ATTACHMENT 1

Major Augmentation Proposal
Options Paper
Establish New Shenton Park Zone Substation
Western Terminal Reinforcement project

MAJOR AUGMENTATION PROPOSAL

Options Paper

ESTABLISH NEW SHENTON PARK ZONE SUBSTATION

Western Terminal Reinforcement Project

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safe reliable efficient

DOCUMENT PURPOSE

For the benefit of those not familiar with the Electricity Networks Access Code 2004, Western Power offers the following clarifications on the purpose and intent of this document:

1. Western Power as a prudent electricity networks business is required to carry out forward planning to identify future reliability of supply requirements and to issue this type of document for proposed "Major Augmentations" to the covered network.

2. The Electricity Networks Access Code 2004 requires that Western Power should properly assess each Major Augmentation to determine whether it maximises the "Net Benefit" to those who generate, transport or consume electricity after considering alternative options.

3. This document contains the results of this assessment and a draft recommended solution to address future supply requirements from the summer of 2015/16. Interested parties are invited to comment on the draft recommendation.

What the document does NOT mean:

A. It does NOT mean that the electricity supply interruptions are imminent. The identified supply requirements are expected to occur some years into the future, assuming that demand for electricity continues to grow as forecast. There is sufficient time between now and then to implement a solution.

B. It does NOT mean that Western Power has been surprised. It is in fact part of the standard Western Power planning processes.

Executive Summary

Introduction

Demand for electricity in the Western Suburbs of Perth is forecast to continue growing into the future and this demand will increase the loading in the electricity network in the area. This is expected to result in the need for investment from summer 2015 to ensure that customers continue to receive a reliable electricity supply. In addition, the age and condition of a significant number of the electricity network's transmission elements and substation assets in the area are expected to reach the end of their useful economic lives within the next 25 years.

Western Power recognises the importance of reliable electricity supply to customers and has completed planning investigations to identify the most appropriate course of action to continue to meet the needs of its customers in the Western Suburbs.

This document outlines the options considered by Western Power to address the need to increase the electricity supply capacity to the Western Suburbs area to meet forecast demand and presents the assessment of those options. Western Power has made a draft recommendation supporting the option which in its view maximises the Net Benefit to those who generate, transport or consume electricity. This option proposes a series of network investments in the Western Suburbs, one of which involves the construction of a new 132/11kV substation at Shenton Park, which is the subject of this document.

In accordance with the requirements of chapter 9 of the Electricity Networks Access Code 2004, Western Power has prepared this Options Paper for public consultation as part of the Regulatory Test process for a Major Augmentation Proposal to the Western Power network. The objective of the Options Paper is to inform the public in general and interested parties in particular of the Major Augmentation Proposal and to obtain input with regard to any additional or alternative considerations. Key stakeholders are encouraged to submit opinions and to offer alternative solutions to the ones proposed here by Western Power. A summary of the outcomes of the public consultation and submissions will be published as part of Western Power's submission to the Economic Regulation Authority (ERA) for a Major Augmentation Proposal and associated Regulatory Test requirements.

The main elements of the Major Augmentation Proposal covered by this Options Paper are as follows:

- The establishment of a new 132kV/11kV zone substation at Shenton Park (SPK) containing 2 x 75MVA 132/11/11kV transformers and 2 line circuits
- The overhead line works associated with the 2 x 132kV WT-SPK line circuits (including the temporary stage involving the 132kV WT- NT line cut-in)
- The conversion and upgrade of the Shenton Park distribution network from 6.6kV to 11kV
- The decommissioning of the existing 66kV/6.6kV Shenton Park (SP) zone substation
- The conversion and upgrade of the Herdsman Parade zone substation distribution network from 6.6kV to 11kV
- The migration of the Herdsman Parade zone substation load to the new 132kV/11kV Shenton Park zone substation
- The decommissioning of the Herdsman Parade 66kV/6.6kV zone substation

Options Considered

The assessment of potential long term development strategies for the Western Suburbs over a 25 year period 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

Assessment of these investment drivers across the Western Suburbs area over the considered 25 year strategy period led to the development of four discrete development Strategies:

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

Non-network alternatives have also been considered as part of these strategies.

In 2015 the first key investment in the Western Suburbs is required at Shenton Park substation. The option at Shenton Park is a key decision that sets the investment direction for the wider area. In order to determine the most appropriate option for Shenton Park it is necessary to understand the long term impact of this decision to ensure a globally efficient outcome rather than just the short term efficiency at Shenton Park alone. Therefore this paper assesses the long term impact of the Shenton Park investment decision in the context of the Western Terminal load area across the 25 year period rather than just the Shenton Park decision in isolation.

Evaluation and Conclusion

With the expected level of asset replacement and forecast network capacity limitations over the 25 years strategy period, there is a significant opportunity to investigate potential alternative approaches for the transmission system design in this area, rather than just considering like-for-like asset replacements or assets with marginally increased thermal capacity.

The four capital investment development strategies identified were evaluated against a range of financial and technical performance metrics resulting in the identification of Strategy 3 as the most appropriate long term development solution for the Western Suburbs area. Strategy 3 is recommended as it meets all the required technical performance standards whilst minimising the present value costs across the 25 year period.

Strategy	Description	NPC, $M	Remaining TX MVA at 2035	$M (NPC) / 2035 MVA
1	Retain 66kV and upgrade network capacity	117.7	42	2.80
2	Shenton Park Upgraded to 132kV with Herdsman Parade decommissioned.	114.8	92	1.25
3	Shenton Park & Medical Centre Upgraded to 132kV with Herdsman Parade & University decommissioned.	**112.1**	107	1.05
4	Full 132kV Migration of Shenton Park, Medical Centre, Wembley Downs & Nedlands with Herdsman Parade & University decommissioned.	119.4	117	1.02

Contained within the four development strategies outlined above are three variations for the specific investment at Shenton Park (Strategy 3 and 4 have the same investment proposed for Shenton Park). The three Shenton Park investment options are summarised below.

Strategy	Substation / Circuit	Proposed Augmentation	Cost, $M (nominal 2010)
1	Shenton Park	New Zone Substation at existing site with 3 x 35 MVA 66/11kV transformers	17.89
2	Shenton Park	New Zone Substation at existing site with 2 x 75 MVA 132/11 kV transformers (dual winding 75 MVA)	23.29
3 & 4	Shenton Park	New Zone Substation at existing site with 2 x 75 MVA 132/11 kV transformers (dual winding 75 MVA) with provision for two additional 132kV feeders	26.03

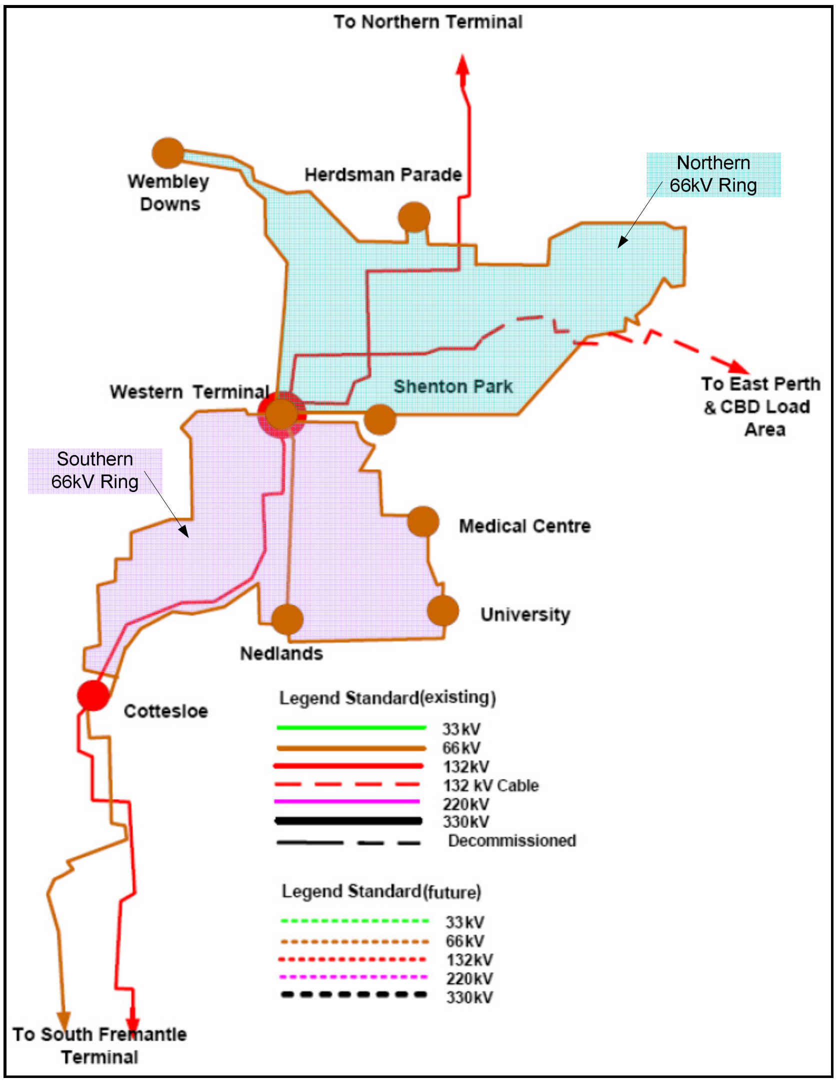
The results of sensitivity testing involving variation in cost and other assumptions also demonstrate an outcome consistent with the base case economic analysis. Strategy 3 is seen to have the lowest Net Present Cost when considering alternative options.

1 Background

1.1 Geographic Area

Western Terminal substation presently supplies six substations in two distinct 66kV rings, one to the North and one to the South as shown in Figure 1 below. The 132kV infeeds to Western Terminal are currently 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 (2011)



1.2 Existing Supply Arrangements

The Western Terminal load area contains mostly residential and commercial loads with some light industrial load and is a mature and well established region. All customers are supplied at 415V with the exceptions of Sir Charles Gardiner Hospital (Medical Centre substation) and the University of Western Australia (University substation) which are currently supplied directly at 6.6kV and Hale School and Floreat Shopping Centre (Wembley Downs substation) which are currently supplied directly at 11kV.

1.3 Committed Network Developments

There are no committed transmission investments for the Western Terminal load area. It is to be noted however that the upgrade of Shenton Park to 132/11kV operation has been incorporated within the preliminary Access Arrangement 3 (AA3) submission.

1.3.1 Medical Centre Regulatory Test Waiver

The QEII Medical Centre (Sir Charles Gairdner Hospital), presently connected to Medical Centre Zone Substation, is in the process of a major upgrade. This upgrade will increase the load from 12.5 MVA to 23 MVA in 2015 then 27.5 MVA by 2020. This load increase is driving a customer-driven project to upgrade the Medical Centre substation distribution voltage from 6.6kV to 11 kV by June 2014.

In March 2008, Western Power made a submission to the ERA to waive the Regulatory Test for a 66/11kV Medical Centre zone substation expansion and voltage conversion of the distribution network. In April 2008, the ERA approved the Regulatory Test waiver and determined that *"the application of a regulatory test in respect of the proposed Major Augmentation would be contrary to the objectives of Chapter 9 of the Access Code".*[1]

As a consequence of the Regulatory Test waiver, this Options Paper is not specifically seeking endorsement or comments regarding the Medical Centre development works. The scope of this work has been included however as it is an integral component of the overall Western Terminal 25 year strategy.

1.4 Existing and Committed Generation Facilities

The Charles Gardner Hospital is proposing a combined heat, cooling and power installation within the hospital but this has been included within the load forecasts. The impact of embedded Photovoltaic (PV) generation is included in the load forecasts on a SWIS wide basis.

Aside from these development plans, there are no additional customer projects regarding the connection of generation within the Western Terminal load area.

[1] The ERA confirmed in 2011 that the Medical Centre Regulatory Test waiver is still valid.

