Project Justification Report

Belconnen Transformer Augmentation

7522037

Table of Contents

Project Summary and Checklist

Project Deliverable	
Belconnen Substation Augmentation	
Select Project Type	Network Asset - New or Replacement
Asset Management Project (AMP)	Yes
Target or Schedule Defined with Reporting Tolerances	No
Project Benefit	Other
Increased network capacity to meet demand.	
Cost Estimate Completed & Attached	No
Risk Assessment Completed	No
Safety Risk Identified / Addressed and/or Safety Plan	No

Document Control

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Date	Version	Author	Description of Change
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Related Documents

Document Title	DM5 Reference / Sharepoint Link / Location

Document Authorisation

Approved by (Signature)	Name	Role	Date

Purpose

The purpose of this document is to provide the basis for choosing to upgrade the Belconnen Zone substation as the preferred method/solution to address the capacity constraints on the network, and to demonstrate prudency and efficiency of the investment in the context of ActewAGL's long term augmentation plans, business goals and vision for the ACT network.

Executive Summary

This Project Justification Report investigates and recommends the augmentation of Belconnen to maintain N-I security, by installing a third transformer at Belconnen zone substation.

Belconnen zone substation is the primary source of power supply for the Belconnen Town Centre and residential area as well as surrounding residential and commercial areas. It supplies power to a number of Australian Government department head offices, the Calvary Hospital, and Westfield Belconnen shopping centre.

For a mixed commercial / residential load such as that supplied by Belconnen zone substation, supply industry practice suggests that system security at the zone substation level needs to provide for a long term transformer overload criteria and rating that allows sufficient time for the replacement of a transformer. Typically this period would be four to six months.

Even with the recent upgrade of transformer cable tails at the Belconnen zone substation the substation continues to operate close to or above the typical cyclic rating of 115% for a mixed commercial / domestic load shape.

The ActewAGL planning criteria requires the system to be designed to a two hour emergency rating which, as the term suggests is a very short term rating, and which requires that the load be reduced to the 6 month cyclic rating within two hours. After the initial two hour period, the load should be maintained at a level below the 6 month cyclic rating to avoid excessive loss of transformer life. The 2012 demand forecast for Belconnen indicated loading in excess of the two hour emergency rating at Belconnen zone substation by 2016. This forecast has however since been revised to include only known and probable customer initiated projects for the first 12-18 months of the forecast period, and to reflect the impact of an uncharacteristically mild summer in 2012, which resulted in a 21% drop in overall system maximum demand.

The current demand forecast shows a supressed projection created by the unusual mild summer conditions in 2012 resulting in low demands over the forecast period. There is a fairly high degree of probability that actual 2014 and 2015 demands will show a rise in the short to medium term.

Based on historical trends, likely medium term (2-5 year) developments in the Belconnen supply area, and a normalisation of weather conditions it is probable that Belconnen substation will approach or exceed its two hour emergency rating within the next three to five years.

The load forecast is reviewed annually and it is recommended that the load growth on the Belconnen zone substation be closely monitored, and capital budget allowance be made in the upcoming regulatory period.

Investigation of the augmentation requirements at Belconnen zone substation included a consideration of a number of alternative supply options:

- **Option1 -** The 'do nothing' option considered continued supply of power from the Belconnen zone substation with no augmentation or demand reduction considerations. This option was discarded on the basis of not meeting the objectives of the project to maintain security, reliability, and quality of supply.

- **Option 2 –** Construction of a new single transformer 132/11kV substation in the vicinity of Mitchell to offload Belconnen zone substation, and to cater for future load growth in the suburbs to the north and east of Canberra city.
- **Option 3 -** Non-network and demand side management options were considered with an expected reduction of demand in the order of 4.5MVA. This potential load reduction option is yet to be confirmed, however it will be fully investigated prior to any recommendation for project approval. Existing embedded generation in the Belconnen area is assumed to be accounted for in the demand forecast and there is no known or probable future large scale embedded generation in the Belconnen distribution area. Solar and PV installations have achieved considerable penetration in Canberra, and the impact on demand reduction in the Belconnen area will be evident in historical results, and reflected through the demand forecast.
- **Option 4 -** Augmentation of the Belconnen zone substation to include a third 55 MVA transformer was investigated and identified as a preferred long term power supply solution under a most probable load growth scenario.

