Regulatory Submission

ACTEWAGL DISTRIBUTION

Review of AER Draft Decision - REPEX

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Document history and status

Revision	Date	Description	By	Review	Approved
Draft	11/12/2014	Draft for client comment	C Jones	J Butler	
Final A	15/12/2014	Some client comments received. U/G cable replacement program still to be finalised.	C Jones	J Butler	S Hinchliffe
Final v.2	11/01/2015	Final client comments incorporated	C Jones	J Butler	S Hinchliffe
Final v.3	17/01/2015	Final edits. ActewAGL changed to ActewAGL Distribution	C Jones	J Butler	S Hinchliffe

Contents

Executive summary

Attachment 6, Section A3 of the AER's draft decision document outlines the AER's findings and estimates for ActewAGL's replacement capital expenditure.

The AER did not accept ActewAGL Distribution's forecast replacement capital expenditure of $132.3 million for the 2014 -19 regulatory period, and instead included an amount of $98.6 million, a reduction of $33.7 million (25.4%). This alternative amount was arrived at by reference to the following assessment techniques:

- Benchmarking at the expenditure category level and trend analysis of historical actual and expected REPEX
- Review of ActewAGL Distribution's major REPEX projects
- Predictive modelling of replacement expenditure requirements

Jacobs® has conducted a high level review of the reasons given by the AER for reducing ActewAGL Distribution's replacement capital expenditure forecast, and we have gathered additional information about the original justifications for projects and programs of work included in ActewAGL Distribution's REPEX forecast.

Based on the information we have gathered we would make the following key findings and observations:

1) The AER attempt in part to justify the decision to reduce REPEX on the basis of two graphs (Figs A8 & A9) which purport to show a correlation between the REPEX of a DNSP and customer density and demand density. Jacobs would suggest that no such correlation exists, and that these two factors are unrelated to the underlying drivers of REPEX. The AER then proceeds to misinterpret the graphs by saying that ActewAGL Distribution *"compares unfavourably under both density measures.",* whereas the opposite is the case.
2) The AER then refers to a graph (Fig. A10) which shows a relationship between the level of REPEX and the size of the asset base (RAB) of the DNSP. Jacobs agrees that there is a correlation between these factors, although with some qualifications. The AER then go on to misinterpret what the graph shows by saying *"…that ActewAGL Distribution has incurred average proportion of REPEX relative to the size of its RAB when compared with other service providers."* Jacobs' interpretation of the same graph is that ActewAGL Distribution's REPEX is materially below the average DNSP trend line by approximately 50%.
3) AER has accepted ActewAGL Distribution's pole replacement strategy, and consequent replacement expenditure forecast for this class of assets.
4) The AER was not satisfied that ActewAGL's proposed forecast REPEX for the overhead conductor and pole top structures categories of expenditure was sufficiently well justified. This category of expenditure was made up of three distinct programs of work, namely:
    - Rural pole top upgrade
    - Pole top hardware renewal/cross-arm replacement
    - Cast iron LV pothead replacement
5) This report provides further background information and justification for these different elements of replacement expenditure. Also included is an assessment of the potential risks and possible consequences should these programs not continue as planned.
6) Jacobs has thoroughly reviewed the ActewAGL Distribution Business Case and implementation strategy for the HV underground cable replacement program, and we endorse the strategy adopted by ActewAGL Distribution. The forecast of expenditure required for this program will be dependent on what is determined during the 'condition assessment' phase of the project.
7) Jacobs fundamentally disagrees with the AER's premise that the future requirement for sustainable long term replacement expenditure for a DNSP can be predicted by looking at recent past expenditure. Such an approach runs the risk of:
    - Failing to recognise where in the investment cycle each asset class sits, relative to the expected life of the asset class/type ie, whether the asset class has a relatively young average age relative to its life-

cycle, reflecting the period in time when it was introduced on the system, or whether it is a mature class of assets with a high average asset age, and an age profile or deteriorating asset condition / reliability, which requires increasing replacement expenditure

- Failing to respond to new and critical information about the ongoing serviceability and safety of certain asset classes. An example of this would be the findings and recommendations of the 2009 Victorian Bushfire Commission that certain types of equipment and components on overhead distributions lines can contribute to an increased risk of starting a bushfire
- Continuing to perpetuate an inadequate level of REPEX investment on the basis that *“if it was the level of investment that has been made in the recent past, it is therefore adequate for the immediate future”.* This simplistic approach fails to recognise that power systems in Australia will continue to age and deteriorate based on historical levels of REPEX (ActewAGL Distribution’s system has aged approximately 1.4 – 1.5 years in the past five years)

8) Jacobs has reviewed the various scenarios in the AER REPEX model and has found some material ‘data errors’ in certain fields, as well as some erroneous outcomes which appear to be generated by the flawed logic of the model. These are summarised in sections 6 of this report, and are covered in greater detail in the Jacobs report *“Focussed Critique of AER’s REPEX – Calibrated Model”*

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to provide input into ActewAGL Distribution's 2014-19 Regulatory Proposal in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Client (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report.

Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

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1. Introduction

Attachment 6, Section A3 of the AER's draft decision outlines the analysis undertaken and reasons given for AER's decision to reduce ActewAGL Distribution's Replacement/Refurbishment Expenditure (REPEX) by $33.7 million (approximately 25.4%) over the 2014/15 – 2018/19 regulatory period.

This document reviews the reasons and justifications for AER's reductions and provides additional information about certain REPEX programs (underground cable replacement, overhead conductors, and pole top structures).

We also comment on the AER REPEX benchmarking undertaken in the draft decision, and provide a comparison of unit rate costs and average asset lives in ActewAGL Distribution's asset management system (RIVA), versus those used in the AER REPEX forecasting model (calibrated version).

2. High level AER findings

The high level AER findings in regard to ActewAGL Distribution's proposed REPEX forecast are that:

- The proposed REPEX forecast exceeds its long term average and ActewAGL Distribution has not provided supporting evidence for the increase
- ActewAGL Distribution's historical REPEX does not compare favourably to that of other service providers in the NEM and appears high
- Measures of 'asset health' suggest that ActewAGL Distribution has not demonstrated that the likely condition of its assets supports its proposed forecast REPEX
- AER's review of ActewAGL Distribution's major REPEX programs identified that ActewAGL Distribution's proposal may overstate the prudent and efficient amount required to meet the capex objectives for certain asset categories. AER specifically queried the REPEX forecasts for underground cable, overhead conductors and pole top replacement programs
- AER's predictive modelling suggests that ActewAGL Distribution's proposal is likely to be overstated. The range of reasonable results based on AER's modelling is between a 5% and 28% reduction of ActewAGL Distribution's proposed REPEX for modelled asset categories
- For categories that were not included in the predictive modelling, AER were satisfied that $22.5 million was likely to be prudent and efficient expenditure

3. Lack of information in the SRP

Jacobs considers that not all possible available information was included in the SRP and attachments, and that perhaps the AER has formed its conclusions without seeing all the background information and working documents.

This paucity of information was also compounded by the AER's decision to not have the AER's technical consultants visit ActewAGL Distribution in person, which would have enabled them to ask questions and seek out further documentation. Often asset policy and strategy documents (which have been supplied in the formal submission documents) can be further supported by reference to other historical data; alternative options analysis and working spreadsheet calculations.

4. Relationship between total REPEX and network scale[1]

This section of the AER draft decision displays a lack of understanding of the fundamental drivers of REPEX in any DNSP. The fundamental drivers of REPEX are:

- The volumes and types of assets on the system
- The overall age profile of the system assets as a whole
- The overall condition and serviceability of the assets on the system, and any specific deficiencies in individual asset classes
- The estimated unit replacement cost of assets that have reached the end of their economic service life

Figures A-8 and A-9[2] and the associated commentary suggests that there is some relationship between the magnitude of REPEX for individual DNSPs and the customer density (customer/km line), as well as the capacity density (installed capacity/route line length). Such a proposition displays a lack of understanding of the nature of the REPEX drivers listed above.

In addition, the interpretation of what the graphs mean, even by the author of this section of the draft decision, is illogical. Commentary under figure A-9 states *“ActewAGL compares unfavourably under both density measures. Further, these measures suggest that predominantly rural based networks incur higher REPEX than urbanised networks.”*

Clearly ActewAGL Distribution has the lowest level of REPEX of all DNSPs in Australia, as reflected on both graph’s A-8 and A-9. How then does the author conclude that ActewAGL Distribution compares unfavourably under both density measures?

Ausgrid is the largest urban distributor on Australia, but has been excluded as an outlier; otherwise it would have demonstrated that *“…rural based networks incur higher REPEX than urbanised networks.”* was an invalid conclusion.

Jacobs agrees, in part, with the proposition that *“…the size of a service provider’s regulatory asset base (RAB) will affect the amount of REPEX it incurs.”*

We qualify this observation however by pointing out that RAB is not a ‘perfect’ denominator to use in cross DNSP comparison because:

- The RAB’s of Australian DNSPs were established at different points in time using different unit rate costs, and using asset quantity data that was not always accurate
- As a particular DNSPs network continues to age, the RAB of existing assets will decline (ignoring new assets added), due to additional depreciation. This will cause the DNSP’s REPEX/RAB ratio to increase and fall above the average REPEX / RAB trend line (making it appear to be inefficient in respect of REPEX). In fact it is an indicator that the ageing system requires more REPEX (not less) to control the deteriorating age profile and declining asset condition.

