Attachment 5.33

Addressing the benchmarking factor for capex and opex

May 2014

Content

About this report

Ausgrid has prepared an attachment as part of its regulatory proposal which demonstrates how we have met the objectives, criteria and factors in the National Electricity Rules (the rules) for capex and opex.[1] In the attachment, we set out how the criteria and factors should be considered as part of the AER's constituent decisions for opex and capex, and set out our evidence in relation to each factor. The purpose of this attachment is to provide further supporting information in relation to how we have addressed the benchmarking factor in the rules.

Benchmarking is one of many factors the AER has to consider in making its decisions. The Rules require that the AER must:

> " …. consider the most recent annual benchmarking report that has been published under rule 6.27[2] and the benchmark capital expenditure that would be incurred by an efficient Distribution Network Service Provider over the relevant regulatory control period. "

Benchmarking is an undefined term in the rules and can encompass many dimensions. The Productivity Commission has defined the term as any method for comparing a firm to other businesses, to itself over time (or between its various divisions) or to an ideal firm.[3]

We note that some of the measures of benchmarking our performance over time have been outlined in our responses to some of the other capex factors in the rules such as those relating to previous expenditure and incentive mechanisms. In particular, we consider that a very important benchmark is our performance against the AER's allowance in the previous period. Under the AER's incentive schemes, DNSPs are provided incentives to reduce expenditure levels below the targets set by the AER, and share these benefits with customers. Our response to these inter-related benchmarking factors are set out in the attachment that addressed the criteria and factors.

Key analysis and findings

The report examines the inherent limitations of benchmarking Australian DNSPs, and the role that benchmarking should play as a partial indicator of efficiency. Our analysis identified that benchmarking has inherent limitations such as inability to conduct 'like for like' analysis across peer firms, data inconsistency and inaccuracy, and failure to meet statistic principles. We think that valid benchmarking may have a role in guiding the regulator to areas requiring further granular analysis. It should not be used to reject a DNSP's proposal, or as a basis to substitute the forecast given the inherent limitations as a tool.

The report assesses the relative weight that should be applied to each of the benchmarking tools identified by the AER in its Forecast Expenditure Assessment Guidelines including economic analysis, aggregated category analysis, and cost category data including the augex and repex models. When deciding if a benchmark is appropriate, we have been guided by the Productivity Commission's review in 2013 which set out 6 criteria for when a benchmarking tool could be used in the process. This includes validity, accuracy and reliability, robustness, simplicity, not subject to manipulation and fitness for purpose. To complement this analysis, we have also sought to understand the available data that can be used for benchmarking and reported on these outcomes. This was based on a detailed Huegin Consulting study of 7 DNSPs in Australia, and data of other DNSPs where available.

Based on this approach, we have placed limited weight on benchmarking analysis as a valid test of the efficiency of our forecast and consider that the AER should do likewise in its assessment. In all cases, the AER's techniques do not meet all the criteria specified by the Productivity Commission. In some cases, such as economic analysis we consider the method may actually provide misleading results and should not be used by a business or the AER to test efficiency. In other cases, the model may provide some insight into the efficiency of a DNSP's forecasts, for instance when the data quality is sound. In these cases, we have considered the underlying data and provided commentary on any observed differences in light of our circumstances and drivers of expenditure.

Our analysis of benchmarking tools suggests that trends in a DNSP's results over time are of more value, that relative efficiencies between DNSPs at a point in time. In this respect the data provided does demonstrate that Ausgrid's growth rates in expenditure are among the lowest out of the peer group studies. This reflects the underlying efficiency savings we have been making as part of NSW industry reform. Once again, however we draw caution on such results as they cannot capture the reasons for observed differences between DNSPs.

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1 Attachment 5.31: "Ausgrid: Addressing the Objectives, Criteria and Factors for capex and opex in the NER", May 2014.

2 The AER intends to release its first benchmarking report in September 2014, and therefore we are not provided with an opportunity to demonstrate or make representations on this report at the time of submitting our regulatory proposal.

3 Productivity Commission, *Electricity Network Regulatory Frameworks*, 26 June 2013, p147.

Structure and contents of document

We have structured our response as follows:

- Section 1 identifies the inherent limitations of benchmarking data and the role of benchmarking. We provide an outline of how we have assessed each of the AER's benchmarking tools outlined in its Forecast Expenditure Assessment Guidelines.
- Sections 2 sets out our findings on economic analysis benchmarking.
- Section 3 sets out our findings on aggregated cost benchmarking.
- Section 4 sets out our findings on cost category comparisons. Attachment A and B provide further information on a joint analysis undertaken by NSW DNSPs on the effectiveness of the augex and repex models respectively.

In this document we have referred to a series of reference material. In order to enable the AER to make a full assessment, we have attached these documents as indicated in the table below at the end of this document.

Appendix number	Name of document
Appendix A	Huegin Distribution Benchmarking study
Appendix B	Joint DNSP analysis on effectiveness of the augex model
Appendix C	Joint DNSP analysis on effectiveness of the repex model
Appendix D	Evans and Peck review of cost drivers

1 Limitations and role of benchmarking

When addressing the capex and opex criteria in the rules, the AER must consider all the factors in the rules, including benchmarking. This means that the AER must come to a view on the extent to which benchmarking is relevant to its constituent decisions in respect of capex and opex, and the weight that should be applied to the analysis it examines. This requires the AER to consider the extent of information available and the probative value of the analysis.

The purpose of this chapter is to provide context on the role of benchmarking as a tool in providing a‘partial indicator’ on the efficiency of a DNSP’s forecast.

- We demonstrate that benchmarking data has inherent limitations, which means that extreme caution must be applied in using the analysis to draw conclusions on the relative efficiency of a DNSP.
- With this in mind, we demonstrate that benchmarking can play a role in helping the regulator or a business uncover potential inefficiencies in its forecasts, but that the data should not be used directly to reject or substitute the proposed expenditure of a DNSP. Rather the analysis can be used to target the AER’s analysis.
- We conclude the chapter by setting out our method for reviewing the AER’s benchmarking techniques in the Forecast Expenditure Assessment Guidelines.

1.1 Limitations of benchmarking

We consider that benchmarking data and techniques should be used with extreme caution due to the errors that arise when using such tools to measure efficiency. These errors arise from the inability of models to account for the inherent differences between DNSPs, data inconsistency and inaccuracy, and low statistical reliability.

The primary issue with benchmarking is that electricity distributors are not homogonous in the Australian market, and therefore ‘like for like’ comparisons cannot be used effectively to draw inferences on efficiency. For example:

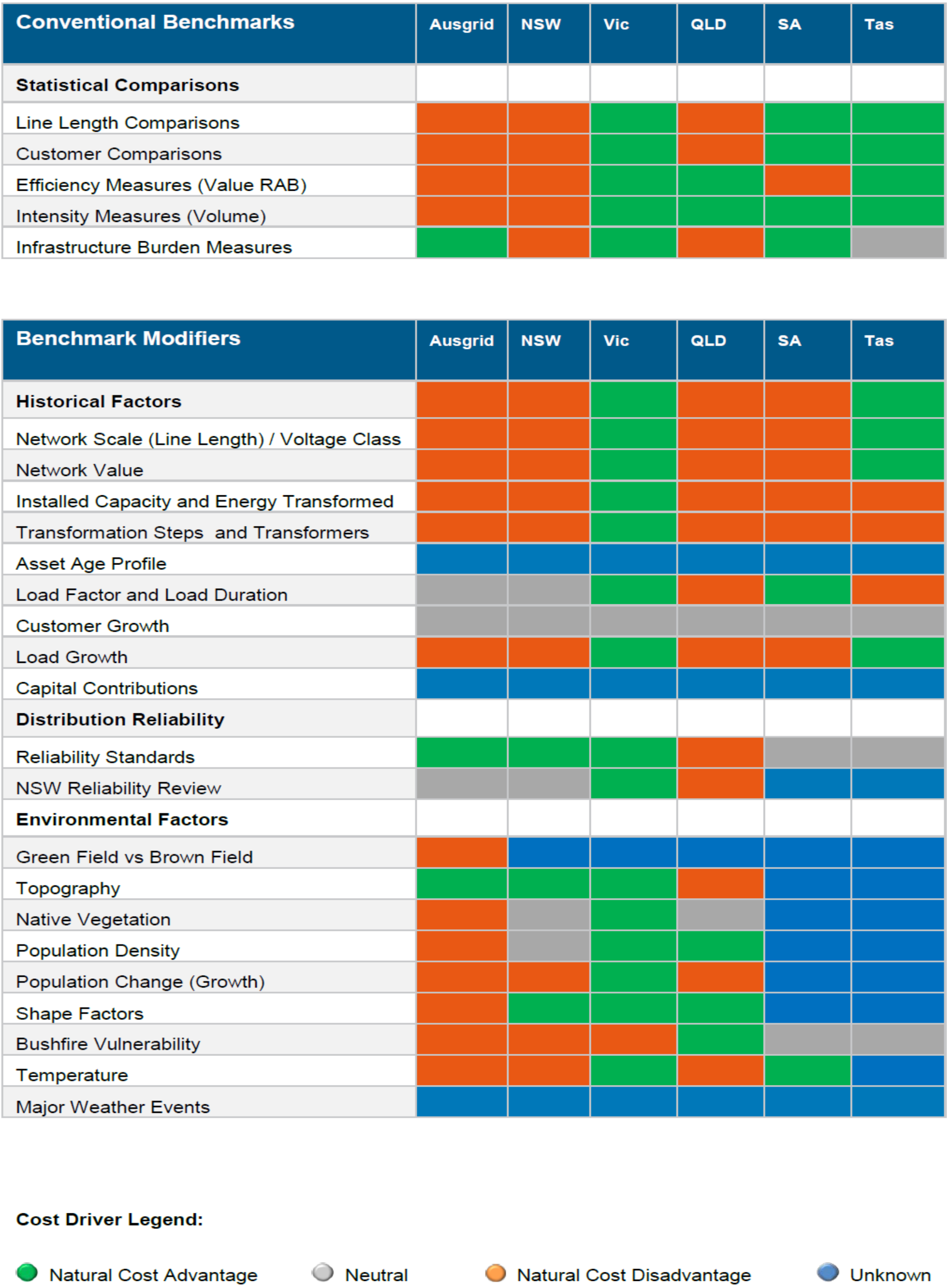
- Each DNSP in Australia operates under unique conditions such as customer density, geographic area, topographic conditions, and the inherent design of network (for instance number of sub-transmission assets). This makes ‘like for like’ comparisons highly problematic, as there is no statistically reliable method for normalising data. For example, a rural DNSP may perform better if expenditure data is normalised by line length, but will likely perform worse if the data is normalised on a per customer basis.
- In Ausgrid’s case, we have a high proportion of transmission assets (dual function assets) that effectively provide a back up to the transmission network. Other DNSPs do not have the same extent of transmission assets, which means that our cost structures are inherently higher for providing services to our customers.
- DNSPs are at relatively different stages of the investment life cycle. These impact heavily on relative replacement and maintenance expenditure, with older networks incurring a higher inherent cost of performing its functions relative to a younger network.
- Jurisdictional differences also play a major part in explaining differentials in cost structures. For example, jurisdictions differ in respect of licence conditions, markets for contestable services, and classification of services.

A report prepared by Evans and Peck for Ausgrid in 2012 draws out the inherent differences between jurisdictions in Australia. Figure 1 on the next page provides a summary of Evans and Peck’s findings which reveals that for historical and environmental reason, some jurisdictions have a natural cost advantage in providing distribution services. Evans and Peck noted:[4]

> “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…. 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.”

4 Evans and Peck, Review of factors contributing to variations in operating and capital costs structures of Australia DNSPs, Final Report, November 2012, p i

Figure 1 - Network cost driver differences



In addition to these issues, benchmarking is often plagued by data issues. Up to this point in time, there has been limited granular data on DNSP's expenditures and operating environment. Even when data is available, we note that it rarely is in a consistent form to draw meaningful judgments. For example, cost accounting policies are so varied between DNSPs that they do not even allow for effective comparison of opex and capex between DNSPs. This means that limited weight can be applied to this data when using it for the purposes of identifying efficiency at the high level.

Finally, we note that our experience with models used by the AER is that they largely fail to meet key principles of statistical validity such as:

- Adequate sample size – In the absence of a large sample size, the results can be skewed by a few firms with similar outcomes. Further, low sample size is counter-intuitively related to the apparent strength of relationship that is observed in tests such as R squared, leading to misleading conclusions. In Australia, there are very few firms in the industry to develop a large enough sample size.

- Comparability of data series – Even within the small sample of Australian DNSPs, there is a great degree of variability in the underlying conditions of distributors in Australia. This breaches a key test of statistical validity which requires the assumptions underpinning data inputs to be consistent.

- Correlation between dependent variables – In multi-variable models such as Total Factor Productivity, many of the factors are highly inter-related with each other.

- Consistency in variations across data range –Tests such as R squared can be misleading if the data series does not show a consistent error range across the data series. This underscores once again the importance of a large sample size.

- Sensitivity analysis does not lead to wide variation in outcomes – An important aspect of statistical application is to test whether the outcome is relatively consistent when other likely variables are used in the analysis.

For these reasons, we have applied a high degree of caution in interpreting benchmarking analysis when testing the validity of our forecasts. In particular, our experience is that high level benchmarks serve to validate the inherent differences between DNSPs, or reflect data inconsistency and incomparability.

The limitations of benchmarking have been emphasised in a review by the Productivity Commission. In 2013, the Productivity Commission was commissioned by the Australian Government to review the extent to which benchmarking could be used by regulators in the electricity industry. The Productivity Commission directly referred to academic articles on the need to select explanatory variables that describe the functions undertaken by a DNSP and the environment in which it performs. In particular it referred to an article by Turvey in 2008 which stated[5]:

> "Comparisons between networks of the costs of these activities can only illuminate differences in the efficiency with which operations and maintenance are carried out if the magnitudes of the tasks of operation and maintenance can be compared. This is a platitude, yet failure to articulate it has led some authors to scrabble around among available data to select a set of "explanatory" variables without displaying any understanding of what an enterprise does and how it does it. Confusion about these matters is rife, as witnessed, for example, by the fact that while some econometric efficiency estimates for electricity distribution treat MWh distributed, km of overhead lines or number of customers as an input, others treat one or more of these variables as an output."

The ACCC's comprehensive review of benchmarking capex and opex in energy networks also came to similar conclusions as the Productivity Commission. The ACCC observed that all benchmarking results in a degree of approximation due to its abstract nature in aggregating many factors into a few variables. It stated[6]:

> "Effective benchmarking requires the modelling of relevant factors affecting the expenditure of the energy networks. These businesses provide a range of services using different types of inputs and may operate in different environmental conditions. Inevitably, benchmarking requires some aggregation of those services, inputs, or environmental conditions into a few variables, resulting in some degree of approximation in the estimation."

1.2 Role of benchmarking as a partial indicator

Despite the limitations identified above, we consider that well designed tools can play a role for a business or regulator to test the efficiency of a forecast. In the sections below, we identify 2 principles in applying benchmarking information:

- Testing the relative effectiveness of the tool to provide insights into efficiency.
- Using the information in a way that enables the decision maker to identify whether there is a potential inefficiency in the forecasts.

5 Productivity Commission, *Electricity Network Regulatory Frameworks*, 26 June 2013, p160.

6 Australian Competition and Consumer Commission, Benchmarking Opex and Capex in Energy Networks Working Paper no.6, May 2012, p12.

Effectiveness of benchmarking

Benchmarking tools need to be designed in a way that provide insights into potential areas of inefficiency, Poorly designed tools or misapplication can mislead the decision maker, resulting in outcomes that do not meet the long term interests of customers. This was a key finding of the Productivity Commission[7]:

> "A key question is how to separate the wheat from the chaff among the various competing approaches, recognising that this will typically involve balancing various criteria …. There is a large literature on estimating the comparative costs of businesses, with much of that literature concentrating on using the 'right' techniques. However, it is equally important to be clear about how to interpret benchmarking results for policy purposes because the misuse of good technical analysis can result in adverse outcomes for consumers and businesses. In particular, comparing the costs between businesses in different jurisdictions without accounting for factors outside the control of the business could provide misleading indicators of managerial efficiency. If used in incentive regulation, this could lead to underinvestment or unwarranted transfers from consumers to the businesses."

The Productivity Commission set out 6 formal criteria for identifying the effectiveness of benchmarking. These include[8]:

- Validity - A valid benchmark should relate to efficiency (or conversely inefficiency) in one or more meaningful dimensions. A valid benchmark should reflect the way that the businesses are run. In particular, comparing the costs between businesses in different jurisdictions without accounting for factors outside the control of the business could provide misleading indicators of managerial efficiency.

- Accuracy and reliability - Accuracy is the degree to which a benchmark provides an unbiased estimate of efficiency, while the reliability (used here in the normal sense of reproducibility) is about the variance of the measure.

- Robustness - This is a subset of accuracy and reliability, but worth emphasizing in its own right. A particularly useful robust measure is one that provides information about the efficiency of an enterprise regardless of its operating environment.

- Manipulation and gaming of data - As in all systems where rewards and punishments depend on incomplete measures of performance, the measured party has incentives to 'look' like a highly performing entity. Accordingly, the regulator should consider the capacity of any particular benchmarking measure to create unforeseen business behaviours.

- Parsimony - A good model should be no more complex than required. This is important in assisting interpretability, avoiding data mining, achieving robust results, reducing data collection costs and allowing greater comparability of results across countries.

- Fit for purpose - Benchmarking has multiple purposes. Some require great accuracy, reliability and robustness. This is particularly important where benchmarking is used to determine a business's revenue allowance. Such benchmark estimates should be highly reliable across time, business types and jurisdictions. The concerns are less where benchmarking is indicative — used to identify areas for possible future investigation, or to reach some prima facie judgment.

The Productivity Commission's criteria set a very high threshold for an effective benchmark, and it is unlikely that any tool would meet all the criteria given the inherent limitations of benchmarking. Given this is the case, there needs to be an element of subjective judgment in deciding whether to disregard a tool in entirety, or whether it may still have some probative value as a partial indicator of efficiency. We consider that some tools may actually lead the decision maker into error, and cannot be verified by reference to a review of programs or projects.

Using benchmarking data to assess the efficiency of a forecast

In some cases, a tool may satisfy some of the criteria of the Productivity Commission's criteria, and be suitable to be used as a partial indicator of efficiency. This does not mean that the tool can be used in a deterministic way to reject proposed expenditure, or to develop alternative or substitute forecasts.

Rather, the analysis could be used as an informative tool to identify potential areas of inefficiency in a forecast, and to target reviews on these areas. This would then require granular analysis of the proposed programs or cost category to check whether the observed result relates to inefficiency, or stems from a reasonable driver of expenditure. This in turn requires a degree of expertise by the decision maker using the tool both from a statistical and engineering perspective. The ACCC came to this view when undertaking its review of capex and opex benchmarking:

[7] Productivity Commission, *Electricity Network Regulatory Frameworks*, 26 June 2013, p163.

[8] This is based on discussion in the Productivity Commission's report, *Electricity Network Regulatory Frameworks*, 26 June 2013, pp168-186.

> "Reflecting current practice and existing expertise, benchmarking should initially be used as an informative tool rather than a determinative one. For example, it can be used as a starting point for a conversation with regulated utilities about the level of operating and/or capital expenditures being incurred and proposed. A more sophisticated application could emerge over time.
>
> Effective cost benchmarking requires a clear understanding of the structure of the costs of the regulated utilities. This, in turn, requires an understanding of the key outputs provided by the benchmarked utilities, the inputs used (and/or the prices of those inputs), and the key environmental factors. It is also useful to understand the nature of any economies of scale or scope in the industry. Engineering studies can help provide a picture of the likely cost drivers, including how the cost drivers interact. This involves complementing in-house resources through access to expert consultants with specialised engineering knowledge and experience in the application of cost-benchmarking methods."[9]

1.3 Analysis of available benchmarking data and models

We have applied the principles described in Section 1.2 above to the methods identified by the AER in the Forecast Assessment Expenditure Guidelines. We have sought to understand the probative value of these tools using the formalised criteria developed by the Productivity Commission.

We have also commissioned reports by Huegin Consulting which helped us to understand the data available at that point in time in respect of applying these tools, and reported on the results. We note that Huegin's report used data that related to our transitional year (2014-15) proposal, and do not fully reflect the updates we have subsequently made as part of our 2015-19 regulatory proposal. We consider however that the updates are not of a nature that alters the substance of Huegin's conclusions, and we therefore consider it is relevant as a partial indicator of our forecasts of required capex and opex for the 2015-19 proposal.

In the following chapters we describe our findings in relation to:

- Economic analysis;
- Aggregated category benchmarking; and
- Cost category benchmarking including the repex and augex models.

We recognise that over time we will have access to better industry data, together with a better understanding of the factors that drive cost differences between DNSPs. The AER is currently undertaking its first information gathering exercise for the purpose of producing a benchmarking report. We consider that increased data does not necessarily improve the probative value of benchmarking tools, and that at all times the decision maker needs to consider whether the tool is effective, and can be used to support more granular analysis of programs and projects.

9 Australian Competition and Consumer Commission, Benchmarking Opex and Capex in Energy Networks Working Paper no.6, May 2012, p14

2. Economic benchmarking analysis

The AER has defined economic benchmarking as applying economic theory to measure the efficiency of a NSP's use of inputs to produce outputs, having regard to environmental factors. There are a number of methods and tools to undertake economic benchmarking such as Total Factor Productivity (TFP)[10] and Data Envelopment Analysis (DEA).[11]

2.1 Effectiveness of technique in guiding decision making

Previous concerns on effectiveness of economic analysis

In late 2013, the AER issued a Regulatory Information Notice to Ausgrid and other DNSPs to collect information relevant to economic benchmarking analysis. In our response to the AER's draft RIN on economic benchmarking, we noted that the application of the tool to guide regulatory decision making would result in error, leading to outcomes that are detrimental to the long term interests of customers. Our view was based on the following reasons:

- We are not convinced that economic benchmarking tools such as Total Factor Productivity (TFP) can be used to infer relative efficiency of DNSPs over time. We consider that the models cannot adequately normalise for differences between DNSPs, and do not provide meaningful assessment of the apparent differences in productivity levels. For example, TFP will show that a firm that replaces ageing assets has declining levels of capital productivity, as the model would show higher prices for capital while maintaining existing service levels. In our view this would be driven by the age of the asset base which is likely to vary between DNSPs, and the output is ensuring that there are not increased safety and reliability risks on the network.

- We consider that economic benchmarking models such as TFP do not provide the AER with guidance on how to target its review of expenditure forecasts, as the information provided is at too high a level to identify potential areas of efficiency. The models and data collected will not provide any guidance on the underlying drivers of apparent productivity rates, and therefore does not provide useful analysis that identifies which areas to review in a DNSP's capex and opex forecasts.

- Finally, the DNSPs in Australia have repeatedly noted that our finance and asset systems have not recorded much of the data in the form required by the AER, and that the information used to populate models would be highly unreliable. This has been independently confirmed by the Australian Energy Market Commission, who conducted a 2 year review of TFP and concluded that available historical data was of poor quality and reliability.

We provided the information required by the RIN to the AER on 30th April 2014. Our basis of preparation has noted areas where we have had to provide best estimates when data was not available in our systems. We have also noted instances where the definitions could be open to interpretation. We understand that this has also been the experience of other DNSPs, which draws into question the quality of information that would be used as part of economic benchmarking. In this respect, our experience under industry reform has also found significant differences between the 3 NSW DNSPs, which would not have been identified if further investigation had not occurred.

This is very concerning when models such as TFP and DEA rely on the totality of variables to form rankings and assessments of efficiency over time. An error in one variable can lead to significant deviations in observed performance. When these errors are multiplied across many variables, the outcomes of the analysis could not be used to infer efficiency.

In addition to data quality issues, we note that there are a number of model specifications being considered by the AER to undertake economic benchmarking.[12] The variety of model specifications shows the difficulty of deriving an input and output relationship that can adequately account for the nature of the industry, and the inherent differences between DNSPs. For example, the outputs generally used are energy consumption, peak demand supplied, capacity of the network and reliability. These output variables are highly integrated, and often will have no relationship to input costs

[10] The AER noted that this when benchmarking businesses that have more than one output and/or more than one input the challenge is including these different values into a common comparable index. MTFP uses revenue and cost shares as weights to overcome this problem and create a value for a firm's output and a value for a firm's input; the productivity of the benchmarked firm is then the difference between these output and input figures. In the context of Australian NSPs this means that a businesses efficiency will be affected by its outputs compared to the industry average and the share of expenditure that these outputs account for.

[11] The AER note that this is a more limited technique than MTFP, because it cannot incorporate as many input and output variables and because it requires more data. Therefore, it proposed using it to cross-check the results of the MTFP analysis. It may be possible to decompose the efficiency scores of DEA to identify different types of inefficiency.

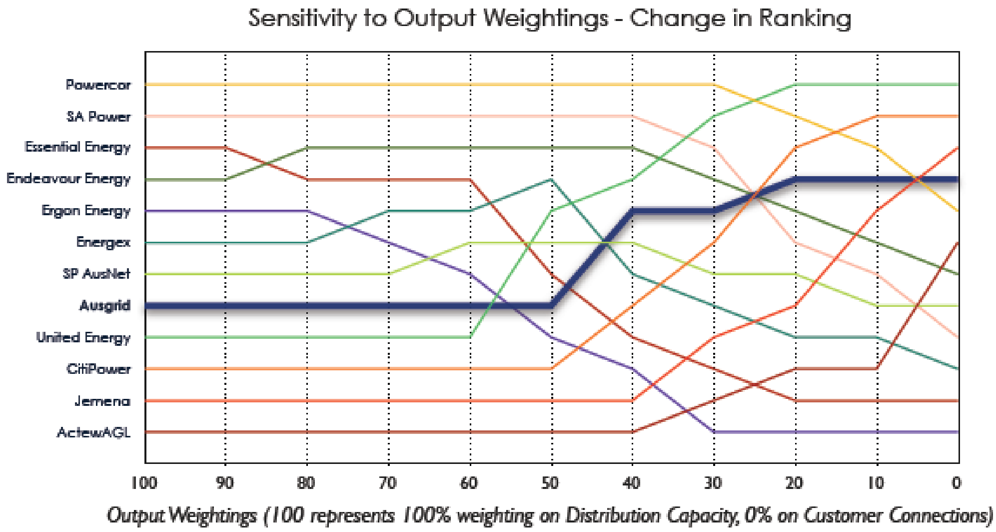
[12] We note that the AER has yet to provide DNSPs with its model specifications, meaning that we are unable to undertake meaningful analysis on whether the model specification is appropriate.

over time. A very simple example is when a DNSP has to undertake significant replacement of its network. While its costs increase, it is producing the same level of output[13] and therefore shows a decline in productivity.

The lack of a precise model specification means that there is a high degree of subjectively in the model applied by the analyst. This point has been borne out in the evidence provided by Huegin Consulting. Huegin noted that[14]:

> "Model errors and bias are always present in economic analysis, which is not an issue in itself, but the diversity of conditions in Australia and in the inherent network designs means that a particular model specification will provide advantage for some businesses and disadvantages for others."

Huegin demonstrate this point by undertaking its own economic benchmarking models. The following diagram shows that variable selection and weightings can skew the outcomes of models such as TFP. In the diagram it shows that Ausgrid ranks 8th among the DNSPs in Australia if distribution capacity is used as an output. In contrast, if 'customer connections' is selected as the variable, then Ausgrid's ranking rises to 5th. Such sensitivity analysis demonstrates that economic benchmarking models reflect the underlying characteristics of the DNSP rather than suggest relative efficiency.



Based on the analysis above, we consider that the use of economic benchmarking should not be used by the AER as it fails to meet any of the criteria identified by the Productivity Commission for effective benchmarking.

- Validity – We consider that economic analysis is not a good determinant of relative efficiency of a DNSP at a point in time, and is more likely to reveal the underlying network and accounting differences of each of the businesses. This can be seen in the diagram above, which shows that a change in the weighting of output variables (only one variable among many) results in vastly different outcomes. Similarly, performance over time can be misleading as a change in the value of one variable may lead to significant changes in perceived efficiencies, even if this variable can be explained with reference to underlying circumstances. For example, the model could not explain when a DNSP is investing to meet a step change in the security of the network as a result of new licence conditions. In these circumstances the RAB would increase greatly, but there may not be a direct relationship with output factors such as reliability, although there may be some improvement in capacity of the network.

- Accuracy and reliability – We consider that the underlying data provided by Ausgrid and other DNSPs is not reliable across all variables. This is concerning given that economic analysis is based on multi-variable models that are only statistically credible if each variable is correct. In developing the data requirements to undertake economic benchmarking, the AER required DNSPs to submit information that could not be provided from systems and financial statements. The AER required that DNSPs provide a 'best estimate' in these cases, and document the methodology. The best estimates were subject to a less onerous form of external assurance.

- Robustness – We consider there are no robust model specifications that can be used for economic analysis. Huegin's analysis notes that all model specifications are subject to bias, and that the outcomes from economic analysis are highly sensitive to the model specification applied. This is particularly the case where there are a small number of DNSPs and they are highly heterogeneous.

13 For instance, replacement does not generally increase capacity of the network. Replacement may improve reliability, but in most cases replacement is to maintain the existing level of reliability on the network (ie: stem a decline in reliability).

14 Huegin Consulting, "Distribution benchmarking study: Essential Energy", 2014, p10.

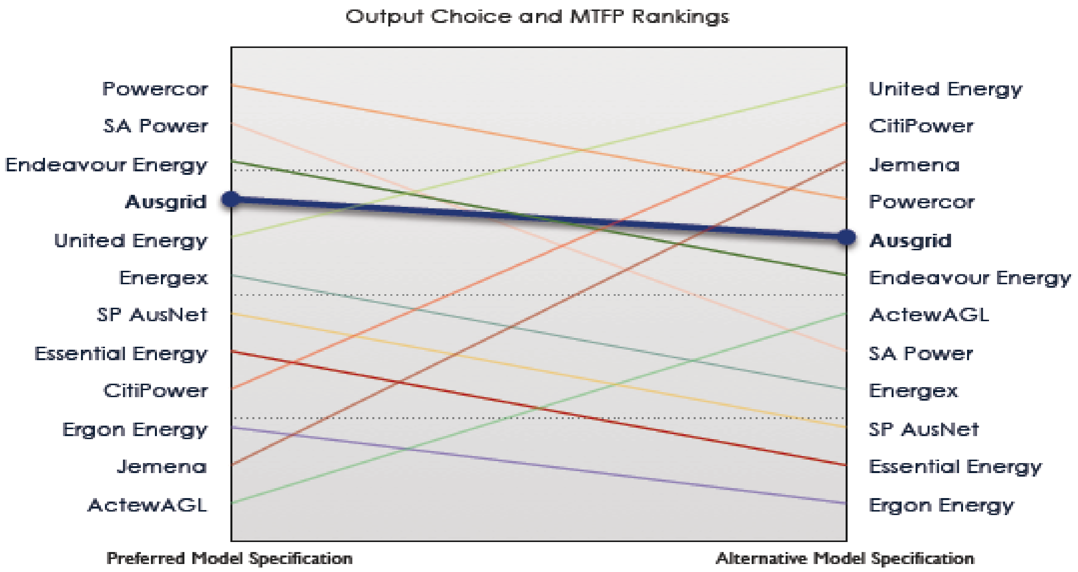
- Manipulation of data – The AER's requirement that DNSPs provide best estimates where actual data cannot be provided, together with ambiguity of definitions may leave it open to a DNSP to report in a manner that puts its circumstances in the best light. This once again underscores the unreliability and inaccuracy of the information.

- Parsimony – In some respects, economic analysis is a simple tool to use, however the complexity of model specifications and the need for expert statistical application mean that the tool is not simply applied in practice. For example, the analyst needs a firm understanding of data quality and statistical principles when selecting the appropriate model design and drawing inferences from that method. At this stage, the AER has not identified the model specification it will use for economic benchmarking, which raises further questions over whether the tool to be applied will be simple.

- Fit for purpose – This is perhaps the deepest difficulty with economic analysis. Due to its lack of granularity, economic analysis cannot be used to identify the programs that may be the cause of inefficiency. This means that it is an excessively poor tool for a business or a regulator to target areas of the program for further review. For instance, even if the analysis can be used to show that change in capex levels (ie: change in value of regulatory asset base) is the driver of perceived inefficiency, it does not provide the business or regulator with any information on which programs or projects should be targeted.

2.2 Analysis of available data

Based on these considerations, we consider that economic benchmarking should have a zero weight in the AER's decision making. If the AER still consider that it provides some form of guidance in its decision making, we note that Huegin's analysis suggests that Ausgrid performs relatively well when using its preferred and alternative model specifications.[15] This can be seen in the diagram below which shows that Ausgrid ranks 4th in terms of the preferred specification and 5th on the alternative specification.



We consider that these results do not provide a cohesive argument for suggesting that Ausgrid ranks above other DNSPs in terms of efficiency. While appealing on the surface, we consider that this would be misleading and that the outcomes relate to the model specification selected by Huegin and the underlying network characteristics of Ausgrid in relation to the model variables and weightings.

15 It should be noted that the specifications are different to the extreme weights in the diagram titled Sensitivity output weightings.

3. Aggregated category benchmarking

Aggregated category benchmarking captures information such as how much a NSP spends per kilometre of line length or the amount of energy it delivers. This can be undertaken for capex or opex.

3.1 Effectiveness of technique in guiding decision making

Aggregated benchmarks have certain advantages over economic benchmarking techniques. A key advantage is that data on actual expenditure, and statistics such as line length, customer numbers, transformer capacity and square kilometers have a high degree of accuracy. It therefore meets the Productivity Commission's review of accuracy and reliability of data, and also limits the ability of DNSPs to manipulate the data in a favorable way. Further the simplicity of the tool in terms of regressing a single variable meets the criteria of parsimony.

The weakness of aggregated techniques is that they fail to meet the other important criteria of the Productivity Commission.

- Validity – There are many network and accounting drivers that underpin differences in the comparative data of DNSPs. They therefore form an important element of explaining relative cost differences, and it is almost impossible to identify whether any particular area of capex or opex is inefficient unless such costs are normalized or removed. This reflects that the tool is not sufficiently granular to identify where variations in costs are occurring and whether these relate to inherent inefficiencies.

- Robustness – Similar to economic analysis, aggregated category benchmarking is subject to model specification issues, and therefore it is difficult to form conclusive opinions on relative efficiency. For instance we note that normalising the data for line length, customer numbers, peak demand, or energy consumption can skew the outcomes. This shows that while DNSPs may not be in a position to manipulate the data, that the analyst is able to choose metrics that may provide support for a pre-conceived view.

- Fit for purpose – The difficulty with the approach is that it is undertaken at a very high level, and does not contain any additional information on where potential inefficiencies may lie. At worst, it can mislead the business or regulator into considering there are inefficiencies which may bias bottom up reviews of expenditure programs.

We consider that using aggregated benchmarks to infer the relative efficiency of DNSPs should be used with extreme caution, and with regard to all factors that may explain performance. Our view is that, if the information is used, it should be accompanied by detailed granular benchmarking of cost categories (see Chapter 5).

While there are key difficulties with inferring the relative efficiencies of DNSPs, we consider that aggregated benchmarks do provide insight on how a DNSP performs over time, such as growth rates in expenditure. The advantage of comparing growth rates is that it uses a consistent data series. This was noted by Huegin Consulting when it stated[16]:

> "Understanding where a business stands in the rankings of productivity of industry participants is interesting, but perhaps not useful. An understanding of the difference between modeled future costs and an individual business' forecasts is useful."

We consider that growth rates over time is useful for the AER's trend analysis, and to identify if there is a particular driver at play for explaining relative growth rates of DNSPs. For instance, at a macro level the AER may identify that a higher relative growth rate is related to a new licence condition, or change in replacement approach which requires further investigation. For a business, it also provides a macro marker of whether efficiency initiatives, such as those we have undertaken as part of industry reform in NSW, are yielding positive results in comparison to expenditure trends of other DNSPs. Caution needs to be attached to any firm conclusions drawn from this type of analysis, as there are questions of validity, robustness and fitness for purpose that must be examined.

With this frame in mind, we sought to understand where Ausgrid fits with respect to different forms of aggregated benchmarks.

3.2 Analysis of available data

[16] Huegin Consulting, "Distribution benchmarking study: Essential Energy", 2014, p12

Capex

The diagrams below show Ausgrid's capex per kilometer and by customer for each year from 2010-11 to 2012-13. The analysis underscores the weaknesses of using aggregated benchmarks in assessing our relative performance. For instance, on a kilometer of line basis we do not perform as well as on an opex per customer basis. Once again this highlights that our inherent network characteristics as an urban operator in a highly dense network drive the outcomes of the analysis.

More importantly, the diagram also shows that Ausgrid has made significant reductions in capex over time, particularly since the introduction of industry reform in NSW. For instance capex per customer has fallen from $981 to $617 between 2011-12 to 2013-14, with our relative ranking improving from fifth to second amongst the peers in the study.

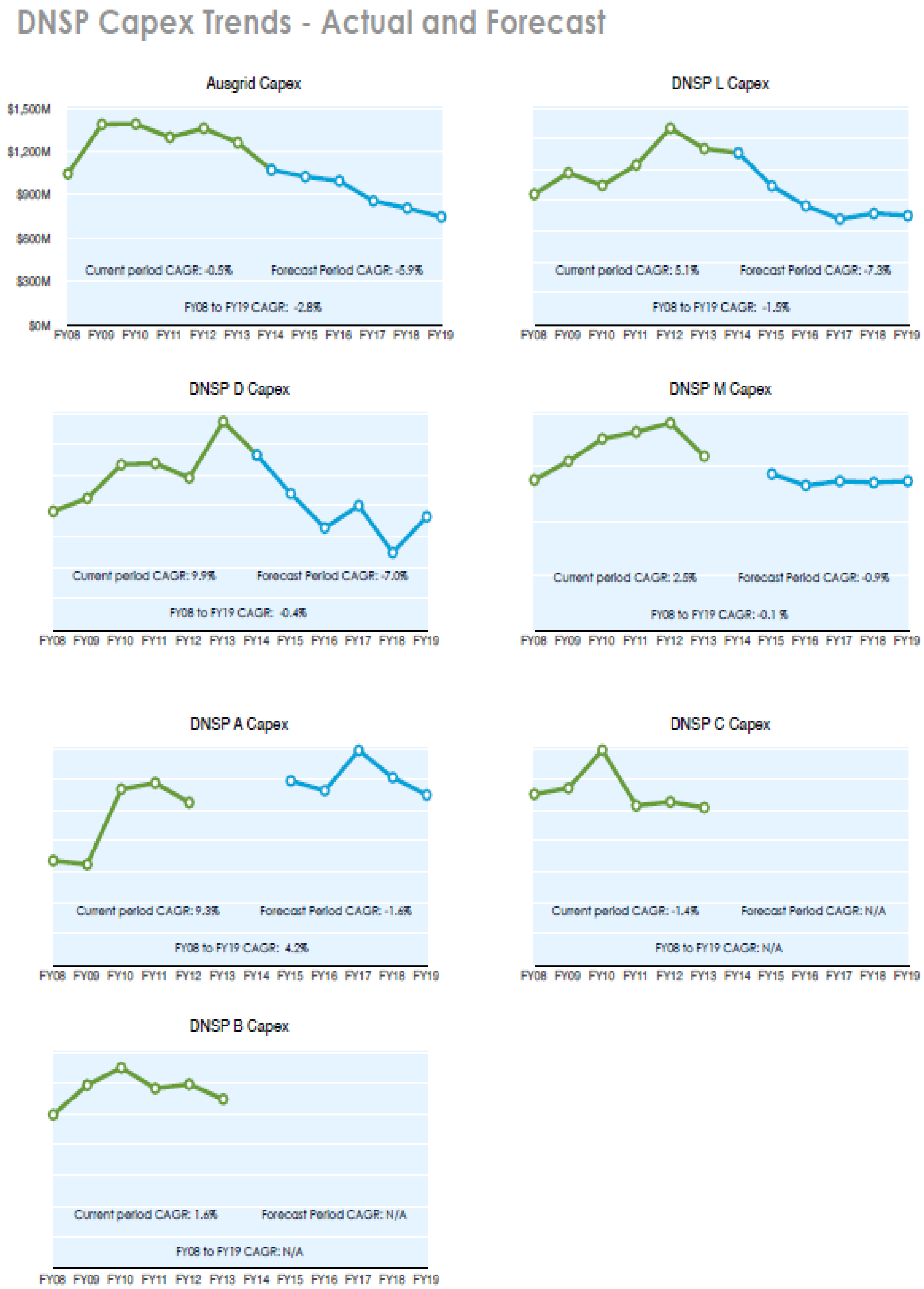
Huegin has provided information which compares Ausgrid's capex levels over the current period (2009-14 period) through to the forecast period (2014-19) relative to other DNSPs. In the 2009-14 period, Ausgrid's compound annual growth rate was -0.5%, which is the second slowest growth rate of capex of the DNSPs in the study over the period. Ausgrid's growth rate is expected to decline further over the 2014-19 period, with a compound annual growth rate of -5.9 per cent.

In our view, this analysis has provided a high level view on the effectiveness of industry reforms in driving efficiency within our businesses. We believe that the evidence provided by Huegin provides a rough 'rule of thumb' to support the position that industry reform has delivered significant efficiencies in our capex forecasts. However, we consider the data by itself does not provide compelling data for the AER to draw sound conclusions on the efficiency of the forecast. This is for 3 reasons:

- Granular data would need to be reviewed to compare the underlying drivers of Ausgrid's capex trends, including granular assessment of the investment programs, drivers and processes. Despite the apparent reductions in capex, we consider that it is not possible to ascertain whether the profile is consistent with changes in our regulatory obligations, demand environment and condition of networks on our assets.

- Similarly trend data comparisons with other DNSPs cannot adequately account for circumstances driving investment in other DNSPs. For instance, other DNSPs may be undertaking similar efficiencies at the same time, or may have found a need to increase their replacement programs.

- We note that capex-opex substitution possibilities can impact the comparison over time. For instance, the reductions in capex may have an impact on opex forecasts.

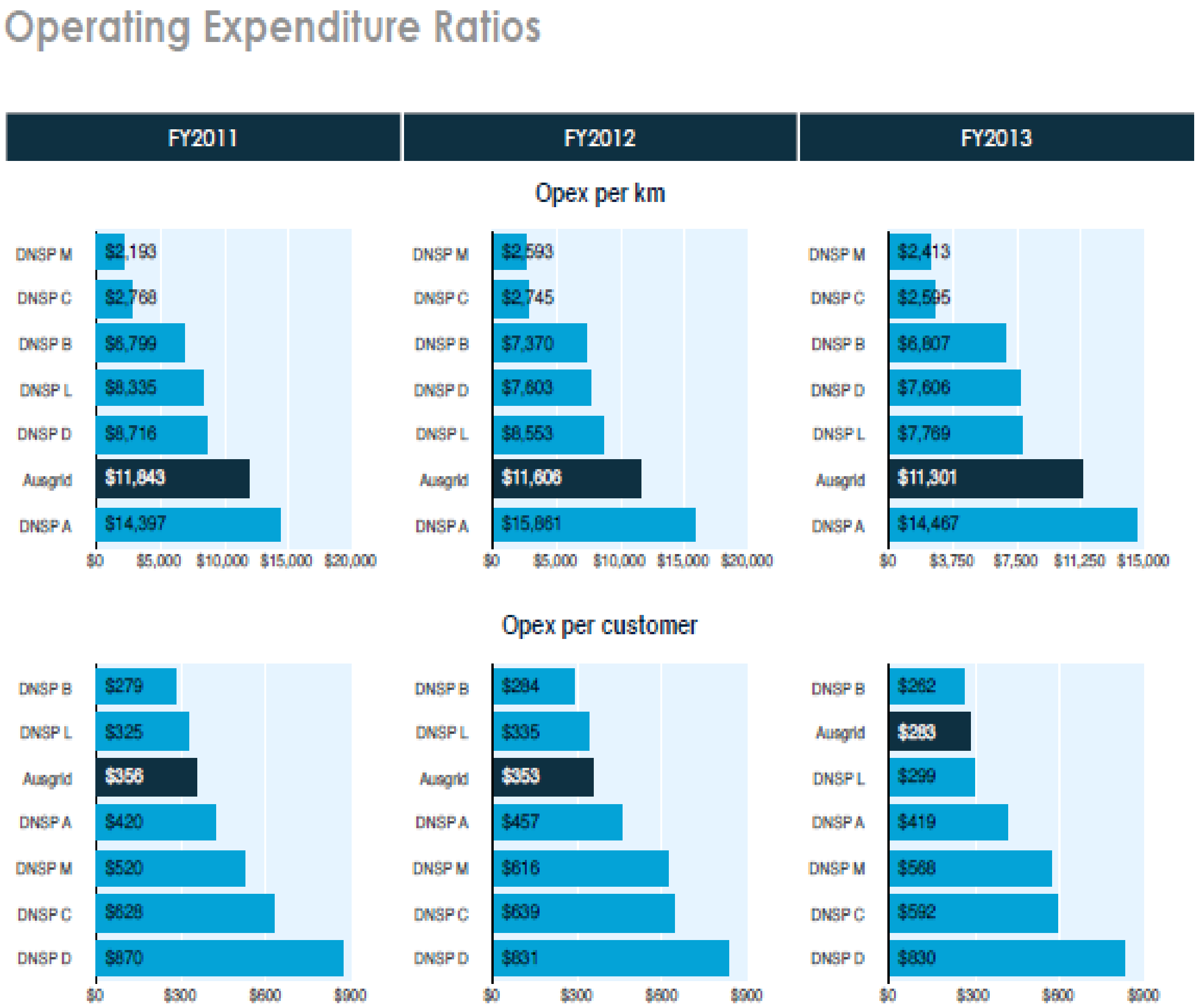


Opex

The diagrams below show Ausgrid's opex per kilometer and by customer for each year from 2010-11 to 2012-13. Similar to capex, the analysis underscores the weaknesses of using aggregated benchmarks in assessing our relative performance. For instance, on a kilometer of line basis we do not perform as well as on an opex per customer basis.

Once again this highlights that our inherent network characteristics as an urban operator in a highly dense network are driving the outcomes of the analysis.