2 Electricity Demand

2.1 Overview

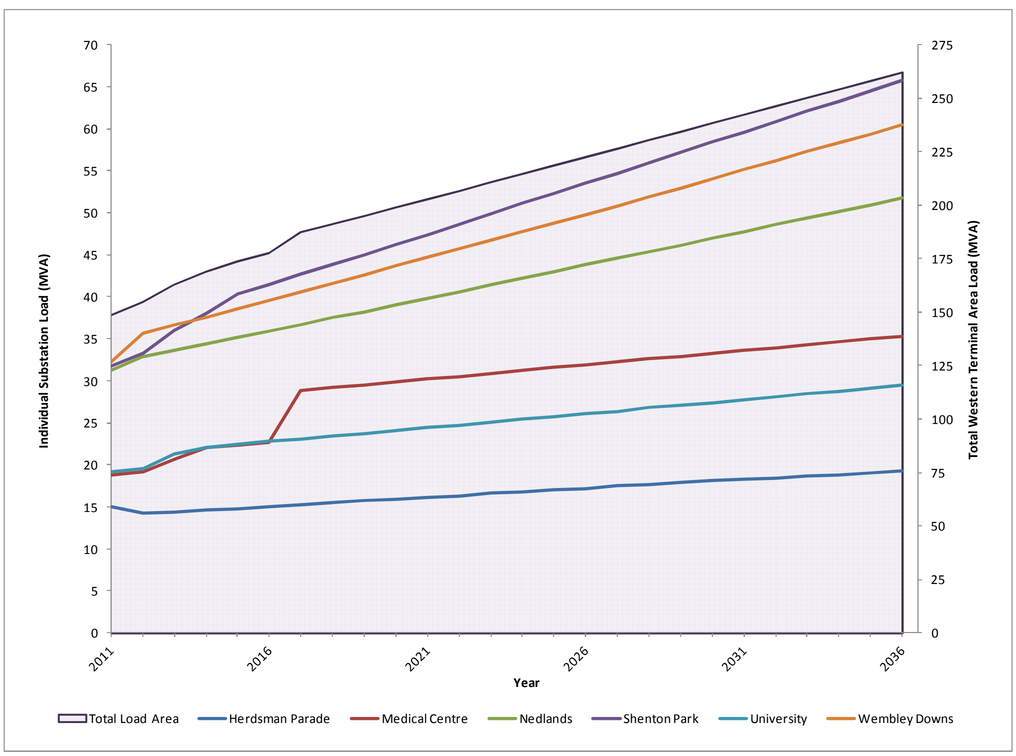
The studies referred to in this Options Paper are based on the Western Power, May 2011 release, load forecast with only firm projects included. The load forecasts for each site are based on a 10% Probability of Exceedance (PoE) which is consistent with the Western Power Transmission Planning Guidelines. The load forecast is utilised as a guide to the triggers and staging of developments described within the strategies. It is noted that these triggers will vary year on year as more refined forecasts are provided, however the comparative assessment of a preferred solution will be largely unaffected.

Peak load diversity has been excluded from this assessment and it is assumed that all substations will peak at the same time to provide a worst case scenario development study. This is considered to be a fair assumption due to the load in the Western Terminal area being primarily residential and concentrated within a relatively compact metropolitan area such that load peaks will naturally occur at comparable times largely driven by high ambient temperatures.

2.2 Load Forecast

It is forecast (as shown in Figure 2 below) that the load growth within the Western Terminal load area over the next 25 years will be driven organically through residential and commercial customers. Developments in the area are expected to be centred on the rationalisation of existing land uses such as higher density residential and commercial buildings, with very few greenfield developments. However, the area contains most of the affluent suburbs of Western Australia and it is experiencing a considerable infiltration of air-conditioning use, which is believed to be the cause of the area's significant load growth in the past few years. The re-zoning and re-development of parts of the Western Terminal load area has contributed significantly to the area's high load growth, with the re-zoning to high density residential of areas such as Mt Claremont resulting in extensive developments of many high electricity-consumption residences.

Figure 2 2011-2036 Load Forecast (10% PoE)



3 Forecast Reliability of Supply Requirements

3.1 Planning Criteria for Network Development

Western Power has security, reliability and quality of supply obligations defined in the Technical Rules (April 2007) and identified in Chapter 12 the Electricity Networks Access Code 2004.

Both of these documents require Western Power comply with *Good Electricity Industry Practice* such that the Western Power network must be able to meet forecast electricity demand during the outage of the single most critical network element (known as the N-1 Criterion[2]) unless agreed with affected parties.

Western Power continuously assesses the current and future capability of its network and takes action to ensure that it will continue to meet the required performance standards. As a part of these planning processes Western Power has identified that action is required to ensure that the network supplying the Western Suburbs of Perth will be able to meet these obligations for forecast peaks demands from summer 2015. Solutions to address the forecast requirements are therefore classified under 'Safety or Reliability' as referenced in 6.52 (b) iii of the Electricity Networks Access Code 2004.

3.2 Supply and Demand Assumptions

In its assessment of the network capability, Western Power has made the following assumptions.

Generation

There is no local transmission connected generation in the Western Terminal Load area. The generation pattern used on the Western Power Network was based on the highest probability generation scenario[3].

The impact of embedded Photovoltaic (PV) generation is included in the 2011 load forecasts on a SWIS wide basis.

Demand

The electricity demand forecast is based on the Western Power central load forecast and hot weather conditions (10% PoE).

The Western Power central forecast contains the under lying load growth plus known load increases that are in excess of the under lying load growth with a high level of confidence of proceeding[4].

Transformer Capacities

The transformer ratings in this document refer to the expected transformer cyclic ratings (35MVA & 75MVA), rather than the respective transformer nameplate ratings (33MVA & 66MVA).

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[2] Refer Clause 2.5.2.2 of the Technical Rules

[3] As described in Chapter 5 in Western Power's 2011 Annual Planning Report

[4] Further information on the Western Power forecasting processes can be found in Chapter 4 of the 2011 Annual Planning Report

3.3 Network Capability and Future Supply Requirements

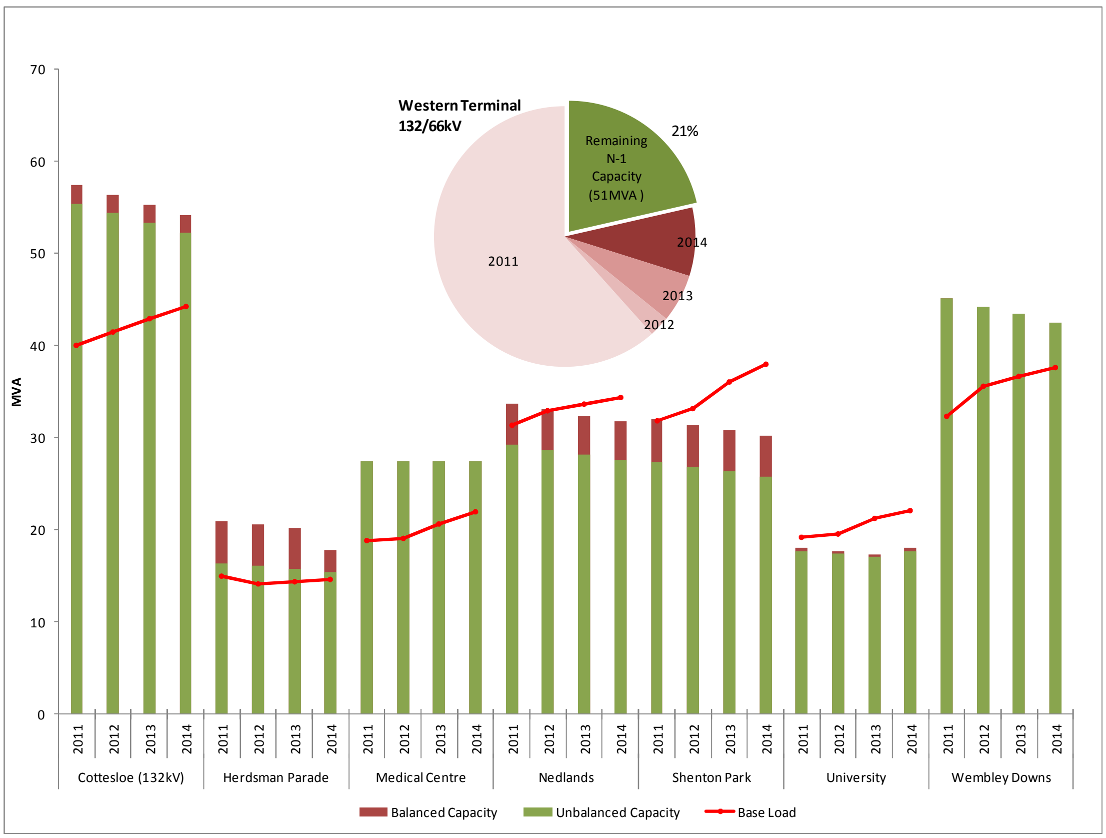
3.3.1 Overview of Transmission System Limitations

3.3.1.1 Substation Capacity

It is seen from Figure 3 below that there is a severe lack of transformer capacity throughout the Western Terminal load area in the immediate to short term. Of the six 66kV substations in the Western Terminal load area, Nedlands, Shenton Park and University are non compliant with the Transmission Planning Guidelines by the 2011/12 summer peak due to insufficient available transformer capacity. Medical Centre and Wembley Downs substations are forecast to be non-compliant with Normal Cyclic Rating (NCR) requirements[5] by 2016 and 2018 respectively.

The total growth of the load area is illustrated by the transformer loading at the Western Terminal 132/66kV transformers which are required to operate to an N-1 security standard. The pie chart shown in Figure 3 illustrates the reduction in available capacity as load increases from 2011-2014 with a remaining capacity of approximately 51MVA (21%) post 2014. There will be insufficient capacity to maintain N-1 compliance by 2020.

Figure 3 Substation Capacity Summary: 2011-2014

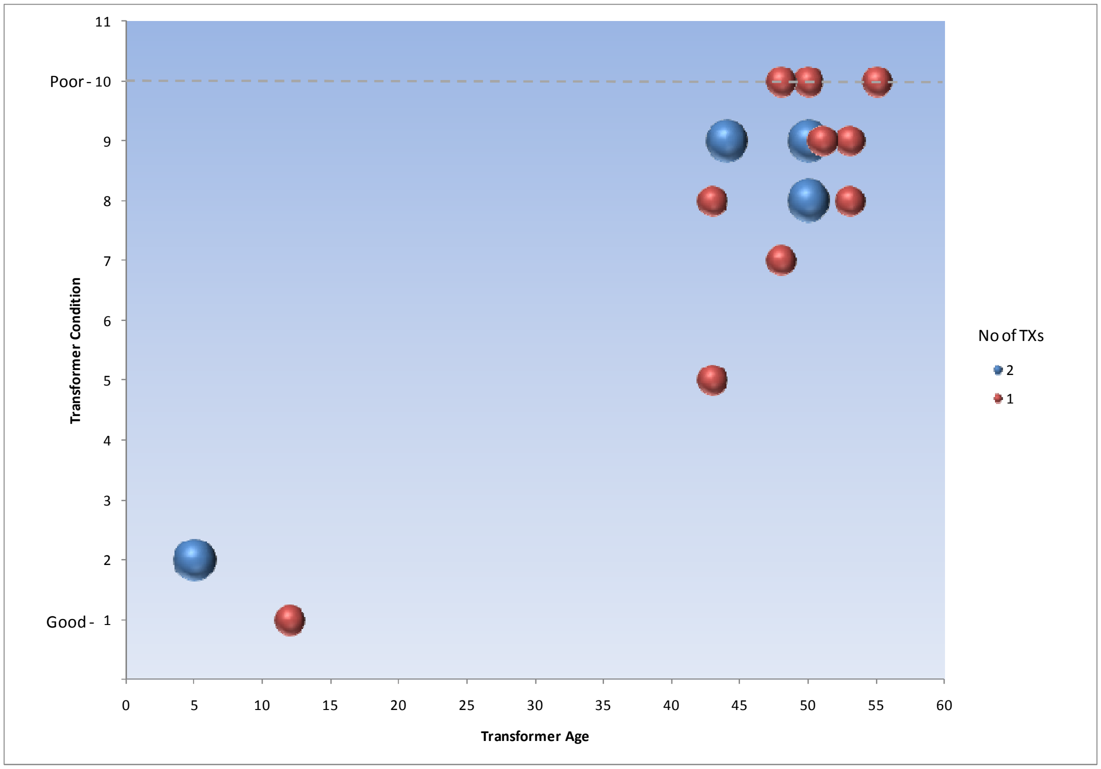


[5] Technical Rules clause 2.5.3.2(b) - The NCR risk criterion permits the loss of a portion of the power transfer capacity at a substation following the unplanned loss of a supply transformer within a substation. The portion of the power transfer capacity that may be lost is the lesser of: (A) 75% of 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.

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 disitributing the total feeder load across all transformers.