Nevertheless, we accept the general relevance of the information shown in figure A-10; however we disagree with the commentary.

> *“Whilst we acknowledge the limitations outlined above, this measure indicates that ActewAGL Distribution has incurred average proportion of REPEX relative to the size of its RAB when compared with other service providers.”* (p6-50)

[1] AER 2014, *Draft Decision ActewAGL Distribution Determination: ActewAGL Distribution Determination:* Attachment 6, p6-47
[2] AER 2014, *Draft Decision ActewAGL Distribution Determination: ActewAGL Distribution Determination:* Attachment 6, pp6-48 & 49

Any reasonable person's interpretation of figure A-10 would be that:

- ActewAGL Distribution shows the lowest level of REPEX spend of any DNSP over the period 2008-13
- ActewAGL Distribution's REPEX over the period 2008-13 is well below the industry average trend line by about 50%

5. ActewAGL response for supporting information

5.1 Pole replacement programme

We note that the AER has accepted ActewAGL Distribution's pole replacement strategy and forecast expenditure.

We also offer the following clarifying comments on a number of points raised in the AER's draft decision document:

- We note AER's comments that: "ActewAGL Distribution reported its staked wooden poles twice in its asset age profile; once as "staking of a wooden pole" and a second time under one of the six wooden pole categories"[3]
- We can confirm that this reporting of staked poles in the RIN spreadsheets is not repeated in the RIVA data used to produce ActewAGL Distribution's proposed forecast for pole replacements. There is no 'double-counting' of staked poles in ActewAGL Distribution's REPEX forecast
- We also note AER's comment that "ActewAGL Distribution appears to have installed virtually all its non-wood poles (concrete, stobie, fibre-glass and steel) within the last 40 years" [4]
- While this may be correct for the other categories, it is not correct for the stobie poles which were all installed prior to 1955
- Further, we note AER's comment that "Typically, we observe that wooden poles are the least expensive type of pole for use in low voltage applications. ActewAGL Distribution's fibreglass pole unit cost is higher than the unit cost that a benchmark average service provider would typically pay for a wooden pole"[5]
- While these may be correct statements for roadside LV poles, and based on initial installed costs or replacement unit costs, it is ActewAGL's experience that they are not true for rear-of-block LV reticulation
- ActewAGL has previously undertaken a life cycle cost benefit analysis of wood versus fibreglass poles in rear-of-block applications, and has found that when taking account of whole of life costs over the average life of wood poles (both staked and un-staked), and the expected average life of fibre-glass poles, fibre glass poles have a lower initial installed cost as well as a lower lifecycle cost. The results of these studies have been provided previously to the AER.

In summary, Jacobs is confident that the REPEX included for the pole replacement programme for 2014-2019 represents prudent and efficient capital expenditure.

5.2 Overhead conductors and pole top structures

We note that AER are not satisfied that ActewAGL Distribution's proposed forecast REPEX for the overhead conductor and pole top structure assets reflects the capex criteria.[6]

Jacobs understands that ActewAGL Distribution is committed to continuing the three key elements of the overhead conductor and pole-top replacement/refurbishment programs, the justifications for which are described in further detail below.

5.2.1 Rural pole top upgrade

ActewAGL Distribution's rural pole top upgrade program was initiated in 2009 to replace deteriorating cross-arms and pole top hardware, and to install vibration dampers, armour rods, and preformed distribution ties on all rural high voltage overhead lines located in high bushfire risk areas.

[3] AER 2014, *Draft Decision ActewAGL Distribution Determination: ActewAGL Distribution Determination:* Attachment 6, p6-101
[4] AER 2014, *Draft Decision ActewAGL Distribution Determination: ActewAGL Distribution Determination:* Attachment 6, p6-55
[5] AER 2014, *Draft Decision ActewAGL Distribution Determination: ActewAGL Distribution Determination:* Attachment 6, p6-55
[6] AER 2014, *Draft Decision ActewAGL Distribution Determination: ActewAGL Distribution Determination:* Attachment 6, p6-57

This program of work was triggered following the experience of other Australian power utilities where hand ties and conductor failures have started bushfires.

One of the outcomes emerging from the 2009 Victorian Bushfire Commission was the adoption of vibration dampers on all long rural overhead spans of 300 meters or longer.

Upgrading the pole-top fittings and replacing deteriorated cross-arms, porcelain silicon carbide surge arresters, installing vibration dampers, armour rods, and preformed distribution ties will significantly reduce the risk of bushfires starting from the ActewAGL Distribution overhead system in high risk rural areas.

Since 2009, the amount of completed works under the rural pole top upgrade program is:

- Reid feeder from Tidbinbilla Road to the end of the feeder at Corin Dam – 20 km (part only)
- Cotter 22 kV feeder –11.2 km
- Tidbinbilla 22 kV feeder spur section to NASA complex – 6 km (part only)
- Cotter 11 kV feeder to REC3911. – 25 km (part only)

Total feeder length of 62.2 km

ActewAGL Distribution has identified the following rural feeders as a high priority for replacement during the 2014-19 period:

- The remainder of the Cotter 11 kV feeder – 18.1 km
- Mackenzie feeder – 27.3 km
- Lower Molonglo East and West feeder – 12.4 km
- Homann feeder –21.3 km
- Black Mountain feeder – 33.4 km

Total feeder length of 112.5 km.

The photographs shown below provide recent examples of the deteriorated condition of pole tops on those sections of the feeders proposed as a high priority for replacement in the 2014-19 period.

Figure 1 March 2014 – Low voltage pole off Cotter 11 kV feeder

Figure 2 December 2014 – Low voltage pole off Cotter 11 kV feeder

Risk and consequence assessment:

As a consequence of the recommendations out of the 2009 Victorian Bushfire Commission, and the experiences of other DNSP's operating distribution systems in bushfire areas, ActewAGL Distribution has previously carried out an assessment of the risks of similar events occurring in its own high bushfire risk areas.

Jacobs understands that ActewAGL Distribution found that the design and construction of many parts of its overhead distribution system suffered from the same deficiencies that were identified by the Victorian Bushfire Commission: ie, a lack of vibration dampers, armour rods and preformed ties, in addition to the usual maintenance problems associated with wooden cross-arms, corrosion of king-bolts and other hardware, and the historical use of porcelain silicon carbide surge arrestors which have a track record of exploding when they fail.

Having recognised the risk of such design and construction deficiencies, as well as the normal maintenance/refurbishment requirements, ActewAGL Distribution took the prudent risk management approach of establishing a targeted refurbishment upgrade program, starting with the highest risk areas. If ActewAGL Distribution were to now fail to complete the program as planned, it is possible that they could be considered culpable in the event that the overhead assets on any of the five (5) feeders concerned were to start a bushfire.

Based on a study of the 2003 Canberra bushfire outcomes, and as an indication of the possible consequences of such an event, the following is a list of risk premiums associated with bushfire risks of different severities:

- $660 million for a severe bushfire
- $528 million for a major bushfire
- $396 million for a moderate bushfire
- $264 million for a minor bushfire

5.2.2 Pole top hardware renewal/cross-arm replacement

In addition to cross-arms and pole top hardware in the high bushfire risk areas, ActewAGL Distribution carries out regular ground based surveys, and some aerial surveys to determine the condition and serviceability of cross-arms and pole top hardware in non-bushfire rural and urban areas.

Most pole top hardware requires renewal/refurbishment at least once or twice during the normal asset lifetime of the pole on which it is mounted. Only those pole-tops that are assessed as being in such a poor condition, that they are unlikely to remain in a safe state during the next routine inspection interval, are replaced. If the pole itself is assessed for replacement, then the pole top assembly is also replaced, and would appear under the pole replacement expenditure forecast.

Where the pole remains in good condition and also meets other criterion (such as good accessibility, no black king bolt installed, or split pole head, etc), the deteriorated cross-arm is scheduled for replacement under the condition based cross-arm replacement program.

By analysing the historical completed work program, the number of future cross-arm replacements can be estimated. The table below shows the number of cross-arms replaced over the past five years.

Table 1 Condition based cross-arm replacement completed between FY08/09 to FY12/13

Work Task Type and Expenditure Type	Number of cross-arms replaced in the Financial Year					
	08/09	09/10	10/11	11/12	12/13	Five Year Total
Replace Cross-arm (Unplanned) OPEX Total	203	192	139	148	118	800
Replace Cross-arm (Unplanned) CAPEX Total	15	34	72	98	4	223
Total	218	226	211	246	122	1023

Although the number of completed condition based cross-arm replacements decreased in FY12/13, there were approximately 103 cross-arm replacements which were scheduled in FY12/13 but were not completed in that financial year. These overdue cross-arm replacements were completed in FY13/14.