More importantly, the diagram also shows that Ausgrid is making reductions in opex over time, particularly since the introduction of industry reform. For instance opex per customer has fallen from $358 to $283, while opex per kilometer has fallen from $11,843 to $11,301. Our relative ranking for opex per customer has improved from 3rd to 2nd best of the industry participants.



Huegin has provided information which compares Ausgrid's opex levels over the current period (2009-14 period) through to the forecast period (2014-19) relative to other DNSPs. In the 2009-14 period, Ausgrid's compound annual growth rate was -3.9% when all other DNSPs experienced a positive growth rate over the period. Ausgrid's growth rate is expected to decline further over the 2014-19 period by 0.3 per cent, leading to a negative growth rate of 0.7 per cent over the last 10 years.

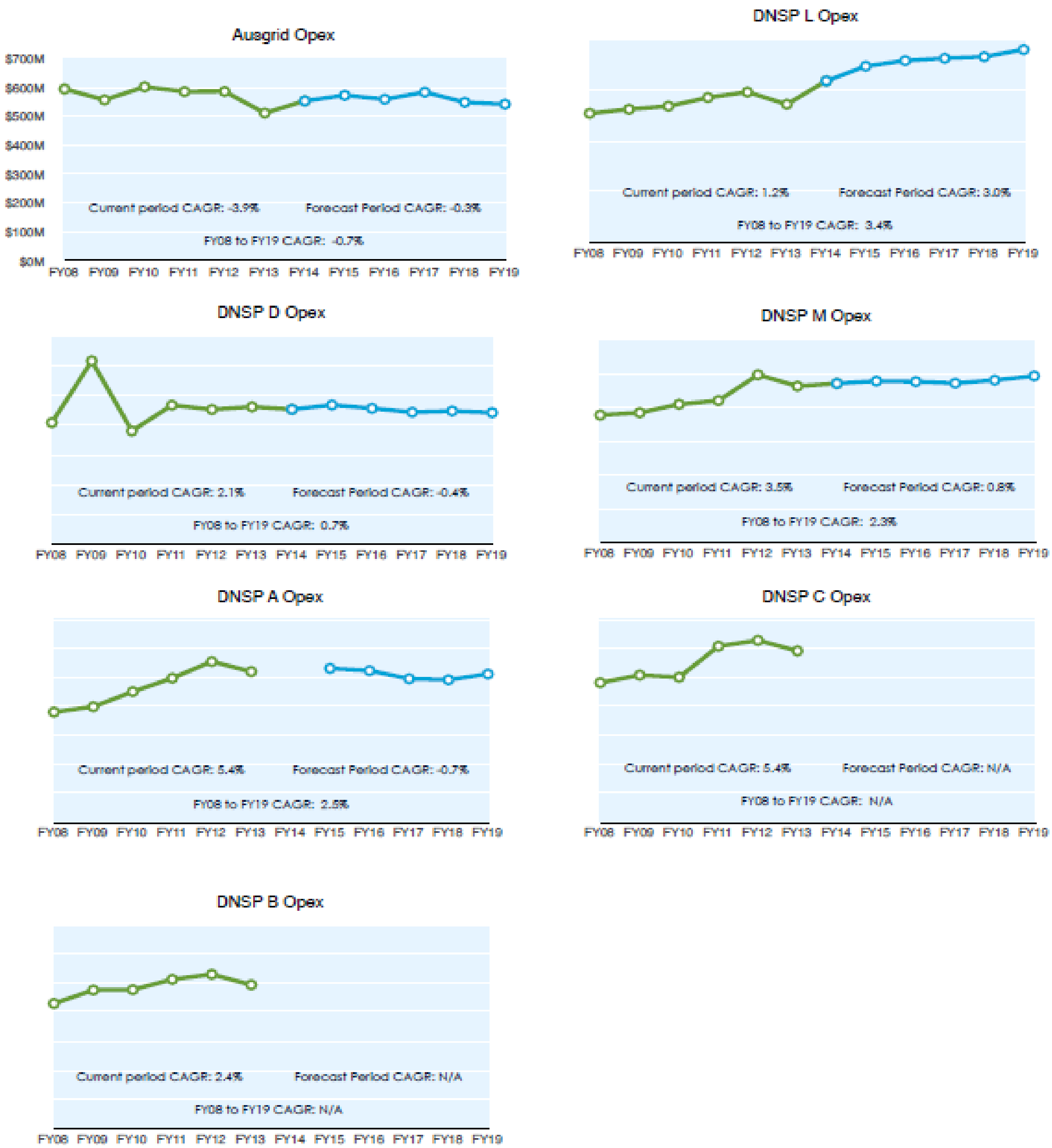
In our view, this was important in providing a high level view on the effectiveness of industry reforms on driving efficiency within our businesses. We believe that the evidence provided by Huegin provides a rough 'rule of thumb' to support the position that industry reform has delivered significant efficiencies in our opex forecasts. We note that trends in opex over time are likely to provide more information than trend data for capex which is lumpy in nature. Nevertheless comparisons need to consider:

- The underlying drivers of Ausgrid's opex trends, including assessment of trends in cost categories. For example the trend may be affected by deterioration or improvement in underlying asset condition, which in turn influences maintenance costs. Similarly, the net benefit of efficiency programs (ie: the savings minus the costs) may be influencing costs in particular categories of expenditure.

- Whether the circumstances impacting other businesses is driving trends relative to the DNSP. For instance, other DNSPs may be undertaking similar efficiencies at the same time, or may have found a need to increase their replacement programs.

- We note that capex-opex substitution possibilities can impact the comparison over time. For instance, the reductions in capex may have an impact on opex forecasts. In this respect, totex comparisons would need to also be examined.

DNSP Opex Trends - Actual and Forecast



Notes:
1. All figures in FY2013 dollars.
2. Data sources are the RINs and directly supplied data from DNSPs.

4. Category level benchmarking

The AER notes that category level benchmarking allows it to compare expenditure across NSPs for categories at various levels of expenditure. Such benchmarking can provide granular cost assessments at the total level, or relative to operating conditions such as vegetation management costs per kilometer. Cost category analysis can also be used as a predictive model such is the case for the AER's repex and augex models.

4.1 Effectiveness of technique in guiding decision making

In our view category analysis partially meets some of the criteria identified in the Productivity Commission's report, but even this is dependent on the manner in which the tool is being used. For the most part, we consider that the benchmark outcomes will be highly unreliable and cannot itself be used to infer relative inefficiency.

- Validity – Theoretically, cost category analysis can lead to more valid conclusions on efficiency of operations than high level benchmarking tools such as economic and aggregate analysis. This rests on the assumption that cost categories are reported consistently across DNSPs and that the data can take into account the drivers of expenditure. From a practical perspective these assumptions do not hold true:
    - The DNSPs in Australia have historically defined and recorded costs using different categorizations. The AER has sought to solve the issue of inconsistency by defining common categories in the RIN for benchmarking purposes. However, the definitions are still open to considerable interpretation, and the data provided will not be on a 'like for like' basis due to historical accounting practices and cost accounting methods. For example, overheads can be interpreted in many ways and will depend on the intrinsic way in which a DNSP has recorded costs in the past.
    - In addition to definitional issues, many of the cost categories are highly inter-related with each other such as maintenance and replacement expenditure. If the category is seen in isolation, it may mislead an analyst to conclude that a DNSP is efficient in one area, and highly inefficient in another.
    - Even within cost categories there is often limited financial information to adequately account for a particular driver of expenditure. For example, data on distribution network projects generally are recorded in bulk on financial systems due to the high volume of small scale projects, and therefore there is limited ability to identify whether drivers of investment relate to a particular issue with a technology type of a local driver such as a large new customer connection.
    - Finally there is no statistic method available to normalise for drivers underlying apparent cost differences. For instance, there is no sound method to account for the different costs that a DNSP incurs from constructing an asset in the CBD compared to an urban area.
- Accuracy and reliability – In many cases, the data can be verified with reference to financial systems and statements, and are accurate and reliable for that DNSP. However, due to the definition and interpretation issues identified above, the data cannot be relied on for the purposes of comparative data. Further, the AER's cost categorisations require DNSPs to map historical data and in some cases use 'best estimates'.
  Key examples are in splits by cost types of overheads which may draw on 'rough methods' due to insufficient data in financial systems. Given that this type of information is not drawn from actual data, there will be occasions when the data is not accurate or reliable to use for comparison.
- Robustness – As identified above, we consider that the data cannot be provided in a 'like for like' form and therefore cannot adequately control or normalise for operating differences between DNSPs.
- Manipulation of data – The AER's requirement that DNSPs provide best estimates where actual data cannot be provided, together with ambiguity on definitions may leave it open to a DNSP to report in a manner that puts its situation in the best light. This underscores issues with the reliability and accuracy of data when comparisons are drawn between businesses.
- Parsimony – To a degree, the AER's method of splitting opex and capex into cost categories is relatively straight forward. However, the AER has requested a high degree of granularity in data such as costs split by labour, materials and contractors. In our view this adds an additional degree of complexity that may lead the AER to form erroneous conclusions, and therefore do not meet the objective of parsimony.
- Fit for purpose – As explained below, cost category analysis may be fit for purpose, if used as a guide to the AER's detailed assessment of programs and projects rather than as a determinant or substitute for expenditure.

Despite not meeting the Productivity Commission's criteria, we consider that category benchmarking is potentially the best tool for a DNSP and regulator to apply when addressing the capex factor for benchmarking. This is because it allows the business and AER to consider whether there is a particular driver underlying cost differences (higher or lower) than peer DNSPs, or where the costs of the DNSPs are changing compared to trend levels for a well explained reason.

In these cases, further examination should be undertaken of the high level cost drivers that may explain the variance. For example, a DNSP's replacement costs may be explained by the relative age or failure rates of the assets on its network, or a new safety standard for a jurisdiction. If variances cannot be explained by different cost drivers, then this would signal that further work needs to be undertaken to assess the reasons for the variance. In this case, the AER may seek to identify the forecast method that was implemented by the DNSP, and the application of that forecasting approach to investment programs and projects. For example, an apparently high unit cost may be explained by a large project that is conducted in the CBD which provides a false picture of cost trends over time.

In the sections below we show how available benchmarks have informed the development and review of our forecasts. We provide information on cost category data, and also address the repex and augex models.

Ausgrid's forecasts have been heavily influenced by industry reform that has focused on customer affordability. Comparative data between the 3 DNSPs and our industry peers have played a role in identifying areas of efficiency, although this has been limited by the inherent issues with undertaking benchmarking. Our experience is that granular data can often paint a misleading picture on the relative efficiency in an area. Even when assessing data amongst the 3 NSW DNSPs, we noted that variances were impacted by definition and cost accounting issues. For example, even simple metrics such as travel costs which form a component of overheads, could not be normalised given that the underlying drivers across the 3 DNSPs are so different. For instance, a rural DNSP such as Essential is likely to have higher relative transport costs per employee than Ausgrid.

For this reason, the reform process and our review of our forecasts have used comparative data with a high degree of caution. Where data has been assessed, we have not taken a simplistic view of assuming that the variance relates to efficiency. Rather we have undertaken a 'bottom up' assessment of underlying policies, forecast methods and cost controls of the DNSPs, in combination with available data and the ground experience of our staff. In this way, we were able to precisely identify the actions within the control of management to deliver efficiencies, whilst continuing to deliver services to our customers.

For the purposes of addressing the benchmarking criteria, we commissioned Huegin to provide cost category comparisons of the benchmarking group using 2009-14 and 2014-19 data if available. This follows from an earlier benchmarking study conducted by Huegin in 2012. Huegin's analysis is framed around understanding potential cost drivers and definitional issues underlying variances in costs between DNSPs. Further, we have examined the validity of specific cost category models such as augex and repex, including more detailed reviews of the model in Appendix B and C respectively.

4.2 Analysis of available data

Huegin Consulting undertook analysis of Ausgrid's expenditure levels for key categories relative to the 6 other DNSPs in the study. In the section below we set out the key results from the study for capex categories and opex categories.

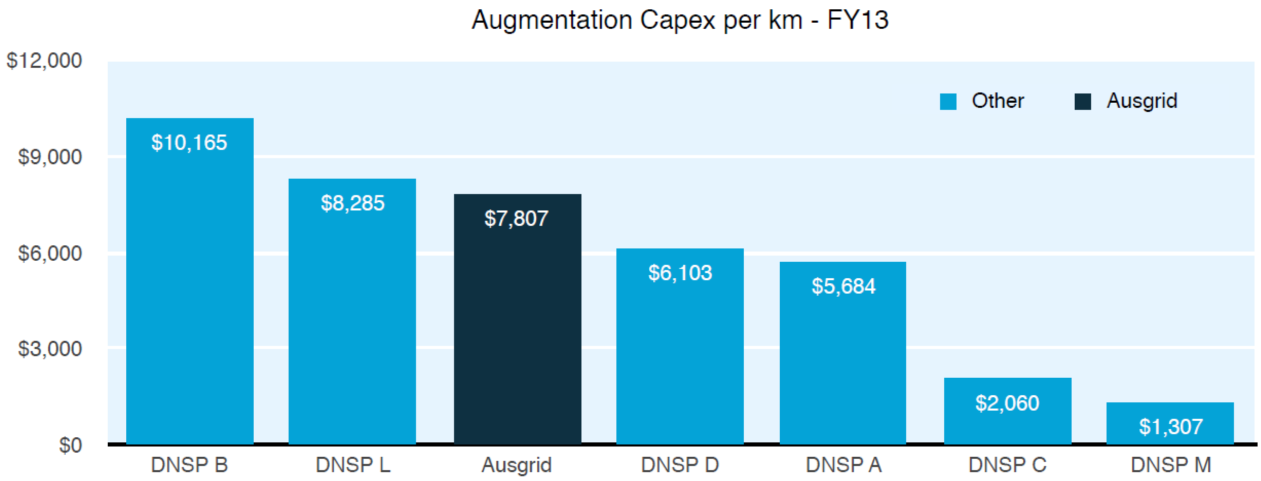
Capex

The Huegin study assesses the expenditure of DNSPs across 3 broad categories – augmentation, replacement and non-system capex. We note that these definitions are not common across DNSPs and in some cases a project may be driven by a combination of these drivers.

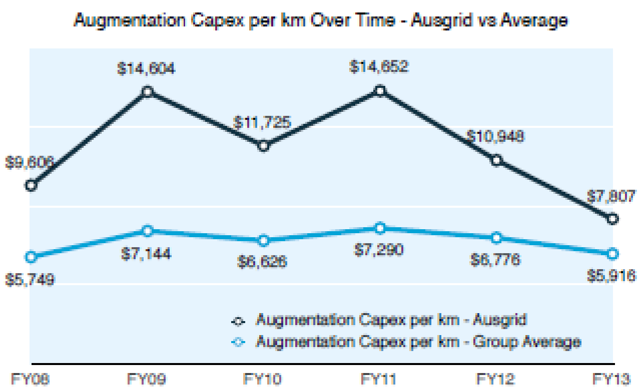
Augmentation expenditure

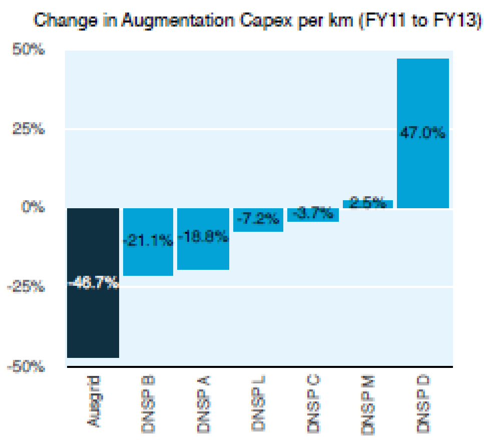
The AER note that this category of expenditure typically involves augmenting network components to ensure they have sufficient capacity to meet forecast demand. The AER have not been entirely clear about whether augmentation also includes works required to connect a new customer, as the AER refer to this as customer initiated connections. Huegin's report includes both customer initiated capex and reinforcements of the network for standard control services.

Huegin's study finds that Ausgrid's costs are on par on a per kilometer basis and are highest on an MVA basis in the 2009-14 period, but this drops significantly by the end of the period. This relates more to the underlying drivers of augmentation at Ausgrid including the imposition of new licence conditions in 2007 to meet a higher degree of security and reliability on the network.



More importantly, since 2011-12, Ausgrid is showing a significant reduction in augmentation expenditure (46.7%) which reflected our underlying circumstances including reductions in spend associated with the industry reform process, and that we had made significant inroads into meeting our backlog of works in response to new security criteria and reliability standards in our licence conditions. It also reflects a lower growth in peak demand compared to historic levels.





In addition to the analysis of augex expenditure, the AER has indicated that it will also be using the augex model as part of its cost category analysis. The augex model compares utilisation thresholds with forecasts of maximum demand to identify the parts of a network segment that may require augmentation. The model then uses capacity factors to calculate required augmentation, and costs per MVA to derive an augex forecast for the DNSP over a given period. The model is applied to segments of the network such as the sub-transmission network, 11kV network and low voltage network.

The AER has not provided us with sufficient information to use the augex model as a basis for comparing our forecasts to that predicted by the model. While we have sought to undertake preliminary analysis, we have noted that data limitations and uncertainty on the AER's preferred segmentation have limited its use. For this reason our response focuses on the effectiveness of the model from a conceptual point of view.

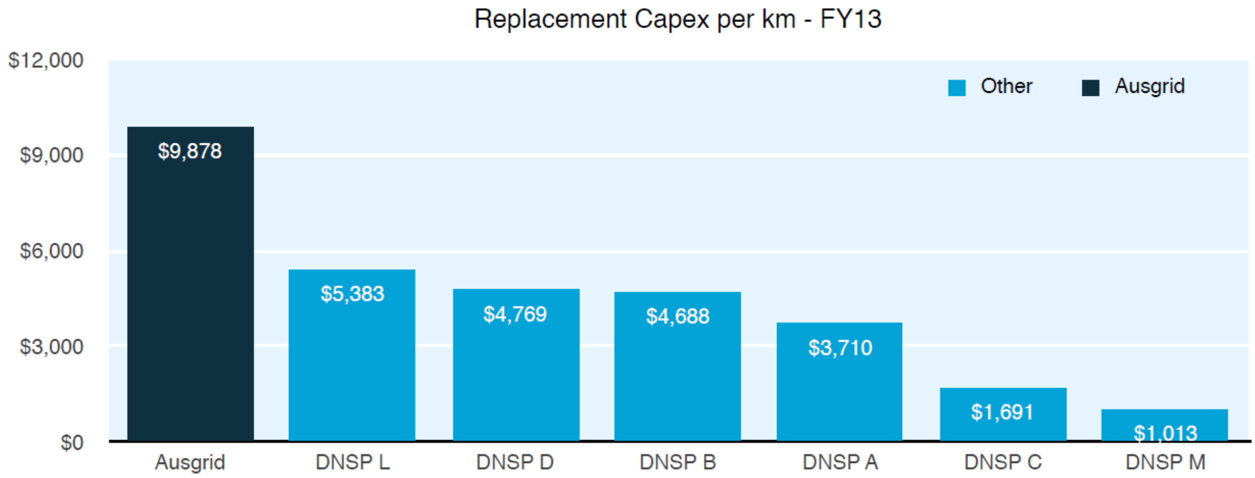
The NSW DNSPs have prepared joint analysis which assesses the effectiveness of the augex model as a benchmarking tool (please see Appendix B). Our key finding is that the model cannot be used to develop an alternative or substitute forecast due to deficiencies in functional form and data limitations.

We note that the tool has almost no use as a test of our forecasts given that the model cannot accurately account for the drivers of capex in the 2014-19 period. In particular, much of our augmentation expenditure is related to pockets of localized growth on the network as a result of spot loads from customer connections or urban infill. The model is not capable of segmenting sufficiently at these localised sections of the network. More information is found at Attachment A

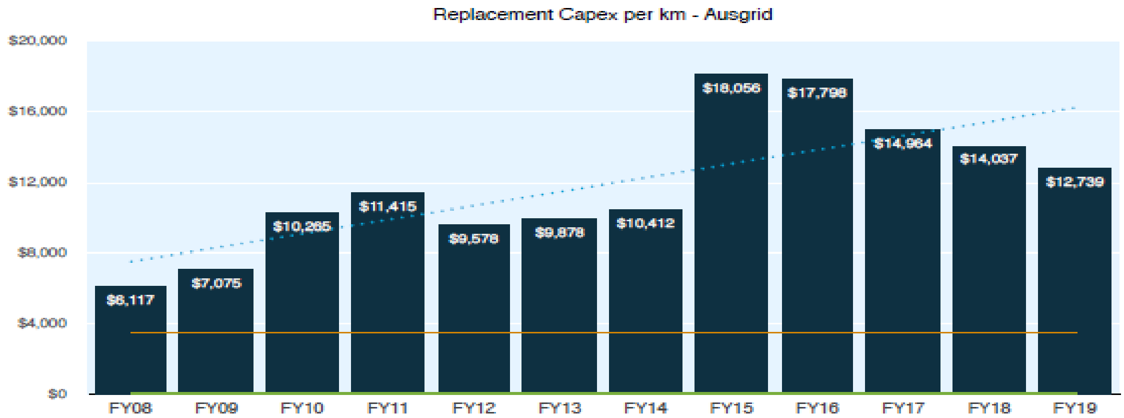
Replacement

The AER define replacement expenditure as the non-demand driven capex to replace an asset with its modern equivalent where the asset has reached the end of its economic life. Economic life is determined by the age, condition, technology or environment of the existing asset. The capital expenditure is regarded as replacement expenditure if it is primarily determined by the existing assets ability to efficiently maintain its service performance requirement.

Huegin note that replacement capex for Ausgrid is higher than other DNSPs in 2012-13 on a kilometre line basis. This reflects the condition of our asset base which contains a high proportion of aged assets.



In the next period, replacement expenditure will be increasing from current levels, as can be seen from the following diagram.



Notes:
1. All figures in FY2013 dollars.
2. Network km for future years have been forecast using the historical growth rate (0.1%).

When reviewed in more detail, it is apparent that the last two years of the period had significant reductions in replacement spend compared to trend levels, and that expenditure rises rapidly in the first two years of the 2014-19 regulatory period.

This can be explained by the review of policies, risk tolerances and delivery policies that has taken place as part of industry reform which temporarily delayed planned projects. As part of this process, we recognised that only essential projects should pass through the approval process, and that large projects in particular required a greater degree of review. For example, we reviewed standards for 11kV brownfield switchgear, and looked at alternative delivery models for underground cable construction. We also examined long term programs for major equipment, and in the process put several large projects on hold while these process were taking place.

The total forecast capex for the 2014-19 period now reflects the efficient and prudent level of replacement capex. It also incorporates the backlog in lumpy large projects that were delayed as a consequence of the review of policies, risk tolerances and delivery policies performed as part of the industry reform process. This explains the large change in capex in the first 2 years of the 2014-19 regulatory period, and why expenditure goes back to trend levels thereafter.

The continued upward trend in replacement expenditure (the blue dotted line) reflects the underlying deterioration in condition of assets on the Ausgrid network. As noted in section 5.2 of our regulatory proposal, the average age of our assets in the distribution and sub-transmission network continue to increase despite significant investment over this period. In part this reflects that we prioritised our resources to improving capacity and security on the network in the last period in response to new license conditions, and as such did not replace enough assets to sustain the condition of assets on the network. This is reflected in increasing failure rates over the period particularly on the distribution network since 2012.

In addition to replacement cost analysis, the AER will also be using the Repex model. It has been described by the AER as a high-level probability based model that forecasts repex for various asset categories based on their condition (using age as a proxy) and unit costs. The AER has used it in determinations to compare NSP forecasts with the repex model outputs to identify and target areas in its forecast program that required detailed engineering and business case review.

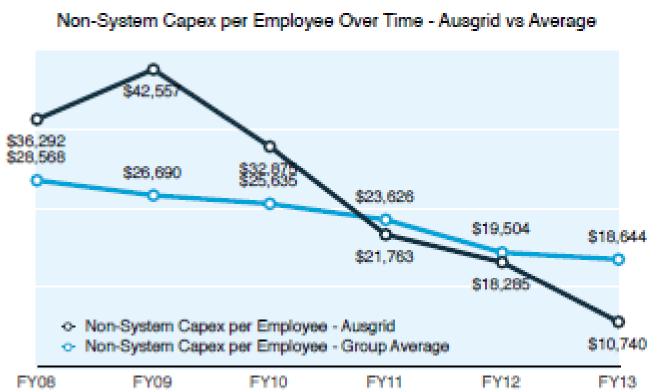
The AER has not provided us with sufficient information on how it will apply the Repex model as a basis for comparing our forecasts to that predicted by the model. While we have sought to undertake preliminary analysis, we have noted that data limitations and uncertainty on the AER's preferred asset categorisations have limited its use. For this reason our response focuses on the effectiveness of the model from a conceptual point of view.

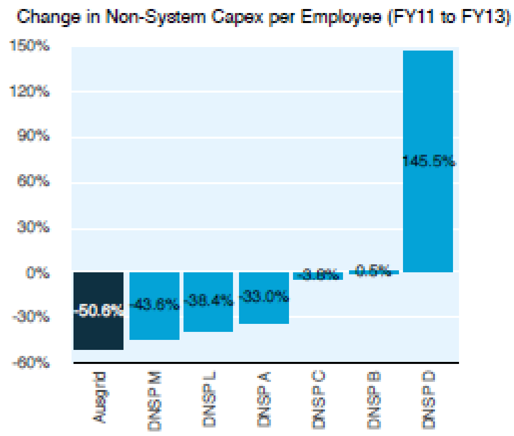
The NSW DNSPs have prepared joint analysis which assesses the effectiveness of the repex model as a benchmarking tool (please see Appendix C). Our key finding is that the model cannot be used to develop an alternative or substitute forecast due to deficiencies in functional form and data limitations. We note that the tool may have limited use as an informative tool for particular asset categories when there is sufficient population size, stability in replacement cycles over time, uniformity in technology type, and the costs are relatively stable over the population size.

Non system capex

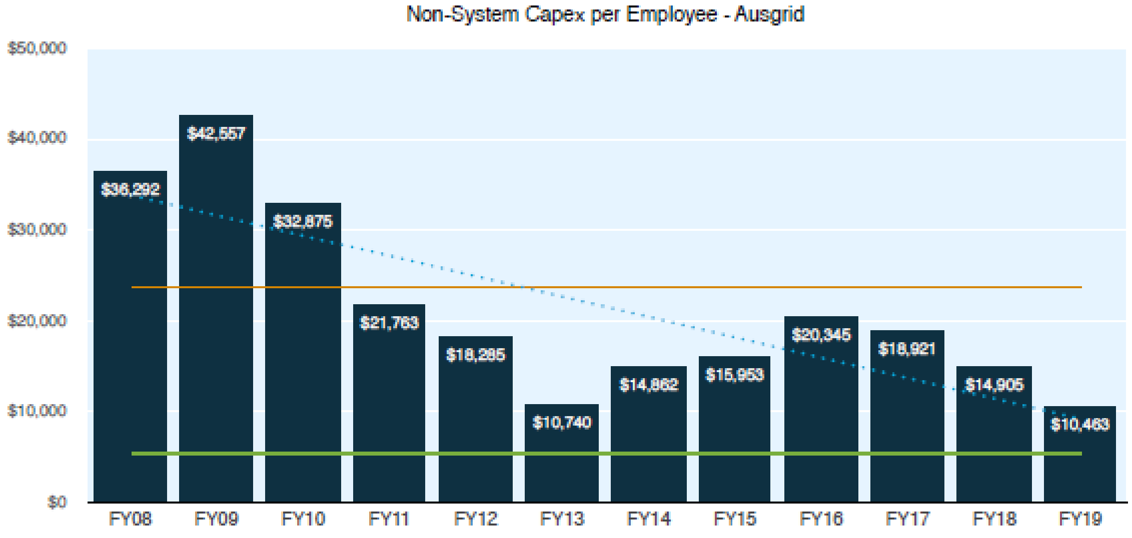
The AER identified the following types of non-network expenditure: IT, motor vehicles, property, SCADA and network control expenditure. Huegin have assessed relative levels of non-system capex based broadly on these categories of expenditure.

Ausgrid's non-system capex was significantly higher than other DNSPs in the study in the first 3 years of the 2014-19 period, but its expenditure levels have shown a significant decline since 2011-12. As can be seen in the graph below, this trend continues in the 2014-19 period, with average expenditure levels declining in comparison to the last 2 years of the regulatory period.





This indicates that industry reform has delivered significant results in reducing non-system capex through changes in strategy and leveraging non-system capex across the 3 DNSPs. It also may be indicative of the high levels of capex in the early years of the period that delivered new functionality to support the larger capex programs, and the change in strategy which changes the focus of expenditure from delivering new capabilities to maintaining existing functions.



Notes:
1. All figures in FY2013 dollars.
2. Employee numbers for future years have been held at the current (FY13) figure.

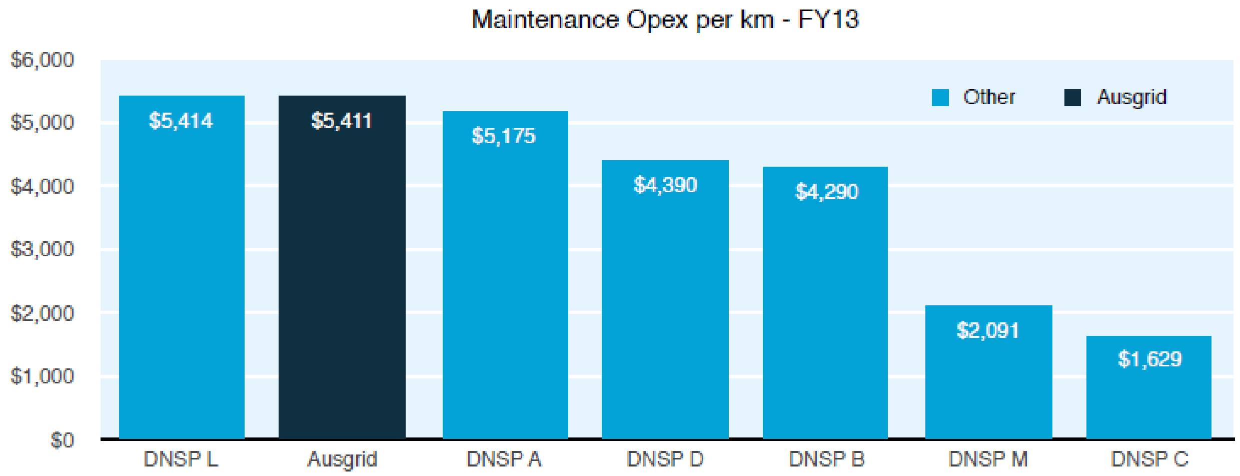
Opex

The Huegin study assesses opex of DNSPs across 2 broad categories – maintenance and operations costs. We consider that relative costs among DNSPs are likely to be shaped by capitalization policies, age and other factors outside the control of management.

Maintenance

The AER define maintenance and emergency response includes all works to maintain the current working condition of an asset or to address the deterioration of an asset. These works include those that may be driven by reliability deterioration or an assessment of increasing risk of failure or performance degradation of a network asset. The AER consider that maintenance related to vegetation management is a separate category of expenditure defined as the process of keeping trees and other vegetation clear of electricity lines to reduce related outages and the potential for fire starts. Vegetation management also includes clearing easements and access tracks associated with electrical assets. Huegin's analysis includes vegetation management as part of its definition of maintenance.

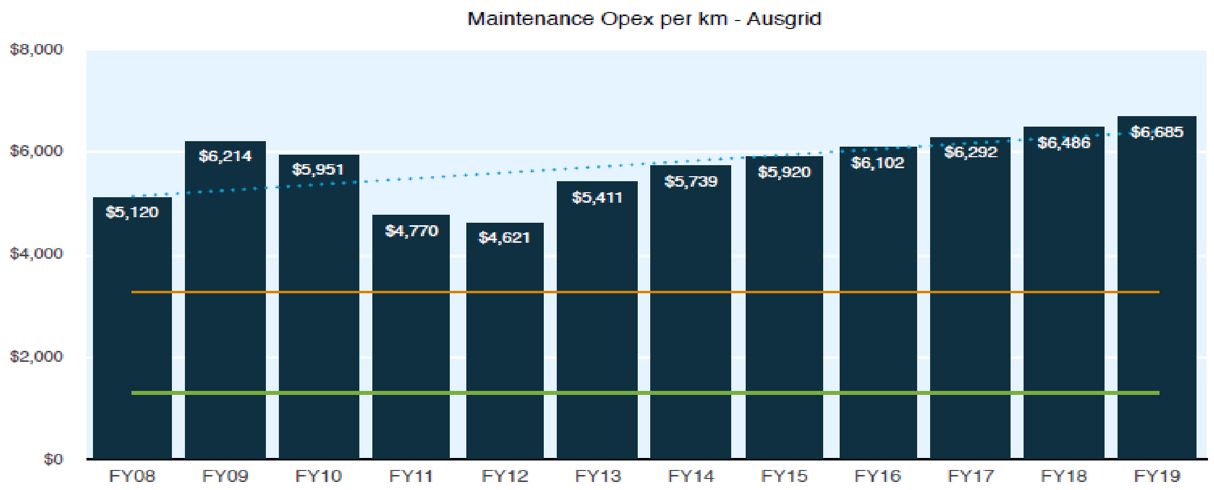
Huegin's analysis shows that Ausgrid's maintenance costs on a per kilometer basis is within the range of 5 of the 7 DNSPs in the study. Huegin note that there are a number of costs drivers of maintenance. For instance, long and radial networks in regional areas carry a significant cost premium in travelling between assets. At the same time, costs can be higher for DNSPs such as Ausgrid that operate in dense, urban areas where there is traffic congestion, complex network design and assets which are more difficult to access and shared with other infrastructure providers.



Huegin also compared the trend in Ausgrid's performance from 2009-10 to 2014-19 and compared this to forecasts for the 2014-19 period. The diagram shows that Ausgrid's maintenance expenditure is growing over the 2014-19 period. The increase in maintenance can be explained with reference to the following factors:

- We have reviewed our obligation under the Electricity Supply (Network Safety and Management) Regulation 2008 regarding the inspection of private installations and the extent of that obligation. We are currently developing processes consistent with that obligation which includes a rigorous inspection process. Where a defect is identified, we will provide the inspection results to the owner for rectification. We anticipate that the existing defect notification process will be used to execute this process. Installations with defects that present major risks and that remain unrectified will face disconnection. The additional cost of complying with our obligation is factored into the total forecast maintenance opex.

- A renewal of contracts with external service providers for vegetation management with cost increases expected to be above CPI.



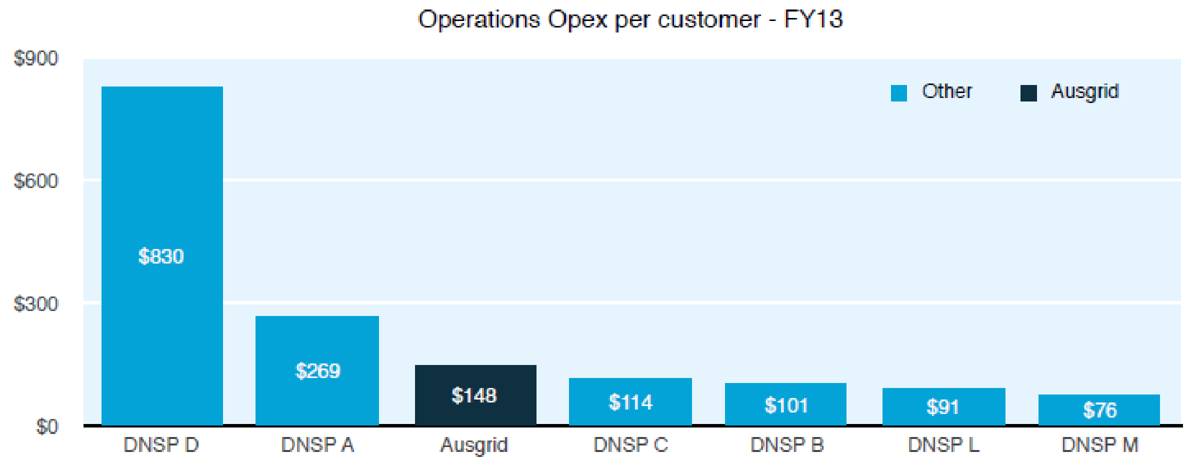
Notes:
1. All figures in FY2013 dollars.
2. Network km for future years have been forecast using the historical growth rate (0.1%).

Operations opex

Huegin define operations opex as network control, systems operations, customer operations and support functions such as IT, property and fleet management. This broadly relates to the AER's definition of non-network costs.

Huegin's operations costs for this study have been compared using the number of customers as the comparison basis. Comparisons of operations costs per customer for the 2013 financial year are shown below.

Huegin's analysis shows that Ausgrid's operations opex is significantly below 2 DNSPs, but is above the costs per customer of 4 other DNSPs in the study. Huegin note that operating costs are largely driven by the location and complexity of the network, customer base and the business scale. This makes comparison particularly difficult, as the number and relative influence of cost drivers varies across businesses.



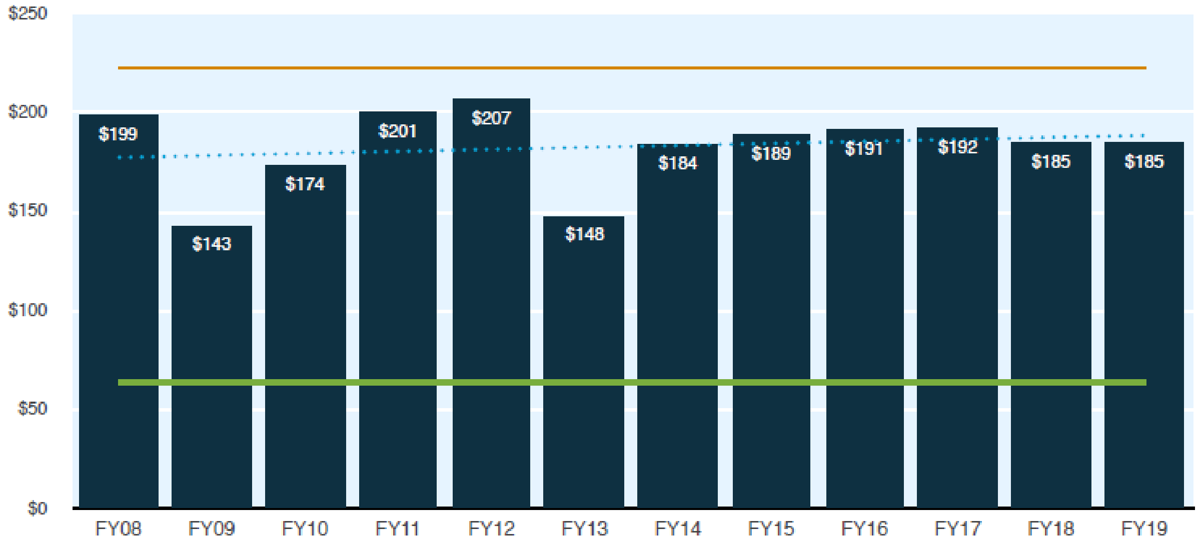
Huegin also compared the trend in Ausgrid's performance from 2009-10 to 2014-19 and compared this to forecasts for the 2014-19 period. The diagram shows that Ausgrid's operating costs were significantly higher in 2011-12 compared to forecasts in the 2014-19 period. We consider there are a range of drivers influencing higher costs.

Leaseback cost of one of our corporate buildings that is forecast to be sold by 30 June 2014. The leaseback is for the period up to 2016-17 and the additional cost will be offset by the lower return on and of capital as the proceeds from the sale of this asset will be deducted from the value of the RAB.

- Forecast changes in the prices of inputs. We anticipate that rate of increases in labour costs and contracted services costs for the next period to be above expected CPI (i.e. real cost escalation).
- Loss of synergy costs from the cessation of the transitional service agreement (TSA) with EnergyAustralia (formerly TRUenergy).
- The impact of the forecast capex on opex requirements including the impact of a reduced capital program on our cost structures.

These are unavoidable increases in our cost base. At the same time, we have implemented efficiency initiatives to minimise the costs impact on our customers.

Operations Opex per Customer - Ausgrid



Notes:

1. All figures in FY2013 dollars.
2. Customer numbers for future years have been forecast using the historical growth rate (0.8%).

APPENDIX A - HUEGIN DISTRIBUTION BENCHMARKING STUDY

Distribution Benchmarking Study

2014

Ausgrid

Ausgrid Distribution Business Benchmarking Study

An updated analysis of comparative cost performance for Ausgrid

In 2012 Huegin completed a benchmarking study for several Australian and one New Zealand distribution business showing comparative performance in costs and outcomes for selected cost categories and functions. Since then, there has been two significant developments:

1. Networks NSW was formed, merging some of the functions of the three NSW distribution businesses; and
2. The Australian Energy Regulator (AER) has released its expenditure forecast assessment guidelines, describing how it intends to use economic and category benchmarking to evaluate the expenditure forecasts of electricity businesses.

The objective of this report is therefore two-fold - to provide an update to the data presented in the previous benchmarking report (which included data up to the 2010/11 financial year) and to investigate the potential outcomes of the application of economic benchmarking to the NSW businesses.

What To Expect

Key points arising from this study

The following salient points are included in the analysis and narrative of this report:

1. Whilst there remains uncertainty in the way the AER will apply benchmarking in the upcoming regulatory determination, it will be a significant factor.
2. As the first businesses to be exposed to techniques that have been abandoned in other jurisdictions due to inherent limitations in application, the NSW distributors face greater uncertainty than those later in the regulatory cycle.
3. Attempts to use benchmarking to gauge efficiency are likely to bring attention to some areas of the Ausgrid current and forecast expenditure.
4. Whilst there may be few surprises in the specific areas of attention, understanding the performance of peers and the magnitude of differences is useful to gauge efficacy of current cost management efforts.
5. Recent opex reductions for Ausgrid compare favourably against the group; and forecast opex is within the range of other available forecasts.
6. Within the opex category, operations costs are forecast to remain flat, with the increase coming from maintenance costs - which will shift focus onto the forecasting methodology.
7. Reduction of system capital expenditure is likely to be a target of the regulator - and Ausgrid has forecast a decrease in this major spend category.
8. Non-System capex has been one target of industry reform, and the results are evident in Ausgrid's recent performance; and whilst the current cost position does not endure throughout the forecast period, expenditure is forecast to remain in a reasonably favourable range.
9. Overhead structures and expenditures are likely to be in focus during the determination; Ausgrid's scale should afford it a level of efficiency, however the congested urban location of much of its network and its location in Australia's most expensive city carries a premium that offsets the scale effect. Ausgrid's large capital program, which appears to be driven primarily by its aged assets, limits its ability to drive further cost reductions in its business.

Inside

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About the Report

This report represents an analysis of Networks NSW historical costs in the context of its peers in the Australian electricity distribution industry. Where possible, forecast data has been included.

The predominate sources of data in this report for the businesses other than the Networks NSW businesses includes:

- Public sources, such as Regulatory Determinations and Performance Reports, for the other electricity businesses; and
- Huegin's own database of historical data.

Any other information sourced from published literature is referenced within the report.

Current Status

This report is currently in final version status, released on 14th May 2014.

Benchmarking Electricity Businesses

Benchmarking of electricity businesses is a global challenge and in Australia - like in many countries - it is a regulatory requirement incorporated into the National Electricity Rules (NER). The Australian Energy Regulator (AER) is responsible for applying those rules to distribution businesses each five years. The distribution businesses also conduct their own benchmarking analysis, with a view to understanding differences in their cost performance to their peers.

Huegin has been involved in benchmarking electricity distribution and transmission businesses for many years in multiple jurisdictions and therefore has an understanding of the inherent challenges and limitations of the techniques and their application. In our experience, there has been a shift in the benchmarking efforts of the industry from a position of undertaking the exercise to support a regulatory proposal to its current purpose of providing visibility of the cost position of peers in order to inform a business' own cost and performance improvement initiatives. The widespread industry reforms affecting all electricity businesses after recent price rises has catalysed that shift. At the same time, the regulator has strengthened its position on benchmarking, augmenting its resources and producing a new framework and approach for expenditure assessment that has benchmarking as a central tenet.

How the benchmarking approaches of the businesses and the regulator co-exist will evolve in the upcoming determination cycle. The benchmarking approaches and methods adopted by industry and the regulator respectively may seem to have converged over time, however their remains a subtle, but significant, difference in the intent. One is to push businesses towards a theoretical frontier of industry efficiency by modeling industry cost functions. Of course the two approaches may ultimately achieve the same purpose, but one clearly has more potential for the unintended consequences of sharp, immediate cost-cutting, rather than targeted productivity improvements in the areas within management control. The diverse nature of operating conditions in the Australian electricity supply industry means that some businesses will experience regulatory shock simply by being the outlier of a cost model that attempts to normalise every difference between a small, heterogeneous group of businesses.

Economic benchmarking has been adopted by the AER

The first cycle of electricity distribution regulatory determinations (starting with NSW/ACT and finishing with Tasmania) under the national framework of the AER has demonstrated the evolving approach of the AER to the challenge of incorporating benchmarking into the determination of an efficient and prudent level of expenditure in the absence of natural competition. During a cycle of increasing electricity prices, bookended by a resource boom and global financial crisis, a myriad of reviews of the electricity industry from bodies such as the Productivity Commission and Australian Competition and Consumer Commission (ACCC) have examined the need for changes to the Rules and the regulatory framework, including the role of benchmarking. Literature reviews, solicitation of expert advice and broad industry and consumer consultation have led to the AER's release of its Expenditure Forecast Assessment Guideline which outlines its intended approach to benchmarking during a regulatory determination. The guideline sets out a multiple technique approach that includes some new and some existing techniques.

New Techniques

In an effort to reduce information asymmetry between the AER and individual businesses the AER will now use more sophisticated economic benchmarking techniques when evaluating expenditure, these include;

- Tornqvist Multilateral Total Factor Productivity (MTFP)
- Data Envelopment Analysis (DEA)
- Econometric analysis
- Category level benchmarking[1]

A brief description of each of these techniques is provided below.