3.3.1.2 Transformer Condition

Figure 4 Load Area 132kV and 66kV Transformer Asset Condition and Age Profile



Whilst age is the predominant factor underpinning the deterioration in electrical asset condition and is often therefore used as an asset replacement driver, for more complex items of electrical equipment (e.g. transformers) specific condition assessments are often used to provide more accurate information relating to the requirement and timing of maintenance activities as well as ascertaining remaining asset lifetimes.

Western Power routinely collects asset condition information for transmission switchgear (132kV 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 being unacceptable condition requiring replacement in the short term. For 132kV and 66kV transformers, Figure 4 above outlines the distribution of transformer ages and accompanying conditions.

It is evident from Figure 4 that the majority of the existing transformers in the Western Terminal area are more than 40 years old and have condition ratings of 8 out of 10 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 11 and 6.6kV supplying transformers and 60 year lifetimes for 132 / 66 kV transformers).

3.3.1.3 Overhead Line Capacity

It is forecast that there will be insufficient 66kV transmission overhead line capacity in the short term, particularly as the North 66kV transmission ring will experience the 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. Additionally, by 2026 there will be a requirement for a new transmission circuit as the transfer limit of the 66kV overhead lines will be exceeded even if all the existing 66kV lines were rebuilt to a modern high capacity standard.

The South 66kV transmission ring is seen to provide adequate capacity throughout the study period.

3.3.1.4 Overhead Line Condition

Table 1 Load Area 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[6]	1976	1.43	105
	WT – WD	1965	5.31	104
	WT – N	1967	3.13	105

From examination of Table 1 above, it is evident that the majority of the existing 66 kV overhead lines in the Western Terminal area will require replacing within a twenty five year period, if a 60 year asset lifetime is considered, with many requiring replacement much sooner given original installation dates in the 1950's and 1960's.

[6] 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.

3.3.1.5 Summary

Figure 5 of Substation Capacity and Condition Limitations

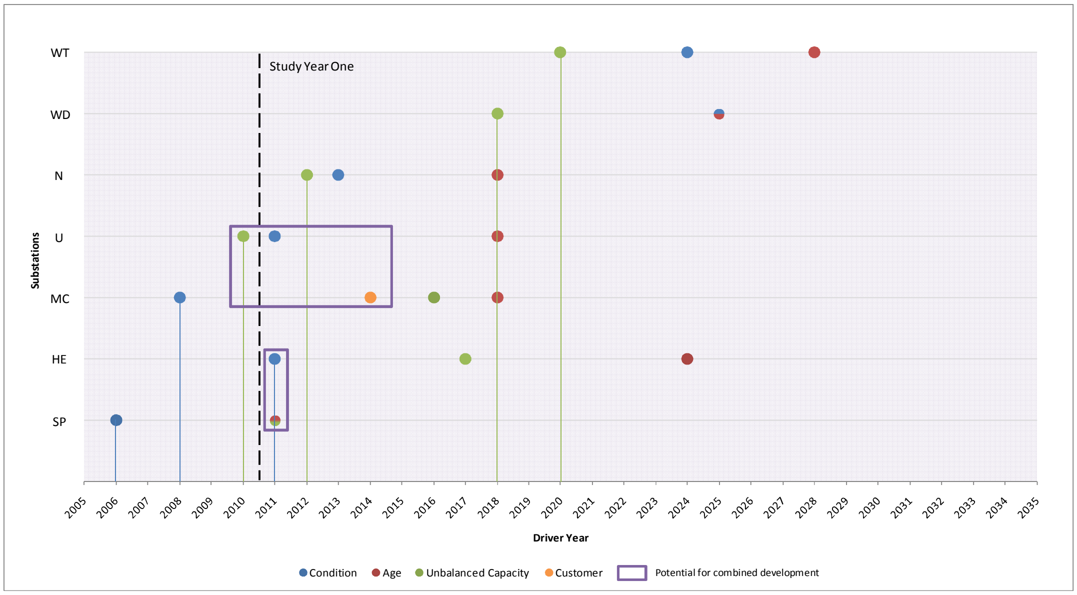


Figure 5 summarises the capacity and condition limitations of each substation within the Western Terminal load area to illustrate the driver and the date of the replacement or reinforcement works required. Line drop downs show the first factor to impact on the substation, with this seen to be evenly split between condition and capacity limitations. There are a number of limitations that have been surpassed to date. Figure 5 further illustrates a potential for combined developments which may provide economic/technical efficiencies due to the geographical locations of the substations and the timings of limitations experienced. Examples of this are Shenton Park and Herdsman Parade with limitations seen in 2011 as well as Medical Centre and University in the period 2011-2014.

It can be seen from previous sections that the majority of the existing Western Terminal 66kV assets, including overhead lines, transformers and switchgear will require replacement within 25 years. The wholesale replacement of a significant proportion of the Western Terminal electrical transmission assets over the next 20 years or so presents an opportunity to consider revising the operating configuration and transmission voltage of the Western Terminal sub-system. This will allow rationalisation of the number of substation locations, overhead transmission lines and increase substation capacity.

3.3.2 Overview of Distribution System Limitations

The demand for electricity in the Western Terminal load area is increasing to the point that some of the existing 6.6kV distribution feeders have exceeded the design limits of 100% of thermal rating. Western Power has assessed the upgrade of the distribution voltage in the Western Terminal load area as part of a separate study, a summary of which has been outlined below.

3.3.2.1 Options Considered

Three options have been considered to address the capacity shortfall of these distribution feeders.

1. Retain 6.6kV:

The first option is to keep the existing Western Terminal load area operating at 6.6kV and install new feeders. According to the 2011 load forecast, an estimated 39 new feeders are required to supply the total forecast load of 112 MVA by the year 2030 if the distribution network remains at 6.6kV. Such a large number of additional feeders will exceed the available circuits to connect, as well as increase cable congestion issues that already exist. The QEII Medical Centre is also seeking to upgrade to 11kV. If the Medical Centre is upgraded to 11kV it would create an island of 11kV near Medical Centre surrounded by the remaining 6.6kV network (University, Shenton Park & Nedlands), further restricting the distribution transfer capacity and decreasing the reliability of the network. The load at Medical Centre is considered too large to adopt a 6.6/11 kV step up transformer to provide wider network interconnection.

2. Upgrade to 11kV:

The second option is to convert the existing 6.6kV distribution network to 11kV operation. The upgrading to 11kV will significantly increase the capacity of the existing distribution network. According to the forecast, an estimated 19 feeders are required to supply the total load of 112MVA expected by the year 2030. Upgrading to 11kV will also significantly reduce the risk of cable congestion that 6.6kV will encounter and will resolve the potential Medical Centre islanding issues. A significant volume of the existing distribution assets are rated for 11kV operation and increasing the voltage will require a limited amount of asset replacement. The existing substations at Cottesloe and Wembley Downs have already migrated from 6.6kV to 11kV in recent years.

3. Upgrade to 22kV:

The third option is to increase the distribution voltage from 6.6kV to 22kV. This will require the wholesale renewal of the existing distribution network and would cause similar islanding problems with customers seeking to operate at 11kV. From the initial investigations, a lot of the existing assets are rated for 11kV so the cost of upgrading from 6.6kV to 11kV is only marginal, however the cost of upgrading to 22kV essentially requires a complete rebuild of the system. According to analysis from the forecasting team, the growth in the area is generally relatively slow except for a few major customers as it is a matured area. Therefore, 11kV will be sufficient to cater the load growth in the area.

3.3.2.2 Preferred Option

Cost benefit analysis for the Western Terminal load area distribution network have been carried out and indicate that there are cost savings to be made by upgrading the distribution system to 11kV combined with the technical advantages stated. It is therefore proposed to transition the entire Western Terminal load area distribution network from 6.6kV to 11kV. This will be staged when each of the zone substations within the Western Terminal load area require replacement. This distribution voltage decision is common to each of the proposed development strategies. The base cost of moving the portion of the 6.6kV network to 11kV that is the same across the four strategies has therefore not been included in the assessment.

Cost allowances have however been included for the variable component of the distribution works, the interconnecting feeders. Those strategies that propose to retire a substation and resupply it from another adjacent substation (e.g. retire University and supply from Medical Centre) have costs to reinforce the interconnecting feeders, including additional feeders, to facilitate the resupply and upgrade to 11kV. For those strategies that propose to retain substations a cost allocation has been included to capture the cost of upgrading to the interconnecting feeders to 11kV only.

3.3.2.3 Reasons to Upgrade the Voltage from 6.6kV

There are good reasons to justify upgrading the existing 6.6kV distribution network to a higher voltage in the Western Terminal load area. These are summarised as follows:

- To meet the forecast of 112MVA of additional feeder capacity at 6.6kV, 39 new feeders are required. The large number of feeders required will exceed the available circuits to connect them to the existing switchboard, as well as increase the exit cable congestion issues that already exist. Expansion of existing switchboards inside the zone substation will be an issue due the limitation of land size available.
- QEII Medical Centre is also seeking to upgrade to 11kV. If Medical Centre substation is upgraded to 11kV, this would mean an island of 11kV near Medical Centre surrounded by the remaining 6.6kV network, severely limiting distribution transfer capacity and decreasing reliability for the Medical Centre.
- The upgrading of the distribution network from 6.6kV to 11kV will result in a 66% increase in capacity on the distribution network.
- The load forecast indicates that Cottesloe and Wembley Downs are amongst the fastest growing substations in the Western Terminal load area. This is problematic because spare capacity installed on the 6.6kV network cannot be utilised to offload the 11kV network unless conversion work is undertaken.
- The cost of converting the distribution network to 11kV could be significantly higher at the initial stage compared with 6.6kV operation, but as a long term investment, conversion to a higher voltage will be the most efficient option compared with retaining 6.6kV.

4 Options Considered

4.1 Network Options

Western Power has carried out detailed planning studies to consider feasible network options. These studies included load flow analysis, fault level studies and other technical assessment to determine the capability of various options to supply future customer electricity needs in the Western Terminal load area.

From the planning studies, four feasible network options to augment the transmission network were identified across the 25 year period. These were evaluated in detail and the present value of each of the costs compared in accordance with the Regulatory Test.

4.1.1 Option 1: Retain 66kV and Upgrade Network Capacity

The first development strategy considered is designed to utilise the existing 66kV network and improve the capacity and condition of the assets with in-situ replacements as required. The drivers for the strategy are due to insufficient capacity and asset condition throughout the load area substations and 66kV transmission system over the 25 year period.

In this Strategy the substation at Shenton Park would be completely rebuilt on the existing site at 66kV with three 66/11kV transformers each 35 MVA rated and with a distribution voltage conversion from 6.6 to 11kV.

The staging and description of developments for this strategy is provided in Table 2 below:

Table 2 Cost Breakdown for Development Strategy 1

Date Required	Substation / Circuit	Proposed Augmentation	Cost, $M (nominal 2010)
2014	Medical Centre	New Zone Substation at existing site with 2 x 35 MVA 66/11kV transformers	$15.23
	Shenton Park	**New Zone Substation at existing site with 3 x 35 MVA 66/11kV transformers**	**$17.89**
	University	New Zone Substation at existing site with 3 x 35 MVA 66/11kV transformers	$16.24
	Western Terminal	Add 132 & 66kV switchgear	$3.61
2015	Western Terminal	Add 100 MVA 132/66 kV transformer	$3.94
	University	Cost increment for upgrading dist interconnectors from 6.6kV to 11kV only	$5.64
	Herdsman	Cost increment for upgrading dist interconnectors from 6.6kV to 11kV only	$3.74
2017	Wembley Downs	Additional 66/11 kV transformer (35 MVA)	$3.72
2018	Nedlands	New Zone Substation at existing site with 2 x 35 MVA 66/11kV transformers	$14.17
	Western Terminal	Add 66 kV line circuit	$1.21
	WT - SP	Add 132 kV cable	$5.63
2020	Herdsman	New Zone Substation at existing site with 2 x 35 MVA 66/11kV transformers	$16.24
	Nedlands	Additional 66/11 kV transformer (35 MVA)	$3.72
2024	Cottesloe	Replace 33 MVA Transformers with dual LV winding 75 MVA units	$6.63
2025	Wembley Downs	New Zone Substation at existing site with 2 x 35 MVA 66/11kV transformers	$13.16
	WT - WD	Rebuild 66 kV line to 132 kV Venus wood pole spec	$2.11
2026	N - U	Rebuild 66 kV line to 132 kV Venus wood pole spec	$1.21
	SP - HE	Rebuild 66 kV line to 132 kV Venus wood pole spec	$4.78
	Western Terminal	New 66 kV transformer, line & bus coupler circuits	$8.83
	WT - N	Rebuild 66 kV line to 132 kV Venus wood pole spec	$1.24
2028	Western Terminal	Replace transformer 1 & 2 with new 2 x 100 MVA.	$7.48
	WT - MC	Rebuild 66 kV line to 132 kV Venus wood pole spec	$1.09
		Re-string 1.39km steel tower line with Venus conductor	$0.70
2029	WD - HE	Rebuild 66 kV line to 132 kV Venus wood pole spec	$1.91
2033	U - MC	Rebuild 66 kV line to 132 kV Venus wood pole spec	$0.65
		Total Capital Cost	**$160.7**
		Total Net Present Cost	**$117.7**

In order to increase substation capacity in the Western Terminal area Strategy 1 proposes all transformers will be replaced in-situ with 35MVA 66/11kV transformers and all 66kV lines are proposed to be uprated in-situ (to the largest permissible capacity Venus conductor - 132kV specification).

