PowerWater

Power and Water Corporation

Preliminary Business Case – Category B

PRD33002

Archer ZSS Augmentation

Proposed:

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A/Chief Engineer
Power Networks
Date: 6/2/2018

Approved:

Michael Thomson
Chief Executive & Chair
Investment Review Committee
Date: 23/02/2018

Endorsed:

Djuna Pollard
Executive General Manager
Power Networks
Date: 15/2/2018

Refer to email
D2018/72353

Finance Review
Date: 06/02/2018

Refer to email
D2018/61450

PMO QA
Date: 09/02/2018

Approval is sought for expenditure of up to $0.2M of the total forecast expenditure to undertake the necessary work to proceed to the next approval gateway (Business Case Approval), including:

- Detailed design;
- Detailed cost estimate; and
- Construction price offer from external contractors through a competitive tender.

The project has a 95% likelihood of being delivered between [redacted]

The revised estimated capital cost is a result of a change in project scope. This is due to an updated demand forecast which showed a lower growth rate for the Palmerston area.

2 PROJECT SUMMARY

Project Title:	Archer ZSS Augmentation		
Project No./Ref No:	PRD33002	**SAP Ref:**	
Anticipated Delivery Start Date:	Jul 2019	**Anticipated Delivery End Date:**	Jun 2020
Business Unit:	Power Networks		
Project Owner (GM):	Djuna Pollard	**Phone No:**	8985 8431
Contact Officer:	Peter Kwong	**Phone No:**	8924 5060
Date of Submission:	23/02/18	**File Ref No:**	D2017/394304
Submission Number:		**Priority Score:**	/100
Primary Driver:	Growth/Demand	**Secondary Driver:**	Compliance
Project Classification:	Capital Category B		

2.1 Prior Approvals

Document Type	Sub Number	Approved By	Date	Capex Value
BNI	10068	Michael Thomson	29/05/2017	[redacted]

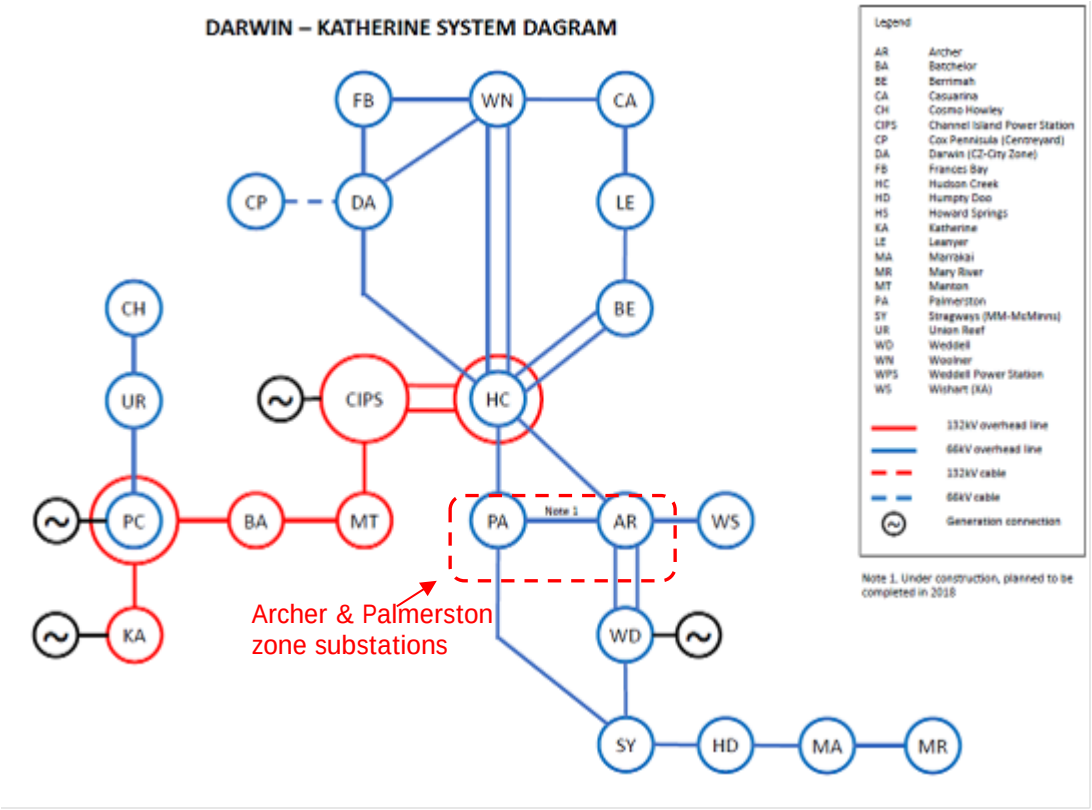
3 INVESTMENT NEED

3.1 Background

Archer Zone Substation is a 66/11kV, two 20/27MVA transformer substation commissioned in 2012 to meet the growing demand and maintain the security of supply for the city of Palmerston.

Palmerston ZSS is a 66/11kV urban substation located approximately 15km southeast of Darwin. As shown in Figure 1, it will be connected to Archer ZSS at 66kV in 2018 when the transmission line between the two substations is completed. Palmerston ZSS comprises two 66/11kV 30/40MVA power transformers and two 22/11kV transformers. A third 66/11kV transformer is scheduled to be installed in 2018 to cater for forecast load growth.

Figure 1: System diagram



3.2 Peak demand and capacity forecasts

This section provides a summary of the peak demand and firm capacity forecasts for Archer ZSS and Palmerston ZSS. They are interrelated because of the assumed permanent and temporary load transfer between the two substations. Further details are included in the planning report. The demand forecasts for the area are based on AEMO's forecasts undertaken on behalf of PWC.[1]

3.2.1 New Load development in the area

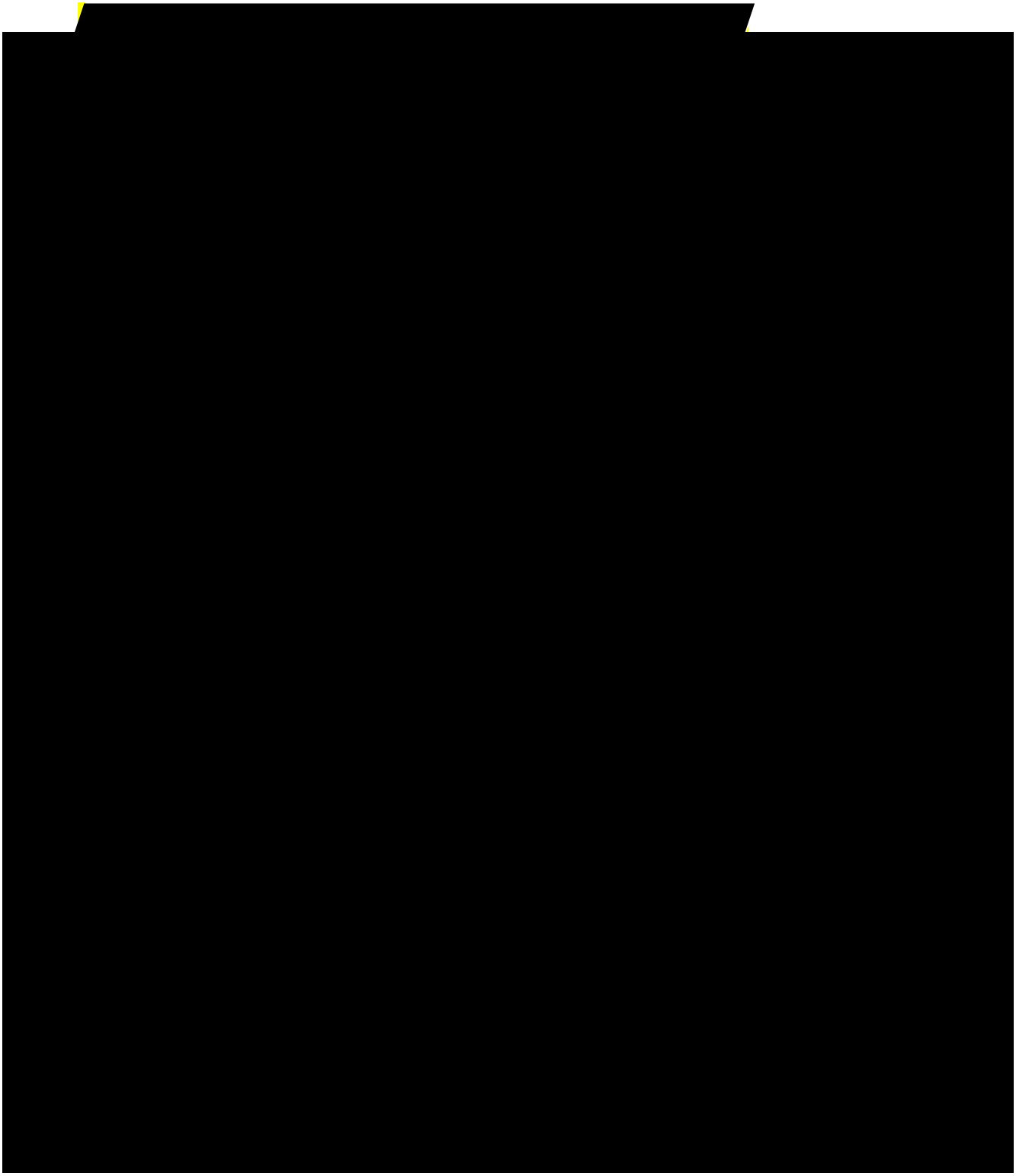
Historically, the load growth in the Palmerston area has averaged 6.0% per annum for the past decade and is the largest localised growth area in the NT.