Technique	Description
Tornqvist Multilateral Total Factor Productivity (MTFP)	When benchmarking businesses that have more than one output and/or more than one input the challenge is including these different values into a common comparable index. MTFP uses revenue and cost shares as weights to overcome this problem and create a value for a firm's output and a value for a firm's input; the productivity of the benchmarked firm is then the difference between these output and input figures. In the context of Australian NSPs this means that a businesses efficiency will be affected by its outputs compared to the industry average and the share of expenditure that these outputs account for.
Data Envelopment Analysis (DEA)	DEA is a linear programming technique that looks at all the inputs used by a firm and all the outputs it produces and then measures how efficient the firm is compared to others in its industry. The efficiency comparison is based on the output/input ratio, which is difficult to define when multiple variables exist and weightings are unknown. DEA tries to solve this problem by using linear programming, which does not require the production function to be known. DEA incorporates all input and output data and finds a weighting that maximizes the ratio of output/input for each firm.
Econometric Analysis	Econometric analysis is the statistical modelling of economic systems using assumed relationships between quantities of certain variables. Econometric analysis requires the development of formulae that describe the dependency of output variables on input variables, so that changes in the latter can be used to predict changes in the former.
Category Benchmarking	Category benchmarking is the simple comparison of costs for specific categories of expenditure, often expressed as a ratio of variables assumed to drive changes in the level of expenditure.

Existing Techniques

The AER will continue to utilise techniques used in previous revenue determinations, these include;

- Economic justification for expenditure
- Reviewing expenditure governance and policies

[1] High level category benchmarking has been used in previous determinations (ratios such as opex/km and capex/load density) however the guidelines suggest that category benchmarking will now be conducted in much greater detail than previously

- Trend analysis
- Category analysis
- Targeted review of projects and programs
- Sample review of projects and programs

This report will focus on the techniques to be used by the AER when benchmarking DNSPs.

Multiple approaches produce multiple results to choose from

The AER has signalled its intent to use benchmarking as a means of predicting appropriate future expenditure levels for individual businesses - shifting the focus from comparison to forecasting. The context of how each of the benchmarking techniques will be applied in the evaluation of total, capital and operating expenditure is outlined below.

Category	Technique	Outcomes Sought
Total Expenditure	MTFP	Overall efficiency and rate of change in efficiency Growth of inputs and outputs Forecast future totex
	DEA	Cross check of MTFP results
Capital Expenditure	Category Benchmarking	Adjust, as required: ○ Augmentation capex ○ Replacement capex ○ Non-network capex ○ Customer initiated capex
Operating Expenditure	MTFP	High level indication of opex efficiency
	Econometric Analysis	Base year efficiency evaluation Annual rate of change
	Category Benchmarking	Adjust, as required: ○ Maintenance and emergency response opex ○ Vegetation management opex ○ Overheads

MTFP, DEA and econometric analysis all have specific limitations and flaws when applied in the Australian electricity distribution environment. Some of the most pertinent of these are discussed in Appendix I.

The AER has consulted widely on its approach; throughout that consultation period a number of assumptions regarding the approach have endured through to the final release of the guideline. These include:

1. That multiple approaches are complementary and can validate each others results;
2. That a model specification can be found that is appropriate for the entire industry and its individual participants;
3. That exogenous variables can be accounted for through regression analysis; and
4. That the results of the models will be robust enough to provide a substitute forecast representative of the appropriate level of expenditure given a distributors individual circumstances.

The extent to which these hold true depends on both the model specification and the ability to normalise for differences between the businesses; these two outcomes are often in tension. Finding a model specification that fits all distribution businesses requires a very simple, high level model, particularly in such a small sample where economic benchmarking principles dictate that small sample sizes necessitate very few input and output variables. So, striving for a robust economic model pushes more costs into the residual (the sum of all variables, including inefficiency, that are not explained by the model cost function) whereas pushing more costs out of the residual into the model variables dilutes the efficacy of the model. For these reasons the adopted approach attempts to eradicate anomalies through the application of multiple techniques. However in our benchmarking experience, two significant challenges remain:

1. The more refined and specific a benchmark measure is, the more unreliable the data becomes; and
2. The more generic and accessible a benchmark model is, the less applicable it becomes to individual businesses in the diverse Australian environment.

The theory that high level economic benchmarking and lower level category benchmarking can complement each other in determining the existence and extent of efficiency improvement opportunities is sound in principle, however there are inherent issues that are amplified by the respective approaches and are not resolved through multiple techniques.

Any economic model specification introduces bias

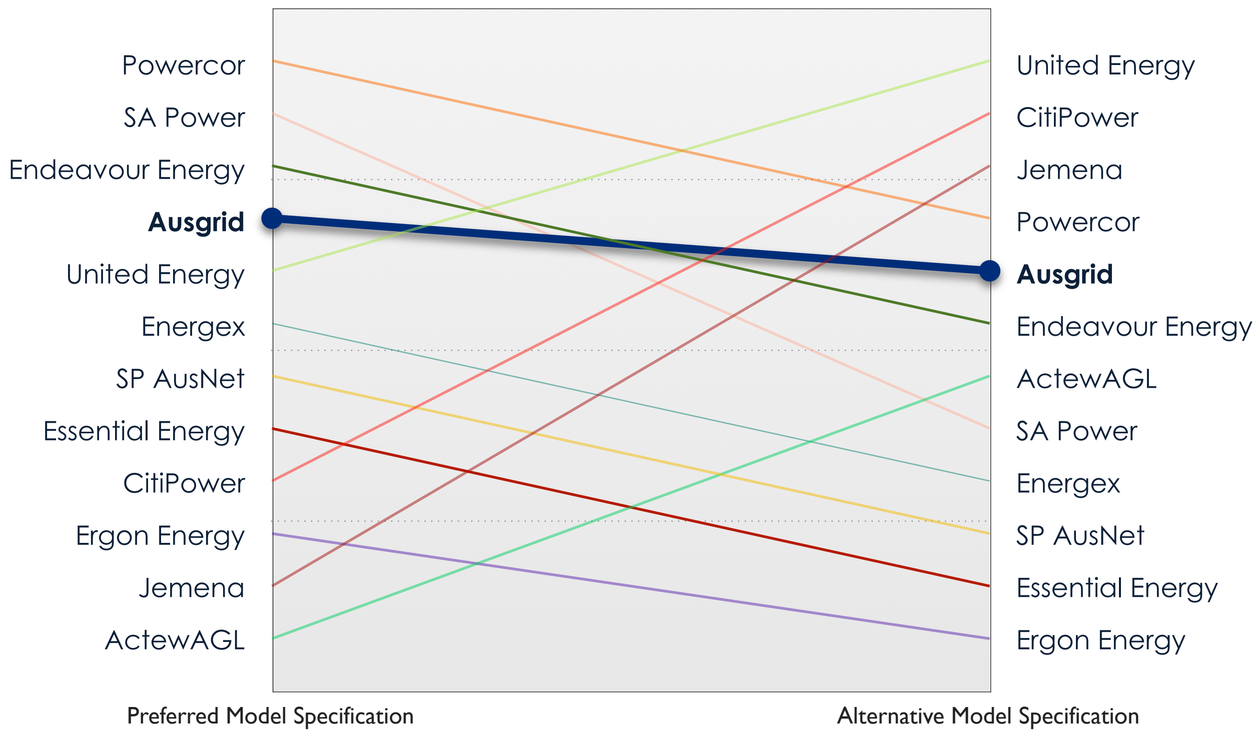
Errors and bias are natural outcomes when striving to fit an academic construct such as an economic model to the real world. An economic model is a simple abstract of a very complex reality and is thus limited in its ability to describe complex, non-linear relationships between variables that are often hard to measure. This is inherent in the economic modelling of any industry or system, not just electricity distribution. Application for electricity distribution benchmarking does, however, compound the issue. Economic benchmarking techniques work best in large pools of homogenous firms producing products and services for a market through transactions of commerce. The application of the techniques has highlighted issues in both the sample size and variation in network attributes in the United Kingdom and Norway - both jurisdictions of much less variability of geography, network size and climate than Australia. Normalisation is difficult because it relies on measuring environmental variables at a level that does not necessarily reflect the impact on costs. For example, the number of heating days in Queensland can be used as a measure of the relative influence of climate on Ergon Energy’s operations, but with a network area of almost 2 million square kilometres, the relevance of the measure is difficult to define.

Model errors and bias are always present in economic analysis, which is not an issue in itself, but the diversity of conditions in Australia and in the inherent network designs means that a particular model specification will provide advantage for some businesses and disadvantages for others. Consider the preferred and alternative specifications of the AER’s economic benchmarking models:

	Preferred model	Alternative model
Inputs	Opex, overhead line length (MVA-kms), underground line length (MVA-kms), transformer capacity (MVA)	Opex, overhead line length (MVA-kms), underground line length (MVA-kms), transformer capacity (MVA)
Outputs	Customer connections, distribution capacity (kVA-kms), reliability	Customer connections, peak demand, reliability

Academically and in practice, there is little consensus as to what constitutes a DNSP output. This point was highlighted by the AER itself in its Better Regulation Issues Paper released in December 2012. The outputs identified by the AER are shown above in the preferred model, however other common outputs include peak demand, energy delivered, service area and network length. Below are benchmarking rankings using 2008/9[2] data and replacing distribution capacity with peak demand as a variable in an MTFP model - that is, the rankings using the AER preferred model are on the left, and the alternative model rankings are on the right (a position towards the top of the graphic indicates a higher relative productivity ranking).

Output Choice and MTFP Rankings



This representation of alternative model specification results not only shows the significant sensitivity of the results to the specification, but also highlights the inherent bias discussed previously. Closer examination shows that the only networks that are favoured in the alternative model are the small, high density, urban networks in Melbourne (Citipower, Jemena and United Energy) and Canberra (ActewAGL). These networks are condensed and meshed

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[2] 2008/9 data has been used as it is the last date from which publicly available data for most Australian DNSPs could be found. Given the relative consistency in the size of inputs and outputs such as capacity, line length, peak demand and customer connections we believe results from using 2008/9 data are likely to be analogous with results using more recent data. Furthermore, the graph highlights the sensitivity of benchmarking results to model specification - this sensitivity is inherent within the approach adopted by the AER regardless of which years data is used.

(the Melbourne networks benefit from the city's flat, grid layout and ActewAGL's subtransmission substations are in a ring pattern) in a small area so their distribution capacity measured in kVA-kms (an output of the preferred model) is small relative to transformer capacity measured in MVA (an input of both models). On the other hand, these businesses also have higher utilisation due to the absence of long radial feeders and therefore peak demand (an output of the alternative model) is higher relative to transformer capacity.

Also of interest is the sharp, opposing direction of businesses with the same management structure and service providers, such as CitiPower and Powercor - indicating the significant influence of network characteristics when compared to any potential systemic managerial inefficiency.

As shown for Ausgrid, the preferred model is slightly more beneficial than the alternative model. However, note that the model construction and data format used by the regulator will differ to that applied by Huegin and whilst the general results may not vary considerably between one analyst and another, it does highlight a further uncertainty in the veracity of results.

The economic benchmarking outcomes may reinforce recent and existing DNSP efforts

Depending on which side of the line of inherent bias each business falls after model specification, the outcomes of the regulatory benchmarking may or may not be favourable. As mentioned earlier, the outcomes of both the regulatory benchmarking efforts in shifting the industry toward a hypothetical efficiency frontier may align with the reform programs most businesses are undertaking themselves. The AER's benchmarking methodology applies economic benchmarking to examine relative efficiency and then more detailed techniques to determine the location in the business where inefficiency resides and the magnitude of adjustment required. If the model specification and particular category benchmarks produce the same signals as the businesses themselves have observed and acted upon, the forecast expenditure arrived at through the AER's analysis may not differ materially from that of the businesses, despite the ranking on the first pass MTFP analysis.

The risk for businesses resides in circumstances where the drivers of their costs are not captured by the modelling techniques. In this case, the businesses will need to provide evidence to justify any deviation from the costs modelled by the economic benchmarking techniques. Thus it is a useful exercise to conduct similar modelling even if it only appears to serve the purpose of validating cost saving programs already under way. The risk of not knowing this information is that an immediate efficiency adjustment based on an unexplained model residual is forced upon a expenditure path that has already had management intervention.

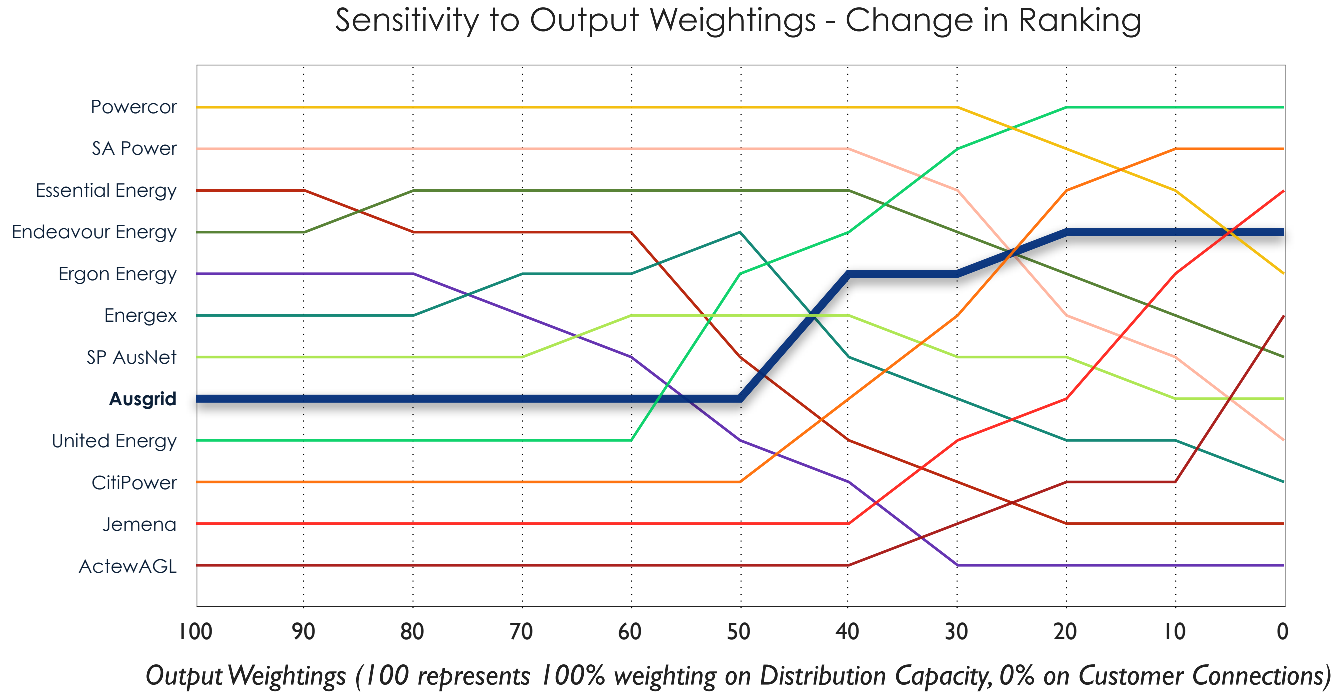
Signals for Ausgrid

To the extent possible by the available data and without confirmation of the exact specification of the AER's economic benchmarking models, Huegin has developed its own economic benchmarking models to present analysis of likely outcomes for electricity distributors. Focusing on Ausgrid, the following sections provide an insight into likely outcomes from an industry-wide economic benchmarking approach. Whilst limited in the ability to inform the existence or magnitude of actual inefficiency, the exercise does at least highlight possible signals that an analyst conducting economic benchmarking observes.

Economic benchmarking is unlikely to show NSW businesses on the efficient frontier

As shown in the earlier plot of MTFP rankings using the preferred and alternative model specifications of the AER, Ausgrid is unlikely to be the most efficient through an MTFP ranking. Using the model specification and data from our model, Ausgrid can expect to land somewhere near the division between the top and second quartiles of the rankings.

The selection of variables is not the only degree of freedom absorbed in the construct of the economic models used by the AER. The relative weighting of the variables will also influence relative rankings. The graph below shows the MTFP rankings based on a model built to the preferred AER specification, but with a variation in the weightings of the two output variables, distribution capacity and customer connections. The far left axis of the plot shows the rankings using a 100%:0% split of the weightings on Distribution Capacity and Customer Connections respectively, continuing through varying the split all the way to a 0%:100% split of weightings.



Naturally, urban distributors are favoured by a higher weighting on customer connections. Assuming that the weightings are unlikely to be positioned close to either end of the range, Ausgrid can expect to be placed between fifth and eighth in terms of its efficiency ranking.

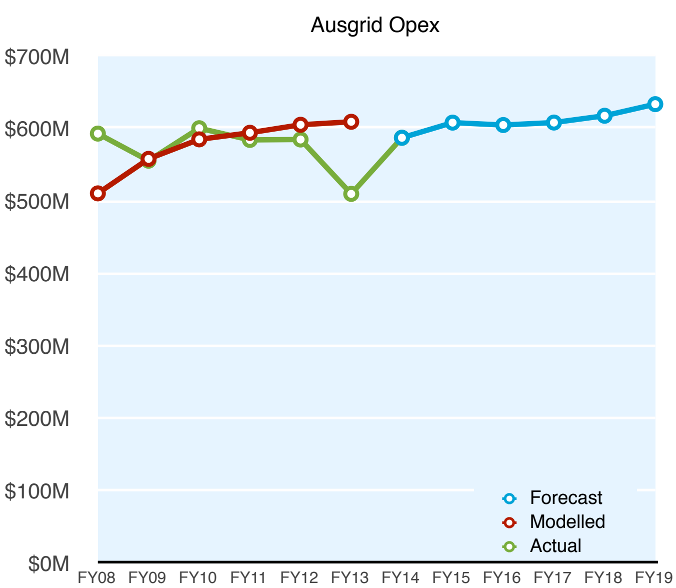
Again, the analysis will change with the release of the AER's exact model specification and industry data, however these ranges are not unexpected for Ausgrid based on previous studies and our experience with the application of economic benchmarking in Australia.

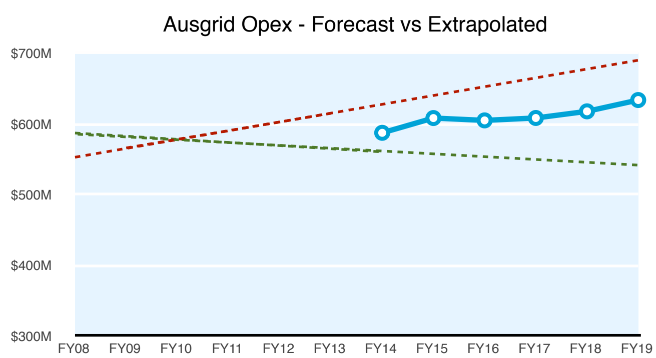
Analysis can identify potential outcomes for individual businesses within the industry

Understanding where a business stands in the rankings of productivity of industry participants is interesting, but perhaps not useful. An understanding of the difference between modelled future costs and an individual business' own forecast expenditure is useful. The AER will predict augmentation and replacement capital expenditure requirements through their augex and repex models respectively. Augmentation and replacement capital expenditure constitute the majority of an electricity distributor's capital program and businesses are encouraged to compare their bottom-up forecasts with the results of the augex and repex models. This analysis is beyond the scope of this report, however category benchmarks for many capital expenditure categories are included later in this report.

Operating expenditure, however, can be modelled using the AER's intended technique - that of econometric analysis. The AER intend to use econometric models to assess base year efficiency and to predict an efficient level of operating expenditure. More information on econometric models is included in Appendix I, but for the purposes of illustrating the application of this statistical technique to a distributor's historical and forecast opex, Huegin have constructed a model based on the information in the regulatory guidelines. Below is a plot of the predicted opex for Ausgrid, compared to actual and forecast opex. Ausgrid's opex in the current period has remained flat, decreasing towards the latter years. This decrease sees Ausgrid's opex move from a position above that predicted by an econometric model, to a position below - where it remains for the forecast next regulatory period. The forecast is, however slightly higher than the extrapolated historical expenditure.

Ausgrid - *forecasts are above historical trend, but below predicted spend*





Variation between:	$	%
Extrapolated Actual and Forecast	-$315,825,000	-10%
Extrapolated Modelled and Forecast	$185,450,000	6%
Extrapolated Actual and Extrapolated Modelled	$501,275,000	15%

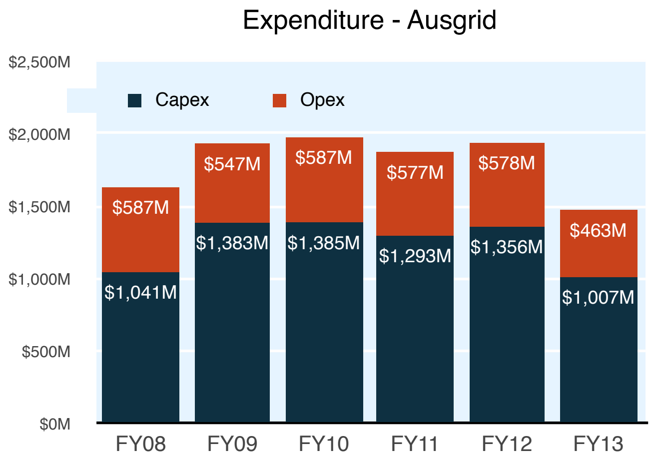
Notes:
1. All dollar figures converted to FY13/14 dollars.
2. No adjustments made to actual figures for non-recurrent costs.
3. Modelled opex is based on extrapolated values from the Huegin econometric model - the AER analysis will differ.

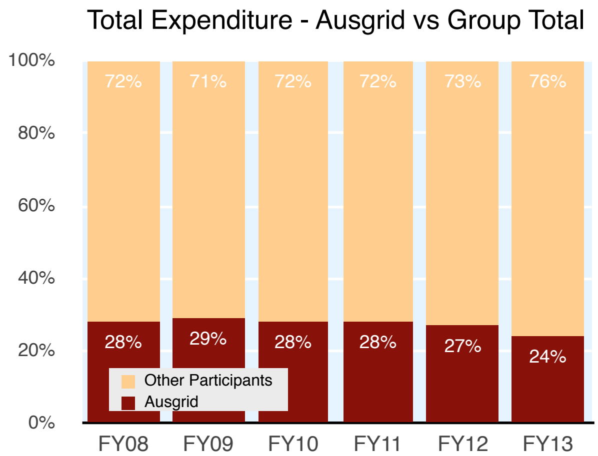
There are more simple means of testing performance

Much of the economic analysis is dependent upon incremental changes in the inputs and outputs defined in the models compared to the industry changes in inputs and outputs. Given the inherent inaccuracy of models, often simple comparisons of rates of change can provide just as much information as detailed calculations of productivity change. This is particularly true of electricity businesses where most of the recurrent costs in the business are fixed in nature and changes in outputs have very little effect on total costs. For example, increased replacement activities due to the network asset age and condition have a much more significant impact on *change* in costs than incremental additions of customer connections. However network age and condition are the result of legacy decisions stretching back decades and are not accounted for in economic benchmarking (other than in an increase in cost).

Comparisons of simple cost trends can therefore provide insight into likely performance in industry economic benchmarking models. How those cost changes have occurred will determine the level of justification required of a business in explaining any variation from the regulatory modelled forecasts that is not accounted for in the model specification. Below and on the following pages are comparisons of trends and annual rates of change for expenditure, showing Ausgrid compared to the benchmarking group average in the period 2008 to 2013 and current and forecast (where available) trends for each individual business.

Aggregate Trend Analysis - Ausgrid and the Benchmark Group

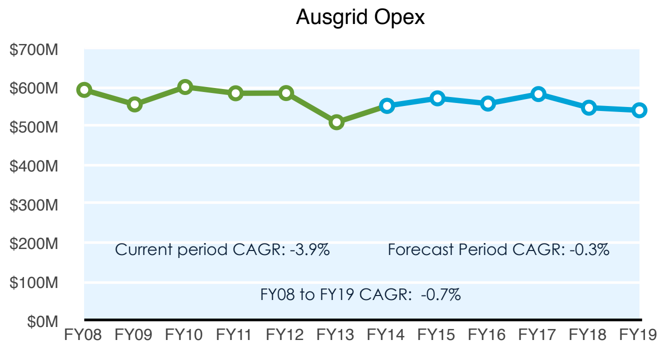


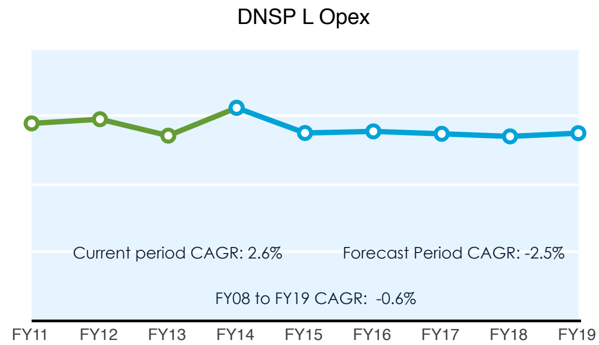


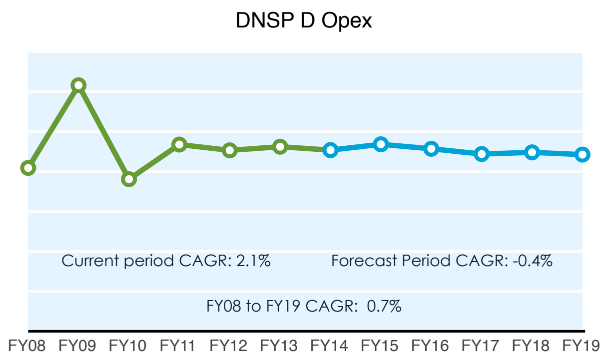
Ausgrid's expenditure has fallen in the most recent complete financial year to levels below the FY08 value in both capex and opex.

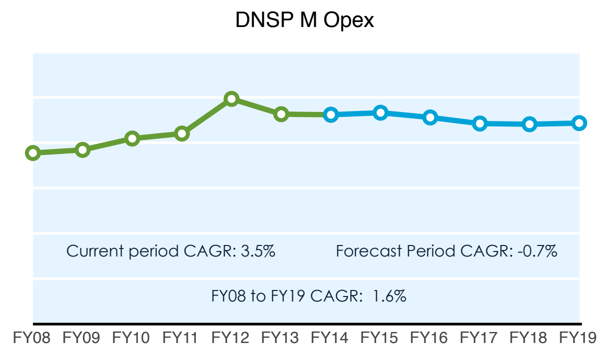
*Amongst the benchmark group, Ausgrid's "share" of total group expenditure has fallen from **28%** in FY08 to **24%** in FY13.*

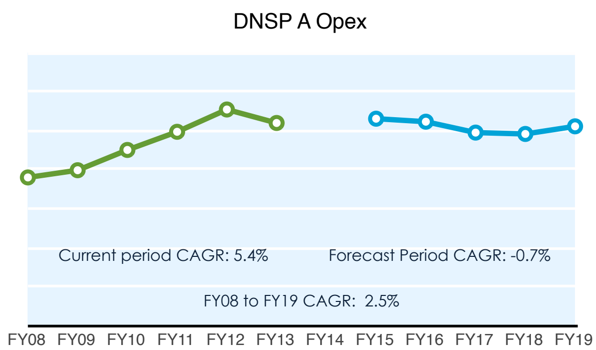
DNSP Opex Trends - Actual and Forecast

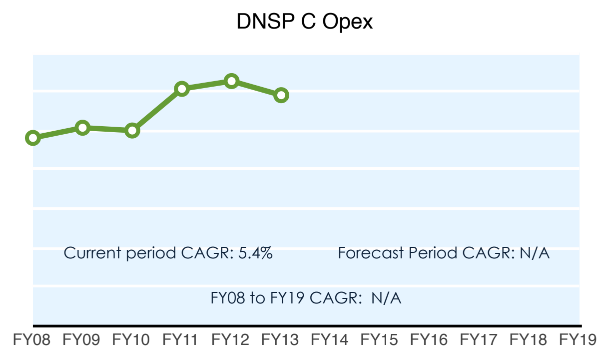


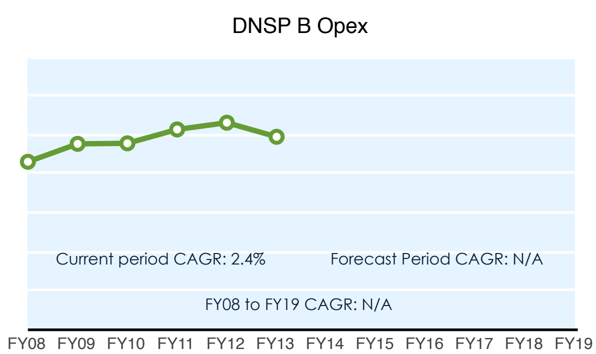








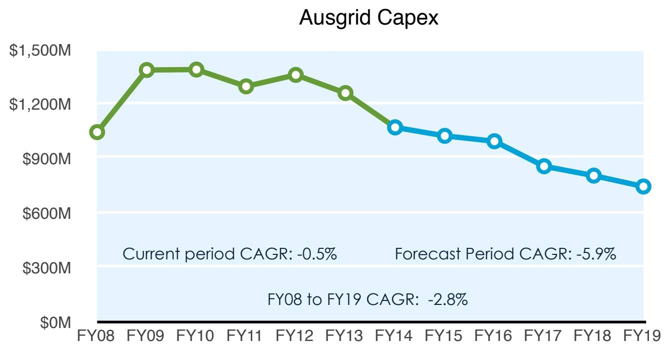


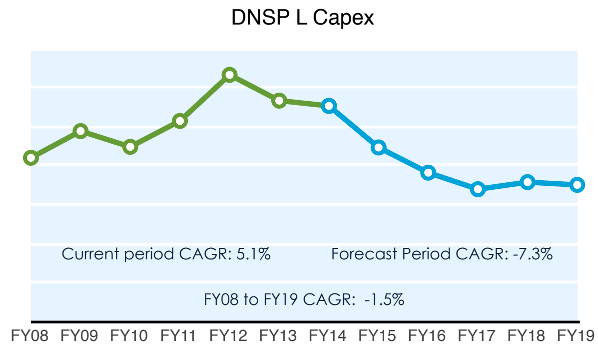


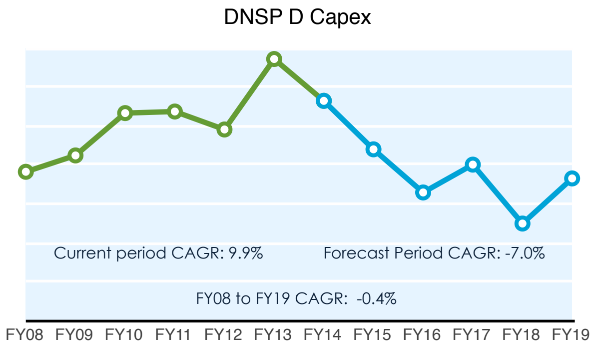
Notes:

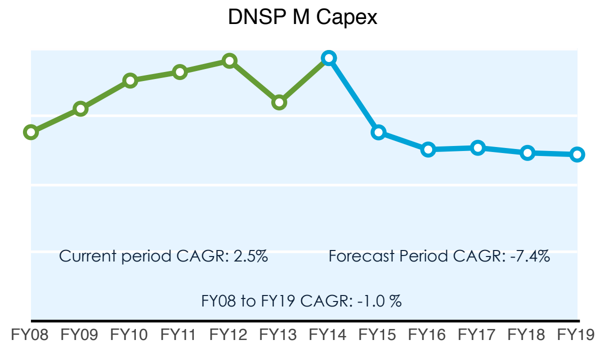
1. All figures in FY2013 dollars.
2. Data sources are the RINs and directly supplied data from DNSPs.

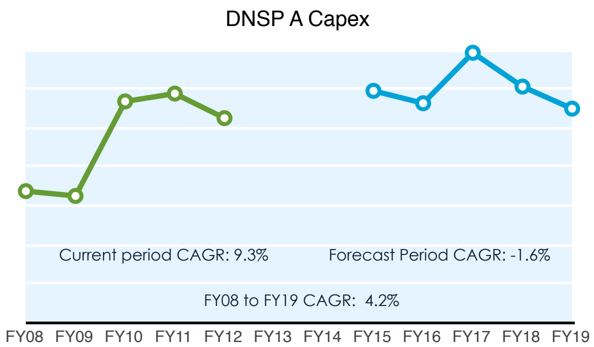
DNSP Capex Trends - Actual and Forecast

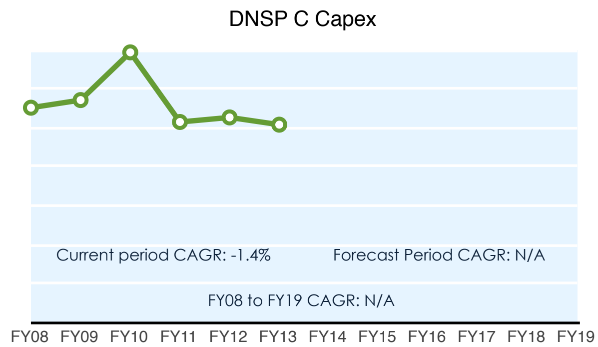


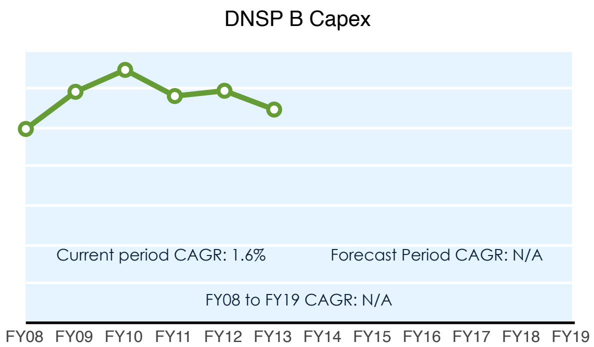












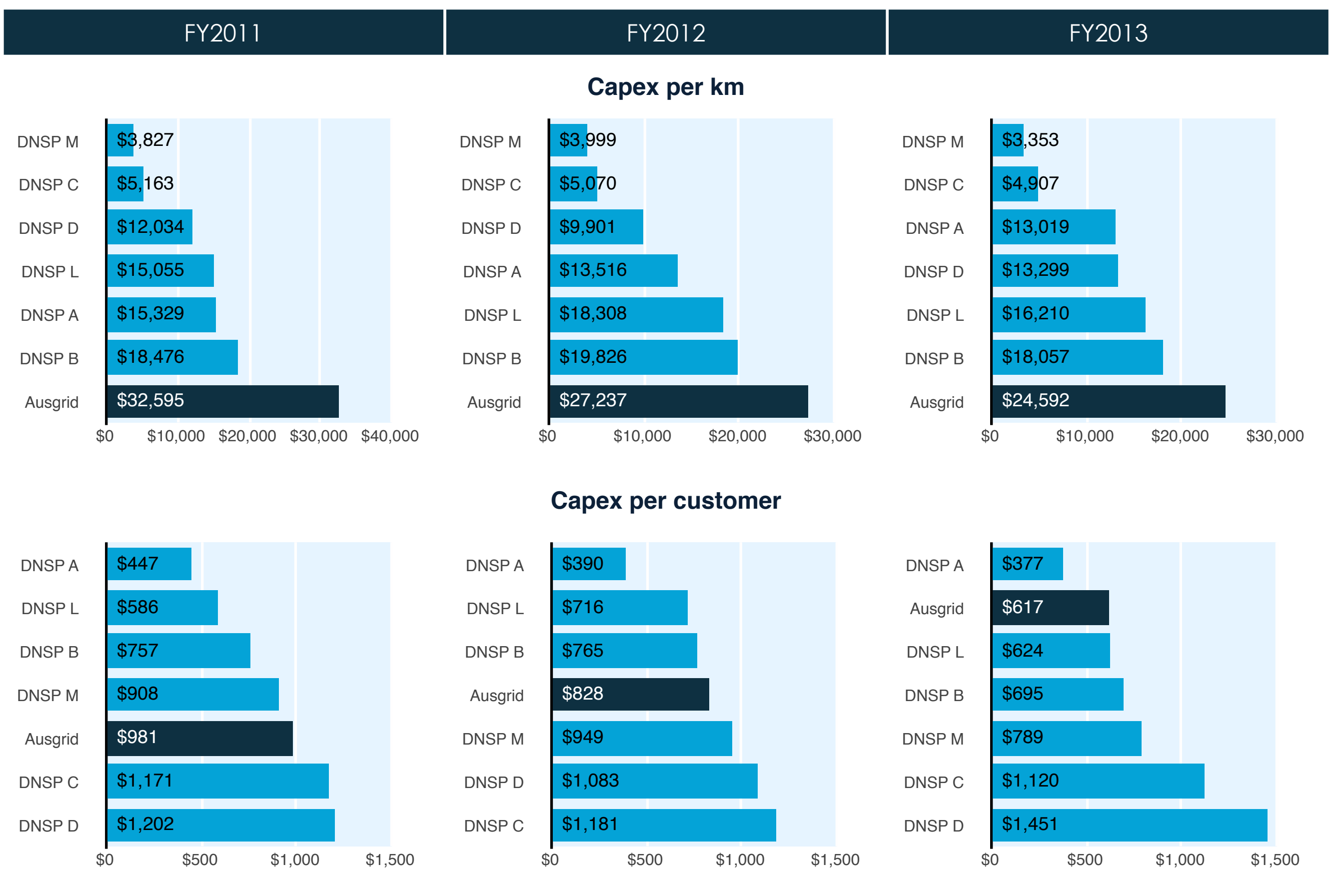
Notes:
1. All figures in FY2013 dollars.
2. Data sources are the RINs and directly supplied data from DNSPs.

Measuring Reform Progress

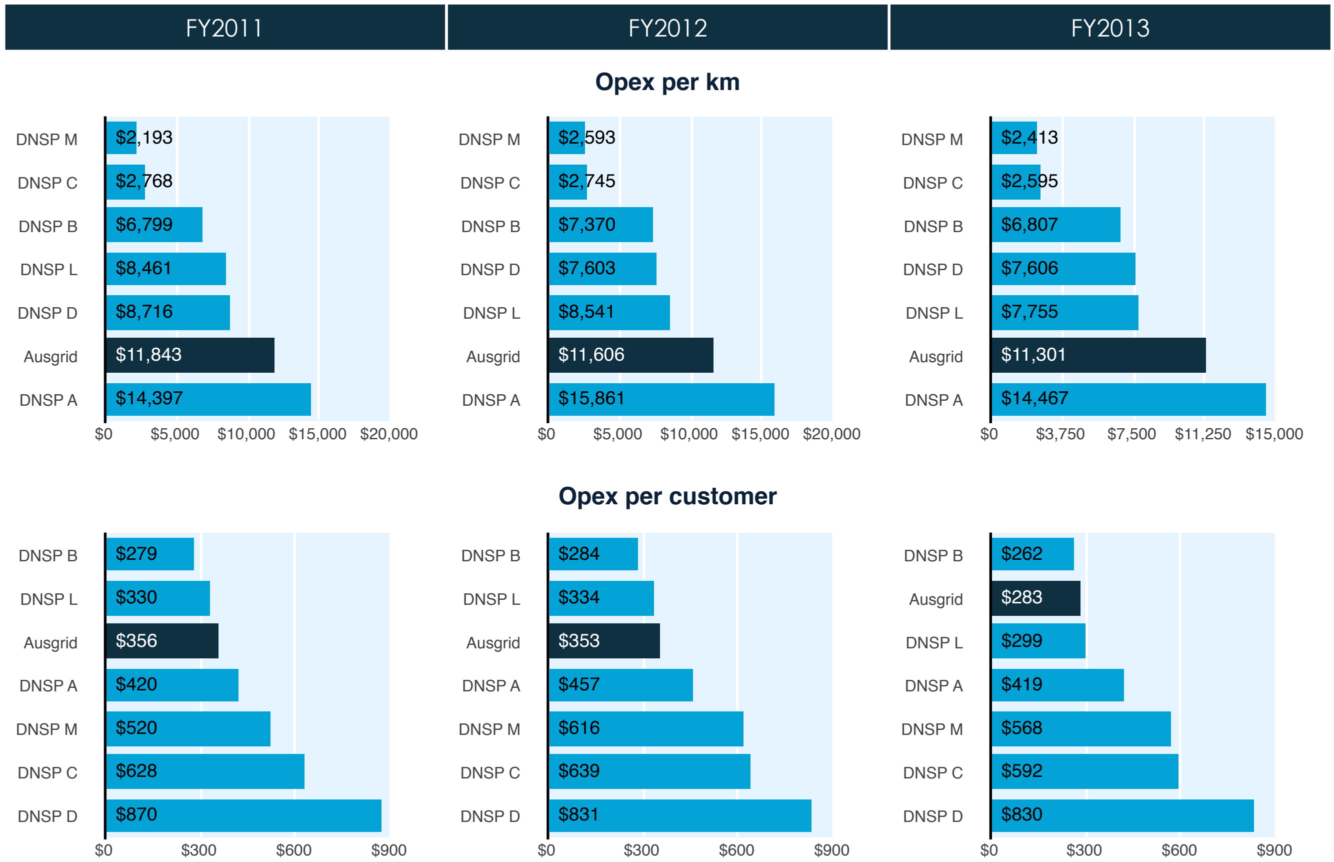
It is useful to understand the current benchmark position of the NSW businesses relative to peers given the considerable change in the past two years. The previous Huegin benchmarking report compared costs across many categories for nine distribution businesses. The report highlighted some differences in cost outcomes and also identified many drivers of those costs. However, the report was based on data up until the 2011 financial year. Given that many of the businesses have also reformed or restructured since then, a more current comparison of cost benchmarks is valuable - particularly given that due to the relativity inherent in economic benchmarking models, the extent to which individual distributor cost savings influence industry rankings depend on the savings made by the rest of the industry.

This section provides an update of some of the significant benchmarks from the previous study based on 2011/12 financial year data and 2012/13 financial year data where available. Whilst the relative positioning of the businesses in many of the categories may be expected, an updated understanding of the magnitude of any differences and, perhaps more significantly the direction of trends, sheds light on the success of cost management relative to peers. At a high level, the movement in the most common benchmark ratios over the past three years is shown below and on the next page. Whilst there is only minor "re-positioning" of businesses amongst the rankings, these incremental changes over time will be important in economic benchmarking techniques as the assessment of individual efficiency is dependent on small changes in large numbers measured against the industry changes.

Capital Expenditure Ratios



Operating Expenditure Ratios



Cost Ratio Positional Changes

Ausgrid's changes in the period for each ratio is summarised below (where a position of 1 indicates the lowest cost and 7 the highest). Positive and negative changes in ranking are highlighted green and red respectively. In relative terms, Ausgrid has improved in terms of Capex per customer and Opex per customer.

	Ausgrid Position		
	FY11	**FY12**	**FY13**
Capex per km	7th	7th	7th
Capex per customer	5th	4th	2nd
Opex per km	6th	6th	6th
Opex per customer	3rd	3rd	2nd

System capex is a large target

System capex - variously reported by businesses as the aggregate of asset replacement, augmentation (both customer and distributor initiated) and other reliability, quality, environmental and legal capital investments - is by far the largest pool of expenditure for an electricity distribution business. The ratio of this system expenditure to capital expenditure on non-system assets such as buildings, plant and fleet and IT varies by the type of business (location, ownership structure, opportunities for shared corporate costs, etc), with a range of 85 to 95% of all capital expenditure attributed to network assets for businesses across the NEM. A breakdown of system and non-system capex per customer by major NEM state is shown below for FY2011, showing the differences between the capital allocation across the states in that year. Capex when measured on a per customer basis will always in be lower in Victoria due to the much higher population density. Observations from this data include the higher percentage of capex attributed to replacement in NSW and the higher levels of non-IT, non-network capex in the government owned businesses of NSW and QLD.

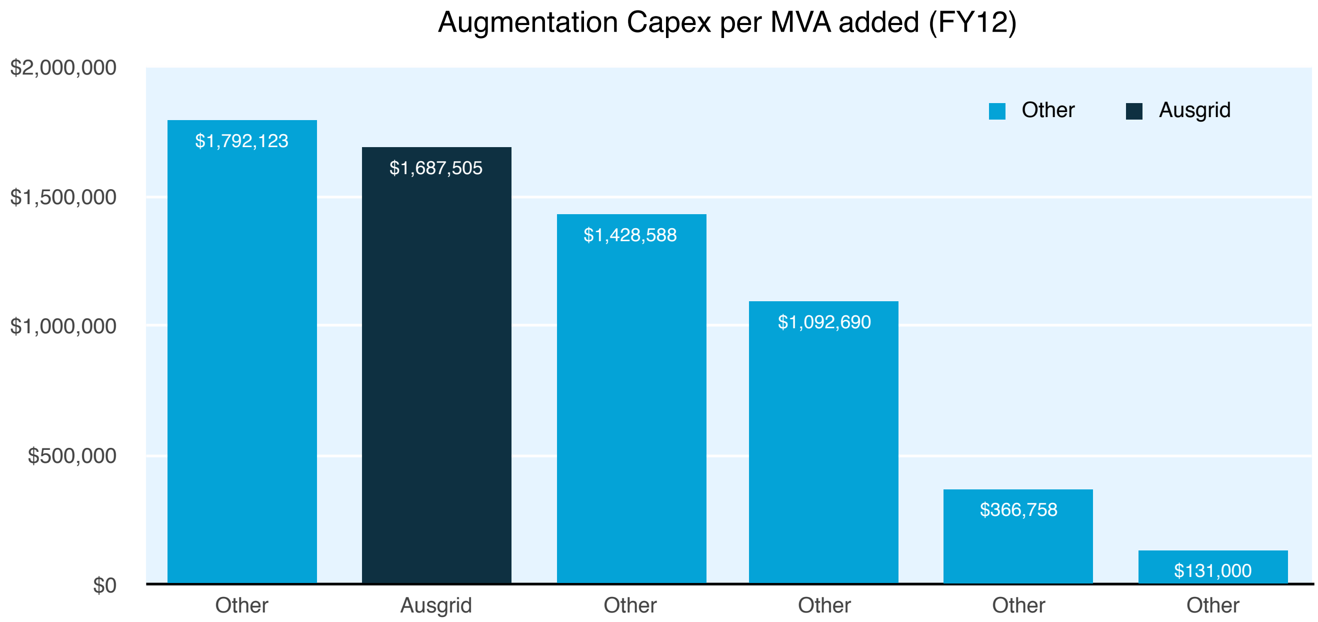
Spend Category	Victoria 2011	NSW 2011	QLD 2011
System Capex per Customer			
Growth - Demand & Connections	$225.05	$290.13	$494.79
Replacement, Reliability & Quality	$50.26	$272.05	$207.45
Environment, Safety, Legal	$57.94	$38.89	$37.89
SCADA and Network IT	$3.20	$33.69	$50.31
Subtotal - System Capex per Customer	**$336.45**	**$634.76**	**$790.44**
Non-System Capex per Customer			
Non-Network IT	$39.87	$32.63	$26.77
Non-Network Other	$12.75	$65.16	$70.13
Subtotal - Non-System Capex per Customer	**$52.62**	**$97.79**	**$96.90**
Total Capex per Customer	**$389.07**	**$732.55**	**$887.34**

Notes:
1. Victorian expenditure for 2011 is based on the AER allowance.
2. NSW and QLD expenditure data is from Regulatory Information Notices and data supplied directly to Huegin.

