

ATTACHMENT 6.8

NETWORK AERIAL PATROL AND ANALYSIS (AP&A) - STEP CHANGE ANALYSIS



Contents

1	Purpose.....	3
2	Summary.....	3
3	Background.....	5
4	Discussion.....	6
4.1	AP&A Cycle Period	7
4.2	Forecast Task Identification Rates – without AP&A.....	8
4.3	Forecast Task Identification Rates - with AP&A	8
4.4	Net Identification Rates and Incremental Tasks	9
4.4.1	Net Incremental Tasks – Pole-top.....	9
4.4.2	Net Incremental Tasks – Low Conductor	10
4.4.3	Summary of Net Incremental Tasks.....	10
4.5	Asset Condition, Task Description & Risk Assessment.....	11
4.5.1	Pole-Top Tasks	11
4.5.2	Low Conductor Tasks.....	15
4.6	Options Analysis.....	16
4.6.1	Options Analysis – Pole-Top Tasks	16
4.6.2	Options Analysis - Low Conductor Tasks	17
4.7	Forecast Programme of Works	18
4.7.1	Forecast Programme of Works – Augex – Option 2	18
4.7.2	Forecast Programme of Works – Opex – Option 2.....	18
	Appendix A: What is AP&A (Lidar).....	19
	Appendix B: AP&A – Managing The Public Safety Risk.....	21
	Appendix C: The Risk Assessment Approach	25
	Appendix D: Regulatory Ground Clearances.....	27
	Appendix E: Proposed Tasks, Unit Rates & Program Cost.....	28
	Appendix F: Electricity Caused Major Fire Events 2009 - 2014	30

1 Purpose

The purpose of this paper is to present to the Australian Energy Regulator (AER) new information that has come to Essential Energy's attention in relation to the condition of rural overhead lines. This information has only become available since the submission of Essential Energy's regulatory proposal for the period 1 July 2015 to 30 June 2019. Essential Energy seeks to amend its proposed operational and capital expenditure in accord with this new asset condition knowledge.

2 Summary

Essential Energy currently carries out a visual aerial inspection of overhead rural power lines in the months prior to the summer bushfire danger period each year. This is a visual patrol only and is limited to locating the most severe asset defects and severe vegetation encroachments.

This paper deals with pole-top asset condition and conductors below statutory clearance which Essential Energy have now been made aware of through the employment of a new process called Aerial Patrol and Analysis (AP&A)¹ which was trialled prior to the 2014/15 summer bushfire period.

There are four principle drivers for Essential Energy to consider:

- > There are limits in the level of detail that the traditional visual aerial patrol can identify. Flying at approximately 70 knots the traditional visual aerial patrol is limited to locating the most serious asset defects including broken crossarms, conductors on crossarms, broken insulators, insulator pins out of arms and very close vegetation defects. Low spans and many intact conditionally failed² components cannot be detected with the traditional visual aerial patrol.
- > The network assets are aging. As assets age, conditional failures of some pole-top defects cannot be adequately detected by the traditional visual aerial patrol or ground line inspection processes. As indicated in Table 4-9, Essential Energy has the second longest calibrated weighted replacement life for all assets; exceeded only by Citipower (a non-comparable underground city based DNSP).
- > The asset component failure rates are high by industry standards. As indicated in Table 4-8, the failure rate of Essential Energy components is over four times the failure rate of all Victorian DNSPs when normalised by line length.
- > An escalating crossarm failure rate is now evident as detailed in section 4.5.1.1 with a resultant increase in risk to network reliability, public safety and fire.

New technology in the form of the AP&A programme is now available. High resolution photography of pole-tops and Light Detection and Ranging (LiDAR) technology enables a higher standard of asset defect identification including:

- > Less obvious conditional failures can be detected with high resolution photography.
- > Low overhead conductors can be identified.
- > Accurate vegetation clearances can be identified.

As a responsible DNSP, Essential Energy has an obligation to utilise modern technology to identify latent conditional failures, hazardous low conductors and vegetation encroachment, to reduce the risk to the community³. This new technology overcomes limitations of the existing visual aerial patrol at reasonable cost to identify these latent failures.

The new AP&A process was trialled and operated across 27 per cent of the rural network prior to the summer of 2014/15 and found a quantum increase in risk issues that are required to be addressed. Specifically:

- > Pole-top Defects – 0.6 per cent of inspected poles had “Emergency”, “Urgent Risk” or “Risk” defects⁴ associated with the pole-top assembly. This is an increase of over six times what is found via the traditional visual aerial patrols.

¹ Refer to Appendix A – What is AP&A (LiDAR)

² Conditionally failed components are those components that are still in service but not able to sustain the intended design limits when called upon to do so. In the context of pole-top assemblies this is usually in a high wind event.

³ Refer to Appendix B: Managing the Public Safety Risk.

⁴ Refer to Appendix C for defect risk assessment and classification.

- > Low Conductors – 11 per cent of inspected spans were identified as below statutory clearance. This is an increase of over six times what is found via traditional inspection techniques.
- > Vegetation Encroachments – 23 per cent of inspected spans were identified as non-compliant with vegetation inside safety clearances. This is an increase of over five times above what is found via traditional inspection techniques.

Given the material increase in identified risks it follows that the AP&A process provides the opportunity to identify and prioritise corrective actions for many otherwise latent conditional failures and encroachments which when corrected, will translate into a reduction in public risk generally, and bushfire risk in particular.

Essential Energy expects that the AP&A programme will assist in containing the pole top assembly failure rate and in so doing assist in maintaining the existing reliability performance. As the AP&A programme is specifically targeted to rural areas with low to very low customer density, it is highly improbable that there will be any measurable system SAIDI improvements as a result of the AP&A programme. There will however, be improvements in public safety and a reduction in bushfire risk as a result of the AP&A programme.

Essential Energy is obligated to implement technology advances such as AP&A where it is reasonable to do so. The AP&A programme will be continued for the next three years effectively covering 91 per cent of the rural network. The inland outback area (Far West – Broken Hill region) will not be inspected with this technology due to its assessed age and risk level not warranting the AP&A inspection process.

Now aware of additional serious network defects, Essential Energy as a prudent network owner is obliged to address and rectify these defects. R2A Due Diligence Engineers state that:

“Essential Energy as a person conducting a business or undertaking has a duty under the provisions of the Work Health and Safety Act 2011 to ensure that, for all foreseeable hazards associated with the operation of the Essential Energy network, all practicable precautions are in place, so far as reasonably possible.”⁵

Due to the improved technology of the AP&A process, the first inspection cycle will result in a one off peak in pole-top defect and low conductor clearance tasks. Rectifying these additional corrective tasks identified from the AP&A programme requires a net incremental cost across the regulatory period as shown in Table 2-1.

Whilst a large volume of additional tasks were identified, Essential Energy does not propose to respond to all tasks in the current regulatory period and has prudently prioritised a limited proportion based on a balance between the cost of the rectification works and the level of risk exposure. The proposed tasks have been identified as tasks which will require corrective action within the current regulatory period in order to contain an otherwise escalating level of risk. Targeted identification and rectification of these otherwise latent defects is prudent and efficient when compared to the alternative options of accepting an increasing failure rate (with associated reactive costs) or bulk replacement under a capital program.

Table 2-1: Summary of AP&A defect correction works⁶

Programme of Works	Proposed Tasks (\$2013/14)		Deferred Tasks (\$2013/14)	
	AUGEX	OPEX	AUGEX	OPEX
Pole-top defects classified as ‘Urgent Risk’ and ‘Risk’	\$0.30M	\$4.89M	-	-
Pole-top defects classified as ‘General Maintenance’	-	-	\$1.33M	\$22.24M
Correction of low conductors	\$77.05M	\$43.00M	\$57.83M	\$32.27M
Correction of vegetation encroachments ⁷	-	\$15.41M	-	-
TOTAL	\$77.35M	\$63.31M	\$59.16M	\$54.51M

⁵ R2A Due Diligence Engineers – Asset / System Failure Safety Risk Assessment, January 2015

⁶ All expenditure is direct, excluding corporate overheads

⁷ Refer to Attachment 7.10 Vegetation Management for all aspects of vegetation

As indicated in Table 2-1, Essential Energy requires a total \$141M (\$77.35M augex + \$63.31M opex) to rectify the proposed pole-top, conductor and vegetation defect tasks in the current regulatory control period. The task quantum was developed as indicated in Appendix E and as follows:

- > Pole-top Defects – Rectify all “Emergency – A1”, “Urgent Risk – A2” and “Risk – A3” tasks during the current regulatory control period. Defer and monitor all “General Maintenance – A4” tasks.
- > Low Conductors – Rectify the 57 per cent most severe non-compliances in the current regulatory control period. Defer and monitor the remaining 43 per cent of tasks for action in subsequent regulatory control periods.
- > Vegetation Encroachments – Rectify all vegetation defects with an encroachment of over 50 per cent on regulatory clearances⁸, during the current regulatory control period. Vegetation clearance defects identified through AP&A are discussed in Attachment 7.10 – Vegetation Management, of our Revised Proposal.

The cost of operating the AP&A process over the first cycle is included in Augmentation Capital (compliance) and not detailed in this paper. This paper only addresses the incremental cost of correcting the identified defect tasks for pole-tops, pole-top assemblies and low conductors identified through the AP&A inspections.

3 Background

In 2014, Essential Energy implemented a new inspection methodology in conjunction with other NSW distribution network service providers (DNSP) under state-wide contracts. The new methodology uses aircraft to perform high definition photography of pole-top assemblies and LiDAR analysis of conductor clearances to vegetation, ground and other circuits. This is referred to as Aerial Patrol and Analysis (AP&A) including LiDAR survey, and is now widely accepted to be industry best practice for improved understanding of pole-top condition, line design profile, and vegetation clearance status.

Most Australian transmission and distribution network service providers are now investing in advanced inspection technologies that provide greater understanding of pole-top conditions and vegetation as these areas have the highest impact on public safety and reliability, particularly for assets in rural environments. Pole-top asset failures are the dominant cause of network initiated fires.⁹

The volume of necessary work resulting from the first phase of AP&A inspections has surpassed Essential Energy's expectations, and was not anticipated at the time of submission of our regulatory proposal for the period 1 July 2015 to 30 June 2019. Notice of this evolving issue was included in our response to the AER issues paper on the 8 August 2014. The following is an extract from that response:

“Essential Energy’s approach to asset renewal is becoming increasingly strategic and sophisticated; for example, LiDAR technology is currently being rolled out over the distribution network. Early results indicate significantly more defects have been found than originally estimated meaning the replacement expenditure proposed by Essential Energy may be underestimated.”¹⁰

This report seeks to describe and discuss in detail the additional expenditure that Essential Energy considers is required to implement the repairs and augmentations necessary to maintain the safety and reliability of its distribution network at the levels required by regulations¹¹, the code of practice¹² and in accord with community expectations.

