DNSP Revenue Proposals

Relationship between Opex and Customer Density for Sparse Rural Networks

Report to

Australian Energy Regulator

from

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About EMCa

Energy Market Consulting associates (EMCa) is a niche firm, established in 2002 and specialising in the policy, strategy, implementation and operation of energy markets and related network management, access and regulatory arrangements. EMCa combines senior energy economic and regulatory management consulting experience with the experience of senior managers with engineering/technical backgrounds in the electricity and gas sectors.

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Findings

1. We have been asked to provide advice to the AER on the cost relationships that can be used in comparing opex between sparse rural DNSPs and rural DNSPs with greater customer density. We were asked to do so based on the intrinsic cost relationships that we expect to find in such businesses, from our experience in management, operations and cost analysis in DNSPs.

2. We have not undertaken, nor were we asked to undertake or to review, comparative benchmarking analysis of DNSPs whose network prices are subject to the AER's regulation. At the time of drafting, we are not aware of the results of the AER's benchmarking analysis except to the extent that this is in the public domain, nor are we aware of the conclusions that the AER is tending to draw from its benchmarking analysis. Our findings should therefore be considered to be of a general nature and should not be construed as advice on the relative operating costs of particular DNSPs, nor their relative efficiencies, nor advice based on quantitative analysis or consideration of the full range of factors that might explain observed cost differences between DNSPs.

3. We consider it is feasible to compare sparse rural DNSPs' costs with other rural DNSPs' costs. Our findings on the intrinsic cost relationships to be taken into account in making such comparisons are as follows:
   - Of the total opex of a rural DNSP, we consider that maintenance costs are likely to comprise approximately 60% to 70%[1]. We consider that the cost relationship for maintenance differs from the cost relationship for non-maintenance opex as described below.
   - For maintenance opex, we consider that the primary cost relationship is with line route length, with maintenance costs increasing as route line length increases. Mathematically, this is equivalent to maintenance costs per customer being inversely proportional to customer density.
   - Other factors being equal, we would expect sparse rural networks to have fewer assets requiring significant maintenance per route length (being, primarily, a lower number of poles and associated assets). Therefore we would expect that the intrinsic maintenance requirements per route length

[1] This proportion includes maintenance support costs, which we consider to be broadly related to the level of direct (field) maintenance.

km for sparse rural networks should be less than for denser networks. However other relevant asset-related factors would include:

  - proportions of SWER (indicative of a lower maintenance cost);
  - proportions of sub-transmission (indicative of a higher maintenance cost); and
  - certain technologies, which may have higher or lower than average costs.

- For non-maintenance opex, we consider that the primary cost relationship is with customer numbers, with non-maintenance costs increasing as the number of customers increases. Mathematically, this is equivalent to non-maintenance opex costs per customer not varying materially with customer density.

4. We consider that the primary cost relationships described above provide a reasonable indication of the main intrinsic opex relationships with customer density that we would expect to find in comparing rural networks. They should not be construed as the only factors affecting such cost comparisons and we propose these relationships as an adjunct to any quantitative analysis.

1 Introduction

1.1 Purpose and scope of requested work

5. Material has been provided to the AER in revised proposals and submissions (particularly from Advisian and Frontier Economics) that presents Ergon and Essential as outliers in a sample of Australian DNSPs. Ergon and Essential have the lowest customer density (customer numbers relative to circuit length) of the Australian DNSPs.

6. The AER has sought expert opinion on the relationship between opex and customer density. In particular, whether the relationship is linear, or whether it increases at an increasing (decreasing) rate as customer density decreases, in comparing opex for sparse rural DNSPs (such as Ergon and Essential) relative to other Australian rural DNSPs.

7. To the limited extent to which we have utilised data to illustrate cost relationships, we have considered the characteristics of the two sparse rural networks by comparison with those of other rural networks nearest in customer density – being Powercor, AusNet Services, SAPN and TasNetworks.

8. The advice and the assessment that we have undertaken is general in nature and is based on our management and technical experience and knowledge of the cost structures and drivers in electricity distribution networks. It does not represent a benchmarking study, nor does it represent an assessment of the AER's benchmarking analysis. We have not undertaken econometric or other statistical analysis of data and we have not analytically assessed the relationship between costs and the range of operating environment factors that we understand the AER has considered in its benchmarking analysis, and which are appended at Appendix A.

1.2 Our approach

9. In considering this matter, we

   i. identified the typical breakdown of asset types in a DNSP, and their maintenance regimes;

   ii. from experience within our team as asset managers of DNSPs, we considered the relative differences in those maintenance regimes that apply to the different asset types in DNSPs, their materiality and the key cost drivers at a macro level;

   iii. considered the drivers of non-maintenance costs;

   iv. compared the physical characteristics of the two sparse rural DNSPs relative to the denser rural DNSPs in order to form a view as to whether the different maintenance regimes in combination with their different physical characteristics and differences in drivers of non-maintenance costs might lead to a non-linear cost relationship, in comparing those businesses with other rural networks.

1.3 Structure of this report

10. Our main findings are summarised at the beginning of the report.

11. In the subsequent three sections we describe the results of our observations in this matter:

   - In section 2, we provide a generic overview of the main DNSP operating expenditure cost components and their drivers, covering maintenance and non-maintenance expenditures;
   - In section 3, we provide a quantitative description of the distinguishing characteristics of the selected rural DNSPs, with emphasis on factors that might influence a cost relationship that would allow comparison between sparse and other rural networks; and
   - In section 4, we present our views on the form of a reasonable cost relationship that would allow opex comparisons to be made between sparse and other rural networks. This is a 'basic' cost relationship that is intended as a guide in undertaking more sophisticated analysis and in interpreting benchmarking results.

12. In Appendix A, we list the operating environment factors that we understand the AER has considered in its benchmarking analysis.

2 Opex cost relationships in rural DNSPs

2.1 Introduction

13. Operating expenditure for a DNSP comprises three main components:

- **Network maintenance costs**: including preventative, corrective and fault maintenance activities on the electricity network. These costs can also be split into direct (field) maintenance costs and indirect maintenance costs (i.e. maintenance support);
- **Network operating costs**: including costs, other than maintenance costs that are associated with the safe and reliable operation of the electricity network; and
- **Corporate overheads**: including other costs associated with the operation of the electricity network business, not specific to the operation of the electricity network. These include customer services, demand management and corporate functions.

14. The AER requires that DNSPs nominate their expenditure by activity, namely: (a) routine and non-routine maintenance; (b) emergency response; (c) vegetation management; (d) network overheads; and (e) corporate overheads.[2]

15. We have reviewed the typical relationship between these activities and the operating expenditure classifications of DNSPs and provide our observations on the cost relationships as they may apply in considering the operating expenditures of sparse rural DNSPs relative to rural DNSPs with greater customer density. Our observations are not intended to be a substitute for justification of efficient and prudent operating expenditure, or associated asset management planning. Whilst we use data from rural DNSPs in this report, we do so to illustrate the levels of materiality of different cost components and of the factors that might influence cost comparisons between rural networks. In

[2] Better Regulation Expenditure Forecast Assessment Guideline for Electricity Distribution, page 28-29

preparing this report, we have not assessed any data for the purpose of making actual comparisons between DNSPs and, in line with our terms of reference, the material presented in this report should not be construed as a benchmarking study or any other form of comparative analysis between particular DNSPs.

2.2 DNSP networks overview

2.2.1 Network characteristics

16. DNSP electricity networks can be described as comprising a sub-transmission network and a distribution network. The sub-transmission network typically operates at 33, 66 or 132kV and is supplied by a number of terminal stations connected to the transmission network. The sub-transmission network supplies zone substations for distribution to customers in the surrounding area. The sub-transmission network typically consists of a series of meshed overhead lines to improve the security or reliability of supply, however in rural areas this may tend to be radial.

17. The distribution network typically operates at 6.6, 11 or 22kV and consists of both overhead and underground lines connected to substations, switchgear and distribution transformers. Feeders in distribution networks operating at 6.6 or 11kV are typically shorter than those operating at 22kV due to limitations on load rating and voltage drop. As a result, networks operating at 6.6 and 11kV typically include a larger number of zone substations and longer sub-transmission networks to service equivalent load areas.

18. The distribution network typically has a lower reliability requirement than sub-transmission networks, and consists of radial lines with interconnection between network sections for transfer of load in the event of a network failure or outage. As customer density reduces, typically associated with rural areas, the overhead line design and construction may move from three phase, three conductor networks to single phase, single conductor networks. These are commonly known as single wire earth return (SWER) networks.

19. The low voltage distribution network typically extends from the distribution transformer in a series of overhead and underground lines, connected to low voltage switchgear and finally attached to customers through service lines.[3]

20. Overhead lines may comprise more than one voltage suspended from a common set of structures. It is common, for example, for LV lines to be strung under HV conductor where the same line route is followed. In urban areas the majority of LV is likely to be under-strung in conjunction with HV lines while, in rural areas, a greater proportion of LV may be required to follow a route that is independent of any HV lines and therefore requires its own structures. Therefore there can be a material difference between circuit length and route length of lines, and this can be significant for determining reasonable maintenance levels.

[3] Customers can also be connected at higher voltage connections to the distribution and sub-transmission network.