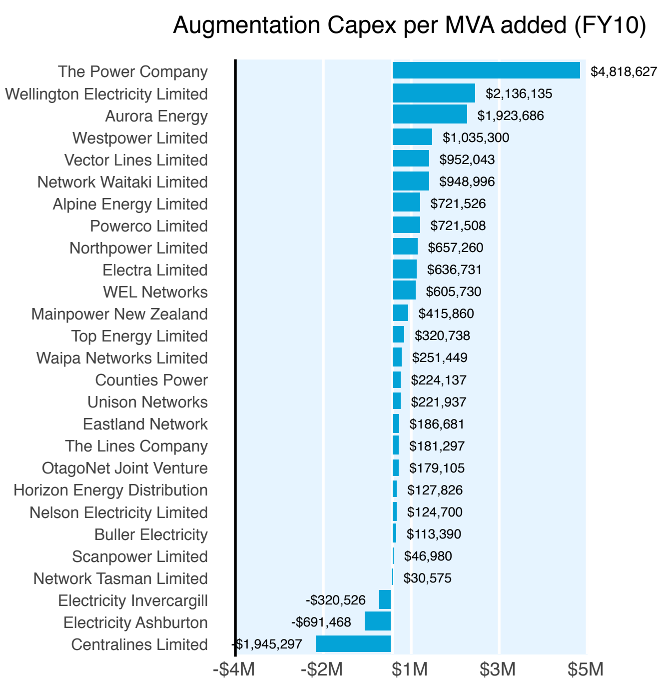
Across all businesses the majority of system capital expenditure is spent on replacing and augmenting network assets - with a historical average of 89% of all system capital expenditure attributed to these two activities. The significance of this figure is highlighted through the AER's intention to forecast these expenditure categories for each business using two MS Excel models - known as the repex and augex models for replacement and augmentation capital expenditure respectively. As discussed previously, reproduction of these models is beyond the scope of this report. General limitations of the models have been well documented through the AER's consultation process, with acknowledgement that the models provide an alternative forecast for the AER to determine the potential existence of anomalies in the forecast of a DNSP, which may be further scrutinised by other means such as category benchmarking. Category benchmarking of capital expenditure is not without its own limitations, most significantly the disconnected nature of the work activity with the accounting of the expenditure. Replacement and augmentation projects can run over several years with inconsistent spend profiles, rendering many cost ratio benchmarks inadequate. For example, one of the category benchmarks for augmentation capex suggested by the AER in the expenditure guidelines is capex per MVA of capacity added. An example of issues encountered in this approach is provided on the following page - showing the volatility of the benchmark over time.

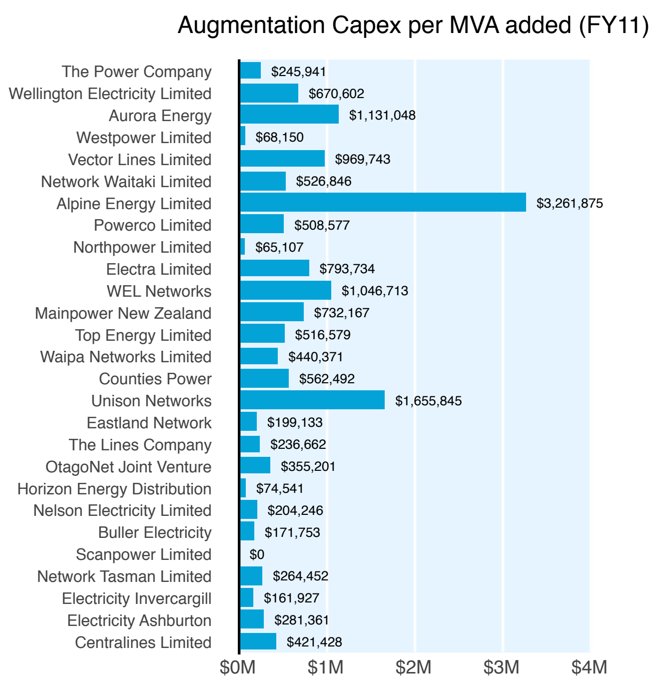
One of the reasons that this volatility exists is the discrepancy in time of the addition of the physical capacity and the capitalisation of the expenditure. Another is that at the macro level, the MVA differential from year to year is measured as a net difference - that is, it includes additions and subtractions through all activities. We understand that the AER intends to address these issues through a more specific data request in the category analysis data templates, however we hold reservations over the ability of each business to provide expenditure figures broken down as required by the category benchmarking RIN to the required level of accuracy.

Augmentation capex is difficult to benchmark; one readily available ratio is augmentation spend per MVA capacity added...



...but as illustrated by data from New Zealand, the ratio is limited in its ability to inform relative efficiency assessments



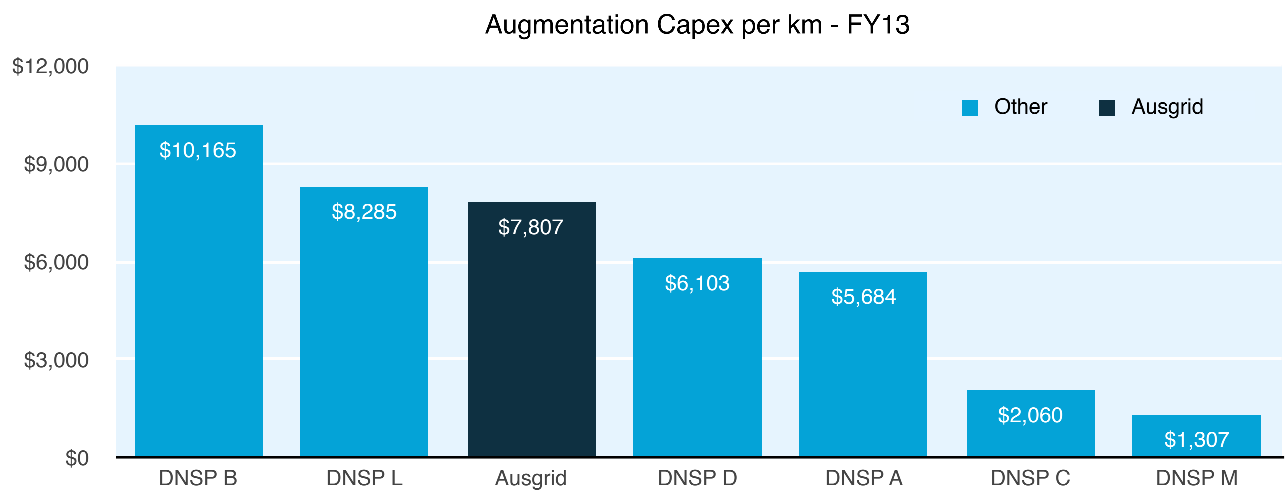


Not only are some individual years negative, but the volatility from year to year is significant, with the businesses ranked from highest cost to lowest on the basis of the FY10 results in each plot.

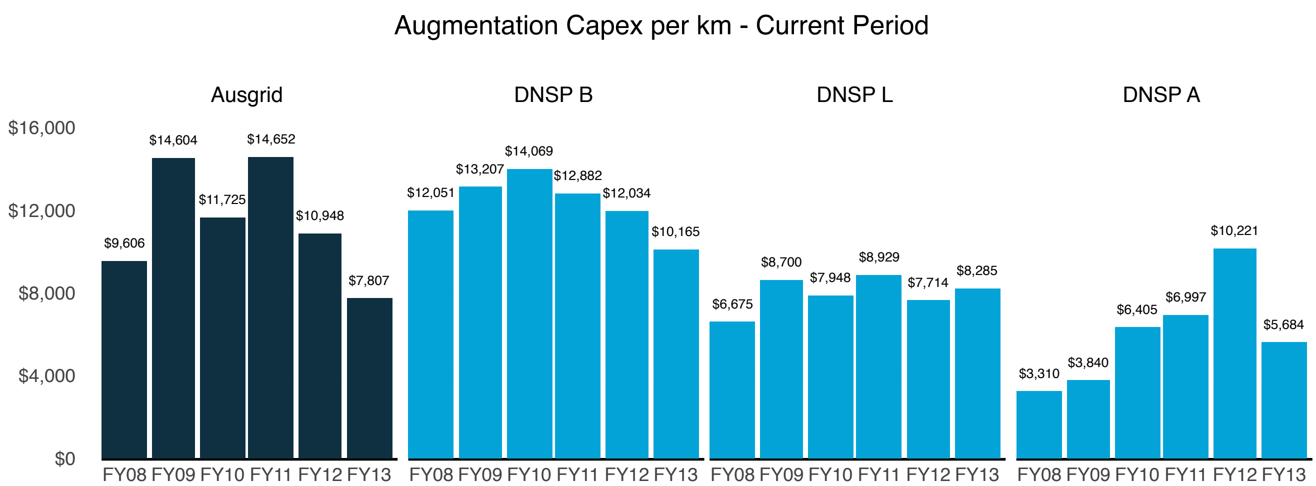
Recent conditions will place a focus on augmentation capex

Notwithstanding the limitations of benchmarking augmentation capital expenditure outlined on the previous page, augmentation capex is likely to be of significant interest to the regulator due to flattening (and in some cases, falling) demand during this current regulatory period and the media and political suggestions that electricity price increases have largely been caused by an increased will of the businesses to augment the network[3]. The following pages show comparisons of augmentation capex within the benchmark group and over time - both in this period and the forecast for the next.

Network kilometres is a more stable comparator of augmentation capex, albeit limited in its describing power. Whilst augmentation capex per km can be compared in a given year (see below), the variation across businesses is due mainly to the size, nature and scale of the businesses - with higher unit costs for CBD/urban, underground assets than long, radial rural networks.



To provide some level of context for these current cost ratios, the augmentation capex per km ratio is shown below over time for Ausgrid and the three DNSPs in this study with conditions and attributes most similar to Ausgrid.



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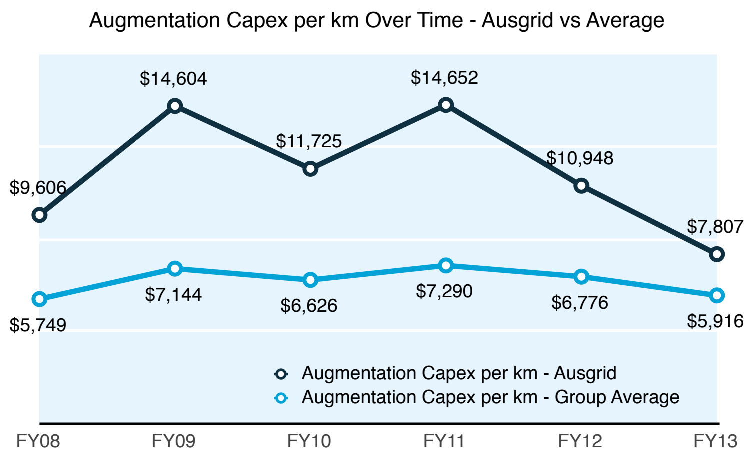
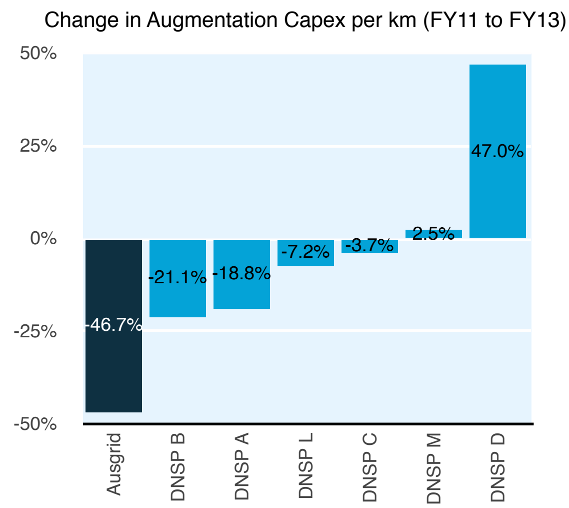
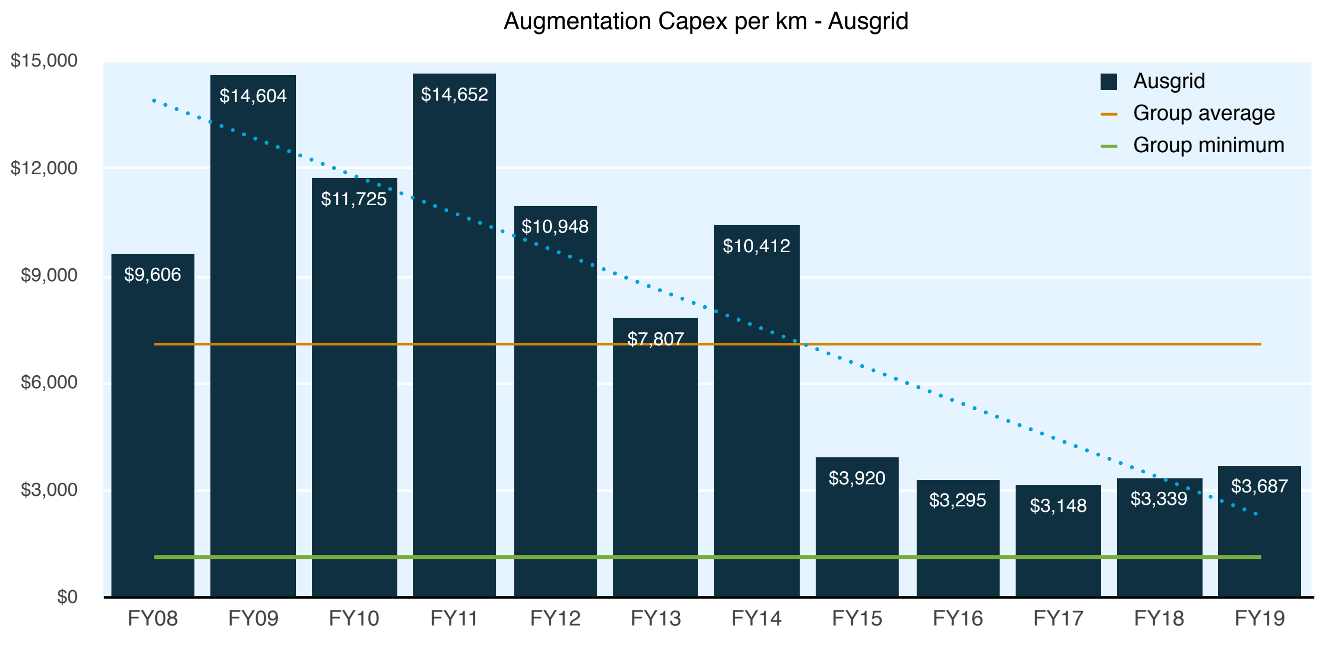
[3] Whilst this is a broadly held view, and somewhat supported by the step change in nationwide augmentation capex at the start of the current period, analysis of these augmentation costs over time and replacement costs over time show that in this period, increased rates of replacement of existing assets has outpaced augmentation growth rates.

As shown in the previous graphic, Ausgrid's augmentation capex per km has decreased significantly. To show the change in this ratio during this period in the context of the benchmarking group, the graphs below depict the Ausgrid augmentation capex per km over time against the group average and the relative change in this ratio for the latest three years.





Finally, the augmentation capex forecast can be compared to the group statistics in this period. The graph below shows the recent and forecast augmentation capex per km, long term trend, and the current period group average and minimum.

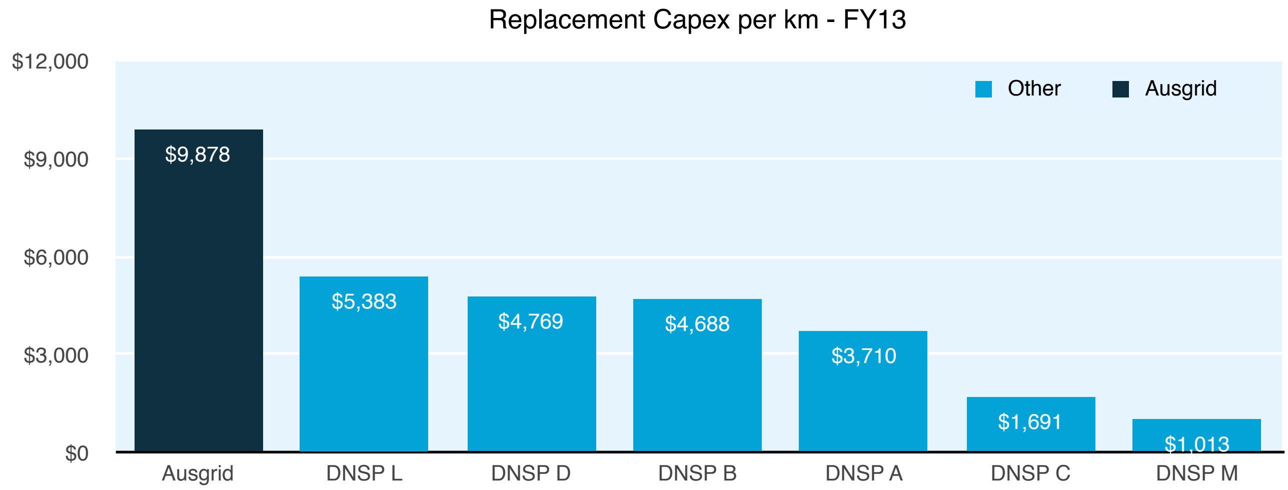


Notes:
1. All figures in FY2013 dollars.
2. Network km for future years have been forecast using the historical growth rate (0.1%).

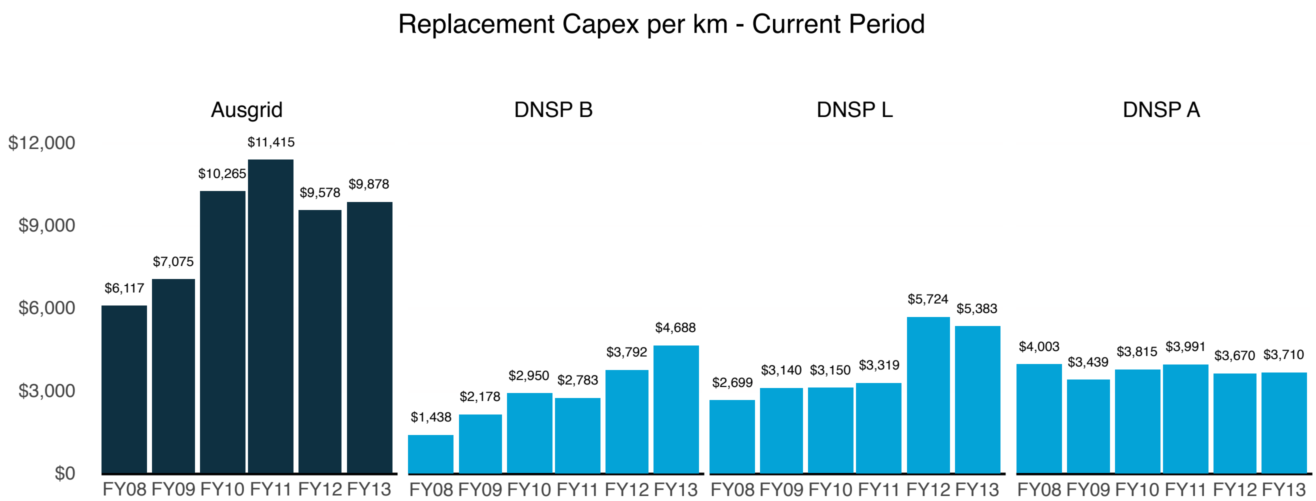
Replacement capex remains a significant driver for Ausgrid's aged assets

The following pages show comparisons of replacement capex within the benchmark group and over time - both in this period and the forecast for the next.

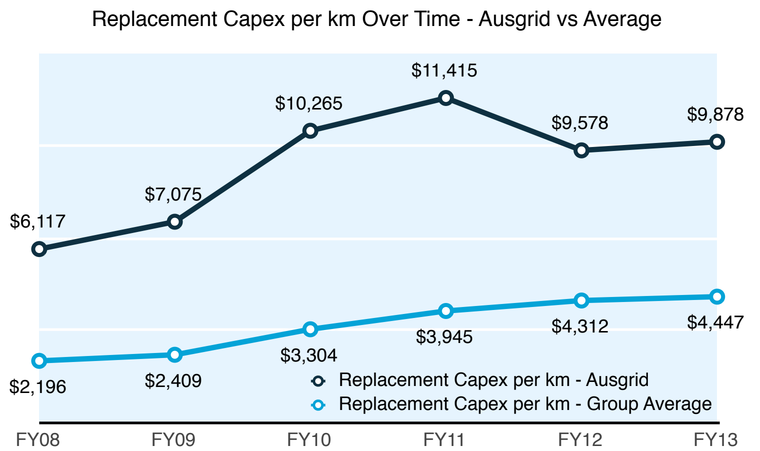
Replacement capex is a significant contributor to Ausgrid's expenditure; the comparison of the cost of replacing assets per kilometre of network amongst the group is shown below for the most recent year.

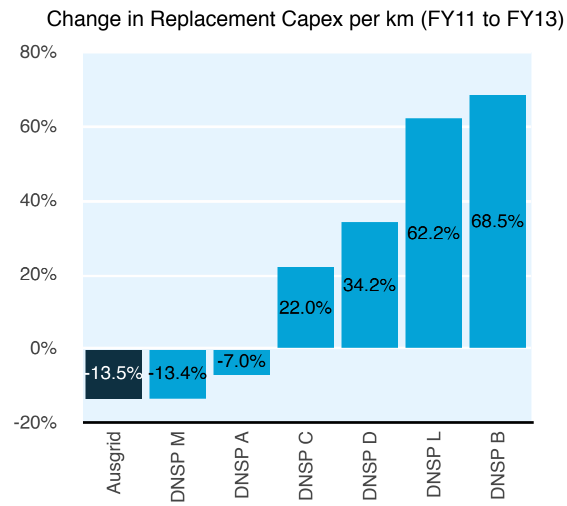


As shown below, the intensity of Ausgrid's asset replacement program has increased in the current period; and whilst some of Ausgrid's closest peers have also increased costs using this ratio, Ausgrid's replacement capex per km remains the highest of the benchmarked businesses.

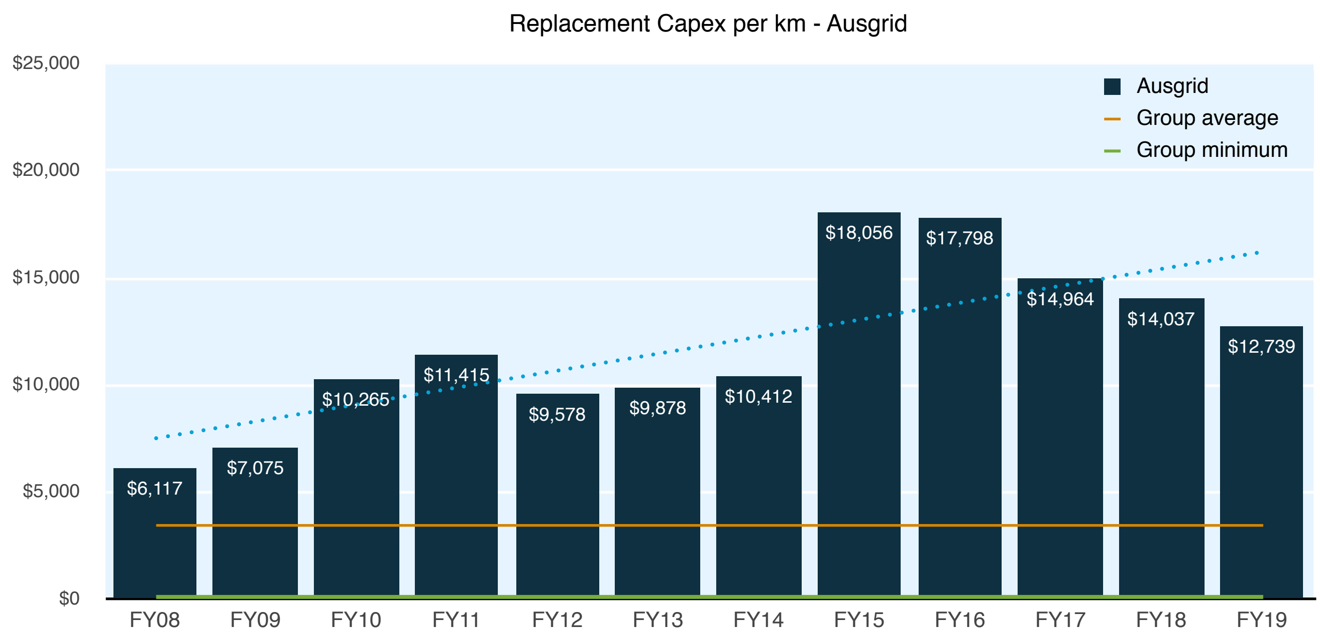


As shown in the previous graphic, Ausgrid's replacement capex per km has increased steadily. To show the change in this ratio during this period in the context of the benchmarking group, the graphs below depict the Ausgrid replacement capex per km over time against the group average and the relative change in this ratio for the latest three years. As shown, whilst Ausgrid's replacement capex per km is relatively high, it is increasing at approximately the same rate as the group average, and in the most recent three years has decreased more than any other business in the study.





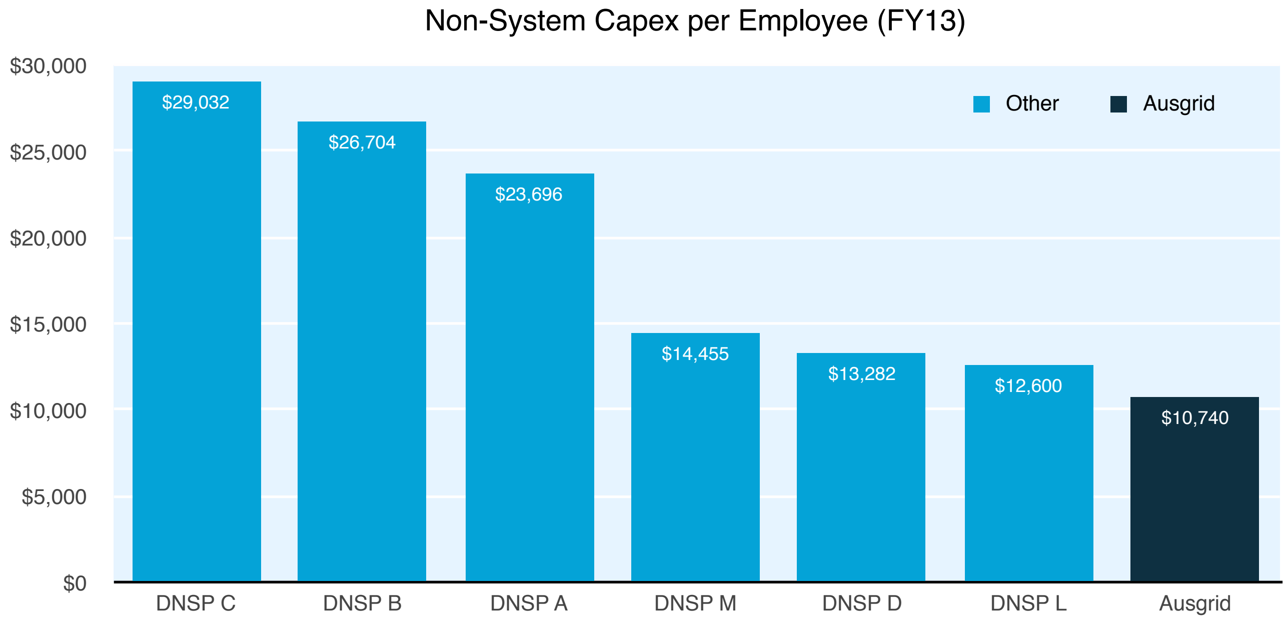
Finally, the replacement capex forecast can be compared to the group statistics in this period. The graph below shows the recent and forecast replacement capex per km, long term trend, and the current period group average and minimum. When viewed in conjunction with the augmentation capex results,



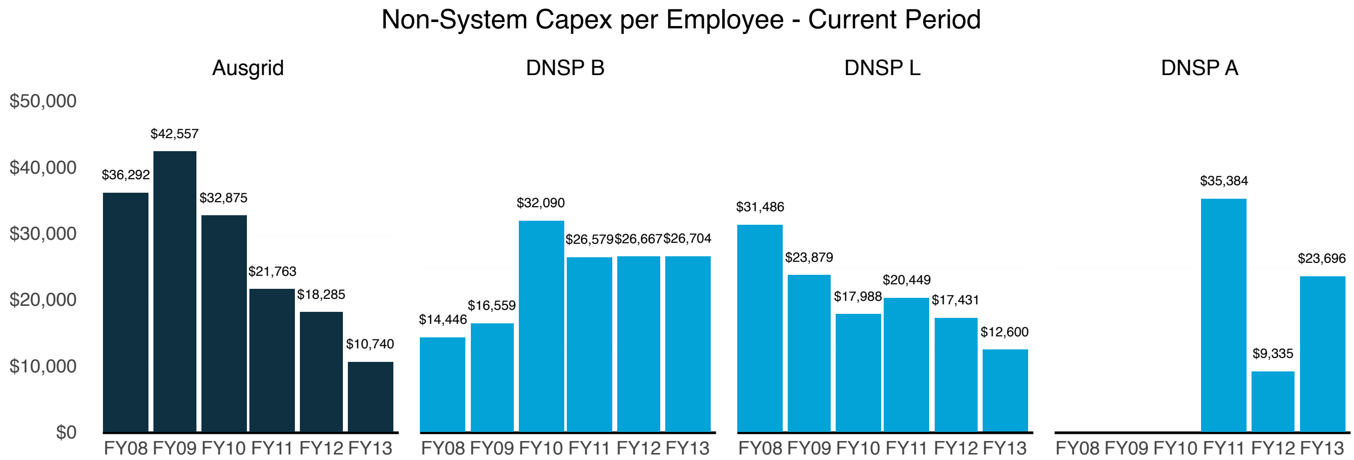
Notes:
1. All figures in FY2013 dollars.
2. Network km for future years have been forecast using the historical growth rate (0.1%).

Non-System capex has been influenced by reform initiatives

Non-system capex includes the capital spent on plant and motor vehicles, property and land and non-system IT assets. A primary driver of non-system capex is the number of employees in the business. A comparison of non-system capex per employee for FY13 is shown below.

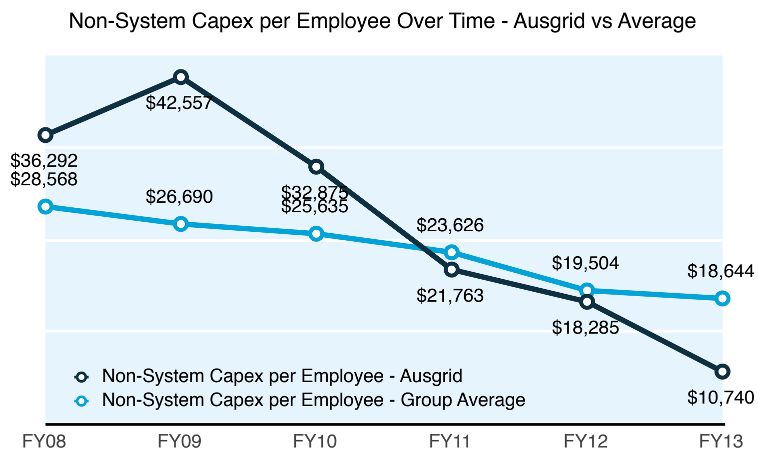


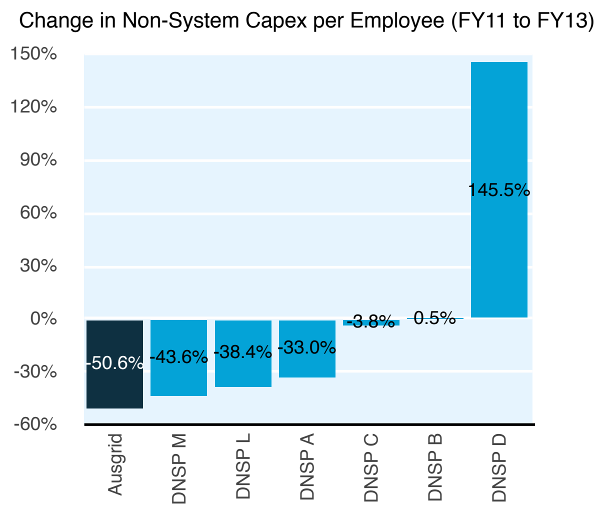
As shown below, Ausgrid has "caught up" to, and overtaken, its peers on this benchmark ratio during this period.



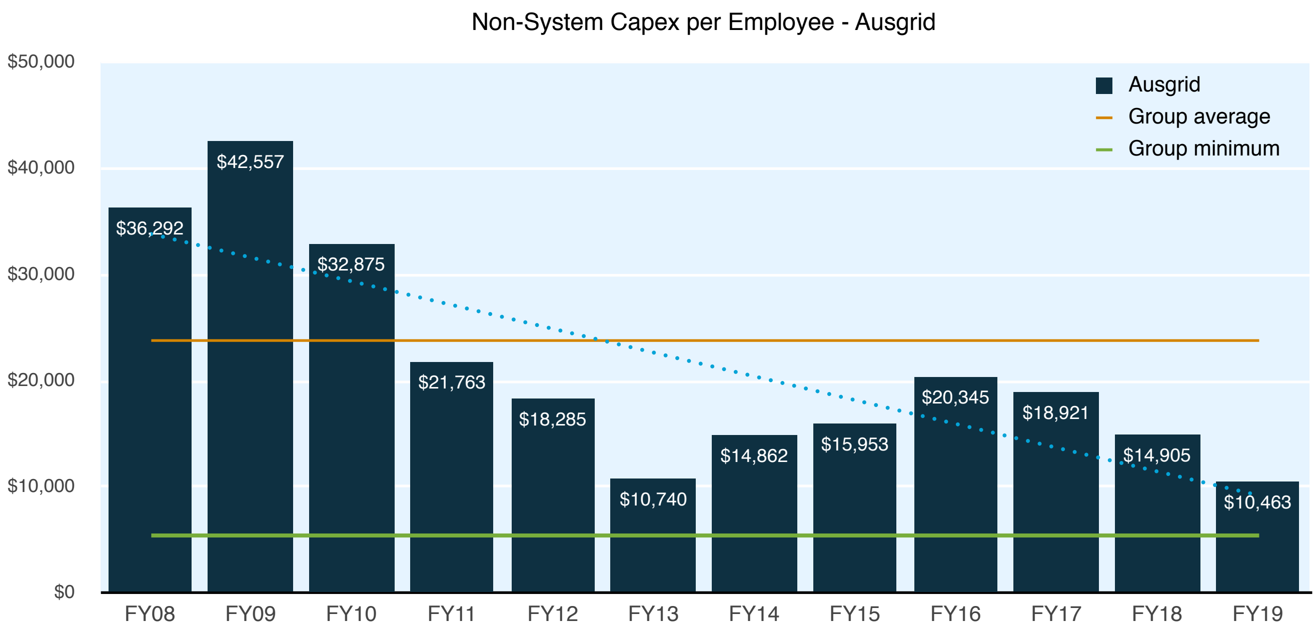
Appendix 2 includes further non-system capex category benchmarks.

To show the change in non-system capex performance during this period in the context of the benchmarking group, the graphs below depict the Ausgrid non-system capex per employee over time against the group average and the relative change in this ratio for the latest three years. As shown, the decrease in this cost category for Ausgrid has seen it dip below the group average, which itself is decreasing. In the most recent three years, many businesses have had significant decreases in this category (industry reform has targeted this category); Ausgrid has had the largest decrease.





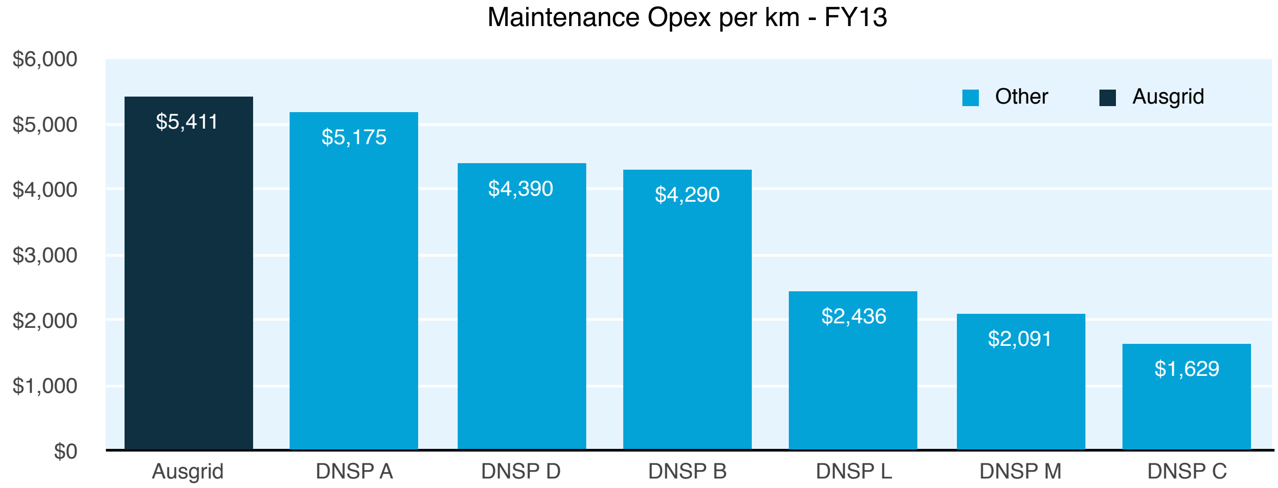
Finally, the non-system capex forecast can be compared to the group statistics in this period. The graph below shows the recent and forecast maintenance opex per km, long term trend, and the current period group average and minimum.



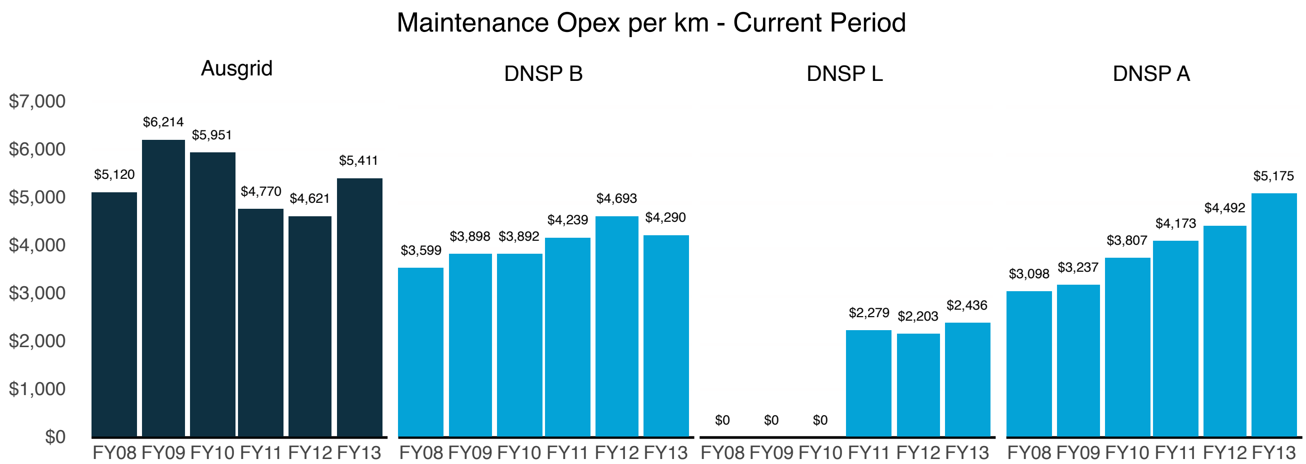
Notes:
1. All figures in FY2013 dollars.
2. Employee numbers for future years have been held at the current (FY13) figure.

Ausgrid's maintenance costs are similar to other urban businesses

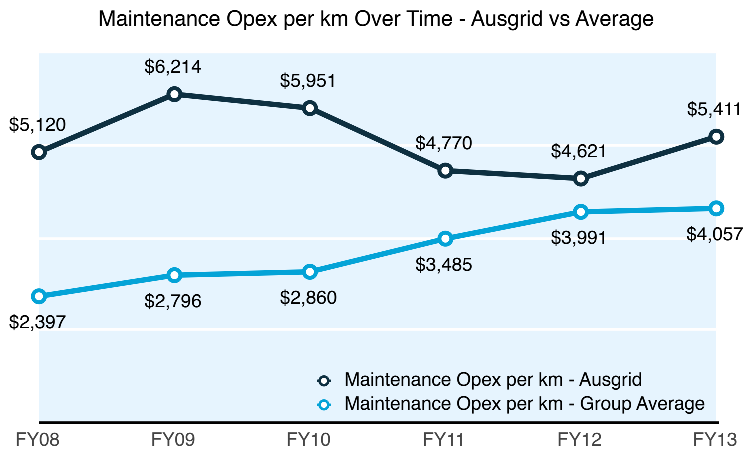
In most cases, more than half of a DNSPs maintenance costs are related to vegetation management and inspection activities (such as planned periodic pole inspections). As such, maintenances costs are largely dependent upon the mobilisation of resources along network routes. A primary cost driver of maintenance costs is therefore the geographic location of the network. Long, radial networks in regional and rural areas carry a significant cost premium in travelling between assets. Dense, urban networks require less travel between assets, however accessibility issues are usually greater (e.g. traffic congestion, proximity of other services, etc.). Comparisons of maintenance costs per kilometre for the 2013 financial year is shown below.

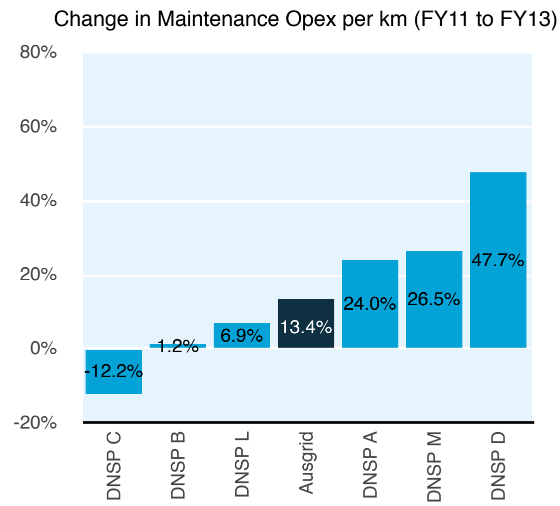


As shown below, Ausgrid's maintenance costs are relatively stable in the current period and within the range of its closest peer networks.

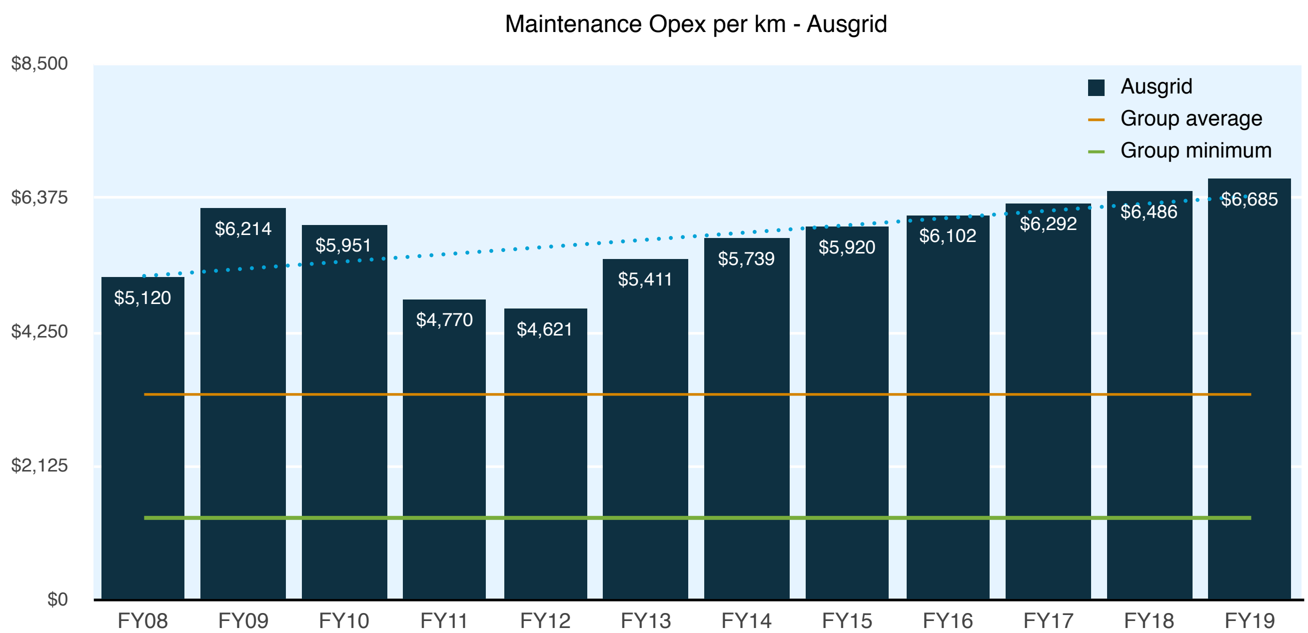


To show the change in maintenance opex performance during this period in the context of the benchmarking group, the graphs below depict Ausgrid's maintenance opex per km over time against the group average and the relative change in this ratio for the latest three years. As shown, the gap between the Ausgrid maintenance cost per km and the group average has reduced over time. In the most recent three years, many businesses have had significant increases in maintenance costs; Ausgrid has the third lowest rise in the group, with the jump in the most recent year driving the increase.