A second 66kV circuit will be required to be constructed between Western Terminal and Shenton Park due to further capacity restrictions in the long term and is proposed to be of cable construction due to the limitation of over-ground land available with the existing WT-NT, WT-SP and WT-MC circuits utilising this route. The WT-C-N 66kV circuit is proposed to be removed once the asset condition has sufficiently deteriorated and the North Fremantle link has been separated to reduce non-essential uprating costs.

This strategy achieves compliance to the year 2035, at which point Medical Centre substation is forecast to have no capacity available and will require further investment at this point to support load growth at this location.

Although the total load area capacity available in 2035 is expected to be 57MVA, the available capacity remaining at Western Terminal limits the amount of load area transformer capacity to 42MVA. If an additional (5th) 132 / 66 kV 100 MVA transformer was installed at Western Terminal by 2035 this would allow the remaining residual area capacity to be increased to 57 MVA at a cost of an additional circa $7M.

4.1.2 Option 2: SP Upgraded to 132kV with HE Decommissioned

Development Strategy 2 looks at reducing the load on the 66kV network in the short term to prevent significant additional investment through the migration of existing Shenton Park load to a new Shenton Park 132kV substation and transferring load from Herdsman substation.

Shenton Park substation has been selected for migration for a number of reasons, namely:

- Existing assets at this substation have far surpassed their condition limitation;
- According to Western Power's Transmission Planning Guidelines the substation is seen to have insufficient capacity in the summer of 2011/2012;
- The load at this substation is expected to grow at the greatest rate in the load area;
- The North 66kV transmission ring experiences N-1 overloading in the short term primarily due to the magnitude of the Shenton Park load
- The Western Terminal to Northern Terminal 132kV line passes by the substation which can be used to facilitate the upgrade to 132 kV at Shenton Park.

It is proposed that the Shenton Park 132kV substation would be constructed adjacent to the existing substation with 2 x 75MVA transformers and the potential to add a third at a later date when required. This capacity would allow the Herdsman Parade substation to be abandoned with the load transferred into the new Shenton Park substation to reduce the level of asset replacement required as the condition of the Herdsman transformers is also seen as a limitation in 2011. Following the load transfer, the old Shenton Park substation would be decommissioned. The staging and description of developments for this strategy is provided in Table 3 below:

Table 3 Cost Breakdown for Development Strategy 2

Date Required	Substation / Circuit	Proposed Augmentation	Cost, $M (nominal 2010)
2014	Medical Centre	New Zone Substation at existing site with 2 x 35 MVA 66/11kV transformers	$15.23
	University	New Zone Substation at existing site with 3 x 35 MVA 66/11kV transformers	$16.24
2015	Herdsman	Cost increment for upgrading dist interconnector capacity and 6.6kV to 11kV transition	$9.44
	Shenton Park	**New Zone Substation at existing site with 2 x 75 MVA 132/11 kV transformers (dual winding 75 MVA)**	**$23.29**
	University	Cost increment for upgrading dist interconnectors from 6.6kV to 11kV only	$5.64
	Western Terminal	Two Additional 132kV circuit breaker	$3.00
2017	Wembley Downs	Additional 66/11 kV transformer (35 MVA)	$3.72
	WT - SP	Add 132 kV cable	$5.63
	WT - WD	132kV double circuit steel pole	$11.62
2018	Nedlands	New Zone Substation at existing site with 2 x 35 MVA 66/11kV transformers	$14.17
2020	Nedlands	Additional 66/11 kV transformer (35 MVA)	$3.72
2024	Cottesloe	Replace 33 MVA transformers with dual LV winding 75 MVA units	$6.63
2025	Wembley Downs	New Zone Substation at existing site with 2 x 35 MVA 66/11kV transformers	$13.16
2026	N - U	Rebuild 66 kV line to 132 kV Venus wood pole spec	$1.21
	Shenton Park	Additional 132/11 kV transformer (dual winding 75 MVA)	$6.39
	Western Terminal	New 66 kV transformer, line & bus coupler circuits	$8.83
	WT - N	Rebuild 66 kV line to 132 kV Venus wood pole spec	$1.24
2028	Nedlands	Replace Transformer 1 & 2 with new 2 x 100 MVA.	$7.48
	WT - MC	Rebuild 66 kV line to 132 kV Venus wood pole spec	$1.09
		Re-string 1.39km steel tower line with Venus conductor	$0.25
2033	U - MC	Rebuild 66 kV line to 132 kV Venus wood pole spec	$0.65
		Total Capital Cost	**$158.6**
		Total Net Present Cost	**$114.8**

Strategy 2 proposes the same series of investments as Strategy 1 with the exception of the upgrade of Shenton Park to 132/11kV and the decommissioning of Herdsman Parade, removing the requirement for an additional circuit to be installed within the North 66kV ring.

This strategy also achieves compliance to the year 2035, at which point Medical Centre substation is forecast to have no capacity available and will require further investment at this point to support load growth at this location.

The remaining available substation capacity across the Western Terminal load area in 2035 is 92MVA.

4.1.3 Option 3: SP & MC Upgraded to 132kV with HE & U Decommissioned

Development Strategy 3 is designed to provide additional capacity at Medical Centre and delay future investments by further deloading the Western Terminal 66kV network. This is proposed to be achieved by upgrading the Medical Centre substation to 132kV operation and abandoning the University substation following the transfer of this load to the new Medical Centre 132kV substation.

Strategy 3 also proposes that the Shenton Park 132kV substation would be constructed adjacent to the existing substation with 2 x 75MVA transformers and the potential to add a third at a later date when required.

The staging and description of developments for this strategy is provided in Table 4 below:

Table 4 Cost Breakdown for Development Strategy 3

Date Required	Substation / Circuit	Proposed Augmentation	Cost, $M (nominal 2010)
2014	Medical Centre	New Zone Substation at existing site with 3 x 35 MVA 132/11 kV transformers	$23.57
2015	Herdsman	Cost increment for upgrading dist interconnector capacity and 6.6kV to 11kV transition	$9.44
	Shenton Park	**New Zone Substation at existing site with 2 x 75 MVA 132/11 kV transformers (dual winding 75 MVA) with provision for two additional 132kV feeders**	**$26.03**
	University	Cost increment for upgrading dist interconnector capacity and 6.6kV to 11kV transition	$9.94
2017	Wembley Downs	Additional 66/11 kV transformer (35 MVA)	$3.72
2018	C - N	Rebuild 66 kV line to 132 kV Venus wood pole spec	$1.75
	Nedlands	Replace of 2 x 35 MVA 66/11kV transformers	$14.17
	SP - MC	132kV double circuit steel pole	$1.15
		Add 132 kV cable	$11.65
	Western Terminal	Two Additional 132kV circuit breaker	$3.00
2020	Nedlands	Additional 66/11 kV transformer (35 MVA)	$3.72
2024	Cottesloe	Replace 33 MVA transformers with dual LV winding 75 MVA units	$6.63
2025	Wembley Downs	New Zone Substation at existing site with 2 x 35 MVA 66/11kV transformers	$13.16
	WT - WD	132kV double circuit steel pole	$11.62
2026	Shenton Park	Additional 132/11 kV transformer (dual winding 75 MVA)	$6.39
	Western Terminal	New 66 kV transformer, line & bus coupler circuits	$8.83
	WT - N	Rebuild 66 kV line to 132 kV Venus wood pole spec	$1.24
2028	Western Terminal	Replace T1 & T2 with new 2 x 100 MVA transformers	$7.48
		Total Capital Cost	**$163.5**
		Total Net Present Cost	**$112.1**

The cost breakdowns for Strategy 3 and 4 in the 25 year development plan for the Western Terminal area were based on 2 x 75 MVA transformers being installed at Medical Centre in 2014. Since these initial studies however, more specific analysis has been undertaken as part of the Medical Centre project, which has led to a new preferred operating arrangement of 3 x 35 MVA transformers. Subsequent cost analysis has indicated however that there is no cost difference between the two different transformer arrangements. The costs used in Table 4 and Table 5 (derived from the long term studies), although based on 2 x 75 MVA transformers, are therefore still representative in terms of cost of the new 3 x 35 MVA arrangement.

This strategy results in the southern 66kV ring being deloaded further with only Nedlands being supplied and it is therefore proposed that the N-C-WT line be uprated when required for condition drivers to minimise costs. The 66kV lines from Nedlands to University, University to Medical Centre and Medical Centre to Western Terminal can then be decommissioned.

As the northern 66kV ring has been unaffected in this strategy from that given in Development Strategy 2 it can be seen that Shenton Park substation has sufficient available capacity. The requirement for a 4th 132/66kV transformer at WT has been pushed back for capacity limitation indefinitely due to the deloading of Herdsman Parade, Shenton Park, University and Medical Centre from the 66kV network.

The total load area capacity available has risen to 107MVA with a combined 77MVA located at the new Shenton Park and Medical Centre 132kV substations. Of the 66kV capacity, none of the 30MVA available is restricted by the Western Terminal transformers resulting in an unrestricted load area total capacity of 107MVA.

4.1.4 Option 4: Full 132kV Migration of SP, MC, WD & N with HE & U Decommissioned

The final development strategy proposed involves Shenton Park, Medical Centre, Wembley Downs and Nedlands and associated transmission lines being upgraded to 132kV operation with Herdsman Parade and University being decommissioned. Following Development Strategy 3, only Wembley Downs and Nedlands are operated at 66kV from the North and South rings respectively. This results in the continued requirement for 132/66kV transformers at Western Terminal to supply these two sites. By upgrading Wembley Downs and Nedlands to 132kV operation, the requirement for the 132/66kV transformers at Western Terminal can be removed entirely with all sites in the load area operating at 132kV and is the basis for Development Strategy 4. Due to limited space at the existing site, it was estimated that the lowest cost option for Nedlands would be a gas insulated switchgear (GIS) solution and was costed as such for the options analysis.

The staging and description of developments for this strategy is provided in Table 5 below:

Table 5 Cost Breakdown for Development Strategy 4

Date Required	Substation / Circuit	Proposed Augmentation	Cost, $M (nominal 2010)
2014	Medical Centre	New Zone Substation at existing site with 3 x 35 MVA 132/11 kV transformers	$23.57
2015	Herdsman	Cost increment for upgrading dist interconnector capacity and 6.6kV to 11kV transition	$9.44
	Shenton Park	**New Zone Substation at existing site with 2 x 75 MVA 132/11 kV transformers (dual winding 75 MVA) with provision for two additional 132kV feeders**	**$26.03**
	University	Cost increment for upgrading dist interconnector capacity and 6.6kV to 11kV transition	$9.94
2017	Wembley Downs	Additional 132-66/11kV 75MVA transformer	$6.39
2018	C - N	Rebuild 66 kV line to 132 kV Venus wood pole spec	$1.75
	Nedlands	New GIS Zone Substation at existing site with 2 x 75 MVA 132/11 kV transformers (dual winding 75 MVA)	$23.92
	SP - MC	132kV double circuit steel pole	$1.15
		Add 132 kV cable	$11.65
	Western Terminal	Two Additional 132kV circuit breaker	$3.00
	WT - N	Rebuild 66 kV line to 132 kV Venus wood pole spec	$1.24
	WT - WD	132kV double circuit steel pole	$11.62
2024	Cottesloe	Replace 33 MVA transformers with dual LV winding 75 MVA units	$6.63
2025	Wembley Downs	New Zone Substation at existing site with 1 x 75 MVA 132/11 kV transformer (dual winding 75 MVA)	$14.10
2026	Shenton Park	Additional 11kV switchboard	$3.08
	Wembley Downs	Additional 132/11 kV (dual winding 75 MVA) transformer	$3.31
		Total Capital Cost	**$156.8**
		Total Net Present Cost	**$119.4**

This development strategy results in a much more radial transmission network than the existing ring design providing greater capacity availability under N-1 conditions. There are seen to be no requirements for additional circuits or uprating of 132kV lines for the foreseeable future.

