2006
transmission and distribution annual planning report

prepared by Networks Business Unit

Western Power

Disclaimer

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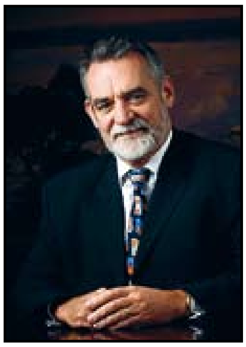
Preface



Welcome to the 2006 Transmission and Distribution Annual Planning Report.

This Annual Planning Report anticipates future requirements on Western Power to provide additional information to users and interested parties on network development plans.

The information provided in this report is intended to be useful to all our stakeholders, and to provide an insight into our network development planning processes.

As the electricity market in Western Australia develops further, our Networks Business Unit expects to play an important and transparent role in serving network users.

As I hope is clear throughout this report, we would value your feedback, both about the amount of information provided here and about projects that may impact on our assumptions.

Doug Aberle

General Manager Networks

Western Power Corporation

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Executive summary

The purpose of this document is to provide existing and prospective network users and other interested parties information on major planned developments on Western Power's South West Interconnected System. It also provides some background on Western Power's network development planning process.

In previous years, Western Power has published 5-year Transmission Network Development Plans for the information of existing and prospective users of its transmission network.

This report supersedes those Transmission Network Development Plans and at the same time provides more information. For example, this report covers ten years rather than five, provides some information on major distribution development plans and highlights areas where demand side management or local generation would help to alleviate network constraints.

This report discusses a range of technical planning matters. A short introduction to network planning issues is therefore provided for the lay reader as an Appendix.

Network Development Planning Process

Western Power's network development plans are based on regional forecasts of peak demand, assumptions about generation developments and a detailed understanding of the capacity of the existing network. These assumptions are used in sophisticated network analysis that ensures each network element satisfies a number of planning and technical criteria.

For convenience, the network is considered to be divided into the bulk transmission network and a number of load areas. As a minimum, each load area is studied in detail every two years to ensure that it will continue to meet the relevant planning and technical criteria. Where there have been significant changes in a load area (perhaps due to significant load growth or a new generator connecting), it will be re-assessed as a matter of priority.

The network planning process is a continuous one. As such, this Annual Planning Report is a snapshot as to the constraints and the network development options as they are currently understood.

Network Planning Assumptions

Three levels of demand forecast are required for network planning purposes:

- A demand forecast for the bulk transmission system, which is broadly based on the demand forecasts reported in the 2005 Statement of Opportunities, and which allows peak network flows across the bulk transmission network to be modelled;
- Demand forecasts for each substation, which are developed by extrapolating previous system peaks for each substation, and which allow peak power flows across each substation element to be modelled; and
- Demand forecasts for each load area, which allow peak power flows across the network elements in each load area to be modelled. These forecasts are developed using the bulk transmission forecasts and the individual substation forecasts.

In each case, the focus is on understanding the most onerous conditions that will affect each network element. For example, the bulk transmission network's most onerous power flows are usually at the time of system peak. An individual substation may have its peak load at a different time to the remainder of the network. Simply using a load forecast for the time of system peak would potentially understate the duty on each substation element, and lead to inadequate development plans. The most onerous operating condition for each load area is derived from a combination of the demand at time of system peak and local demand peaks, depending on the characteristics of that load area.

The peak demand for electricity is highly sensitive to temperature. The forecasts used for network planning purposes are based on a 10% Probability of Exceedance: that is, Western Power's peak demand forecast, probabilistically, is likely to be exceeded one year in every ten.

The timing, location and type of generation projects are the other main planning assumptions. The 2005 Statement of Opportunities Report identifies 'committed' and 'announced' projects. Committed projects are included in the base assumptions used for the system analysis underpinning this Annual Planning Report. Scenario analysis has been performed based on the 'announced' generation projects to assess the impact on the network.

The need for network development is highly sensitive to the location and type of generation development. Through the open access regime, Networks is aware of generation projects that cannot be reflected in this public document. For this and other reasons, future development plans may be materially different from those published here.

Where prudent to do so, Networks will seek to anticipate generation location decisions, and commence investment to ensure that the network can respond to market needs in a timely fashion. This investment will be subject to, among other things, the regulatory regime, access code and capital contributions policy. Further details are available from our Strategy & Regulation Branch.

Network constraints

Over the ten years considered by this report, a number of network constraints have been identified based on the network planning assumptions described above. These are summarised in Table i.

Depending on the nature of the network constraints, different solutions may be available. In some cases, it may be possible to avoid network augmentation if demand side or generation solutions are brought forward in the right locations.

Load area	Immediate network constraints[1]
Bulk transmission	Largely driven by generation location decisions
Northern Terminal	Thermal capacity of transmission lines and substation capacity shortfalls
Muja	Voltage constraints on long lines and distribution network limitations
Kwinana	Thermal and voltage constraints on transmission lines and substation capacity shortfalls
Cannington	Substation capacity shortfalls
Bunbury	Thermal and voltage constraints on transmission lines and substation capacity shortfalls
Western Terminal	Substation capacity shortfalls
East Perth	Thermal capacity of transmission lines and substation capacity shortfalls
Southern Terminal	Substation capacity shortfalls
South Fremantle	Thermal capacity of transmission lines and substation capacity shortfalls
East Country	Voltage constraints on transmission lines and substation capacity shortfalls
Eastern Goldfields	Voltage and stability constraints on transmission lines
North Country	Highly sensitive to connection of generation and/or loads

Table i Summary of Network Constraints

Committed Projects

In light of the most pressing constraints identified above, Western Power intends to proceed with the following 'committed' projects to alleviate these network constraints. Projects are deemed to be committed when, among other things, they have achieved Western Power's internal Capital Project Approval. While these projects are committed, they may still change in timing, scope and cost prior to commencement as a consequence of revised forecasts and other risk factors.

The following committed projects are intended for the bulk transmission system. Expected in service dates are provided in brackets.

- Construct a new 330kV overhead transmission line between Kemerton and Kwinana (2005)
- Installation of fault level limiting reactors at Kwinana and Southern Terminal (2005)
- Construct a new 132kV overhead transmission line with option for upgrade to 330kV between Southern Terminal and Cannington Terminal (2005)
- Establish a new 330/132kV terminal station at Guildford (2006)
- Establish a new 330/132kV transformer station at Kenwick (2006)
- Upgrade the existing 132kV line between Kwinana and South Fremantle from split phase to double circuit operation (2006)
- Install reactive compensation at selected substations (2006)
- Construct a new 330kV overhead transmission line between Shotts and Kemerton (2007)
- Establish a new 330/132kV terminal station at Neerabup (2008)

Table ii below provides summary information on the committed projects in each load area.

Load area	Summary of committed projects
Bunbury	Install an additional transformer at an existing substation
Cannington	Upgrade the capacity of an existing 132kV transmission line Establish a new substation Install an additional two transformers at existing substations

[1] *Load areas can exhibit all these typs of constraint - the table highlights the most immediate concerns.*

East Country	Upgrade the capacity of an existing transformer
East Perth	Upgrade the capacity of two existing transmission lines
Eastern Goldfields	Establish a new 132kV interconnection substation
Kwinana	Establish two new substations
Muja	-
North Country	Establish a new substation
Northern Terminal	Establish a new 132kV transmission line Establish three new substations Install additional five transformers at existing substations
South Fremantle	Upgrade a double circuit 66kV line Establish a new substation Install an additional transformer at an existing substation
Southern Terminal	Distribution network reinforcements and extensions Establish two new substations Install an additional two transformers at existing substations
Western Terminal	Upgrade an existing substation

Table ii Summary of committed projects

Networks intends to publish an updated list of committed projects every six months on the Western Power website at www.westernpower.com.au.

Network Development Options

Where constraints are identified for later years, network development options have been identified. The term 'network development options' is used deliberately. These options represent Network's preferred development approach, given available information at the time of consideration. Demand and generation assumptions are likely to change considerably before any commitment to the project is made. Furthermore, these options have not yet been subject to a detailed engineering review, which could change the preferred option. Finally, there may well be demand side or generation options that would delay, advance, change or remove the need for these projects. Indeed, the intention of publishing this information is to provide sufficient information for project developers to bring forward proposals in this regard.

The network development options for the bulk transmission network include:

- Install reactive compensation at selected substations network wide (2007)
- Install a third 330kV/132kV transformer and 132kV fault limiting reactors at Southern Terminal (2008)
- Install a 132kV static VAr compensators at Southern Terminal (2008)
- Establish a new 330kV transmission line between Kwinana and Southern Terminal (2008)
- Modify and upgrade existing 132kV transmission line between Southern Terminal and South Fremantle (2010)
- Construct a new double circuit 330kV transmission line between Kemerton and South East Terminal (2010)
- Establish a new 330kV switchyard at South East Terminal (2010)
- Install a 500MVA 330/132kV transformer at Cannington Terminal (2013)

Table iii on the next page provides summary information on the network development options for each load area.

Invitation to provide feedback

Networks would welcome feedback on the contents of this report, in particular where parties consider that they could assist in alleviating network constraints and where parties are considering connecting to the network. We would also welcome feedback on the information presented in this report.

Comments on this document should be sent to:
Manager System Planning
Western Power Corporation
GPO Box L921
Perth WA 6842

Telephone: (08) 9326 6293
Facsimile: (08) 9326 4425

Load area	Summary of network development options
Bunbury	Install six additional transformers at existing & new substations Install one new set of 132kV capacitor banks Establish one new substation Upgrade four existing transmission lines Construct three new transmission lines
Cannington	Install five additional transformers at existing & new substations Install five sets of capacitor banks Establish one new transmission line Establish three new substations Upgrade three existing transmission lines
East Country	Install two additional transformers at existing substations Upgrade one existing transformer Upgrade four existing transmission lines Install additional capacitor banks
Eastern Goldfields	Install four additional transformers at existing substations Establish one new transmission line Reinforcement to support power transfer capacity
East Perth	Install an additional transformer at an existing substation Upgrade one existing substation Establish one new substation Establish two new transmission lines Upgrade three existing transmission lines Underground existing overhead transmission lines Establish a new terminal station Upgrade an existing terminal station
Kwinana	Install four additional transformers at existing & new substations Install four sets of capacitor banks Establish two new substations Upgrade one existing transmission line Establish a new terminal station
Muja	Install five additional transformers at existing substations Construct two new transmission lines Upgrade one existing transmission line Distribution network reinforcements
North Country Region	Install three additional transformers at existing substations Establish three new substations Construct four new transmission lines Establish two new terminal stations Distribution network reinforcements and extensions
Northern Terminal	Install sixteen additional transformers at existing and future substations Establish seven new substations Construct one new transmission line Upgrade two existing transmission lines Distribution network reinforcements and extensions
South Fremantle	Establish one new substation Upgrade three existing substations Upgrade four existing transmission lines
Southern Terminal	Install three additional transformers at existing and new substations Install three sets of capacitor banks Establish three new substations Construct two new transmission lines
Western Terminal	Install one additional switchboard at an existing substation Upgrade three existing substations

Table iii Summary of Network Development Options

1 Introduction

The 2006 Transmission and Distribution Annual Planning Report ("APR") describes Western Power's Networks Business Unit's ("Networks") network development plans between 2006 and 2016.

The report's structure is as follows:

- Chapter 2 describes Networks' planning process and standards;
- Chapter 3 explains the key assumptions (namely demand and generation forecasts) that underpin the network development plans reproduced here;
- Chapter 4 explains the network constraints that would arise if no further action were taken by Networks;
- Chapter 5 sets out the committed projects intended to address the most pressing constraints;
- Chapter 6 describes the network development options available to resolve constraints in later years; and,
- Chapter 7 invites feedback on the information contained in this report.

This report discusses a range of technical planning matters. A short introduction to network planning issues is therefore provided for the lay reader as an Appendix.

The remainder of this Introduction describes the purpose of this document more fully, its interaction with the Statement of Opportunities Report and an overview of the role of Networks.

1.1 Purpose of this document

The purpose of this document is to provide existing and prospective network users and other interested parties information on planned developments on Western Power's South West Interconnected System ("SWIS"). It also provides some background on Western Power's planning process.

This 2006 APR is published against a developing legislative background. The Electricity Industry Bill 2003 envisages licences for the construction and operation of transmission and distribution systems, publication of an access code and further regulations. It is therefore probable that there will be some further requirement on Networks to publish information in respect of network development plans. As yet, that exact requirement is unclear.

Nonetheless, Networks has decided to anticipate its future regulatory regime in this respect. The publication of this report allows it and interested parties to understand the market's requirements for information.

In preparing this report, Networks has drawn on various recommendations published during the electricity sector reform process. The need for network information is addressed in the Electricity Reform Taskforce ("ERTF") report[2], the Draft Governance Framework Report and the Draft Detailed Market Design[3].

In line with these various recommendations, the purpose of this document is as set out above. In detail, its purpose is to:

- Identify constraints on the transmission network likely to emerge in the next ten years;
- Provide advance information on the nature and location of the constraints. This information should allow other parties to formulate and propose options to relieve the constraints. These options may include local generation, Demand Side Management ("DSM") or other economic options;
- Discuss options for relieving each constraint including network and other options; and,
- Provide further details on the load forecast data used as the basis for this analysis.