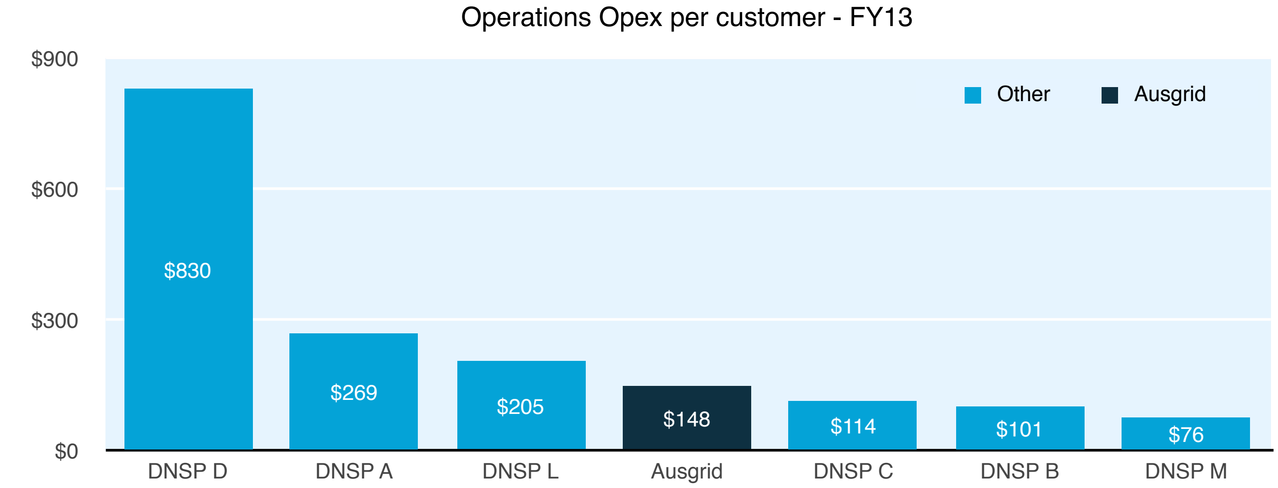
Finally, the maintenance opex forecast can be compared to the group statistics in this period. The graph below shows the recent and forecast maintenance opex per km, long term trend, and the current period group average and minimum.



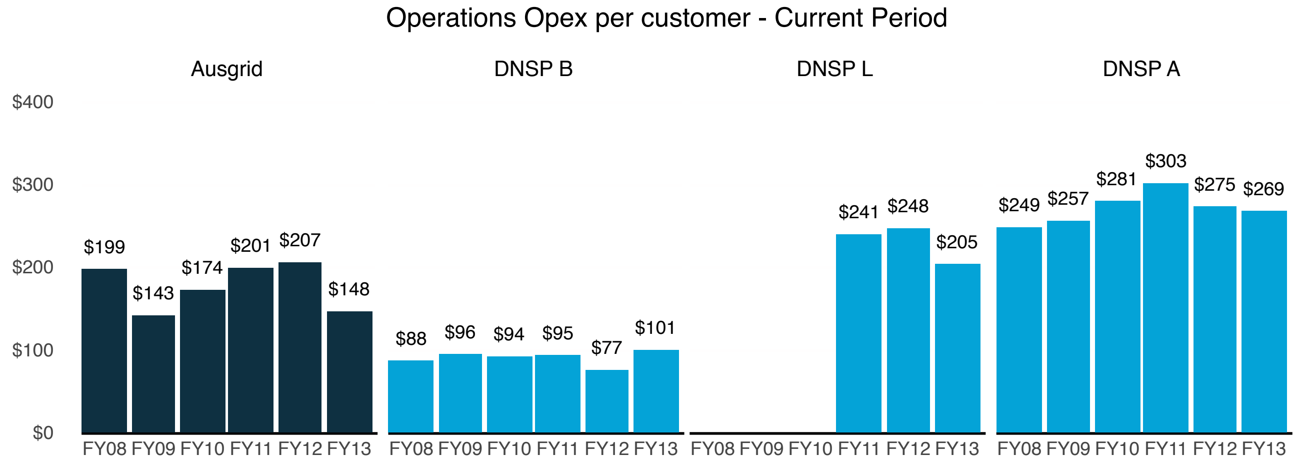
Notes:
1. All figures in FY2013 dollars.
2. Network km for future years have been forecast using the historical growth rate (0.1%).

Ausgrid's operations costs are slightly higher than peer businesses of similar size and location

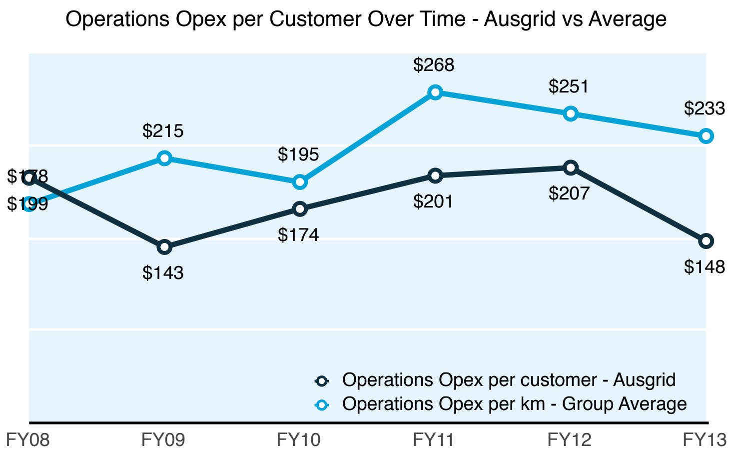
Operations costs include network control, systems operations, customer operations and support functions such as IT, property and fleet management. As such, these costs are largely driven by the location and complexity of the network, its customer base and the business scale. This makes comparison particularly difficult, as the number and relative influence of cost drivers varies across businesses. Operations costs for this study have been compared using the number of customers as the comparison basis. Comparisons of operations costs per customer for the 2013 financial year is shown below.

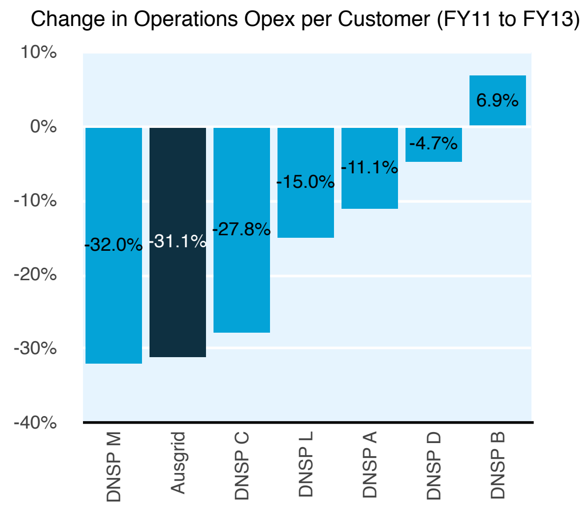


As shown below, Ausgrid's operations costs are relatively stable in the current period and within the range of its closest peer networks.

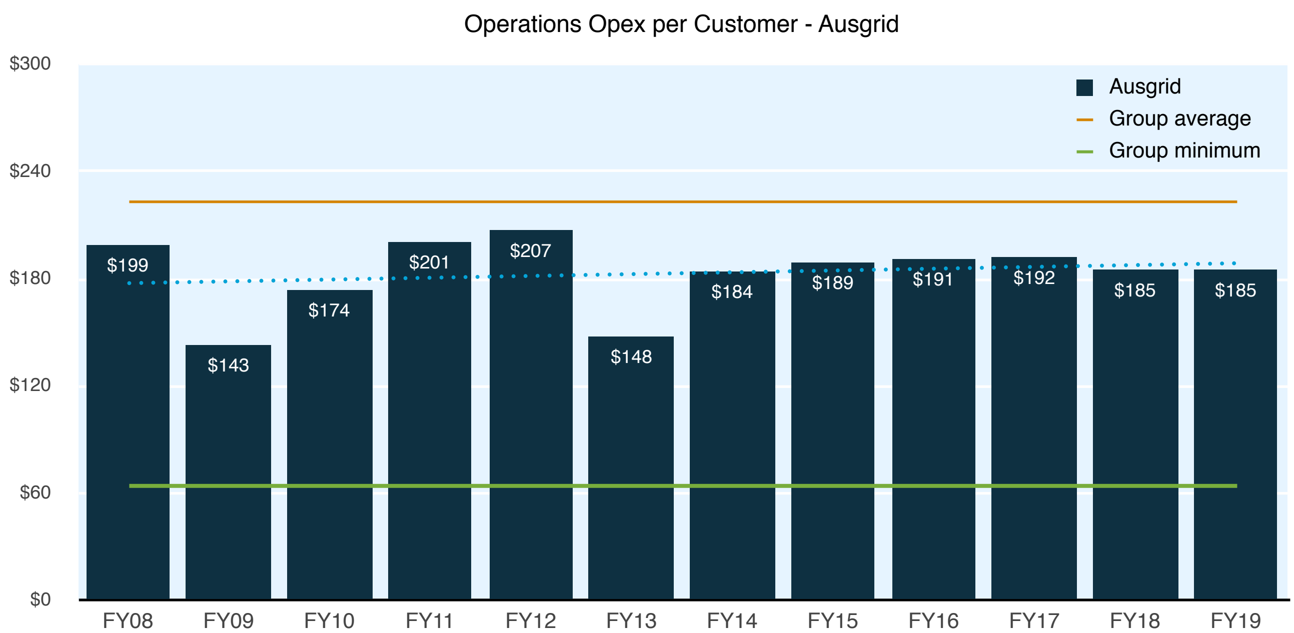


To show the change in operations opex performance during this period in the context of the benchmarking group, the graphs below depict Ausgrid's operations opex per customer over time against the group average and the relative change in this ratio for the latest three years. As shown, the gap between the Ausgrid operations cost per km and the group average has been relatively consistent over time. In the most recent three years, many businesses have had significant decreases in operations costs - due to many of the targets of NSW and QLD reform programs residing in this cost category.





Finally, the operations opex forecast can be compared to the group statistics in this period. The graph below shows the recent and forecast operations opex per customer, long term trend, and the current period group average and minimum - showing that Ausgrid's operations costs per customer are forecast to remain under the group average.



Notes:
1. All figures in FY2013 dollars.
2. Customer numbers for future years have been forecast using the historical growth rate (0.8%).

Overheads are likely to be a focus of the determination

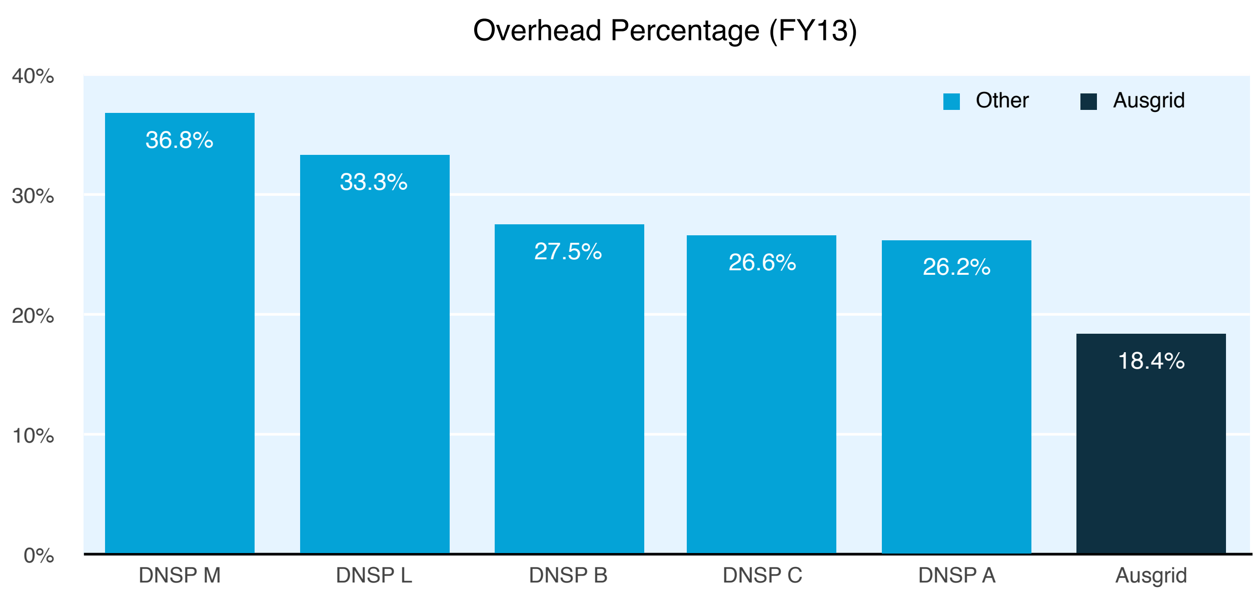
Augmentation, replacement, maintenance and operating activities can all be modelled to an extent through unit costs and volumes based on expected rates of growth in particular drivers. Overheads and indirect costs, however are largely a function of business structure and ownership, management decisions and legacy programs. This makes them difficult to forecast through modelling, other than extrapolating historical budget trends. It also makes them susceptible to unfavourable benchmarking outcomes.

Capital projects can be deferred or ceased immediately, but the overheads that build up over years of increased activity associated with those programs cannot be curtailed so readily. Overhead costs themselves cannot easily be compared across businesses due to the variation in cost allocation and accounting methodologies. A meaningful analysis requires significant data mining, treatment and analysis effort that many of the businesses are currently finding challenging within their own entity, let alone across businesses.

The accumulation of overheads is mostly associated with the supporting activities, or indirect costs, that underpin the direct cost of building, operating and maintaining network assets. As such, comparison of some of the non-core, or supporting, functions provides insight into relative productivity. Comparisons of several cost ratios and efficiency indicators are presented below and on the following pages.

Overhead Allocations

The functions that accumulate costs in the overhead pool could be compared directly to other businesses as a means of benchmarking overhead costs, however each business manages and reports overhead costs differently. As a high-level comparison of the overhead "intensity" of each business, the average overhead percentage of total spend was compared in the previous benchmarking report. An updated view of this information is provided below.

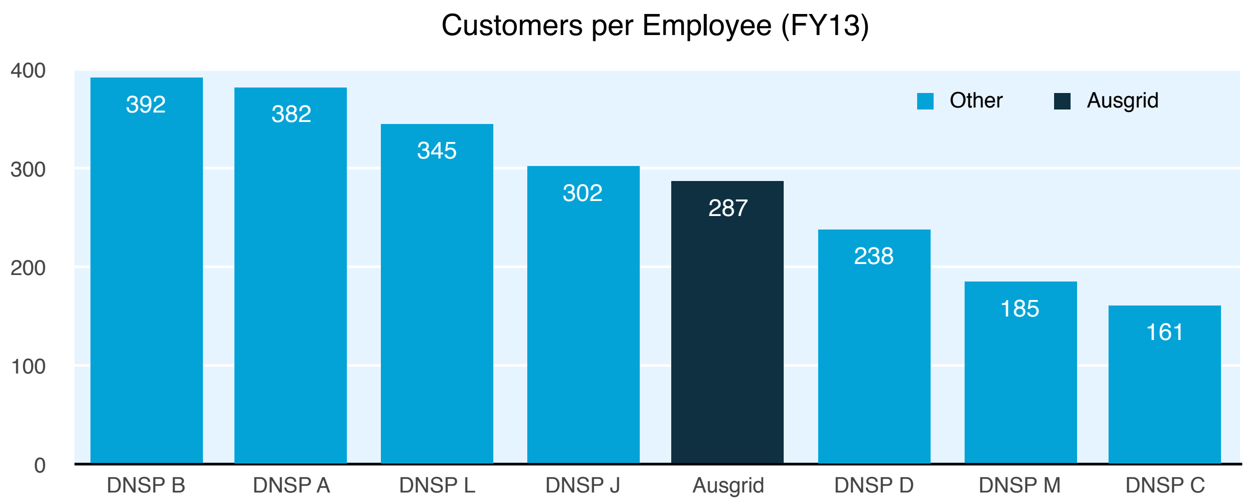


Changes to cost allocation methodologies by at least one business in the sample and the network reforms in most states and territories has narrowed the range between the lowest and highest proportions of overhead across the group since the previous benchmarking report.

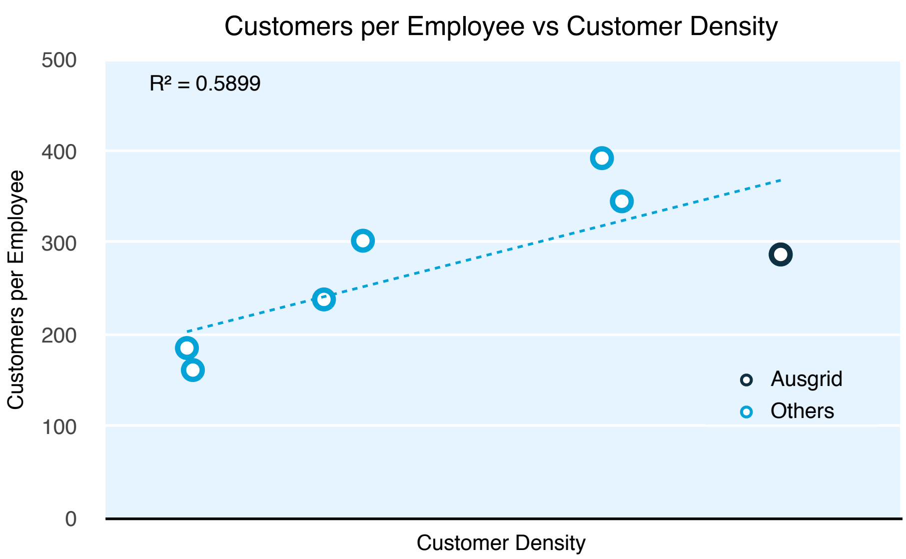
Workforce Management

Whilst the capital expenditure associated with many non-system assets and functions is often reported in a way that allows comparison across peers, the operating expenditure associated with management functions and support activities are pooled into overhead accounts (to varying degrees) and allocated to direct expenditure functions via each DNSPs Cost Allocation Methodology. This makes comparison of costs difficult, however efficiency and productivity programs are inevitably associated with changes in the workforce. This section presents some key workforce management statistics for the NSW businesses and others.

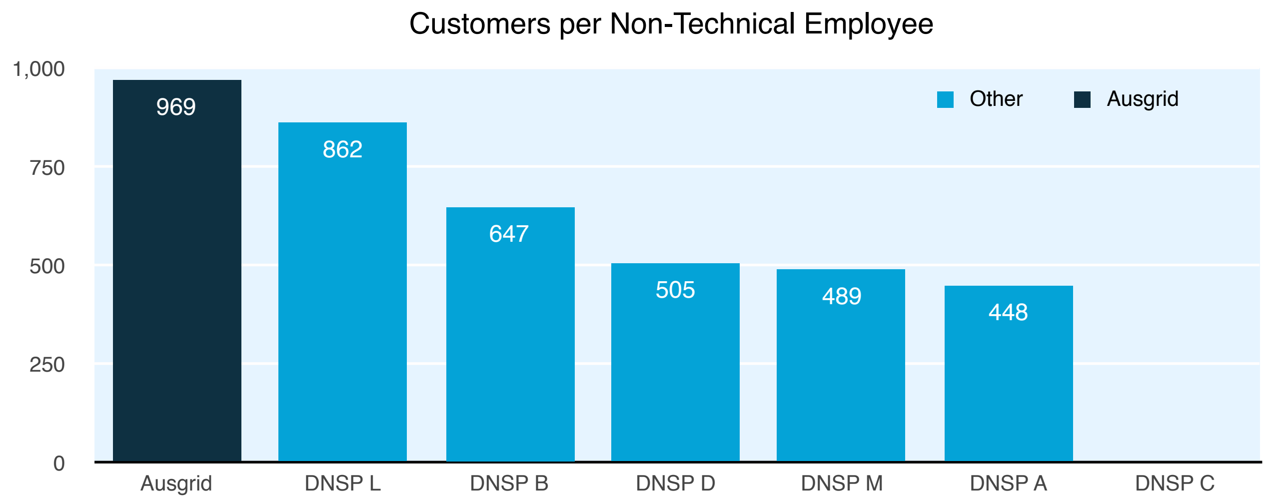
The number of customers serviced by the workforce varies by network type - with urban distributors enjoying an "economy of proximity" over their rural counterparts. Whilst simple ratios such as customers per employee need to be considered in the context of the various structures, contractor policies, etc, they are at least a useful high level indicator of the service intensity of each network business. The graph below shows a comparison of customers per employee for several businesses.



To understand the relationship between this ratio and location, the above figures can be plotted against the customer density of each network - showing a reasonable relationship between the two (below).



Whilst it might be tempting to draw some inferences about relative efficiency posed by the previous analysis, it should be noted that some networks are more capital and maintenance intensive than others. Removing the employees that are associated with the capital program and maintenance (including apprentices) from the figures used in the ratio analysis above leads to a "customer per non-technical employee" ratio. As shown below, this level of analysis presents a different view of relative performance.



Given the difference in this ratio to the overall workforce customer to employee ratio, Ausgrid can be seen to have significant scale advantage in the ability of its non-technical workforce to service a large customer base, but a significant technical workforce that is driven by a larger capital program than many of its peers.

In the absence of more detailed information about the structures and policies of the businesses, it is once again useful to analyse the changes in workforce size and output over time. Most of the businesses participating in the Huegin benchmarking study have undergone some sort of reform or efficiency program. Huegin analysed the changes in the workforce amongst those businesses with the key results shown below.

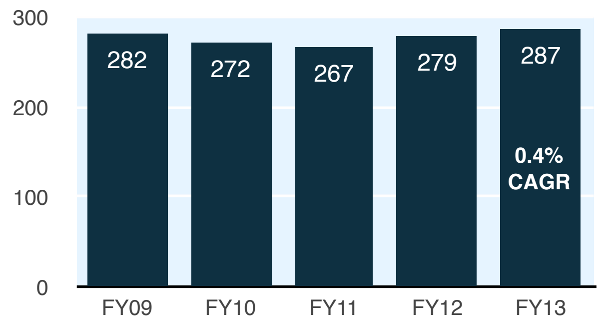
	Year on Year Change						
DNSP	FY10	FY11	FY12	FY13	2009-13 CAGR	Year Maximum Size Recorded	Difference Between Current and Maximum
Ausgrid	4.6%	2.7%	-3.3%	-2.7%	0.2%	FY 2011	-5.8%
DNSP M	4.2%	0.9%	1.6%	-5.5%	0.2%	FY 2012	-5.5%
DNSP L	0.6%	1.3%	-3.5%	-6.7%	-1.7%	FY 2011	-9.9%
DNSP B	1.4%	1.3%	-0.8%	-9.8%	-1.7%	FY 2011	-10.5%
DNSP C	-0.1%	2.6%	0.5%	-7.1%	-0.9%	FY 2012	-7.1%
DNSP D		7.3%	5.4%	2.0%		FY 2013	0.0%
DNSP J[1]	14.7%	-12.3%	-19.2%	-4.2%	-4.9%	FY 2010	-32.1%

Notes:

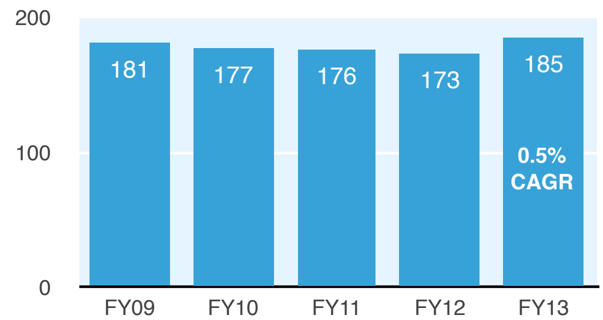
1. DNSP J's figures include the transition of a business unit to another entity.

To balance out the impact of customer growth, the change in the customer to employee ratio over time is also shown below - the CAGR figure on the right of each graph represents the compound annual growth rate in the ratio between the first and last measurement.

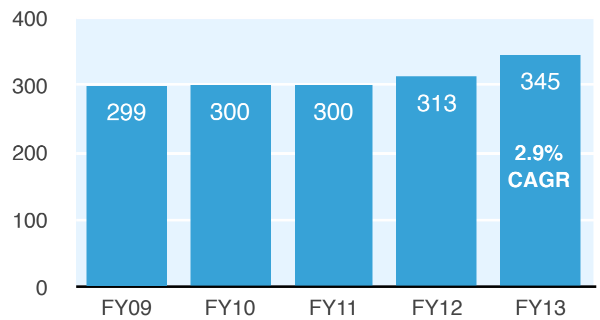
Customers per Employee - Ausgrid



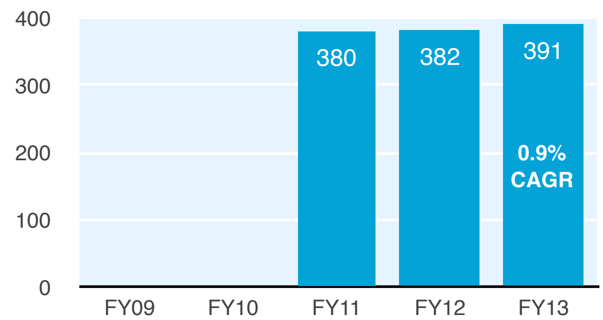
Customers per Employee - DNSP M



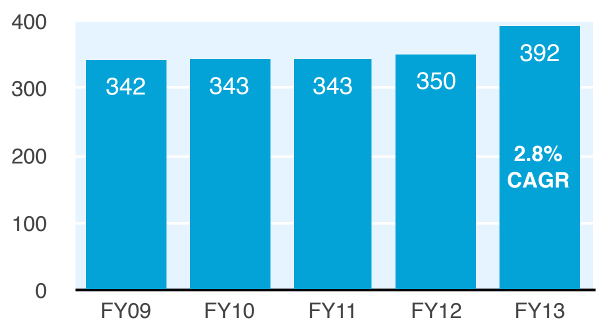
Customers per Employee - DNSP L



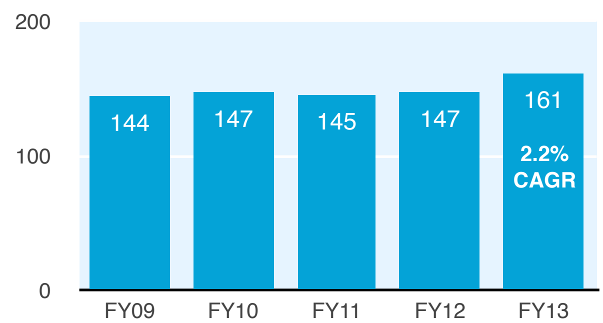
Customers per Employee - DNSP A



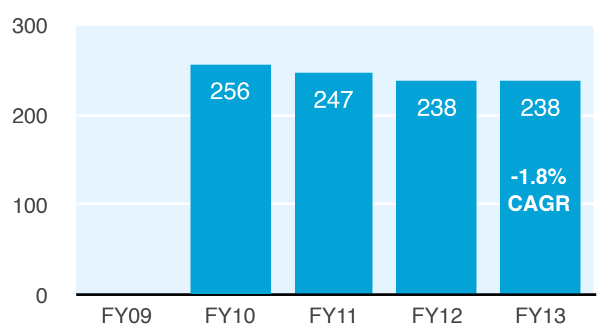
Customers per Employee - DNSP B



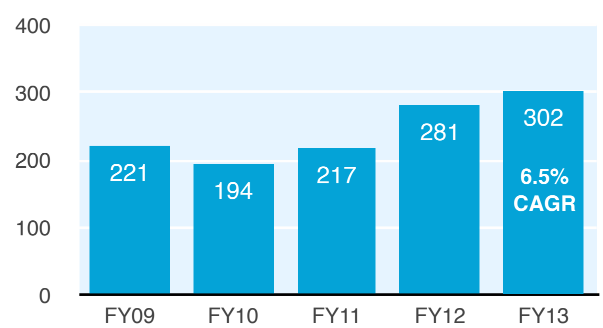
Customers per Employee - DNSP C



Customers per Employee - DNSP D



Customers per Employee - DNSP J



SUMMARY & CONCLUSIONS

Economic Benchmarking

Ausgrid is likely to benchmark around the second quartile using economic benchmarking methods.

Economic benchmarking is significantly limited in the Australian electricity supply context. Heterogenous networks and locations, unique environmental factors, data inconsistencies and a small sample size all contribute to statistically unstable and unsuitable economic models.

The movement of groups of DNSPs around the model solution space with the change in model specification or variable weightings demonstrates the existence of multiple clusters within the sample size, which all require a different model specification. Attempts to normalise are likely to show Ausgrid in a less favourable position than is perhaps warranted.

Expenditure Trend Analysis

Trend analysis will be used by the regulator; the recent efforts of Ausgrid to reduce costs will provide a favourable indication.

Whilst economic benchmarking is unlikely to show Ausgrid on the frontier, recent and forecast trends of expenditure are likely to show a more rapid movement toward the frontier, as well as significant contribution to frontier shift over time (due to Ausgrid's size within the industry).

The forecast flattening and reduction of operating expenditure, and the forecast plunge in capital expenditure show indications at this early stage of being of a greater magnitude than Ausgrid's peers. With Ausgrid's size, its relative improvement against industry performance is likely to be significant.

System Capital Expenditure

Ausgrid's capex is forecast to drop to levels not achieved since the period before this current one; system capital expenditure reduction is a major driver.

Ausgrid has forecast a significant decrease in system capital expenditure; particularly in its subtransmission network.

Whilst asset replacement appears likely to continue to be a major driver of capital works, augmentation is forecast to reduce significantly over the course of the next regulatory control period.

Non-System Capital Expenditure

A reasonably significant proportion of Ausgrid's reduced capital expenditure is driven by savings in non-system assets - particularly property.

Previous benchmarking reports by Huegin have highlighted the cost premium associated with non-system capex costs for DNSPs operating in large capital cities.

In Sydney in particular, property management costs were found to be a major cost premium for Ausgrid, with land rates and taxes far beyond other cities.

Whilst in total, non-system capital expenditure has historically been high in other urban centres, Ausgrid has always displayed a 10 to 20% cost premium above the common benchmarks in this category. Ausgrid's forecast costs in this category however display a reduction to levels commensurate with many of its peers. Property management is a significant driver of this benchmark cost improvement.

Maintenance and Operations Opex

Ausgrid's opex forecast trends are reasonable, however an adjustment may be made under the base-step-trend model.

Ausgrid's maintenance has always benchmarked reasonably well against similar size businesses or businesses with similar location and density. The increase forecast for the next period may change that position, however Ausgrid does have higher equipment failure rates than other DNSPs.

Ausgrid's operations opex is reasonably comparable to similar peers, although with Ausgrid's scale, one may argue it should be achieving lower costs per customer. However analysing the structure of Ausgrid's operations opex accounts, and considering the relative performance on overheads allocation (where Ausgrid has the lowest ratio in the group), suggests that Ausgrid accounts for costs in the operations opex category that other businesses accrue in overheads. That is, Ausgrid appears to have some "stranded" costs in its operations opex category.

Other Efficiency Indicators

Overheads and workforce size and productivity are other indications of absolute and relative efficiency, and changes in productivity.

Ausgrid appears to have relatively low overheads, although the results are skewed by the different cost allocation methodologies between businesses.

When comparing the ratios of customers to employees (albeit this is a flawed comparator, without knowledge of the level of outsourcing in each business), one may observe that Ausgrid should be able to achieve higher ratios through scale. Breaking the ratio down into technical and non-technical resources, however, indicates that the number of customers serviced by Ausgrid's non-technical workforce is far superior to its peers.

The large capital program of the recent past has necessitated a large technical workforce at Ausgrid - who are not primarily driven by the number of customers, rather the size and nature of the works program.

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APPENDIX B - JOINT DNSP ANALYSIS ON EFFECTIVENESS OF THE AUGEX MODEL

Appendix B to Attachment 5.33

Networks NSW

AUGEX Model Benchmark Review - Summary

March 2014

AUGEX Model Benchmarking Review

Purpose

The AUGEX model has been developed by Brian Nuttall on behalf of the AER as a tool for review of augmentation capital expenditure programs put forward as part of DNSP's 5-year regulatory proposals. The tool is relatively new, having been developed in 2012 and is yet to be applied in the context of a regulatory determination.

The purpose of the model is to allow the AER to apply high level analysis to a proposal to determine whether the requested capital expenditure is in line with what would be predicted by the model, thus enabling a faster, more hands-off approach to determining a DNSP's capex allowance. The AUGEX model is one of a number of modelling tools the AER has indicated it intends to use in testing the veracity of a DNSP's capital expenditure proposal. The move towards a more mechanistic method for determining capex allowances is driven in part by past difficulties the AER has experienced in conducting sufficiently detailed reviews of forecast capital projects.

According to the AER, the aim of the AUGEX model is to simplify the analysis of complex forecasting methods while still maintaining some ability at the aggregate level to allow for the main drivers of augmentation. The AUGEX model also provides a benchmarking framework that complements the high level assessment approaches the AER can use to assess augmentation expenditure and the more forensic, detailed engineering reviews of expenditure conducted by the AER. The AER will use the AUGEX model initially as a screening tool to identify the sub-categories of expenditure which should be subject to more detailed examination. They may also use the AUGEX model as a reference to set revenue at a future date as they continue to refine it and their assessment methodologies for augmentation capex.

Networks NSW understands the AER's reasons for wanting to apply a more mechanistic approach to examining capex proposals, and acknowledges that such an approach would be less expensive and faster to apply in the context of a determination. Therefore, Networks NSW has applied the AUGEX model to its expenditure proposals to assess its application and robustness and to identify any issues that might need to be addressed in the capital submissions up front.

Unlike the application of the REPEX model, the application of the AUGEX model has been of limited value internally. The issues identified with the application of the model are, we believe, so significant that its application would require significant adjustment outside the model, and ultimately require an examination of detailed planning information to make a decision under the Rules.

The remainder of this report highlights the deficiencies identified in applying the model in practice and in good faith.

Data and model limitations

Models are designed to approximate reality. Models works best when sufficient data points are modelled and deliver results that are statistically representative of the actual results. According to the AER's AUGEX model guidance handbook, to achieve this approximation, "assets are considered as populations rather than individuals. The model does not hold specific limits or attempt to assess specific constraints or solutions. Instead, it assesses aggregate capacity and expenditure levels, based upon aggregate planning parameters that can be used for benchmarking purposes." The model however recognises that different parts of the network have different planning parameters and in an attempt to improve the accuracy "The model allows the network to be constructed from various network segments, each with their own set of planning parameters. This allows some level of disaggregation to capture different augmentation circumstances that could affect benchmarking. For example, where one part of a network (e.g. distribution feeders) could have a significantly different economic loading point or augmentation solution to another part of the network (e.g. sub-transmission lines)."

Disaggregating the network in this way highlights some weaknesses in the model's application to reality. By disaggregating the network into a number of segments, each segment has a smaller sample of data to model and inaccuracies are introduced into the modelled outputs.

Sub-transmission assets

Sub-transmission assets are the highest voltage assets on a distribution network. The augmentation of the sub-transmission network generally occurs as the addition of relatively large amounts of capacity on subtransmission feeders of subtransmission / zone substations however solutions to overcoming capacity constraints are generally unique. They depend on the nature of the constraint and the configuration of the relevant part of the network. Furthermore, the number of constraints and associated augmentation projects at this level of the network is relatively small and there are therefore no 'average' sub-transmission projects. As a result, the AUGEX model outputs for this level of the network are likely to be significantly at variance with the actual expenditure requirements.

Furthermore, because of their size, expenditure on subtransmission network augmentation projects may occur over a number of years, with no relationship between expenditure in a particular year and the capacity added in that year.

The range of costs associated with these projects is wide, as is the amount of capacity added, leading to a large variation in the cost per MVA of capacity added by each project, and in each year. It is considered that modelling of augmentation expenditure at this level of the network will not provide the AER with meaningful benchmarking information with which to assess the expenditure forecast. Because of their unique nature, it is considered that assessment of the forecast for augmentation of the subtransmission network is better carried out by detailed engineering assessment of individual augmentation projects.

11 / 22kV distribution assets

The AUGEX model is considered to apply best in relation to augmentation of the 11 / 22kV distribution network. This is due to the fact that there are many augmentation projects of a similar nature within this asset class. This type of expenditure is reasonably effectively modelled within AUGEX.

The limitation that AUGEX experiences in modelling this level of the network arises from the fact that much of the augmentation of this part of the network is aimed at alleviating constraints other than thermal constraints. In particular, augmentation may be carried out to overcome fault rating exceedances or voltage constraints. Augmentation for fault rating reasons is specifically excluded from modelling within AUGEX as it is not related to increased demand on the network. Augmentation to overcome voltage constraints is to be modelled within AUGEX. However these parts of the network must be modelled in their own network segment.

The difficulty in applying the AUGEX model at the 11/22kV level of the network arises because of the difficulty that many DNSPs do not separate project financial data in a sufficiently detailed manner to enable distinctions to be made between the various types of expenditure and as a result, the accuracy of expenditure modelling is questionable.

For some DNSPs augmentation to overcome voltage constraints represents a major part of their augmentation program. Modelling of these types of augmentation is complex, with capacity factors varying according to the location of the constraint on a feeder. The benchmarked variable of cost per MVA capacity added is highly variable in these situations, rendering benchmarking comparisons invalid.

For these reasons care must be taken by the AER when considering AUGEX outputs for this level of the network.

Low voltage (LV) network

The application of the AUGEX model to the LV network is similar to its application to the 11kV network. At a total level, there are many LV network augmentation projects in any one year, and conceptually, average cost data is available. However, cost data is not available at the level of disaggregation that the AER seeks. This is because the amount of expenditure in each year in augmentation of the low voltage network by DNSPs is generally small relative to the level of expenditure invested at other levels of the network. The benefits that may be obtained from establishing systems that provide detailed cost data for this work are outweighed by the costs associated with maintaining such systems.

DNSPs will generally consider the expenditure requirements for their entire LV network as a whole because making estimates at any lower level of disaggregation requires too many assumptions to be made to have confidence in the accuracy of the estimates. Benchmarking AUGEX outputs at similarly disaggregated levels will also be fraught with such inaccuracies and is not considered to be sufficiently robust to allow the AER to make any determination of the efficient levels of capital investment at the disaggregated level.

Substitutability of assets between asset classes

Another limitation of the model that the AER's guidance handbook has recognised but not provided practical guidance to address is the substitutability of assets in one segment for those in another. This is relevant when determining the most efficient solution to overcome a capacity constraint, and is particularly relevant for assets in the subtransmission segments.

For example, in many instances in NSW load growth on a 33kV network has been addressed by moving to a 132kV network solution which involves construction of new zone substations that bypasses the 33kV network and transforms electricity directly from 132kV to 11kV. Not only do the network assets in each category have a different cost structure but such a move will generally be carried out as part of a long term strategy determined as the most efficient way of meeting the forecast growth in demand in an area over a long time horizon (i.e. 10-20 years). In the timeframe considered by AUGEX, a solution involving establishment of a 132kV zone substation to overcome a constraint at an existing 33kV substation is likely to be highlighted by the model as inefficient expenditure. However, such a finding does not recognise the fact that fewer assets will need to be established in the long term by following this strategy.

Similarly, the AUGEX model does not account for the circumstances in which a network that has typically invested in overhead networks is forced to invest in more underground assets, due to greater urbanised development. The cost difference between these two network types can be as high as ten to one. Where past expenditures have been largely expended on overhead network assets, the AUGEX model is likely to underestimate future expenditure if underground assets are required.

The model's lack of capability in catering for substitution between asset categories limits its most useful application to a 'whole of network' level. Application to the network as a whole removes the necessity to address substitutability of networks asset categories and alleviates the requirement to obtain detailed cost information in favour of general estimates of cost of capacity across the network. What the model may lose in granularity by doing this, it would make up in reasonableness and credibility.

Calibration

The AER originally anticipated that the AUGEX model outputs would be calibrated to historic expenditure levels, similar to the way that the REPEX model is calibrated. The model handbook that the AER published refers to calibration of the model, but no guidance is provided as to how such calibration is to be achieved. In fact, it is not clear that evaluation of augmentation capex forecasts will involve model calibration at all.

Furthermore, it is not clear what value calibration to historic expenditure levels may add to the AER's assessment process. Unlike replacement capex (although there are also issues with calibration of the REPEX model), where asset age, used as a proxy for replacement need, is known in advance, the need for augmentation can change from year to year. The AUGEX model has as one of its inputs the DNSP's global peak demand forecast, but peak demand, when considered on a spatial basis as is required for augmentation decisions, can be volatile from year to year.

The use of historic capital expenditure to forecast expenditure is too simplistic a concept for application in the context of multimillion dollar businesses. The drivers of network augmentation are in most respects outside the control of the network. To assume that the past is a good predictor of the future requires acceptance that the drivers of past expenditure, their strength and timing will be the same in future as it has been in the past. Networks NSW consider that that this is too simplistic an assumption to be reasonably applied at the current time. If expenditure has been deferred in past years due to project delays or a change in relative priorities, expenditure within a period may be lower than it would have been in the absence of those factors. If future expenditure is calibrated to that lower than ideal level of expenditure in the past, future expenditure will also likely to be lower than required as it is based on a level of spend that is too low and unsustainable in the long term.

An example of the type of external influence that renders the use of calibration to historic expenditure levels invalid can be seen in the Design, Reliability and Performance licence conditions imposed on the NSW DNSPs by the NSW government in 2007. These licence conditions imposed a requirement to provide N-1 security on most subtransmission assets by 30 June 2014. Achieving this required significant levels of expenditure. As this level of supply security has now been achieved and this requirement has been removed from our licence conditions from the start of the next regulatory period, augmentation expenditure will be significantly reduced in future compared to the past and calibrating expenditure forecasts to historic levels will produce meaningless results.

Conclusion

The AER's search for a suite of tools to assist them in making consistent and less time consuming regulatory decisions in relation to forecast capital expenditure is understandable and laudable. The NSW DNSPs have applied the model in good faith but have met a number of problems in applying the model.

For good decisions to be made, the models must be based on robust underlying concepts, and utilise appropriate and consistent data. DNSPs do not necessarily have the data required by the model in the level of detail required. A lack of data may lead to modelling inaccuracies and inappropriate decisions if the model outputs are relied on too heavily. It is considered that data capture, or lack thereof, is a significant limitation to robust application of AUGEX.

Experience gained reviewing the model has highlighted the fact that extracting what appear to be the simplest data from the network is more complex on closer inspection. Care must be taken to ensure that data from an individual business is compared on a similar basis to information from other firms, particularly if that firm is to be used as a benchmark, or to create a benchmark for another firm.

The AUGEX model lacks appropriate testing and application in a regulatory context to help inform and improve the model's future application. The lack of clarity around how the model will be applied and/or calibrated severely limits the extent to which the AER can rely on the model to provide an appropriate comparison of a forecast against a benchmark. For a regulator, the model must be applied with care, and any findings from its application treated with scepticism. The tool is not well enough developed to allow the regulator to infer that cuts to a program are required, nor does it allow a regulator to determine the level of forecast expenditure reduction that is appropriate.

Having reviewed the model in detail, Networks NSW considers that AUGEX may usefully be used as a first level test as to the efficiency of the augmentation program as a whole. However, care must be taken to understand the investment context, environmental and political influences, as well as the underlying principles of network design and data capture before a model of this type can be used to substitute for detailed and appropriate expert interrogation of individual projects and their drivers.

APPENDIX C - JOINT DNSP ANALYSIS ON EFFECTIVENESS OF THE REPEX MODEL

Appendix C to Attachment 5.33

Networks NSW

Report - REPEX Model Review

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About this report

The purpose of this report is to set out the joint findings of the NSW DNSPs (Networks NSW) on the repex model that the AER intends to use to assess the proposed replacement capex of Ausgrid, Endeavour Energy and Essential Energy in the 2014-19 regulatory determinations.

In its Forecast Assessment Expenditure Guidelines, the AER has indicated that the model will be used as part of its assessment of the proposed replacement capex of the DNSPs. The model predicts the likely expenditure on network asset categories, based on the age profile, replacement age and average expenditure.

The report tests the conceptual effectiveness of the repex model, and consequently the role and weight that should be attached to the outcomes of the model when the AER makes its regulatory determination.

The AER has not provided sufficient time to enable us to compare our replacement expenditure forecasts to those predicted by the repex model. The AER issued a final RIN on 7 March 2014, which was the first time the AER had identified the asset categories that would be used to populate the repex model. We consider that the AER should release the findings of its repex model prior to finalising its draft determination to enable us to properly respond to its findings.

The key finding of this report is that the repex model should be used with extreme caution by the AER, and only as a complement to other types of in-depth assessment of a DNSP's proposal and supporting documents. We have made the following observations when reviewing the model:

- The repex model has severe limitations and deficiencies - The repex model is a very high level tool that cannot be used as a substitute for detailed planning analysis due to its construct, data and application limitations.

- The repex model could be used to target a further, more detailed review of a DNSP's program - We consider that the repex model may play a role in the AER's assessment of our capex. However, due to its limitations, the model should never be used to reject or substitute proposed forecasts. Rather, the model could be used effectively to target programs or projects for further detailed review, particularly in areas where a DNSPs forecasts appear to be significantly higher or lower than predicted by the model.

- The repex model should be disregarded for certain sub-categories - The reliability of the repex model will vary depending on the underlying characteristics of the asset group being reviewed. In some cases, the data and model limitations may lead to very inaccurate results. For example, due to the small sample size of large sub-transmission assets, the repex model will be highly inaccurate. In other cases, the repex model may provide a meaningful comparator to help target the AER's detailed review. For instance, the model may be more effective for certain distribution assets where there are large populations, homogeneity in technology, failure modes and costs, and consistency in replacement levels and costs over time.

1. Description and use of repex model

In this section, we identify the purpose of the repex model, how it works, and the AER's intended application of the model to its review of NSW DNSP's proposed capex.

1.1 Purpose and background of model

In its Forecast Assessment Expenditure Guidelines, the AER noted that the repex model will be used as part of its assessment of the proposed replacement capex of the DNSPs. The AER first applied the repex model to the 2011-15 regulatory determinations for Victoria and has also used it for the 2012-17 regulatory determination for Aurora Energy (Tasmanian DNSP).

The repex model marks a shift in the AER's assessment methods, where it increasingly relies on high level tools to guide its decision making, compared to detailed engineering reviews of forecasts. The model is a type of benchmarking tool as it meets the Productivity Commission's definition of a "method for comparing a firm to other businesses, to itself over time (or between its various divisions) or to an ideal firm."[1]

1.2 Description of model and key variables

The AER's repex handbook provides a description of the underlying premise and workings of the model. The model is contained in a series of Microsoft spreadsheets that require input data to predict the likely replacement capex on network assets over a 20 year period. The AER can re-calibrate the model to use recent historical expenditure and the benchmark data of peer DNSPs.

