching) • Non Urban restorations – 30 min (remote switching) and 4 h (manual switching)
N	Possible loss of supply for single contingency of up to 8 hours urban and 12 hours non urban while the network is reconfigured or repaired or mobile equipment is deployed. • Urban restorations – 30 min (remote switching), 3 h (manual switching) and 8 h (mobile generation or mobile substation) [2] • Non Urban restorations – 30 min (remote switching), 4 h (manual switching) and 8 h (mobile substation) [2] or 12 h (mobile generation).

Appendix C LGA Coverage:

The coverage of these networks was aligned against local government or statistical as below NSW

In NSW,

- Ausgrid covers 53 Statistical Local Areas including Sydney and Newcastle regions.
- Essential Covers 96 local government areas.
- Endeavour covers the remaining LGAs.

Population using 2011 census data was mapped against each SLA to show densities.

A comparison using 2001 Census data was also provided, although SLA boundaries did not directly correlate.

Matching was made to:

- Bankstown – in 2011, 3 SLA areas are defined, though these are only 1 in 2001. The total population was proportionally allocated to each 2011 SLA, although this does not account for areas of higher growth in one SLA as compared to others.
- Gosford in 2011 comprises 2 SLAs whereas in 2001, only 1 was present. This was normalised through a proportional division of total 2001 population.
- Hornsby in 2011 comprises 2 SLAs whereas in 2001, only 1 was present. This was normalised through a proportional division of total 2001 population.
- Hunters Hills was not a SLA in 2001 – the state suburb 2001 data was used, but the total are of the suburb was 3.6km2 compared to the SAL at 5.7km2.
- Lake Macquarie in 2011, 3 SLA areas are defined, though these are only 1 in 2001. The total population was proportionally allocated to each 2011 SLA, although this does not account for areas of higher growth in one SLA as compared to others.
- Leichardt SLA was much larger in area in 2001 than in 2011, resulting in what appears to be a loss of population. This anomaly could not be corrected at the SLA level. This population was recorded in Sydney West.
- Newcastle Inner SLA - 3 SLA areas are defined, though these are only 1 in 2001. The total population was proportionally allocated to each 2011 SLA, although this does not account for areas of higher growth in one SLA as compared to others.
- Sydney West is larger than its predecessor Sydney Remainder SLA. It includes part of the former Leichardt SLA.

- South Sydney SLA in 2001 is generally the area now covered by Sydney East and Sydney South SLA. The population was apportioned.
- Upper Hunter had no direct correlation other than the Hunter Indigenous Area, which was larger than the Upper Hunter SLA.
- Wyong SLA in 2001 has been split into two SLAs. This was normalised through a proportional division of total 2001 population.

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