Soon after Archer became operational in 2012, 15MVA of load was transferred from Palmerston ZSS to the new Archer ZSS because the peak load exceeded Palmerston ZSS's firm capacity. The subsequent increases in load have been shared between Palmerston and Archer ZSSs.

The significant growth in the City of Palmerston is projected to continue into the near future, with a number of land developments near completion, including: [redacted] and continued residential expansions of the new suburbs of Zuccoli

[1] AERReportForPWC_V3

and Mitchell Creek. Refer to Figure 2 for the relative locations of these developments to Palmerston and Archer ZSSs.

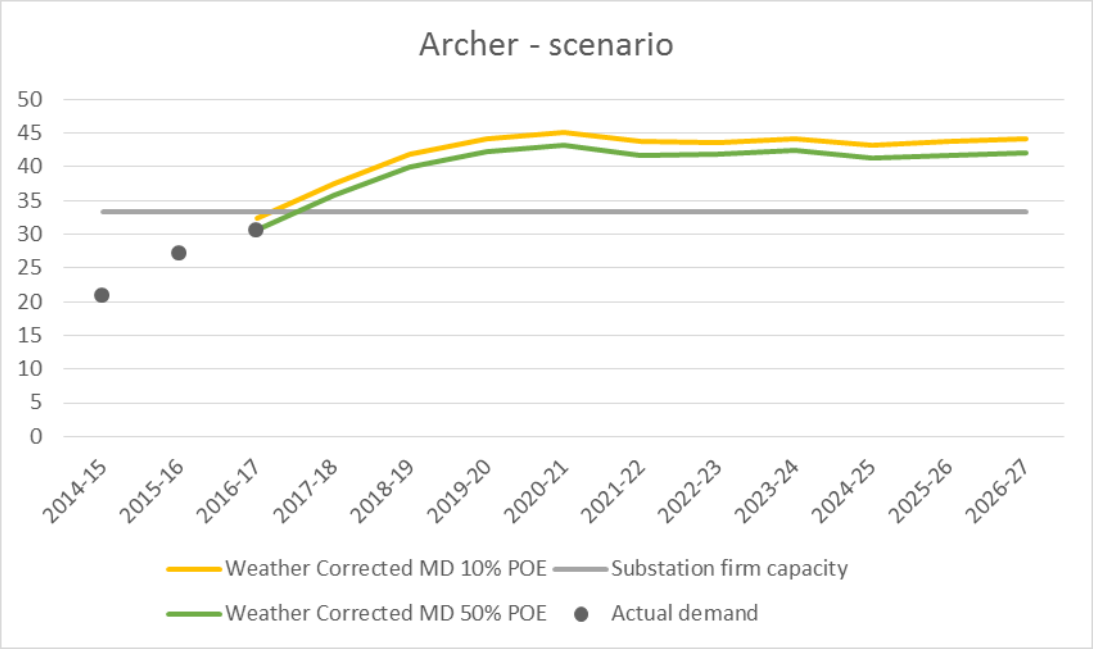


was commissioned. The peak demand forecast[2] and firm capacity is shown in Figure 3. The firm capacity of Archer ZSS comprises 30.3MVA from a single transformer plus 3MVA distribution transfer capacity. As shown in Figure 3,

[2] DTC available within the 60 minute limit to meet the Class C Planning Criteria

the current firm capacity of 33.3MVA will be exceeded by the forecast peak demand [P50] in the wet season of 2017/18.

Figure 3: Archer ZSS - peak demand forecast and firm capacity (MVA)



3.3 Risk analysis

Figure 4 shows the current rating, inherent rating (in 2024, i.e. if no action is taken in the interim), and the residual (post-treatment) risk ratings associated with the current supply capacity from Archer ZSS:

(i) *Current rating:* The Current rating (2017) is assessed to be 'Medium' because in the 'Unlikely' event there is a single transformer outage at Archer ZSS, there should be sufficient supply capacity in the area to restore loads to all customers. However, there is some risk that the restoration time will not meet the Class C supply criteria. This consequence is classed as 'Moderate'.
In the case of the 'Rare' event of complete loss of Archer ZSS for a prolonged period, there would be insufficient capacity to meet all the load growth for an extended period, even with the deployment of a NOMAD mobile substation.[3] Customers' supply will be interrupted for many hours whilst load is transferred to contiguous adjacent substations. This consequence is classified as 'Moderate'. The risk rating is therefore 'Medium'.

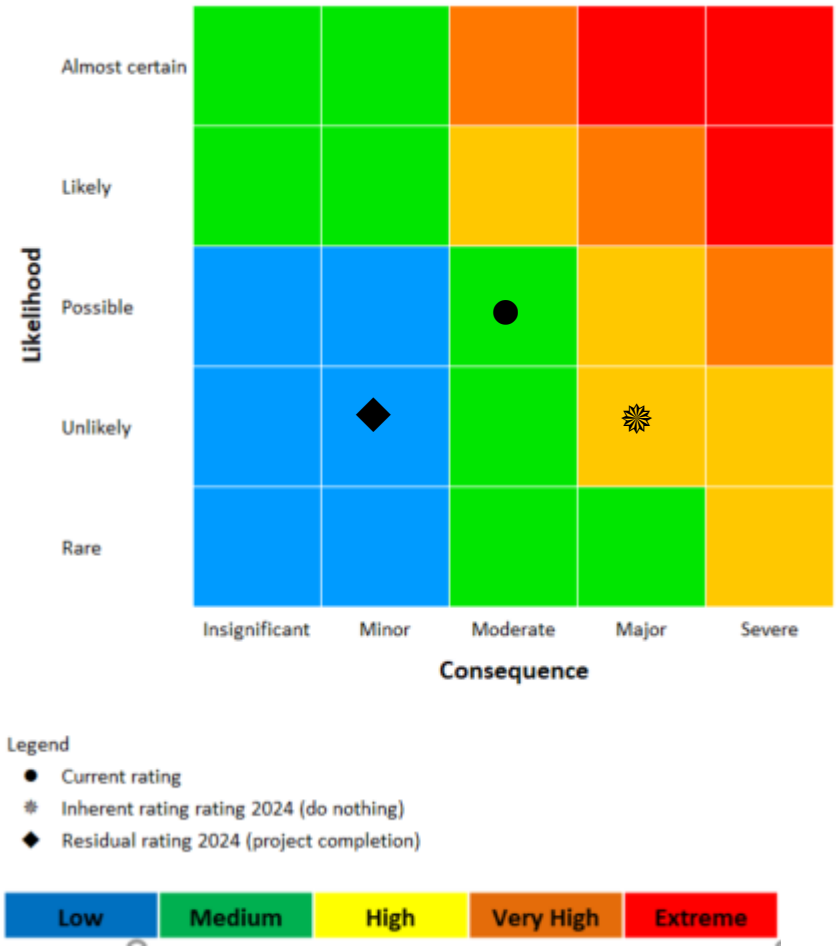
(ii) *Inherent rating:* As discussed in sections 3.1-3.2.4, there is expected to be insufficient firm capacity to supply the forecast peak demand in the load area for the unlikely failure of a transformer at Archer ZSS. Up to 11.7MVA of load will be interrupted until supply from Archer ZSS can

[3] PWC has two NOMAD modular substations, one of which is currently permanently deployed in Wishart (refer to PRD33001 – Preliminary Business Case PBC – Construct Wishart ZSS

be restored. This consequence is rated as ‘Major’. The risk rating is therefore ‘High’.

