Planning Report Clyde North (CLN) Zone Substation Service Level Constraints

AMS – Electricity Distribution Network

PUBLIC

Document number	AMS 20-316
Issue number	1
Status	DRAFT
Approver	
Date of approval	

ISSUE/AMENDMENT STATUS

Issue Number	Date	Description	Author	Approved by
0.1	21/03/19	Initial Draft	Jason Pollock	
0.14	27/03/19	Draft	Jason Pollock	
1.0	11/04/19	Draft for WSP review	Jason Pollock	
1.1	27/05/19	Updated draft post customer forum feedback on WSP review	Jason Pollock	
1.2	14/06/19	Final Draft for EDPR submission	Jason Pollock	

Disclaimer

This template is for generating internal and external document belonging to AusNet Services and may or may not contain all available information on the subject matter this document purports to address.

The information contained in this document is subject to review and AusNet Services may amend this document at any time. Amendments will be indicated in the Amendment Table, but AusNet Services does not undertake to keep this document up to date.

To the maximum extent permitted by law, AusNet Services makes no representation or warranty (express or implied) as to the accuracy, reliability, or completeness of the information contained in this document, or its suitability for any intended purpose. AusNet Services (which, for the purposes of this disclaimer, includes all of its related bodies corporate, its officers, employees, contractors, agents and consultants, and those of its related bodies corporate) shall have no liability for any loss or damage (be it direct or indirect, including liability by reason of negligence or negligent misstatement) for any statements, opinions, information or matter (expressed or implied) arising out of, contained in, or derived from, or for any omissions from, the information in this document.

Contact

This document is the responsibility of AusNet Services.

Please contact the indicated owner of the document with any inquiries.

T Langstaff
AusNet Services
Level 31, 2 Southbank Boulevard
Melbourne Victoria 3006
Ph: (03) 9695 6000

Table of Contents

1 Executive Summary

AusNet Services is a regulated Victorian Distribution Network Service Provider (DNSP) that supplies electrical distribution services to more than 729,000 customers. Our electricity distribution network covers eastern rural Victoria and the fringe of the northern and eastern Melbourne metropolitan area.

As expected by our customers and required by the various regulatory instruments that we operate under, AusNet Services aims to maintain service levels at the lowest possible cost to our customers. To achieve this, we develop forward looking plans that aim to maximise the present value of economic benefit to all those who produce, consume and transport electricity in the National Electricity Market (NEM).

This report presents our forward looking investment plans to manage the existing and emerging service level constraints in the Clyde North (CLN) zone substation supply area to ensure that we maintain service levels to our customers over the short and long term. The report outlines how we quantify service risk, identifies and assesses the costs and benefits of potential options to mitigate the identified risks, and provides forward looking plans outlining the optimal service level risk mitigation solutions, and timing of those solutions, to maintain service levels.

1.1 Identified Need

Clyde North (CLN) Zone Substation consists of two 66/22 kV 20/33 MVA transformers supplying two 22 kV buses and seven 22 kV feeder circuits. The substation supplies approximately 30,000 residential, commercial, industrial and agricultural customers in Victoria's southeast growth corridor.

The supply area is surrounded by Cranbourne (CRE) and Hampton Park (HPK) Zone Substations in the west, Berwick North (BWN) Zone Substation in the north and Officer (OFR) Zone Substation in east.

CLN Zone Substation is a summer peaking substation with a forecast maximum demand growth rate averaging 4.4% per annum over the next 10-year period. The growth in demand is predominately driven by the significant expansion of residential and commercial development in Melbourne's southeast growth corridor.

The zone substation summer maximum demand recorded in 2017/18 was 63.6 MVA. The forecast summer maximum demand is given in Table 1.

Table 1: Forecast Summer Maximum Demand

Probability of Exceedance (POE)	Forecast Summer Maximum Demand 2018/19 (MVA)	Forecast Summer Maximum Demand 2024/25 (MVA)
50%	68.8	89.7
10%	73.3	95.8

The zone substation capacity, consisting of a nameplate rating of 66 MVA, and 'N' and 'N-1' cyclic ratings of 87.3 MVA and 43.5 MVA respectively, is insufficient to reliably supply the forecast maximum demand, meaning that the current level of supply to our customers is expected to diminish if some service level risk mitigation action is not undertaken.

In addition to the zone substation constraints, supply capacity is also limited at the feeder circuit level, where electricity demand growth is forecast to exceed the capacity of multiple feeder circuits, similarly resulting in a service level reduction unless some risk mitigation action is taken.

1.2 Proposed Preferred Option

The options analysis identifies that the proposed preferred option, being the one that maximises the net economic benefit to all those that produce, consume and transport electricity in the NEM, is to install a third 20/33 MVA transformer and third 22 kV switchboard at Clyde North (CLN) zone substation by November 2024, at a project cost of [C.I.C] (Real, $2018).

Applying a discount rate of 6.44% per annum, this proposed preferred option has a net economic benefit of [C.I.C] (Real $2018) over the forty-five-year assessment period.

1.3 Next Steps

This planning report outlines the service level risk mitigation investment that AusNet Services has assessed as providing the optimal balance of supply reliability and cost.

While this planning report outlines our plans for maintaining service levels and serves to support our revenue request for the 2022-26 EDPR period, the proposed investment is subject to the regulatory investment test for distribution (RIT-D). As such, the proposed investment will be confirmed via the formal RIT-D process, and works will not commence until this process is complete.

AusNet Services intends to commence the RIT-D process in September 2019, with preparation of Stage One of the RIT-D, the non-network options report.

2 Introduction

2.1 Purpose

This planning report outlines existing and emerging constraints to supplying reliable and cost efficient electrical power to over 30,000 AusNet Services customers in the Clyde North (CLN) Zone Substation supply area.

It outlines AusNet Services' regulatory obligations and asset management strategies for maintaining service levels, and presents an assessment of potential options and proposed plans to maintain service levels in line with our customers' expectations, regulatory requirements and our asset management objectives.

The service level constraints and options analysis presented within this report are prepared with consideration of the regulatory investment test for distribution (RIT-D), including the RIT-D application guidelines and the industry practice application guidelines for asset replacement planning, albeit without the formal consultation stages that form a key part of the RIT-D process.

In line with this, and with the aim to assess and identify the option that maximises the present value of net economic benefit to all those who produce, consume and transport electricity in the National Electricity Market, the service level constraints assessment and risk mitigation plans consider customer demand for electrical power and asset capability and reliability, and weigh these aspects against the long and short term customer cost implications and consequences of unreliability on security of supply, safety and the environmental impacts.

2.2 Scope

The scope of this planning report is limited to the equipment within Clyde North (CLN) Zone Substation.

It excludes sub-transmission lines and distribution feeders entering and exiting the zone substation.

2.3 Asset Management Objectives

AMS 01-01 Asset Management System Overview, outlines AusNet Services' high-level asset management objectives, which are to:

- Comply with legal and contractual obligations;
- Maintain safety;
- Be future ready;
- Maintain network performance at the lowest sustainable cost; and
- Meet customer needs.

AMS 20-01 Electricity Distribution Network Asset Management Strategy, outlines AusNet Services' electricity distribution network objectives, which are to:

- Improve efficiency of network investments
- Maintain long-term network reliability
- Implement REFCLs within prescribed timeframes
- Reduce risks in highest bushfire risk areas
- Achieve top quartile operational efficiency
- Prepare for changing network usage.

3 Background

3.1 Substation Description

AusNet Services is a regulated Victorian Distribution Network Service Provider (DNSP) that supplies electrical distribution services to more than 729,000 customers. AusNet Services' electricity distribution network covers eastern rural Victoria and the fringe of the northern and eastern Melbourne metropolitan area.

Clyde North (CLN) Zone Substation consists of two 66/22kV 20/33 MVA transformers supplying two 22 kV buses and seven 22 kV feeder circuits. The substation supplies approximately 30,000 residential, commercial, industrial and agricultural customers in Victoria's southeast growth corridor.

The supply area is surrounded by Cranbourne (CRE) and Hampton Park (HPK) Zone Substations in the west, Berwick North (BWN) Zone Substation in the north and Officer (OFR) Zone Substation in east, as shown in Figure 1.

Electricity demand and population growth in the southeast growth corridor has been strong in recent years, which led to the establishment of CLN zone substation in 2004 to help manage growth by off-loading HPK and BWN zone substations and feeders.

In 2012, CRE zone substation was established to further off-load HPK zone substation and the feeders heading west and south, and CLN zone substation and the feeders heading west, north and south.

Prior to establishing CLN zone substation, the areas shown in Figure 1 were supplied from the combination of BWN and HPK zone substations.