The average number of condition based cross-arm replacements each year is 225 (800 OPEX +223 CAPEX + 103 overdue over five years = 225 condition based cross-arms replacements per year).

It is forecast that in the next five years, $1.1 million is required every year for unplanned cross-arm replacement.

Historically, the majority of condition based cross-arm replacements were carried out under OPEX. However, all cross-arm replacement should be part of CAPEX, as it is considered as an asset renewal expenditure. As a result, there should be an increase of $1.1 million in CAPEX, and a reduction of $1.1 million OPEX per year in ‘Overhead conductors and pole top hardware’. It should be noted that ActewAGL Distribution are not proposing any increase in asset replacement quantities or unit rate costs for this category of work.

Jacobs has reviewed ActewAGL Distribution’s pole-top assembly replacement / refurbishment program and considers it to be efficient and prudent.

Risk and consequence assessment:

The failure of pole top hardware and cross-arms is probably the most common form of failure on the overhead distribution system, and it often causes the overhead conductors to sag excessively, or fall to the ground. The risk to public and worker safety is significant in such an event. Depending on the circumstances, the consequences can vary from “minimal” to a worker or public fatality.

This program is required to ensure the ongoing safety and serviceability of the overhead distribution system, and should be retained unchanged.

5.2.3 Cast iron LV pothead replacement

ActewAGL Distribution has approximately 500 LV cast iron potheads that were installed on the LV system during the 1970's. The majority of them are located in residential back yards, or other highly populated areas such as schools and pedestrian areas, etc. The low voltage cast iron pothead replacement program is a necessary expenditure to reduce the safety risk to workers and the public.

There have been several cases where the low voltage cast iron pothead has failed and exploded. In early 2014, shrapnel debris from a low voltage cast iron pothead explosion caused a near miss to an ActewAGL Distribution linesman, who was working in the vicinity.

The explosive failure of these potheads is caused when pitch inside the pothead leaches out over time. As a result, the live internal terminal is exposed, and moisture and oxygen build up in the gaps. The lack of effective insulation causes a fault, and the fault energy causes the cast iron to explode.

The photographs below show a cast iron LV pothead in service, and the remnants of one that has suffered an explosive failure.

Figure 3 Typical cast iron LV pothead

Figure 4 and Figure 5 Damage caused by explosive failure of cast iron LV pothead:

Several options to manage this cast iron pothead failure risk were investigated.

The options that were considered included:

Option 1:

Do nothing; continue with opportunistic replacement basis and accept the risk of failure which could potentially cause a human fatality. This option is unacceptable.

The probability of failure is on average, two per year. The safety consequence can be severe.

The majority of the cast iron potheads on the ActewAGL Distribution network are located in public areas. While they are mostly located in customer backyards, some are located near schools and high use pedestrian areas.

Option 2: Condition based replacement program

This option involves initiating a dedicated inspection program to assess the condition of the low voltage cast iron pothead, and having a condition based replacement program.

In order for the condition based replacement to be effective:

1) An inspection or condition assessment technique must be available to consistently predict imminent failures.
2) An inspection or condition assessment technique is ‘conveniently’ measurable or observable
3) There must be sufficient lead time (warning time) to allow for the planned replacement.
4) The probability of failure can be kept to an acceptable level.

After consideration of all practical aspects of this option, it was resolved that there is currently no established condition assessment technique to effectively detect imminent failures.

Option 3: Completely phase out from the network (Replacement program)

Option 3A: Age based replacement program. Initiate a replacement program to replace all low voltage cast iron potheads.

The aim is to completely phase out all low voltage cast iron potheads @ 50 per year over the next 10 years.

- 25 will be replaced on **age** based priority basis every year.
- 25 will be replaced on an opportunity basis every year
- The replacement priority will be given to the oldest potheads.
- The average cost of this replacement program is $103,000 per year for the next ten years.

Option 3B: Prioritised risk based replacement program. Initiate a replacement program to replace all low voltage cast iron potheads on a risk priority basis.

The aim is to completely phase out all low voltage cast iron potheads @ 50 per year over the next 10 years.

- 25 units will be replaced on a **risk** based priority basis every year
- 25 units will be replaced on an opportunity basis every year
- The replacement priority will be given to potheads located near schools and high pedestrian areas
- Average cost of this replacement program is $103k per year for the next ten years

Option 3B is the recommended option and it is planned to completely replace and remove all types of outdoor low voltage cast iron potheads located in public places.

Risk and consequence assessment:

Although the average failure rate of two per year is not high, each failure presents a significant safety risk to ActewAGL workers and the public. The close proximity of the potheads to the public, and the explosive nature of failures imposes an unacceptably high risk, with serious consequences.

5.3 HV underground cables

Jacobs note that the AER is not satisfied that ActewAGL Distribution's proposed forecast REPEX for underground cables reasonably reflects the capex criteria.

This section of the report specifically addresses the following paragraphs of the AER's draft decision document which question the derivation of fault rate trends in underground cables:

> *"ActewAGL Distribution reports that HV underground cable replacements have increased in the period between 2008 and 2013. We observe that the number of faults during the 2009–14 period varied modestly upwards and downwards from year to year, with the average number of faults around 29 per year. ActewAGL has provided a high and low estimate of the number of number of faults forecast for the 2014–19 period. The low estimate is an average of 27 faults per year, and the high estimate an average of 44 faults per year. At best the number of failures will be similar to the 2009–14 period and at worst will increase by one and a half times. ActewAGL Distribution did not provide any further information to indicate its expectations within the range of estimates. We do not consider this information supports an increase in failures in the 2014–19 period compared to the 2009–14 regulatory control period.*
>
> *Further, ActewAGL Distribution has not explained the methodology it applied to derive the forecast rates. ActewAGL appears to have derived the upward trend in failures by applying trend lines to extrapolate future failure rates per kilometre. ActewAGL then appears to have applied these failure rates to its forecast of underground cable length for each year of the 2014-19 period to arrive at a forecast of total underground cable failures in that period. This assumption would predict failures in newly laid cables as well as older cables. We are not satisfied this is a reasonable method of forecasting failure rates. This is because it assumes that a portion of newer assets will fail in proportion to an observed trend in the network."*[7]

[7] AER 2014, *Draft Decision ActewAGL Distribution Determination: ActewAGL Distribution Determination:* Attachment 6, p6-56

ActewAGL Distribution fault rate forecast methodology:

The ActewAGL Distribution methodology for forecasting high voltage underground cable faults is as follows:

- Sample data used is the actual number of underground high voltage cable faults each calendar year from 2002 to 2013 (inclusive). Note that during this period; some old cables were replaced with new, which tends to reduce the fault rate in the sample data, making the model conservative
- Regression analysis was used to determine curves of best fit, one linear, one polynomial
- The curves were used to forecast the expected number of faults per annum. The linear curve formed the lower estimate, the polynomial formed the upper estimate
- The forecast fault rates were then used to determine the expected maintenance costs
- Fault rates will NOT be influenced by repairs to old cables, based on the repair to 'bad as old' asset management analysis on patching aging systems
- Fault rates WILL be influenced by new cables REPLACING old cables in the future. The level of influence will be calculated by pro rata of (km of old cable – km of new cable)/(km of old cable)

Operational experience with cable faults:

It has been ActewAGL Distribution's practice in the past, to run the underground cables to failure. In the past, cable repairs have generally been limited to the removal of faulted sections. Over the previous five years, reactive repairs and replacements have been increasing rapidly.

Most repair work has been on the cable joint or termination, and an increasing number of underground cables are reaching the end of their life. This was especially observed in cables installed in 1943 in the suburbs of Griffith and Kingston, where the steel armour tape and the lead metallic sheath of the cable showed signs of corrosion during cable repairs.