As all substations are supplied at 132kV from Western Terminal and not restricted by the 132 / 66 kV transformers there are now no restrictions on achieving the maximum remaining capacity at individual substations. Consequently, the remaining total substation capacity within the load area in 2035 is 117MVA, the greatest of all the development strategies. It can also be seen that the requirement for additional capacity at the substations has been pushed back to beyond 2050 with the added advantage of fewer substations and assets to manage.

4.2 Non Network Options

Non network solutions in the Western Terminal load area could take the form of local generation (as a network control service) and Demand Side Management (DSM).

The Western Suburbs of Perth currently contain no existing connected generation of sufficient size which could be contracted under a network control service contract. There are no proposed generators currently seeking connection in the Western Suburbs that could provide network control services in the future.

An Assessment of the Demand Side Management (DSM) option to defer the Shenton Park Substation investment in 2015 has been considered.

The benefits of DSM arise from the net monetary saving obtained by deferring reinforcement investment to later years. These benefits are calculated in Net Present Cost (NPC) terms for comparison with the costs of other options.

The Western Power Demand Management Business Model provides indicative costs for DSM services from residential providers of at least $500 / kVA. These figures are considered as conservative values and are used as a screening tool to identify where DSM investments could potentially offer a viable alternative.

The volume of DSM required to defer Shenton Park substation for one year in 2015 is 5350 kVA. Using $500 / kVA, the total cost of a DSM solution would be at least $2.68M. The cost benefit of deferring Shenton Park for one year in 2015 is $1.9M, indicating based on these figures there would be no advantage in deferring the Shenton Park substation development.

DSM solutions can make a meaningful contribution to the deferment of capital expenditure in electricity networks and Western Power will continue to investigate DSM options in the Western Suburbs across the study period. However due to the relative costs and benefits DSM options have not been progressed at Shenton Park.

5 Format and Inputs to Analysis

5.1 Regulatory Test Requirements

The Regulatory Test is an assessment under Chapter 9 of the Electricity Networks Access Code 2004 of whether a proposed Major Augmentation to a covered network maximises the Net Benefit (measured in present value terms to the extent that it is possible to do so) to those who generate, transport or consume electricity after considering alternative options.

Western Power's proposed Major Augmentation is considered defensible if it applies the Regulatory Test properly using reasonable market scenarios and varying levels of growth at relevant places. Western Power must also use reasonable timings for project commissioning dates and construction timetables.

The Regulatory Test Guidelines[7] provide direction in identifying methods for determining which option maximises Net Benefits. Areas to be considered for analysis should include but not be limited to construction, operation and maintenance costs, changes to fuel consumption arising through different generation dispatch, changes in voluntary load curtailment caused through reduction in demand side curtailment, changes in ancillary services and changes in involuntary load shedding caused through savings in reduction in lost load.

5.2 Cost of Network Augmentations

The financial analysis considers all foreseeable cost impacts of the proposed network augmentations. The cost to implement each of the feasible options outlined in Section 4 has been estimated by Western Power. The capital cost estimates utilised in this assessment have been derived from the Western Power estimating building blocks.

The Western Power building block cost estimates have been developed using the Western Power Estimating Centre's Success Estimator software and database for standard design and typical engineering parameters as well as by investigating historical cost figures and typical expenditure.

Where required, input was also sought from technical specialists within Western Power to gain expert knowledge on specific items to reduce the tolerance on estimates. A sensitivity analysis to the cost estimates for each option has been included in the Financial Analysis (Section 6).

5.3 Other Inputs to Analysis

While this Regulatory Test is specifically about the investment at Shenton Park in 2014 to address the identified requirements at this site in the medium term, the economic analysis compares development scenarios for the entire Western Terminal load area out until 2036.

The timing of the components for each strategy is based on meeting the Western Power central load forecast, as published in the Western Power Annual Planning Report. The actual timing of the anticipated projects may change as a result of the ongoing review of load forecasts for the Western Terminal Load area during the 25 year planning horizon.

The capital cost of the component of the distribution upgrade from 6.6kV to 11kV that was common to all options was excluded from the options analysis[8]. The total value of this common component was estimated to be $4.0M.

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[7]Refer http://www.erawa.com.au/3/651/48/electricity_access__regulatory_test_guidelines.pm

[8] The specific work listed in the tables in Section 4.1 for Herdsman Parade and University substations have however been included in options analysis as this work varied across the proposed strategies.

6 Financial Analysis

The economic analysis undertaken considered the present value cost of alternative options over the twenty-five year period from 2011/12 to 2036/37.

6.1 Present Value Analysis

The previous sub-sections have presented the details of the individual development strategies considered for the Western Terminal load area, as well as key financial and technical parameters associated with each. This section now brings the strategies together to contrast and compare the costs and benefits of each in order to identify the optimal strategy for the Western Terminal load area over the next 25 years. Table 6 summaries the Net Present Cost assessment for the identified strategies using a nominal discount rate of 10.56% and inflation according to forecast CPI.

Table 6 2035 Financial Characteristics

Strategy	Description	NPC, $M	Remaining TX MVA at 2035	$M (NPC) / 2035 MVA
1	Retain 66kV and upgrade network capacity	117.7	42	2.80
2	Shenton Park Upgraded to 132kV with Herdsman Parade decommissioned.	114.8	92	1.25
3	Shenton Park & Medical Centre Upgraded to 132kV with Herdsman Parade & University decommissioned.	**112.1**	107	1.05
4	Full 132kV Migration of Shenton Park, Medical Centre, Wembley Downs & Nedlands with Herdsman Parade & University decommissioned.	119.4	117	1.02

It is evident from review of Table 6 that the strategy with the lowest Net Present Cost is Development Strategy 3. Critically though, the difference in Net Present Cost between the lowest cost option and the highest cost option is circa 6% with all of the strategies having similar investment costs.

From this analysis it is evident that even though the NPC figures are of the same order, the four strategies each provide a different available transformer capacity by the year 2035. This can be summarised by considering the ratio of NPC ($M) / MVA (2035) as follows:

- Strategy 1: 117.7 $M / 42 MVA = 2.80
- Strategy 2: 114.8 $M / 92 MVA = 1.25
- Strategy 3: 112.1 $M / 107 MVA = 1.05
- Strategy 4: 119.4 $M / 117 MVA = 1.02

These ratios indicate that Strategy 1 provides the least advantages in terms available transformer capacity compared with the other strategies. Furthermore, Strategy 2 is seen to be slightly less advantageous than Strategies 3 & 4 in this regard.

Therefore, for a similar NPC, Strategies 3 & 4 are seen to provide the most efficient spend in terms of available transformer capacity and as such will be more robust against unforeseen changes in load requirements by the year 2035.

The requirement for capital investment across the Western Terminal load area will continue beyond 2035, and therefore it is important to give consideration to the residual substation capacity remaining across the Western Terminal area. In order to better understand this impact further analysis out to 2050 was conducted. This identified that further investments were required under Strategy 1 and 2 only as shown below in Table 7.

Table 7 2050 Financial Characteristics

2050	Strategy 1	Strategy 2	Strategy 3	Strategy 4
NPC, $M	119.5	116.8	**112.1**	119.4

The NPC of Strategy 1, 2 and 4 when accounting for the forecast 2050 reinforcements is now materially higher than that of Strategy 3.

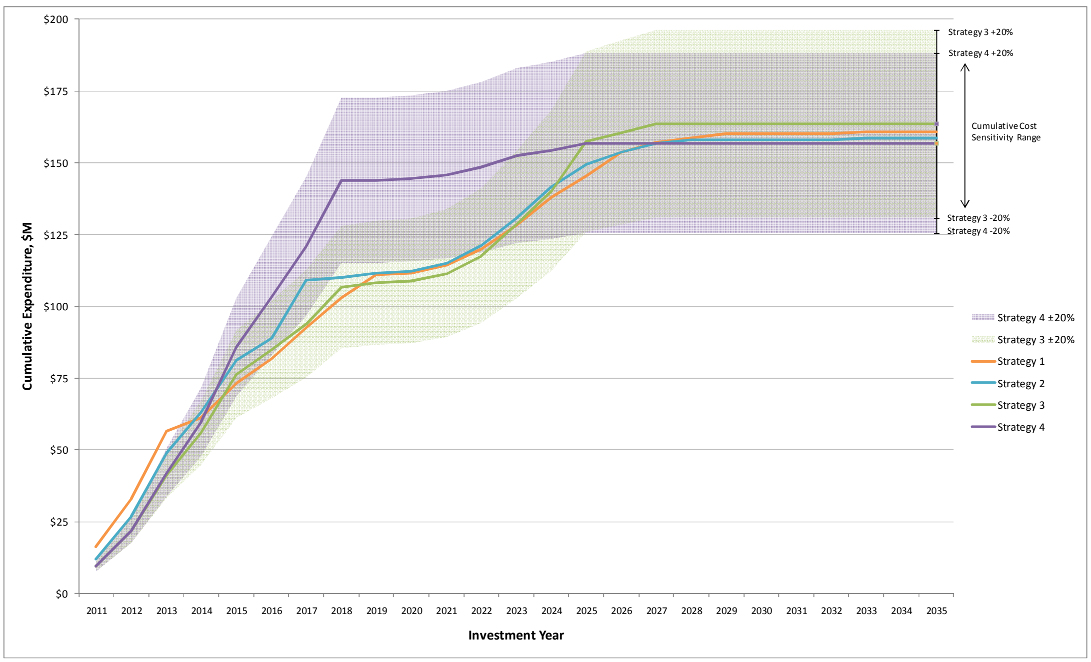
6.2 Sensitivity Analysis

6.2.1 Cost Building Blocks

As outlined in Section 4, the total capital cost calculated for each development strategy has been based on the required number of asset units as well as the Western Power estimating building blocks. The building blocks are however average costs for delivering the outlined equipment and works required and are not fully detailed costs estimates taking account of site specific requirements. They will therefore be subject to a degree of variation and revision at a later stage.

At this time it can however be stated that whilst the costs are considered appropriate for this assessment a tolerance margin of ±20% does need to be considered. Figure 6 below illustrates the cumulative capital investment expenditure but with a ±20% cost tolerance band applied to Strategy 4 (in light purple) and Strategy 3 (light green).

Figure 6 Sensitivity Analysis of Development Strategy Investment Cost



The overlap between the considered cost tolerance for Strategy 4 and 3 is shown in Figure 6 as the darker shaded area (labelled Cumulative Cost Sensitivity Range). The key consideration here is that the overlap between the two cost tolerance ranges (some $57.4 M) encompasses the base estimated capital cost for all four considered strategies easily.

Hence, consideration is required to be given to other metrics to enable the desirability of each development strategy to be more thoroughly assessed.

