APPENDIX 4.5

Augmentation capital expenditure review for Energex

Augmentation Capital Expenditure Review

Energex 2016 to 2020 Capital Expenditure Review

Energex

25 June 2015

Revision: 2

Reference: 247254

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Executive summary

Aurecon has been engaged to review Energex's 2016 - 2020 Augmentation Capital Expenditure Submission (Augex) to the Australian Energy Regulator (AER) with particular reference to the reliability, power quality and LV fusing components of the submission.

Findings

The review of Energex's proposed reliability improvement submission has identified direct costs of approximately $179,000 for urban feeders and $259,000 for rural feeders, representing the business as usual expenditure on worst performing feeders. This was not clearly identified in the original submission. In addition increases in unit costs to between $425,000 and $526,000 per feeder have been identified for the future reliability improvement of worst performing feeders due to the increased likelihood of higher cost augmentation strategies being required to effect the necessary improvement. Energex's proposal to address 22 feeders per year has been found to be necessary to at least maintain the status quo with regards to worst performing feeder performance. These factors combined indicate that Energex has assessed an appropriate minimum level of augmentation expenditure to achieve improvements in worst performing feeder reliability performance, as required under their Distribution Authority.

The review of Energex's proposed LV monitoring submission has focussed on existing and forecast solar PV penetration and the impact on the network. Our review shows that significant consideration has been given to the issues faced by Energex due to the increasing penetration of Solar PV. There is a body of evidence showing a linkage between customer voltage complaints and the growth of solar PV penetration. Energex has a significantly greater penetration of solar PV, than any other state, and very different network conditions, so comparisons with what is being done other states are not valid. The results of modelling show that when both the 11 kV network and LV networks are considered together, the impact of Solar PV penetration is more severe than previously expected.

The review of Energex's proposed LV fusing program has identified that the proposal is based on sound engineering and is necessary for compliance with ENA guidelines and to safeguard public safety.

Conclusions

Reliability improvement program

Based on our analysis Aurecon estimates an improvement program expenditure requirement of around $47 million (direct $) over five years. This estimate is based on addressing at least 22 worst performing feeders per annum, at an expected average cost of approximately $425,000 each. Aurecon believes that it will be necessary to address at least one third of the expected numbers (60 to 70) of worst performing feeders each year. This provides a benchmark for comparison against Energex's own expenditure forecast.

Aurecon believes that this expenditure will enable sufficient reliability improvements to be achieved in order to comply with Energex's Distribution Authority. This is based on the interpretation of the requirements of the Distribution Authority being consistent with a requirement to improve a number of feeders in the group, rather than a requirement to improve the average performance of the group of feeders, or to achieve a mandated target.

Aurecon concludes that Energex's revised submission for a proposed expenditure of $39.9 million (direct $) on reliability augmentation is towards the bottom of the expenditure bandwidth required for compliance, and may result in some reliability impact requiring management using measures other than capital expenditure.

Power quality monitoring program

The review of Energex's proposed LV monitoring submission has focussed on the examination of the following factors:

- Forecast growth in solar PV penetration
- The need for monitoring and the areas targeted
- The sample size chosen for monitoring
- Other monitoring options
- The influence of growth on the level of monitoring proposed
- The expected voltage excursions in relation to the solar PV penetration
- The impact on the network of voltage excursions and the risks posed thereby
- The cost of monitoring and remediation, and the business case

Our review shows that significant consideration has been given to the issues faced by Energex due to the increasing penetration of Solar PV. There is a body of evidence showing a linkage between customer voltage complaints and the growth of solar PV penetration. However, the collection of data over the past few years is limited and not sufficient to demonstrate the full impact at customer terminals. It has therefore been necessary to demonstrate this with detailed modelling.

The results of Aurecon's modelling show that when both the 11 kV network and LV networks are considered together, the impact of Solar PV penetration is potentially more severe than previously expected. Some form of monitoring is essential to enable a reliable understanding of the impact to be gained, and this is not linked to the expected growth of solar PV penetration, but is clearly a need that exists already.

Energex has proposed to install a number of monitors to gather information at transformers, and on low voltage circuits. Based on the results of the investigation we have undertaken, Aurecon believes that the monitoring Energex proposes is appropriate in terms of both the areas targeted and the number of monitoring devices proposed for deployment. Further we believe that reducing the number of monitors proposed would result in insufficient accuracy for the results to be effective in gaining a deep understanding of the impact of solar PV penetration, and would also result in potentially ineffective or unnecessarily costly mitigation strategies being employed. As such we believe Energex's proposed expenditure of $25 million for LV monitoring in the forthcoming regulatory period is the minimum expenditure necessary to achieve worthwhile results.

Energex has also proposed an expenditure of $13.4 million to cover remediation capital works in the forthcoming regulatory period. We have reviewed the scope and estimated cost of Energex's program and consider it to be at the lower end of our estimated range of expected outcomes. This could result in Energex having to manage a higher network risk associated with the impact of solar PV penetration.

LV fusing program

Aurecon's conclusion is that Energex's proposal to complete the LV fusing program by the end of 2017/18, is based on sound engineering, and has been assessed based on appropriate risk management strategies. As such we believe that the proposed expenditure is appropriate and fully justified. We also believe that this is required to comply with ENA guidelines, is in line with industry best practice, and is necessary to safeguard public safety.

Augmentation Capital Expenditure Review

Date 25 June 2015
Reference 247254
Revision 2

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1 Introduction

1.1 Background

Aurecon has been engaged to review Energex's 2016-2020 Augmentation Capital Expenditure Submission (Augex) to the Australian Energy Regulator (AER) with particular reference to the reliability, power quality and LV fusing components of the submission. This follows proposed reductions to these program as outlines in the Preliminary Decision recently handed down by the AER.

1.2 Methodology

Aurecon staff have a strong background in capital expenditure planning for a variety of augmentation strategies, and significant depth of experience in dealing with solar PV related network impacts. This experience flows from our involvement in numerous capital planning projects for Queensland utilities, and from our recent experience with large solar PV generation projects. Aurecon also has a long standing and detailed appreciation of risk management strategies required to assess complex engineering and safety issues, which has been developed though the establishment of our internal Safe Design process.

The methodology applied to this task has been to leverage the experience of our senior staff members to review Energex's regulatory submission, the Preliminary Decision handed down by the AER, and numerous supporting and related documents that have been provided by Energex, or obtained from our own sources. A number of engineering calculations have also been performed where necessary to derive further supporting information to assist in the development of recommendations, or to assess the strength of Energex's supporting arguments. Consultation has also been undertaken with Energex staff members to obtain clarifications where these have been necessary.

Aurecon would like to commend the responsiveness of Energex's staff members, and we thank those involved for their helpfulness and speed of response to our requests for information and data.

1.3 Documentation reviewed

Aurecon staff members have reviewed the following documents and information:-

- AER – Preliminary decision Energex distribution determination - Overview - April 2015
- AER – Preliminary decision Energex distribution determination - Attachment 6 - Capex - April 2015
- Energex Network Reliability Strategic Plan 2015-2020
- Energex Revised Reliability Program
- Energex Power Quality Strategic Plan
- Energex Solar PV Connections Forecast – Revised Regulatory Proposal

- Energex Power Quality Augex Forecast – Revised Regulatory Proposal
- AER EGX 010 – Q1 Augmentation_190115 - as submitted (response to questions)
- AER EGX 015 – Opex final response_300115 - as submitted
- AER EGX 051 Reliability_130315_as submitted (response to questions)
- EMCa – Review of Energex augex and repex – April 2015
- AER_Feeder_Performance (spreadsheet with SADI & SAIFI data for 2139 11 kV feeders from 2009/10 to 2013/14)
- SIFT_Reliability_Projects (spreadsheet with project data from 2008 to 2015)
- WPF_History_Detail (spreadsheet with data on worst performing feeders from 2010/11 to 2014/15)
- WPF_Reclosers (spreadsheet containing information on protective equipment installed on worst performing feeders)
- 2013-14_Rural_WPF_Projects – scope (spreadsheet containing scope information for 2104 WPF projects)
- 11kV_Feeder_Length (spreadsheet containing information on circuit kilometres for 11 kV feeders)
- PV Stats Summary (spreadsheet containing data on solar PV penetration (system level data)
- solar_voltinv_analysis_v3 (spreadsheet containing analysis of solar penetration on 40398 distribution transformers)
- Energex_Solar PV Survey (survey information containing data regarding penetration of solar PV systems for Energex, Ausgrid, Powercor and SA Power Networks)
- Reactive Augementation Due To Solar (spreadsheet containing data on solar PV remediation costs)
- LINE_DATA, TRF_DATA, (DINIS data files enabling the dynamic modelling of solar PV on 11 kV and low voltage feeders)
- Energex LV Fusing Program Strategy document, dated 15/5/2015
- SEG-08-09 Review of Fuse Protection of Low Voltage Feeders V2
- SEG-08-09A Covering Memo on Fuse Protection of Low Voltage Feeders
- Strategy for LV Fusing Retrofit Program
- Selection guide for HV Expulsion drop out and LV HRC fuses (TSD0019i)

2 Reliability augmentation

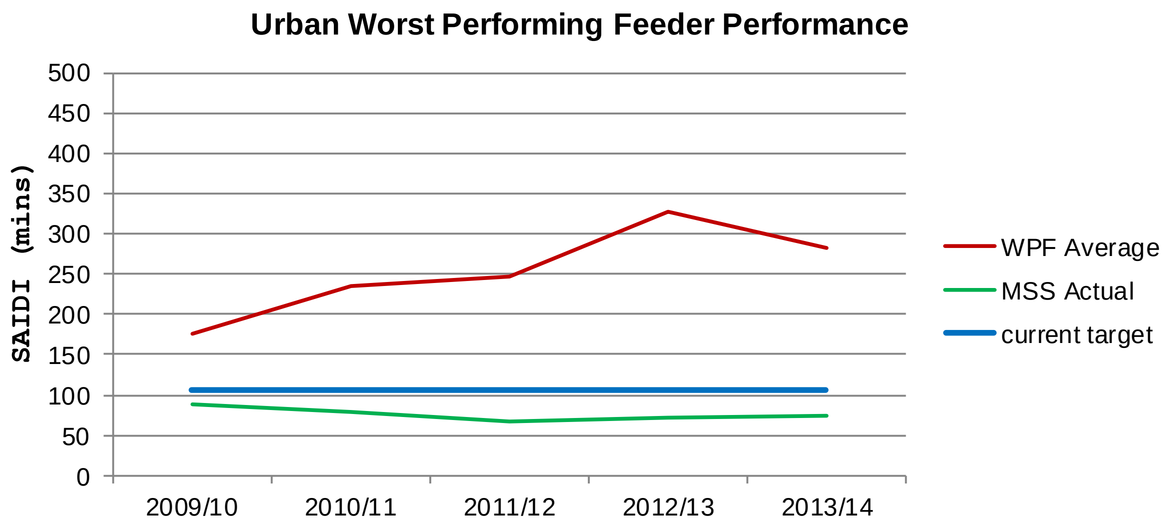
2.1 Review of 2010 - 2015 reliability augmentation tasks

Energex project records for 2010 to 2015 were reviewed to investigate the augmentation tasks that were undertaken for reliability improvement. Energex was targeting improvements in the averages of their key reliability indices, the system average interruption duration index (SAIDI), and the system average interruption frequency index (SAIFI). The targeted reliability projects were aimed at achieving the required minimum service standards (MSS) levels for urban and rural SAIDI and SAIFI respectively.

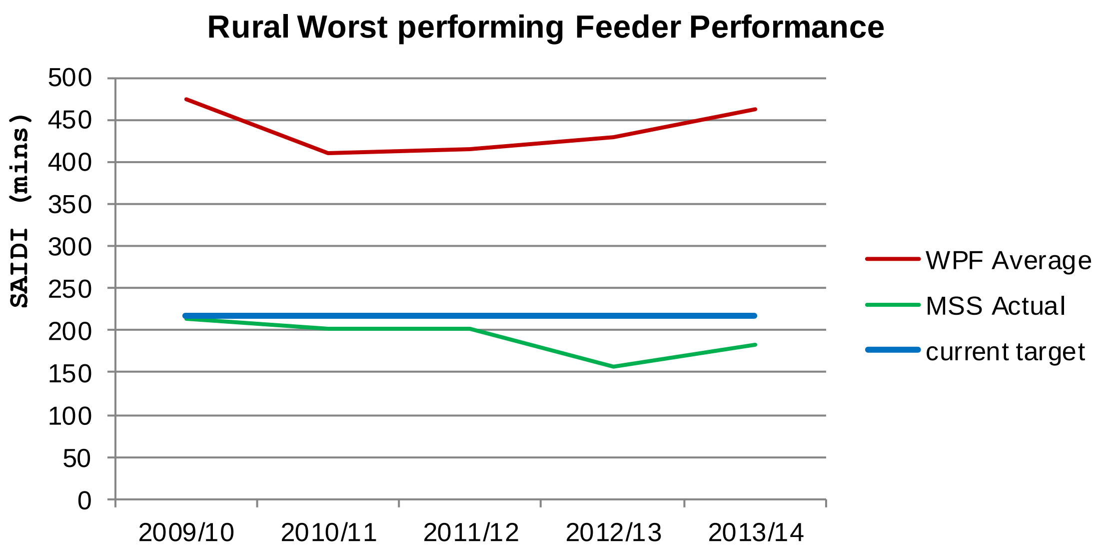
Worst performing feeders (WPF) were reported on as required, but no target was set to improve the average performance of worst performing feeders. Instead worst performing feeders were targeted where their contribution to the overall SAIDI and SAIFI performance, would result in a maximum reduction to the overall system average, for the minimum expenditure. This necessarily resulted in many feeders being augmented with animal proofing, line fault indicators, fuses, some sections of new overhead line to tie feeders together, as well as a one or more reclosers and sectionalisers. A smaller number of feeders were split to reduce fault exposure, and limited application of Covered Conductor Thick (CCT) was also seen where fault rates were high. These augmentation choices are listed in Energex's Reliability Planning Guideline (Table 19), and have generally been used in the order of merit listed.

2.2 Findings

The work undertaken in 2010 to 2015 has resulted in significant improvements to Energex's Urban and rural SAIDI and SAIFI averages achieving results for the system average figures, which are well below the target. The graphs below show the average system performance compared to the targets and the performance of the worst performing feeders.