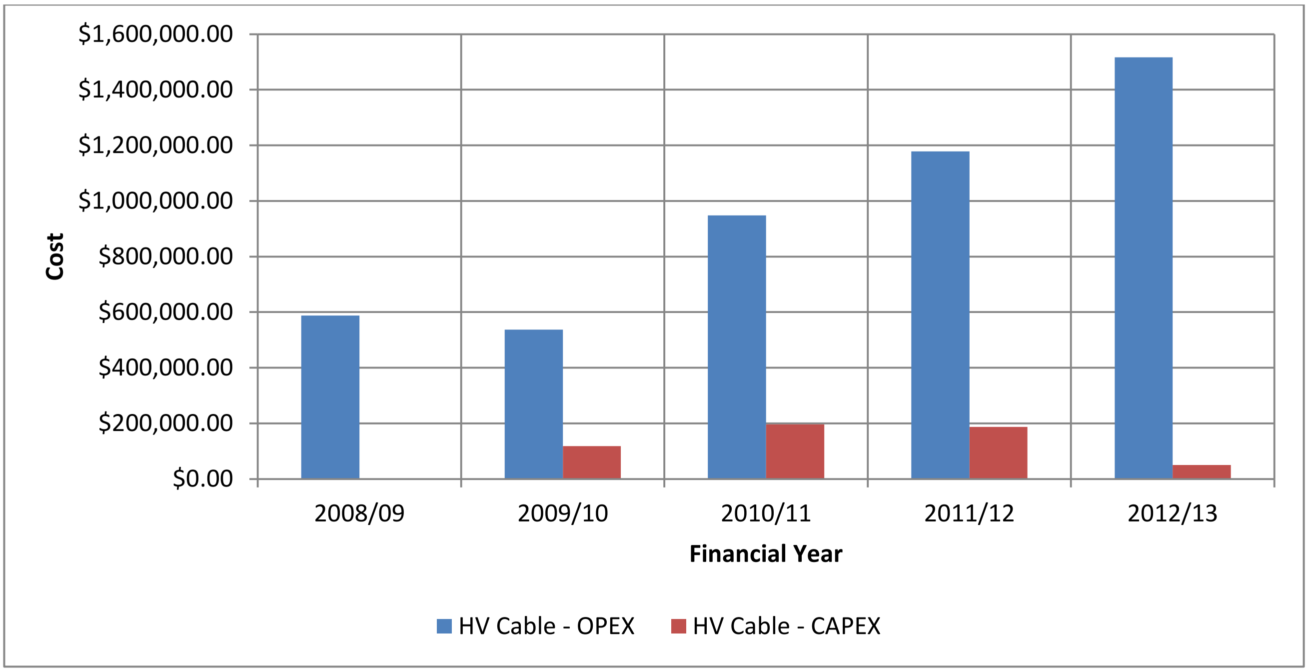
Once the metallic sheath is compromised, moisture ingress into the cable will eventually lead to failure.

ActewAGL Distribution's condition assessment and fault analysis to date has revealed that most fault repair work in the past has been done on cable terminations and cable joints, but there is now an increasing number of failures associated with the degradation of the cable insulation and protective sheathing itself.

In addition, it is noted that 15% of all HV cable currently exceeds the average asset life of 50 years, and this will increase to 26% over the next 10 years.

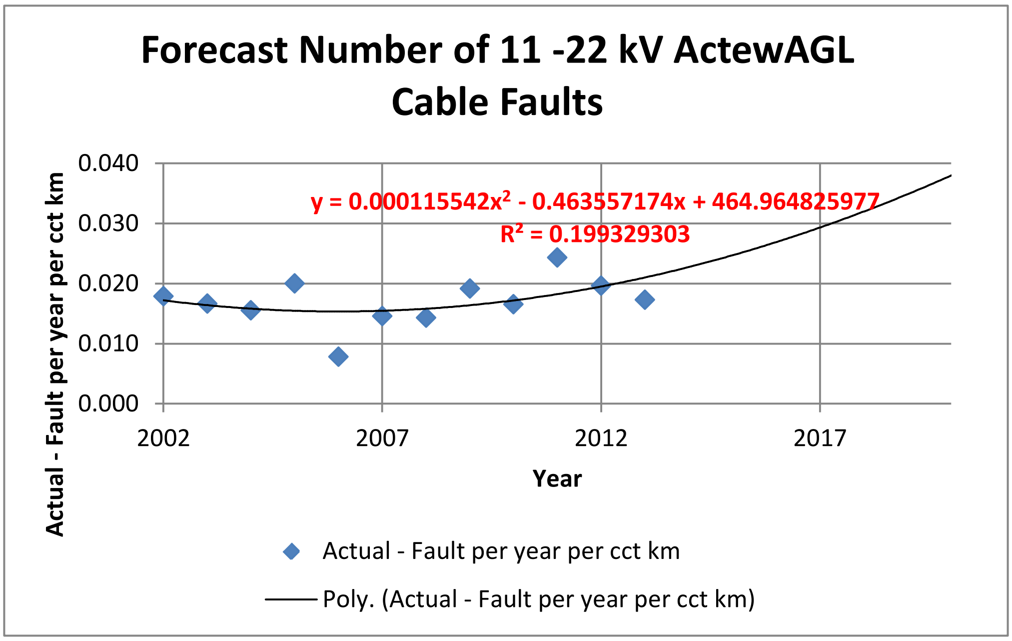
There is evidence that the underlying level of the reactive maintenance costs of underground cables is increasing rapidly as shown in the figure below.

Figure 6 Historical underground cable reactive maintenance costs



This increasing trend in reactive maintenance costs on underground cables is supported by ActewAGL Distribution's statistical analysis of the trend in underground cable faults (2002 – 2013), as shown in the figure below.

Figure 7 ActewAGL Distribution Analysis of HV Cable Fault Rate



ActewAGL Distribution business case for addressing increasing cable failure rate:

ActewAGL Distribution undertook an initial cable replacement trial on the Yamba 11 kV feeder, which supplies the Canberra hospital, and was one of the worst performing feeders on the distribution network. The feeder was 48 years old, contained multiple cable joints over its 3.7 km length, and had suffered a total of 10 faults over an 11 year period. This represents a fault rate in excess of 10 times the ActewAGL Distribution average.

From the experience gained with this initial trial replacement, and the knowledge gained from the cable condition in the vicinity of the joints, ActewAGL Distribution then developed a sound business case based on the analysis of three options:

- **Option 1** – maintain the existing run to failure strategy, and accept the increasing reactive maintenance costs;
- **Option 2** – Replace all underground paper insulated cables over 60 years of age, and all XLPE cables over 50 years of age; and
- **Option 3** – Initiate condition monitoring of underground cables based on historical performance, and prioritise sections for replacement based on cable condition.

Based on a cost/benefit analysis undertaken of the three options, ActewAGL has decided to implement the condition monitoring strategy under Option 3, which Jacobs considers to be the most prudent and efficient strategy, and totally consistent with ActewAGL Distribution's asset management philosophy.

It should be noted however that only after commencing and obtaining some initial results from the 'condition monitoring' phase of the program will it be possible to make accurate forecasts of future cable replacement requirements.

The ActewAGL Distribution business case for the condition monitoring and cable replacement program is attached as Appendix 1, and the section of the Jacobs report *"Capex/Opex trade-off issues"* dealing with the case study on underground distribution cable replacement cable replacement is attached as Appendix 2.

Asset age profile of ActewAGL Distribution's underground cable population:

In the draft decision document the AER also made the following observation about the age profile of ActewAGL Distribution's underground cable system:

> *"Finally, the asset age profile of ActewAGL Distribution's underground cable population does not appear to support the proposed increase in expenditure. ActewAGL Distribution considers its HV underground cables have an average service life of 50 years. We discuss the magnitude of ActewAGL Distribution's economic lives further in the section on predictive modelling. Notwithstanding this, the majority (72 per cent) of ActewAGL Distribution's high voltage underground cables are reported as younger than 40 years"*[8]

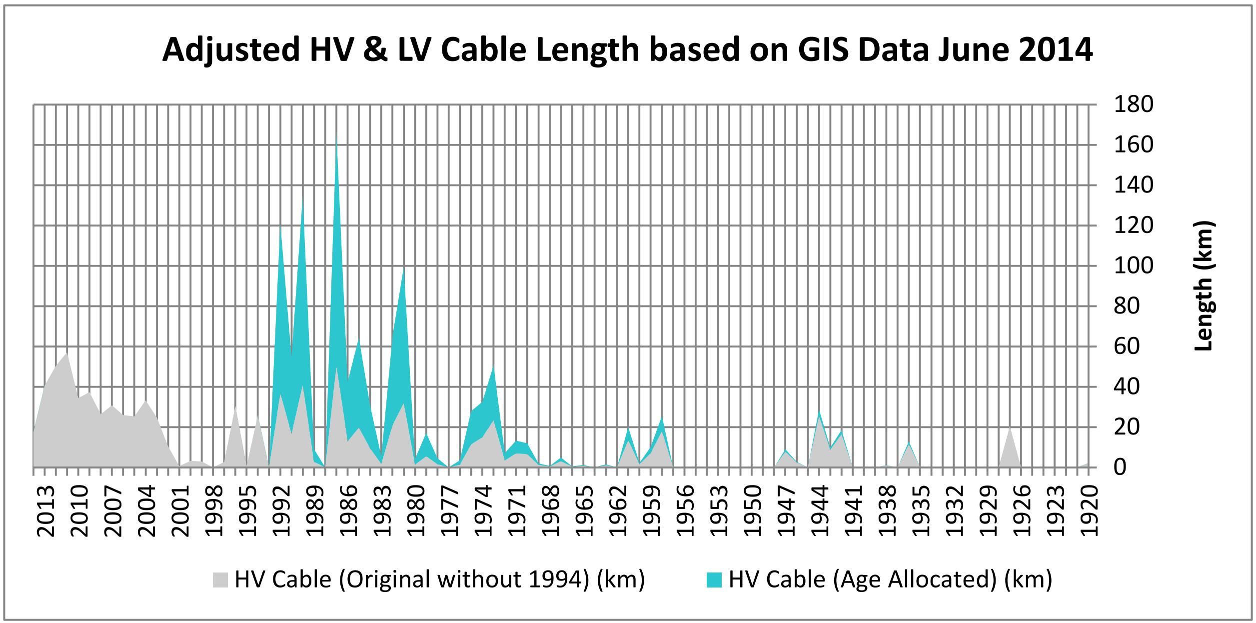
The above reference is no doubt based on the graph shown in Figure A-14[9] of the draft decision document, which shows a large 'spike' in cables installed about 20 years ago in 1994. This spike is not 'real', as it represents a large proportion of ActewAGL Distribution's underground cables, which had unknown ages at the time when the data was first loaded into the GIS system.