Premise of model

The underlying premise of the model is that age is a proxy for the many factors that drive individual asset replacements. The AER notes that with time, network assets age and deteriorate. This can affect their condition, which in turn can impose risks associated with the asset's failure such as network performance, safety, environmental damage and operational risks.

The model simplistically predicts the volume of replacement based on the age of system assets on a distributor's network. To do this, the model requires information on the age of assets, and the likely age of replacement. As a final step, the model predicts the total expenditure by multiplying volumes by the average cost of replacing an asset in that group.

The AER acknowledges that network planners do not solely rely on asset age to forecast replacement needs in the future[2]:

> "It should be recognised that the managers of capital assets will frequently rely on alternative techniques to determine their asset replacement strategies. A particular approach may include critical impact, condition based or risk based techniques or a mix of these or other techniques. They are all valid approaches and may give superior estimates of replacement need in particular circumstances."

[1] Productivity Commission, *Electricity Network Regulatory Frameworks*, 26 June 2013, p147.
[2] Australian Energy Regulator, *Replacement Expenditure Model Handbook – Electricity Network Service Providers*, November 2013.

In the section on model and data limitations, we highlight how the fundamental premise of the model cannot adequately account for all the drivers of replacement, and that using age as a proxy for replacement may provide a misleading picture of replacement needs.

'Base case' of the model

The repex model can be manipulated in a number of ways to test the replacement capex proposed by the DNSP. In the first instance, the AER uses the information provided in a DNSP's RIN to derive results for the model (termed the 'base case'). The steps involved in the 'base case' are explained in the AER's handbook and are summarised below.

1. Asset categorisation and grouping - The model requires the NSP's network asset base to be broken down into a number of discrete asset categories. This categorisation is required to reflect variations in asset lives and unit costs between different asset types. The AER's regulatory proposal RINs for NSW DNSPs mandate high level categories, but provide the ability for DNSPs to include lower level sub-categories.

2. Inputs – The key inputs required by the repex model relate to the age profile of each sub-category of assets, the mean age of replacement, and the unit replacement costs of assets within this group. These are collected by the AER as part of the RIN and are described below.

    - Age profile - Reflects the volume of the existing assets at the various ages within the asset category at a static point in time. The model allows the installation dates to go backwards up to 90 years from the current date of the age profile.

    - Mean age and standard life - These two parameters define the probability distribution of the replacement life for the asset category. The AER assume a normal distribution around the mean.

    - Unit replacement cost - This parameter defines the average unit cost to replace one unit within the asset category. This unit cost must reflect the volume unit used within the age profile.

3. Outputs - The model takes these inputs and produces the following outputs for each asset categories:

    - Age and asset value statistics and charts of the age profile - The model provides summary information of the age profile. This is presented at the asset category and asset group level. This covers information such as total volumes and replacement costs, proportions of the total network, average ages and lives, and proportions of aged assets.

    - 20-year replacement forecasts - Based upon the input data, the model produces year-by-year forecasts of asset replacement for the following 20 years. The forecasts prepared include individual asset category forecasts and aggregated asset group forecasts.

The 20 year replacement forecasts are based on a function within the model that provides a probabilistic estimate that an asset in the group will be replaced at a specific age. The model assumes that the probability is normally distributed around the mean age, taking into account the standard deviation.

Calibration

In addition to the 'base case', the AER also undertakes a calibration exercise to' fit' the function of the model to historical replacement volumes and costs of the DNSP. This involves:

- Using historical replacement volumes over the most recent 5 years of actual data to adjust the mean replacement life until the forecast volume of replaced assets in the first year of the forecast period equals the average actual volume.

- Adjusting the unit replacement cost to reflect most recent data on the costs of replacing assets.

- Re-calibrating the model (ie: refreshing the outcomes) to allow for the new data.

The AER also note that as part of its calibration technique, it may use other scenarios such as using asset life and unit costs of other DNSPs that it has collected through the benchmarking process.

1.3 Application of repex model by AER in decision making

In its Forecast Expenditure Assessment Guidelines (FAEG), the AER has indicated that it will use the repex model as part of its overall assessment on a DNSP's repex forecast. In addition to the repex model the AER will assess the forecasting approach, consider benchmarks and trend analysis of past expenditure, and performing detailed project reviews. It notes that:

> "When a NSP's forecast repex shows a significant divergence from the historic trend or our expenditure modelling we will assess the information supporting the NSP's forecasting approach and move to conducting more detailed project reviews."

The AER has stated that in instances where it consider the analysis shows that a NSP's proposed repex does not conform to the capex criteria, it may be used (in combination with other techniques) to generate a substitute forecast.

The AER has been less clear about the weight it applies to the 'base case' form of the model, relative to calibrations of the model that rely on historical levels of replacement by the DNSP or benchmark data from other DNSPs.

As noted in section 4, we consider this lack of clarity raises issues on whether the model can be used in a neutral manner, and the ability of the AER to choose a substitute level of capex from a range of model outcomes.

2. Limitations and deficiencies of the repex model

In preparing our proposal we have sought to test whether the repex model can provide an indicator of the efficiency of our replacement forecasts.

We have not been able to undertake a detailed review of the model outcomes relative to our forecasts, as we have not been provided the populated model the AER intends to use. For this reason our review has been limited to a high level conceptual examination of the model. In doing so, we have examined the AER's repex handbook, undertaken preliminary analysis on template models, and reviewed the AER's determinations for Victorian and Tasmanian DNSPs.

Based on this review, we consider that the repex model is less structurally flawed than the augex model, but still has a number of shortcomings. These include weaknesses in the model construct, the underlying data quality and statistical validity, and the application of the model by the AER. These deficiencies are explained in greater detail below.

2.1 Deficiencies with model construction

It is important to recognise that a model is an abstract reflection of complex reality, and will therefore never be perfect. Modelling is a key tool used to predict the future, and is therefore used by a prudent network planner to varying degrees in developing forecasts of volumes and unit costs.

The key question is whether the construction of the repex model can lead to an accurate prediction of the replacement level that a prudent and efficient DNSP would incur in their circumstances.[3] In addressing this question, we have identified 3 central weaknesses with the model that limit its effectiveness to replicate the real world circumstances of a DNSP.

Cannot account for the real world drivers of replacement

As noted in section 1, a key premise of the repex model is that age asset is an accurate proxy for the likely time that an asset is replaced. There is little doubt that an asset's condition deteriorates with time, and will exhibit a higher probability of failure towards the end of its life.

However, we consider there is a high degree of variability around a 'mean' age of replacement that limits the accuracy of its use in predicting volumes of replacement. Even with technologies that experience uniformity in failure mode, there are cases where a prudent DNSP will replace an asset much before, or after, the mean age of replacement. These natural variations in 'wear and tear' of the asset relate to:

- Innate differences in the manufacturing quality of the asset and the installation process and complexity.

[3] In turn, this leads to deeper questions such as the risk tolerance threshold that a prudent DNSP would adopt. For instance, how many safety and reliability incidents that a prudent DNSP is willing to accept from asset failures. It also raises issues such as whether early replacement is an efficient response to ensuring sustainable rates of replacement. The repex model largely ignores these types of considerations by assuming that the average age of replacement is efficient and that a DNSP would not look to long term efficiency considerations such as early replacement of assets to enable steady and sustainable levels of investment over time.

- Operating and topological differences when the asset is used over time, for instance an asset installed in coastal regions may likely be exposed to salt water corrosion.
- Differences in maintenance of similar assets over time. For example, Ausgrid's assets were previously owned by local councils, each which had a different approach to maintenance. Obviously, assets that were well maintained over time will exhibit longer lives even if there is uniformity in failure modes.

The likely age of replacement will also depend on the consequences of failure. A prudent DNSP will often undertake proactive replacement programs that strive to replace assets before they fail in service, particularly to mitigate high safety or reliability consequences. For instance, an asset located close to the general public is more likely to be replaced that one in an isolated area when there is a chance of explosive failure. This means that assets which have uniform failure modes may have very different replacement ages.

Using age as a proxy also fails to take into account other drivers of capex such as duty of care programs. In these cases, age (ie: deterioration in condition) is not the primary driver of replacement but rather the need to ensure our assets meet modern day safety or environmental standards. A key example is clearance heights for feeders, which may not meet a required standard for public safety.

It is for this reason that a prudent network planner uses a greater variety of tools and information to determine than age based modelling to forecast replacement programs. For instance, for large and costly assets on the sub-transmission network, the prudent planner would look to conditional data of the individual asset, and undertake granular risk-consequence analysis.

For categories of assets that contain a high population, the planner may use more high level tools such as models. However, the model would be configured to best reflect the individual circumstances of the DNSP and the condition of the asset base. While age based analysis may feature in such analysis, it is likely that a prudent planner would also use other data sources to guide its forecasts including conditional data from inspections, failure mode analysis, trends in failure rates, and consequence of failure analysis.

Sub-categories may not be sufficiently granular to reflect replacement age

A key assumption of the repex model is that individual assets in a population share common characteristics, and accordingly that there can be a level of accuracy in predicting replacement costs and age. [4] The repex model allows DNSPs to identify sub-categories of assets under the AER's major categories of assets. For example, a DNSP can provide data on feeder by voltage and/ or technology type so as to group assets with common failure modes and likely similar replacement ages.

However, there are a diverse range of technologies on a DNSP's network, which means that sub-groups will rarely contain assets with similar failure modes. In some cases, this issue arises due to a lack of quality data on asset age profiles and replacement lives for assets, which mean that

[4] As noted above, even if these conditions are present, age will never be able to accurately account for the real world drivers of replacement.

technologies need to be clustered together. This means that even at a sub-category level, the mean age of replacement will be imprecise.

Our preliminary examination of data to be used in the repex model suggests that the sub-categories we have provided as part of our RIN contain multiple technologies. As such, the outcomes of the repex model are likely to be inaccurate even at the sub-group level.

Average unit costs do not provide a realistic estimate of costs

The repex model uses 'average' unit costs for sub-categories of assets to predict the likely levels of expenditure of a DNSP. We consider that this is a problematic assumption and does not provide a realistic expectation of unit costs. Each replacement job is likely to be different due to site specific factors, even when there is sufficient uniformity in the asset being replaced.

On the sub-transmission parts of the network, costs become very site specific and may be impacted by the type of job being undertaken. For instance, the replacement of underground cables in Sydney Harbour will be far more expensive than replacing the same asset in a land area. It is for this reason that network planners consider site specific costs of major projects, rather than relying on average costs as a basis of a forecast.

On the 11kV and distribution network, an averaging approach may provide a more accurate indication of future costs. In these cases, there is a greater population of assets and potentially less variation in scope differences. Even in these cases, there is likely to be significant variation in the types of jobs being undertaken and the complexity of the task.

A prudent network planner may not be able to accurately forecast the cost of each individual project but would seek to identify whether there are differences in the type of project being constructed and account for this with different unit rates for particular jobs. In contrast, the repex model is limited in its inability to account for variations and distributions around the mean, and may be impacted by outliers in costs.

A further limitation with using average costs is when the asset has a long delivery time as is the case with sub-transmission major projects. In these cases, the expenditure and commissioning of the asset can be separated by many years, leading to a mismatch in average unit costs for a particular year.

A key example is switchboard replacement. Typically the switchgear is purchased 1 or 2 years ahead of the installation as it takes 9 to 18 months to deliver. Similar issues arise on most sub-transmission replacement activity such as transmission feeders which is characterised by lumpy investments across a number of years. It should be noted that lumpy projects generally relate to sub-categories where there is a paucity of sample data, exacerbating the inaccuracy of the repex model.

2.2 Problems with data quality and statistical validity

An axiom of modelling is that underlying data should be accurate and reliable, and should meet the key principles underlying statistical validity. In the sections below we note that the repex model fails to meet these conditions.

Data quality and accuracy

Similar to the augex model, the underlying data on age of assets, replacement ages and expenditure costs can be highly unreliable and accurate for certain asset categories. The data quality issues are expanded on in our response to the RIN. We note that the AER's RIN has required this information to be provided despite Ausgrid raising issues in the past with the quality of information available to us. At the time, the AER noted that they still require us to provide the information even if it is in the form of a best estimate.

As explained in our response to the RIN, in some areas the information is so unreliable that we believe the outcomes of the model should not be used at all. We also note that average costs of replacement is a highly unreliable measure of costs when there are small sample sizes and significant variation in costs, such as for sub-transmission assets.

Statistical validity

We note that the AER's repex model handbook does not identify a quantitative statistical test for evaluating the effectiveness of the repex model. We consider that the results of the repex model for each sub-category may fail to meet one or more of the following principles underlying statistical validity:

- Sample size – We consider that for many sub-categories (for example, sub-transmission assets) there are insufficient samples to be confident in the outputs of the model.

- Sample representative of population – For the reasons noted in Section 2.1, we consider that the underlying data for each sub-category is unlikely to contain asset technologies with different failure characteristics and therefore cannot be used accurately to predict replacement age.

- Algorithm is sound – An algorithm sets out the calculation steps involved in developing the function that is used to predict the outputs. We note that the AER has generally used information on the mean and standard deviation to 'fit' a normal distribution. This is a very broad assumption, and reflects the lack of samples to derive a more precise algorithm. The algorithm would likely be different for each sub-category, and this means that the replacement density curve is likely to be very imprecise.

- Model outcomes holds outside data range - In many cases, there is insufficient data to know when the asset is likely to be replaced. In some cases, the technology may only be first exhibiting signs of failure, which we know will increase rapidly in the forthcoming regulatory period based on inspection of the equipment.

2.3 Application of the model

All models involve an element of subjectivity and judgement in application. A key concern of the NSW DNSPs is that the AER's handbook lists a number of uses of the model from the 'base case', to calibration with past data, to benchmarking with other DNSPs.

We consider that with so many outputs at its disposal, the AER may be misled into thinking there is a potential inefficiency. At worst, the use of multiple models may result in ‘cherry picking’ outcomes that are used to provide weight to reject a DNSP’s forecast. In the sections below, we discuss the limitations with the various ways the repex model can be manipulated to provide alternative output values.

Aggregation

The AER has suggested that aggregation of sub-category assets may be used to draw conclusions, particularly when benchmarking with peer DNSPs. For instance, the AER may sum together the values of all replacement capex for feeders, including all the different voltages and technologies.

We consider that aggregation of individual sub-categories is likely to lead to errors in the predictive values. This is due to the errors and limitations of certain sub-categories of expenditure included under a major category. For example, the AER may use data for a sub-category where the DNSP has explicitly stated that data is estimated due to lack of information.

Calibration

In previous determinations, the AER has used ‘calibration’ functions when the base case suggests that a far higher level of expenditure is warranted. In these cases, the AER has used most recent historical data or substituted benchmarking data to ‘refit’ the model to derive alternative outcomes. When the AER has re-calibrated the models they have found that DNSP’s proposed forecasts exceed the predicted values of the model.

In our view this raises significant concerns with the validity of the model given that the ‘base case’ could produce results that the AER considered were invalid. In these cases, it would be incorrect to use a flawed model with different input data (either benchmark of past expenditure) to derive a conclusion that the AER considered was not anomalous. In our view, this is a type of backsolve to validate the use of the model.

In any case, we have identified flaws in relying on such information for the purposes of re-fitting the model.

Substituting base case data with recent historical estimates

The model may also be calibrated to compare actual levels of expenditure undertaken in the current period. We consider that this assumption may not necessarily provide a reflection of the level of expenditure needed to maintain the safety and reliability of the network. This is for 3 reasons:

- A DNSP may change in planning standards or risk assessments, driving a change in replacement levels compared to the past. Indeed this was the experience encountered by NSW DNSPs in the mid 2000s when comprehensive reviews identified a need to increase levels of replacement due to under-investment in the past.
- New standards might be imposed in terms of safety, environmental or worker safety that necessitates an increase in replacement needs.
- A DNSP may detect a change in failure rates or risks for an asset class prompting the need to develop a proactive replacement program.

Benchmarking

When the deficiencies in functional form and data limitations are multiplied across the industry, it becomes clear that the model is even poorer when used as a benchmark tool across DNSPs. For benchmarking to be valid, the regulator would need to ensure that the quality of data is sound at a sub-category level, and that the data is comparable. This assumption does not hold due to the following factors:

- Data may not be comparable as DNSPs have different technologies on their networks which are likely to exhibit different failure modes. For example, the Powercor and SP AusNet replacement ages generated by Nuttall Consulting[5] for underground cable assets are approximately 43 years whereas for Jemena and United Energy, replacement ages are 60 years. Our more detailed analysis indicates that the 40 year asset is most likely driven by failing LV cables such as the Consac type which are becoming known to regulators world wide as a problem.

- Data quality is unlikely to be of a consistent quality across all DNSPs. We note that where sub-categories are different, benchmarking could only be used at an aggregate level. However this would contain data sets where the information is of a poor quality, and may also relate to different technologies installed on the network.

- Each DNSP is likely to have different unit costs due to inherent differences in design and construction, and different cost accounting methods, for instance allocation of overheads.

[5] Nuttall Consulting, "Report – Capital Expenditure" June 2010, p33

3. Application and weight to be applied to repex model

We note that the AER intends to use the repex model as part of its overall assessment on the replacement capex proposed by a DNSP.

3.1 How the model should be used by the AER

Despite the limitations identified in Section 2, we consider that the repex model can play a role as a partial indicator of the efficiency of elements of the replacement capex. The NSW DNSPs have applied 2 principles that should be considered when applying benchmarking tools such as the repex model:

- Testing the relative effectiveness of the tool to provide insights into efficiency.
- Using the information in a way that enables the decision maker to identify whether there is a potential inefficiency in the forecasts.

Effectiveness of the repex model

The NSW DNSPs note that the Productivity Commission undertook a comprehensive review of the use of benchmarking in a regulatory setting. A key finding was that poorly designed tools or misapplication can mislead the decision maker, resulting in outcomes that do not meet the long term interests of customers. For this reason, the Productivity Commission recommended that benchmarking techniques need to meet 6 criteria.

Using the available explanatory information provided by the AER we have sought to analyse the repex model in relation to the 6 criteria. This is set out in Attachment A. The key findings of our analysis are:

- The underlying model and data limitations mean that the repex model does not sufficiently satisfy the criteria of an effective benchmark.

- The relative effectiveness of the repex model largely depends on the underlying characteristics of the asset group. This means that in some cases, the model should be disregarded entirely and not used as part of the AER's assessment approach. In other cases, the model does provide the regulator with information that can help guide its detailed review of replacement programs that are higher or lower than the model's predictions.

- The lack of clarity on how the AER will use the multiple forms of the model (base case, calibrated forms) to target its detailed reviews of programs and projects raises issues on subjectivity in the application of the outcomes.

- Multiple forms of the model may lead the AER into error, particularly where it has used data from other DNSPs to calibrate the model.

Use of model in decision making

For these reasons we consider that limited reliance should be placed on the model's outcomes when assessing the replacement capex of the DNSPs. In particular, he model should not be used to reject a DNSP's proposal without further assessing the detailed forecast methods, investment plans and costings underlying the proposed capex. Further, the outcomes of the model should not be used as a basis for substituting an alternative estimate of replacement capex.

In our view, the most effective way to use the repex model is to:

- Only use the repex model for sub-categories that meet the conditions identified in Section 3.2 below. In other cases, the AER should not use the model outcomes at all to guide decision making

- For sub-categories that meet the conditions, the AER would use the repex model to target programs where a DNSP is outside a reasonable range (either higher or lower in costs). The AER could use the different forms of the model to perform this check, but must give consideration as to whether deviations in outcomes are driven by deficiencies in the model specifications.

- The AER would undertake a detailed review of the programs which the repex model considers sit outside the range predicted by the repex models. The AER would undertake a neutral review of the underlying strategies and policies, the forecasting methods, other trend analysis, and the detailed basis underlying the proposed expenditure.

- Where the AER finds an issue, it would seek explanation and reasons from the business prior to forming a conclusion. This ensures that relevant material has not been disregarded in the AER's assessment.

- If having reviewed the material in light of the capex criteria, the AER considers that the proposed expenditure should be rejected, the AER should base a substitute on the identified issues rather than rely on the outcomes of the repex model.

3.2 What asset categories could the repex model be used for?

Taking these issues into account, we consider that the repex model can only be used for a very limited range of sub-categories, and should not be calibrated using the data of other DNSPs unless data quality is sound. We consider that the repex model will likely work best when the following factors are present:

- The underlying data quality is accurate and reliable. This includes appropriate checks on any benchmarking material provided by other DNSPs to ensure the data can be relied on, and is comparable.

- There is sufficient granularity in technology types such that asset category types are based on assets that exhibit uniformity in failure modes and similar safety or reliability consequences.

- The assets need to have a known failure / replacement rate which has been stable for over 5 years and is expected to continue for the next 5 or more years with no anticipated changes.

- When assets which have short construction lead and delivery timelines, typically 3 months or less, this scope includes handover to construction, scheduling of resources, management and delivery of construction phase and closeout of project costs.

- The sample size to determine average expenditure of works is large, and is not highly variable over time.

In our view, this type of assessment needs to be taken by the AER on each sub-group category in the model. In this regard we note that the AER's high level groupings are based on the type of asset, for instance poles, feeders, switchgear and transformers.

We consider that the effectiveness of the repex model is more dependent on where the individual asset type sits in the network (ie: sub-transmission, 11kV or the lower voltage distribution network). For example, the model may be more suitable for low voltage underground feeders, compared to 132kV feeders due to greater sample sizes and therefore more confidence in variability of costs. For this reason, we have reviewed the effectiveness of the model in relation to the elements of the network.

Sub-transmission assets

We consider the model will be highly ineffective at predicting the forecast capex for sub-transmission assets, and should not be used at all in the AER's assessment. This is based on how the asset performs against the factors we have outlined.

While the underlying data quality is likely to be far more accurate than other elements of the network, the key weakness with sub-transmission assets is the limited sample size upon which to base analysis. This means that inputs such as average age of replacement and unit costs are based on a few assets and therefore cannot be relied on for analytical purposes. The issue becomes worse when the underlying technologies in the population are substantially different and exhibit varying failure modes, meaning that the replacement age of assets is likely to vary significantly.

A further weakness is that sub-transmission assets are marked by high variability in costs due to site specific factors. For example, replacing sub-transmission cables under the harbour will have a significant cost premium relative to replacing a cable in a less dense suburb. It is for this reason that DNSPs generally undertake detailed costings on major equipment rather than rely on averages of the past. In addition, these projects can take many years to build meaning that financial data may not provide an accurate picture of the average cost of replacing the asset.

Given these deficiencies, we consider that a preferred method of assessment should be to undertake a detailed review of underlying asset management strategies, forecast methods, investment cases, and costing estimate data.

11kV (High voltage) assets

We consider the repex model may have some merit as a high level assessment tool for 11kV replacement, but that the outcomes have a high degree of error. There are a large population of 11kV feeders, which means that an experienced network planner may use models as part of a prudent long term forecasting approach. However, the planner's model would likely be more complex than the repex model to cater for information such as failure rate trends and variations in costs.

When looked at on the surface, 11kV assets meet many of the factors identified above for using repex as an assessment tool. For instance, there is a greater sample size to undertake analysis, and less apparent variability in scope of works to replace an 11kV asset. Further, construction times would not span longer than a year. For this reason, we consider that it may have some merit in being applied.

At the same time, there are a number of complexities that need to be considered prior to using the repex model for assessment purposes:

- While there are greater numbers of 11kV assets in service than sub-transmission assets, there is a diverse range of technologies that are installed across our networks. These are likely to have different failure modes, and consequently asset lives. At a sub-category level this issue may be addressed through providing data in a granular manner, however there is limited data quality at more granular levels.

- Similarly, the type and location of an 11kV asset will greatly impact the complexity of replacing an 11kV asset, and therefore we would expect there to be variability in costs. For this reason the average unit cost may not be a reliable estimate, unless the sub-categories relate to the complexity of the project.

- There is very little replacement being undertaken on the 11kV networks across the 3 businesses, and therefore a paucity of samples to use when estimating the average life.

For these reasons, we think the outcomes of the repex model for testing the forecast of 11kV investment should be used with caution.

We also note benchmarking data of peer DNSPs is very problematic and should not be applied by the AER. The costs of conducting 11kV will greatly depend on the underlying area where works are taking place. For instance, replacing an 11kV asset in a highly dense urban area creates additional costs, such as multi-way ductlines in the Sydney CBD . We also note that DNSPs such as Victoria use a 22kV voltage configuration which means that peer comparisons cannot be used.

Distribution assets

Distribution assets such as substations and low voltage feeders are perhaps the most amenable for applying the repex model. Distribution assets are numerous in volume and therefore an experienced planner may use similar types of models to identify long term forecasts. In this respect, distribution assets meet many of the conditions for using repex as an assessment tool.

For instance, there is generally a large sample size at a sub-category level, which means that assets can be designated to common technologies that exhibit similar failure modes. For instance LV Consac cables have common failure modes, and there is a sufficient population to draw inferences on the appropriate replacement age. However the model will only be accurate if there is sufficient granularity of assets in the model. For instance Consac cables are part of the underground cable category in the model, which comprise many construction types including HSL, HDPE, and XLPE, each of which have a variety of failure modes and therefore expected replacement lives.

The weakness with distribution assets is that data quality is likely to be poor, particularly age profiles and historic replacement ages. This means that the predictive value of the model is likely to be imprecise. We consider the issue of data quality becomes even more of a problem when our replacement ages and unit costs are compared to other DNSPs. Our understanding is that other DNSPs also have very poor quality data at the distribution level of the network, and therefore the application of benchmarking data will result in errors when reviewing the outcomes of the model.

Benchmarking unit costs and asset ages to peer distributors adds a further complexity, and is very likely to result in misleading outcomes. At the distribution level, there are network specific drivers that explain cost differentials and the average age of replacement. For example, the cost of replacing a Sydney CBD substation (which comprise three 1000kVA transformers and switchgear) is far higher than a rural substation of equivalent voltage(comprising one 50kVA transformer and High Voltage Dropout fuses).

Attachment A – Assessment of repex model compared to Productivity Commission criteria

Productivity Commission criteria	Productivity Commission's description of criteria	NSW DNSPs' assessment of repex model relative to Productivity Commission criteria
Validity	A valid benchmark should relate to efficiency (or conversely inefficiency) in one or more meaningful dimensions. A valid benchmark should reflect the way that the businesses are run. In particular, comparing the costs between businesses in different jurisdictions without accounting for factors outside the control of the business could provide misleading indicators of managerial efficiency.	For the reasons identified in Section 2.1 of this document, we consider the repex model does not adequately reflect the drivers of replacement.
Accuracy and reliability	Accuracy is the degree to which a benchmark provides an unbiased estimate of efficiency, while the reliability (used here in the normal sense of reproducibility) is about the variance of the measure.	For the reasons identified in section 2.2 we consider that the underlying data on replacement age and average costs is not accurate for each asset sub-category in the model. This means that the predictive values are only accurate and reliable for certain sub-categories inputted by the DNSP.
Robustness	This is a subset of accuracy and reliability, but worth emphasizing in its own right. A particularly useful robust measure is one that provides information about the efficiency of an enterprise regardless of its operating environment.	We consider that the model is not robust as the average age of replacement and unit costs are impacted by a number of factors not considered in the model. We refer the AER to Section 2 of this document
Manipulation and gaming of data	Manipulation and gaming of data - As in all systems where rewards and punishments depend on incomplete measures of performance, the measured party has incentives to 'look' like a highly performing entity. Accordingly, the regulator should consider the capacity of any particular benchmarking measure to create unforeseen business behaviours.	As noted in section 2.3, we consider that the AER's use of calibrations and benchmarking data may lead to cherry picking of the data series to draw inaccurate conclusions.
Parsimony	Parsimony - A good model should be no more complex than required. This is important in assisting interpretability, avoiding data mining, achieving robust results, reducing data collection costs and allowing greater comparability of results across countries.	The model is relatively simple, but contains complexity due to the number of manipulations and forms that can be applied by the AER in drawing conclusions.
Fit for purpose	Benchmarking has multiple purposes. Some require great accuracy, reliability and robustness. This is particularly important where benchmarking is used to determine a business's revenue allowance. Such benchmark estimates should be highly reliable across time, business types and jurisdictions. The concerns are less where benchmarking is indicative — used to identify areas for possible future investigation, or to reach some prima facie judgment.	We consider that the model is only fit for purpose when the AER applies it in the manner set out in section 3.1.

APPENDIX D - EVANS AND PECK REVIEW OF COST DRIVERS

Ausgrid

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

Final Report

November 2012

Executive Summary

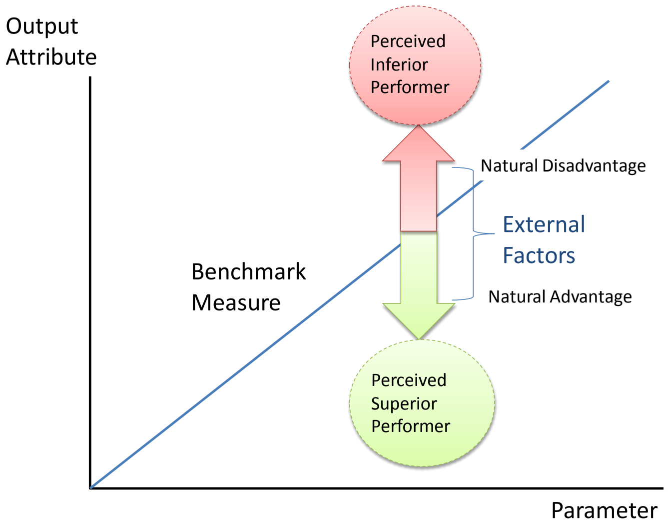
Commonly, and not surprisingly, there is an expectation that it should be a relatively simple matter to establish benchmarks comparing the performance of Distribution Network Service Providers (DNSPs) from an economic and service level perspective. A seemingly logical conclusion is that such benchmarking 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.

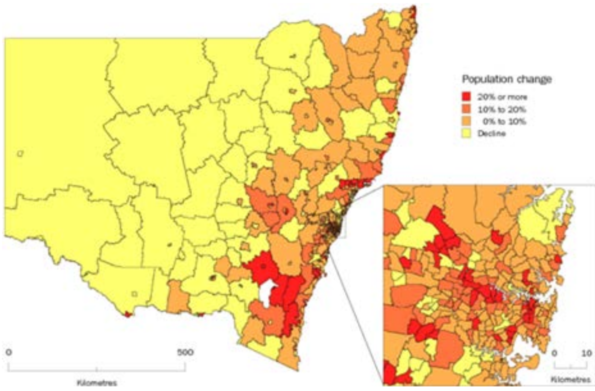
We considered a range of characteristics and have subsequently reported on a number of key comparison. Whilst there are complex factors which make it difficult to support the assertion that any network is actually 'similar' to another network, and accepting that there is probably no single measure to 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	Natural Cost Disadvantage	Natural Cost Disadvantage	Natural Cost Advantage	Natural Cost Disadvantage	Natural Cost Advantage	Natural Cost Advantage
Customer Comparisons	Natural Cost Disadvantage	Natural Cost Disadvantage	Natural Cost Advantage	Natural Cost Disadvantage	Natural Cost Advantage	Natural Cost Advantage
Efficiency Measures (Value RAB)	Natural Cost Disadvantage	Natural Cost Disadvantage	Natural Cost Advantage	Natural Cost Advantage	Natural Cost Disadvantage	Natural Cost Advantage
Intensity Measures (Volume)	Natural Cost Disadvantage	Natural Cost Disadvantage	Natural Cost Advantage	Natural Cost Advantage	Natural Cost Advantage	Natural Cost Advantage
Infrastructure Burden Measures	Natural Cost Advantage	Natural Cost Disadvantage	Natural Cost Advantage	Natural Cost Disadvantage	Natural Cost Advantage	Neutral

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

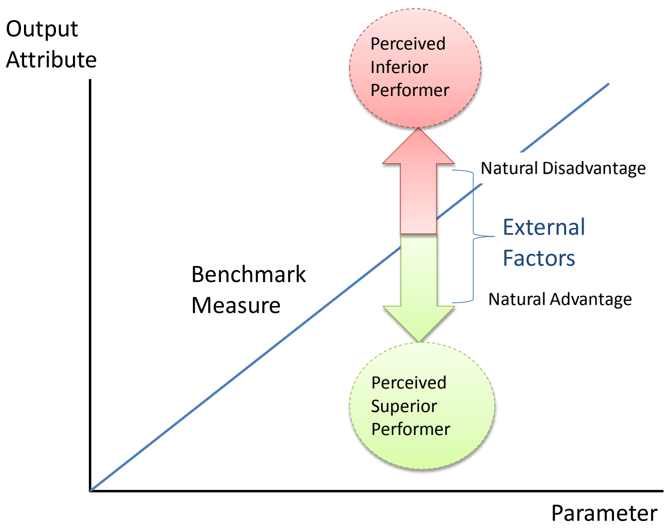


Figure 1-1: Impact of External Factors on Benchmarking

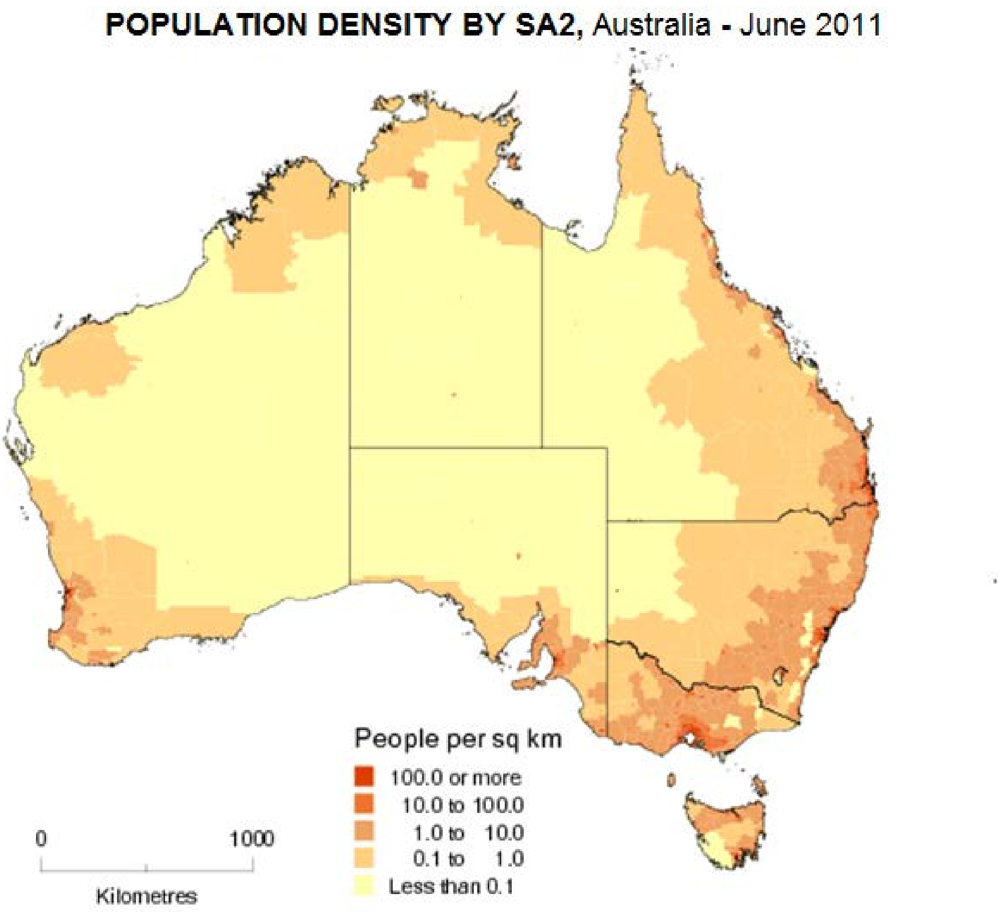
Benchmark modifiers described in Section 3 effectively demonstrate that popular benchmarks based on selective partial indicators do not accurately account for underlying business conditions and historical factors which otherwise contribute greatly to the true cost performance.

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.

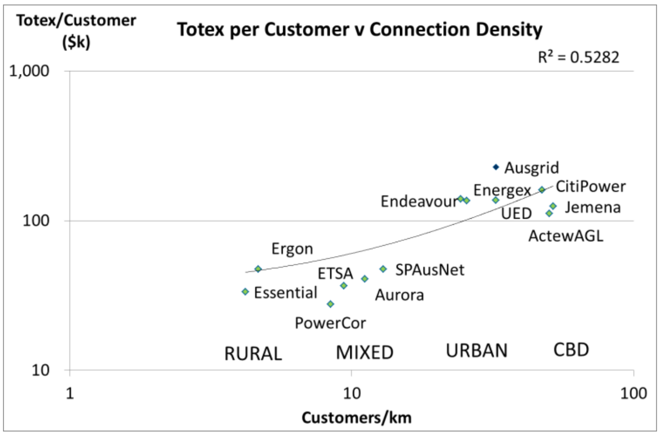


Figure 2-1: Total Cost/km and Customer Density

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.

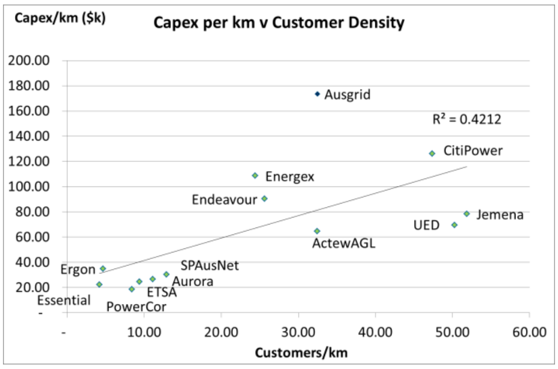


Figure 2-2: Capex per km and Customer Density

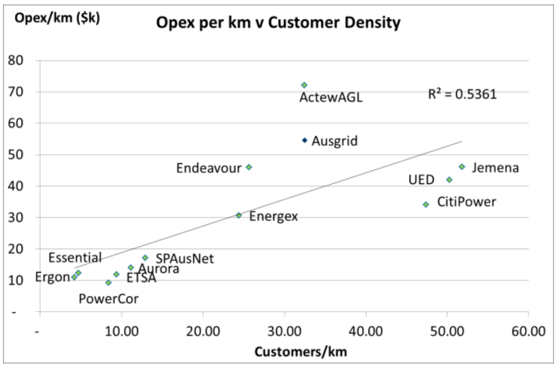


Figure 2-3: Opex per km and Customer Density

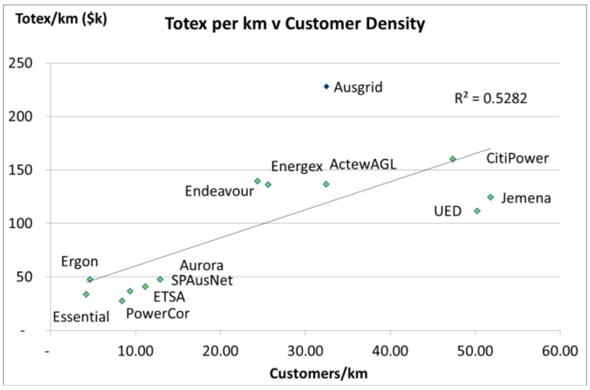


Figure 2-4: Totex per km and Customer Density

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.

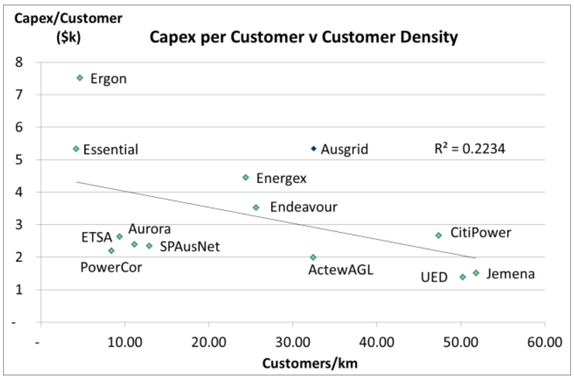


Figure 2-5: Capex per Customer vs Customer Density

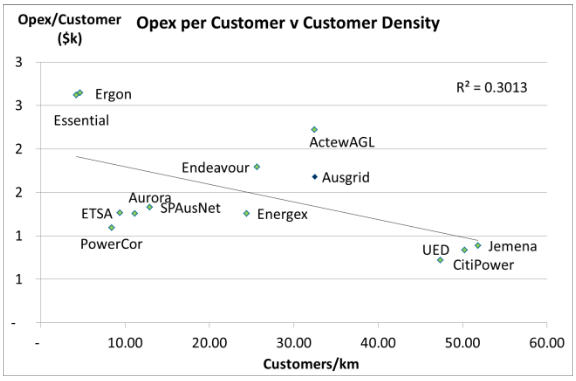


Figure 2-6: Opex per Customer vs Customer Density

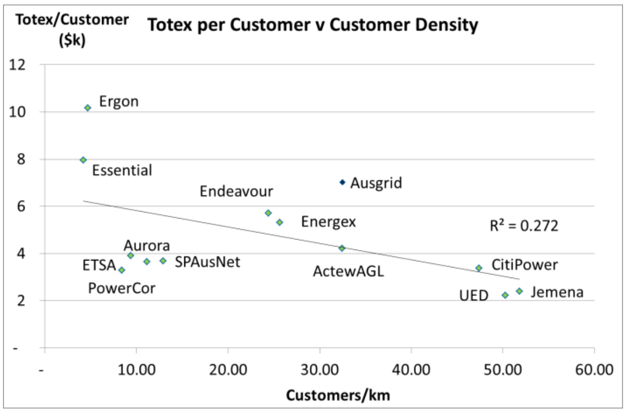


Figure 2-7: Totex per Customer vs Customer Density

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.

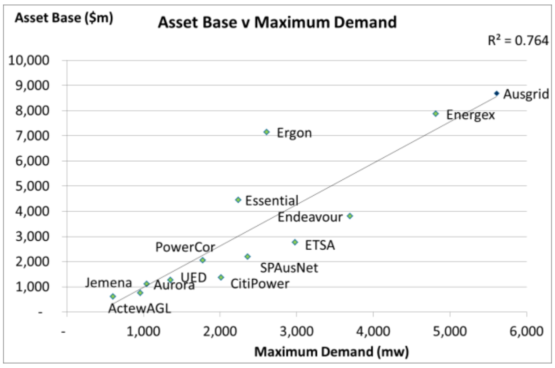
In many cases there are strong scale relationships between variables regardless of the network type (rural, urban, and mixed) whilst other relationships are distorted by the specific influences of network type, size or value. Most importantly, this analysis illustrates that cost drivers differ between 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



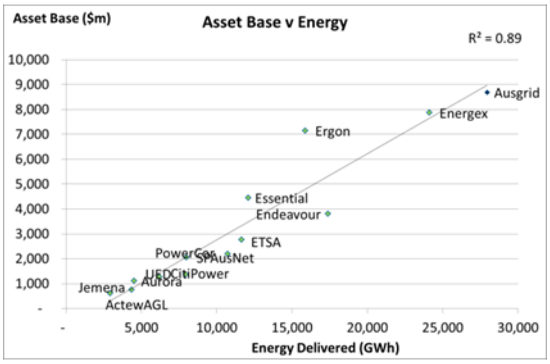
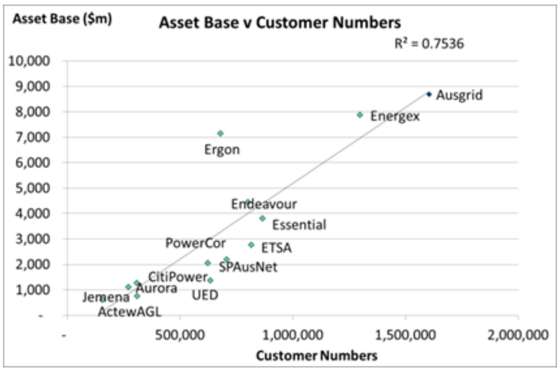


Figure 2-8: Asset Base vs. Maximum Demand **Figure 2-9: Asset Base vs. Energy**

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



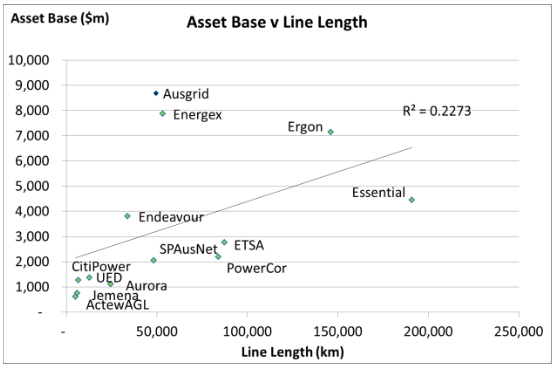
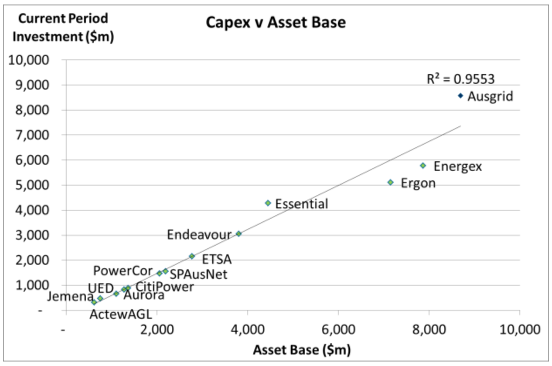


Figure 2-10: Asset Base vs Customer Numbers **Figure 2-11: Asset Base vs Line Length**

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



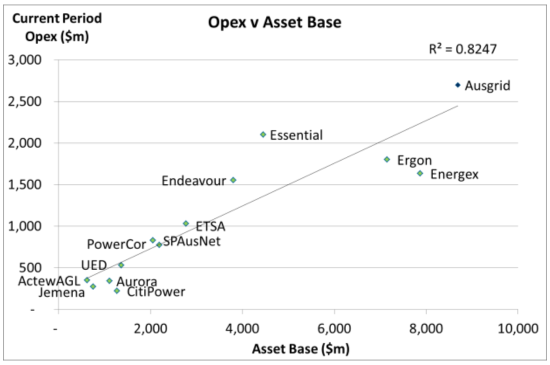


Figure 2-12: Capex v Asset Base

Figure 2-13: Opex vs Asset Base

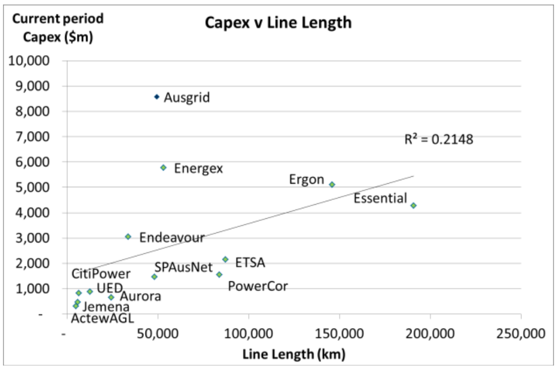
The capex and opex relationships shown in Figure 2-12: Capex v Asset Base and Figure 2-13: Opex vs Asset Base illustrate the efficiency of investment into the network and the expenses incurred in operating and maintaining the network. Ausgrid, Essential, Endeavour, ETSA and SP AusNet all fall on or above 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



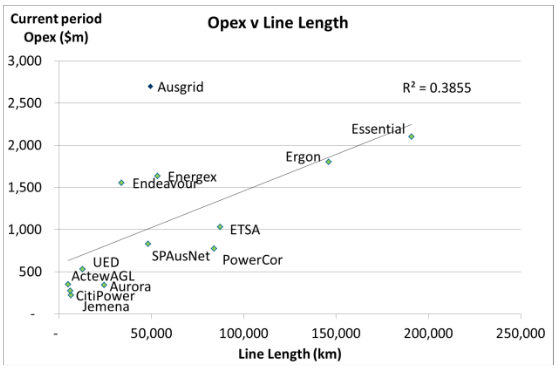
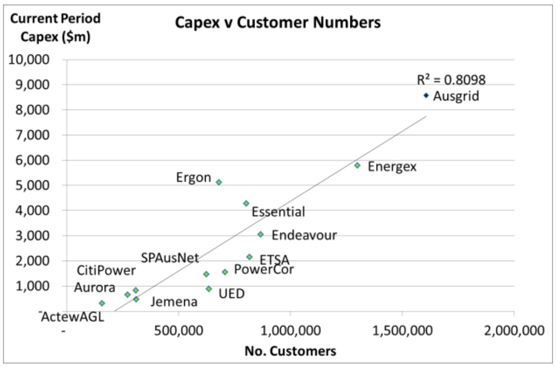


Figure 2-14: Capex vs Line Length

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



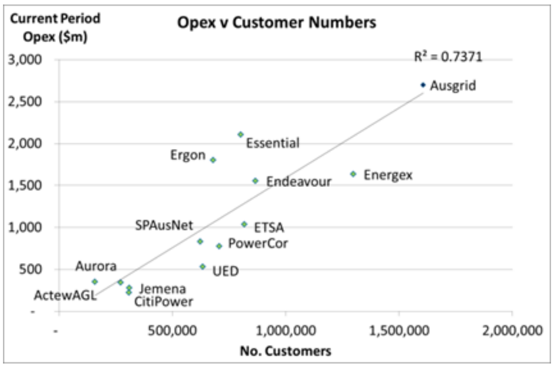


Figure 2-16: Capex vs Line Length

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.