  Networks intends to publish this document on an annual basis. Future versions will likely include:

- Ongoing planning analysis and identification of network constraints;
- An update of the SWIS load forecasts taking into account actual peak load readings for future summers and winters; and,
- Enhancements required by legislation or in line with external feedback.

1.2 Interaction with the Statement of Opportunities Report

This report complements the role of the 2005 Statement of Opportunities report. While the Statement of Opportunities focuses on the overall adequacy of generation capacity, the focus of the APR is on the adequacy and development of the network components of the SWIS.

Where applicable, the generation and demand forecast information used in the preparation of this APR has been largely based on the 2005 Statement of Opportunities. Given the inherent complexity of the network planning process, it is necessary to allow sufficient time for assimilating relevant new or revised information in the Statement of Opportunities to produce network development outcomes that reflect any such information. As a consequence, publication of the APR follows the Statement of Opportunities.

2 *Available at www.ertf.energy.wa.gov.au*

3 *Available at www.eriu.energy.wa.gov.au*

1.3 Interaction with other Networks' capital expenditure programmes

This report focuses on likely network augmentations. It does not describe Network's complete capital expenditure programme, which includes:

- Rural Power Improvement Programme: This $48 million special targeted spending programme is funded equally by the State Government and Western Power and is in addition to funds allocated to other programmes to enhance power supplies in the regions. The four year RPIP, beginning in 2005, will fund projects that are difficult to justify under Western Power's normal prioritisation process because the cost of the work is high compared with the relatively few customers in those areas. For further details, please see Western Power's website.
- State Underground Power Programme: In 1996, the State Government of Western Australia embarked on a programme to retrofit older urban areas with underground power supplies. For further details, please see the WA Office of Energy website at www.energy.wa.gov.au.
- Asset management: Networks has an extensive programme for the replacement of assets as they near the end of their useful lives. This programme is the subject of the Asset Management Report, which is available at www.westernpower.com.au.

1.4 Role of Networks Business Unit

Western Power was established, under the Electricity Corporations Act 1994, from the State Energy Commission of Western Australia ("SECWA"). Western Power is responsible for planning, maintaining, operating and expanding the power system that generates, transmits and delivers electricity to Western Australians. Networks is accountable for the wires business.

Networks has two primary responsibilities:

- To manage the transport of electrical energy to good industry practice; and,
- To provide non-discriminatory access to network capacity in Western Australia.

The first responsibility requires Networks to plan, operate, manage, develop and augment the physical assets. The second responsibility is intended to facilitate competitive generation and retail markets. The two responsibilities are, of course, closely interrelated.

It is expected that the role of Networks will develop further with the proclamation of the Electricity Industry Bill 2003 and enactment of subsequent licences, access codes and regulations.

2 Network development planning process

This Chapter provides an overview of the network development planning process, our understanding of customer expectations, the planning criteria used in developing the network and other technical requirements.

As a prudent commercial organisation, Networks applies risk management when determining its network development options. Applying widely accepted network investment criteria, Networks' planning process is strongly focussed on balancing networks costs against the impact of unreliable supply on its customers.

Those planning principles are applied within the planning and development framework, illustrated in Figure 2.1. The Network Investment Strategy takes into account:

- Planning Criteria: Following consultation, Western Power has established Transmission and Distribution Planning criteria under the relevant Regulations that, broadly, describe the design requirements for the network under various scenarios.
- Technical Code: Similarly and again following extensive consultation, Western Power has established

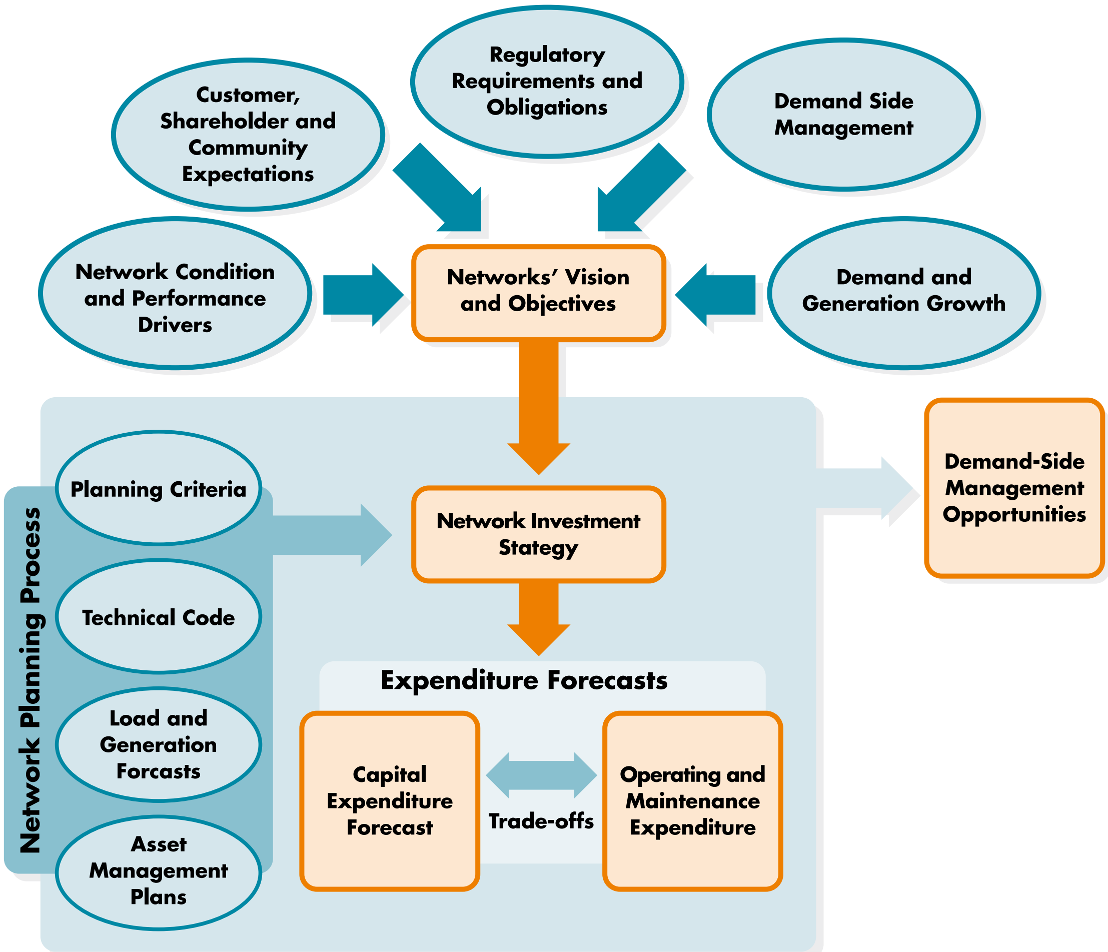

Figure 2.1 Overview of network planning process

Technical Codes for Transmission and Distribution that, amongst other things, set performance standards for the networks and technical requirements for plant connected to the network.

- Load and generation forecasts: Networks uses a rigorous process to develop detailed forecasts of load and generation across its networks. This process includes obtaining independent expert advice on key planning parameters, such as projections of State economic growth. Networks must also make prudent assumptions about the development of generation projects. Its approach is described further in Chapters 3 and 4.
- Asset management plans: Amongst other things, the asset management plans are based on condition assessments of Networks' plant to ensure that it will

continue to provide reliable service. These condition assessments drive the asset replacement element of the Network Investment Strategy. Networks' asset management plans are detailed in the Asset Management Report, which is available at www.westernpower.com.au.

- Networks' Commercial Objectives: Networks' wider strategy is developed in light of the various drivers illustrated in the figure, and includes the normal commercial objectives of any company, as currently required for Western Power under the Electricity Corporation Act 1994. Looking forwards, it is worth noting that Networks' future regulatory environment is uncertain, both in terms of economic regulation and the role of the Director of Energy Safety.

These various inputs are used in sophisticated network analysis that ensures each network element satisfies a number of planning and technical criteria (described further in the introduction to network issues in the Appendix) - broadly that:

- Each individual piece of network equipment is operated within its design limits. This requires voltage and power transfer for each asset to be assessed under a wide range of potential conditions, including for example modelling the effect of faults on the network. Failure to meet voltage design limits can result in malfunction or damage to customer equipment, while exceeding power transfer limits creates potential safety hazards and reliability issues arising from the failure of network equipment due to overloads;
- The network can withstand credible faults and unplanned outages. A fault is considered credible if it is considered likely given the prevailing circumstances. If there is a credible fault or unplanned outage, all plant must still operate within its design limits and the network must continue to deliver its required performance;
- Quality of supply is maintained to the appropriate standards. Quality of supply is a term that embraces voltage, frequency and other technical aspects of power supply;
- Potential for future growth is adequately provided for, where economically viable to do so: ensuring that Western Power's electricity networks do not impede Western Australia's economic development. This may mean, in some circumstances, installing 'larger' plant than is immediately required, to cater for expected load growth over the next, say, ten years; and
- Environmental impacts are responsibly managed.

For convenience, the network is considered to be divided into the bulk transmission network and a number of load areas. As a minimum, each load area is studied in detail every two years to ensure that it meets the relevant planning and technical criteria. Where there have been significant changes in a load area (perhaps due to significant load growth or a new generator connecting), it will be re-assessed as a matter of priority.

The network planning process is a continuous one. As such, this Annual Planning Report is a snapshot as to the constraints and the network development options as they are currently understood. As underlying assumptions change, as further studies are carried out and as each development option's details are confirmed, there will be changes to the plans published here.

2.1 Network Development Analysis

As discussed above, the planning and operation of electricity networks must meet certain technical requirements. There are various factors that will change power flows across the network, which must be taken into account when planning and operating the system:

- Changes in network configuration either by construction of new elements or outages of existing network elements. For example, introducing new parallel electricity lines affects the network performance.
- Location and timing of new generation sources impacts on thermal capacity, stability and fault performance, and thus the need for network augmentation.
- Location and timing of major new loads or load centres. For example, the location and timing of a new aluminium smelter may advance or defer the need for network augmentations.
- Rate of forecast network load growth and long-term growth trends also determine the need for network augmentations. For instance, high growth scenarios will advance network augmentation requirements.

The network development analysis presented in this Annual Planning Report (or any such document) is highly sensitive to changes in any of these factors. Therefore, network development analysis can only indicate likely network constraints. Similarly, the options for addressing these constraints are based on specific assumptions and judgements regarding future events. Variations from these specific assumptions may change the development scenario profoundly.

2.2 Customer Expectations

Publicly available surveys have found that consumers expect, in order of preference, their electricity supply to be provided at:

- Reliable levels;
- Appropriate quality; and,
- Low prices.

The network planning and development process depends crucially on understanding and managing customer expectations at the local network level.

Reviews of previous public surveys have noted the importance of methodology in understanding customer preferences. For example, consumers must be given specific examples of reliability improvements before they will express a preference for even limited price rises. Increased understanding of customer expectations allows a better-informed trade-off between acceptable customer service and cost. This further supports the new regulatory regime, and may inform changes to the transmission and distribution planning criteria.

2.3 Transmission Network Planning Standards

Western Power develops its transmission network in line with the network planning criteria[4], published by Western Power as required by the Electricity Transmission Regulations 1996.

Generally, Networks' transmission system is a meshed network with a high proportion of elements in service at any given time. The transmission system is broadly divided into the bulk transmission network, the sub-transmission network, radial networks and substations.

Planning criteria for the transmission network are based on a thorough risk analysis. This analysis takes into account:

- The size, extent and sensitivity of load or generation which may be affected;
- The physical location of various components of the network and their exposure to damage risk;
- The relative merits of other alternatives; and
- The efficient use of capital.

2.3.1 The Bulk Transmission Network

The bulk transmission network operates at 330kV and 132kV. It consists of the power station switchyards, major terminal switchyards and the transmission lines that interconnect them.

The bulk transmission network is designed to withstand a single unplanned outage without loss of load.

Moreover, the bulk transmission network is generally designed to withstand one forced outage and one planned outage at 80% of forecast peak load (assuming generation rescheduling after the first outage).

For example, this would provide sufficient network capacity to cope with a planned outage (for maintenance or construction activities) at the same time as a second unplanned outage (due to a network fault). When there are two coincident outages and demand is more than 80% of forecast peak load, there may not be adequate network capacity to supply all load.

The economic justification for this high level of supply security (and consequently reliability) is the high capacity of the bulk transmission network - losses of supply on the bulk transmission network may affect very many customers.

2.3.2 The Sub-transmission Network

The sub-transmission network operates at 132kV and 66kV. It consists of zone substations that transform these primary voltages to 33kV, 22kV, 11kV and 6.6kV secondary voltages and the transmission lines that interconnect them.

The sub-transmission network is generally designed to withstand a single unplanned outage without loss of load.

When there is more than one outage at the same time, there may not be enough network capacity to meet all load. Sometimes, in mitigation, there may be limited back-up capacity available via the distribution network.