This includes heeding important lessons learned from major events within the industry such as the Black Saturday Fires of 2009. In regard to balancing inspection effectiveness (risk) and inspection cycle (cost) the Bushfire Royal Commission stated:

“Although either one of these two factors alone will considerably reduce the risk of in-service failure, the distribution businesses made a deliberate choice to offset improvements in one (the inspection effectiveness) with relaxation of the other (the inspection cycle). In practice, they have forgone an opportunity to improve safety in order to reduce costs.

⁸ Encroachments of less than 50 per cent will be deferred for correction in cyclic maintenance

⁹ Bushfire risk assurance panel fire reports: Essential Energy 2012_13 Full year fire report; Essential Energy End of season 2013_14 fire report

¹⁰ NSW DNSPs' Response to the AER's Issues Paper 08/08/2014 – Attachment 1 page 9

¹¹ Electricity Supply Act 1995; Electricity Supply (Safety and Network Management) Regulation 2008

¹² Electricity Transmission and Distribution Asset Management: Code of Practice

It is not satisfactory that the distribution businesses can decide that a specific level of bushfire risk is 'acceptable' and rely on the benefit of improved processes and technology to maintain that risk level (instead of reducing it) in order to decrease their operating costs or increase their profits. Distribution businesses should take all reasonable opportunities to reduce bushfire risk. In particular, they should not trade improvements achievable by shortening the inspection cycle against those arising from improved inspection methods.

No inspection regime will detect all failures during inspections, and improvements in processes and equipment will always be limited by the effectiveness of inspections.”VBRC Chairman’s statement ¹³

There are also expectations of other state based agencies responsible for community safety which require consideration. Two recent examples of this are contained in letters received by Essential Energy’s CEO in regard to the AER draft decision from NSW RFS and Fire and Rescue NSW;

“It would appear that the broader ramifications of the draft determinations have not been subject to a detailed risk assessment by the AER and I strongly encourage the AER to undertake detailed risk assessments of the broader impacts of these determinations in their current form.” - Commissioner Shane Fitzsimmons, NSW Rural Fire Service 2014 ¹⁴

And

“.....the impact of the draft determination could be a greater reliance on Fire & Rescue NSW in storm situations, due to smaller numbers of available utility staff and less vegetation management activities. As illustrated above, I am deeply concerned that this could lead directly to greater loss of life and property in the community due to fire crews being engaged for even longer periods at "wires down" incidents.

I am hopeful that you will be able to provide some reassurance that this will not be the case. You may also be able to advise whether or not the AER plans to consult more widely on its draft determination, and whether detailed risk assessments of the broader impacts of its draft determination have or will be conducted. I am available at short notice to meet and discuss this significant issue. “Commissioner Greg Mullins, Fire and Rescue NSW 2014 ¹⁵

It is incumbent on Essential Energy to maintain a safe network. The new technology available through the new AP&A process will be adopted as:

- > It identifies otherwise latent defects; a proportion of which would fail prior to being identified for replacement by any other routine inspection programmes.
- > It materially reduces the community risk of asset failures and fire ignition when combined with an appropriate defect task prioritisation process and corrective programme of works.
- > By identifying conditionally failed components with more accuracy, it is possible to selectively replace conditionally failed assets rather than embark on the high cost alternative of bulk replacement using age as a proxy for condition.
- > The asset failure rate that would be expected to climb with an increase in average age (reducing average condition) can be contained to a reasonable level.

4 Discussion

The Essential Energy asset inspection programme is set out in the Network Asset Management Plan (NAMP). The NAMP identifies the inspection and corrective maintenance activity required for the efficient management of the overhead network assets. The programmes are further detailed in the Asset Management Plans (AMP’s) for Overhead Distribution Feeders and Overhead Sub-transmission Feeders. The NAMP and AMP’s set out the following main inspection programmes for overhead lines:

¹³ VBRC Final Report: VBRC_Vol2_Chapter04_Electricity Caused Fire published July 2010

¹⁴ Letter extract received from Commissioner Shane Fitzsimmons, NSW Rural Fire Service 5 December 2014. (Refer Attachment 3.3 – Appendix B)

¹⁵ Letter extract received from Commissioner Greg Mullins, Fire & Rescue NSW 4 December 2014. (Refer Attachment 3.3 – Appendix B)

- > Pole and Line Inspection – this is a four yearly ground line inspection limited to visual inspection of the pole, excavation and drilling of the pole below ground level to determine sound wood and visual inspection of the bottom, sides and ends of crossarms.
- > Visual Aerial Patrol – a pre-summer visual aerial patrol is undertaken on all rural high voltage overhead lines to check for vegetation encroachments, damaged crossarms, hardware, insulators and damaged conductor. Only serious vegetation encroachments can be identified by this method.

The visual aerial patrol is limited to a trained observer looking for the most obvious defects, broken components and storm damage while flying in a fixed wing aircraft at 70 knots. This is a difficult process and a detailed inspection is not possible.

AP&A (LiDAR) is a relatively recent enhancement to the visual aerial patrols that rural DNSPs such as Essential Energy have customarily performed in the months leading up to the start of the bushfire season. AP&A inspections combine two inspection techniques onto one aerial platform. The first is to use high definition photography to provide a clear visual record of the condition of the pole-top assets such as insulators and crossarms. The second is to use LiDAR equipment to accurately measure the clearances from overhead conductors to the surrounding vegetation and the ground.

When detected, defects are visually assessed and depending on their severity, are categorised into a suitable risk bracket (A1 – Emergency, A2 – Urgent Risk, A3 – Risk or A4 – General Maintenance). Once categorised, the defects become tasks which are programmed for corrective action as the circumstances require. The risk assessment and defect categorisation approach is further discussed in section 4.5 and Appendix E; options analysis is discussed in section 4.6.

With the known limitations of the visual aerial patrol, Essential Energy commenced a trial of 44,000 kilometres (27 per cent of the rural network) of the new AP&A process. In the first year of AP&A implementation (2014), Essential Energy found that the technique identified a much higher volume of asset defects, vegetation encroachments, and low conductor clearances than expected. This new process:

- > Utilises advances in technology to provide a higher standard of inspection.
- > Has proven to identify greater numbers of conditionally failed components (mostly timber crossarms).
- > Can accurately identify low conductors below regulatory clearance.
- > Utilises high definition photography to inspect rural low voltage overhead lines from greater altitude. Previously with visual patrols flying at lower altitude rural low voltage lines could not be inspected due to customer and livestock disturbances.

This paper details the additional operational and augmentation expenditure required to rectify defects associated with pole-top equipment, and to restore non-compliant conductor spans to safe statutory ground clearances. The effect on the vegetation management programme is detailed in Attachment 7.10 - Vegetation Management.

4.1 AP&A Cycle Period

Essential Energy's rural network¹⁶ consists of 1,083,531 poles and has been calculated to total 161,522 kilometres in length. An AP&A inspection is not required of the total rural network annually. Traditional visual aerial patrols are adequate for the identification of obvious pole-top defects and significant vegetation encroachments. It is therefore proposed to conduct a four yearly cycle of AP&A across approximately 91 per cent of the rural network; the remaining balance of the rural network having been assessed as being of an age and risk level that currently does not require AP&A. On this first pass of AP&A, it is evident that many pole-top defects are being identified that are in a conditionally failed state. Table 4-1 details the scope of the proposed AP&A programme. Overall programme outcomes will be reviewed and used to determine the optimum AP&A programme in future cycles.

¹⁶ Excludes urban (non-bushfire prone) proportion of Essential Energy network

Table 4-1: Planned AP&A inspection programme - Rural Network

	2014/15	2015/16	2016/17	2017/19	Total Inspected via AP&A	Total Excluded from AP&A
Rural OH Line Inspected (km)	43,696	41,510	40,593	21,186	146,985 km	14,537 km
Rural Poles Inspected (units)	291,696	253,916	246,239	194,162	986,013 poles	97,518 poles
Rural Network Inspected (%)	27%	26%	25%	13%	91%	9%

4.2 Forecast Task Identification Rates – without AP&A

Traditional inspection techniques include ground pole and line inspections as well as visual aerial patrols. Using these traditional inspection techniques, the forecast identification rates and forecast task volume for rural overhead line defects are detailed in Table 4-2. Each traditional inspection technique has limited effectiveness in identifying particular defects. It is noted that:

- > Low conductors cannot be identified via visual aerial patrols due to the visibility from the aircraft. Historically, ground pole and line inspections were the only effective method of identifying low conductor spans.
- > Pole-top defects can be difficult to identify via traditional inspection methods. Limited visibility and access constraints limit the effectiveness of ground pole and line inspections; while flight speed constrains identification from visual aerial patrols.

Table 4-2: Forecast task identification rates without AP&A

Task Type	Traditional Identification Rate (per 1000 poles)	Forecast Tasks for 91% of Rural Network
Low conductor spans	18.188	17,933
Pole-top defects classified as ‘Emergency’, ‘Urgent Risk’ and ‘Risk’	0.870	858
Pole-top defects classified as ‘General Maintenance’	0.583	575

4.3 Forecast Task Identification Rates - with AP&A

During the 2014/15 pre-summer period, 27 per cent of the rural network was inspected with the AP&A process amounting to 291,696 poles and approximately 44,000 kilometres of line. The AP&A task identification rates from the poles inspected in 2014 is considered statistically significant and forms a reasonable basis to forecast future identification rates for the balance of the target area; at least for the first initial AP&A cycle. The forecast task identification rates from this process provide the data to forecast the total potential task pool for the first complete cycle as detailed in Table 4-3.

Table 4-3: Forecast task identification rates with AP&A

Task Type	AP&A Identification Rate (per 1000 poles)	Forecast Tasks for 91% of Rural Network
Low conductor spans	112.258	110,688
Pole-top defects classified as ‘Emergency’, ‘Urgent Risk’ and ‘Risk’	5.807	5,726
Pole-top defects classified as ‘General Maintenance’	19.897	19,619

4.4 Net Identification Rates and Incremental Tasks

Table 4-2 and Table 4-3 show an increase in AP&A identification rates when compared to the identification rate using traditional inspection techniques. This increase in identification rates results from AP&A technology being able to identify a gradual deterioration in condition due to aging. Furthermore, it is evidence that the AP&A process is a warranted technological improvement to identify defects developing on the network prior to functional failure.