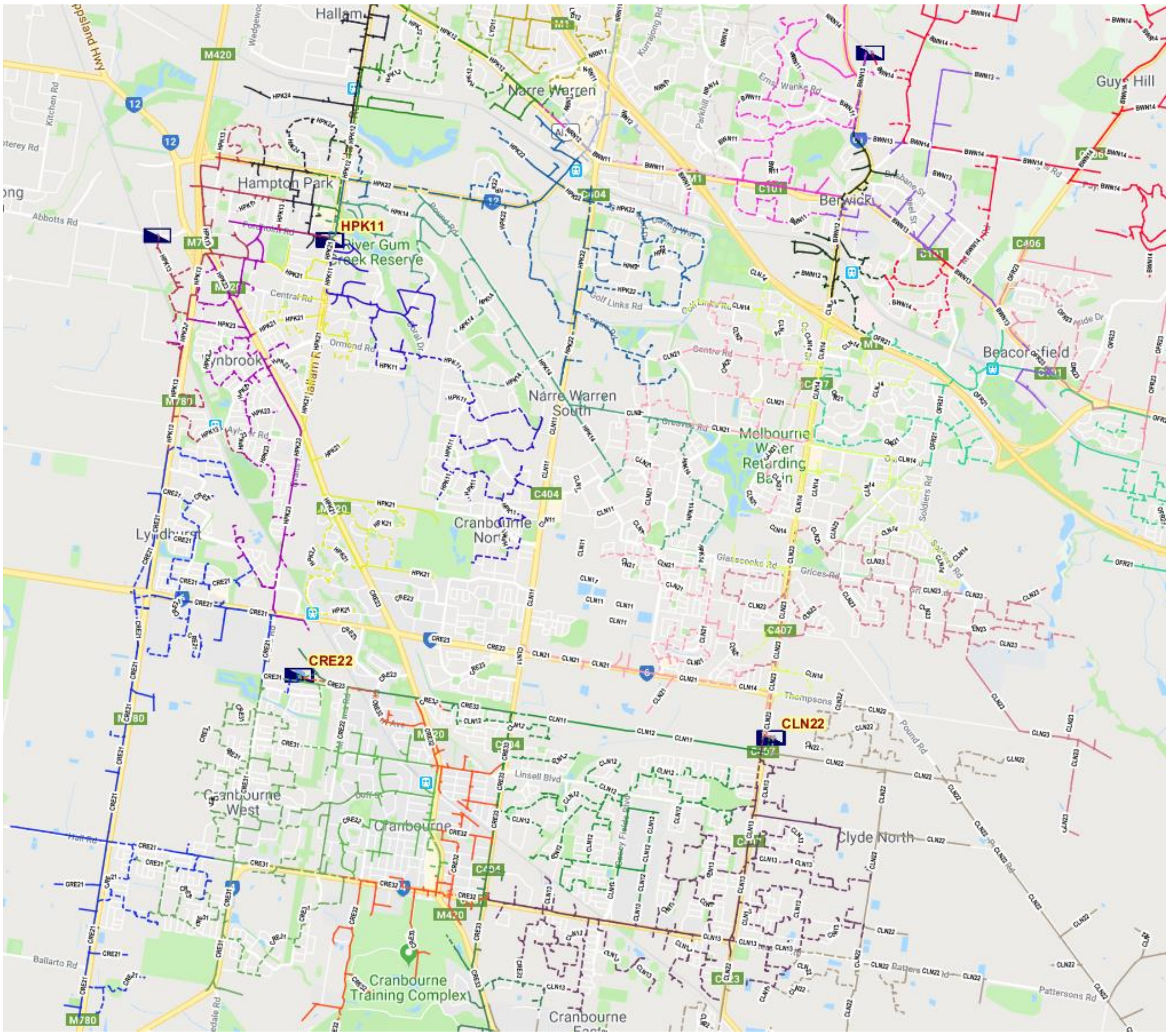


Figure 1: CLN and surrounding zone substation geographical feeder arrangements

The configuration of the primary electrical circuits within and surrounding CLN is as shown in the single line diagram of Figure 2.

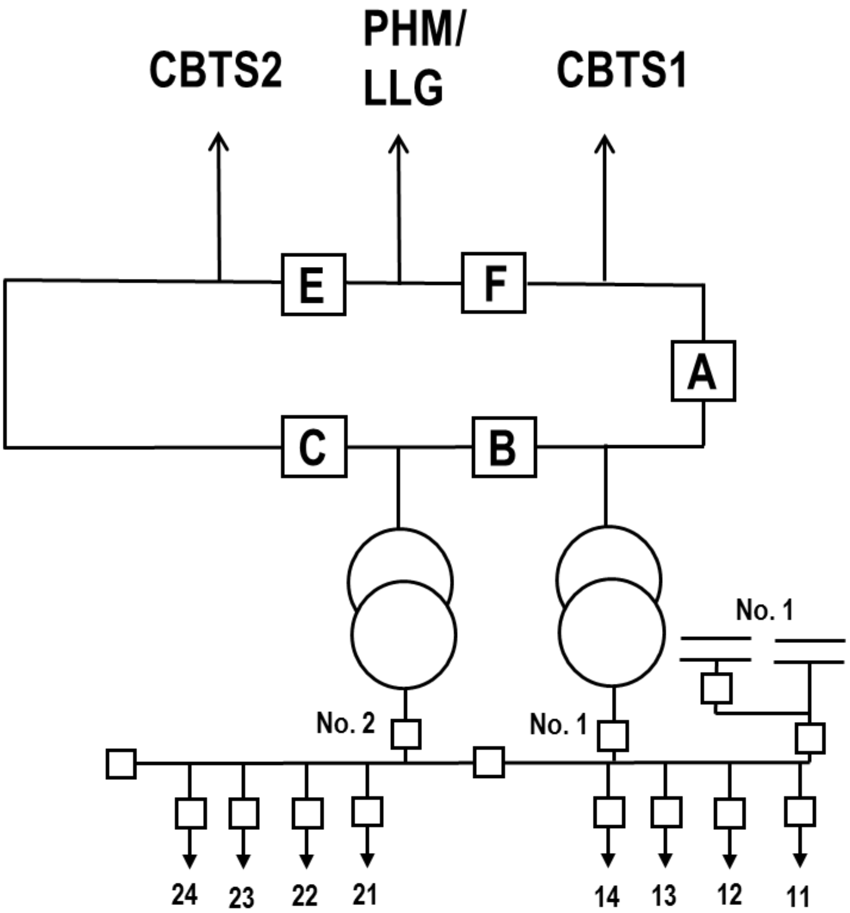


Figure 2: Existing Single Line Diagram of CLN

3.2 Customer Composition

CLN has seven 22 kV feeders supplying AusNet Services' customers. Table 1 provides detail of the 22 kV supply feeders.

Table 2: CLN feeder information

Feeder	Feeder Length (km)	Feeder Description	Number of Customers	Customer Type
CLN11	20.8	Summer peaking, urban feeder	1,480	97.2% residential 1.6% commercial 0.4% industrial 0.7% farming
CLN12	29.1	Summer peaking, urban feeder	4,890	98.8% residential 1.2% commercial
CLN13	47.3	Summer peaking, rural short feeder	7,019	98.9% residential 1.1% commercial
CLN14	32.0	Summer peaking, urban feeder	4,382	97.7% residential 2.1% commercial 0.2% farming

Feeder	Feeder Length (km)	Feeder Description	Number of Customers	Customer Type
CLN21	33.6	Summer peaking, urban feeder	5,636	98.4% residential 1.2% commercial 0.2% industrial 0.2% farming
CLN22	106.1	Summer peaking, rural short feeder	2,694	88.5% residential 3.2% commercial 0.3% industrial 7.9% farming
CLN23	31.2	Summer peaking, rural short feeder	4,100	99.2% residential 0.7% commercial 0.1% farming

3.3 Asset Condition

To provide a consistent assessment of the condition of an asset, AusNet Services applies a common condition scoring methodology. This methodology uses the known condition details of each asset and grades that asset against common asset condition criteria.

Asset condition is measured with reference to an asset health index on a declining condition scale from C1 to C5, as outlined in Table 3.

AusNet Services' strategy and approach to monitoring the condition of assets is further described in *AMS 10-13 Condition Monitoring*.

Table 3: Asset condition scoring methodology

Condition Score	Condition	Condition Summary
C1	Very good	Initial service condition
C2	Good	Deterioration has minimal impact on asset performance. Minimal short term asset failure risk.
C3	Average	Functionally sound showing some wear with minor failures, but asset still functions safely at adequate level of service.
C4	Poor	Advanced deterioration – plant and components function but require a high level of maintenance to remain operational.
C5	Very Poor	Extreme deterioration approaching end of life with failure imminent.

