10 DECEMBER 2019

THE LONG-RUN IMPLICATIONS OF REGULATORY REPEX ALLOWANCES

REPORT PREPARED FOR SA POWER NETWORKS

CONTENTS

1 EXECUTIVE SUMMARY

1. Frontier Economics has been retained by SA Power Networks (SAPN) to provide advice on the long-run implications of regulatory replacement expenditure (repex) allowances.

2. We begin by setting out a series of intuitive propositions that we consider to be uncontroversial as they follow from simple logic:

   Repex requirements depend on the age profile of the network assets at the time of each regulatory determination. Other things being equal, a regulatory period that begins with an older set of assets will require relatively more repex than a regulatory period that begins at a time when the age profile of the assets is younger.

   a. Other things being equal, a lower repex allowance will result in more in situ failures as fewer assets that have been identified for replacement are able to be replaced.

   b. A reduction in the repex allowance can be more costly in the long run as it results in more in situ failures that are more costly than scheduled replacements due to their effects on reliability and network safety (including bushfires).

   c. Every non-redundant asset must eventually be replaced, so a reduction in the repex allowance in one period will result in the 'disallowed' assets having to be replaced in a future regulatory period.

3. We then note that a large proportion of SAPN's assets (originally built out in the 1950s and 1960s) is now reaching an age where a greater proportion are requiring replacement, creating a 'bow wave' as they move through time. We also note that the assets in the SAPN network have a materially older age profile than corresponding assets in other networks.

4. The main contribution of this report is our development of a simplified age-based modelling approach that is calibrated to actual data from the SAPN network which illustrates long-term repex trends as well as the effects of disallowing required repex expenditure.

5. The analysis begins with the current age profile of SAPN's assets and a distribution of anticipated asset life for each asset class. It then tracks the age profile of assets over time and predicts replacement expenditure on the basis of the anticipated asset life and on the assumption that replacement with this timing will maintain overall network performance at current levels.

6. The model confirms the propositions set out above and demonstrates that:

   a. In the absence of some form of productivity improvements that enable service performance and safety standards to be maintained at lower cost, it would be inappropriate to use a simple historical average approach to set repex allowances.[1] Such an approach disregards the age profile of the assets at the time of the regulatory determination. The age profile will change over time as assets age and are replaced. Consequently, the required number of replacements may be materially above or below or equal to the requirement from the previous regulatory period.

   b. Since SAPN's network assets are relatively old by any metric, SAPN is entering a phase where defect rates are increasing and relatively more asset replacements are required.

[1] That is, if the approach to repex management remains constant over time, and if the age profile of assets changes over time (e.g., because a 'bow wave' of assets built out at the same time moves through time towards the end of their useful lives) a simple average of historical repex costs will be inappropriate.

c. The disallowance of required expenditure results in rising in situ failure rates, a likely inability to maintain network safety and reliability objectives, and higher repex expenditure in subsequent regulatory periods.

7. In its recent Draft Decision for SAPN’s 2020-25 regulatory control period, the AER set SAPN’s repex allowance on the basis of historical averages over a five-year period. A major shortcoming with this approach is that it fails to recognise the age profile of SAPN’s assets, and the fact that SAPN has a large cohort of relatively old assets that are moving as a bow wave towards the end of their useful lives. The method used by the AER to set allowances relating to unmodelled repex would produce the same repex allowance regardless of whether the existing network assets are all relatively new or approaching the end of their lives. As such, it is very unlikely that the allowance provided in the AER’s Draft Decision reflects SAPN’s true repex requirements.

8. We consider that the approach to assessing SAPN’s repex forecasts could benefit from the adoption of some aspects of the approach followed by the energy regulator in Great Britain, Ofgem. The AER’s proposed approach for SAPN contrasts with the Ofgem approach in the following ways:

   a. Whereas the AER used age-based repex modelling to assess just 24% of SAPN’s repex forecasts, during the last round of price controls for electricity distribution businesses (RIIO-ED1), Ofgem applied age-based repex modelling to assess approximately 80% of the businesses’ proposed repex.

   b. The AER has excluded a number of important asset classes (such as poles) from its repex modelling in the SAPN Draft Decision on the grounds that those assets are unique to SAPN. Ofgem does not use uniqueness as a reason to exclude asset classes from its age-based repex modelling.

   c. The AER’s Draft Decision takes very little account of the specific circumstances faced by SAPN, when setting the repex allowance—in particular, the fact that SAPN has a relatively old network that will require major replacement activity soon in order to maintain quality, reliability, security of supply and safety. By contrast, Ofgem’s approach to assessing repex forecasts recognises explicitly the different circumstances of individual businesses.

2 SOME SIMPLE PROPOSITIONS IN RELATION TO REPEX ALLOWANCES

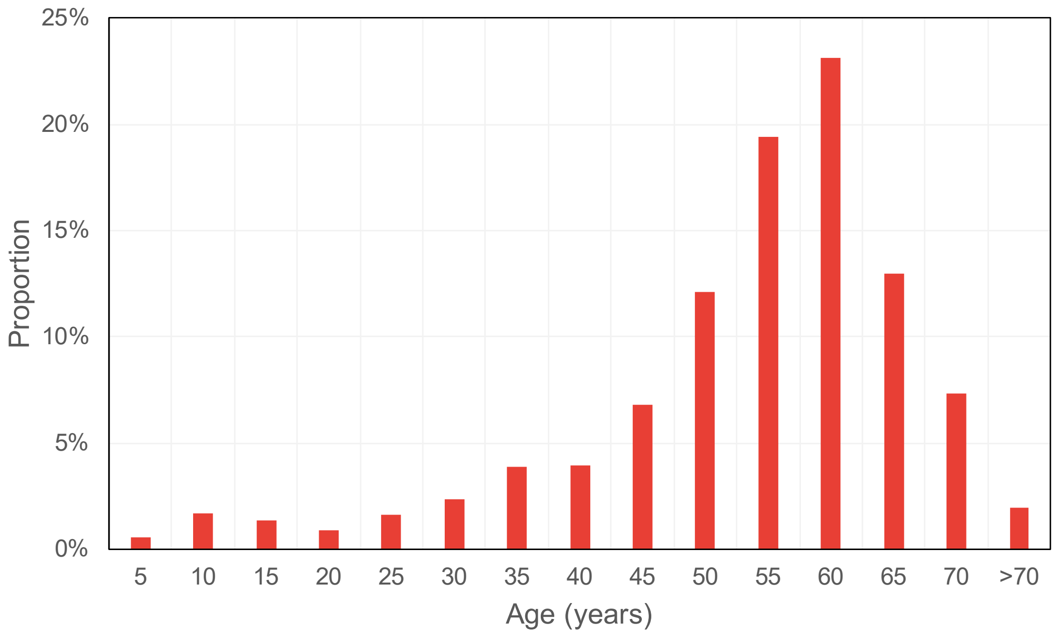
2.1 Overview

9. In this section, we set out a number of simple, common-sense propositions in relation to regulatory repex allowances. The following section then develops a simplified model to illustrate these propositions, calibrated to actual data pertaining to the SAPN network.

2.2 Proposition 1: Repex requirements will not grow smoothly over time

10. The first proposition is that repex requirements are likely to vary over time as a function of the age profile of each class of assets in the network. For example, the SAPN network was largely constructed during the 1950s and 1960s such that the majority of its assets are now 50 to 70 years old. This is illustrated by the age distribution of poles in the SAPN network as set out in **Figure 1** below.

Figure 1: **Age profile of poles for SAPN network**



Source: SAPN asset register and RIN response.

11. **Figure** 1 shows that the SAPN network was largely built out between 50 and 70 years ago and that relatively little expansion of the network has occurred since that time. Indeed, the number of poles added to the network over the last 30 years is very small, relative to the primary construction phase of the network.

12. Because they are simple mechanical structures, as poles age, their component materials degrade and they are more likely to require replacement. The poles that were added to the network during the build phase in the 1950s and 1960s are now at or approaching 70 years of age and are more likely to require replacement as they age further. This creates the effect of a ‘bow wave’ moving through the repex cycle – as time passes, the peak of the above distribution moves to the right and the number of required replacements increases materially.

13. After this peak moves through (i.e., the old assets are replaced) the repex requirements will fall as there are relatively few poles in the age brackets that follow.

14. In summary, it is not the case that repex requirements can be sensibly modelled by simply extrapolating expenditure from prior years. Such an approach implies that repex requirements are independent of the age profile of each class of assets in the network at the time of the particular regulatory determination. However, the above example of poles in the SAPN network demonstrates that the age profile of a class of assets can be materially peaked, reflecting that the network was largely built out during a relatively short period. As those assets age they create a bow wave of repex requirements, to be followed by reduced repex requirements.

2.3 Proposition 2: A lower repex allowance will result in more in situ failures

15. The second proposition is that a lower repex allowance will result in more in situ failures. To once again take the example of network poles, we understand that SAPN follows a Condition Based Risk Management (CBRM) approach to identifying poles that are in need of rectification. This essentially involves a determination of the likelihood of each pole failing during the following year. The CBRM approach then considers the cost of failure for each pole, including the pure financial cost, and also the costs in terms of network reliability and safety (including the risk of bushfires). The output of the CBRM approach is an ordered plan for rectification of ‘high consequence’ poles (i.e., those for which failure would have the most severe consequences on network reliability and safety) via either refurbishment or replacement.

16. The key objective of the CBRM approach is to maintain the safety and reliability of the network, which involves prioritising the replacement of ‘high consequence’ poles.

17. If the regulator disallows the required repex, the network will clearly replace fewer assets. The poles that have been identified as having the highest combination of risk and ‘value’ will be the first to be replaced, but a reduced repex allowance will mean that some poles that have been identified as requiring replacement cannot be replaced except at a loss to the network.

18. Reduced replacement work will inevitably result in more in situ failures than there would otherwise have been.

2.4 Proposition 3: Replacing assets after they have failed is more expensive than orderly replacement as part of a repex program

19. The third proposition is that replacing assets after they have failed is more costly than orderly and planned replacement of assets identified as part of a managed program. As noted above, in situ asset failures can have significant consequences for network reliability and safety (including bushfires).

20. Thus, in terms of long-run cost efficiency, there is a need to balance:

    a. Short-term savings that could be made by reducing repex expenditure; against

b. The higher costs associated with more in situ asset failures.

2.5 Proposition 4: All assets must eventually be replaced – it is simply a matter of when

21. The fourth proposition is that all non-redundant network assets must eventually be replaced – the only question is when the replacement will be made. The important implication of this proposition is that when an asset is identified for replacement by the CBRM approach, but funding for that replacement is disallowed, that asset will require replacement in a future regulatory period.

22. That is, a reduction in repex allowances, relative to the requirements of the CBRM approach, will result in more repex expenditure being required in future regulatory periods to address a backlog of deferred replacement activity, as well as more high consequence in situ asset failures, as above. This raises issues of balancing 'inter-generational equity' among current and future consumers.

3 SIMPLIFIED MODELLING ANALYSIS

3.1 Overview of a simple age-based model

23. In order to demonstrate the validity of the propositions set out in the previous section, we have developed a simple, stylised age-based repex model, which we calibrate using actual data from the SAPN network.

24. In order to keep the analysis as simple as possible, we have focussed the model on three asset classes—poles, overhead conductors and underground cables. However, the insights from our modelling of these asset classes, which demonstrate the validity of the propositions set out above, applies readily to all of SAPN's asset classes.

25. The model demonstrates, using actual SAPN data, that:

    a. Repex requirements depend on the age profile of the network assets at the time of each regulatory determination. Other things being equal, a regulatory period that begins with an older set of assets (due to historical reasons, including when the network was first built out and how hard the network has 'run' the assets) will require relatively more repex than a regulatory period that begins at a time when the age profile of the assets is younger. In the case of SAPN, a large proportion of assets (originally built out in the 1950s and 1960s) is now reaching an age where a bow wave of assets is moving towards the end of their useful lives.

    b. Other things being equal, a lower repex allowance will result in more high consequence in situ failures leading to a reduction in the safety and reliability of the network.

    c. A reduction in the repex allowance can be more costly in the long run as it results in more in situ failures that are more costly than scheduled replacements due to their effects on reliability and network safety (including bushfires).

    d. Every non-redundant asset must eventually be replaced, so a reduction in the repex allowance in one period will result in the 'disallowed' assets having to be replaced in a future regulatory period.