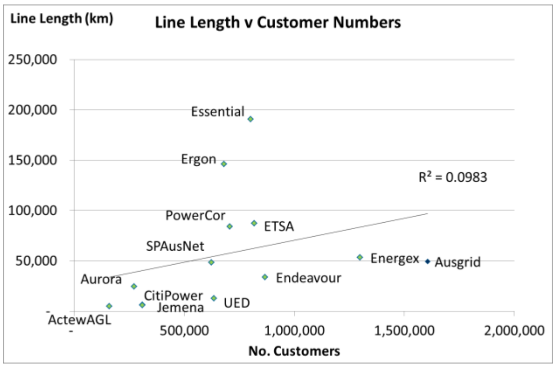
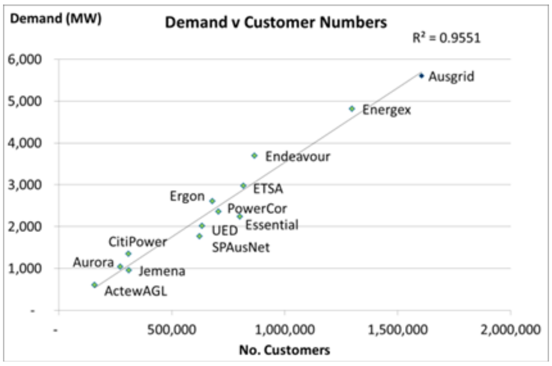


Figure 2-18: Line Length v Customer Numbers

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.



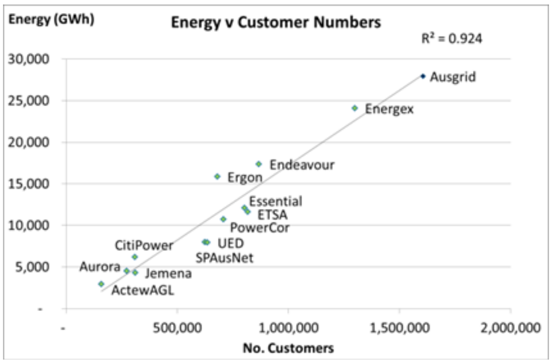


Figure 2-19: Demand vs Customer Numbers **Figure 2-20: Energy vs Customer Numbers**

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.

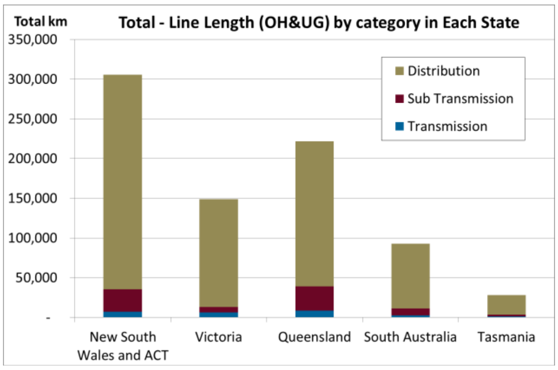


Figure 3-1: Total Line Length (Overhead and Underground)

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.

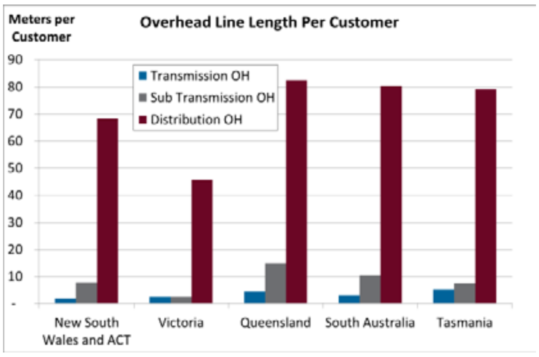


Figure 3-2: OH Length Per Customer

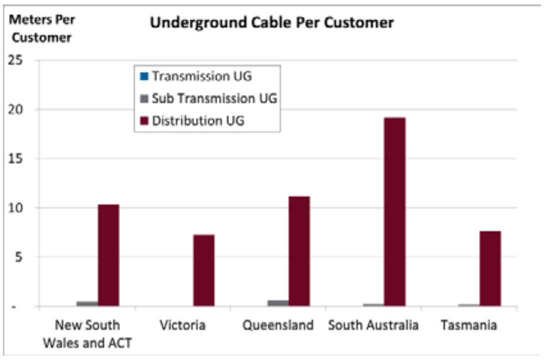


Figure 3-3: UG Cable Per Customer

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.

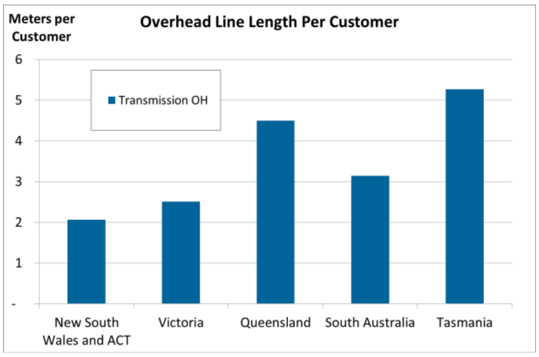


Figure 3-4: Transmission OH Per Customer

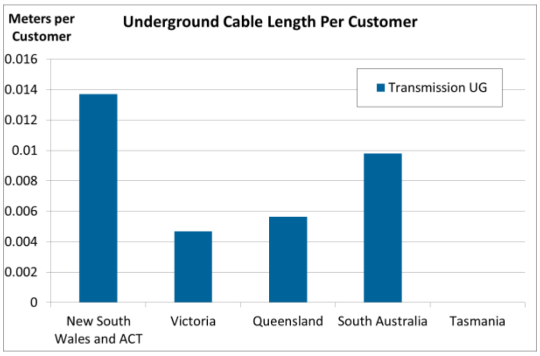
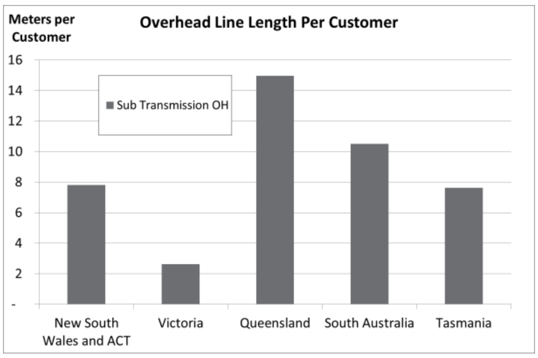


Figure 3-5: Transmission UG Per Customer



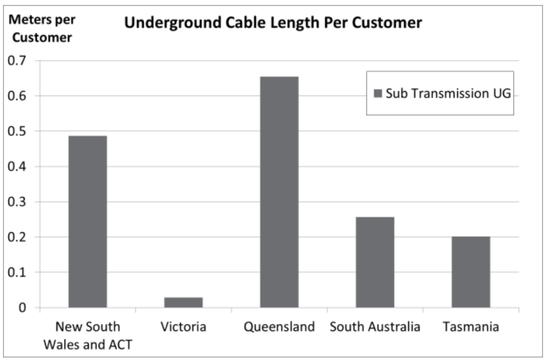
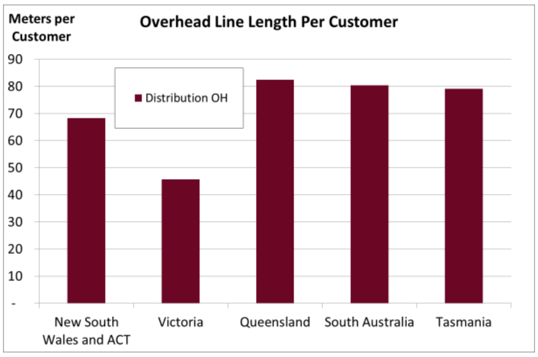


Figure 3-6: Subtransmission OH Per Customer **Figure 3-7: Subtransmission UG Per Customer**



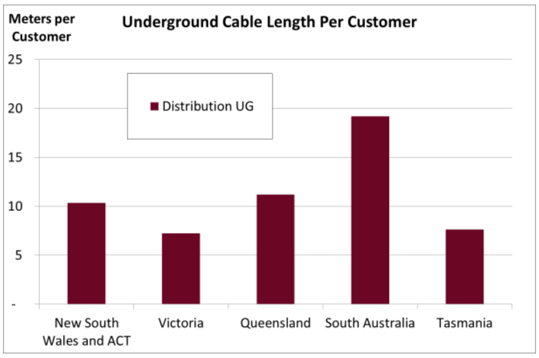


Figure 3-8: Distribution OH Per Customer **Figure 3-9: Distribution UG Per Customer**

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.

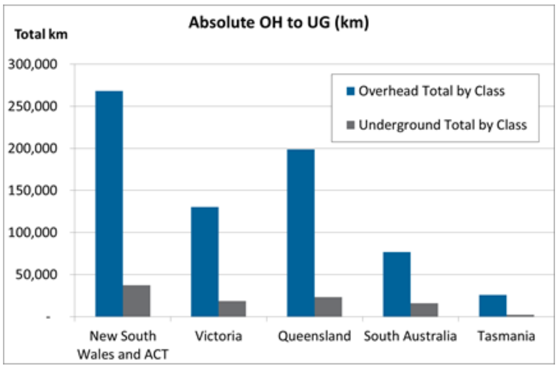


Figure 3-10: Overhead to Underground

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.

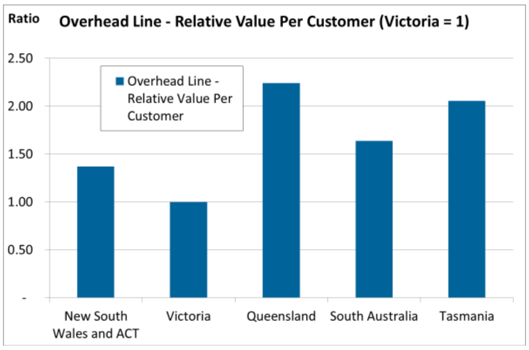


Figure 3-11: OH Relative Value Per Customer

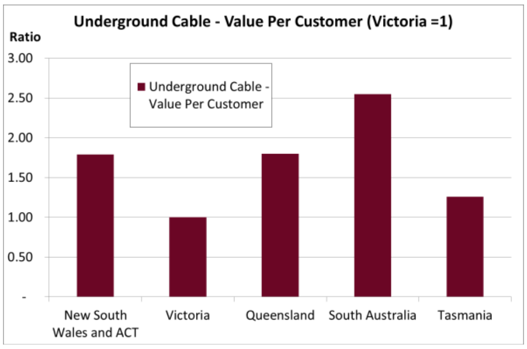


Figure 3-12: UG Relative Value Per Customer

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.

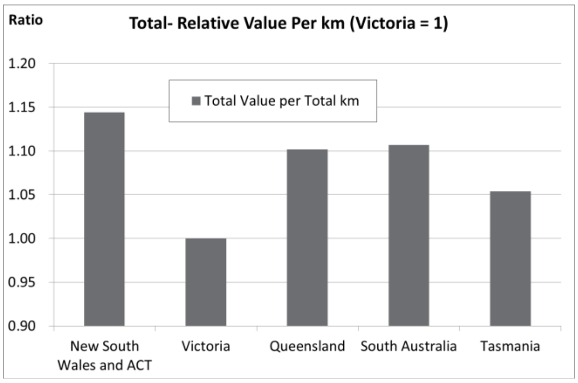


Figure 3-13: Total Relative Value

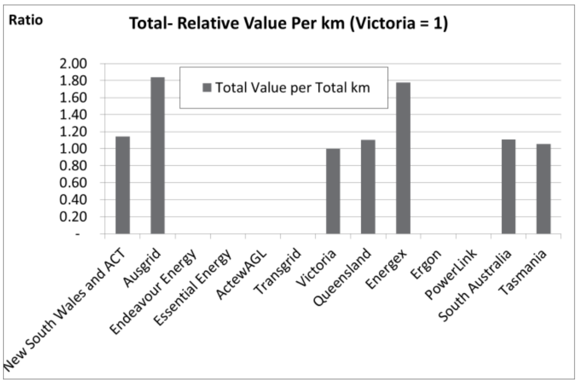


Figure 3-14: Total Relative Value (Ausgrid)

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.

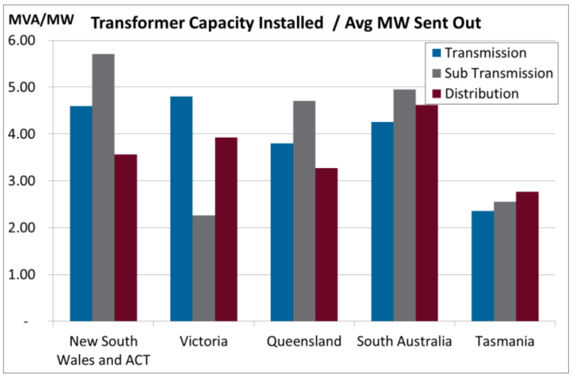


Figure 3-15: Tx Capacity per Average MW Sent Out

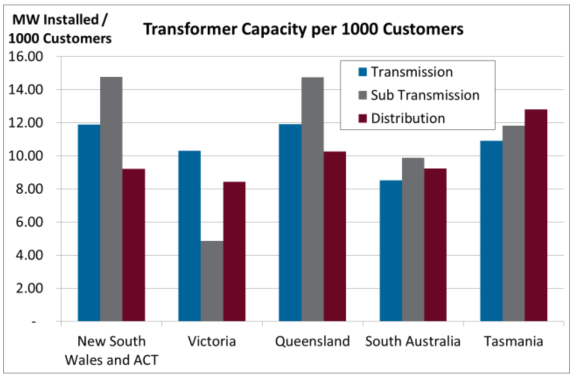


Figure 3-16: Tx Capacity per 1000 Customers

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.

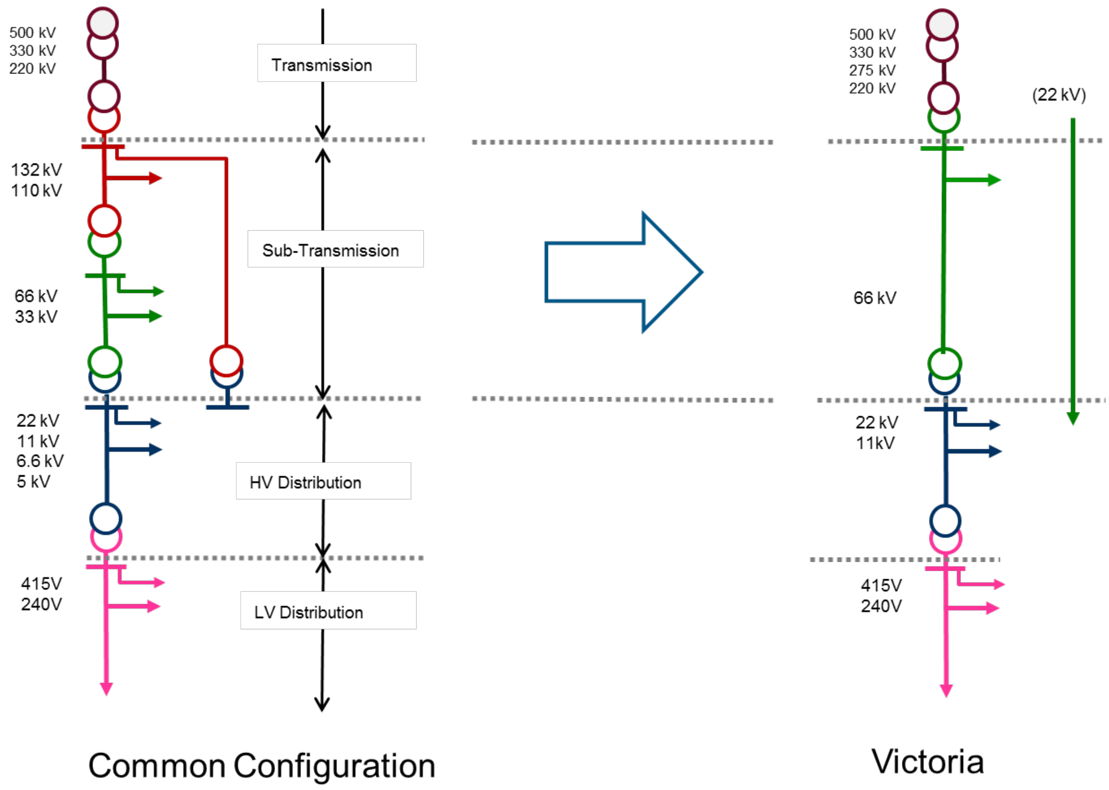


Figure 3-17: Typical Distribution Network Arrangement

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.

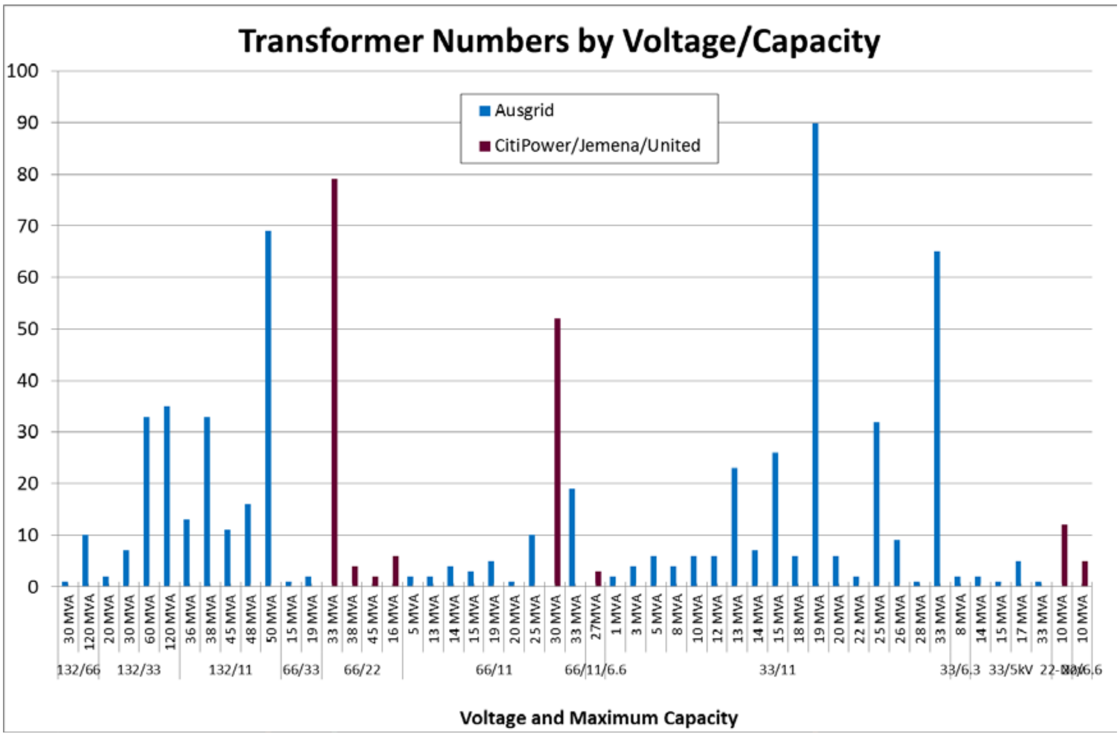


Figure 3-18: Transformer Numbers by Voltage/Capacity

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	Natural Cost Disadvantage	Natural Cost Disadvantage	Natural Cost Advantage	Natural Cost Disadvantage	Natural Cost Disadvantage	Natural Cost Disadvantage

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.

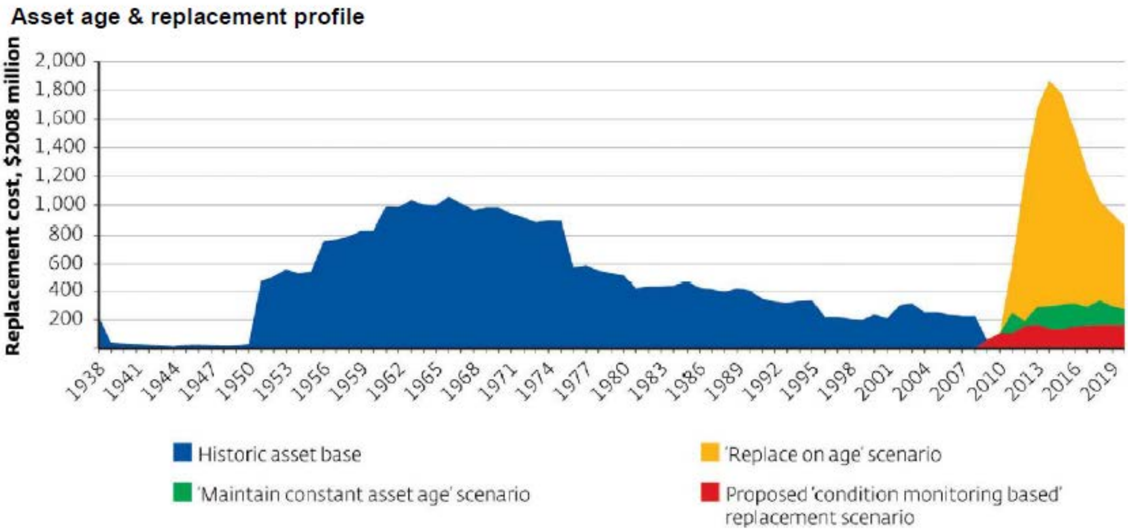


Figure 3-19: Typical Asset Age and Replacement Profile

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.

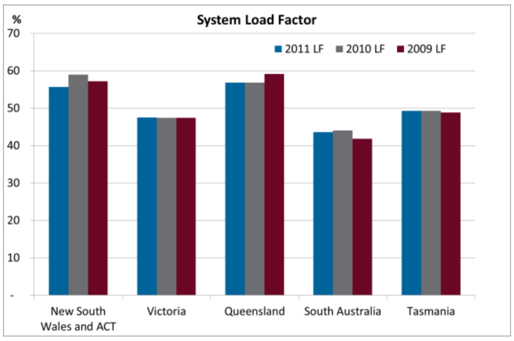
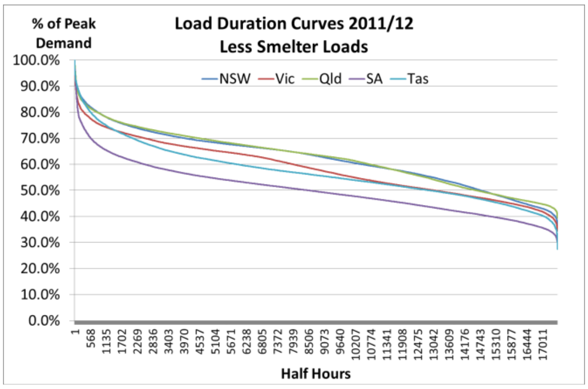


Figure 3-20: System Load Factor

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



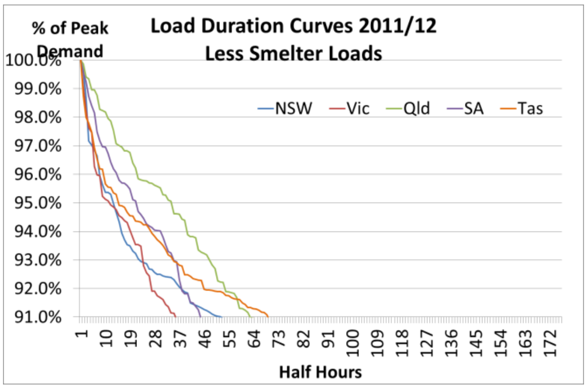


Figure 3-21: Load Duration Curves

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.

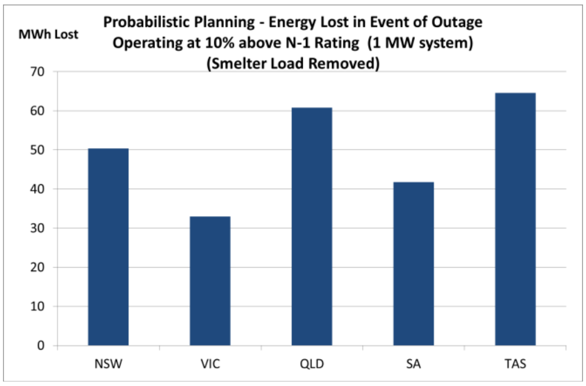


Figure 3-23: Probabilistic Planning – Energy Lost

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.

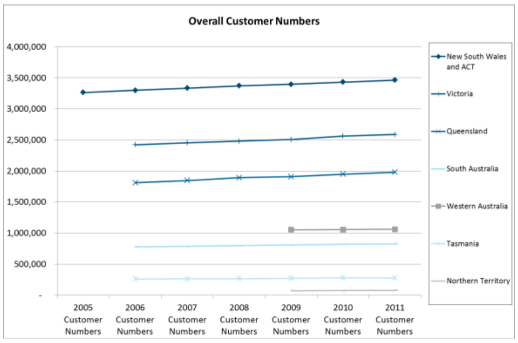


Figure 3-24: Customer Growth

Customer growth is generally consistent across all states.

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

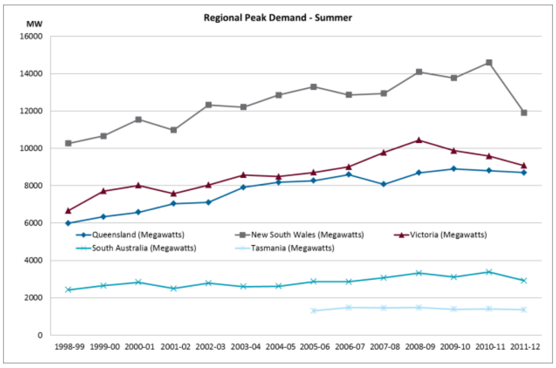
Table 10: Summary – Customer Growth

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.



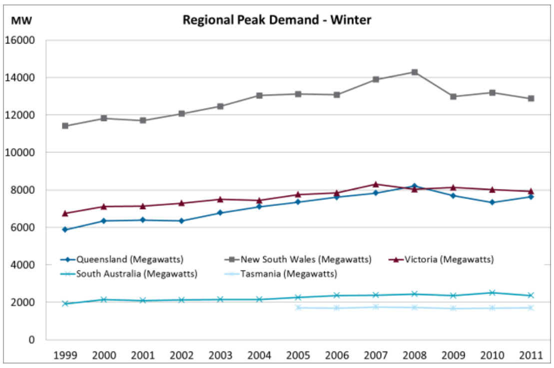


Figure 3-25: Regional Peak Demand – Summary

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.

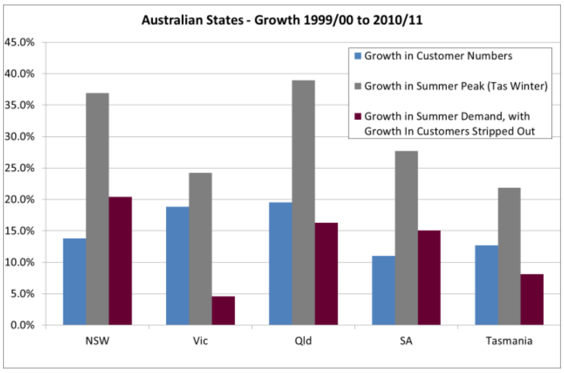


Figure 3-27: Growth in Summer Peak - Excluding Customer Growth

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").

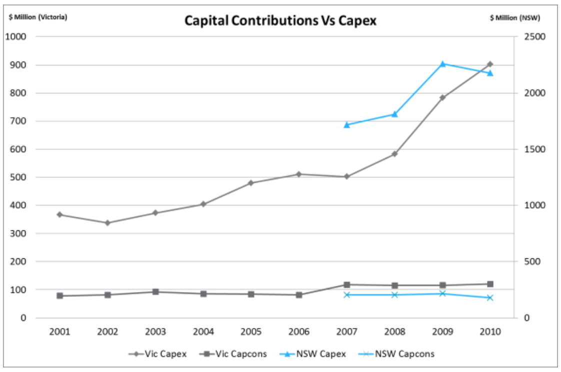


Figure 3-28: Capital Contribution and Capex

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	Natural Cost Advantage	Natural Cost Advantage	Natural Cost Advantage	Natural Cost Disadvantage		

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

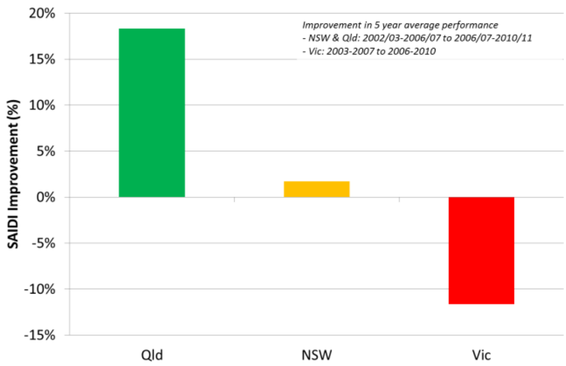


Figure 3-29: 5 year average reliability improvement 2002/03-2006/07 to 2006/07-2010/11

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 green-field, 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

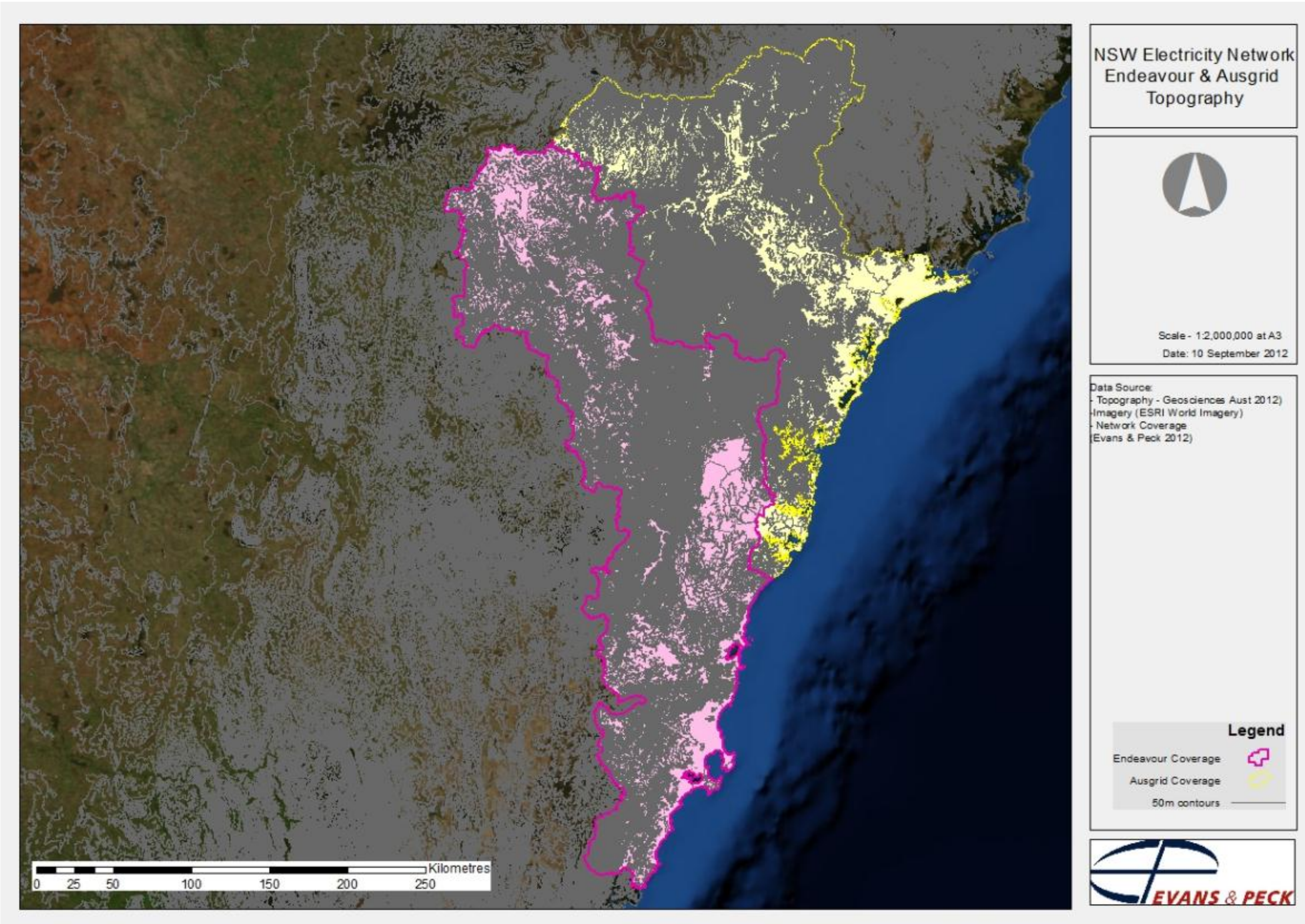


Figure 3-30: NSW Topography - Ausgrid

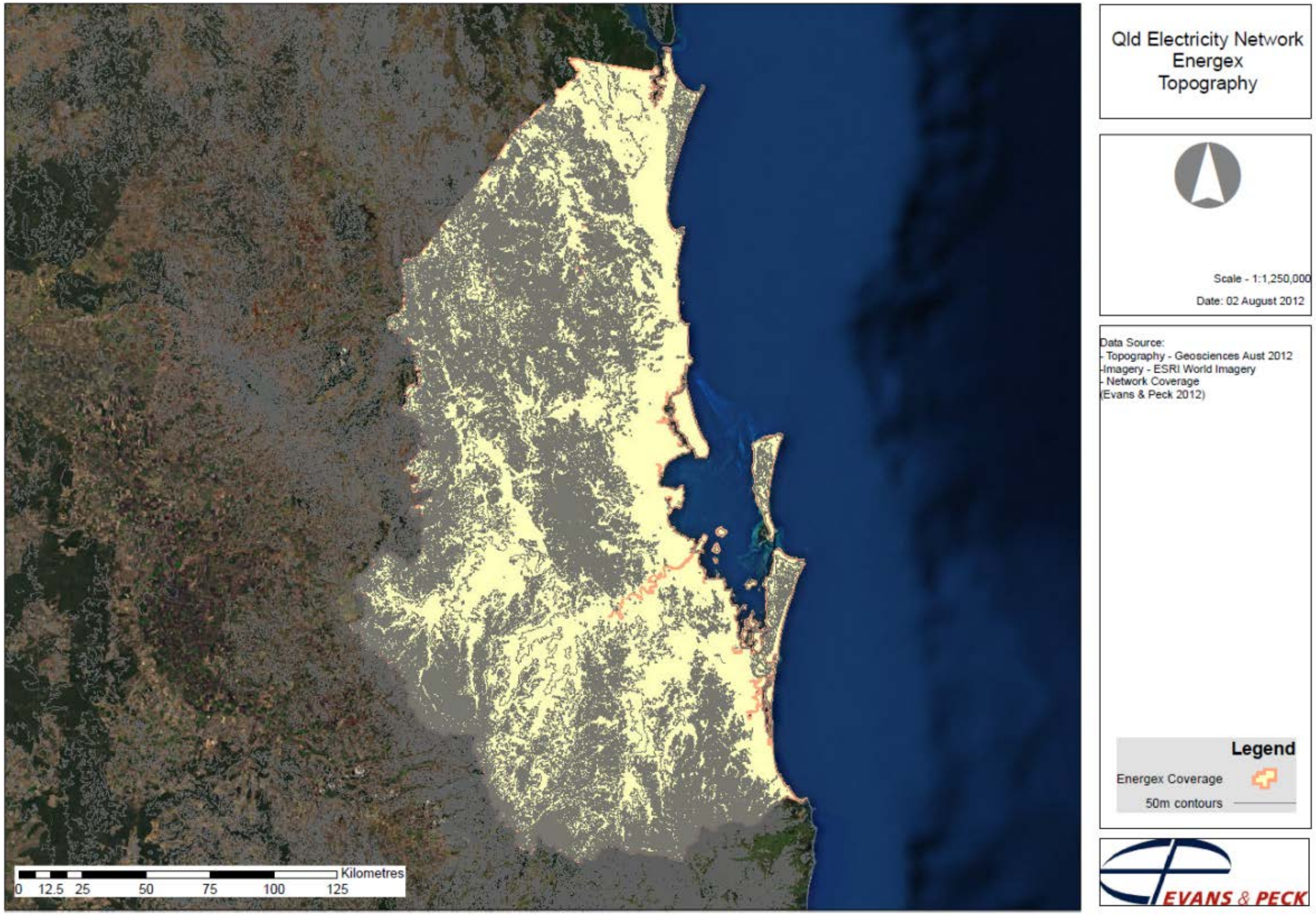


Figure 3-31: QLD Topography – Energex

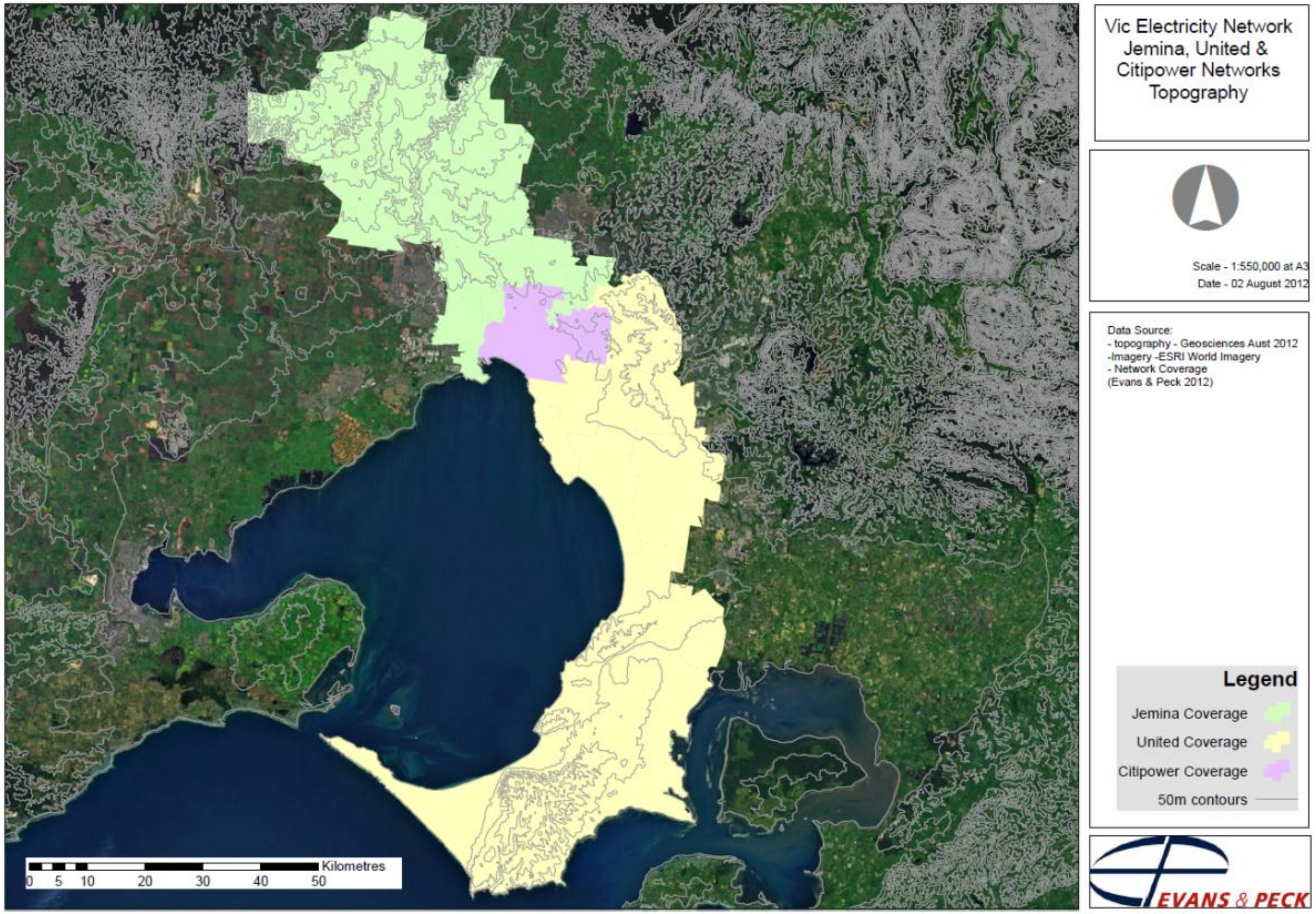


Figure 3-32: Vic Topography - CitiPower, Jemena, United

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	Natural Cost Disadvantage	Neutral	Natural Cost Advantage	Neutral	Neutral	Neutral