ActewAGL Distribution knows which suburbs these cables of 'unknown age' are located in and has since undertaken a reallocation of the cable asset age profile based on the known establishment dates for these suburbs.

The revised asset age profile is contained in Figure 8 below:

[8] AER 2014, *Draft Decision ActewAGL Distribution Determination: ActewAGL Distribution Determination:* Attachment 6, p6-56
[9] AER 2014, *Draft Decision ActewAGL Distribution Determination: ActewAGL Distribution Determination:* Attachment 6, p6-53

Figure 8 Revised HV cable age distribution based on establishment date of suburbs



6. AER predictive modelling

Jacobs has reviewed the manner in which AER's predictive modelling of REPEX has been applied to ActewAGL Distribution in the draft decision document and comments as follows:

6.1 Base case model

Jacobs fundamentally disagrees with the AER's premise that *"…our view of ActewAGL Distribution's long-term REPEX requirements as evidenced by its past expenditure will provide ActewAGL Distribution with a reasonable opportunity to recover at least its efficient costs."*[10]

Simply put, future requirements for sustainable replacement and refurbishment expenditure cannot be predicted by past trends and averages of actual volumes and expenditure.

We note the past and future base case profile contained in figure A-18[11] (note the vertical axis scale is incorrect), which is not dissimilar to other REPEX forecast profiles that we have seen on many occasions previously. The AER commentary following figure A-18 suggests that the step-up/trend down replacement profile is in some way unusual, or unexpected.

In reality it is Jacobs experience that in a capital constrained environment, expenditure on REPEX is to some degree 'discretionary', and is often given lower priority than expenditure on customer driven capex, demand driven capex, and regulatory, statutory/environmental and safety capex.

Historically, it is not unusual for DNSPs to underspend on REPEX over significant periods of time and to defer 'non-critical' replacement and refurbishment of assets, creating a potential bow-wave of impending replacements.

It shows a lack of understanding of basic distribution network maintenance and refurbishment/replacement practices for the AER to make the statement:

> *"… if ActewAGL Distribution's actual asset replacement profile followed its base case replacement lives, the older assets would have:*
>
> - *Already reached the end of their economic (replacement) lives and so would have already been largely replaced; and*
> - *Would therefore not be expected to be in the asset age profile, or be in such insignificant volumes that it would not materially affect the outcome of REPEX modelling."*[12]

6.2 The calibrated model

We note that the calibrated model uses replacement lives and standard deviations based on ActewAGL Distributions' replacement volumes over the past five years. However we are not convinced that this modelling approach produces valid results. The use of the past five years REPEX spend and volumes is not necessarily representative of a long term sustainable programme that will see ActewAGL Distribution manage its assets in an efficient manner into the future, and to maintain average asset lives at a level to deliver an acceptable service standard.

We note the comment that *"… the historically high volume of asset replacement work that ActewAGL Distribution has carried out over the last five years is likely to have changed its asset age profile from five years ago. That is, by spending a large amount on REPEX in the last regulatory control period, ActewAGL Distribution is expected to have replaced a significant number of its older assets. This in turn may be expected to reduce the*

[10] AER 2014, *Draft Decision ActewAGL Distribution Determination: ActewAGL Distribution Determination:* Attachment 6, p6-11
[11] AER 2014, *Draft Decision ActewAGL Distribution Determination: ActewAGL Distribution Determination:* Attachment 6, p6-60
[12] AER 2014, *Draft Decision ActewAGL Distribution Determination: ActewAGL Distribution Determination:* Attachment 6, p6-60

overall age of its network. If the average replacement life and the standard deviation stays the same, but the networks overall age is reduced, fewer assets will need to be replaced in the next period."[13]

Jacobs strongly disagrees with these observations based in part on the AER's own analysis, and in part on information already submitted in the SRP (appendix B17.1).

Firstly, we are unclear as to how the AER came to the conclusion that ActewAGL Distribution has carried out a 'high' volume of asset replacement work over the past five years. It has also recently become apparent to us, that the AER's 'base case' model for ActewAGL Distribution is populated with asset replacement quantities which are different to, and generally higher than, the asset replacement quantities shown in ActewAGL Distribution's RIN spreadsheets. This issue is covered in more detail in the Jacobs report *"Focussed Critique of AER's REPEX – Calibrated Model"*, and has led Jacobs to the conclusion that the AER's REPEX model for ActewAGL Distribution produces invalid results.

Secondly, we draw your attention again to figure A-10[14] of the draft decision document which clearly shows that ActewAGL Distribution's REPEX during 2008-13 was about 50% below the average trend line for all benchmarked DNSPs. Again, by what measure or comparison does the AER consider that ActewAGL Distribution's past REPEX has been 'high'?

Thirdly, and most importantly, we draw your attention to appendix B17.1 of the ActewAGL Distribution SRP, section 1.3, which clearly states that the weighted average age of the ActewAGL Distribution network increased from 24.88 years in 2007/08 to 26.3 years in 2012/13. These average ages come directly out of ActewAGL Distribution's asset databases, and we have a high degree of confidence in their robustness. Again, we ask the question: By what measure or comparison does the AER consider that ActewAGL Distribution's past REPEX has been high?

[13] AER 2014, *Draft Decision ActewAGL Distribution Determination: ActewAGL Distribution Determination:* Attachment 6, p6-61 & 62
[14] AER 2014, *Draft Decision ActewAGL Distribution Determination: ActewAGL Distribution Determination:* Attachment 6, p6-50

Appendix 1. HV underground cable condition assessment business case

H.V Underground Cable Condition Assessment Business Case

Version Number: 1.0

Effective date: 04/04/2014

Version Control

Version	Date	Description	Changed by	Reviewed By
1.0	04/04/2014	First Draft	N Lee	M Schulzer

Approval

The signatures of the people below indicate an understanding of the purpose and content of this document by those signing it. By signing this document you indicate that you approve of the proposed project outlined in this business case and that the next steps may be taken to create a formal project in accordance with the details outlined herein.

Name	Title	Signature	Date
Santanu Chaudhuri	Network Performance Manager		
Dennis Stanley	Senior Branch Manager Asset Strategy & Planning		

Summary

This business case recommends the initialisation of condition monitoring of high voltage underground cables and prioritisation of the high voltage underground cable replacement with suspected problems.

It is recommended to condition monitor 3 critical HV feeders between FY14/15 to FY15/16 and increase to condition monitor of 5 critical HV feeders from FY16/17 and onwards.

It is also estimated that 700metres of cable section will be identified for replacement in FY14/15 from the condition monitoring. And 4.5km of cable section will be identified for replacement from FY15/16 and onwards.

This initiative will reduce the highest risk of asset failure.

Background

- There are 1,475km of high voltage underground cables in ActewAGL network
- It is estimated that 12% of these high voltage underground cables are older than 60 years.
- In the past, ActewAGL has adopted the strategy to run the underground cables to failure.
- In the past, any replacement decisions have been driven by repeated root cause failure.

Table 1: Estimated age group of underground cables

Age Group (Years old)	Length (km)	Percentage of our network (%)
1 to 10	317	22%
11 to 20	113	8%
21 to 30	244	17%
31 to 40	359	25%
41 to 50	158	11%
51 to 60	49	3%
61 to 70	70	5%
Over 70	105	7%
Unknown	22	2%

