Project Planning Report

T0308402, T0368532, T0342732 & N0348860 – Establishment of a New Zone Substation at QEII Medical Centre

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Record of Revisions

Revision number	Date	DM version	Revised by	Description
Version 2	July 2012	9	Brett Miller	Updated for pre-NFIT preparations

Documents Referenced In This Document

DM#	Title of Document
1704860	General feeder information spreadsheet
3501244	Network Planning manual
6800863	Western Power's Technical Rules
6086008	Demand Management Business Model
7169167	NFIT fact sheet
8088307	Electricity Networks Access Code 2004
8381133	Western Terminal load area long term strategic option review
8391821	Medical Centre Project Planning Definition (for A1 estimate)
8395072	Medical Centre distribution scope of works
8638471	Medical Centre community engagement plan
8695508	Western Terminal – regulatory, community and stakeholder engagement strategy and management plan
8758588	Shenton Park Project Planning Report
8769448	Investment Evaluation Model (IEM) for Medical Centre
8776187	Medical Centre transmission A1 estimate report
8785755	Letter confirming Regulatory Test Waiver validity for Medical Centre
8828035	Medical Centre A1 distribution estimate
8998584	Medical Centre A2 Estimate Risk Register
9137850	Western Terminal decision document
9630557	Medical Centre pre-NFIT submission
9908925	Medical Centre Project Delivery Checklist

DM#	Title of Document
9924874	IEM – Third transformer brought-forward analysis
9941551	Loading Results for NPC Analysis for MC & U substations
9941556	NPC Analysis for MC & U substations
9983486	A0 Estimate for third transformer timing comparison

Other Documents That Reference This Document

DM#	Title of Document

Stakeholders (people to be consulted when document is updated)

Position / Branch / Section

Notification List (people to be notified when document is updated)

Position / Branch / Section

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Executive Summary

Introduction

The existing Medical Centre (MC) zone substation is a reduced firm capacity substation located in the Western Terminal load area, consisting of three 66/6.6 kV transformers and two 6.6 kV switchboards. The MC zone substation is categorised as 'reduced firm' given that whilst there are three transformers installed at the substation (T1, T2 and T3), only two can be loaded at any time due to the limited number of low voltage (LV) switchboards.

The substation currently supplies Sir Charles Gairdner Hospital (SCGH) and all other facilities located at the Queen Elizabeth II Medical Centre (QEII). The existing MC zone substation also supplies Hollywood Hospital and other local customers.

A long term strategic option review[1] was undertaken which identified several problematic conditions in the Western Terminal load area. These include a customer-driven connection requirement, insufficient capacity to support forecast load growth, asset age/condition and network reliability issues.

The customer-driven connection requirement is associated with the major expansion plans that the QEII Medical Centre is undertaking over the next few years. To ensure the QEII Medical Centre's load growth requirements are met, the Department of Health submitted an access application in 2006 for an increase in electrical load from 12.7 MVA to 23.08 MVA by 2015 in addition to an upgrade from 6.6 kV to 11 kV, requiring construction of a new Medical Centre (MCE) zone substation by 30 June 2014.

The QEII driver, in conjunction with the Western Power drivers (i.e. insufficient capacity to support forecast load growth, asset age/condition and network reliability issues) were assessed over a 25 year period with a view to establishing a robust, long-term solution that provides global efficiency across the entire Western Terminal load area, not just the individual substations contained within the area.

From this assessment, four long term development strategies for the Western Terminal load area were prepared, evaluated against a range of financial and technical measures and a recommended strategy identified.[2] The recommended strategy[3] seeks to provide further capacity in the region and delay further investment[4] whilst also meeting the needs of the QEII. One of the elements of this strategy is to upgrade the MC zone substation to 132 kV and transfer to it the load from the existing University (U) zone substation.

Subsequent sensitivity analysis has determined that, without the anticipated increased load forecast for the QEII Medical Centre redevelopment represented in the access application, the new MCE substation would not be required until 2016. Therefore, the customer

[1] Western Terminal load area – long term strategic option review (DM# 8381133)
[2] Development Strategy 3 (refer DM# 8381133)
[3] Refer to Western Terminal Decision Document (DM# 9137850)
[4] Western Terminal load area – long term strategic option review (DM# 8381133), p40

access application has caused the new MCE substation project to be brought forward by two years from 2016 to 2014. Only two 33 MVA transformers are required to meet the QEII Medical Centre's forecast load growth, whereas the long-term strategic review had identified the need for a total of three transformers to meet long-term strategic needs, including forecast load growth, network constraints and regulatory compliance issues.

It is possible to defer the installation of the third transformer until 2016 and still address the remaining network constraints. However, a separate cost analysis has been undertaken as part of this Project Planning Report which demonstrated that installing this transformer in 2014 as part of the site establishment project is more efficient than installing it as part of a separate project in 2016. This is primarily due to additional site mobilisation and project management costs associated with undertaking this work as part of a separate project. These costs have been demonstrated to outweigh the benefit of deferring this transformer until 2016 by approximately $370k.[5]

This Project Planning Report outlines the underlying network problems that need to be addressed at the MC zone substation, assesses the potential alternative solutions and recommends a preferred option. The preferred option is recommended on the basis of its ability to resolve technical issues, cost, satisfy customer requirements and align with the recommended long term strategy for the area.

Given the nature of the supply to the QEII Medical Centre, it is considered an essential service and consequently N-1 (firm capacity) reliability is required from the network.

Transmission elements

Based on the forecast load growth in the Western Terminal load area and the anticipated block load increase at the QEII, there will be insufficient transformer capacity at both the existing MC and U zone substations to supply customers in the area.

The U zone substation has been non-compliant with the transformer capacity requirements of the Technical Rules[6] since summer 2011 and the existing MC zone substation is forecast to be non-compliant with the N-1 reliability requirement by 2016 (including the proposed increase in the QEII load).

Furthermore, much of the primary plant in the Western Terminal load area is over 40 years old and as such will require replacement between 2012 and 2022.

Distribution elements

Analysis of the existing distribution feeder configuration at the MC and U zone substations has shown that two feeders[7] are currently at or exceeding their rated capacity. By 2014/15, five feeders[8] are forecast to exceed their rated capacity.

5 Refer Section 4.3 of this Project Planning Report
6 Technical rules (clause 2.5.4(b))
7 These feeders are MC202 (100%) and MC204 (100%)
8 These feeders are MC202 (110%), MC204 (114%), U212 (101%), U213 (118%) and U216 (102%)

Furthermore, the existing distribution network has insufficient Distribution Transfer Capacity (DTC) and as such is non-compliant with the Technical Rules.[9] This non-compliance is irrespective of the QEII's expansion plans.

Feeders that exceed their rated capacity impose a high risk of cable failure during summer peak periods and, without adequate DTC, this could lead to extended customer outages. This is particularly significant as there are five customers registered for life support on the network and many of the feeders supply medical facilities such as the SCGH and Hollywood hospitals.[10]

Summary of options

Five different options for MC zone substation, each aligned with the approved long term strategy for the Western Terminal load area, were evaluated to resolve the issues outlined above and a summary of these options and their resultant costs and benefits are shown in Table 1 below. For evaluation purposes, options are compared using Scoping Phase (A1) estimates.

9 Technical Rules (clause 2.5.5.3 (b) 2 (A))

10 Although the Sir Charles Gairdner and Hollywood hospitals have standby generation, extended network outages are still unacceptable.

Table 1: Summary of options[11]

#	Option title	Nominal capital cost ($M)[12]	PV Total cost ($M)[13]	Improves reliability	Increases capacity	Mitigates risk	Comments
1	Establish new 132/66/11 kV zone substation with two 66 MVA transformers	43.569	49.48[14]	☑	☑	☑	Although this option has the same NPC as Option 3 it is discounted on the basis of the increased technical risk introduced by the non-standard transformers. Not recommended
2	Establish new 66/11 kV new zone substation with three 33 MVA transformers	44.891	50.00	☑	☑	☑	Highest nominal capital cost and NPC. In addition this option represents suboptimal asset utilisation as the three 66/11 kV transformers will need to be replaced before the substation can be energised to 132 kV. Not recommended
3	Establish new 132-66/11 kV new zone substation with three 33 MVA transformers	43.567	49.47	☑	☑	☑	Least nominal capital cost and equal least cost NPC. Addresses all network constraints and customer requirements without introducing any additional technical risk. **Recommended option**
4	Demand Side Management	N/A	N/A	☒	☒	☒	DM savings are lower than savings from deferring the recommended option by one year. A DM solution would also not be able to address the ageing/poor condition assets. Not feasible.
5	Transfer load to surrounding zone substations	N/A	N/A	☒	☒	☒	The redistribution of load through switching is not achievable due to the existing constrained capacity issues on the surrounding distribution feeder network. Not feasible.

Recommendation

It is recommended that Option 3 be implemented to establish a new 132-66/11 kV MCE zone substation on land provided by the QEII adjacent to the existing MC zone substation site.

11 From Investment Evaluation Model (DM# 8769448)

12 Nominal Capital Cost ($M) reflects the total nominal cost required to complete each option (initial investment).

13 PV Total costs ($M) reflects the present value of the capital and operating costs required to complete the 10 year investment pathway for each option.

14 Of the feasible options in Table 1, Options 1 and 3 have coincidentally resulted in almost identical NPC figures of $49.48M and $49.47M respectively. Although it is rare that two options should produce such a similar net present costs, the figures used in these calculations have been verified to be correct.

This project will provide sufficient additional capacity to the network around the existing MC and U zone substations by undertaking the following:

- by June 2014 – Construct a new 132-66/11 kV zone substation (MCE) with three 33 MVA transformers, initially energised at 66 kV, adjacent to the existing MC on land provided by QEII.
- from June 2014-June 2015 – Transition customers (from MC and U substations) on 6.6 kV to 11 kV supplies provided by MCE.
- in June 2015 – Decommission the existing MC and U[15] zone substations.[16]

The installation of three 33 MVA 132-66/11 kV transformers and the associated distribution works will address the following issues:

- customer-driven load increase and voltage upgrade[17]
- regulatory non-compliance
    - o by providing sufficient N-1 capacity to avoid an unacceptable level of load at risk (Technical Rules 2.5.2.2 (b))
    - o by providing the required feeder backup (Technical Rules 2.5.5.3 (b) (2) (A))
    - o by providing the required feeder capacity (Technical Rules 2.6(a))
- forecast load growth at MC and U zone substations
- asset age/condition at MC and U zone substations
- consistency with the Western Terminal load area long term strategic option review

The option analysis indicates that the total PV costs of Options 1 and 3 are very similar and both options address the network and customer requirements, therefore the selection of the preferred option was made on the basis of the reduced risk represented by Option 3 as follows:

- From a technical risk perspective, Option 1 requires the installation of two 132-66/11/11 kV transformers, representing a non-standard unit (i.e. a reconfigurable 132/66 kV high voltage (HV) winding coupled with dual 11 kV low voltage (LV) windings). This type of transformer is not commonly used in the electrical industry. Western Power has no experience using a transformer of this kind and its introduction would require a new suite of designs to be created, resulting in additional technical risk. Due to the complexity associated with this type of transformer, the construction time is also anticipated to be

[15] Due to complexities associated with the distribution voltage conversion from 6.6kV to 11kV, the U decommissioning may not occur until 2017.
[16] The preferred long-term Development Strategy also recommends the future upgrade to 132 kV but this upgrade is not part of the recommended option in this business case.
[17] Three transformers would still be required in 2016 even if the QEII upgrade was not proceeding (refer Section 4 for full details).

longer than a more standard unit and therefore has the potential to impact project delivery.

- By comparison, Option 3 involves installing three 132-66/11 kV transformers. Although this option also features a reconfigurable 132/66 kV HV winding, it only utilises a single 11 kV LV winding. From a design perspective this is a simpler solution. Therefore, the technical risk and anticipated delivery time is less in comparison to Option 1.

Option 3 is considered the most appropriate option to meet the requirements associated with reasonable forecasts of growth of covered services.

The implementation of Option 3 will be undertaken using appropriate design standards and competitive procurement of materials and delivery services. This demonstrates that Western Power is efficiently minimising costs and therefore satisfies part (a) of the New Facilities Investment Test (NFIT).

The majority of the expenditure associated with this project is necessary to maintain the safety and reliability of the network, and as such satisfies part (b) of the NFIT test. This is explained in more detail in Section 7.8 below.

The remaining portion of the project is associated specifically with the customer-driven connection requirement and meets Section 6.52(b)(i) of NFIT with the following exceptions:

- Connection assets
- Shared works not offset by incremental revenue

These components are anticipated to be fully-funded by the customer. Full details of this assessment are outlined in Western Power's Pre-NFIT application (DM# 9630557).

Implementing the project will reduce corporate risk from 'High' to 'Medium" as outlined in Section 7.3.

Budget allocations for this project are already included in Access Arrangement 3 (AA3) estimates and the Approved Works Programme (AWP).

1 Introduction

1.1 Report objectives

The objective of this report is to provide a detailed options analysis for reinforcing the supply to the MC zone substation and the surrounding area. This report discusses the project drivers, options and investment scenarios and recommends an efficient solution considering technical, economic, social and environmental issues.

This report will be used for briefing internal and external stakeholders during the project's initiation, scoping and planning phase of the Works Program Governance Model (WPGM).

1.2 Project objectives

The objective of this project is to select the optimal investment option for reinforcing the supply to the MC zone substation and the surrounding area that meets the requirements of the Technical Rules and the Transmission Network Planning Guidelines (TNPG).

The selected option should address the identified project drivers and align with long term strategic objectives in the Western Terminal load area.

The project will also be subject to the requirements of the NFIT as assessed by the Economic Regulatory Authority (ERA).

1.3 Western Power requirements – Technical Rules and NFIT

Network investments of this nature undertaken by Western Power are subject to NFIT which is designed to ensure consumers only pay for the most economically efficient solution.

Further details on NFIT requirements can be found in the *Electricity Networks Access Code 2004*[18] and the NFIT fact sheet.[19])

Any reinforcement of MC and the surrounding area must comply with the requirements set out in DM# 6800863 (Technical Rules).

18 Electricity Networks Access Code (DM# 8088307)
19 The NFIT fact sheet (DM# 7169167)

2 Background

2.1 Western Terminal load area

The Western Terminal load area is presently supplied by six[20] substations in two distinct 66 kV rings, one to the north and one to the south of Western Terminal as shown in Figure 1 below. The 132 kV system in-feeds to Western Terminal are supplied via Cottesloe/Amherst, Cook Street and Northern Terminal. The load area covers most of the South West Inner Metropolitan area, extending from City Beach and Wembley Downs in the North, to Mosman Park in the South, Nedlands and the Swan River in the East with the western boundary being the coastline.

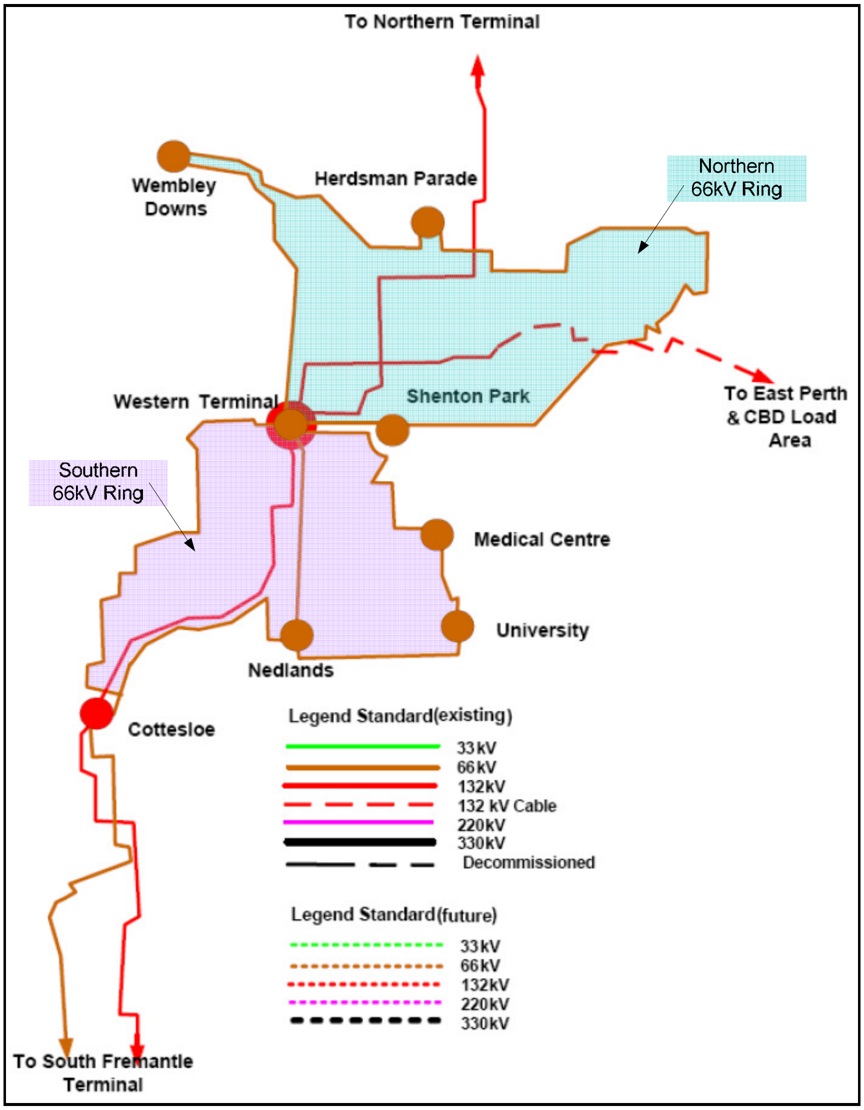


Figure 1: Western Terminal load area overview in 2011

20 Cottesloe substation has recently been converted to 132 kV operation. Some 66 kV equipment still remains (used as a T-point for the WT-N/NF 71 line) but there are no 66 kV transformers supplying load at this substation.

The area is a mature and well established region and contains mostly residential and commercial loads, with some light industrial load. All customers are supplied at 415V with the exceptions of the QEII (supplied by MC zone substation) and the University of Western Australia (UWA) (supplied by U zone substation) which are currently supplied directly at 6.6 kV and Hale School and Floreat Shopping Centre (supplied by Wembley Downs substation) which are currently supplied directly at 11 kV.

2.1.1 Medical Centre zone substation

The existing MC zone substation is a two-line, three-transformer 66/6.6 kV substation with a double-bus LV switchboard, and is located on the corner of Monash Ave and Caladenia Cres in Nedlands as shown in Figure 2 below:

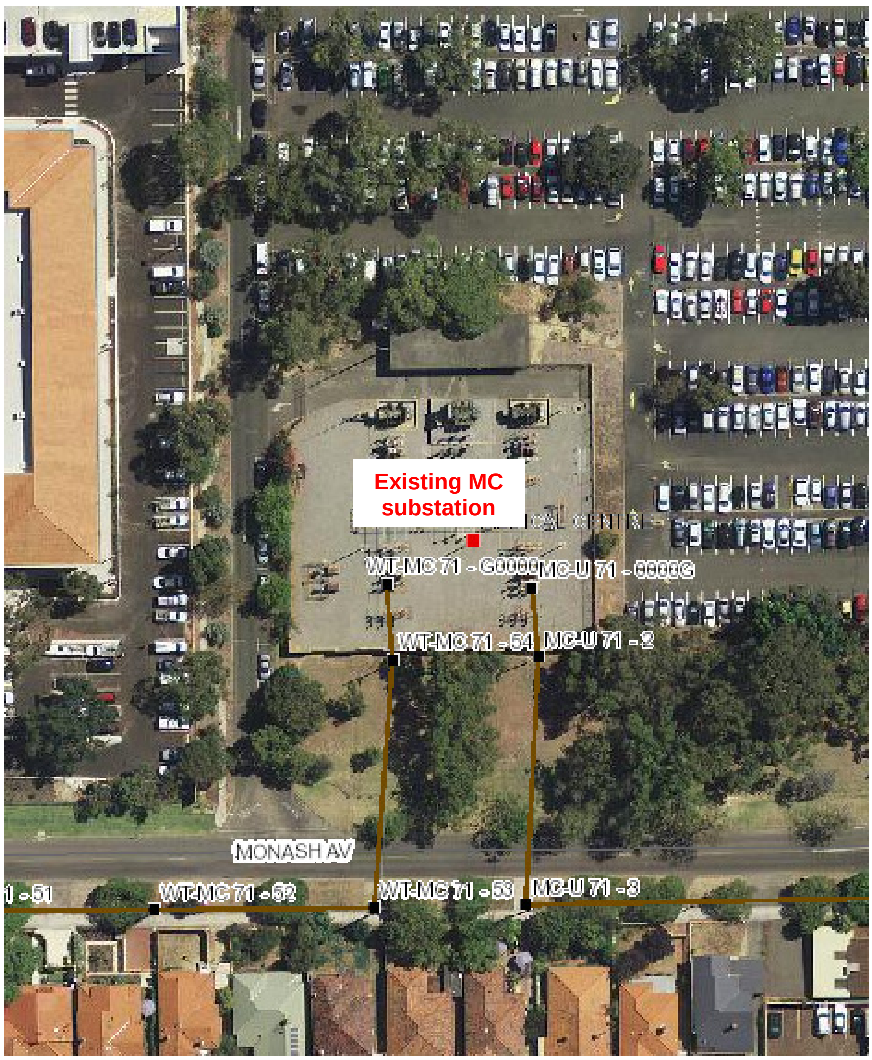


Figure 2: Aerial photograph of the existing MC zone substation

The MC zone substation is a 'reduced firm' substation. While there are three transformers installed at the substation (T1, T2 and T3), only two can be loaded at any time due to the limited number of LV switchboards. Transformer T2 is usually unloaded and acts as a spare in the event of an unplanned outage. An Automatic Transformer Switching Scheme (ATSS) is used to restore supply for such an event.