26. The analysis begins with the current age profile of SAPN's assets and a probability distribution for asset life – specifically, we use a normal distribution based on the mean asset life and the standard deviation around that. The parameters used for each of the three asset classes examined are set out in **Table 1** below.

Table 1: Asset life parameters

	POLES	CONDUCTORS	CABLES
Mean asset life (years)	75	85	66
Standard deviation (years)	20	10	12
Maximum asset life (years)	120	105	90

Source: SAPN.

27. The probability distribution of asset lives implies a unique set of expected defect rates in each age category. That is, the asset life distribution implies that a certain proportion of assets will develop defects between the ages of say 50 and 55 years, a certain proportion will develop defects between the ages of 55 and 60 years, and so on. The model then tracks the assets over time. As assets age, they become more prone to defects and will have to be replaced or they may fail in situ.

28. The model then calculates the volume of replacement activity required on the assumption that asset replacements, if undertaken at times consistent with the asset life probability distribution, will maintain network in situ failure rates, and thus network safety and reliability performance at current levels.[2]

29. Next, the model calculates the volume of required replacement, and the associated costs, if the regulator provides less revenue allowance than is required to undertake the replacement activity, under the following assumptions:

    a. Unfunded replacement work is deferred to the next regulatory control period. If the regulator disallows a significant portion of the required repex, deferral of expenditure can create a large backlog of replacement work that needs to be accommodated in the next regulatory control period alongside replacement work that would otherwise naturally need to occur in that period; and

    b. The cost of rectifying an in situ failure is more expensive than conducting planned rectification of the same asset.

30. The model outputs are produced for 20 regulatory control periods into the future (each assumed to last five years), so that the long-term implications of regulatory allowances on replacement activity can be analysed.

31. Details about the inputs and assumptions used in the model, and about the structure of the model, are provided in the Appendix to this report.

32. We do not suggest that this modelling approach should be used as the basis for determining the dollar repex allowance that should be made in SAPN's case. Rather, the goal is to construct a model that is intuitive, transparent and accessible to all stakeholders, and which is calibrated to data for the SAPN network, in order to gain insights with respect to future repex trends and demonstrate the effects of different levels of repex allowances on the long-run costs associated with network asset replacement works.

[2] The model does not distinguish between high- and low-consequence defects. Thus, not all in situ failures have the same consequence and the CBRM system would have the effect of minimising the consequences of failures by prioritising the replacement of high-consequence assets.

3.2 Model outputs

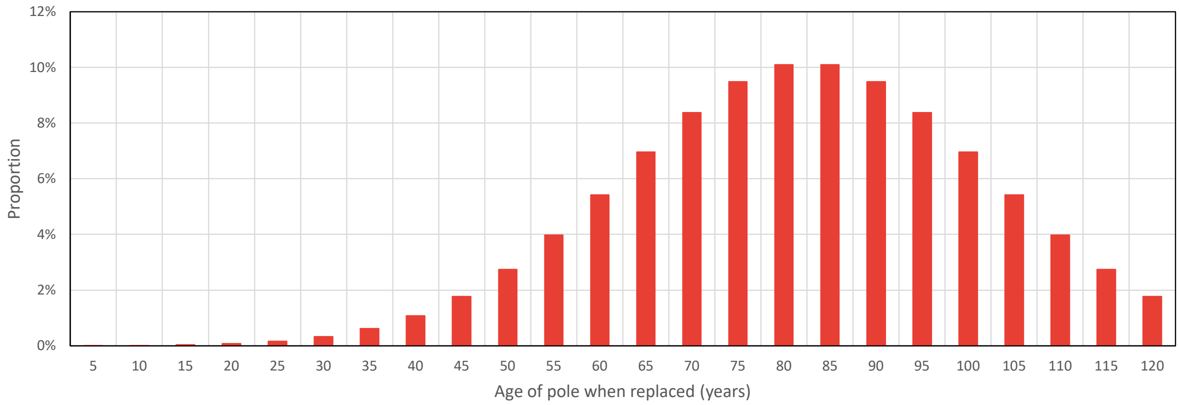
Distribution of asset lives

33. The first model output is a distribution of the lifespan of assets in each class. As explained in the Appendix to this report, the model begins with a set of defect rates for each age category (e.g., 50-55 years, 55-60 years, and so on) that is selected to be consistent with the mean and standard deviation of asset lives. Consequently, we observe the distribution of the lifespan of the assets that is output by the model as a check that the model is indeed producing outputs that are consistent with the input assumptions.

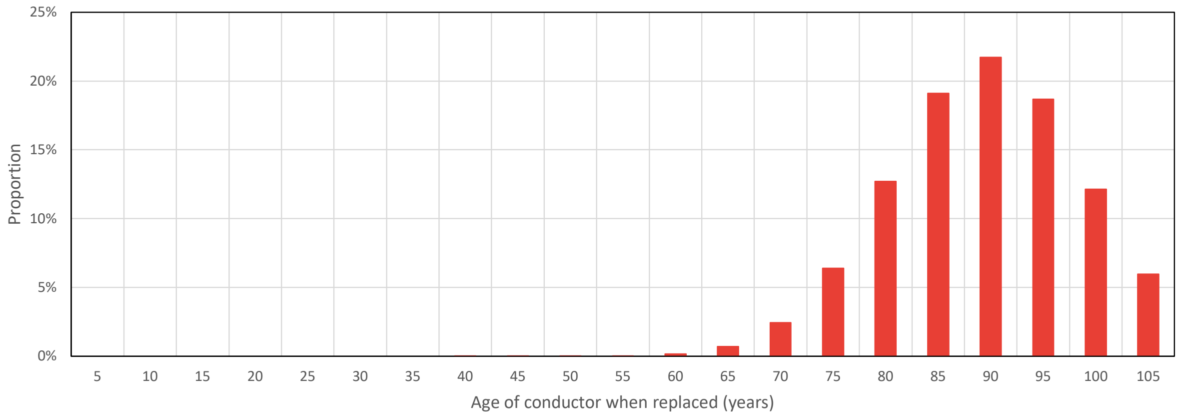
34. The distribution of the lifespans of pole, conductor and cable assets is set out in **Figure 2** below.

Figure 2: Distribution of asset lifespans

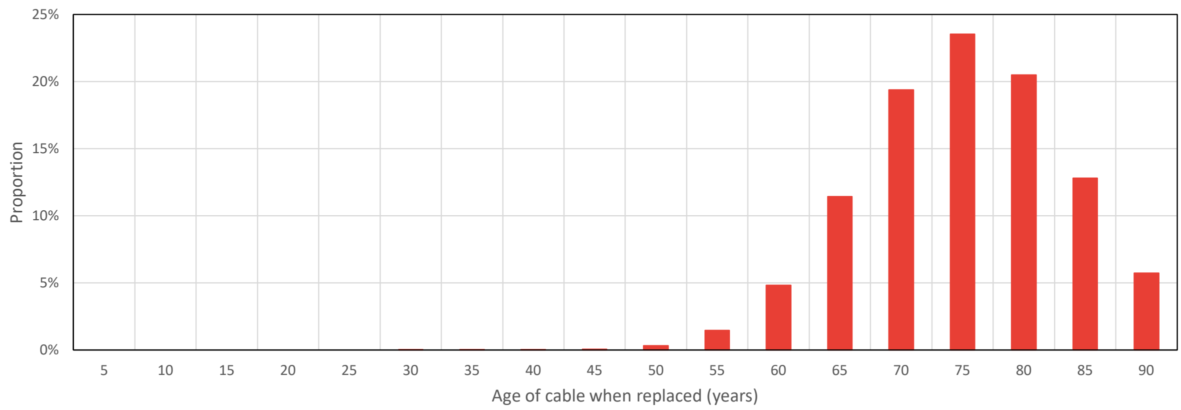
Poles



Conductors



Cables



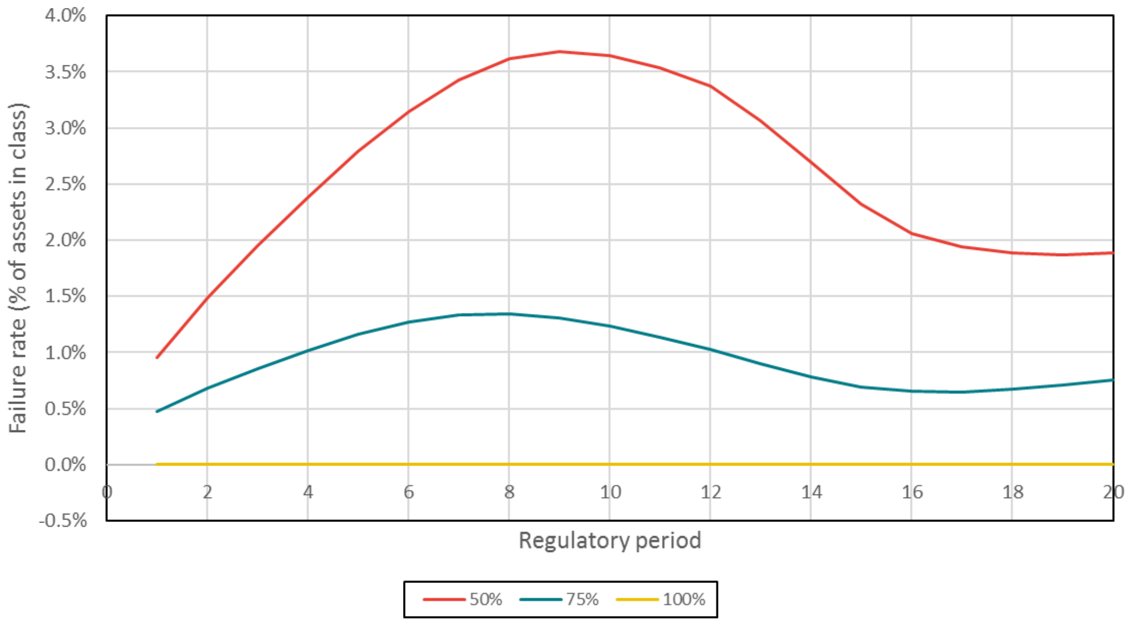
Source: Model output.

Incremental In situ failure rates

35. The model outputs a quantification of incremental in situ failure rates. Any asset that has been identified as requiring replacement, but is not replaced because insufficient funding has been made available, is subject to the risk of in situ failure. These failures are incremental to the baseline levels of in situ failure that SAPN experiences on the network owing to a range of factors including the inability of inspection regimes to identify all defects, third party and storm damage. For the purposes of the modelling, we assume that these baseline levels of asset failure would remain constant, thereby maintaining a fixed level of asset safety and reliability performance.

36. The incremental in situ failure rates for SAPN network poles are summarised in **Figure 3** below. If 100% of the required budget is allowed, every pole that has been indicated for replacement will be replaced and the incremental failure rate will be zero. For lower levels of funding, there are higher rates of incremental failures. In these cases, there is a peak in the distribution of failures as the 'bow wave' of older assets moves through time. For example, a large proportion of the SAPN network was constructed in the 1950s. Thus, a large proportion of poles will reach the end of their lives, and require replacement, at approximately the same time. If funding is unavailable for this large volume of replacements, a large number of incremental situ failures would be expected to occur.

Figure 3: **Incremental failure rates by AER repex allowance relative to required amount – poles**



Source: Frontier Economics analysis.

Note: Failure rates are expressed as the proportion of total assets to experience a preventable failure during a 5-year regulatory period. The curves represent different levels of AER allowance, relative to SAPN requirements.

