Powerlink Queensland

Project Assessment Conclusions Report

26 September 2018

Maintaining reliability of supply to Ingham

Document Purpose

For the benefit of those not familiar with the National Electricity Rules (the Rules) and the National Electricity Market (NEM), Powerlink offers the following clarifications on the purpose and intent of this document:

1. The Rules require Powerlink to carry out forward planning to identify future reliability of supply requirements and consult with interested parties on the proposed solution as part of the Regulatory Investment Test for Transmission (RIT-T). This includes replacement of network assets in addition to augmentations of the transmission network.
2. Powerlink must identify, evaluate and compare network and non-network options (including, but not limited to, generation and demand side management) to identify the '*preferred option*' which can address future network requirements at the lowest net cost to electricity consumers. This assessment compares the net present value (NPV) of all credible options to identify the option that provides the greatest economic benefits to the market.
3. This document contains the results of this evaluation, and a final recommended solution to address the reliability of supply issues arising from the ageing transformers at Ingham South Substation from December 2019.

Contents

Executive Summary

Ingham South Substation was established in 2005 as a replacement for the original Ingham Substation. Two 132/66kV transformers connect the Powerlink substation to the Ergon Energy switchyard at Ingham supplying the local area. Both transformers are now over 50 years old, having previously been installed at other locations on the network.

The transformers (T1 and T2) are nearing the end of their technical service lives, with an increasing risk of failure. The failure of a transformer can result in an extensive replacement timeframe increasing the risk of loss of supply to the local area, and in extreme cases, could present a risk to the safety of personnel and members of the public.

Planning studies have confirmed there is an enduring need for the transformer capacity to maintain the supply of electricity in the Ingham area.

This presents Powerlink with operational and compliance issues, requiring resolution. Since consideration for this investment is driven by an obligation in the National Electricity Rules (the Rules), it is a 'reliability corrective action' under the Regulatory Investment Test for Transmission (RIT-T).

This Project Assessment Conclusions Report (PACR) represents the final step of the RIT-T process prescribed under the Rules undertaken by Powerlink to address the condition risks arising from ageing transformers at Ingham South Substation. It contains the results of the planning investigation and cost-benefit analysis of credible options. In accordance with the RIT-T, the credible option that maximises the present value of net economic benefits is recommended for implementation.

Credible options considered

Powerlink identified three credible network options to address the identified need, as presented in Table 1.

Table 1: Summary of credible options

Option	Description	Indicative capital cost ($m, 2017/18)
Base option:	Refit both T1 and T2 in 2019, then replace both T1 & T2 in 2032	10.5
Option 1:	Replace T1 and refit T2 in 2019, then replace T2 in 2032	8.1
Option 2:	Replace both T1 and T2 in 2019	5.7

Evaluation and conclusion

The RIT-T requires that the proposed preferred option maximises the present value of net economic benefit, or minimises the net cost, to all those who produce, consume and transport electricity in the market.

In accordance with the expedited process for this RIT-T, the PSCR made a draft recommendation to implement Option 2, replacement of both transformers by December 2019. The estimated capital cost of the proposed preferred option is $5.7 million in 2017/18 prices. Powerlink is the proponent of the proposed network project.

There were no submissions received in response to the PSCR.

As the outcomes of the economic analysis contained in this PACR remain unchanged from those published in the PSCR, the draft recommendation has been adopted without change as the final recommendation, and will now be implemented.

1. Introduction

This Project Assessment Conclusions Report (PACR) represents the final step of the RIT-T process prescribed under the Rules undertaken by Powerlink to address the condition risks arising from the ageing transformers at Ingham South in North Queensland. It follows the publication of the Project Specification Consultation Report (PSCR) published in June 2018 that adopted the expedited process for this RIT-T, as allowed for under the Rules for investments of this nature.

The Project Specification Consultation Report (PSCR):

- described the identified need that Powerlink is seeking to address, together with the assumptions used in identifying this need
- set out the technical characteristics that a non-network option would be required to deliver in order to address the identified need
- described the credible options that Powerlink considered may address the identified need
- discussed specific categories of market benefit that in the case of this specific RIT-T assessment are unlikely to be material
- identified the preferred option and that Powerlink was claiming an exemption from producing a Project Assessment Draft Report (PADR).

Powerlink identified Option 2, replacement of both transformers by December 2019 at an indicative capital cost of $5.7 million, in 2017/18 prices, as the preferred option to address the identified need.