A major portion of the demand at the existing MC zone substation comes from SCGH, which is part of the QEII. Therefore, the MC zone substation reinforcement plans are closely coupled with the hospital's expansion needs. Under the present configuration, all QEII loads are supplied from the T1 transformer.

2.1.2 University zone substation

The existing U zone substation is a two-line, two-transformer 66/6.6 kV substation with a double-bus LV switchboard, and is located on the corner of Fairway and Myers St in Crawley as shown in Figure 3 below:

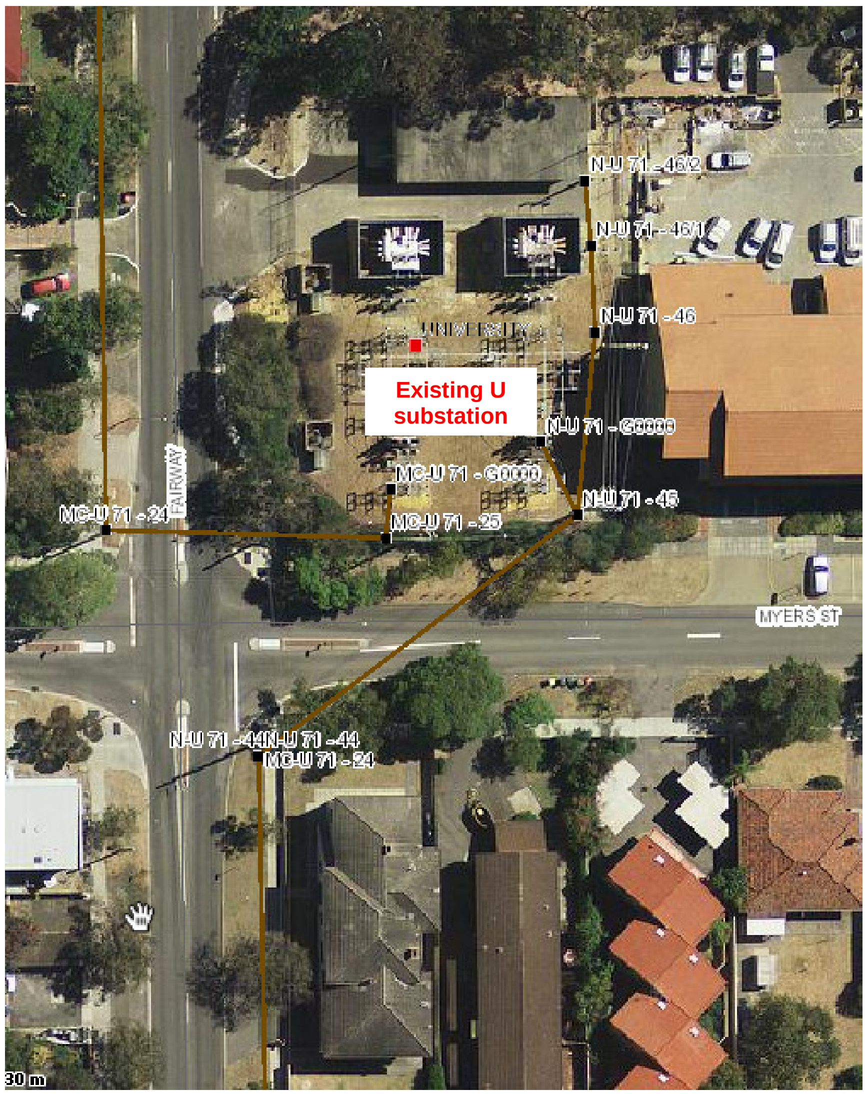


Figure 3: Aerial photograph of the existing U zone substation

The U zone substation was converted to Normal Cyclic Rating (NCR)[21] operation in 2000 and supplies both residential and commercial customers, including the UWA's Crawley Campus (UWA). Present arrangements are such that UWA's load is supplied from a single transformer and the other transformer supplies all other loads.

2.2 Medical Centre and University feeders

The QEII and the surrounding area (Crawley, Subiaco and Nedlands) are currently supplied via 6.6 kV feeders from the existing MC and U feeders.

There are seven dedicated feeders[22] supplying the QEII (MC221-MC227) and eight dedicated feeders[23] supplying the UWA (U203-U210). These feeders are maintained by the customers and Western Power does not have a record of the individual HV feeder loads.

All other customers (4,038) are supplied by Western Power distribution feeders (U212, U213, U215, U216, MC202, MC204 and MC206). Currently these Western Power distribution feeders supply 4,038 customers as shown in Table 2.

Table 2: Customers connected to existing MC and U feeders[24]

Feeder	Number of customers[25]	Number on life support	2010/11 Summer peak(A)	Feeder utilisation
MC202 Hollywood Hospital SW 2	2	Patients in Hospital	93	30%
MC202 Arras RMU	682	1	219	100%
MC204 Monash Ave	591	2	220	100%
MC206 Hollywood Hospital SW 1	2	Patients in Hospital	228	74%
U212 55 Broadway	797	1	300	97%
U213 Park Ave	243	0	148	48%
U215 Broadway Fair	1,039	0	280	90%
U216 20 Bruce St	682	1	305	98%

Network diagrams for the MC and U feeders are shown in Appendix B. It is evident from Table 2 that there are two main issues affecting the distribution networks supplied by the existing MC and U zone substations:

21 Technical Rules clause 2.5.4(b) - The NCR risk criterion permits the loss of a portion of the power transfer capacity at a substation following the unplanned loss of a supply transformer within a substation. The portion of the power transfer capacity that may be lost is the lesser of: (A) 75% of the power transfer capacity of the smallest supply transformer within the substation; and (B) 90% of the power transfer capacity of the rapid response spare supply transformer.

22 These are MC221, MC222, MC223, MC224, MC225, MC226 and MC227.

23 These are U203, U204, U205, U206, U207, U208, U209 and U210.

24 Extracted from DM# 1704860 and ENMAC at 31 March 2011

25 General feeder information DM# 1704860

- feeder loading exceeding 100% of rated capacity (and the 80% utilisation rate prescribed in the Distribution Network Planning Guidelines (DNPG)
- insufficient backup capability as defined by the Technical Rules, clause 2.5.5.3 (b) 2 (A) states that in the metro area:

  "distribution feeders must be designed so that, if an unplanned single feeder outage occurs due to failure of the exit cable, the load on the faulted feeder can be transferred to other feeders with the following provisions:

  (A) No other feeder will pick up more than 50% of the peak load from the faulted distribution feeder";

As shown in Table 2 above, there are currently a total of five registered customers on life support and supplied by the MC202, MC204, MC206, U212 and U216 feeders (in addition to patients in Hollywood Hospital).

The MC202 and MC204 feeders supply Hollywood Hospital. Depending on the type of fault, the current network situation means that supply to Hollywood Hospital could be interrupted for more than 12 hours because of cable faults on high demand days. High demand days occur at least five days each summer.

Section 5.2 outlines the risks and impacts of the overloaded feeders under fault conditions.

3 Long term (25 year) development plan

3.1 Overview

In October 2011, a review of the Western Terminal load area[26] was undertaken to determine strategic network investment options for the area. The purpose of the review was to prepare a strategic plan:

> *"to guide network engineering decisions along a clear, economically sound investment path and underpin future New Facilities Investment Test (NFIT) submissions to the Economic Regulation Authority (ERA) of Western Australia"*[27]

The review assessed options over a 25 year period and gave specific consideration to a range of network investment drivers:

- network reinforcement to accommodate area load growth over 25 years
- asset replacement to address age and condition related deterioration
- rationalisation of existing substation sites
- customer driven connection works

In determining the specific network investment for MC, it is crucial to consider the outcomes of the 25 year development plan to ensure that a globally efficient outcome can be achieved, rather than just short term efficiency at MC alone.

The key aspects of the 25 year plan that form the basis of the network investment decision at MC are described in detail in the following sections.

3.1.1 Load growth

It is forecast (as shown in Figure 4 below) that the load growth within the Western Terminal load area over the next 25 years will be mainly driven by ongoing autonomous growth in demand to supply residential and commercial customers.[28] Developments in the area are expected to be centred on the rationalisation of existing land use, with higher density residential and commercial buildings and very few green-field developments. The re-zoning and re-development of parts of the Western Terminal load area continues to be a key factor in the area's load growth.

26 Western Terminal load area – long term strategic option review (DM# 8381133)
27 Ibid. p1
28 Western Terminal load area long term strategic option review (DM# 8381133) p8

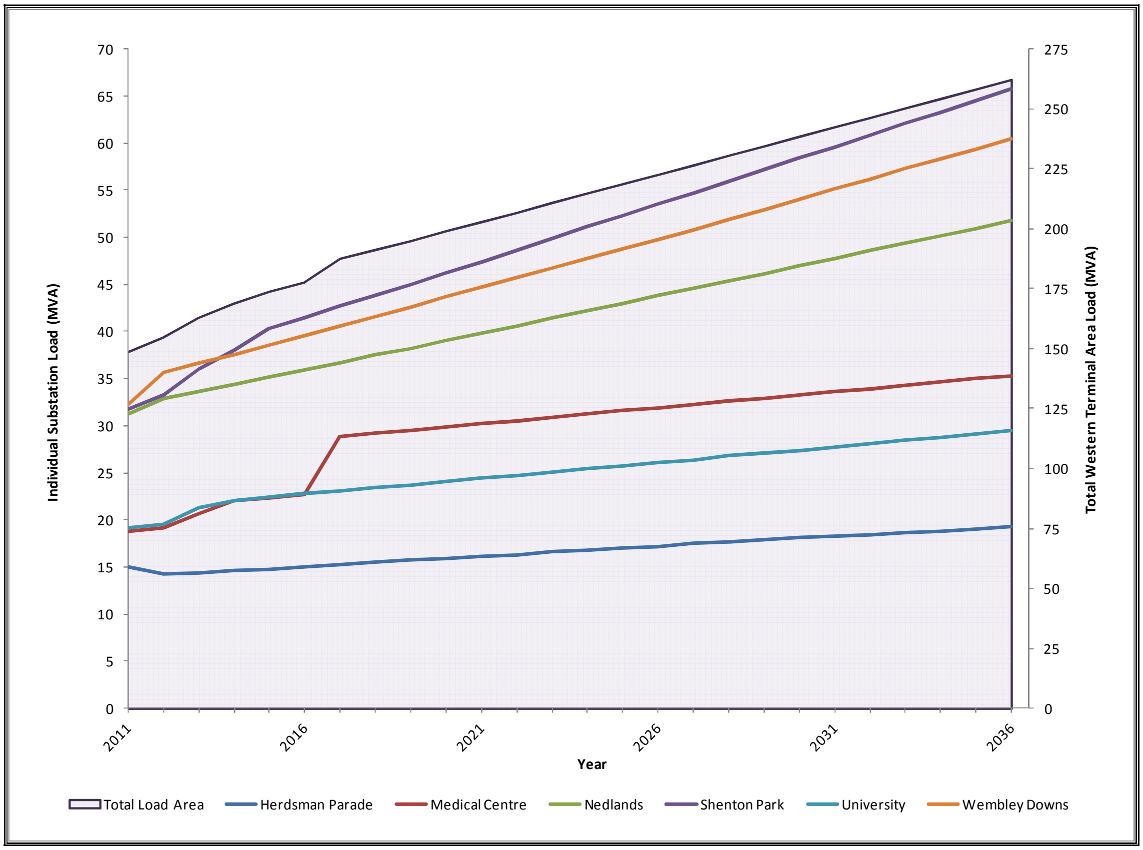


Figure 4: 2011-2036 load forecast (10% PoE) for the Western Terminal load area

This data was based on the Western Power, May 2011 release, load forecast with all non-committed load transfer schemes and other proposed developments omitted. The load forecasts for each site are based on a 10% probability of exceedance (PoE), consistent with the Western Power's TNPG.

Aside from the planned customer connections described in this report, there are no additional customer projects regarding the connection of generation within the Western Terminal load area.

3.2 Emerging network constraints

The long term strategic option review identified several emerging network constraints driving investment in the network in the Western Terminal load area. These include:

- Customer-driven connection works.
- The impact of prospective future load growth on substation and overhead line capacity.
- Asset age, condition and anticipated replacement profiles.
- Network reliability requirements and Technical Rules compliance.

The following sections outline key aspects of these issues that are driving the need for change at the existing MC and U zone substations.

3.2.1 Customer requirements

3.2.1.1 QEII Medical Centre

The QEII is presently connected to the existing MC zone substation and is undergoing a six year redevelopment programme. The development programme includes the construction of a New Children's Hospital, a Western Australian Institute for Medical Research facility, a PathWest facility, an expanded SCGH Cancer Centre and a new Mental Health Unit. The first stage of construction is planned to be completed in 2015.

The major expansion will increase the QEII electrical load from the present level of 12.5 MVA to 27.5 MVA by 2020 (with a load of 23 MVA expected by 2015). The step change in load at MC zone substation is illustrated in Figure 4 above.

The QEII has requested that the existing MC zone substation be upgraded from 6.6 kV to 11 kV by June 2014 to accommodate these expansion plans.

Given the essential service nature of the supply to QEII, N-1 (firm capacity) reliability is required from the network.

3.2.1.2 University of Western Australia

In addition UWA, which is currently connected to the existing U substation, is increasing its load by 4.6 MVA by 2016.

The NCR capacity of the existing U zone substation was exceeded in summer 2011. Therefore, any increased load on the zone substation will mean more load is at risk of being shed in the event of a contingency.

3.2.2 Capacity constraints

3.2.2.1 Substation capacity

The Western Terminal load area long term strategic option review identified a significant lack of transformer capacity throughout the Western Terminal load area in the immediate to short term.[29]

Figure 5 below illustrates the substation capacity in the Western Terminal load area over the next four years and the load expected at each of these substations.

[29] Western Terminal load area long term strategic option review (DM# 8381133) p9

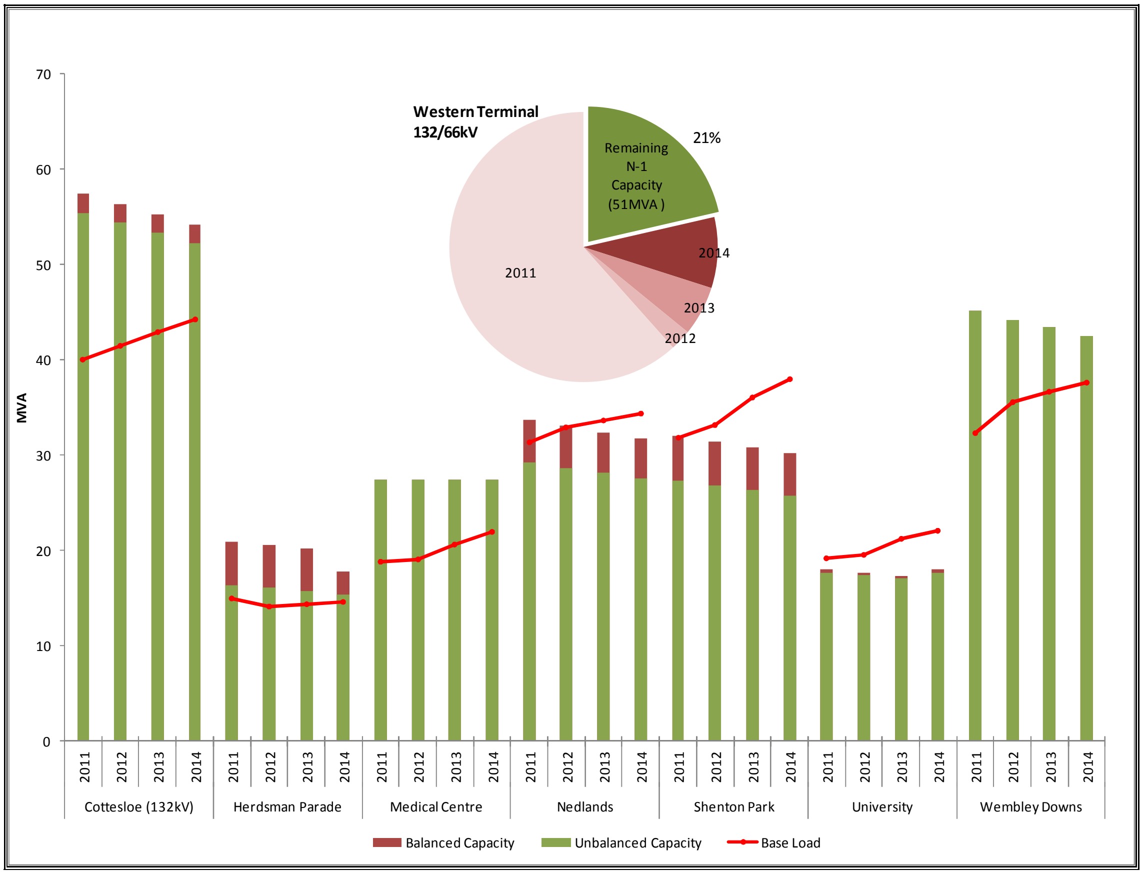


Figure 5: Western Terminal load area substation capacity summary (2011-2014)

Of the six 66 kV substations in the Western Terminal load area, Nedlands, Shenton Park and University were non-compliant with the requirements of the Technical Rules for the 2011/12 summer peak due to insufficient available transformer capacity. Additionally, MC and Wembley Downs substations are forecast to be non-compliant with the Technical Rules by 2016 and 2018 respectively[30].

The Western Terminal 132/66 kV transformers, that are required to operate to an N-1[31] security standard, are forecast to have insufficient capacity to maintain N-1 compliance by 2020.

3.2.2.2 Overhead line capacity

In addition to the substation capacity limitations, there will also be insufficient 66 kV transmission overhead line capacity in the short term, particularly as the North 66 kV transmission ring will be exposed to overloading of the Western Terminal to Wembley Downs overhead line under contingency outage conditions of the Western Terminal to Shenton Park overhead line by 2015. Even if all the existing 66 kV lines were rebuilt to a modern high capacity standard, there will be circuit overloads under contingency outage conditions by 2026.

30 This includes the proposed increase in the QEII load.

31 N-1 reliability requires that all loads can be restored quickly if a single component on the network fails.

3.2.3 Asset age and condition

3.2.3.1 Transformer and switchgear

Asset age is the main contributor to deterioration in electrical asset condition and consequently is often used in decisions on asset replacement. However, for more complex items of electrical equipment (e.g. transformers), specific condition assessments are often used to provide an indication of remaining asset lifetimes.

Western Power routinely collects asset condition information for transmission switchgear (132 kV and 66 kV) as well as transformers. The collated condition parameters are used to calculate an overall condition rating for each transformer on a scale of 1 to 10, with ten representing an unacceptable condition that requires replacement in the short term.

Figure 6 below outlines the distribution of transformer ages and accompanying conditions for 132 kV and 66 kV transformers in the Western Terminal load area.