The capital cost of the preferred option (Option 4) project is estimated at $12.7M (2013/14 direct costs, excluding on-costs).

Load transfers between zone substations are being, and will continue to be, exploited to defer the pending overload at Belconnen zone for as long as possible prior to implementation of the preferred option. Plans are already in place to transfer around 3.0MVA of load off Belconnen in early 2014 (to Civic and Latham). Further transfers will be investigated for technical feasibility and economic soundness.

It is the recommendation of this project justification report that the augmentation of the Belconnen Zone substation, by the installation of a third transformer and associated works, be included in the capital forecast as a “contingent project” subject to the magnitude of actual demand growth over the next few years.

Definition of Project Need

Business Objectives

The ActewAGL business objectives are to manage the distribution network in a prudent and cost efficient manner while meeting the requirements of the Electricity Distribution (Supply Standards) Code. To this extent the reference documents in Table 1 provides the basis and requirements of the network planning drivers and guidelines.

The reference documents from external organisations can be accessed from the ActewAGL websites.

Table 1: Rules, Standards and Guidelines for Distribution Network Planning

Doc No.	Description	Source
1	Utilities ACT 2000 (ACT)	ACT
2	ACT Electricity Distribution Supply Standards Code	ACT
3	Service Target Performance Incentive Scheme (STPIS)	AER
4	Distribution Network Planning and Expansion Framework	ActewAGL
5	Distribution Network Augmentation Criteria	ActewAGL

Doc No.	Description	Source
6	National Electricity Rules	AER
7	Network Performance Targets	ActewAGL
8	Demand Side Management Planning Process	ActewAGL
9	ACTPLA Criteria	ACTPLA
10	TAMS Criteria	TAMS
11	Design Manual	ActewAGL
12	NPV Methodology	ActewAGL
13	RIT–(D) Process	AER
14	Federal Government Guidelines	SEWPEC

Project Objectives

The objectives of the Belconnen zone substation augmentation project are to:

- Identify and select a prudent and cost efficient network or non-network augmentation solution that:
  - *Meets the required network planning criteria and performance standards*
  - *Complies with all relevant legislation, regulations and administrative requirements*
  - *is able to be implemented within the time required*
- Achieve appropriate capacity for the expected demand in the Belconnen distribution area over the extent of the forecast period
- Achieve and maintain the security of supply at the Belconnen zone substation for the extent of the forecast period
- Ensure the reliability of supply to the existing and future Belconnen customers

Network Description

Belconnen Substation

The Belconnen zone substation is the primary source of power supply for the Belconnen Town centre and the surrounding residential areas. It was built in 1976 and has been servicing the Belconnen District for 36 years. The substation was designed as a two 132 kV/11 kV power transformer substation with two 11 kV switchboards.

The continuous firm rating of this substation is 55 MVA in both summer and winter.

The two hour emergency capacity of the substation, which was recently increased in 2013 by the upgrading of the 11kV transformer cables, is 74 MVA and 76 MVA in summer and winter respectively. This rating represents the allowable peak load that the substation can supply for a period of two hours, while tolerating an acceptable rate of loss of life of the electrical equipment (mainly the transformers). The two hour period allows for manual load transfers to be undertaken reducing the load on the affected substation to within its longer term 6 month cyclical thermal limits.

Belconnen zone substation is a summer peaking station and the two hour timeframe may not always be achievable, especially during the summer months. A number of factors affect the ability to transfer load off Belconnen including the limited number of feeder ties available (four 11kV ties with Latham, two with Civic, and two with Gold Creek), the existing loading on tie feeders, and the variation in daily and annual load curves.