Asset conditions are discussed in the Asset Health Reports for the key asset classes, namely power transformers, instrument transformers and circuit breakers, with information on asset condition rankings, recommended risk mitigation options and replacement timeframes.

A summary of the condition of key assets at CLN zone substation is provided in Table 4.

Table 4: CLN asset condition scores

Asset Type	Number of Assets				
	C1	**C2**	**C3**	**C4**	**C5**
66 kV Circuit Breakers	5				
66 kV Current Transformers	12				
66 kV Voltage Transformers	11		2		
66/22 kV Power Transformers		2			
22 kV Circuit Breakers	15	1			
22 kV Current Transformers	22				
22 kV Voltage Transformers	4				

These conditions scores are then used to calculate the asset failure rates using the Weibull Hazard function, as presented in Equation 1.

Equation 1: Weibull Hazard Function

$$r(t) = \frac{\beta t^{\beta-1}}{\eta^{\beta}}$$

Where:

t = Time (condition based age)

η = Characteristic life (Eta)

β = Shape Parameter (Beta)

A Beta (β) value of 3.5 has been used to calculate the failure rates of all assets considered in the zone substation risk-cost model.

The condition based age (t) depends on the specific asset's condition and characteristic life (η). The characteristic life represents that average asset age at which 63% of the asset class population is expected to have failed. Table 5 gives the characteristic life values for each asset classes considered in the risk-cost model.

Table 5: Equipment Characteristic Life Values

Equipment	Characteristic Life (η) (years)
Power transformers	50
Circuit breakers	45
Voltage transformers	40
Current transformers	30

3.4 Zone Substation Supply Capacity

Clyde North (CLN) zone substation is a summer peaking substation with a forecast maximum demand growth rate averaging 4.4% per annum over the next 10-year period. The growth in demand is predominately driven by the significant expansion of residential and commercial development in Melbourne's southeast growth corridor.

The zone substation summer maximum demand recorded in 2017/18 was 63.6 MVA. The forecast summer maximum demand is given in Table 6.

Table 6: Forecast Summer Maximum Demand

Probability of Exceedance (POE)	Forecast Summer Maximum Demand 2018/19 (MVA)	Forecast Summer Maximum Demand 2024/25 (MVA)
50%	68.8	89.7
10%	73.3	95.8

Figure 3 shows the forecast maximum demand and supply capacities (cyclic ratings) of CLN zone substation. As the figure shows, demand already exceeds the N-1 cyclic rating, which is the station's supply capacity when one transformer out of service, and is forecast to exceed the station's N rating, which is the station's supply capacity with all assets in service, within the 2022-26 EDPR period.

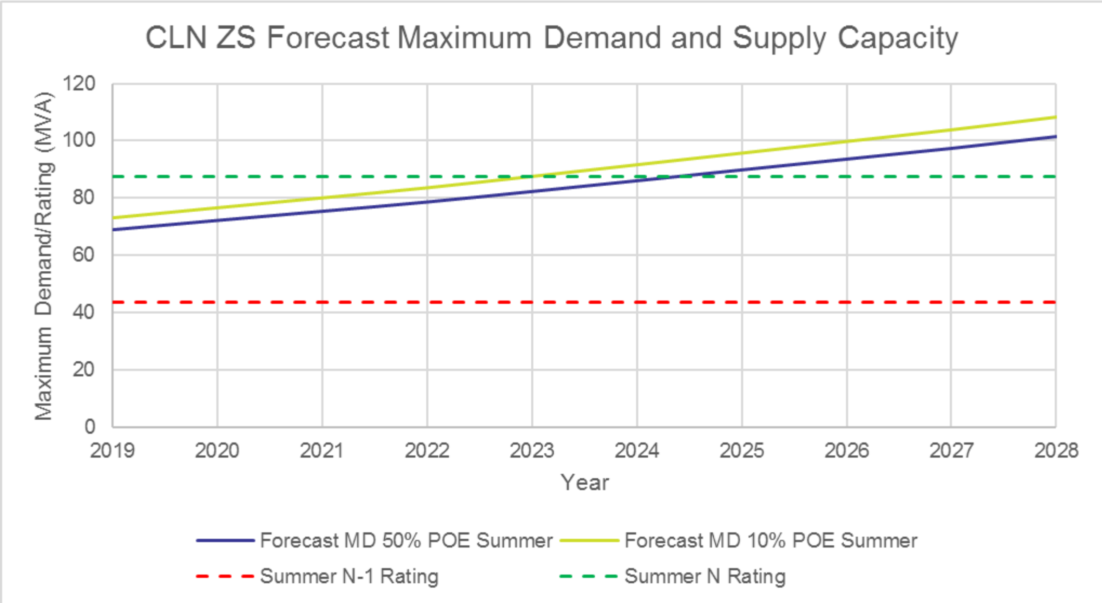


Figure 3: Clyde North Zone Substation forecast maximum demand and supply capacity

3.5 Load Duration Curves

The zone substation load duration curves that feed into the risk-cost assessment model are derived from historical actual demands between:

- 1 October 2016 and 31 March 2017 for the summer 50% probability of exceedance (POE) curves;
- 1 April 2017 and 30 September 2017 for the winter 50% POE curves;
- 1 October 2013 and 31 March 2014 for the summer 10% POE curves; and
- 1 April 2017 and 30 September 2017 for the winter 10% POE curves.

The historical hourly demands are separated by season and unitised based on the recorded maximum demand within that season (summer and winter) and time period. This allows the load duration curve to be scaled according to the seasonal forecast maximum demand for each year of the assessment period.

The 50% POE unitised load duration for CLN zone substation is presented in Figure 4, and the 10% POE unitised load duration for CLN zone substation is presented in Figure 5.