21. While lines may be overhead or underground, in all rural DNSPs almost all lines are overhead.

2.2.2 Maintenance characteristics

22. DNSPs typically employ an asset management policy and framework that includes defined objectives and performance outcomes for each asset class. The strategies are then translated into a description of inspection and maintenance standards that define the inspection and maintenance activities to achieve the declared performance, risk outcomes and compliance standards for the DNSP. Typical drivers comprise: (i) safety; (ii) compliance; (iii) reliability; and (iv) power quality.

23. Inspection frequencies and maintenance practices are typically aligned with the risk classifications and risk management framework of the DNSP and aligned with industry practice. Network assets deemed critical to the safe operation of the electricity network, or which have a significant influence on the reliable performance of the electricity network, may require increased inspection frequencies or consideration of multiple inspection techniques, e.g. ground-based and aerial imaging. Specific environmental and land-use considerations may also have an influence on the optimal inspection frequency and schedule achieved by the DNSP.

24. Specific inspection requirements may also be nominated for some network assets to collect information to assist manage declining asset condition, including known history of faults or defects, or risks associated with the operation of the network, e.g. oil sampling of transmission transformers. The additional information collected may lead to the development of a targeted asset replacement program, for example switchgear refurbishment or replacement in response to elevated safety risk or poor performance. The inspection routines are intended to enable more targeted maintenance opex and replacement capex, where the benefits are considered to offset the increased cost of inspection.

2.3 Cost relationships for maintenance expenditure

2.3.1 Context

25. We consider the relative differences in maintenance regimes that apply to the different asset types in DNSPs, their materiality[4] and the key cost drivers at a macro level.

[4] Our assessment of materiality is to establish a general relationship between particular assets, maintenance activities and its corresponding cost function, and in doing so it is intended as a guide and not as the definitive basis of assessment or comparison with each of the DNSPs included in this report.

26. From our experience we expect that maintenance expenditure for rural DNSPs typically comprises approximately 60% to 70%[5] of total opex.

2.3.2 Routine and non-routine maintenance

Definitions

27. Routine and non-routine maintenance comprises the operating expenditure (for this purpose, excluding vegetation management) that is required to maintain the safe and reliable operation of the electricity network. This may include: (i) visual inspection; (ii) examination; (iii) testing and functional checking; and (iv) preventative treatment or corrective repair of the asset.

28. We estimate that routine and non-routine maintenance typically comprises approximately 40% of total maintenance opex in a rural DNSP[6]. We consider the typical differences and influences of the cost relationships against the asset categories below.

Sub-transmission networks

29. Due to the criticality of overhead sub-transmission lines, these assets are typically subject to ground-based and aerial maintenance activities to ensure an accurate assessment of the complete structure and conductors is undertaken, using a combination of methods including visual inspection, imaging, examination, testing and treatment.

30. For underground cables, specific inspection and maintenance requirements are generally associated with cable terminations and particular cable technologies (i.e. gas filled or oil-filled cables) to manage identified conditions or to meet compliance obligations. The quantity of cables however is generally low, and has a low impact on overall maintenance expenditure.

31. Non-routine condition assessment surveys are used to collect more detailed asset condition data to plan asset renewal and replacement programmes. Specific inspections may also be undertaken for areas susceptible to bushfire risk or storms and to ascertain the level of network resilience or risk present to security of supply in advance of anticipated weather conditions.

32. Pole and structure inspections typically form the largest part of routine maintenance requirements for sub-transmission networks, and can be dominated by the cost of materials.

33. We estimate that maintenance of sub-transmission assets comprises approximately 5% of routine and non-routine maintenance opex. This category of expenditure is typically a function of line length and, due to the importance of these assets, is likely to be a higher cost per km than distribution feeders.

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[5] This proportion includes maintenance support costs, which we consider to be broadly related to the level of direct (field) maintenance.

[6] The percentages given here and for subsequent components of maintenance are intended as indications of relative materiality only. To preserve summation integrity we have presented these as point estimates, though in practice there are tolerance ranges around each value.

Zone substations

34. Zone substation assets include substation plant and equipment, and operational buildings.

35. Zone substation transformers and switchgear are typically considered critical network assets. Information on their location and condition is generally well established and assists implementation of Condition Based Risk Management (CBRM) techniques.

36. Maintenance involves both intrusive and non-intrusive assessment methods based on the type of asset, insulating medium and condition assessment requirements. Non-intrusive assessment methods (e.g. oil sampling) and functional testing are preferred and commonly applied to assets such as transformers, with associated cooling.

37. Inspection and maintenance activities are typically scheduled for plant and equipment within a zone substation (i.e transformers, switchgear and instrument transformers) to capture associated work efficiencies.

38. Requirements for secondary systems, scada, communications and auxiliary equipment typically include condition assessment, and targeted functional testing. Similarly, DNSPs typically employ a condition-based maintenance approach to operational building and site assets including security fences and enclosures and fire systems, where maintenance activities are generally limited to taking actions that address an immediate risk or hazard.

39. Major plant items such as transformers and switchgear typically form the largest part of the routine maintenance requirements of zone substations.

40. We estimate that maintenance of zone substation assets comprises approximately 5% of routine and non-routine maintenance opex. Due to the complexity of these assets, this category of expenditure is typically a function of the number of zone substations and associated numbers of major equipment items (e.g. transformers and switchgear) rather than their individual or total electrical capacity.

Distribution feeders

41. Overhead lines make up the largest proportion of assets on an electricity distribution network, and require the highest proportion of maintenance. Routine maintenance typically includes ground-based inspections, collection of asset condition and defect data and actions to address any immediate safety hazards. It is common to bundle inspections of multiple assets into a single inspection visit, typically associated with a pole asset.

42. The condition of poles is assessed both above and below ground by a combination of methods including visual inspection, examination and testing. Visual inspection at the pole typically includes the associated pole-mounted equipment and conductors.

43. Cable networks operating below 33kV do not typically have specific maintenance requirements, and unless identified as a critical asset or where

the condition and/or reliability is of concern, this asset class would not typically attract routine maintenance.

44. Pole and structure inspections typically form the largest part of the routine maintenance requirements of distribution feeders.

45. We estimate that maintenance of distribution feeder assets would comprise approximately 80% of routine and non-routine maintenance opex in the rural DNSPs. The level of maintenance expenditure on distribution feeders is largely a function of line length; however in section 3 we qualify this by considering the most significant factors that may influence the extent to which feeder maintenance is more than or less than proportional to line length.

Distribution transformers

46. Routine maintenance for distribution transformers is typically limited to visual inspection of its components for assessment of condition as the maintenance strategy applied by most DNSPs is one of run to failure. The degree of inspection may vary between distribution transformers installed on overhead and underground networks, as:

- in overhead lines, the inspection is often bundled with the inspection of other assets on the pole structure which includes assessment for oil leaks, visible signs of condition defects and noise level; and
- in underground networks, the transformer may be associated with outdoor cabinets, distribution substation rooms or compounds and associated switchgear that also require inspection and condition assessment.

47. Distribution transformers are typically sized based on standard ratings. For rural networks, we would expect to see a prevalence of small size transformers that may be over-sized for their load, however reflect an economically efficient size for the application.

48. Maintenance methods are typically non-intrusive, involving visual observations and assessments of the exterior and fittings of the transformer. Strategic or critical distribution transformer sites may require additional oil sampling, power quality or noise measurements to be undertaken.

49. Visual inspection, functional or other testing may also extend to the associated switchgear, earth connections and earth mat and other associated equipment.

50. We estimate that maintenance of distribution transformer assets comprises approximately 5% of routine and non-routine maintenance opex. This category of expenditure mostly relates to the number of such transformers, rather than their capacity. However, to the extent that a single factor dominates, it may better considered to be related to line length rather than the size or number of distribution transformers installed on the network, as the visual inspection is the larger component of expenditure and this is more closely related to line length. Where a DNSP has a higher percentage of underground distribution network, the number of distribution transformers installed on the network has a larger influence on the cost relationship.

Low voltage networks

51. The condition assessment of low voltage networks is often undertaken as part of other maintenance activities, such as the bundled overhead line inspections and often limited to the identification of known defect types.

52. For overhead lines, the inspection and condition assessment is typically limited to defect management identified as part of the general line inspection program.

53. Inspection and condition assessment of service lines (including clearance from vegetation, structures and the ground) and insulation condition may also form part of the routine maintenance activities. The increasing incidence of service line failures has resulted in some DNSPs packaging their inspection of service lines with a targeted replacement program. Other DNSPs have a regular inspection regime, which for some jurisdiction includes corrective repair and replacement of the service line and the service connection points.

54. For underground networks, the inspection and condition assessment is often limited to major assets such as low voltage switchgear and switching points that are often associated with the distribution transformer. The maintenance strategy for underground cable, cable joints, connection boxes, pillars and connection pits is typically one of run-to-failure, and given the difficulty of locating and inspecting these items, many are excluded from routine maintenance.

55. Maintenance of low voltage networks is typically a small component of the routine maintenance requirements, as maintenance of assets in this category is either combined into the maintenance activities of distribution feeders and distribution transformers, or responded to as part of reactive or defect management and emergency response maintenance. We estimate that stand-alone maintenance activities for LV would typically comprise less than 5% of routine and non-routine maintenance opex.