The cyclic rating considers a longer term overload condition typically associated with the replacement of long lead items such as power transformers or 11kV zone switchgear. The cyclic overload rating is lower than the emergency rating, and in the case of Belconnen zone substation would typically be around 63 MVA.

Load Demographics

Belconnen is one of the original districts of the Australian National Capital and is subdivided into 25 suburbs, sections and blocks. As at the 2011 census, the district had a population of 92,444 people and was the most populous district within the Australian Capital Territory (ACT). It is situated approximately 7 kilometres to the north-west of the central business district of Canberra.

Within the Belconnen Town Centre are a number of Australian Government department head offices including the Department of Immigration and Border Protection, the Australian Bureau of Statistics, the Australian Broadcasting Authority, the Australian Communications and Media Authority, and the Australian Taxation Office.

The Calvary Hospital is a privately operated public hospital, located in the Belconnen suburb of Bruce. Also in the suburb of Bruce are a number of sporting and education facilities including the University of Canberra (UC), the Canberra Institute of Technology (or CIT), the Australian Institute of Sport (AIS), and Canberra Stadium.

Belconnen’s retail and commercial development revolves predominantly around the Westfield Belconnen shopping centre located within the Belconnen Town Centre. Additional local commerce activity includes large and smaller department stores, clothes retailers, car dealerships, homeware stores, supermarkets, and specialist grocery outlets.

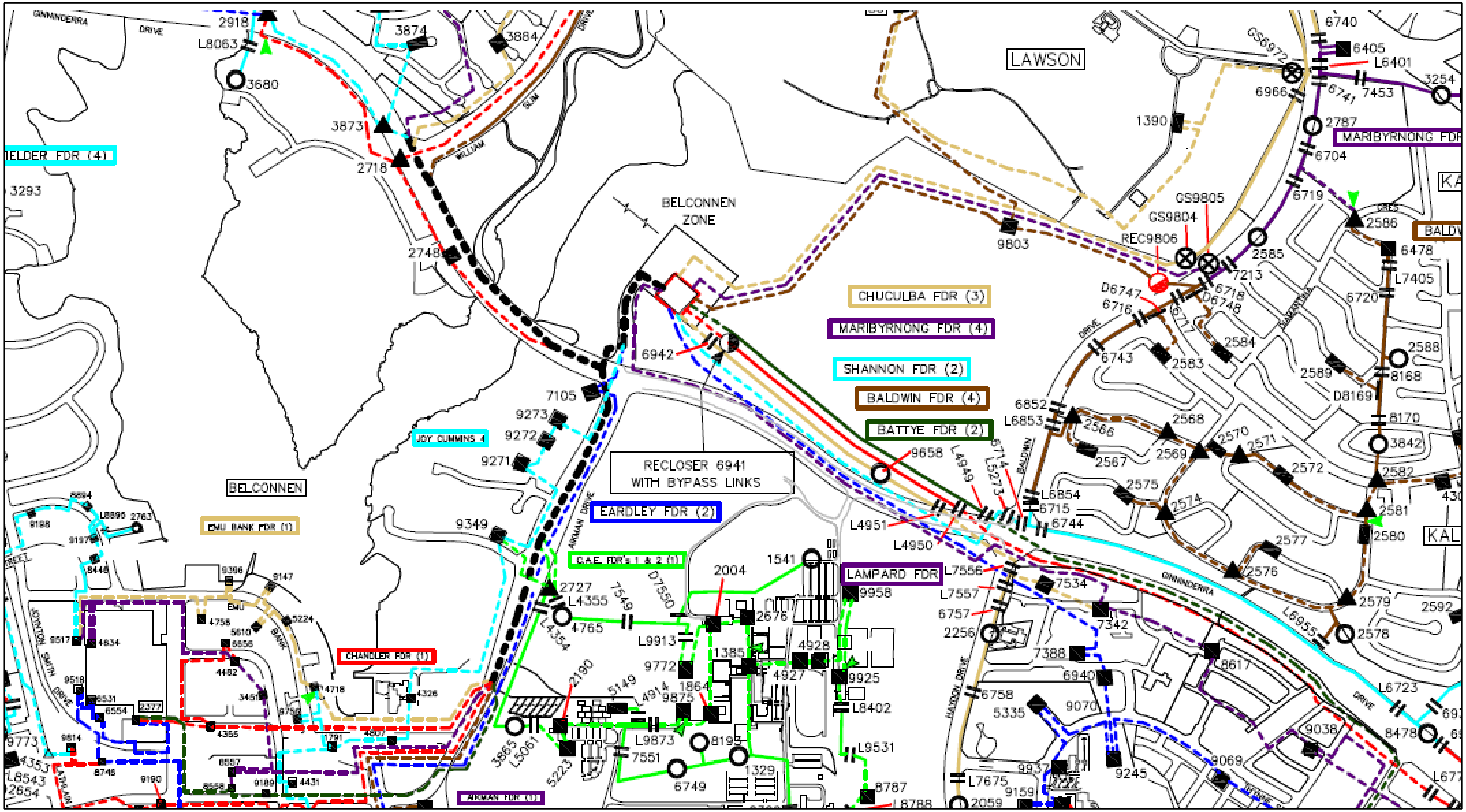
The residential and industrial development in the area is characterised by predominantly detached single family homes on suburban blocks, with pockets of medium density housing units or town houses. The most recent suburb to be gazetted, in 1986, is Lawson where infrastructure works have commenced and residential development is currently in progress.