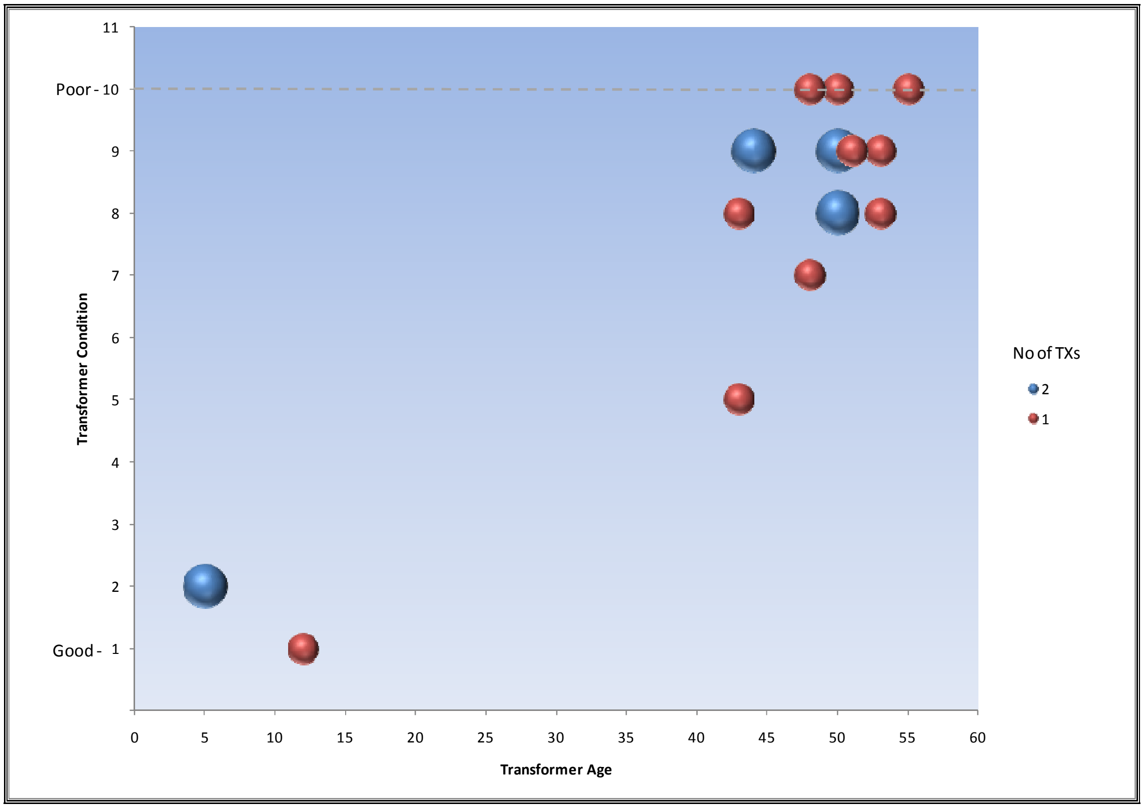


Figure 6: 132 kV and 66 kV transformer asset condition and age profile

Figure 6 reveals that the majority of the existing transformers in the Western Terminal area are more than 40 years old and have condition ratings of 8 or higher. The majority of transformers in the Western Terminal load area will therefore require replacement within 10 to 15 years (based on 50 year lifetimes for transformers with 11 or 6.6 kV secondary windings and 60 year lifetimes for 132/66 kV transformers).

The profile for the 132 kV and 66 kV switchgear in the Western Terminal load area exhibits a similar distribution of asset age and associated conditions. Consequently, the 132 kV and 66 kV switchgear in the area will also require replacement within the next 10 to 15 years.

3.2.3.2 Overhead lines

Table 3 below outlines the age profile of the transmission lines in the Western Terminal area:

Table 3: Western Terminal overhead transmission line age profile

Lines	From – To substation	Year installed	Length (km)	Rating (MVA)
132 kV	WT – C	2009	7.39	210
	WT – CK	2002	6.09	210
	NT – WT	1978	20.63	243
66 kV	CK – HE	1967	8.35	80
	CK – SP	1967	4.09	80
	C – N	1955	4.4	93
	HE – WD	1969	4.8	80
	MC – U	1973	1.64	80
	N – U	1966	3.05	80
	WT – C	1980	7.76	80
	WT – MC	1973	4.12	105
	WT – SP[32]	1976	1.43	105
	WT – WD	1965	5.31	104
	WT – N	1967	3.13	105

From examination of Table 3 above, it is evident that the majority of the existing 66 kV overhead lines in the Western Terminal area will require replacement within a 25 year period, if a 60 year asset lifetime is considered. Many will require replacement much sooner given original installation dates in the 1950's and 1960's.

Given the required wholesale replacement of a significant proportion of assets over the next 20 years or so, there is an opportunity to consider revising the operational configuration and transmission voltage of the Western Terminal sub system.

3.2.4 Network reliability and Technical Rules compliance

The Technical Rules provide standards, procedures and planning criteria governing the construction and operation of the electricity network.

[32] The majority of the Western Terminal – Shenton Park line has been rebuilt as a double circuit (along with the Western Terminal – Medical Centre line) steel pole 132 kV specification overhead line, however short sections of the existing 1970's vintage wood pole line remain in service.

Analysis undertaken as part of the Western Terminal load area long term strategic option review[33] noted that three substations (Nedlands, Shenton Park and U) were non-compliant with Technical Rules in respect of transformer capacity (clause 2.5.4(b)) in the 2011 summer peak. Insufficient transformer capacity puts network reliability at risk.

Wembley Downs substation is also forecast to be non-compliant on the same grounds in 2018.

Additionally, MC substation is forecast to be non-compliant with the N-1 criterion of the Technical Rules (clause 2.5.2.2) by 2016.

The distribution forecast studies (refer Section 5.2) have revealed that 75% of existing MC and U feeders did not comply with Technical Rules clause 2.5.4(b) by the 2014 summer peak. This means there is deterioration in the reliability of the network because of insufficient distribution transfer capacity.

3.2.5 Summary of constraints

Figure 7 below summarises the capacity and condition limitations of each substation within the Western Terminal load area to illustrate the drivers and expected timing for replacement or reinforcement works. Line drop-downs show the first factor to impact on the substations, with the investment drivers being evenly divided between condition and capacity limitations. There are a number of limitations that have been surpassed to date.

Figure 7: Summary of substation capacity, age and condition constraints

[33] Western Terminal load area long term strategic option review (DM# 8381133)

In the figure above, 'unbalanced capacity' refers to the substation capacity that reflects the impact of operating the substation with the LV bus sections open, resulting in unbalanced loading on the transformers. The term 'balanced capacity' on the other hand, refers to the substation capacity that can be achieved when operating the substation with the LV bus sections closed (i.e. paralleling the transformers), thus evenly distributing the total feeder load across all transformers.

Figure 7 further illustrates the potential for combined developments which may provide economic/technical efficiencies due to the geographical proximity of the substations and the coincident timing of limitations. Examples of this are Shenton Park and Herdsman Parade, with limitations seen in 2011 as well as MC and U in the period 2011-2014.

With the expected level of asset replacement and forecast network capacity limitations identified in the Western Terminal load area over the next 25 years, there is a significant opportunity to investigate potential alternative approaches for the transmission system design in this area, rather than just implement like-for-like asset replacements. This approach has been adopted for the Medical Centre project and all other investments in the Western Terminal load area.

3.2.6 Long term development strategies

Assessment of the investment drivers across the Western Terminal load area over the 25 year period led to the development of four discrete development strategies:

- Development Strategy 1 – Retain 66 kV and upgrade network capacity.
- Development Strategy 2 – Shenton Park upgraded to 132/11 kV, Herdsman Parade load transferred to Shenton Park and Herdsman Parade decommissioned.
- Development Strategy 3 – Shenton Park and Medical Centre upgraded to 132/11 kV, Herdsman Parade load transferred to Shenton Park, University load transferred to Medical Centre, Herdsman Parade and University decommissioned.
- Development Strategy 4 – Full 132 kV Migration of Shenton Park, Medical Centre, Wembley Downs and Nedlands with Herdsman Parade and University decommissioned.

These development strategies were evaluated against a range of financial and technical measures resulting in the identification of Development Strategy 3 as being the most appropriate long term solution for the area. Development Strategy 3 was recommended as it met all the required technical performance standards whilst minimising the present value of costs over the 25 year period.

A summary of the net present costs for each considered strategy and the remaining transformer capacity that each solution provides by the year 2035 is summarised in Table 4 below:

Table 4: Summary of net present cost analysis for each development strategy

Strategy	Description	NPC ($M)	Remaining transformer MVA in 2035	NPC for remaining MVA in 2035
1	Retain 66 kV and upgrade network capacity	117.7	42	2.80
2	Shenton Park upgraded to 132 kV with Herdsman decommissioned.	114.8	92	1.25
3	Shenton Park and MC upgraded to 132 kV with Herdsman and U decommissioned.	**112.1**	107	1.05
4	Full 132 kV migration of Shenton Park, MC, Wembley Downs and Nedlands with Herdsman and U decommissioned.	119.4	117	1.02

In summary, the preferred development strategy, Development Strategy 3, comprises the following elements of work:[34]

- Shenton Park substation is migrated to 132 kV, with Herdsman Parade substation load transferred to Shenton Park.[35]
- The new MCE zone substation is migrated to 132 kV with a design adopted to maximise the available substation capacity, with the existing MC and U zone substation load transferred to the new MCE zone substation. This will proceed as follows:
    - By June 2014 - Construction of a new MCE zone substation (132-66/11 kV) adjacent to the existing MC zone substation on land provided by the QEII (initially energised at 66 kV).
    - From June 2014 to June 2015 – Transition of customers on 6.6 kV to 11 kV supplies to be provided from the new zone substation.
    - In June 2015 – Decommission the existing MC and U[15] zone substations.
    - In November 2018 – Transition the new MCE zone substation from 66 kV to 132 kV supply.

The construction of a new MCE zone substation has been indentified as one of the first projects to be executed under Development Strategy 3. The main reasons for this are:

- A customer-driven project to upgrade the existing MC zone substation to 11 kV by June 2014.

[34] Western Terminal load area long term strategic option review (DM# 8381133) p68
[35] Refer Project Planning Report tor Shenton Park for further details (DM# 8758588)

- Anticipated non-compliance with the N-1 criterion of the Technical Rules (clause 2.5.2.2) for MC zone substation by summer 2016.
- Non-compliance with the NCR criterion of the Technical Rules (clause 2.5.4(b)) for U zone substation since summer 2011.
- Anticipated non-compliance with the Technical Rules (clause 2.5.5.3 (b) 2 (A) for the distribution network.
- Forecast load growth that cannot be supported by the existing network.
- The age and condition of existing assets suggests the majority of assets will need replacement over the ten years from 2012.

This 25 year strategy was endorsed by the General Manager Networks on 02/03/12.[3]

3.2.7 Medical Centre and University investments

Contained within the four development strategies described above are two variations for the specific investments at the existing MC and U zone substations as follows:

1. Retain the existing 66 kV MC and U zone substations and undertake capacity upgrades and asset replacements as necessary (Development Strategies 1 and 2).
2. Construct a new MCE zone substation at 132 kV and transfer the existing MC and U loads to the new substation. Decommission the existing MC and U 66 kV zone substations (Development Strategies 3 and 4).

Although Development Strategy 3 was demonstrated to be the most efficient solution for the Western Terminal load area over a 25 year period, further analysis of the individual investments at MC and U substations was undertaken to determine whether there is also local efficiency in the short term (five year period).

NPC analysis was therefore undertaken[36] which excluded all components of work except those required to be undertaken at MC and U zones substations in the next five years. The results of this analysis are shown in Table 5 below:

Table 5: Net present cost analysis for each variation over 5 year period

Variation	Description	NPC ($M)
1	Retain existing 66 kV MC and U substations. Undertake capacity upgrades and asset replacements as necessary.	25.7
2	New 132 kV MC substation. Existing MC and U load transferred to the new MC. Existing MC and U substations decommissioned.	**23.7**

[36] Refer DM# 9941551 and DM# 9941556 for full details of this analysis

This analysis shows that rationalising the two existing 66 kV MC and U zone substations into one new 132 kV MCE zone substation has the lowest net present cost over a five year period, compared with retaining the existing 66 kV substations.

3.2.8 Summary of outcomes

The following conclusions have been drawn from the analysis undertaken in the long term strategic option review for the Western Terminal load area, and underpin the investment decisions in the MC area:

- There is no acceptable ‘do nothing’ option. Action is required now to ensure that reliability of supply obligations can be maintained in the Western Terminal load area. Western Power must therefore plan new works to allow adequate lead time to ensure continued reliable electricity supply to customers in the area. ‘Doing nothing’ is not consistent with requirements of the Technical Rules with which Western Power must comply.
- Development Strategy 3 is the recommended solution for network reinforcement in the Western Terminal load area as it meets all the required technical performance standards, whilst minimising the present value costs across the 25 year period.
- Development Strategy 3 recommends (amongst other network investments) the construction of a new 132 kV MCE zone substation and the transfer of all the existing MC and U loads to the new substation, following which the existing 66 kV MC and U zone substations are to be decommissioned.
- The recommended network investment at MC and U zone substations has been demonstrated to be the most efficient solution in net present cost terms both in the short term (five year period) for the local area and in the long term (25 year period) for the broader Western Terminal load area.

4 Impact of the QEII Medical Centre upgrade

The analysis undertaken for the network reinforcement in the Western Terminal load area has assessed all the main project drivers, including the customer request to upgrade the QEII. This has led to the decision to adopt Development Strategy 3 as the preferred investment solution for the area, of which the construction of a new 132 kV MCE zone substation in 2014 is a key component.

However, in order to better understand the impact that the QEII upgrade is having on the selected investment strategy, it is also important to investigate what network investments Western Power would be undertaking if the QEII upgrade was not going ahead.

This will help to distinguish between which components of the preferred solution are driven by the customer, and which are driven by Western Power needs (such as load growth and asset age/condition drivers) and will support the NFIT assessment that will be undertaken for this project.

4.1 Investment triggers (including the QEII upgrade)

As outlined in Section 3.2.4, there are a number of constraints occurring at different times for each of the substations in the Western Terminal load area. The timing of these constraints dictates when the subsequent network investments are triggered.

As illustrated in Figure 7 previously, the first main driver (unbalanced capacity) at U substation occurs in 2010.

At MC, apart from the 2008 condition driver, the first driver for network reinforcement is the customer-driven block load increase in 2014 (represented by the orange dot in Figure 7).

The condition drivers shown for MC and U substations (2008 and 2011 respectively) are based on indicative assessments only. The assets identified at these substations can however be carefully managed to allow operation beyond these dates through increased condition monitoring and maintenance programs. Typically, assets with condition ratings of 'bad' can remain in service for a further 5-10 years and assets rated 'poor' a further 10-15 years with appropriate maintenance. These are only typical outcomes however, and dependent on the outcomes of site-specific condition assessments which may initiate an earlier investment.

Given the close proximity of MC and U substations and the established distribution network interconnectivity, a single investment solution that consolidates these two substations is possible.

Consideration of all the identified constraints has resulted in the need to establish a new 132 kV MCE zone substation with three 33MVA transformers[37] in 2014.

This solution involves managing the existing capacity constraint at U so as to align it with the equivalent MC constraint in 2014. This can be achieved using distribution transfer techniques such as repositioning open points to redistribute load to surrounding substations. The risk associated with managing the U capacity constraint in this way is considered small.

4.2 Investment triggers (not including the QEII upgrade)

For comparative purposes, an assessment of the constraints in the Western Terminal area without the QEII customer driver was undertaken to determine exactly how much the investment at MCE is being accelerated as a result of the QEII hospital upgrade.

Without the increase in customer load, then Western Power's objective would be to defer the U substation unbalanced capacity constraint long enough such that it could be aligned with the equivalent MC constraint. Undertaking this deferral would allow one new 132 kV MCE zone substation with three 33MVA transformers to be established on the QEII site that would accommodate the load of the two existing 66 kV MC and U substations, resulting in a more efficient outcome for the area.

4.2.1 Distribution transfers

To facilitate the U capacity constraint deferral in this scenario, a number of distribution transfers would need to be undertaken. The details of these transfers as well as an estimated cost for completing these components of work are described below:

<u>Transfer 3 MW from Wembley Downs to Herdsman:</u>

- 1500m of 400mm² XLPE cable is required for a new feeder
- 1 x 4+0 Ring Main Unit (RMU)

Total cost = $0.85M

<u>Transfer 3 MW from Nedlands to Cottesloe:</u>

- Switching using existing interconnection is possible for this request.

Negligible cost for this transfer

<u>Transfer 4 MW from U to MC:</u>

- 1500m of 400mm² XLPE cable is required a new feeder
- 1 x 4+0 RMU

Total cost = $0.85M

[37] The third transformer is only required by 2016, however it has been demonstrated to be more efficient to instead install it in 2014 as part of the site establishment project (refer Section 4.3 for details).

4.2.2 Summary of constraints

The above distribution transfers, in addition to the removal of the customer block load requirement, have the effect of shifting the original network constraints at Wembley Downs, University and Herdsman Parade substations as illustrated in Figure 8 below:

Note: The latest load forecast (May 2012) has been used for this analysis, which is different to what was used in the long term strategic option review (May 2011). However considering the latest figures, Development Strategy 3 would still be selected as the preferred strategy and each of the individual investments would still be triggered in the same year. As such, using the latest forecast for this comparison is still valid.

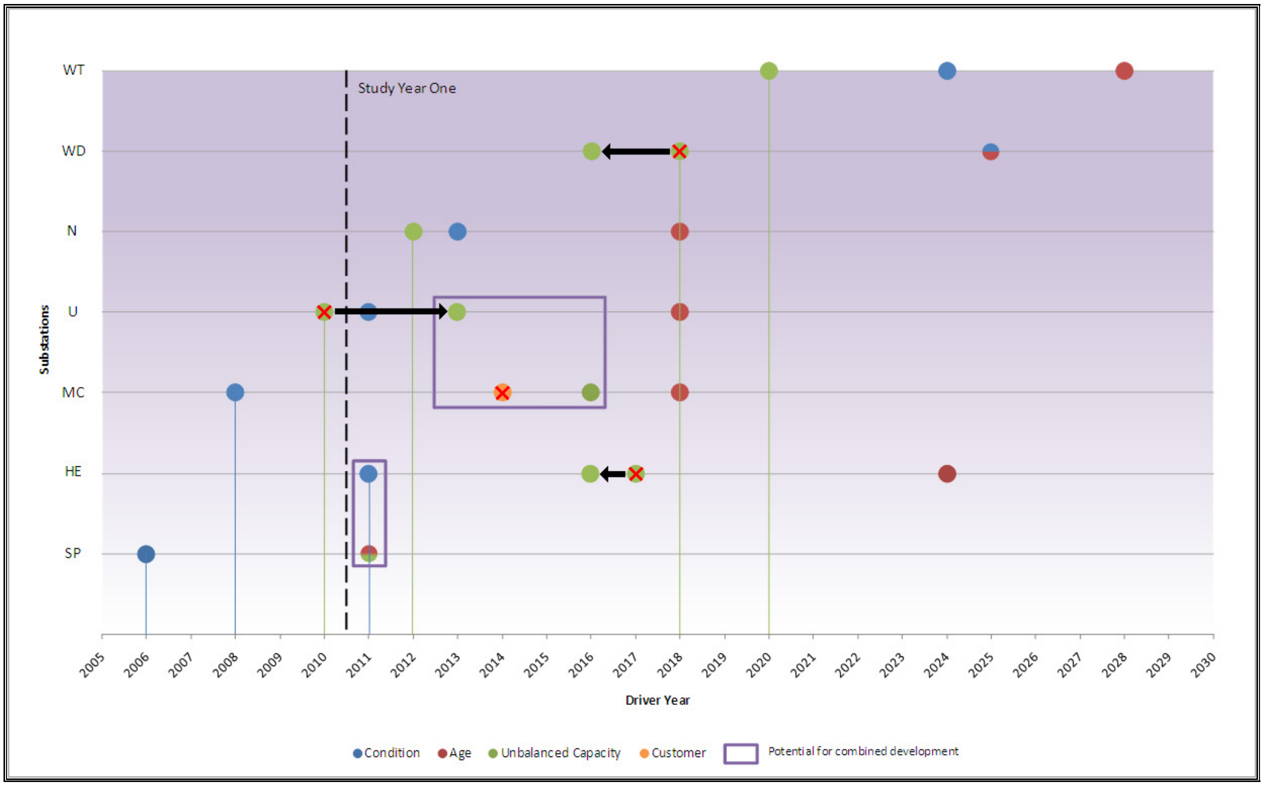


Figure 8: Summary of constraints (without QEII upgrade)

It is evident from Figure 8 that in the absence of the QEII customer-driven timing requirement, the first main driver at MC (unbalanced capacity) occurs in 2016, rather than 2014.

At U, the unbalanced capacity constraint has been deferred as a result of the proposed distribution transfers to the year 2013. As with Development Strategy 3, a small level of risk would need to be taken at U to facilitate the deferral of the capacity constraint remedy by approximately three to four years (thereby aligning it with the primary unbalanced capacity driver at MC in 2016). Again, by carefully managing this with the aforementioned distribution transfer techniques, this can be achieved.

Although the Herdsman Parade and Wembley Downs unbalanced capacity drivers have been brought forward (one and two years respectively), it is anticipated that the establishment of the new Shenton Park 132/11 kV substation in 2015 (being undertaken as part of a separate project) will create sufficient network capacity to accommodate the load at these substations.

This analysis shows that without the QEII hospital upgrade project, a new 132 kV MCE zone substation with three 33 MVA transformers on the QEII site would only be required by the year 2016 (rather than 2014). In this scenario, it is the capacity constraint that triggers the need for the investment, rather than the customer driven requirements.

4.2.3 Investment options

In order to determine the cost difference of establishing a new MCE in 2016 compared with 2014, two feasible options were investigated. The first option is to establish a new 132/11 kV MCE zone substation in 2016 (with no interim 66 kV stage), and the second option is to establish a new 132-66/11 kV MCE zone substation, initially energised at 66 kV, with an upgrade to 132 kV in 2018.