Graph 2-1 **Urban WPF Performance (SAIDI)**



Graph 2-2 **Rural WPF Performance (SAIDI)**

These graphs show that while the average system performance has improved, the average performance of the worst performing feeders has deteriorated. The 2014/15 MSS limits are also shown for comparison. This is likely to be due to the low number of worst performing feeders that were addressed. Only approximately 20% of the group of worst performing feeders were addressed from 2011 to 2015, this is considered to be too small a selection to have a significant impact on the average. Energex's strategy was to select feeders that could be significantly improved for moderate expenditures. Given the targets that were set, this was an appropriate strategy, and the result show that it has been successful.

The label "worst performing feeder" is relative to where the feeder is located. The criteria used to distinguish a worst performing feeder in an urban area is a SAIDI/SAIFI target of 106/1.26, while the rural criteria are 218/2.46 (SAIDI/SAIFI). Hence an urban feeder that marginally exceeds the reliability target for "worst performing" status would still be well under the target for a rural feeder. Future assessments of worst performing feeders will necessarily focus on rural feeders in the majority, with possibly only four or five feeders addressed per year being urban feeders. Based on our assessment, if 150% x the rural SAIDI/SAIFI target is considered as the threshold for both urban and rural feeders to be assessed as “worst performing”, then it is likely that approximately 60 to 70 feeders per year will be listed as “worst performing”. While the majority of the worst performing feeders will be found in rural areas this criteria will also result in a small number of urban feeders in the urban/rural fringe areas being listed as worst performing. Feeders in these areas typically have more exposure to faults due to their greater length, and often it is also more costly to achieve a significant improvements on these feeders.

The table below shows the numbers of worst performing feeders and the corresponding projects

Table 2-1 Worst performing feeders and projects 2010 to 2015

Year	Number of Feeders in WPF Category	WPF Projects in Subsequent Year
2010/11	76 urban, 63 rural	6 urban, 24 rural
2011/12	82 urban, 62 rural	12 urban, 20 rural
2012/13	80 urban, 65 rural	29 urban, 22 rural
2013/14	62 urban, 63 rural	0 urban, 12 rural
2014/15	83 urban, 56 rural	Work in progress (2 rural completed)

This shows that typically 30% of the rural feeders that reach the worst performing performance level (ie 150% of the category target) are addressed in the following or subsequent years. As worst performing feeders were not separately targeted, it was necessary to undertake a detailed review of the 2010 to 2015 program of works to identify the expenditure on worst performing feeders. This was undertaken by matching the feeders on the WPF lists to the feeders listed in the project descriptions. Fifteen reliability projects that targeted 33 kV improvements, flood resilience projects or similar non 11 kV projects were excluded from the analysis as the focus was on 11 kV feeders only. The remaining 421 projects included 221 single feeder projects and 200 multiple feeder projects. For the projects addressing multiple feeders, the total project cost was divided by the number of feeders being addressed. This results in an approximated cost per feeder which may not be accurate when considered individually, but when looking at the entire program, this is expected to produce reasonably accurate average per feeder project costs.

From January 2010 to February 2015 a total of $47,773,548 was expended to address 146 worst performing feeders with reliability improvement projects. Of these 52 were urban feeders and 94 were rural feeders, resulting in an average annual expenditure of $9,554,710 of which $2,641,147 was spent on an average of 10 urban worst performing feeders and a total of $6,913,563 was spent on an average of 19 rural worst performing feeders. The resulting average costs to address a worst performing feeder are $253,956 for urban feeders and $367,743 for rural feeders. This data is provided in Appendix A.

These costs include overheads, and if an overhead allocation of 42% is used the corresponding direct costs are approximately $178,842 for urban feeders and $258,974 for rural feeders. This represents the business as usual expenditure on worst performing feeders.

2.3 Examination of requirements for 2016 – 2020

2.3.1 Factors influencing reliability performance

Energex’s demand forecast is not predicting growth in demand, but demand growth is not one of the causes for worst performing feeders. Feeder reliability is primarily affected by the fault rate (faults per 100 km of exposure per year), and by the length of exposure. The fault rate is influenced year on year by weather patterns, and vegetation growth. These factors are variable, but when unusual events are excluded and three year averages are considered, much of the variability is factored out. The operational expenditure on vegetation management is a key factor in maintaining vegetation corridors, and this has a significant bearing on reliability performance. Energex is planning to continue the vegetation management programs at their current level of effectiveness, so this should not be a factor in the consideration of future reliability performance.

The impact of new connections will generally result in some increase in the exposure, and this is primarily a factor of population growth. Migration to the South East of Queensland was significant prior to 2010, but in recent years this has dropped to a more steady natural level. Energex data shows that in the last 3 years, network growth has been consistently in the vicinity of 79 km per annum in urban areas and 108 km per annum in rural areas. Similar trends are expected in the forthcoming regulatory period. Considering these factors, the expectation for the 2016 to 2020 period is for similar numbers of worst performing feeders to be identified year to year.

2.3.2 Overview of Energex's Distribution Authority requirements

The WPF list for 2014/15 has been reviewed to determine the likely scope of work for reliability projects, and the expected expenditure. The list has been distilled down to a total of 66 feeders, based on the rural WPF criteria. Of these 66 feeders, 51 exceed 218 SAIDI minutes (this is 150% of the rural MSS for SAIDI performance), but were within the SAIFI target, 2 exceed 2.46 average interruptions (this is 150% of the rural MSS for SAIFI performance), but were within the SAIDI target, and 13 exceed both the SADI and SAIFI measures. There would be many more feeders on this list if the urban MSS targets were considered in addition. The only urban feeders on this list were those that exceeded 150% of the rural SAIDI and SAIFI targets.

2.3.3 Existing reliability equipment, and its impact on future expenditure

The existing equipment on these feeders was examined. This examination has shown that 36 of these feeders have limited application of reliability improvement equipment already in service. It is expected that these feeders can have their reliability performance addressed by normal low order of merit reliability improvement methods as listed in Table 19 of the Reliability Planning Guideline. Thus the reliability of these feeders can be improved by the addition of fuses, isolators, feeder ties, reclosers and/or sectionalisers. Such project scopes are likely to result in similar expenditure to previous year's projects, ie $258,974 per feeder (direct cost).

A further 30 feeders were found to already have a significant application of reliability improvement equipment already in service. These feeders have most likely already received treatment for poor reliability in previous years, but are still on the list due to poor performance. Of these feeders, 27 had significant circuit lengths, all greater than 100 km. This large exposure is likely to be the primary cause of the poor reliability.

Once a number of reclosers, sectionalisers and other low order of merit techniques have been applied to improve a feeder's reliability performance further application of the same techniques usually does not result in a meaningful improvement in reliability. The next step to improve the feeder's performance is to split it into two or more feeders and significantly reduce the exposure to faults. Energex has a large proportion of short feeders, with the average length being 12.8 km, and the standard deviation being 20 km.

Thus, approximately 95% of Energex's 11 kV feeders have less than 52.8 km of circuit length (the mean plus 2 standard deviations). Long feeders have the greatest fault exposure, due to their significant circuit length, and hence should logically be targeted for splitting to improve reliability. For feeders in excess of 100 km of circuit length (<1.5% of the population), this is likely to be necessary to achieve any reasonable improvement in reliability performance. This results in a cost profile that is approximately 3.1 times more expensive than the low order of merit improvement techniques. Applying these criteria there are 27 projects that were examined which would require an expenditure of $802,819 per feeder.

Energex's feeder population of 1751 was examined to determine their outage rate performance. Short feeders (ie those less than 5 km in length) were excluded, as they can skew outage rate data. The dataset with short feeders excluded revealed that the mean outage rate is 7.6 outages per 100 km per year, and the standard deviation is 12.2. Thus an outage rate of 32 outages per 100km per year was used as a benchmark (the mean plus 2 standard deviations). Only 73 feeders in the Energex network (less than 5%) have outage rates that exceed of this value. Of the 30 feeders reviewed above, 3 were found to have a significantly higher outage rate than others, ie in excess of 32 outages per 100 km per year. These three feeders are likely to be candidates for replacement of bare overhead conductor with CCT. This has a cost profile that is approximately 11 times more expensive than the low order of merit improvement techniques. Applying these criteria these 3 projects would require an expenditure of $2,848,714 per feeder to address their poor reliability performance.

2.3.4 Review of Energex's expenditure forecast

The examination of past projects has shown that in any given year between 10% and 40% of the feeders listed on the WPF lists are addressed with projects. This review has shown that Energex selects feeders carefully based on an examination of the causes of poor reliability. It is difficult to predict which feeders may be chosen from the 2014/15 list for reliability projects in 2016, without going into a more detailed project by project assessment. However, if a simple criteria is adopted, for example, considering feeders with greater than twice the SAIDI minutes required for inclusion on the WPF list (ie those feeders exceeding 436 SAIDI minutes), then a list of 28 projects results, with a total cost of $18,413,051. The average project cost for this cohort is $657,609 per feeder (direct cost). This data is provided in appendix B.

In the five years from 2010 to 2014 (inclusive), Energex addressed on average 32.5% of the rural worst performing feeders on the lists. As Energex plan to address only feeders exceeding the rural WPF target then it would be reasonable to expect a similar proportion to be addressed going forward, ie approximately one third, or 22 feeders. In practice the capital planning process undertaken by Energex is likely to further optimise the scope of work involved, potentially saving up to 20%, as well as reducing the number of feeders selected. On this basis it would be reasonable to expect a direct cost of $ 525,647 per feeder, on average. This numbers are simply derived by multiplying the above costs and feeder numbers by 0.8 to represent the 20% saving following project optimisation. While this 20% reduction is arbitrary, it is consistent with our experience in optimising capital planning works programs. Subsequent years are likely to be similar, although there are likely to be variations from the mean number in some years. Therefore this analysis results in the expectation of a required average annual expenditure of $11.6 million, or $58 million over the regulatory period. This is a very similar figure to Energex's original expenditure forecast.

2.3.5 Review of worst performing feeders lists and unit costs

This unit cost of $526,000 (approx.) is significantly higher than the average unit cost seen in the 2010 to 2015 projects. To resolve this apparent conflict a number of recent projects were examined to determine the scope to see if larger scopes are becoming more common. The 2015 projects were examined to review the scopes involved.

There were only 2 completed in 2015, which were MCW7 and MCW11. The scope of these feeders involved only lower order remedial measures (1 x ACR, plus 2 x LBS on MCW7, and 1 x sectionaliser on MCW11). It was felt that this sample was too small to give a reasonable indication. Therefore, a number of 2014 projects were also examined. Of the 12 worst performing feeders addressed by reliability projects in 2014 it was found that 25% (3 projects) included some replacement of bare overhead with CCT. In general it does appear that many of the projects on the WPF lists now have already seen low order of merit treatments in past years, and now as the lowest cost alternatives have already often been employed, higher cost alternatives will most likely need to be employed to further address the reliability issues of these feeders.

The results of this assessment clearly illustrate the need for higher expenditures per feeder going forward. Hence, for Energex to maintain the relative reliability performance of the worst performing feeder cohort over the next regulatory period, it is likely that the cost of reliability improvement projects to address worst performing feeders in the 2016 to 2020 period will approach an average cost in the vicinity of $526,000 per feeder (direct cost). Energex's WPF list for 2014/15 contained 66 feeders, as discussed above. These all exceeded 150% of the rural SAIDI/SAFI targets, so the list used is clearly only focussed on worst performing feeders. Energex propose to address 18 rural and 4 urban feeders (22 in total), and based on past business as usual activity, and our assessments this is a very reasonable number to address. To address fewer would be likely to result in increasing customer complaints. Therefore, to address 22 feeders per year on average will result in an annual expenditure of $ 11.6 million, or a total of $58 million for the 5 year program. Our view is that this is an entirely reasonable proposal.

2.3.6 Energex's obligations and Aurecon's alternative expenditure forecast

Energex now has an obligation to improve the reliability performance of worst performing feeders as part of its Distribution Authority. Previously Energex was only required to report on worst performing feeders. It is noted that no target for improvement has been mandated, so the requirement is left open to interpretation.

Based on past performance, it is likely that Energex's proposed approach to address 22 feeders per year will maintain the status quo. It is unlikely that addressing approximately one third of the feeders on the WPF lists per year will result in significant reduction in the average performance of that cohort. However to address less than one third is likely to result in increased numbers of complaints from residents in the affected areas. Therefore we believe the number of feeders that Energex proposes to address is appropriate.

There is some scope to further reduce the average costs. Energex may choose to address only those feeders that require minimum scopes, and may restrict application of CCT to only one feeder per year, and may restrict the number of feeders split to only two per year, which would reduce the average per feeder cost to approximately $425,000. This is considered an available option as there is no mandated target to achieve, and as long as a reasonable number of feeders can be addressed and improved, it would be reasonable to claim that the requirements of the Distribution Authority would be satisfied.

2.4 Conclusions

Based on the above analysis Aurecon estimates an improvement program expenditure requirement of around $47 million (direct $) over five years. This estimate is based on addressing at least 22 worst performing feeders per annum, at an expected average cost of approximately $425,000 each. Aurecon believes that it will be necessary to address at least 1/3 of the expected numbers (60 to 70) of worst performing feeders each year. This provides a benchmark for comparison against Energex's own expenditure forecast.

Aurecon believes that this expenditure will enable sufficient reliability improvements to be achieved in order to comply with Energex's Distribution Authority. This is based on the interpretation of the requirements of the Distribution Authority being consistent with a requirement to improve a number of feeders in the group, rather than a requirement to improve the average performance of the group of feeders, or to achieve a mandated target.

Aurecon concludes that Energex's revised submission for a proposed expenditure of $39.9 million (direct $) on reliability augmentation is towards the bottom of the expenditure bandwidth required for compliance, and may result in some reliability impact requiring management using measures other than capital expenditure.