(iii) *Residual rating:* The proposed project will increase the firm capacity such that in the ‘Unlikely’ event of a single transformer failure at Archer ZSS, it is unlikely there will be any loss of supply to customers for more than the 60 minutes required under the Supply criteria. A ‘Minor’ consequence classification is attributed to the possibility that there may be significant number of commercial and industrial customers interrupted for a short period. The risk rating is therefore ‘Low’.

Figure 4: Archer ZSS load area supply risk assessment[4]



It is Power and Water's current practice to take action on risks that have an inherent rating of 'HIGH' or above. The PBC summarises the proposed response to this impending risk.

4 STRATEGIC ALIGNMENT

This project aligns with the Corporation's key result areas of operational performance and customer centricity, where the goals are to be an efficient provider of services and delivering on customers' expectations.

This project will allow PWC to safely and reliably meet current and future demands for the Palmerston area.

5 TIMING CONSTRAINTS

The timing for this project is driven by load growth in the Palmerston area. The new capacity will need to be available when the demand exceeds the cyclic firm capacity of Archer Zone Substation and the ability to transfer load to Palmerston ZSS. It is expected that this will be realised by the wet season

[4] Based on Power Network's Risk Assessment Guide

of 2017/18 but delivery constraints mean that it cannot be delivered until 2018/19.

6 EXPECTED BENEFITS

Driver/Objective	Benefit	Current State	Future State
Growth / Demand	Sufficient capacity to supply forecast load growth in the Palmerston City area with provisions to meet future load growth.	The peak demand forecast indicates that the loading on Archer ZSS will exceed the firm capacity by 2017/18.	Archer ZSS can cater for forecast load growth in the area (in conjunction with Palmerston ZSS) with (N-1) firm capacity.

7 REQUIREMENTS

The solution selected must resolve the need to cater for the increased demand in the Palmerston area and provide a reliable supply during credible contingency events and support reliability targets during unplanned events and planned maintenance activity. It is also preferable to minimise impact on existing operational capabilities and system security during construction.

PWC will also require compliance with the following:

- Northern Territory Electricity Reform Act;
- Power and Water's Network Licence as issued by the Utilities Commission, and;
- Network Planning Criteria and Electricity Networks (Third Party Access) Code.

8 OPTIONS

8.1 Options Development

Five options have been considered, as discussed below:

8.1.1 Option 1 – Do nothing (deferral of the preferred option)

The forecast maximum demand on Archer Zone Substation is expected to exceed the firm capacity by the summer of 2017/18. If no action is taken, PWC will be non-compliant with the supply contingency requirement of the Network Planning Criteria. Up to an estimated 11.7 MVA would be at risk of being without power for credible contingency events.

This option is not considered to be technically feasible.

8.1.2 Option 2 – Upgrade Archer Zone Substation with a third power transformer

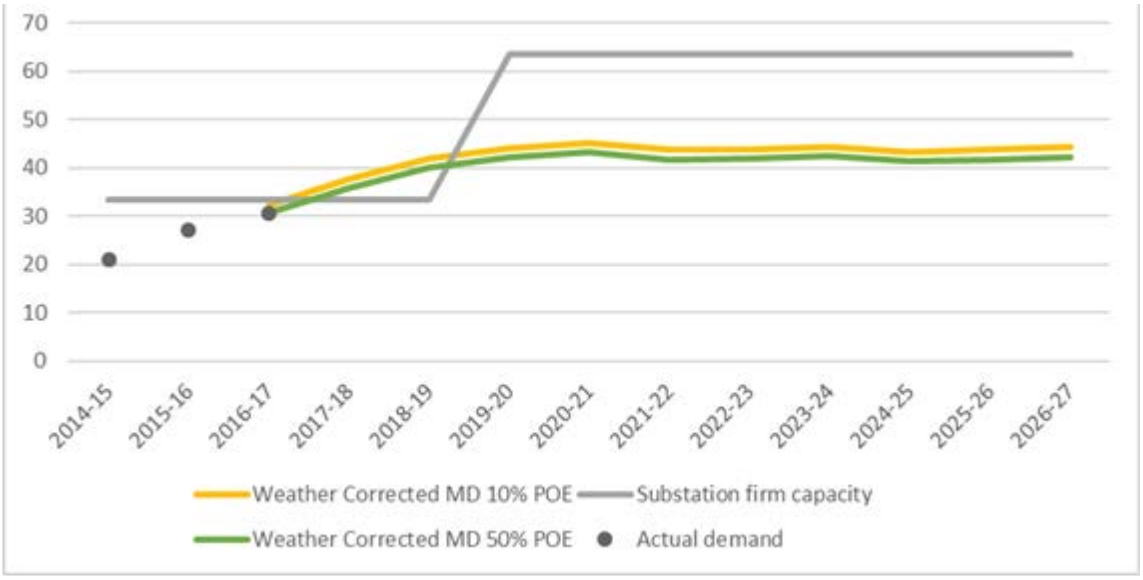
This option involves involve installing a third 66/11kV, 20/27 MVA transformer and a new 11kV switchboard section at Archer ZSS. Based on typical design, procurement, and construction times, this work cannot be completed until 2019/20. The transformer will have similar specifications to the existing units and will increase the normal cyclic rating of the substation to cater for expect load growth in the Palmerston area to 63.6MVA (with additional firm capacity from distribution transfer), as shown in Figure 5. The base cost estimate for Option 2 is [redacted]

The advantages of Option 2 are:

- It provides a technically compliant, long term basis for supplying the existing and forecast load growth in the Archer area;
- The design is based on PWC's standard 66/11kV substation design, reducing development, implementation, and operational costs compared to non-standard options;
- It is consistent with good industry practice;
- It will be located close to the load centre, reducing distribution losses and helping to meet both Class C Supply criteria in the event of an unplanned outage at either Palmerston ZSS or Archer ZSS;
- It provides supply diversity in the (unlikely) event of catastrophic failure at Palmerston ZSS substation;
- It is consistent with PWC's planning strategy of building standardised zone substations in preference to fewer very large ones (except where the load density is high, e.g. Darwin CBD). Power Networks has determined that 20/27MVA transformers are most appropriate; and
- As well as increasing the firm capacity of the substation, the capacity for additional 11kV feeders from Archer ZSS will also be increased.

The disadvantage of this option is that it is the most expensive approach and its economic viability depends on the load continuing to increase, which is currently not forecast to occur.