NER clause 5.16.4(z1) provides for a Transmission Network Service Provider (TNSP) to claim exemption from producing a PADR for a particular RIT-T application if all the following conditions are met:

- the estimated capital cost of the preferred option is less than $41m
- the preferred option has been identified in the PSCR noting exemption from publishing a PADR
- the preferred option (or other credible options) do not have a material market benefit
- submissions to the PSCR did not identify additional credible options that could deliver a material market benefit.

There were no submissions received in response to the PSCR that closed on 12 September 2018. As a result, no additional credible options that could deliver a material market benefit have been identified as part of this RIT-T consultation.

As all of the conditions are now satisfied, Powerlink has not issued a PADR for this RIT-T and is now publishing this PACR, which:

- describes the identified need and the credible options that Powerlink considers may address the identified need
- provides a quantification of costs and reasons why specific classes of market benefit are not material for the purposes of this RIT-T assessment
- provides the results of the net present value (NPV) analysis for each credible option assessed, together with accompanying explanatory statements
- identifies the preferred option for investment by Powerlink and details the technical characteristics and estimated commissioning date of the preferred option
- describes the consultation process followed for this RIT-T together with the reasons why Powerlink is exempt from producing a PADR.

Since this investment is driven by an obligation in the Rules, it is a ‘reliability corrective action’ under the RIT-T.

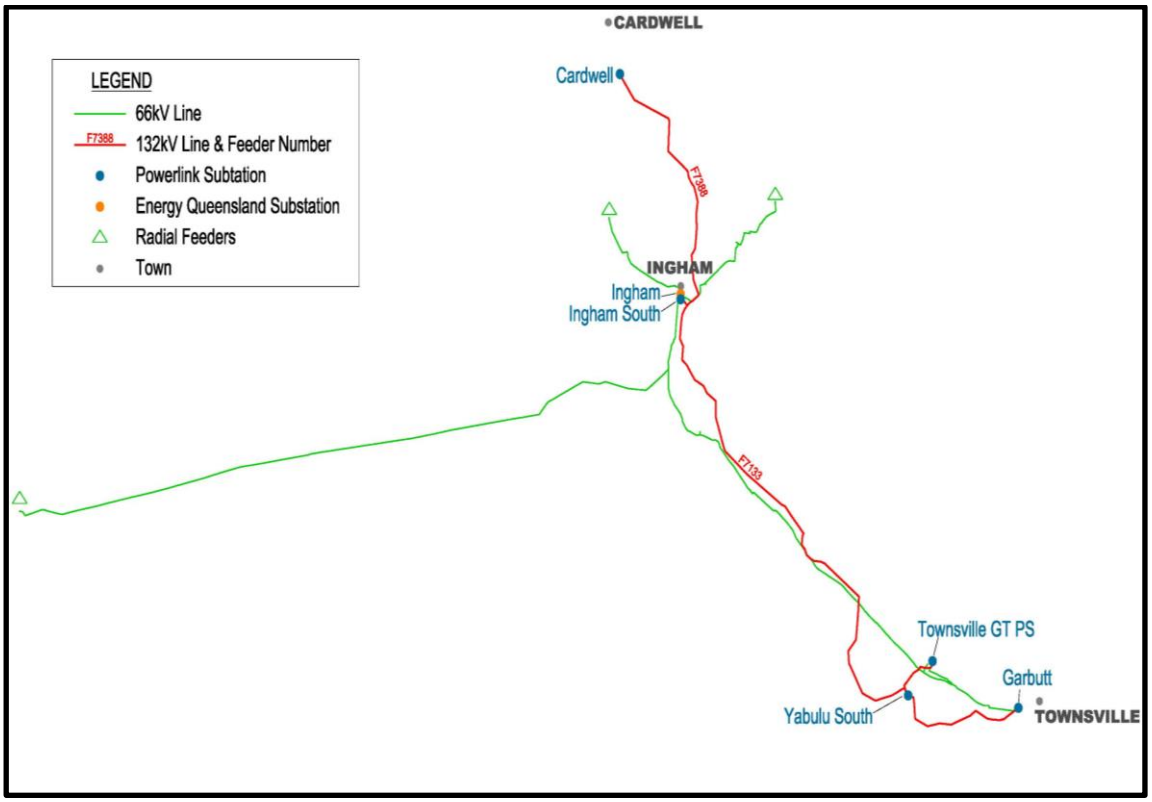
2. Identified need

2.1 Geographical and network overview

Ingham South Substation was built in 2005 to replace the original Ingham Substation and service a growing demand for electricity in the region. It consists of a switchyard operating at 132kV and 66kV and provides the injection point for Ingham and surrounding areas.[1]

The Ingham South Substation location and transmission network connections are shown in Figure 2.1.