For both of these options, a Net Present Cost (NPC) assessment was undertaken for the entire Western Terminal load area over the 25 year period, using A0 building block estimate costs (± 50%). The results were then compared with Development Strategy 3 (which includes the QEII upgrade).

This analysis was done using the same building block estimate costs as used in the long term strategic option review for the Western Terminal load area.

The scope of each of the two identified options is outlined below.

Note: The distribution transfers proposed in these options would still need to be undertaken as part of Development Strategy 3, but would occur in later years. As such, the costs for these transfers have been represented as portions of the original scope that have been brought forward, rather than new elements of work altogether.

4.2.3.1 Option A – Establish MCE in 2016 at 132 kV

The key elements of this option are as follows:

- No QEII Medical Centre upgrade project.
- Establish 132/11 kV substation in 2016, energised at 132 kV (no interim 66 kV stage).
- Undertake the following distribution transfers in 2013:
  - Transfer 3 MW from Wembley Downs to Herdsman
  - Transfer 3 MW from Nedlands to Cottesloe
  - Transfer 4 MW from U to MC.

A breakdown of the costs that differ from Development Strategy 3 is shown in Table 6 below. All other elements of the scope for this option are the same as Development Strategy 3 and therefore have not been included in the table below.

Note: The colours shown in the table are used to indicate the following:

- Green text - components of work that have been deferred and therefore result in a cost saving in net present terms.
- Red text - components of work that have been brought forward and therefore result in a cost increase in net present terms.
- Black text - components of work that have not moved with respect to Development Strategy 3 and therefore do not result in a change in cost.

Table 6: Option A – Costs that differ from Development Strategy 3

Substation/ Circuit	Description	Cost ($M)	Year	Change
MC	132/11 kV TXs installed	6.63	2016	Deferred 2 yrs
MC	132 kV line circuits, single bus	2.74	2016	Deferred 2 yrs
MC	132 kV transformer circuits, single bus	2.57	2016	Deferred 2 yrs
MC	132 kV bus coupler	1.11	2016	Deferred 2 yrs
MC	11 kV switchboards with tilt panel sw/room Type 1	6.16	2016	Deferred 2 yrs
MC	Site Works - standard zone substation Metro	1.91	2016	Deferred 2 yrs
MC	Zone sub relay room (brick wall)	1.46	2016	Deferred 2 yrs
MC	Other substation costs - estimate	1.00	2016	Deferred 2 yrs
Herdsman	11 kV distribution work brought forward to 2013	0.85	2013	$0.85M brought forward 2 yrs
Herdsman	11 kV feeders with 3 x 1C 400Al XLPE	8.59	2015	Remaining work in same year
U	11 kV distribution work brought forward to 2013	0.85	2013	$0.85M brought forward 2 yrs
U	11 kV feeders with 3 x 1C 400Al XLPE	9.09	2017	Remaining work deferred 2 yrs
Shenton Park - MC	132 kV double circuit steel pole - Venus	1.15	2016	Brought forward 2 yrs
Shenton Park - MC	132 kV 2000mm^2 U/G	11.42	2016	Brought forward 2 yrs
Shenton Park - MC	132 kV cable transition structure	0.22	2016	Brought forward 2 yrs
Western Terminal	132 kV breaker and half 3 ocb, 3 gantry 2 cct	3.00	2016	Brought forward 2 yrs

Net present cost resulted in a total cost for this option (including all other Western Terminal investments) of $110.4M.

4.2.3.2 Option B – Establish MCE in 2016 at 66 kV and migrate to 132 kV in 2018

The key elements of this option are as follows:

- No QEII upgrade project.
- Establish 132-66/11 kV MCE substation in 2016, energised initially at 66 kV.
- Upgrade to 132 kV in 2018 (to align with asset age drivers).
- Undertake the following distribution transfers in 2013:
    - Transfer 3 MW from Wembley Downs to Herdsman
    - Transfer 3 MW from Nedlands to Cottesloe
    - Transfer 4 MW from U to MC.

A breakdown of the costs that differ from Development Strategy 3 is shown in Table 7 below. All other elements of the scope for this option are the same as Development Strategy 3 and therefore have not been included in the table below.

Table 7: Option B – Costs that differ from Development Strategy 3

Substation/ Circuit	Description	Cost ($M)	Year	Change
MC	132/11 kV TXs installed	6.63	2016	Deferred 2 yrs
MC	132 kV line circuits, single bus	2.74	2016	Deferred 2 yrs
MC	132 kV transformer circuits, single bus	2.57	2016	Deferred 2 yrs
MC	132 kV bus coupler	1.11	2016	Deferred 2 yrs
MC	11 kV switchboards with tilt panel sw/room Type 1	6.16	2016	Deferred 2 yrs
MC	Site Works - standard zone substation Metro	1.91	2016	Deferred 2 yrs
MC	Zone sub relay room (brick wall)	1.46	2016	Deferred 2 yrs
MC	Other substation costs - estimate	1.00	2016	Deferred 2 yrs
Herdsman	11 kV distribution work brought forward to 2013	0.85	2013	$0.85M brought forward 2 yrs
Herdsman	11 kV feeders with 3 x 1C 400Al XLPE	8.59	2015	Remaining work in same year
U	11 kV distribution work brought forward to 2013	0.85	2013	$0.85M brought forward 2 yrs
U	11 kV feeders with 3 x 1C 400Al XLPE	9.09	2017	Remaining work deferred 2 yrs

Net present cost resulted in a total cost for this option (including all other Western Terminal investments) of $109.0M.

4.2.4 Comparison of options

NPC analysis undertaken for options without the QEII Medical Centre upgrade project were compared with the preferred long term Development Strategy 3 (which includes the QEII upgrade) as summarised below.

Table 8: Comparison of strategic options (NPC)

Strategic Option	NPC ($M)
Strategic Option 1	110.4
Strategic Option 2	109.0
Preferred long-term Development Strategy 3	112.1

Of the two alternative options proposed above, Option B results in the lowest NPC of $109.0M, compared with Option A which had an NPC of $110.4M. Option B would therefore be selected as the preferred solution if the QEII upgrade was not proceeding as it represents the lowest cost solution based on the available information (i.e. building block estimate costs).

Selecting Option B would result in a cost saving of approximately $3.1M (NPC) when compared with Development Strategy 3 (which has an NPC of $112.1M). Importantly, the main scope elements in Option B and Development Strategy 3 are the same, however the year in which each of these components is triggered is different.

Note: *This NPC analysis was undertaken based on A0 building block costs calculated over a 25 year period across the entire Western Terminal Load Area. Therefore, the NPC costs are for comparative purposes only and do not reflect the actual costs of bringing forward the construction of the new MCE substation. These will be determined at a more accurate A2 estimate level as part of the business case preparation.*

4.3 Transformer timing

As identified in the previous section, the QEII hospital upgrade project has brought forward the requirement to establish a new MCE substation to 2014, albeit with two transformers instead of three.

The requirements for the third transformer installation and the associated timing considerations are examined in detail in the following sections.

4.3.1 Without the QEII upgrade project

The following table outlines the forecast capacity requirements for the MC and U substations for a scenario without the QEII hospital upgrade in the years 2014 and 2016:

Table 9: MC and U capacity without QEII project

Scenario	S/S	Capacity	2014		2016	
			MVA	Loading	MVA	Loading
Retain existing MC and U substations	U	16.95	19.69	116.17%	20.28	119.65%
	MC	25.00	20.10	80.40%	21.00	84.00%
	U + MC	41.95	39.79	94.85%	41.28	98.40%

It is evident that without any intervention the existing U substation will be unable to accommodate the forecast load growth in both 2014 and 2016. The MC substation by contrast has some spare capacity in both of these years.

As described in Section 4.2 above, if such a situation existed, this excess U load (approximately 4 MW) would be offloaded to the existing MC substation through distribution transfers, resulting in the following:

Table 10: MC and U capacity without QEII project including distribution transfers

Scenario	S/S	Capacity	2014		2016	
			MVA	Loading	MVA	Loading
Retain existing MC and U substations and undertake Dx transfers	U	16.95	15.67	92.45%	16.28	96.05%
	MC	25.00	24.10	96.40%	25.00	100.00%
	U + MC	41.95	39.77	94.80%	41.28	98.40%

This shows the effect of deferring the U capacity constraint by making use of the spare capacity at the existing MC substation. This allows the establishment of the new MCE substation to be deferred until 2016, instead of 2014.

If in 2016, the new MCE substation was established with only two 33 MVA transformers, the following loadings would be observed:

Table 11: MCE capacity (2 TXs) without QEII project

Scenario	S/S	Capacity	2014		2016	
			MVA	Loading	MVA	Loading
New MCE with 2 TXs in 2016 incorporating both MC and U load	U	16.95	15.67	92.45%	-	-
	MC	25.00	24.10	96.40%	-	-
	MCE (2 TXs)	33.00	-	-	41.28	125.09%

The total load of the existing U and MC substations is forecast to be 41.28 MVA in 2016 (including the QEII upgrade), which is greater than the capacity of a new 132-66/11kV substation with two 33 MVA transformers would provide (i.e. 33 MVA firm capacity).

Installing all three transformers in 2016 by comparison would give the following:

Table 12: MCE capacity (3 TXs) without QEII project

Scenario	S/S	Capacity	2014		2016	
			MVA	Loading	MVA	Loading
New MCE with 3 TXs in 2016 incorporating both MC and U load	U	16.95	15.67	92.45%	-	-
	MC	25.00	24.10	96.40%	-	-
	MCE (3 TXs)	66.00	-	-	41.28	62.55%

The installation of three 33 MVA transformers in 2016 provides the necessary capacity to accommodate the combined load of the existing U and MC substations.

Therefore, in the absence of the QEII Medical Centre project, Western Power would establish a new 132-66/11kV substation with three 33 MVA transformers in 2016 to provide adequate capacity and address the identified network constraints.

4.3.2 With the QEII upgrade project

The following table outlines the forecast capacity requirements for the MC and U substations including the QEII hospital upgrade in the years 2014 and 2016:

Table 13: MC and U capacity with QEII project

Scenario	S/S	Capacity	2014		2016	
			MVA	Loading	MVA	Loading
Retain existing MC and U substations with no Dx transfers	U	16.95	19.69	116.17%	20.28	119.65%
	MC	25.00	24.54	98.16%	25.44	101.76%
	U + MC	41.95	44.23	105.44%	45.72	108.99%

As is consistent with the previous section, the existing U substation will be unable to accommodate the forecast load growth in both 2014 and 2016 (this is irrespective of the QEII Medical Centre expansion). The existing MC substation on the other hand, is close to full capacity in 2014, and exceeds its capacity in 2016 when including the additional increase in load associated with the QEII upgrade.

The offload of U substation to the existing MC substation is not viable in this situation as there is no spare capacity at MC. As such, a new MCE substation would be required in 2014 to accommodate this excess capacity.

If the new MCE substation was established with only two transformers, the following loadings would be observed:

Table 14: MCE capacity (2 TXs) with QEII project

Scenario	S/S	Capacity	2014		2016	
			MVA	Loading	MVA	Loading
New MCE with 2 TXs in 2014 incorporating MC load only	U	16.95	19.69	116.17%	20.28	119.65%
	MC	25.00	-	-	-	-
	MCE (2 TXs)	33.00	24.54	74.36%	25.44	77.09%

Two transformers are sufficient to support the increase in the existing MC substation load in both 2014 and 2016 however the U substation capacity is still exceeded.

Having established the new MCE with two 33 MVA transformers however, there is sufficient spare capacity at this substation to accommodate the excess U load.

If the excess U load (approximately 4 MW) was offloaded to the new MCE substation, the following loadings would be observed:

Table 15: MCE capacity (2 TXs) with QEII project including distribution transfers

Scenario	S/S	Capacity	2014		2016	
			MVA	Loading	MVA	Loading
New MCE with 2 TXs in 2014 incorporating MC load and 4 MVA of U load	U	16.95	15.69	92.57%	16.28	96.05%
	MC	25.00	-	-	-	-
	MCE (2 TXs)	33.00	28.54	86.48%	29.44	89.21%

This shows that establishing a new 132-66/11kV substation with two 33 MVA transformers in 2014, in conjunction with the transfer of approximately 4 MW of load from U, would be sufficient to meet the increased load requirements of QEII Medical Centre and those of Western Power. The third transformer is only required in 2016.

This supports the fact that the QEII has brought forward the need to establish a new 132-66/11kV substation from 2016 to 2014, with two of the three 33MVA transformers.

4.3.3 Third transformer installation

Even though the third transformer at MCE is strictly only required in 2016 to adequately address the network constraints, this approach requires that the work is undertaken as part of a separate project. From past experience, splitting projects in such a way results in additional cost due to the inefficiencies primarily associated with additional site mobilisation and project management costs.

Therefore a separate piece of analysis was undertaken to compare the possible savings from combining all three transformers into one project (as compared to two separate projects), against the potential savings obtained from deferring the third transformer installation until 2016.

An A0 building block estimate[38] was therefore initiated to determine the difference in cost between the following scenarios:

Scenario 1: In 2014: Establish new 132-66/11kV substation with three 33 MVA transformers.

Scenario 2: In 2014: Establish new 132-66/11kV substation with two 33 MVA transformers in 2014.

In 2016: Install the third 33 MVA transformer.

A summary of the A0 estimate costs is shown in the table below:

[38] Refer DM# 9983486 for A0 estimate details

Table 16: A0 estimate costs for MCE third TX scenarios

Scenario	Cost ($M)
Scenario 1 (Total)	18.17
Scenario 2 (2014)	14.39
Scenario 2 (2016)	4.60

A NPC analysis[39] was then undertaken based on the above A0 cost estimates. The results are summarised in the table below:

Table 17: Net present costs for MCE third TX scenarios

Scenario	Total NPC ($M)
Scenario 1	17.34
Scenario 2	17.71

The results show that undertaking the third transformer in 2014, rather than 2016, has expected savings of $370k in net present terms. This shows that for this particular scenario, the efficiencies gained in undertaking all of the work as part of a single project outweighs the benefits of deferring the third transformer until 2016.

As such, all options analysed in Section 6 of this Planning Report involving the installation of 33 MVA transformers have been estimated based on all three transformers being installed in 2014, as similar savings (as demonstrated above) are expected for these options.

[39] Refer DM# 9924874 for IEM spreadsheet associated with this NPC analysis

5 Project issues and drivers

There are multiple issues and drivers affecting the need for reinforcement in the MC zone substation area. Some of these have already been identified as part of the long term strategic option review in Section 3 of this document, and mainly focus on globally efficient outcomes for the Western Terminal load area. These are summarised as follows:

- Customer-driven connection works.
- The impact of prospective future load growth on substation and overhead line capacity.
- Asset age, condition and anticipated replacement profiles.
- Network reliability requirements and Technical Rules compliance.

Further elements have also been identified as part of the specific project development for the MC area and primarily focus on shorter term local efficiency. These additional elements are outlined below:

- substation land availability
- distribution feeder capacity and backup capability limitations
- Access Code considerations
- rationalisation of existing substations

Collectively, the issues and drivers identified in the long term strategic option review for the Western Terminal load area and the QEII project development will form the overall justification for investment in the MC area.

The following sections provide a detailed description of the additional issues and drivers identified as part of the specific QEII project development.

5.1 Substation land availability

Western Power considered utilising the existing MC zone substation site to construct the new MCE zone substation. However, the QEII confirmed that it intends to redevelop that land and instead is providing additional land to Western Power, adjacent to the existing MC zone substation for construction of a new MCE zone substation. The location of the existing MC zone substation and the proposed location for the new MCE zone substation are shown in Figure 9 below:

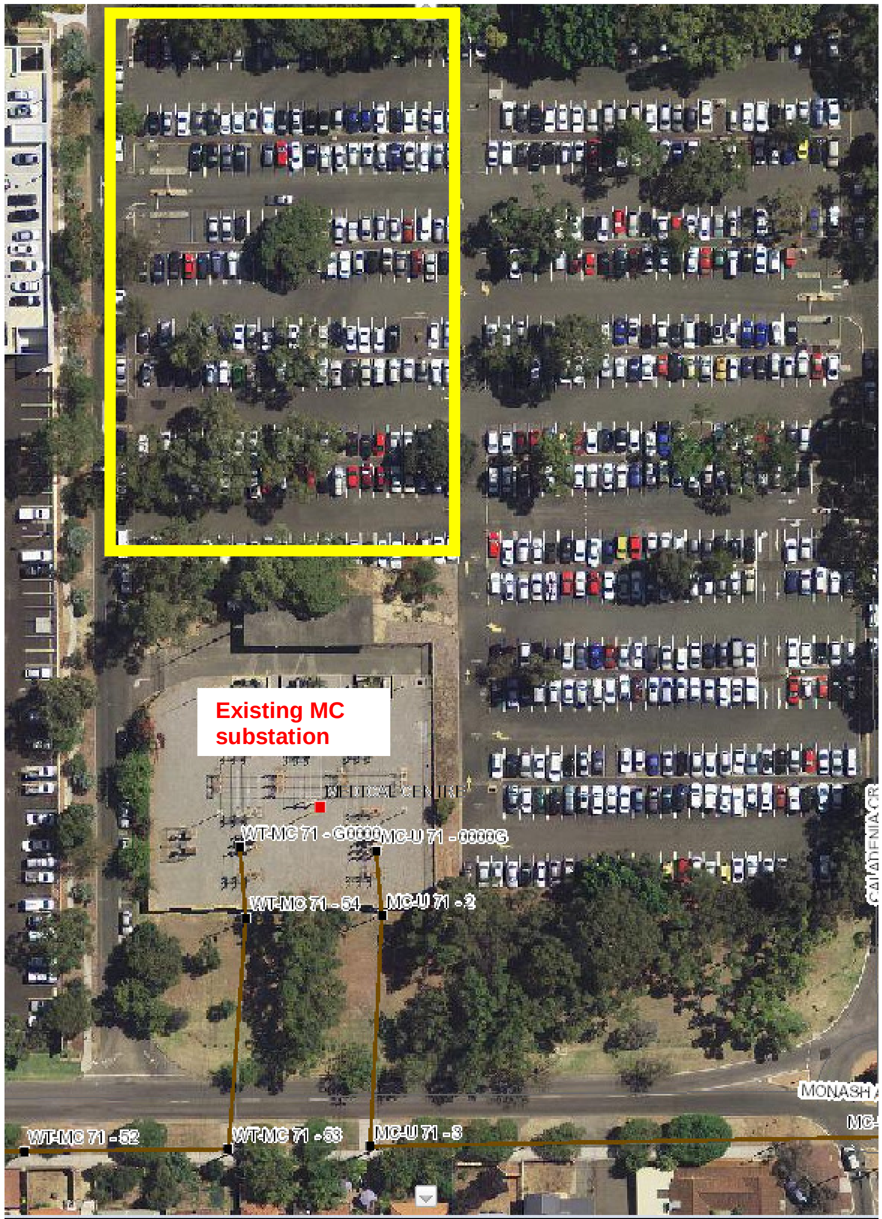


Figure 9: Aerial photograph of the proposed location of the new MCE substation

The decision to locate the new zone substation on the land provided by QEII stems from the following considerations:

- There is no other land available nearby upon which to locate the new MCE zone substation.
- Construction of the new MCE zone substation can be undertaken offline so the construction environment is safer and the associated works more efficient and cost effective.
- The site provided is located very close to the source of the load (the QEII Medical Centre) and so the feeder length supplying the hospitals and other medical facilities is shorter than it would otherwise have been.

The QEII has plans to redevelop the existing MC substation site and the existing land holding will need to be returned to the QEII following decommissioning of the existing 66/6.6 kV MC substation. The customer has indicated that it is not prepared to entertain any delay with the return of this land.

As outlined in Section 4.3 above, the installation of a new 132-66/11kV substation with two 33 MVA transformers in 2014 is sufficient to provide a redundant N-1 supply to accommodate both the existing MC load and the increased QEII load.

The third transformer is not required as a result of the QEII's expansion plans or the requirement to return the existing land holding to QEII, but as outlined in section 4.3.3 above this is being undertaken in 2014 (rather than 2016) for efficiency reasons of economies of scope (which is a consideration under clause 6.52(a) of NFIT).

5.2 Distribution feeder capacity and backup capability limitations

As outlined in Section 2.2 above, there are three street load feeder exit cables[40] at the existing MC zone substation and seven dedicated feeders[41] to the QEII.

There are four street load feeder exit cables[42] in the existing U zone substation and eight dedicated feeders[43] to the UWA. Some of these feeders supply sensitive customers such as Hollywood Hospital and individuals reliant on life support equipment.

As noted in Section 2.2, there are two issues affecting the distribution feeders at the existing MC and U zone substations:

- Feeder loading exceeding 100% of rated capacity
- Insufficient backup capability[44]

Table 18 below shows both the historical 2010/11 loads for the MC and U feeders, as well as the projected loads for 2014/15.

It is evident that the MC202 and MC204 feeders, which have a summer peak of 219A and 220A respectively in 2010/11, are operating at or beyond their feeder rating of 220A. Furthermore, feeders U213 and U216 will be operating beyond their feeder rating of 310A[45] by 2013/2014.

