MAJOR AUGMENTATION PROPOSAL

Options Paper

MID WEST ENERGY PROJECT – SOUTHERN SECTION

NEERABUP TO ENEABBA

DATE:

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safe reliable efficient

Executive Summary

Western Power has assessed various options to address energy network constraints and selected a preferred option (Mid West Energy Project - southern section), which satisfies the Regulatory Test.

The preferred option entails the construction of a double circuit 330 kV transmission line from the Perth metropolitan area to Eneabba in the Mid West, and the interconnection of the existing 132kV Three Springs substation with a new 330kV Three Springs Terminal.

As part of an interim supply arrangement, Karara Metals Limited (KML) will have constructed (i) a new double circuit 330kV transmission line from Eneabba to Three Springs, initially operating at 132kV, (ii) a new step-up 132/330kV terminal station at Three Springs, and (iii) a new 330kV transmission line from Three Springs to the Karara Mine site (via Koolyanooka). These facilities (funded by KML) will have been commissioned and operating for approximately 18 months prior to completion of the proposed 330kV transmission line from Perth to Eneabba.

On completion of the proposed 330kV transmission line to Eneabba, the pre-existing Karara transmission line and the Three Springs Terminal will be reconfigured to form a 330kV transmission line from Neerabup to Three Springs to Karara, and a step-down 330/132kV Three Springs Terminal.

Background

Western Power's South West Interconnected Network (SWIN) extends into the Mid-West region, the main centre of which is Geraldton. The part of the network servicing the Mid-West is known as the North Country network and is a long network spanning 400km from the northern outskirts of Perth to north of Geraldton. The length of the network and the purposes for which it was initially designed mean that it is electrically weak and has limited capacity to supply load. The network characteristics and their relationship with the rest of the interconnected system mean that capacity to connect generators to this network is also limited.

A number of major resource project proposals exist within the region, each of which will involve substantial power supply requirements. The existing network does not have the capacity to supply the power required by any of these projects.

Furthermore, the Mid West region is recognised as being a prospective major contributor to the renewable generation market in Western Australia with numerous plans for wind farms in the region. At present there are constraints within the network (as well as within the broader electricity system) that limit the ability of new windfarms to connect in this region.

This document outlines the options considered by Western Power to address the need to increase the electricity supply capacity to the Mid West region to meet forecast demand and presents the preliminary assessment of those options, confirming the preferred option satisfies the Regulatory Test. This preferred option, (Mid West Energy Project (southern section)) is capable of supplying forecast Mid West demand and will allow the connection of prospective new loads and generators in the region.

In addition, it is forecast that supply capacity to the region north of Eneabba and Muchea will be constrained from 2011/12 onwards for natural load growth conditions. The Mid West Energy Project (southern section) goes some way towards addressing these issues. If this project did not proceed then an alternative major network augmentation would be required by 2015/16 to address the natural load growth needs of Geraldton.

Load Forecast

The key drivers for the proposed major augmentation relate to the need to meet the electricity demands of existing and prospective customers, particularly:

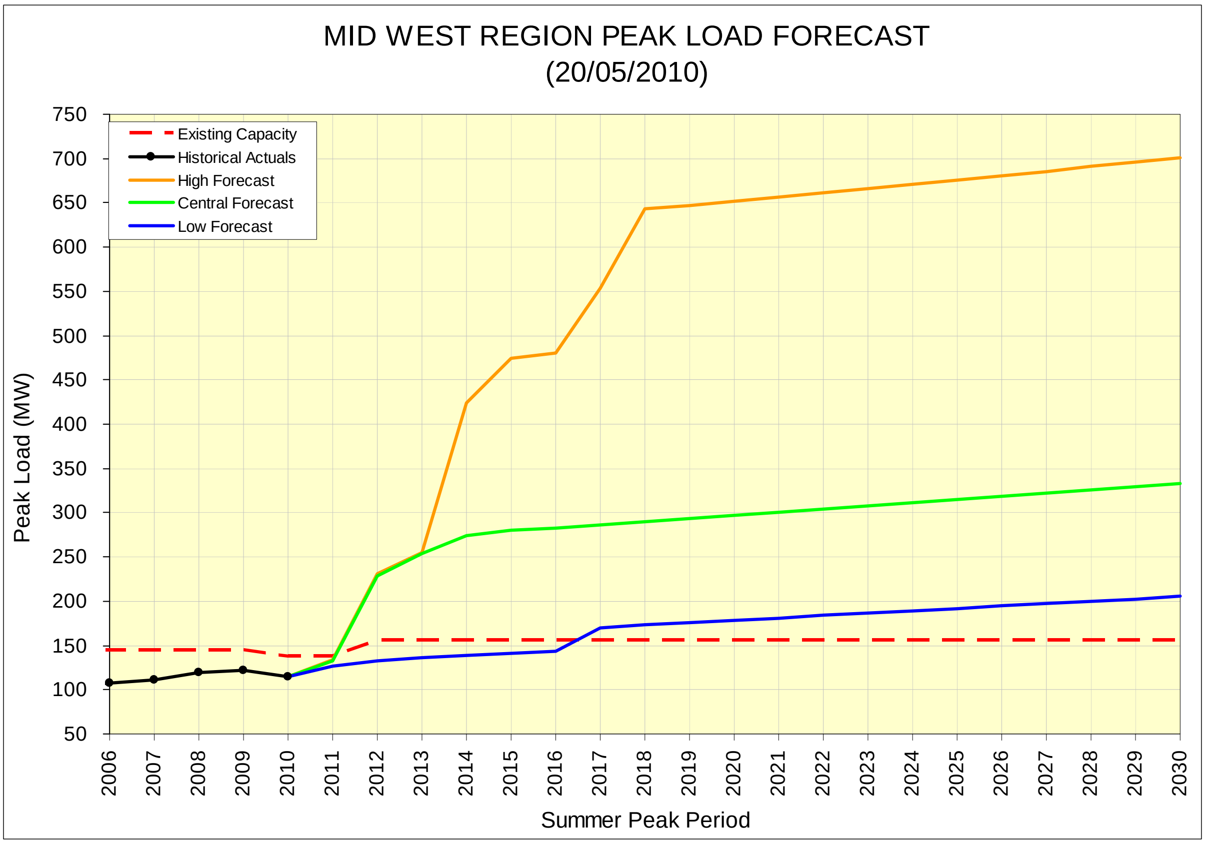
- Major new iron ore mining and processing loads east of Three Springs; and load growth from the proposed new port developments and industrial estate at Oakajee north of Geraldton;
- Substantial new wind (and other) generation projects seeking to connect to the network along the coastal region north of Pinjar; and
- Underlying natural load growth, mainly in the Geraldton region.

In assessing network capability and identifying appropriate options for reinforcement, Western Power has considered three load forecast scenarios – low, central and high.

The forecast peak demand for the North Country region for each scenario is shown in Figure 1. This forecast indicates that there is an impending problem whereby electricity demand will far exceed supply capacity within the next few years for the central and high case load forecast. Of particular note is the order of magnitude increase over the existing network capacity that is required to service the new loads in the region. This project proposal relates specifically to the central and high forecast cases.

For the low case load forecast, demand still exceeds supply capacity, but to a much lesser degree and at a later date.

Figure 1 Mid West Peak Load Forecast (ex Eneabba / Muchea)



The first major load proposal is Karara Metals Limited's new mine at Karara. This project will have an interim supply arrangement from August 2011 (initial demand up to 95MW, provided on a non-firm basis by the existing 132kV network). This interim supply is highly contingent on satisfactory network conditions and will require load shedding by Karara for numerous network events. By March 2013 the full load requirements of 120MW for Stage 1 of Karara will be met with completion of this proposed 330kV major augmentation.

The other step increase in demand under the central load forecast case relates to the Oakajee Port. The high forecast case includes the second stage development of the Karara project and other mining / industrial developments in the Mid-West region.

Options

Western Power identified and evaluated a number of options to increase the power transmission capacity in the Mid-West region to meet the forecast increased electricity demand, together with a forecast increase in electricity generation in the region.

The options assessed included network reinforcement, local generation and demand side management solutions.

The network reinforcement options considered included the construction of 132kV, 220kV, 275kV double circuits and 330kV single and double circuits as well as a number of alternative approaches, such as the use of reactive compensation or Direct Current (HVDC) transmission.

The non-network alternatives included local isolated generation and local interconnected generation operated as a network control service as well as demand management programs.

Only the 220kV double circuit, 275kV double circuit, 330kV single circuit and 330kV double circuit transmission line options were found to be viable. These four network options present viable means of supplying the central case load forecast and being expanded to meet the high case load forecast. To be considered as viable alternative options they have to be capable of supplying the load forecast both in terms of meeting the forecast quantum of demand and its forecast timing.

Of the viable solutions, the double circuit 330kV transmission line was determined to be the solution that maximises net benefit across a range of forecast scenarios, as defined in the Regulatory Test and therefore this is the recommended option. Further evidence of maximising net benefits is given in Section 6 of this report.

All options have been assessed as similar in terms of benefit delivery (i.e. meet forecast need). We have considered NPC and selected the DC 330kV option as it provides NPC in the lower range but includes greater flexibility, greater non-economic benefit and can be expanded at least cost to deliver capability required to meet the high load forecast as shown in Table 1.

Table 1 - Net Present Cost and Performance Comparison of Options

Option	Est Mine Load Serviced[1]	Load Scenario	
		Central NPC$M	High[2] NPC$M
220 kV Double Circuit	250 MW	$232	$556
330 kV Single Circuit	275 MW	$238	$429
275 kV Double Circuit	380 MW	$272	$475
330 kV Double Circuit	480 MW	$268	$282

Recommended Option

The recommended option entails the construction of a double circuit 330kV transmission line from Neerabup to Eneabba. This transmission line will be constructed along the route of an existing 132kV transmission line, which will need to be decommissioned. The new transmission line will initially operate with one circuit at 330kV and the other at 132kV (effectively replacing the decommissioned 132kV line) until such time as there is sufficient electricity demand or new generator connections to warrant the conversion of the second circuit to 330kV.

The new 330kV transmission line will connect to Neerabup terminal at its southern end, and to a new 330kV transmission line (to be constructed by others) at its northern end near Eneabba.

A 330kV/132kV transformer will be installed at Three Springs to interconnect the existing 132kV network with the new 330kV Karara transmission line. This transformer interconnection will be initially constructed by Karara to provide start—up supply to its mine but once the 330kV transmission line from Perth is connected, it will be reconfigured provide increased capacity to Geraldton to meet the underlying load growth needs of the area.

[1] Capacity stated is at mine site, not for the entire network and is for the central case load forecast. The mine site capacity has been calculated after all other load in the region has been supplied.

[2] Includes the cost of additional transmission works required to supply the high case load forecast.

Below, Figure 2 shows the existing network layout and Figure 3 shows the network arrangement following this proposed augmentation.