56. Because much of the low voltage network is overhead and lines are combined on the same structures as HV lines, we consider that stand-alone route length is a more appropriate indicator than circuit length. We would expect to see a much lower volume of low voltage network for rural and sparse rural DNSPs and that more of the low voltage network is likely to be radial and installed on dedicated poles independent of distribution feeders. For urban DNSPs, we would expect that the low voltage network has a higher proportion of meshed design and is on poles shared with distribution feeders. As a consequence, this would indicate that sparse rural DNSPs are more likely to have a higher proportion of their low voltage circuit length classified as route kilometres, compared with DNSPs with higher proportions of urban network.

57. The classification of the low voltage network length will have a corresponding impact in the discussion of vegetation management and emergency response expenditure, for which we also consider that route length is a better indicator of required expenditure levels.

2.3.3 Vegetation management

58. Vegetation management includes the combination of inspection, notification (where required), routine, targeted and reactive trimming and clearance of

vegetation from electricity network assets. This is almost exclusively associated with sub-transmission and distribution overhead lines and therefore there is a very small component associated with zone substations and other assets.

59. For sub-transmission lines, vegetation management typically extends to the maintenance of easements and access tracks. For distribution lines, vegetation management includes maintaining a profile around the low voltage and/or distribution feeder lines and service lines. The vegetation clearance activities for the low voltage and distribution feeders are often bundled together.

60. DNSPs seek to establish a tolerable clearance profile around overhead lines to ensure the safe and reliable operation of the electricity network until the next planned maintenance cycle, including allowance for growth. Consideration of the vegetation growth rates and proactive management of re-growth form part of current industry practices.

61. In many jurisdictions, local councils and electricity customers may have responsibility for vegetation management, where vegetation may encroach on electricity network assets. Each DNSP has processes and systems to inspect, advise and manage the removal of vegetation according to local regulations. The management of these processes, and interaction with third parties, can have a material impact on vegetation management expenditure.

62. We consider that vegetation management typically comprises approximately 40% of total maintenance opex for rural DNSPs. The impact of local environmental conditions (e.g. rainfall and vegetation type) can significantly influence the associated vegetation management requirements. This category of expenditure is typically most closely related to line route length.

2.3.4 Emergency response

63. This includes restoration and repair activities that are triggered by a safety incident or significant safety hazard, failure of a component of the electricity network, or area-wide emergency.

64. For the sub-transmission network, the number of emergency events is typically low, but each can have a high consequence. The DNSP response is often specific to the type of event and or asset involved. Part of the management strategy includes holding strategic or system spares to minimise the impact associated with a failure or event.

65. For the distribution network, the number of events is often high but with lower consequences per event. The DNSP response is typically managed onsite by a repair work crew, or the asset is returned to an interim safe operating state and scheduled for subsequent repair or replacement.

66. In managing systemic asset issues or known defects, it is often more cost effective to consider an asset renewal or replacement plan targeted to the asset class, rather than reactive repair under an emergency response program. This may require additional inspection activities to assist with prioritisation of the program.

67. We estimate that emergency response maintenance comprises approximately 20% of total maintenance opex. This category of expenditure is more closely related to the current and forecast performance of the distribution network than it is to other factors, as it reflects the underlying condition of the network and its likelihood of failure. On balance, we consider that emergency response is likely to be more closely related to network line length, than to numbers of customers.

2.4 Cost relationships for non-maintenance expenditure

2.4.1 Network operating expenditure

68. The costs associated with the operation of the network include the staffing of the control centre(s), operational switching personnel, outage planning personnel, provision of authorised network personnel, planning and asset management.

69. DNSPs may include material or major operating expenditure projects separately to their routine and non-routine maintenance projects.

70. Compliance with jurisdictional planning or government policy initiatives may drive increased expenditure in network operating expenditure. For example, in some jurisdictions, DNSPs have a regulatory obligation to inspect private / consumer owned poles and to take action if a hazard is present. We don't consider this to have a generally material impact on comparisons between rural DNSPs, however it is evidence of the type of regulatory requirements that may impact the operating expenditure requirements.

71. The maturity of the asset management system, extent of network control and communications infrastructure and scale of the demand management program are some of the characteristics that may influence the corresponding network operating costs for a DNSP.

72. We estimate that network operating costs comprise approximately 15% to 20% of total opex. We consider that network operating costs are closely aligned with the amount of work undertaken on the network, which could be measured by its total expenditures (capital and operating) or, as a proxy, by the number of customers that it services.

2.4.2 Corporate overheads

73. Corporate overheads include corporate functions such as finance, human resources, legal, regulatory, customer service, information technology and other costs that are related to the provision of distribution services in accordance with a DNSP's Distribution Licence.

74. Corporate overheads are a product of the business structure, corporate policies and strategy employed by the DNSP and can vary significantly across DNSPs. Some of the differences between DNSPs may involve matters such as inclusion of management fees, insurance costs and financing structures. This

may also be significantly influenced by the outsourcing of such services, which may reduce the amount of capital employed, but with a higher resulting operating expenditure. An example of this is the use of SPARQ for the provision and management of Ergon's IT systems and services.

75. We estimate that corporate overheads comprise approximately 15% to 20% of total opex, and largely reflect fixed costs of the DNSP. Other factors being equal, we consider that corporate overhead costs would be related to the size of the business, which could be measured by its total expenditures (capital and operating) or, as a proxy, by the number of customers that it services. We consider it reasonable to expect that there would be some economies of scale and we note, in this regard, the factors of less than unity that TNSPs and DNSPs have tended to use in rolling forward their corporate opex requirements using 'base step trend' approaches, in their regulatory proposals.

2.5 Summary

76. We have considered, at a high level the material elements of opex for a DNSP and major drivers of cost.

77. We consider that with the exception of the fixed costs associated with corporate overheads, there is an increasing relationship between the other maintenance and non-maintenance costs with line length.

78. We note that the AER in its recent draft decision for Essential Energy[7] has considered a number of operating environment factors in its models. We have not reviewed these nor do we make observations on the application of these exogenous factors or their role in the benchmarking analysis undertaken by the AER, as the scope of our work in this assignment is to identify intrinsic cost relationships in comparing rural DNSPs with different densities, rather than to consider factors more generally that might affect cost comparisons between DNSPs. For reference, however, we have listed these factors in Appendix A.

[7] AER, Essential Energy draft decision Attachment 7: Operating expenditure, page 7-103. In its consideration of the discretion afforded to the AER, the AEMC determined that the AER must exercise its judgement as to the circumstances which should or should not be included in its benchmarking and nominated a number of likely exogenous factors to take account of in its analysis. Refer to AEMC, RULE DETERMINATION National Electricity Amendment (Economic Regulation of Network Service Providers) Rule 2012, Capex and opex allowances and factors, page 113

3 Distinguishing characteristics of rural DNSPs

3.1 Introduction

79. In this section we provide information on certain physical and technical characteristics of a selection of rural DNSPs. We have sought to identify the main factors from the physical data and customer base of these DNSPs that might materially affect a cost comparison between the two sparse rural DNSPs and other rural DNSPs with greater customer density.

80. In discussing each of these factors individually, we stress that each consideration is of that factor alone. In particular, indications that a particular factor may lead to a higher (/lower) intrinsic cost for a particular type of DNSP should be read with the perspective that this considers the particular factor in isolation (i.e. ‘other things being equal’); also that, unless qualified, the indications that we provide should not be read as necessarily suggesting a material effect. At the conclusion of this section, we seek to provide experience-based advice on likely net impact trends and materiality. While our summary assessment is guided by some empirical data, in line with our scope, our summary is intended to provide guidance and does not provide empirically definitive cost relationships.

3.2 Comparative characteristics

81. We have reviewed the information supplied in the DNSP RINs to understand the distinguishing characteristics of a selection of rural DNSPs. The DNSPs were selected as being:

- Queensland: Ergon;
- New South Wales: Essential Energy;
- Victoria: Powercor and AusNet Services;

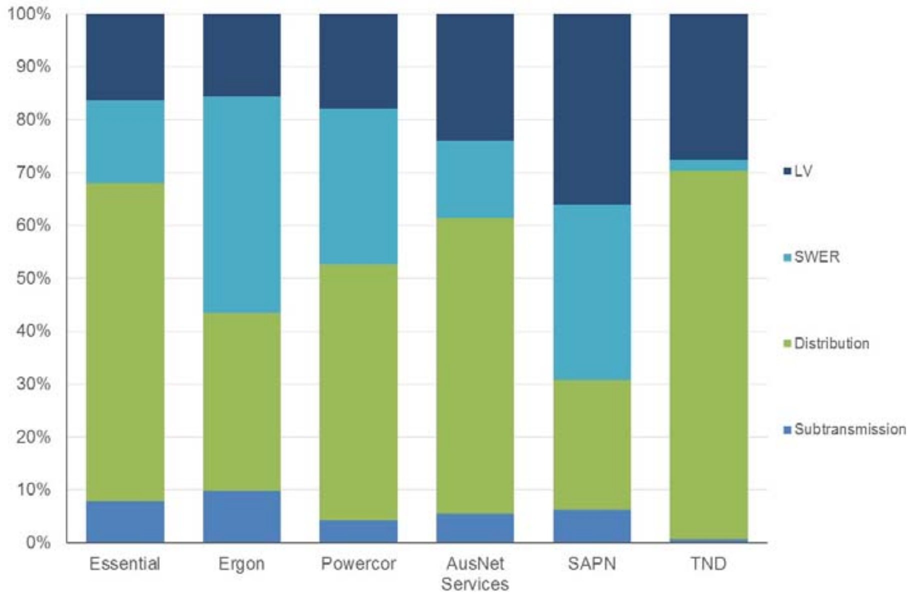
- South Australia: SA Power Networks (SAPN); and
- Tasmania: TasNetworks.