3 Power quality augmentation

3.1 Power quality challenges 2016 – 2020

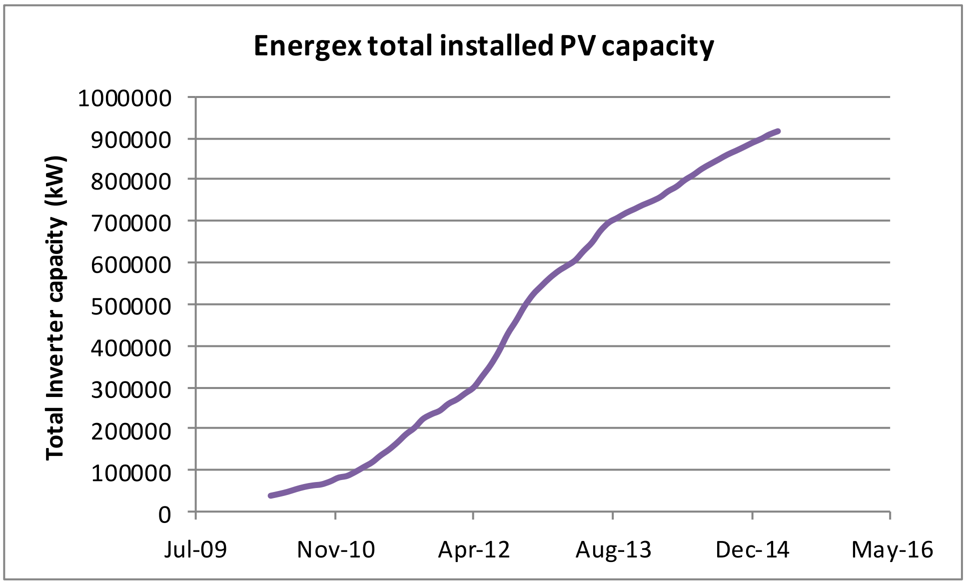
3.1.1 Background

The past few years have seen unprecedented growth in solar photo-voltaic (PV) installations on domestic premises. As the penetration of solar PV installations has increased, utility engineers have been dealing with a number of problems not previously encountered. Networks were originally designed for power to flow in one direction, from the large and usually remote generating power station to the customer at the low voltage end of the network. Voltage management practices and system designs were geared to manage the voltage drops that resulted from this power flow.

The impact of embedded generation has seen power flowing in the opposite direction to that originally intended.

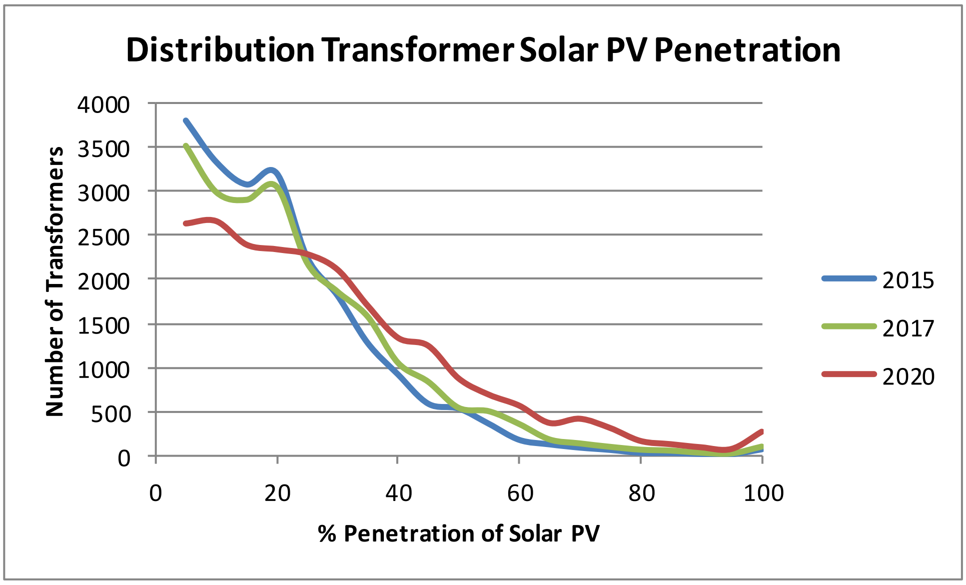
3.1.2 Review of Energex forecast growth in Solar PV penetration

As at April 2015, there was 916.7 MW of solar PV inverter capacity on the Energex network. At the peak of its growth, the solar PV penetration grew by 304 MW between 2012 and 2013. Over the last few years the penetration has been growing network wide at the rate of 163 MW per year, but in the last year this has slowed to 133 MW, and is currently growing at 9 to 10 MW of inverter capacity per month. However, this still results in a substantial yearly increase and is the direct result of increasing solar PV penetration in LV areas. The graph provided below illustrates this growth.



Graph 3-1 Total Energex installed Solar PV Capacity

Energex measures their local area solar PV penetration based on the ratio of the kW of installed inverter capacity to the transformer capacity supplying the low voltage areas in question. There are currently significant numbers (thousands) of transformers with solar PV penetrations between 10% and 35%, and a total of 3013 that have penetrations in excess of 35%. There are even small numbers of transformers that have solar PV equipment installed that exceeds the transformer rating. Energex forecasts indicate that this trend will continue, as shown in the graph below.



Graph 3-2 Transformer PV penetration

Neglecting growth in transformer numbers, (i.e. just considering this population of transformers), by 2020 Energex's forecast predicts that 6,540 transformers will have solar PV penetrations of 40% or greater, and there will then be 3,959 transformers with 50% or greater penetration of solar PV. The EMC review has questioned these projected growth rates. There is an expectation implied in the EMC review that the reduction of the feed in tariff to much less generous levels, will reduce growth in solar PV penetration. This is the case, but there are also a number of growth drivers which support the Energex forecast. Firstly there are a large number of solar PV installation providers in the market all attempting to maximise their turnover. Secondly the cost of solar panels is constantly reducing as world-wide demand pushes up production volumes. Thirdly the cost of installing a solar PV system is now low enough that commercial premises are now in a position where installation of a solar system can be financially beneficial. This is due to the fact that these businesses purchase electricity on one of the commercial tariffs, (which are more expensive than the domestic tariff), and they can amortise and offset the cost of the installation against their operating costs. Aurecon believes that these three factors will provide sufficient support to maintain growth in the vicinity of 8 to 10 MW of inverter capacity per month. This is difficult to substantiate, but we believe this to be the most likely scenario, based on our market knowledge, and our involvement with larger solar PV schemes. The view that growth in solar PV penetration will continue is also shared by D. Burtt and P. Dargusch in their paper entitled "The cost effectiveness of household photo-voltaic systems in reducing greenhouse gas emissions in Australia: Linking subsidies with emission reductions" which is published in the Elsevier Applied Energy Journal no 148, 2015 pp439-448.

However if these aspects are ignored and the Energex forecast is reduced, and we take a very conservative view, reducing the growth to half the number of connections that Energex has forecast, the net result is a growth from current levels to 1,100 MW by 2019/20. This is similar to the penetration level predicted in Energex's forecast for 2016/17. Effectively, if Energex's forecast is overstated, this would only delay the expected impact by approximately 3 years. However this still results in 3981 transformers which will have solar PV penetrations of 40% or greater, and there will also then be 2093 transformers with 50% or greater penetration of solar PV.

3.1.3 Review of voltage monitoring proposal

Energex proposes to install monitoring devices on approximately 1800 distribution transformers supplying LV reticulated areas, and 4200 customer connection points, (an average of 2.3 customers in each LV area supplied by these transformers). This is in response to the stated expectation that 6540 transformers will grow from 25% solar PV penetration to exceed 40% solar PV penetration by 2020.

Even with the very conservative forecasting approach outlined above there will be 3,981 transformers with over 40% solar PV penetration. However the starting point in 2014 is the same number of transformers which currently have 25% or greater penetration of solar PV, ie 8358 transformers. Energex has no way to reliably predict which transformers will grow from 25 % to 40% penetration or greater, and propose to monitor 21.5% (approximately) of the current population that have potential to grow to 40% penetration. It follows from this observation that the growth of solar PV penetration is not actually relevant to the extent of monitoring proposed. This is explained further below.

Energex has five main types of load profiles, these being residential, commercial, mixed either primarily commercial or primarily residential, and industrial. These all have different load curves and will respond differently to the impact of solar PV. Within these five groups there are also geographical location and socio economic differences that impact and potentially alter the load curves, and the impact that solar PV penetration will have on the voltage profile. The known impacts are as follows:

- Transformer overloading
- Voltage excursions beyond statutory limits
- Voltage unbalance exceeding statutory limits
- Excessive neutral currents
- Harmonic distortion

Energex has experienced all these effects to varying degrees. The original submission highlights these issues, but does not establish a solid link between the increased incidence of these issues and the growth on Solar PV penetration, or with the rising cost of remedial measures. Aurecon believes that clearly establishing such a link will strengthen the justification for monitoring and remedial measures. However our review has also found that the necessary data to establish an unequivocal link has not been collected. It is therefore suggested that Energex follow through with this work in the future.

One of the most concerning consequences of these impacts is potential safety hazard to the public, which can arise when there is high neutral current combined with poor clamp performance or failure.

Monitoring of transformer loads and voltages, neutral integrity and low voltage network voltage levels is necessary for the following reasons:

- To reliably determine the extent of the above impacts
- To define the level of Solar PV penetration and network properties where problems will start to be significant
- To provide ongoing measurements to verify the effectiveness of remedial measures

3.1.4 Assessment of sample size for voltage monitoring

Energex requires a relatively high level of accuracy for these measurements to accurately determine the cause and effect relationship and to verify the effectiveness of remedial measures. The network impacts involved here are significant but relatively small in measurement terms. The maximum variation in voltage is +/-6%, (this is the current statutory requirement, as Energex has not yet adopted the 230 Volts standard), with roughly half this being taken up by regulation on the 11 kV system, and the rest in the LV network. It is therefore necessary that any statistical sampling technique used to gather data is accurate to approximately one third of the range of variation, ie +/-2%, otherwise results gathered may not be reliable.

Statistically a sample size of 1,358 LV areas is needed to obtain statistically significant (to 95% confidence) set of accurate data (to +/-2% accuracy) if we are considering aspects common to 21.5% of a population of 8,358 units. If 100% of the population were equally predictable the sample size for comparison, would only need to be 95. However, in this situation the effective population size is smaller than the apparent total, as each load profile classification will respond differently to the impact of solar PV, and this compounds the difficulty of choosing a representative sample size to determine the impacts with sufficient accuracy to design reliable and cost effective mitigation strategies. Within each LV area the transformer must be monitored, the end of the LV circuit must be monitored, and at least one other point in the LV network should be monitored to obtain meaningful data. Hence this requires at least 4,074 monitoring devices.

The spread of customer load curves, and other factors that may influence the effect that solar PV penetration will have on system voltage profiles, compounds the difficulty of the task Energex faces to reliably determine the impacts of solar PV penetration. It also compounds the difficulty of proposing and then testing remediation approaches. Energex's proposed sample size of 4,200 is likely to a give reasonably significant (95% confidence), dataset of information with approximately +/- 2% accuracy, which may be sufficient to quantify and understand the complexity of the problems they are facing. It is unlikely that monitoring levels significantly lower than those proposed will be effective. Insufficient levels of monitoring will yield unreliable results, and will effectively be a waste of resources. Correct selection of the monitoring sample is critical if the data gained is to be of any use.

3.1.5 Consideration of other options for voltage monitoring

Options for monitoring low voltage networks are limited. Unlike some Australian utilities there has not been a widespread application of smart meters in Energex's supply area, so the option of using existing metering is not available, as the vast majority of existing meters have no voltage monitoring facility, and those that do are not concentrated in the areas of interest. The proposed deployment of LV monitoring is the only effective means to gather real network data on the impact of solar PV penetration.

Energex proposes to limit the role out in the early years to provide the opportunity to review and improve the monitoring schemes. This is a prudent approach, but the sharp increase after year 3 may prove to be challenging to resource. Aurecon would expect that a gradual increase over the first three years may be easier to manage, and this could be further supported in the submission with some consideration of the resourcing issues.

After this five year period, further monitoring may or may not be necessary. Five years of experience is likely to provide Energex with sufficient data to determine if further expansion of the monitoring program is required or whether it could be held at the level achieved in 2020. Further, the possibility of a smart meter role out should not be discounted, which would render monitoring of LV circuits unnecessary, such that only the transformer monitoring would still be necessary. Aurecon would recommend that the continuation of the monitoring program is subject to review prior to the 2020 regulatory submission.

3.2 Energex in comparison to other utilities

The past few years have seen unprecedented growth in solar photo-voltaic (PV) installations on domestic premises. This has been a feature giving concern to engineers in most utilities. However growth in Queensland is significantly exceeds that experienced in other states.

The table below shows some data for a selection of Australian Utilities as at 30 June 2014.

Table 3-1 A sample of Australian Electricity Utility solar PV statistics

Utility	Ausgrid	Energex	Powercor	SA Power Networks
Customers with PV	80,053	285,578	75,539	195,351
Average inverter size (kW)	2.42	3.37	2.84	3.68
Installed Capacity (kW)	193,744	961,957	214,613	718,910
Residential Customers	1,433,270	993,716	441,044	590,448
Non-residential Customers	226,449	377,046	312,869	256,398
Pole Mounted Transformers	15,937	32,113	82,113	59,991
Pad-mounted Transformers	17,053	14,142		13,996
Overhead Circuit km	19,645	14,563	9,676	
Underground Circuit km	7,099	11,620	3,509	
Penetration **customers with solar PV per LV area**	2.4	6.2	0.9	2.6
Penetration **Average kW of solar PV per LV area**	5.9	20.8	2.6	9.7

As evidenced by the above data Energex is experiencing a significant penetration in terms of total installed kW, and in terms of installed kW per distribution transformer. Furthermore the network designs used across the country are quite different. Considering Energex and SA Power Networks for example, (the two highest penetration examples), we see an After Diversity Maximum Demand (ADMD) in Energex's network of 4 kVA, and ADMD in SA Power Networks of 8 KVA. This would indicate that the average LV circuit length in South Australia is approximately half that found in Energex's area. This then leads to the conclusion that the Energex network will be significantly more sensitive to solar PV generation than the network in South Australia.

Although there has been insufficient time available to collate data for all utilities, it is clear that Energex is experiencing penetration of Solar PV installations per LV area (per transformer) that exceed those experienced by other utilities by a factor of between 2 and 8 times. In fact only a very small number of utilities worldwide (in the USA and Germany) have a higher solar PV penetration when the impact on low voltage networks is considered. This makes Energex's situation difficult to compare with other Utilities, and results in the need to implement measures that are not comparable to practices adopted by other utilities. Energex is likely to require significantly greater levels of monitoring and remediation than any other Utility in Australia.