Figure 2.1: Ingham South Substation - Location & Connections



2.2 Description of identified need

Under the Rules and statutory requirements[2], Powerlink is required to meet minimum reliability standards. In particular Powerlink must plan and operate its network such that it can meet forecast peak electricity demand during an outage of the most critical single network element.

With peak demand forecast to remain at or slightly above current levels[3], it is vital that the Ingham South Substation have the ongoing capacity to meet these demands.

This places an obligation on Powerlink to undertake actions that address the risks associated with the potential failure of one or both transformers at Ingham South.

2.2.1 Assumptions underpinning the identified need

The failure of a single transformer at Ingham South, and the subsequent reliance on the other similarly aged transformer, presents a high level of risk to the stable and continuous supply of electricity to Ingham and the surrounding area.

---

[1] Ingham South Substation is supplied by two 132kV feeders. The two 132/66kV transformers are connected to Ergon Energy's 66kV switchyard at Ingham

[2] Schedule 5.1a System Standards and 5.1.2 Network Reliability of the Rules, and Queensland Transmission Authority T01/98

[3] Powerlink's Transmission Annual Planning Report 2018

The transformers are nearing the end of their technical service life, resulting in an increased likelihood of failure. In the case of Ingham South, both transformers have a comparable risk profile, meaning the prospect of both failing within a similar timeframe is substantially increased.

Transformers are large and complex items of plant that are both difficult and expensive to repair, which can leave them out of service for long periods of time.

Powerlink's obligations as a TNSP mean that it must maintain (including repair and replace if necessary) its transmission grid to ensure the adequate, economic, reliable and safe transmission of electricity, including the ability to meet peak demand if a major element of the network was to fail. For Ingham South, this includes the availability of a second transformer to maintain the load should the first transformer fail.

2.2.2 Description of asset condition and risks

Both transformers are over 50 years old and in accordance with accepted asset management principles have been comprehensively assessed to estimate the end of service life of their major components, as well as their overall technical service life. This process included on-site condition assessments, desktop evaluation of historical oil and insulation test results and through the evaluation of maintenance and fault data.

The component parts of a transformer can be divided into three broad groupings from an operational and maintenance perspective:

- insulation - winding paper and insulating oil
- mechanical – tanks, radiators, pipe work, desiccant breathers, bushings, internal clamping structures, tap changers
- ancillary – transformer secondary systems including cabling and instrumentation.

Of these it is the mechanical components which primarily begin to fail first due to their ongoing exposure to the environment. In this case the transformers have been subjected to coastal and tropical environments since first being commissioned at Gladstone in 1966.

This combination of salt laden air and high moisture content has impacted the condition of all externally exposed metal components, despite ongoing anti-corrosion treatments. Protective galvanised coatings have begun to break down on several components including radiators, connecting pipework, control system cabinets, bushing mountings and flanges.

The sealing integrity of numerous joints and valves has been compromised, resulting in an increased observation of oil leaks around the radiator cores, bushings and conservator tanks.

Many of the transformers' mechanical parts are no longer technically supported by the manufacturer, with spares difficult to source. Consequently, obsolescence becomes an issue with ongoing maintenance of the transformers.

As the transformer systems and components deteriorate, their probabilities of failure increase, leading to decreased transformer availability.

3. Submissions received

Powerlink published a PSCR in June 2018 calling for submissions from Registered Participants, the Australian Energy Market Operator (AEMO) and interested parties on the credible options presented, including alternative credible non-network options that could address the risks arising from the ageing transformers at Ingham South Substation.

There were no submissions received in response to the PSCR that was open for consultation until 12 September 2018. As a result, no additional credible options that could deliver a material market benefit have been identified as part of this RIT-T consultation.

4. Credible options assessed in this RIT-T

Powerlink has considered three credible network options[4] as shown in Table 4.1.