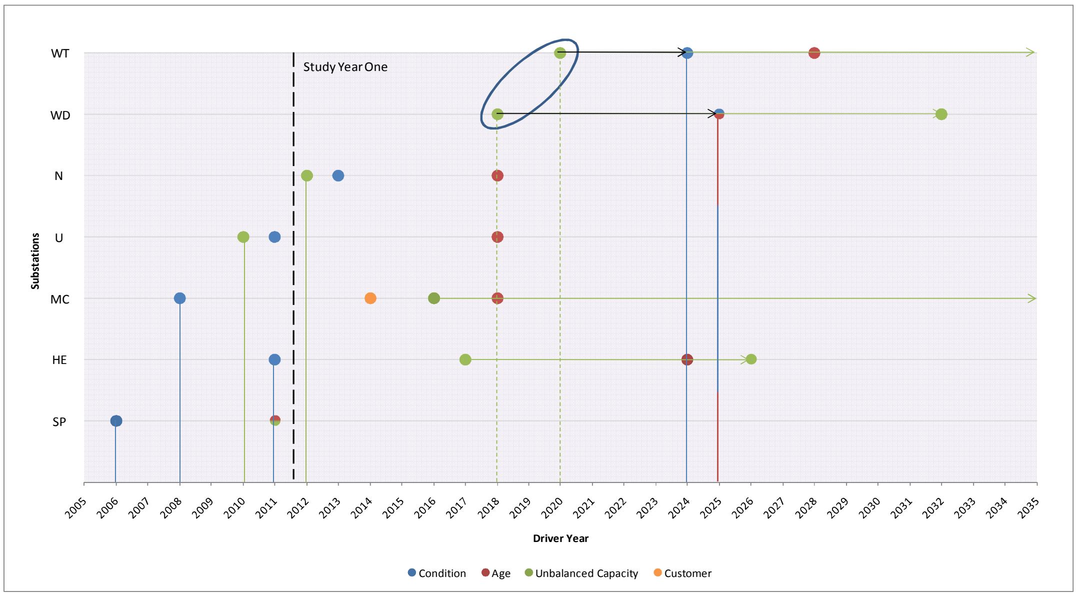
6.2.2 Demand Growth

The driver underpinning much of the required reinforcement of the Western Terminal transmission system over the considered strategy period is the lack of network capacity and the impact of prospective future demand growth. The assessment has been based on the May 2011 Western Power demand forecast which provides a projection of the prospective future demand at each substation in the Western Terminal area to 2035.

This forecast has been central to this assessment and demand figures have been incorporated and used to identify the network capacity limitations. The output of these studies and the identification of specific network capacity restrictions has been combined with the other identified asset investment drivers (age and condition related replacement) to generate the timeline of substation and network investment requirements outlined previously in Figure 5.

However, whilst the considered Western Power demand forecast indicates the most likely demand growth path across the Western Terminal area over the considered strategy period it is important to understand the sensitivity of the resulting study outcomes to potential variations in actual demand growth. To this end the Western Power demand forecast growth rate for Western Terminal substations up to 2035 has been halved and the timeline of substation and network investment requirements redrawn to illustrate the potential impact on this assessment, as shown in Figure 7 below.

Figure 7 Sensitivity Analysis of Trigger Points with Reduced Demand Growth



Of those investment triggers that were previously forecast the only change as a result of the revised demand growth rate has been to Wembley Downs and Western Terminal substations. At Wembley Downs the reduced demand growth has pushed the capacity investment trigger out to 2032. However, the age / condition of the Wembley Downs 66/11 kV transformers is such that this will now be the trigger for investment in 2025. Similarly for Western Terminal, the reduced demand across the 66 kV network has pushed the capacity investment trigger previously identified for 2020 out to potentially beyond 2035. However, the condition of two of the Western Terminal 132 / 66 kV transformers is such that they will now be the trigger for investment around 2024 to 2028.

In summary, the requirement for capital investment across the Western Temrinal area is not expected to change significantly, even if the expected future demand growth rate is half the expected rate. The only two substations that would potentially see some revision to the investment requirements are Western Terminal and Wembley Downs substation. That said, asset age / condition investment drivers will become the backstop at both substations meaning that the benefit gained through potentially lower demand growth, in terms of deferred capital investment, is not likely to be significant. Additionally, with respect to the outcomes of this study, as the bulk of the capital investment triggers will remain as previously identified, potential variations in future Western Terminal area demand growth will not have any material impact on the recommended development strategy.

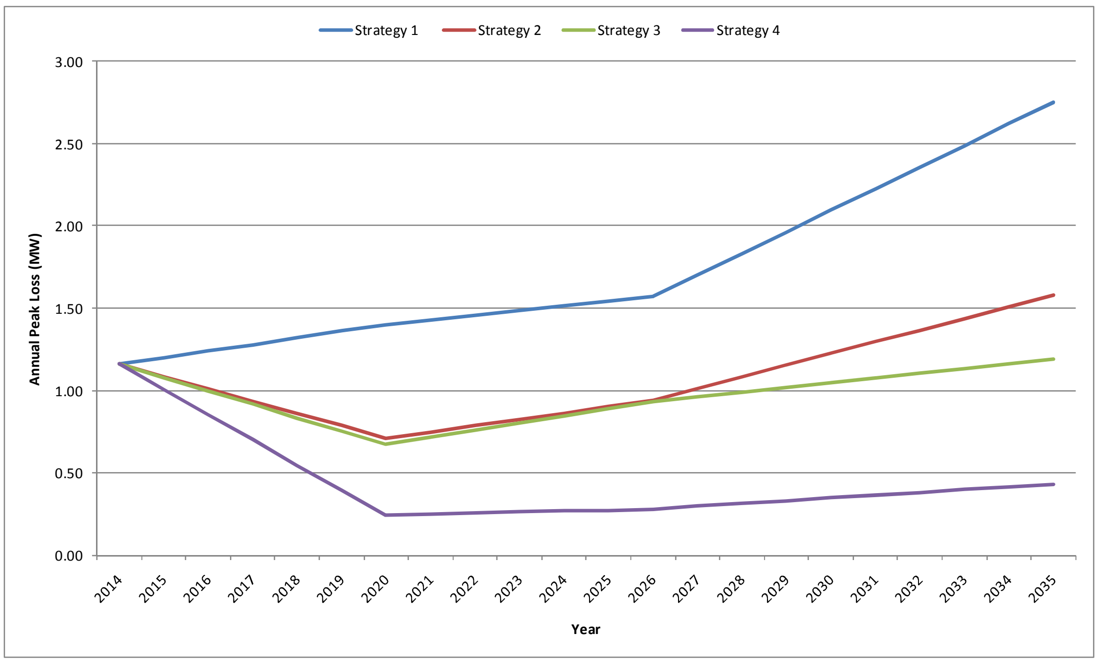
6.3 Other Relevant Factors

6.3.1 Losses

The opportunity to migrate to a higher transmission system voltage across the Western Terminal area, whether in whole or part, brings with it the potential to reduce electrical (MWh) losses. A comparison of losses throughout the Western Terminal load area for each development strategy in the year 2035 was undertaken, including real power losses in both transformers and transmission lines within the load area.

The impact of the strategies on losses over the study period is illustrated in Figure 8 below. Losses values for the years 2014, 2020, 2026 and 2035 have been calculated and a linear interpolation applied. It can be seen that by retaining the 66kV network (Strategy 1) that the losses will continue to rise and demand grows. By introducing greater numbers of 132kV assets in the load area the losses can be seen to reduce as deloading of the Western Terminal transformers and lower line losses occurs, as is seen in Strategies 2-4, with the greatest impact occurring as a result of the higher number of 132kV assets installed under Strategy 4. Following proposed strategy developments, losses begin to increase with forecast load increases in the area.

Figure 8 Comparison of Development Strategy Power Losses 2014-2035



Based on an average load factor for the Western Terminal area of 42.6%[9] and a cost of energy of $56/MWh an indicative NPC of the capitalised cost of losses over the study period is shown in

Table 8 below.

[9] Western Power Summer Loads and Trends Report 2012-2030 quotes annual load factors (average load/Peak load) for each of the Western Terminal substations as: SP (43%), MC (47%), N (39%), WD (37%) and U (47%).

Table 8 Indicative Capitalisation of Losses NPC Analysis for 2014-2035

Strategy	Total Losses (MW)	NPC Capitalised Losses, $M
1	38.0	1.60
2	23.3	1.03
3	21.0	0.96
4	**9.8**	**0.53**

The NPC analysis outlined above indicates that through the reduction of losses a financial saving over the considered 25 year strategy period of over $1 million could be achieved with the implementation of Strategy 4 over Strategy 1. Strategies 2 and 3 also provide reduced losses in comparison with Strategy 1, although diminished financial savings in comparison with Strategy 4.

Increases in energy prices over time (including the impact of increased carbon prices) have not been factored into this analysis, which would have increased the value of the loss reductions.

6.3.2 Overhead Line Length

It is recognised that reductions in overhead line circuit lengths through network investment brings with it benefits associated with lower operation and maintenance costs.

Over the five years 2006/07 to 2010/11 Western Power's maintenance expenditure on the existing eight 66kV overhead lines in the Western Terminal area was $591,626 with an average expenditure per km per year of $3,607. The reduction in overhead circuit length between Strategy 1 and 4 is 9.7km and could lead to an indicative reduction in maintenance costs of circa $35,000 per annum. The impact of this has not been included in the options analysis described in Section 4.

Some of the options outlined in Section 4.1 have significant line decommissioning components. Further analysis is required to determine which of these overhead line route corridors will be required for further network developments and which will no longer be required.

6.3.3 Substation Sites

Strategies 2, 3, and 4 involve the decommissioning of the existing 66kV substations at University and Herdsman Parade. The substation site at University is leased to Western Power by the University of Western Australia who own the freehold. The substation site at Herdsman is owned freehold by Western Power and could be sold on completion of the works. The Corporate Real Estate branch of Western Power has estimated the value of the land, based on recent sales, in the range of $5.2M to $5.7M. The Herdsman site would require remediation prior to sale and this is estimated at $0.5M to $1.6M, depending on whether ground water remediation is required, it is likely to take 1.5 – 3 years to complete the remediation process. The net impact of this is that Strategies 2, 3 and 4 could recover costs in the range of $3.6M - $5.2M. The impact of this has not been included in Table 8 & 9. Also not included in the options analysis are the nonrecurring operational costs associated with decommissioning HE ($1.2M) and U ($1.5M) substations.

6.3.4 Ability to Up-rate Existing Overhead Lines

A further risk associated with Development Strategy 1, in particular, is that all existing 66 kV overhead lines are assumed to be replaced with a modern high capacity standard. There is a possibility that statutory line clearances will not be achievable using the modern standard at the desired operating temperature (85 deg C) across the entire 66 kV Western Terminal network, or that wholesale pole replacement may result in difficulties in construction as well as associated community acceptance issues due to taller poles and larger cross section conductors[10]. This may necessitate the need for additional cable circuits at significant additional cost. Strategies 2 is also similarly affected, although to a lesser degree, with Strategy 3 and 4 unlikely to be affected at all as all circuits have a summer rating far in excess of that required at 2035, even if lower rated line designs are adopted.

[10] The highest rated line conductor current employed within the Western Terminal 66 kV network is Centipede AAC, which has an overall diameter of 26.5mm versus 33.8mm for Venus – circa 28% larger.

7 Conclusions

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

- There is no acceptable 'do nothing' option. Action is required now to ensure that reliability of supply obligations can be maintained from the 2015/16 summer. An increase in the transmission network & substation capability is required by the summer of 2015/16 to maintain a reliable power supply to customers in the Western Suburbs of Perth during critical network contingencies. 'Doing nothing' is not consistent with requirements of the Technical Rules that Western Power must comply with;

- Western Power must plan new works to allow adequate lead time to ensure continued reliable electricity supply to the Western Suburbs of Perth in the peak load periods from summer 2015/16;

- Planning studies were undertaken to evaluate potential network options to address the future supply requirements in the Western Suburbs of Perth. Four development strategies have been evaluated in detail;

- Contained within the four development strategies are three distinct investment options at Shenton Park (the Shenton Park component of Strategies 3 and 4 are the same). The options are shown in the Table 9 below.

Table 9 Shenton Park Option Costs

Strategy	Substation / Circuit	Proposed Augmentation	Cost, $M (nominal 2010)
1	Shenton Park	New Zone Substation at existing site with 3 x 35 MVA 66/11kV transformers	17.89
2	Shenton Park	New Zone Substation at existing site with 2 x 75 MVA 132/11 kV transformers (dual winding 75 MVA)	23.29
3 & 4	Shenton Park	New Zone Substation at existing site with 2 x 75 MVA 132/11 kV transformers (dual winding 75 MVA) with provision for two additional 132kV feeders	26.03

- Economic analysis carried out as part of this assessment has identified that Strategy 3 - Shenton Park & Medical Centre upgraded to 132/11kV, Herdsman Parade load transferred to Shenton Park, University load transferred to Medical Centre with Herdsman Parade & University decommissioned, is the least NPC cost solution over the 25-year period of the analysis. The results of sensitivity testing involving variation in cost and other assumptions also demonstrate an outcome consistent with the base case economic analysis. Strategy 3 is therefore considered to maximise Net Benefits when considering alternative options;

- While it is recognised that each of the strategies have Net Present Cost of the same order of magnitude as Strategy 3 when considering the tolerances of the estimates, Western Power believes there are also some comparative strategic advantages contained within Strategies 3 & 4 in the context of the development of the power system, in terms of reducing overhead line circuit kilometres, losses and maintenance costs. It is considered by Western Power to be a finely balance decision. Western Power has recommended Strategy 3 principally on its lower NPC cost.