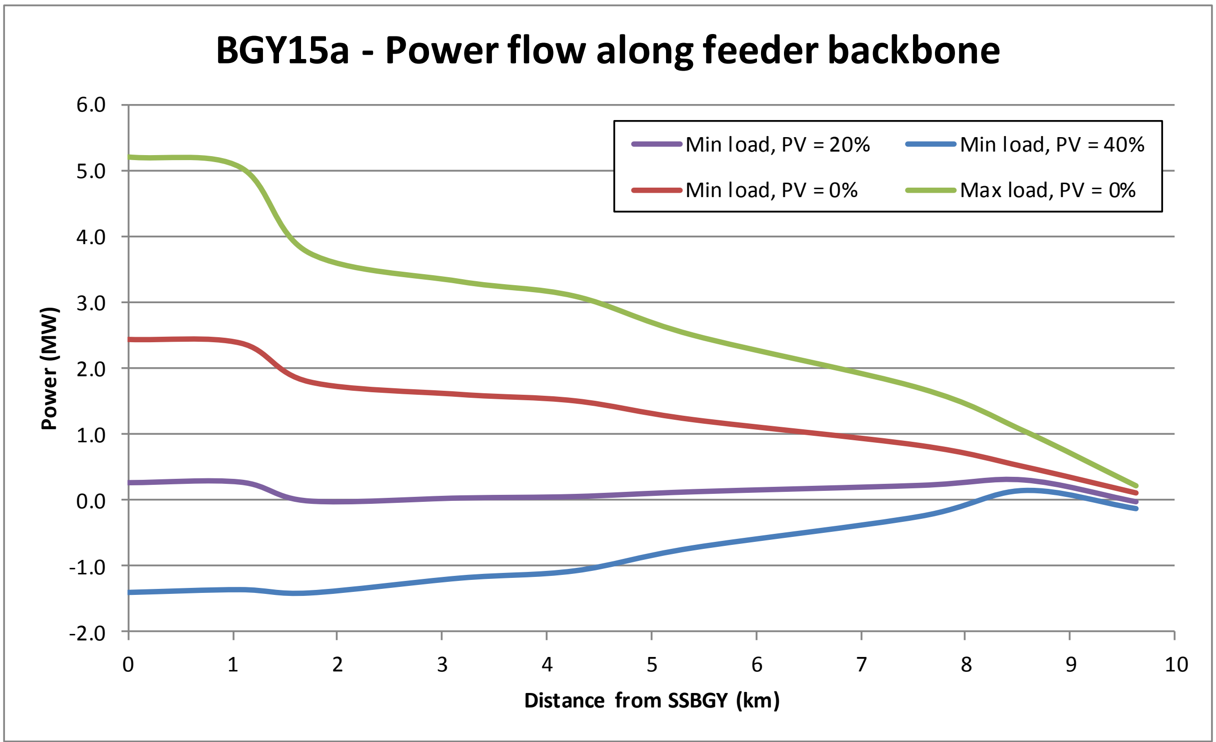
3.3 Modelling and results

3.3.1 Background

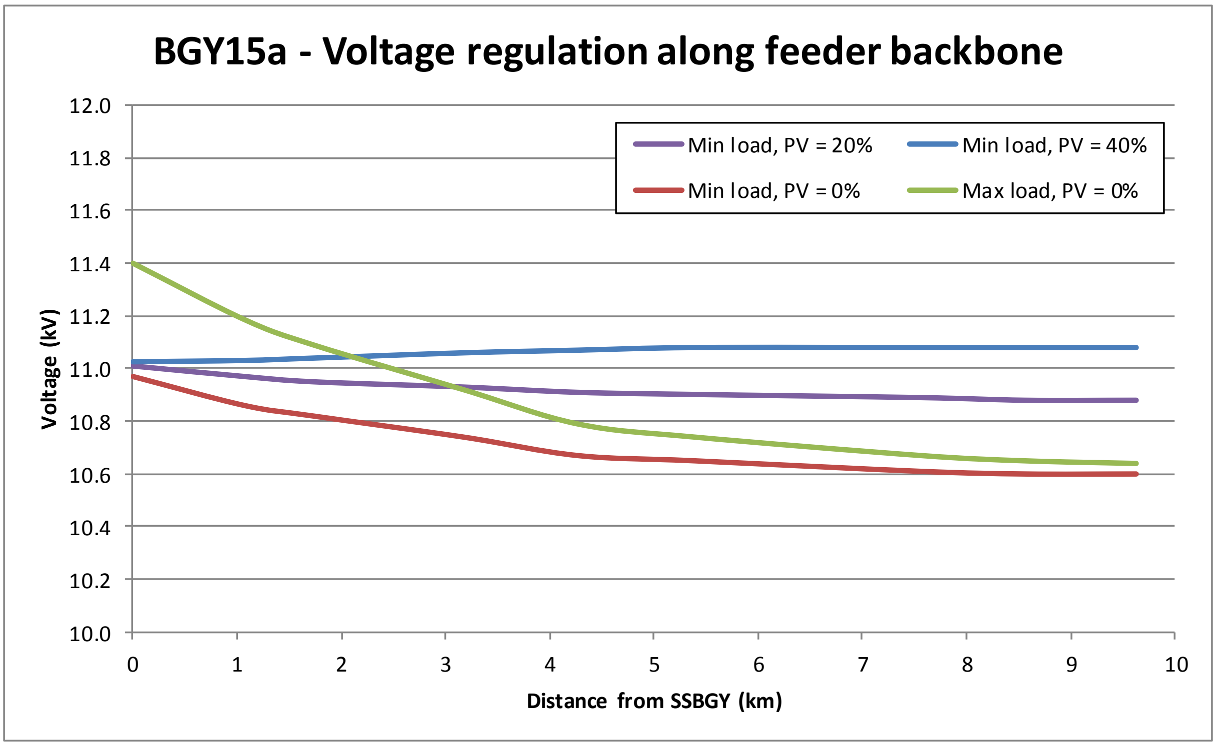
Energex has previously commissioned some modelling of the impact of solar PV penetration. This appears to have been concentrated on modelling the impacts on the low voltage system, and has been used as a basis for Energex's expectations of the scale and nature of problems that are likely to follow the growth in solar PV penetration. In practice, Aurecon is aware that a proportion of Energex's feeders are experiencing reverse power flows, as evidenced by the progression shown on 11 kV feeder CMD3A shown in figure 6 of the Power Quality Strategic Plan. While Aurecon is aware that Energex has undertaken some modelling of the effects of reverse power flow on 11 kV feeder voltage profiles, this is not developed further in the strategic plan. This phenomenon is likely to result in significant impacts to the 11 kV voltage profile and when this is combined with the impact on the low voltage network greater excursions in voltage are likely than have been postulated.

3.3.2 Additional modelling and feeder selection

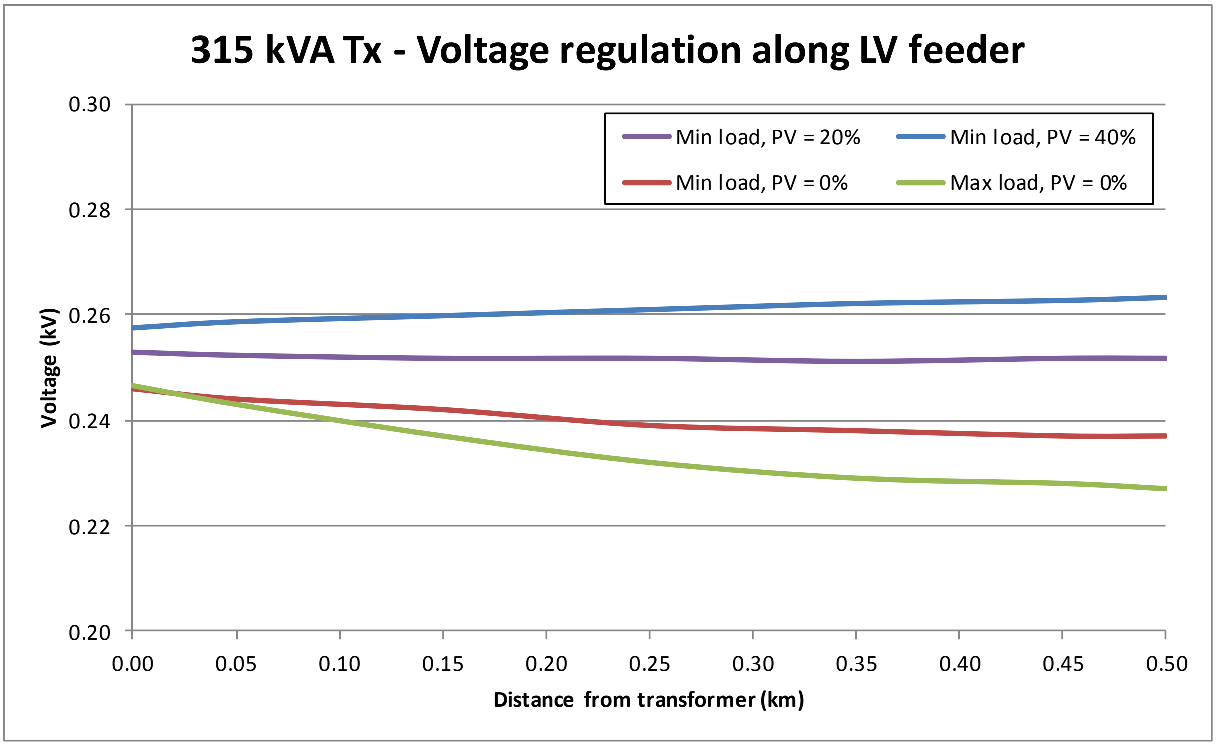
Aurecon has undertaken some limited modelling including the 11 kV system to demonstrate the impacts for 20% penetration and 40% penetration of solar PV, and examples of this are given below.



Graph 3-1 Power Flow in 11 kV feeder BGY15A



Graph 3-2 Voltage Regulation - BGY15A Feeder Backbone



Graph 3-3 Voltage Regulation – LV system supplied by 315 kVA Transformer

The graphs provided above are results of dynamic modelling that includes the combined effect on both the 11 kV system and the low voltage network. These results show voltage envelopes that approach statutory limits at 20% penetration. They also show a significantly worsening situation as the penetration reaches 40%, with widespread breaches of statutory requirements being likely. The modelling above was undertaken on 11 kV feeder BGY15A. This feeder was selected for the following reasons.

- It is an urban feeder, with a residential load profile
- It has an average of 25% solar PV penetration
- It is a relatively long urban feeder with a backbone length of 9.63 km, and a total circuit length of 17.76 km
- It supplies newly developing areas with approximately 48% of its circuit length being underground cable

Based on the above it is expected that BGY15A will clearly show some of the effects of solar PV penetration, but is not likely to be a worst case example. There are 15% of Energex's 11 kV feeders with greater overhead circuit lengths, and there are rural feeders which will have significantly longer backbones, and both these properties would contribute to more extreme examples of the effects of solar PV penetration.

The solar PV penetration on this feeder is 25% on average, but there are 6 distribution transformers (out of the total population of 33 distribution transformers) that have zero penetration. If those are removed from the calculation, then the average penetration of solar PV on this feeder is 30%. Ten distribution transformers have 35% or greater penetration (approximately 37% of the population), and 6 have 40% or greater penetration (approximately 22% of the population). The maximum penetration on this feeder was 52% for SP8639-D which is a 100 kVA transformer. This feeder was chosen as an example to develop a full model it was expected to have a voltage profile consistent with the 85th percentile of the feeder population (ie only 15% of feeders will have more extreme results). Obviously this cannot be verified without doing significantly more modelling, but Aurecon believes that this feeder will be very close to the performance of the 85th percentile, and as such it is a good choice to examine these effects.

3.3.3 Results of modelling

Graph 3.1 above shows the power flow along the feeder. The green trace shows the maximum load case which is the evening peak at around 6 pm. The red trace shows the day time minimum load case during the middle of the day (not the actual minimum which would be around 3 am). The purple trace shows the power flow for an average of 20% solar PV penetration (note, this penetration level has already been exceeded on this feeder). The blue trace shows the power flow for an average 40% penetration along this feeder. The feeder is loaded to approximately 5.2 MVA at peak load. At minimum daytime load with no solar PV, the power flow is approximately 2.4 MVA. With no PV generation, the power flow drops progressively towards the end of the feeder as normally occurs. This feeder shows a heavy concentration of load at between 1km and 2km from the substation, which is likely to be the relatively recent housing estate developments to the west of the Bruce Highway, between Narangba, and Burpengary. These are very obviously more densely developed areas than the surrounds, and this can be clearly seen by viewing the image of the area on a platform like Google Earth. At an average 20% PV penetration (on a high solar day) the power flow beyond this area is entirely supplied by Solar PV during the middle of the day, and between approximately 2 km and 4km from the substation the power flow is close to neutral. At an average 40% solar PV penetration, (on a high solar day), the power flow along the feeder, almost for its entire length flows back to the substation.

The effect of the solar PV power flow on the 11 kV feeder voltage is shown in graph 3.2 above. This shows the normal situation for minimum and maximum load (the red and green traces respectively), and shows a maximum of 3.9% voltage regulation in the 11 kV network, which happens to be at the start of the feeder. For 20% solar PV penetration, the voltage profile is considerably flattened, but still shows a voltage drop, albeit a moderate one at the end of the feeder of 1.1%. As the solar PV penetration reaches 40% on average, the feeder shows a voltage rise at the end of 0.8%, resulting in total regulation of 4.4%. While this does not seem excessive, it must be remembered that the feeder will now exhibit a 3.9% voltage variation at the front when there is no solar PV influence (at night, and on rainy or cloudy days) and a 4.4% voltage variation at the end, depending on whether there is a solar PV influence or not. It should also be noted that the voltage at the end of the feeder could swing from 11,080 to 10,600 and back in a reasonably short time, as moving cloud cover travels across the area. This will require different distribution transformer tap settings than standard and it may be difficult to accommodate all the variations that will be experienced.

3.3.4 Impact on low voltage network

The impact on the low voltage network is demonstrated in graph 3.3 above, which shows an LV network supplied by a 315 kVA transformer. This network is modelled based on a standard Moon conductor open wire arrangement, with a maximum circuit length of 500m, with 60 customers connected with and ADMD of 2.6 kVA, and with an average inverter size of 3 kVA. This shows a normally healthy voltage range of 237 to 227 Volts (4.2% regulation) with no solar PV influence. As the solar PV penetration reaches 20% of transformer capacity, the upper voltage range extends to 252 Volts (10.4% regulation), which is just inside statutory limits. At this penetration the LV network shows a voltage drop of 1.1 Volts to the end of the LV circuit (-0.5%). This is a very flat voltage curve, and represents an increase in voltage that is nearly 8 Volts above the level that would be expected at the same time of day if there was no influence from solar PV generation. The voltage at the transformer terminals is 252.9 Volts, which is 6.3 Volts higher than would be expected at the same time of day if there was no influence from solar PV generation. This is the result of the impact of solar PV generation on the 11 kV feeder voltage profile.