There are five interconnections between the MC204 feeder and other feeders.[46] Similarly, U213 has two feeder interconnections which are U216 and MC202.

[40] These are MC202, MC204 and MC206.
[41] These are MC221, MC222, MC223, MC224, MC225, MC226 and MC227.
[42] These are U212, U213, U215 and U216.
[43] These are U203, U204, U205, U206, U207, U208, U209 and U210.
[44] As defined by the Technical Rules (clause 2.5.5.3(b)2(a)
[45] This is based upon Network Planning manual (DM# 3501244)
[46] These are N204, N205, U212, U216 and SP210.

Table 18: Historical and projected MC and U feeder loads

Feeder	Rating of exit cable (A)	2010/2011		2014/2015	
		Load (A)	Utilisation of peak (%)	Load (A)	Utilisation of peak (%)
MC202 Hollywood Hospital SW 2	310	93	30%	93	30%
MC202 Arras RMU	220	219	**100%**	243	**110%**
MC204 Monash Ave	220	220	**100%**	251	**114%**
MC206 Hollywood Hospital SW 1	310	228	74%	228	74%
U212 55 Broadway	310	300	97%	314	**101%**
U213 Park Ave	310	148	48%	367	**118%**
U215 Broadway Fair	310	280	90%	245	79%
U216 20 Bruce St	310	305	98%	315	**102%**

During summer peak periods, the configuration and high loading on some of the MC feeders will limit the availability of DTC so increasing the amount of load shedding following feeder faults. Therefore, the existing MC feeders are exceeding design limits under 6.6 kV operation. This circumstance and the potential impacts upon customers are best illustrated by the examples shown in Figure 10 and Figure 11 below.

Figure 10 shows the MC202 feeder with a peak load of 243A. Given a theoretical fault scenario, the entire MC202 load would be required to be back fed via interconnecting feeders MC204 and U213. Figure 10 also shows that no load can be transferred onto the interconnected feeders under emergency conditions.

That would leave 243A of load remaining on the MC202 feeder that could not be back fed via existing interconnecting feeders. This would mean that approximately 1,100 customers (based on average peak per customer of 2.5 kVA) would not be able to be supplied and therefore would need to be shed from the network.

Clause 2.5.5.3 (b) (2) (A) in the Technical Rules (DM# 6800863) states that in the urban area:

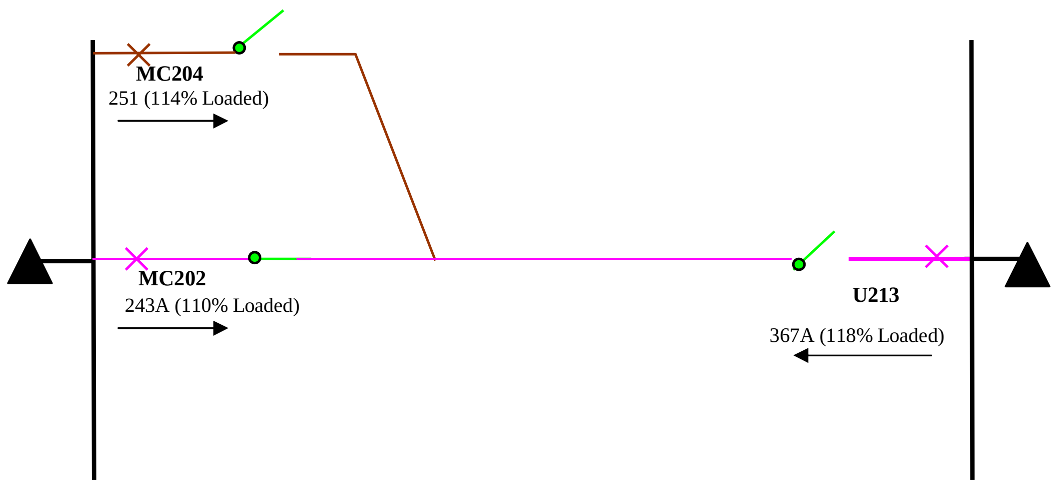
> *"distribution feeders must be designed so that, if an unplanned single feeder outage occurs due to…failure of the exit cable, the load on the faulted feeder can be transferred to other feeders with the following provisions:*

(A) no other feeder will pick up more than 50% of the peak load from the faulted distribution feeder…"

The scenario described in Figure 10 would therefore not comply with the requirements of the Technical Rules 2.5.5.3 (b) (2) (A).

MC202

Before theoretical fault scenario using the peak loading on 2014/2015:



After theoretical fault scenario using the peak loading on 2014/2015:

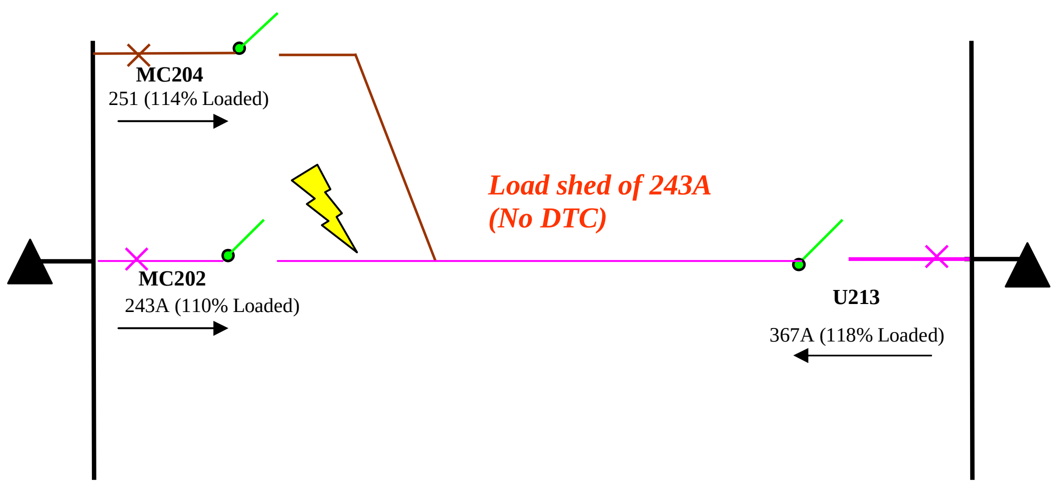


Figure 10: Fault during summer 2014/15 peak loading (MC202 off-load scenario)

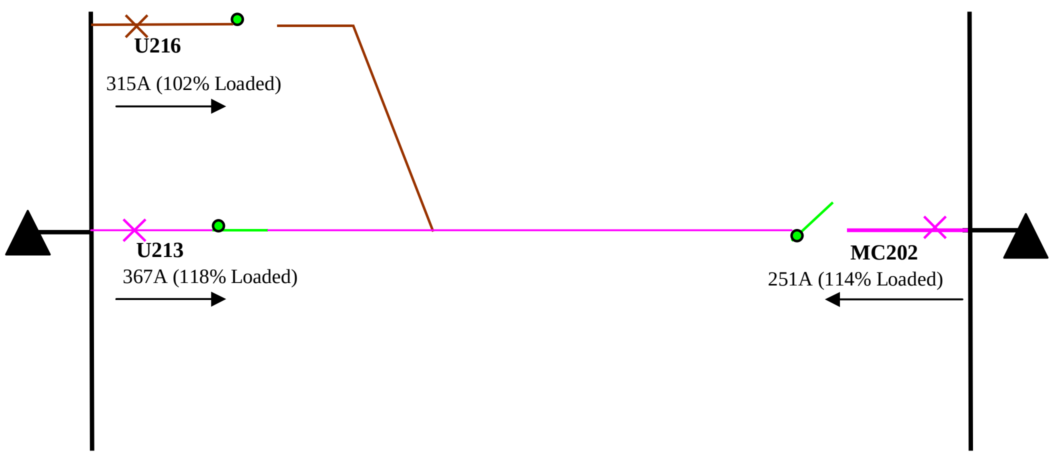
Part of this project will involve the conversion of existing U feeders to 11 kV. This is required because the existing U feeders are exceeding their design limit under operation at 6.6 kV. This circumstance and the potential impacts upon customers are best illustrated by way of the example in Figure 11.

As illustrated by Figure 11 below, the U213 feeder will have a peak load of 367A according to the 2014/15 forecast. Given a theoretical fault scenario, the entire U213 load would be required to be back fed via interconnecting feeders U216 and MC202.

The situation in Figure 11 shows that no load can be transferred onto the interconnected feeders under emergency conditions. This would leave 367A worth of load remaining on the U213 feeder that could not be back fed via existing interconnecting feeders. This would mean that approximately 1,600 customers (based on an average peak load per customer of 2.5 kVA) would not be able to be supplied and so would need to be shed from the network.

U213

Before theoretical fault scenario using the peak loading on 2014/2015:



After theoretical fault scenario using the peak loading on 2014/2015:

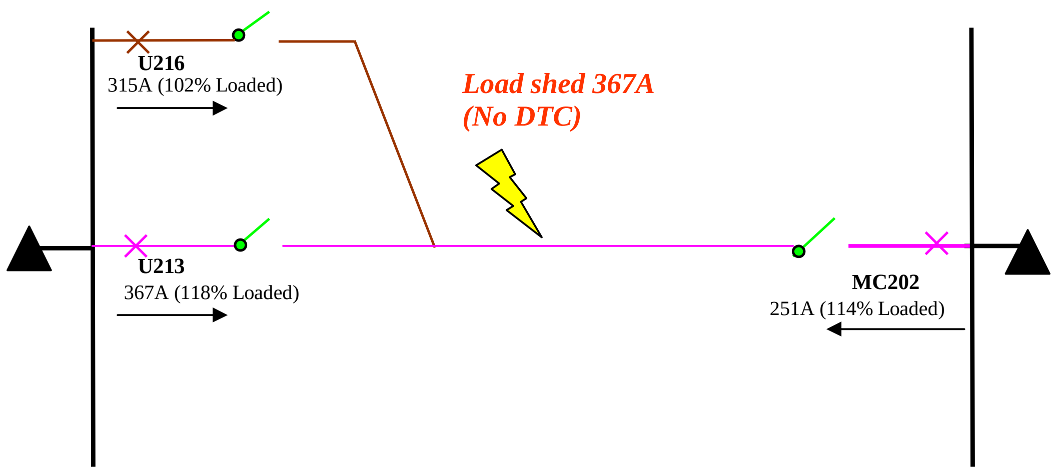


Figure 11: Fault during summer 2014/15 peak loading (U213 off-load scenario)

The scenario described in Figure 11 would therefore not comply with the requirements of the Technical Rules 2.5.5.3 (b) (2) (A), namely the design of urban feeders for sufficient backup capabilities.

5.3 Access Code considerations

5.3.1 Regulatory Test

In March 2008, Western Power applied to the ERA for a Regulatory Test waiver (clause 9.23 of the Code) on the grounds that establishing a new 66/11 kV MCE zone substation was the only feasible solution to provide the required network capacity to support the forecast load growth due to the expansion of the QEII and the surrounding area (DM# 8785755). The Regulatory Test waiver was granted in April 2008.

5.3.2 New Facilities Investment Test (NFIT)

Section 6.52(a) of the Code requires Western Power to demonstrate that the amount invested in the proposed project does not exceed the amount that would be invested by a service provider efficiently minimising costs.

This is covered in more detail for the recommended option in Section 7.8.1 below.

The project outlined in this Project Planning Report is required to maintain the reliability of the network and to comply with the Technical Rules as explained in Section 3.2.4 above.

In addition, if undertaken in 2016, the entire proposed expenditure for the project would have met the 'safety and reliability' conditions of the test. This is covered in more detail for the recommended option in Section 7.8.2 below.

5.4 Substation rationalisation

The proposed construction of and subsequent transfer of load to the new MCE zone substation will eventually include the decommissioning of the existing MC and U zone substations. Therefore, the two existing zone substations will be replaced by one new zone substation which is in line with Western Power's preferred long term development strategy for the Western Terminal load area.

5.5 Business impacts

The project will have the following impact on the business:

- Minimise the risk of compliance failures under the Technical Rules related to overloading and load shedding.
- Provision of additional capacity to reduce the likelihood of shortfalls from summer 2014.
- Reduce overloading risk on MC202, MC204, U213, U215 and U216 feeders by increasing capacity. This will ensure no further accelerated loss of cable life.
- Reduce the load on MC202, MC204, U213, U215 and U216 feeders to improve the amount of DTC in the area.

- Maintain the reliability of supply to more than 4,000 customers by ensuring that there is spare DTC at MC catchments in the event of an outage.

By providing these benefits, the project will maintain the corporate strategic objectives of Reliability, Safety (Public Safety) and Corporate Reputation.

5.6 Current state of project planning

As this project is one of the first parts of the recommended long term strategy for the Western Terminal load area, some components of the project are still being investigated.

5.6.1 Design

The proposed new MCE zone substation is unlikely to be designed and constructed using standard plant. Although standard 33 MVA transformers will be used for the preferred option, the switchboard will be non-standard as there is a requirement for six to ten feeder circuits per switchboard instead of the standard four feeder circuits per board.

Operating the transformers independently will contribute to lower fault levels. However, this arrangement may limit the ability to evenly balance the load between each of the transformers, thus the substation will be operating at its unbalanced capacity, which would be marginally lower than its balanced capacity (i.e. with all transformers operated in parallel).

5.6.2 Location

The proposed location for the new zone substation is very close to the existing MC zone substation. An aerial photograph of the proposed location is shown in Figure 9 above. This land will be provided by the customer (QEII) and the size is limited to 50 m x 80 m.

5.6.3 Stakeholder engagement

Engagement with the local community raised several issues that need to be addressed through the Development Approval process.

These were the need for a road safety audit, a traffic management plan and a good understanding of how the new zone substation will be constructed.

Two facilitated workshops have been held (on the 30th November 2011 and 13th February 2012 respectively) with key stakeholders and affected landowners.

- The first workshop outlined the proposal, timing, staging, options and possible boundary treatment options to determine how the new zone substation will look.
- The second workshop determined a preferred option (including boundary treatment) from the photomontages created from the preferences expressed in the first workshop.

Broad community consultation on the preferred option was also undertaken to allow for all comments on the proposed new zone substation.

5.6.4 Customer transfer to the new zone substation

Once the new MCE 132-66/11 kV zone substation is constructed, all the 6.6 kV customers supplied by the existing MC zone substation will be migrated to 11 kV and supplied by the new infrastructure. As part of the migration process, the existing MC zone substation will need to be retained and operated at the same time as the new MCE zone substation for up to 18 months.

In line with the long term Western Terminal load area Development Strategy 3 the new MCE zone substation will be migrated from a 66 kV to 132 kV supply in 2018. The 132 kV supply to the new MCE zone substation will be provided by the double circuit running from the new 132/11 kV Shenton Park zone substation. This will be constructed with a required in service date of November 2018.

5.6.5 References

- Planning studies – model extracted from PowerFactory load flow simulation (refer to):
  - load rejection
  - distribution fault level limitation
- Technical rules compliance - Technical rules (Refer to DM# 6800863) clause 2.5.5.3 (b) 2 (A).

6 Investment path and option recommendation

As outlined in Section 3 above, this project forms one part of the recommended long term development strategy for the Western Terminal load area.

The recommended strategy 'Development Strategy 3' seeks to provide further capacity in the region and delay further investment.[47] A staged approach is proposed for this as follows:

- Shenton Park substation migrated to 132 kV, with Herdsman Parade substation load transferred to Shenton Park by November 2014.[48]
- The new MCE zone substation migrated to 132 kV with a design adopted to maximise the available substation capacity, with the existing MC and U zone substation loads transferred to the new MCE zone substation. This will proceed as follows:
    - By June 2014 - Construction of a new MCE zone substation (132-66/11 kV) adjacent to the existing MC zone substation on land provided by the QEII.
    - From June 2014 to June 2015 – Transition of customers on 6.6 kV to 11 kV supplies to be provided from the new zone substation.
    - In June 2015 – Decommission the existing MC and U[15] zone substations and return the existing MC substation land to QEII.
    - In November 2018 – Transition the new MCE zone substation from 66 kV to 132 kV supply.

The potential changes to the existing MC and U zone substations have been identified as one of the first projects to be executed under Development Strategy 3. Apart from the emerging transmission and distribution issues identified in Section 5, the main driver for this is the QEII's requirement for an 11 kV distribution supply voltage in 2014. This means that a transformer change would be required at the existing MC zone substation by 2014.

A number of options have been identified for the MC and U areas as follows:

1. Establish a new 132-66/11 kV MCE zone substation with two 66 MVA transformers initially energised at 66/11/11 kV (transmission reinforcement).
2. Establish a new 66/11 kV MCE zone substation with three 33 MVA transformers (transmission reinforcement).

47 Western Terminal load area – long term strategic option review (DM#8381133), p40
48 Refer to DM# 8758588 for further details

3. Establish a new 132-66/11 kV MCE zone substation with three 33 MVA transformers (transmission reinforcement).
4. Demand side management (non-network reinforcement).
5. Transfer load to surrounding substations (distribution reinforcement).

Each of the five options is discussed in more detail in the following sections. Furthermore, each option has been compared and evaluated on the basis of the following:

- technical viability
- compliance with the Technical Rules
- time to implement
- risk mitigation
- projected benefits
- cost (NPC)

In particular, the following technical points have also been considered when comparing alternative options:

- Like-for-like replacement of zone substation assets will not solve the substation capacity constraint. Therefore the transformers must also be upgraded in capacity.
- The upgrading of the distribution network to 11 kV will result in significantly increased capacity on the distribution network. However, conversion is a relatively long process which will require detailed planning and scheduling of works to minimise disruption to customers.
- The QEII is seeking to upgrade to 11 kV.
- Remaining at 66 kV will mean that the 66 kV transformer capacity at WT must be upgraded to accommodate the increased load.

Following this evaluation the recommended option is outlined in Section 6.6 below.

6.1 Option 1 – New 132-66/11 kV zone substation with two 66 MVA transformers initially energised at 66/11 kV

6.1.1 Scope

6.1.1.1 Transmission works

This option is to establish a new MCE 132-66/11 kV zone substation to address the network capacity shortfall.

Construction of the MCE zone substation will include the installation of two 66 MVA, 132-66/11/11 kV transformers and provision for 20 distribution feeders. Initially, the transformers will be energised at 66 kV with the capability of being energised at 132 kV at a later date (currently planned for November 2018).

The QEII has offered an area of land for the construction of the new MCE zone substation. This is a site adjacent to the existing MC zone substation as QEII wish to redevelop the existing MC zone substation site once it becomes available. The suitability of the potential site has been investigated in detail. Firstly, the potential site complies with the size requirement for a new zone substation. For Option 1, this is a footprint requirement of 50m by 80m (4,000 m^2). Secondly, the proximity of the potential site to the existing site ensures short feeder lengths to supply the QEII. Finally, as the construction of the new MCE zone substation can occur off-line this provides a safer working environment and more efficient construction programme.

The location of the new MCE site is shown in Figure 9 above. The proposed site of the MCE zone substation is superimposed upon an aerial map of the existing MC zone substation and surrounds.

The project is to be carried out in two main stages.

The first stage is the construction of the new MCE zone substation. This involves:

- undertaking requisite site preparation
- constructing the new AIS 66 kV rated busbar to accommodate two line circuits and two transformer circuits
- reconfiguring the existing 66 kV WT-MC71 and MC-U71 lines in order to supply 66 kV to the new zone substation
- installing two new 66 MVA, 132-66/11/11 kV transformers
- installing new, single busbar, LV switchboards and a switch room, including four 5 MVAr capacitor bank sets
- the staged conversion of the U and MC zone substations distribution networks from 6.6 kV to 11 kV

The second stage of the scope involves the decommissioning, demolition and removal of the existing plant and buildings from the 66/6.6 kV MC and U zone substations (including the transmission lines supplying the decommissioned zone substations). This second stage also includes the modification of the protection and communications systems for the transmission lines and rehabilitation of the decommissioned substations' sites to acceptable standards.

The first stage is required in service by 30 June 2014 and the second stage is required in service by 30 June 2015.

A more detailed description of the scope of works required can be found in DM# 8391821.

6.1.1.2 Distribution works

The distribution works associated with Option 1 encompasses the installation of new feeders and the upgrading of non 11 kV rated assets in the MC and U areas.

Nine new feeders would be established from the new MCE zone substation to integrate with the existing network and to enable the transfer of load from the existing MC and U zone substation to the new MCE zone substation.

Part 1 of the distribution element of this project is to convert all the existing MC feeders to 11 kV and install three new feeders from the new MCE zone substation to replace the existing MC202F, MC202R, MC204 and MC206 feeders. The 11 kV conversions will then increase the capacity by 70% per feeder.

The completion of part 1 of the distribution element of this project allows some network reconfiguration to improve MC202 and MC204 feeder loading. Table 19 below illustrates the significant improvement in the utilisation of the MC feeders after the completion of the first part of the distribution element of this project.