Figure 5: Archer ZSS – increase in firm capacity from adding a 3rd transformer



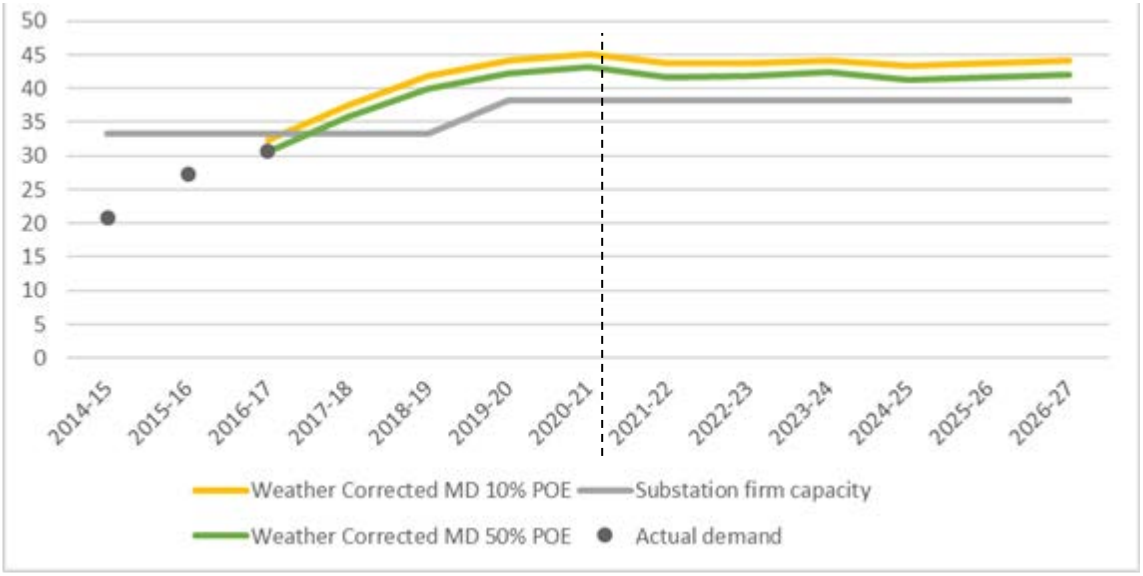
8.1.3 Option 3 – Uprating the capacity of the two existing power transformers

The possibility of uprating transformers at Archer Zone Substation to provide ODAF (Oil Direct Air Forced) cooling has been investigated with the manufacturer. One transformer is capable of ODAF cooling but the second unit is only capable of the ONAF rating. Due to design of the transformer, ODAF capability cannot be implemented without replacing the whole transformer. Based on typical design, procurement and construction lead times, the transformer uprate and replacement work cannot be completed until 2019/20.

As well as replacing one of the transformers, the 11kV cables from the transformer to the 11kV switchboard will also need to be upgraded to cater for the increased capacity. The base cost estimate for Option 3 is [redacted]

As shown in Figure 6, this disadvantage option does not provide sufficient additional firm capacity to meet is that it provides virtually no firm capacity margin above the forecast peak demand.

Figure 6: Archer ZSS – increase in firm capacity from replacing the transformers with higher rated units

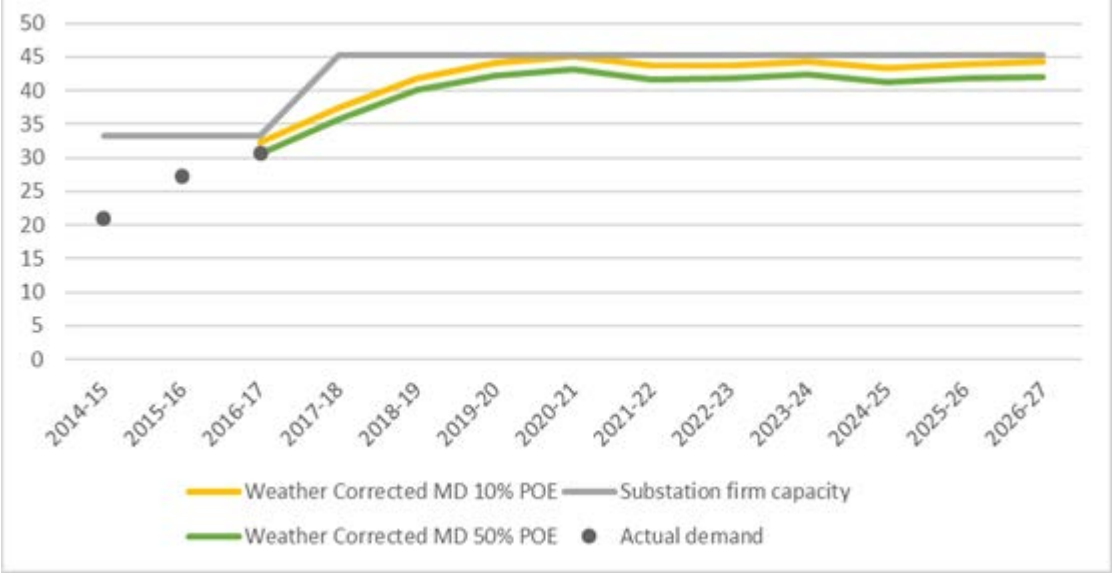


8.1.4 Option 4 - Add connection facilities for a Nomad modular substation (Preferred Option)

PWC has two 12MVA 66/11kV NOMAD modular substations, to provide emergency response capacity and to provide continuity of supply during planned work[5]. Archer ZSS can be modified to provide connection and commissioning of a NOMAD within 24 hrs. Once the NOMAD is commissioned, the firm capacity will be sufficient to supply the peak load. To help reduce the risk of material non-compliance with the Planning Criteria (Class C), remote controlled 11kV switches will be installed as part of this option to allow rapid transfer of load to Palmerston substation following the single contingency. The total cost of this work is estimated to be [redacted] and is required by 2019/20.

[5] One of the two NOMAD substations is currently connected to the network on a semi-permanent basis at Wishart, however the plan is to release it for its intended purpose by establishing a Wishart ZSS in the next RCP (refer to PRD33001)

Figure 7: Archer ZSS – increase in firm capacity from adding NOMAD modular substation connection (MVA)



One of the two NOMADs are likely to be stored at Archer ZSS when not deployed elsewhere to reduce the connection time in case of failure of one of the two 66/11kV power transformers or associated switchgear.

The advantage of this option is that it avoids the need for installation of a third transformer at Archer (Option 2), which would likely be underutilised for the foreseeable future. Option 2 can still be deployed if the peak demand increases to the point where a third transformer is economically justified. The connection work proposed can also assist with reducing operating costs if the NOMAD needs to be connected at Archer ZSS to manage planned outages[6].

The disadvantage of this option is that there is the risk that the Class C supply criterion might not be satisfied if the unplanned outage of the transformer occurs at the worst possible time. The proposed installation of remote controlled distribution switches will speed up the transfer of excess load to the contiguous substations, minimising the need for load shedding until the NOMAD is commissioned.

8.1.5 Option 5 – Demand Management/Non-network solution

Based on PWC's research, the most likely sources of demand management are via (i) curtailment contracts with large commercial and industrial customers in the area[7], and (ii) through initiatives targeted at residential customers, such as subsidising installation of solar PV and storage units. PWC does not have access to other forms of demand management such as ripple

[6] i.e. if a transformer circuit needs to be taken out of service for maintenance of one or more elements

[7] Typically, this is arranged through a third party 'aggregator'

control or smart meter activated control of customer loads (such as air conditioners).[8]

To comply with the Class C Supply requirements, the load curtailment would have to be achieved within 60 minutes, which is relatively short notice.[9]

Referring to Figure 3, this option requires up to 12MVA of reliable peak demand reduction to be available in the event of a significant unplanned outage of an Archer ZSS transformer circuit.

The major advantage of Option 5 is that if either the required dispatchable, interruptible load was available, or permanent peak load reduction was guaranteed through solar PV/storage, it would defer a network solution at Archer ZSS, allowing more time to assess actual load growth and review the load forecast.