The industrial sector of Belconnen consists of some light industry and manufacturing, including automotive repair, plumbing, electrical, building, etc. as well as small arts and crafts manufacturing and sales outlets. There is no heavy industry.

There is a significant primary industry producer nearby providing eggs to Canberra and the surrounding region.

Figure 1 shows the Belconnen distribution area and the immediate surrounding suburbs of Belconnen, Lawson, McMellar, and Bruce.

Figure 1: Belconnen Zone Substation Distribution Area

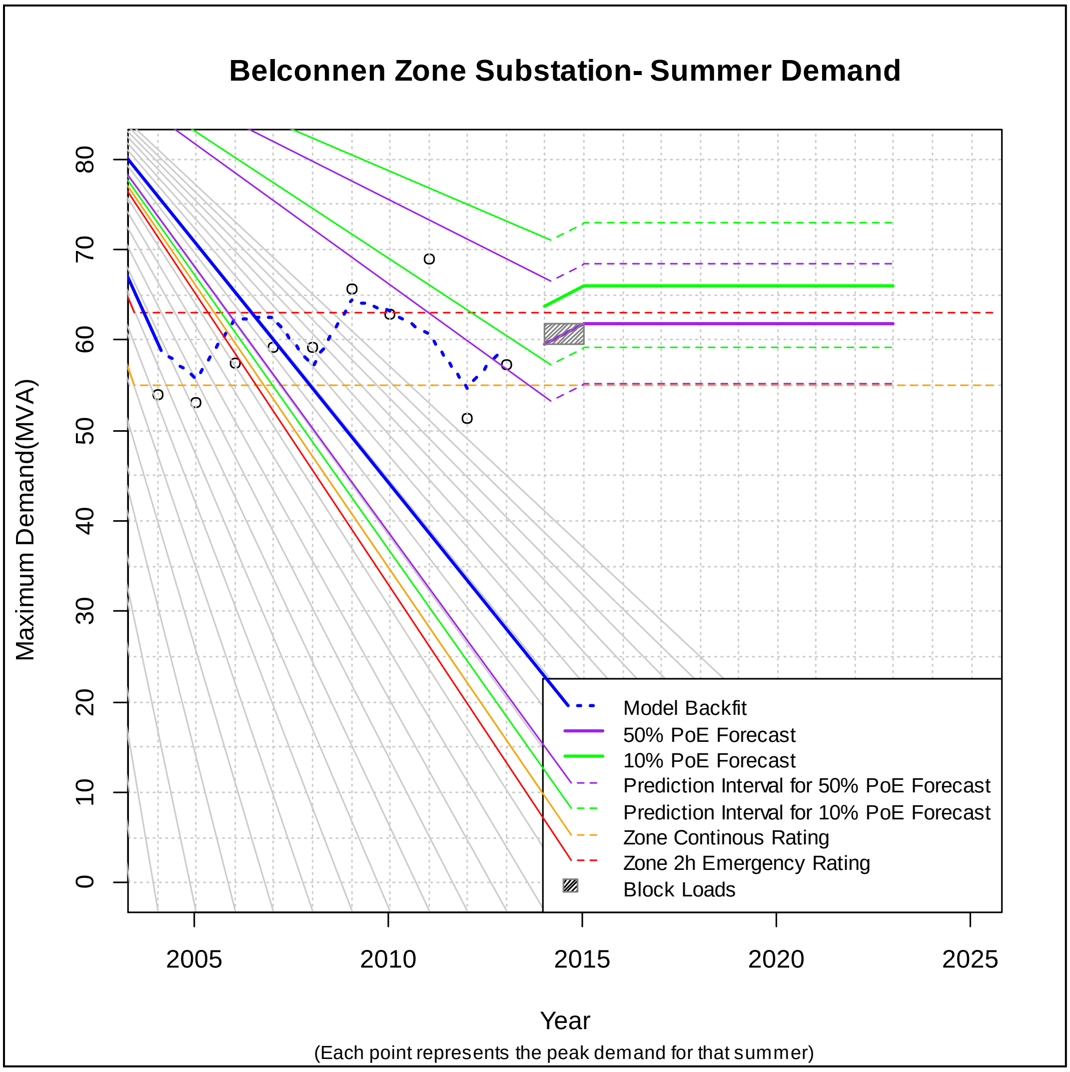


Demand growth

The demand forecast for the ActewAGL network is reviewed annually on a zone substation by zone substation basis. Known and probable customer initiated projects are analysed and where these spot loads are substantially above historical load growth the forecast is adjusted accordingly.

The summer demand forecast for the Belconnen zone substation is provided in Figure 2

Figure 2: Belconnen Zone Substation Demand Forecast



The demand forecast above considers both a 50% and a 10% PoE, and provides a prediction interval range around the base line forecast to account for demand increases which have been excluded from the baseline forecast and a minimum demand increase accounting for lower than expected demand growth.

The forecast above presents a supressed projection of demand for Belconnen, and is impacted by the mild weather conditions in 2012/13 that resulted in the maximum summer demand at Belconnen being 26% lower than the 2011/12 maximum demand, and 18% lower than the average of the preceding 5 years.