At a solar PV penetration of 40% of transformer capacity, the voltage reaches 263 volts (15.0% regulation) which is well outside statutory limits. At this penetration the LV network shows a voltage rise of 5.8 Volts to the end of the LV circuit (2.4%). This is a rising voltage curve, and represents an increase in voltage that is nearly 26 Volts above the level that would be expected at the same time of day if there was no influence from solar PV generation. The voltage at the transformer terminals is 257.5 Volts, which is 11.6 Volts higher than would be expected at the same time of day if there was no influence from solar PV generation. This is the result of the impact of solar PV generation on the 11 kV feeder voltage profile.

The figures derived for voltage rise on the LV network correspond to the results of LV modelling that Energex has undertaken. However, this does not tell the full story, as it neglect the impact of increases to the 11 KV feeder voltage profile. While the zone substation voltage management algorithm can be adjusted to partially compensate for some of this effect, it cannot eliminate all of the effect. In some substations where commercial load profiles with little or no solar PV penetration, and residential load profiles with high solar PV penetration, are both controlled under a common voltage management algorithm, there may be little opportunity for improvement. Aurecon therefore believes that Energex's forecast of the extent of voltage problems is likely to be understated.

In practice a voltage level of 263 Volts would not eventuate, as most inverters would trip as a result of the voltage exceeding their high voltage limit. However this would instead result in numerous complaints from customers as they would not be generating the solar energy they would be expecting. A significant increase in complaints has been evident from a review of Energex's complaint records.

This clearly shows that the impact of solar PV is more severe than would be expected from some of the simple LV modelling that has been done previously. This also demonstrates a greater voltage range than shown in the Energex strategic plan. Based on the results of this modelling it is likely that Energex will have a more expansive issue to deal with than is currently expected.

3.3.5 Extension of modelling activities

While modelling is a very useful tool to assist in the understanding of network problems, and a valuable means to test remediation theories, it is not suitable to predict the extent and location of network problems. This is due to the large number of assumptions that are made in developing models. In practice there are many variables that contribute to network performance in a location. Some of these are:

- Different load curves across location due to geographical or socio-economic properties of the area in question.
- Different solar PV penetrations and average inverter sizes, (reflective of the marketing activities of solar PV providers active in various areas), which impact network performance
- Network properties, which relate to the age of the network
- Position on the 11 kV network
- Zone substation fault levels and transformer tap changer control algorithms
- The presence or otherwise of 11 kV regulators
- The degree of unbalance between phase connections
- Tap settings on distribution transformers

These differences make modelling sufficient numbers of scenarios very time consuming, and also result in uncertainty about the effectiveness of remediation measures being applied across the network in view of all the variables that exist.

However, when backed up with real network data, modelling can be a valuable tool to design cost effective remediation measures. Without the data that will be provided by the proposed monitoring program, modelling in itself is not sufficiently accurate to avoid situations where ineffective remediation measures may be implemented, thus resulting in wasted effort and/or unnecessary expenditure. In addition this type of modelling is very complex and time consuming, and not suited to large scale studies.

Aurecon’s assessment of the LV monitoring expenditure has revealed that it is essential to establish a monitoring program to gather data required to clearly identify the extent of network problems, and to use as input to modelling the network and testing possible remediation measures. Our assessment also indicates that he level of monitoring proposed by Energex is the minimum necessary to obtain worthwhile data.

3.3.6 Likely remediation measures

There has been a very definite increase in voltage related insurance claims, with the costs increasing almost exponentially since 2010/11. This has been clearly linked to solar PV penetration and the resulting high voltage problems it causes. This has necessitated remediation, which is likely to continue to be a requirement, and which is also likely to grow as solar PV penetration increases.

To enable some measures to be determined for the likely cost of future remediation, Energex has reviewed past remediation measures from January 2014 to June 2015 and has identified that the average remediation cost was $65,000, with the range between $24,000 and $170,000. These measures were reactive measures in response to voltage complaints.

A review of possible options has identified that low order options such as balancing loads, and altering transformer tap settings, are the first options to be exercised. These are generally operational cost expenditures. Following these the options are to upgrade the distribution transformer, install a new distribution transformer and split the LV system, or to re-conductor the LV mains. These will be capital expenditures. As the growth in solar PV penetration continues, there will be new technology options developed to deal with the issues. However, at present these are some way into the future and cannot be factored in to the expenditure forecasts for the forthcoming regulatory period.

Energex has estimated a unit cost of $16,000 per LV area, (capital cost) to cover remediation requirements. This is based on the assumption that targeted and pro-active remediation will enable some savings to be made. Aurecon's review would support a higher unit cost, which we expect would be in the vicinity of $25,000. This could result in Energex having to manage a higher network risk associated with the impact of solar PV penetration.

3.4 Conclusions

The review of Energex's proposed LV monitoring submission has focussed on factors outlined in the above considerations. Our review shows that significant consideration has been given to the issues faced by Energex due to the increasing penetration of Solar PV. There is a body of evidence showing a linkage between customer voltage complaints and the growth of solar PV penetration. However, Energex's collection of data over the past few years has been more focussed at the distribution transformer level and has not been sufficient to demonstrate the full impact on customer voltages. It has therefore been necessary to demonstrate this with detailed modelling.

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The results of Aurecon's modelling show that when both the 11 kV network and LV networks are considered together, the impact of Solar PV penetration is potentially more severe than previously expected. Some form of monitoring is essential to enable a reliable understanding of the impact to be gained, and this is not linked to the expected growth of solar PV penetration, but is clearly a need that exists already.

Energex has proposed to install a number of monitors to gather information at transformers, and on low voltage circuits. Based on the results of the investigation we have undertaken, Aurecon believes that the monitoring Energex proposes is appropriate in terms of both the areas targeted and the number of monitoring devices proposed for deployment. Further we believe that reducing the number of monitors proposed would result in insufficient accuracy for the results to be effective in gaining a deep understanding of the impact of solar PV penetration, and would also result in potentially ineffective or unnecessarily costly mitigation strategies being employed. As such we believe Energex's proposed expenditure of $25 million for LV monitoring in the forthcoming regulatory period is the minimum expenditure necessary to achieve worthwhile results.

Energex has also proposed an expenditure of $13.4 million to cover remediation capital works in the forthcoming regulatory period. We have reviewed the scope and estimated cost of Energex's program and consider it to be at the lower end of our estimated range of expected outcomes. This could result in Energex having to manage a higher network risk associated with the impact of solar PV penetration.

4 Distribution augmentation

4.1 Low voltage fusing

Energex has implemented a program to equip distribution transformers from 100 kVA capacity and above, with low voltage fuses to protect each of the supplied low voltage circuits. Aurecon has been provided with background documentation of this program, and we have reviewed the following documents in detail.

- Energex LV Fusing Program Version 2 dated 15/5/2015
- Review of Fuse Protection on Distribution Transformers and Low Voltage Feeders SEG-08-09
- Change to Distribution Fusing Standard – Introduction of Low Voltage Fuses for Transformers above 100 kVA SEG-08-09A
- Transformer Low Voltage Fusing Strategy 28 May 2013

These documents are listed in Section 1.3. The program expenditure to date, and the forecast for the next regulatory period is given below in Table 4-1.

Table 4-1 LV fusing program expenditure

	Actuals						Forecast		
	09/10	**10/11**	**11/12**	**12/13**	**13/14**	**14/15**	**05/16**	**16/17**	**17/18**
$ Direct	$368	$1,122,000	$4,277,184	$5,694,379	$15,856,195	$22,978,586	$22,985,630	$22,985,628	$22,985,627
$ inc OH	$1,184	$1,573,125	$6,350,862	$8,032,703	$23,154,559	$35,213,914	$34,313,690	$34,146,885	$34,130,367
Units	1	399	820	1,064	1,973	3,269	3,269	3,269	3,269
Direct Unit Rate	$368	$2,812	$5,216	$5,352	$8,037	$7,029	$7,031	$7,031	$7,031

Unit costs have varied from the inception of the program, as the detailed scope has been developed further following the early experience. Energex has considered the practices adopted in other Australian utilities, and as evidenced by the above documentation, Energex has also undertaken detailed technical investigations and risk assessments in arriving at their proposed program.

4.2 Risk assessment

Aurecon has reviewed the performance of 11 kV expulsion drop out (EDO) fuses in comparison to low voltage high rupture capacity (HRC) fuses when low voltage faults occur. The following results are provided for information.

Table 4-2 LV HRC fuse performance vs HV EDO fuse performance

		3 Phase Fault				2 Phase Fault - Line-to-Line				1 Phase Fault			
Transformer Size (kVA)	Distance of fault from start of line (m)	Fault Current on LV side (A)	Fault Current on HV side (A)	Fuse Blow-out Time - LV Fuse (s)	Fuse Blow-out Time - HV Fuse (s)	Fault Current on LV side (A)	Fault Current on HV side (A)	Fuse Blow-out Time - LV Fuse (s)	Fuse Blow-out Time - HV Fuse (s)	Fault Current on LV side (A)	Fault Current on HV side (A)	Fuse Blow-out Time - LV Fuse (s)	Fuse Blow-out Time - HV Fuse (s)
200	100	3114	131	0.085	0.631	2697	66	0.098	3.96	2084	51	0.514	15.228
	200	1981	83	0.586	1.75	1716	42	0.784	25.056	1219	30	2.6	38.16
	300	1450	61	0.982	5.16	1256	31	2.4	37.068	861	21	6.5	47.988
	400	1143	48	3.4	18.504	990	24	4.6	44.712	666	16	28	>50
315	100	3688	155	0.069	0.747	3194	78	0.083	6.571	2330	56	0.334	23.857
	200	2194	92	0.424	2.56	1900	46	0.658	31.714	1299	31	2	43.5
	300	1560	66	0.892	16	1351	33	1.6	41.929	900	22	6	>50
	400	1210	51	2.8	27.786	1048	26	4.2	47.429	689	17	19	>50
500	100	4177	175	0.25	1.667	3617	88	0.49	21.284	2521	61	0.95	34.685
	200	2355	99	1.225	15.824	2040	50	4.375	40.145	1356	33	16	48.584
	300	1639	69	5.5	30.715	1420	35	10	47.591	927	22	>50	>50
	400	1257	53	24	38.656	1088	27	38	>50	705	17	>50	>50

#Red cells denote clearing time greater than 5 seconds

##Fault currents represented by '>50' denotes a fuse blow-out time greater than 50 seconds

The results presented in Table 4-2 show that the majority of cases where only HV protection is provided result in excessive clearing times, and many instances where faults are not likely to clear (i.e. where clearing times > 50seconds are indicated).

When LV fuses are provided in accordance with Energex recommendations, the majority of instances will result in adequate clearance times. Faults on large transformers show excessive clearing times for faults at 400 m or greater from the transformer, and possible failure to clear, (clearing times in excess of 50 sec) for single phase faults at 300 m or greater from the transformer. It would be possible to avoid excessive clearing times in the few cases mentioned above by the addition of extra fuses (with a lower rating) at 300m from the transformer. However, for the majority of installations, large transformers supply more heavily loaded areas, and LV networks extending to 300 m or more away from 500 kVA transformers would represent a very small proportion of the population. Most heavily loaded networks would be limited to shorter lengths due to the heavier circuit loadings, which result in limitations to the practical circuit length due to excessive voltage drop. It is therefore concluded that the application of Energex's LV fusing guidelines will result in satisfactory protection for the vast majority of situations.

The assessment of risk associated with the above scenario is as follows and is based on AS/NZS ISO 31000:2009 Risk management – Principles and guidelines (this originated from AS/NZS 4360:1995).

One of the primary hazards associated with the provision of electricity via overhead networks is the possibility of human contact with conductors that have fallen and remain energised. While there are others, this hazard is the one addressed by fuse protection, and other protective devices. In particular with reference to overhead low voltage networks fuse protection is the most common means to address this hazard.

With reference to the previous practice, where only HV fuse protection was provided for transformers of 100 kVA ratings or above, the risk assessment involves an assessment of the consequences of the hazard occurring, and the likelihood of the hazard occurring. The consequences, considering the worst case must be considered "Disastrous" as there is the possibility of death if a person comes into contact with live fallen low voltage conductors. Fallen conductors are not an everyday occurrence, and most commonly result from severe storm activity. However, given the high proportion of scenarios shown in Table 4.1, where fuse clearance is either very slow or may not occur at all, the likelihood of a person coming in contact with live fallen conductors may be considered "Likely" if nothing else were done. In practice there are media campaigns in place to warn people of the dangers of fallen power lines, and it is an aspect most people are aware of. As a result of these extra measures that are in place the likelihood can reasonably be considered to be “Unlikely”. The combination of a “Disastrous” consequence and an “Unlikely” likelihood results in an “Extreme” risk.

When the application of low voltage fusing is considered the consequences do not change, but the fact that the vast majority of scenarios now have adequate protection clearance times must result in the likelihood becoming “Very Unlikely”. The combination of a “Disastrous” consequence and a “Very Unlikely” likelihood result in a “High” risk. For overhead networks the risk cannot be reduced any further. Given that the “high” risk rating remains, media campaigns and other measures to warn people of the danger of fallen power lines should continue.

Energex has undertaken their own risk assessment using a somewhat different risk scoring method, but they have arrived at the conclusion that LV fusing is a necessary step to reduce the risk to public safety. In addition Energex has recommended the following measures:

- Continuance of the public awareness campaign
- A program to fit LV spacers (to prevent conductor clashing)
- A move towards LVABC as their standard, and a replacement program for bare conductors
- A vegetation trimming program
- A 24/7 emergency response to deal with fallen conductors

These measures are consistent with the “High” residual risk that is the outcome of our assessment.

Energex also considered that the timeframe for completion of the LV fusing program and determined that it should be completed in a maximum of 7 years. Acceleration of the program to achieve completion within 4 years was considered, but found to be unwarranted.

4.3 Best practice

The Energy Networks Association (ENA) issued the National Low Voltage Electricity Network Electrical Protection Guideline (ENA Doc 014-2006) with the following aims in mind:

- To promote safety for customers, the public and industry workers
- To promote nationally consistent practices
- To promote economic efficiency through standardisation
- To simplify the interpretation of regulatory requirements placed upon Network Operators, Service providers, their employees, and their contractors

The guideline also identifies situations where practices or technology may not represent a safe situation, and identifies measures to address these situations.

Throughout Australia, Electricity Distribution Network Service Providers (DNSP’s) have adopted this standard, as it represents current best practice, and provides a cost effective and prudent means to minimise the potential risks, that the public and industry workers may face in the event of incidents resulting in fallen low voltage conductors.