Table 4.1: Summary of credible network options

Option	Description	Indicative capital cost ($m, 2017/18)
Base option	Refit both T1 and T2 in 2019, then replace both T1 & T2 in 2032	10.5
Option 1	Replace T1 and refit T2 in 2019, then replace T2 in 2032	8.1
Option 2	Replace both T1 and T2 in 2019	5.7

The ongoing difference in operating and maintenance costs between the refitted and new transformer options is not expected to be material with respect to the overall capital costs and has no impact on the overall NPV rankings. These costs have been excluded from the economic analysis.

Under all credible options, work would commence in early 2019 with completion of initial works by December 2019. This addresses the identified need in a timely manner and avoids a situation where corrective maintenance of obsolete ageing assets is no longer practical.

4.1 Base option: refit both transformers in 2019, replace both transformers in 2032

Powerlink is the proponent of this option.

The base option involves refitting both transformers in 2019, and then replacing both in 2032.

This represents the conventional option under which the minimum number of ageing components is replaced, retaining and refitting the more significant components of the transformer that have remaining anticipated life. This will allow the current transformers to remain in service for another 14 years before requiring replacement. Replacement would then occur in 2032.

The work will require the sequential decommissioning and off site upgrade of each transformer, leaving the substation with only a single ageing transformer in place during the refit process. This approach gives some flexibility in assessing future developments by deferring the replacement of the assets.

The base option will also require multiple deployments of specialist resources to complete the project. The indicative capital cost of this option is $10.5 million in 2017/18 prices.

[4] Detailed information on the three credible options as well as a list of additional options that have been considered but not progressed, due to not being either economically or technically feasible, is available in the PSCR.

Table 4.2: Main project components for the base option

Components		Cost ($k, 2017/18)	Construction timetable and commissioning date
STAGE 1 Refit T1 & T2	• De-energise and dismantle transformer T1, and transport to factory • Refit transformer and replace components as required • Undertake factory acceptance testing • Transport transformer T1 to site, assemble, test and commission • Repeat for transformer T2	4,770	2019 – 2020
STAGE 2 Replace T1 & T2	• Design and construct modifications to civil works at Ingham South • Procure, install and commission two (2) new 40MVA transformers • Dismantle and dispose of old transformers • Modify protection settings at Yabulu & Cardwell Substations	5,707	2032 – 2033
TOTAL		**10,477**	

4.2 Option 1: replace one transformer and refit one transformer in 2019, replace one transformer in 2032

Powerlink is the proponent of this option.

Option 1 involves the 2019 replacement of one transformer followed immediately by the refit of the second, and finally replacement of the second transformer in 2032.

This option allows for the commissioning of a new transformer on site before the second transformer is taken out of service for a refit, but will still requires multiple deployments to site.

This approach has less risk attached than the base option as the substation will be serviced by a new transformer during refit of the second transformer. This approach gives some flexibility in assessing future developments by deferring the replacement of one of the assets.

The indicative capital cost of this option is $8.1 million in 2017/18 prices.

Table 4.3: Main project components for Option 1

Components		Cost ($k, 2017/18)	Construction timetable and commissioning date
Stage 1 Replace T1	• Design and construct modifications to civil works at Ingham South • Procure, install and commission one (1) new 40MVA transformer • Dismantle and dispose of old transformer • Modify protection settings at Yabulu & Cardwell Substations	2,853	2019
Stage 1A Refit T2	• De-energise and dismantle transformer, and transport to factory • Refit transformer and replace components as required • Undertake factory acceptance testing • Transport transformer T1 to site, assemble, test and commission	2,385	2019
Stage 2 Replace T2	• Design and construct modifications to civil works at Ingham South • Procure, install and commission one (1) new 40MVA transformer • Dismantle and dispose of old transformer • Modify protection settings at Yabulu & Cardwell Substations	2,853	2032
TOTAL		**8,091**	

4.3 Option 2 – replace both transformers in 2019

Powerlink is the proponent of this option.

Option 2 involves replacement of both transformers in 2019.

This option allows for the commissioning of a new transformer on site before the second transformer is taken out of service for replacement. Due to the shortened timeframe for which the Ingham region will be supported by a single transformer, this option has less risk than either the base option or Option 1.

Option 2 also has the least call on the mobilisation of resources in that all work will be completed within a single mobilisation to site.

The indicative capital cost of this option is $5.7million in 2017/18 prices.