Table 19: Projected MC feeder loads in 2014/15 after part 1 reinforcement

Feeder	2014/15 (before part 1)		2014/15 (after part 1)	
	Load (A)	Utilisation (peak load)	Load (A)	Utilisation (peak load)
MC202 Hollywood Hospital SW 2	93	30%	197 (Both front and rear feeder will be merged as New Feeder 1)	63%
MC202 Arras RMU	243	**110%**		
MC204 Monash Ave	251	**114%**	146 (New Feeder 2)	47%
MC206 Hollywood Hospital SW 1	228	74%	141 (New Feeder 3)	46%

The spare capacity created by new feeders 1, 2 and 3 will cater for the forecasted load growth in the area over the next 10-15 years.

Part 2 of the distribution element of this project is to convert all the existing University feeders to 11 kV and install six new feeders from the new MCE zone substation. The 11 kV conversions will increase the capacity by 70% per feeder. This information is illustrated in Table 20 below.

Table 20: Projected University feeder loads in 2014/15 after part 1 and part 2 distribution reinforcement (*U203 to *U210 are dedicate feeders to UWA)

Existing feeder	New feeder	2014/15 (before part 1 & 2)		2014/15 (after part 1 & 2)	
		Load (A)	Utilisation (peak load)	Load (A)	Utilisation (peak load)
U212 55 Broadway	New Feeder 4	314	**101%**	186	60%
U213 Park Ave	New Feeder 6	367	**118%**	210	67%
U215 Broadway Fairway	New Feeder 5	245	79%	177	57%
U216 Bruce Street	New Feeder 7	315	**102%**	194	63%
*U203 Agriculture West *U204 Anatomy *U205 Molecular & Chemical *U206 Agriculture West	New Feeder 8	N/A	N/A	270A	87%
*U207 Central Plant 2 *U208 Central Plant 1 *U209 Arts *U210 Physics	New Feeder 9	N/A	N/A	270A	87%

The completion of parts 1 and 2 of the distribution elements of this project allow for some network reconfiguration to improve load balance on the feeders and increase DTC. This project will also bring the network up to an acceptable standard of compliance with the Technical Rules as well as maintaining the reliability and security of supply to customers. Furthermore, the project will allow Western Power to optimise the investment made in the new MCE zone substation by enabling the utilisation of additional capacity provided by the new transformers.

The new MCE zone substation has only one exit route for the feeder cables which limits the options for the installation of the nine new feeders.

Based on a simulation from Cymcap[49], a minimum separation of 600 mm is required between each of the new feeders to avoid cable derating. The required cable separation is achieved by installing a cable tunnel with a culvert system along the feeder exit route.

A site survey has been conducted to identify the distribution assets that are not currently rated for operating at 11 kV. All HV assets within the MC and U distribution areas which are found not rated at 11 kV must be replaced.

Network reconfiguration will also be required to help evenly re-distribute the load once the new feeders have been established from the new MCE zone substation. This reconfiguration will also assist in re-aligning the local distribution catchment areas of MC and U by improving the feeder utilisation. Overall, DTC in the area will also increase as available spare distribution capacity is re-disbursed across the feeders in the area.

A more detailed description of the distribution scope of works required can be found in DM# 8395072.

6.1.2 Benefits/Business impact

Following commissioning of the new MCE zone substation in June 2014, the existing loads supplied by MC 66/6.6 kV and U 66/6.6 kV zone substations will be off-loaded to the new MCE 132-66/11 kV zone substation.

Once the new MCE zone substation is established, both the old MC and U zone substations can be decommissioned.

The new MCE zone substation as outlined in Option 1 will provide greater flexibility for the distribution network during planned and un-planned outages. Option 1 also ensures sufficient supply capacity for existing and forecast loads to connect in the U and MC network areas.

The off-loading of overloaded feeders will also mitigate public safety issues arising from supply interruptions (refer to Section 7.3 for more details).

Option 1 will address the non-compliance issues with the Technical Rules as follows:

- clause 2.5.4 (b) (Normal Cyclic Rating (NCR) criterion), by providing sufficient capacity to avoid unacceptable load 'at risk'
- clause 2.5.5.3 (b) 2 (A), as feeder backup requirements will be satisfied

6.1.3 Estimate

The planning estimate costs of the transmission and distribution works for this project are given in Table 21 below. For a more detailed breakdown of the A1 cost estimates for the new MCE zone substation refer to DM# 8776187 for the transmission works and to DM# 8828035 for the distribution works.

[49] The Cymcap software is used to perform ampacity and temperature rise calculations for power cable installation. It addresses steady state and transient thermal cable rating.

Table 21: Breakdown of costs (in 2011/12 dollars) for the establishment of the new 132/66/11/11 kV MCE zone substation

Key components	Risk free (Base) ($000s)	Risk allowance at P80 ($000s)	Total cost ($000)
Transmission	24,226	2,552	26,779
Distribution	12,668	1,267	13,935
Total cost	36,895	3,819	40,714

The total nominal capital cost of Option 1 is $43.569 million.[50]

6.2 Option 2 – Establish a new 66/11 kV zone substation with three 33 MVA transformers

6.2.1 Scope

6.2.1.1 Transmission works

This option is to establish a new MCE 66/11 kV zone substation to address the network capacity shortfall. The construction of a new 66/11 kV zone substation includes the installation of three 33 MVA, 66/11 kV transformers and provision for 18 distribution feeders.

Option 2 would also to be carried out in two main stages, similar to those outlined for Option 1 above. The main differences in scope for Option 2 compared to Option 1 are:

- installation of three 33 MVA 66/11 kV transformers instead of two 66 MVA 132-66/11/11 kV transformers
- provision for 18 distribution feeders instead of 20
- installation of three switchboards instead of two switchboards
- installation of three 5 MVAr capacitor bank sets instead of four as in Option 1

The first stage of Option 2 is required in service by 30 June 2014 and the second stage is required in service by 30 June 2015.

A more detailed description of the scope of works required can be found in DM# 8391821.

6.2.1.2 Distribution works

These are the same as for Option 1.

6.2.2 Benefits/Business impact

Option 2 will provide a similar outcome to Option 1 but with the following exceptions:

- three 5 MVAr capacitor banks instead of four in Option 1 (one capacitor banks per switchboard)

50 From Investment Evaluation Model (DM# 8769448)

- there is a plan to energise the new MCE zone substation at 132 kV in November 2018
  - for Option 2, the three 33 MVA 66/11 kV transformers will then need to be replaced with three 33 MVA 132/11 kV transformers in 2018

6.2.3 Estimate

The planning estimate costs of the transmission and distribution works for this project are given in Table 22 below. For a more detailed breakdown of the A1 cost estimates for the new MCE zone substation refer to DM# 8776187 for the transmission works and to DM# 8828035 for the distribution works.

Table 22: Breakdown of costs (in 2011/12 dollars) for new 66/11 MCE zone substation establishment

Key components	Risk free (Base) ($000s)	Risk allowance at P80 ($000s)	Total cost ($000)
Transmission	25,171	2,429	27,601
Distribution	12,668	1,267	13,935
Total cost	37,839	3,696	41,536

The total nominal capital cost of Option 2 is $44.891 million.[50]

6.3 Option 3 – Establish a new 132-66/11 kV zone substation with three 33 MVA transformers

6.3.1 Scope

6.3.1.1 Transmission works

This option is to establish a new MCE 132-66/11 kV zone substation to address the network capacity shortfall. The construction of a new 132-66/11 kV MCE zone substation includes the installation of three 33 MVA, 132-66/11 kV transformers and provision for 18 distribution feeders.

Option 3 would also need to be carried out in two main stages, similar to those outlined for Option 1 above. The main differences in scope for Option 3 compared to Option 1 are:

- installation of three 33 MVA 132-66/11 kV transformers instead of two 66 MVA 132-66/11/11 kV transformers
- provision for 18 distribution feeders instead of 20
- installation of three switchboards instead of two switchboards
- installation of three 5 MVAr capacitor bank sets instead of four as in Option 1

A more detailed description of the scope of works required can be found in DM# 8391821.

6.3.1.2 Distribution works

These are the same as for Option 1.

6.3.2 Benefits/Business impact

Option 3 will provide a similar outcome to Option 1 but with the following exceptions:

- three 5 MVAr capacitor banks instead of four in Option 1 (one capacitor banks per switchboard)
- the three 33 MVA 132-66/11 kV transformers are 132 kV ready

6.3.3 Estimate

The planning estimate costs of the transmission and distribution works for this project are given in Table 23 below. For a more detailed breakdown of the A1 cost estimates for the new MCE zone substation refer to DM# 8776187 for the transmission works and to DM# 8828035 for the distribution works.

Table 23: Breakdown of costs (in 2011/12 dollars) for new 66/11 MCE zone substation establishment

Key components	Risk free (Base) ($000s)	Risk allowance at P80 ($000s)	Total cost ($000)
Transmission	24,339	2,429	26,768
Distribution	12,668	1,267	13,935
Total cost	37,007	3,696	40,703

The total nominal capital cost of Option 3 is $43.567 million.[50]

6.4 Option 4 – Demand Side Management (DM)

An effective demand side solution requires a minimum customer take-up within an acceptable timeframe, to achieve the required load reduction. The required reduction in demand to be achieved by DM in this instance is 12 MVA by 2015.

The benefits of demand side management arise from the net monetary saving obtained by deferring reinforcement investment to later years. These benefits are calculated in NPC terms for comparison with the costs of other options.

According to the Demand Management Business Model[51], project deferment savings generally need to be in excess of $200 per kVA for DM to be financially viable. Table 24 below shows the estimated monetary savings generated by deferring the recommended option.

As can be seen in Table 24, the estimated benefit of a DM option for a 1 year deferral is about $183.30 per kVA which is less than the estimated value of $200 per kVA required for the DM option to be viable. Furthermore, the Demand Management Business Model suggests that the baseline value of a DM option of $200 per kVA is for

[51] DM# 6086008 - Demand Management Business Model

a commercial or industrial area and the value of DM in a residential area needs to be much higher (approx. $500 per kVA) to be viable.

Table 24: Potential savings from deferring the project

Present required in service date	Present	Deferral
	By end of 2014	**By end of 2015**
Proposed solution	Option 3	DM
Cost (incl. Escalation)	$43.57M	$45.36M
Net Present Cost (NPC)	$37.51M	$35.31M
Deferral savings (in real terms)		$2.2M
Demand reduction required		12 MVA
Demand management value ($ per KVA)		$183.30

In the table above the NPC of the capital expenditure has been used, as the operational expenditure associated with the first year (i.e. the year deferred by using DM) of a newly established substation is considered negligible. Note: the above analysis was conducted with a discount rate of 10.65% any reduction in this rate would only serve to make DM less economic.

6.5 Option 5 – Transfer load to surrounding zone substations

Option 5 involves the transfer of load from the existing MC zone substation to adjacent zone substations. The feeders that are interconnected with the MC zone substation are U213, U216 and SP210.

The scope to transfer load to adjacent zone substations was considered within the options analysis process. However, it was determined that there is insufficient spare capacity on contiguous feeders and zone substations to accommodate additional load transfer.

As highlighted in Table 18 earlier, most of the interconnected feeders are either at or nearing the planning criteria for load capacity or will be in breach of the Technical Rules by 2014/2015. As a result, if a fault were to occur there would be inadequate back feeding capability. Therefore, customer power outages would need to be sustained while repairs were undertaken.

Consequently, Option 5 is considered not feasible as the existing capacity issues of the feeder networks cannot be effectively addressed by completing network switching operations.

6.6 Summary of options and recommendation

Of the options considered, all those involving the construction of a new zone substation (Options 1, 2 and 3) will address the network capacity shortfalls and achieve compliance with the Technical Rules and Planning Guidelines.

An Investment Evaluation Model (IEM) was prepared to financially evaluate the identified options. Key outputs from the IEM, (also presented in Appendix A) are:

- nominal expenditure profiles for each option
- a Net Present Cost assessment for each option
- the selection of a recommended option from a financial perspective incorporating the implications of NFIT

Table 25 below, provides a summary of the options considered within this Project Planning Report.

Table 25: Option analysis summary

#	Option title	Nominal capital cost ($M)[12]	PV Total cost ($M)[13]	Improves reliability	Increases capacity	Mitigates risk	Comments
1	Establish new 132/66/11/11 kV zone substation with two 66 MVA transformers	43.569	49.48[14]	☑	☑	☑	Although this option has the same NPC as Option 3 it is discounted on the basis of the increased technical risk introduced by the non-standard transformers. Not recommended
2	Establish new 66/11 kV new zone substation with three 33 MVA transformers	44.891	50.00	☑	☑	☑	Highest nominal capital cost and NPC. In addition this option represents suboptimal asset utilisation as the three 66/11 kV transformers will need to be replaced before the substation can be energised to 132 kV. Not recommended
3	Establish new 132-66/11 kV new zone substation with three 33 MVA transformers	43.567	49.47	☑	☑	☑	Least nominal capital cost and equal least cost NPC. Addresses all network constraints and customer requirements without introducing any additional technical risk. **Recommended option**
4	Demand Side Management	N/A	N/A	☒	☒	☒	DM savings are lower than savings from deferring the recommended option by one year. A DM solution would also not be able to address the ageing/poor condition assets. Not feasible.
5	Transfer load to surrounding zone substations	N/A	N/A	☒	☒	☒	The redistribution of load through switching is not achievable due to the existing constrained capacity issues on the surrounding distribution feeder network. Not feasible.

Based on the NPC analysis, Options 1 and 3 are shown to be more cost effective when compared with Option 2.

From a technical perspective, Option 1 involves installing a 132-66/11/11 kV transformer, which is a non-standard unit (i.e. reconfigurable 132-66 kV HV winding coupled with dual 11 kV LV windings) and is uncommon in the electrical industry.

Western Power has no experience using a transformer of this kind and its introduction would therefore require a new suite of designs to be created, resulting in additional technical risk. Due to the complexity of this type of transformer, the construction time is also anticipated to be longer than a more standard unit and therefore has the potential to impact the project delivery.

By comparison, Option 3 involves installing a 132-66/11 kV transformer. Although this also features a reconfigurable 132-66 kV

HV winding, it only utilises a single 11 kV LV winding. From a design perspective this is simpler solution and therefore the technical risk and anticipated delivery time is less in comparison to Option 1.

Option 3 is therefore the recommended as preferred option on the following grounds:

- It effectively addresses the key drivers of this Project Planning Report.
- It achieves compliance with the Technical Rules, specifically the following areas at risk of non-compliance:
    - Sufficient N-1 capacity to avoid an unacceptable level of load at risk is provided (clause 2.5.2.2 (b))
    - The required feeder backup is provided (clause 2.5.5.3 (b) (2) (A))
    - The required feeder capacity is provided (clause 2.6(a))
- It is the equal least-cost option in net present terms.
- Of the two least-cost solutions it presents the least technical and delivery risk.
- It is consistent with the long term planning strategy for the Western Terminal.

7 Recommendation

It is recommended that approval be granted to reinforce the MC network as specified in Option 3, Section 6.3.1 above, with all associated distribution works completed by June 2015.

The estimated nominal capital cost of the recommended program of works is $43.567 million.[50]

7.1 Option selection

As noted above, Options 4 and 5 were not considered viable because of the additional costs and risks associated with each of them.

Only Options 1, 2 and 3 are considered as viable given that:

- The existing MC zone substation supplies hospitals and as such is considered an essential service. Therefore, N-1 reliability (firm capacity) is required on the network.
- The QEII is providing land upon which the new zone substation will be constructed.

As Options 1, 2 and 3 met the viability criteria above, the choice of Option 3 as the recommended option was made on the grounds of the technical solution it provides, the lower cost of implementing the option and the residual risk that exists once the option has been implemented

Table 25 in Section 6.6 compares each of the five options.

7.2 Business impact

The business impacts of this project are:

- Reduced likelihood of overloading on the MC feeders with positive impacts on asset life and reduced faults.
- The provision of switching capabilities to offload neighbouring feeders.
- Increased DTC in the area allowing, in the events of faults, loads to be switched to avoid load shedding.
- Improved quality of supply by redistributing the load in the catchment areas of MC and U to supply their immediate localities.
- Improved reliability and security of supply for more than 4,000 customers by ensuring that there is spare network capacity (DTC).
- Additional capacity for new growth until the load reaches transformer capacity.

By providing these benefits, the project will maintain the corporate strategic objectives related to Reliability, Safety (Public Safety) and Corporate Reputation.

7.3 Risk analysis

7.3.1 Uncontrolled risk

The risks associated with doing nothing and not proceeding with this project are:

- Inability to meet an increase in load from new customers and increased demand from existing customers, particularly the new hospital development at QEII.
- Additional asset replacement costs associated with damaged equipment.
- A requirement to implement load shedding to prevent further damage to equipment during peak periods.
- Not achieving system optimisation including improved reliability, quality of supply and reduction in losses.
- Non-compliance with the Technical Rules (refer to DM# 6800863) clause 2.5.5.3 (b) 2 (A), as feeder backup requirements will not be satisfied.
- Potentially incurring reliability penalty fees for not meeting minimum reliability targets and lost revenue.
- Possible serious injury to public, particularly those on life support as a result of supply outages.

The information in Table 2 (Section 2.2) above shows that more than 4000 customers could potentially be impacted by a fault under peak demand conditions.

Assessment of this risk was detailed in Section 5.2 above.

If nothing is done to the network, the load on the faulted feeder will not be able to be backed up, due to insufficient DTC.

The uncontrolled risk rating of 'High' is shown in Figure 12 below

7.3.2 Residual risk

The level of uncontrollable risk will be reduced by Western Power taking action to increase capacity and reliability on the Medical Centre network. By completing this project, the risk ranking will move from a 'High' ranking to a 'Medium' ranking as shown in Figure 12 below.

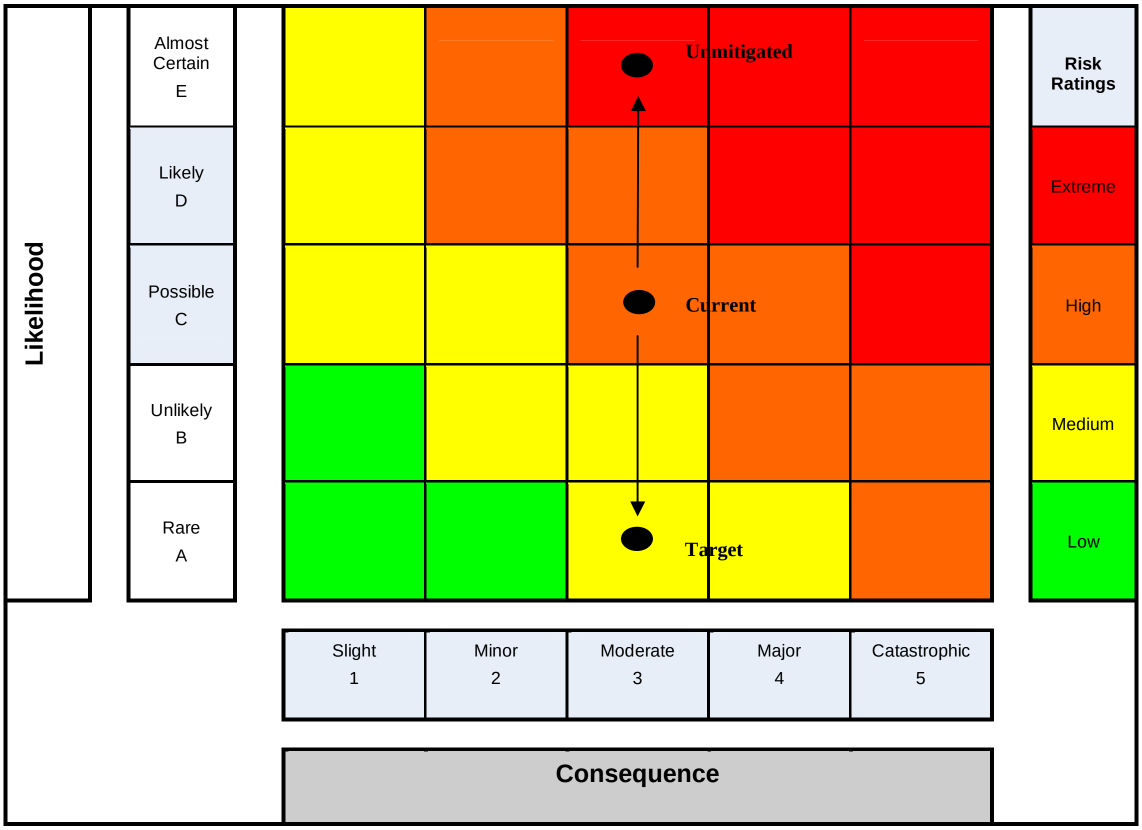


Figure 12: Overall assessment of residual risk

7.3.3 Delivery risk

This project presents a very small technical risk to Western Power associated with the use of reconfigurable 132-66 kV HV windings on the MCE transformers. One singular design will need to allow for operation at both 132 kV and 66 kV voltages. Other than this, the project will use known and proven technology, management skills and experience that are regularly and successfully applied in similar projects managed by Western Power.