This section details how the net incremental tasks that have been forecast for pole-top and low conductor defects. In general, the net incremental tasks are the AP&A forecast task volume reduced by the traditional forecast task volume. The net identification rate and net incremental task volume are used to determine the incremental expenditure required to rectify the identified defects.

4.4.1 Net Incremental Tasks – Pole-top

Only tasks classified as ‘Emergency’, ‘Urgent Risk’ and ‘Risk’ are considered when determining the net incremental pole-top tasks. ‘General Maintenance’ tasks are unlikely to warrant a response within the current regulatory period (outside of normal scheduled maintenance); these tasks are an indication of emerging condition and the data is retained to assist with future analysis.

As shown in Table 4-4, there are 4,867 incremental pole-top tasks that are a result of the new AP&A inspection process. For pole-top tasks, there will be a fault & emergency reduction to this value as outlined in section 4.4.1.1.

Table 4-4: Incremental task identification – Pole-top¹⁷

Year ¹⁸	Number of Poles Inspected	Traditional Inspection Techniques		AP&A Inspection Techniques		Incremental Tasks Identified
		Identification Rate ¹⁹ per 1000 poles	Forecast Task Volume	Identification Rate per 1000 poles	Forecast Task Volume	
2014/15	291,696	0.88	257	5.87	1,712	1,455
2015/16	253,916	1.49	378	9.94	2,524	2,145
2016/17	246,239	0.60	148	4.00	985	838
2017/18	194,162	0.39	76	2.60	505	429
Total	986,013	0.870	858	5.807	5,726	4,867

4.4.1.1 Fault and Emergency Reduction – pole-top assemblies

Allocating an offset for prevented Fault and Emergency (F&E) pole-top assembly failures is required to ensure that the total cost estimate of the programme is not overstated. The following assumptions have been used:

- > 30 per cent of all ‘Emergency’ (A1) and ‘Urgent Risk’ (A2) work tasks are assumed to fail prior to identification by another means and the cost of rectification has been excluded. The offset is included in forecast program costs.
- > For ‘Risk’ (A3) work tasks, it is assumed 10 per cent of tasks would have failed prior to being identified by another inspection programme. This proportion of rectification costs has been excluded from the step change to implement the programme.

Table 4-5 details the number of identified tasks that would have caused functional failures had they not been identified through the AP&A²⁰ programme and the avoided F&E tasks.

¹⁷ Emergency, Urgent Risk and Risk tasks only. General Maintenance is excluded as these tasks will be deferred.

¹⁸ FY 2018 is not shown since the AP&A inspections will be completed in FY2017 with no comparison to FY2018. Further, AP&A inspection typically performed with the April to September period (before the fire season). For example, the 2014/15 results are for the patrols prior to the 2014/15 bushfire danger period.

¹⁹ Identification rate varies depending on the different asset condition across localities. Rate based on historical data from traditional inspections.

²⁰ Urgent Risk and Risk tasks only. General Maintenance is excluded as these tasks are considered unlikely to result in failures prior to the next inspection.

Table 4-5: Fault and emergency avoided work tasks

Additional Emergency (A1) & Urgent Risk (A2) Tasks	Additional Risk (A3) Tasks	F&E avoided A1 & A2 Tasks @ 30%	F&E avoided Risk (A3) Tasks @ 10%	Total F&E Avoided Tasks
919	3975	277	398	676

A total of 676 conditional failures are estimated to eventuate into functional failures prior to identification by another inspection method or cycle. These tasks have been discounted from the pole-top incremental tasks and the estimated cost of the AP&A programme of works.

4.4.2 Net Incremental Tasks – Low Conductor

Low conductor defects have traditionally been detected by the ground pole and line inspection process. Where the asset inspector suspected low conductors and the span can be accessed, the conductors would be measured with a range finder to establish if regulatory clearance existed. Table 4-6 details the incremental low overhead conductor task identification through the new AP&A process.

Table 4-6: Incremental task identification – Low Overhead Conductors

Year ²¹	Number of Poles Inspected	Traditional Inspection Techniques		AP&A Inspection Techniques		Incremental Tasks Identified
		Identification Rate per 1000 poles	Forecast Task Volume	Identification Rate per 1000 poles	Forecast Task Volume	
2014/15	291,696	18.188	5,305	112.258	32,745	27,440
2015/16	253,916	18.188	4,618	112.258	28,504	23,886
2016/17	246,239	18.188	4,479	112.258	27,642	23,164
2017/18	194,162	18.188	3,531	112.258	21,796	18,265
Total	986,013	18.188	17,933	112.258	110,688	92,755

4.4.3 Summary of Net Incremental Tasks

A summary of the incremental pole-top tasks and low overhead conductor tasks are detailed in Table 4-7. This incremental summary details the tasks over and above the tasks that would be found from the conventional ground pole and line inspection and visual aerial patrol and also the expected reduction in Fault and Emergency tasks.

²¹ FY 2018 is not shown since the AP&A inspections will be completed in FY2017 with no comparison to FY2018. Further, AP&A inspection typically performed with the April to September period (before the fire season). For example, the 2014/15 results are for the patrols prior to the 2014/15 bushfire danger period.

Table 4-7: Summary of net incremental tasks

Year	Poles Inspected	Pole-top Incremental Tasks ²²	Pole-top F&E Task Reduction	Net Pole-top Tasks	Net Low Conductor Tasks ²³
2014/15	291,696	1,455	200	1,256	27,440
2015/16	253,916	2,145	174	1,971	23,886
2016/17	246,239	838	169	668	23,164
2017/18	194,162	429	133	296	18,265
Total	986,013	4,867	676	4,191	92,755

4.5 Asset Condition, Task Description & Risk Assessment

Tasks from AP&A can be generally classified as:

- > Pole-top tasks – Refer to section 4.4.1 and 4.5.1
- > Low overhead conductor tasks– Refer to section 4.4.2 and 4.5.2
- > Vegetation encroachment – Refer to Attachment 7.10 Vegetation Management

4.5.1 Pole-Top Tasks

4.5.1.1 Pole-top Asset Condition and Failure Rates

The conditionally failed components which are predominately timber crossarms, if left in service would eventually result in functional failures. The assessment of a timber crossarm whether from the ground or from a high resolution photograph is not an exact science. The variability in timber fibre strength and strength reduction from decay cannot be objectively measured in any practical sense on an in-service component. The assessment relies on experienced operatives visually assessing the asset from images or during an on-site inspection. Replacement is scheduled for assets with a high risk of functional failure, ensuring that the failure rate is contained to a tolerable level. Essential Energy has a high component failure rate as detailed in Table 4-8 compared to the Victorian DNSP's as recorded by the Victorian State safety regulator.

Table 4-8: Total Asset Failures 2013

Category	Essential Energy ²⁴	All Victorian DNSP's ²⁵
Total Asset Failures	10,809	2,269
Normalised Asset Failures (/100km)	5.9	1.4
Normalised Asset Failures (/1000 poles)	7.9	1.8

The asset failure rate for Essential Energy is some 4.2 times higher than for the Victorian DNSP's. This indicator is systemic of a network with low historical replacement expenditure and long calibrated replacement lives. As shown in Table 4-9, Essential Energy's calibrated replacement life of 70.3 years is only exceeded by one NEM DNSP being Citipower, with an incomparable city underground network.²⁶ Consequently when compared to peers, Essential Energy pushes assets to greater average replacement lives.

²² Pole-top assembly tasks exclude General Maintenance (A4) tasks as these are scheduled at next routine maintenance only

²³ Not all low mains tasks will be scheduled for completion in this regulatory period. A risk approach will be taken as detailed in section 4.5.2.2 and Appendix E

²⁴ Essential Energy Electricity Network Incident Report - Excludes fuse operations

²⁵ Safety Performance Report on Victorian Electricity Networks 2013, Energy Safe Victoria, June 2014, p. 7

²⁶ Refer to Attachment 6.6 – Response to AER draft decision of replacement expenditure, p 31

Table 4-9: Weighted asset calibrated life²⁷

DNSP	Average Weighted Life (years)	Variance
Essential Energy	70.3	0%
Ausgrid	59.6	-15%
Endeavour	50.4	-28%
VIC Benchmark	64.2	-9%
Aurora	57.9	-18%
United	70.3	0%
Jemena	61.1	-13%
AusNet	66.8	-5%
Powercor	64.7	-8%
CitiPower	78.9	12%
AER Benchmark	67.5 ²⁸	-4%

Essential Energy’s higher calibrated replacement life is evident in the historical spend profile, displayed in Figure 4-1 which shows that Essential Energy has historically low replacement rates that are on the frontier of industry performance.