37. In **Figure 3**, the peak of the 50% distribution occurs slightly after the peak of the 75% distribution. This is because the lower (50%) regulatory allowance results in periods of 'catch-up' replacement being required such that:

   a. There are a large number of failures occurring in one regulatory period that must be prioritised for rectification in the following period to avoid reliability and/or safety problems; and

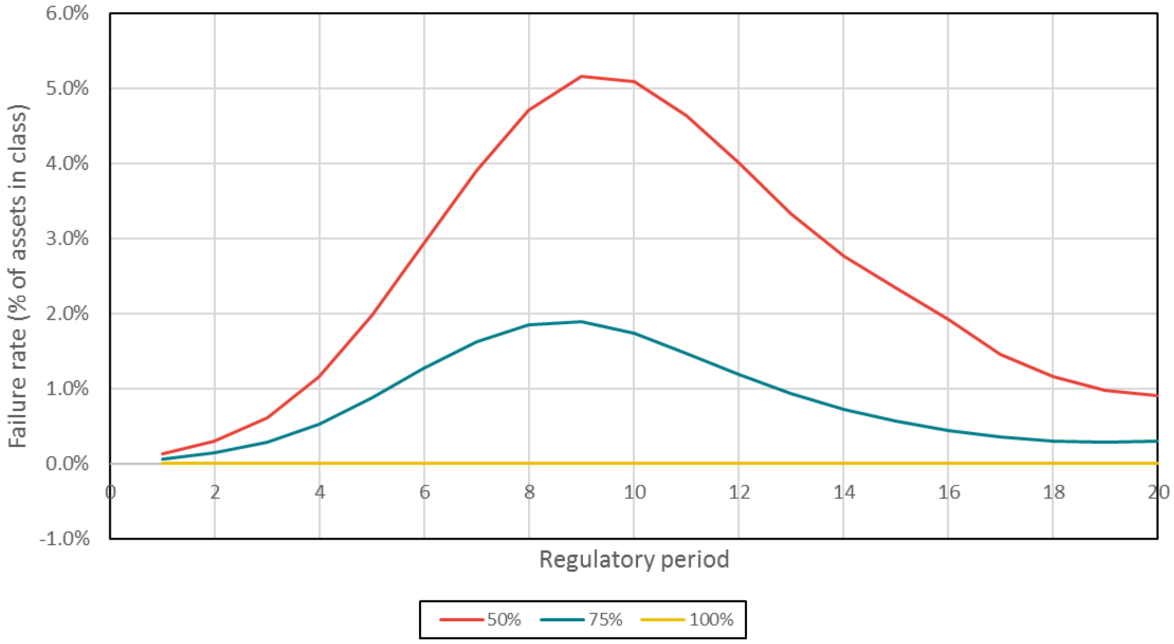
   b. The 'catch-up' expenditure from the previous period leaves less funding available to address new defects in the current period, so the failure rate increases and requires rectification in the following period.

38. This has the effect of pushing the 'bow wave' of replacements further into the future.

39. By way of benchmarking the practical significance of these failure rates, we note that a failure rate of 1% implies approximately 6,000 failures during a 5-year regulatory period or 100 in situ pole failures per month.

40. **Figure 4** and **Figure 5** present the in incremental situ failure rates for overhead conductors and underground cables, respectively. Both charts show that, as with poles, the lower the proportion of regulatory funding to address required replacement work, the greater will be the rate of incremental in situ asset failures. This demonstrates that the effect that is shown in **Figure 3** is not in any way due to the uniqueness of SAPN's poles or the failure rates or longevity that may be attributable to the particular technology reflected SAPN's poles. Rather, the effect is one that can be generalised to other asset classes.

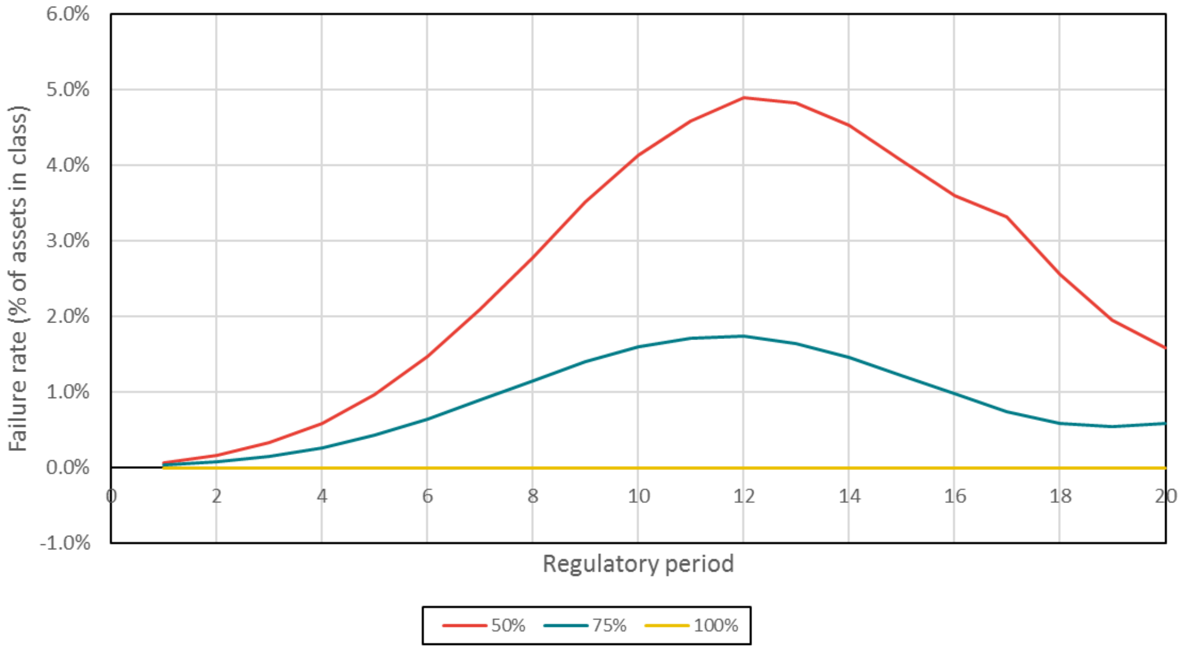
Figure 4: Incremental failure rates by AER repex allowance relative to required amount – conductors



Source: Frontier Economics analysis.

Note: Failure rates are expressed as the proportion of total assets to experience a preventable failure during a 5-year regulatory period. The curves represent different levels of AER allowance, relative to SAPN requirements.

Figure 5: Incremental failure rates by AER repex allowance relative to required amount – cables



Source: Frontier Economics analysis.

Note: Failure rates are expressed as the proportion of total assets to experience a preventable failure during a 5-year regulatory period. The curves represent different levels of AER allowance, relative to SAPN requirements.

Total repex relative to the asset base

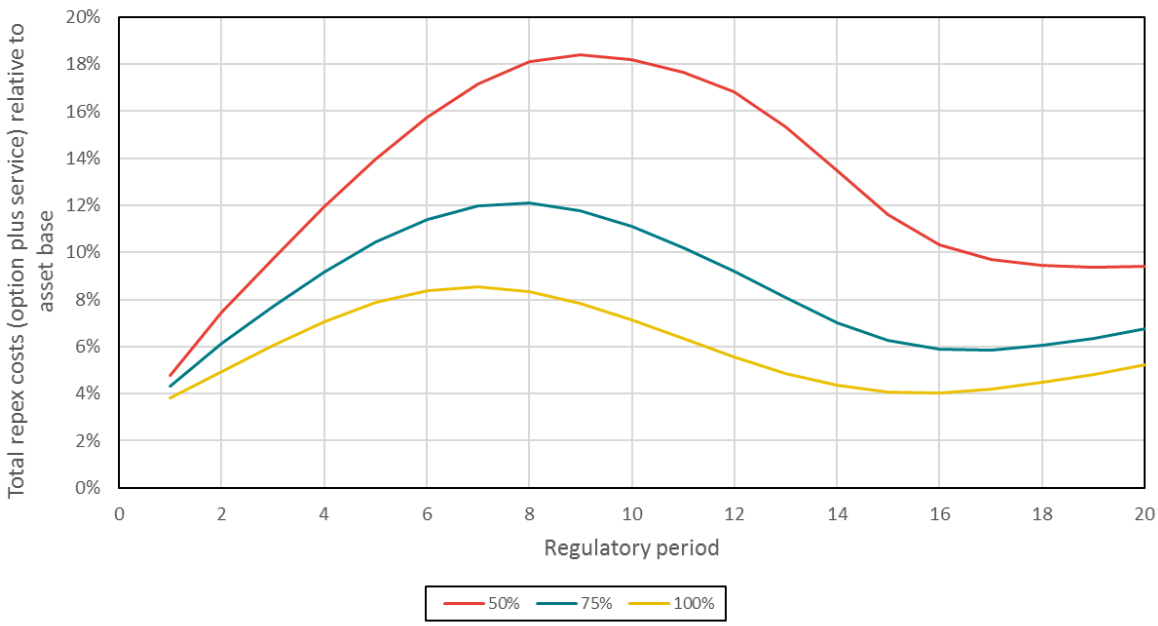
41. The model calculates the total amount of repex related to poles required for each regulatory period, relative to the value of the asset base, as shown in **Figure 6** below. The figure below takes into account the estimated failure premium to reflect the additional cost of in situ failures (in terms of network reliability and safety, including bushfires). That is, the figures represent what the AER refers to as 'option costs' (the costs of replacing assets) and 'service costs' (the costs of a reduction in network reliability and safety).

42. The yellow curve shows the case where all required expenditure is funded by the regulator and there are no in situ failures. This case clearly shows the 'bow wave' as assets age and are replaced, followed by a trough during the period when the "old' assets have been replaced and the age profile becomes weighted towards younger assets.

43. The other curves indicate the effects of incremental in situ failures at lower levels of funding allowed by the regulator. In those cases, replacements are delayed (such that the peak is pushed further into the future) and the overall cost is higher due to the additional costs associated with failed assets. The bow wave of investment that reflects replacement of assets according to their natural life cycle—as shown in the yellow curve—is amplified by the deferral of expenditure from one period to the next, if the regulator allows less revenue than is required to fund that required replacement.

Figure 7 and **Figure 8** shows a similar pattern for overhead conductors and underground cables.

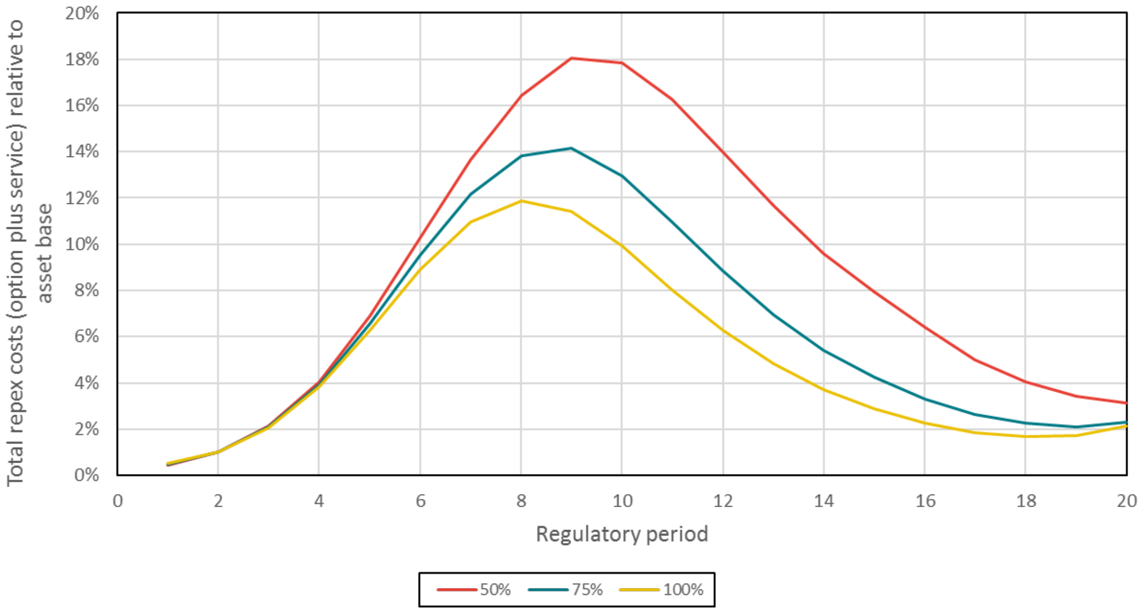
Figure 6: **Total repex costs (option costs plus service costs) relative to asset base – poles**



Source: Frontier Economics analysis.

Note: Vertical axis represents total repex expenditure (option costs plus service costs – including the safety/reliability cost associated with in situ replacements) relative to the total replacement value of the asset class.