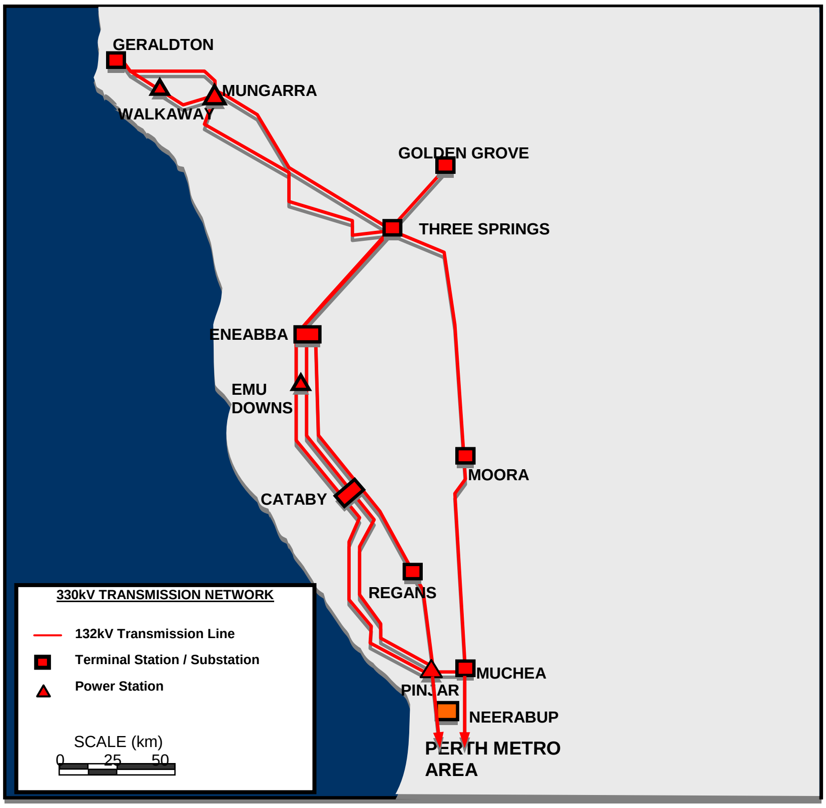


Figure 2 Mid West Region – existing network layout.

Figure 3: Mid west region – proposed network layout

Public Consultation

Western Power will conduct a public consultation process to inform interested parties of the 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. A summary of the outcomes of the public consultation and submissions will be published as part of Western Powers Regulatory Test submission to the ERA.

Summary

Western Power has identified that a major augmentation is required to meet forecast demand for electricity and that the recommended solution (a new double circuit 330 kV transmission line from Neerabup to Eneabba with a 330/132kV terminal station at Three Springs) maximises net benefit compared to the alternative options.

The deferral of this reinforcement would impede the development of the proposed Karara mine and require an alternative reinforcement plan to be adopted to meet the natural underlying load growth needs of the Geraldton region. Whilst there is limited capability to supply the natural load growth in the Geraldton region through demand management and local generation, this capability is insufficient to meet the near term electricity needs of the region.

Deferral will also inhibit the ability to connect new large generators (including windfarms) to the network north of Pinjar. As the region is highly prospective for wind generation, lack of network access may make it difficult for Western Australia to locally source its Renewable Energy Target (RET) obligations.

1 Introduction

The Mid West region of Western Australia is a major area of economic growth in the State. Geraldton is the major regional centre in the region, servicing the local communities and the agricultural and mining industries. Most of the population is based in the Geraldton-Greenough coastal strip and historically the majority of the electricity demand in the region has also come from this area.

While mining has always played a part in the economy of the region, its importance has increased in recent years and there are prospects of substantial expansions in the near future. In particular, a new major mining industry based on energy intensive magnetite iron ore processing is under development in the area east of Three Springs, and is a key driver in the forecast growth in electricity demand for the Mid West region. The Oakajee Port (OPR) development north of Geraldton is being developed as a new deepwater facility to export the bulk of the Mid West iron ore industry production.

In addition to increasing load demand, the coastal region between Pinjar and Geraldton is highly prospective for new wind generation projects seeking to gain access to the WA Wholesale Energy Market (WEM).

The federal government's RET target of 20% of all energy generated to be renewable by 2020 will require 4,750GWh of renewable energy generation to meet Western Australia's needs. At present the only proven large scale renewable energy generation technology is wind. Whilst the renewable energy requirement could theoretically be generated anywhere in Australia, the high yield for wind farms located along the coastal strip between Perth and Geraldton make this region very attractive for wind farm proponents.

The North Country transmission network provides electricity supply to the Mid-West region. This is a long 132kV network spanning 400km from the northern outskirts of Perth to north of Geraldton. The network characteristics mean that it provides limited capacity to supply load growth and that the capacity to connect generators to this network is also limited.

The existing North Country transmission network does not have the capacity to meet the forecast electricity needs of existing and prospective customers. The Mid West Energy Project (southern section) outlined in this document is intended to meet those forecast needs, in particular:

- major new iron ore mining and processing loads east of Three Springs; and load growth from the proposed new port developments and industrial estate at Oakajee north of Geraldton;
- substantial new wind generation (and other) projects seeking to connect to the network along the coastal region north of Pinjar; and
- underlying natural load growth in the Geraldton region.

This document provides detail regarding the forecast loads, the network limitations, the options considered for meeting forecast needs, comparison of the net benefits arising from the alternative options and demonstration that the recommended option, (Mid West Energy Project (southern section)) maximises net benefits and therefore satisfies the Regulatory Test.

2 Regulatory Approvals

2.1 Regulatory Approvals

Under the Electricity Networks Access Code 2004 (the Code) the proposed southern section of the Mid West Energy Project is considered to be a "major augmentation" as it is a transmission augmentation exceeding $30M. The regulatory obligations defined in the Code require that major augmentations satisfy two tests: the Regulatory Test and the New Facilities Investment Test (NFIT).

Western Power has completed a preliminary Regulatory Test and NFIT assessment which demonstrated that both tests are satisfied. The Code requires that Western Power consult formally with the public on its preliminary Regulatory Test assessment, to allow interested parties the opportunity to raise issues or concerns which need to be considered in the Regulatory Test submission to the ERA. Western Power intends to proceed with the public consultation in July 2010.

2.2 Regulatory Test Assessment

To satisfy the Regulatory Test Western Power must assess that the preferred option maximises the net benefit after considering alternative options. In this context net benefit measures the difference between the benefits the preferred option delivers to those who generate, transport and consume electricity in the SWIS with the increased costs incurred by those parties if the preferred option proceeds. Further description of the net benefits are included in Section 6.

Western Power has considered a range of network and non-network alternatives as described above and determined that four network options present viable means of supplying the central case load forecast and being expanded to meet the high case load forecast. To be considered as viable alternative options they have to be capable of supplying the load forecast both in terms of meeting the forecast quantum of demand and its forecast timing. The viable alternative options are construction of a double circuit 220kV line, 275kV or 330kV line or a single circuit 330kV line.

All alternatives were assessed as delivering similar benefits to parties who produce, consume and transport electricity in the SWIS. The alternative options were compared by considering the net present cost (NPC) of each option, the additional costs of work that would be required to extend each option to supply the High Case load forecast, and non-economic benefits delivered.

3 Reason for Network Augmentation

Western Power is responsible for the planning and operation of the South West Interconnected Network (SWIN), of which the North Country network is a part.

Karara Metals Limited have approached Western Power to provide a network supply to its proposed Karara Iron Ore mine in the Mid West. This mine is located approximately 215km east-southeast of Geraldton and 320km north-northeast of Perth. The closest connection point to the SWIN for the proposed mine is Three Springs (approximately 100km to the south-east of the mine). This part of the SWIN is very remote with limited capacity and network augmentation will be required to accommodate the load request.

Western Power has undertaken planning studies in relation to this request, taking into consideration its own forecasts for natural load growth and other block loads in the North Country region.

The proposed mine requires supply from August 2011. Western Power will provide up to 95MW of non-firm capacity by this time (utilising the existing 132kV network). Following completion of the augmentation proposed in this submission, the demand of Karara will increase to 120MW, from March 2013. Until the completion of the project proposed in this submission, the supply to Karara will be limited and will be subject to a load shedding scheme designed to maintain supply reliability and quality to existing customers within the bounds of the *Technical Rules*.

Planning activities for the SWIN are undertaken with reference to the *Technical Rules,* as approved by the ERA. These *Technical Rules* define the limits for operation of the network and the considerations to be made in determination of the transmission network's power transfer limits that are required to maintain safe and reliable operation of the network.

The technical requirements that apply to the design and operation of the network include:

- performance standards in respect of service standard parameters (supply quality); and
- network planning criteria, including contingency criteria, steady-state criteria, stability criteria and quality of supply criteria.

In its planning activities Western Power has identified constraints in its ability to meet future needs of the Mid West region. The clauses of the *Technical Rules* that are of particular interest in this region are:

- 2.2.2 Steady State Power Frequency Voltage;
- 2.2.7 Transient Rotor Angle Stability;
- 2.2.9 Short Term Voltage Stability;
- 2.2.11 Long Term Voltage Stability;
- 2.5.2.1 N-0 Criterion; and
- 2.5.2.2 N-1 Criterion.

3.1 Existing supply capacity and constraints

The Mid West region is presently supplied by a 132kV system. This system comprises a number of 132kV transmission lines connecting to Perth via Pinjar power station. The system is also supported by locally connected generation - gas, diesel and wind fuelled power stations are located within the region. The output of these power stations is used to provide voltage support and to supplement the limited capacity of the transmission lines.

The existing system is presently operating close to its capacity limit and system studies have identified that for the underlying growth trend there is an impending constraint in

2011/12. This constraint is a voltage stability constraint in the Geraldton region and affects load in the area around Geraldton. A further constraint (thermal capacity of transmission lines) has been identified for 2015/16 and affects all substations located north of Eneabba and Muchea (refer to figure 4).