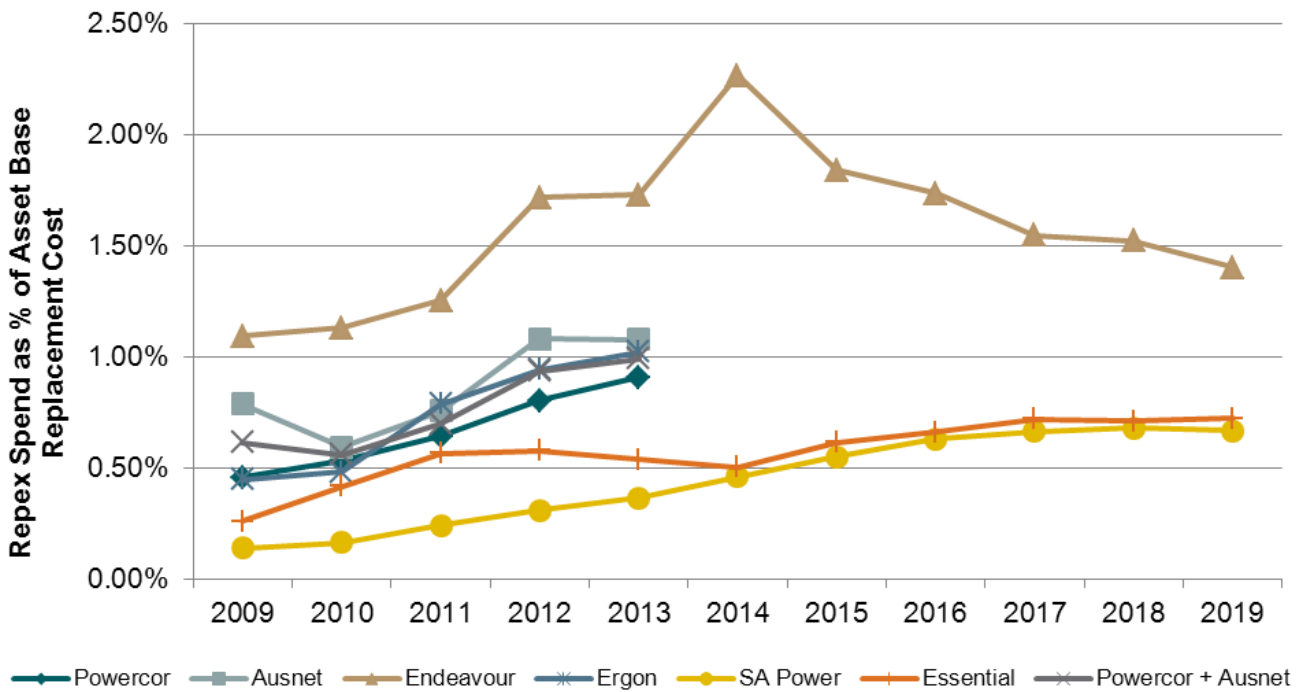


Figure 4-1: Repex spend by asset base replacement cost^{29 30}

²⁷Source: Nutall Consulting, Report - Aurora Revenue Review, Nov 2011 and AER NSW draft decision 2014-19 calibrated Repex Models. Victorian and Tasmanian data based on 2004/05 to 2008/09 period. SA Power, Ergon and Energex are not included due to lack of AER published calibrated ages.

²⁸ AER data – outliers greater than 1 standard deviation removed. Refer to Attachment 6.6 – Response to AER draft decision of replacement expenditure.

²⁹ Replacement costs determined using; RIN asset quantities and the AER’s NEM Benchmarked unit costs - categories included Poles, OH Conductor, UG Cable, Services, Transformers, Switchgear (including categories added by DNSP’s under these headings) – where a benchmarked unit cost does not apply to DNSP listed category the DNSP’s calculated (historic) unit cost is used.

³⁰ Annual Repex spend determined using: RIN table 2.2.1 - Poles, OH Conductors, UG Cables, Service Lines, Transformers, Switchgear and Other (DNSP listed Other – this category is mostly used by Ausgrid and Endeavour)

Figure 4-1 provides a benchmark of repex spend normalised by asset replacement cost of each DNSP; this is used due to the strong correlation between asset quantities and replacement expenditure demand. Each DNSP's asset quantities are applied to the AER's provided NEM benchmarked unit costs to provide an asset base replacement cost. The AP&A inspection process is required to ensure Essential Energy's fiscally efficient low replacement strategy can be maintained without undue escalation in failure rates and resultant risk.

Essential Energy's timber crossarm failure rate is known to be increasing. Figure 4-2 shows an increasing trend in the probability of failure for timber crossarms related to supply interruptions sourced from outage data. The data has been normalised for the population of timber crossarms in service in each year. Based on the trend, the need for intervention is compelling. Essential Energy has determined to use the improved technology of the AP&A process rather than pursue a more expensive bulk replacement strategy or accept escalating fault and emergency opex costs and in so doing, will be able to identify the conditionally failed components and allocate resources to the most severe defects.

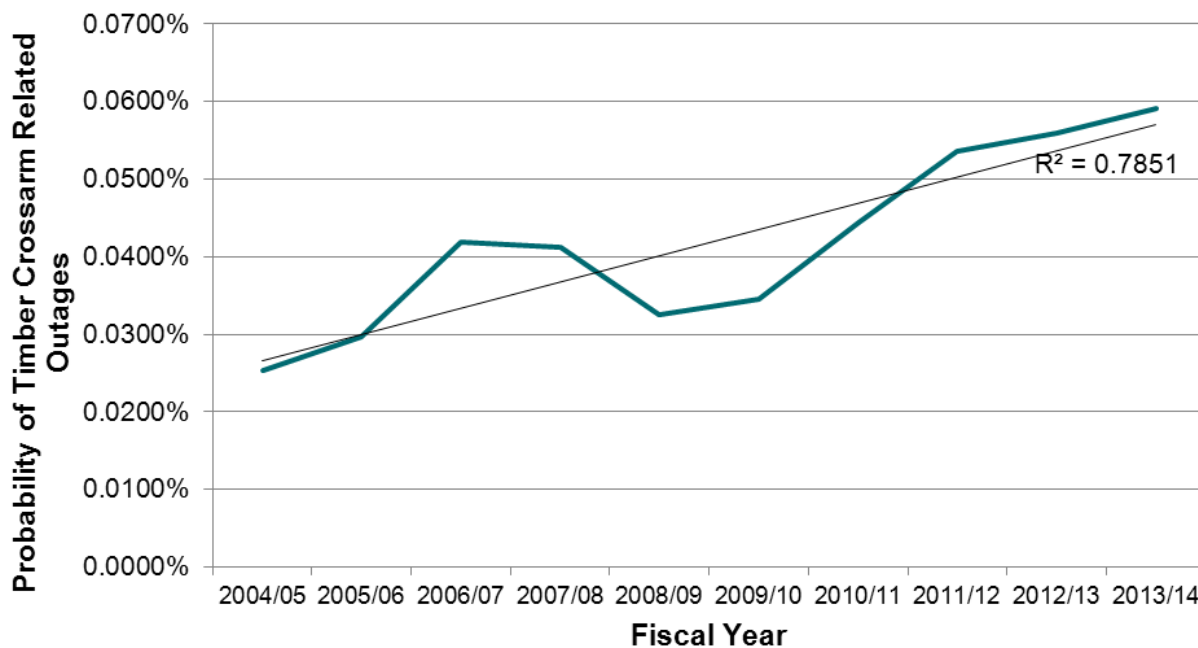


Figure 4-2: Probability of timber crossarm related outages

4.5.1.2 Pole-top Task Descriptions

Pole-top tasks include but are not limited to:

- > Severely piped and split pole heads
- > Broken crossarms
- > Split and decayed crossarms
- > Wind milling crossarms
- > Corroded fixing hardware
- > Severely weathered crossarms
- > Termite infestation
- > Decay in crossarms and pole heads
- > Broken insulators
- > Insulator pins wearing through crossarms
- > Eye bolts pulling through crossarms
- > Broken and corroded ties
- > Corroded conductor
- > Conductors on arms
- > Missing fixing hardware.

Figure 4-3 show typical pole-top defect tasks from high resolution photography. These photos demonstrate the value of the AP&A programme; traditional inspection methods such as ground based inspections and visual aerial patrols are unable to identify many of these defects.



Crossarm deteriorated, severe weathered cracks – A3 Task



Crossarm deteriorated, hole in end of arm – A3 Task



Crossarm deteriorated – A3 task



Large crack and hole in end of crossarm – A3 task



Crossarm deteriorated, deep cracks, weathered – A3 task



Crossarm deteriorated, deep crack, weathered– A3 task

Figure 4-3: Sample 2014 AP&A pole-top asset photographs

The photo samples show that typically the crossarms deteriorate on the top face which is most exposed to the weather. The condition on the top of the arm where the condition is often poorest is not visible to the ground line inspector, hence the increased volume of defected crossarms identified by the AP&A inspection process.

Each of the photographs taken undergoes desktop review by the contracted service provider and Essential Energy technical staff to ensure the correct priority and risk categorisation is allocated. Tasks are packaged to coincide with other maintenance, escalated or deferred as the circumstances require. Pole-top defect tasks are typically Opex in nature with a small percentage being Augex; where pole replacement is required.

Approximately 70 per cent of network fire starts³¹ occur from asset failures; of which the majority are pole-top asset failures. The number of escaped fires peaks in the fire danger period with potential for significant impact to communities and the environment. Assessment of fire risk is detailed in Appendix B.

To mitigate this risk Essential Energy is focussed on minimising the unplanned pole-top asset failures particularly throughout the bushfire danger period by identifying and attending to defects detected by aerial inspections.

Verifiers classify the condition of tasks from the high resolution photographs based on the risk and severity of the defect. The tasks are then allocated to one of the following categories which determines required rectification period:

- > A1 - Emergency (<48 hours)
- > A2 – Urgent Risk (<14 days).
- > A3 – Risk (<6 months)
- > A4 – General Maintenance (deferred to next opportunity or next inspection review)

The risk prioritisation of defect tasks is detailed in Appendix C.

4.5.2 Low Conductor Tasks

4.5.2.1 Low Conductor Data and Proposed Rectification Strategy

The 2014 pilot of the AP&A (LiDAR) survey detected a potential 32,745 (11 per cent of spans surveyed) high voltage and low voltage spans below statutory clearances. This includes high voltage spans surveyed on cool days, that when profiled for typical summer temperatures, were below statutory clearances.

Site audits have been undertaken to confirm the results of the survey and where appropriate, the data has been cleansed to ensure that only non-compliant tasks have been retained.

A total of 110,688 identified tasks have been forecast for the current AP&A cycle. Due to the task quantum, Essential Energy plan to rectify 57 per cent of the tasks within the current regulatory control period. The remaining 43 per cent will be addressed in subsequent years. A risk assessment is performed to prioritise the rectification of high risk tasks.

4.5.2.2 Risk Assessment of Low Overhead Conductor Tasks

Low clearance to exposed (bare) energised overhead conductors and apparatus falls directly within the scope of Network Fatal Risk 1.1 – Contact with Electricity. The likelihood of contact will be related to the actual clearance, most commonly ground clearance, and the land use at the point of the non-compliant clearance. Non-compliant clearances which are less than the minimum clearance for people or public activities are classified as CAT1 defects due to the increased potential for fatal consequences taking into account the land use scenarios³².

All low spans are non-compliant in regard to the statutory requirements and efforts to address this, need to be demonstrated. The regulatory requirements and clearances are detailed in Appendix D. It is acknowledged that the low spans detected, represent different levels of public risk and should be addressed in an orderly fashion.

It is expected that once the spans detected by AP&A are rectified, a much lesser rate of identification is likely in future regulatory periods. To a material degree, the increase in identified work tasks is as a consequence of the new technology assisting with identification of non-compliant spans.

There are three stages to managing the risk of low overhead conductors:

³¹ Essential Energy annual fire reports: Full year fire report 2012/13, End of season fire report 2013/14.