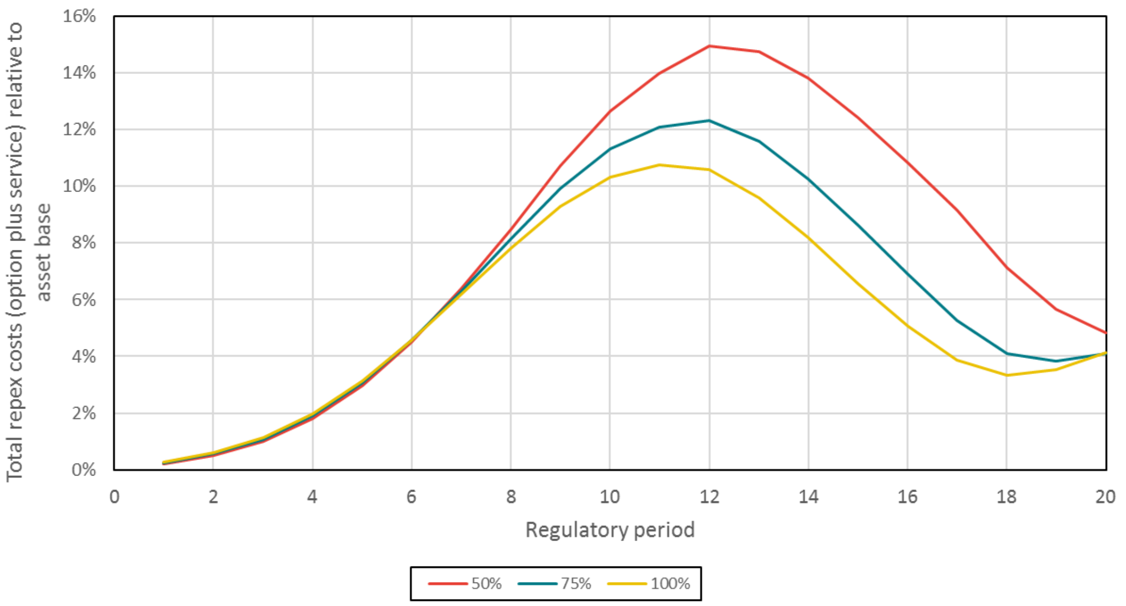
Figure 7: **Total repex costs (option costs plus service costs) relative to asset base – conductors**



Source: Frontier Economics analysis.

Note: Vertical axis represents total repex expenditure (option costs plus service costs – including the safety/reliability cost associated with in situ replacements) relative to the total replacement value of the asset class.

Figure 8: **Total repex costs (option costs plus service costs) relative to asset base – cables**



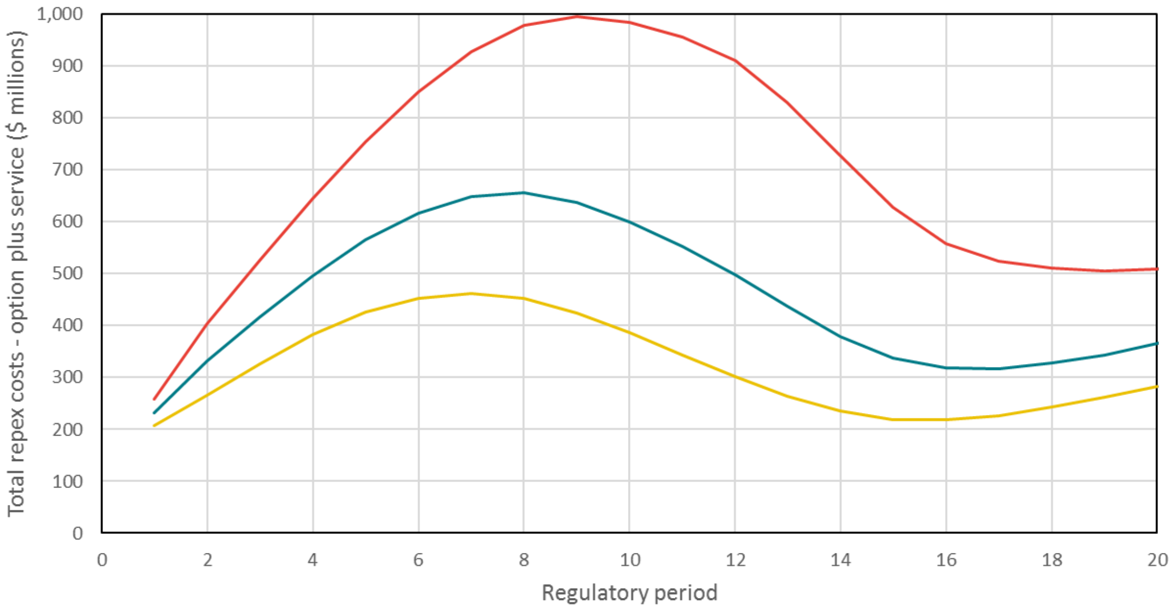
Source: Frontier Economics analysis.

Note: Vertical axis represents total repex expenditure (option costs plus service costs – including the safety/reliability cost associated with in situ replacements) relative to the total replacement value of the asset class.

Dollar cost of repex by regulatory period

44. The model also calculates the total dollar cost of repex claimed in each regulatory period as shown in **Figure 9** below.

Figure 9: **Total repex costs(option plus service) by regulatory period – poles**



Source: Frontier Economics analysis.

Note: Vertical axis represents total cost including regulatory repex allowance and additional cost to replace in situ failures (i.e., cost of safety and reliability).

45. **Figure 9** above shows that there can be peaks and troughs in the cost of asset replacement even if the regulator allows the full amount of required repex. This is due to the natural life cycle of assets—in particular, the fact that a large cohort of poles were installed together when most of the network was constructed originally, and most of this cohort will need to be replaced at approximately the same time, other things remaining equal.

46. However, the Figure also shows clearly that the lower the proportion of required repex actually allowed by the regulator:

    a. the greater will be the cost burden shifted on to future consumers—as demonstrated by rightward shift in the peak of the curve as the proportion of regulatory funding declines; and

    b. the higher will be the cost of asset replacement over the long-run. This is because the cost of rectifying in situ failures is typically higher than the cost of planned replacement, and inadequate funding of repex leads to greater deferral of replacement, and greater incidence of in situ failures with all of the resultant consequences in relation to network safety and reliability.

47. In order to illustrate the second of these points more clearly, we calculated the net present value (NPV) of the stream of repex under each funding scenario, assuming as the relevant discount rate the pre-tax real Weighted Average Cost of Capital (WACC) that SAPN adopts when conducting business case assessments, 2.63%.[3] These NPVs, which are presented in **Table 2**, show that the long-run cost of regulatory under-funding of required repex can be very

[3] This WACC was provided to us by SAPN.

material. That is, the lower the proportion of the repex requirement allowed by the regulator, the larger the cost of replacement work over the long-run. Ultimately, it is future consumers that will shoulder this unnecessary cost burden.

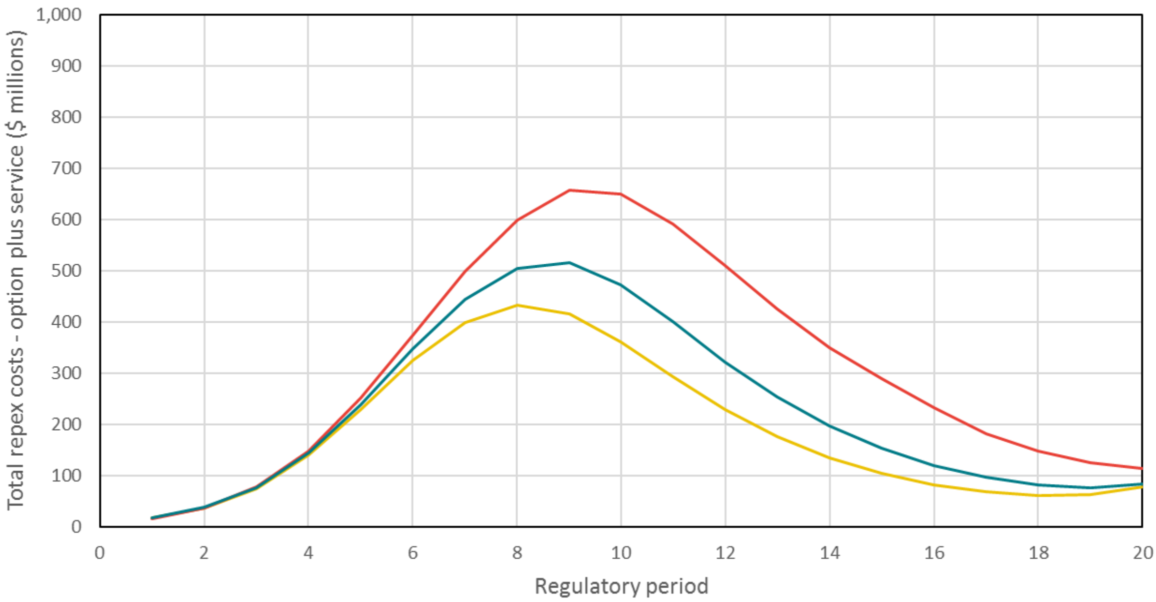
Table 2: NPV of total repex costs for poles (including option and service costs) over 20 regulatory periods assuming different levels of required repex funded through regulatory allowances ($ million)

PROPORTION OF REGULATORY FUNDING	NPV OF REPEX
50%	$11, 061
75%	$7,296
100%	$5,168

Source: Frontier Economics analysis. Includes consequences of in situ asset failures – effects on network reliability and safety.

48. **Figure 10** and **Figure 11** present the required repex for overhead conductors and underground cables, respectively, and shows how this required expenditure varies as the proportion of required funding allowed by the regulator is varied. As with poles, the figures below show that the lower the proportion of required repex allowed by the regulator, the more costly will be replacement over the long-run, and the greater will be the cost borne by future consumers, all else remaining equal.

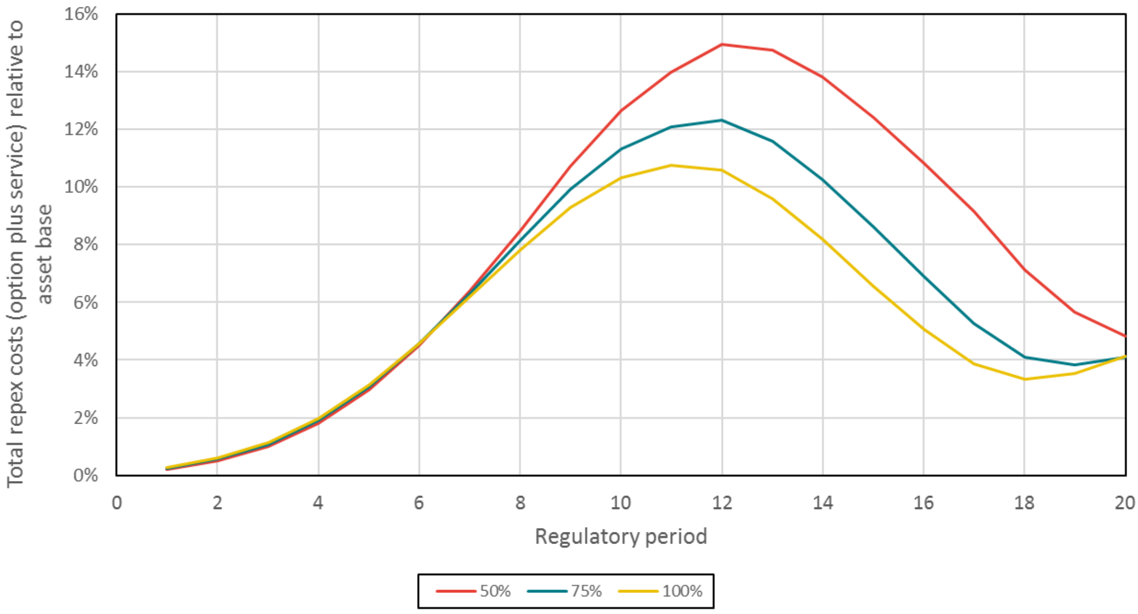
Figure 10: **Total repex costs (option plus service) by regulatory period – conductors**



Source: Frontier Economics analysis.

Note: Vertical axis represents total cost including regulatory repex allowance and additional cost to replace in situ failures (i.e., cost of safety and reliability).

Figure 11: **Total repex costs (option plus service) – cables**



Source: Frontier Economics analysis.

Note: Vertical axis represents total cost including regulatory repex allowance and additional cost to replace in situ failures (i.e., cost of safety and reliability).