82. In the following sub-sections we provide an overview of the comparative characteristics of the above six rural DNSPs and the potential impact that each of these characteristics might have on their relative cost relationships.

3.2.1 Line length and line types

83. Of the six rural DNSPs, the two sparse rural networks have lower proportions of LV, averaging 16% of line length as against 27% of line length for the other rural DNSPs. As noted in the previous section, a greater proportion of LV is likely to be under-strung in urban areas and so, while the two sparse rural DNSPs have lower proportions of LV, more of it is likely to be on stand-alone structures requiring dedicated maintenance.

Figure 1: Relative line types by function



Source: EMCa analysis from RIN data

84. We observe in Figure 1 that the extent of the sub-transmission network for the two sparse rural networks is approximately 10%, compared with an average of just under 7% for the other networks.[8] Other things being equal, we would expect to see higher maintenance costs reflective of the higher proportion of sub-transmission network, however on balance we consider that this would not have a significant impact because of the relatively small weighting of sub-transmission.

85. Ergon and SAPN have a higher proportion of SWER than their peers, representing approximately 50% of their distribution and sub-transmission networks. Higher proportions of SWER network would indicate lower maintenance costs associated with this asset category against line length. However, of the two sparse rural networks, Essential has relatively little SWER

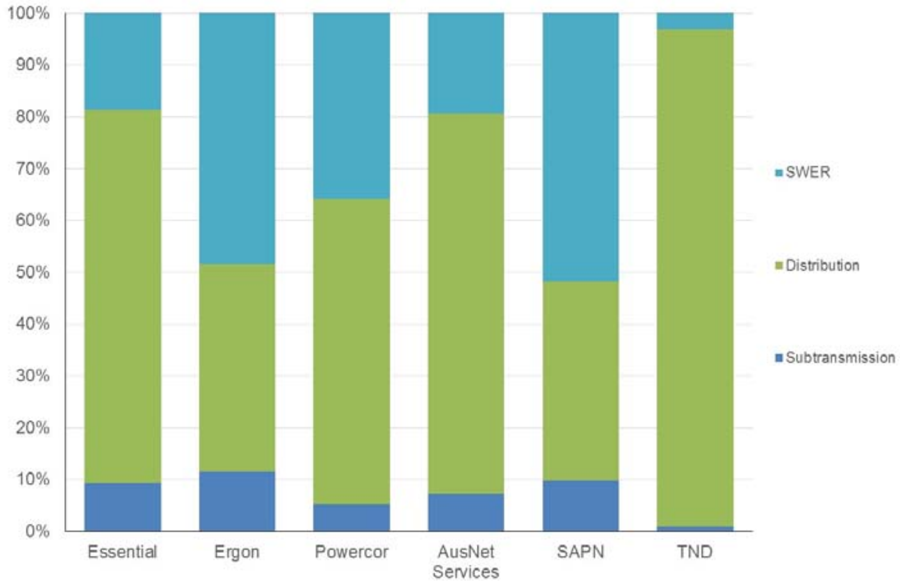
[8] Once LV is excluded, however, we note that SAPN has a similar proportion of sub-transmission to the two sparse rural networks, i.e. around 10%

and Ergon's proportion of SWER is less than SAPN, a network with more than three times the customer density.

86. As described in the previous section, SWER is likely to have significantly lower maintenance costs per km than three phase feeder. However there does not appear to be a direct relationship between relative amounts of SWER and customer density, therefore to the extent that it is deemed necessary in comparing networks to account for their proportions of SWER, this would need to be done on a case by case basis.

87. For further comparison, we have shown the relative line lengths excluding LV assets in Figure 2.

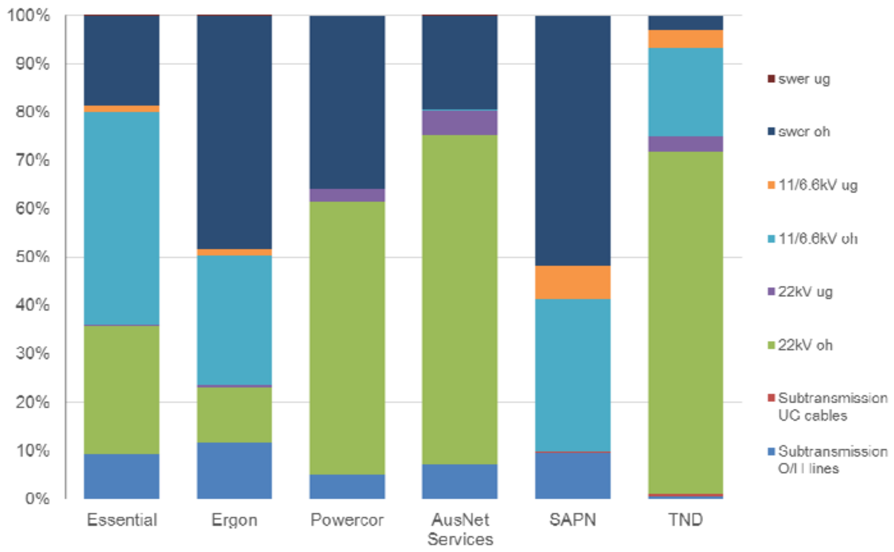
Figure 2: Relative line types by function (excluding LV assets)



Source: EMCa analysis from RIN data

88. In Figure 3, we observe that Essential, Ergon and SAPN have a larger proportion of 6.6kV and 11kV network when compared to the other rural DNSPs. Distribution feeders designed for 6.6kV and 11kV networks are typically shorter than for 22kV, and suggest more concentrated load areas or lightly loaded feeders to manage voltage regulation. The higher proportion of network at these voltages suggests either a higher number of feeders per zone substation or a higher number of zone substations, and associated sub-transmission network.

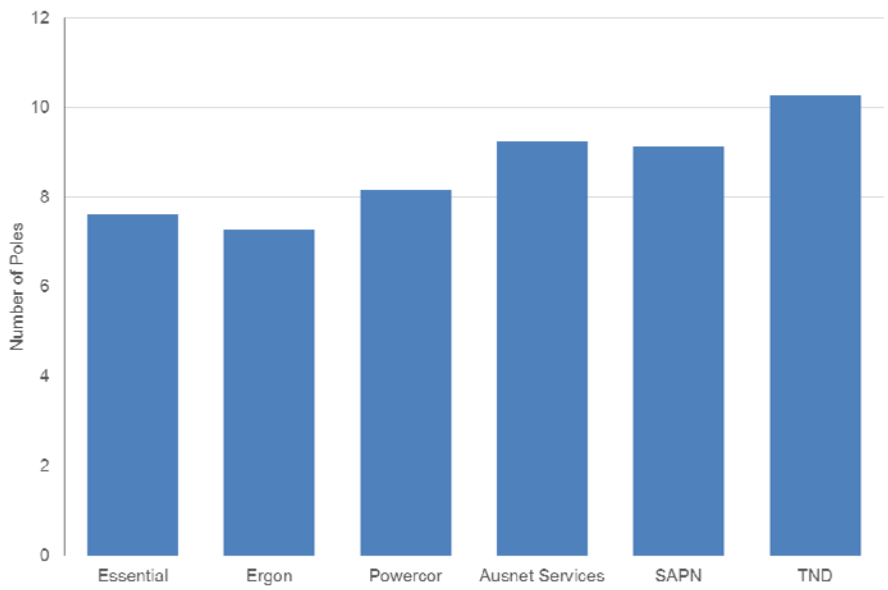
Figure 3: Relative line type – detail (excluding LV)



Source: EMCa analysis from RIN data

89. Figure 4 shows the relative density of poles in the lines of the six rural DNSPs. Poles (and associated hardware) are the assets for which the majority of line maintenance is undertaken. This analysis shows that the sparse rural DNSPs tend to have a lower density of poles than the denser rural networks and, other factors being equal, we consider that this would lead to a lower maintenance cost per km of line length, for those businesses.

Figure 4: Relative asset density of lines – poles per km



Source: EMCa analysis of data provided by AER

90. In terms of materiality, our experience is that lines maintenance dominates all other maintenance in a DSNP.[9] Therefore to the extent that it is deemed necessary to consider factors other than raw circuit length in comparing

[9] We have supported this view by reviewing a selection of Asset Management Plans and similar documents and RIN data that the six DNSPs have submitted to the AER, and from which we were able to derive a reasonable proxy for maintenance costs.

between DNSPs, we would tend to focus on factors influencing lines maintenance costs. Our focus would tend to be on:

- determining a reasonable proxy for route length, as opposed to circuit length. In the absence of firm data on route length, this would largely involve considering and adjusting for the relative amounts of under-strung LV circuits;
- considering the relative density of the line assets, in terms of the ratio of spans (poles) to line length. To the extent that sparse networks are likely to have longer spans and a lower number of poles per km, then (other factors being equal) this would tend to lead to lower maintenance costs for sparse networks, as a function of route length;
- considering the relative proportions of SWER line; and
- considering the relative proportions of lines with a sub-transmission function as opposed to lines with a feeder function.[10]

3.2.2 Zone substations

91. We observe that both of the sparse rural networks have more zone substation transformers than the average for the other networks.[11] Switchgear, with its associated maintenance regime, generally has an increasing relationship with the increasing number of transformers.