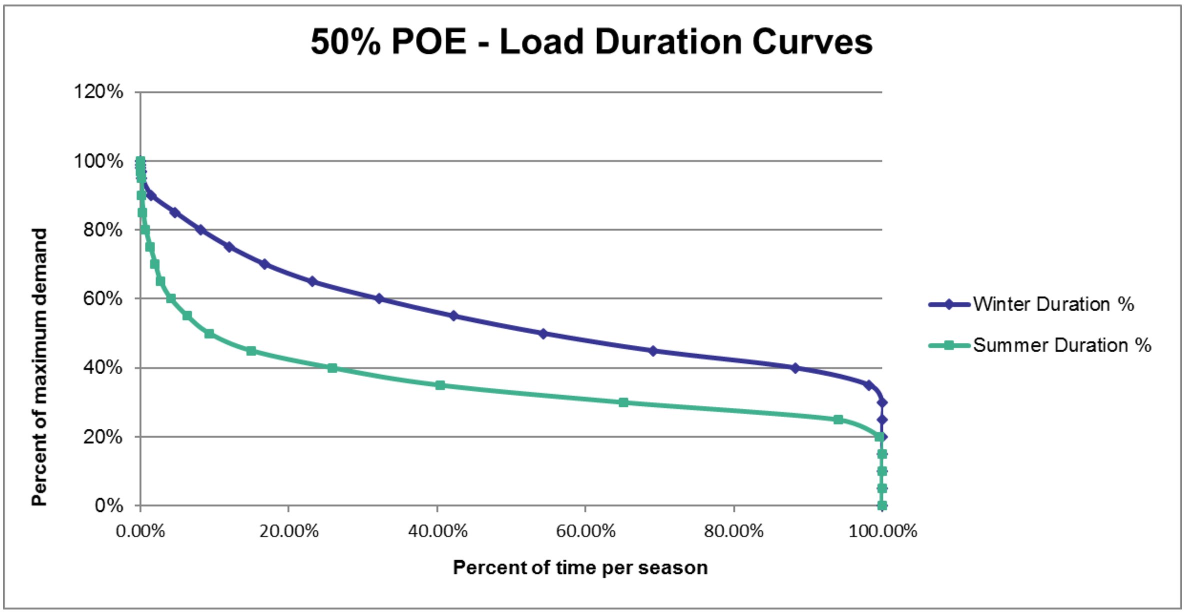


Figure 4: Clyde North Zone Substation 50% load duration curves

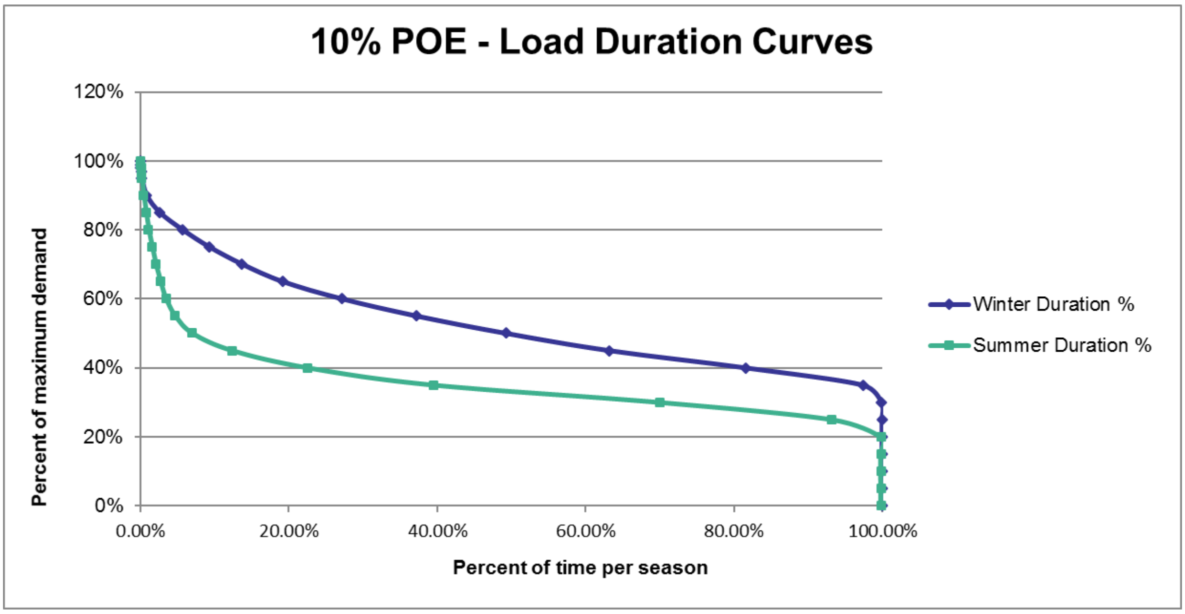


Figure 5: Clyde North Zone Substation 10% POE load duration curves

3.6 Feeder Circuit Supply Capacity

In addition to the zone substation constraints, supply capacity from CLN zone substation is also limited at the feeder circuit level, where electricity demand growth is forecast to exceed the capacity of two CLN feeder circuits within the 2022-26 period.

Table 7 presents the rating and annual forecast maximum demand of the 22 kV feeder circuits supplied from CLN zone substation. The ratings presented are the continuous summer feeder circuit ratings, and the forecast maximum demand levels represent a 50% probability of exceedance forecast. The shaded cells show when the feeder demand is forecast to exceed the feeder circuit rating.

Table 7: Forecast utilisation of Clyde North Zone Substation feeders

Feeder	Rating (A)	Forecast Maximum Demand (A)						
		2020	2021	2022	2023	2024	2025	2026
CLN11	360	176	178	182	185	187	188	190
CLN12	335	283	286	290	294	300	308	314
CLN13	347	340	362	381	405	430	454	478
CLN14	325	281	292	301	309	318	327	337
CLN21	358	308	316	324	332	339	346	354
CLN22	375	221	244	269	297	325	354	383
CLN23	323	312	341	370	405	443	479	514

3.7 Load Transfer Capacity

Clyde North (CLN) zone substation is surrounded by Cranbourne (CRE) and Hampton Park (HPK) zone substations in the west, Berwick North (BWN) Zone Substation in the North and Officer (OFR) Zone Substation in East.

CLN Zone Substation has multiple feeder interconnections with its neighbouring zone substations, as outlined in Table 8, which have potential to provide emergency load transfer during periods of limited or insufficient supply capacity.

Table 8: CLN feeder interconnections to adjacent zone substations

CLN Feeder	Adjacent Connecting Feeders	Connection Point Location relative to CLN Zone Substation
CLN11	CRE23, CRE33, HPK11	West
CLN12	CRE33, CRE32	West
CLN13	CRE33	South West
CLN14	OFR21, BWN12	North East
CLN21	HPK14, HPK22	North West
CLN22	CRE33	South West
CLN23	None	

Table 9 presents the rating and forecast maximum demand of feeder circuits supplied from zone substations adjacent to CLN zone substation, and that have normally open connection points to CLN feeders. The ratings presented are the continuous summer feeder circuit ratings, and the forecast maximum demand levels represent a 50% probability of exceedance forecast. The shaded cells show when the feeder demand is forecast to exceed the feeder circuit rating.

Table 9: Rating and demand of feeders connecting to Clyde North Zone Substation

Feeder	Rating (A)	Forecast Maximum Demand (A)						
		2020	2021	2022	2023	2024	2025	2026
BWN12	273	297	300	300	300	302	305	305
CRE23	360	240	244	247	247	248	248	250
CRE32	360	282	282	283	287	289	289	289
CRE33	335	263	275	286	298	311	323	333

Feeder	Rating (A)	Forecast Maximum Demand (A)						
		2020	2021	2022	2023	2024	2025	2026
HPK11	293	293	293	293	293	293	293	293
HPK14	330	264	265	268	272	274	276	278
HPK22	311	282	286	290	295	301	307	312
OFR21	375	358	369	380	392	405	417	430

Based on the feeder circuit connections to adjacent zone substations, and other relevant limitations, the emergency load transfer capacity away from CLN zone substation is 30.1 MVA in 2018/19, reducing to 23.0 MVA by 2024/25, as presented in Table 10.

Table 10: Emergency load transfer capacity away from CLN Zone Substation

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Forecast emergency load transfer capacity (MVA)	30.1	28.8	27.5	26.3	25.2	24.1	23.0	22.0	21.0	20.1

4 Other Issues

4.1 Regulatory Obligations

This planning report acknowledges AusNet Services obligations as a Distribution Network Service Provider under the National Electricity Rules with particular emphasis on:

Clause 5.15 and 5.17 of the National Electricity Rules, which outlines the regulatory investment tests generally and the regulatory investment test for distribution specifically.

Clause 6.5.7 of the National Electricity Rules, which requires AusNet Services to only propose capital expenditure required in order to achieve each of the following:

(1) meet or manage the expected demand for standard control services over that period;

(2) comply with all applicable regulatory obligations or requirements associated with the provision of standard control services;

(3) to the extent that there is no applicable regulatory obligation or requirement in relation to:

(i) quality, reliability or security of supply of standard control services; or

(ii) the reliability or security of the distribution system through the supply of standard control services

to the relevant extent:

(iii) maintain the quality, reliability and security of supply of standard control services, and

(iv) maintain the reliability and security of the distribution system through the supply of standard control services; and

(4) maintain the safety of the distribution system through the supply of standard control services.

Section 98(a) of the Electricity Safety Act, which requires AusNet Services to:

design, construct, operate, maintain and decommission its supply network to minimise as far as practicable –

(a) the hazards and risks to the safety of any person arising from the supply network; and

(b) the hazards and risks of damage to the property of any person arising from the supply network; and

(c) the bushfire danger arising from the supply network.

The Electricity Safety Act, which defines ‘practicable’ to mean having regard to –

(a) severity of the hazard or risk in question; and

(b) state of knowledge about the hazard or risk and any ways of removing or mitigating the hazard or risk; and

(c) availability and suitability of ways to remove or mitigate the hazard or risk; and

(d) cost of removing or mitigating the hazard or risk.

Clause 3.1 of the Electricity Distribution Code, which requires AusNet Services to:

(b) develop and implement plans for the acquisition, creation, maintenance, operation, refurbishment, repair and disposal of its distribution system assets and plans for the establishment and augmentation of transmission connections:

(i) *to comply with the laws and other performance obligations which apply to the provision of distribution services including those contained in this Code;*

(ii) *to minimise the risks associated with the failure or reduced performance of assets; and*

(iii) *in a way which minimises costs to customers taking into account distribution losses.*

4.2 Station Configuration Supply Risk

The configuration of CLN means that failure of some 22kV and 66kV circuit breakers will result in an immediate loss of supply from CLN zone substation until the failed equipment can be switched out, isolated and the station supplies restored.

This would be for an estimated duration of two hours, which is the typical time it takes operators to travel to site and manually re-configure circuits to isolate the failed equipment and sequentially restore supply to as many customers as possible.

Additionally, failure of any equipment will result in supply outages to customers as backup circuit breakers operate to isolate the failed equipment.

Table 11 lists the estimated bus outage consequence factors for each major type of equipment based on the substation layout.

Table 11: CLN Bus Outage Consequence Factors

Equipment	Estimated Bus Outage Consequence
Transformer	0%
22 kV circuit breaker	50%
66 kV circuit breaker	50%
22 kV current transformer	50%
66 kV current transformer	50%
22 kV voltage transformer	0%
66 kV voltage transformer	0%

4.3 Investments Impacting Customer Supply Arrangements

This section outlines planned and committed investments that are expected to impact the customer supply arrangements in the area Clyde North supply area.

