H.V Underground Cable Condition Assessment Project Justification Report

Version Number: 1.2

Effective date: 7/1/2015

Version Control

Version	Date	Description	Changed by	Reviewed By
1.0	04/04/2014	First Draft	N Lee	M Schulzer
1.1	20/12/14	Added forecast methodology	M Schulzer	N Lee
1.2	07/01/15	Minor rev to forecasting methodology	G Pallesen	N/A

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 project justification report 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 project justification report 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 approximately 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%

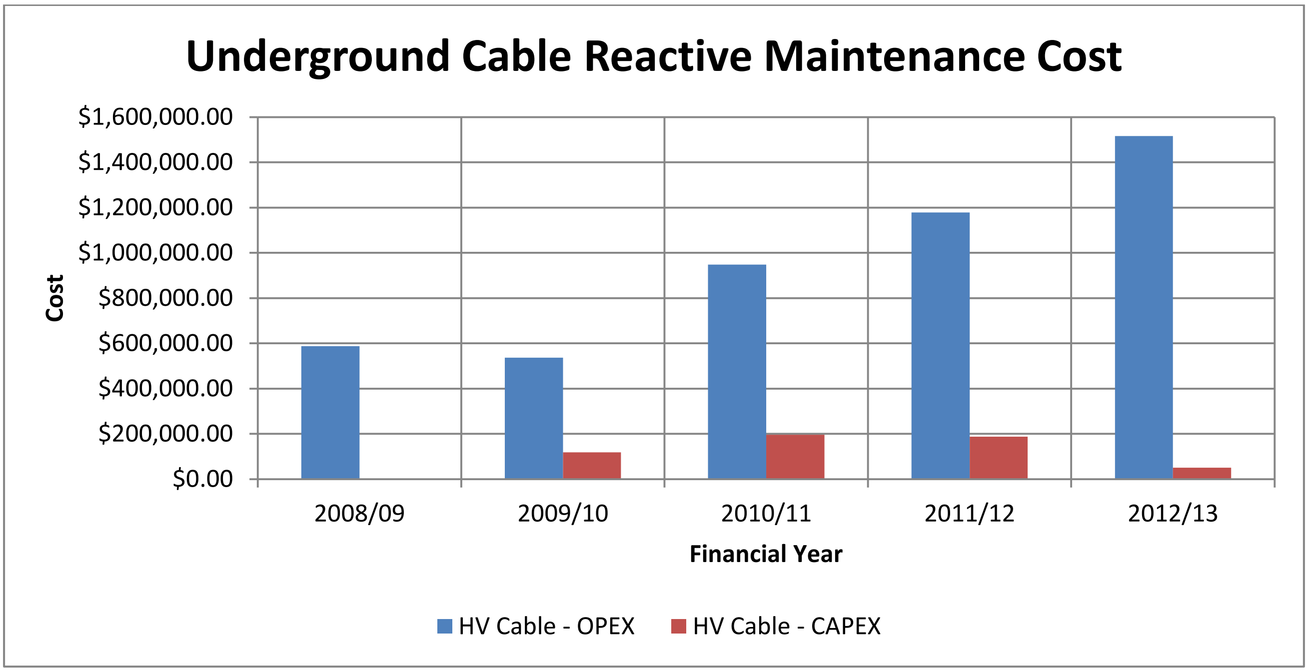
Table 2: Estimated underground cable type

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



Forecast Methodology

The 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)
- 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 to lower estimate, the polynomial formed the upper estimate. Note that the sample data over a significant duration results in an increasing fault rate as cables age.
- The forecast fault rates were then used to determine the expected maintenance costs.
- Note that the fault rates are NOT influenced by new cables to service new customers.
- 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)