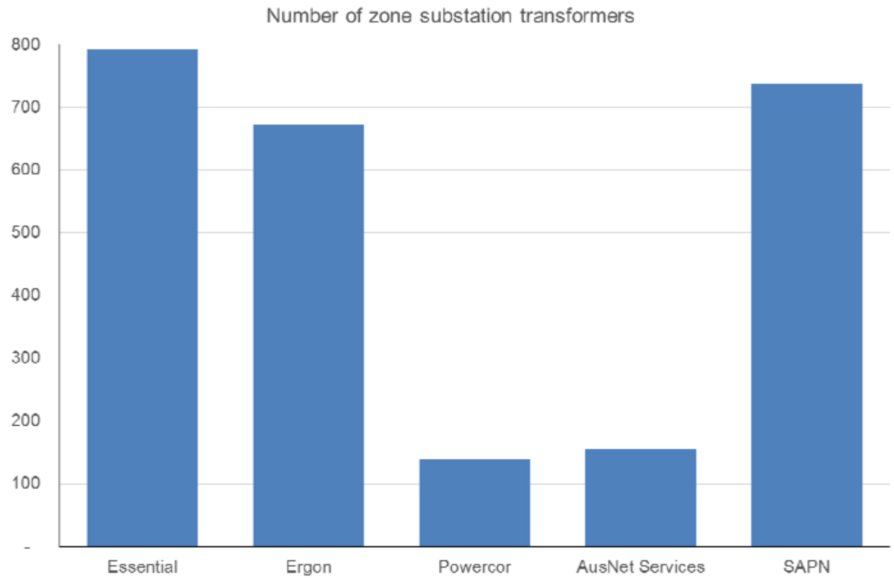
92. We observe smaller average zone substation transformer sizes for the sparse rural DNSPs due to the spatial diversity of the population and electricity demand, corresponding with a higher number of zone substations for distribution feeders operating at 6.6kV or 11kV and a higher proportion of the sub-transmission network supplying those zone substations. Corresponding with this, we observe a considerably greater number of zone substation transformers per customer for the sparse rural networks.

93. Other things being equal, we would expect maintenance costs for Essential, Ergon and SAPN to be proportionally higher (as a function of line length) due to inclusion of a higher proportion of zone substation assets with associated higher maintenance requirements. However, in aggregate we consider that maintenance of zone substations is a small proportion of total DNSP maintenance costs (refer to section 2) and so there would be a low weighting on variations in zone substation costs between DNSPs.

[10] Absent better data, this could be done on a voltage basis; however the preferable consideration is the actual function of the line.

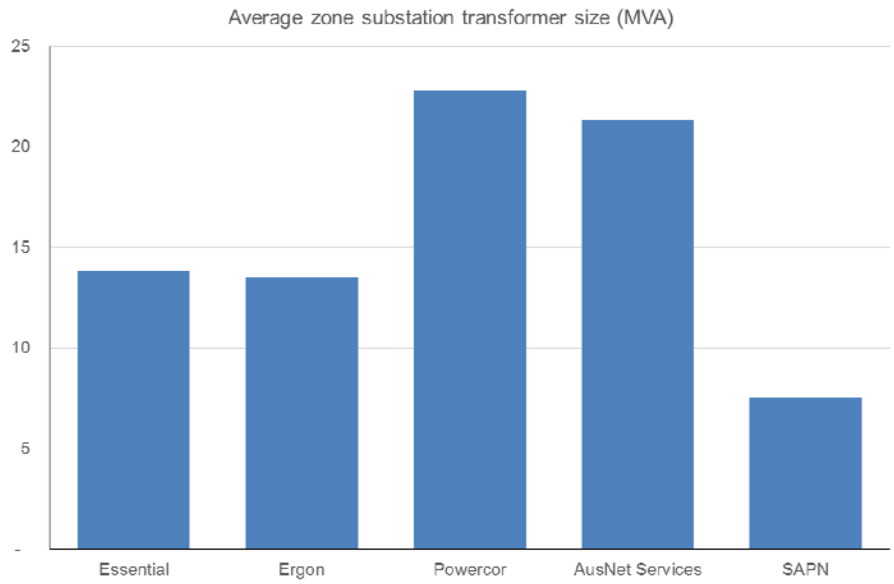
[11] We note the apparently large number of zone substation transformers in SAPN. This may be because SAPN's overall customer density results from it having in effect two sub-networks – one supplying the city of Adelaide and its immediate surrounds and the other supplying a sparse rural customer population not unlike that supplied by Ergon and Essential. We have not sought evidence for this hypothesis which, in any case, does not detract from our observation.

Figure 5: Number of zone substation transformers



Source: EMCa analysis from RIN and other asset data[12]

Figure 6: Average zone substation transformer size (MVA)

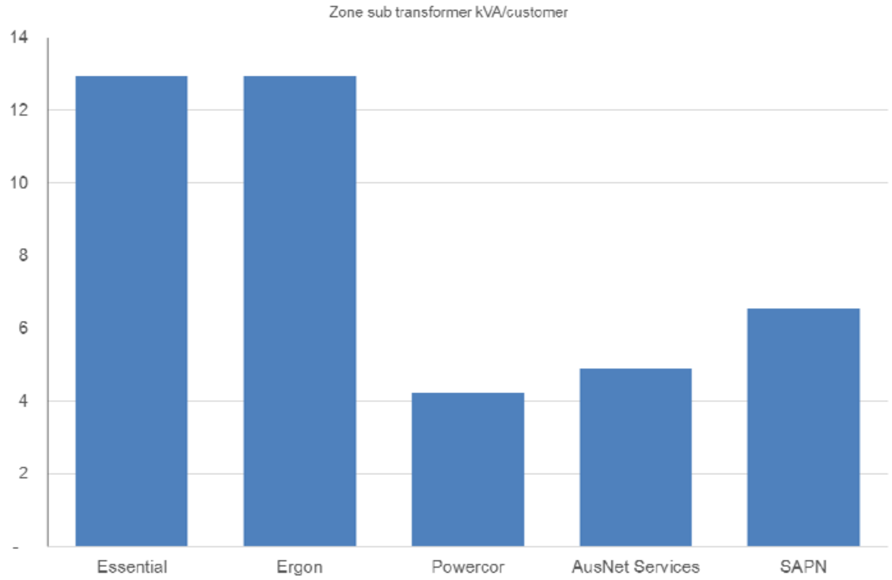


Source: EMCa analysis from RIN data and other asset data[13]

[12] We note that this data is in some instances derived from data on total transformer capacities and average transformer sizes. Also that the data available to us did not indicate any zone substation transformers in TND.

[13] Ibid

Figure 7: Zone substation capacity per customer (kVA/customer)



Source: EMCa analysis from RIN data and other asset data

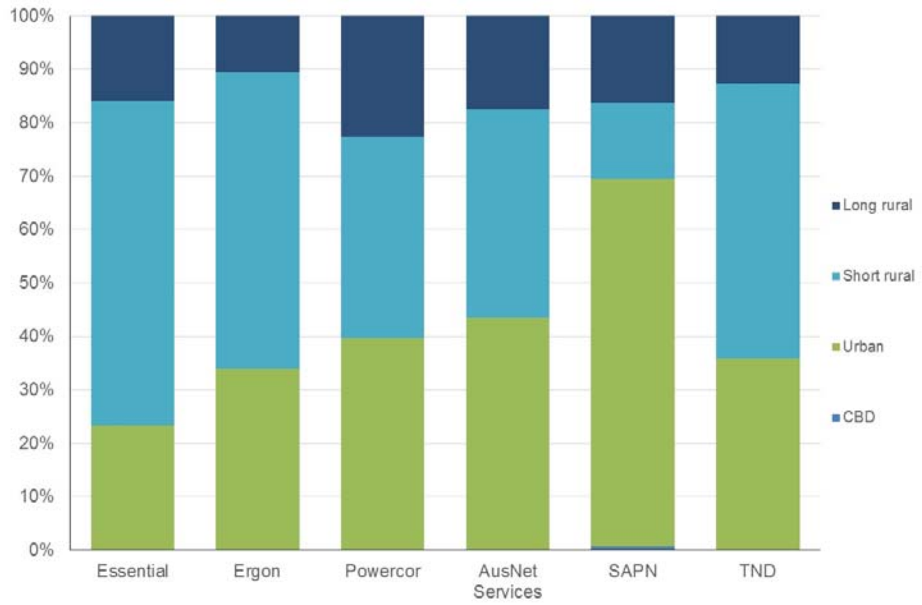
3.2.3 Customer numbers and customer types

94. By customer numbers, we observe that Essential, Ergon and TasNetworks have a higher proportion of short rural distribution network and SAPN a higher proportion of urban network. As expected, Essential and Ergon have fewer urban customers than the other rural networks; however it is notable that both of the sparse rural networks do have significant numbers of urban customers.

95. It is also notable from Figure 8 that the two sparse rural networks do not have high proportions of customers on long rural feeders. This is consistent with them both having a relatively larger amount of sub-transmission and larger numbers of zone substations, as described in the previous two subsections.

96. On balance, we do not observe such markedly different customer feeder characteristics as to render comparisons between the sparse rural networks and the other rural networks infeasible.