- Both of these strategy 3 & 4 share a common investment at Shenton Park in 2015 and only diverge in their approach in 2018 with differing investments at Nedlands substation. Therefore the option to move to Strategy 4 remains open until 2018. Western Power intends to review this analysis again prior to the 2018 decision and it will likely be the subject of a future Regulatory Test and public consultation. A comparison of the key benefits of Strategies 3 & 4 is shown in Table 10 below.

Table 10 Comparison of Strategy 3 & 4

Strategy	Advantages	Disadvantages
Strategy 3	NPC lower by $7.3M Extracts maximum 66 kV asset lifetime	Higher MWH losses Greater number of overhead line routes and total length 66 kV infrastructure remains at Western Terminal for long term
Strategy 4	Remaining 2035 TX capacity 10 MVA higher Lower capital cost / remaining TX MVA capacity ratio Reduced 2035 total circuit route numbers and length MWH losses 53% lower	Requires GIS switchgear at Nedlands Early replacement of WD assets

- Should the draft recommendation in this Option Paper be adopted (Strategy 3), then a new 132 kV zone substation would be constructed at Shenton Park containing 2 x 75 MVA 132/11/11kV transformers with provision for two additional 132kV feeder circuit breakers for summer 2015 to ensure continued reliability of electricity supply to customers in the Western Suburbs of Perth.

8 Draft Recommendation

Based on the conclusion drawn from the analysis and Western Power obligations under the Electricity Networks Access Code 2004 for Major Augmentations it is recommended that the following investments be taken forward.

- The establishment of a new 132kV/11kV zone substation at Shenton Park (SPK) containing 2 x 75MVA 132/11/11kV transformers and 2 line circuits
- The overhead line works associated with the 2 x 132kV WT-SPK line circuits (including the temporary stage involving the 132kV WT- NT line cut-in)
- The conversion and upgrade of the Shenton Park distribution network from 6.6kV to 11kV
- The decommissioning of the existing 66kV/6.6kV Shenton Park (SP) zone substation
- The conversion and upgrade of the Herdsman Parade zone substation distribution network from 6.6kV to 11kV
- The migration of the Herdsman Parade zone substation load to the new 132kV/11kV Shenton Park zone substation
- The decommissioning of the Herdsman Parade 66kV/6.6kV zone substation

The cost of this option is $35.68M in nominal dollars including distribution upgrade costs, project oncosts and risk and has been determined as part of the A1 estimate process using more refined figures than were available during the initial options analysis. This cost also includes the common components of the distribution upgrade from 6.6kV to 11kV that was omitted as part of the options analysis.

It should be noted that the draft recommended strategy for the Western Suburbs is Strategy 3 and that the projects identified within it will be taken forward in due course. Some of these investments will be the subject of future Regulatory Tests.

9 Consultation

In accordance with the Electricity Networks Access Code 2004 Western Power invites submission from all interested parties on this Options Paper

Submissions are due by 10 April 2012.

Please address all submissions to:

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Tel (08) 9218 5167

Following consideration of all received submissions, Western Power expects to publish a final recommendation in May 2012.

10 Appendix 1: Technical Details of Options 3

As set out in this Options Paper, Western Power examined four 25 year development strategies for the Western Terminal load area to address the electricity supply capacity constraints and meet forecast demand. The following diagrams summarise the proposed scope of works under Option 3 which has been identified as the preferred network development solution.

The following figures illustrate the main stages of the proposed network augmentation, followed by a summary of the technical details relevant to each of the stages:

Figure 9 Initial Transmission Network Arrangement in 2013

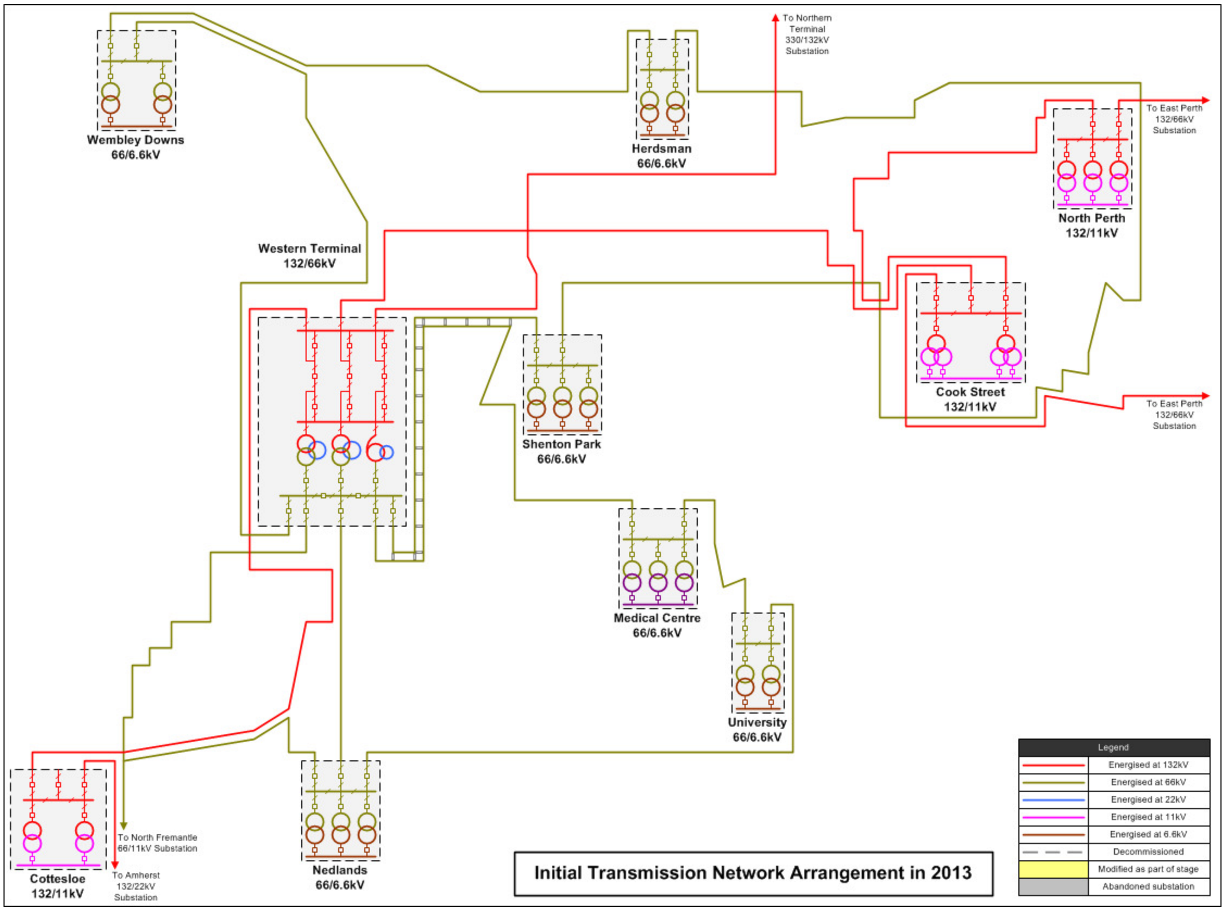
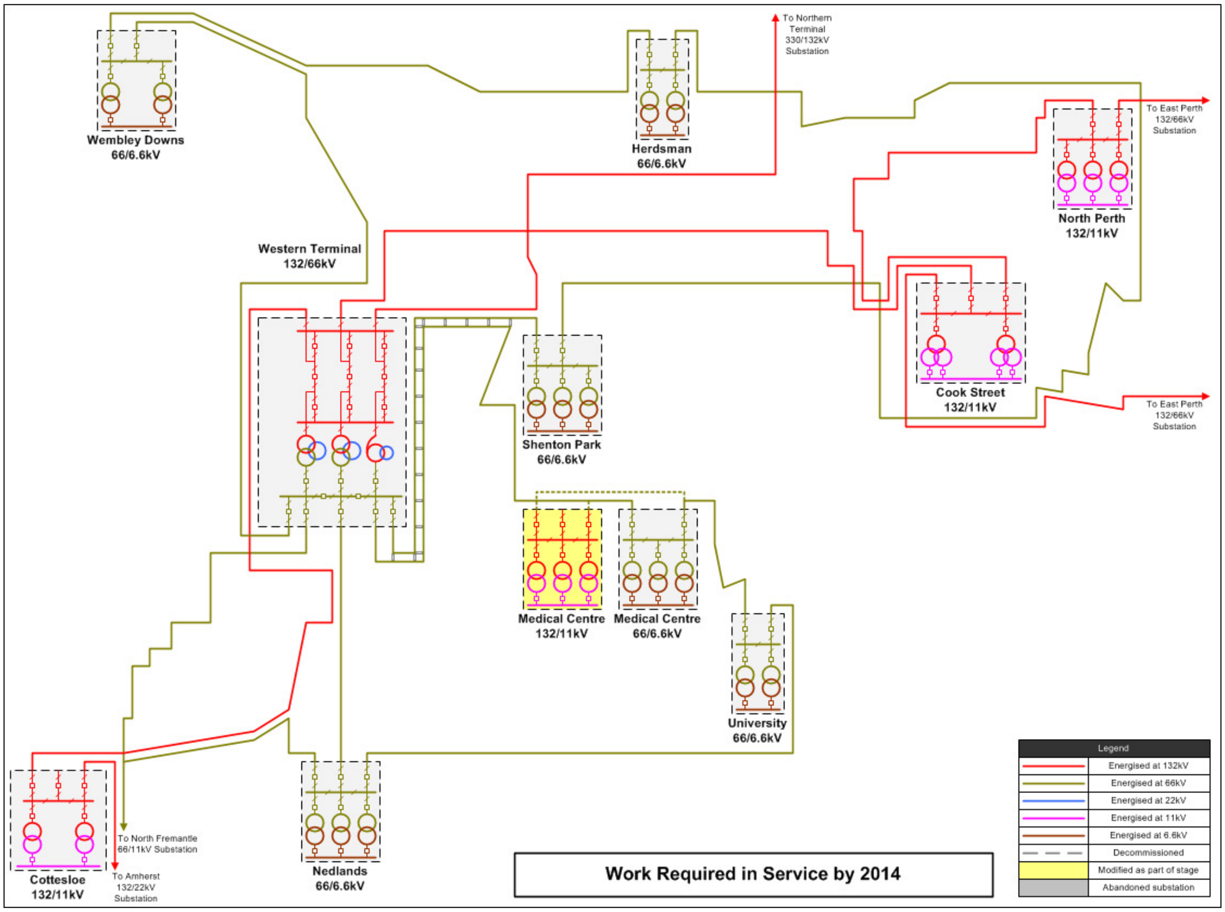