The 2013/14 peak summer demand was up from the 2012/13 demand, but still below the 2011/12 maximum demand, resulting in the demand forecast that is essentially flat over the 2015-19 regulatory period.

It is highly probable that as more normal summers and winters are experienced, positive maximum demand growth will recur. Historical trends, known and probable customer projects, and the normalisation of weather patterns are strong indicators that continued demand growth can be expected over the next five year period.

The Belconnen distribution area has been identified from the ActewAGL database of known and probable new customer connections, as the highest demand growth area in the ActewAGL network. The minimum demand increase by 2015 is estimated at 3.56 MVA.

Block loads identified in the 2013 Demand Forecast report, and included in Figure 1 above, account for a probability weighted demand increase of around 2.3 MVA by 2015. These expected block load increases are provided in Table 2 below.

Table 2: Belconnen zone substation block loads

Development type	Supply source feeder	Expected ADMD Increase (MVA)	Supply Required Date	Project probability
Residential & Commercial Development	Eardley Feeder	-0.06	17/06/2013	100%
Residential Development	Meacham Feeder	0.06	17/09/2013	100%
Commercial Development	Eardley Feeder & Joy Commins Feeder	3	1/01/2015	50%
Residential & Commercial Development	Cameron North feeder	2	1/02/2015	40%

Further block load developments over and above normal growth, and which have not been included in the demand forecast, are likely to continue to drive demand growth in the Belconnen area over the next five years.