Table 4.4: Main project components for Option 2

Components		Cost ($k, 2017/18)	Construction timetable and commissioning date
Replace T1 & T2	• Design and construct modifications to civil works at Ingham South • Procure, install and commission two (2) new 40MVA transformers • Dismantle and dispose of old transformers • Modify protection settings at Yabulu & Cardwell Substations	5,707	2019
TOTAL		**5,707**	

4.4 Material inter-network impact

Powerlink does not consider that any of the credible options being considered will have a material inter-network impact, based on AEMO's screening criteria.[5]

5. Materiality of Market Benefits

Powerlink does not consider that transformer replacements at Ingham South Substation will provide any market benefits due to the nature of the project.

5.1 Market benefits that are not material for this RIT-T assessment

None of the transformer replacement options will have an impact on wholesale market outcomes. The Australian Energy Regulator (AER) has recognised that if the proposed investment will not have an impact on the wholesale market, then a number of classes of market benefits will not be material in the RIT-T assessment[6]. Consequently, no market benefits have been estimated as part of this RIT-T.

More information on consideration of individual classes of market benefits can be found in the PSCR.

6. General modelling approach adopted to assess net benefits

6.1 Analysis period

The RIT-T analysis has been undertaken over a 20-year period, from 2019 to 2039. A 20-year period takes into account the size, complexity and expected life of a new transformer.

6.2 Discount rate

Under the RIT-T, a commercial discount rate is applied to calculate the NPV of costs and benefits of credible options. Powerlink has adopted a real, pre-tax commercial discount rate of 7.04%[7] as the central assumption for the NPV analysis presented in this report.

Powerlink has tested the sensitivity of the results to changes in this discount rate assumption, and specifically to the adoption of a lower bound discount rate of 3.47%[8] and an upper bound discount rate of 10.61% (i.e. a symmetrical upwards adjustment).

6.3 Description of reasonable scenarios

The RIT-T analysis is required to incorporate a number of different reasonable scenarios that are used to estimate market benefits. The number and choice of reasonable scenarios must be appropriate to the credible options under consideration.

[5] In accordance with Rules clause 5.16.4(b)(6)(ii). AEMO has published guidelines for assessing whether a credible option is expected to have a material inter-network impact.
[6] AER, *Final Regulatory Investment Test for Transmission Application Guidelines,* September 2017, version 2, page 13.
[7] This indicative commercial discount rate has been calculated on the assumptions that a private investment in the electricity sector would hold an investment grade credit rating and have a return on equity equal to an average firm on the Australian stock exchange, as well as a debt gearing ratio equal to an average firm on the Australian stock exchange.
[8] A discount rate of 3.47 per cent is based on the AER's Final Decision for Powerlink's 2017-2022 transmission determination, which allowed a nominal vanilla WACC of 6.0 per cent and forecast inflation of 2.45 per cent that implies a real discount rate of 3.47 per cent. See AER, *Final Decision: Powerlink transmission determination 2017-2022* | *Attachment 3 – Rate of return*, April 2017, p 9.

The choice of reasonable scenarios must reflect any variables or parameters that[9] are likely to affect the ranking of the credible options:

- where the identified need is reliability corrective action; or
- affect the sign of the net economic benefits of any of the credible options, for all other identified needs.

Powerlink has considered capital costs and discount rate sensitivities individually and in combination and found that these variables do not affect the relative rankings of credible options or identification of the preferred option. As sensitivities (both individually and in combination) do not affect ranking results, Powerlink has elected to present one central scenario in Table 6.1 below.

Table 6.1: Reasonable scenarios adopted

Key variable/parameter	Central scenario
Capital costs	100% of central capital cost estimate
Discount rate	7.04%

7. Cost-benefit analysis and identification of the preferred option

7.1 Net present values

Table 7.1 outlines the net present value (NPV) for each credible option. The table also shows the corresponding ranking of each option, illustrating that the NPV of Option 2 is the lowest cost preferred option.

Table 7.1: Net present values for each credible option (NPV $m, 2017/18)

Option	Central scenario	Ranking
Base option	-4.7	3
Option 1	-4.5	2
Option 2	-4.2	1

Table 7.2 sets out the NPV for options 1 and 2 relative to the base option. It shows that Option 1 and Option 2 are expected to cost $0.23 million and $0.45 million less than the base option respectively in present value terms. Based on this analysis, Option 2 is the preferred option.