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

Table 17: Summary – Native Vegetation/ Environmentally Sensitive Areas

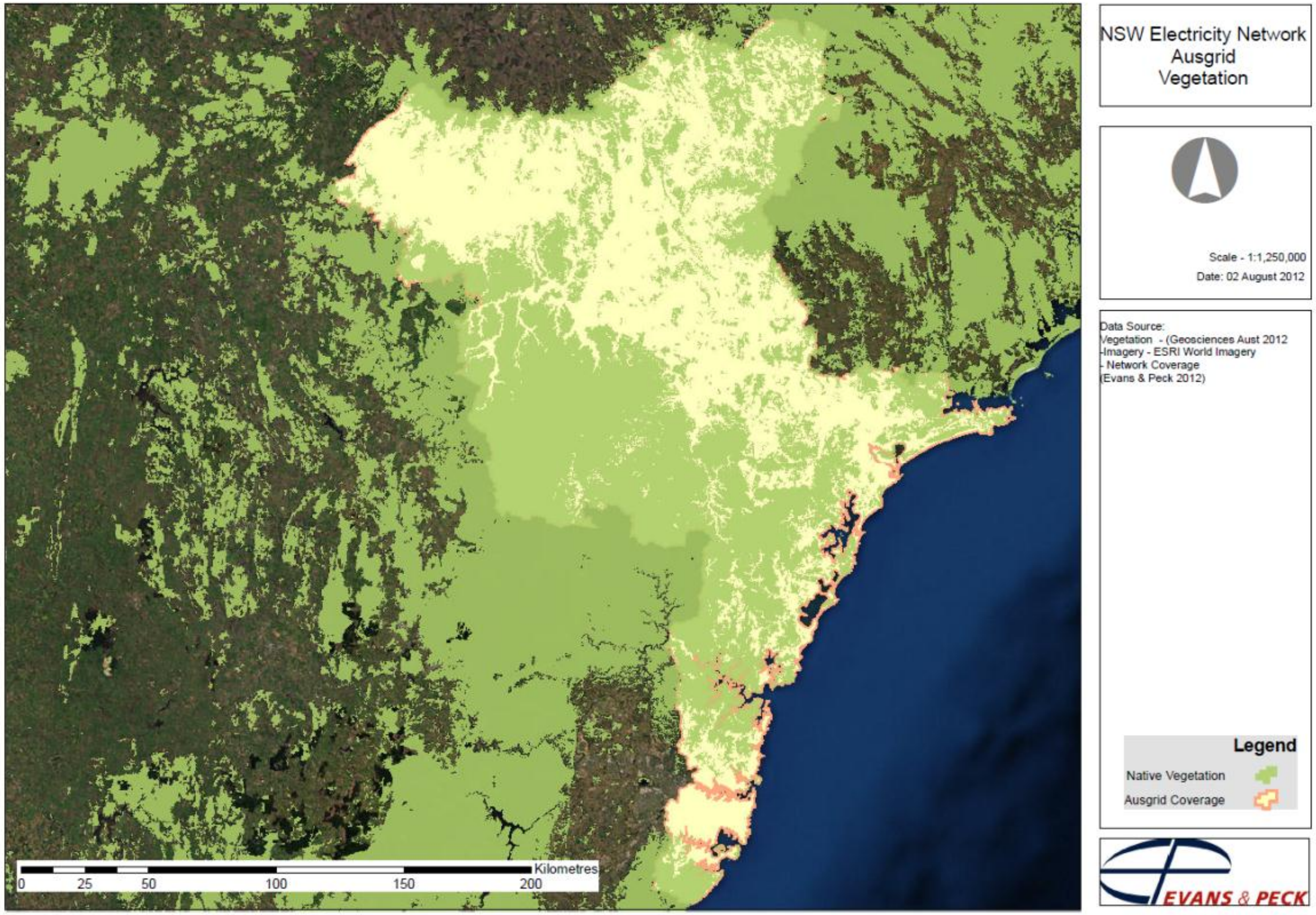


Figure 3-33: NSW Vegetation - Ausgrid

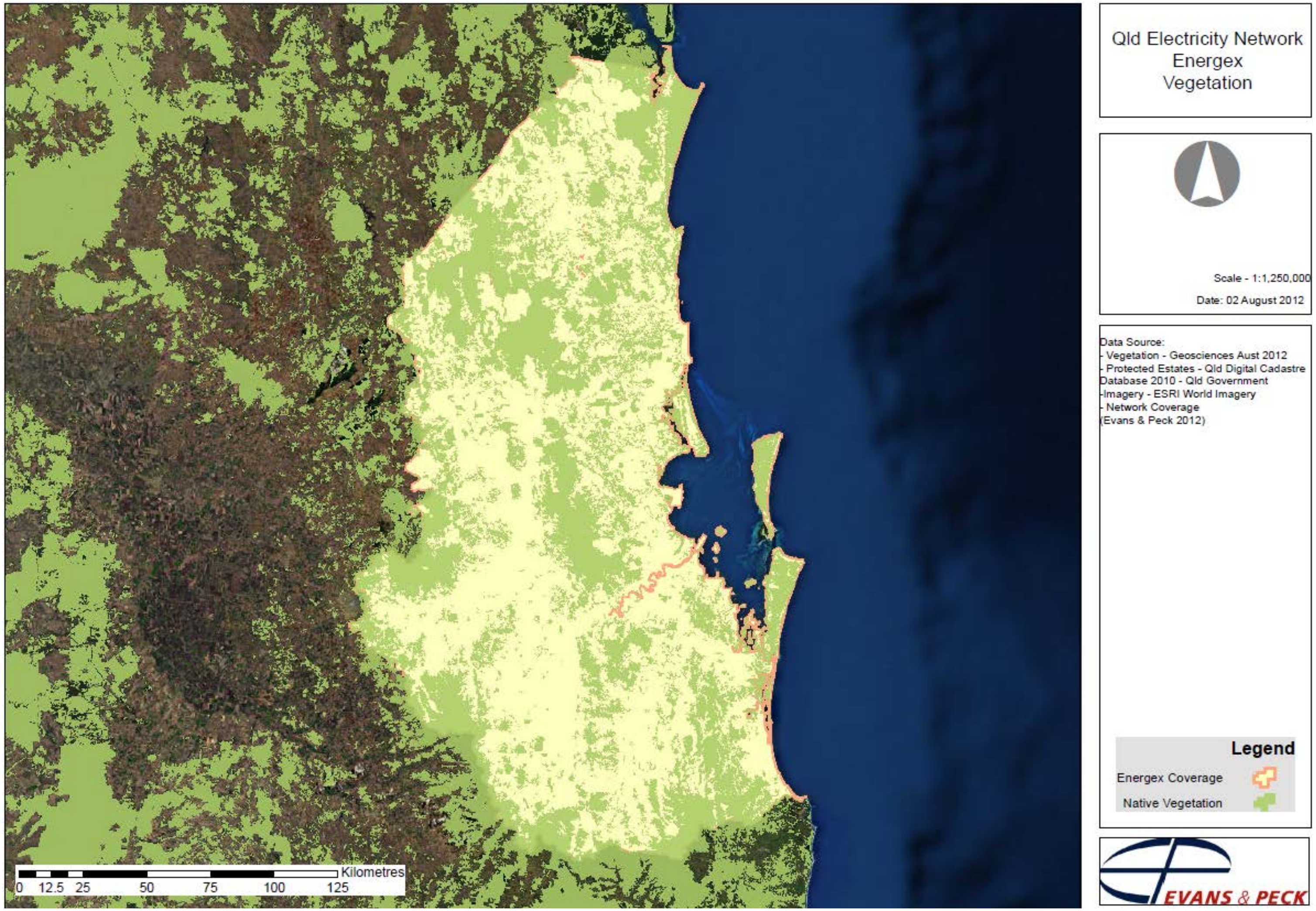


Figure 3-34: QLD Vegetation - Energex

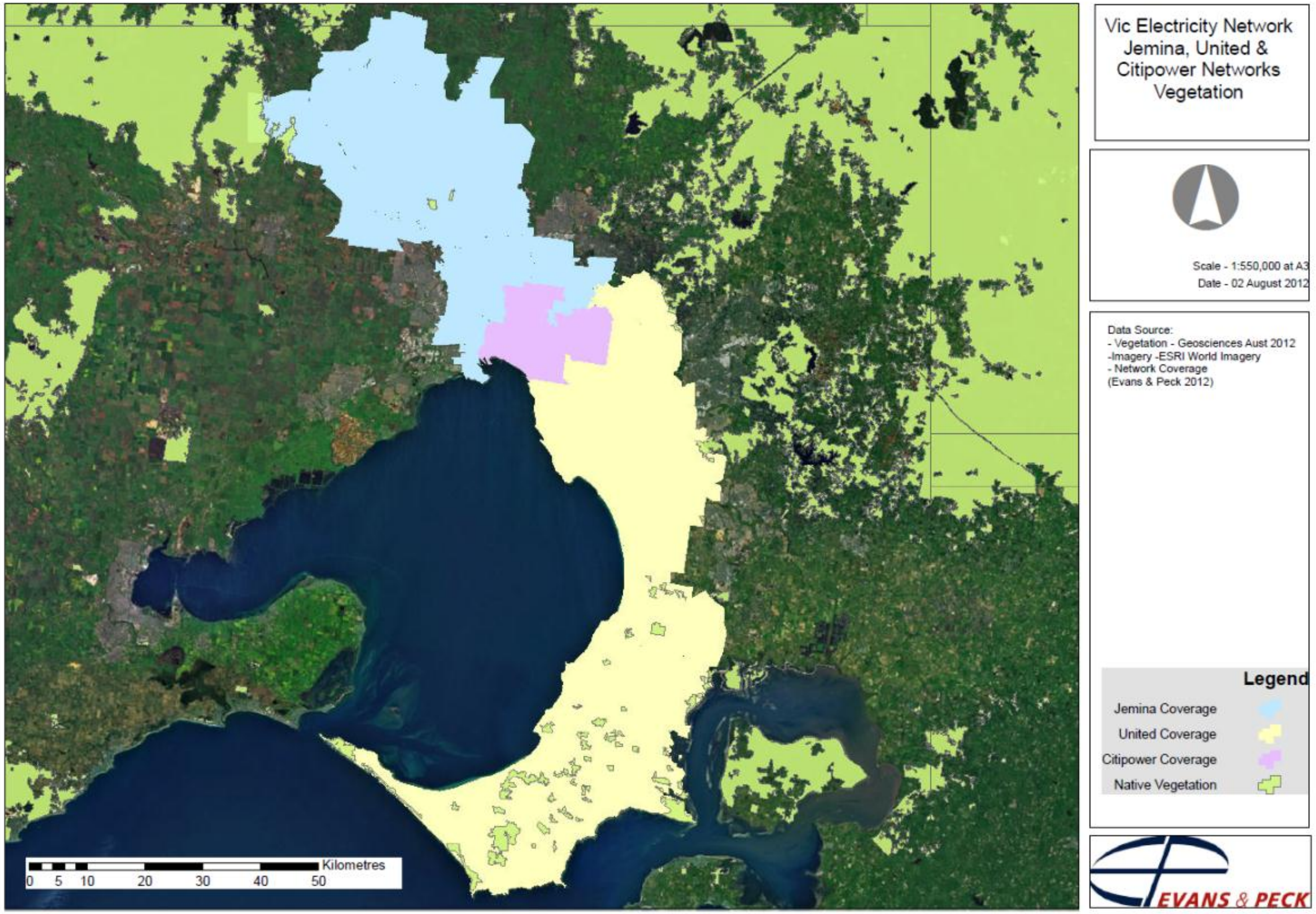


Figure 3-35: Vic Vegetation – CitiPower, Jemena, United

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.

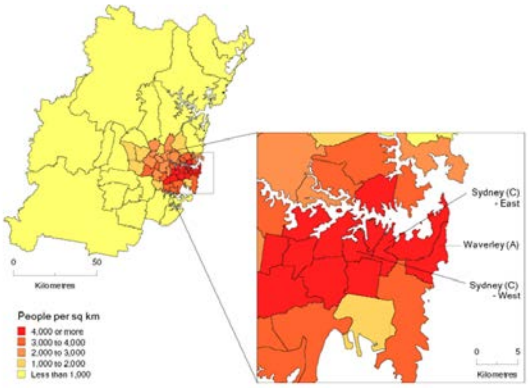


Figure 3-36: Population Density by SLA, Sydney - 2010-11

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

Table 18: Summary - Population Density

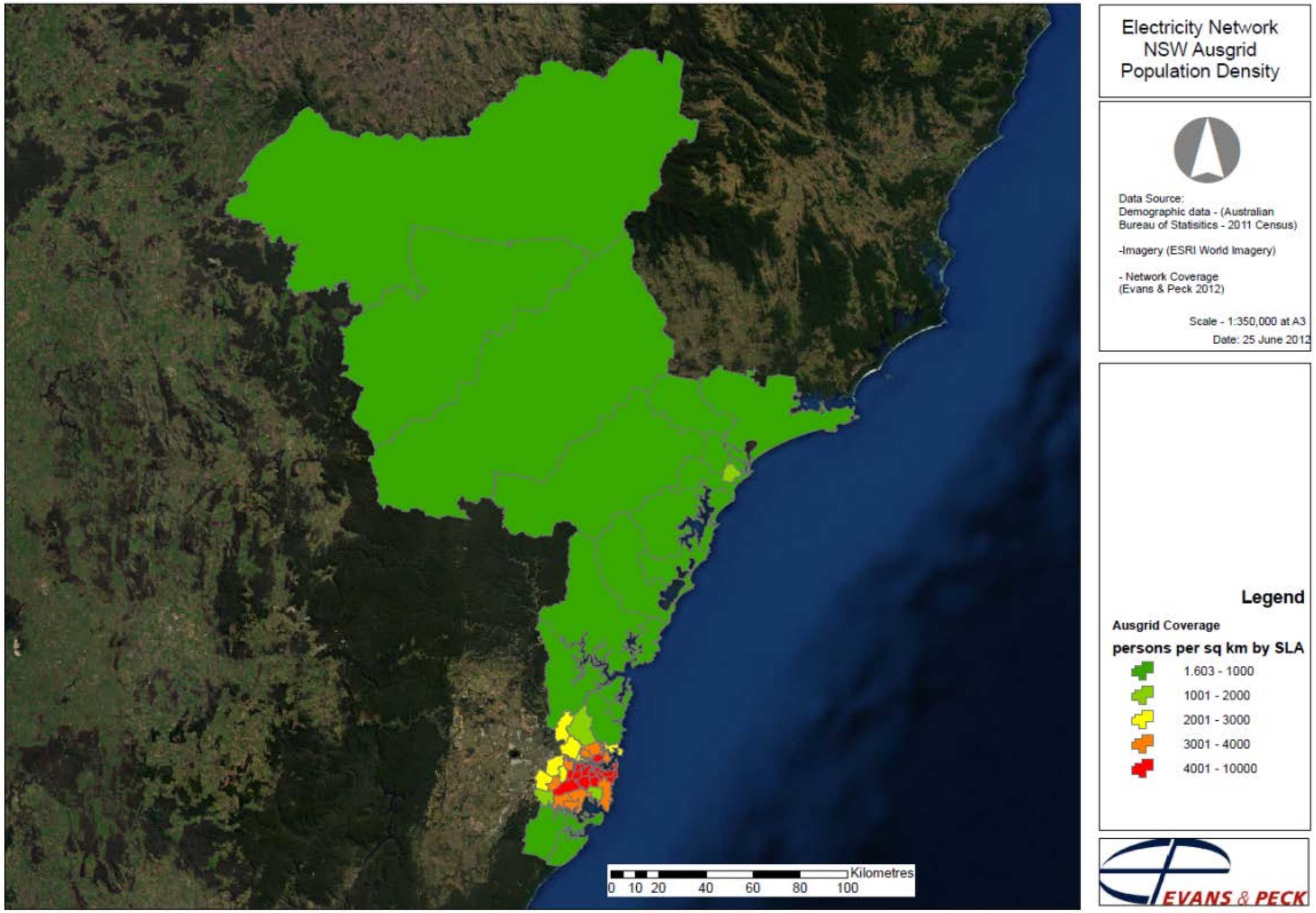


Figure 3-37: Population Density – Ausgrid

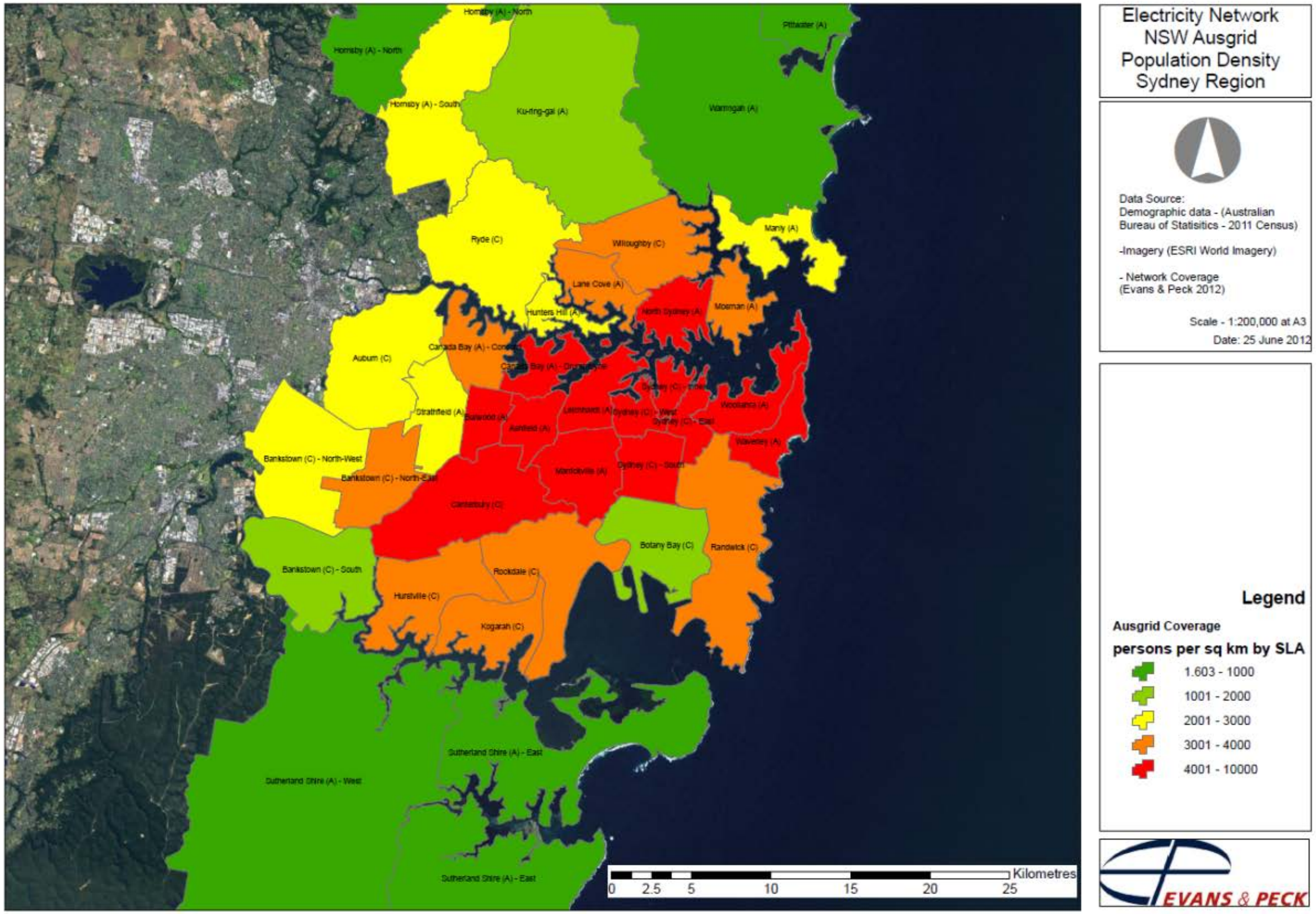


Figure 3-38: Population Density - Ausgrid (Sydney Region)

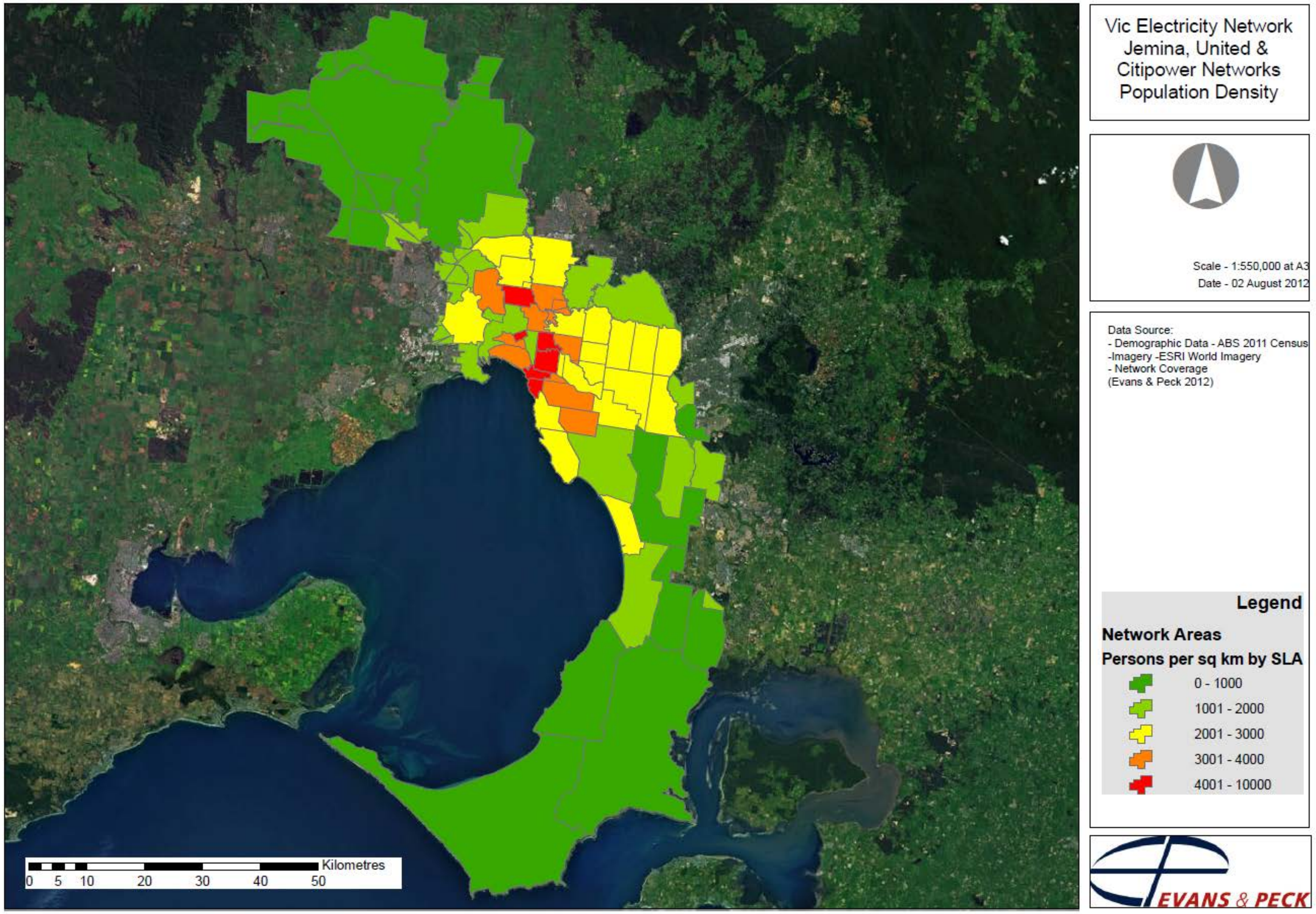
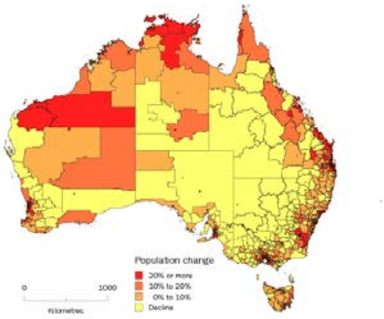


Figure 3-39: Population Density - Victoria Urban

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.



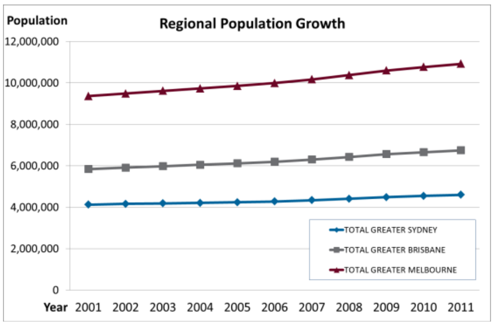


Figure 3-40: Load Duration Curves

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.

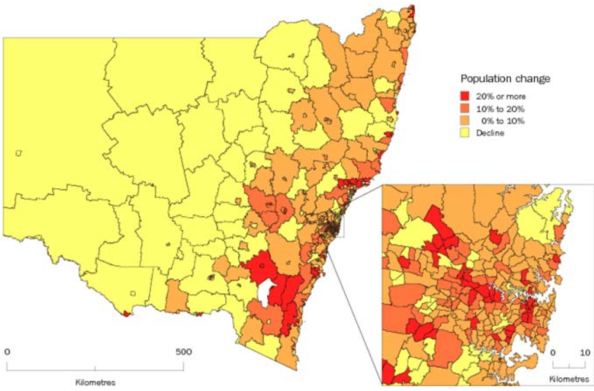


Figure 3-42: SLA Population Change, New South Wales - 2001-11

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.

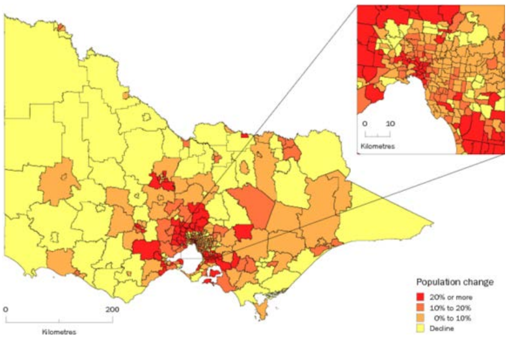


Figure 3-43: SLA Population Change, Victoria - 2001-11

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.

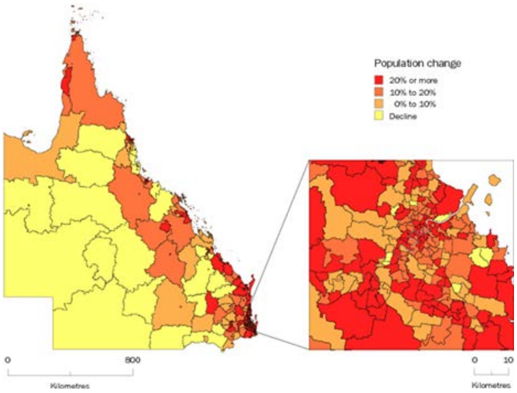


Figure 3-44: SLA Population Change, Queensland - 2001-11

	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.

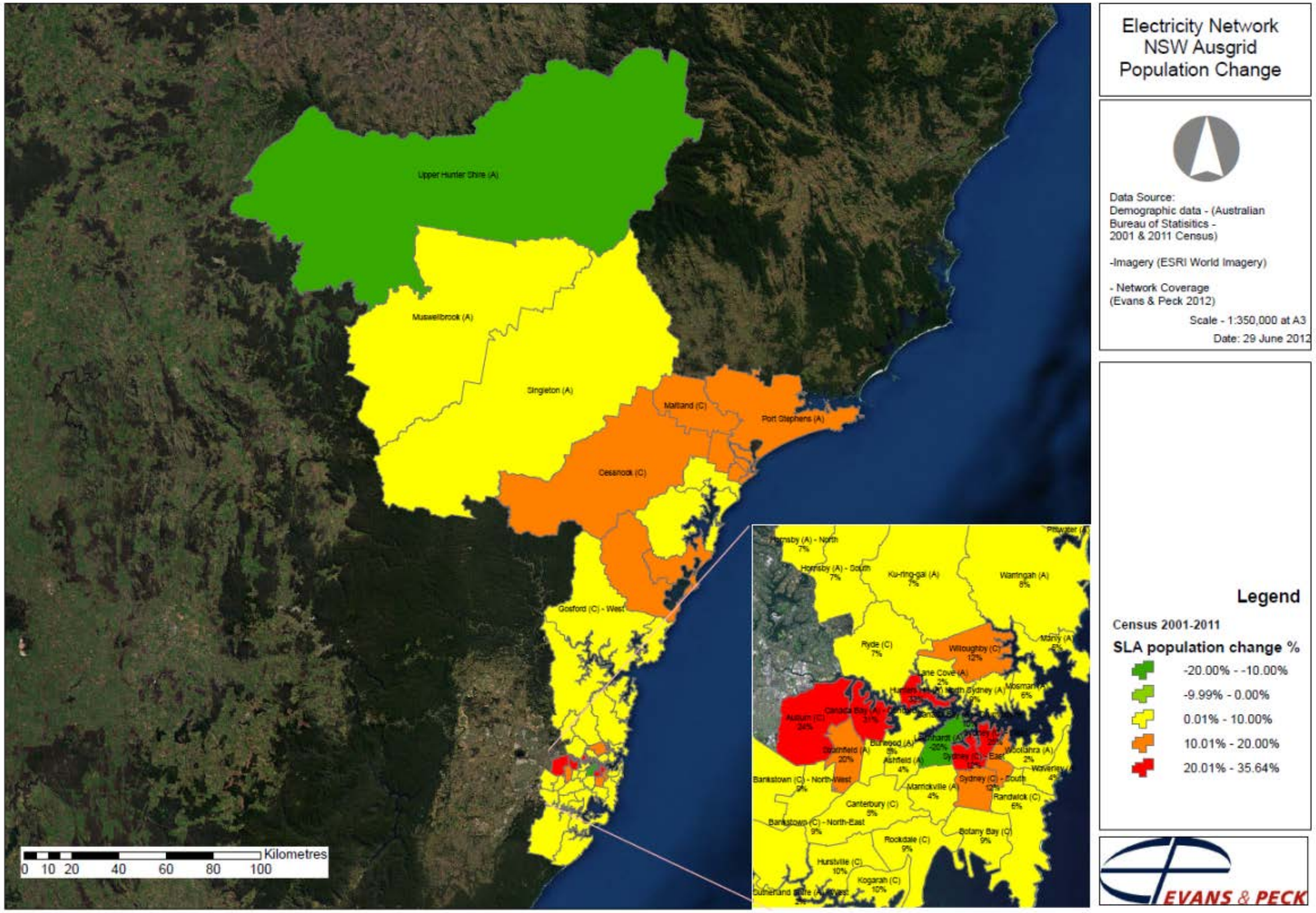


Figure 3-45: NSW Population Change

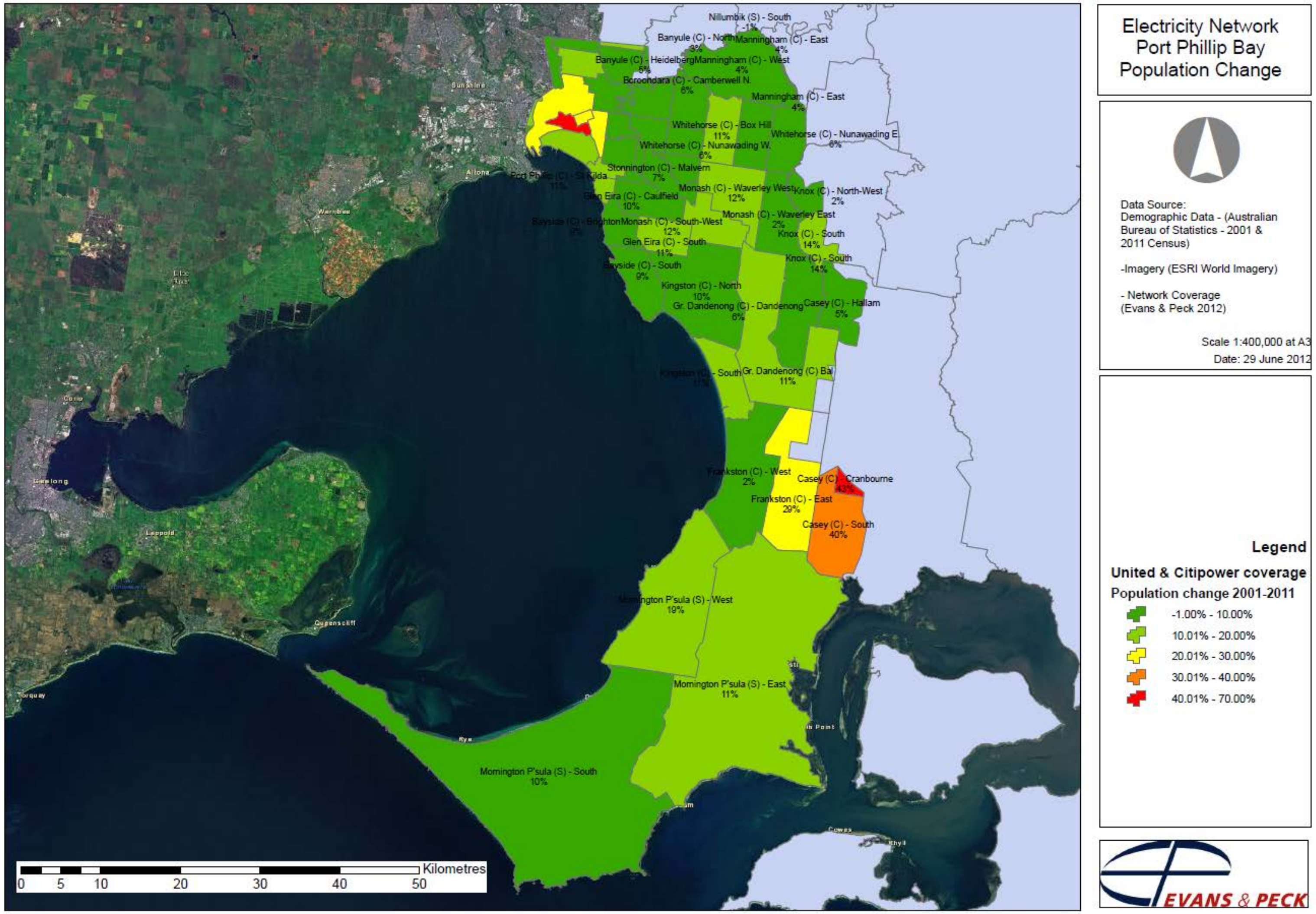


Figure 3-46: Vic Population Change – Urban

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						

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

Table 20: Summary - Shape Factors

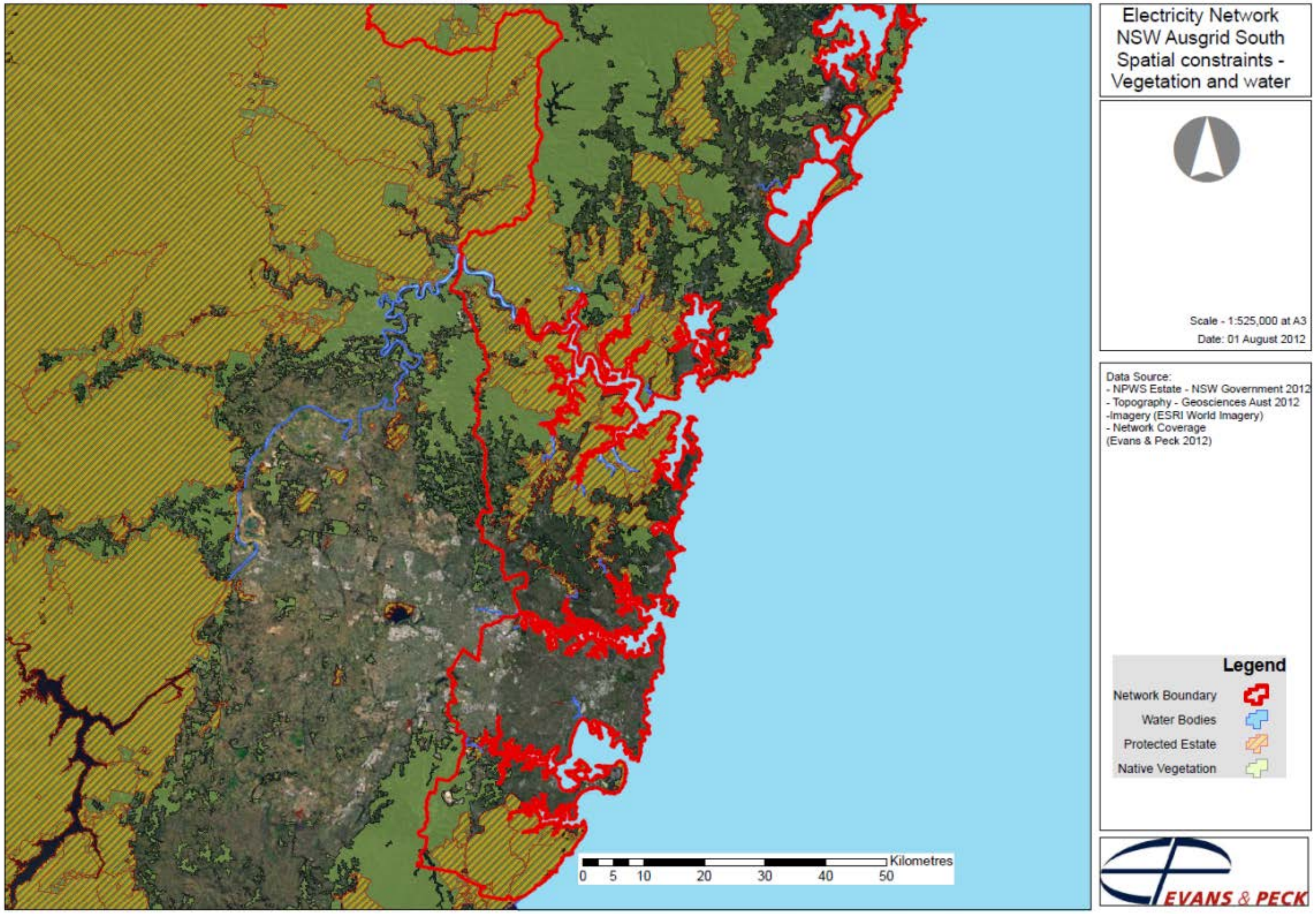


Figure 3-47: NSW Protected Estate - Ausgrid

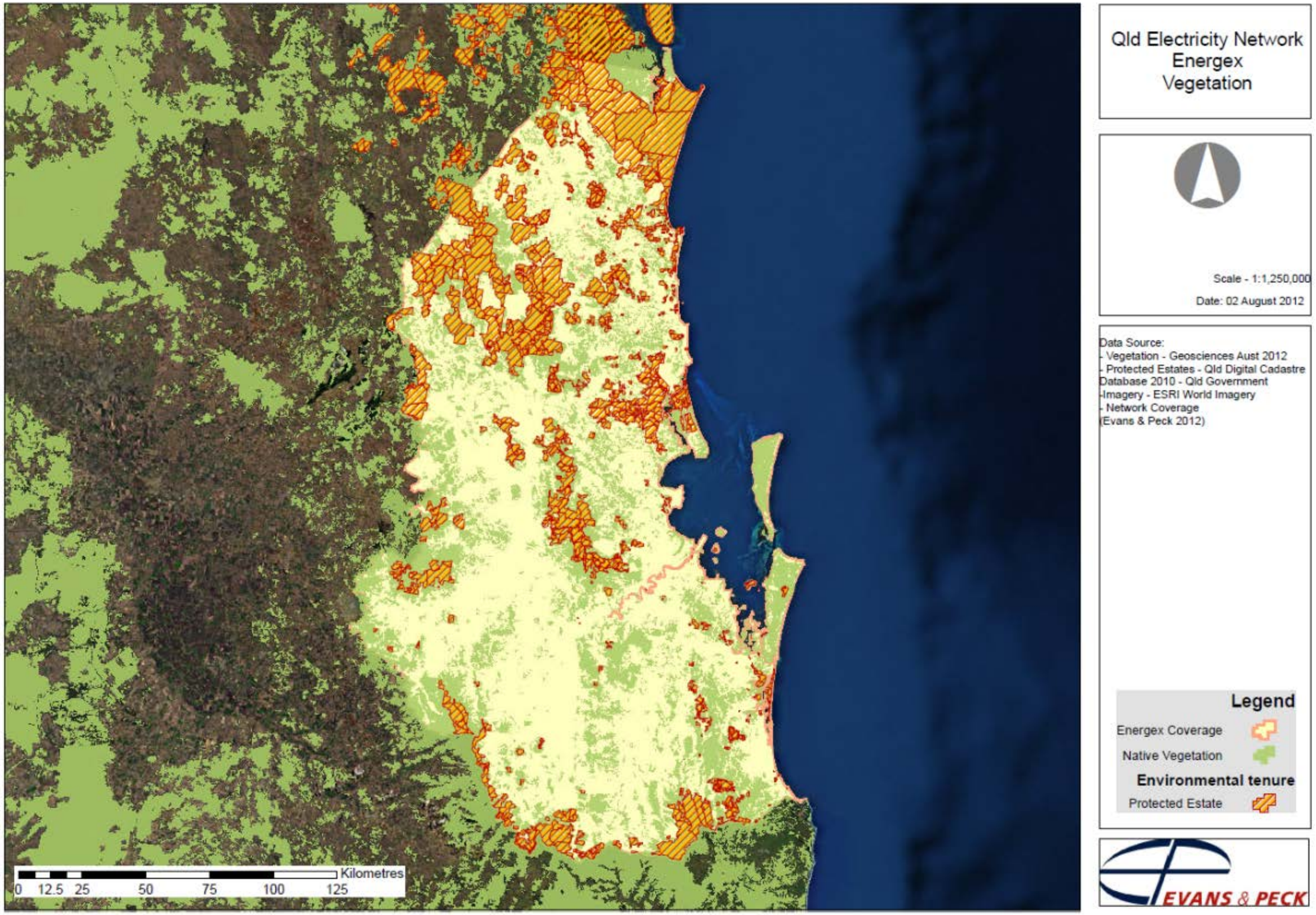


Figure 3-48: QLD Protected Estate - Energex

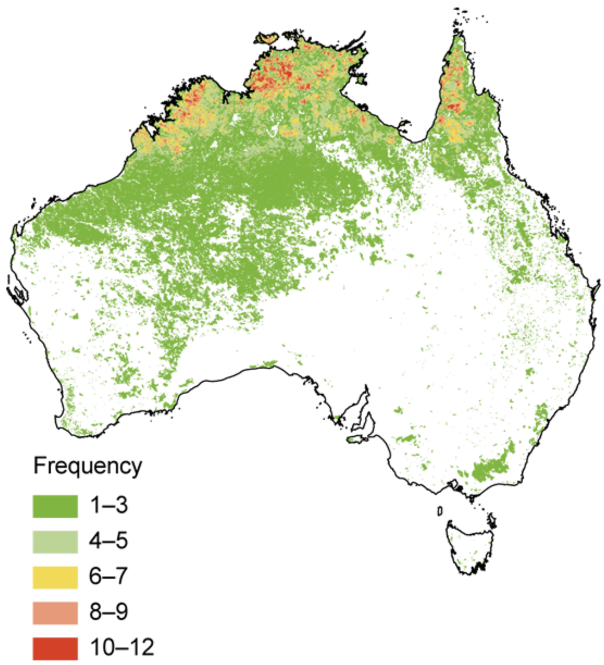
3.4.6 Bushfire Vulnerability

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.

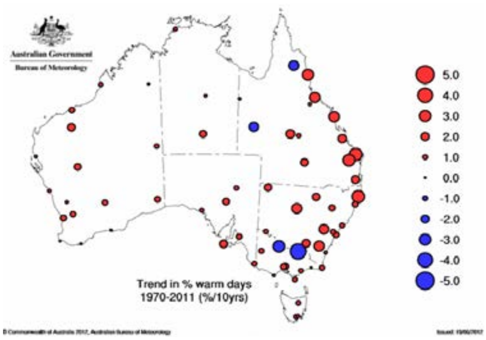


Figure 3-50: Trend in Percentage Warm Days

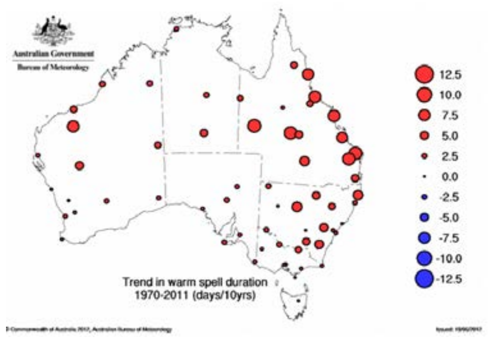


Figure 3-51: Trend in Warm Spell Duration

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.

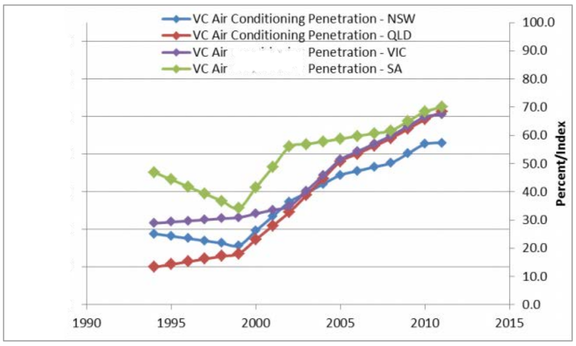


Figure 3-52: Air Conditioning Penetration

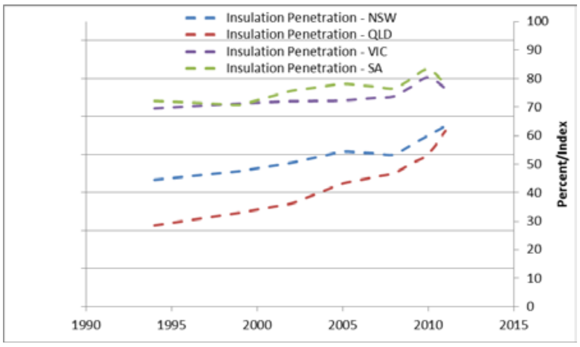


Figure 3-53: Insulation Penetration

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						

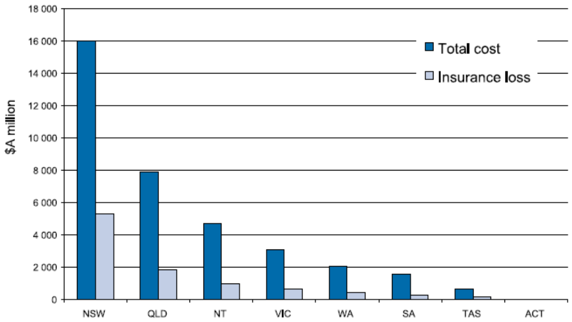
Cost Driver: Natural Cost Advantage Neutral Natural Cost Disadvantage Unknown

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.



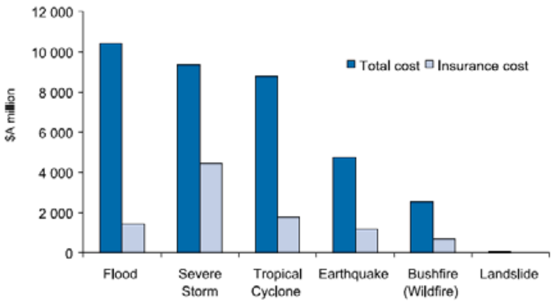


Figure 3-54: Disaster Cost by State and Territory **Figure 3-55: Costs by disaster Type**

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

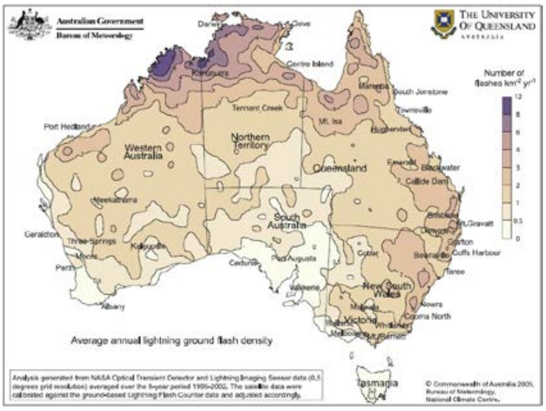


Figure 3-56 Average Annual Lightning Ground Flash Density

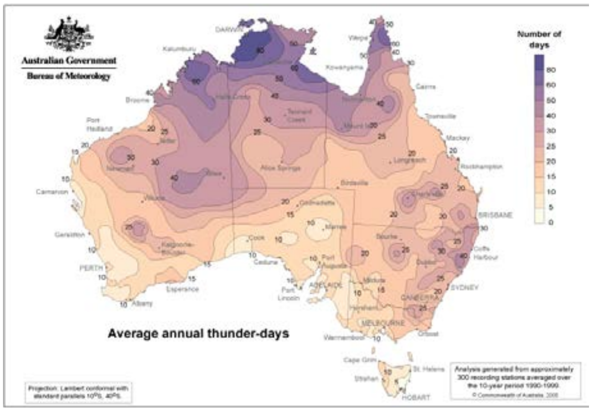


Figure 3-57: Average Annual Thunder Days

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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