Total repex costs

49. Although we re-iterate that the purpose of this review has been to gain insight on long-term repex trends and implications of repex deferral, we have compared the outputs of the model against SAPN's forecasts for the 2020-25 regulatory period. The repex expenditure in the 'FE model' column is based on a regulatory allowance sufficient to fund 100% of assets that are indicated as requiring replacement. In this case there are no incremental service costs associated with a diminution in safety and reliability levels.

50. The total repex costs identified by our simplified age-based repex model are contrasted with the SAPN revised proposal in **Table 3** below. We note that the SAPN proposal is based on reduced repex expenditure that is possible due to an investment in IT systems and processes (the Assets and Work program) that would enable SAPN to better identify high-consequence assets and achieve other bundling related efficiencies. This would enable SAPN to minimise repex expenditure while maintaining network reliability and safety levels as explained further in Section 4.1 below.

Table 3: Repex expenditure for 2020-25 regulatory period ($ millions)

	POLES	CONDUCTORS	CABLES
FE model	206.72	18.57	18.60
SAPN	189.52	18.10	12.29

Source: Frontier Economics calculations, SAPN revised proposal, AER Draft Decision. Measured in dollars as at end FY2020.

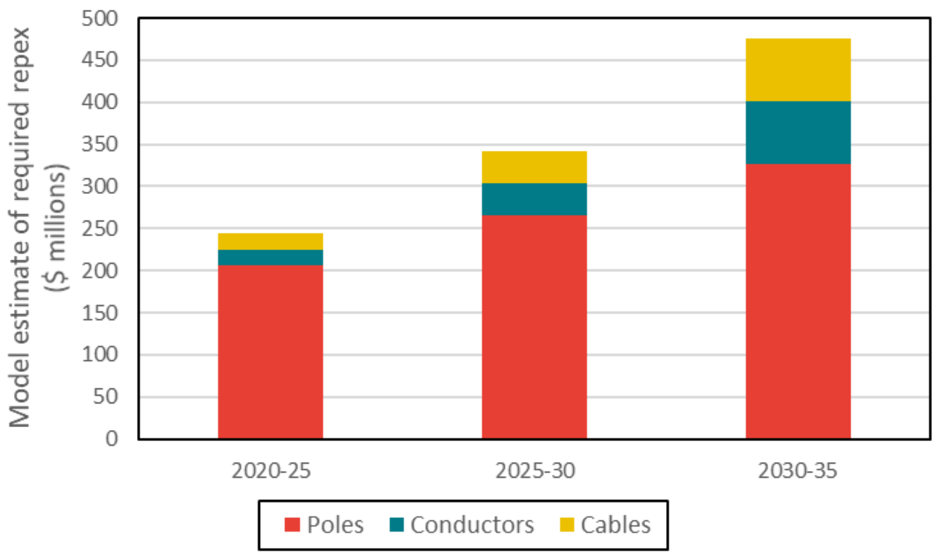
51. The total repex costs identified by our age-based repex model, for each of the next three regulatory control periods, are set out in **Table 4** below. This table shows that the required expenditure increases materially as the bow wave of aging assets moves through time and more assets approach the end of their useful lives. This is shown clearly in **Figure 13** below.

Table 4: Model estimate of required repex expenditure ($ millions)

REGULATORY PERIOD	2020-25	2025-30	2030-35
Poles	206.72	266.41	326.88
Conductors	18.57	37.37	74.84
Cables	18.60	38.63	73.60

Source: Frontier Economics calculations. Measured in dollars as at end FY2020.

Figure 12: Model estimate of required repex ($ millions)



Source: Frontier Economics calculations

4 THE APPROACH TAKEN IN THE AER'S DRAFT DECISION

4.1 Overview of the Draft Decision

52. SAPN proposed a repex allowance for the 2020-25 regulatory control period of $637.2 million ($2019–20). The AER's Draft Decision proposed a total repex allowance of $508.5 million ($2019–20)—i.e., $128.6 million lower than was proposed by SAPN.

53. Figure 13 below presents SAPN's historical repex, the historical repex allowances provided by the AER, SAPN's repex forecast for the 2020-25 regulatory control period and the AER's proposed repex allowance for the 2020-25 regulatory control period as set out in the Draft Decision.

54. The AER assessed SAPN's repex proposal in two categories:

    a. Modelled repex. The AER used its age-based repex model to assess approximately 24% of SAPN's repex proposal;[4] and

    b. Unmodelled repex. The AER used a simple average of repex over a 5-year historical period (2013-14 to 2017-18) to assess the remaining 76% of SAPN's repex proposal.[5] The period used to assess the simple trends used to set the unmodelled repex allowance component excluded SAPN's forecasts of repex for the last two years of the current regulatory control period, 2018-19 and 2019-20. Actual expenditure is now available for the 2018/19 financial year. As Figure 13 shows, for the final two years of the current regulatory period (FY19 for which actual data is now available and the forecast for FY20) repex is materially higher than the actual repex incurred in the five years used in the AER's average calculation.

55. In the AER's Draft Decision the vast majority SAPN's repex proposal was assessed using only a rudimentary historical average. This historical average fails to recognise the age profile of SAPN's assets, and the fact that the SAPN has a large cohort of relatively old assets that results in a bow wave of assets moving towards the end of their useful lives. The AER's simple averaging approach would produce the same repex allowance regardless of whether the existing network assets are all relatively new or approaching the end of their lives.

56. The National Electricity Rules (NER) prescribe a set of capital expenditure (capex) objectives that a DNSP's capex forecasts must satisfy. The capex objectives specify that the DNSP's forecasts must (amongst other objectives):[6]

    a. meet or manage the expected demand for standard control services over the regulatory control period;

    b. maintain the quality, reliability and security of supply of standard control services;

    c. maintain the reliability and security of the distribution system through the supply of standard control services; and

[4] The categories of modelled repex assessed by the AER were: underground cables, switchgear – unmodelled, service lines and overhead conductors.

[5] The categories of unmodelled repex assessed by the AER were: poles, pole top structures, SCADA and protection assets, Switchgear unmodelled – 66 kV Northfield Gas Insulated Switchboard and other repex.

[6] NER, Rule 6.5.7(a).

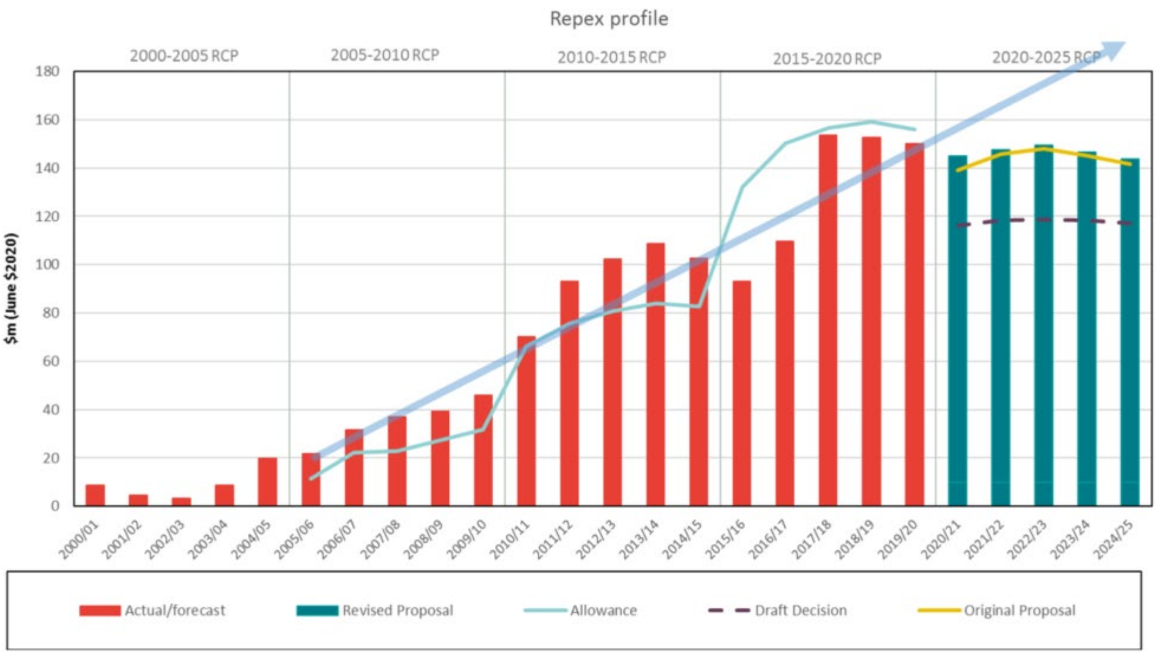
d. maintain the safety of the distribution system through the supply of standard control services.

57. Further, the NER requires that the AER must accept the forecast of required capex of a DNSP if it satisfies each of a set of expenditure criteria, including that the forecast capex is a realistic expectation of the demand forecast and cost inputs required to achieve the capital expenditure objectives.[7]

58. In this case, the AER has substituted SAPN's repex forecast with its own forecast. The vast majority of the AER's substitute repex forecast is based on simple historical averages that fail to account for the age profile of SAPN's assets. As such, the AER's substitute forecast fails to recognise the bow wave of assets that will require replacement as they age toward the end of their useful lives in order to maintain quality, reliability, security of supply and network safety. This raises questions about whether the AER's substitute repex forecast (which represents its Draft Decision on repex) satisfies the requirements of the NER.

59. We note that SAPN's proposed repex expenditure is materially lower than even an extrapolated trend would suggest. We understand that SAPN has been able to reduce its proposed repex expenditure below the levels of the last three years of the current regulatory period on the basis that investment in IT related systems and processes would enable SAPN to better identify high-consequence assets and achieve other bundling related efficiencies. This would enable SAPN to minimise repex expenditure while maintaining network reliability and safety levels.

Figure 13: **AER draft repex decision ($2019-20)**



Source: SAPN data.

[7] NER, Rule 6.5.7(c)(iii).

4.2 Unique circumstances of the current regulatory period

60. In November 2012, the Australian Energy Market Commission (AEMC) introduced major changes to the economic regulation of electricity distributors under chapter 6 of the NER. To allow consumers to receive the benefit of the new rules the AEMC made transitional rules under chapter 11 of the NER. In accordance with those transitional rules, the AER:[8]

   a. Made a Preliminary Decision for SAPN for the 2015-20 regulatory control period on 29 April 2015. This Preliminary Decision covered the period 1 July 2015 to 30 June 2016; and

   b. Revoked that Preliminary Decision in October 2015 and substituted it with a new determination that took effect at the date of revocation and applied for the remainder of the 2015-20 regulatory control period.

61. We understand from SAPN that it viewed the capex allowances provided by the AER for the first two years of the 2015-20 regulatory control period (i.e., 2015-16 and 2016-17) as uncertain, given the requirement on the AER to first make a preliminary decision and then subsequently revoke that decision. SAPN advised us that it managed this uncertainty by underspending its repex allowance materially in 2015-16 and 2016-17. We understand that other factors including extreme storm conditions and changes in the management and types of repairs being undertaken also contributed to this underspend. By contrast, actual and forecast repex in the remaining years of the 2015-20 regulatory control period are in line with the allowance provided by the AER. This can be seen clearly in **Figure 13**.

62. The AER has used SAPN's actual repex in 2015-16 and 2016-17 in order to establish the trend that is subsequently used to set most of the Draft Decision repex allowance for the 2020-25 regulatory control period. However, the circumstances relating to those two years appear to be anomalous, for the reasons described above.

63. Even if the AER were minded to apply simple historical averages to set repex allowances for the 2020-25 regulatory control period, it would be inappropriate to assign 40% weight to years that represent such anomalous repex outcomes.