4.3.1 Zone Substation Feeder Works

AusNet Services has two new 22 kV feeder installations, connecting to CLN zone substation, that are currently in the construction stage. However, there is currently only one spare feeder exit circuit breaker available to accommodate the committed new feeders.

In the short term AusNet Services will connect two feeder lines to a single feeder exit circuit breaker, in what is known as a piggy-back feeder arrangement. While this arrangement allows both new feeders to be established before existing feeders are loaded above their thermal capacity, piggy-back feeder connections are undesirable, and only ever done as a temporary arrangement, because they result in poorer reliability due to the increased consequence of an outage associated with the higher load and number of customers connected to the single feeder exit circuit breaker.

Maintaining long term customer reliability at the feeder level relies on the establishment of a third 22 kV switchboard at CLN zone substation in the near future.

4.3.2 Critical Peak Demand Tariff

In 2011, AusNet Services introduced the critical peak demand (CPD) tariff for large customers. This tariff is part of the standard tariff structure that applies to all large business customers, which is defined as those having an expected annual energy consumption of 160 MWh or more.

This tariff structure gives customers the opportunity to minimise electricity consumption, or seek alternative supply sources, between 3pm and 7pm Australian Eastern Daylight Time (AEDT) on the five CPD days nominated by AusNet Services between 1 December and 31 March each year.

For customers on this tariff, AusNet Services calculates their average peak demand across the five CPD days, and this forms the basis of the ‘demand critical peak’ component of their tariff for the next 12 months. By reducing their demand on the nominated CPD days, customers have the opportunity to reduce their energy costs while assisting AusNet Services to manage supply risks in the local area.

Demand reduction responses in the CLN zone substation supply area have proven relatively strong on CPD nominated days, suggesting there are customers in the area that are price responsive and may be willing to provide firm demand response action via a network support contract. There are 65 large customers supplied from CLN zone substation. However, it is estimated that up to 90% of the demand response has been delivered by only six customers, four of which are already engaged by AusNet Services to provide network support demand management services.

As presented in Figure 6, while large customers are available to offset the demand, particularly throughout the middle of day, their contribution to the zone substation peak, and therefore their ability to reduce the zone substation peak demand, is somewhat diminished because their demand requirements are typically somewhat reduced by the time the zone substation peak evening peak arrives.

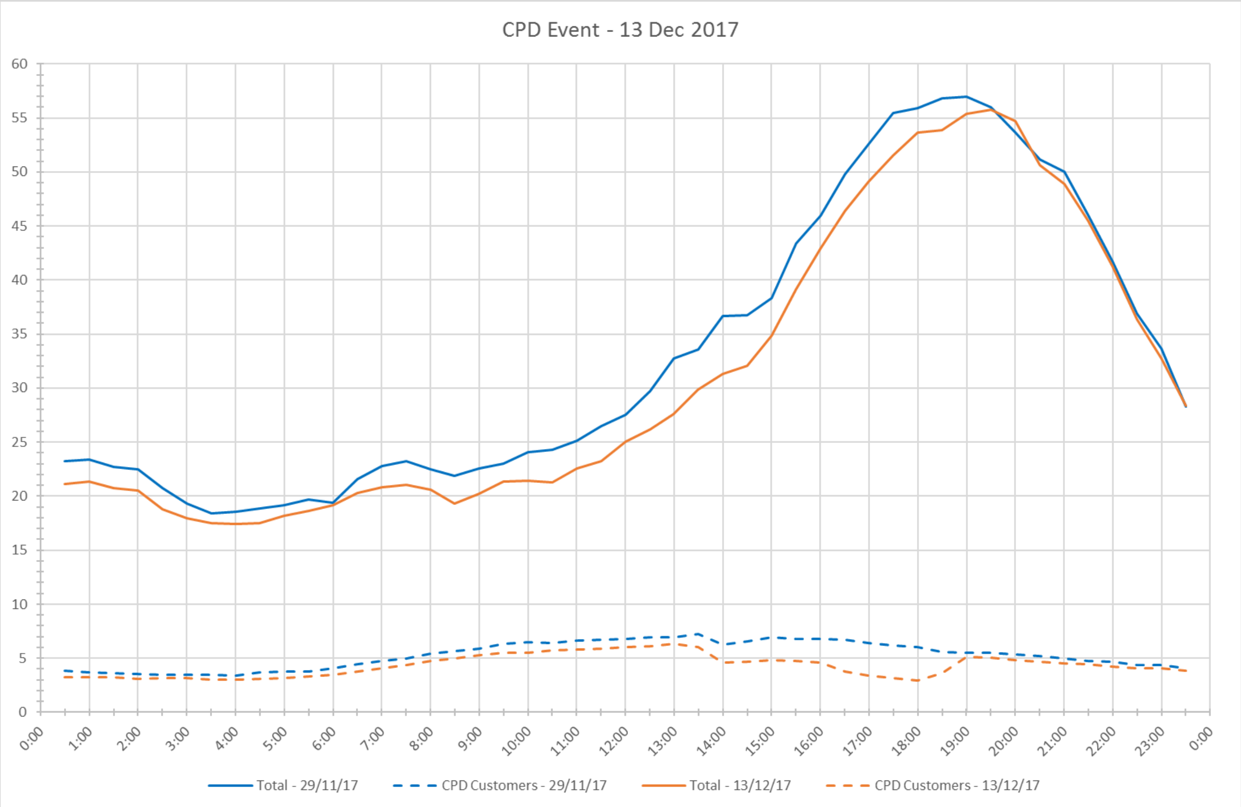


Figure 6: Large customer contribution to zone substation load

4.3.3 Network Support Contracts

AusNet Services currently contracts 1863 kW of demand management network support services in the CLN zone substation supply area. These network support services are provided by four large customers, and are all located on feeder CLN22. The contracts were established to help manage supply risks associated with feeder circuit loading levels on CLN22, but also help by reducing the zone substation loading at peak demand times.

Demand management network support services are renegotiated on an annual basis to ensure their continued need and actual level of support is appropriate.

5 Identified Need

CLN zone substation consists of two 66/22 kV 20/33 MVA transformers, supplying two 22 kV buses and seven 22 kV feeders, and supported by two 6 MVAR of capacitor banks connected to the No.1 22 kV bus.

CLN zone substation has a continuous nameplate rating of 66 MVA and a cyclic capacity of 87.3 MVA and a firm cyclic capacity of 43.5 MVA based on its 'N' and 'N-1' cyclic ratings respectively.

The substation supplies approximately 30,000 residential, commercial, industrial and agricultural customers. Electricity demand supplied from CLN is forecast to grow an average of 4.4% per annum over the forward planning period to 2028. This growth in demand is predominately due to new housing and commercial developments in the southeast growth corridor.

AusNet Services' asset condition monitoring suggests the zone substation assets are generally in "Good" or "Very Good" condition, and therefore have a low probability of failing and reducing the substation's supply capacity. Despite the low probability of failure, the loading on the zone substation already well exceeds the substation's firm supply capacity, and is forecast to exceed its system normal supply capacity within the 2022-26 period.

In addition to the zone substation constraints, supply capacity is also limited at the feeder circuit level, where electricity demand growth is forecast to exceed the capacity of multiple feeder circuits, in the CLN and surrounding zone substation supply areas, within the 2022-26 period.

To provide the optimal balance of cost and reliability to our customers, action is required to manage the expected level of involuntary load shedding that would otherwise be required to maintain loading to within asset capabilities during both system normal and network asset outage conditions.

6 Risk and Options Analysis

6.1 Risk-Cost Model Overview

AusNet Services' risk-cost model quantifies the benefits of potential investment options by comparing the service level risk of the Do Nothing (Counterfactual) option with the reduced service level risk assuming the credible option is place.

The investment cost to implement the credible option is then subtracted from the monetised benefit to compare credible options and identify the option that maximises the net economic benefit (the proposed preferred option).

The areas of service level risk costs, and risk cost reduction benefits, that AusNet Services considers include:

- Supply risk;
- Safety risk;
- Collateral damage risk;
- Reactive replacement;
- Environment risk;
- Operations and maintenance costs; and
- Losses.

Further details on this model can be found in AusNet Services' Risk-Cost Assessment Model Methodology paper.

6.2 Risk Mitigation Options Considered

This section outlines the potential options that have been considered to address the identified service level risk and need to invest, and summarises the key works and costs associated with implementing these options.

It presents both the credible and non-credible options considered, and, where relevant, outlines why particular option are considered non-credible.