The disadvantages of Option 5 are:

(i) PWC has no experience with securing dispatchable, interruptible load and limited experience with reliably reducing residential peak demand through PV/storage solutions;

(ii) Depending on the solution offered, the cost of non-network solutions may not be economic:

- If an opex solution is provided, the annual cost would need to be less than the annualised cost of the preferred network solution (approx $0.4m pa);[10] and
- The installed capital cost per kW of PV plus storage units is currently significantly higher than the cost/kW of the preferred network solution.[11]

PWC will continue to explore the technical and commercial viability of this option prior to submitting the Business Case for Approval. In the interim, it is not considered to be a technically viable solution due to the uncertainty of it reliably limiting peak load demand.

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[8] It is unlikely that turning off air conditioner compressors, even for as little as 15 minutes at a time will be accepted as a demand management initiative in the Northern Territory due to the prevailing climatic conditions

[9] Based on PWC's research, advance notice of at least several hours is typically required to arrange the necessary arrangements within the business' premises

[10] If it is available, interruptible load can be assumed to cost between $75-$350/kVA, depending on the technology deployed (refer to AusGrid, *Regulatory Proposal, 2014-19, Attachment 6.12*, page 13, and Oakely Greenwood, *Advice on the DMIS,* pages 15-17*)*

[11] Current solar PV installed costs are in the range of $800-1100/kW and storage costs are about $1000- $1400/kWh (e.g. refer to Clean Energy Council, report by Entura, *Analysis of Demand-Side Management Opportunities, Task 1C,* page 40)

8.2 Comparative cost analysis

PWC is currently developing a probabilistic risk-cost methodology which, when completed will be used to compare options and confirm the economically optimum time for investment.

Table 2 summarises the results of a comparative cost analysis, the details of which are included in Appendix A. Only options 2, 3, and 4 are technically viable, for the reasons provided in section 8.1. Of the technically viable options, Option 4 – Install connection facilities for Nomad modular substation – has the lowest NPC.

Table 2: Summary of comparative capital cost analysis

Option	Capital cost ($M)	Net Present Cost ($M)	Comments
1 – Do nothing	[redacted]	[redacted]	Not technically viable.
2 – Add 3rd 20/27MVA transformer 66/11kV at Archer ZSS	[redacted]	[redacted]	Meets peak demand forecast for the forseeable future
3 – Replace 2 x 20/27MVA transformers with 20/27/33MVA transformers	[redacted]	[redacted]	Meets peak demand forecast for the forseeable future
4 – Install connection facilities for NOMAD modular substation	[redacted]	[redacted]	Lowest NPC. May not fully comply with the Class C supply criteria at all times
5 – Demand management/non-network solution	[redacted]	[redacted]	Assumed to be not technically viable, but will be explored before final approval

8.3 Non-cost attributes

An analysis of the non-cost attributes for each option has been completed using the multi-criteria analysis method. The attributes are selected considering major risks and priorities to achieve Project Objectives. A weighting is allocated to each, totalling 100%. Each attribute is given a score out of 5 (from 1 – Fails to satisfy, to 5 – exceeds requirements); the score is then multiplied by the relevant weighting to give the weighted score that is summarised in the table below.

Project Objectives	Technical & System Risk	Stakeholder Risk	Env. Risk	Commercial

Criteria	Supply Contingency Criteria	Maintain System Security	Catering for Future Demand	Standard Assets	Constructability	Continuity of Supply	Safety	Community Impact	Approvals	Oil Contamination	Land Clearing	NPV/C
Weighting (%)	10	10	10	5	5	10	10	5	5	5	5	20
Option 1	0.1	0.1	0.1	0.15	0.2	0.3	0.3	0.05	0.2	0.2	0.2	1.0
Option 2	0.4	0.4	0.4	0.15	0.15	0.4	0.3	0.15	0.2	0.15	0.2	0.4
Option 3	0.3	0.3	0.3	0.15	0.10	0.3	0.3	0.15	0.2	0.2	0.2	0.6
Option 4	0.3	0.3	0.3	0.15	0.2	0.4	0.3	0.15	0.2	0.2	0.2	0.8

8.3.1 Evaluation Summary

Weighted Scores:

Option 1: Deferral	2.9
Option 2: Install third transformer	3.3
Option 3: Upgrade existing transformers	3.1
Option 4: Install Nomad connection	3.5

8.4 Preferred Option

The preferred option (Option 4) is to install the necessary infrastructure at Archer ZSS to facilitate rapid connection of a NOMAD modular substation and remote controlled 11kV switches in the distribution network to enable rapid load transfer to contiguous substations in the event of a transformer failure. The base cost estimate for Option 4 is [redacted]

This is the preferred option for the following reasons:

- It is a commercially prudent approach, with the lowest NPC;
- It allows time to analyse peak load in the Palmerston area over the next RCP; and

The proposed solution and timing does not change with either high case [P10] load growth assumptions.

The design of the Nomad connection will be to the existing PWC Substation Standards and will be similar in layout to the current zone substation. This will maximise constructability and reduce design risk.

There will be minimal civil works to the site as the zone substation was constructed with the provision for the installation of a third transformer. This space will be utilised for the location of the Nomad substation.

9 PROJECT OUTLINE

9.1 Project Description

This project is to install a connection point for the Nomad portable substation.

9.1.1 Scope Inclusions

The scope of the project includes:

- A 66kV bay to allow for a Nomad connection;
- Facilities to allow connection to the existing 11kV switchboard;
- Modifications to the existing protection and control system to cater for the Nomad substation connection; and
- Installation of remote switching to distribution switchgear to allow load transfer from Archer to Palmerston Zone Substation.

9.1.2 Scope Exclusions

- None

9.1.3 Assumptions

- The identified ring main units in the distribution system can be upgraded to remote operation.

9.1.4 Dependencies

- None

9.1.5 Key Stakeholders

Name	Title / Business Unit
Internal – Governance Stakeholders	Chief Executive
	Investment Review Committee
Internal – Governance Stakeholders	Executive General Manager Power Networks
	Chief Engineer
	Group Manager Service Delivery
Internal – Design Stakeholders	Senior Manager Networks Development and Planning

	Manager Major Projects
	Senior Manager Network Assets
	Manager Protection
External – Authorities	Environmental Protection Authority
	Aboriginal Areas Protection Authority
External - Other	Local Residents
	Ministers
	Utilities Commission
	Australian Energy Regulator

9.2 Capital Cost

A risk adjusted cost estimate (RACE) was conducted on the preferred option based on latest design, scope and cost information.

Based on the analysis, the project has a 90% likelihood of being delivered between [redacted]

[redacted]

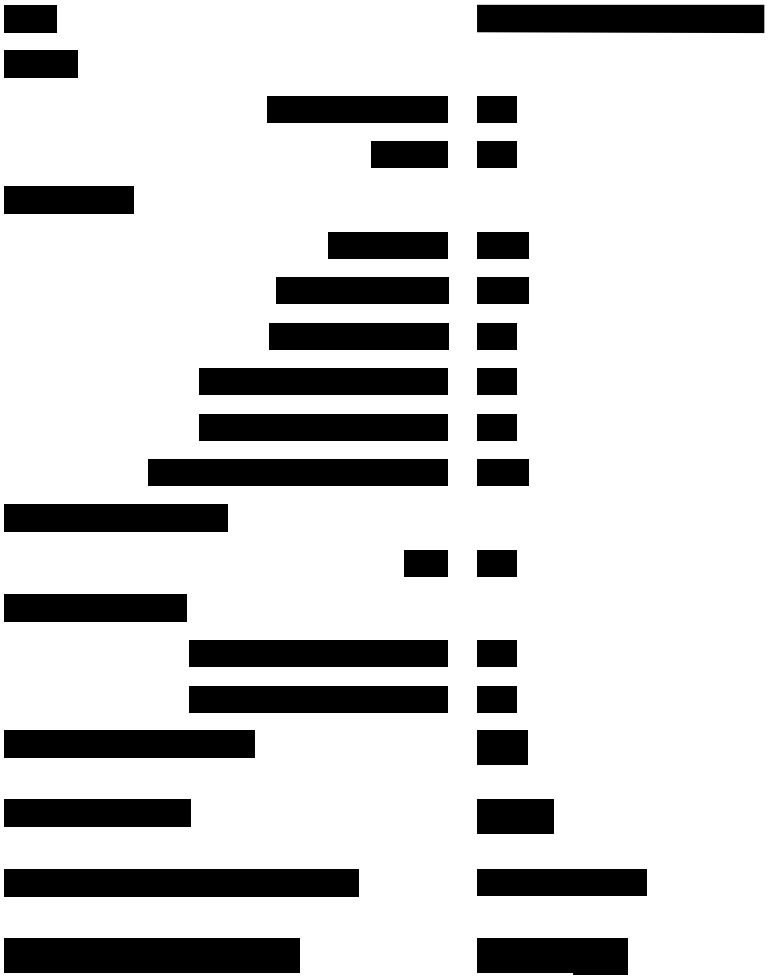

Table 1 – Base Capital Cost Estimate

9.2.2 Risk and Contingency

The current estimate has been developed largely based on PWC and consultant estimates considering previous experience with similar works. The contingency amount, calculated as the P95 value minus the expected P50 value, is currently $ 0.11M.