³² Common Network Defects Prioritisation Framework - NNSW , 2014

1. Given the volume of tasks identified by LiDAR measurements, a desktop risk evaluation is applied based on information available from the aerial survey to determine the site inspection priority.
2. An estimate of those requiring action within the regulatory period 2015 – 2019 is undertaken.
3. Each span must ultimately be site inspected to ascertain the public risk level and to review all site conditions to determine a suitable priority and the appropriate rectification action.

As an initial pass, each task has been scored on three criteria provided by the LiDAR data:

- > *Is the conductor over a roadway?*
- > *How far below the required height is the conductor using four ranges (<10%, 10-20%, 20-30%, >30%)?*
- > *What type of conductor is it (low voltage, high voltage, sub-transmission)?*

This provides a guide to the priorities for further site assessment which allows more layers of information. The prioritisation framework for low overhead lines is articulated in the Network Defects Prioritisation Framework (NDPF). The approach provides for risk based classification of low clearance defects based upon factors of actual clearance deviation, conductor type, public access and operating voltage. Appendix C includes an extract of the important table from the framework.

4.6 Options Analysis

Essential Energy acknowledges that it is not possible, nor prudent to attempt completion of all tasks, therefore tasks have been classified in terms of risk severity in order to respond to a limited number of the higher risk tasks.

Several options for rectification of predicted defects are contained in Table 4-10. These show the difference in the forecast required investment and identify the balanced approach implemented by Essential Energy in selecting an option that considers both the risk exposure and subsequent impact on Augex and Opex. Option 2 has been adopted as the preferred approach.

4.6.1 Options Analysis – Pole-Top Tasks

A number of options are discussed in Table 4-10 for rectification of tasks associated with pole-top asset condition. Option 2 is the preferred case which seeks to balance the resource impact and public safety outcomes.

Table 4-10: options with different levels of risk acceptance

Tasks Classification	Task Volume	Forecast Opex \$M	Forecast Augex \$M	Comment
Option 1 Emergency and Urgent tasks. A1 & A2 Priority completion expected within 48 hours & 14 days respectively	803 793 OPEX 10 AUGEX	\$0.9M	\$0.06M	This would result in removal of the most immediate priority tasks or very high risk tasks only. Results in deferral of many crossarms with significantly deteriorated or degraded condition. This is not considered an acceptable risk position as A3 rated tasks deferred under this option are conditionally failed and in a wind event will likely fail. This leads to increased risk of fire starts and/or potential contact by public with fallen wires. Deferral of crossarms rated as A3 risks is not standard industry accepted practice.

Tasks Classification	Task Volume	Forecast Opex \$M	Forecast Augex \$M	Comment
Option 2 (preferred option) Emergency, Urgent and Risk tasks A1, A2 & A3	4,191 4,141 OPEX 50 AUGEX	\$4.9M	\$0.3M	The majority of these are (A3) crossarms which rate a material risk and are conditionally failed. A high wind event may result in failure. This option minimises the tasks to be rectified to only those which represent a high degree of uncertainty for failure in a high wind event, with ensuing public risk. It allows for deferral of a considerable number of A4 tasks.
Option 3 All tasks - including those where asset degradation is least significant A1, A2, A3, & A4	23,235 22,956 OPEX 279 AUGEX	\$27.1M	\$1.6M	The most significant proportion of tasks found are classified as A4 – General Maintenance. That is to indicate that the asset is degraded to a point where replacement should be considered over the coming years. For efficiency these are normally packaged in preparation for replacement if and when the opportunity arises to visit the asset before the next inspection cycle or are left and monitored by future inspections Essential Energy does not consider it is prudent or necessary to accelerate replacement of these tasks.

4.6.2 Options Analysis - Low Conductor Tasks

A number of options are discussed in Table 4-11 for rectification of tasks associated with low overhead conductors. Option 2 is the preferred case which seeks to balance the resource impact and public safety outcomes.

Table 4-11: Options with different risk tolerance

Tasks Classification	Task Volume	Forecast Opex \$M	Forecast Augex \$M	Comment
Option 1 25% of identified tasks. Most severe/high risk tasks prioritised.	23,189 17,392 OPEX 5,797 AUGEX	\$18.8M	\$33.7M	Not considered an acceptable risk position to leave majority of tasks below statutory clearances in public accessible places. Rectification of 25 per cent does not mitigate a substantive number of high risk sites.
Option 2 (preferred option) 57% of identified tasks. Most severe/high risk tasks prioritised.	52,989 39,741 OPEX 13,247 AUGEX	\$43.0M	\$77.1M	This option balances the public risk and forecast costs. It allows for deferral of some 43 per cent of the required investment without a material increase in public risk. This would allow rectification of most trafficable sites.
Option 3 All identified tasks under statutory clearances.	92,755 69,566 OPEX 23,189 AUGEX	\$75.3M	\$134.9M	Attending to all low spans within the regulatory period would put significantly more pressure on the opex and augex allocations. It does not include any deferral which Essential Energy considers overly risk averse.

4.7 Forecast Programme of Works

The forecast work tasks and the estimated cost are set out in more detail in Appendix E.

4.7.1 Forecast Programme of Works – Augex – Option 2

Table 4-12 details the forecast augmentation programme of works to address the augex required to rectify A1, A2 & A3 pole-top work tasks (option 2) and 57 per cent of the low overhead conductors (option 2).

Table 4-12: Proposed programme of works – augex

AUGEX	2014/15	2015/16	2016/17	2018/19	Total
Pole-top Augex Tasks	15	24	8	4	50
Low Conductor Augex Tasks	3,919	3,411	3,308	2,609	13,247
Proposed Incremental Tasks	3,934	3,435	3,316	2,612	13,297
Pole-top Augex ³³	\$87,642	\$137,616	\$46,657	\$20,659	\$292,574
Low Conductor Augex ³⁴	\$22,796,193	\$19,843,667	\$19,243,705	\$15,173,861	\$77,057,426
Total Expenditure	\$22,883,835	\$19,981,282	\$19,290,362	\$15,194,520	\$77,350,000

4.7.2 Forecast Programme of Works – Opex – Option 2

Table 4-13 details the forecast operating programme of works to address the opex required to rectify A1, A2 & A3 pole-top work tasks (option 2) and 57 per cent of the low overhead conductors (option 2).

Table 4-13: Proposed programme of works – opex

OPEX	2014/15	2015/16	2016/17	2018/19	Total
Pole-top Opex Tasks	1,240	1,948	660	292	4,141
Low Conductor Opex Tasks	11,757	10,234	9,925	7,826	39,741
Proposed Incremental Tasks	12,997	12,182	10,585	8,118	43,883
Pole-top Opex ³⁵	\$1,466,050	\$2,301,997	\$780,467	\$345,585	\$4,894,099
Low Conductor Opex ³⁶	\$12,720,555	\$11,073,009	\$10,738,223	\$8,467,200	\$42,998,988
Total Expenditure	\$14,186,605	\$13,375,006	\$11,518,691	\$8,812,785	\$47,893,087

³³ For pole-top augex unit cost refer to Appendix E

³⁴ For low conductor augex unit cost refer to Appendix E

³⁵ For pole-top opex unit cost refer to Appendix E

³⁶ For low conductor opex unit cost refer to Appendix E

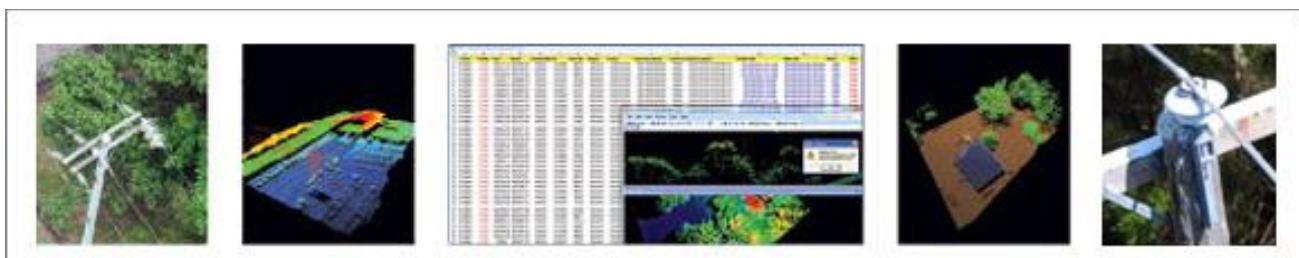
APPENDIX A: WHAT IS AP&A (LIDAR)

Aerial Patrol and Analysis (LiDAR) inspections of the network utilise high definition photography and radar cameras on aircraft to survey the overhead assets. All pole-tops are photographed for detailed desktop analysis in the office environment. LiDAR is used to determine distances and conductor profiles in a 3D model. This provides conductor ground clearances and accurate measurement of clearances between vegetation and conductors.

Essential Energy employed two vendors in 2014 to provide this service from a competitive tendering process. The vendors used were HAWCS and FUGRO based in Brisbane QLD.

Reporting & Delivering:

- A high resolution digital image of asset, linked to the pole number/asset ID.
- A map of every feeder patrolled with hotlinks to the image.
- Additionally, images are geo-referenced and tagged with Lat / Lon, Date / Time and height.
- Every vegetation exception would feature on this map, hotlinked to a digital photo and image of the LiDAR scan of the area, with an accurate measurement determining distance from the conductor.
- Fault & Vegetation Template Spreadsheets customized for needs & systems.
- Aircraft Track Files: showing exact flight paths and heights.
- Reports are provided in PDF format.
- GIS exported data.



Comparing the different inspection systems

Caution should be exercised in drawing conclusions about one inspection system versus another without a full understanding of the value each provides. As an example, on the surface of the findings discussed in this paper, the value of the traditional inspection methods may be questioned in light of the fact that the AP&A has detected more trees, more pole-top assets with defects and more ground clearance issues. Without going into a full and detailed analysis of all the inspection methods and results here, it is fair to say that they perform different functions at different cost structures and used correctly complement each other. As a quick example the aerial inspection processes strength is the top down view of the assets but it does not provide the asset manager with understanding of the remaining timber pole life, nor do they provide earthing integrity readings, as the ground line inspections do.