Aurecon has considered the historical and proposed expenditure provided by Energex, and our view is that Energex's program to install LV fusing on distribution transformers rated at 100 kVA and above is fully justified. In addition the proposed seven year timeframe is considered to be a practical approach to achieve the desired outcome while balancing resource requirements with other important business activities. In Aurecon's view this program is required to comply with ENA guidelines, is in line with industry best practice, and is necessary to safeguard public safety.

4.4 Conclusions

Aurecon's conclusion is that Energex's proposal to complete the LV fusing program by the end of 2017/18, is based on sound engineering, and has been assessed based on appropriate risk management strategies. As such we believe that the proposed expenditure is appropriate and fully justified. We also believe that this is required to comply with ENA guidelines, and is in line with industry best practice, and is necessary to safeguard public safety.

Appendix A
Review of 11 kV feeder reliability projects 2010 to 2015

Totals

Year	2010	2011	2012	2013	2014	2015	Totals (2010 to 2014)	Averages (2010 to 2014)
Total Capex spend on Reliability for 11 kV feeders	**$14,668,629**	**$26,844,812**	**$30,212,045**	**$40,658,932**	**$21,126,348**	**$2,790,918**	**$133,510,765**	**$26,702,153**
Total Reliability Projects	54	84	91	143	64	6	436	87
WPF's total on lists	139	144	145	125	139			
Capex spend on Worst Performing Feeders	**$8,491,167**	**$10,578,991**	**$10,778,856**	**$13,937,316**	**$3,987,218**	**$774,751**	**$47,773,548**	**$9,554,710**
Total WPF projects	21	30	32	51	12	2	146	29

Urban

Year	2010	2011	2012	2013	2014	2015	Totals (2010 to 2014)	Averages (2010 to 2014)
Urban WPF's on lists	76	82	80	62	83			
Urban WPF's addresssed with projects	5	6	12	29	0	0	52	10
Capex spend on Urban WPF's	**$963,456**	**$1,525,699**	**$3,781,381**	**$6,314,095**	**$621,105**	**$0**	**$13,205,736**	**$2,641,147**
% Capex spend on Urban Worst Performing Feeders	6.6%	5.7%	12.5%	15.5%	2.9%	0.0%		

Rural

Year	2010	2011	2012	2013	2014	2015	Totals (2010 to 2014)	Averages (2010 to 2014)
Rural WPF'son lists	63	62	65	63	56			
Rural WPF's addresssed with projects	16	24	20	22	12	2	94	19
Capex spend on Rural WPF's	**$7,527,711**	**$9,053,293**	**$6,997,475**	**$7,623,221**	**$3,366,113**	**$774,751**	**$34,567,813**	**$6,913,563**
% Capex spend on Rural Worst Performing Feeders	51.3%	33.7%	23.2%	18.7%	15.9%	27.8%		

Appendix B
Review of 2015 worst performing feeders

WPF LIST 2014/15 Rural and Urban

Feeder		Asset Area	Lgth (km)	Cust	Suburbs	SAIDI Performance: SAIDI All (3Yr Avg)	SAIDI Norm (11/12)	SAIDI Norm (12/13)	SAIDI Norm (13/14)	**SAIDI Norm (3Yr Avg)**	SAIDINorm (3Yr 33kV Avg)	SAIDINorm (3Yr LVT Avg)	SAIDI Avg Trend Green - Last Year < 3Yr Avg	Tick - 2Y Avg < 60% 3Yr Avg Star - 2Y Avg < 80% 3Yr Avg	SAIFI Performance: SAIFI All (3Yr Avg)	SAIFI Norm (11/12)	SAIFI Norm (12/13)	SAIFI Norm (13/14)	**SAIFI Norm (3Yr Avg)**	SAIFINorm (3Yr 33kV Avg)	SAIFINorm (3Yr LVT Avg)	SAIFI Avg Trend Green - Last Year < 3Yr Avg	Tick - 2Y Avg < 60% 3Yr Avg Star - 2Y Avg < 80% 3Yr Avg
HLG1	Rural	MS	11.5	17	DUNWICH	1595	661	0	4123	1595	211	5	↓	–									
PTR3	Urban	MN	0	2	MURARRIE	1571	0	4714	0	**1571**	0	0	↑	–									
PTR1	Urban	MN	0	3	MURARRIE	1552	0	4655	0	**1552**	0	0	↑	–									
RBK9A	Urban	WE	3.1	298	COLLINGWOOD PARK, REDBANK	887	4	2649	7	**887**	858	29	↑	–									
SIS2	Rural	MS	40.4	984	AMITY, DUNWICH, NTH STRADBROKE ISLD	1327	828	230	1282	780	481	53	↓	–									
NPD1	Urban	MN	2.4	5	JOYNER, KURWONGBAH, WHITESIDE	1011	2012	326	0	**779**	0	13	↑	✓									
SIS1	Rural	MS	27.3	1182	POINT LOOKOUT	1311	825	306	1097	743	481	32	↓	–									
AMR2	Rural	NC	115.7	759	AMAMOOR, CALICO CREEK, DAGUN, GILLDORA, KANDANGA, KANDANGA CREEK, KYBONG, LAGOON POCKET, LANGSHAW, LONG FLAT, MOOLOO, THE DAWN	932	886	793	507	729	1	47	↑	–	4.20	3.07	4.81	3.33	**3.74**	0.33	0.26	↑	–
BMT1	Rural	NC	119.7	632	BELLI PARK, BLACK MOUNTAIN, BOLLIER, CARTERS RIDGE, COOROY, FEDERAL, IMBIL, RIDGEWOOD, TUCHEKOI	2100	644	532	887	688	108	48	↓	–	5.86	4.29	5.37	4.82	**4.83**	1.70	0.25	↑	–
KCY2	Rural	MN	111.2	380	JIMNA, KILCOY, MOUNT KILCOY, SANDY CREEK, SHEEP STATION CREEK, WINYA	1035	320	912	787	673	43	32	↓	–	6.64	1.24	6.01	8.27	**5.17**	2.33	0.15	↓	–
MTB15A	Rural	SC	93.2	761	BEECHMONT, BENOBBLE, BINNA BURRA, CANUNGRA, FERNY GLEN, FLYING FOX, ILLINBAH, LOWER BEECHMONT, PINE CREEK, SARABAH, TAMBORINE MOUNTAIN, WITHEREN	1748	804	376	659	613	14	28	↓	–	6.11	8.43	3.17	4.33	**5.31**	1.00	0.12	↑	★
MGP13A	Rural	SC	92.4	1031	AUSTINVILLE, MUDGEERABA, NATURAL BRIDGE, NERANWOOD, NUMINBAH VALLEY, SPRINGBROOK	2968	772	370	679	607	0	37	↓	–									
RWD1	Rural	WE	193	527	ARATULA, CALVERT, COLEYVILLE, EBENEZER, LANEFIELD, LOWER MOUNT WALKER, MERRYVALE, MOORANG, MOUNT FORBES, MOUNT WALKER, MT MORT, MT WALKER WEST, ROSEVALE, ROSEWOOD, TAROME	931	265	195	1279	580	28	27	↓	–									
GBN3	Rural	NC	37.3	125	ANDERLEIGH, DOWNSFIELD, NEERDIE, ROSS CREEK, SANDY CREEK	594	0	1154	546	566	35	30	↑	–									
MLY4	Rural	NC	31.4	617	MALENY, MONTVILLE, NORTH MALENY, WITTA	1538	293	539	827	553	71	49	↓	–	5.92	1.14	4.43	7.93	**4.50**	1.38	0.22	↓	–
LLY1	Rural	WE	113.8	516	BLENHEIM, LAIDLEY, LAIDLEY CREEK WEST, LAIDLEY SOUTH, MULGOWIE, THORNTON, TOWNSON	1104	530	576	505	537	59	29	↑	–									
MCN3	Urban	MS	11	55	CORNUBIA, MOUNT COTTON	535	1309	207	84	**533**	346	46	↑	✓	3.77	7.87	2.34	1.09	**3.77**	2.67	0.20	↑	✓
GGR1	Rural	WE	76.7	832	COLLEGE VIEW, CROWLEY VALE, FOREST HILL, GLENORE GROVE, LAIDLEY NORTH, LAKE CLARENDON, LAWES, PLAINLAND	531	888	563	142	531	32	65	↑	★									
GBN4	Rural	NC	143.6	726	COONDOO, DOWNSFIELD, GOOMBOORIAN, GYMPIE, KIA ORA, NEERDIE, ROSS CREEK, WILSONS POCKET, WOLVI	1034	48	684	827	520	0	25	↓	–									
CRB25A	Rural	SC	51.3	1214	CURRUMBIN VALLEY, CURRUMBIN WATERS, TALLEBUDGERA, TALLEBUDGERA VALLEY	902	642	671	204	506	0	125	↑	–									
GYM9B	Rural	NC	30.7	167	CANINA, CEDAR POCKET, EAST DEEP CREEK, GREENS CREEK, MONKLAND, WOLVI	1564	764	625	50	479	0	29	↑	★									
MRB2	Rural	WE	35	51	ESK, GLEN ESK, MOOMBRA, MURRUMBA, TOOGOOLAWAH, WIVENHOE POCKET	610	726	553	140	473	78	57	↑	★									
TRP2	Rural	WE	64.5	710	CLARENDON, COOMINYA, LOWOOD, PATRICK ESTATE, RIFLE RANGE, TARAMPA	546	765	217	419	467	151	71	↑	★									
ABT8	Urban	MS	0.2	2	MORNINGSIDE	467	37	937	419	**464**	0	74	↑	–									
EMP15A	Urban	MS	2.2	50	EIGHT MILE PLAINS	448	1265	0	78	**448**	0	448	↑	✓									
MLY1	Rural	NC	73.9	770	BELLTHORPE, BOOROOBIN, MALENY, REESVILLE, STANMORE, WOOTHA	2083	418	517	405	447	51	48	↑	–	5.60	3.96	4.37	5.21	**4.51**	1.33	0.21	↓	–

WPF LIST 2014/15 Rural and Urban

Feeder		Asset Area	Lgth (km)	Cust	Suburbs	SAIDI Performance							SAIDI Avg Trend Green - Last Year < 3Yr Avg	Tick - 2Y Avg < 60% 3Yr Avg Star - 2Y Avg < 80% 3Yr Avg	SAIFI Performance							SAIFI Avg Trend Green - Last Year < 3Yr Avg	Tick - 2Y Avg < 60% 3Yr Avg Star - 2Y Avg < 80% 3Yr Avg
						SAIDI All (3Yr Avg)	SAIDI Norm (11/12)	SAIDI Norm (12/13)	SAIDI Norm (13/14)	**SAIDI Norm (3Yr Avg)**	SAIDINorm (3Yr 33kV Avg)	SAIDINorm (3Yr LVT Avg)			SAIFI All (3Yr Avg)	SAIFI Norm (11/12)	SAIFI Norm (12/13)	SAIFI Norm (13/14)	**SAIFI Norm (3Yr Avg)**	SAIFINorm (3Yr 33kV Avg)	SAIFINorm (3Yr LVT Avg)		
BHD35A	Rural	SC	58.7	1446	BURLEIGH HEADS, REEDY CREEK, TALLEBUDGERA, TALLEBUDGERA VALLEY	969	580	359	385	441	0	92	↑	–									
KCY4	Rural	MN	117.3	731	KILCOY, MOUNT ARCHER, MT DELANEY, NEURUM, ROYSTON, SANDY CREEK, STONY CREEK, VILLENEUVE, WINYA, WOODFORD	552	311	212	792	438	113	27	↓	–	5.56	1.44	2.67	8.37	**4.16**	2.50	0.14	↓	–
CRY5A	Rural	NC	16.5	88	COOROY, EUMUNDI, TINBEERWAH	453	232	999	72	434	15	9	↑	–									
TGW3	Rural	WE	159.9	420	AVOCA, AVOCA VALE, BRAEMORE, COLINTON, GREGORS CREEK, HARLIN, LINVILLE, MOORE, MT STANLEY, SCRUB CREEK, YIMBUN	649	526	490	267	428	20	21	↑	–	4.93	4.46	2.98	4.21	**3.88**	1.34	0.13	↓	–
RLB16A	Rural	MS	30.1	256	CARBROOK, MOUNT COTTON, REDLAND BAY	733	258	815	205	426	49	25	↑	–									
TRP3	Rural	WE	49.2	294	BRIGHTVIEW, CLARENDON, LOWOOD, MT TARAMPA, RIFLE RANGE, TARAMPA	441	616	176	438	410	151	69	↓	–									
JBB16A	Rural	SC	38.8	1043	JIMBOOMBA, LOGAN VILLAGE, STOCKLEIGH, TAMBORINE, YARRABILBA	1206	264	437	517	406	3	53	↓	–									
IPL1	Rural	SC	158.1	520	BARNEY VIEW, INNISPLAIN, MAROON, MT LINDESAY, OAKY CREEK, PALEN CREEK, RATHDOWNEY, RUNNING CREEK, TAMROOKUM CREEK	419	753	118	331	401	174	36	↑	✔									
IPL3	Rural	SC	126.1	459	CANUNGRA, CHINGHEE CREEK, CHRISTMAS CREEK, DARLINGTON, HILLVIEW, LAMINGTON, OAKY CREEK, TABOOBA	443	635	250	316	401	204	19	↑	✦									
WFD1B	Rural	MN	66.3	325	CEDARTON, COMMISSIONERS FLAT, PEACHESTER, STANMORE, WOODFORD	2167	123	179	899	400	64	16	↓	–									
NBR15A	Rural	NC	27	549	IMAGE FLAT, KIAMBA, KULANGOOR, NAMBOUR, YANDINA	389	380	535	252	389	0	71	↑	–									
TGW2	Rural	WE	107.5	273	BIARRA, ESKDALE, IVORY CREEK, MOUNT BEPPO, OTTABA, TOOGOOLAWAH	473	236	700	231	389	22	21	↑	–									
MLY3	Rural	NC	77.6	2027	CONONDALE, CURRAMORE, ELAMAN CREEK, MALENY, REESVILLE, WITTA	1239	382	499	259	380	52	55	↑	–	5.31	3.34	4.94	3.34	**3.87**	1.33	0.28	↑	–
TGW1	Rural	WE	127.5	395	CABOONBAH, COAL CREEK, COOEEIMBARDI, CRESSBROOK, FULHAM, LOWER CRESSBROOK, MOUNT BEPPO, SCRUB CREEK, SOMERSET DAM, TOOGOOLAWAH	402	283	614	240	379	29	23	↑	–									
ABY5A	Rural	WE	13.2	26	AMBERLEY, JEEBROPILLY, WALLOON	541	98	879	152	376	7	4	↑	–									
AGT31A	Rural	MS	27	396	LARAPINTA, PALLARA, WILLAWONG	2008	816	234	74	375	0	38	↑	✔									
IBL2	Rural	NC	86.2	706	BELLA CREEK, BOLLIER, BORUMBA DAM, BROOLOO, GHEERULLA, IMBIL, LAKE BORUMBA, MOY POCKET	1794	402	476	234	371	78	29	↑	–									
AMR3	Rural	NC	98.7	337	AMAMOOR, BOLLIER, COLES CREEK, COORAN, DAGUN, GOOMONG POCKET, GYMPIE, IMBIL, KANDANGA, KYBONG, LAGOON POCKET, TRAVESTON, TUCHEKOI	1470	569	361	180	370	1	18	↑	✦									
MBG4	Rural	WE	69.2	414	FAIRNEY VIEW, FERNVALE, GLAMORGAN VALE, HAIGSLEA, LARK HILL, LOWOOD, MARBURG, VERNOR, WANORA	1049	302	107	696	368	3	41	↓	–									
KWH1	Rural	NC	61.9	537	COOLABINE, KENILWORTH, KIDAMAN CREEK, MAPLETON, OBI OBI	2096	75	255	750	360	3	43	↓	–									
LLY4	Rural	WE	41	902	FOREST HILL, LAIDLEY, LAIDLEY HEIGHTS, LAIDLEY NORTH, PLAINLAND, SUMMERHOLM	358	259	284	529	357	59	18	↓	–									
JBB13A	Rural	SC	46.1	1128	JIMBOOMBA, MUNDOOLUN, TAMBORINE	1694	349	109	612	357	3	8	↓	–									
YDA1B	Rural	NC	15.9	404	NINDERRY, YANDINA	435	193	498	369	354	19	45	↓	–	5.40	4.08	4.94	4.14	**4.39**	1.67	0.24	↑	–
MCN2	Rural	MS	9.3	69	MOUNT COTTON	393	234	520	297	350	95	21	↑	–									
CNB24A	Rural	MS	29.4	1195	CARBROOK, CORNUBIA, MOUNT COTTON	350	529	371	149	350	0	41	↑	✦									
TAB3	Urban	MN	1.8	154	ALBION	436	307	191	547	**348**	1	73	↓	–									
MSV2	Rural	WE	49.8	166	BLACK DUCK CREEK, EAST HALDON, JUNCTION VIEW, LEFT HAND BRANCH, MT SYLVIA, WOODBINE	2514	67	88	890	348	74	26	↓	–									