9.3 Estimated Operating Cost Impact

Ongoing operating and maintenance costs of the new substation are detailed below.

Item	Annual Incremental Cost
Planned Maintenance	5,890
Preventative Maintenance	2,670
Unplanned Maintenance	1,380

TOTAL	**9,940**

Table 2 – Estimated Operating Cost Impact

9.4 Project Milestones

Project Phase (end)	Investment Planning	Project Development	Commitment	Implementation	Review
Original Plan (BNI)	05/2017	07/2019	12/2019	06/2021	06/2022
Current Forecast	05/2017	07/2019	12/2019	06/2020	09/2020
Actual Completion	05/2017				

10 RISK MANAGEMENT AND COMPLIANCE

A preliminary risk register has been established to address project risk. This is included in Appendix B. This register will form the basis of the Project Risk Register into the project delivery phase. The register will be regularly reviewed and updated as required to ensure all identified risks are managed as the project progresses.

10.1 Technical and System Issues

The existing zone substation and 66kV switchyard will continue to be operational and construction staff working on this project will need to follow PWC AAR (Access to Apparatus Rules).

Modifying the existing 66kV switchyard will involve a short term bus outage. The outage will be scheduled away from peak periods and in close consultation with System Control to minimise system security risk.

Design of the new Nomad connection bay will be in accordance with the PWC Zone Substation Design Practises Manual.

11 PROJECT IMPLEMENTATION

This project is to be managed by the Power Networks' Project Management group. It is planned that the project will be delivered using the "Design and Construct" methodology through an external contractor.

Testing and commissioning will be managed by Power Networks' Test and Protection group.

It is expected that the majority of electrical equipment will be procured through the D&C contract, with detailed specifications from PWC.

11.1.1 Resourcing Requirements (to next gateway)

Resource Type/Role	How Many?	Internal/ External?	Anticipated Start Date	Duration Required	Allocation (% time or # hrs/days/ wks/mths)
Project Manager	1	Internal	Jan 2019	6 months	10%
Planning Engineer	1	Internal	Jan 2019	6 months	10%
Design Engineer	1	External	Jan 2019	6 months	50%

12 FINANCIAL IMPACT

12.1 Funding Arrangements

The capital expenditure for this project will need to be approved by the AER's 2019-24 Network Price Determination, which is recovered through standard control network tariffs.

Based on the most up to date information, the project cost estimate has been revised to [redacted] The revised cost is based on the estimated costs provided in the concept design and additional estimates for internal PWC expenditure.

12.2 Capital Expenditure

The capex in the table below is in $2017-18, and is excluding capitalised overheads and cost escalation.

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]					[redacted]
[redacted]	[redacted]					[redacted]

12.2.1 Variance Coverage

N/A

12.3 Incremental Operating Expenditure

An operating expenditure of approximately $9,940 per annum is expected for the maintenance of the new transformer and switchboard extension. Upon completion of the project, the operating cost of the new transformer will be included in the operational budget and forecasted in regulatory processes.

APPENDIX A

DETAILED FINANCIAL ANALYSIS

Introduction

The purpose of this Appendix is to provide details of the options analysis for Archer ZSS Augmentation.

Table A1 below outlines the estimated capital expenditure for options 2, 3 and 4. The operational cost of option 3 is zero as the existing transformers are replaced and there will not be a net increase in assets. This is reflected in the operational cash flows below.

Commercial analysis of Option 1 (deferral) was not undertaken as it is not considered to be a viable alternative due to the risk of major outages as a result of equipment failure.

Table A1 – Estimated Capital & Operating Expenditure

Option	Capex – Base Costs ($M)	Opex – Base Costs ($000's)
Option 2 – Add 3rd 20/27MVA transformer 66/11kV at Archer ZSS	[redacted]	$30 (from 2021/22)
Option 3 – Replace 2 x 20/27MVA transformers with 20/27/33MVA transformers	[redacted]	$0
Option 4 – Install connection facilities for NOMAD modular substation	[redacted]	$9.9 (from 2020/21)

Assumptions

In modelling the options, technical, economic and cost parameters were included. The technical and cost data was provided by Power Networks and the economic data was sourced from Pricing and Economic Analysis (PEA). Base cost capital expenditure was based on the consultant's feasibility study.

In the assumptions, all costs exclude GST or other government charges.

The common variables employed in the Discounted Cash Flow (DCF) model are presented in Table A2 below.

These variables are consistent with the 2019-24 Regulatory Proposal to the AER and are considered appropriate for use in the detailed commercial analysis.

Table A2 – Common Variables

Variables	
Nominal Pre-Tax WACC	6.96%
CPI – 2017/18	2.42.0%
CPI after 2017/18	2.42%

Time Horizon of Project	40 years

Option 1 - Deferral

Commercial analysis of Option 1 (deferral) was not undertaken as it is not considered to be a viable alternative due to the risk of major outages as a result of equipment failure.

Option 2 – Add 3rd 20/27MVA transformer 66/11kV at Archer ZSS

The analysis for this option includes capital expenditure of [redacted]

Option 3 – Replace 2 x 20/27MVA transformers with 20/27/33MVA transformers

The analysis for this option includes capital expenditure of [redacted]

Option 4 – Install connection facilities for NOMAD modular substation

The analysis for this option includes capital expenditure of [redacted]

Least cost analysis

Based on the DCF analysis undertaken, the least cost option is Option 4. This is summarised in Table A3 below.

Table A3 – Net Present Cost of Options

Option	NPC ($M)
Option 2 – Add 3rd 20/27MVA transformer 66/11kV at Archer ZSS	[redacted]
Option 3 – Replace 2 x 20/27MVA transformers with 20/27/33MVA transformers	[redacted]
Option 4 – Install connection facilities for NOMAD modular substation	[redacted]

Tariff cover

This project capex (2019/20 expenditure) will be submitted as part of the 2019 Regulatory Proposal to the AER. The AER's Final Determination will

provide the approved level of net capital expenditure for the 2019-24 period. In so far as the Regulated Networks annual capital expenditure program remains at this level (or lower), Networks will earn a guaranteed rate of return through standard control service charges until the commencement of the next regulatory control period in 2024-25.