This planning criteria broadly applies to parts of the network supplying urban areas in the Perth metropolitan region and major regional centres. These parts of the network tend to be characterised by relatively high load densities and shorter transmission lines.

2.3.3 Radial Networks

Radial networks operate at 220kV, 132kV and 66kV and generally supply loads of less than 20MW. The 220kV network supplies Eastern Goldfields due to the large distance between the supply source and load centre. The 132kV and 66kV radial networks generally supply regional townships in Western Australia's south-west region. These 132kV and 66kV radial networks include zone substations that transform these primary voltages to 33kV or 22kV.

Radial networks are designed taking into account analysis of network reliability, risk and economic factors. Radial network backup may be provided by other parts of the transmission network, the distribution network, local generation or not at all, depending on this analysis.

It is not always economic to provide full redundancy on the radial networks due to their large line-lengths, geographically dispersed loads and generally smaller loads (when compared to metropolitan areas).

[4] *Available at www.westernpower.com.au*

2.3.4 Substations

Networks' substations interconnect the sub-transmission network with the distribution network. Each substation is designed to meet criterion that depend on the substation's location and the type of load it supplies:

- Substations in the Perth Central Business District ("CBD") are designed to provide the highest level of security due to the relative importance of the load supplied by these substations;
- Regional substations are designed to provide the next highest level of security due to the long travelling times required before plant can be repaired or replaced, although there are some remote substations designed to provide a relatively low level of security, for reasons described further below; and
- Substations in the Perth metropolitan area are designed to accept a higher level of risk of load shedding as they are accessible for plant repairs or replacement.

The designs of the various types of substations recognise the need to optimise security of supply and capital expenditure.

- CBD - substations that supply the CBD are designed to withstand the failure of a single item of plant without any sustained loss of load. They are also designed to withstand the failure of either two items of plant or both transmission lines supplying a substation with only a temporary interruption to load.
- Regional - most substations supplying regional areas are designed to withstand the failure of a single item of plant without sustained loss of any load. A small number of regional substations are designed to withstand the failure of a single item of plant with a small risk that up to 10% of the load may need to be shed. This risk only applies for 1% of the time throughout a year, and is based on the availability of suitable spares.

A small number of regional substations are not able to continue to supply load for a failure of a single item of plant. These substations have usually been established for one customer where the customer has accepted the risk. If nearby loads then take the opportunity to be supplied by these substations, it is not economic to provide higher supply security.

- Metropolitan - most substations supplying the Perth metropolitan area are designed to withstand the failure of a single item of plant (about a one in twenty year event), accepting that some load may be shed, on a rotational basis, for up to 9 hours. Since 1996, Networks has accepted the risk of short-duration load-shedding to maximise the utilisation of substation capacity. As a result Networks has realised substantial financial benefits by deferring capital expenditure.

2.4 Distribution Network Planning Standards

The distribution network operates at 33kV, 22kV, 11kV, 6.6kV and 415V. It is broadly separated into CBD, metropolitan and rural networks. Each of these categories is further discussed below.

Networks' distribution system is generally designed to operate radially. Normally, the loss of a network element will lose supply to a number of users. The length of interruption for customers will be mitigated by the following factors:

- Ties between feeders provide backup connections when the normal feeder is out of service.
- Reclosers and sectionalisers are also used. To ensure that equipment is not needlessly out of service, some equipment will automatically reenergize the network element after a short delay. This is known as 'reclosing'. Sectionalisers allow the location of the fault to be identified and service restored to customers 'upstream' from the fault.
- Networks plan to utilise fault indicators, load break switches and remote control pole top switches to improve the speed of fault location and isolation, which facilitates more rapid restoration.

At first glance embedded generation could assist in these circumstances. However, embedded generation must disconnect from the network if its local distribution feeder is separated from the wider power system. If the embedded generation could remain connected, this would be known as islanded operation. Networks' distribution system cannot support islanded operation because it is not fitted with synchronising equipment to reconnect islanded feeders to the wider power system.

2.4.1 CBD

The CBD distribution network is an open-meshed and remotely-switched design. This facilitates rapid restoration of supply to healthy sections of the network after faults. In addition, CBD zone substations automatically reconfigure feeders after the loss of step down transformers. The total loss of a single zone substation requires manual network reconfiguration to restore supplies within four hours.

CBD feeders are normally limited to 50% of their maximum rated capacity. This provides leeway to remotely reconfigure the network and so restore load after a feeder outage.

2.4.2 Metropolitan

Metropolitan distribution networks are open-meshed networks with radial feeders and inter-feeder ties that can be switched into service as required[5]. This moderate level of interconnection between feeders and a planned maximum feeder loading of 80% allows for the transfer of load between feeders after a fault. In contrast to the CBD, this transfer of load may require a number of manual switching operations.

This feeder arrangement minimises fault levels and simplifies technical and operational requirements. With multiple open points, improved supply restoration times are possible, although the initial loss of supply will still occur.

2.4.3 Rural

The distribution networks in rural areas are radial and are much longer than metropolitan feeders, with limited inter-feeder ties. As a result, supply restoration after network faults takes longer. Some distribution feeders can be very long, with no interconnection to accelerate supply restoration.

Users requiring security of supply above the standard design philosophy will be provided with network back up where practicable. However, on-site standby generation may be the only economic solution. Investment to provide additional security of supply is normally at the user's expense.

2.5 Technical Planning Requirements

Aside from the planning criteria described above, Networks applies technical requirements to ensure that the quality of electricity supplied to customers is acceptable.

These requirements affect the design of the network and of its elements. They include characteristics such as flicker, voltage limits, waveform distortion and waveform unbalance. Broadly speaking, the requirements are found in various national and international codes of practice and standards. They are widely accepted by electricity utilities and by electrical equipment manufacturers.

Networks has other obligations established by legislation:

- The Electricity (Supply Standards and System Safety) Regulations 2001 contains various quality-related benchmarks.
- The requirements of the Electricity Transmission Access Technical Code and the Distribution Technical Code and Planning Criteria - documents concerned with the connection of new users and established under the Electricity Corporation Act 1994 following consultation by Western Power[6].

[5] *These are known as 'normally open points'.*
[6] *Electricity Transmission Access: Technical Code* and *Electricity Distribution Regulations: Technical Code,* Western Power Corporation, Perth.

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3 Network planning assumptions

This Chapter provides some background on the latest planning assumptions underpinning this Planning Report. The main network planning assumptions are peak demand across the network and the location of new generation.

3.1 Developing and applying electricity demand forecasts

In contrast to the Statement of Opportunities Report, which provides forecasts at the overall system level, the network development planning process also requires forecasts for each substation and terminal station. To then determine augmentation needs, Networks assesses network capability against electricity demand forecasts by:

- Direct comparison with each network element's thermal rating; and
- Computer simulations to identify thermal, voltage, stability and fault rating constraints.

The results of this analysis are discussed in the next Chapter.

3.1.1 Typical Drivers of Load Growth

In the SWIS, typical drivers of load growth include:

- Penetration of air-conditioners. Recently, increased residential air-conditioning has increased electricity demand significantly. If air-conditioner penetration increases further, weather sensitivity is likely to increase strongly.
- New residential sub-divisions. There is rapid growth in new residential developments along the northern and southern coastal strip towards Two Rocks and Mandurah as detailed in the Metropolitan Development Program - Urban Land Release Plans, released by the Western Australian Planning Commission, and available at www.wapc.wa.gov.au.
- In-fill growth in older metropolitan suburbs resulting in increased housing and hence increased load density.
- Isolated larger customers such as shopping centres and particular industrial/commercial loads. There have been a number of announcements of sizeable industrial loads to come into operation over the next decade. These loads are included in the base assumptions when they can be considered as committed, using similar criteria to those used in the Statement of Opportunities Report.

3.1.2 Networks' Load Forecasting Methodology

Three levels of demand forecast are required for network planning purposes:

- A demand forecast for the bulk transmission system, which is broadly based on the demand forecasts reported in the Statement of Opportunities Report, and which allows peak network flows across the bulk transmission network to be modelled. An overall load forecast for the bulk transmission network is the sum of individual substation forecasts at the time expected system peak load, corrected to match the demand forecasts reported in the Statement of Opportunities;
- Demand forecasts for each substation, which are developed by extrapolating previous peaks for each substation, and which allow peak power flows across each substation element to be modelled. Networks' forecasting methodology is based on statistical analysis of historic load information for every substation and terminal station. Expected block loads are, as appropriate, added to these demand forecasts; and
- Demand forecasts for each load area, which allow peak power flows across the network elements in each load area to be modelled. These forecasts are developed using the bulk transmission forecasts and the individual substation forecasts.

In each case, the focus is on understanding the most onerous conditions that will affect each network element. For example, the bulk transmission network's most onerous power flows are normally at the time of system peak. An individual substation may have its peak load at a different time to the remainder of the network. Simply using load forecast for the time of system peak would potentially understate the duty on each substation element, and lead to inadequate development plans. The most onerous operating condition for each load area is derived from a combination of the demand at time of system peak and local demand peaks, depending on the characteristics of that load area.

The SWIS load forecast as reported in the 2005 Statement of Opportunities exhibits a load growth of approximately 3.4% pa, which is in line with historical load growth. Individual years and substations vary significantly around this average. The load growth in recent years has exceeded the average growth rate. This is reflected in this years forecast in the 2005 Statement of Opportunities, which exceeds the forecast of the previous year by approximately 120MW.

3.1.3 Managing Weather Sensitivity Risks in Demand Forecasting

The SWIS's highest peak demand is generally mid-week after a consecutive string of hot and humid days with temperatures between the high thirty and the mid-forty degrees, with hot and humid conditions overnight. For example:

- In a hot summer, such as the summer of 1997, (peak day temperatures - maximum 44.5°C, minimum 29.0°C) peak demand was about 150MW above that on an average summer peak day; and
- During a mild summer, such as 2002, (peak day temperatures - maximum 36.3°C, minimum 21.5°C), peak demand was about 100MW below that of an average summer peak day.

To account for weather-related variation in forecasts, peak demand is expressed as Probability of Exceedance ("PoE") values. Taking 50% PoE as an example, out of ten demand readings, on average five readings would be over the 50% PoE value and five would be below the 50% PoE value. Similarly, on average one sample would be above the 10% PoE value and nine samples would be below the 10% PoE value.

The peak demand day has generally occurred between the end of the summer school holidays and the middle of March. Over the past 50 years, the average of the highest maximum temperatures each summer has been 41°C. The average of the highest minimum temperature each summer has been 26°C. This average 'hottest' day is the basis of peak demand projections and is known as the 50% PoE. The variations that may occur on warmer or milder 'hottest' days are known as the 10% and 90% PoEs respectively.

Networks uses the 10% PoE in its modelling. This provides an appropriate level of flexibility in network development plans.

3.2 Location of new generation

As noted in the Introduction, Networks provides non-discriminatory access to the SWIS. Pricing signals are provided to Users of the network by Networks with the intention of optimising the development of the system including the location of new generation sources. However, Networks may not direct the location for new generation. Therefore, Networks must make prudent assumptions regarding possible generation development scenarios in its network development planning process.

The 2005 Statement of Opportunities reports that 1577MW of new generation capacity (including 387MW of committed generation capacity) may connect to the SWIS during the next 5 years. The 2005 Statement of Opportunities reports that a further 1100MW of new generation capacity is proposed to connect in the subsequent 5 years.

The location for this generation capacity is unknown, however it is anticipated that a considerable proportion of this capacity will be located south of the Perth metropolitan area in the region between Pinjarra and Collie. This assumption is based on the availability of fuel resources for coal, gas and renewable plant, as well as compatible process industries for cogeneration plant.

Networks relies on proponents to provide details of their projects early enough to allow timely network reinforcement. While proponents provide information in good faith, there is a range of factors that can change the feasibility, timing, size and location of such projects. Moreover, in some instances proponents only provide details of their intentions once the projects are nearly committed to minimise the commercial risk to the project. Equally, through the open access regime, Networks is aware of generation projects that cannot be reflected in this public document. It is possible therefore that future development plans will be materially different from those published here.

Networks' planning process must manage the high level of uncertainty associated with the timing, size and location potential future generation sources. The impact of this uncertainty is exacerbated by the time taken to complete major transmission network augmentation projects, such as the construction of 330kV transmission lines required to accommodate large new generation sources. The construction phase of a generation project can take as little as two years, whereas establishing a new transmission line can take up to seven years from conception to commissioning. Much of the time required to establish a new transmission line is associated with the environmental processes that need to be completed to identify and gain approval for line routes.

Without the necessary network infrastructure to provide minimum levels of power transfer capability, generator outputs may need to be restricted to maintain network safety, reliability and security. Such restrictions may have an adverse impact on the development of a competitive generation market. Consequently, Networks planning processes are designed to identify universally required network developments and to commence investment to ensure that the network can respond to market needs in a timely fashion. This investment will be subject to, among other things, the regulatory regime, Access Code and capital contributions policy.