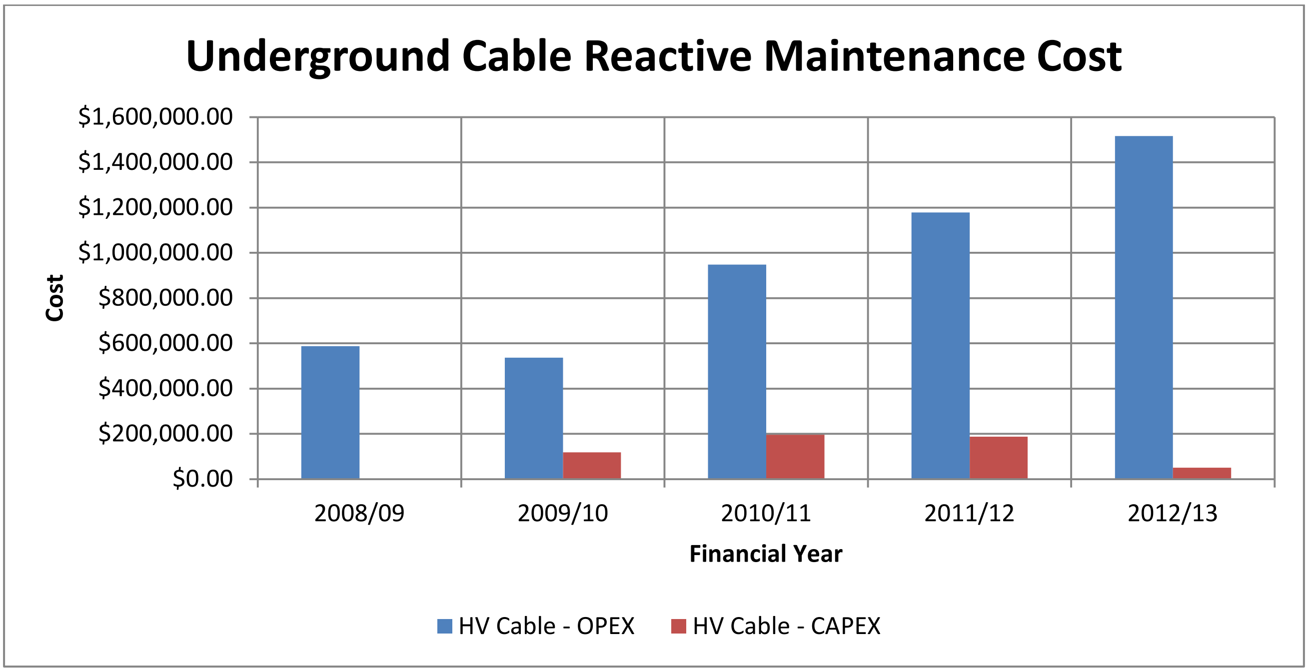
Table 2: Estimated underground cable type

Cable Type	Length (km)	Percentage of our network (%)
XLPE Insulated	430	30%
Paper Insulated	984	69%
Unknown	22	2%

Current Situation

- In the past 5 years, reactive repairs and replacements have been increasing, see Figure 1.
- Most repair work is on the cable joint or termination, and an increasing number of underground cables are reaching the end of their life.
- This was observed in Griffith and Kingston where the steel armour tape and the lead metallic sheath of the cable showed signs of corrosion during cable repairs. These cables were installed in 1943.
- Once the metallic sheath is compromised, moisture ingress into the cable will eventually lead to failure.

Figure 1: Historical underground cable maintenance cost



Analysis

- The HV cable fault rate is trending upwards. By 2020, we may expect up to 64 high voltage cable faults in that year (Figure 2 and Table 3).
- If this remains as the status quo, there is a risk of expenditure on possible cable repairs of up to $7.1 million in 2020, see Figure 3 and Table 4, with essentially no reduction in the future risk of cable failure
- Control needs to be put in place to stop the increasing reactive repair cost of the HV underground cable.

Table 3: Forecast number of high voltage cable fault

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Forecasted HV cables length (km)	1280	1306	1332	1358	1386	1413	1441	1470	1500	1530	1560
Forecasted number of cable faults (High estimate)	33	37	41	46	51	57	64	71	79	87	97
Forecasted number of cable faults (Low estimate)	25	26	27	28	29	30	31	32	33	34	35