WPF LIST 2014/15 Rural and Urban

Feeder		Asset Area	Lgth (km)	Cust	Suburbs	SAIDI Performance									SAIFI Performance								
						SAIDI All (3Yr Avg)	SAIDI Norm (11/12)	SAIDI Norm (12/13)	SAIDI Norm (13/14)	**SAIDI Norm (3Yr Avg)**	SAIDINorm (3Yr 33kV Avg)	SAIDINorm (3Yr LVT Avg)	SAIDI Avg Trend Green - Last Year < 3Yr Avg	Tick - 2Y Avg < 60% 3Yr Avg Star - 2Y Avg < 80% 3Yr Avg	SAIFI All (3Yr Avg)	SAIFI Norm (11/12)	SAIFI Norm (12/13)	SAIFI Norm (13/14)	**SAIFI Norm (3Yr Avg)**	SAIFINorm (3Yr 33kV Avg)	SAIFINorm (3Yr LVT Avg)	SAIFI Avg Trend Green - Last Year < 3Yr Avg	Tick - 2Y Avg < 60% 3Yr Avg Star - 2Y Avg < 80% 3Yr Avg
GYGGYS6	Rural	NC	96.5	611	ALBERTON, GLANMIRE, GYMPIE, JONES HILL, KYBONG, MONKLAND, TANDUR, THE DAWN, TRAVESTON, WOONDUM	376	530	204	310	348	1	30	↑	✦									
KCY5	Rural	MN	55.2	546	GREGORS CREEK, HARLIN, HAZELDEAN, KILCOY, WINYA, WOOLMAR	451	47	499	490	345	66	15	↓	–	5.40	0.29	4.70	7.03	**4.01**	2.33	0.07	↓	–
NBR7A	Rural	NC	55	2149	BLI BLI, NAMBOUR, ROSEMOUNT	345	541	34	458	344	10	47	↓	–	3.95	5.72	0.16	5.95	**3.95**	0.35	0.20	↓	–
FDS4	Rural	WE	105.7	364	COLEYVILLE, HARRISVILLE, MOUNT FORBES, MUTDAPILLY, PEAK CROSSING, PURGA	346	162	170	700	344	0	16	↓	–									
THL3	Rural	WE	100.5	436	FORDSDALE, GRANTHAM, LOWER TENTHILL, MA MA CREEK, MT WHITESTONE, UPPER TENTHILL, VERADILLA, WEST HALDON, WINWILL	513	494	251	280	342	99	46	↑	✦									
BHD23A	Rural	SC	29.4	1223	BURLEIGH HEADS, CURRUMBIN VALLEY, ELANORA, TALLEBUDGERA	1317	529	340	152	341	1	92	↑	✦									
TBV2	Rural	MS	49.1	283	BEAUDESERT, BIRNAM, BOYLAND, MUNDOOLUN, TABRAGALBA, TAMBORINE	338	0	290	724	338	24	68	↓	–									
TBV3	Rural	MS	20.1	366	TAMBORINE	1805	0	546	456	334	20	6	↓	–									
PWC4	Rural	NC	87.6	1794	COES CREEK, DULONG, FLAXTON, HUNCHY, LANDERS SHOOT, MONTVILLE, NORTH MALENY, PALMWOODS, PERWILLOWEN, TOWEN MOUNTAIN, WEST WOOMBYE, WOOMBYE	941	516	271	213	333	24	52	↑	✦									
CPD1	Rural	WE	89.6	392	BLANCHVIEW, DERRYMORE, FLAGSTONE CREEK, HELIDON, LILYDALE, MA MA CREEK, MIDDLE RIDGE, PRESTON, ROCKMOUNT, SILVER RIDGE, STOCKYARD, UPPER FLAGSTONE	332	367	404	218	330	0	20	↑	–									
EZRRWD4	Rural	WE	55.6	272	EBENEZER, MOUNT FORBES, MUTDAPILLY, ROSEWOOD, THAGOONA, WALLOON, WILLOWBANK	354	27	156	805	330	61	17	↓	–									
IPL3	Rural	SC	126.1	459	CANUNGRA, CHINGHEE CREEK, CHRISTMAS CREEK, DARLINGTON, HILLVIEW, LAMINGTON, OAKY CREEK, TABOOBA										4.89	4.70	3.94	2.80	**3.81**	2.33	0.14	↑	–
MRB2	Rural	WE	35	51	ESK, GLEN ESK, MOOMBRA, MURRUMBA, TOOGOOLAWAH, WIVENHOE POCKET										5.08	3.18	5.49	2.57	**3.75**	1.50	0.20	↑	–

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						Sustained Event Causes (11kV and above) - 3Yr Avg												Existing feeder characterisitic data						Probably Reliability Improvement Scope				
Feeder		Asset Area	Lgth (km)	Cust	Suburbs	Outages (3Yr Avg)	O/H Equip	U/G Equip	Trees	Animals	Lightning	Substation	No Cause	Accidental	Overload	Other / Planned	Fault Rate (Faults/100km/year)	O/H Length (m)	U/G Length (m)	Reclosers	Sectionalisers	MDO's	Ties to adjacent	Fuses, ties, isolators, reclosers & sectionalisers	Split Feeder	CCT	Likely reliability project cost	Likely reliability project cost for SAIDI Norm > 436 mins
HLG1	Rural	MS	11.5	17	DUNWICH	1.3	0	0	0	0	0.3	0	0.3	0.3	0	0.6	11	11410	103	0	0	0	1	Yes			$258,974	$258,974
PTR3	Urban	MN	0	2	MURARRIE	0.7	0	0	0	0	0	0	0	0.3	0	0.3		4129	2213	0	0	0	3	Yes			$258,974	$258,974
PTR1	Urban	MN	0	3	MURARRIE	0.7	0	0	0	0	0	0	0	0.3	0	0.3		4129	2213	0	0	0	3	Yes			$258,974	$258,974
RBK9A	Urban	WE	3.1	298	COLLINGWOOD PARK, REDBANK	0.7	0	0	0	0	0	0.7	0	0	0	0	23	2114	1021	0	0	0	3	Yes			$258,974	$258,974
SIS2	Rural	MS	40.4	984	AMITY, DUNWICH, NTH STRADBROKE ISLD	9	1.7	0	0.7	0	0	0	0.7	0.3	0	5.6	22	35700	560	6	2	4	3		Yes		$802,819	$802,819
NPD1	Urban	MN	2.4	5	JOYNER, KURWONGBAH, WHITESIDE	6	0	0	0	0	0	0	0	0	0	6	250	2265	176	0	0	0	4	Yes			$258,974	$258,974
SIS1	Rural	MS	27.3	1182	POINT LOOKOUT	2.3	1	0	0	0	0	0	0.7	0.3	0	0.3	8	24379	2943	4	1	1	3	Yes			$258,974	$258,974
AMR2	Rural	NC	115.7	759	AMAMOOR, CALICO CREEK, DAGUN, GILLDORA, KANDANGA, KANDANGA CREEK, KYBONG, LAGOON POCKET, LANGSHAW, LONG FLAT, MOOLOO, THE DAWN	32	3.7	0	1.3	0.3	0.7	0	0.3	0.3	0	22.6	28	115847	0	3	1	4	6		Yes		$802,819	$802,819
BMT1	Rural	NC	119.7	632	BELLI PARK, BLACK MOUNTAIN, BOLLIER, CARTERS RIDGE, COOROY, FEDERAL, IMBIL, RIDGEWOOD, TUCHEKOI	31	1.7	0	1.3	0	0	0.7	1.7	0.3	0	24.3	26	120206	893	4	6	3	6		Yes		$802,819	$802,819
KCY2	Rural	MN	111.2	380	JIMNA, KILCOY, MOUNT KILCOY, SANDY CREEK, SHEEP STATION CREEK, WINYA	14.3	1.3	0	2	0.3	0.3	0.3	0	0.3	0	10.7	13	114546	0	4	4	0	3	Yes	Yes		$802,819	$802,819
MTB15A	Rural	SC	93.2	761	BEECHMONT, BENOBBLE, BINNA BURRA, CANUNGRA, FERNY GLEN, FLYING FOX, ILLINBAH, LOWER BEECHMONT, PINE CREEK, SARABAH, TAMBORINE MOUNTAIN, WITHEREN	20.3	1.7	0	3.3	0.3	0.3	0	1.7	0.3	0.3	11.7	22	89842	2578	5	10	3	4		Yes		$802,819	$802,819
MGP13A	Rural	SC	92.4	1031	AUSTINVILLE, MUDGEERABA, NATURAL BRIDGE, NERANWOOD, NUMINBAH VALLEY, SPRINGBROOK	24.3	2.7	0	4.3	0	0	0	2	0	0	15	26	89776	4349	6	6	14	7		Yes		$802,819	$802,819
RWD1	Rural	WE	193	527	ARATULA, CALVERT, COLEYVILLE, EBENEZER, LANEFIELD, LOWER MOUNT WALKER, MERRYVALE, MOORANG, MOUNT FORBES, MOUNT WALKER, MT MORT, MT WALKER WEST, ROSEVALE, ROSEWOOD, TAROME	16	1.7	0	0.3	0.3	0.3	0.3	1.7	0	0	10.3	8	184572	244	5	3	4	3		Yes		$802,819	$802,819
GBN3	Rural	NC	37.3	125	ANDERLEIGH, DOWNSFIELD, NEERDIE, ROSS CREEK, SANDY CREEK	4.3	0.7	0	0	0	0	0	0	0	0	3.3	12	37245	33	2	2	0	2	Yes			$258,974	$258,974
MLY4	Rural	NC	31.4	617	MALENY, MONTVILLE, NORTH MALENY, WITTA	10	1.3	0	1.7	0.3	0.7	0.3	1	0	0	4.3	32	34742	723	3	1	1	6	Yes			$258,974	$258,974
LLY1	Rural	WE	113.8	516	BLENHEIM, LAIDLEY, LAIDLEY CREEK WEST, LAIDLEY SOUTH, MULGOWIE, THORNTON, TOWNSON	11.3	2	0	0.3	0.3	0.3	0	1	0.7	0	6.3	10	112681	1484	3	2	3	2	Yes	Yes		$802,819	$802,819
MCN3	Urban	MS	11	55	CORNUBIA, MOUNT COTTON	6.3	0.3	0	1	0	0.3	0	1	0	0	4	57	10790	174	2	0	0	5	Yes			$258,974	$258,974
GGR1	Rural	WE	76.7	832	COLLEGE VIEW, CROWLEY VALE, FOREST HILL, GLENORE GROVE, LAIDLEY NORTH, LAKE CLARENDON, LAWES, PLAINLAND	21	1	0	1	0.7	0.7	0	1.3	0.3	0	16	27	58552	13	3	1	1	6	Yes			$258,974	$258,974
GBN4	Rural	NC	143.6	726	COONDOO, DOWNSFIELD, GOOMBOORIAN, GYMPIE, KIA ORA, NEERDIE, ROSS CREEK, WILSONS POCKET, WOLVI	24.3	1.7	0	1.3	0	0	0	1.3	0	0	19.4	17	141672	115	4	4	9	2	Yes	Yes		$802,819	$802,819
CRB25A	Rural	SC	51.3	1214	CURRUMBIN VALLEY, CURRUMBIN WATERS, TALLEBUDGERA, TALLEBUDGERA VALLEY	32.3	1.3	0	4.7	0	0.7	0	0.3	0.3	0	23.6	63	50885	6087	7	9	7	5		Yes	Yes	$2,848,714	$2,848,714
GYM9B	Rural	NC	30.7	167	CANINA, CEDAR POCKET, EAST DEEP CREEK, GREENS CREEK, MONKLAND, WOLVI	12	2.3	0	1.3	0	0.7	0	0.3	0.3	0	7	39	29720	306	2	2	2	7	Yes			$258,974	$258,974
MRB2	Rural	WE	35	51	ESK, GLEN ESK, MOOMBRA, MURRUMBA, TOOGOOLAWAH, WIVENHOE POCKET	6.7	1	0	0	0.7	1	0	1	0	0	3.3	19	34547	74	0	2	0	3	Yes			$258,974	$258,974
TRP2	Rural	WE	64.5	710	CLARENDON, COOMINYA, LOWOOD, PATRICK ESTATE, RIFLE RANGE, TARAMPA	21	0.7	0	1	1	0.3	0	2	0.3	0	14.3	33	21384	1029	1	0	1	7	Yes			$258,974	$258,974
ABT8	Urban	MS	0.2	2	MORNINGSIDE	1	0	0	0	0	0	0	0	0	0	1	500	0	167	0	0	0	0	Yes			$258,974	$258,974
EMP15A	Urban	MS	2.2	50	EIGHT MILE PLAINS	0	0	0	0	0	0	0	0	0	0	0	0	0	2510	0	0	0	3	Yes			$258,974	$258,974
MLY1	Rural	NC	73.9	770	BELLTHORPE, BOOROOBIN, MALENY, REESVILLE, STANMORE, WOOTHA	14.3	2	0	2.3	0.3	0.3	0	1.7	0.7	0	6.7	19	73358	913	3	6	4	4		Yes		$802,819	$802,819
BHD35A	Rural	SC	58.7	1446	BURLEIGH HEADS, REEDY CREEK, TALLEBUDGERA, TALLEBUDGERA VALLEY	28	1.7	0	5	0	0.3	0	3.3	0	0	17.6	48	53793	4573	5	13	5	7		Yes	Yes	$2,848,714	$2,848,714
KCY4	Rural	MN	117.3	731	KILCOY, MOUNT ARCHER, MT DELANEY, NEURUM, ROYSTON, SANDY CREEK, STONY CREEK, VILLENEUVE, WINYA, WOODFORD	19.7	2.7	0	1.7	0.7	0.3	0.3	0	0.3	0	13.7	17	115810	2230	7	5	0	7	Yes	Yes		$802,819	$802,819
CRY5A	Rural	NC	16.5	88	COOROY, EUMUNDI, TINBEERWAH	4.3	1	0	0	0	0.3	0	0.3	0.3	0	2	26	16539	279	0	0	0	3	Yes			$258,974	$0
TGW3	Rural	WE	159.9	420	AVOCA, AVOCA VALE, BRAEMORE, COLINTON, GREGORS CREEK, HARLIN, LINVILLE, MOORE, MT STANLEY, SCRUB CREEK, YIMBUN	26	2.3	0	0.3	0	0	0	1.3	0	0.3	21	16	160159	102	5	1	5	6		Yes		$802,819	$0
RLB16A	Rural	MS	30.1	256	CARBROOK, MOUNT COTTON, REDLAND BAY	10.3	0.3	0.3	1.3	0	0	0	0.7	0	0	7.6	34	27657	3039	0	0	8	9	Yes			$258,974	$0
TRP3	Rural	WE	49.2	294	BRIGHTVIEW, CLARENDON, LOWOOD, MT TARAMPA, RIFLE RANGE, TARAMPA	10	0.7	0	0	0	0	0	2.7	0	0	5.7	20	39234	0	1	1	2	7	Yes			$258,974	$0
JBB16A	Rural	SC	38.8	1043	JIMBOOMBA, LOGAN VILLAGE, STOCKLEIGH, TAMBORINE, YARRABILBA	9.7	0.7	0	2.3	0.3	0	0	0.3	0	0	5.7	25	33494	5687	5	1	3	5		Yes		$802,819	$0
IPL1	Rural	SC	158.1	520	BARNEY VIEW, INNISPLAIN, MAROON, MT LINDESAY, OAKY CREEK, PALEN CREEK, RATHDOWNEY, RUNNING CREEK, TAMROOKUM CREEK	16	1	0	0.7	0.7	0.7	0.7	0.7	0	0	10.3	10	161040	74	6	2	12	4		Yes		$802,819	$0
IPL3	Rural	SC	126.1	459	CANUNGRA, CHINGHEE CREEK, CHRISTMAS CREEK, DARLINGTON, HILLVIEW, LAMINGTON, OAKY CREEK, TABOOBA	11.3	2.3	0	1.3	0.7	0.7	0.7	0	0	0	6	9	123127	495	7	4	2	4	Yes	Yes		$802,819	$0
WFD1B	Rural	MN	66.3	325	CEDARTON, COMMISSIONERS FLAT, PEACHESTER, STANMORE, WOODFORD	9.7	0.7	0	1	0	0	0	0.3	0.3	0	7	15	66141	201	2	3	1	7	Yes			$258,974	$0
NBR15A	Rural	NC	27	549	IMAGE FLAT, KIAMBA, KULANGOOR, NAMBOUR, YANDINA	9.7	0.7	0.3	1	0	0	0	0.3	0	0	8	36	25960	1216	1	0	1	4	Yes			$258,974	$0
TGW2	Rural	WE	107.5	273	BIARRA, ESKDALE, IVORY CREEK, MOUNT BEPPO, OTTABA, TOOGOOLAWAH	15.7	2.3	0	0.3	0.7	0	0	2	0	0	10	15	108150	310	3	0	2	7	Yes	Yes		$802,819	$0
MLY3	Rural	NC	77.6	2027	CONONDALE, CURRAMORE, ELAMAN CREEK, MALENY, REESVILLE, WITTA	22.7	2.3	0	3	0.3	0.3	0	2	0	0	14	29	80930	2148	4	4	2	7	Yes			$258,974	$0
TGW1	Rural	WE	127.5	395	CABOONBAH, COAL CREEK, COOEEIMBARDI, CRESSBROOK, FULHAM, LOWER CRESSBROOK, MOUNT BEPPO, SCRUB CREEK, SOMERSET DAM, TOOGOOLAWAH	21.3	2.7	0	0	0.3	0	0	2	0	0	16	17	125765	0	3	1	2	3	Yes	Yes		$802,819	$0
ABY5A	Rural	WE	13.2	26	AMBERLEY, JEEBROPILLY, WALLOON	3.3	1.7	0	0	0	0	0	0.7	0	0	1	25	12968	204	0	0	0	2	Yes			$258,974	$0
AGT31A	Rural	MS	27	396	LARAPINTA, PALLARA, WILLAWONG	4.3	0.3	0	0.7	1.3	0.3	0	0	0.3	0	1.3	16	16617	9867	2	0	0	5	Yes			$258,974	$0
IBL2	Rural	NC	86.2	706	BELLA CREEK, BOLLIER, BORUMBA DAM, BROOLOO, GHEERULLA, IMBIL, LAKE BORUMBA, MOY POCKET	14.3	1	0	0.3	1	0	0	0.7	0.3	0	10.4	17	87044	49	3	1	4	4		Yes		$802,819	$0
AMR3	Rural	NC	98.7	337	AMAMOOR, BOLLIER, COLES CREEK, COORAN, DAGUN, GOOMONG POCKET, GYMPIE, IMBIL, KANDANGA, KYBONG, LAGOON POCKET, TRAVESTON, TUCHEKOI	14.3	1.3	0	0	0.3	0	0	0.7	0	0	12	14	97687	1019	4	3	0	9	Yes			$258,974	$0
MBG4	Rural	WE	69.2	414	FAIRNEY VIEW, FERNVALE, GLAMORGAN VALE, HAIGSLEA, LARK HILL, LOWOOD, MARBURG, VERNOR, WANORA	11.7	0	0	0.3	0	1	0	0.3	0.3	0	9.3	17	70867	140	1	1	1	6	Yes			$258,974	$0
KWH1	Rural	NC	61.9	537	COOLABINE, KENILWORTH, KIDAMAN CREEK, MAPLETON, OBI OBI	13	0.3	0	0.3	0	0	0	1	0	0	7.3	21	64195	413	4	2	1	2	Yes			$258,974	$0