Table 7.2: NPV for options 1 and 2 relative to the base option (NPV $m, 2017/18)

Option	Central scenario	Ranking
Option 1	0.23	2
Option 2	0.45	1

7.2 Sensitivity analysis

Powerlink has investigated the following sensitivities on key assumptions:

- a 25% increase/decrease in capital costs
- a lower discount rate of 3.47% as well as a higher rate of 10.61%.

[9] AER, *Final Regulatory Investment Test for Transmission*, June 2010, version 1, paragraph 16, p. 7

Given that the only difference between the options relates to the difference in their capital costs, sensitivity tests show that Option 2 is preferable to both the base option and Option 1 under all sensitivities (both considered individually and in combination).

7.3 Preferred option

Based on the conclusions drawn from the NPV analysis, and the Rules requirements relating to the proposed replacement of transmission network assets, it is recommended that Option 2 be implemented to address the risks arising from the ageing transformers at Ingham.

This option allows for the commissioning of a new transformer on site before the second transformer is taken out of service for replacement. Due to the shortened timeframe for which the Ingham region will be supported by a single transformer, this option has less risk than either the base option or Option 1 and delivers cost savings during construction through a single mobilisation of resources to site.

Sensitivity testing shows the analysis is robust to variations in the capital cost and the discount rate assumptions. Option 2 is therefore considered to satisfy the requirements the RIT-T and is the proposed preferred option.

8. Conclusions

The following conclusions have been drawn from the analysis presented in this report:

- Powerlink has identified condition risks arising from the ageing transformers at Ingham South Substation requiring action
- TNSPs must maintain (including repair and replace if necessary) their transmission grid to ensure the adequate, economic, reliable and safe transmission of electricity, including the ability to meet peak demand if a major element of the network was to fail. For Ingham South Substation, this includes the availability of a second transformer to maintain the load should the first transformer fail
- the increasing likelihood of faults associated with the ageing transformers compels Powerlink to undertake reliability corrective actions at Ingham South Substation if it is to continue meeting the reliability standards set out in the Rules
- studies were undertaken to evaluate three credible options; all three credible options were evaluated in accordance with the AER's RIT-T
- Powerlink published a PSCR in June 2018 requesting submissions from Registered Participants, AEMO and interested parties on the credible options presented, including alternative credible non-network options which could address the transformer condition risks at Ingham South Substation
- the PSCR also identified the preferred option and that Powerlink was adopting the expedited process for this RIT-T, claiming exemption from producing a PADR as allowed for under NER clause 5.16.4(z1) for investments of this nature
- there were no submissions received in response to the PSCR which was open for consultation until 12 September 2018. As a result, no additional credible options that could deliver a material market benefit have been identified as part of this RIT-T consultation
- the conditions specified under the Rules for exemption have now been fulfilled
- the result of the cost-benefit analysis under the RIT-T identified that Option 2 is the highest net benefit solution over the 20-year analysis period. Sensitivity testing showed the analysis is robust to variations in the capital cost assumption and the discount rate used. As a result Option 2 is considered to satisfy the RIT-T
- the outcomes of the economic analysis contained in this PACR remain unchanged from those published in the PSCR. Consequently, the draft recommendation has been adopted without change as the final recommendation and will now be implemented.

9. Final Recommendation

Based on the conclusions drawn from the NPV analysis and the Rules requirements relating to the proposed replacement of transmission network assets, it is recommended that Option 2 be implemented to address the increasing risk of failure of the transformers at Ingham South Substation.

Option 2 minimises the time that supply to the Ingham region is dependent upon an ageing transformer. This option provides for shorter duration replacement outages, reducing reliability of supply risk during implementation and delivers cost savings during construction through a single mobilisation of resources to site.

Overall the simplified project scope of Option 2, when compared to the other options, will allow Powerlink to undertake the corrective actions in a timely and cost effective manner.

Powerlink is the proponent of the proposed option with an estimated capital cost of $5.7 million (2017/18 prices).

Construction activities will start on site in early 2019 with completion of the project by December 2019.

Powerlink will now proceed with the necessary processes to implement this recommendation.

Contact us

Registered office	33 Harold St Virginia Queensland 4014 Australia
Postal address:	GPO Box 1193 Virginia Queensland 4014 Australia
Contact:	Roger Smith Manager Network and Alternate Solutions
Telephone	(+617) 3860 2328 (during business hours)
Email	networkassessments@powerlink.com.au
Internet	www.powerlink.com.au