Figure 2: Forecast number of high voltage cable fault

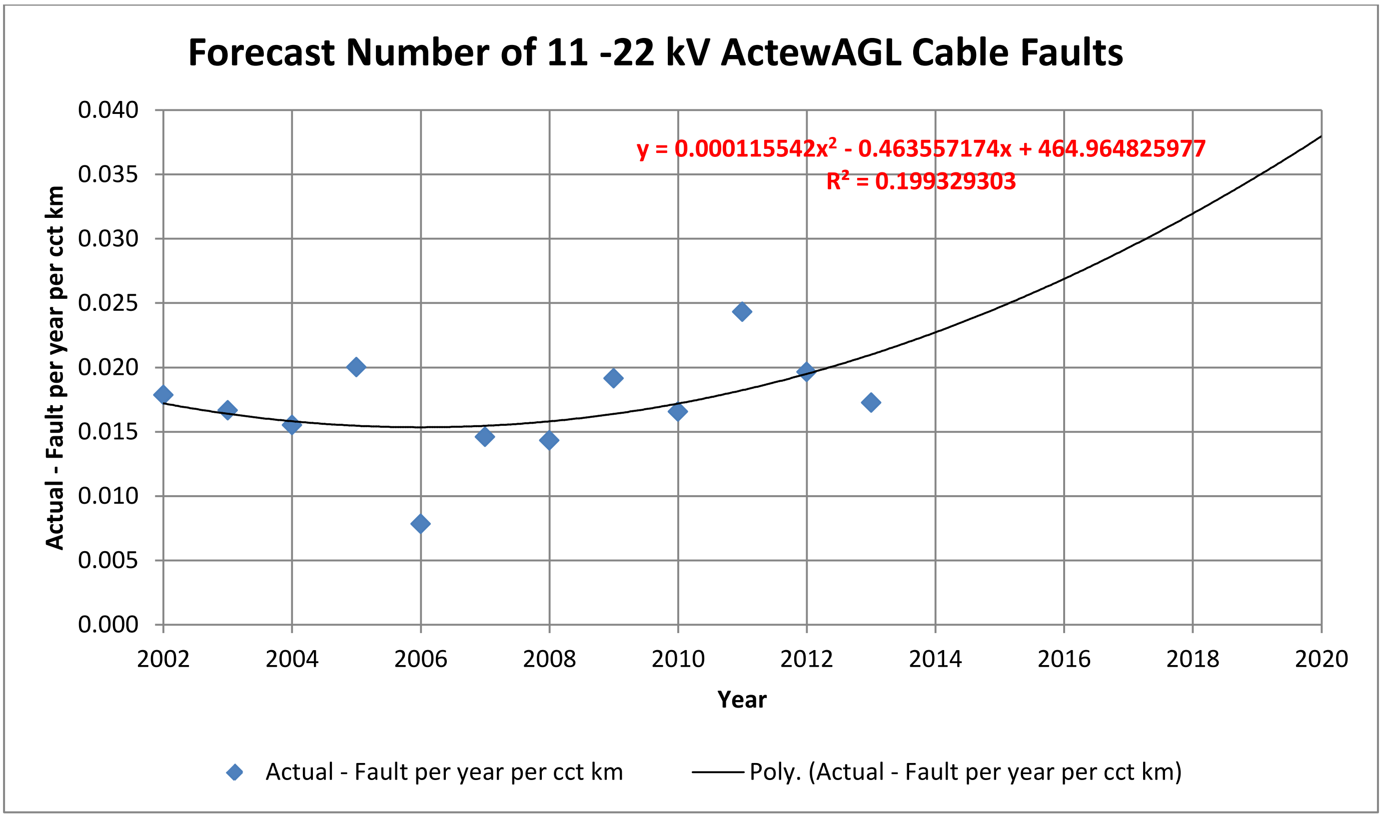


Figure 3: Forecast reactive maintenance cost

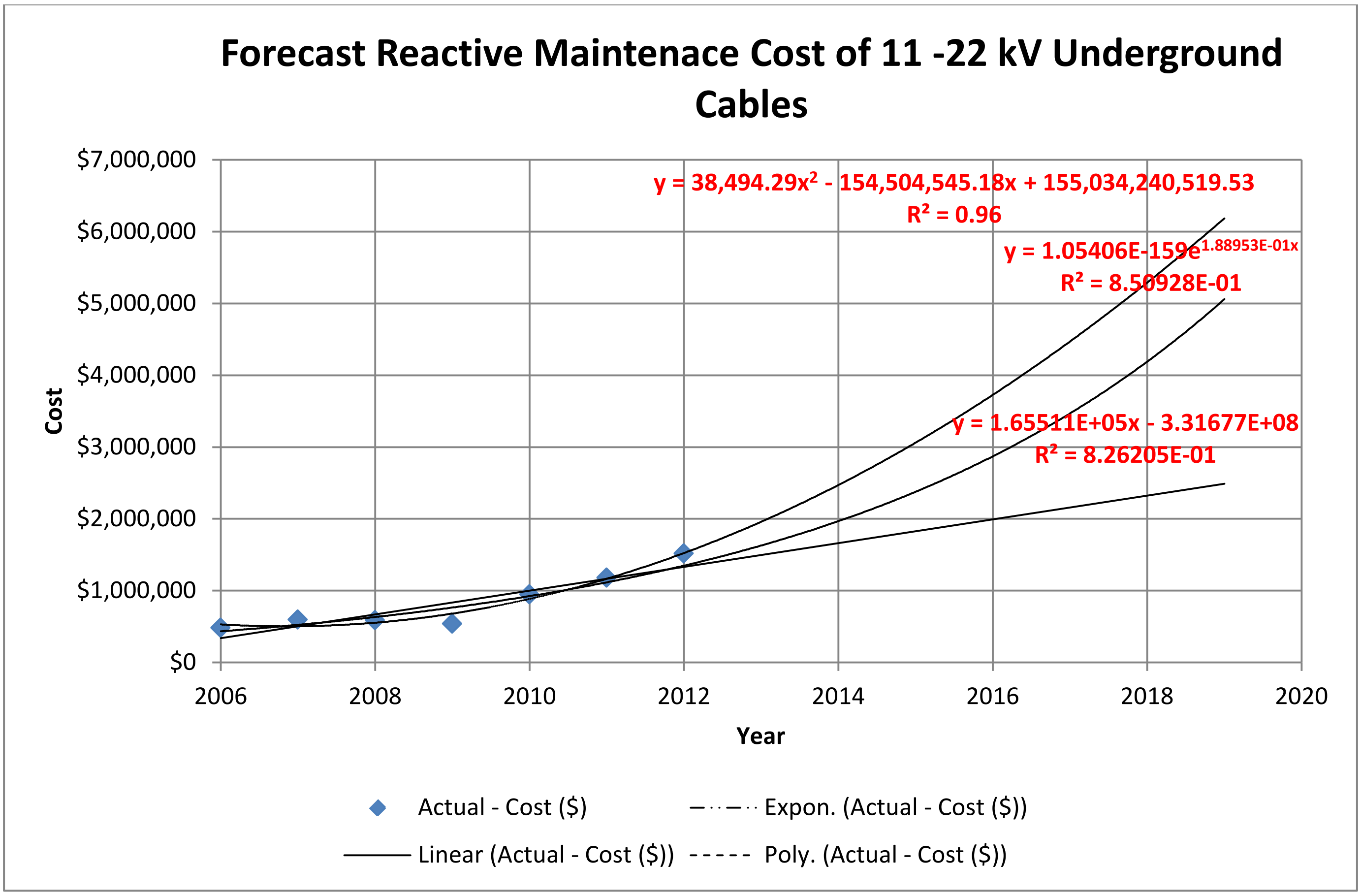


Table 4: Forecast reactive maintenance cost

Forecast Cost ($)	2014	2015	2016	2017	2018	2019	2020
Low Estimate (Linear)	$1,662,154	$1,827,665	$1,993,176	$2,158,687	$2,324,198	$2,489,709	$2,655,220
Medium Estimate (Exponential)	$2,053,323	$2,480,499	$2,996,544	$3,619,948	$4,373,045	$5,282,818	$6,381,860
High Estimate (Polynomial)	$2,471,648	$3,060,597	$3,726,535	$4,469,461	$5,289,376	$6,186,280	$7,160,172
Average estimate	$2,062,375	$2,456,254	$2,905,418	$3,416,032	$3,995,540	$4,652,936	$5,399,084

Options

1. Maintain the status quo and accept the rising cost.

2. Replace all underground paper insulated cables over 60 years old and XLPE cables over 50 years old.
    - If this strategy is adopted, over 175km will be due for replacement
    - The estimated cost is 175,000m x $250/m = $43,750,000 +/- 30% capital expenditure over the next 5 years.

3. Initiate condition monitoring of underground cables and prioritise sections of the underground cable replacement with suspected problems.
    - Condition monitoring of 3 HV critical and feeders between FY14/15 to FY15/16 and increase to condition monitoring of 5 HV critical and feeders from FY16/17 and onwards.
    - Estimate of 700metres cable section replacement in FY14/15 identified from condition monitoring. Then 4.5km of cable section replacement from FY15/16 and onwards.

Table 5: Cost of adaptation of this option

	14/15	15/16	16/17	17/18	18/19
Condition Monitoring OPEX	$146,688	$146,688	$244,480	$244,480	$244,480
Cable Replacement CAPEX	$175,000	$1,125,000	$1,125,000	$1,125,000	$1,125,000
Cable Reactive repair work - OPEX	$1,887,375	$1,331,254	$1,780,418	$2,291,032	$2,870,540

Conclusion

Estimated cost of future cable repairs drives the need to implement risk reduction strategy. This implies an extensive replacement program, preferably targeted to the highest risk of asset failure.

Recommendation

- Condition monitor.
- Replacement program based on results of condition monitoring.

Appendix 2. Case Study 4 – HV underground cable replacement

4 Underground distribution cable replacement – case study

4.1 Overview

ActewAGL has an aged and growing underground distribution network. 15% of the underground cables have exceeded their average service life and an additional 11% will exceeded their average service life in the next 10 years. These aged cables are failing at an increasing rate.

To address this trend, ActewAGL has been both efficient and prudent in developing an asset management strategy. The strategy involves the initiation of a condition monitoring regime of high voltage underground cables and prioritisation of the high voltage underground cable replacement with suspected problems.

Three critical HV feeders will be condition monitored between FY14/15 to FY15/16 increasing to condition monitoring of five critical HV feeders from FY16/17 and onwards.

It is estimated that 700 m of cable section will be identified for replacement in FY14/15 from the condition monitoring, and 4.5 km of cable section will be identified for replacement from FY15/16 and onwards.

This initiative will reduce the highest risk of asset failure.

4.2 Introduction

All new sub-division developments in the Australian Capital Territory (ACT), are reticulated with an underground distribution network since the 1980s. The underground cable asset is managed and categorised by the voltage level, insulation type and the type of cable construction.

Most of ActewAGL's high voltage cables are three core cables. The cable conductor material is either stranded aluminium or copper for HV and LV mains power cable and copper for LV service cable.

Consac cables were installed in ActewAGL from 1960s to mid-1970s and polymeric cables have been used in the industry since the 1980s. Table 1 below, details to total lengths of underground cable in the ActewAGL distribution network.

Table 1 Cable population

Cable type by voltage	Length in service	Average service lift
HV UG cables	1,460 km	50 years
LV UG cables	1,236 km	50 years
Service UG cables	1,898 km	50 years

4.3 Asset age

ActewAGL maintains and operates approximately 1,460 km of high voltage (11 kV and 22 kV) cable. Of this length, 15% is older than 50 years and 12% is older than 60 years.

Table 2 Cable age

Age group (years in service)	Length (km)	% of network
1 - 10	317	22
11 - 20	113	8
21 - 30	244	17
31 - 40	359	25
41 - 50	158	11
51 - 60	49	3
61 - 70	70	5
Over 70	105	7
Unknown	22	2

High voltage underground cables are considered to have an average service life of 50 years for HV and LV cables. As such 15% ActewAGL's HV cable is older than it's considered service life, and a further 11% will exceed its service life in the next 10 years. This statistic is reflected in the graph of cable failure rates below.

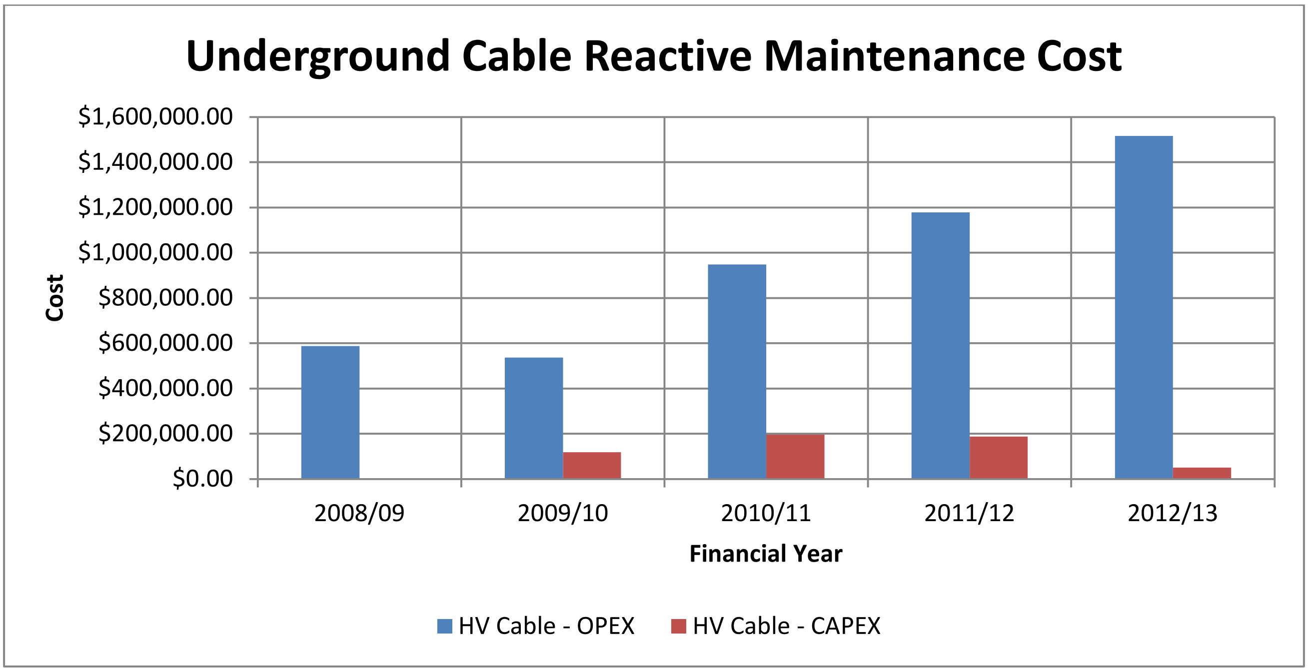
4.4 Asset performance

It has been ActewAGL's practice in the past, to run the underground cables to failure. Cable repairs have generally been limited to the removal of faulted sections. Over the previous five years, reactive repairs and replacements have been increasing, see Figure 4-1.