The Statement of Opportunities identifies 'committed' and 'proposed' projects. Committed projects are included in the base assumptions used for the system analysis underpinning this Annual Planning Report. Scenario analysis has been performed on the 'proposed' generation projects to assess the impact on the network. The following sections develop scenarios that allow consideration of network constraints arising from potential new generation.

The consideration of these various scenarios enables Networks to identify elements of commonality between generation development scenarios and where particular development options are beneficial to all development scenarios. Where this occurs, the network development option can be demonstrated to be sound from a regulatory perspective allowing the Networks reinforcements to be progressed in a timely manner. A basic level of access to the network would then be available for whichever development scenario eventuates. As particular generators commit to connecting to the network, additional network reinforcement is likely to be required to tailor the network to suit that particular connection. Therefore, some generator output constraints may still be required until all reinforcements can be completed.

In developing and considering these scenarios, Networks is neither recommending particular locations nor is it judging which generation projects are most likely to succeed. It is simply ensuring that its network plans are robust to potential generation developments.

3.2.1 Southern Generation Development Scenario

The 2005 Statement of Opportunities reports that 1662MW of new generation is committed or proposed to connect in the southern part of the SWIS by 2014, with 1152MW of this due to connect within the next 5 years. Committed projects reported in the 2005 Statement of Opportunities are as follows:

- A 140MW generator in the Pinjarra area.
- A 52MW upgrade of existing plant at Muja.

Proposed projects reported in the 2005 Statement of Opportunities are as follows:

- 2 x 140MW cogeneration plants in 2007/08.
- One cogeneration plant[7] per year from 2008/09 until 2014.
- 3 x 200MW coal fired to be connected near Collie in 2008, 2010 and 2012.
- A 30 MW upgrade to existing plant at Muja.

The large extent of new generation proposals for this area are considered realistic given the ready access to a range of fuel sources together with suitable process industries that could accommodate cogeneration projects.

The development of new generation sources in the southern areas exposes the network to the following limitations:

- Increased requirement for reactive power support within the metropolitan area.
- Over loading of 330/132kV transformers interconnecting the 330kV bulk transmission and 132kV sub-transmission networks.

Additional reactive power support is required for two reasons. Firstly, the four 330kV transmission lines between the south-west generation sources and the Perth metropolitan area are all around 200km long. 330kV lines of this length can transfer no more than 500MW of power each before voltage stability limits begin to constrain their power transfer capacity. To maintain stable and secure network operation at loading levels above 500MW, reactive power support is required. Even with this measure, the risks of system voltage collapse are significantly increased.

Secondly, with increased baseload power generation at 330kV, the 132kV generation elsewhere in the network is displaced. Most usually this displaced generation is located near to the Perth metropolitan area and due to its proximity to the load, it would normally provide dynamic reactive power support to stabilise the network during faults. When this generation is displaced, the reactive power support normally provided by it needs to be sourced from elsewhere.

Means of alleviating the demand for increased reactive support include the provision of alternative sources of reactive power (e.g. Static VAr Compensators SVCs) or by reducing the load transferred by transmission lines by either connecting additional lines or by reducing generator outputs.

The increased loading of the 330kV network that will result from the connection of new generation sources at 330kV will require additional 330/132kV transformer capacity within the Perth metropolitan area, which is the main load centre.

Therefore, significant network augmentations would be required to enable the SWIS to accommodate additional generation in the South West region. All or some of the following network reinforcements would be required to accommodate the new generation proposed in the 2005 Statement of Opportunities:

- Construction of 330kV transmission lines from the south-west region into the Perth metropolitan area;
- Installation of additional reactive power compensation, in the form of static VAr Compensators (SVC), shunt capacitor banks within the metropolitan area and/or series line capacitor banks on the major 330kV infeeds to the metropolitan area;

[7] *The size of these cogeneration plants is not listed in the 2005 Statement of Opportunities.*

- Imposition of generation scheduling restrictions;
- Installation of additional 330/132kV transformer capacity in the metropolitan area;
- Construction of additional transmission lines within the metropolitan area; and,
- Establishing new terminal stations within the metropolitan area.

Additional generation beyond that proposed in the 2005 Statement of Opportunities would extend the reinforcement works outlined above. The most significant works would entail the construction of new 330kV transmission lines between the south-west region and Perth. The installation of reactive power compensation will provide temporary alleviation of network constraints. Providing longer-term solutions to these constraints would require construction of additional 330kV interconnectors and hence the acquisition of new transmission line easements. This process can take between 3 to 5 years owing to the potentially lengthy environmental approvals and public consultation procedures.

3.2.2 Northern generation development scenario

This generation scenario has been developed around the generation projects outlined in the 2005 Statement of Opportunities and has been extended considering the potential fuel sources in the area. The committed projects published in the 2005 Statement of Opportunities are as follows:

- A 90MW windfarm in the Geraldton area
- An 80MW windfarm near Cervantes

Beyond these two projects, there is potential for further development of renewable as well as development of fossil fuel energy resources in the area. There is one plan announced in the 2005 Statement of Opportunities for a 100MW power station in the area fired by coal seam methane. However, Networks has no further information relating to this project.

The northern part of the SWIS extending from the Perth metropolitan area to Geraldton is supplied via a number of long parallel 132kV transmission lines. With a distance of approximately 400km between Northern Terminal and Geraldton, this is a long and weak interconnection and it provides only limited power availability for this area of the state. This system operates close to its power transfer limits.

This area is constrained by thermal, voltage and stability limitations, described further below.

- Thermal: Most of the 132kV transmission lines in the North Country area were originally designed for a 65°C maximum conductor operating temperature. Taking into account the ambient temperature conditions the thermal ratings of the lines would allow for power transfers of up to 85MVA (without considering synchronous stability limits).
- Voltage: Due to the long route of the North Country system and its relatively high power transfer requirement, high loads can cause the system voltage in the North Country area to drop to unacceptable levels.
- Synchronous stability transfer limits: Due to the long interconnection between the North Country system and the SWIS, faults on the interconnection or in the SWIS can cause synchronous instability between generator groups in the Perth metropolitan area and North Country. This situation may be exacerbated by the connection of additional generators in the North Country. Provided the power transfer from the metropolitan area to the North Country region is held below the transient stability limits, local generation in the North Country area will retain synchronism with the metropolitan system for system faults that are cleared normally. If the power transfers are excessive then units may lose synchronism. Therefore, the connection of generation in the North Country region may necessitate significant network reinforcements to alleviate the network constraints.

In addition to the network limitations within the northern area, the connection of additional generation sources in this area exposes the network within the Perth metropolitan region to the following limitations:

- Increased requirement for reactive power support; and
- Overloading of the 132kV transmission lines.

Additional reactive support is needed for two reasons. Firstly, the additional generation provided by the windfarms means that generation elsewhere in the network is displaced. Most usually this displaced generation is located near to the Perth metropolitan area and due to its proximity to load, it would normally provide reactive power support to stabilise the network during faults. When this generation is displaced, the reactive power support normally provided by it needs to be sourced from elsewhere. Secondly, the remoteness of the proposed windfarms and the long 132kV transmission lines that connect them to the load centre means the lines are too weak to transfer any reactive power from the windfarms to the load centre.

The 132kV transmission network in the northern Perth area was originally designed for load to be transferred northwards. With the connection of large sources of generation north of this region, the power flow is reversed with load flowing into the Perth region. The network has not been designed for this scenario and needs reinforcing.

Therefore, substantial network augmentation will be required to enable the connection of additional generation sources in the area north of Perth. Some or all of the following work would be required to accommodate the generation projects included in the 2005 Statement of Opportunities:

- Installation of additional reactive power compensation, in the form of static VAr Compensators (SVC), shunt capacitor banks within the metropolitan area and/or series line capacitor banks on the major 132kV infeeds to the metropolitan area;
- Imposition of generation scheduling restrictions; and,
- Establishing new 132kV transmission lines within the metropolitan area.
- Establishing a 330kV bulk transmission network north of Perth to towards the Geraldton region; and,
- Installation of additional 330/132kV transformer capacity in the metropolitan area.

As noted earlier, establishing 330kV transmission lines would require a substantial lead-time with approval for and acquisition of transmission line easements taking in the order of 3-5 years.

3.2.3 Metropolitan generation development scenario

A single proposal for connection of a new 120MW generator in the Perth metropolitan area is identified in the 2005 Statement of Opportunities. Subsequent to publication of the 2005 Statement of Opportunities, the finalisation of the Power Procurement Process confirmed the connection of a new 320MW power station at Cockburn.

Beyond these, Networks is unaware of any additional prospects for the connection of additional generators within the metropolitan area. The 2005 Statement of Opportunities also notes the prospective retirement of generating plant located at Kwinana. The proposed new generators are as follows:

- A 120MW combined-cycle generator in the Kwinana area
- A 320MW combined-cycle generator at Cockburn

The electricity transmission network within the Perth metropolitan area is characterised by high loads and high fault levels. The fault levels on the 132kV network within the metropolitan region are nearing design levels and the 132kV network between the metropolitan power stations and terminal stations is loaded to capacity. As a result Networks require that all new generating sources within the metropolitan area be connected to the 330kV network. To facilitate this requirement, it may be necessary to establish new 330kV transmission interconnectors within the Perth metropolitan area to connect new power stations with the bulk transmission network.

The development of additional generation within the Perth metropolitan area will expose the following network limitations:

- Higher fault levels;
- Increased loading of the 330kV transmission network within the metropolitan area (for some connection locations); and,
- Increased loading of 330/132kV transformers interconnecting the 330kV bulk transmission and 132kV sub-transmission networks.

The retirement of some generators within the Perth metropolitan area also exposes some network limitations. These are as follows:

- Reduced reactive power support for the network during faults;
- Increased demand for reactive power support due to replacement of metropolitan generation with remote generation and resultant higher loading of long 330kV bulk transmission lines; and,
- Increased loading of 330/132kV transformers interconnecting the 330kV bulk transmission and 132kV sub-transmission networks.

Therefore the connection of additional generations sources within the Perth metropolitan area would require some network augmentation, but may also have some beneficial effect on the network by providing reactive power support. The exact siting of generation within the metropolitan areas would significantly affect the network development required. The concentration of new generation in the southern part of Perth, alongside existing generation, would increase network loading and fault levels, requiring some reinforcement. The siting of new generation in the northern part of Perth would initially require the establishment of a new 330kV connector but should minimise any other fault uprate, network reinforcements or reactive power support requirements.

3.2.4 Eastern generation development scenario

There are no current generation project proposals for connection to the eastern part of the SWIS. The inclusion of this generation development scenario here seeks to provide a general overview of the existing network and the constraints that are likely to be encountered with the connection of generation in this part of the network.

The connection points at Northam and Kalgoorlie are presented for illustrative purposes.

Generation at Northam

This scenario has been included (even though there are few convenient fuel sources) to illustrate the impact of significant generation developments in the area.

Northam zone substation is interconnected into the metropolitan area via three 132kV lines and a normally open 66kV transmission line. The transmission system supplying Northam has been designed to supply relatively small loads in the Northam and its surrounding areas. It also provides back-up capacity to supply loads in the areas surrounding Merredin.

Given that the network was designed to supply relatively small loads, there would be significant thermal, voltage and stability constraints associated with power transfer from Northam into the metropolitan area. Further, significant line losses may result from this power transfer. Network reinforcement costs to cater for the connection of significant amounts of generation in this area are likely to be high due to the absence of existing 330kV transmission infrastructure or strong points of connection at lower voltages. For example, the straight line distance from Northam substation to the closest 330kV circuit line is approximately 67km. The network reinforcements associated with this scenario are similar to those required for the Northern generation development scenario.

Generation at Kalgoorlie

Kalgoorlie is located approximately 550km east of the Perth metropolitan area and is connected to the SWIS via a radial 220kV transmission line. There is potential for generation proponents to propose connecting to this system to supply local load and potentially export surplus power into the SWIS given that:

- There is an existing gas pipeline providing a readily available source of fuel;
- There are existing process industries in the area; and,
- There is an existing 220kV transmission system.

The interconnection from Muja in the south-west to Kalgoorlie is via a 650km long 220kV transmission line that was originally designed and constructed in 1984 to supply loads in the Kalgoorlie area. Due to its length, reactive power compensation is required along the 220kV line to maintain the voltage profile along the line (enabling power transfer capacity to the Kalgoorlie area).

At the time the 220kV line was designed and constructed, it was intended that generators were connected to the network in the Eastern Goldfields area for emergency stand-by purposes only, to supply some load when the radial 220kV line was out-of-service.

More recently generators have connected in the Kalgoorlie area to supply local load. A remedial action scheme ("RAS") has been installed at Kalgoorlie to island this generation for local and remote faults in the SWIS, which could otherwise result in synchronous instability. This scheme is required in service only when power transfer exceeds certain thresholds.

Operation of the RAS and subsequent islanding of the generation in Kalgoorlie can result in substantial and abrupt changes in power flow along the 220kV line from Muja to Kalgoorlie. The system was not designed to cater for such large abrupt changes in power transfer (there are limitations in the dynamic range of fast acting reactive power compensation equipment and therefore while the RAS enhances the transfer capability of the existing system, it also imposes limits on the amount of power that can be exported from generators in the Kalgoorlie area without undertaking additional reinforcements.