The following options were considered to address the identified service level risk and need to invest:

1. Do nothing different (counterfactual);
2. Large customer demand management network support;
3. Residential battery network support;
4. Embedded generation network support;
5. Network reconfiguration;
6. Installation of a third transformer installation at Clyde North Zone Substation; and
7. Installation of a third transformer and third switchboard at Clyde North Zone Substation (preferred option).

An economic cost-benefit assessment is used to assess and rank the economic efficiency of each option.

The following sections provide a brief summary of each of these options.

6.2.1 Option 1 – Do nothing different (counterfactual)

The Do Nothing Different (counterfactual) option assumes that AusNet Services would not undertake any investment, outside of the normal operational and maintenance processes.

Under this option, increasing supply risk would be managed by increased levels of involuntary load reduction.

Increased non-supply risks, such as those associated with safety, collateral damage, reactive replacement and environmental impacts, would be accepted as unmanaged rising risk costs.

The Do Nothing Different (counterfactual) option establishes the base level of risk, and provides a basis for comparing potential options.

Since this option assumes no investment outside of the normal operational and maintenance processes, this is a zero investment cost option.

6.2.2 Option 2 – Large customer demand reduction network support

This option is to contract large customers capable of providing demand management network support services, by reducing their load in response to an AusNet Services instruction.

In assessing the feasibility of engaging demand management services to address the identified service level risk, large customers in the supply area were identified, their historical response to critical peak demand (CPD) days was assessed, and how their load levels align to the zone substation daily and peak demand periods was considered. On that basis, this option assumes 3.0 MW of demand management network support is contracted to help mitigate the identified service level risks.

The network support costs applied in quantifying the costs and benefits associated with this option have been based on current fee rates of existing large custom demand management network support contracts.

The demand reduction available capacity (3.0 MW) is effectively modelled in the risk-cost model as a negative load, and is presented as an option cost by multiplying the available capacity (MW) by an annual capacity cost of [C.I.C]per annum.

This availability cost is added to the energy curtailment (demand management activation) cost, which is monetised by multiplying the reduction in expected unserved energy (MWh) each year by an energy curtailment activation cost of [C.I.C].

Based on the 3 MW capacity and the forecast reduction in expected unserved energy delivered by this option, Table 12 presents the estimated costs of this option.

Table 12: Option 2 Demand Reduction Network Support Costs

	2021	2022	2023	2024	2025
Availability Cost ($M)	C.I.C				
Activation Cost ($M)					
Total cost ($M)					

6.2.3 Option 3 – Residential battery network support

This option is to contract with a non-network aggregator for residential battery discharge, in response to an AusNet Services instruction.

Although the physical support comes from customer installed batteries discharging into the network to offset demand, network support contracts would actually be between AusNet Services and network support aggregators, rather than directly with residential customers.

This option assumes 2.0 MW of residential battery network support contracts, which is optimistic compared to the level of customer installed batteries currently connected to AusNet Services' network.

The assessed level of network support is considered optimistic because AusNet Services is currently aware of approximately 400 customer battery installations, totalling approximately 3.8 MW of installed capacity, across the entire distribution network.

There are currently only sixteen known customer battery installations in the CLN zone substation supply area, totally less than 100 kW of installed capacity. However, recently announced government incentives and any aggregator recruitment processes would likely increase uptake rates.

The battery available capacity (2.0 MW) is effectively modelled in the risk-cost model as a negative load, and is presented as an option cost by multiplying the available capacity (MW) by an annual capacity cost of [C.I.C] per annum.

This availability cost is added to the battery discharge (activation) cost, which is monetised by multiplying the reduction in expected unserved energy (MWh) each year by the battery discharge activation fee of [C.I.C].

Based on the 2.0 MW capacity and the forecast reduction in expected unserved energy delivered by this option, Table 13 presents the estimated costs of this option.

Table 13: Option 3 Battery Discharge Network Support Costs

	2021	2022	2023	2024	2025
Availability Cost ($M)	C.I.C				
Activation Cost ($M)					
Total cost ($M)					

6.2.4 Option 4 – Embedded generation network support

This option is to contract with an embedded generator to provide network support services in response to an AusNet Services request.

The assessed network support capacity is 10 MW which, based on the average forecast growth in maximum demand over the period, could potentially to delay an alternative investment by three to four years.

The embedded generator available capacity (10 MW) is effectively modelled in the risk-cost model as a negative load, and is presented as an option cost by multiplying the available capacity (MW) by an annual capacity fee of [C.I.C].

This availability cost is added to the dispatch (activation) cost, which is monetised by multiplying the reduction in expected unserved energy (MWh) each year by the generator dispatch activation cost of [C.I.C].

Based on the 10 MW capacity and the forecast reduction in expected unserved energy delivered by this option, Table 14 presents the estimated costs of this option.

Table 14: Option 4 Embedded Generation Network Support Costs

	2021	2022	2023	2024	2025
Availability Cost ($M)	C.I.C				
Activation Cost ($M)					
Total cost ($M)					

6.2.5 Option 5 – Network reconfiguration

This option investigates the ability of the network to support load transfers from CLN Zone Substation to adjacent zone substations, in order to reduce the load on the CLN Zone Substation 66/22kV transformers.

Clyde North (CLN) Zone Substation is surrounded by Cranbourne (CRE) and Hampton Park (HPK) Zone Substations in the west, Berwick North (BWN) Zone Substation in the north and Officer (OFR) Zone Substation in east.

CLN Zone Substation has a number of feeder interconnections with its neighbouring zone substations, as outlined in Table 15.

Table 15: CLN feeder interconnections to adjacent zone substations

From Feeder	To Feeder	Connection Point location – Figure 1
CLN11	CRE23, CRE33 or HPK11	West
CLN12	CRE33 or CRE32	West
CLN13	CRE33	South West
CLN14	OFR21 or BWN12	North East
CLN21	HPK14 or HPK22	North West
CLN22	CRE33	South West
CLN23	None	

The forecast loading on the CLN feeders and neighbouring zone substation feeders are presented in Table 16.

Table 16: Feeder summer 50% POE maximum demand forecasts

Feeder	Rating (A)	Forecast (A)						
		2020	2021	2022	2023	2024	2025	2026
CLN11	360	176	178	182	185	187	188	190
CRE23	360	240	244	247	247	248	248	250
CRE33	335	263	275	286	298	311	323	333
HPK11	293	293	293	293	293	293	293	293
CLN12	335	283	286	290	294	300	308	314
CRE32	360	282	282	283	287	289	289	289
CRE33	335	263	275	286	298	311	323	333
CLN13	347	340	362	381	405	430	454	478
CRE33	335	263	275	286	298	311	323	333
CLN14	325	281	292	301	309	318	327	337
OFR21	375	358	369	380	392	405	417	430
BWN12	273	297	300	300	300	302	305	305
CLN21	358	308	316	324	332	339	346	354
HPK14	330	264	265	268	272	274	276	278

Feeder	Rating (A)	Forecast (A)						
		2020	2021	2022	2023	2024	2025	2026
HPK22	311	282	286	290	295	301	307	312
CLN22	375	221	244	269	297	325	354	383
CLN23	323	312	341	370	405	443	479	514

As per the feeder circuit maximum demand forecasts presented in Table 16, many of the feeders connecting CLN Zone Substation to its neighbouring zone substation are heavily loaded and, as detailed in the following sections, incapable of being reconfigured to permanently transfer load off CLN Zone Substation. This network reconfiguration option is therefore considered to be a non-credible option to address the identified supply risk and need to invest.

However, for the purposes of this assessment, conceptual benefits were quantified assuming a 2.5 MW load transfer option could be achieved at a zero investment cost.

Network reconfiguration constraints

This section outlines the constraints limiting the ability to complete network reconfiguration load transfer works away from CLN Zone Substation to adjacent zone substations, and demonstrates why this option is considered to be non-credible.

Despite its inclusion in the quantification of risk mitigation options section.

BWN12

With the planned connection of two new large loads in 2019, including 1.5 MW to a Metro Trains substation and 1.3 MW to Berwick Hospital, the demand on BWN12, as presented in Table 16, is forecast to exceed the existing feeder rating.

As a result of the forecast overload, BWN12 will be upgraded to carry the new load, but even after its upgrade will have insufficient capacity to off-load CLN zone substation via permanent feeder reconfigurations and load transfers.

CRE23

The spare capacity available in CRE23 is 120 A in summer 2020 and reduces to 110 A by summer 2026. However, due to the existing feeder geography and configuration majority of the CLN11 feeder has to be transferred to CRE23 and it is more than 120 A thus over-loading CRE23 feeder.

Thus it is not possible to off-load CLN11 to CRE23.