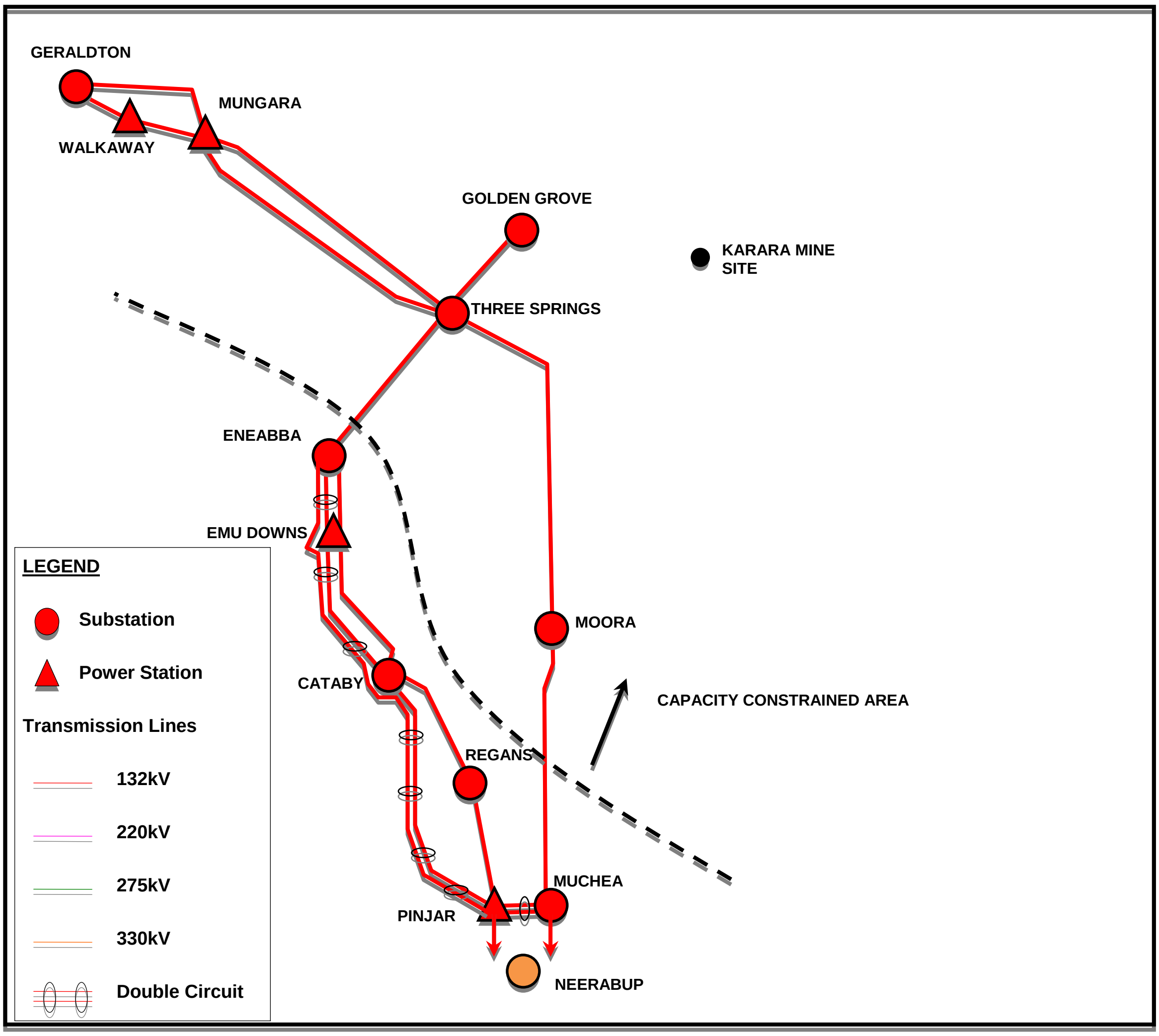


Figure 4: Existing network layout showing area where capacity is constrained

As load continues to grow in the future, additional thermal constraints of the transmission lines connecting Geraldton as well as further voltage stability issues will arise. The nature and timing of the future constraints will be affected by the solutions adopted for the immediate constraints and understanding these is relevant in option assessment and selection.

Preliminary technical and economic studies to identify and rank options to resolve the voltage and thermal constraints outlined above have been completed. A number of solutions are available to meet the underlying load growth needs – ranging from demand management, generation connected as a network control service to network augmentation. While a preferred network augmentation has been identified, it does not require substantial expenditure until around 2015/16. It is expected that the issue could initially be managed through the use of demand management and local generation (as network control services).

Network augmentation would be the only alternative available to offer network connection to either:

- substantial new load developments above the natural (underlying) load growth forecast; or
- market generators (i.e. any generator intending to earn income from the reserve capacity and energy markets)

Although generators providing network control services could be accommodated, these generators would be dispatched only as required to support the local area load and could not participate in the wholesale energy market (WEM) nor could they earn reserve capacity payments.

The forecast new block loads contained within the central and high case load forecasts for this region require substantially greater network capacity than the underlying load growth. This need has therefore required the consideration of other, much higher capacity alternatives. The needs of the underlying load growth are acknowledged here to promote the understanding that the proposed project alleviates the need for reinforcement work to address those issues. In the event that a major augmentation to supply the central or high forecast did not proceed then a different major augmentation would be proposed to meet the underlying load growth needs of the region.

3.2 Load forecast

Western Power has considered a range of load forecast scenarios in its planning activities. Central, Low and High load growth scenarios have been prepared for system studies.

The low forecast scenario does not include any new major load developments and is reasonably reflective of underlying load growth for the region. In a similar manner to meeting just underlying load growth as discussed above, the network would require reinforcement to accommodate the low load forecast. However, the extent and timing of reinforcement would be substantially different to the central and high growth scenarios. The augmentation proposal just sufficient to meet the low load forecast would be insufficient to supply the central or high forecast. The selection of the preferred option has considered which option provides the least cost means of being able to address all load growth scenarios.

This submission therefore concentrates on the central and high load growth scenarios.

The load forecast has been broken down into two distinct components – underlying (natural) growth of the existing customer base and block load growth relating to the development of major new loads in the region. Each of these is discussed below. The low scenario models forecast underlying demand and no new block loads, the central scenario includes committed block loads and a small number of the most likely prospective block loads, the high forecast expands on the central view by assuming more aggressive underlying demand growth and an additional number of highly prospective block loads.

3.2.1 Underlying Natural Load Growth

Underlying (or natural) load growth is generally associated with the expansion of existing activities and population within a region. Load growth results from increased population, expanding economic activity and the resultant enhanced economic status of the population allowing greater consumption of consumer goods.

Geraldton is the key centre in the region for underlying load growth, accommodating approximately 67% of the Mid West region's total population. According to data published by the Australian Bureau of Statistics, Geraldton has experienced 2.6% pa population growth over the last 4 years[3]. Prior to 2005, population growth in the Geraldton region was relatively subdued, especially compared with Perth and the remainder of Western Australia. Since 2005, population growth in the Geraldton region has exceeded that of Perth and Western Australia overall (in percentage terms). Data relating to personal income growth also indicates that since 2005, Geraldton kept pace with Perth and the remainder of the state – supporting the theory that strong population growth is related to strong economic activity within the region as indicated in Table 2.

Table 2: Economic Activity and Population Growth

	Geraldton	Perth	Western Australia
Population Growth 2004-2009	2.6%	2.4%	2.3%
Population Growth 2001-2009	1.8%	2.2%	2.1%
Personal Income Growth 2004-2008	6.2%	6.2%	6.2%

The economic growth in the Mid West region is based largely on mining. The new mining developments discussed below are expected to bring both social and economic benefits across the region leading to secondary growth effects for the local community that will increase the underlying electrical load of the region, particularly in and around Geraldton.

The central forecast scenario includes underlying natural load growth of 42 MW over the 10 year period from 2010 – 2020, equivalent to a 3.2% annual compound growth rate.

The high forecast scenario includes underlying natural load growth of 51MW over the 10 year period from 2010 – 2020, equivalent to a 3.7% annual compound growth rate.

3.2.2 Major New Block Load Demand

New industries or developments within a region are generally referred to as block loads and require a different forecasting methodology than natural load growth. Where natural load growth can be estimated by extrapolating historical trends, block loads introduce a new dimension to the load characteristics of a region and are individually assessed to determine whether they are sufficiently likely to proceed to be included in the demand forecast. This assessment considers factors such as the magnitude of the proposed connection, the type of industry, its proposed operating regime and its likelihood of proceeding.

The last five years have seen an upsurge in mining activity with three iron ore projects now exporting ore through Geraldton and many more being planned. These have the potential to make the region a major participant in the overall state mining sector.

[3] Australian Bureau of Statistics, http://www.abs.gov.au/

A reference study by Economic Consulting Services (ECS)[4] provided forecasts of the potential benefits of the iron ore industry for the Mid West region. These included the creation of 1,360 jobs during construction followed by 4,254 direct jobs in the region for at least 25 years and in excess of 12,000 direct and indirect jobs throughout WA. ECS estimated that the region would add $1.5 billion dollars a year to the Gross State Product, while contributing $7 billion and $3.5 billion dollars in project royalties to the Federal and State Governments respectively over the project life.

The ECS study identified a large number of projects with a significant potential power demand in the region, focusing on projects that have strong potential to be in production by the end of 2014.

The projects that Western Power assessed as having a high chance of proceeding are reflected in the demand forecasts for the Mid West Region.

The loads associated with these resource projects are an order of magnitude higher than the existing regional demand and will have a fundamental impact on the network requirements for the region.

Supporting the mineral extraction processes will be a new deep water port at Oakajee (25km north of Geraldton). This port development will initially require an electrical supply to commence operations in 2014. The new port has been located to facilitate the development of a heavy industrial area around the port. The developers envisage that the industrial area will act initially as a service centre for new mining developments, but will also offer opportunities for minerals processing and even manufacturing industry. Therefore there is potential for additional load requirements in the future, however these are yet to be quantified.

The central case load forecast indicates additional new block loads totalling around 140MW (diversified) over the 10 year period from 2010-2020, with most load growth occurring within the next few years and primarily related to the development of Stage 1 of the Karara Mine.

The high case load forecast incorporates a further 350MW of prospective load related to major project developments that have a reasonable probability of being realised. There is potential for additional load growth beyond the high case.

[4] ECS North Country Reinforcement Benefit Cost Analysis May 2009

3.2.3 Load Forecast Summary

The components of the various scenarios and the resulting forecasts for 2020 are shown below.

Table 3: 2020 Demand Scenarios

Demand Components	2020 Demand Scenario (MW)		
	Low	**Central**	**High**
Peak Load	115	115	115
Underlying / Natural Growth	36	42	51
Block Loads			
Small Block Loads	3	12	14
Large Block Loads (including Karara, Oakajee, Geraldton Port Authority and other prospective mining loads in the Mid West.)	24	128	472
Non-Diversified System Peak	**205**	**333**	**701**
Diversified System Peak	**178**	**297**	**652**

3.3 New generator connections

The coastal location between Pinjar and Geraldton provides a very prospective wind resource with wind load factors well in excess of 40% (compared with around 30-40% in most locations nationally) and relatively straightforward access to land. Western Power currently has enquiries from proponents seeking to develop over 1,300MW[5] of wind generation projects in this locality.

The Federal Government's Renewable Energy Target (RET) requires that 45,000GWh of all energy produced (nationally) by 2020 be obtained from renewable sources. Therefore the demand for connections of renewable generation is expected to increase with time. At present wind generation is the only proven and operational form of large-scale renewable energy generation in Australia, and it is therefore reasonable to conclude that a high proportion of new renewable energy projects are likely to wind based.

The production advantage of windfarms located on the Mid West coast are likely to sustain strong interest for wind generator developments in the area. The wind reserve in the Mid West region is greater than elsewhere in the SWIS, estimated to be 40% capacity factor, and will provide a greater return for the same investment for developers. For example if the capacity factor of a wind farm is 30% then a 100MW wind farm would produce 263GWh annually, while a 40% capacity factor windfarm would produce 350GWh annually and a 50% capacity factor windfarm would produce 440GWh annually.

At present, the ability to develop windfarms along the Mid West coastal region is constrained by the weak nature of the existing network north of Pinjar. Augmentation of the Mid West transmission network would create significantly enhanced opportunities for large scale wind projects to access the transmission network, along the route length.

[5] 780MW between Pinjar and Eneabba; and 530MW between Eneabba and Geraldton

Western Australia will need to produce annually (or acquire) 4,750 GWh of renewable energy by 2020[6]. To meet this target, almost 1,100MW (at 50% capacity factor, 1,350MW at 40% capacity factor) of installed wind generating plant is required by 2020. It is also recognised that existing and alternative sources of renewable energy will make up this total. eg existing wind generation and pv solar schemes.