To achieve efficient delivery of the project, the assigned Operations Division Project Manager has completed a Deliverability Checklist (DM# 9908925). The checklist ensures that the project's Business Case Estimate costs are compared to similar recently completed projects.

As part of this process, the Project Manager will review a Risk Register (DM# 8998584) which is created by the Estimating Centre team at Western Power when forming the Business Case Estimate. This ensures that the appropriate risks have been identified and that the appropriate level of risk funding has been allocated to estimate.

A competitive external bidding process is performed to ensure the lowest market rate is attained from preferred contractors' quotes. This cost is compared with the Distribution Quotation Management (DQM) estimated cost created with reference to the completed designs from the Distribution Design teams.

Contracts will not be awarded to tender candidates if the anticipated spending will exceed the approved business case value.

A change control request is required to be approved by the sponsor and project manager to release additional funds as and when required.

The project risks associated with the delivery of this project are summarised in Table 26 below.

Table 26: Project risks

Risk	Assessment	Mitigation
Management experience risk	Low	This project involves the purchase of standard equipment. Many similar projects have been undertaken and completed successfully over recent years.
Technology risk	Low	The use of 132-66 kV reconfigurable primary windings on the MCE transformers presents a small technical risk. Both 132/11kV and 66/11kV transformers have been utilised in the past. Western Power's established standards for these types of zone substations can be adapted to suit this application.
Construction and completion risk	Low	This work relates to establishment of a new zone substation and associated distribution works. The work has a low risk, as a number of similar projects have been successfully undertaken over recent years. Site visits have been made to the Medical Centre site to explore site issues and confirm the feasibility of the project.

7.3.4 Stranded asset risk

There is minimal risk of the new asset becoming stranded. This is because the existing assets are already operating at, or close to, full capacity. Furthermore, with the certainly around the QEII Medical Centre upgrade and the well-established customer street load in the area, the risk that proposed new substation capacity will not be utilised is considered negligible.

The new substation and associated feeders will address the existing capacity and transfer shortfalls and adequately provide for the future load growth.

7.3.5 Regulatory risk

The existing U zone substation is non-compliant with the NCR criterion of the Technical Rules (clause 2.5.4(b)) from the 2011/12 summer peak due to insufficient available transformer capacity. In addition the existing MC zone substation is expected to be non-compliant with the N-1 criterion of the Technical Rules (clause 2.5.2.2) by 2016.

In the distribution network, feeder loading at the existing MC and U zone substations for three feeders is exceeding 100% of rated capacity. In addition, there is insufficient feeder backup capability as defined by the Technical Rules (clause 2.5.5.3 (b) 2 (A)).

Increasing capacity and reliability in the MC network will address these regulatory risks by providing N-1 compliance for the QEII. This is regarded as an essential service for the hospitals and other medical facilities present on the site. The distribution network enhancements will ensure sufficient capacity is provided to meet the overall electricity demand at the MC and U zone substations.

7.4 Corporate risk

The individual types of corporate risk are illustrated in Table 27 below.

Table 27: Corporate risk assessment

#	Risk criteria	Risk	Assessment			Risk description and impact (Current risk – what can go wrong in the current situation and what are the potential impacts of this?) (Target risk – what is the rationale for risk improvement, how will the proposed work mitigate the current risk?)
			Consequence	Likelihood	Rating	
1	**Safety**	Current	3	C	High	The issues in the Western Terminal load could result in outages presenting health/safety risks to local customers. It is forecast there could be insufficient capacity by 2016 therefore the likelihood is rated 'possible'.
		Target	3	A	Medium	The proposed solution will provide additional capacity to effectively mitigate the likelihood of outages and associated safety risk. Therefore the likelihood of such a safety issue occurring reduces to 'rare'.
2	**Customers**	Current	2	C	Medium	In the absence of sufficient transformer capacity and feeder transfer capacity, faults occurring during peak demand periods will result in extended outages for customers. The QEII upgrade project would be significantly impacted as Western Power would not be able to provide a reliable and secure electricity supply for this essential service. Potentially more than 4,000 customers supplied by the existing MC and U substations could be affected by outages lasting up to 12 hours. Increasing levels of overloading are expected to lead to more faults. Currently, outages are considered 'possible' but if the situation is not addressed this could be expected to increase to 'almost certain' beyond 2016.
		Target	3	A	Medium	The proposed solution will provide the necessary transformer capacity for load growth and DTC to facilitate networks switching in the event of a fault, therefore effectively mitigating the supply risk.

#	Risk criteria	Risk	Assessment			Risk description and impact (Current risk – what can go wrong in the current situation and what are the potential impacts of this?) (Target risk – what is the rationale for risk improvement, how will the proposed work mitigate the current risk?)
			Consequence	Likelihood	Rating	
3	**Legal/ compliance**	Current	3	C	High	Failure to respond to the customer access application will breach Western Power's regulatory obligation under the Access Code to use reasonable endeavours to accommodate an access application. Western Power is aware of the current non-compliance with certain requirements of the Technical Rules, namely clauses 2.5.2.2 (b), 2.5.5.3 (b) (2) (A) and 2.6(a). Therefore failure to address this could be interpreted as intentional and lead to regulatory action including improvement notices and/or fines.
		Target	2	A	Low	The proposed solution will address Western Power's obligations under section 2.7 and 2.8 of the Access Code. The proposed solution will address the existing non-compliance and so any future breaches could be considered unintentional or isolated so reducing the consequence to 'minor'.
4	**Reputation**	Current	3	C	High	As the development of the QEII site is a critical project for the WA community, any failure to deliver on time is likely to result in damage to key stakeholder confidence and critical state media attention. In the absence of additional transfer capacity and DTC, faults during peak periods will result in extended outages to potentially all 4,000 customers supplied by the MC and U substations.
		Target	2	A	Low	The proposed solution by the required RIS date will meet the requirements of the customer access application and provide the required transformer capacity and DTC and so will effectively mitigate the reputational risk for Western Power.
5	**Environment**	Current	2	A	Low	There is a slight risk of localised environmental damage associated with asset failure due to overloading although this would be expected to be immediately restored.
		Target	2	A	Low	The proposed works will effectively mitigate the environmental risk by as older assets, more prone to failure will be replaced.
6	**Financial**	Current	2	C	Medium	The main financial risk is in the loss of potential revenue with insufficient network capacity to supply increased future load. In addition, increasing levels of overloading will

#	Risk criteria	Risk	Assessment			Risk description and impact (Current risk – what can go wrong in the current situation and what are the potential impacts of this?) (Target risk – what is the rationale for risk improvement, how will the proposed work mitigate the current risk?)
			Consequence	Likelihood	Rating	
						lead to increased fault levels and possible permanent damage to existing distribution assets. This, in turn, will increase replacement costs.
		Target	1	A	Low	The proposed solution provides 70 MVA of capacity (approximately 30 MVA more than the combined capacity of the existing MC and U substations) and replaces older assets with new which will effectively mitigate the financial risk.

Overall, the recommended upgrades will lower the corporate risk from 'High' to 'Medium' reflecting compliance with the Technical Rules and the improved ability to supply new customers and transfer load without shedding during faults through increased transformer capacity and DTC. The total risk movement is shown in Figure 13 below:

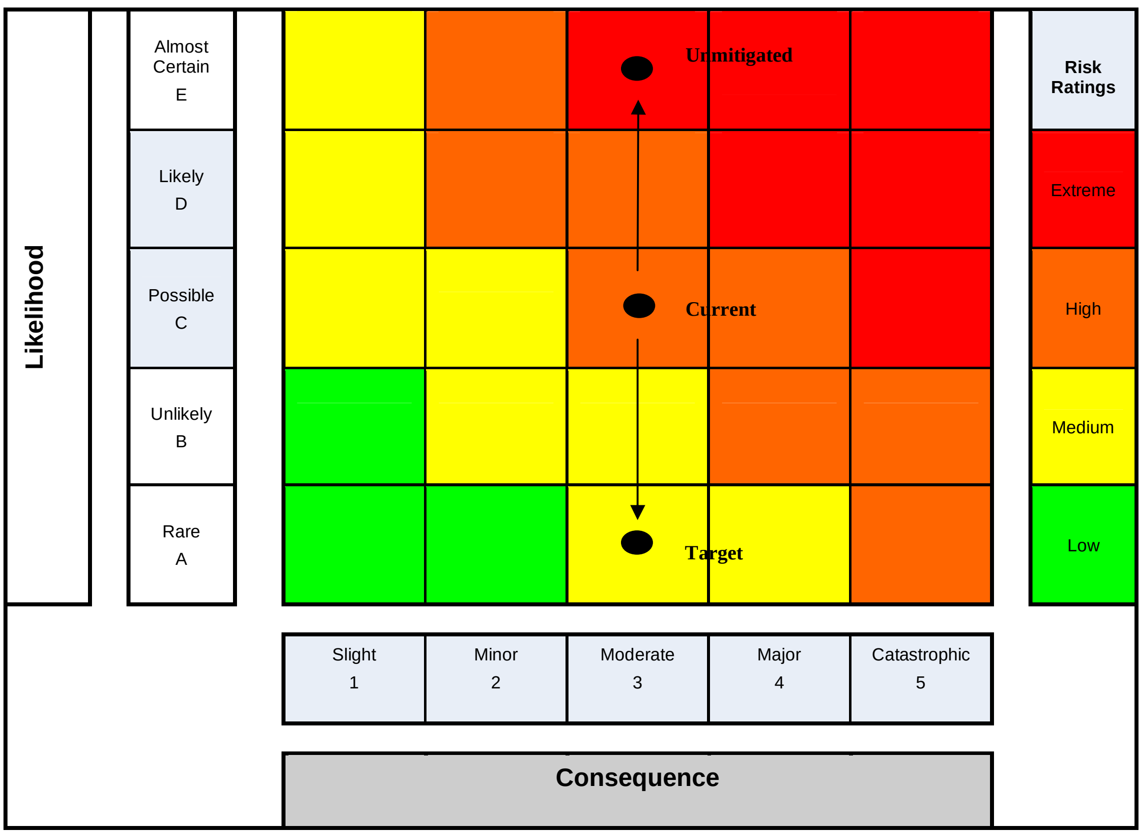


Figure 13: Overall risk movement

7.5 Financial assessment

The total nominal capital cost of the recommended option is $43.567 million as shown in Table 25 above. This figure includes an allowance for risk of $3.696 million and allowance for escalation of $2.864 million.

The NPVs of capital and operating expenditure are $37.51 million and $11.96 million respectively ($49.47 million in total).

Table 28 below shows the profiling of capital expenditure over the five years from 2012.

Table 28: Nominal expenditure profile five years from base year (2012) ($M)

Option 3 – Construction of new MCE zone substation with 3 x 33 MVA 132-66/11 kV transformers	2012 $M	2013 $M	2014 $M	2015 $M	2016 $M	Total $M
Escalated nominal capital budget from IEM for the recommended option	6.747	12.124	20.069	4.626	0.000	43.567

Note: *The above figures are based on A1 estimate costs, and will subsequently be refined at the A2 level as part of the business case development.*

The expenditure is classified as capital under the Capacity Expansion Regulatory category.[52]

This project already has budget allocated for it in AA3 estimates and the Approved Works Programme (AWP).

An Investment Evaluation Model (DM# 8769448) has been prepared for comparing options; this model is the main source of the financial information shown above.

7.6 Procurement and delivery strategy

All available primary plant will be sourced from inventory. The remaining services, materials and equipment required to undertake this program are sourced in accordance with Western Power's corporate and procurement policies. This ensures compliance with the following requirements:

- Western Power's agreements are established via a competitive process to meet business requirements and deliver value for money.
- The selection, evaluation and award process is supported by the engagement of relevant subject matter experts, meeting Western Power's standards including safety, environmental, technical, commercial and qualitative.
- All equipment procurement is facilitated by panel agreements, short form contracts or strategic alliance agreements.

[52] It is envisaged that a small element of this project is likely to be customer-funded due to the brought-forward costs. This is explained in more detail in the pre-NFIT submission (DM# 9630557)

The construction of building, Civil Works and Steel Structures, Electrical Construction and line works will be awarded to external contractor which are subject to a competitive tender process or Request for Quotation (RFQ) process. This Competitive External Bidding Process is performed to ensure the lowest market rate is attained from preferred contractor's quotes. Internal resources may be used as an alternative option as required.

Distribution works which may use either internal resources or Distribution Delivery Partners (DDP) are subject to the workload and available resources at the time the works are required.

7.7 Communications strategy

The construction work associated with this project will be carried out within the proposed MCE zone substation site.

Environment and Community Engagement Branch will manage environmental issues and stakeholder liaison in accordance with our standard procedures and do not expect that there will be any unusual impediments to the successful completion of this project. The Community Engagement Plan[53] has already been prepared and outlines the community consultation activities that will be undertaken.

7.8 Access Code considerations

Section 6.52(a) of the *Electricity Networks Access Code 2004* (the Code) requires Western Power to demonstrate that the amount invested in the proposed project does not exceed the amount that would be invested by a service provider efficiently minimising costs.

Section 6.52(b) of the Code is satisfied if one or more of three conditions are met, namely:

- The anticipated incremental revenue for the new facility is expected to at least recover the new facilities investment.
- The new facility provides net benefits in the covered network over a reasonable period of time that justifies the approval of higher reference tariffs.
- The new facility is necessary to maintain safety or reliability of the covered network or to provide contracted covered services.

This project is a combined investment that addresses both customer-driven requirements and Western Power needs. Accordingly, these two components of the overall investment will be assessed separately with respect to Section 6.52(b) of the Code as follows:

53 The Community Engagement plan reference is DM# 8638471.

Customer-driven components of work:

- Establish a new 132-66/11 kV MCE zone substation with two 33 MVA 132-66/11 kV transformers.
- Transfer the load from the existing 66/6.6 kV MC zone substation to the new 132-66/11 kV MCE zone substation and upgrade the operating voltage from 6.6 kV to 11 kV.
- Decommission the existing MC zone substation.

Western Power driven components of work:

- Install the third 33 MVA 132-66/11 kV transformer and associated 11 kV switchboard at MCE zone substation.
- Transfer the load from the existing 66/6.6 kV University (U) zone substation to the new 132-66/11 kV MCE zone substation and upgrade the operating voltage from 6.6 kV to 11 kV.
- Decommission the existing U zone substation.

The reasons the proposed expenditure meets Sections 6.52(a) and 6.52(b) of the Code are set out below.

7.8.1 NFIT part (a)

Section 6 describes the options considered and Section 7 outlines the relative advantages of the preferred option. Since the cost of the preferred option is less than the cost of any alternative that provides equivalent reliability and capacity benefits, it represents the least cost option.

The proposed new MCE zone substation will also be designed in accordance with Western Power's design standards for 132/22 kV zone substations (DM# 3470476) which have been peer reviewed by Hydro Tasmania and deemed to be "industry standard".

Section 7.6 describes the competitive process that will be used to procure a contractor to deliver the project. Project materials will be procured from suppliers established by a competitive process.

The combination of option selection, competitive procurement of materials and delivery services demonstrates that Western Power is efficiently minimising costs and therefore satisfies part (a) of the NFIT test.

7.8.2 NFIT part (b)

Customer-driven components of work:

Western Power considers that the new facilities investment associated with the customer-driven connection works meets Section 6.52(b)(i) with the following exceptions:

- Connection assets
- Shared works not offset by incremental revenue

Full details of this assessment are outlined in Western Power's Pre-NFIT application (DM# 9630557).

Western Power driven components of work:

The Western Power component of the proposed investment is directed at increasing capacity at the Medical Centre zone substation and phasing out the ageing assets that needs to be replaced.

The project is required to maintain the reliability of the network consistent with the obligations that arise from 'Technical Rules' clause 2.5.5.3(b)2(A) (urban distribution feeders to be designed for sufficient backup capabilities). The risk analysis described in Section 7.3 also demonstrates that this project is required for the safety of the public. The project therefore also satisfies Section 6.52(b) (iii) of the code as the expenditure is necessary to maintain the safety and reliability of the network and to ensure the network is able to provide contracted covered services.

8 Conclusion

A summary of the options considered for reinforcement at Medical Centre is provided in Table 25 above and is replicated here for information.

Table 29: Summary of option costs and benefits

#	Option title	Nominal capital cost ($M) [12]	PV Total cost ($M) [13]	Improves reliability	Increases capacity	Mitigates risk	Comments
1	Establish new 132/66/11 kV zone substation with two 66 MVA transformers	43.569	49.48[14]	☑	☑	☑	Although this option has the same NPC as Option 3 it is discounted on the basis of the increased technical risk introduced by the non-standard transformers. Not recommended
2	Establish new 66/11 kV new zone substation with three 33 MVA transformers	44.891	50.00	☑	☑	☑	Highest nominal capital cost and NPC. In addition this option represents suboptimal asset utilisation as the three 66/11 kV transformers will need to be replaced before the substation can be energised to 132 kV. Not recommended
3	Establish new 132-66/11 kV new zone substation with three 33 MVA transformers	43.567	49.47	☑	☑	☑	Least nominal capital cost and equal least cost NPC. Addresses all network constraints and customer requirements without introducing any additional technical risk. **Recommended option**
4	Demand Side Management	N/A	N/A	☒	☒	☒	DM savings are lower than savings from deferring the recommended option by one year. A DM solution would also not be able to address the ageing/poor condition assets. Not feasible.
5	Transfer load to surrounding zone substations	N/A	N/A	☒	☒	☒	The redistribution of load through switching is not achievable due to the existing constrained capacity issues on the surrounding distribution feeder network. Not feasible.

This table shows that Option 3 is the most cost effective and feasible option to solve the problems of:

- regulatory non-compliance
  - by providing sufficient capacity to avoid an unacceptable load at risk (Technical Rules 2.5.4 (b), NCR criterion)
  - by providing the required feeder backup (Technical Rules 2.5.5.3 (b) (2) (A))
- forecast load growth

  - provision of 70 MVA of capacity (approximately 30 MVA more than the combined capacity of the existing MC and U substations) to accommodate increasing demand in the existing MC and U areas

- consistency with the Western Terminal load area long term strategic option review

It is recommended that Option 3 be chosen and approval be granted to establish a new 132-66/11 kV zone substation (MCE) on land provided by the QE II Medical Centre adjacent to the existing MC zone substation site. Construction of the MCE zone substation will include installing three 33 MVA 132-66/11 kV transformers as outlined in Section 6.3 above.

Note: The costs outlined in Table 29 above have been determined using A1 estimate costs as part of the specific QEII project development. These costs are more refined than those used in the long term strategic option review for the Western Terminal load area (DM# 8381133), which used building block costs. Furthermore, the long term strategic option review excluded costs that were common to all options (as the assessment was only undertaken for comparative purposes). The costs determined as part of the QEII project development therefore represent the most accurate figures available at this stage of the project cycle and will not align with those determined as part of the long term strategic option review for the Western Terminal load area.

Appendix A. Investment Evaluation Model

A.1 Output from the IEM, DM# 8769448

Investment Evaluation Model Output # 1 - Options Analysis & Sensitivity Analysis

A Options Analysis - Net Present Cost for each Option by Expenditure Type in Real Terms

All Values in Millions ($M) / Ranking of 1 reflects Lowest NPC

	Options	Options Analysis					
		Total Capex	Capex Rank	Total Opex	Opex Rank	Total Expenditure	Overall Rank
1	132/66/11/11 new substation with two 66MVA transformers ene	37.51	2	11.97	2	49.48	2
2	66/11 new substation with three 33MVA transformers	37.85	3	12.15	3	50.00	3
3	132-66/11 new substation with three 33MVA transformers	37.51	1	11.96	1	49.47	1
4	Demand Side Management (DM)	N/A	N/A	N/A	N/A	N/A	N/A
5	Transfer load to surrounding zone substations	N/A	N/A	N/A	N/A	N/A	N/A
6	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Least Cost Option (Capex Rank)	Option 3
Least Cost Option (Total Rank)	Option 3

B Sensitivity Analysis - Parameters

Sensitivity Parameters	Business Case Capex	Other Capex	Business Case Opex	Other Opex
High State (%) - User to Amend as Required	110%	150%	110%	150%
Medium (Base Case %)	100%	100%	100%	100%
Low State (%)	90%	50%	90%	50%

C Sensitivity Analysis - NPC (Total Expenditure) over the Evaluation Period across Sensitive Inputs

All Values in Millions ($M)

	Options	Sensitive Financial Inputs					
		NPC if only Capex Inputs Change			NPC if only Opex Inputs Change		
		High State	Med (Base Case)	Low State	High State	Med (Base Case)	Low State
1	132/66/11/11 new substation with two 66MVA transformers ene	53.23	49.48	45.73	50.68	49.48	48.28
2	66/11 new substation with three 33MVA transformers	53.78	50.00	46.21	51.21	50.00	48.78
3	132-66/11 new substation with three 33MVA transformers	53.22	49.47	45.72	50.67	49.47	48.28
4	Demand Side Management (DM)	N/A	N/A	N/A	N/A	N/A	N/A
5	Transfer load to surrounding zone substations	N/A	N/A	N/A	N/A	N/A	N/A
6	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	N/A	N/A	N/A	N/A	N/A	N/A	N/A

D Sensitivity Analysis - Ranking of Options by NPC (Total Expenditure) across Sensitive Inputs

Ranking of 1 reflects Lowest NPC

	Options	Sensitive Financial Inputs					
		Ranking if only Capex Inputs Change			Ranking if only Opex Inputs Change		
		High State	Med (Base Case)	Low State	High State	Med (Base Case)	Low State
1	132/66/11/11 new substation with two 66MVA transformers ene	2	2	2	2	2	2
2	66/11 new substation with three 33MVA transformers	3	3	3	3	3	3
3	132-66/11 new substation with three 33MVA transformers	1	1	1	1	1	1
4	Demand Side Management (DM)	N/A	N/A	N/A	N/A	N/A	N/A
5	Transfer load to surrounding zone substations	N/A	N/A	N/A	N/A	N/A	N/A
6	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	N/A	N/A	N/A	N/A	N/A	N/A	N/A

E Selection of Recommended Option

Recommended Option	Option 3	DM reference of IEM:	8769448

If the preferred option which efficiently minimises cost is not recommended, please ensure justification for this recommendation is provided within the business case.