The three neighbouring feeders to CRE23 (CRE31, CRE32 and CRE33) are running close to their ratings and the spare capacity available in CRE23 will be required for contingencies in CRE feeders. This spare capacity will also be used in contingencies in heavily loaded CLN feeders.

CRE31 and CRE32

CRE31 has very high forecast load growth over the forward planning period and is planned to be reconfigured with CRE32. This reconfiguration will utilise the available spare capacity on CRE32, 78 A in 2020, to address the emerging loading issues on CRE31. This proposed feeder reconfiguration will further reduce the load transfer capacity from CLN12 to CRE32.

Further, due to the existing configuration of the CLN12 feeder, transferring CLN12 to CRE32 would require complete transfer of CLN12 to CRE32.

This level of transfer would result in overload of CRE32, and is therefore not feasible.

CRE33

CRE33 has an average forecast growth of 10 A per year. The spare capacity available in CRE33 is 72 A in 2020 and is forecast to reduce to 2 A by 2026.

Lang Lang (LLG) zone substation is a single transformer and single 66 kV line substation. During outage events it is supplied from CRE zone substation, via CRE33, and other neighbouring zone substations. The spare capacity in CRE33 is therefore required to support LLG zone substation can cannot be utilised to permanently off-load CLN zone substation via feeder reconfigurations and load transfers.

HPK11

HPK11 feeder is forecasted to operate at the rating during next seven-year period. The feeder will be risk managed during the seven-year period, and therefore cannot be utilised to permanently off-load CLN zone substation via feeder reconfigurations and load transfers.

HPK14

The spare capacity available in HKP14 is 66 A in summer 2020 and is forecast to reduce to 52 A by summer 2026. Due to the existing HPK14 and CLN21 feeder configurations, the minimum load that could be transferred from CLN21 to HPK14 is greater than 120 A. Transferring this amount of load is not feasible because it would overload HPK14.

It is therefore not feasible to off-load CLN21 to HPK14.

Additionally, the two neighbouring feeders to HPK14, HPK11 and HPK22, are operating close to their ratings and the spare capacity available in HPK14 is required to provide back-up supply to under contingencies conditions.

HPK22

HPK22 feeder is forecast to operate close to its rating during the next seven-year period. It therefore has no spare capacity off-load CLN zone substation via feeder reconfigurations and load transfers.

OFR21

OFR21 is situated in the south east growth corridor and, as presented in Table 16, is forecast to be loaded above its rating by 2022. This feeder therefore has insufficient capacity available to permanently off-load CLN zone substation via feeder reconfigurations and load transfers.

6.2.6 Option 6 – Installation of a third transformer and third switchboard at Clyde North Zone Substation (proposed preferred option)

This option is to install a third 66/22 kV 20/33 MVA transformer and a third 22 kV switchboard at Clyde North (CLN) Zone Substation. Installation of a third transformer would increase the zone substation nameplate rating from 66 MVA to 99 MVA, the ‘N’ cyclic rating from 87.3 MVA to 130.1 MVA and the ‘N-1’ cyclic rating from 43.5 MVA to 87.3 MVA. This increased capacity would be sufficient to reliably supply the forecast maximum demand at the zone substation level.

With installation of a third 22 kV switchboard, this option would provide new 22 kV feeder exits from CLN zone substation and will thereby enable installation of the new CLN feeders planned within the 2022-26 EDPR period.

This option has an estimated capital of [C.I.C] (Real, $2018).

6.2.7 Option 7 – Installation of a third transformer at Clyde North Zone Substation

This option is to install a third 66/22 kV 20/33 MVA transformer at Clyde North (CLN) Zone Substation. Installation of a third transformer would increase the zone substation nameplate rating from 66 MVA to 99 MVA, the ‘N’ cyclic rating from 87.3 MVA to 130.1 MVA and the ‘N-1’ cyclic rating from 43.5 MVA to 87.3 MVA.

While this option would be sufficient to reliably supply the forecast maximum demand at the zone substation level, it does not allow piggy-backed feeders to be separated out and connected to individual feeder exit circuit breakers, and therefore doesn’t fully address the identified need. Since this option doesn’t fully address the identified need, it is considered to be a non-feasible option and has not been assessed further.

6.3 Risk-Cost Model Results

6.3.1 Existing Service Level Risk

Figure 7 shows the existing service level risk. The risk costs are dominated by supply risk driven by the increasing demand forecast for the substation.

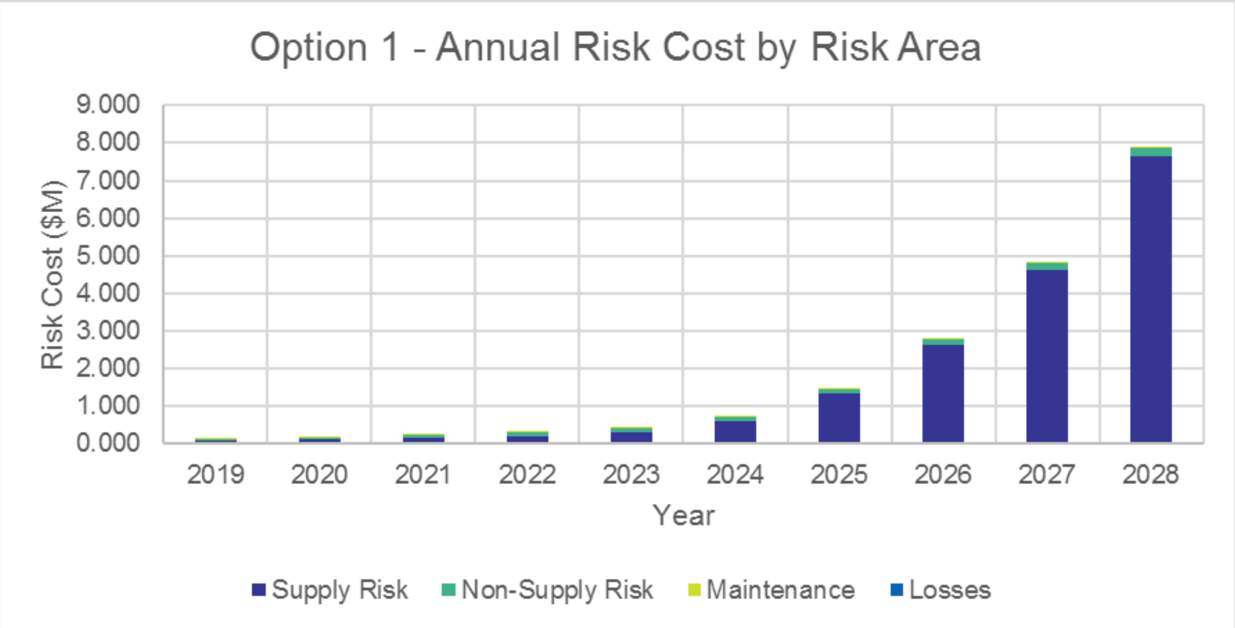


Figure 7: Do Nothing Different – Service Level Risk Cost

6.3.2 Economic Cost Benefit Analysis

The economic analysis allows comparison of the economic cost and benefits of each option to rank the options and to determine the economic timing of the preferred option.

It quantifies the capital, operation and maintenance costs along with service level risk reduction benefits for each option.

Table 17 lists the annualised net economic benefit of each option for each year, with the option that maximised the benefit in each year highlighted.

Table 17: Annualised net economic benefit ($M)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Option 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Option 2	C.I.C									
Option 3										
Option 4										
Option 5										
Option 6										

This indicates that Option 5 is the most economic option prior to 2025, with Option 6 becoming the most economic option from summer 2024/25.

6.3.3 Sensitivity Analysis

Table 18 presents the net present value (Real $2018) of net economic benefits under a variety of sensitivities. The net economic benefit assessment takes account of each option's total capital, operating and maintenance costs, compared to the reduction in service level risk cost that option is expected to deliver.

The robustness of the economic assessment is tested for the following sensitivities:

- Asset failure rates, varied at ±50% of the base failure rates;
- Maximum demand forecasts, varied to ±5% of the base forecast;
- Value of customer reliability (VCR) of [C.I.C], varied to ±25% of the base VCR;
- Proposed option costs, varied to ±15% of the base option costs;
- Value of statistical life (VoSL) of [C.I.C], varied from a [C.I.C] low case, to a [C.I.C] high case.
- Discount rate of 6.44%, varied to ±2% per annum of the base discount rate;

The preferred option under each sensitivity is highlighted, and the option that maximises net benefits under the majority of sensitivities is considered the proposed preferred option.