APPENDIX B

DETAILED RISK REGISTER

Refer:

PRD33002 Risk Analysis Archer ZSS Augmentation

PWC Ref: D2017/475924

APPENDIX C

SUMMARY PROJECT PROGRAM

Task	*Baseline*			*2019*				*2020*			
	Plan Start	*Plan Duration*	*Percent Complete*	*Q1*	*Q2*	*Q3*	*Q4*	*Q1*	*Q2*	*Q3*	*Q4*
Options Study	Jul 17	6 wks	100%								
Concept Design	Jul 19	6 wks	80%								
Planning and Permits	Jul 19	10 wks									
Detailed Design	Aug 19	10 wks									
Procurement	Sep 19	16 wks									
Civil Construction	Nov 19	16 wks									
Distribution Installation	Feb 20	16 wks									
Secondary Installation	Feb 20	4 wks									
Commissioning and Energisation	May 21	4 wks									

APPENDIX D

PLANNING REPORT

Refer:

NPR1602 Archer Zone Substation Loading Issues – Third Transformer Requirement

PWC Ref: D2016/73870

PowerWater

Report No:	NPR1602	File No:	D2016/73870
Date:	19 Feb 2018	Container No:	F2005/13996
Author:	Craig Owens		
Approved by:	Tat Au-Yeung – Senior Manager Network Development and Planning		
Revision:	Final		
Title:	Archer Zone Substation Loading Issues		

Report Circulation:

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1. Executive Summary

This report documents a study to investigate the options to supply the increased load at the Archer zone substation. The maximum demand supplied by the Archer zone substation is forecast to exceed the firm capacity in 2017/2018 based on AEMO's 2017 load forecasting values. The maximum demand is expected to be further increased significantly in the later years due to the new loads Wishart Industrial Estate and the Zuccoli subdivision.

This report discusses the following options to meet the forecast load growth at Archer substation

1.) Do Nothing
2.) Transfer the load to other Zone Substations
3.) Network Augmentation in the 11 kV network

4.) Upgrade Transformer 1 to ODAF cooling
5.) Demand Management (Non network solutions)
    (a) Reduce the maximum demand
        - PV installations
        - Capacitor banks
6.) Increase the capacity of the Archer zone substation by installing a third transformer

Option 2, transferring load to adjacent Zone Substations, and Option 6b, the installation of a third transformer at Archer Zone Substation are both found to be effective options.

It is expected that option 2 will be a relatively low cost option, which will allow the higher cost option 6b to be delayed. A detailed study will be required to determine the optimal timing of the two options to ensure the network continues to meet the forecast maximum demand and the requirements of the Network Technical Code and Network Planning Criteria.

The implementation of option 2 prior to option 6 is expected to delay the need for the third transformer at Archer Zone Substation by up to three years, meaning that it will be required by June 2024 at the latest, still within the 2019-24 regulatory control period.

2. Table of Contents

3. List of Figures

4. List of Tables

5. Network Planning Criteria

The relevant clauses in the Power Networks Network Technical Code and Network Planning Criteria, December 2013 that apply to this study are:

Part A – Legislative Requirements

Part B – Network Technical Code

1.7 Obligations

2.3 Power frequency voltage levels

4.2 Power system security principles

4.3 Power system security obligations and responsibilities

4.5 Control of network voltages

8 Disconnection and reconnection of plant and equipment

Part C – Network Planning Criteria

The purpose of Network Planning Criteria is to strike a balance between each User's need for a safe, secure, reliable, high quality electricity supply and the desire for this service to be provided at minimal cost. At the same time, environmental and social considerations shall be taken into account.

13 Introduction

14 Supply contingency criteria

15 Steady state criteria

18 Construction standards criteria

19 Environmental criteria

Of particular importance for this study is chapter 14 of the Network Planning Criteria, 'Supply contingency criteria'. Table 13 on page 126 of the Network Planning Criteria defines that for a load over 5 MVA and up to 50 MVA in a CBD or Urban area, area demand is required to be restored within 60 minutes after a single contingency. This is referred to as class of supply C.

In most cases the most critical single contingency is the loss of a single zone substation power transformer.

6. Introduction

6.1. Background

The maximum demand of the Archer zone substation is increasing due to proposed developments at [redacted] and [redacted] subdivision, as well as underlying growth of the existing load. The description of the proposed new developments and their expected additional maximum demand are listed in Table 1

Table 1 Proposed Additional Loads

Description	Load (MVA)
[redacted]	2.3
[redacted]	1.4
[redacted]	7.2
[redacted]	2.8
[redacted]	7.0
[redacted]	2.2
[redacted]	1.5

This represents a total notional additional maximum demand of 24.4 MVA. Given the uncertainties around the timing and diversity between the loads of these proposed developments, the normal network planning approach is to consider the network impacts of 50% of the above peak load being connected. That is, an additional 12.2 MVA. In this network planning report the more moderate load growth expected in AEMO's 2017 load forecast is considered.

6.2. Existing Network

Archer zone substation was commissioned in 2012 with 2 new transformers as listed below.

Table 2 - Archer transformer ratings

Transformer Description	Voltage (kV)	Install Date	Nameplate Rating (MVA)		Normal Cyclic Rating (MVA)	Long Emergency Rating (MVA)
			ONAN	ONAF	ONAF	ONAF
Transformer 1	66/11	2011	20	27	30.3	34.1
Transformer 2	66/11	2012	20	27	30.3	34.1

Cyclic capacity calculations have been carried out using PWC's TranCyc software which implements the algorithm described in AS 2374.7 - 1997

The detailed calculations are available in RM8 container: D2014/465312

The "Long Emergency" rating provided in the calculations document is appropriate to use for network planning purposes. The 34.1 MVA loading is expected to result in an ageing rate of 10 days/day and is recommended not to be continued for more than 6 months. In the event of a transformer failure it is reasonable to expect that a replacement transformer will be available and commissioned within 6 months.

6.3. Scope of Study

The scope of study is to determine the required actions to be able to meet current load and future growth

The study will consider possible options to delay capital expenditure and interim arrangements for meeting expected load forecasts.

7. Overview of works and rationale for the network investment

7.1. Existing system

Palmerston and the surrounding areas are supplied from Palmerston and Archer zone substations. The majority of the load is supplied via the 11 kV distribution networks, and Palmerston also supplies a 22 kV network.

7.2. Forecast Loading

Forecast maximum demand at Archer zone substation over the next decade is shown in Figure 1 below. The forecast was produced by AEMO in 2017[12].

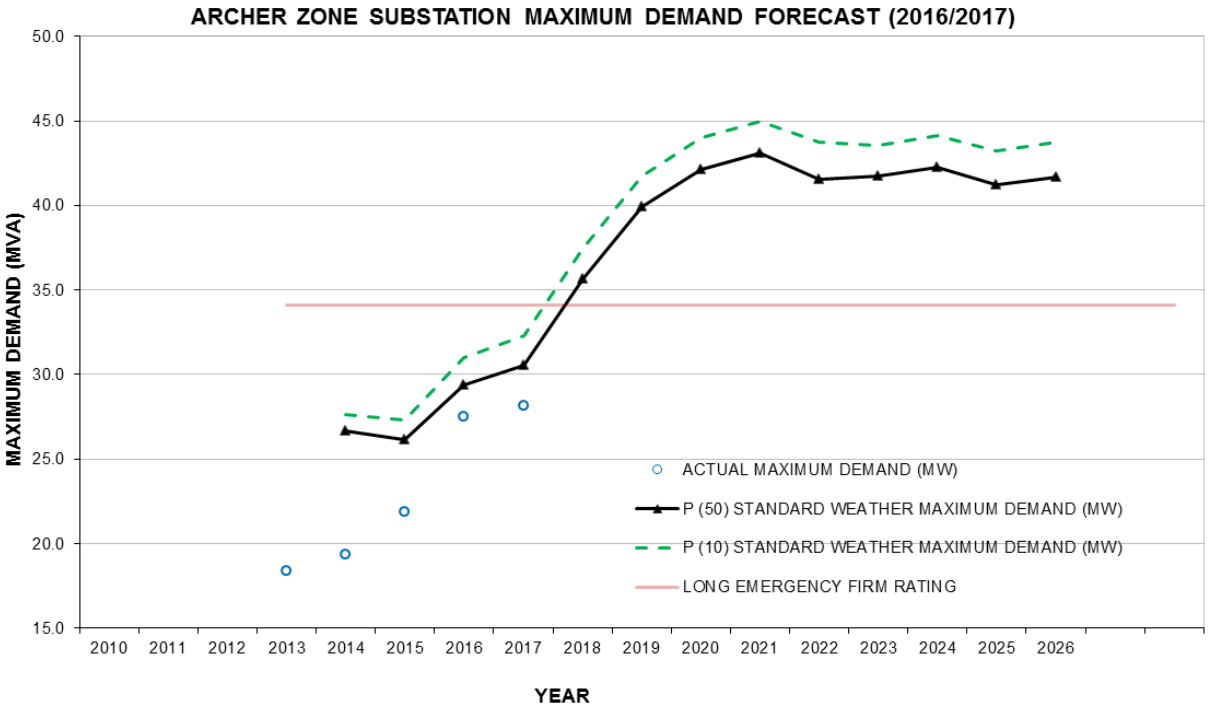


Figure 1 - Archer Substation load forecast

7.3. Identification of network limitations

As can be seen from Figure 1 above, maximum demand on the Archer zone substation is expected to exceed the substation's cyclic firm capacity in 2018.