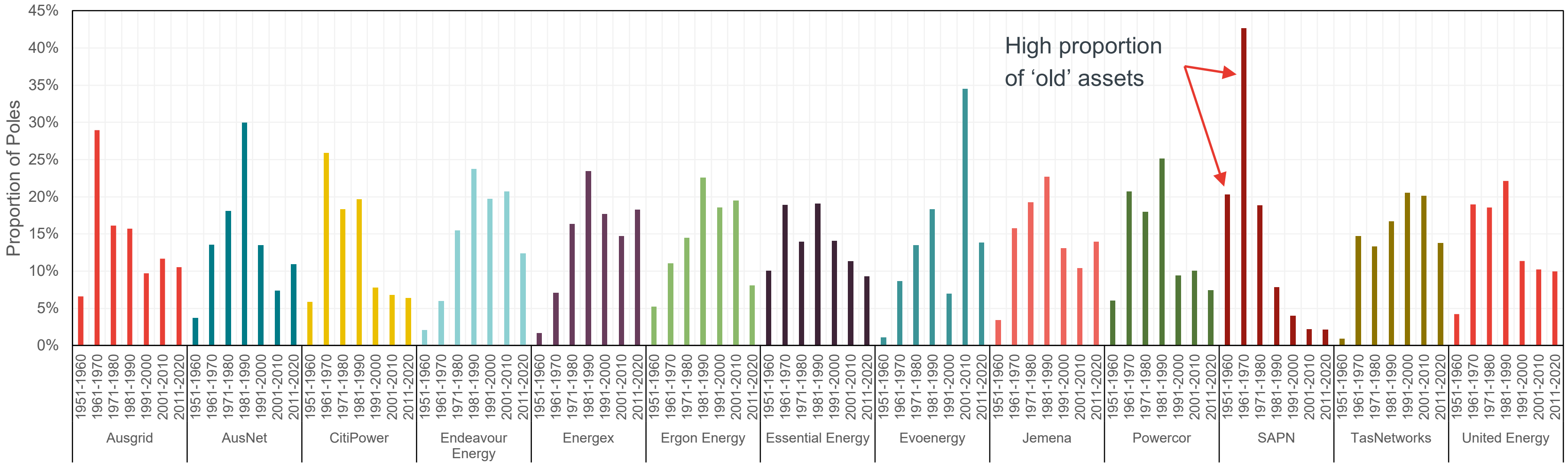
4.3 No recognition of the 'bow wave' of older assets requiring replacement

64. As explained above, a key weakness of the AER's use of simple trend analysis to set a very large proportion of SAPN's repex allowance is that such an approach fails to recognise that the age profile of is not uniform. That is, a very large proportion of SAPN's network was built within a very short period of time, between 60 to 70 years ago. The lumpiness of that investment creates a large bow wave of assets that will need to be replaced as they reach the end of their useful lives. The AER's trend analysis fails to recognise this bow wave effect.

65. **Figure 14** compares the age distribution of SAPN's poles against those of other DNSPs. This Figure shows that SAPN's pole assets are typically much older than that of other DNSPs. The majority of poles in the SAPN network were placed in the 1950s and 1960s. Other DNSPs have a much smaller proportion of poles that were placed that long ago. At the other end of the distribution, SAPN clearly has a materially lower proportion of poles placed during this century, compared with other DNSPs.

[8] SAPN Final Decision 2015-20, Overview, October 2015, p. 8.

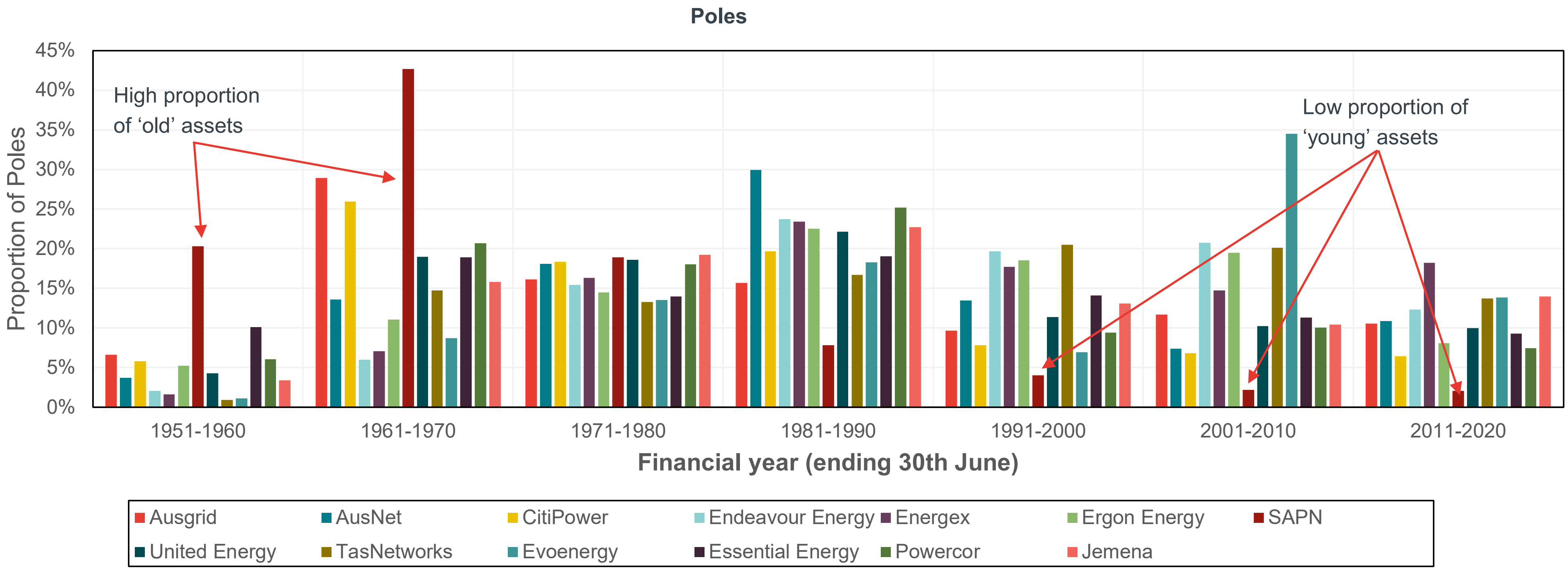
Figure 14: Age profile of pole assets by DNSP

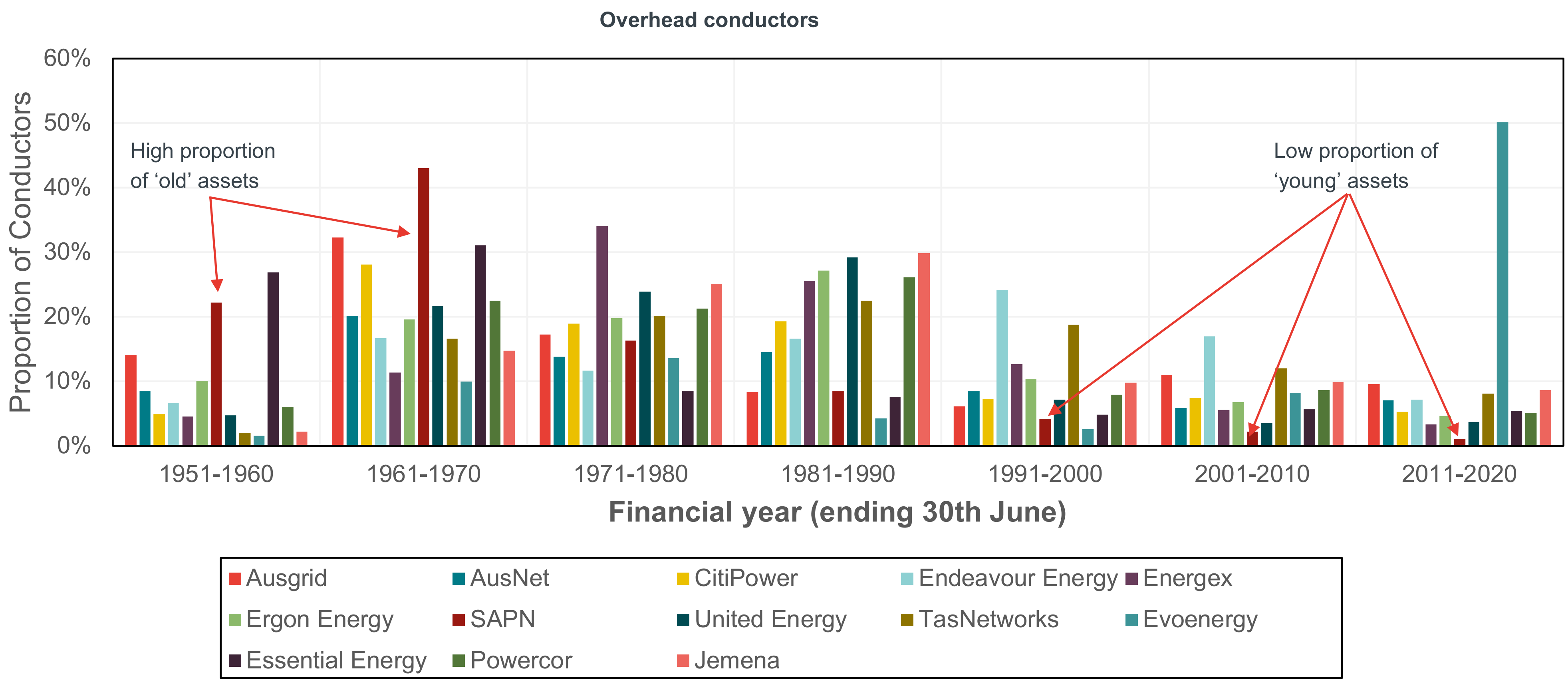


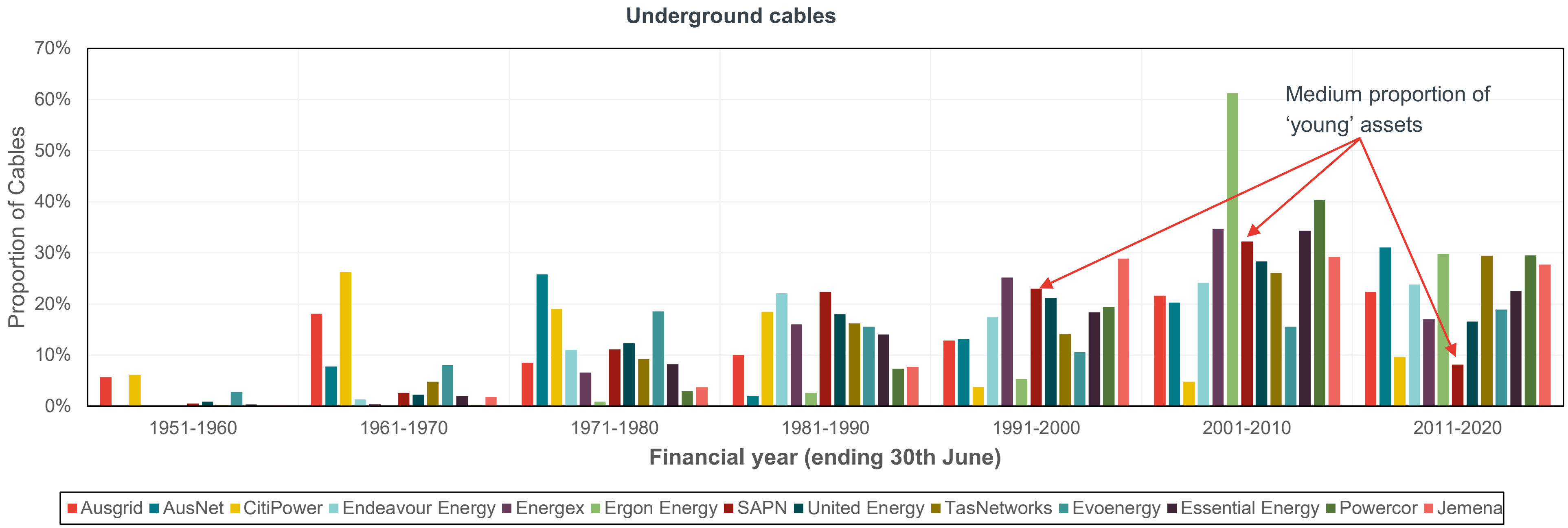
Source: Category Analysis RIN data; Frontier Economics analysis.

66. This age profile is not unique to SAPN’s poles. **Figure 15** below shows that SAPN has a similar age distribution in other asset classes, such as overhead conductors. SAPN has a relatively small proportion of ‘old’ underground cables compared to other DNSPs, while its proportions of ‘new’ underground cables are relatively similar to that of other DNSPs—reflecting the fact that it was only recently that most DNSPs undertook significant undergrounding. We note that according to the 2018 Economic Benchmarking RIN data, roughly only 20% of SAPN’s circuit length is underground.