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

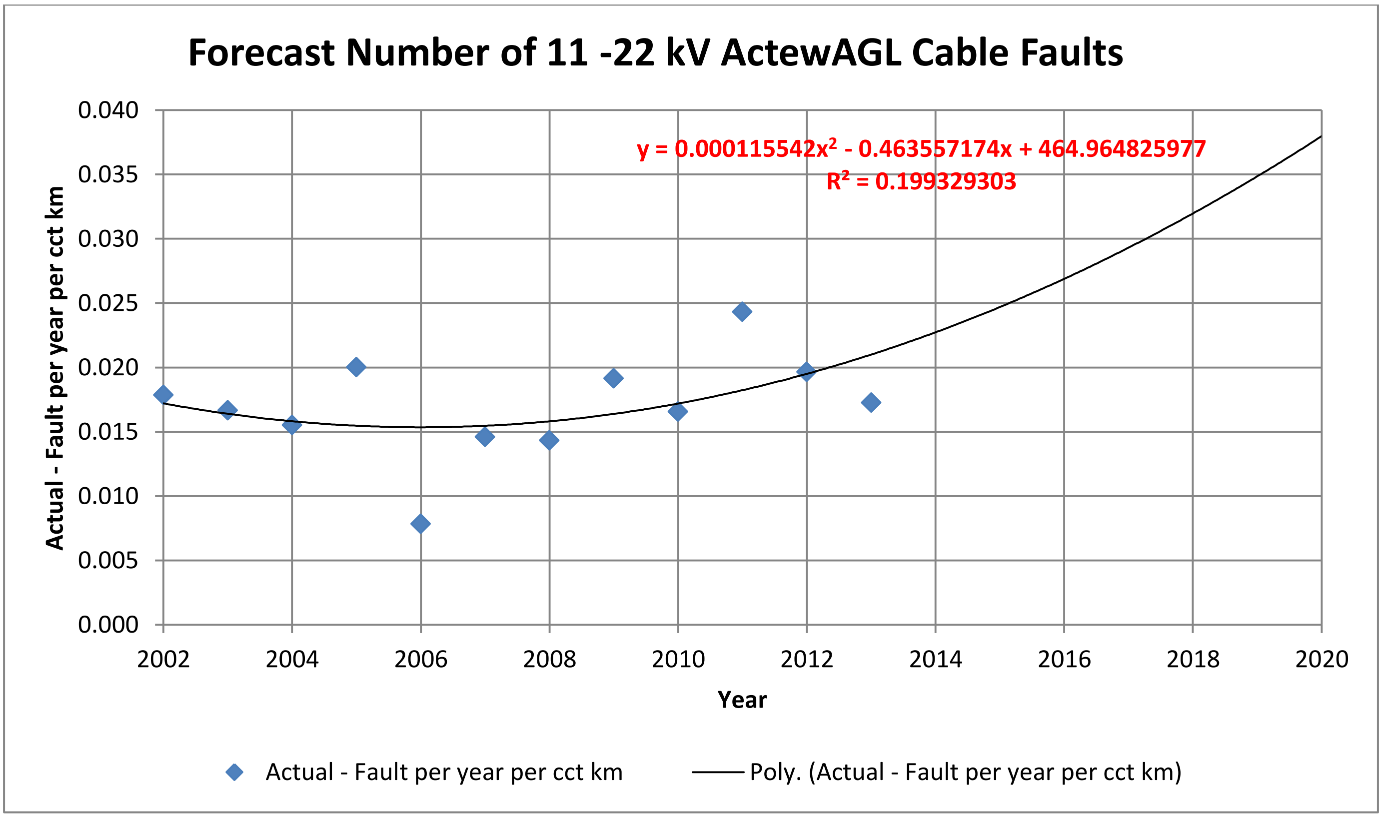


Figure 3: Forecast reactive maintenance cost

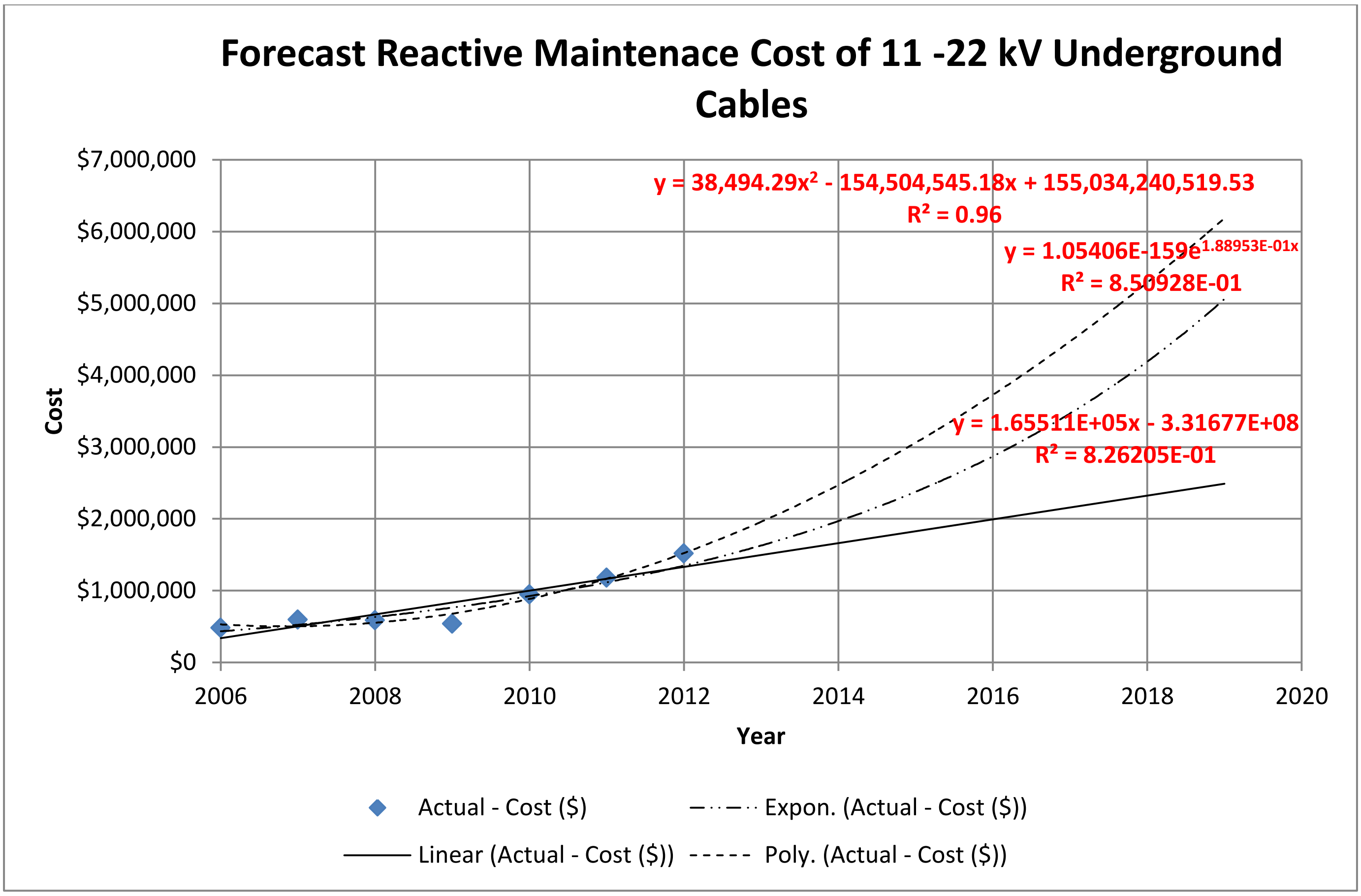


Table 4: Forecast reactive maintenance cost

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.