WPF LIST 2014/15 Rural and Urban

Feeder		Asset Area	Lgth (km)	Cust	Suburbs	Sustained Event Causes (11kV and above) - 3Yr Avg												Existing feeder characterisitic data						Probably Reliability Improvement Scope				
						Outages (3Yr Avg)	O/H Equip	U/G Equip	Trees	Animals	Lightning	Substation	No Cause	Accidental	Overload	Other / Planned	Fault Rate (Faults/100km/year)	O/H Length (m)	U/G Length (m)	Reclosers	Sectionalisers	MDO's	Ties to adjacent	Fuses, ties, isolators, reclosers & sectionalisers	Split Feeder	CCT	Likely reliability project cost	Likely reliability project cost for SAIDI Norm > 436 mins
LLY4	Rural	WE	41	902	FOREST HILL, LAIDLEY, LAIDLEY HEIGHTS, LAIDLEY NORTH, PLAINLAND, SUMMERHOLM	13.3	0.3	0	0	1	0.3	0	2.3	0.7	0	7.7	32	45258	2288	2	1	4	7		Yes	Yes	$2,848,714	$0
JBB13A	Rural	SC	46.1	1128	JIMBOOMBA, MUNDOOLUN, TAMBORINE	6.7	0.3	0	2.3	0.3	0	0	0	0.3	0	2	15	41077	3899	6	1	2	6	Yes			$258,974	$0
YDA1B	Rural	NC	15.9	404	NINDERRY, YANDINA	5.3	1.3	0.3	1	0	0.3	0	1.3	0.3	0	0.7	33	13213	2709	0	0	0	5	Yes			$258,974	$0
MCN2	Rural	MS	9.3	69	MOUNT COTTON	3.7	0.7	0	0	0	0.7	0	0.3	0	0	1.3	40	7694	1638	1	0	0	3	Yes			$258,974	$0
CNB24A	Rural	MS	29.4	1195	CARBROOK, CORNUBIA, MOUNT COTTON	10	0	0.7	0.7	0.3	0	0	1.3	0.3	0	5.4	34	23380	6883	4	0	1	7	Yes			$258,974	$0
TAB3	Urban	MN	1.8	154	ALBION	2.7	0.3	0	0	0.7	0	0	0.7	0	0	0.3	150	894	947	0	0	0	3	Yes			$258,974	$0
MSV2	Rural	WE	49.8	166	BLACK DUCK CREEK, EAST HALDON, JUNCTION VIEW, LEFT HAND BRANCH, MT SYLVIA, WOODBINE	3.3	0	0	0	0	0	0	1	0	0	2.3	7	49828	0	1	0	0	1	Yes			$258,974	$0
GYGGYS6	Rural	NC	96.5	611	ALBERTON, GLANMIRE, GYMPIE, JONES HILL, KYBONG, MONKLAND, TANDUR, THE DAWN, TRAVESTON, WOONDUM	16.3	2	0	0	0.7	0	0	0	0	0	12.6	17	96815	137	3	3	8	8		Yes		$802,819	$0
KCY5	Rural	MN	55.2	546	GREGORS CREEK, HARLIN, HAZELDEAN, KILCOY, WINYA, WOOLMAR	10	0.7	0	0.7	0.3	0.3	0.3	0.7	0	0	7	18	53791	1390	2	3	2	3	Yes			$258,974	$0
NBR7A	Rural	NC	55	2149	BLI BLI, NAMBOUR, ROSEMOUNT	15.3	1.7	0	1.3	0	0.3	0.3	0.3	1	0	10.7	28	49017	4765	4	4	5	7		Yes		$802,819	$0
FDS4	Rural	WE	105.7	364	COLEYVILLE, HARRISVILLE, MOUNT FORBES, MUTDAPILLY, PEAK CROSSING, PURGA	19.3	2	0	0	0.3	0	0	1	0.3	0	14	18	108899	120	3	4	1	7	Yes	Yes		$802,819	$0
THL3	Rural	WE	100.5	436	FORDSDALE, GRANTHAM, LOWER TENTHILL, MA MA CREEK, MT WHITESTONE, UPPER TENTHILL, VERADILLA, WEST HALDON, WINWILL	6.3	1	0	0	0.3	0	0	1.3	0.3	0	3	6	100374	102	2	5	0	5	Yes	Yes		$802,819	$0
BHD23A	Rural	SC	29.4	1223	BURLEIGH HEADS, CURRUMBIN VALLEY, ELANORA, TALLEBUDGERA	8.3	0	0	1.7	0	0	0.3	0.3	0	0	5.3	28	25540	3281	5	13	2	11	Yes			$258,974	$0
TBV2	Rural	MS	49.1	283	BEAUDESERT, BIRNAM, BOYLAND, MUNDOOLUN, TABRAGALBA, TAMBORINE	4	0.3	0	0.3	0	0	0	0	0.3	0	2.7	8	46467	385	1	5	1	3	Yes			$258,974	$0
TBV3	Rural	MS	20.1	366	TAMBORINE	4	0.7	0	1.3	0	0	0	0.3	0.3	0	1.3	20	19675	93	2	2	1	3	Yes			$258,974	$0
PWC4	Rural	NC	87.6	1794	COES CREEK, DULONG, FLAXTON, HUNCHY, LANDERS SHOOT, MONTVILLE, NORTH MALENY, PALMWOODS, PERWILLOWEN, TOWEN MOUNTAIN, WEST WOOMBYE, WOOMBYE	26	0.7	0	5.3	0.7	0.3	0	1.3	0	0	16.3	30	86405	880	5	5	13	8		Yes		$802,819	$0
CPD1	Rural	WE	89.6	392	BLANCHVIEW, DERRYMORE, FLAGSTONE CREEK, HELIDON, LILYDALE, MA MA CREEK, MIDDLE RIDGE, PRESTON, ROCKMOUNT, SILVER RIDGE, STOCKYARD, UPPER FLAGSTONE	5	0.3	0	0	0.3	0	0	1.7	0.3	0	2.3	6	89026	1255	4	2	4	2	Yes			$258,974	$0
EZRRWD4	Rural	WE	55.6	272	EBENEZER, MOUNT FORBES, MUTDAPILLY, ROSEWOOD, THAGOONA, WALLOON, WILLOWBANK	6.7	1	0	0	0	0.3	0.3	0.3	0.3	0	4	12	58052	890	3	3	2	5	Yes			$258,974	$0
IPL3	Rural	SC	126.1	459	CANUNGRA, CHINGHEE CREEK, CHRISTMAS CREEK, DARLINGTON, HILLVIEW, LAMINGTON, OAKY CREEK, TABOOBA	11.3	2.3	0	1.3	0.7	0.7	0.7	0	0	0	6	9	123127	495	7	4	2	4	Yes	Yes		$802,819	$0
MRB2	Rural	WE	35	51	ESK, GLEN ESK, MOOMBRA, MURRUMBA, TOOGOOLAWAH, WIVENHOE POCKET	6.7	1	0	0	0.7	1	0	1	0	0	3.3	19	34547	74	0	2	0	3	Yes			$258,974	$0
																										Total Expenditure		$18,413,051
																										Average cost per feeder		$657,608.98

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