Figure 8: Relative customer numbers by feeder type

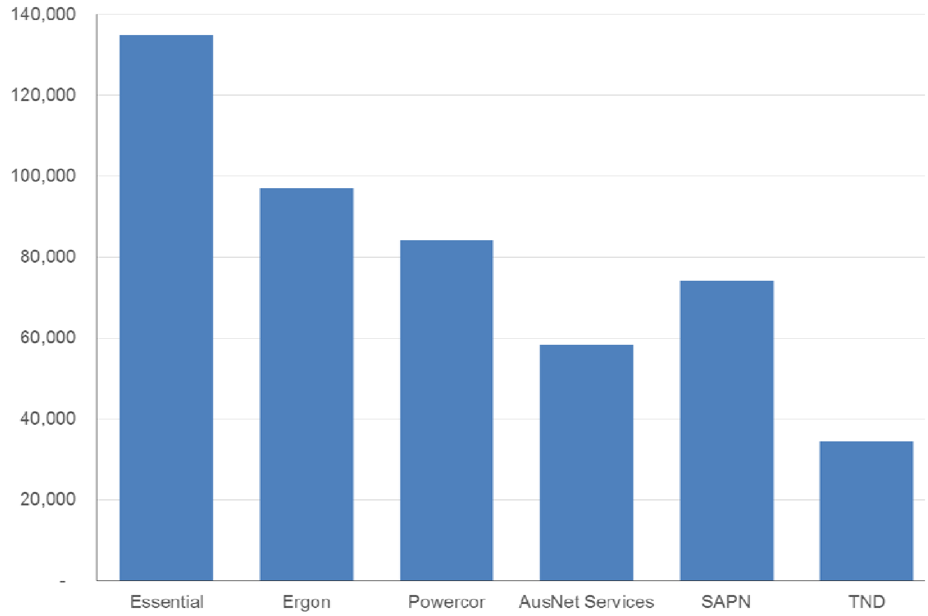


Source: EMCa analysis from RIN data and other asset data

3.2.4 Distribution transformers

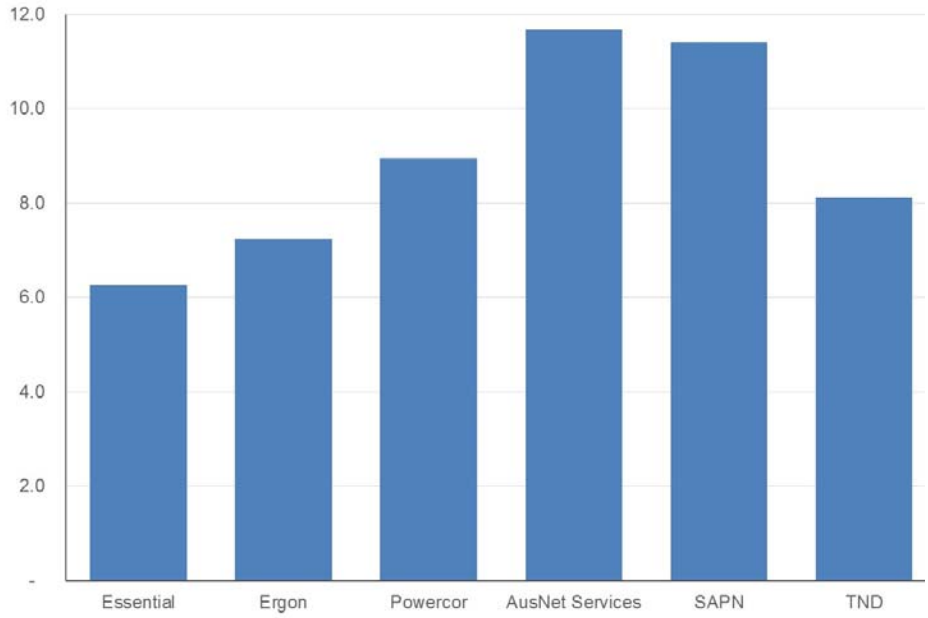
97. We observe that the two sparse rural networks have the highest number of distribution transformers and that on average these distribution transformers serve a smaller number of customers than for the denser rural networks. Since switchgear generally has an increasing relationship with the increasing number of transformers, this results in a greater amount of switchgear to be maintained. Other things being equal, this would tend to lead to costs per customer increasing as a function of decreasing customer density.

Figure 9: Number of distribution transformers



Source: EMCa analysis from RIN and other asset data

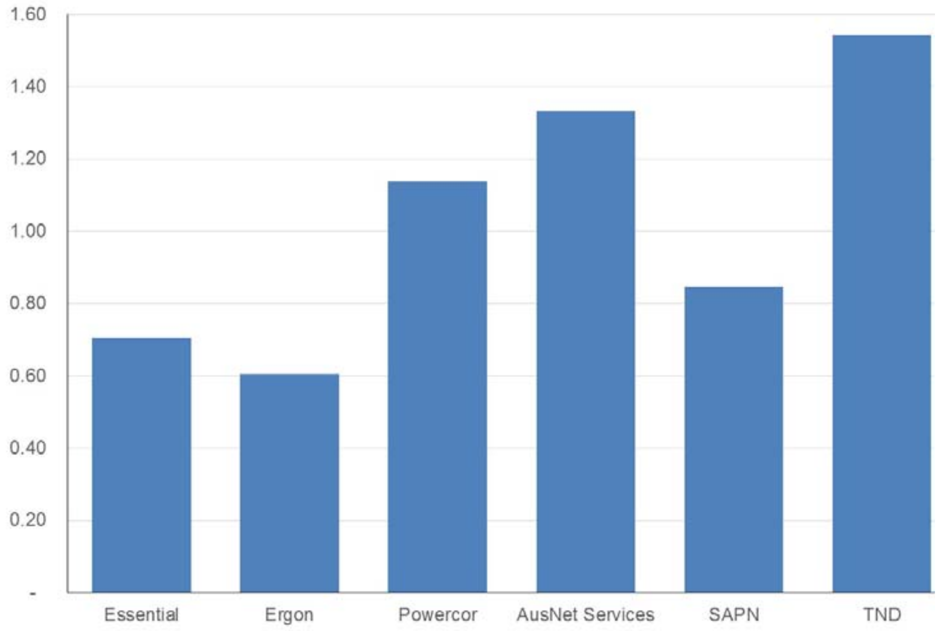
Figure 10: Customers per distribution transformer



Source: EMCa analysis from RIN data and other asset data

98. As we observe in figure 11 below, the sparse rural networks appear to have a smaller number of distribution transformers per km of circuit length[14]. Other things being equal, this would tend to lead to a lower cost per km, if the cost of distribution transformers was considered to be a function of line length. However our experience is that the normal maintenance mode for distribution transformers is 'run to failure', with routine inspections comprising a small proportion of overall maintenance requirements and generally undertaken in conjunction with line inspections.

Figure 11: Distribution transformers per km



Source: EMCa analysis from RIN data and other asset data

[14] The measure of circuit length used here comprises sub-transmission and feeders, but excludes LV.

3.3 Maintenance costs as a function of main DNSP characteristics

99. The two sparse rural networks, relative to the other rural DNSP businesses, can be described as comprising the following characteristics, relevant to their intrinsic operating and maintenance costs:

Higher sub-transmission, which has a higher cost/km

100. The two sparse rural networks have amongst the highest proportion of sub-transmission networks. However the proportions of sub-transmission are relatively small, at around 8-10% of the total line length. Despite the higher maintenance cost/km that is likely associated with sub-transmission, we would not expect this to have a material effect on the costs of these businesses because of the relatively small amounts of sub-transmission and the relatively small differences between the sparse rural and other rural networks.

101. The two sparse rural networks have relatively high proportions of 6kV and 11kV networks, characteristic of shorter feeders, or lightly loaded feeders sometimes associated with urban areas. This is characteristic of supporting a higher number of zone substations and a higher level of sub-transmission network.

SWER has a lower cost/km, but Ergon and Essential have very different proportions

102. While Ergon has amongst the highest proportion of SWER of the rural networks, Essential has amongst the lowest. We consider that SWER is likely to have a lower maintenance cost per km, due to it being only single phase conductor and with typically long spans, therefore fewer poles. DNSPs must meet the same safety and compliance requirements for SWER as for all other line. However maintenance expenditure driven by reliability and power quality requirements is more likely to be focused on the denser parts of the system, where the expenditure has greater impact. On balance, we consider it likely that SWER maintenance is less per unit of line length and that materially different proportions of SWER line would be likely to influence cost comparisons between DNSPs.

103. Putting aside Tasmania, which has almost no SWER, the proportions of SWER vary from around 50% (Ergon and SAPN) down to around 20% (Essential and AusNet). We consider that the relatively wide range of proportions of SWER coupled with material differences in maintenance costs for SWER compared with a 3-phase distribution feeder, would combine to have a material effect on required maintenance costs in the rural businesses considered. However this does not appear to be a factor that necessarily distinguishes the two sparse rural businesses from the other rural businesses.

High proportion of short-rural indicative of distributed customer centres

104. Higher proportions of short-rural networks in Essential, Ergon and TasNetworks reinforce the physical network characteristics described above

including higher proportions of sub-transmission networks with a higher cost function.

105. Notwithstanding other contributing factors, sparse rural DNSPs would likely incur higher costs of network support opex associated with the distances required to undertake the work program as labour would be a large proportion of opex, and these costs would be expected to increase with line length. We would also expect non-maintenance costs, largely driven by fixed costs, to be higher for rural DNSPs with low density networks and lower customer numbers.