A.2 Output from the IEM, DM# 8769448,

Investment Evaluation Model Output # 2A

A Total Business Case Capital Expenditure (in Nominal terms)

All Figures in Millions ($M)

#	Option	Base Capex Budget * (A)	Risk Allowance (B)	Escalation Allowance (C)	Total Capex Budget (D=A+B+C)
		Nominal Capital Expenditure			
1	132/66/11/11 new substation with two 66MVA transformers energised	36.895	3.819	2.855	43.569
2	66/11 new substation with three 33MVA transformers	37.840	3.696	3.355	44.891
3	132-66/11 new substation with three 33MVA transformers	37.007	3.696	2.864	43.567
4	Demand Side Management (DM)	N/A	N/A	N/A	N/A
5	Transfer load to surrounding zone substations	N/A	N/A	N/A	N/A
6	N/A	N/A	N/A	N/A	N/A
7	N/A	N/A	N/A	N/A	N/A
8	N/A	N/A	N/A	N/A	N/A

B Total Business Case Operating Expenditure over the Evaluation Period (in Nominal terms)

All Figures in Millions ($M)

#	Option	Base Opex Budget * (A)	Risk Allowance (B)	Escalation Allowance (C)	Total Opex Budget (D=A+B+C)
		Nominal Operating Expenditure			
1	132/66/11/11 new substation with two 66MVA transformers energised	34.200	0.000	91.939	126.139
2	66/11 new substation with three 33MVA transformers	34.814	0.000	93.776	128.590
3	132-66/11 new substation with three 33MVA transformers	34.190	0.000	91.914	126.105
4	Demand Side Management (DM)	N/A	N/A	N/A	N/A
5	Transfer load to surrounding zone substations	N/A	N/A	N/A	N/A
6	N/A	N/A	N/A	N/A	N/A
7	N/A	N/A	N/A	N/A	N/A
8	N/A	N/A	N/A	N/A	N/A

Please Note "N/A" reflects that an option is either not applicable or not feasible as per the selection in Section 4 of the Business Case Inputs worksheet.
Please refer to the Options Analysis section of the business case for details.

* This column represents the total unescalated budget for each option pre any applicable Risk & Escalation allowances. This amount includes all applicable direct base costs plus all indirect costs attributable to the business case option.

DM reference of IEM: 8769448

Investment Evaluation Model Output # 2B

C Annual Budget Breakdown for the Recommended Option (in Nominal Terms)

All Figures in Millions ($M)

Recommended Option: Option 3

Cost Type	Pre Base Year	2012	2013	2014	2015	2016	Totals
Capex							
Unescalated Nominal Budget (excl. risk allowance)	0.000	6.135	10.518	16.653	3.701	0.000	37.007
Escalation Allowance	0.000	0.000	0.555	1.753	0.556	0.000	2.864
Escalated Nominal Budget (excl. risk allowance)	0.000	6.135	11.073	18.406	4.256	0.000	39.870
Risk Allowance	0.000	0.613	1.051	1.663	0.370	0.000	3.696
Escalated Nominal Capex Budget (incl. risk)	0.000	6.747	12.124	20.069	4.626	0.000	43.567
Opex							
Unescalated Nominal Budget (excl. risk allowance)	0.000	0.000	0.000	0.000	0.000	0.855	0.855
Escalation Allowance	0.000	0.000	0.000	0.000	0.000	0.189	0.189
Escalated Nominal Budget (excl. risk allowance)	0.000	0.000	0.000	0.000	0.000	1.044	1.044
Risk Allowance	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Escalated Nominal Opex Budget (incl. risk)	0.000	0.000	0.000	0.000	0.000	1.044	1.044

Please Note that the above 'Yearly Budget Breakdown' only presents the funding implications of the chosen option for five years from the base year (inclusive).

A.3 Output from the IEM, DM# 8769448

Investment Evaluation Model Output # 3

A NFIT Compliance Summary

(All values in $ Millions unless stated)

	(A)	(B)	(C=A+B)	(D)	(E=C+D)	(F)	(G)	(H=E+F+G)		(I=(D+F+G)/C)
Recommended Option	Present Value Business Case Capex Expenditure	PV Connection Works	PV BC Capex Subject to 6.52(b) of NFIT	PV BC Capex which satisfies Safety & Reliability Test	PV BC Capex Not Satisfied by S&R test	PV Incremental Revenue Test	PV Net Benefits Test	PV BC Capex Not Satisfied under Section 6.52(b) of NFIT	PV Customer Contributions	Section 6.52(b) NFIT Test Ratio
Option 3	-37.51	0.00	-37.51	37.51	0.00	0.00	0.00	0.00	0.00	1.00

Recommended Option - Section 6.52(a) of the Access Code	Option 3
Primary test of Section 6.52(b) of the Access Code:	Safety and Reliability
Internal Assessment of NFIT:	NFIT Compliant
Total Nominal CAPEX (in $M) which satisfies NFIT:	$43.567
DM reference of IEM:	8769448

Appendix B. Distribution feeder circuits

B.1 Medical Centre zone substation

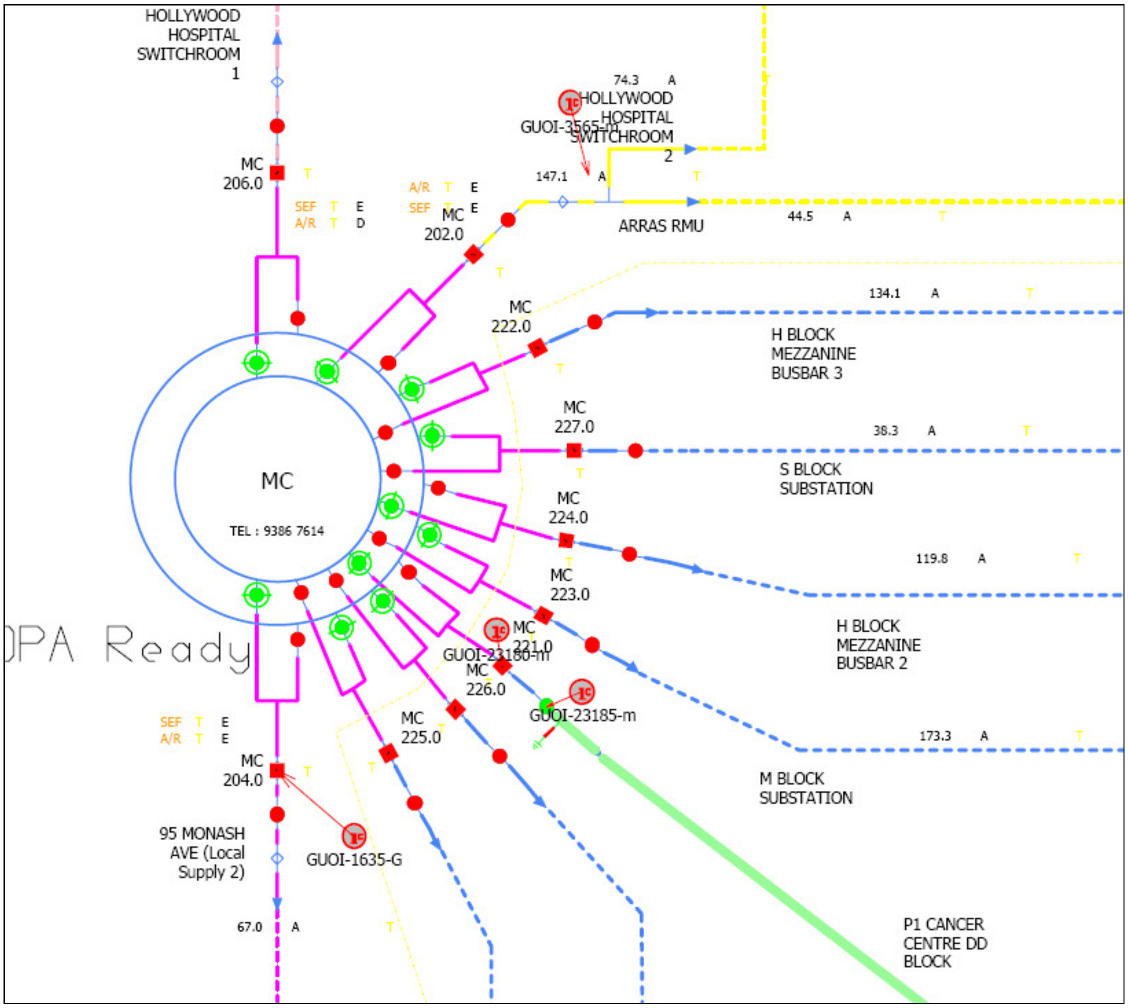


Figure 14: Medical Centre distribution feeder circuits

B.2 University zone substation

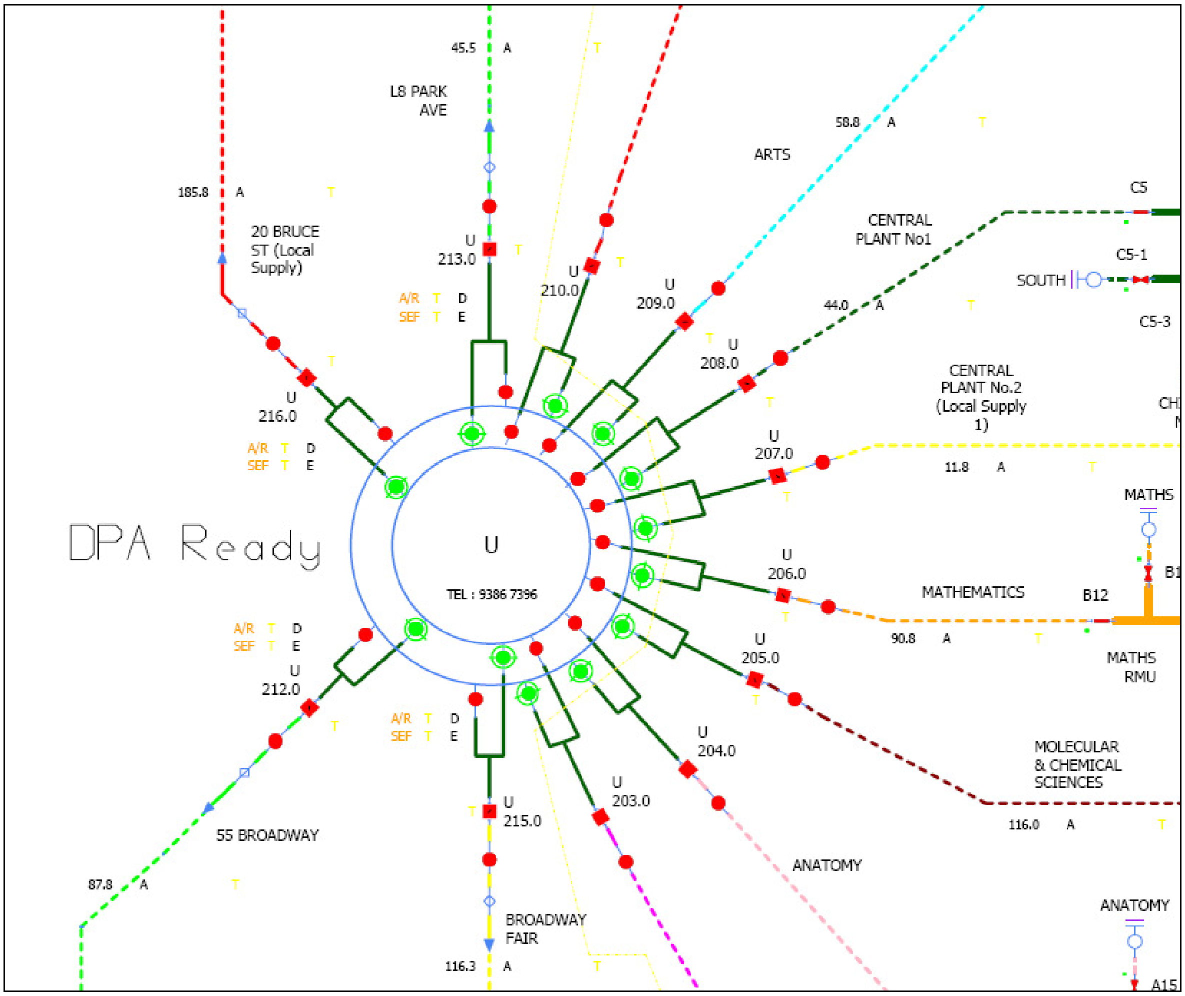


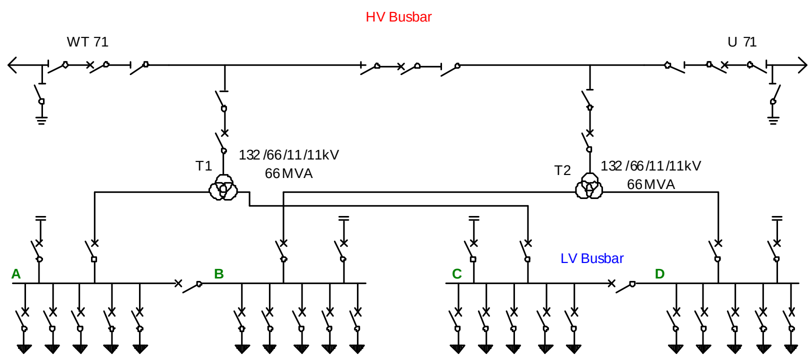
Figure 15: University distribution feeder circuits

Appendix C. Load rejection study for 66 MVA transformers

The following supplementary analysis was undertaken part of the Option 1 consideration (i.e. the use of 66 MVA transformers) to better understand the implications of the dual LV winding configuration on voltage control.

Parameters

TAP HV-Side	9
Load A	14.85MW, 7.19MVAr
Load B	14.85MW, 7.19MVAr
Load C	14.85MW, 7.19MVAr
Load D	14.85MW, 7.19MVAr
Bus A & B paralleled	
Bus C & D paralleled	



Contingency - Losing of	Voltage (p.u.) - Automatic Tap		Voltage (p.u.) - Fixed Tap	
	Bus A & B	Bus C & D	Bus A & B	Bus C & D
None	1.02	1.02	1.02	1.02
Load D	1.00	1.03	1.00	1.02
Load C & D	0.98	1.03	1.02	1.06
T2	1.01	1.01	0.90	0.90
T2 & Load D	0.98	1.04	0.95	1.02
T2 & Load C & D	0.91	1.03	0.98	1.09

Figure 16: Contingencies impact on voltage

Figure 16 shows that during contingencies of losing a transformer and/or load, the voltages of all the busses are within the Technical Rules.

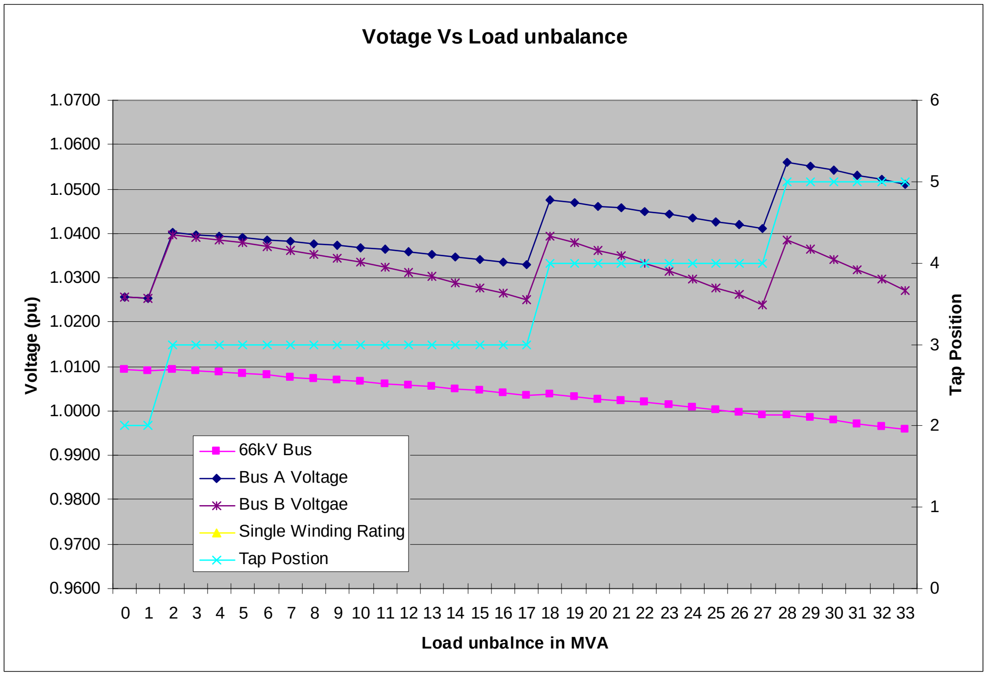


Figure 17: Load unbalance vs. Voltage (66kV)

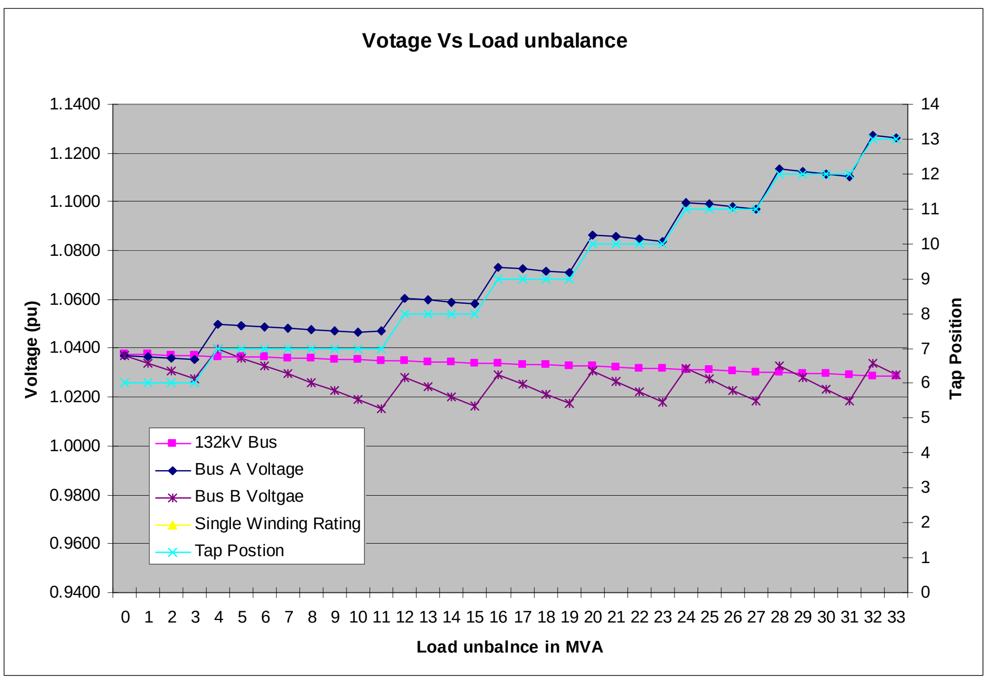


Figure 18: Load unbalance vs. Voltage (132kV)

Figure 17 and Figure 18 above show that as the amount of unbalance load increases, the voltages difference between bus A and bus B are widened. However, these voltages are still within Technical Rules limit (i.e. between 0.90 and 1.10 p.u.)

Appendix D. Bibliography

D.1 List of formal references

The studies associated with this planning report are based on the following technical references and formal Western Power documents.

Table 30: Formal documents referenced in this document

DM# Ref	Title of document
6800863	Technical Rules
4880519	Rural Distribution Planning Criteria
	Electricity Industry (Network Quality and Reliability of Supply) Code 2005
	ENA C(b)1-2006, Guidelines for Design and Maintenance of Overhead Distribution and Transmission Lines
3341162	Risk Assessment Criteria