It is also problematic to make direct comparisons with traditional aerial patrols and the AP&A (LiDAR) as the scope for reporting for the traditional process is different. For example in the absence of tools to accurately measure clearance distances the observers are simply making an estimate of a tree's clearance within ranges of 0-1.5m or 1.5-3m off the

conductor by sight. The traditional method does not take into account the span length and sag & sway calculations as the more precise AP&A method does using backend algorithms. Therefore the traditional method is not being asked to identify all clearance breaches as the AP&A is, but a simplified view of trees that might be relatively close to conductors by the naked eye. Naturally this results in fewer sightings by the traditional method but the practical completion of patrols is faster and costs less. It is a reasonable balance between cost and risk identification for the vast rural network so much so that it can be afforded on an annual basis before the fire season.

AP&A proposed inspection schedule:

The schedule is based on managing impact and expenditure each year and the order is based on the bushfire risk potential but programme priorities also take account of pole-top component conditions reported from aerial patrol and the status of vegetation management.

Planned priority for contracted AP&A (LiDAR) services are:

1. 2014 - All Essential Energy Regional Risk Profile = “High” zone (291,000 spans)
2. 2015 - Majority of the Northern except for depots in the lower part (240,000 spans)
3. 2016 - Lower part of Northern and inland part of Southern (241,000 spans)
4. 2017 - North Coast region (140,000 spans)
5. The Far West region is not being considered for LiDAR at this stage as it has been assessed as low risk.



Figure 4-4: AP&A Inspection schedule map

APPENDIX B: AP&A – MANAGING THE PUBLIC SAFETY RISK

AP&A inspections assist in reducing the risk of bushfires emanating from powerlines by accurately identifying trees within the safety clearance zones as well as those approaching these clearances. It also captures the condition of the pole-top assets in order to identify asset maintenance and replacement needs. Many of the damaged or degraded assets identified by AP&A are a bush fire or public shock risk.

The AP&A also assists in enhancing public safety by identifying ground clearances that do not meet the statutory minimum heights. Identifying and rectifying these reduces the potential for wire strikes by machinery or public coming into direct contact with live conductors.

Figure 4-6 below indicates the states of VIC, NSW and TAS have the largest saturation of bushfire potential zones as a percentage of the land mass. The potential for impact on lives and public assets can be seen when you overlay the corresponding population density. This bush fire risk profile is notable particularly when compared to other states such as SA and QLD. Whilst most of Australia experiences wildfires, impact on communities and consequential losses in the states of VIC, NSW and TAS have been historically higher than the other states when looking back over 100 years as highlighted by Risk Frontiers³⁷.

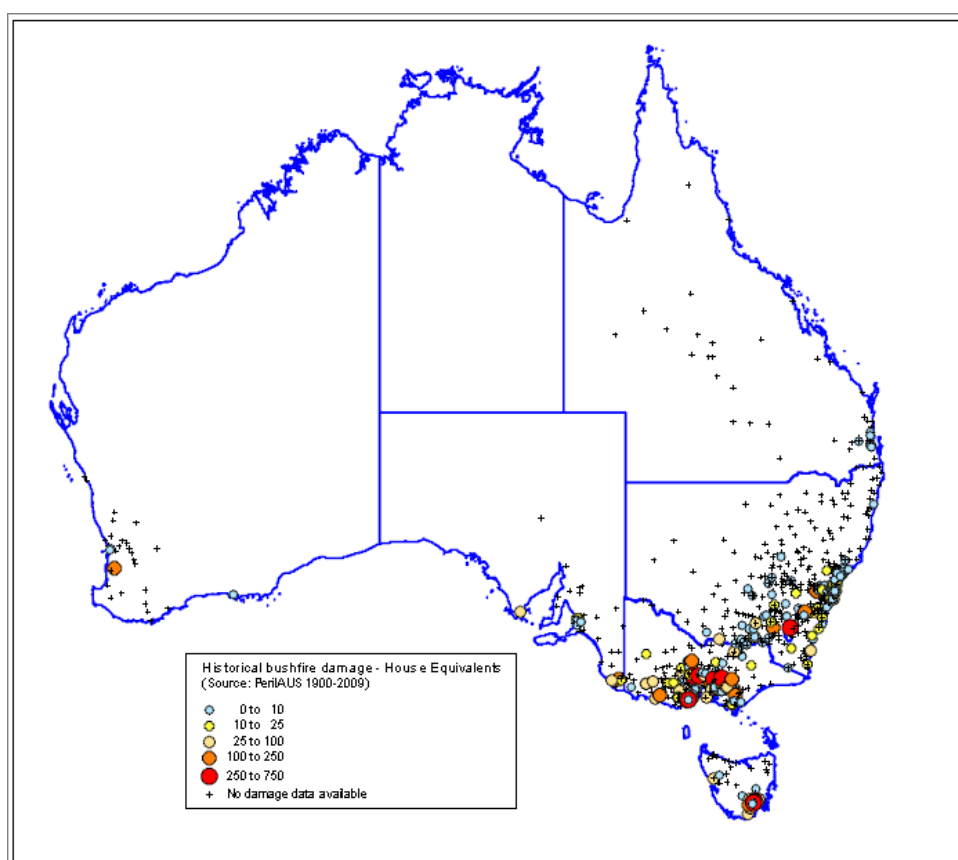


Figure 4-5: Historic House losses: PerilAUS 1900-2009

Although Figure 4-6 shows NSW has no extreme rated zones, it cannot be complacent as it does have significant areas rated as Very high, high, and moderate. Fires under these conditions have often been associated with serious consequences to the general public.

³⁷ Risk Frontiers & Bushfire CRC publication: Bushfire penetration into urban areas in Australia: A spatial analysis, January 2010, page 4 Fig. 3.

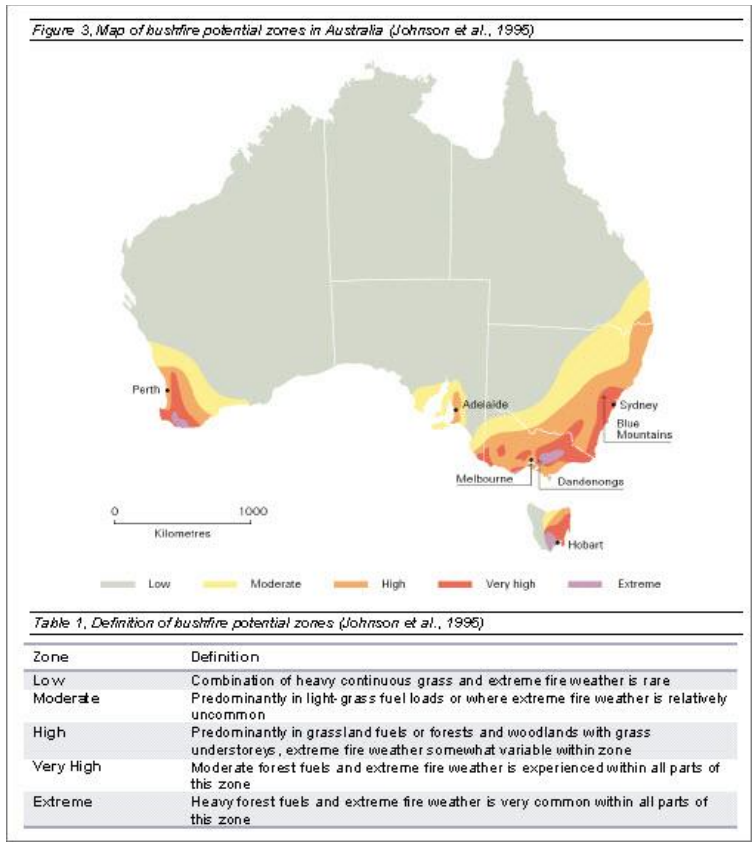


Figure 4-6: State Bushfire Risk Differences

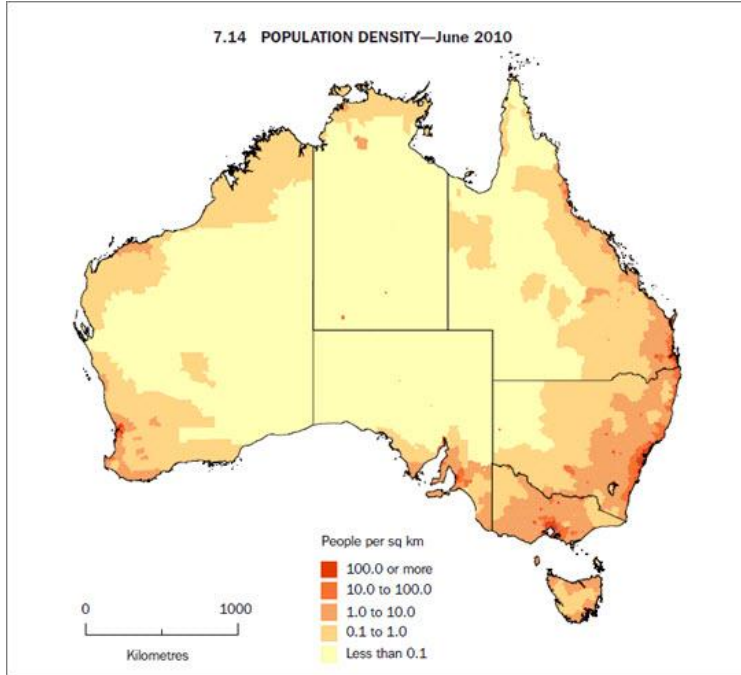


Figure 4-7: Population Distribution 2010 ABS

Essential Energy’s Network was responsible for approximately 800 fire starts in the last two years (2012/13 -2013/14). The vast majority of these occur at the most dangerous time (in the bushfire danger period - Spring and Summer) when conditions are most conducive to ignition of surrounding vegetation and more difficult to suppress. The trend over many years shows that approximately 70 per cent of all network fires are due to asset “in service” failures of which the

vast majority are associated with pole-top assets and conductors. The AP&A investment in pole-top photography is an effort to manage this risk to an acceptable level.