Western Power commissioned a study to assess the benefit that wind generation proponents would derive from strengthening of the Mid West transmission network and to investigate whether this would also benefit electricity consumers. This study, by ACIL Tasman, concluded that under a range of scenarios the most likely outcome of a stronger transmission network in the Mid West region would be greater participation by wind generators in the electricity market. In all scenarios there was a benefit to electricity consumers - resulting in lower costs to electricity consumers. The scenarios considered included cases where there was a reduction in revenue received by wind generators (e.g. scenarios requiring the wind generators pay for greater ancillary services; or capacity credits given wind generator installations are reduced).

Other generation developments based on local gas and coal resources are also possible in the vicinity of the proposed Mid West transmission line. The southern section Mid West transmission line will enhance the ability to connect new generation sources north of Perth.

3.4 Summary - Drivers for reinforcement

The Mid West region is an area of Western Australia that is experiencing strong population and economic growth, with potential for major new developments in the mining and power generation industries.

Historically the region has been supported through a small 132kV transmission network. The existing electricity network is nearing its capacity, and does not have the capability to even start addressing the needs of the proposed new industries.

There is an option available to provide an incremental increase in network capacity that will serve the underlying load growth needs of the region. However, this option does not provide any opportunity for new developments in the region. These industries have high potential for being realised, but have vastly greater power demands than the existing network is able to provide and their progress has been impeded to date due to this limitation. To enable development of these industries, a network augmentation that provides an ‘order of magnitude’ increase in network capacity is required.

[6] Assuming that the 45,000 GWh represents around 20% of all energy nationally and using the IMO’s 2009 forecast for energy sent out in 2020.

4 Options Considered

4.1 Network solutions

A range of network solutions was identified for consideration. An initial screening assessment of these was undertaken to separate the viable and non-viable solutions, thereby identifying the solutions that would be subject to more thorough technical and financial assessment.

Each of the network solutions considered concentrated on increasing capacity between the northern outskirts of Perth (Pinjar or Neerabup depending on connection type and voltage) and Eneabba. Eneabba is the termination point of a transmission line proposed by Karara to connect their mine with the SWIN. The ability to extend the proposed reinforcement further northwards from either Eneabba or Three Springs to Geraldton to meet future needs was included in the comparison of viable options.

To be viable, a potential solution needed to meet the central load forecast. It also needed to incorporate potential for extension or enhancement to accommodate the high load forecast. The non-viable solutions are discussed briefly below, noting the reasons for exclusion from further assessment.

The options remaining for consideration were all transmission line reinforcements, reflecting the need to provide significantly greater capacity into a regional area with limited existing capacity. A range of voltages and configurations were assessed for the transmission line reinforcements.

4.1.1 Non-Viable Network Solutions

4.1.1.1 Reactive Compensation

Voltage limited networks can often be enhanced through the use of reactive power compensation (shunt capacitors, STATCOM or SVC[7], or series capacitors[8]). However, the North Country network is already heavily compensated with capacitor banks installed within most substations and is operating close to its limit. Furthermore, the amount of additional load to be connected is far beyond the present capabilities of the network and reactive compensation is only able to achieve relatively minor increases in network capacity.

Therefore reactive compensation is not suitable for providing substantially greater network capacity required to accommodate the proposed mining or generation connections.

4.1.1.2 Direct Current Link (HVDC)

HVDC provides a cost effective alternative to AC (alternating current) transmission when high power transfer is required across very long distances. The advantage of DC over AC transmission is that it is not reliant on the transport of reactive power to support voltage (the

[7] STATCOM. SVC (Static Var Compensator): An item of plant that is capable of producing dynamic reactive compensation and is commonly used to support voltage and aid voltage stability within electricity networks.

[8] Series Capacitor: A capacitor connected in series with the transmission line, used to effectively shorten (electrically) the length of the line (by reducing the effective line impedance). This has the effect of reducing the amount of reactive power required to maintain satisfactory voltage regulation at the load centre.

limiting factor in AC transmission when transferring high power across long distance). HVDC is also attractive in that the transmission line construction costs are much lower compared to three phase AC transmission lines as fewer conductors are required.

Offsetting the cost advantages of the line construction are high costs in the converter stations required at either end of the transmission line. The converter stations are necessary to make the conversion between AC and DC systems and integrate the DC link into the existing transmission grid. HVDC systems are usually point-point type transmission systems, as any intermediate connections along the line also require converter stations (at additional expense and additional complexity).

The economic 'break-even' distance for HVDC transmission (the distance beyond which it becomes economically favourable compared to traditional AC transmission) is related to the power transfer level. It has typically been considered to be around 600km, however technology advances are reducing this all the time. The break-even distance would be greater for a system that required intermediate converter stations due to the additional expense involved with each of these.

The project proposed in this submission entails construction of a 200km transmission line, with a possible future extension to 400km total length. It is intended that there are various connection points along the route length to enable access for wind generation stations. Only one connection point is required for the foreseen mining loads, however there are other potential loads which may require additional connection points. It has been noted that geographic diversity is a key element to facilitating the successful integration of wind generation into electricity networks. Geographic diversity reduces the risk of sudden changes to wind generation input to the system, minimising the ancillary services required to ensure reliability of supply. This need for geographic diversity in wind generation leads to a need for multiple interconnections between generators and the network.

A preliminary economic assessment was completed for this option and the outcome indicated that it would be a more expensive option with less flexibility than the others included in the viable options list.

As Western Power has not previously used HVDC technology (although it has been successfully implemented in three locations within Australia, along with many others throughout the world) there is an element of risk in adopting such an option, and given that financially competitive alternatives exist this risk is considered unnecessary. Such risk would only normally be adopted if the project were to offer substantial cost savings.

This option was therefore not considered to be viable due to the lack of financial advantage combined with higher technological risk for Western Power and reduced flexibility for new connections.

4.1.1.3 132kV Double Circuit Transmission Line

This solution entails rebuilding an existing single circuit, low capacity 132kV transmission line between Pinjar power station and Eneabba substation as a double circuit, high capacity line.

As the new line will replace an existing line, it only adds one more 132 kV circuit to the existing system. This alternative will only provide 40-60MW of supply capability at the Karara mine site, which is not sufficient for their needs. Therefore this option was not considered further.

4.1.2 Viable Network Solutions

Each of the viable network solutions are discussed briefly below, further detail regarding the options and an options assessment is included in section 5.

4.1.2.1 220kV Double Circuit

A 220kV double circuit transmission line from Pinjar or Neerabup to Eneabba would replace the existing low capacity 132kV transmission line. The higher transmission voltage means that this option would provide up to 250MW of supply capability at the Karara mine site and other locations east of Three Springs (as well as meeting the regional load out to 2029). Western Power currently operates a 220kV transmission line to supply the Goldfields region and therefore has experience with this operating voltage.

This option would require establishing a new transformation point at either Pinjar or Neerabup to provide the 220kV source voltage for the transmission line.

In order to minimise the initial cost, development would be staged with one circuit of the double circuit initially operated at 132kV to provide ongoing connection to the existing 132kV substations at Regans and Cataby (maintaining existing connections). This option meets the requirements of the central case load forecast with some spare capacity, but is not sufficient to meet the total needs of future development at Karara nor Extension Hill without further reinforcement.

To meet the high case load forecast, the full capability of the double circuit line would be required and the second circuit would be converted to 220kV by around 2013. This conversion process would require establishing new 132kV supplies to the Regans substation. Further reinforcement would be required by 2014. This further reinforcement would need to be a major investment project and has been included in the net present cost comparisons. For comparison purposes, a scenario centred on rebuilding the existing inland Pinjar-Muchea-Moora-Three Springs 132kV transmission line as a 220kV double circuit transmission line has been assumed. Details of the proposed route are yet to be determined. It should be noted that no work has been done to obtain a line route or to progress environmental approvals for this additional augmentation.

As noted above, to meet the high case forecast, an additional new line could be required as early as 2014. As no work has been undertaken with regard to identification and gaining approval for another line route meeting this date will have significant risk. Although it is anticipated that much of the route would follow the existing route for the inland 132kV line (via Muchea and Moora to Three Springs) environmental assessment would still need to be undertaken to establish that this is the best alternative. Identification and approval of transmission line routes can be a lengthy process and therefore this option does present a delivery risk to new block loads included in the high case load forecast.

4.1.2.2 275kV Double Circuit

Western Power does not presently operate any 275kV transmission networks however there are numerous others within Australia, meaning that there is ready access to suitably tested plant as well as design and construction expertise. This voltage was considered as it may provide sufficient capacity to meet needs at a lower cost than 330kV.

A 275kV double circuit transmission line from Pinjar or Neerabup to Eneabba (replacing the existing 132kV single circuit) would provide 380MW of capacity at mine site locations east of Three Springs (plus meeting the regional load out to 2029).

This alternative would be sufficient to meet the central load forecast requirements, with some spare capacity to accommodate additional load growth such as Extension Hill and therefore further assessment and economic analysis has been completed.

In order to minimise the initial cost, development would be staged with one circuit of the double circuit initially operated at 132kV to provide ongoing connection to the existing 132kV substations at Regans and Cataby (maintaining existing connections). This arrangement would be sufficient to meet the central load forecast requirements.

To meet the high case load forecast scenario, the full capability of the double circuit line would be required and the second circuit would be converted to 275kV by around 2015. This conversion process would require establishing new 132kV supplies to the Regans substation. Further reinforcement would be required by 2020 and is therefore included in the net present cost comparisons for this option. For comparison purposes, a scenario centred on rebuilding the existing inland Pinjar-Muchea-Moora-Three Springs 132kV transmission line as a 275kV double circuit transmission line has been assumed. Details of the proposed route are yet to be determined. It should be noted that no work has been done to obtain a line route or to progress environmental approvals for this additional augmentation.

4.1.2.3 330kV Double Circuit

The 330kV double circuit option would provide 480MW at mine site locations east of Three Springs (plus meeting the regional load out to 2029). Accordingly, it not only provides sufficient capacity to meet Karara's stage 1 and 2 load requirements, but will also cover other projects in the high load case forecast (including Extension Hill) and additional load growth in the region beyond the high forecast.

In order to minimise the initial cost, development would be staged with one circuit of the double circuit initially operated at 132kV to maintain existing connections to the existing 132kV substations at Regans and Cataby. This arrangement would provide sufficient capacity to meet the central case load forecast and the high case load forecast until 2016.

Ultimately to achieve the full capability when required, the second circuit would be converted to 330kV. To complete this line conversion, new 132kV lines would need to be constructed to connect to Regans substation. No further (major) work is required to meet the high case load forecast scenario.

Within this option, a range of conductor types and sub-conductor bundle configurations have been examined with a view to minimising total present value cost (trading higher upfront cost of the line with larger conductors against lower operating cost of losses).

4.1.2.4 330kV Single Circuit

A single circuit 330kV transmission line would provide 275MW at mine site locations east of Three Springs (plus meeting the regional load out to 2029) – i.e. marginally better than a double circuit 220kV line in terms of capability. This option would be sufficient to meet all of

Karara's requirements, but does not meet the total needs of others included in the high case forecast.

To meet the load development scenario envisaged in the high case forecast, an additional major network reinforcement would be required, possibly as early as 2015/2016.