Given that generation in the Kalgoorlie area can be operated in a synchronously stable mode if power transfer across the Muja - Kalgoorlie 220kV interconnection is maintained within a particular threshold, there is then scope for additional generation to be accommodated within the Eastern Goldfields system. Power transfer limitations imposed by synchronous instability constraints would need to be managed with the careful design of power plant to ensure that the system operates in a synchronously stable state.

If the amount of generation connected in the Kalgoorlie area exceeds the local load, then power would be transferred from the across the 220kV transmission line into the SWIS via Muja. This has similar effects as the southern generation development scenario with similar network reinforcement requirements.

4 Network constraints

The SWIS is grouped into 12 load areas primarily along geographical lines - Northern Terminal, Muja, Kwinana, Cannington, Bunbury, Western Terminal, East Perth, Southern Terminal, South Fremantle, East Country, Eastern Goldfields, and North Country. A new load area called Guildford will be created by the end of 2006 with the construction of Guildford Terminal. A number of existing substations including Midland Junction, Forrestfield, Darlington and Kalamunda will be allocated to the Guildford load area. The bulk transmission network interconnects these Load Areas. Figure 4.1 provides a simplified single line representation of the SWIS.

Historically, these load areas tended to consist of a number of zone substations centred on a major terminal station. However, with increasing numbers of substations being cut into interconnecting transmission lines to minimise zone substation establishment costs, the network is becoming increasingly meshed.

Each load area has its own unique characteristics and load growth in the area tends to be influenced by them. For example, the load areas supplying the northern and southern coastal areas are experiencing rapid load growth due to residential housing developments, whereas growth in the Eastern Goldfields areas is highly sensitive to the activities of mining companies in response to world metal prices. As might be expected, the greatest distinctions are between load areas that cover urban and rural load areas.

The following sections describe each load area in greater detail, identify the major drivers of load growth for each area and discuss potential constraints. The discussion commences with the bulk transmission network and the impact of the generation scenarios described in Chapter 4.

4.1 Bulk Transmission Network

Power is transferred over the 330kV and 132kV bulk transmission networks from five major and a number of smaller interconnected power stations to twelve bulk supply terminals for transformation to lower voltages. Electrical energy is then distributed to a host of zone substations supplying localised areas via the sub-transmission networks operating at 132kV and 66kV voltages.

In assessing the adequacy of the bulk transmission network, generation forecasts are of equal importance as load forecasts given that the timing, size, and location of new generation connections significantly affect the network development. Consequently, network performance studies have been conducted assuming that required additional generation is connected to the bulk transmission network, although there is some uncertainty regarding when and where new generating units will be connected and located.

The network reinforcements identified to address the generation scenarios are indicative only. Detailed studies are necessary for each generation proposal on a case-by-case basis to determine the required reinforcements and refine the overall development program. In particular, these may result in:

- Significantly more fault level control measures;
- Significantly more work with transmission lines including upgrades, new lines and new terminal stations; and,
- Altered reactive power support measures.

Based on the uncertainties and assumptions noted above, the assessment of the bulk transmission network indicates that a majority of the constraints expected to arise over the next 10 years relate to thermal, voltage support and fault level rating limitations. The works described below for the bulk transmission system, focuses on the common reinforcement elements between the scenarios set out in Section 3.2.

The common requirements between all generation scenarios indicate that to accommodate the forecast load growth and potential generation developments, it will be necessary to reinforce the bulk transmission network by providing additional reactive power support within the metropolitan area and by increasing the 330/132kV transformer capacity within the Perth metropolitan area. Measures to reduce the network impact of particular 330kV line outages will also be required to limit the amount of reactive power support required.

These activities are reflected in the proposed project schedule by:

- The establishment of new 330/132kV terminal stations at Kenwick Link and Neerabup (Committed Projects);
- The installation of Static VAr Compensators (SVC) at Southern Terminal; and,
- The reinforcement of the 330kV transmission network between Southern Terminal and Kwinana.

In addition to the network reinforcements referred to above that are common to most generation development scenarios, some additional network reinforcements have been included in the project schedule. The inclusion of these reinforcements is based on Networks' assessment of the lead time for projects to accommodate some of the generation proposals published in the 2005 Statement of Opportunities and the likelihood that these projects will be necessitated by some form of new generation in the near future. The inclusion of these projects does not represent an endorsement by Networks of the generation proposals currently driving them, nor does it represent a commitment by Networks to proceed with the project according to the current scope and schedule. The scopes and schedules

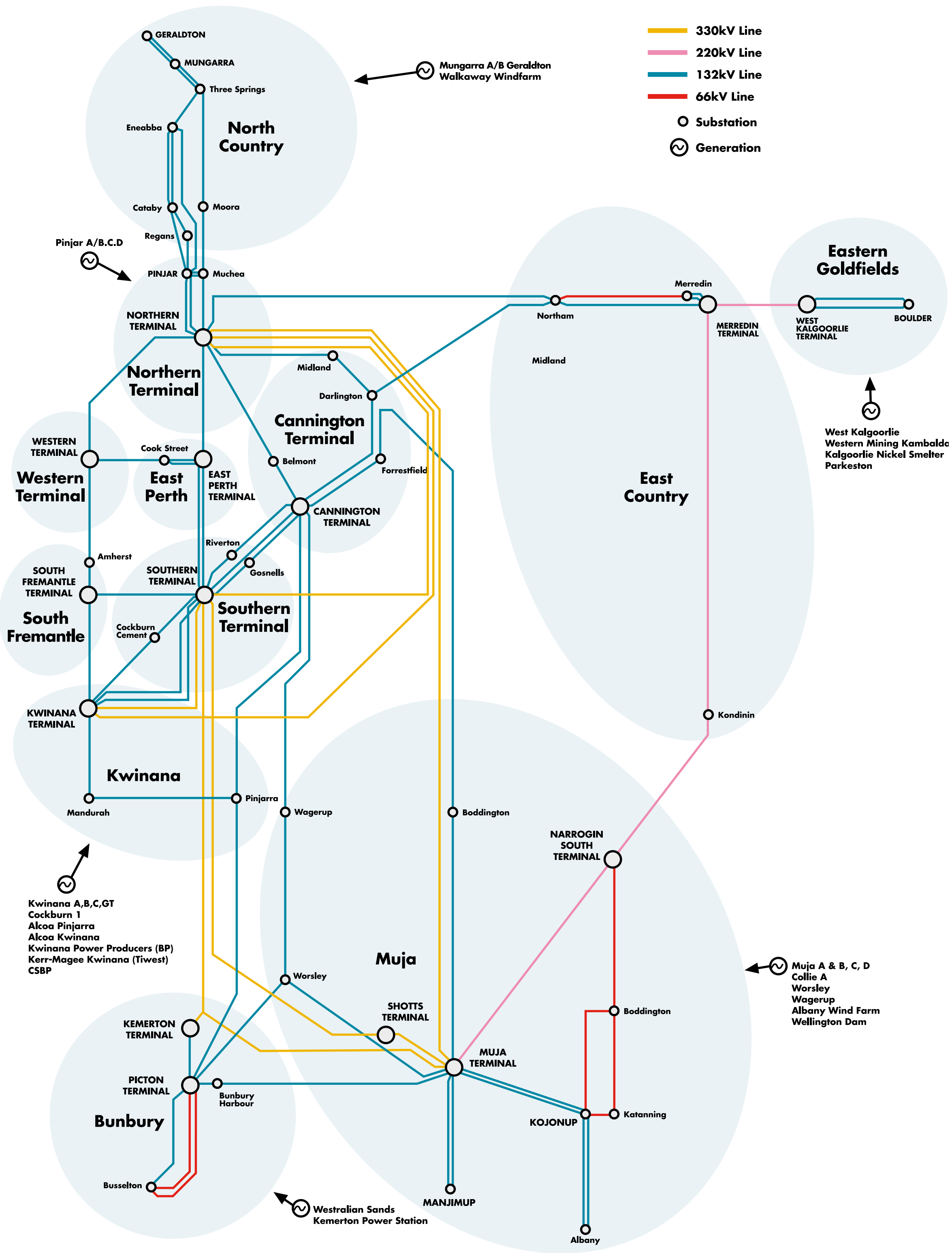

Figure 4.1 Simplified SWIS single line diagram.

associated with these projects will be reassessed by Networks as new information on generator proposals is made available and consequently may alter significantly.

4.2 Northern Terminal

The Northern Terminal Load Area covers the northern part of the Perth Metropolitan region - extending from the coast to Osborne Park and Morley in the south, to Yanchep in the north, and West Swan in the east. At 700MW, the load area represents approximatly 22% of the total load in Western Power's SWIS. There are presently 14 substations in the load area, all with a summer peak.

The area contains commercial, light industrial, residential and semi-rural loads. Parts of the area are sparsely populated but will be subjected to intensive residential and some commercial development in coming years. Long-term development plans indicate that heavy industrial load centres may be developed in the area within 20 years.

The recent trend of high load growth is expected to continue for the next ten years. Beyond this, overall development may moderate, as vacant land becomes scarce. Even so, there may be localised growth pockets, particularly along the north-western coastal strip.

The average load growth for this load area is forecast to be in the order of 5% to 6% per annum, almost double the forecast system average.

The major problems facing the Northern Terminal network in the future are primarily related to the thermal capacity of transmission lines and the capacity of zone substations to supply growing load. The northern extremity of the network is affected by voltage limitations, due to its remoteness from the bulk supply points. It is anticipated that the voltage problems will be mitigated by the solutions required to overcome thermal line loading problems.

If achieved, the forecast load growth would require the establishment of at least ten new substations and the construction of two new transmission lines during the next 10 years. In addition, a number of existing substations will need to be up-rated. The increased load in the area has a significant effect on the loading of transmission lines.

Depending on precise location, embedded generation or DSM could reduce these constraints. For example, embedded generation at Ellenbrook, Mullaloo and Wanneroo would be particularly helpful.

4.3 Muja

The Muja Load Area supplies predominantly agricultural loads, with some mining, milling and light industrial loads. It extends from Muja Power station to Manjimup and Beenup in the south-west, Albany in the south-east, Boddington in the north and Narrogin in the north-east. Due to the large geographical area, the Load Area's substations supply their peak loads at different times:

- The substations supplying predominantly domestic loads normally supply their peak load during winter;
- The substations supplying mining and agricultural loads normally supply their peak load during summer; and
- Some substations have very little seasonal variation in load.

Local load growth is generally subdued, although there are some developing areas and there have been some new mining loads connected recently. Albany, the main population centre, has had the most significant load growth of the area recently and is forecast to grow at a rate of around 3.5% per annum over the next 10 years. The loads at Narrogin, Wagin and Katanning substations are forecast to grow on average 2% per annum, while the rest of the load area has a forecast load growth of 1% or less.

One of the major restrictions to load growth in parts of this load area is the lack of distribution network capacity to supply new loads in remote locations.

This load area is characterised by long transmission lengths, and as a result, the major problems facing this network in the future are voltage related.

Depending on precise location, embedded generation or DSM could reduce these constraints. For example, either at Albany would be particularly helpful.

4.4 Kwinana

The Kwinana Load Area roughly follows the administrative boundaries of the City of Kwinana, and the Towns of Rockingham and Mandurah. All the substations in this area supply their peak load during summer.

Two infrastructure developments are anticipated to have a major long-term impact on the area. These are:

- The South West Metropolitan Railway project that plans to extend the South West Metropolitan Railway to Rockingham and Mandurah by 2007.
- The Kwinana freeway has recently been extended to Safety Bay and a further section between the Mandurah bypass and Lake Clifton is due for completion by 2008. The section of freeway between Safety Bay and Mandurah is due for completion by 2011.

Both of these major infrastructure projects are expected to provide a more attractive environment for residential development. Ultimately, these projects will accelerate development and therefore load growth in the area from Rockingham to south of Mandurah.

The load in the Kwinana Load Area is forecast to grow at an average rate of around 8%.

The constraints identified for the Kwinana Load Area relate to:

- Thermal constraints associated with the transfer of large amounts of load from Kwinana across the 132kV network to other areas;
- Voltage constraints in the southern part of the area are expected to become more prominent as residential development at the extremities of the network increases load; and
- Substation capacity constraints resulting from large residential load growth around Rockingham and Mandurah that will require new substations to be established within the area.

Depending on precise location, embedded generation or DSM could reduce these constraints.

4.5 Cannington

The Cannington Load Area covers the south-eastern metropolitan area, bounded by the Swan and Canning Rivers and extending east to Mundaring. The load area supplies a broad mix of load types ranging from industrial and commercial to residential and semi-rural. All the substations in this area supply their peak load during summer.

Commercial and industrial loads in the area are experiencing strong growth, and overall load demand in the area is growing at around 4%. The residential areas in Cannington Load Area are fairly well established and domestic load growth is expected to be relatively subdued but steady. Urban consolidation and major development projects, many of which will be located along the shores of the Swan and Canning rivers, will be the main drivers for domestic load growth in the well developed residential areas. Urban sprawl will be one of the main drivers for domestic load growth in the fringe areas.