Figure 15: Age profile of poles, overhead conductors and underground cables by DNSP




Overhead conductors
Proportion of Conductors
60%
50%
40%
30%
20%
10%
0%
High proportion of 'old' assets
Low proportion of 'young' assets
1951-1960
1961-1970
1971-1980
1981-1990
1991-2000
2001-2010
2011-2020
Financial year (ending 30th June)
Ausgrid
AusNet
CitiPower
Endeavour Energy
Energex
Ergon Energy
SAPN
United Energy
TasNetworks
Evoenergy
Essential Energy
Powercor
Jemena



Source: Category Analysis RIN data; Frontier Economics analysis.

5 COMPARISON WITH THE OFGEM APPROACH

5.1 Overview

67. Like the AER, Ofgem uses age-based repex modelling to assess DNSP repex proposals. However, there are a number of important differences between the AER's and Ofgem's use of age-based repex modelling, as has been highlighted in the Draft Decision:

   a. During the last set of price controls for electricity distribution businesses (RIIO-ED1), Ofgem used repex modelling to test, on average, about 80% of the repex proposed by DNSPs. This contrasts with the very low proportion—only 24%—of the repex proposed by SAPN that was tested by the AER;

   b. The AER has excluded several of SAPN's asset categories from its age-based repex model either because SAPN's assets are unique amongst DNSPs in Australia, or because the AER had insufficient information to populate its repex model. Ofgem faces these same information constraints when it assesses the repex proposals of DNSPs in the UK. However, Ofgem has found solutions to overcome these challenges. By contrast, rather than addressing those challenges as Ofgem has done, the AER has defaulted to the use of simple historical average that have produced unrealistic forecasts of repex for SAPN; and

   c. Ofgem takes considerable care to reflect the individual circumstances of individual DNSPs in its repex modelling. The AER's repex model has the capacity to do the same. However, because the AER has restricted the use of its repex model in SAPN's case, the AER's Draft Decision repex allowance does not properly reflect SAPN's particular circumstances—namely, the bow wave of assets moving through time due to the fact that the bulk of the SAPN network was built out during the 1950s and 1960s with assets that largely remain in place today.

68. We elaborate on these points below and conclude that the approach to assessing SAPN's repex forecasts could benefit from the adoption of some aspects of the approach followed by Ofgem.

5.2 The Ofgem approach

5.2.1 The proportion of assets included in the repex model

69. We understand that at RIIO-ED1, on average, Ofgem modelled approximately 80% of total repex allowances via its age-based repex model. This contrasts with the 24% that the AER has been able to model for SAPN.

5.2.2 Treatment of unique assets

70. We understand that the AER has not used is age-based repex model for several asset classes that the AER considered to be unique to SAPN. For example, the AER excluded from its repex

modelling SAPN's Stobie poles because such poles are only used in the South Australian network.[9]

71. Ofgem does not consider uniqueness to be a valid reason for eliminating an asset class from the age-based repex model. An age-based repex model requires estimates of the useful age of the asset and information about failure rates at certain ages and repex unit costs. This information can be obtained from engineering experts. Ofgem uses specialist engineering experts to fill such information gaps. For instance, in its RIIO-ED1 business plan expenditure assessment methodology document, Ofgem stated that:[10]

> *7.24. We understand that [age-based repex] modelling has limitations and will not fully take account of all relevant factors. Where a company has provided robust evidence to support higher numbers than suggested in the model, we have made adjustments. This work has been supported by our technical consultants, DNV KEMA, who have provided specialist knowledge to our team.*

72. In addition, SAPN has compiled data on the distribution of asset lives for each asset class, which we have used to undertake the modelling presented in this report. There is no reason why that the AER could not use these data, at least as a starting point, to calibrate its repex model. These data could be tested using specialist engineering advice if the AER did not wish to rely exclusively on data provided by DNSPs.

73. We understand that Ofgem does not use uniqueness of an asset class as a reason to eliminate assets from its age-based repex model. By way of one example, we understand that, within the UK grid, only Northern Powergrid Northeast (NPgN) has 20kV poles,[11] and that this unique asset class was included in Ofgem's repex model. That is, Ofgem conducted a process of compiling the required information so that the asset class could be included in its age-based repex model. The decision about whether or not to include an asset in Ofgem's repex model is not driven by uniqueness.

5.2.3 Reflection of circumstances of individual businesses

74. We understand that Ofgem makes an attempt to reflect individual businesses' circumstances in its modelling by using the business's historical replacement work and actual age of assets as inputs to the model. Consequently, if a business had stretched the lives of its existing stock of assets, and industry values for the mean and variance of asset lives are applied, the Ofgem model would flag that significant replacement work would be required, as a large volume of the particular business's assets would be towards the right-hand-side of the age distribution.

75. We understand that the AER's repex model is similar in this regard to the Ofgem model. For some of SAPN's asset classes, the AER has compiled the required age profile information and used its repex model to determine the regulatory allowance. However, for some major asset classes, the AER has not undertaken this exercise and instead used a very basic historical averaging approach to determine the allowance. As explained in Section 4, such an approach is, by its very nature, effectively independent of the particular age profile of the assets in question.

76. We are advised that, where the AER has performed an age-based analysis using its repex model that properly reflects the age of SAPN's network assets, the allowances produced by the AER's models broadly reflect SAPN's requirements. However, where the AER has

[9] SAPN Draft Decision, October 2019, Attachment 5, p. 48.

[10] Ofgem, RIIO-ED1 business plan expenditure assessment - methodology and results, 6 December 2013, p. 35.

[11] Northern Powergrid Appendices A and B for ENA Engineering Recommendation G81 - Part 1: Design and Planning, September 2013, version 2.0, p. 3.

bypassed its repex model and used a simple historical average instead, the allowances are materially below SAPN's requirements – because these allowances do not reflect the age profile of the SAPN network assets.

A INPUT ASSUMPTIONS AND STRUCTURE OF SIMPLE AGE-BASED MODEL

Poles

Input data

General structure of input data

77. The input data required to calibrate the model to the SAPN network is set out below. All references in square brackets are to cells in the Excel model that accompanies this report.

78. The input requirements for the model are as follows:

a. Current age profile of assets [J5:J28]. This consists of data on the proportion of assets in each 5-year age bracket. The source of this data is the SAPN asset register, which contains, amongst other information, an entry for every pole in the SAPN network.

b. Rectification rates for each age bracket [D6:D29]. This consists of data on the proportion of assets in each age bracket that are likely to require rectification over the following 5-year period. These figures have been derived to be consistent with the asset life distribution (characterised by the mean, standard deviation and maximum asset life set out in **Table 1**).

c. Refurbishment rates for each age bracket [E6:E29]. This consists of data for each age bracket on the proportion of all assets in that bracket that are rectified via refurbishment. For example, a figure of 40% would indicate that, of all assets in that age bracket that are identified for rectification (because they have been entered on the condition report) 40% are refurbished and 60% are indicated for replacement.

The refurbishment of a pole is considered to extend its life for 20 years (a figure identified by SAPN's experience with refurbishments), in which case it is moved into the appropriate younger age bracket.

d. Replacement allowance [E33]. This is an assumption about the proportion of SAPN's proposed repex that will be allowed by the AER. Our modelling varies this assumption to test the sensitivity of various output metrics to the level of the regulatory allowance.

e. Failure rate [E34]. This cell contains an assumption about the proportion of assets that are likely to fail during the next 5-year period among assets that have been identified as requiring replacement, but for which funding is not available under the regulatory allowance. That is, if an asset has been identified for replacement and no funding is available to make that replacement, what is the probability of it failing in situ during the next five years? This is based on SAPN's historical experience with in situ failures. The model begins with a baseline failure rate and then considers the additional failures expected to arise if the repex allowance is lower than what is required. Thus, if the regulatory repex allowance is set equal to the modelled repex requirement, the number of incremental in situ asset failures is, by definition, zero. For lower levels of the regulatory allowance, fewer assets will be replaced resulting in incremental in situ failures.

f. Cost of scheduled replacement [E35]. This cell represents the average dollar cost of an orderly 'scheduled' replacement of one of the assets in question. For example, for poles, the average dollar cost of replacement is $8,361, computed as the total estimated cost of replacing all poles in the network divided by the number of poles in the network.

g. Failure premium [E36]. This cell represents the ratio of the cost of replacing an asset after failure relative to the cost of an orderly replacement of such an asset. For example, for poles, the CBRM quantifies the average cost of a pole failure as $20,000 – representing the costs associated with network reliability and safety. Consequently, the cost of replacing a failed asset, relative to a scheduled replacement is (20,000 + 8,361) / 8361 = 3.4 times. A multiple of 3 times is adopted in our model as a conservative figure.

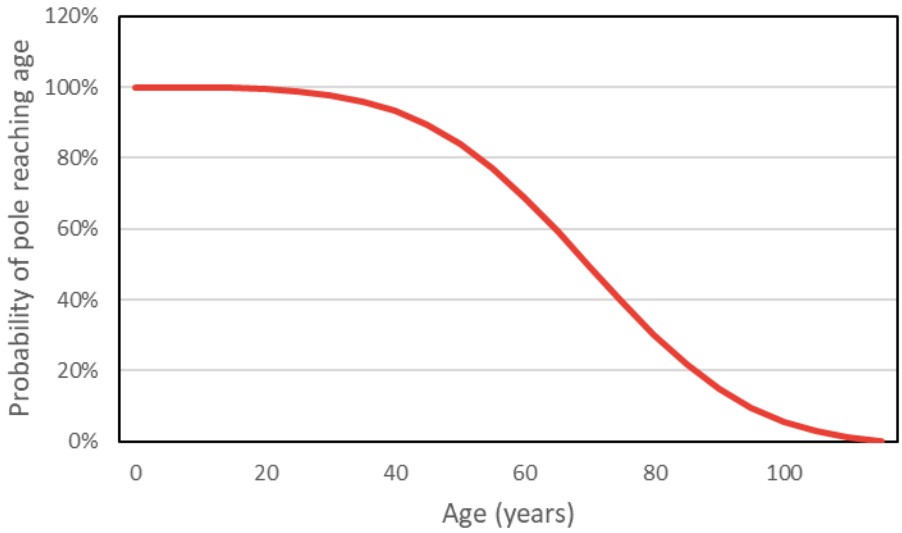
h. The number of assets in the class [E38]. This cell contains the total number of assets in the relevant class throughout the SAPN network.

Input data for poles

79. The current age profile for poles in the SAPN network is summarised in Figure 1 above.

80. The distribution of rectification rates has been derived so as to produce a distribution of asset lives as set out in **Figure 2** above. This implies the distribution of defect-free longevity (i.e., the probability that a pole will reach a certain age without registering a defect) as set out in **Figure 16** below.

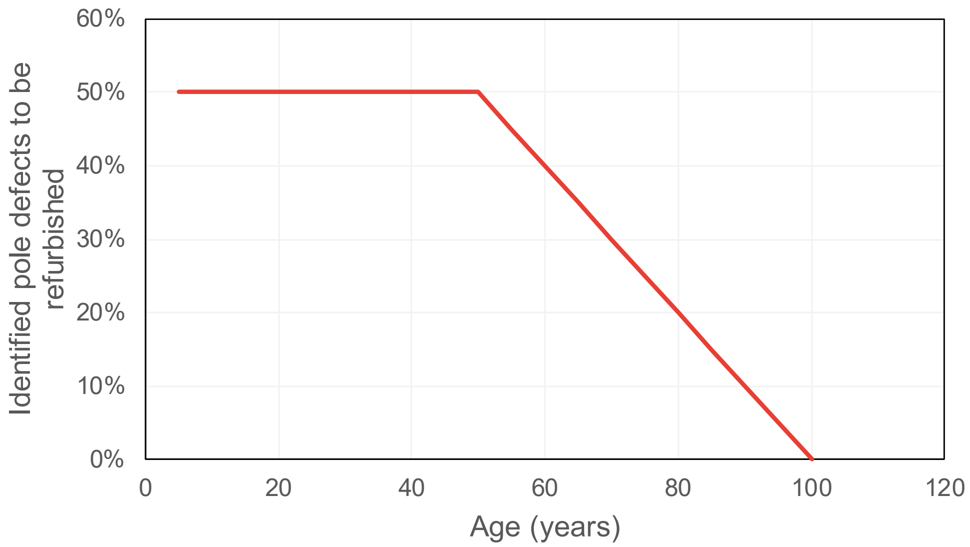
Figure 16: Probability of SAPN network pole reaching a certain age without being indicated for replacement



Source: SAPN data; Frontier Economics analysis.