This further reinforcement would need to be a major investment project and has therefore been included in the net present cost comparisons. For comparison purposes, rebuilding the existing inland Pinjar-Muchea-Moora-Three Springs 132kV transmission line as a 330kV transmission line has been assumed. Details of the proposed route are yet to be determined. It should be noted that no work has been done to obtain a line route or to progress environmental approvals for this additional augmentation.

As noted above, to meet the high case forecast, this reinforcement could be required as early as 2016. As no work has been undertaken with regard to identification and gaining approval for another line route meeting this date will entail substantial risk. Although it is anticipated that much of the route would follow the existing route for the inland 132kV line (via Muchea and Moora to Three Springs) environmental assessment would still need to be undertaken to establish that this is the best alternative. Identification and approval of transmission line routes can be a lengthy process and therefore this option does present a delivery risk for new block loads in the high case load forecast.

4.2 Non-network solutions

4.2.1 Local Generation (as isolated non-grid supply)

This option would minimise investment in new network infrastructure by requiring new or expanding loads in the region to acquire local generation services (either at their site or connected via a private transmission link) to suit their needs. This option would not enable any new market generators to connect to the SWIN.

The cost of energy to the customer will be the primary criteria influencing the decision of a prospective load to pursue either network connection or isolated supply. Two factors that greatly impact cost of energy when considering an isolated supply are:

- reliability of power supply; and
- availability of fuel source.

In large networks, reliability of supply is secured through the use of multiple generation units spread across different regions utilising different fuel sources. The use of different types of fuel sources adds diversity to the energy mix in terms of generating plant efficiency as well as energy security. Generation plant is a mixture of base load, mid-merit and peaking plant to suit the load profile.

Reliance on a stand-alone power station introduces greater risk for large customers as they may not have an alternative source of energy in the event of unavailability. Generating units within power stations have relatively high rates of unavailability compared with transmission network elements. In large networks this issue is be managed through the connection of large numbers of generating units. Generator maintenance and outages are scheduled, taking advantage of the cyclic nature of load demand of the entire system, taking into account plant breakdowns and relying on the availability of alternative generators during that time. For a single site with almost constant load, this is not possible and to ensure adequate reliability, greater redundancy is required meaning additional generating units need to be installed. This increases the overall cost of the energy to the customer.

The availability of a ready fuel source at the proposed power station will also affect energy cost. Many power stations are located adjacent to facilities that they need to operate efficiently – cooling water and fuel source and utilise large transmission networks to transport electricity produced. The transport of fuel to the generation site increases costs.

Western Power commissioned an investigation into the likely cost of stand alone generation for a customer of a similar size to the foundation customer for this transmission line (KML). This report made the assumptions that power would be supplied via combined cycle gas turbines (CCGT) backed up by an open cycle gas turbine (OCGT). The primary fuel source would be gas, fed via a lateral pipeline from the Dampier-Bunbury Gas Pipeline (DBGP). On-site oil tanks would be used to provide short term fuel back-up. To provide an adequate degree of reliability (plant redundancy) to a peak load of 140MW (average load 120MW) four gas turbines would be required (3 x 50MW CCGT plus 1 x 35MW OCGT).

The cost of installing and operating this stand-alone plant would be around 20% greater than in the SWIS due to its isolated location and smaller unit size compared to plant within the SWIS. The assessment determined that an additional cost of around $50/MWh would apply to an isolated generation plant. The cost of the Mid West Energy Project (southern section) is less than this amount, hence a network connection offers a more efficient solution for the customer.

The fact that KML has requested a network connection suggests that they also view this as the most efficient means of energy delivery for their operation (stand-alone generation vs network connection). Western Power understands that KML has entered into a supply arrangement with Verve Energy. Western Power conclude that the cost of alternative isolated supply is greater for the customer and therefore this is not an efficient outcome.

4.2.2 Local Generation (as network support control service)

This option would enable the connection of new loads to the SWIN and these loads would be supplied by new locally connected generators directly contracted to the new loads.

Due to the capacity limitations within the existing network, the new generators would only operate as a network support control service and not as a market generator (i.e. it would not be able to contribute to system reserve capacity and could not participate in the wholesale electricity market generally). The extent to which this would apply is dependent on the connection location for any new generator proposing this type of service.

The advantage of this option compared with the stand alone local generation is the ability to locate close to a fuel source. To minimise the need for any augmentation to the SWIN (there would still need to be a separate transmission connection between the customer and the generator), any potential network control generator would need to be located conveniently (i.e. near to Eneabba or Three Springs which is the proposed connection point for the first major customer).

Similar to the stand-alone generation option, the need to achieve adequate reliability of supply will be an issue. To achieve a level of reliability expected as standard from a grid connected supply, a greater level of redundancy will need to be installed within the power station, thereby resulting in increased energy costs.

Whilst there are several generation proposals in the region the majority are wind generation prospects that do not provide adequate output reliability for a dedicated customer.

Given the short time before supply is required, it is unlikely that an alternative new project would be able to achieve the required environmental approvals and construct a plant to meet the supply requirements.

There is also a need for the generator to hold an energy supply contract with KML. Western Power understands that KML has a signed agreement with Verve and Western Power is not aware of any proposal for Verve to construct new generation near Eneabba or Three Springs to supply Karara.

Also any generator would require a transmission connection and based on existing project enquiries it is unlikely they could be established in the required timeframes given the current state of progress.

4.2.3 Demand Side Management (DSM)

In November 2009, Western Power commissioned a demand management feasibility study for the Geraldton region to investigate the demand management alternatives to the reinforcement of the northern section of the North Country region. In particular, the investigation sought to quantify demand management options and assess the costs of implementing these to potentially defer the need for network augmentation or mitigate the risk of delay in construction.

DSM initiatives can only reduce peak demand incrementally and due to the connection of dominant large mining block loads in the southern North Country region will not contribute to deferment of the southern section Mid West project network augmentation. Accordingly, they cannot on their own replace the need for line reinforcement. DSM can however make a real contribution to deferment of expenditure and mitigation of risks around future northern section network augmentations. Western Power will continue its work within the DSM environment with regard to supporting the Geraldton load, but accepts that it is not a viable option to provide capacity to the proposed major new loads in the region and does not enable the connection of new renewable generators in the region.

5 Assessment of Options

5.1 Assessment of Viable Options

The viable options for further consideration were all transmission line reinforcements, reflective of the need to provide significantly greater capacity into a remote region with limited existing capacity. The options considered in further detail were:

- 220kV Double Circuit;
- 275kV Double Circuit;
- 330kV Double Circuit; and
- 330kV Single Circuit.

The following sections describe the high level scope of each of these options. A power transfer capability (in MW) is quoted for each option. This capability has been calculated at the proposed mine site location and referenced to an N-0 reliability criteria (i.e. equivalent to an non firm level of service to new mining customer loads). The forecast natural load growth needs of the region have been accommodated within the proposed reinforcement options at a standard N-1 level of reliability.

A. 220kV Double Circuit

This option entails rebuilding the existing single circuit wood pole Pinjar-Regans-Emu Downs-Eneabba 132kV transmission line as a double circuit 220kV transmission line.

The 220kV transmission voltage provides an intermediate step between 132kV and 330kV.

While Western Power uses 220kV to supply the Kalgoorlie region, there are no 220kV supplies available near the Perth region. Therefore this option will also require a transformer to be installed at the Perth end of the transmission line. This transformer would be located at either Pinjar (220/132kV) or Neerabup (330/220kV). Pinjar has more space available for the transformer installation, although ultimately Neerabup will be a stronger supply source. Environmental restrictions exist at both sites and further work would be required to identify the best location for the transformer and obtain the necessary approvals.

The double circuit line would initially operate with one side energised at 220kV and the other at 132kV to maintain the existing supplies to Regans substation and Emu Downs wind farm while minimising the initial cost of the project.

At Eneabba, the new transmission line will connect with another proposed new transmission line to be established by Karara. This line will emanate from Eneabba and connect at Three Springs before proceeding to the Karara mine site. At Three Springs a 220/132kV transformer will be installed. Initially this transformer will be used by Karara to source an interim, non-firm supply from the 132kV network until the proposed new transmission line from Neerabup is complete. Ultimately the transformer may be used by Western Power to increase electricity supply capacity to the Geraldton region.

The capacity under this arrangement would be adequate to meet the central load forecast.

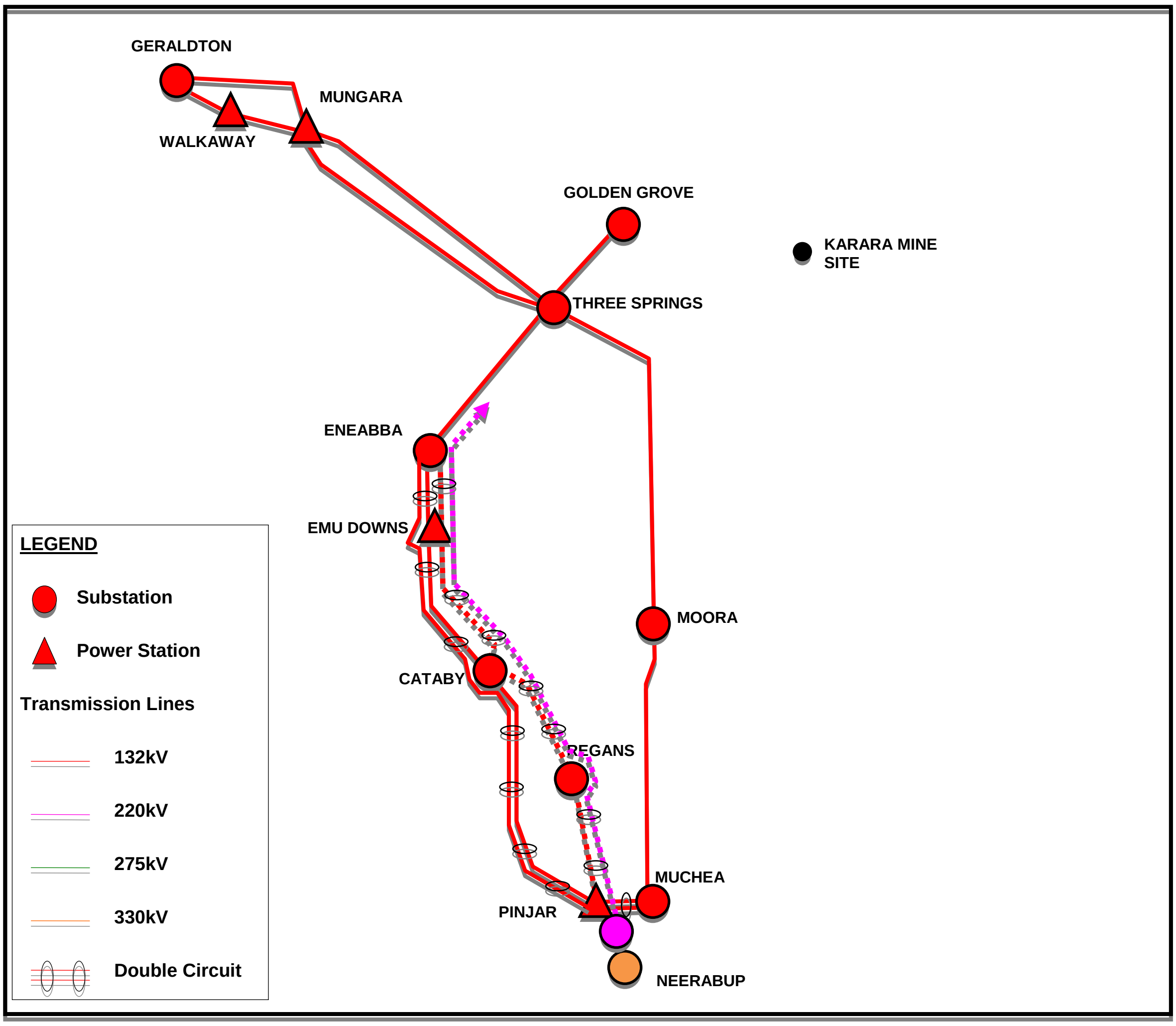


Figure 5: 220kV Double Circuit Option (initial arrangement)

The 220kV double circuit transmission line would provide 250MW of capacity at mine site locations east of Three Springs (plus meeting the regional load out to 2029). This alternative would therefore be sufficient to meet Karara's stage 1 requirements, with some spare capacity to accommodate additional prospective load growth in the Mid West. There would be insufficient capacity to meet all loads in the high case load forecast.