The second Southern Terminal-Cannington Terminal 132kV line, due to be completed by December 2005, will provide adequate network supply to the Cannington area for the next 10 years.

The major constraints identified in the Cannington Terminal Load Area are associated with substation capacity in the developing pockets of the load area. The forecast of increased industrial loads will require three new substations to be established and capacity enhancements within the area during the next 10 years.

Depending on precise location, embedded generation or DSM could reduce these constraints.

4.6 Bunbury

The Bunbury Load Area covers a large region from Pinjarra in the north to Margaret River in the south. The region supplies a diverse range of load types, varying from mining and minerals processing, to timber milling, light industry, food production, domestic and agriculture. The substations within this load area predominantly supply their peak load during summer. However, some substation loads are increased by the influx of tourists during holiday seasons.

The load in this area has grown rapidly, particularly around Picton, Busselton and Margaret River, primarily due to the expansion of the tourism, wine and food producing industries and some residential development. This expansion is expected to continue over the medium term.

Major residential development projects, many located along the coastal strip south of Bunbury and spot developments along the Leeuwin-Naturaliste line, will be the key drivers for forecast load growth.

Large industrial developments are expected around Kemerton and Pinjarra.

Bunbury area load growth is expected to be around 4%, driven by the major load centres of Picton, Bunbury Harbour and Busselton. The highest rate of load growth, at 5.3%, is forecast at Picton substation.

The main constraints identified in the Bunbury Load Area are the voltage and thermal capacity limits of transmission lines and the capacity of substations to meet growing load demand. The forecast load growth in this area will require additional capacity between Waterloo, Busselton and Margaret River.

Depending on precise location, embedded generation or DSM could reduce these constraints. For example, either at Margaret River or Bussleton would be particularly helpful.

4.7 Western Terminal

The Western Terminal Load Area is bound by the Perth CBD to the east, Swan River to the south, coast to the west, and the suburbs of Scarborough and Yokine to the north. It predominantly supplies commercial and residential customers in the Western Suburbs.

There are two major loads in the area - Sir Charles Gardiner Hospital and the University of Western Australia. These loads are supplied directly at 6.6kV from the Medical Centre and University substations respectively.

The substations in this area generally supply well-established mature suburbs with above average socio-economic demographic. Load growth in the area is most likely to arise from the uptake of residential air-conditioning, redevelopment of small pockets of land and/or infill developments.

Analysis of available data and information pertaining to new residential, commercial, industrial and infrastructure developments in the load area indicates that most substations are likely to experience steady growth in load over the medium to long term. The only exceptions are Medical Centre and University, which are likely to see increased load growth due to planned expansions at the hospital and university.

The average forecast load growth for substations in the Western Terminal Load Area is around 2.8%. Cottesloe, Nedlands, Shenton Park and Wembley Downs, which are the four largest substations in the load area, are growing at over 3% per annum, with Cottesloe and Shenton Park in particular experiencing significant jumps in peak demand during summer 2004.

Over the next 10 years, substation capacity constraints will be the most significant development issues in this area. It is expected that primary operating voltage conversions of existing 66kV substations to 132kV will be necessary to augment capacity in the Western Terminal Load Area.

Depending on precise location, embedded generation or DSM could reduce these constraints.

4.8 East Perth

The East Perth Load Area includes the CBD, the Town of Vincent (North Perth, Mt Lawley), the City of Subiaco, and parts of Maylands. The substations within the East Perth Load Area all supply predominantly commercial loads with peak load during summer. The CBD load represents around 10% of the total system peak load.

Load growth in the East Perth Load Area has been subdued over the last 5 years. A lack of any significant new development, redevelopment of the East Perth precinct, and redevelopment associated with the Northbridge tunnel, appears to have shifted load profiles and temporarily reduced load. With the completion of these developments, it seems likely that underlying growth and the connection of block loads will cause higher levels of load growth over the short term.

The potential for future load growth in the East Perth Load Area is largely related to the growth in the economy and the resulting increase in commercial activity in the CBD. It is recognised that strong economic growth could lead to a commercial building boom and significant load growth with little warning.

Perth CBD population growth is reasonably high at double the Perth metropolitan average. However, high population growth has not translated into high load growth. The residential load profile compliments the area's dominant commercial load profile as population growth has contributed to energy growth without increasing peak demand.

The forecast load growth for the area is higher than average for the next five years. This is due to a number of large new loads including the Perth Convention Centre, Woodside Building & East Perth Redevelopment Project.

Given the level of expected load growth, transmission line and zone substation capacity constraints are anticipated over the next 10 years.

Depending on precise location, embedded generation or DSM could reduce these constraints.

4.9 Southern Terminal

Southern Terminal Load Area (from Riverton and Canning Vale in the north, to Cockburn Cement in the west and Byford in the south) substations supply a mixture of commercial, industrial and residential customers with peak load during summer.

Many substations in the area have experienced rapid load growth over the last 5 years due to increased land development activities. In particular, the area supplied by Cockburn Cement substation has seen load growth at close to 9% per annum due to new commercial loads around Jervoise Bay and local residential subdivisions. As there is still much vacant land in the area, rapid load growth appears likely to continue.

Two Water Corporation pump stations, in Armadale and Brookdale, are planned for 2007. The Perth Urban Railway group has also proposed a feeder station at Glen Iris to be supplied directly from Southern Terminal with a planned in-service date of early 2006.

The forecast load growth rates for substations in the Southern Terminal Load Area range from 2% to 5%.

The main constraints facing the Southern Terminal Load Area during the next 10 years relate to shortfalls in substation capacity. It is forecast that the rapid load growth will require five new substations to be established in the area within the next 10-12 years.

Depending on precise location, embedded generation or DSM could reduce these constraints.

4.10 South Fremantle

The South Fremantle Load Area is relatively compact and mainly supplies the City and Port of Fremantle. The load area extends south to Beeliar, east to the Kwinana Freeway and north to the Swan River. All substations in the area supply a mixture of local commercial, industrial and residential customers and supply their peak load during summer.

This area is well established and therefore is not expected to experience rapid load growth in the medium to long term. Load growth in the area is most likely from redevelopment of small areas of land or infill developments. The load growth in the area is forecast to be steady at around 4%. Notable future block loads in the area include the expansion of Fremantle Port and Murdoch University.

The existing South Fremantle to O'Connor 66kV transmission line is being upgraded and converted to a 132kV insulated line. It is intended that this line will initially continue to be operated at 66kV. It will then be energised at 132kV as part of the future conversion of existing 66kV substations at O'Connor, Myaree and APM to 132kV.

An additional constraint will be a shortfall in the bulk transmission capacity supplying South Fremantle Terminal. At present, it is envisaged that the South Fremantle to Southern Terminal 132kV line will be converted from a split phase to a double circuit line to overcome this problem.

Depending on precise location, embedded generation or DSM could reduce these constraints

4.11 East Country

The East Country Load Area covers an extensive area, primarily wheat belt areas to the east of the Perth Metropolitan area, bounded by Sawyers Valley in the west and Southern Cross in the east. The network supplies a mixture of wheat belt, water pumping and mining loads. The Mundaring-Kalgoorlie water pipeline is a significant portion of the load in this area. The main population centre of the region is at Northam and York. The peak loading for this area occurs during summer.

Analysis of the historic load growth and regional development information indicates that the substations in this area will have relatively low growth rates. The towns in this area are mostly mature and experiencing little growth. There is potential for industrial and commercial development in the region, which may accelerate demand at any of the substations and this potential requires close consideration. The highest rates of growth in this area are predicted to occur at the substations in the areas near the coast and the Perth metropolitan area. The substations with the highest rates of growth in this region are Sawyers Valley (4.3%), and Northam (5.1%). These substations not only supply the local town associated with the substation but also support the surrounding county areas through the distribution network.

Given the level of expected load growth, zone substation capacity constraints are anticipated to be the major issues in this load area. In addition, the large distances and the relatively low voltages (66kV and 132kV) used to transmit power through this region mean that the transmission capacity is limited by voltage constraints, and in some cases thermal constraints are also apparent. Load growth will exacerbate these constraints.

Depending on precise location, embedded generation or DSM could reduce these constraints.

A number of substations within the East Country Load Area are sensitive to industrial and mining developments. There is potential for a number of large projects that would result in substantially increased electrical load to proceed. This situation will be monitored in order to identify developments that would increase network loads beyond the forecast and require additional network reinforcements.

4.12 Eastern Goldfields

The Eastern Goldfields Load Area is relatively compact, supplying mainly mining loads in the vicinity of Kalgoorlie. This load area is supplied by a radial 220kV line which supplies four other substations at Narrogin South, Kondinin, Merredin and Yilgarn. The substations in the Eastern Goldfields load area supply predominantly mining and industrial loads and there is little seasonal variation in the loads.

Over the medium term, the Eastern Goldfields area has exhibited consistent growth. The nature of the mining industry means that demand for electricity is largely dependent on international commodity prices. Historically, load growth from year to year has varied with the demand for output from the mines but, over the medium term, has continued to grow.

The load growth predicted for the Eastern Goldfields area is approximately 3.9%. This trend includes the average growth of the mining loads. However, the mining loads have the potential to suddenly change the growth. This may necessitate rapid changes to the network reinforcement plans, and will require close monitoring.

The substations at Narrogin South, Kondinin, Merredin and Yilgarn supply areas that are mostly mature and experiencing insignificant growth. There is some potential for mining, industrial and commercial development in the region to accelerate demand at these substations.

Because of the large distance to transmit power to this region, the transmission capacity is limited by voltage and synchronous stability constraints - although in some cases thermal constraints may also arise. A constraint on power transfer capacity is the most significant issue facing the Eastern Goldfields load area over the next 5 years. A review of available options to provide a long-term solution to alleviate this critical constraint has been performed and study results are presently under consideration by Western Power's Strategy & Regulation branch.

4.13 North Country

The North Country Load Area is located north of the Perth metropolitan region, stretching from Regans Ford and Moora to Kalbarri. The load area extends into the northern areas of the wheat belt, around 150km eastwards from the coast. The load area supplies a range of mining and industrial loads, as well as many rural centres and the main population centre of Geraldton. All the substations in this area supply their peak load during summer.

The population of the Geraldton area has been growing at slightly above the State average growth of 1.5% and the load growth forecast for the substations supplying Geraldton is in the order of 3%. The load growth is highest in the coastal areas of Geraldton, Kalbarri, Dongara, and Jurien. The load growth forecast for the remaining substations in the area is much more subdued and is expected to be around 1%.

The load growth of the region has prompted the development of a new substation at Rangeway, which is presently under construction.

Heavy reliance is placed upon the use of generating plant at Mungarra and Geraldton to maximise the network capacity. Networks plan to continue to use this generating capacity to defer major transmission reinforcement works for as long as possible. Any retirement of the generating units at Mungarra or Geraldton with no replacement would result in the advancement of major transmission reinforcement works.

Due to the limited amount of spare capacity within this network, any additional loads, or higher than forecast load growth, will accelerate the need for major transmission reinforcements. The lack of transmission capacity in the NCR is becoming a major impediment to:

- The development of renewable energy projects in the NCR. There is up to 500MW of wind energy developments proposed for the NCR. A significant proportion of these are not able to proceed due to a lack of transmission capacity.
- The potential development of coal fired base load power generation utilising coal resources located north of Perth, which can be expected to enhance the security of Western Australia's electricity supply system and alleviate stress on the existing 330kV south to north transmission backbone.
- Providing electricity supply to proposed large industrial and mining loads.
- Facilitate the future retirement of ageing generating plant at Geraldton and Mungarra.

Depending on precise location, DSM could reduce these constraints.

A number of substations within the North Country Load Area are sensitive to industrial and mining developments. There is potential for a number of large projects that would result in substantially increased electrical load to proceed. This situation will be monitored in order to identify developments that would increase network loads beyond the forecast and require additional network reinforcements.

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5 Committed projects

In this Chapter, we provide information on the committed projects intended to address the most pressing constraints discussed in the previous section.

In this Chapter, we broadly follow the definition used in the Statement of Opportunities , namely that a project is identified as Committed if the following criteria are met:

- The project has purchased/settled/acquired land (or commenced legal proceedings to acquire the land) for the construction of the proposed development;
- Contracts for the supply of major components of plant and equipment have been finalised;
- All planning consents, approvals and licences have been secured;
- Capital Plan Approval has been achieved; and
- Construction has commenced, or a firm date for construction has been set.

Please note that while the projects in Table 5.1 below have met the criteria, they may still change in timing, scope and cost prior to commencement as a result of revised forecasts and other factors. The table includes projects expected to cost more than two million dollars.