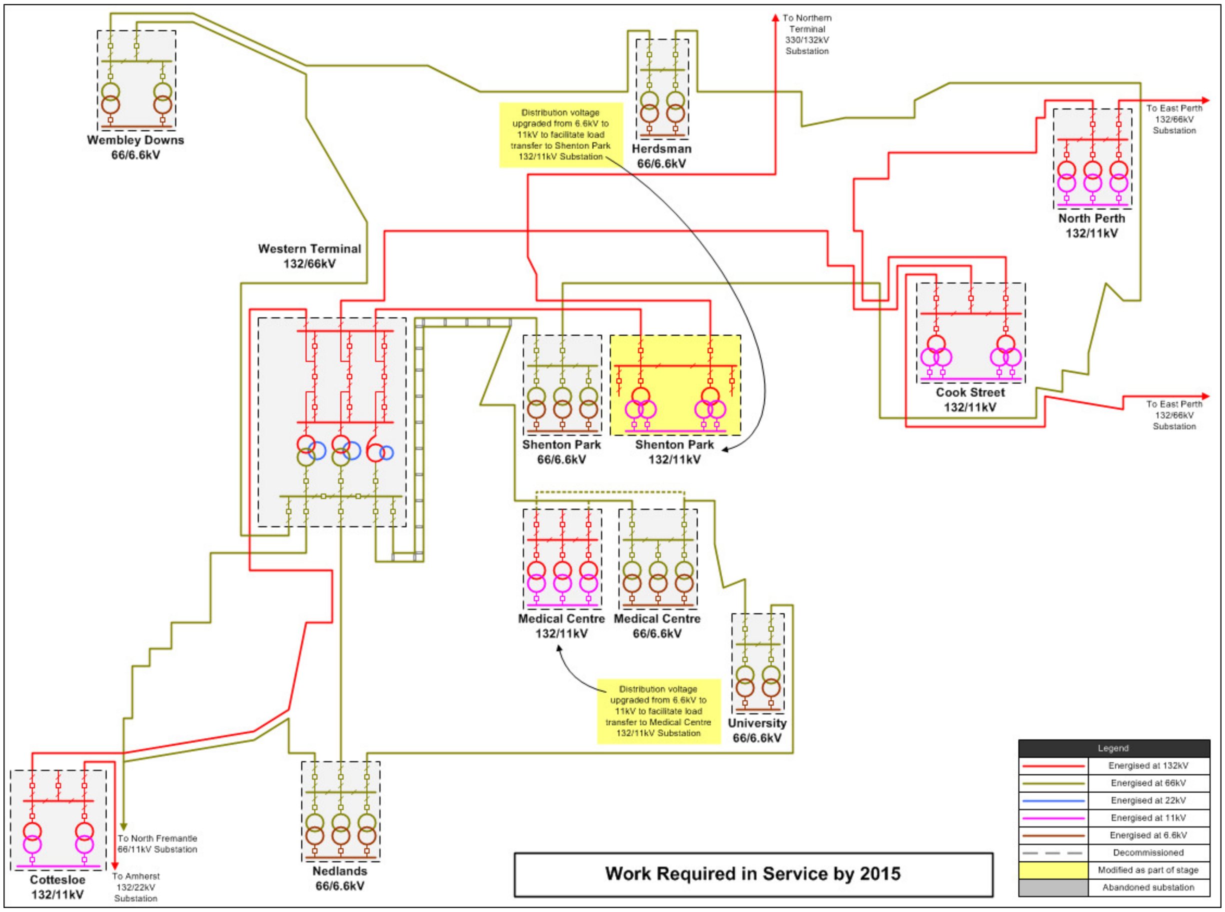
Figure 10 Strategy 3 – Work Required in Service by 2014



Medical Centre Zone Substation (2014):

- Construction of a new 132/11kV zone substation (initially energised at 66kV) adjacent to the existing site comprising 2 line circuits, 3 transformer circuits and 2 bus coupler circuits.
- Installation of 3 new 35 MVA 132-66/11kV transformers.
- Installation of 3 new 11kV switchboards.

Figure 11 Strategy 3 – Work Required in Service by 2015



Herdsman Zone Substation (2015):

- Upgrade of existing 6.6kV distribution network to 11kV to facilitate the transfer of the Herdsman load to the new Shenton Park zone substation.

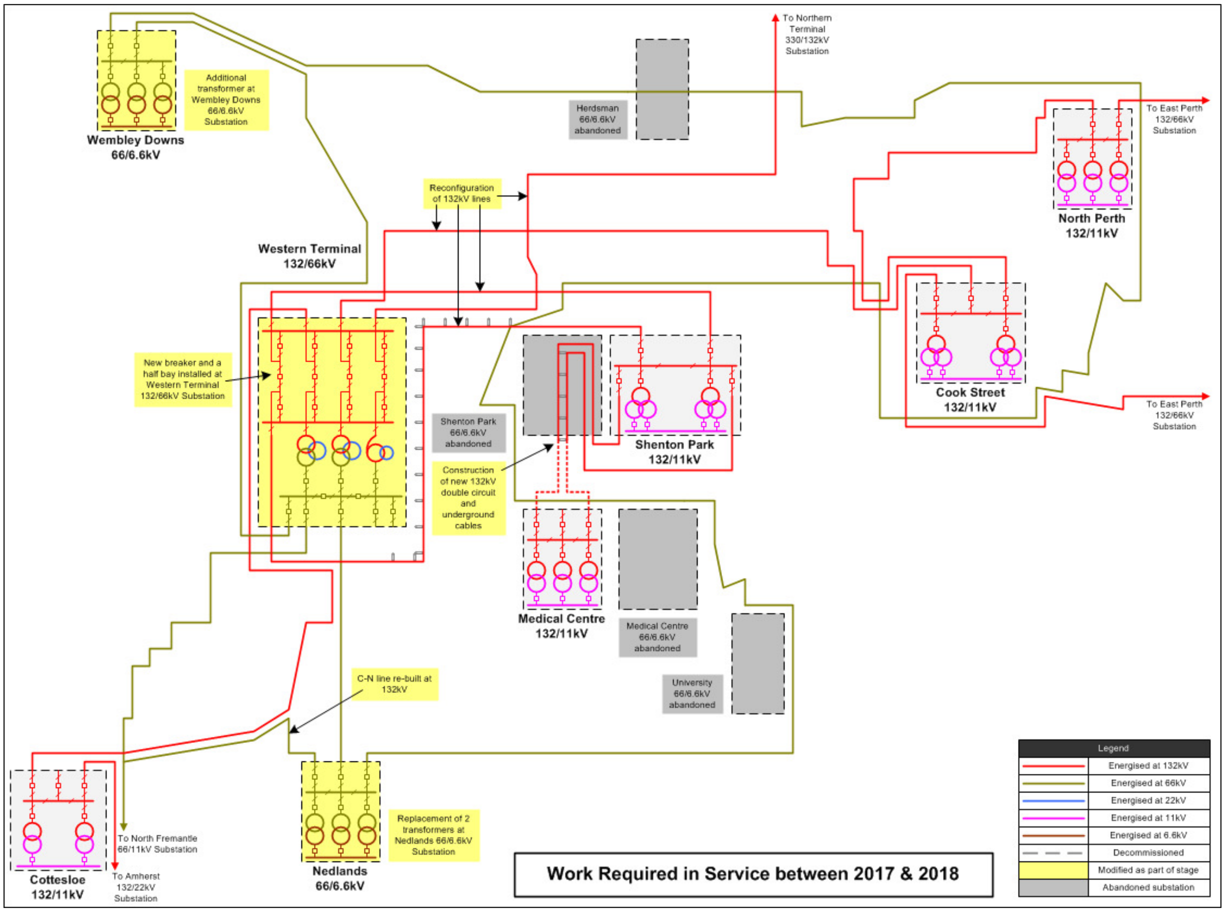
Shenton Park Zone Substation (2015):

- Construction of a new 132/11kV zone substation adjacent to the existing site comprising 4 line circuits, 3 transformer circuits and 2 bus coupler circuits.
- Cut-in of the new zone substation into the WT-NT 132kV transmission line.
- Installation of 2 new 75 MVA 132/11kV transformers (dual LV winding).
- Installation of 2 new 11kV switchboards.

University Zone Substation (2015):

- Upgrade of existing 6.6kV distribution network to 11kV to facilitate the transfer of the University load to the new Medical Centre zone substation.

Figure 12 Strategy 3 – Work Required in Service between 2017 & 2018



Wembley Downs Zone Substation (2017):

- Installation of a new 35 MVA 66/11kV transformer.
- Installation of a new 11kV switchboard.

C-N Transmission Line (2018):

- Rebuild the existing 66kV line to 132kV using wood pole construction.

Nedlands Zone Substation (2018):

- Replace existing transformers with 2 new 35 MVA 66/11kV units.
- Construction of 2 new line circuits and 3 new transformer circuits.

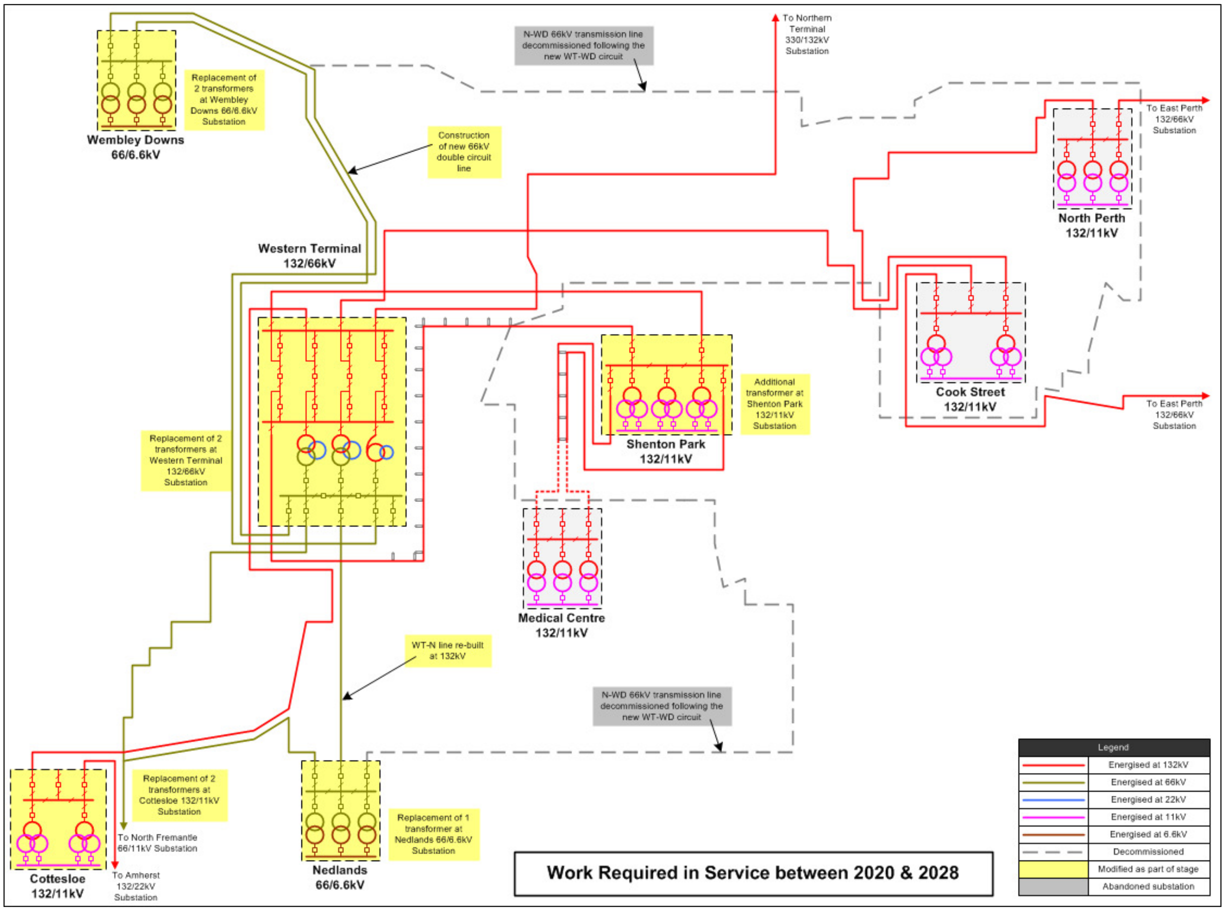
SP-MC Transmission Line (2018):

- Construction of a new 132kV double circuit line using steel pole construction.
- Installation of a new 132kV underground cable and associated transition structures.

Western Terminal Substation (2018):

- Construction of a new breaker and a half bay comprising 3 circuit breakers, 3 gantries and 2 circuits.

Figure 13 Strategy 3 – Work Required in Service between 2020 & 2028



Nedlands Zone Substation (2020):

- Installation of an additional 35 MVA 66/11kV transformer.
- Installation of an additional 11kV switchboard.

Cottesloe Zone Substation (2024):

- Replace existing 33 MVA transformers with 2 new 75 MVA 132/11kV units (dual LV winding).

Wembley Downs Zone Substation (2025):

- Construction of a new 66/11kV zone substation adjacent to the existing site comprising 2 line circuits and 2 transformer circuits.
- Installation of 2 new 35 MVA 66/11kV transformers.

WT-WD Transmission Line (2025):

- Construction of a new 132kV double circuit line using steel pole construction.

Shenton Park Zone Substation (2026):

- Installation of an additional 75 MVA 132/11kV transformers (dual LV winding).
- Installation of 2 new 11kV switchboards.

Western Terminal Substation (2026):

- Construction of 4 new line circuits, 2 new transformer circuits and 2 new bus coupler circuits.

WT-N Transmission Line (2026):

- Rebuild the existing 66kV line to 132kV using wood pole construction.

Western Terminal Substation (2028):

- Replace existing 100 MVA transformers with 2 new 100 MVA 132/66kV units.