To accommodate load growth above the central load forecast, greater capacity is required. Initially the second side will need to be converted to 220kV and this could be as early as 2013 for the high load forecast case. As part of this conversion, a second transformer would be required at Neerabup or Pinjar and the Emu Downs and Regans sites would need to be connected to alternative 132kV lines. The Emu Downs wind farm will be connected to the Pinjar-Eneabba 132kV line (a relatively simple exercise) and a new 132kV supply to Regans substation will be required (up to 20km of 132kV transmission line).

For the high case load forecast scenario substantial additional work would be required by around 2015. This would require the construction of another new transmission line. At present no route has been indentified for such a line. For the purposes of this study utilising the existing corridor of the 132kV inland route via Moora has been assumed.

The net present cost of this option is $232 M for the central case forecast or $556 M for the high case forecast.

Compared with the 330kV options, this option includes additional costs such as the need to establish a new voltage transformation point in the Perth region as there are no 220kV supplies in the northern part of the SWIS at present. Unlike the 275kV option however this issue of strategic spares may be alleviated given that there are already other 220kV plant within the network.

Table 4 : Option Summary – 220kV Double Circuit

Cost (NPC)	$ 232 M (Central forecast) $ 556 M (High forecast)
Benefits	Sufficient capacity to meet Karara Stage 1 plus an additional 130MW load in the mine site locality. Compared with the 275kV option this alternative delivers less capacity but does not introduce a new voltage level into the system.
Risks	Additional needs beyond 250MW will require a second reinforcement. This will entail another new transmission line, probably along the Muchea-Moora-Three Springs corridor. Potential delay in provision of supply to new customers if a second reinforcement is required (time required to establish an additional new transmission line route).

B. 275kV Double Circuit

This option entails rebuilding the existing single circuit wood pole Pinjar-Regans-Emu Downs-Eneabba 132kV transmission line as a double circuit 275kV transmission line. The SWIN does not presently have a 275kV supply available and therefore a transformer will need to be installed at the Perth end of the transmission line. This transformer would be located at either Pinjar (275/132kV) or Neerabup (330/275kV). Pinjar has more space available for the transformer installation, although ultimately Neerabup will be a stronger supply source. Environmental restrictions exist at both sites and further work would be required to identify the best location for the transformer and obtain the necessary approvals.

The double circuit line would initially operate with one side energised at 275kV and the other at 132kV to maintain the existing supplies to Regans substation and Emu Downs wind farm while minimising the initial cost of the project.

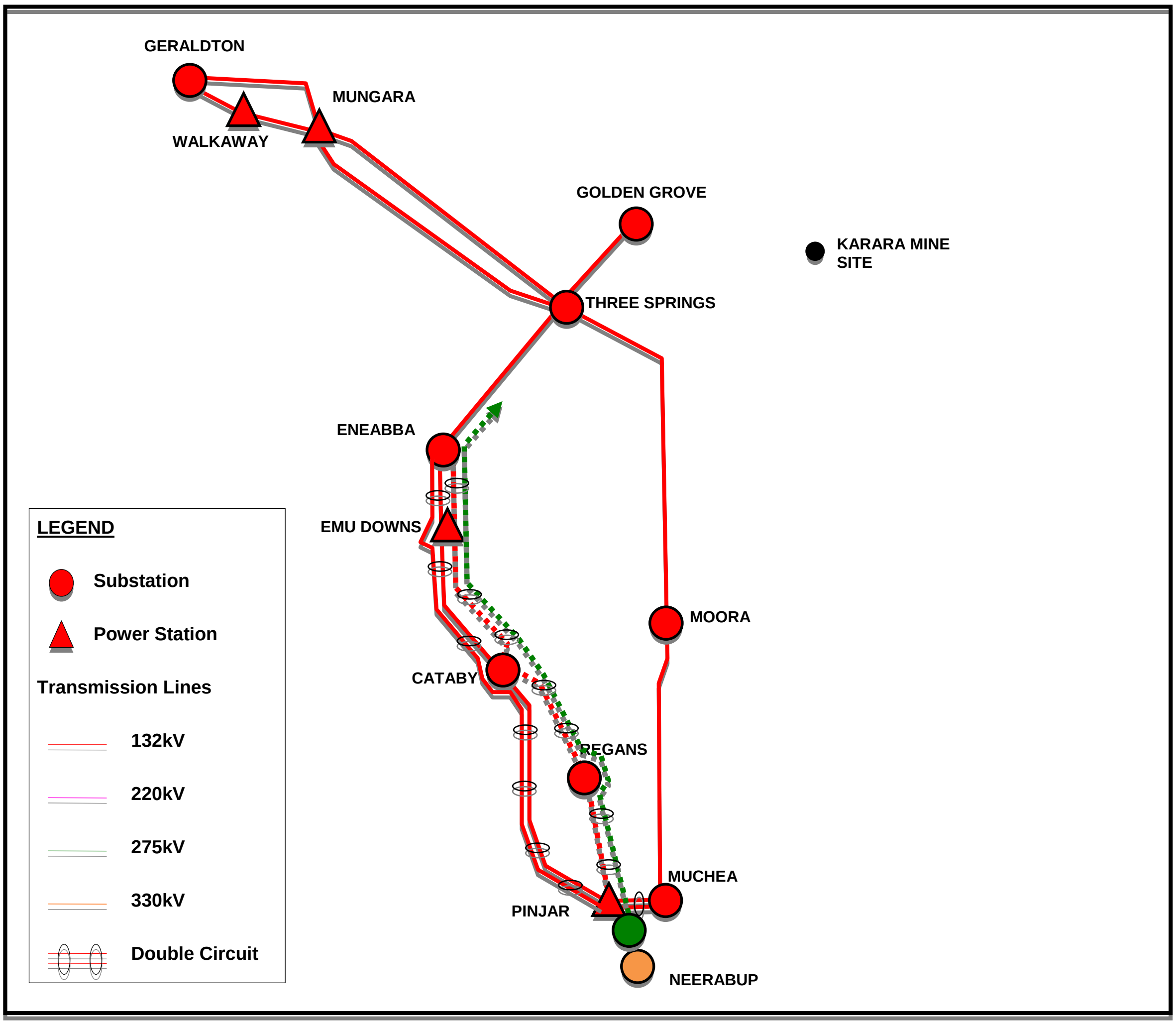


Figure 6: 275kV Double Circuit Option (initial arrangement)

At Eneabba, the new transmission line will connect with another proposed new transmission line to be establised by Karara. This line will emanate from Eneabba and connect at Three Springs before proceeding to the Karara mine site. At Three Springs a 275/132kV transformer will be installed. Initially this transformer will be used by Karara to source an interim, non-firm supply from the 132kV network until the proposed new transmission line from Neerabup is complete. Ultimately the transformer will be used by Western Power to increase electricity supply capacity to the Geraldton region.

This arrangement would provide an initial supply capacity of 150MW at the mine site (which would incrementally reduce as load in the remainder of the region grows).

To meet any additional block load, greater capacity is required and the second side will need to be converted to 275kV. According to the present forecasts this could be as early as 2014 for the high case. As part of this conversion, a second transformer would be required at Neerabup or Pinjar and the Emu Downs and Regans sites would need to be connected to alternative 132kV supplies. The Emu Downs wind farm will be connected to the Pinjar-Eneabba 132kV line (a relatively simple exercise) and a new 132kV supply to Regans substation will be required (up to 20km of 132kV transmission line).

For the high case load forecast substantial additional work would also be required by around 2020. This would require the construction of another new transmission line. At present no route has been indentified for such a line. For the purposes of this study utilising the existing corridor of the 132kV inland route via Moora has been assumed.

The 275kV double circuit transmission line would provide 380MW of supply capacity at mine site locations east of Three Springs (plus meeting the regional load out to 2029). This alternative would therefore be sufficient to meet KML's stage 1 requirements with some additional capacity available to supply additional prospective loads in the Mid West.

The net present cost of this option is $272 M for the central case load forecast or $475 M for the high case load forecast. The cost of this option is therefore greater than the double circuit 330kV option. Although this seems counter intuitive (given the lower voltage) there are additional costs associated with a 275kV option such as the need to establish a new voltage transformation point in the Perth region as there are no 275kV supplies within the SWIN at present. There would also be additional operating costs with requirements to hold strategic spares (including a spare transformer) for a new voltage level.

Table 5 : Option Summary – 275kV Double Circuit

Cost (NPC)	$ 272 M (Central forecast) $ 475 M (High forecast)
Benefits	Sufficient capacity to meet Karara Stage 1 plus either Karara Stage 2 or Extension Hill Stage 1 while still providing some spare capacity to accommodate new load beyond that.
Risks	Additional needs beyond 380MW will require a second reinforcement. This will entail another new transmission line, probably along the Muchea-Moora-Three Springs corridor. Introduction of a new voltage level into the SWIS, adding operational and asset management complexity and adding to the need for strategic system spares. Highest cost option for the central load forecast.

C. 330kV Double Circuit

This option entails rebuilding the existing single circuit wood pole Pinjar-Regans-Emu Downs-Eneabba 132kV transmission line as a double circuit 330kV transmission line. An existing line from Neerabup to Pinjar (presently operated at 132kV but constructed at 330kV) will be used to connect the new line with the 330kV network at Neerabup.

The line would initially operate with one side energised at 330kV and the other at 132kV to maintain the existing supplies to Regans substation and Emu Downs wind farm.