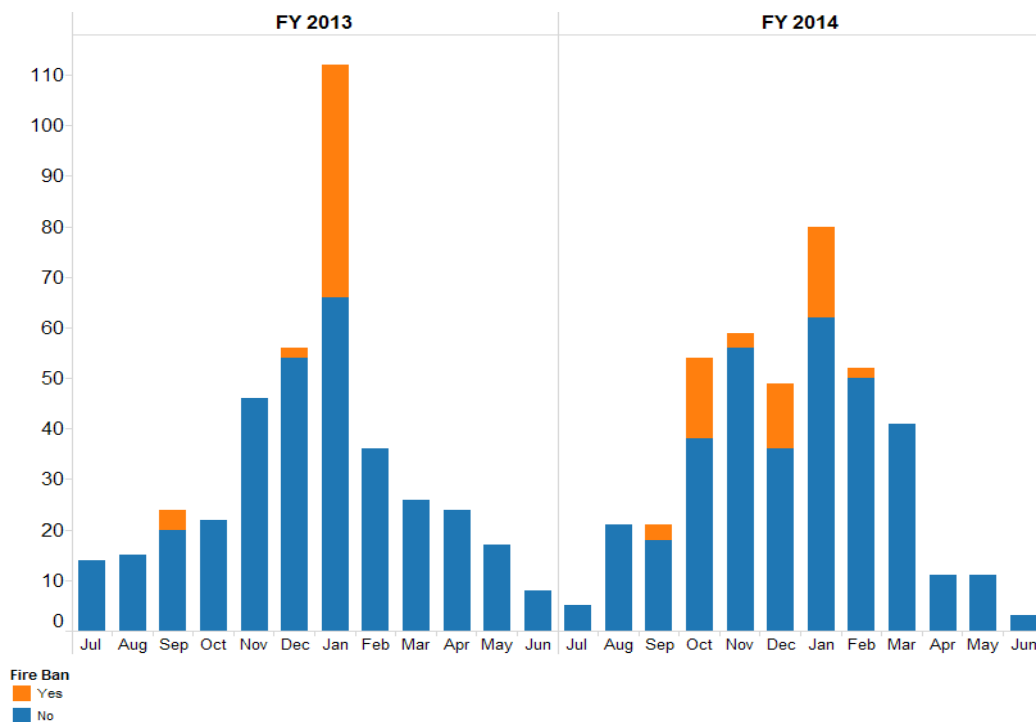


Figure 4-8: Oct-Mar Peak in Network Fire Start

Majority of network fire starts occur year to year in the NSW fire danger declaration period. This has been the general trend since network fire start records have been kept. This trend should not be surprising as network faults producing sparks occur all year round but in the cooler / wetter months when vegetation is greener, the available sparks are not able to cause ignition of the greener vegetation or if they do, more often self-extinguish.

Table 4-14: Network Fire starts by cause group

SC Cause Code Group	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Asset Breakdown	67.07%	81.65%	68.06%	69.49%	69.86%
Vegetation contact with assets	17.37%	8.26%	9.95%	9.89%	13.52%
Bird/Animal contact	8.98%	3.67%	10.47%	15.54%	12.11%
Human activity contact with assets	6.59%	6.42%	11.52%	5.08%	4.51%
Grand Total	100.00%	100.00%	100.00%	100.00%	100.00%

Recent Phoenix Fire modelling conducted by Australian fire modelling expert, Dr Kevin Tolhurst and his team at University of Melbourne, of potential losses due to fires emanating from powerlines in NSW shows that there is potential for losses of hundreds of homes from a single fire event in severe fire weather conditions experienced by NSW in recent times and within the Essential Energy footprint. A responsible asset manager must acknowledge these facts, and it is therefore incumbent on distributors to utilise inspection tools such as AP&A inspection to mitigate such risk, particularly in regard to providing appropriate levels of network maintenance and replacement. This challenge becomes more evident when considered in conjunction with climate change forecasts of more frequent extreme fire weather days for NSW³⁸.

³⁸ CSIRO: Understanding Extreme Weather Changes, 20th Nov 2012: www.csiro.au/Outcomes/Environment/Extreme-Events/Understanding-extreme-weather-changes.aspx; NSW Dept of Environment & Heritage: NSW Climate change snapshot Nov 2014

Low Conductor Ground Clearances

Wirestrike of overhead conductors by people and machinery is not uncommon particularly in a rural setting where farms typically contain a mixture of network overhead powerlines, residences and people. Over the years there has been a steady increase in the use of larger agricultural machinery for on-farm efficiencies and lower wires that were once avoidable are not necessarily so today. With this in mind distributors like Essential Energy have to be vigilant in their detection and correction of wires under the statutory height requirements. A number of fatalities and injuries result from wire strikes in the industry in Australia each year. The statutory minimum ground clearances for conductors are the primary driver to mitigate these accidents.

APPENDIX C: THE RISK ASSESSMENT APPROACH

The allocation of a risk categorisation is applied to corrective maintenance tasks as they are reported. This is a primary driver of the prioritisation placed on corrective actions. It is an industry practice to apply risk classifications to groups of task types as they are repetitive, high volume individual tasks which have similar characteristics in terms of the potential for failure based on condition.

Whilst there may be minor variations in description and definitions, these classifications are used throughout the industry as “pre-determined” classifications for typical corrective tasks. They have been developed over a lengthy period of time in consideration of engineering principles, standards, historic events, failure histories, community and regulatory expectations, and many years of condition monitoring by DNSPs to rely on.

Existing Task Category Definitions

Corrective work tasks are recorded in the company's Asset Management System (AMS) with a repair priority (severity) reflecting the associated risk condition. The identification of corrective work tasks must be made based on the condition of the component as observed by the Asset Inspector during the inspection process.

- > **Emergency:** A1 – The component has functionally failed and poses an immediate risk.
- > **Urgent risk:** A2 - The defect is assessed as a high risk with the potential to affect continuity of supply, safety or pose a significant environmental risk. These defects require rectification within 14 days.
- > **Risk:** A3 - The defect is assessed as a medium level risk with the potential to affect system reliability, safety, or the environment if left in its present condition and will require rectification within a six month period.
- > **General Maintenance:** A4 - These defects pose no short term threat to system reliability or safety but if left untreated would have the potential to create unnecessary network issues over time.

The *urgent risk* and *risk* classifications generally fall into the category of ALARP principles.

As Low As Reasonably Practicable (ALARP)

Core to this concept is “reasonably practicable”. The objective is to eliminate risk. If it is not reasonably practicable to eliminate a risk, then it should be minimised to as low as reasonably practicable (in accordance with the hierarchy of controls). ALARP is the level of risk that is tolerable and cannot be reduced further without the expenditure of cost, time and/or effort that is disproportionate to the benefit gained or where the solution is impractical to implement.

Low Ground Clearance Tasks

Low clearance maintenance tasks to exposed (bare) energised overhead conductors and apparatus fall directly within the scope of Network Fatal Risk 1.1 – Contact with Electricity. The likelihood of contact will be related to the actual clearance, most commonly ground clearance, and the land use at the point of the low clearance task. Low clearances which are less than the minimum clearance for people shall be classified as CAT 1 task due to the potentially fatal consequences of the contact in the land use scenarios.

The following two tables show the response for the two most common conductor low clearance types:

- > CAT1 – Immediate Rectification
- > CAT2 – Rectify within 1 month
- > CAT3 – Rectify within 6 months
- > CAT4 – Rectify within 2 years or when packaged with other works

LV Bare / Insulated / Covered & HV ABC

- > Task Prioritisation – LV Bare / Insulated / Covered & HV ABC Conductors

	Over the carriageway of designated 4.6 m roads	Over the carriageway of all other roads	Over land other than the carriageway of roads	Over land which due to its steepness or swampiness is not traversable by vehicles
≤ 3.2 m	CAT 1	CAT 1	CAT 1	CAT 1
> 3.2 m and ≤ 4.7 m	CAT 1	CAT 1	CAT 2	CAT 4 (Min. Clearance 4.5 m)
> 4.7 m and ≤ 5.0 m	CAT 1	CAT 3	CAT 3	CAT 4 (Min. Clearance 4.5 m)
> 5.0 m and < 5.5 m	CAT 2	CAT 3	CAT 3	No Task

11, 22 or 33 kV Bare Conductor or CCT

- > Task Prioritisation – 11,22 or 33kV Bare Conductors or CCT

	Over the carriageway of designated 4.6 m roads	Over the carriageway of all other roads	Over land other than the carriageway of roads	Over land which due to its steepness or swampiness is not traversable by vehicles
≤ 3.3 m	CAT 1	CAT 1	CAT 1	CAT 1
> 3.3 m and ≤ 5.1 m	CAT 1	CAT 1	CAT 2	CAT 3 (Min. Clearance 4.5 m)
> 5.1 m and ≤ 5.4 m	CAT 1	CAT 3	CAT 3	CAT 4 (Min. Clearance 4.5 m)
> 5.4 m and < 6.7 m	CAT 2	CAT 3	CAT 3 (Min. Clearance 5.5 m)	No Task

APPENDIX D: REGULATORY GROUND CLEARANCES

The minimum allowable ground clearances for all lines are illustrated in the Regulatory Code of Practice: Electricity *transmission and distribution asset management 2009*.

Overhead lines, excluding service lines, “other cable systems” and aerial lines within substations, shall have all conductors located so that the distances to ground in any direction from any position to which any part of such conductors either sag at maximum design temperature or move as a result of wind pressure which could reasonably be expected to occur at the location of the overhead line, are not less than the distances specified in Table 4-15 Table 4-16.

Table 4-15: Section 5.3.5.1 - Clearance to Ground of Exposed and Insulated Conductors

TABLE 1 Nominal system voltage (U) (Volts)	Over the carriageway of roads (mm)	Over land other than the carriageway of roads (mm)	Over land which due to its condition is not traversable by vehicles (mm)
Exposed or insulated U < 1,000 OR Insulated conductor with earthed screen U > 1,000	5,500	5,500	4,500
Insulated conductor without an earthed screen U > 1,000	6,000	5,500	4,500
Exposed or covered conductor 1,000 < U < 33,000	6,700	5,500	4,500
33,000 < U < 132,000	6,700	6,700	5,500
132,000 < U < 220,000	7,500	7,500	6,000
220,000 < U < 330,000	8,000	8,000	6,700
330,000 < U < 500,000	9,000	9,000	7,500

Aerial service lines and “other cable system” shall have the line located so that the distances to ground in any direction from any position to which any part of such lines either sag at maximum design temperature or move as a result of wind pressure which could normally prevail, are not less than the distances specified in Table 4-16.