Table 18: NPV of Net Economic Benefit Analysis

Scenario	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Base Case	$0.00	C.I.C				
High Asset Failure Rate	$0.00					
Low Asset Failure Rate	$0.00					
High Demand	$0.00					
Low Demand	$0.00					
High VCR	$0.00					
Low VCR	$0.00					
High Option Cost	$0.00					
Low Option Cost	$0.00					
High VoSL	$0.00					
Low VoSL	$0.00					
High Discount Rate	$0.00					
Low Discount Rate	$0.00					

The sensitivity analysis indicates the preferred option is Option 6, as it has the highest net benefit under all sensitivities tested.

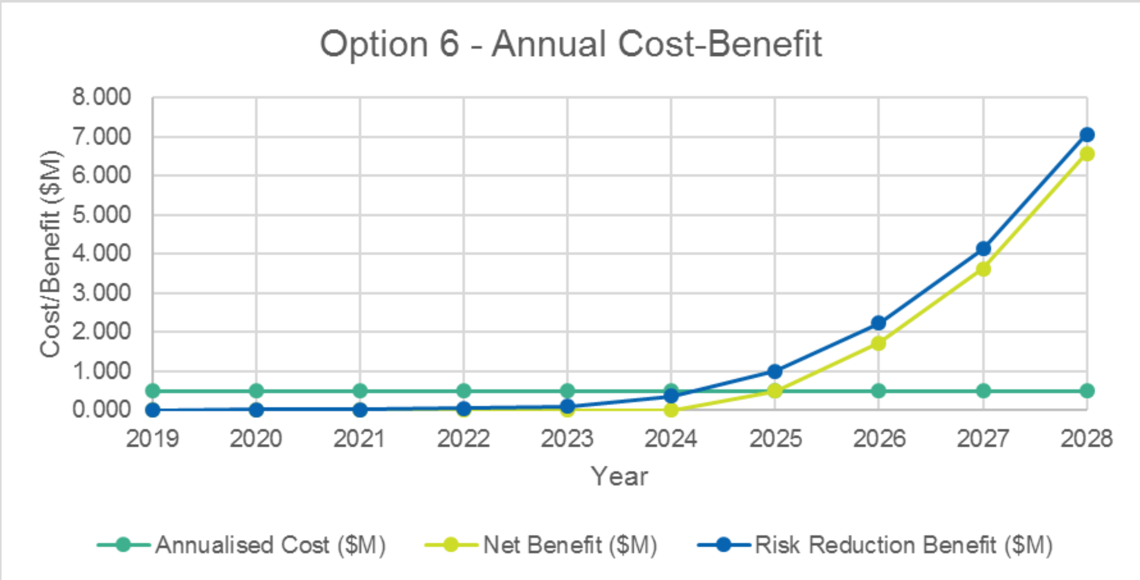
6.3.4 Optimal Economic Timing of Proposed Preferred Option

The annual benefit of implementing a credible alternative option to the Do Nothing Different (counterfactual) is the difference between total service level risk cost with a credible option in place, and the total service level risk cost of the Do Nothing Different option.

The optimal economic timing of the proposed option is the point in time when the annual benefit of implementing the proposed option outweighs the annualised cost to implement that option.

The optimal economic timing to implement the proposed preferred option is by summer 2024/25, as presented in Figure 8.

Figure 8: Economic timing of the proposed preferred option



7 Conclusion and Next Steps

The assessment outlined in this report shows that the service level risk to customers supplied from Clyde North (CLN) zone substation is forecast to grow to unacceptable levels within the 2022-26 EDPR period.

The forecast increase in service level risk is predominately driven by significant electrical power demand growth in Victoria's southeast growth corridor, and insufficient capacity to supply that forecast demand under system normal and network outage conditions.

While electrical power supply to the Clyde North area is already supported by existing network support contracts, the assessment shows that additional demand management network support could provide positive net benefits prior to installation of the third 66/22 kV 20/33 MVA transformer at CLN zone substation, but that this additional demand management network support would not defer the proposed preferred solution.

7.1 Proposed Preferred Option

The options analysis identifies that the preferred option, being the one that maximises the net economic benefit to all those that produce, consume and transport electricity in the NEM, is to install a third 20/33 MVA transformer and third 22 kV switchboard at Clyde North (CLN) zone substation by November 2024, at an estimated capital cost of [C.I.C] (Real $2018).

Applying a discount rate of 6.44% per annum, this proposed preferred option has a net economic benefit of [C.I.C] (Real $2018), relative to the Do Nothing Different option, over the forty-five-year assessment period.

7.2 Next Steps

This planning report outlines the service level risk mitigation investment that AusNet Services has assessed as prudent, efficient and providing the optimal balance of supply reliability and cost.

While this report outlines AusNet Services' plans for maintaining service levels, and serves to support AusNet Services' revenue request for the 2022-26 EDPR period, the proposed investment is subject to the regulatory investment test for distribution (RIT-D).

As such, the proposed investment will be confirmed via the formal RIT-D process, which includes publication of three reports at the various RIT-D stages, and includes a formal consultation process where interested parties can make submissions that help identify the optimal solution.

AusNet Services intends to commence the RIT-D process in September 2019, with preparation of Stage One of the RIT-D, the non-network options report.

APPENDIX A PREFERRED OPTION DETAILS

A.1 Scope of Work

Figure 9 shows the proposed post-augmentation single line diagram of the proposed preferred option. As shown in red, the key option works include establishing a new 66/22 kV transformer, a 66 kV circuit breaker to facilitate connection of the new transformer, and a new 22 kV switchboard to facilitate connection of the new transformer and separation of the temporarily piggy-backed feeders that are currently in the construction phase.

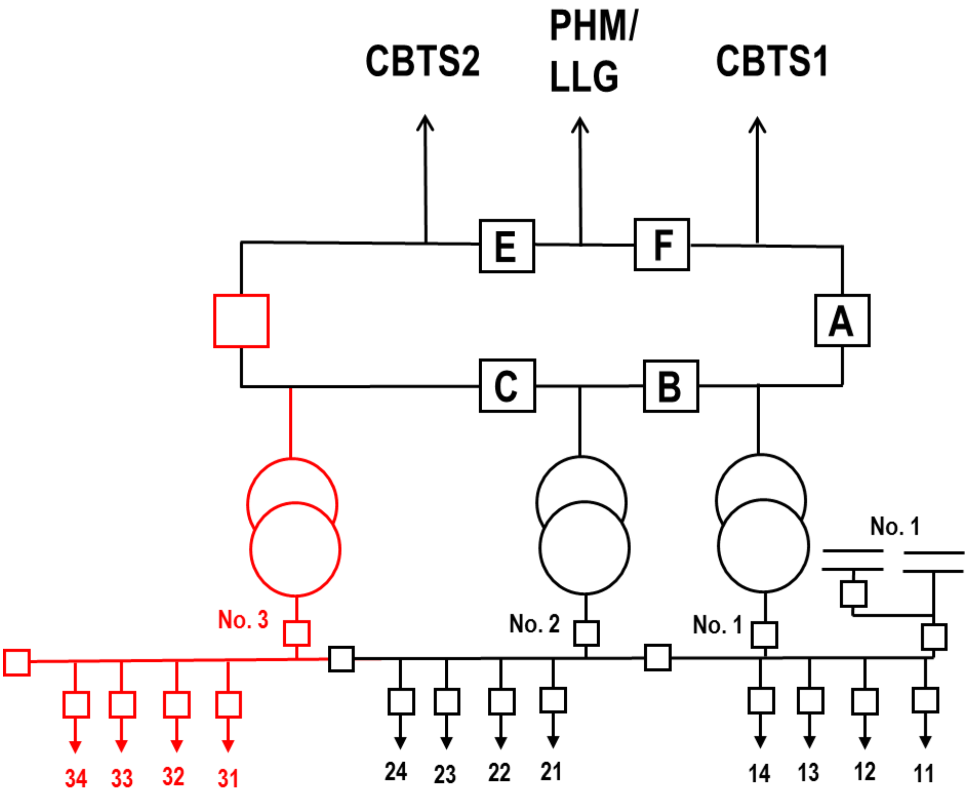


Figure 9: Post Augmentation Single Line Diagram of CLN

A.2 Project Cost Summary

Table 19: Proposed Preferred Option Cost Estimate

Design	
AusNet internal costs	
Sub-contractor indirect	
66 kV equipment	
22 kV equipment	
Transformers	
Line works	
Infrastructure - civil works	
Infrastructure - building works	
Infrastructure - services	
Protection & control systems	
Land / easement purchase	C.I.C
Metering cost	
Outages	
Spares	
Nominal risk allowance	
Project direct costs	
Management contingency	
Project direct costs plus contingency	
Overheads	
Finance charges	
Operating expenditure	
Wdv (written down value) of assets to be retired	
Total	