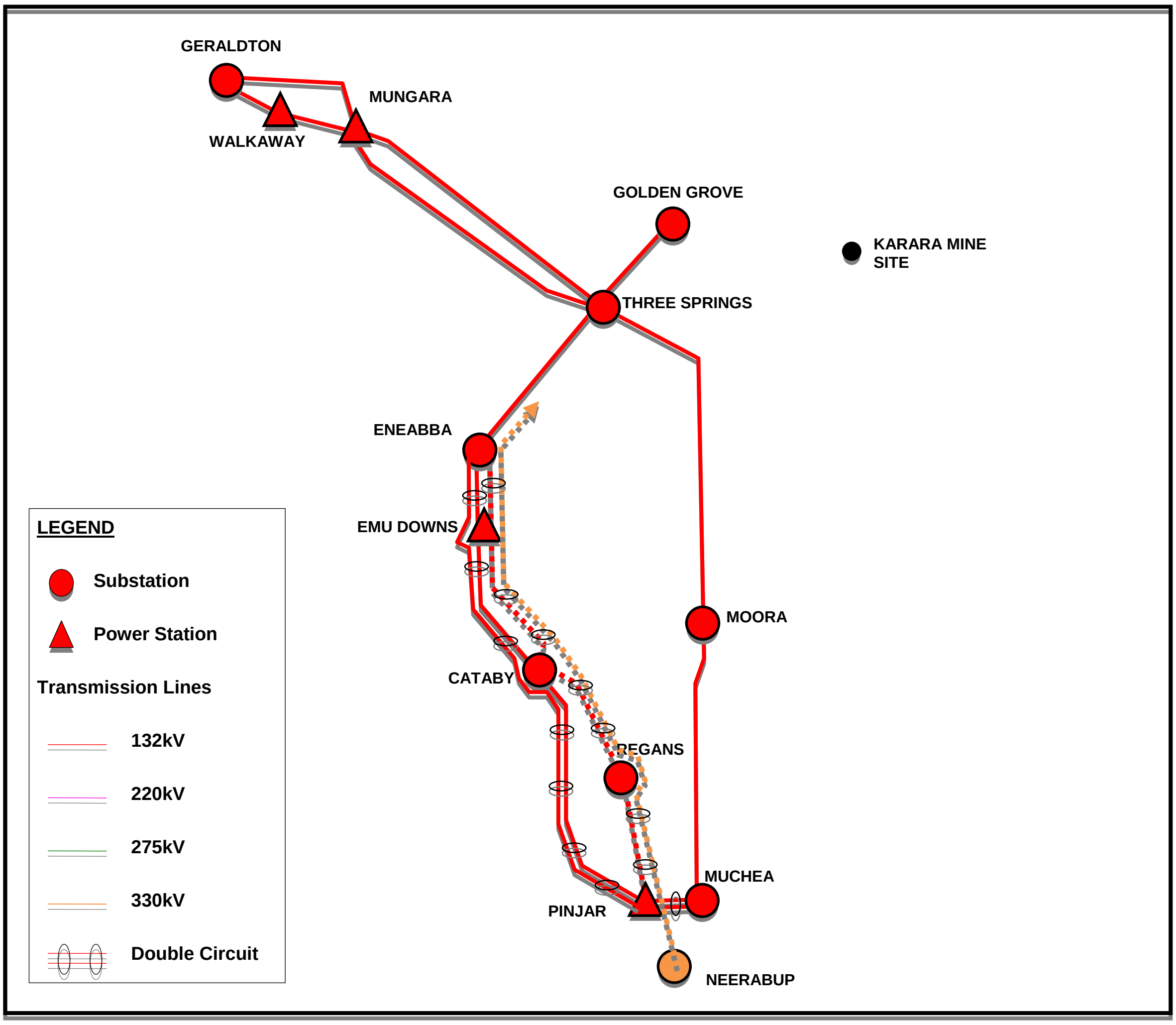


Figure 7: 330kV Double Circuit Option (initial arrangement)

At Eneabba, the new transmission line will connect with another proposed new transmission line to be established by Karara. This line will emanate from Eneabba and connect at Three Springs before proceeding to the Karara mine site. At Three Springs a 330/132kV transformer will be installed. Initially this transformer will be used by Karara to source an interim, non-firm supply from the 132kV network until the proposed 330kV transmission line from Neerabup is complete. Ultimately the 330/132kV transformer will be used by Western Power to increase electricity supply capacity to the Geraldton region.

This arrangement would provide sufficient capacity to meet the central load forecast case.

To meet the increasing needs of the region under the high load forecast case, greater capacity is required (by 2016) and the second side of the double circuit will need to be converted to 330kV. When this occurs, the Emu Downs wind farm will be connected to the Pinjar-Eneabba 132kV line (a relatively simple exercise) and a new 132kV supply to Regans substation will be required.

This option would provide 480MW of capacity at mine site locations east of Three Springs (plus meeting the forecast regional load out to 2029).

The estimated net present cost of this option is $268 M for the central load forecast case. The additional work required to meet the high load forecast case (convert the second circuit to 330kV and provide alternative 132kV supply to Regans substation) would increase the NPC to $282 M.

There is some scope for optimisation of transmission line design for this option. Work is underway comparing a range of conductor types and sub-conductor bundle configurations (trading higher upfront cost of the line with larger conductors against lower operating cost of losses. This optimisation work would apply equally to most options and would not alter the costs enough to change the comparative economic assessment of options.

Table 6: Option Summary – 330kV Double Circuit

Cost (NPC)	$ 268 M (Central forecast) $ 282 M (High forecast)
Benefits	Sufficient capacity to meet Karara Stage 1 and other prospective loads in the Mid West region. Highest capacity option – therefore represents the option that will facilitate the greatest level of load and generation development in the region.
Risks	Option 12% higher cost than single circuit 330kV option for the central forecast scenario.

C. 330kV Single Circuit

This option entails constructing a new single circuit 330kV transmission line alongside the existing single circuit wood pole Pinjar-Regans-Emu Downs-Eneabba 132kV transmission line. (Note that this would require some modification to the existing environmental approvals relating to the line route, as the corridor width would be increased.) An existing line from Neerabup to Pinjar (presently operated at 132kV but constructed at 330kV) will be used to connect the new line with the 330kV network at Neerabup.

At Eneabba, the new transmission line will connect with another proposed new transmission line to be established by Karara. This line will emanate from Eneabba and connect at Three Springs before proceeding to the Karara mine site. At Three Springs a 330/132kV transformer will be installed. Initially this transformer will be used by Karara to source an interim, non-firm supply from the 132kV network until the proposed 330kV transmission line from Neerabup is complete. Ultimately the 330/132kV transformer will be used by Western Power to increase electricity supply capacity to the Geraldton region.

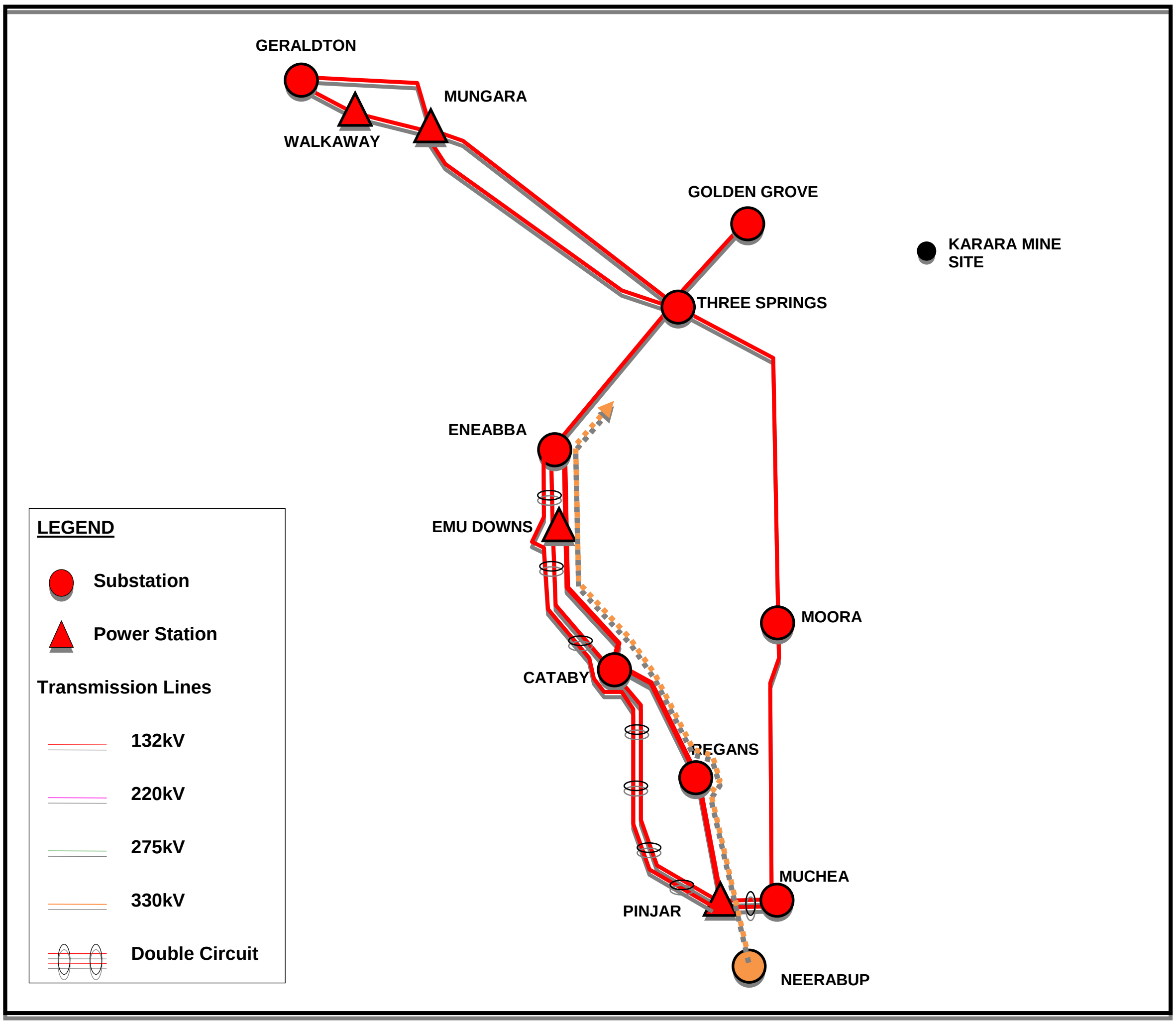


Figure 8: 330kV Single Circuit Option (initial arrangement)

The single circuit 330kV option would provide 275MW at mine site locations east of Three Springs (plus meeting the regional load out to 2029). This option would therefore be sufficient to meet the central load forecast, but does not meet the total needs of the high case load forecast.

To meet the high case load forecast scenario, an additional major network reinforcement would be required by around 2016. This additional reinforcement would again require the provision of substantial new capacity into the region in the form of a new transmission line. For comparison purposes, in the net present cost analysis it has been assumed that the additional project would comprise a rebuild of the existing inland Pinjar-Muchea-Moora-Three Springs line as a 330kV line, including the provision of 330/132kV transformers at Moora and Muchea. Details of the proposed route are yet to be determined. It should be noted that no work has been done to obtain a line route or to progress environmental approvals for this additional augmentation.

The estimated net present cost of this option is $238 M for the central load forecast case. The additional work required to meet the high case load forecast (establish an additional 330kV transmission line) would increase the NPC to $429 M.

Table 7: Option Summary – 330kV Single Circuit

Cost (NPC)	$ 238 M (Central forecast) $ 429 M (High forecast)
Benefits	Sufficient capacity to meet Karara Stage 1 plus an additional 155MW load in the mine site locality.
Risks	Additional needs beyond 275MW will require a second reinforcement. This will entail another new transmission line, probably along the Muchea-Moora-Three Springs corridor. Potential delay in provision of supply to new customers if a second reinforcement is required.