Table 4-16: Section 5.3.5.2 - Clearances to Ground of Insulated Service Lines

TABLE 2 Service line and “other cable systems” location	Distance from ground any direction (mm)
Over the centre of each carriageway of a public road	5,500
Over any part of a Freeway, Primary Arterial Rd or Highway	5,500
Over any part of a carriageway of a public road (other than the centre)	4,900
Over a vehicular crossing of a footway in a public road (other than a residential driveway)	4,500
Over land which is not associated with a residential dwelling which is likely to be used by vehicles	4,500
Over a vehicular crossing of a footway in a public road for a residential driveway and any other part of a footway	3,000
Over land which is, or likely to be, used by vehicles and is associated with a residential dwelling	3,000
Land not likely to be used by vehicles	2,700

APPENDIX E: PROPOSED TASKS, UNIT RATES & PROGRAM COST

Essential Energy has utilised risk classifications to determine an appropriate action for the identified tasks. Options include rectifying the task in the current regulatory control period or deferring until subsequent periods. Essential Energy has proposed to:

- > Rectify all pole-top A1, A2 and A3 tasks within the current regulatory control period. (refer to Table 4-17)
- > Defer all pole-top A4 tasks for the current regulatory control period. The tasks will be recorded in the Asset Management System (AMS), monitored and then re-assed in the next AP&A inspection cycle. (refer to Table 4-18)
- > Rectify the higher risk (57 per cent) of the low conductor tasks during the current regulatory period. The remaining 43 per cent will be re-assessed in the next AP&A inspection cycle and rectified in subsequent regulatory control periods (refer to Table 4-19)

Table 4-17: Pole-top corrective tasks required in 14-19 RCP (A1, A2 & A3 tasks only)

	Poles Inspected	Tasks Identified by Traditional Inspection	Tasks Identified by AP&A Inspection	Net Incremental Identified Tasks	Fault & Emergency Task Reduction	Tasks Deferred	Total 14-19 Proposed Tasks (=Net Incremental – F&E Tasks – Deferred Tasks)
2014	291,696	257	1,712	1,456	200	-	1,256
2015	253,916	378	2,524	2,146	174	-	1,971
2016	246,239	148	985	837	169	-	668
2017	194,162	76	505	429	133	-	296
TOTAL	986,013	858	5,726	4,868	676	0	4,191

Table 4-18: Pole-top corrective tasks required in 14-19 RCP (A4 tasks only)

	Poles Inspected	Tasks Identified by Traditional Inspection	Tasks Identified by AP&A Inspection	Net Incremental Identified Tasks	Fault & Emergency Task Reduction	Tasks Deferred	Total 14-19 Proposed Tasks (=Net Incremental – F&E Tasks – Deferred Tasks)
2014	291,696	170	5,804	5,634	-	5,634	0
2015	253,916	148	5,052	4,904	-	4,904	0
2016	246,239	144	4,900	4,756	-	4,756	0
2017	194,162	113	3,863	3,750	-	3,750	0
TOTAL	986,013	575	19,619	19,044	0	19,044	0

Table 4-19: Low conductor corrective tasks required in 14-19 RCP

	Poles Inspected	Tasks Identified by Traditional Inspection	Tasks Identified by AP&A Inspection	Net Incremental Identified Tasks	Fault & Emergency Task Reduction	Tasks Deferred	Total 14-19 Proposed Tasks (=Net Incremental – F&E Tasks – Deferred Tasks)
2014	291,696	5,305	32,745	27,440	N/A	11,764	15,676
2015	253,916	4,618	28,504	23,886	N/A	10,241	13,646
2016	246,239	4,479	27,642	23,164	N/A	9,931	13,233
2017	194,162	3,531	21,796	18,265	N/A	7,831	10,434
TOTAL	986,013	17,933	110,688	92,755	0	39,766	52,989

The Essential Energy works estimating team have determined an appropriate unit rate for these types of tasks and this proposed program. Table 4-20 details the average unit rates for defect correction. The rates were built using a

bottom up approach of the resource requirements for an efficient delivery and have since been checked by dividing actual historical account spend, by units volumes at a “whole of business” level.

Table 4-20: Unit Rates \$2014

Task	Expenditure	Unit Rate (\$)	Corrective Action
Pole-top Defects	AUGEX	\$5,817	Replace pole ³⁹
	OPEX	\$1,182	Replace defective pole-top asset (crossarms)
Low Conductors	AUGEX	\$5,817	Replace pole ⁴⁰
	OPEX	\$1,082	Rectify low clearance without pole replacement

Utilising the above unit rates and identified tasks, a program cost can be calculated as shown in Table 4-21. The program cost has been divided into an AUGEX component and an OPEX component as the work task requires. Tasks have been reviewed to determine an appropriate proportion of AUGEX and OPEX related work.

- > For pole-top tasks –
 - 1.2 per cent of tasks are AUGEX related (ie/ pole replacements)
 - 98.8 per cent of tasks are OPEX related (ie/ crossarm repair)
- > For low conductor tasks –
 - 25 per cent of tasks are AUGEX related (ie/ pole replacements)
 - 75 per cent of tasks are OPEX related (ie/ other than pole replacements)

Table 4-21: Proposed Program Cost - AUGEX & OPEX

Task	Proposed AUGEX	Proposed OPEX
Pole-top Defects (A1, A2 & A3 tasks)	\$0.3M	\$4.89M
Low Conductors (57% of tasks)	\$77.05M	\$43.00M
TOTAL	\$77.35M	\$47.89M

Table 4-22: Deferred Program Cost - AUGEX & OPEX

Task	Deferred AUGEX	Deferred OPEX
Pole-top Defects (A4 tasks)	\$1.33M	\$22.24M
Low Conductors (43% of tasks)	\$57.83M	\$32.27M
TOTAL	\$59.16M	\$54.51M

³⁹ Based on pole replacement rate from ESS_17 and ESS_46 IC Pole Replacement and Reinforcement Investment Case, May 2014.

⁴⁰ Based on pole replacement rate from ESS_17 and ESS_46 IC Pole Replacement and Reinforcement Investment Case, May 2014

APPENDIX F: ELECTRICITY CAUSED MAJOR FIRE EVENTS 2009 - 2014

Table 4-23 below shows that there has been nine major electrical overhead powerline caused fires in the past five year period. Major fires as a result of powerlines cannot be considered an uncommon event and DNSPs in susceptible zones must be vigilant. The indicative costs below are only indicative of property value losses and do not include the overall community costs (losses relating to trade, personal items, life, pets, environment, etc.) nor do they capture the community anguish and grief.

Table 4-23: Electricity caused major fire events⁴¹

Details of Fire	Fire Origin
<p>Kilmore East Fires 2009 VIC</p> <p>121 lost lives; 1244 homes lost; 533 Home damaged; 76,000Ha \$1.1b class action – \$494M agreed settlement. Power company contribution \$378.6 million</p>	<p>12.7kV SWER line belonging to SP Ausnet is alleged to be the source of the fire. A 3/12 steel conductor break 2.78m from pole termination, long span - approx. 1km in length. (SP Ausnet)</p>
<p>Beechworth Fire 2009 VIC</p> <p>2 fatalities & 260 properties affected. 30,000Ha \$33M class action settlement, SP Ausnet contribution \$9M</p>	<p>22kV conductor down at location of fire origin – Large tree branch fell over the line. The tree was 27m from the line but considered a “hazard” tree in the hazard space. (SP Ausnet)</p>
<p>Horsham Fire 2009 VIC</p> <p>The Horsham Golf Club and 13 homes were destroyed in the fire which burned nearly 2,500 hectares of land, 160 km’s fencing. \$40M class action</p>	<p>12.7kV SWER conductor off pole, Pole cap with an integrated SWER insulator attached fell, 3 coach screws at 120deg apart normally secure the cap to the pole. The screws were found on the ground. (Powercor)</p>
<p>Coleraine Fire 2009 VIC</p> <p>1 Home; General Farm losses; 1 injured; 792Ha pay out of several million dollars to between 20 and 25 Coleraine bushfire victims after expert loss assessments are submitted.</p>	<p>12.7kV SWER conductor off pole, broken tie wire allowed conductor to come off insulator. (Powercor).</p>
<p>Pomorneit Fire 2009 VIC</p> <p>1320Ha; General farm losses; rail infrastructure affected. \$10M</p>	<p>Clashing HV conductors due to clearances between dual circuit 66 & 22kV conductors on the same pole, pole leaning & history of similar clashes. (Powercor)</p> <p>The fire burned 1,300 hectares of farmland at Pomorneit and Weerite. Dairy farmer and CFA brigade captain Terrence Place led a class action against Powercor, alleging that clashing powerlines had started the fire. On the day a judgement was to be handed down, the parties agreed to a settlement. Justice Beach has now approved that settlement in the Supreme Court, sitting in Warrnambool. About 30 claimants will receive 100 per cent of costs, expected to total about \$10 million.</p>

⁴¹ Information sourced from various media reports and law firm websites.

Details of Fire	Fire Origin
<p>Murrumbidgee Fires 2009 VIC</p> <p>Joined up to the Kilmore fire to cause destruction of towns of Marysville and Kinglake.</p> <p>Murrumbidgee Saw Mill, Wilhelmina Falls Road, Murrumbidgee. It is alleged that the most probable cause of the fire was a break in an electrical conductor resulting from deficiencies in the construction and configuration of a power pole, killing 40 people, destroying over 500 homes, and causing millions of dollars of damage. It is alleged that the power utility company was negligent in, amongst other things, the construction and configuration of the power pole</p> <p>Pending class action</p>	<p>22kV Conductor falling on fence line. Original thought to arson and due to police criminal investigation at the time of the Royal Commission, cause could not be explored through the VBRC process. After the VBRC and further investigation, police dismissed arson as the probable cause and reported that investigations concluded that a fallen powerline in proximity to the origin of the fire was the most likely cause. SP Ausnet</p>
<p>Perth Hills Fires 2014</p> <p>55 Homes lost</p> <p>\$20M losses</p>	<p>Fallen private power pole (Western Power)</p>
<p>Springwood Fires 2013 NSW</p> <p>The ensuing blaze destroyed 200 houses and badly damaged another 200 properties.</p> <p>\$200M pending class action</p>	<p>Tree branch falling on low voltage power line causing conductors to clash and fall. (Endeavour Energy).</p> <p>The Springwood-Winmalee-Yellow Rock Bushfire of October 17 2013 is alleged to have started when poorly-maintained trees fell on electrical conductors in Links View Road, Springwood on the afternoon of October 17.</p>
<p>Mickleham Road Fires 2014 VIC</p> <p>Homes destroyed</p> <p>\$50M pending class action</p> <p>22,900 hectares of agricultural and bush land, destroying more than 20 homes and more than 2000 kilometres of fencing, and killing hundreds of cattle, more than 14,000 sheep and unknown numbers of native fauna.</p>	<p>Tree fallen on HV conductors from outside clearance space.</p>