Load area	**Location**	**Committed Project**	**Expected Completion Date**
Bulk Transmission Network	Kemerton to Kwinana	Construct a new 330kV overhead transmission line	2005
	Kwinana Terminal	Install 132kV fault level limiting reactors	2005
	Southern Terminal	Install 132kV fault level limiting reactors	2005
	Southern Terminal to Cannington Terminal	Construct a new 132kV overhead transmission line with option for upgrade to 330kV	2005
	Guildford Terminal	Establish a new 330/132kV terminal station with a 330kV switchyard	2006
	Kenwick Link	Establish a new 330/132kV transformer station	2006
	Kwinana to South Fremantle	Upgrade an existing 132kV transmission line from split phase to double circuit operation	2006
	Network wide	Install reactive compensation at selected substations	2006
	Shotts to Kemerton	Construct a new 330kV transmission line	2007
	Neerabup	Establish a new 330/132kV terminal station	2008
Bunbury	Marriott Road	Install a second transformer	2005
Cannington Terminal	Rivervale	Install a second transformer	2006
	Forrestfield	Install a second transformer	2006
	Cannington to Rivervale	Upgrade transmission line capacity	2006
	Bentley	Establish a new substation	2007
East Country	Merredin	Upgrade 132/66 kV transformer	2006
Eastern Goldfields	Parkeston Power Station	Establish a new 132kV interconnection substation	2005
East Perth	James St to Milligan St	Upgrade capacity on both transmission lines	2007
Kwinana	Meadow Springs	Establish a new substation	2005
	Waikiki	Establish a new substation	2007

Load area	Location	Committed Project	Expected Completion Date
Muja	-	-	-
North Country Region	Rangeway	Establish a new substation	2006
Northern Terminal	Landsdale	Install a third transformer	2005
	Malaga	Install a second transformer	2005
	Clarkson	Establish a new substation	2006
	Padbury	Establish a new substation	2006
	Pinjar to Wanneroo	Construct a new 132kV transmission line	2006
	Henley Brook	Establish a new substation	2007
	Yokine	Install a third transformer	2007
	Morley	Install a third transformer	2008
	Padbury	Install a second transformer	2008
South Fremantle	Kwinana to South Fremantle	Upgrade existing split phase 132kV transmission line for double circuit operation	2006
	Amherst	Install a third transformer and capacitor banks	2007
	Bibra Lake	Establish a new substation	2007
Southern Terminal	Murdoch	Establish a new substation	2006
	Southern River	Establish a new substation	2006
	Byford	Install a third transformer	2007
	Southern River	Install second transformer	2007
	Murdoch	Distribution network extensions	2007
	Southern River	Distribution network reinforcements	2007
Western Terminal	Cottesloe	Upgrade existing 66/6kV substation for 132/11kV operation	2009

Table 5.1 Committed Projects

6 Network development options

The network development options identified in this section only provide an indication of Networks' most favoured network augmentation solution. These solutions are based on information available at the time of network performance assessments and are in addition to the committed projects in section 5. Changes in load forecasts, generation forecasts and other factors will significantly affect the plans presented. Further detailed technical and economic assessments of each individual option are necessary at the time when the project is required.

Following such a detailed investigation, the option selected to address identified network constraints may or may not involve the solution described here. Clearly, the options selected to address the network constraint are selected on their technical and economic merits at the time.

In particular, if interested parties are able to identify DSM or distributed generation options that would address the constraints discussed in Chapter 4, the need for these projects may be reduced.

Network development options expected to cost more than two million dollars are detailed in Table 6.1 below.

Load area	**Location**	**Network development**	**Expected option completion date**
Bulk Transmission Network	Network wide	Install reactive compensation at selected substations	2007
	Southern Terminal	Install a third 330/132kV transformer and 132kV fault level limiting reactors	2008
	Southern Terminal	Install a 132kV static VAr compensator	2008
	KW-ST 92	Establish a new 330kV transmission line	2008
	Southern Terminal to South Fremantle	Modify and upgrade existing 132kV transmission line	2010
	Kemerton to South East Terminal	Construct a new double circuit 330kV transmission line	2010
	South East Terminal	Establish a new 330kV switchyard	2010
	Cannington Terminal	Install 500MVA 330/132kV transformer supplied from Southern Terminal	2013
Bunbury	Waterloo	Acquire line easement	2008
	Busselton	Install first 132/22kV transformer, remove one 66/22kV transformer	2009
	Busselton to Margaret River	Acquire line easement	2010
	Busselton to Margaret River	Construct a new 132kV transmission line	2011
	Marriott Road	Install a third transformer	2011
	Margaret River	Replace two existing 66/22kV transformers with one new 132/22kV transformer	2011
	Picton to Capel to Busselton	Upgrade existing 66kV line for 132kV operation	2011
	Busselton	Install second 132/22kV transformer, remove one 66/22kV transformer	2012
	Capel	Upgrade existing 66kV substation for 132kV operation	2012
	Pinjarra	Install a second transformer	2012

Load area	Location	Network development	Expected option completion date
	Preston Park to Capel	Construct second 132kV line	2014
	Picton	Install additional 132kV capacitor banks	2014
	Preston Park	Establish a new Substation	2014
	Preston Park	Install a second transformer	2014
	Muja to Bunbury Harbour	Upgrade transmission line capacity	2014
	Picton to Preston Park	Construct a second 132kV line	2014
Cannington Terminal	Guildford to Midland Junction	Establish 2nd line	2006
	Kewdale	Establish a new Substation	2008
	Welshpool to Belmont	Upgrade transmission line capacity	2008
	Darlington	Install a third transformer and capacitor banks	2010
	Rivervale	Install a third transformer and capacitor banks	2010
	Kalamunda	Install a third transformer and capacitor banks	2011
	Belmont to Rivervale Line	Upgrade transmission line capacity	2011
	Cannington to Welshpool	Upgrade transmission line capacity	2012
	Bentley	Install a third transformer and capacitor banks	2013
	Kewdale	Install a third transformer and capacitor banks	2013
	Victoria Park	Establish a new substation	2013
	Hazelmere	Establish a new substation	2015
East Country	Mundaring Weir and Sawyers Valley	Install 1MVAr distribution capacitor banks at Mundaring Weir and Sawyers Valley	2006
	Merredin	Upgrade existing transformer capacity	2006
	Sawyers Valley	Install 9 MVAR 66 kV Capacitor bank	2008
	Northam	Install a second transformer	2008
	Cannington Terminal to Mundaring Weir	Rebuild existing 66kV transmission line with 132kV construction	2010
	Mundaring Weir to Sawyers Valley	Rebuild existing 66kV transmission line with 132kV construction	2011
	Northam to Wundowie	Rebuild existing 66kV transmission line with 132kV construction	2012
	Sawyers Valley to Wundowie	Rebuild existing 66kV transmission line with 132kV construction	2012
	Northam	Install 3rd 132/22 kV Tx	2015

Load area	Location	Network development	Expected option completion date
Eastern Goldfields	Eastern Goldfields	Upgrade power transfer capability	2008
	Piccadilly	Install a third transformer	2009
	Black Flag	Install a third transformer	2010
	WKT-BKF 82	Construct a new second 132 kV transmission line	2011
	West Kalgoolie Terminal	Install a new 132/33kV Transformer	2012
	Boulder	Install a new 132/33kV Transformer	2015
East Perth	East Perth Area	Undergrounding of existing overhead 132kV transmission lines for East Perth Redevelopment Authority	2006
	Joel Tce	Upgrade existing 66kV substation for 132kV operation	2008
	East Perth to Belmont	Rebuild 132kV Transmission line	2012
	Wellington St to Hay St	Upgrade capacity on both transmission lines	2013
	James St	Establish a new Substation	2015
	East Perth	132kV Switchyard Fault Uprate	2015
	James St	Establish a new Terminal Station and transmission line	2016
	James St to Cook St	Establish a new 132kV transmission line	2016
	Cook St	Install a third transformer	2016
Kwinana	Meadow Springs	Install a second transformer and capacitor banks	2011
	Medina	Install a third transformer and capacitor banks	2012
	Waikiki	Install a second transformer and capacitor banks	2012
	Clifton	Establish new substation	2014
	Meadow Springs	Install a third transformer and capacitor banks	2014
	Pinjarra to Mandurah	Upgrade transmission line capacity	2014
	Baldivis	Establish new substation	2015
	Peel Terminal	Establish a new 330/132kV terminal station	2015
Muja	Mt. Barker	Distribution network reinforcements	2007
	Mt. Barker	Install a second transformer	2008
	Kojinup	Install a new 66/22kV transformer	2008
	Kojonup to Albany	Upgrade transmission line capacity	2009
	Kojonup to Wagin	Upgrade transmission line capacity	2010

Load area	Location	Network development	Expected option completion date
	Kojonup to Albany	Construct a new 132kV transmission line	2011
	Bridgetown	Install a third transformer	2012
	Wagin	Install a third transformer	2013
	Beenup	Install a third transformer	2016
	Mt Barker to Denmark	Construct a new 132kV transmission line (to be initially operated at 22kV)	2016
North Country Region	Geraldton	Distribution network reinforcements & extensions	2007
	Rangeway	Install a second transformer	2010
	Chapman Substation	Install a second transformer	2010
	Northampton Area	Construct a new 132 kV transmission line from Chapman (initially operated at 33 kV)	2010
	Geraldton (Moonyoonooka)	Install a new 330/132kV transformer	2010
	Pinjar to Geraldton	Construct a new 330kV transmission line	2010
	Moonyoonooka to Rangeway	Construct a new 132kV transmission line	2011
	Jurien Bay Area	Construct a new 132 kV transmission line from Eneabba (initially operated at 33 kV)	2011
	Koorda Area	Construct a new 132kV transmission line (initially operated at 33 kV) (If Government funds/grant is available)	2011
	Cataby (Badgingarra)	Install a new 330/132kV transformer	2012
	Wongan Hills	Establish a new substation	2012
	Wongan Hills	Install a second transformer	2013
	Dongara	Establish a new substation	2016
	Rudds Gully	Establish a new substation	2016
Northern Terminal	Padbury	Install a third transformer	2008
	Clarkson	Install a second transformer	2008
	Joondalup	Establish a new substation	2009
	Northern Terminal to Mt Lawley	Upgrade transmission line capacity	2009
	Northern Terminal to North Beach	Upgrade transmission line capacity	2009
	Wangara	Establish a new substation	2010
	Malaga	Install a third transformer	2011

Load area	Location	Network development	Expected option completion date
	Osborne Park Industrial Area	Establish a new substation	2011
	Wangara	Install a second transformer	2011
	Bayswater	Establish a new substation	2012
	Henley Brook	Install a second transformer	2012
	Joondalup	Install a second transformer	2012
	Warwick	Establish a new substation	2012
	Warwick	Install a second transformer	2012
	Clarkson	Install a third transformer	2013
	Muchea	Install a third transformer	2014
	Wangara	Install a third transformer	2014
	Joondalup	Install a third transformer	2015
	Northern Terminal	Install a third transformer	2015
	Stirling	Establish a new Substation	2015
	Hocking	Establish a new substation	2016
	Manning St	Install a third transformer	2016
	Wanneroo to Hocking	Establish a new double circuit 132kV transmission line	2016
	Osborne Park Industrial Area	Install a second transformer	2016
	Stirling	Install a second transformer	2016
	Yanchep	Replace an existing transformer	2016
South Fremantle	O'Connor to Myaree	Upgrade transmission line capacity	2009
	Southern Terminal to South Fremantle	Upgrade existing split phase 132kV transmission line for double circuit operation	2010
	Australian Paper Mills to Myaree	Upgrade transmission line capacity	2010
	South Fremantle to Australian Paper Mills	Upgrade transmission line capacity	2010
	Myaree	Upgrade existing 66kV substation for 132kV operation	2011
	O'Connor	Upgrade existing 66kV substation for 132kV operation	2011
	Australian Paper Mills	Upgrade existing 66kV substation for 132kV operation	2012

Load area	Location	Network development	Expected option completion date
Southern Terminal	ST-SNR-WGP/APJ 81	Cut SNR into exisiting line	2008
	Murdoch	Install a second transformer and capacitor banks	2010
	Thornlie	Establish a new substation	2010
	Willetton	Establish a new substation	2010
	Jandakot	Establish a new substation	2013
	Southern Terminal to Jandakot	Construct a new 132kV transmission lines	2013
	Southern River	Install a third transformer and capacitor banks	2014
	Willetton	Install second transformer	2014
Western Terminal	Medical Centre	Add third LV switchboard	2007
	Wembley Downs	Establish new 132/11kV substation to be initially operated at 66/11kV	2010
	Western Terminal to Cook St	Upgrade existing 132kV transmission line capacity	2010
	Medical Centre	Replace two existing transformers	2012
	Nedlands	Upgrade existing 66/6kV substation for 132/11kV operation	2013
	Shenton Park	Upgrade existing 66/6kV substation for 132/11kV operation	2014
	Western Terminal to Northern Terminal	Upgrade existing 132kV transmission line capacity	2014
	South Fremantle to Amherst	Upgrade existing 132kV transmission line capacity	2015

Table 6.1 Network Development Options

7 Invitation to provide feedback

Networks would welcome feedback on this inaugural Transmission and Distribution Annual Planning Report.

Comments on this document should be sent to:
Manager System Planning
Western Power Corporation
GPO Box L921
Perth WA 6842

Telephone: (08) 9326 6293
Facsimile: (08) 9326 4425

Networks would particularly like to hear from parties who are considering investments that, based on the information provided here, would appear to either:

- Delay requirements for network development options; and
- Accelerate requirements for network development options.