6 Net Benefits

6.1 Overview of Regulatory Test

The *Regulatory Test* is an assessment under Chapter 9 of the Electricity Networks Access Code 2004.

The test determines whether a proposed *major augmentation* to a *covered network* maximises the *net benefit after considering alternative options*. A service provider must not *commit* to a *major augmentation* before the Authority determines, or is deemed to determine, that the test is satisfied.

Western Power has assessed that a major augmentation is required to meet forecast demand for electricity and that the recommended solution (a new double circuit 330 kV transmission line from Perth to Eneabba with a 330/132kV terminal station at Three Springs) maximises net benefit compared to the alternative options.

Hence the preferred option Mid West Energy Project (southern section) satisfies the Regulatory Test. A public consultation will commence in July to allow interested parties to comment on that assessment and allow a submission to be made to ERA after considering any issues raised during the consultation. The requirement to consult is specified in the Access Code.

6.2 Options

Western Power identified and evaluated a number of options to increase the power transmission capacity in the Mid-West region to meet the forecast increased electricity demand, together with a forecast increase in electricity generation in the region.

The options assessed included network reinforcement, local generation and demand side management solutions.

The network reinforcement options considered included the construction of 132kV, 220kV, 275kV double circuits and 330kV single and double circuits as well as a number of alternative approaches, such as the use of reactive compensation or Direct Current (HVDC) transmission.

The non-network alternatives included local isolated generation and local interconnected generation operated as a network control service as well as demand management programs.

Only the 220kV double circuit, 275kV double circuit, 330kV single circuit and 330kV double circuit transmission line options were found to be viable.

6.3 Maximising Net Benefit

All viable options have been assessed as similar in terms of benefit delivery (i.e. meet forecast need). Western Power has compared the net present cost of alternative transmission options including the works required to meet both the central case load forecast and high case load forecast. The Mid West Energy Project (southern section) maximises net benefit as it;

- Has a net present cost which is comparable with other options capable of supplying the central case load forecast;
- Offers a significantly lower cost option for supplying high case load forecast;
- Delivers additional non-economic benefits compared to the other options; and
- Delivers similar benefits to those who generate, transport and consume electricity in the SWIS as other alternatives.

6.4 Financial Analysis

Of the viable solutions, the double circuit 330kV transmission line was determined to be the solution that maximises net benefit across a range of forecast scenarios, as defined in the Regulatory Test.

Table 8 summarises the 20 year net present cost (NPC) assessment of the options identified above, using a nominal discount rate of 10.65%[9] and inflation according to forecast CPI.

Table 8: Net Present Cost and Performance Comparison of Options

Option	Estimated Mine Site Load Serviced[10]	NPC for Load Scenario	
		Central	High[11]
220kV Double Circuit	250 MW	$ 232 M	$ 556 M
330 kV Single Circuit	275 MW	$ 238 M	$ 429 M
275 kV Double Circuit	380 MW	$ 272 M	$ 475 M
330 kV Double Circuit	480 MW	$ 268 M	$ 282 M

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[9] Discount rate is derived from the Pre Tax WACC allowed in the Access Arrangement

[10] Capacity stated is at mine site, not for the entire network and is for the Central forecast development scenario. The mine site capacity has been calculated after all other load in the region is supplied.

[11] The NPC includes the cost of all additional transmission work required to supply the high case load scenario.

Figure 9 depicts the capability of each option to meet the peak demand for the region with respect to meeting the central and high case load forecast.

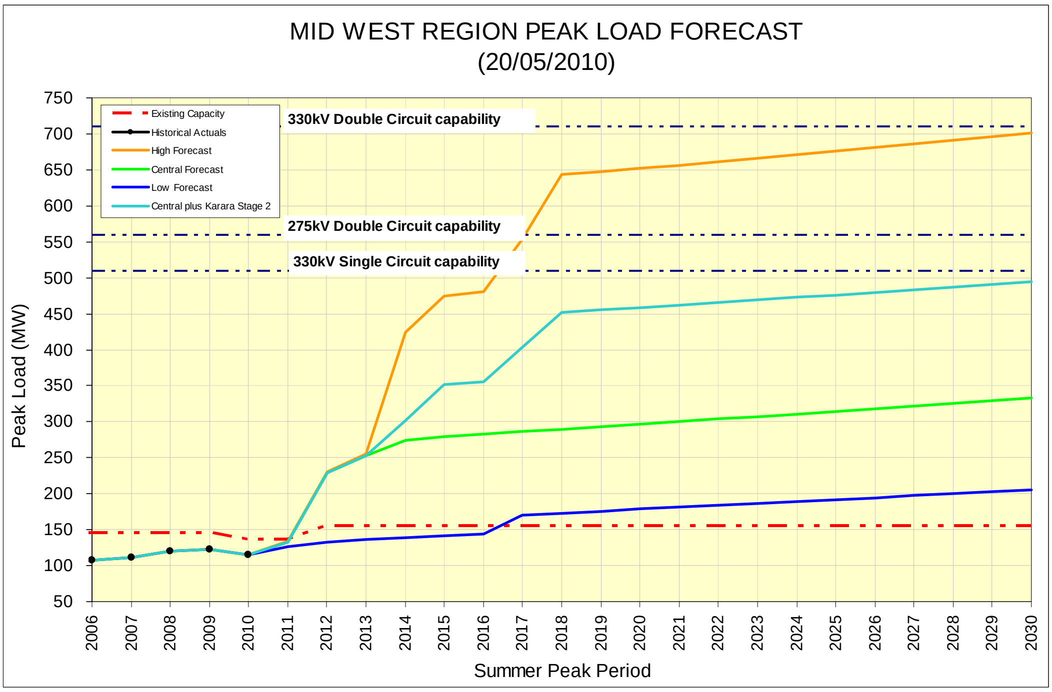

Figure 9: Network Capability vs Forecast Load (Option Comparison)

For the central case load forecast, the NPC of the options considered is within the range of $232M - $272M (i.e. a 17% variation) and within the accuracy of the cost estimates.

Therefore, the capacity provided by each option is a material consideration in the selection of a preferred option. While each option provides sufficient capacity to meet the central load forecast, there is a wide variation in the capacity provided by the options (250 – 480 MW), with the 330kV double circuit option providing substantially greater capacity than any of the alternatives.

The inherently greater capacity of the double circuit 330kV option provides a substantially lower cost alternative (by at least 50% or $150M in net present cost terms compared with the next lowest alternative) for the high case load forecast.

Therefore, for the central case load forecast each of the options provides an adequate solution to the identified network constraint. However, in the event of the high case load forecast, the additional capacity inherent in the double circuit 330kV network reinforcement represents a substantial benefit in terms of future cost savings. This option therefore provides economies of scale – provided the additional capacity is warranted. It is therefore critical to understand the probabilities associated with each of the forecast cases, together with any additional (economic and non-economic) benefits associated with each option.

The block load forecast noted that the central case load forecast includes only loads associated with Stage 1 of the Karara iron ore mine proposed by Karara Metals Limited together with initial loads from Oakajee Port and Rail and Geraldton Port Authority. Other prospective loads in the Mid West region have only been included in the high case load forecast. Neither the central case nor the high case load forecast includes provision for loads beyond the planning horizon.

In assessing the options, Western Power has given weight to the probability that high load forecast will be realised and should be taken into account in network planning. Only one of the four options considered has the capacity to cover this load scenario without construction of additional transmission lines. The prospect of additional transmission line works exposes existing and future users to the risk that further investment in a second major network reinforcement will be required within a few years. This is demonstrated by the high net present cost of these options for the high forecast. Additionally, the second reinforcement that would be required for either of these options may be required as early as 2014 for the 220kV option or 2015 for the single circuit 330kV option. As work investigating this second reinforcement has not commenced, there is a risk that neither could be delivered on time to meet customer needs.

6.5 Other Benefits

Given the relatively close costs (for the central case load forecast) between the options, Western Power believes that consideration of other benefits associated with each option should contribute to the option selection.

Western Power's assessment of each option identified inherent benefits with the 330kV double circuit option.

These are given in the table below.

Table 9: Non-economic Benefits of Double Circuit 330kV Option

Double Circuit 330kV
• Best power transfer capacity / corridor width balance.
• Single power transmission corridor for high and central forecast case.
• Narrower environmental footprint (through use of single, narrower corridor).
• Single major construction phase – minimising safety and construction risks.
• Minimum lead time risk for new major resource projects.

Western Power considers that the impact to communities and local landscape by large transmission lines will be reduced by maximising the amount of power transfer along a single corridor – i.e. adopting the double circuit 330kV option. The single circuit 330kV option will require a second transmission line corridor alongside the existing 132kV transmission line and potentially an additional 330kV transmission corridor within a few years for the high load forecast. The double circuit 220kV and 275kV options may also require an additional transmission line corridor within a few years.

Large scale resource projects not accommodated by the 220kV or single circuit 330kV options will be exposed to the development lead time associated with delivery of a new major transmission line, estimated at 6 years from conception. This delivery lead time risk may result in deferment of new resource projects or impose additional high costs of temporary on-site generation on these projects.

7 Recommended Option

Overall, the assessment of options concluded that the construction of a double circuit 330kV transmission line from Pinjar to Eneabba is the preferred option. This option is estimated to cost (in NPC terms) $268M for the central load forecast case and $282M for the high load forecast case.

The other viable options were the construction of a double circuit 220kV line, a double circuit 275kV line, and a single circuit 330kV transmission line from Perth to Eneabba, at an estimated cost of $232M, $272M and $238M respectively for the central case load forecast. Making these options less competitive was their cost for the high case load forecast, namely $556M, $475M and $429M, respectively.

The double circuit 330kV line option has been selected as the preferred option as this option:

- meets the needs of the foundation customer (Karara Mining Limited) and the load forecast for the next 20 years;
- provides an additional 220MW of network capacity (80% of the total) above the single circuit line option at a net present cost of approximately $30M (12%) greater for the central load case, demonstrating economies of scale;
- has a net present cost $150M (50%) lower should the high load forecast case eventuate;
- minimises the environmental and social impacts faced by local communities by maximising he power transferred along the transmission line corridor;
- reduces the environmental, social and commercial risks that would be associated with the single circuit option under a high load case scenario (i.e. a further major reinforcement in the region within a few years); and
- maximises the potential for generation connections in the region (by maximising the new capacity provided).

The completion of this transmission network reinforcement will facilitate the development of new mining prospects in the Mid West region – facilitating the continued economic and social development of the region.

The new transmission line will offer the opportunity for new wind farms to be established along the coastal region between Perth and Eneabba. These generators will contribute towards a more competitive market for energy in the SWIS, resulting in lower prices for electricity consumers.

Western Power has made provision for the high case load forecast in making this selection. When considering the load forecasts, although the central case load forecast scenario does represent an order of magnitude load increase for the entire region, this load increase is related to a single new project. As the region is currently subject to substantial interest from several parties, it is reasonable to assume that a higher case than this will result. Even considering the high case load forecast scenario, no provision has been made within this for any unforseen new developments in the region.