3.4 Opex and its relationship with DNSP characteristics

3.4.1 Introduction

106. Based on our experience of the management, operation and cost structures in a range of electricity networks, we have identified a number of DNSP characteristics that are likely to influence the level of opex for each business.

3.4.2 Maintenance expenditure

107. We would expect that the relationship between maintenance expenditure and line length should be close to linear. We consider that the largest proportion of maintenance related expenditure is related to overhead lines (between 85% and 95%), and that the nature of the maintenance activities is generally proportional to line length, with some adjustment required for pole density.

108. Vegetation expenditure is expected to be directly proportional to the number of spans[15] where vegetation maintenance is required. We would expect vegetation management activities for low voltage associated with distribution feeders to be undertaken at the same time, to ensure the required vegetation profile is achieved.

109. The requirements to maintain clearances for vegetation exist for all lines, which drives the inspection activity; however not all lines or spans may require cutting or vegetation clearance activities.

110. Routine maintenance activities are expected to be directly proportional to line length. However, we note that as the overhead line spans get longer for some long rural and SWER lines, the number of assets per kilometre decreases. The cost associated with inspection and routine maintenance is largely determined by the time at the individual asset to undertake the inspection or maintenance activity. On the assumption that travel distances can be normalised by other means, the inspection and maintenance costs per km would therefore be expected to be lower in the less dense parts of the network and therefore lower on average for sparser networks.

[15] A span is the length of line between any two adjacent poles, therefore the total number of line spans in a network approximates the number of poles.

111. We expect that an increasing proportion of sub-transmission lines and zone substation assets will increase the relative maintenance opex required. Sub-transmission assets are typically low in number, however the requirements are more labour intensive and often more expensive than activities on distribution feeders. We would expect sub-transmission maintenance costs to be proportional to sub-transmission line length and for maintenance for zone substations to be related to numbers of zone substation assets, particularly transformers.

112. Distribution transformer and switchgear costs are more likely related to the numbers of assets than the MVA due to the practices in some networks of installing larger transformers due to their low incremental cost, and the relationship to the line inspection practices of DNSPs.

113. Non-routine maintenance and emergency maintenance are expected to be impacted by the general condition and design of the electricity network, and performance level required. Electricity networks are seldom homogeneous, however a large proportion of legacy and problematic assets is likely to place upward pressure on the degree of non-routine and emergency maintenance activities and corresponding expenditure. Existing poor performance may bias this expenditure category.

114. The impact of local environmental conditions, i.e. prevalence and consequence of storm events and bushfires, can significantly influence the size of emergency response expenditure.

115. Maintenance costs include a combination of fixed and variable costs and are driven by the size of the network. We consider that maintenance costs per km are likely to have a decreasing relationship with line length for sparse rural DNSPs, subject to the effect of other operating environment factors included above.

3.4.3 Network operating costs

116. The network topology and geographical area is likely to be a large influence on the network operating cost requirements. Often the electricity network in rural areas does not follow gazetted roads, making access to the network for maintenance more difficult and extending typical travel and maintenance times.

117. Similarly, as the total service area of a DNSP increases, more depots, plant and equipment and personnel are typically required to maintain a particular level of service and system performance. This relationship is not directly proportional, as we expect that opportunities exist to deliver more innovative outcomes via management strategies and maintenance practices, to develop contracting strategies and through relationships within and between DNSPs to share available resources. As an example the home location of staff is often an important determinant of cost, where the staff are able to start the job on site rather than assembling at a depot. This is particularly the case for fault maintenance where the residence is effectively the depot for standby purposes.

118. We observe that reliability performance requirements tend to be not as high for remote rural customers as for general rural customers, and in turn not as high

as for urban and CBD customers. This lower reliability tends to apply to sparse rural networks, since they have a higher proportion of remote rural customers. Therefore as the requirements for customer contact and interaction are not as high, the associated costs should not have a directly increasing relationship with numbers of customers.

119. Similarly, for outage notification, outage coordination, traffic management and other related works management processes, we would expect these to be lower in sparse rural and rural areas relative to urban parts of a network.

120. Network operating costs include a component of fixed and variable costs and vary with the work done on the network. On balance, we consider that network operating costs are not likely to be greatly impacted by customer density.

Corporate overheads

121. The impact of extreme weather events and other system events are more pronounced in a rural DNSP due to access and other locational diversity issues. Insurance and related financial management structures may be impacted by the geographical spread of assets.

122. Supporting resources may be similarly impacted by the location diversity, requiring greater investment in corporate resources, higher travel requirements and duplicate facilities in regional areas.

123. Notwithstanding the above, on balance we consider that customer density does not greatly affect the level of corporate overheads incurred by a DNSP.

3.5 Conclusions in relation to sparse rural DNSPs

124. We consider that for sparse rural DNSPs, relative to other rural DNSPs:

- Costs per customer are likely to be higher for sparse rural businesses;
- To the extent that costs are considered to be most closely related to a single dominant factor, we consider that line route length is a reasonable explanatory variable for maintenance;
- We consider there are a range of secondary factors that apply to the maintenance costs, and which vary with the characteristics of the assets of the business. Where there is a dominant secondary factor we would expect that this would relate to the line maintenance costs and that the maintenance costs per km would vary with the ratio of poles per km. With fewer poles per km, sparse rural networks would tend to have lower maintenance costs per km (other factors being equal);
- We consider that non-maintenance opex is less directly related to line length and that, to a first approximation, a reasonable proxy would be to express these costs as being related to the number of customers.

125. On balance, we consider it reasonable to expect that sparse rural networks are less costly (on a per km basis) than DNSPs with a denser rural / urban mix, though more costly on a per customer basis.

4 Opex cost relationship

4.1 Introduction

4.1.1 Recap on required opinion

126. The AER has asked us to provide advice on the nature of opex cost relationships between rural DNSPs. In particular the AER has asked us for advice as to whether we consider the expected cost relationship is linear or non-linear in comparing sparse rural DNSPs with other rural DNSPs[16].

127. As is required by the AER, our assessment is based on consideration of the intrinsic factors driving cost relationships between DNSPs across a range of customer densities. Since the majority of opex is for maintenance, these intrinsic factors are largely technical and are based on consideration of the maintenance regimes that are applied to the different types of assets that comprise the network. We have also considered the intrinsic factors within a DNSP that drive non-maintenance opex.

128. Our advice is based solely on the experience within our team of the management of, and cost structures within DNSPs. We have examined the cost structures of a range of rural DNSPs in order to evidence their cost build-up; however we have not sought to compare the costs of particular DNSPs in order to draw conclusions on their relative efficiencies, nor were we required to under our terms of reference.

129. We use the term “intrinsic factors” here to distinguish between cost drivers that are intrinsically related to the nature of a DNSP network and its customer base, as opposed to cost factors that relate to the prudence and efficiency of decisions taken by management in operating and maintaining that network and

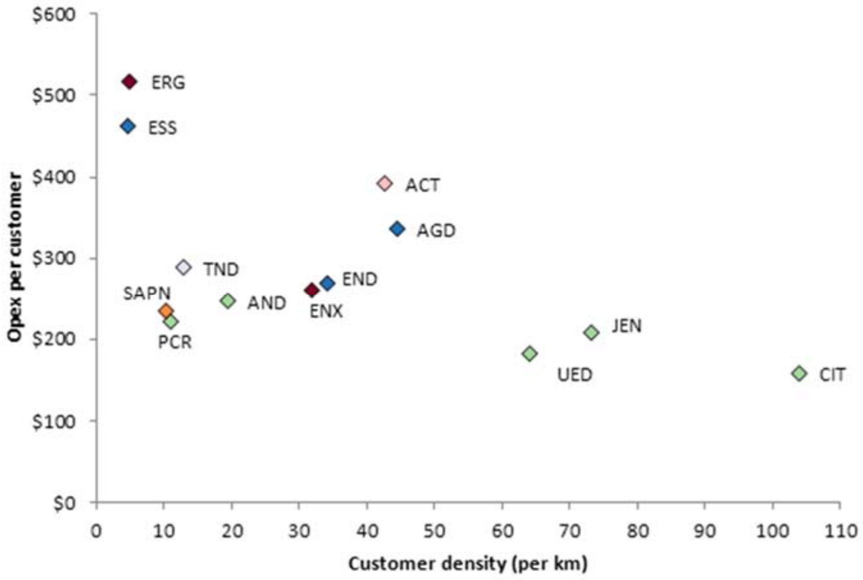
[16] We are aware that, in its opex benchmarking analysis, the AER has calibrated its models taking account of a range of urban and rural DNSPs, including some outside of Australia. However our brief was to consider only the cost structures in sparse rural DNSPs as compared with other Australian rural DNSPs. For this purpose, Ergon and Essential are considered sparse rural DNSPs while Powercor, SAPN, AusNet services and TasNetworks are considered denser DNSPs albeit with a considerable proportion of rural customers.

servicing its customer base. The AER has asked us for advice on the former and we understand that the purpose of this is to assist the AER with its judgments about relative prudence and efficiency and which it is making based on other analysis which in effect assumes certain intrinsic cost relationships.[17]

4.1.2 Problem definition – The cost relationship that the AER is seeking advice on

130. In commencing this work, the AER drew our attention to Figure 12 in its Benchmarking Report, and which is reproduced below. This figure shows opex/customer as a function of customer density, with the sparse rural DNSPs showing a markedly higher cost/customer than the denser rural DNSPs.