Relevant information will be incorporated in the Networks' planning process and reflected in any updates to Networks Committed Projects and in future editions of the Annual Planning Report.

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Abbreviations

APR	Annual Planning Review
CBD	Central Business District
DNSP	Distribution Network Service Provider
DSM	Demand Side Management
DUOS	Distribution Use of System Charge
EPA	Environmental Protection Authority
ERA	Economic Regulation Authority
ERTF	Electricity Reform Taskforce
Firm Capacity	A substation designed to the N-1 reliability criteria must be capable of withstanding the loss of any single transmission plant item comprising the substation transformer circuits at any load level without loss of load.
IPP	Independent Power Producers
KA	Kilo Amperes (Measure of Electrical Current)
KV	Kilo Volts (Measure of Electrical Potential)
MDP	Metropolitan Development Plan
MVA	Mega Volt Ampere (Measure of Electrical Demand)
MW	Mega Watts (Measure of the Active Component of Electrical Demand)
N - 0	A substation designed to the N reliability criteria means that all load supplied by the substation may be lost as the result of an outage on any single transmission plant item comprising the substation.
N - 2 at 80% Peak Load	N-2 criteria means that the consequences of the coincidence of one planned and one unplanned outage of transmission elements, at or below 80% of peak load, will normally result in supply being maintained without loss of load, provided generation is rescheduled prior to the second outage.
NCR Criteria	A zone substation designed to the NCR reliability criteria allows for the loss of an amount of load equivalent to a transformer's pre-outage loading at any load level ensuing the outage of any single transmission plant item comprising the substation transformer circuits. Loss of load is permitted for the period required to install the Rapid Response Spare Transformer (RRST).
PoE	Probability of Exceedance
SECWA	State Energy Commission of Western Australia
SWIS	South-West Interconnected System
TNSP	Transmission Network Service Provider

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Appendix - Introduction to network issues

Planning and operating electricity networks

Electricity networks are used to transport electricity from the power station to the customer. The transmission network allows the bulk transport of power across long distances at high voltages. The distribution network delivers electricity from the transmission substation to the end customer, usually over shorter distances and at lower voltages.

The planning, design, operation, maintenance and augmentation of electricity networks must ensure that:

- Each individual piece of network equipment is operated within its design limits. This requires voltage and power transfer for each asset to be assessed under a wide range of potential conditions, including for example modelling the effect of faults on the network. This is illustrated in the figure below. Failure to meet voltage design limits can result in malfunction or damage to customer equipment, while exceeding power transfer limits creates potential safety and reliability hazards;
- Quality of supply is maintained to the appropriate standards. Quality of supply is a term that embraces voltage, frequency and other technical aspects of power supply;
- Potential for future growth is adequately provided for, where economically viable to do so: ensuring that Western Power's electricity networks do not impede Western Australia's economic development. This may mean, in some circumstances, installing 'larger' plant than is immediately required, to cater for expected load growth over the next, say, ten years; and
- Environmental impacts are responsibly managed.

In planning and operating the system, it is important to distinguish between system security and supply to individual customers. For example, the system is insecure, even if all customers are currently being supplied, if there is a credible fault that would lead to widespread loss of supply. The system is secure, even if some customers are currently without power, if the system can withstand a credible fault. The most famous example of this paradox was in California in early 2001 where suburbs were subjected to rolling black-outs to maintain overall system security.

Overall, a secure system is likely to lead to more reliable supplies to customers.

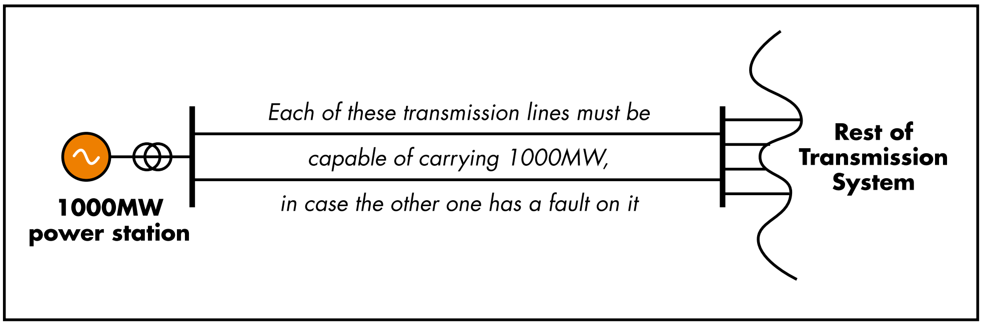

Figure - need for back-up facilities

- The network can withstand credible faults and unplanned outages. A fault is considered credible if it is considered likely given the prevailing circumstances. For example, a simultaneous fault on two adjacent circuits might be considered credible in a severe storm, but not in normal weather conditions. If there is a credible fault or unplanned outage, all plant must still operate within its design limits and the network must continue to deliver its required performance. Required performance will be related to the underlying economics. For example:
  - In a CBD, a fault or unplanned outage on the transmission system should not result in a loss of supply. The large number of customers connected to the system justifies back-up systems.
  - In a rural distribution network, a fault may result in a loss of supply but this should be for a limited load and a limited time. There will be contingency plans to restore supplies after a fault. The smaller number of customers connected to a rural system is unlikely to justify extensive back-up systems;

Faults on electricity networks

A 'fault' on the electricity network may be caused, among other things, by lightening strikes, catastrophic failure of equipment, debris falling on lines or vegetation touching lines. A fault will tend to result in:

- A very high current flowing towards the location of the fault, many times the normal rating of the network equipment, known as the fault current;
- A very low voltage (tending towards zero) near the location of the fault.

If a network fault were not addressed immediately, it could eventually blackout the whole system. As such, networks are designed to immediately isolate the faulted network element from the rest of the network. For example, if a crane were to stray too close to a distribution line and cause a fault, the distribution line would be automatically switched out of service.

Short-lived faults are known as transient faults. For example, a lightening strike will cause a temporary fault on the network. To ensure that equipment is not needlessly out of service, transmission equipment will automatically reenergize the network element after a short delay. This is known as 'reclosing'. If the fault is still present, the network element will be automatically isolated once more. The network element will remain isolated until the fault has been investigated and repairs effected.

Circuit breakers are used to switch out the faulted elements. Clearly, circuit breakers must be capable of interrupting the very high currents safely. To this end, circuit breakers (and associated equipment) have fault current ratings. Complex calculations are carried out to identify the potential fault currents at different locations on the network, and the circuit breakers installed must have a fault current rating that is greater than the potential fault current.

Similarly, all other network equipment must have a fault withstand capability greater than the potential fault current at its network location. That is, it must be able to safely carry fault current, albeit for a very short time. The extremely short-lived nature of fault current explains why plant can carry fault current many times it's rating in normal use.

Two things primarily affect the potential fault current at a point on the network: the proximity to generation and the impedance of the local network. Fault current is 'fed' by generation, and so the nearer the network element is to a power station, the greater the potential fault current. Impedance can be described as an object's opposition to the flow of electric current. A low impedance network will therefore give rise to a high fault current, where a high impedance network will limit fault currents.

The isolation of faulted equipment will, generally, increase flows on other network elements. If this contingency would overload another network element, so-called 'pre-contingent' action will be taken. This means that the network will be operated less efficiently to allow for the possibility of a contingency or fault.

Meshed and radial networks

An electricity network is described as highly meshed when each substation is connected to a number of other substations, as illustrated in the figure below.

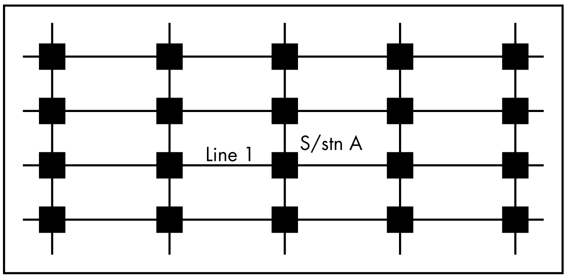

Figure - Highly Meshed Network

The main advantage of a highly meshed network is clear - if line 1 were taken out of service, substation A would still supplied by three other lines. The meshed network provides a secure supply. However, a network as highly meshed as the figure's would also be extremely expensive to develop. This expense is often justified on the transmission network.

A radial network is illustrated in the figure below.

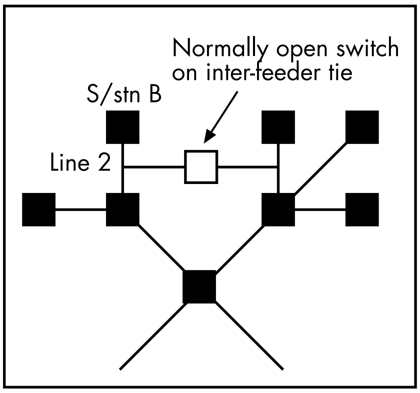

Figure - Meshed Network

It can be seen that the radial network is inherently less secure - if line 2 is lost, substation B would lose its supply. Nonetheless a radial network is much cheaper than a meshed network and so is suitable for distribution networks. Furthermore, a meshed distribution network could give rise to very high fault currents.

Inter-tie feeders are used to provide fast restoration of supplies following faults. Following a fault, the affected network will be switched out of service, and the normally open switch energised. The switch is normally open as to have it energised before the fault would give rise to very high fault currents.

Peak Demand, weather and diversity

Peak electricity demand may last for only a few hours. However, the network must be capable of supplying the maximum load that occurs.

The extent of simultaneous consumer demand affects peak demand significantly. For example, a bakery's peak demand may occur overnight when it is in full production. During the day, its demand is likely to be low. On the other hand, an office building would normally operate during business hours and shutdown overnight. Maximum demand in an office building tends to occur during the mid-afternoon. This load diversity is helpful to networks, as it tends to reduce demand peaks and increases asset utilisation.

The figure below shows typical load demand profiles for substations supplying mostly residential, mixed residential/commercial and mostly commercial load. Residential loads tend to peak later in the evening towards 2000 hours whereas commercial loads tend to peak in mid-afternoon at approximately 1500 hours. The mixed residential/commercial profile is a reasonable composite of the residential and commercial profiles, where the peak depends on the mix of residential and commercial loads.

While the underlying trend in peak demand may be steady, peak demand in any particular year is very sensitive to prevailing weather conditions. Heating loads in winter and air-conditioning loads in summer are the two main influences on peak demand. On a particularly hot (or cold) day, everyone turns on the air-conditioner (or heater) at roughly the same time. This simultaneous consumption behaviour drives peak demand. Moreover, most air-conditioners are turned on during the hottest part of the day and turned off as the temperature declines in late afternoon, exacerbating peak demand - air-conditioning loads are described as having low diversity..

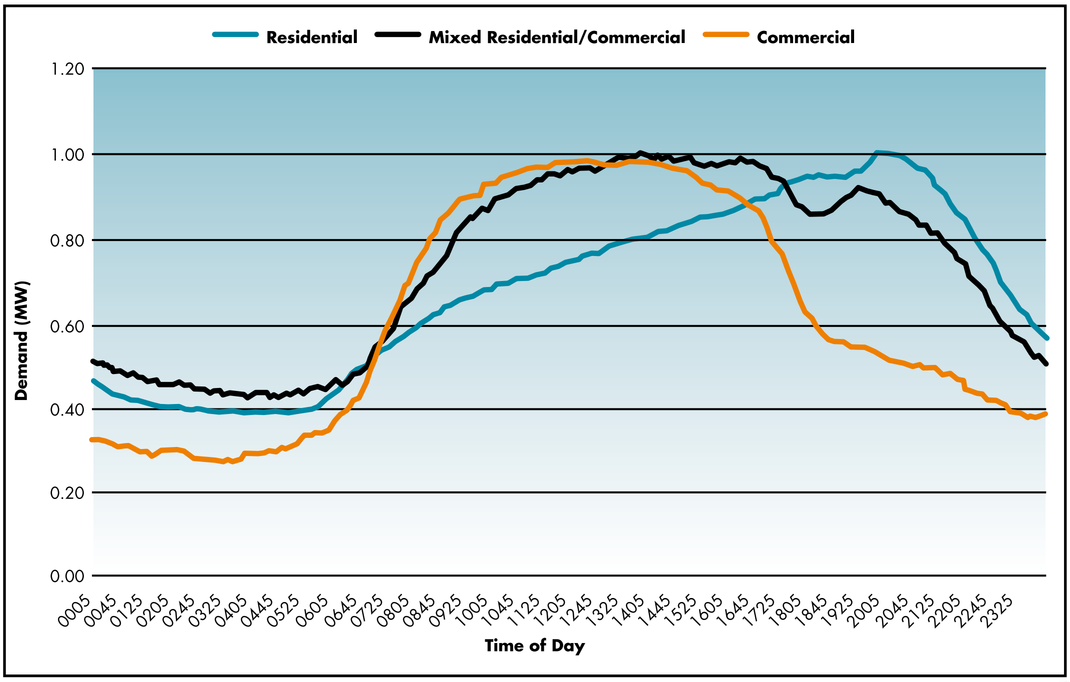

Figure - Typical SWIS load profiles for different load types during summer substation peak.

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