Most repair work has been on the cable joint or termination, and an increasing number of underground cables are reaching the end of their life. This was especially observed in Griffith and Kingston where the steel armour tape and the lead metallic sheath of the cable showed signs of corrosion during cable repairs. These cables were installed in 1943.

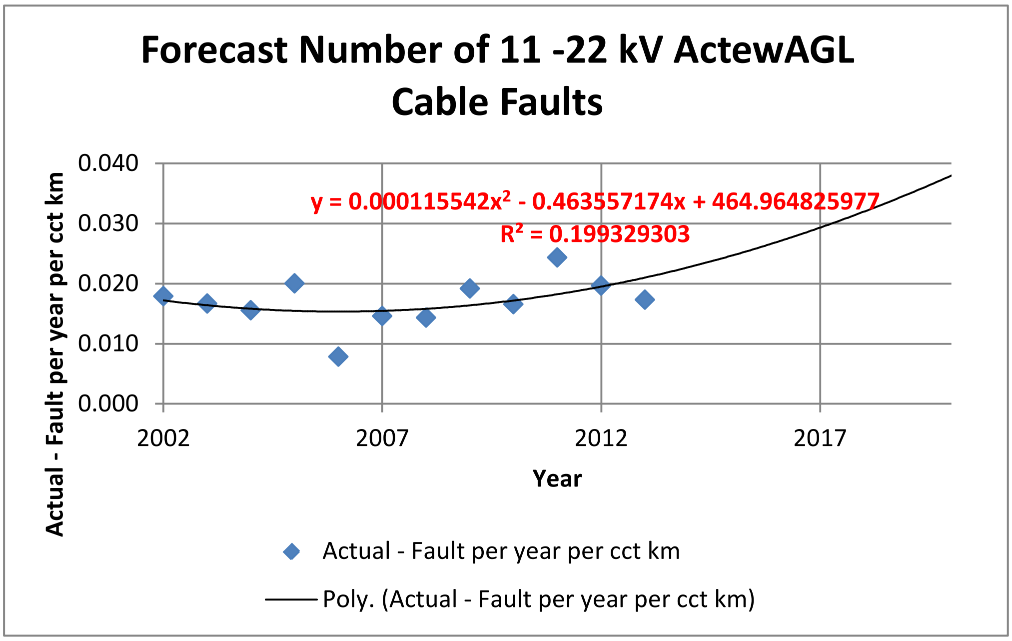
Once the metallic sheath is compromised, moisture ingress into the cable will eventually lead to failure.

Figure 4-1 Historical underground cable maintenance cost



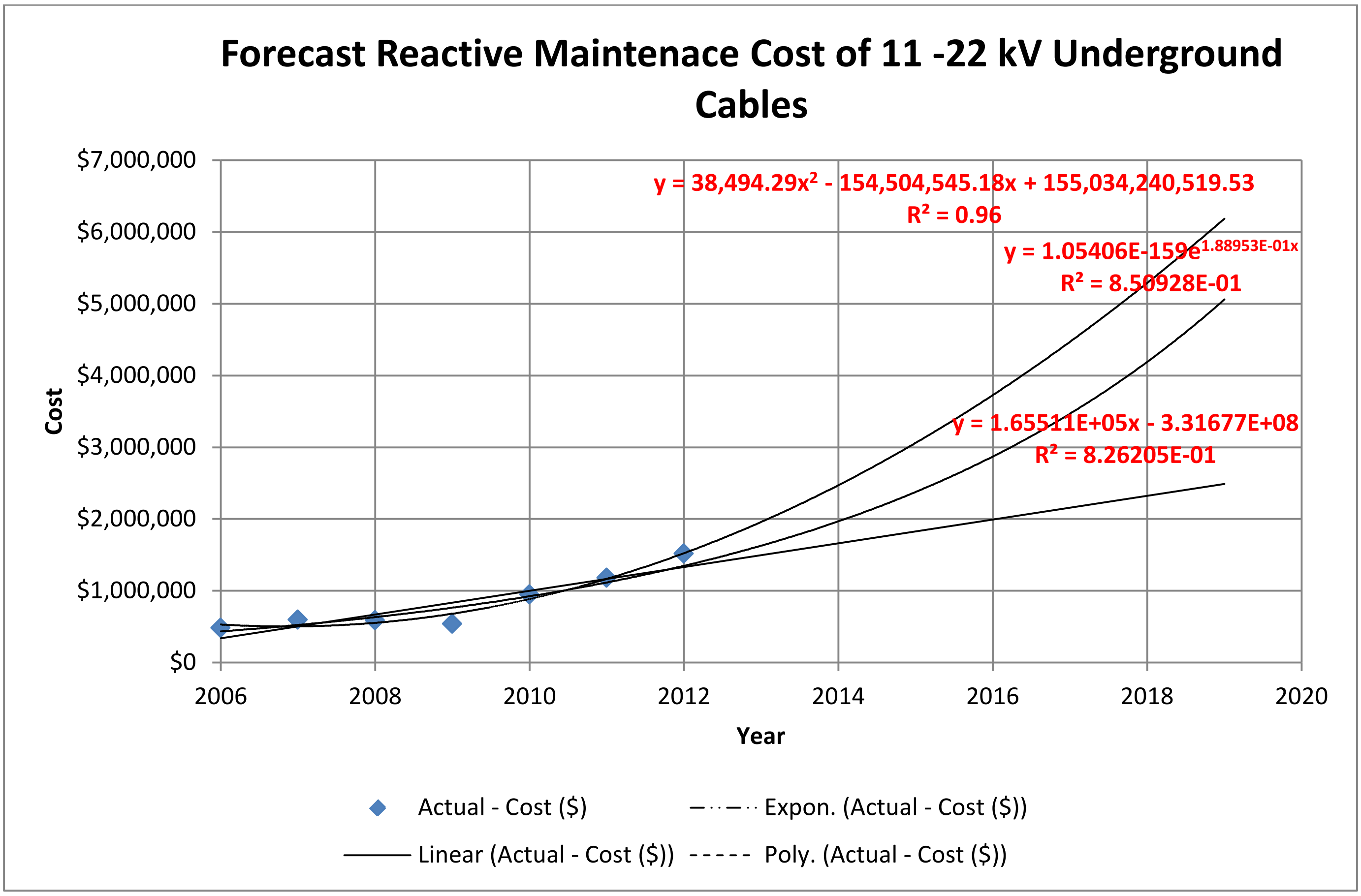
It can be seen that the HV cable fault rate is trending upwards. By 2020, we may expect up to 64 high voltage cable faults in that year (Figure 4-2). If this remains as the status quo, there is a risk of expenditure on possible cable repairs of up to $7.1 million in 2020, see Figure 4-3, with essentially no reduction in the future risk of cable failure.

Figure 4-2 Forecast number of high voltage cable fault



In the past five years, reactive repairs and replacements have been increasing, see Figure 4-3. Most repair work is on the cable joint or termination, and an increasing number of underground cables are reaching the end of their life. This was observed in Griffith and Kingston where the steel armour tape and the lead metallic sheath of the cable showed signs of corrosion during cable repairs. These cables were installed in 1943. Once the metallic sheath is compromised, moisture ingress into the cable will eventually lead to failure.

Figure 4-3 - Forecast reactive maintenance cost



4.5 Asset replacement strategy

4.5.1 Immediate response

To address the increasing number of cable failures, in June 2013, ActewAGL examined the root cause of the cable failures and determined that the failures were occurring predominantly at cable joints. ActewAGL decided to commence strategic feeder replacement and a desk top investigation was undertaken of three critical feeders, namely the Yamba, Belmore and ANU back up feeders. It was decided to augment the Yamba feeder.

The Yamba feeder is fully underground and supplies the Canberra Hospital from the Woden substation. The feeder is 48 years old and contains 27 joints and is 3.7 km in length and recorded eight cable failures in the period 2002 – 2012. An additional two cable failures occurred in 2013. On average it takes two and one half days to repair a cable failure after the fault location is identified.

The feeder was replaced in full in 2013/14.

4.5.2 Longer term strategy

ActweAGL considered three options to address the declining performance of the underground network. They were:

1) Maintain the status quo and accept the rising cost
2) Replace all underground paper insulated cables over 60 years old and XLPE cables over 50 years old
    - If this strategy is adopted, over 175 km will be due for replacement

- The estimated cost is 175,000 m x $250/m = **$43,750,000 ±30%** capital expenditure over the next five years

3) Initiate condition monitoring of underground cables and prioritise sections of the underground cable replacement with suspected problems

   - Condition monitoring of three HV critical and feeders between FY14/15 to FY15/16 and increase to condition monitoring of five HV critical and feeders from FY16/17 and onwards
   - Estimate of 700 m cable section replacement in FY14/15 identified from condition monitoring. Then 4.5 km of cable section replacement from FY15/16 and onwards

Option three has been accepted and is to begin implementation during the 2014/15 financial year.