7.4. Material inter network impact

No material inter network impacts have been considered in this study. This study has only considered the 11kV network in the areas supplied by the Archer and Palmerston substations and does not consider interactions on the 66/132kV transmission network.

There has not been a study of the impact of system changes on fault levels.

[12] D2017/446920 - NPR1602 Supporting Document - ARCHER Zone Substation Maximum Demand Forecast (2016-2017)

7.5. Consideration of demand management and/or local generation

From observation of Figure 1 above, a reduction in forecast maximum demand of approximately 4.0 MVA would be expected to delay the need for additional network investment by 1 year.

PWC has not identified any demand management opportunities which would be expected to delay the need for additional network investment at Archer Zone Substation.

8. Options Considered

8.1. Do Nothing

This option is not considered reasonable since the forecast maximum demand on Archer Zone Substation is expected to exceed the cyclic firm capacity in the 2017/18 financial year.

8.2. Post-contingent transfer of load to adjacent substations

Under Class of supply C in the Network Planning Criteria area load must be restored within 60 minutes of the first supply contingency.

It may be possible to meet this requirement by providing post contingent network switching capability in the 11 kV network to allow any load above the cyclic rating of a single transformer at Archer to be switched to Palmerston substation, in the event of a failure of one transformer at Archer. It is likely that this switching capability would need to be remote controlled to meet the 60 minute requirement in the Network Planning Criteria.

It may also be possible to transfer some load permanently to adjacent substations.

8.3. Upgrade existing Transformers to ODAF cooling

The possibility of uprating transformers at Archer zone substation to provide ODAF cooling has been investigated. Unfortunately due to design details of transformer 1, ODAF cooling cannot be applied to this unit. Since firm capacity at a Zone Substation is defined as the rating with the highest rated single element out of service, this approach will not lead to an increase in the firm rating for Archer Zone Substation.

8.4. Demand Management

A demand management option which reduces the maximum demand on Archer substation by approximately 4.0 MVA would allow higher cost network investments to be delayed by one year.

PWC has not identified any demand management options which would meet this requirement.

8.5. Install Third Transformer at Archer

Archer zone substation was designed to house 3 x 66/11 kV transformers. The installation of the third transformer, with similar specifications to the existing units, will increase the normal cyclic rating of the substation from 34.1 MVA to 68.2MVA. As can be seen from Figure 1 above this cyclic rating would exceed the forecast load for the period until 2026, and ensure that the network meets the Network Planning Criteria for this period.

9. Recommended Works

A business case should be prepared detailing NPV analysis of the two options which have been identified as possible:

- 8.2 Post-contingent transfer of load to adjacent substations
- 8.5 Install Third Transformer at Archer

It is likely that option 8.2 will not be a final solution to the loading issues, although it may be able to delay the need for the more expensive option 8.5, and thus be an economically prudent approach.

10. PSS Sincal Load Flow Model

A detailed 11 kV Sincal network model is available which can be used to analyse the capacity in the 11 kV network for the implementation of option 8.2.

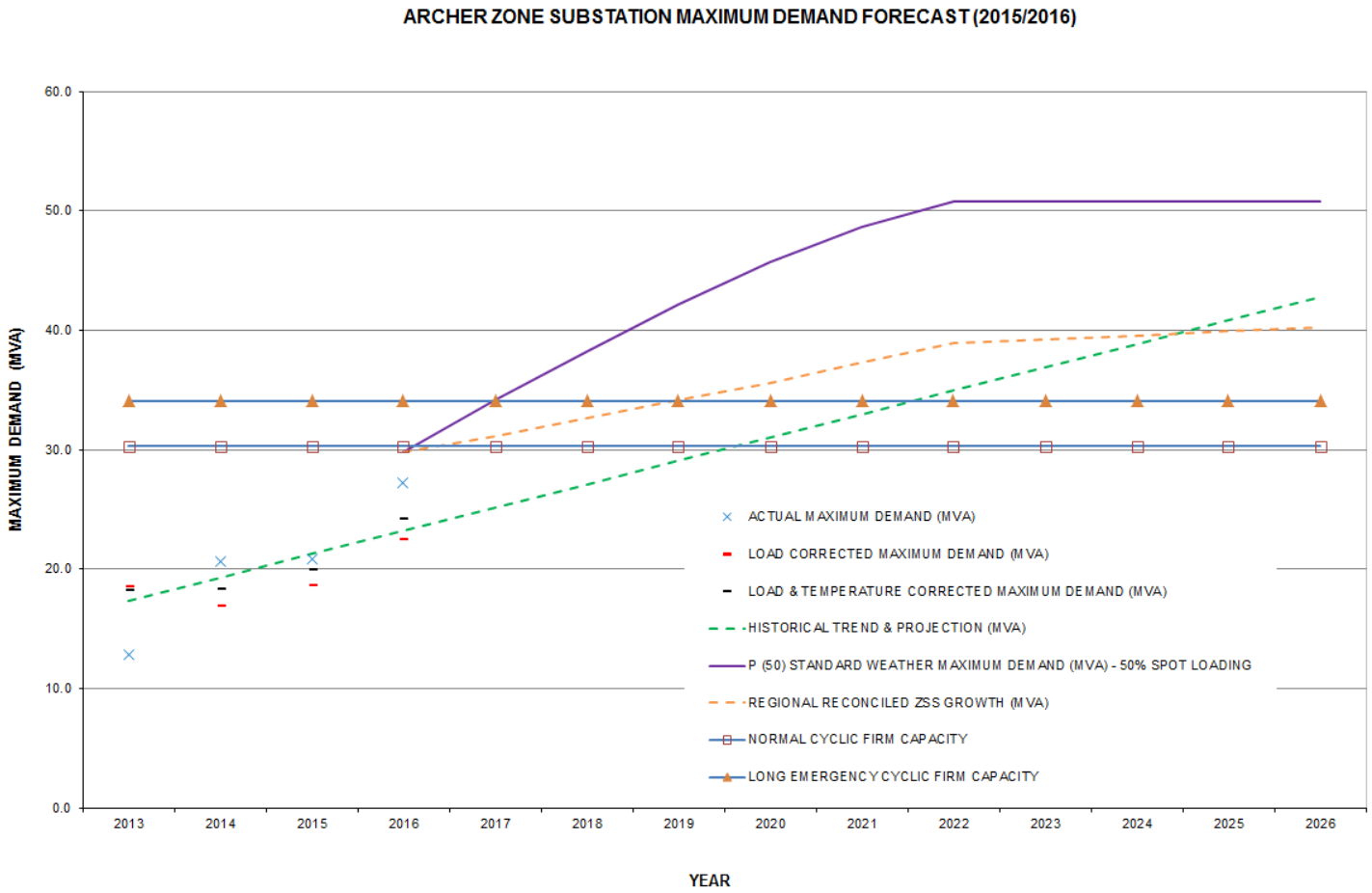
11. Conclusions and Recommendations

A business case should be prepared to analyse the two options which have been identified as possible.

12. Appendix 1 – Reference Load Forecast

The load forecast produced by AEMO in 2017 is used as the basis of the analysis in this report. The earlier internal forecast is attached here for reference.

Figure 2: Graph - Archer Zone Substation Maximum Demand Forecast (2015/2016) [13]



[13] Archer Zone Substation Maximum Demand Forecast (2015/2016). PWC Reference: D2016/33705