These include the Lawson commercial and residential developments. Based on the May 2014 ACT forecast dwelling occupation rates, and assuming a 35% uptake rate, demand in these areas is expected to increase up to around 1 MVA during the forecast period, as shown in Table 3 below.

Table 3: Belconnen distribution area major developments

	Unit	2015	2016	2017	2018	2019	2020
Lawson	Dwellings	20	125	132	125	125	225
Cumulative Increase	Dwellings	20	145	277	402	527	752
Demand (kVA)	**35%**	**25**	**178**	**339**	**492**	**646**	**921**

Effects of embedded generation within the Belconnen zone

Large scale embedded generation units connected to the ActewAGL network are required to be scheduled in accordance with AEMO as intermittent generators whereas smaller PV units are not required to be registered as all units have either automatic or small generation exemption.

The majority of future embedded generation within the next 5 years are likely to be large scale Solar PV farms and the anticipated future total capacity is approximately 40MW.

ActewAGL is currently not aware of any new large scale generators planned that would impact on the Belconnen supply area. There is an existing bio-gas generator (3 MVA) located at the Belconnen Waste Transfer Station that connects into the Belconnen substation. The availability of supply from this plant is uncertain and has not been included in the analysis.

Small scale solar PV panels are installed at the domestic level to low voltage (230/400V) distribution network. Information regarding small scale embedded generation connected in the Belconnen supply area is provided in **Error! Reference source not found.**

Table 4: Belconnen Load Transfers

Suburb	Sites Connected	Installed capacity (W)
Belconnen	96	326,315
Belconnen District	7	89,329
Total	**103**	**415,644**

As at 30 September 2013 the total capacity of embedded generation connected in the Belconnen distribution network was 415.6 kW and there were 103 customers with embedded PV systems connected to the distribution network.

The forecast system growth in PV installations for the next 5 years is expected to remain stable at historic trend levels. Based on these system wide historical trends the projected number of installations in the Belconnen distribution area will be approximately 157 installations with an installed capacity of 627 kW.

The power generation from solar PV systems at its peak generation is generally only approximately 75% of its nominal rated capacity. This is due to a variety of losses associated with inefficiencies and mismatches inherent in the system. The peak generation rate also varies significantly based on the time of day and the season and rarely coincide with system peak demand periods.

An analyses of the effect of solar PV generation during peak demand periods in the Belconnen system found that it has a potential to reduce demand on the Belconnen zone substation by around 700 kW and 200 kW in the summer and winter months respectively by 2017.

The analysis was inconclusive on whether PV installations will have a significant effect on current and future peak demands in the Belconnen area.

The effect of PV installations was not directly accounted for in the demand forecast as their impact on peak demands was not expected to be significant.

Impact of planned load transfers on Belconnen substation demand forecast

ActewAGL currently has limited data on load transfers/switching. Nevertheless, effects of load transfers/switching are approximated and accounted for when deemed material, e.g. abnormal historical maximum demands caused by temporary switching are eliminated, and permanent load transfers are factored into the models.

Load transfer between zone substations is the preferred solution to decrease the impact of zone substation constraints and to defer investments associated with other solutions. The transfer of load was investigated for Belconnen zone substation and involved the shifting of load to the adjacent Civic and Latham zone substations. The total impact of the load transfer is, however, reduced by the necessity to transfer load from the Gold Creek zone substation to accommodate load growth in that area also. The results of the potential load transfer opportunities are shown in **Error! Reference source not found.**

Table 5: Belconnen Load Transfers

From	To	MVA	Date
Belconnen	Civic and Latham	-5	Jan 2014
Gold Creek	Belconnen	+3	Jan 2015
Net impact	Belconnen	-2	Jan 2015

After consideration of all the known and likely load transfers onto, and away from the Belconnen zone substation, the following table details the existing summer and winter maximum demands on Belconnen over the period to 2023. Note that this forecast contains the full impact of the downturn in summer loads in 2012 and 2013, and minimal block load increases.