81. The refurbishment rate that has been used in the modelling is set out **Figure 17** below. This Figure shows that, for poles 50 years of age or younger, half of the defects identified will result in a refurbishment (usually via reinforcement of the base of the pole to correct for ground-level corrosion) rather than a replacement. For older poles, it is often more economical to replace a defective pole rather than refurbish it, given its relatively shorter remaining life. The refurbishment rate in **Figure 17** below implies that 43.5% of all pole defects will be refurbished, which is broadly consistent with the 45% refurbishment rate in the two-year data period that forms the basis of our analysis.

Figure 17: **Proportion of identified pole defects that are refurbished**



Source: Frontier Economics analysis of SAPN data.

Structure of the model

82. The model is structured as a series of panels, whereby each panel performs some calculations and then feeds into the next. The progression of the analysis through each panel is as follows:

   a. Panel A [Rows 3-30]. The model begins with the current age distribution (i.e., at the beginning of the regulatory period) of assets in the particular asset class.

   b. Panel B [Rows 31:57]. Assets indicated for rectification are a function of the current age distribution (Panel A) and the distribution of the age of assets when indicated for rectification (Paragraph 78.b above).

   c. Panel C [Rows 58-84]. Assets indicated for refurbishment are a function of the current age distribution (Panel A) and the distribution of the proportion of assets that are refurbished when indicated for replacement (Paragraph 78.c above).

   d. Panel D [Rows 85-111]. Assets requiring replacement are all those indicated for rectification (Panel B) less those that are to be refurbished (Panel C).

   e. Panel E [Rows 112-138]. Allowed replacements are a function of the assets requiring replacement (Panel D) and the regulatory allowance (Paragraph 78.d above). Assets in the oldest age bracket (i.e., approach the end of their useful lives) are replaced first and any remaining budget is assigned pro rata to younger assets.

   f. Panel F [Rows 139-165]. Failures to be replaced are computed by assuming that any asset that is indicated as requiring replacement (Panel C) and which is not funded via the regulatory allowance (Panel D) will fail during the next 5-year period with probability set according to Paragraph 78.e above. Failed assets are assumed to go into the oldest age bracket to be 'first in line' (i.e., prioritised) for replacement during the next period.[12]

[12] In reality, failed assets would have to be replaced immediately even if that cost was outside the regulatory budget. Thus, it may be more realistic to model those failures as 'over-budget' expenditure in one regulatory period to be recovered in the next regulatory period. However, this would add considerable complexity to the model and would not assist in illustrating better the

83. Panel G [Rows 166-192]. The distribution at the end of the 5-year regulatory period is computed by starting with the opening distribution and rolling each asset forward one age class, adjusting for refurbishments, replacements, and failures as above.

Overhead conductors

Input data

General structure of input data

84. The general structure of the input data is generally the same as for the poles analysis.

85. The only difference is that refurbishment takes a different form. Whereas poles are refurbished by staking at ground level, conductors are patched. This involves replacing a section of the conductor (e.g., 1-3 metres in length) rather than an entire conductor span. For example, a 40% figure would indicate that, of all assets in that age bracket that are identified for rectification 40% are patched and 60% are indicated for replacement The patching of a conductor is considered to extend its life for 10 years (a figure identified by SAPN’s experience with patching), in which case it is moved into the appropriate younger age bracket.

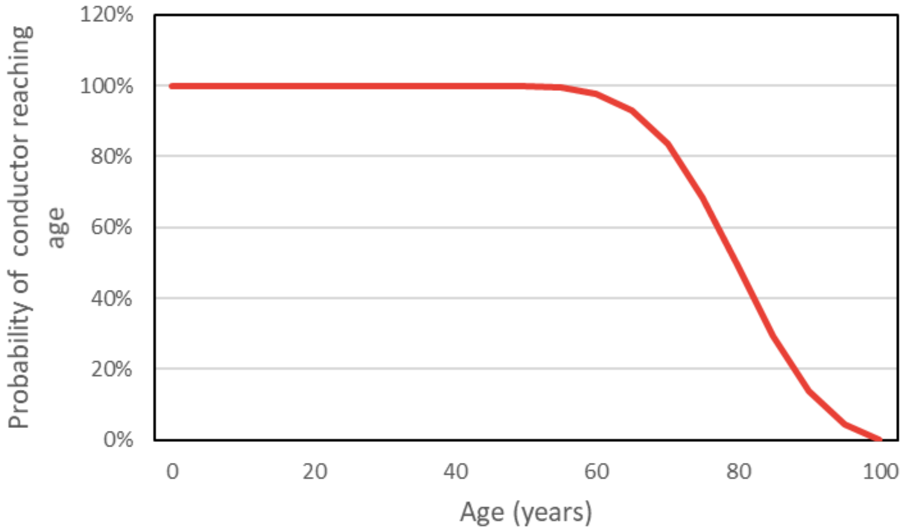
86. As for poles, the failure premium represents the ratio of the cost of replacing an asset after failure relative to the cost of an orderly replacement of such an asset. For example, for conductors, the average cost of a conductor failure is $20,900 per km – representing the costs associated with network reliability and safety. Consequently, the cost of replacing a failed asset, relative to a scheduled replacement is (20,900 + 12,000) / 20,900 = 1.6 times. A multiple of 1.5 times is adopted in our model as a conservative figure.

Input data for overhead conductors

87. The distribution of rectification rates has been derived so as to produce a distribution of asset lives as set out in **Figure 2** above. This implies the distribution of defect-free longevity (i.e., the probability that a conductor will reach a certain age without registering a defect) as set out in **Figure 18** below.

long-term effects of different levels of regulatory funding. Hence, we make the simplifying assumption that any replacement activity in the current period that is not funded through regulatory allowances is prioritised for replacement in the next period,

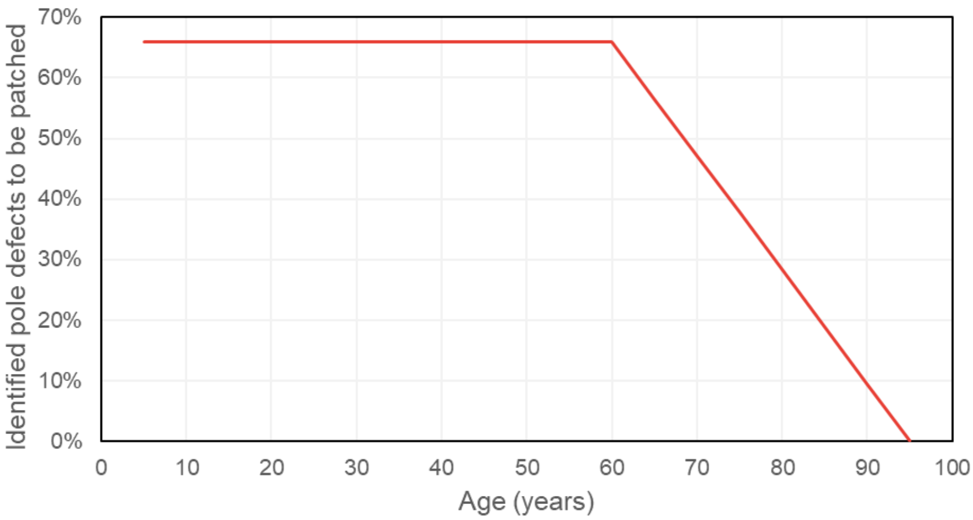
Figure 18: Probability of SAPN network conductor reaching a certain age without being indicated for replacement



Source: SAPN data; Frontier Economics analysis.

88. The patching rate that has been used in the modelling is set out Figure 19 below. This Figure shows that, for conductors 60 years of age or younger, 66% of the failures identified will result in patching rather than a replacement. Once a conductor has been patched twice, the next time it fails it is always replaced. This is the starting point for the patching rate, assuming that there is a 66% chance that any conductor will be patched for its next failure. For older conductors, it is often more economical to replace a defective conductor rather than patch it, given its relatively shorter remaining life.

Figure 19: **Proportion of identified conductor failures that are patched**



Source: Frontier Economics analysis of SAPN data.

Underground cables

Input data

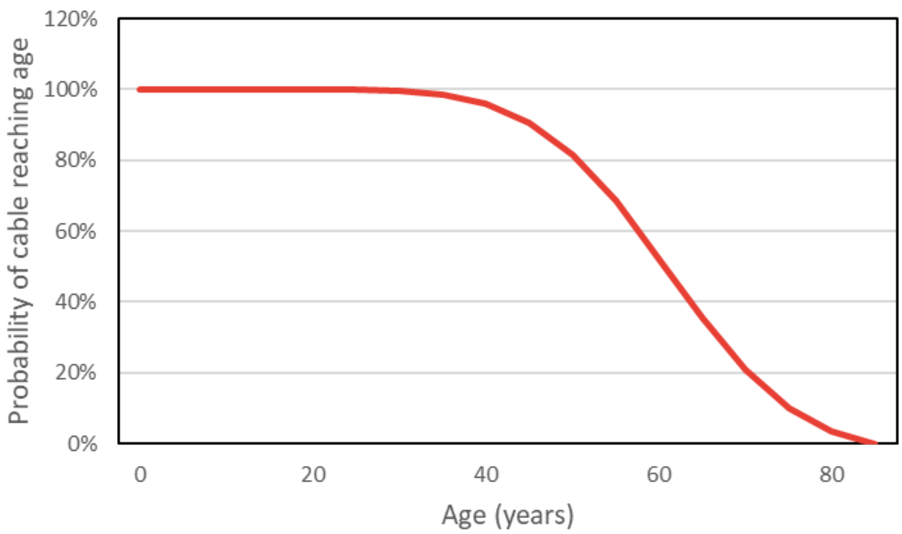
General structure of input data

89. The general structure of the input data for underground cables is the same as for overhead conductors, with all inputs having the same interpretation.

Input data for underground cables

90. The distribution of rectification rates has been derived so as to produce a distribution of asset lives as set out in **Figure 2** above. This implies the distribution of defect-free longevity (i.e., the probability that a cable will reach a certain age without registering a defect) as set out in **Figure 20** below.

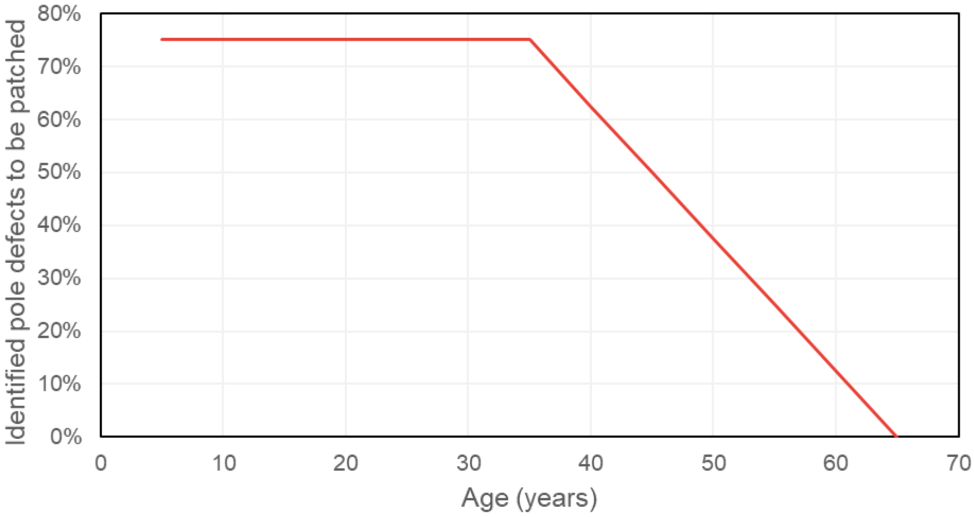
Figure 20: Probability of SAPN network cable reaching a certain age without being indicated for replacement



Source: SAPN data; Frontier Economics analysis.

91. The patching rate that has been used in the modelling is set out Figure 21 below. This Figure shows that, for conductors 35 years of age or younger, 75% of the failures identified will result in patching rather than a replacement. Once a conductor has been patched three times, the next time it fails it is always replaced. This is the starting point for the patching rate, assuming that there is a 75% chance that any cable will be patched for its next failure. For older cables, it is often more economical to replace a defective cable rather than patch it, given its relatively shorter remaining life.

Figure 21: **Proportion of identified cable failures that are patched**



Source: Frontier Economics analysis of SAPN data.

frontier economics

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