Figure 12: Operating expenditure per customer compared to customer density (average 2009–2013)



Source: AER 2014 Annual distribution benchmarking report, AER, Figure 12

131. While the AER has asked us to consider only the rural DNSPs (which on this graph, are those with a customer density of less than 20 customers/km) the AER was interested in whether the relationship between the two sparse rural DNSPs and the denser rural DNSPs is intrinsically linear or whether there are factors that might explain a revealed cost that is either above or below a linear trend. We understood the AER's terms of reference, in conjunction with the AER's reference in initial meetings to the graph above, as seeking to understand whether opex/customer has a linear relationship with customer density and, if not, what relationship can reasonably be assumed.

[17] EMCa has not been involved in the AER's benchmarking or econometric modelling and, whilst we have had an overview-level briefing on this work, we have not reviewed it, nor were we required to. Further, we are not aware of the conclusions that we understand the AER is drawing based on that work.

4.2 Our assessment

4.2.1 Primary cost relationship

Maintenance

132. In considering the application of maintenance to the DNSPs' networks, we consider that the majority of expenditure is directed towards sub-transmission lines and distribution feeders. To the extent that distribution transformers are maintained (and which we consider to be only a small component of overall DNSP maintenance) then the number of such transformers too can be considered to be closely aligned with feeder (route) length.

133. Therefore as stated in the previous section, our view is that the primary maintenance cost relationship is with the length of the network.

134. In subsequent sub-sections we consider other factors that may suggest that the intrinsic relationship is non-linear, but for the purpose of defining a first-order cost as a function of customer density we use a working assumption that the primary cost function is a constant cost per km. This first-order relationship of maintenance cost to line length leads mathematically to an inverse relationship between maintenance costs/customer and customer density, as shown by rearranging the equations below.

Where:

C is the Number of Customers

L is the Line Length

D is Customer Density (C/L)

M is Maintenance Cost

and k is an assumed maintenance unit cost per km of line ($\$/\mathrm{km}$)

then:

$$M = kL$$
$$\frac{M}{C} = \frac{kL}{C}$$
$$\frac{M}{C} = \frac{k}{(C/L)}$$
$$\frac{M}{C} = \frac{k}{D}$$

135. That is, if the maintenance cost is a function of an assumed unit cost per kilometre multiplied by the line length, then the maintenance costs/customer can be represented by a maintenance unit cost per km divided by customer density.

Non-maintenance

136. As discussed previously, we consider that the non-maintenance costs, comprising network operating costs along with management and corporate costs, comprise around 30% to 40% of opex in the rural DNSPs. We consider that this is less likely to be a primary function of line length and that, to the extent that a single dominant driver can be identified, a more reasonable proxy for these is costs per customer.

137. That is, if the non-maintenance cost is a function of costs per customer, then the non-maintenance costs/customer approaches a constant.

4.2.2 Non-linearities

138. While we consider that the primary opex cost function for a DNSPs can be reasonably described by a maintenance cost relationship that is linear with line length and a non-maintenance cost relationship that is linear with customer numbers, there are intrinsic factors that may lead to a degree of non-linearity. The nature of these factors, and our views on their relative significance, was described in section 3 and we summarise them here as follows:[18]

- we would expect that DNSPs with fewer poles per km will have lower average costs per km;
- we would expect that DNSPs with a higher proportion of subtransmission line to maintain, will have higher average costs per km;
- we would expect that DNSPs with a greater proportion of SWER, will have lower average costs per km;
- we would expect that the primary maintenance cost relationship is with route length rather than circuit length. Since much of LV is under-strung then, absent route length information, we consider that HV feeder and sub-transmission length is a better proxy for route length than measures including LV. However sparse rural DNSPs are likely to have a greater proportion of LV that is not under-strung and therefore intrinsically (on a measure of line length that excludes LV) sparse rural DNSPs would have a higher average cost per km;
- we would expect that DNSPs with a low customer density will have a lower reliability component of maintenance expenditure, and to the degree that this is material, it may result in a lower maintenance costs per km (assuming that this situation is acceptable and not in the process of being rectified). Oher factors being equal, this is more likely to apply to sparse rural DNSPs and intrinsically this should lead to a lower average cost per km; and
- to the extent that non-maintenance costs are considered to be closer to a function of customer numbers than route km, mathematically this ‘constant’ cost per customer should lead to a lower expected average opex cost per km for sparse rural DNSPs.

139. Consistent with our terms of reference, we have not sought to quantify the individual or aggregate effect of the non-linearities referred to above.

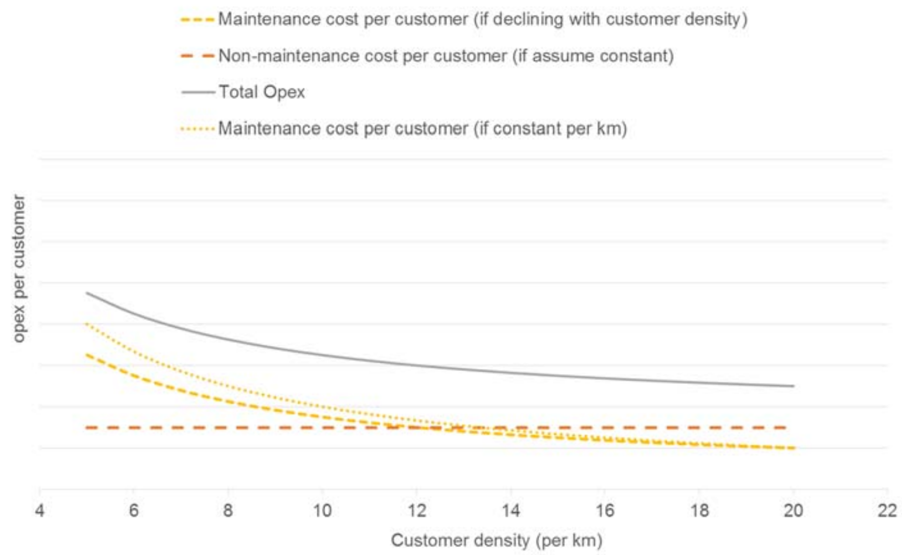
4.2.3 Total opex cost relationship

140. We can illustrate the effect of an assumed constant maintenance cost per km and an assumed non-maintenance related opex cost per customer. The latter leads mathematically to a lower aggregate opex cost per km for sparse rural networks. A lower ratio of poles per km in the sparse rural networks would tend to further lower aggregate opex costs per km in the sparse rural networks.

[18] Noting that each factor is considered individually

141. The following diagram illustrates the combined effect on an opex cost curve against customer density of: (1) a first-order constant maintenance unit cost related to line length (giving an inverse relationship with customer density); (2) the first-order inverse maintenance cost relationship with customer density but with the effects of a second-order lower pole density for sparser networks; and (3) total opex costs with an assumed constant non-maintenance cost per customer. While Figure 13 is representational only, it can be seen that the opex cost per customer is still higher for the sparser networks, but that the total opex cost trend is flatter than the first-order maintenance cost trend.

Figure 13: Illustrative opex cost relationship with customer density[19]



Source: EMCa analysis prepared for illustrative purposes only

4.2.4 Other cost relationship influencing factors

142. In this report, we have focused on the primary factors that may influence the cost of opex in comparing between rural networks with differing customer densities. There are numerous other factors (other than management and operational prudence and efficiency) that may influence opex. We have been provided with a list of factors that we understand the AER has considered, and which we have reproduced in Appendix A.

143. It is not within our scope to review this list, nor have we reviewed the AER's consideration of these factors and those that it has chosen to incorporate in its benchmarking analysis. We observe that, to the extent that any of these factors is material, then it would influence the basic cost functions that we have described in the preceding assessment. In combination, we consider that such factors might lead to a 'tolerance band' around the basic cost functions that we have suggested.

[19] An inverse relationship has been modelled to represent the decreasing maintenance cost/km with decreasing customer density to illustrate the impact to the total cost relationship.

Appendix A Summary of AER operating environment factors

We are advised that the AER has considered the following factors in its benchmarking of opex.

- Network access
- Activity scheduling
- Asset age
- Back yard reticulation
- Bushfires
- Building regulations
- Capitalisation practices
- Capital contributions
- Contaminated land management
- Contestable services
- Corrosive environments
- Critical national infrastructure
- Customer density
- Cyclones
- Demand management
- Economies of scale and scope
- Environmental variability
- Environmental regulations
- Fire ants
- Grounding conditions
- Past ownership
- Mining boom cost impacts
- Licence conditions
- Line length
- Line sag
- Load growth
- Load factor
- Cultural heritage
- Network control centres
- Mix of demand to non-demand customers
- OH&S regulations
- Outsourcing
- Planning regulations

- Private power poles
- Population growth
- Proportion of 11kV and 22kV lines
- Proportion of wood poles
- Radio networks
- Rainfall/humidity/fungal rot
- Reliability outcomes
- Rising and lateral mains
- Risk appetite
- Safety outcomes
- Service classification
- Shape factors
- Skills required by different service providers
- Advanced metering infrastructure
- Solar uptake
- Special customer requirements
- Extreme weather
- Subtransmission
- SWER
- Taxes and levies
- Temperature
- Termite exposure
- Traffic management
- Transformer capacity owned by customers
- Transmission connection point charges
- Topography
- Unregulated services
- Undergrounding
- Underground services
- Division in responsibility for vegetation management
- Work conditions