Table 6: Belconnen Demands

Zone Substation	Belconnen				
Season		**S**	**W**		
Rating	Continuous	55	55		
	Emergency	63	76		
Post upgrade	Continuous	55	55		
	Emergency	74	76		
Zone substation load forecast, MVA		**50%PoE**		**10%PoE**	
	2014	55.8	53.1	60.0	53.5
	2015	60.3	57.6	64.5	58.0
	2016	60.3	57.6	64.5	58.0
	2017	60.3	57.6	64.5	58.0
	2018	60.3	57.6	64.5	58.0
	2019	60.3	57.6	64.5	58.0
	2020	60.3	57.6	64.5	58.0
	2021	60.3	57.6	64.5	58.0
	2022	60.3	57.6	64.5	58.0
	2023	60.3	57.6	64.5	58.0

Network Supply Capacity and Constraints

As a prudent and efficient network operator ActewAGL is required to take all reasonable steps to maintain sufficient network capacity while protecting the integrity and reliability of supply to meet customer demands. This requirement is obligated under the Electricity Distribution (Supply Standards) Code, December 2000.

The ActewAGL Distribution Network Augmentation Criteria directs the planning standards and targets for the augmentation and expansion of the distribution network in compliance with the Code and considers all the key components of the distribution network, including zone substations.

In relation to zone substations, the criteria require that an N-1 security of supply be maintained, and that network elements with N-1 security standards have sufficient capacity to carry the expected maximum load under single contingency condition with no loss of load.

To meet the required supply security, the criteria requires that the zone substations not exceed their two-hour emergency rating under10% PoE demand conditions.

General electricity industry practise would be to design zone substation capacity to a continuous cyclic rating, allowing for a longer term (e.g. 6 months) loading which would result in an acceptable loss of transformer life. This may be one day of its design life for each day of service or one month of its design life for each day of service, and is largely dependent on the thermal stresses as a result of daily load curve of the substation.

Daily load curves differ for domestic, commercial/industrial and mixed domestic/commercial/industrial loads. Cyclic ratings are also affected by ambient temperatures, and a summer peaking substation would typically have a lower cyclic rating than a winter peaking substation.

The cyclic rating provides for major contingencies involving long lead items such as power transformers and zone switchgear. Typically the cyclic rating would allow for an overload period of up to six months. Table 1 provides typical cyclic overload ratings for different daily load profiles.

Table 7: Typical Cyclic Overload Factor Ratings

Demand Load Profile	Summer	Winter
Domestic/Residential	1.2	1.35
Mixed Domestic/Commercial	1.15	1.25
Commercial/Industrial	1.1	1.15

The Belconnen distribution area consists of a mix of domestic and commercial loads and a typical overload factor of 115% of nameplate rating would apply to determining the cyclic overload rating of the substation under N-1 conditions, which is assessed to be approximately 63MVA. In 2013 the transformer cable tails at Belconnen were augmented, increasing the two hour emergency rating to 74 MVA in summer and 76 MVA in winter. This recently increased emergency rating has not been shown in Figure 2 above.

The baseline demand forecast, excluding known and probable demand increases beyond 12-18 months and ignoring historical demand growth trends exceeds the cyclic rating of the transformers of 63 MVA by 2015. Including probable loads and historical growth trends the demand forecast approaches the newly established two hour emergency rating of the substation.

Credible Supply Solutions and Alternatives

A number of potential network and non-network alternatives have been considered for relief of the future capacity constraints at Belconnen zone substation, and these are discussed briefly below:

Option 1: Do Nothing

With Belconnen zone substation operating at its cyclic rating and a high probability that actual demand growth will exceed the forecast and reach the new two hour emergency rating the 'do nothing' option would leave the substation at risk during peak demand periods, and of breaching the security criteria for ActewAGL zone substations.

Existing constraints in the ability to transfer loads off Belconnen zone substation mean that the reliability of supply to customers would be compromised under Option 1. This would be further exacerbated as the future loading approached the two hour emergency rating of the substation resulting in the need to be able to transfer even larger amounts of load during N-1 contingency conditions.

In the event that a long lead time component such as a power transformer or zone switchgear is faulted it is likely that the remaining transformer would be required to operate substantially above its rated capacity for an extended period of time, severely impacting on its operational life.

The 'do nothing' option is not considered a technically or operationally feasible alternative.

Option 2: Construction of a new single transformer 132/11kV substation

Under option 2 a new 132/11kV substation would be built, most likely in the general area of Mitchell, and this substation would be used to off-load the Belconnen zone substation. The new substation would be equipped with a single 132/11kV transformer, and would be of a configuration similar to the proposed Molonglo substation.

Depending on the amount of load picked up from Belconnen, and the subsequent load growth in the supply area of the new substation, a second 132/11 kV transformer would be installed when the total load on the substation reached approximately 15MVA.

The new zone substation could be sited in the near vicinity of the Bruce to Gold Creek 132kV transmission line, to minimize 132kV connection costs.

Under option 2, no augmentation would be required at Belconnen zone substation during the study period.

Option 2 is considered to be technically and operationally feasible, but is not the most economic option, and is therefore not preferred.

Option 3: Non-network Demand side management

ActewAGL is investigating potential demand side solutions in order to relieve the demand on the Belconnen Zone substation thereby deferring capacity upgrade works.

Belconnen Westfield is close to multiple expansion sites, with the Belconnen zone substation also supplying initial Molonglo valley suburban expansions.

A number of demand side management solutions are, and will continue to be considered, with peak demand reduction expected to be in the vicinity of 4.5 MVA. Evaluation and assessment of potential options is scheduled to be complete by July 2014, with implementation of the preferred solution taking approximately 2 to 18 months thereafter.

Details of the demand side management options being considered were not available at the time of completing this report.

Option 4: Substation Augmentation: Third Transformer

The opportunity to augment the Belconnen zone substation with the installation of a third transformer was investigated.

The scope of the augmentation includes:

Belconnen Zone Substation Works

- Install & commission 3 x 132kV switchgear bays (line bay, transformer bay & bus section)
- Install & commission 1 x 132kV/ 11kV Power Transformer and NET
- Install & commission 1 x 11kV Switchboard
- New 11kV switch room building.
- Commission all associated protection and control for the above assets.

132kV Line Augmentation Works

- Towers and structures to connect 132kV sub-transmission line to the new line bay.

The capital cost estimate for this option is $12.7M (2013/14 direct costs, excluding on-costs) with an expected initial investment in 2016/17 and commissioning in 2018/19.

Option 4 represents a technically and operationally feasible option, and demonstrates the lowest NPV costs of those options which can be presently estimated.

Economic comparison and Selection of Preferred Solution

A very preliminary comparison of total capital costs, and NPV evaluation has been carried out on the preferred option, and those alternative options for which sufficient information is currently available, and the results are summarised in Table 8 below:

Table 8: Estimated capital costs & NPV analysis of options

Options	Total Capital (10-15 year period)	NPV of Capital Cost	Implementation Feasibility of Option
Do Nothing	-	-	Lead to breaking security of supply criteria Lead to potential overload of equipment for sustained periods Reliability deterioration to customers Not a credible solution

Options	Total Capital (10-15 year period)	NPV of Capital Cost	Implementation Feasibility of Option
New 132/11kV substation similar to Molonglo (inclusive of 11kV feeder costs)	$29.2	$21.6	No upgrade costs at Belconnen zone substation
Non Network Option	TBD	TBD	TBD
Belconnen Upgrade (including 11kV feeder costs)	$16.7	$12.4	Technically and operationally feasible option Lowest cost option

The augmentation of the Belconnen Zone substation provides a long term supply solution for the Belconnen distribution area under a highly probable actual growth scenario.

Installation of the third transformer would achieve the objectives of providing sufficient capacity for the projected demand, maintaining security of supply within the requirements of the Planning Criteria, and maintaining the reliability of supply to the Belconnen customers.

The capital cost of the project is estimated at $12.7M.

Recommendation

It is recommended that the augmentation of the Belconnen Zone substation be included in the capital forecast as a contingent project subject to actual demand growth.